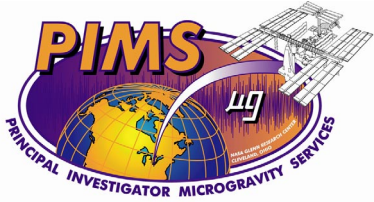


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# International Space Station (ISS) Measured Vibratory Environment

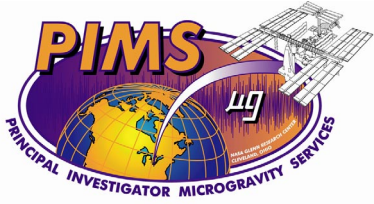
Principal Investigator Microgravity Services (PIMS)  
Kenneth Hrovat



# Outline

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- A Couple of Important Notes on Vibratory Data
- **Vehicle**
  - Shuttle Docking
  - Air conditioner [**SKV**]; Система Кондиционирования Воздуха (**СКВ**)
  - Control Moment Gyroscope (**CMG**)
- **Experiment**
  - Gas Analysis System for Metabolic Analysis of Physiology (**GASMAP**)
  - Microencapsulation Electrostatic Processing System (**MEPS**)
- **Crew**
  - Sleep/Wake
  - Public Affairs Office (**PAO**) Event
  - Exercise
    - Resistive Exercise Device (**RED**)
    - Cycle Ergometer with Vibration Isolation System (**CEVIS**)
    - Russian Velosiped (**Velo**)
    - ~~• Russian Segment Treadmill Vibration Isolation System (**TVIS**)~~
- Principal Component Spectral Analysis (**PCSA**)



## Important Notes on Vibratory Data

---

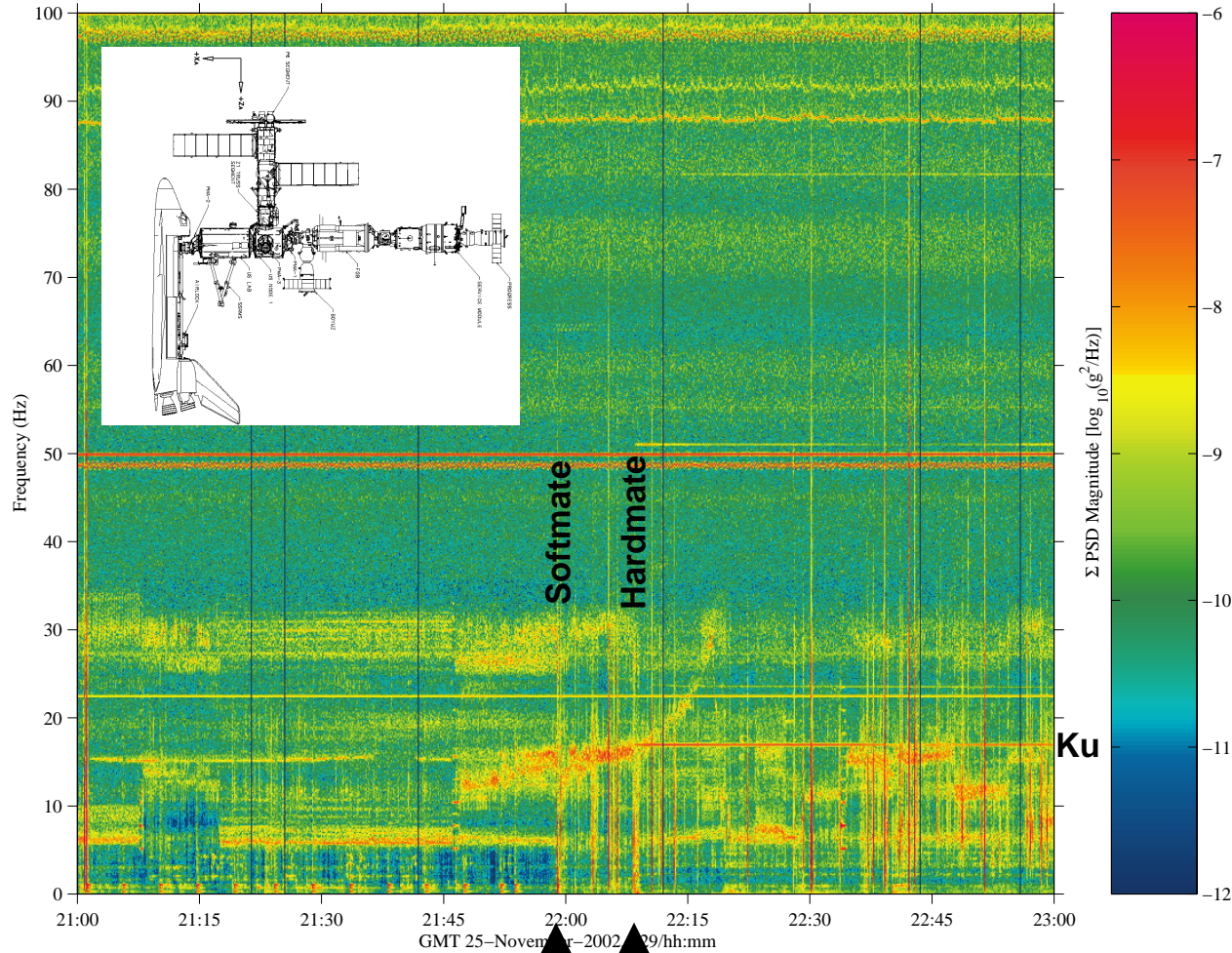
- Always demean vibratory data because Space Acceleration Measurement System (**SAMS**) sensors are not intended for low-frequency, quasi-steady measurements. If acceleration measurements below 0.01 Hz are needed, then seek Microgravity Acceleration Measurement System (**MAMS**) data. This instrument is dedicated to measurement below 0.01 Hz with special procedures and analysis to get precise accounting of quasi-steady regime, including the mean.
- Vibratory acceleration data are not mathematically mapped to other locations because the rigid body assumption does not hold at these higher frequencies.

# Shuttle Docking QUALIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
 250.0 sa/sec (100.00 Hz)  
 Δf = 0.122 Hz, Nfft = 2048  
 Temp. Res. = 8.192 sec, No = 0

STS-113 Docking

Increment: 5, Flight: UF2  
 Sum  
 Hanning, k = 3499  
 Span = 8.00 hours



Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

**Notes:**

The Shuttle docks at the forward end of the US Lab to a Pressurized Mating Adapter (PMA-2). Initial contact is referred to as “softmate” even though its impact is typically greater in magnitude than the “hardmate” event. A typical Shuttle docking is as follows:

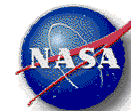
- (1) initial contact and capture (softmate)
- (2) pause several minutes to let relative motion between the two spacecraft damp out
- (3) drive latches to make solid mechanical connection (hardmate)

Upon completion of the hardmate, the two spacecraft effectively become one structure from a vibratory acceleration transmission perspective. This is usually evidenced by measurements made on the space station, which show the signature of the Shuttle’s Ku-band antenna. This antenna is nearly continuously dithered at 17 Hz to prevent mechanical stiction and usually is accompanied by higher harmonics (most notably 34 and 51 Hz).

Regime:	Vibratory
Category:	Vehicle
Source:	Shuttle Docking



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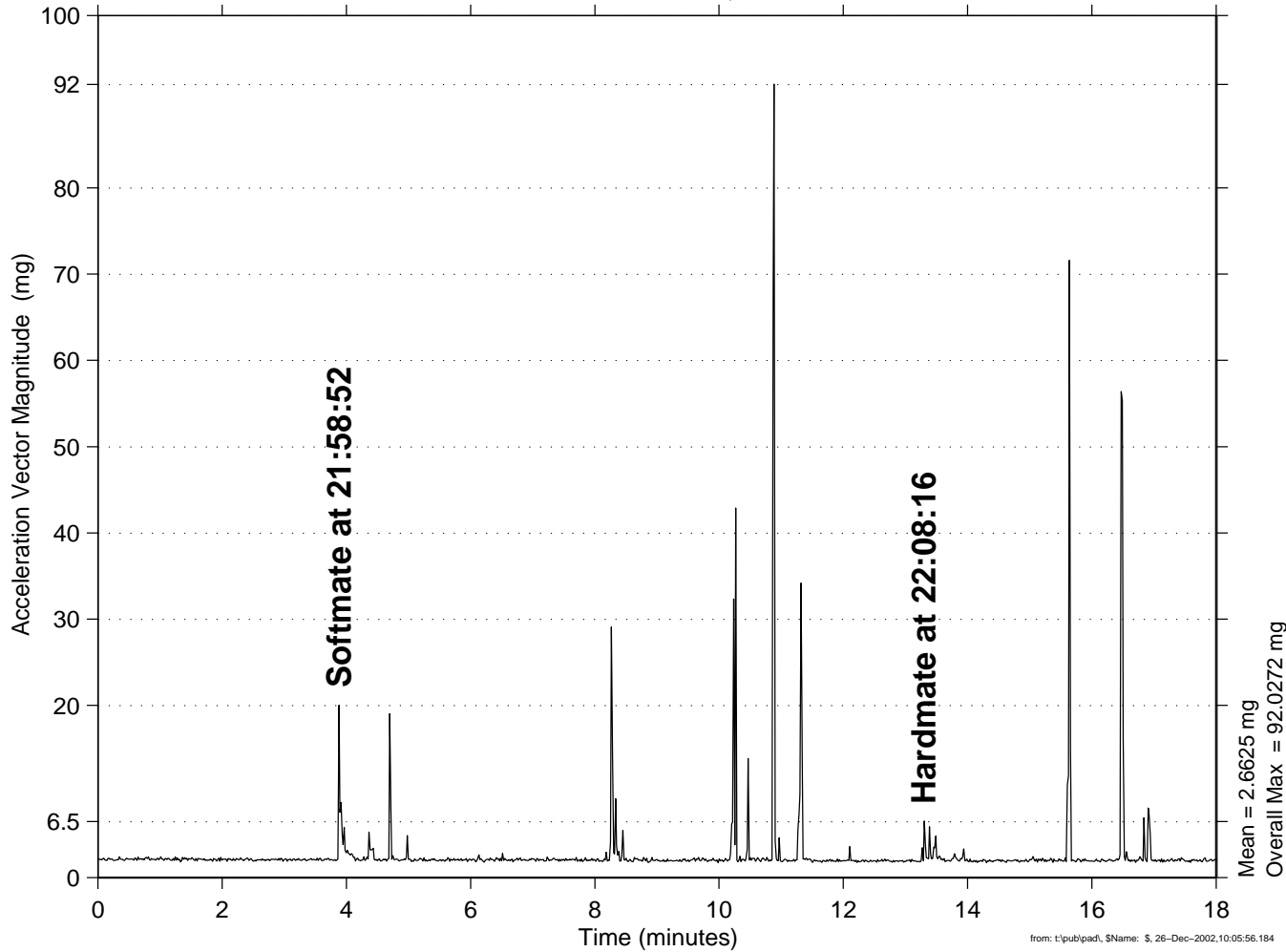
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# Shuttle Docking QUANTIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)

Increment: 5, Flight: UF2  
Vector Magnitude  
Interval Max  
Size: 1.00, Step: 1.00 sec.

STS-113 Docking  
Start GMT 25-November-2002, 329/21:55:00.003



### Data Description

Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval max

#### Notes:

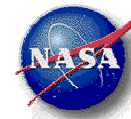
The 1-second interval max plot is annotated to show the STS-113 Shuttle docking sequence:

- (1) initial contact and capture at about the 4-minute mark; **softmate: 20 mg**
- (2) pause about 10 minutes to allow the relative motion between the two spacecraft dampen out
- (3) drive latches to make solid mechanical connection; **hardmate: 6.5 mg**

This interval max plot also shows that other impulsive events can dwarf the primary docking impact events. In this case, a peak acceleration of about 92 mg took place between the softmate and hardmate events.



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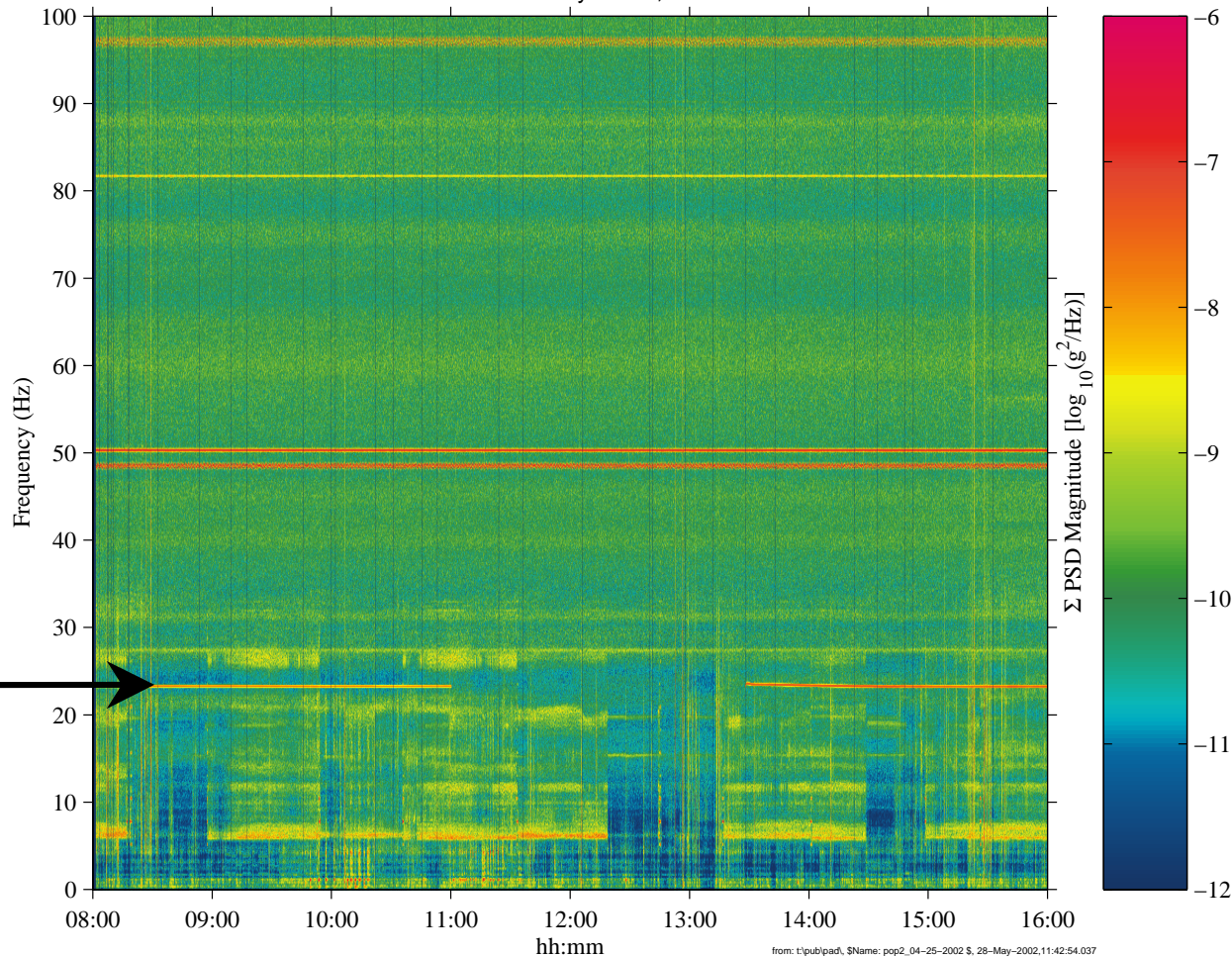
Regime:	Vibratory
Category:	Vehicle
Source:	Shuttle Docking

# SKV Air Conditioner Qualify

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

SAMS 121f02  
Start GMT 24-May-2002,08:00:00

Increment: 4, Flight: 8A  
Sum  
Hanning, k = 3471  
Span = 8.00 hours



from: t:\pub\padf, \$Name: pop2\_04-25-2002 \$, 28-May-2002,11:42:54.037



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Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 4, Flight: 8A
Plot Type	spectrogram

### Notes:

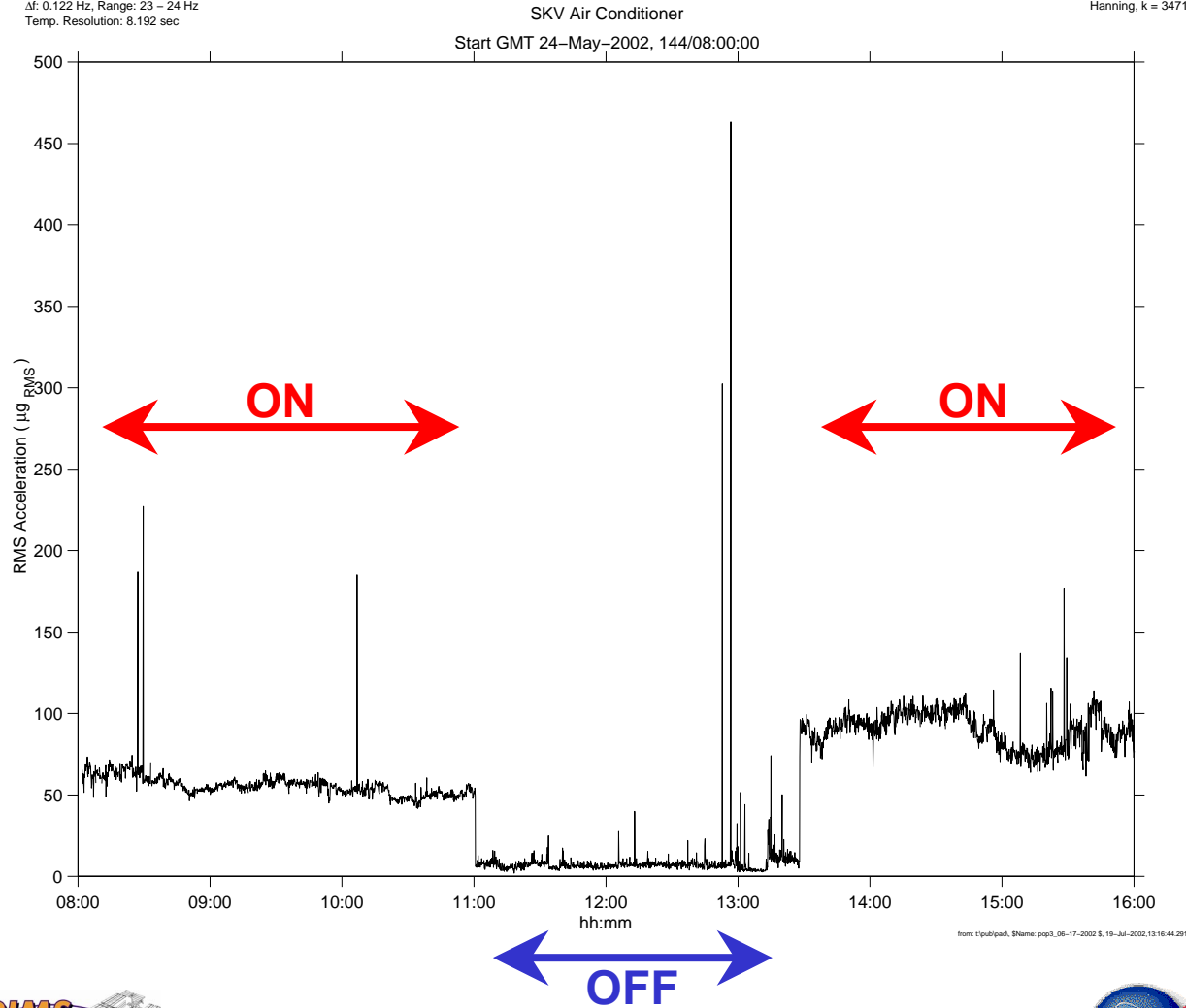
- This Russian air conditioner is part of the Environmental Control and Life Support System (ECLSS).
- As part of preparation for an ExtraVehicular Activity (EVA), the crew will move ducting in order to work with hatches. It has been noted that this is accompanied by a temporary deactivation of the air conditioner.
- Nominally one SKV is operating, but there are times when both SKV-1 and SKV-2 are on.
- The nearly continuous operation of this equipment produces a narrowband disturbance near 23.5 Hz. This spectral peak serves as vibratory beacon signal.

Regime:	Vibratory
Category:	Vehicle
Source:	SKV Air Conditioner

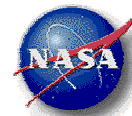
# SKV Air Conditioner Quantify

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
Δf: 0.122 Hz, Range: 23 - 24 Hz  
Temp. Resolution: 8.192 sec

Increment: 4, Flight: 8A  
121f02[-90.0 0.0 -90.0]  
Hanning, k = 3471



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Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 4, Flight: 8A
Plot Type	interval RMS

### Notes:

For the 8-hour period shown in the figure, Parseval's theorem was used to derive the RMS acceleration level for a narrow band around the SKV air conditioner's operating frequency. The results for the frequency band from 23 to 24 Hz is tabulated below:

SKV	GMT	Median ( $\mu\text{g RMS}$ )
ON	08:00 - 11:00	55.4
OFF	11:00 - 13:28	6.8
ON	13:28 - 16:00	91.2

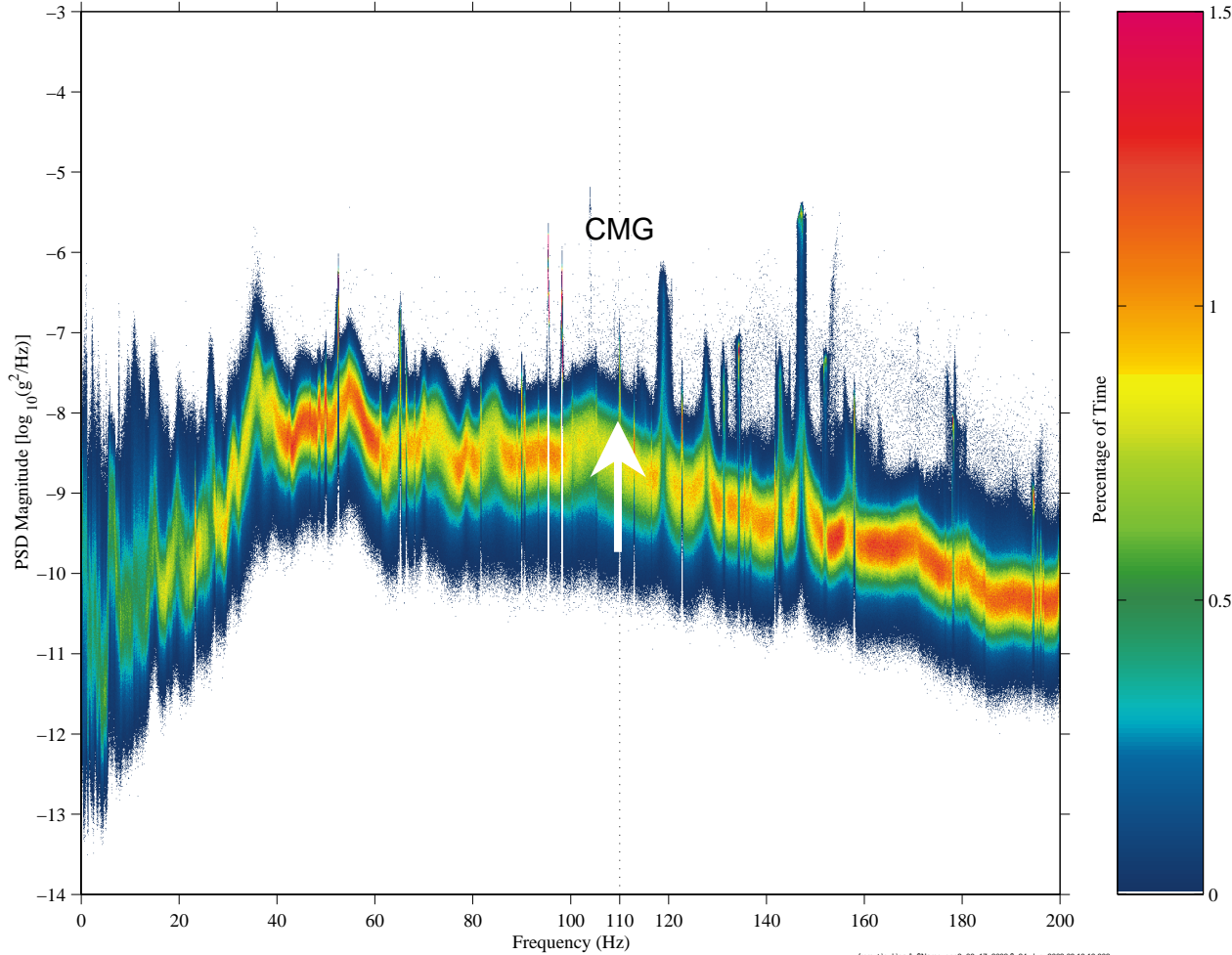
Regime:	Vibratory
Category:	Vehicle
Source:	SKV Air Conditioner

# Control Moment Gyroscope (CMG) QUALIFY

sams2, 121f03 at LAB1O1, ER2, Lower Z Panel:[191.54 -40.54 135.25]  
500.0 sa/sec (200.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 4096  
Temp. Res. = 8.192 sec, No = 0

SAMS 121f03  
GMT 05-Oct-2002 through 07-Oct-2002

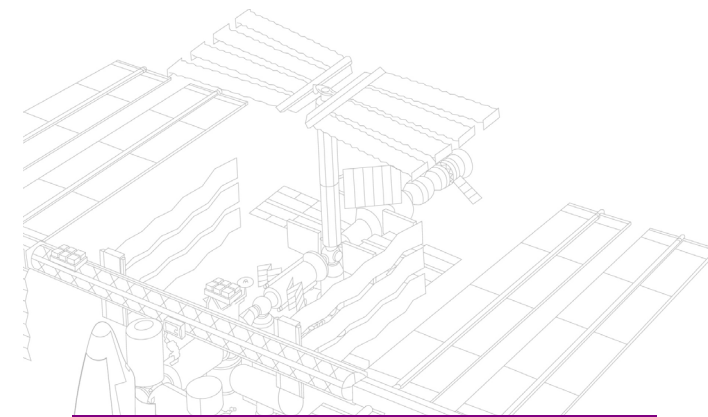
Increment: 5, Flight: UF2  
Sum  
hanning, 31141 PSDs  
Total of 70.9 hours



from: t:\pub\pad5, \$Name: pcp3\_06-17-2002 5, 24-Jun-2002,06:19:13.602

Data Description	
Sensor	SAMS, 121f03 500.0 sa/sec (200.00 Hz)
Location	LAB1O1, ER2, Lower Z Panel
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	PCSA

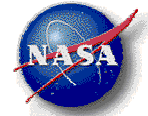
**Notes:**  
There are 4 control moment gyroscopes (CMGs) located on the Z1 truss structure (currently, only 3 are operational). These rotate at 6,600 revolutions per minute (RPM) within 1 RPM (1/60 Hz) to provide non-propulsive attitude control for the space station. The principal component spectral analysis (PCSA) plot at the left summarizes the acceleration spectrum for a 3-day span. As seen by the narrow spectral peak at 110 Hz, these gyros are tightly controlled in frequency.



Regime:	Vibratory
Category:	Vehicle
Source:	Control Moment Gyroscope (CMG)



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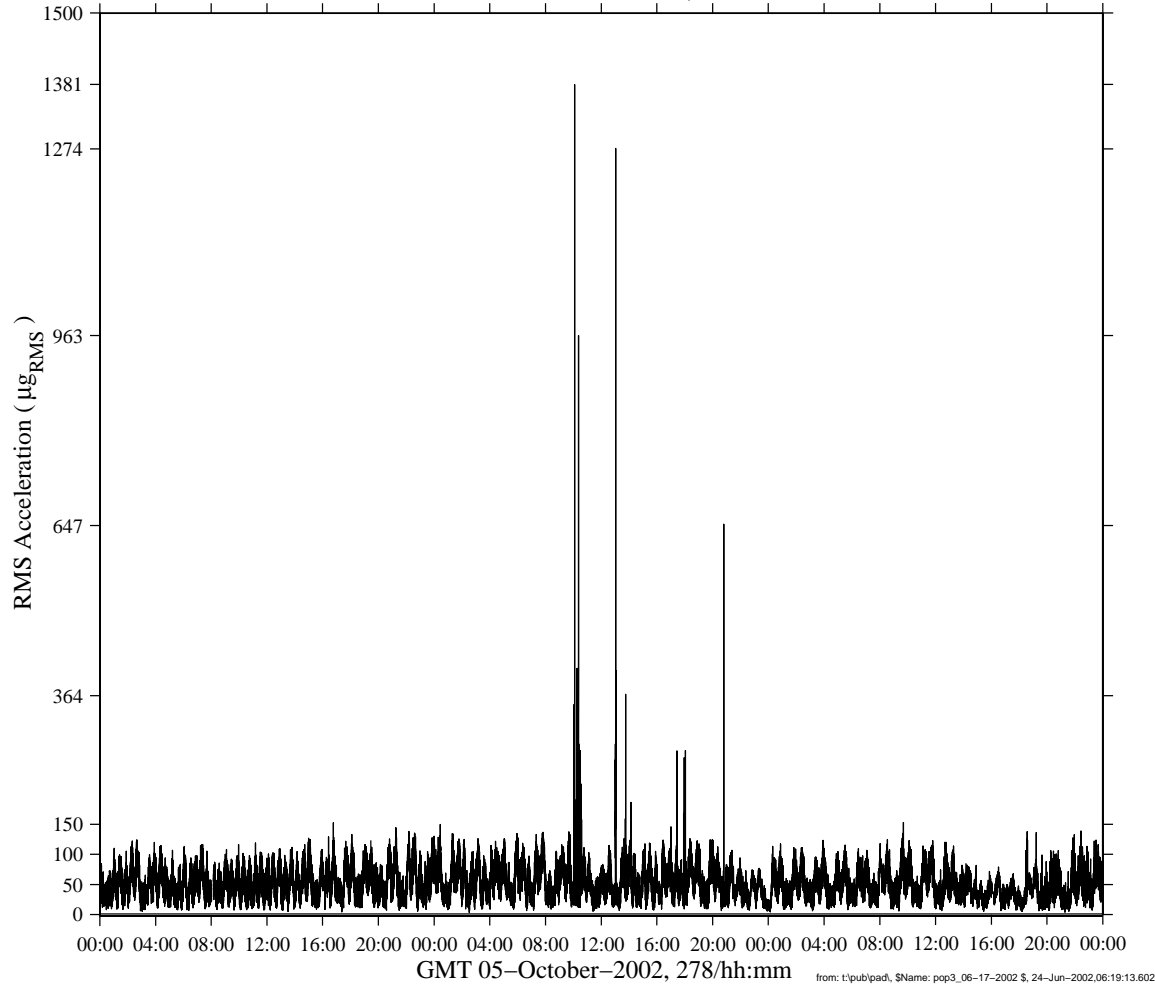


## Control Moment Gyroscope (CMG) QUANTIFY

sams2, 121f03 at LAB1O1, ER2, Lower Z Panel:[191.54 -40.54 135.25]  
500.0 sa/sec (200.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfit = 4096  
Temp. Res. = 8.192 sec, No = 0

CMGs, 109.983 < f < 110.017 Hz  
Start GMT 05-October-2002, 278/00:00:00

Increment: 5, Flight: UF2  
Sum  
Hanning, k = 31141  
Span = 72.00 hours

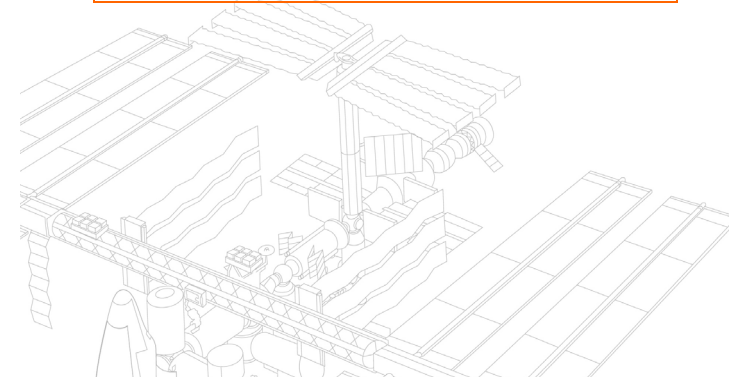


Data Description	
Sensor	SAMS, 121f03 500.0 sa/sec (200.00 Hz)
Location	LAB1O1, ER2, Lower Z Panel
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

**Notes:**  
The plot shows interval RMS values during a 3-day period for a narrow frequency band (109.983 to 110.071 Hz) around the CMG operating frequency (110 Hz). Statistics gathered for this time frame show:

- 95<sup>th</sup> percentile: 94.9  $\mu\text{g}_{\text{RMS}}$
- median: 47.7  $\mu\text{g}_{\text{RMS}}$
- mean: 50.9  $\mu\text{g}_{\text{RMS}}$

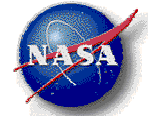
This plot also shows that this small frequency band will also register much higher RMS levels not necessarily attributable to nominal operation of the CMGs.



Regime:	Vibratory
Category:	Vehicle
Source:	Control Moment Gyroscope (CMG)



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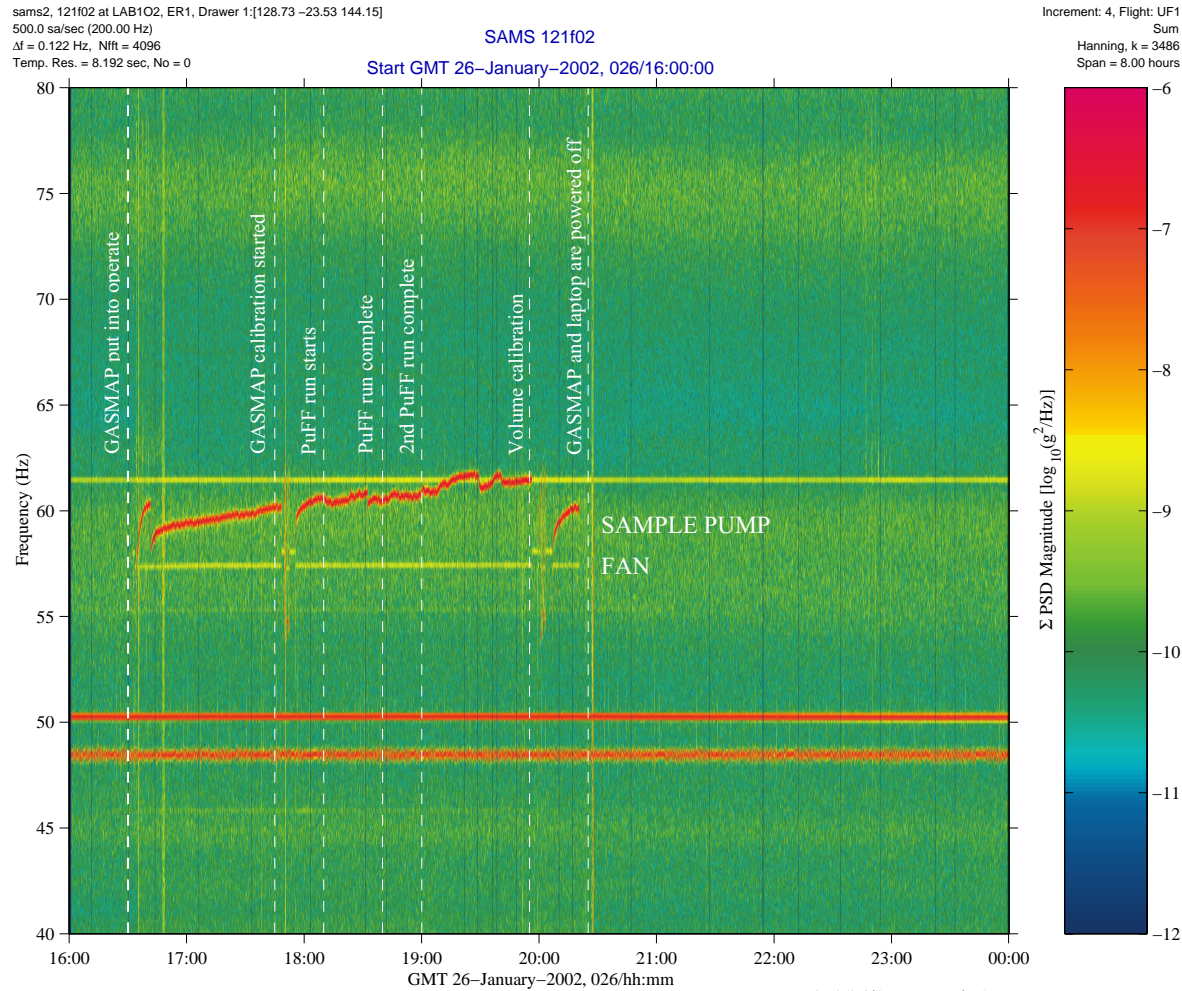
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# Gas Analysis System for Metabolic Analysis of Physiology (GASMAP) Qualify



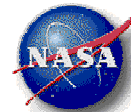
Data Description	
Sensor	SAMS, 121f02 500.0 sa/sec (200.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 4, Flight: UF1
Plot Type	spectrogram

## Notes:

The GASMAP device is used to monitor and analyze both inhaled and exhaled breath streams to determine their gas concentrations. Two GASMAP signatures are noted in the figure near 60 Hz: **a sample pump and a fan**. This equipment is located in the HRF rack #1 (LAB1S2) and used for the Pulmonary Function in Flight (PuFF) experiment, which studies effects of extravehicular activity (EVA) and long-term exposure to microgravity on the pulmonary function. As discussed with payload developers, the frequency changes away from nominal operation are likely a function of varying loads on the sample pump. The pump frequency ranged from 54 Hz (for brief calibrations) up to 62 Hz after the second PuFF run. The fan is tightly controlled in frequency but also transitions from baseline of about 57.4 Hz up to 58.1 Hz noted during calibrations.



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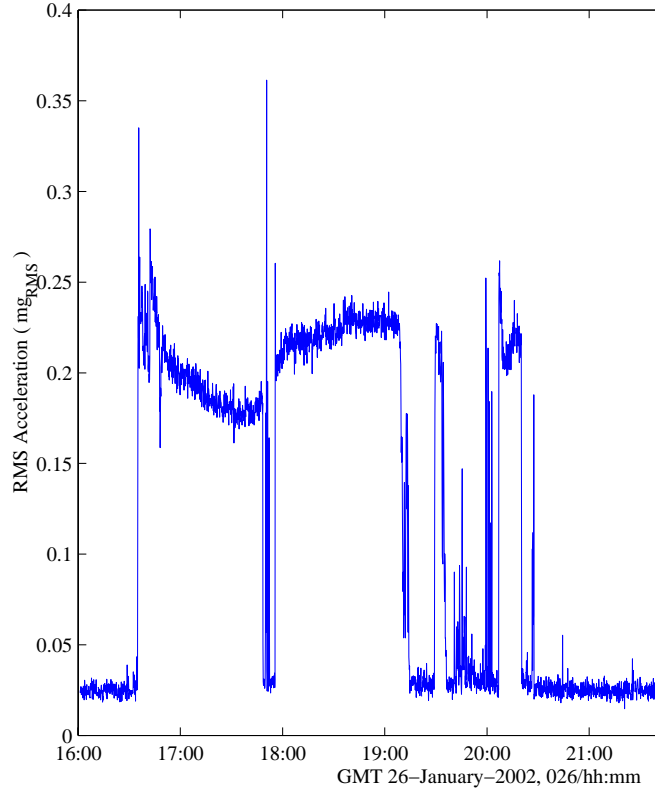
Regime:	Vibratory
Category:	Experiment Equipment
Source:	GASMAP

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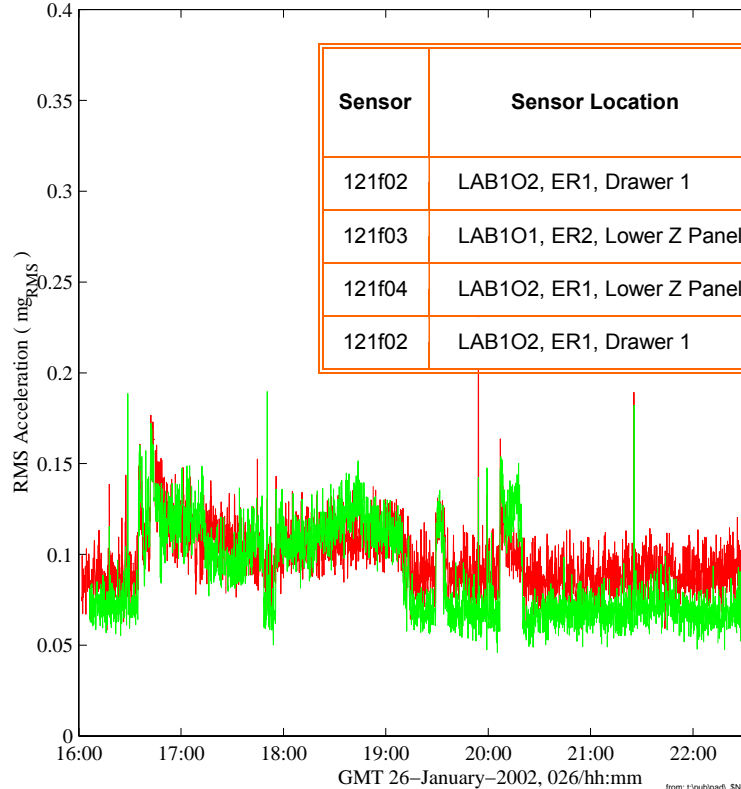
# Gas Analysis System for Metabolic Analysis of Physiology (GASMAP) Quantify

Data Description	
Sensor	SAMS, 121f02 500.0 sa/sec (200.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 4, Flight: UF1
Plot Type	interval RMS

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
500.0 sa/sec (200.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 4096  
Temp. Res. = 8.192 sec, No = 0  
SAMS 121f02 (Drawer 1, ER1, I  
GASMAP Sample Pump (58.2 < f <



250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0  
SAMS 121f03 (Z-panel, ER2, LAB1O1)  
SAMS 121f04 (Z-panel, ER1, LAB1O2)  
GASMAP Sample Pump (58.2 < f < 61.2 Hz



Sensor	Sensor Location	GASMAP Equipment	Frequency Range (Hz)	State	RMS Acceleration (ug <sub>RMS</sub> )
121f02	LAB1O2, ER1, Drawer 1	SAMPLE PUMP	58.2 – 61.2	OFF	24
				ON	>200
OFF	91				
ON	>115				
121f03	LAB1O1, ER2, Lower Z Panel	FAN	57.2 – 57.6	OFF	70
121f04	LAB1O2, ER1, Lower Z Panel			ON	>115
121f02	LAB1O2, ER1, Drawer 1	FAN	57.2 – 57.6	OFF	8
				ON	19



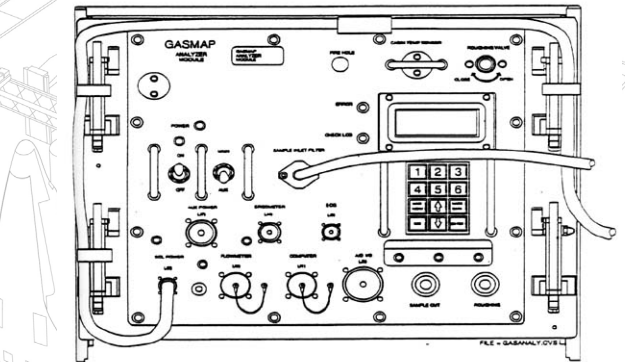
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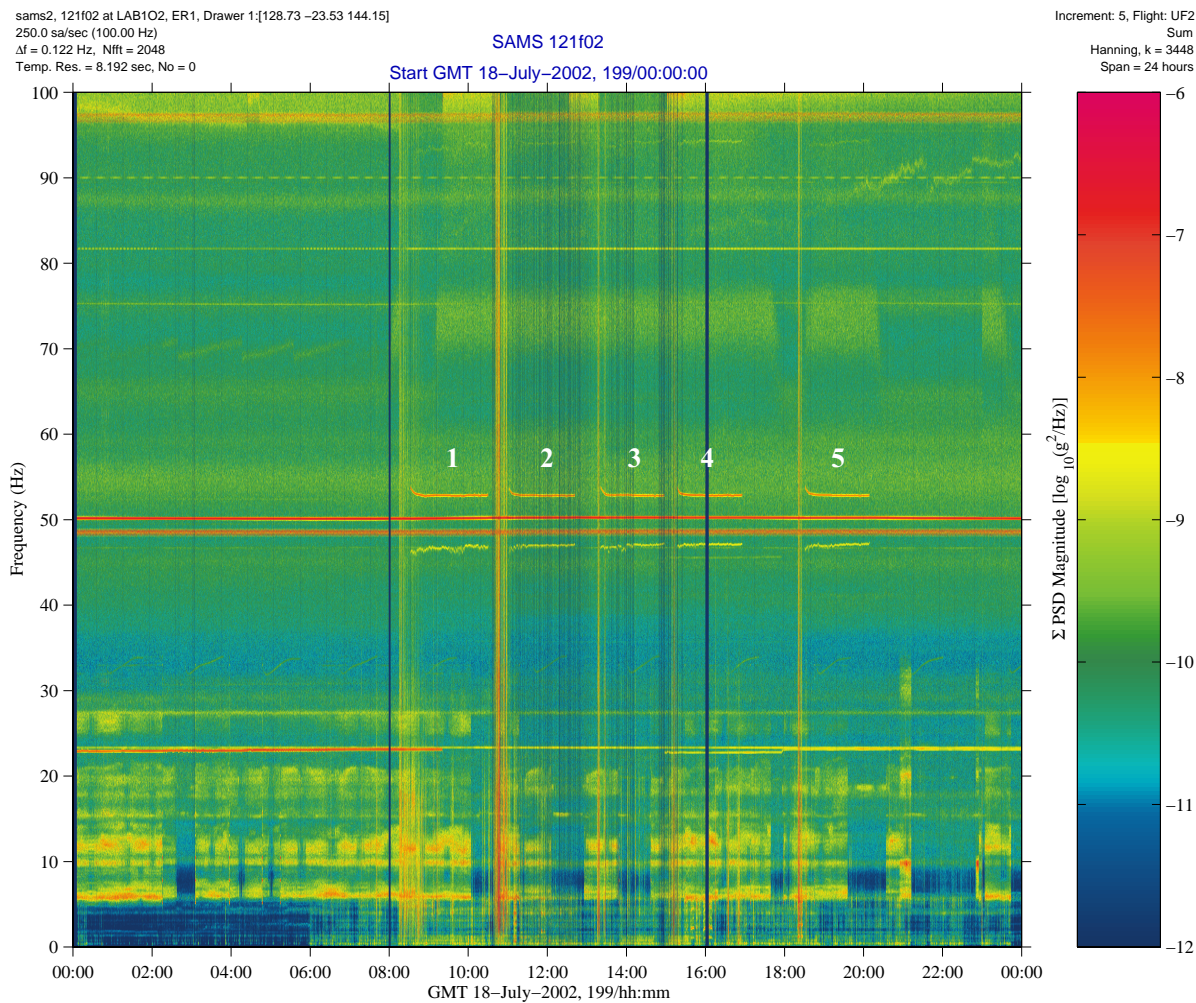
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Regime:	Vibratory
Category:	Experiment Equipment
Source:	GASMAP

# Microencapsulation Electrostatic Processing System (MEPS) Qualify

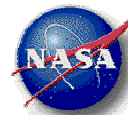


Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

**Notes:**  
 The MEPS is located in locker #8 of ER1 (LAB1O2) near the 121f02 sensor in RTS drawer 1. This 24-hour spectrogram readily shows 5 MEPS sample runs with the start/stop delimited by 2 narrowband signals. The weaker of these was centered at 47.1 Hz and the stronger at 52.8 Hz. Note that each of the 5 runs is preceded by the impulsive events of Process Chamber Module (PCM) insertion.



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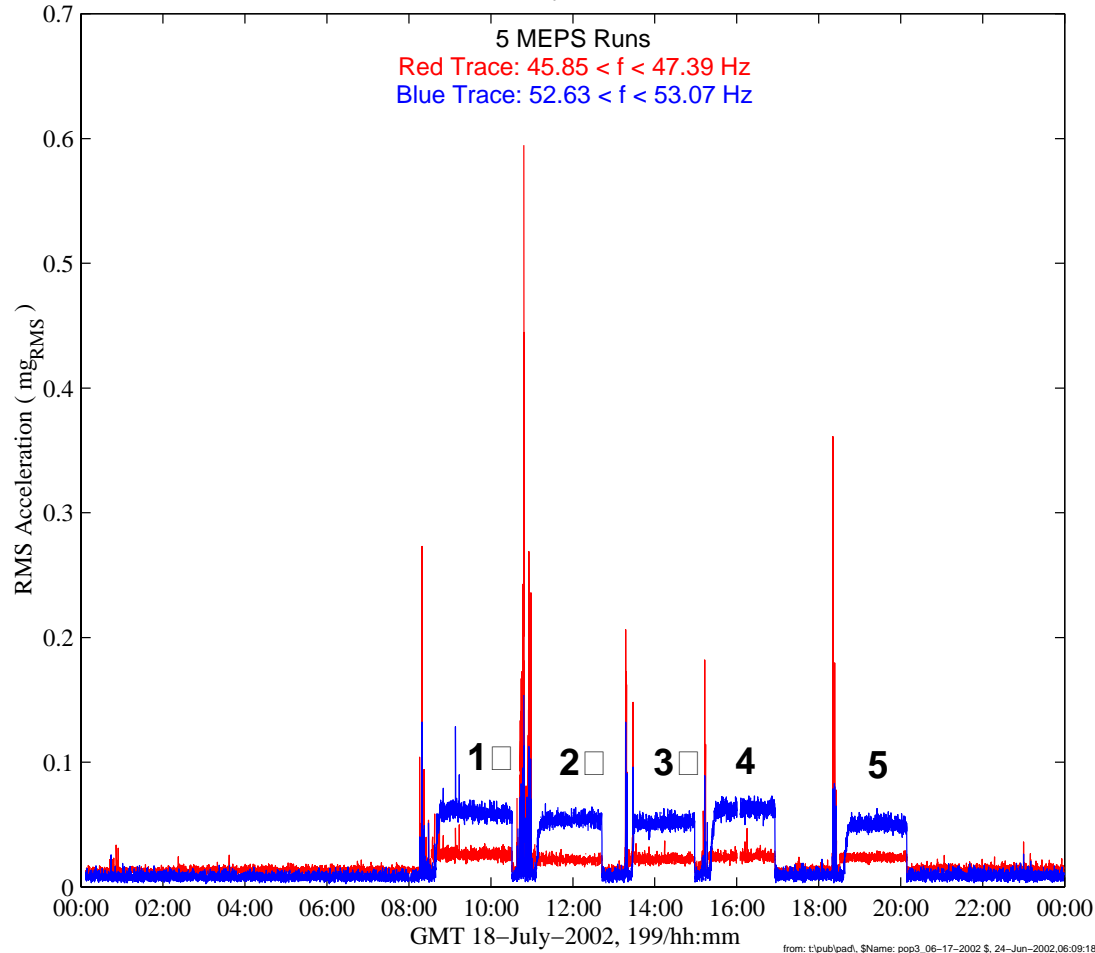
Regime:	Vibratory
Category:	Experiment Equipment
Source:	MEPS

# Microencapsulation Electrostatic Processing System (MEPS) Quantify

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

Start GMT 18-Jul-2002, 199/00:00:00

Increment: 5, Flight: UF2  
Sum  
Hanning, k = 3448  
Span = 24 hours



Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

### Notes:

This interval RMS versus time plot corresponds to the same time frame as that of the 24-hour spectrogram shown on the "qualify" page. This figure shows the contribution of the 2 narrowband signals that accompany the MEPS runs. The red trace gives the RMS acceleration for the fainter, low-frequency signal centered at 47.1 Hz. This signal steps from about 14 to 24  $ug_{RMS}$  in the frequency range from 45.85 to 47.39 Hz. Likewise, the blue trace for the stronger signal centered at 52.8 Hz steps from about 9 to 54  $ug_{RMS}$  in the frequency range from 52.63 to 53.07 Hz. The largest transient in this time frame was 103 mg and is attributed to insertion of the Process Chamber Module (PCM) for the 2nd sample run.



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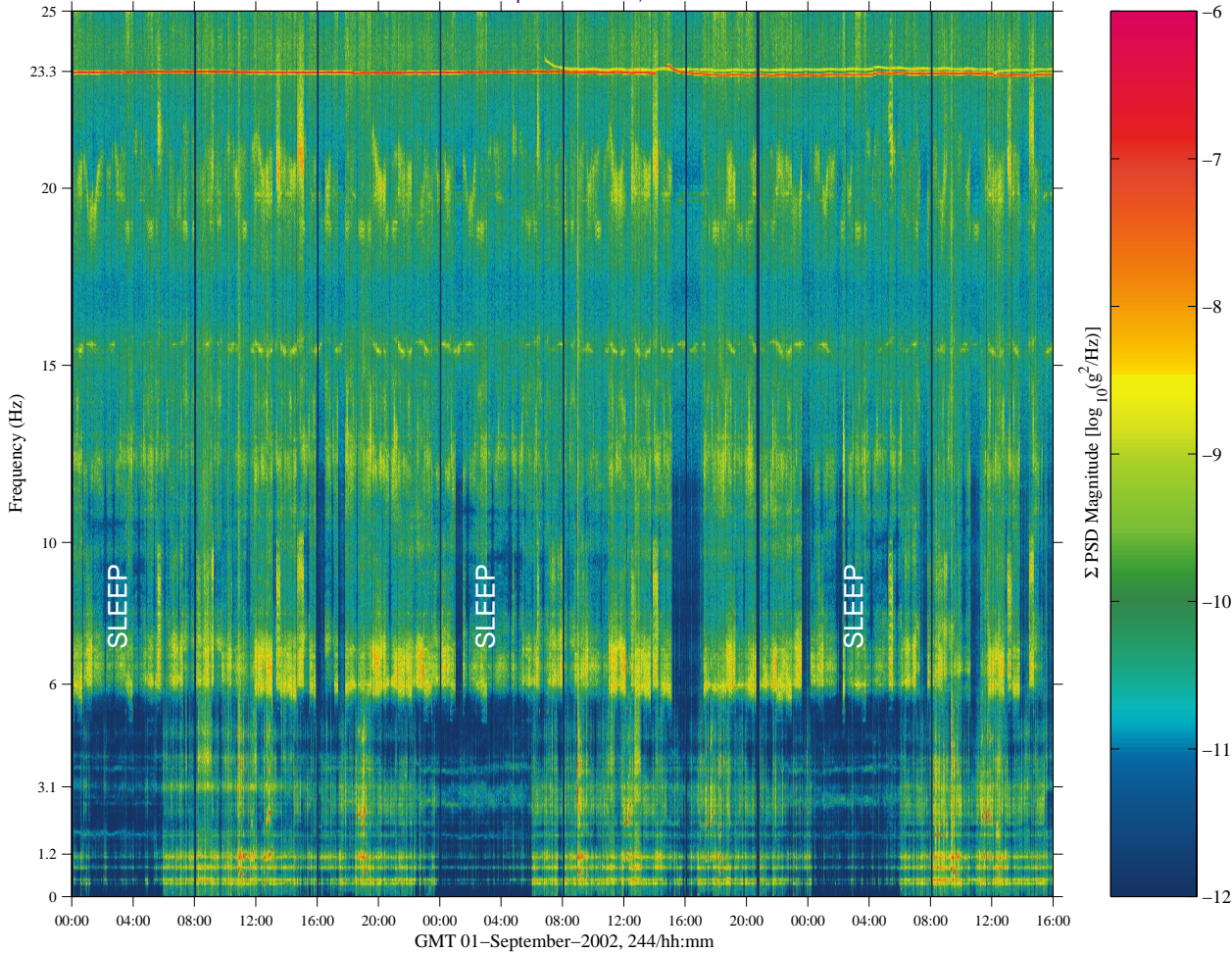
Regime:	Vibratory
Category:	Experiment Equipment
Source:	MEPS

# Sleep/Wake QUALIFY

sams2, 121f03 at LAB101, ER2, Lower Z Panel[191.54 -40.54 135.25]  
 62.5 sa/sec (25.00 Hz)  
 Δf = 0.031 Hz, Nfft = 2048  
 Temp. Res. = 32.768 sec, No = 0

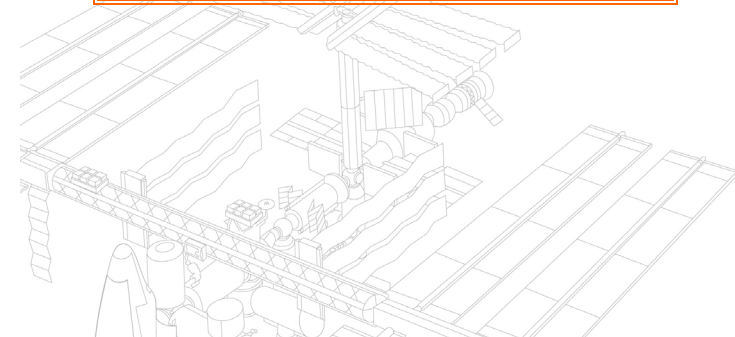
SAMS 121f03

Start GMT 01-September-2002, 244/00:00:00



Data Description	
Sensor	SAMS, 121f03 62.5 sa/sec (25.00 Hz)
Location	LAB101, ER2, Lower Z Panel
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

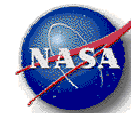
**Notes:**  
 This figure shows 3 sleep periods over a 64-hour span. The impact of crew wake periods relative to sleep is primarily below about 6 Hz. This is seen as a shift toward the blue end of the PSD magnitude color scale below about 6 Hz during the 3 sleep periods. The transition from sleep to wake is typically a sudden event owing to a wake alarm, while the transition from wake to sleep is gradual as might be expected. Signatures for both Russian air conditioners (SKV-1 and SKV-2) are also seen here toward the top of this figure at about 23.3 Hz. The slightly lower frequency and more intense SKV is on for this entire 64-hour duration, while the other one starts just after the end of the 2<sup>nd</sup> sleep period.



Regime:	Vibratory
Category:	Crew
Source:	Sleep/Wake



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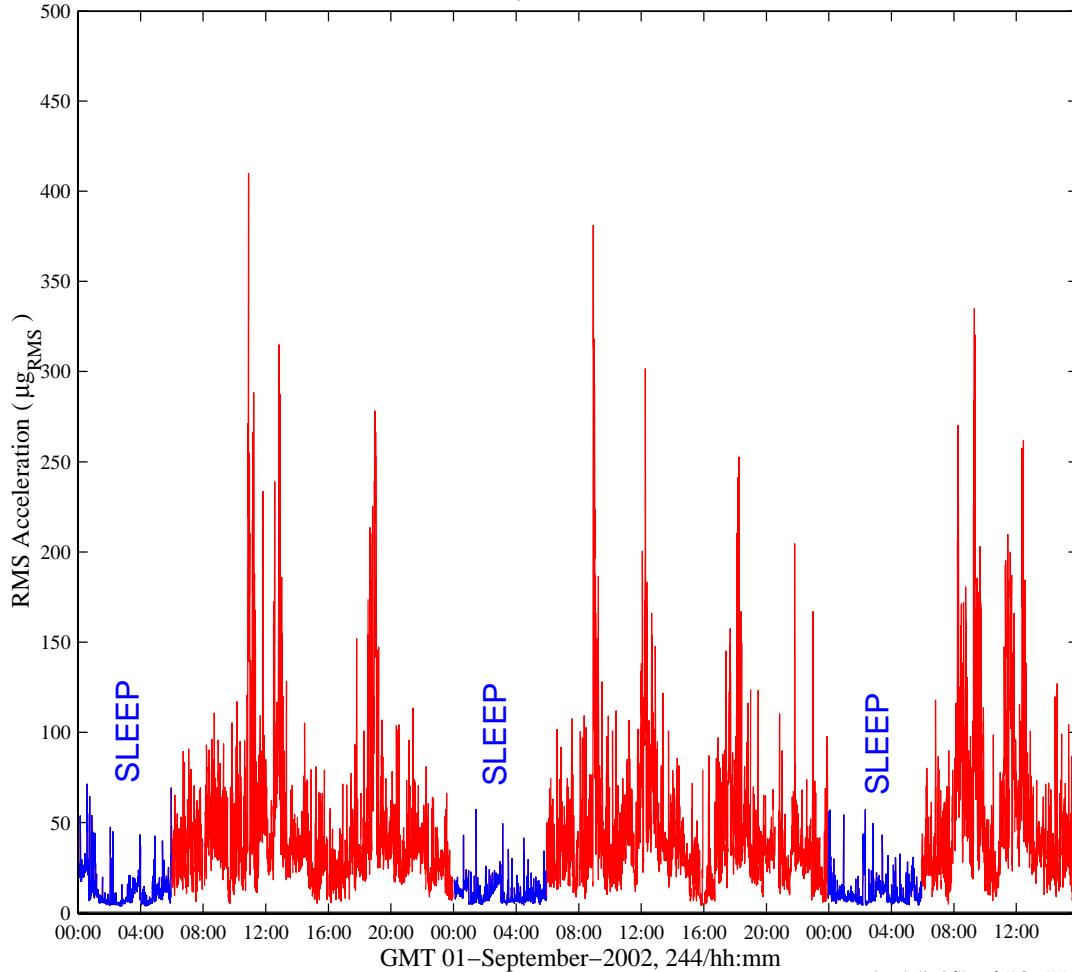
# Sleep/Wake QUANTIFY

sams2, 121f03 at LAB1O1, ER2, Lower Z Panel:[191.54 -40.54 135.25]  
 62.5 sa/sec (25.00 Hz)  
 $\Delta f = 0.031$  Hz, Nfft = 2048  
 Temp. Res. = 32.768 sec, No = 0

Sleep/Wake,  $0 < f < 6$  Hz

Start GMT 01-September-2002, 244/00:00:00

Increment: 5, Flight: UF2  
 Sum  
 Hanning, k = 6801  
 Span = 64.06 hours



from: t:\pub\pad, SName: S\_30-Dec-2002.12:15:54.735

Data Description	
Sensor	SAMS, 121f03 62.5 sa/sec (25.00 Hz)
Location	LAB1O1, ER2, Lower Z Panel
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

### Notes:

The plot shows interval RMS values during a 64-hour period for the frequency band below 6 Hz. This is the portion of the acceleration spectrum that shows contrast between crew sleep and wake periods. Statistics gathered for this time frame show:

#### SLEEP

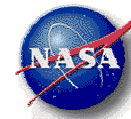
95<sup>th</sup> percentile: 25.8  $\mu\text{g}_{\text{RMS}}$   
**median:** 8.4  $\mu\text{g}_{\text{RMS}}$   
 mean: 11.2  $\mu\text{g}_{\text{RMS}}$

#### WAKE

95<sup>th</sup> percentile: 123.6  $\mu\text{g}_{\text{RMS}}$   
**median:** 34.9  $\mu\text{g}_{\text{RMS}}$   
 mean: 46.0  $\mu\text{g}_{\text{RMS}}$



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Regime:	Vibratory
Category:	Crew
Source:	Sleep/Wake

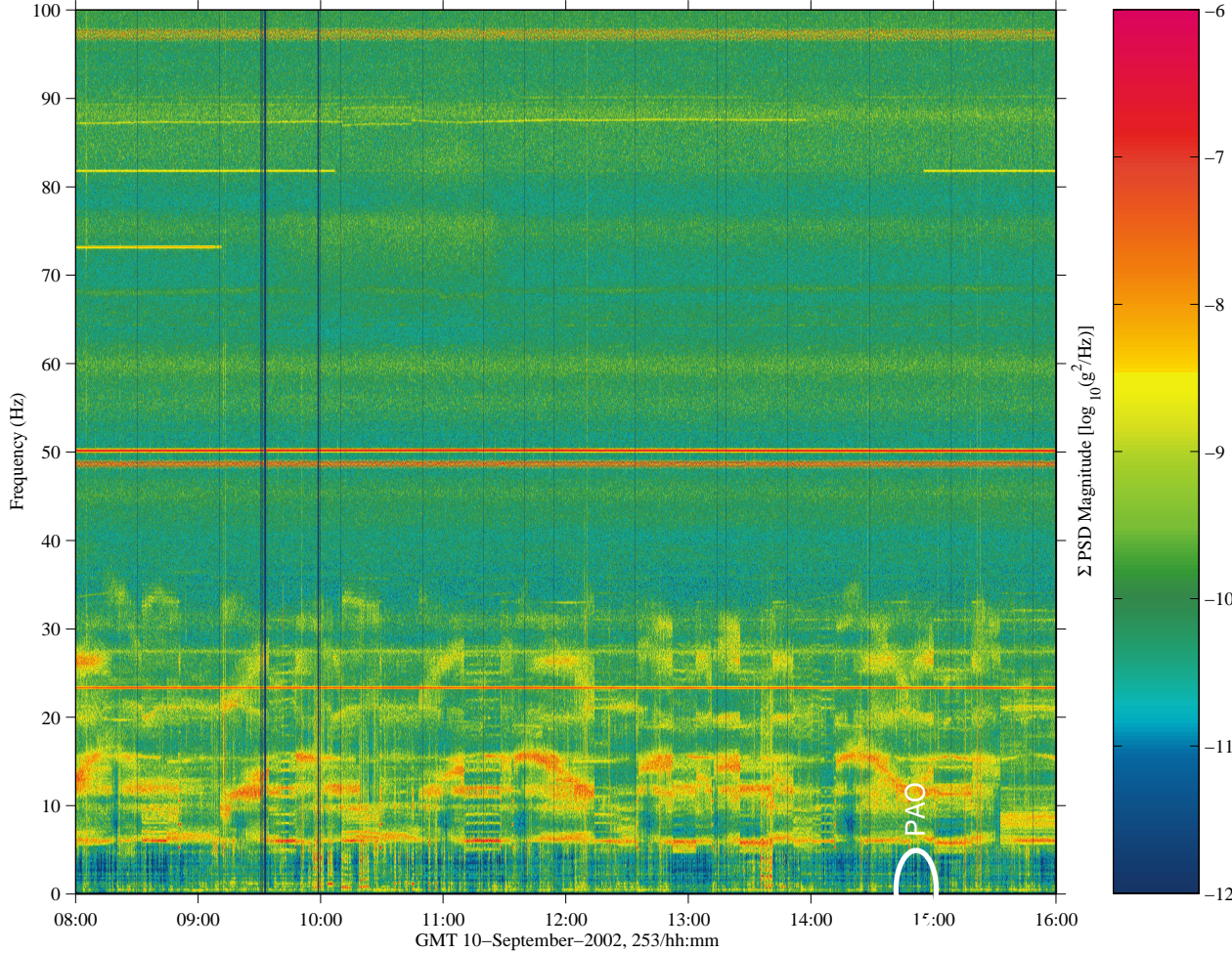
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# Public Affairs Office (PAO) Event QUALIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

SAMS 121f02  
Start GMT 10-September-2002, 253/08:00:00

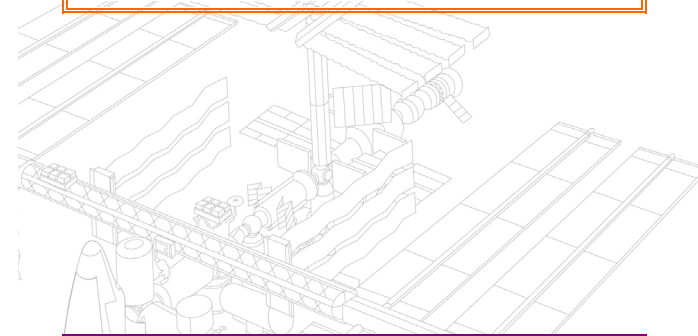
Increment: 5, Flight: UF2  
Sum  
Hanning, k = 3483  
Span = 8.00 hours



from: t:\pub\paed, \$Name: pop3\_06-17-2002 \$, 24-Jun-2002,06:09:18.383

Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

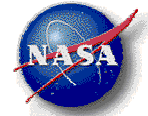
**Notes:**  
For a microgravity environment that mimics crew sleep, one can consider PAO events that occupy the entire crew (note that some PAO events occupy only part of the crew). These events typically last at least 10 minutes or so with the crew gathered in front of a video camera participating in an interview. During this time the crew is usually quite still, but there are times when they demonstrate various things that require them to push-off or otherwise apply a force to vehicle structure. The figure here shows the subtle contrast between nominal activity and all 3 crew participating in a PAO event from about 14:45 to about 15:00. Like crew sleep the difference lies primarily below about 6 Hz.



Regime:	Vibratory
Category:	Crew
Source:	Public Affairs Office (PAO) Event



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## Public Affairs Office (PAO) Event QUANTIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]

250.0 sa/sec (100.00 Hz)

$\Delta f = 0.122$  Hz, Nfft = 2048

Temp. Res. = 8.192 sec, No = 0

PAO Event,  $0 < f < 6$  Hz

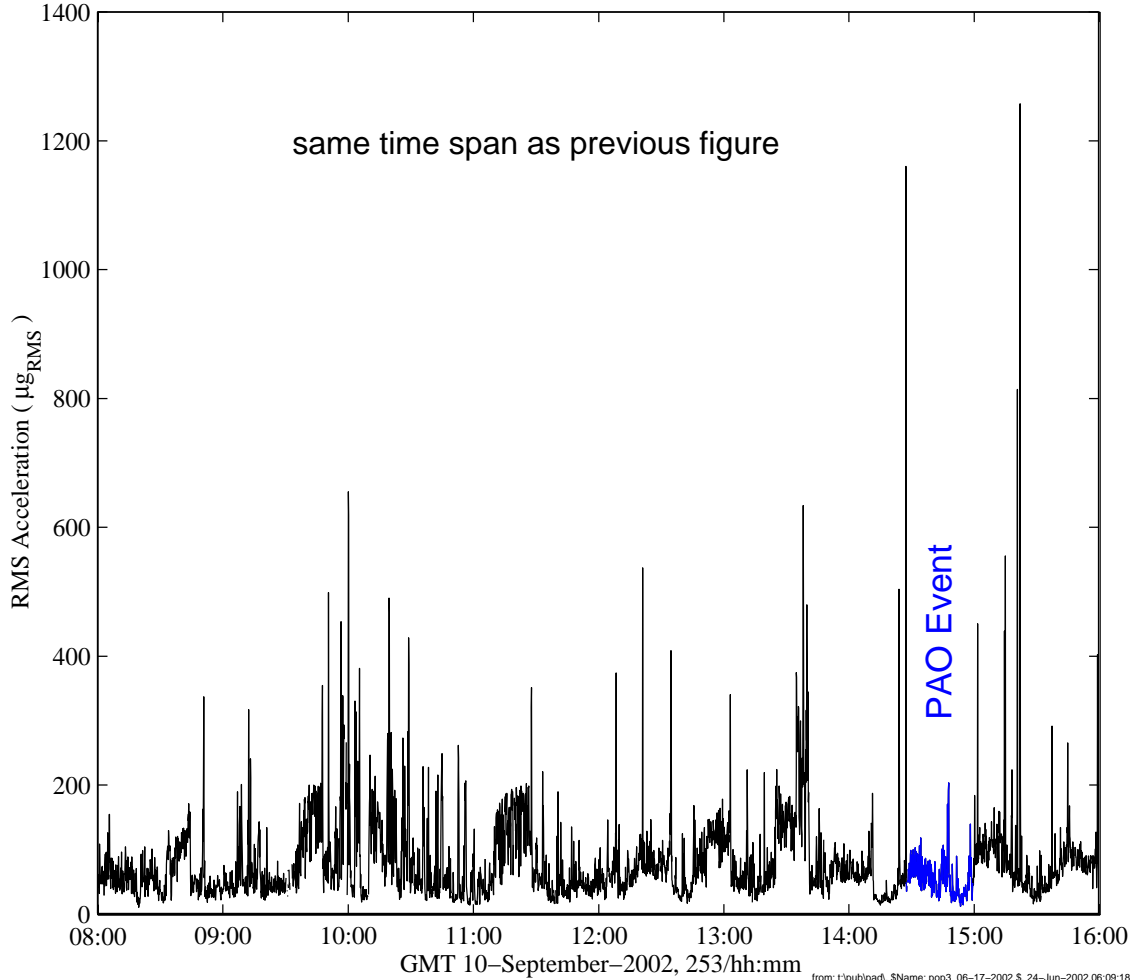
Start GMT 10-September-2002, 253/08:00:00

Increment: 5, Flight: UF2

Sum

Hanning, k = 3483

Span = 8.00 hours



Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

**Notes:**

This figure shows that the RMS acceleration values below 6 Hz during the PAO event are noticeably smaller than the rest of this 8-hour period. The RMS levels are typically about midway between the crew sleep and crew wake levels. Statistics gathered for this time frame show:

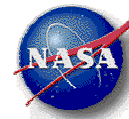
PAO Event median: 49.9  $\mu\text{g}_{\text{RMS}}$

Non-PAO median: 61.9  $\mu\text{g}_{\text{RMS}}$

Note that PAO durations (10 minutes or more) may be enough time for investigators to be opportunistic about scheduling certain autonomous or ground-commanded aspects of their experiment to be performed during this time, particularly for those sensitive below 6 Hz.



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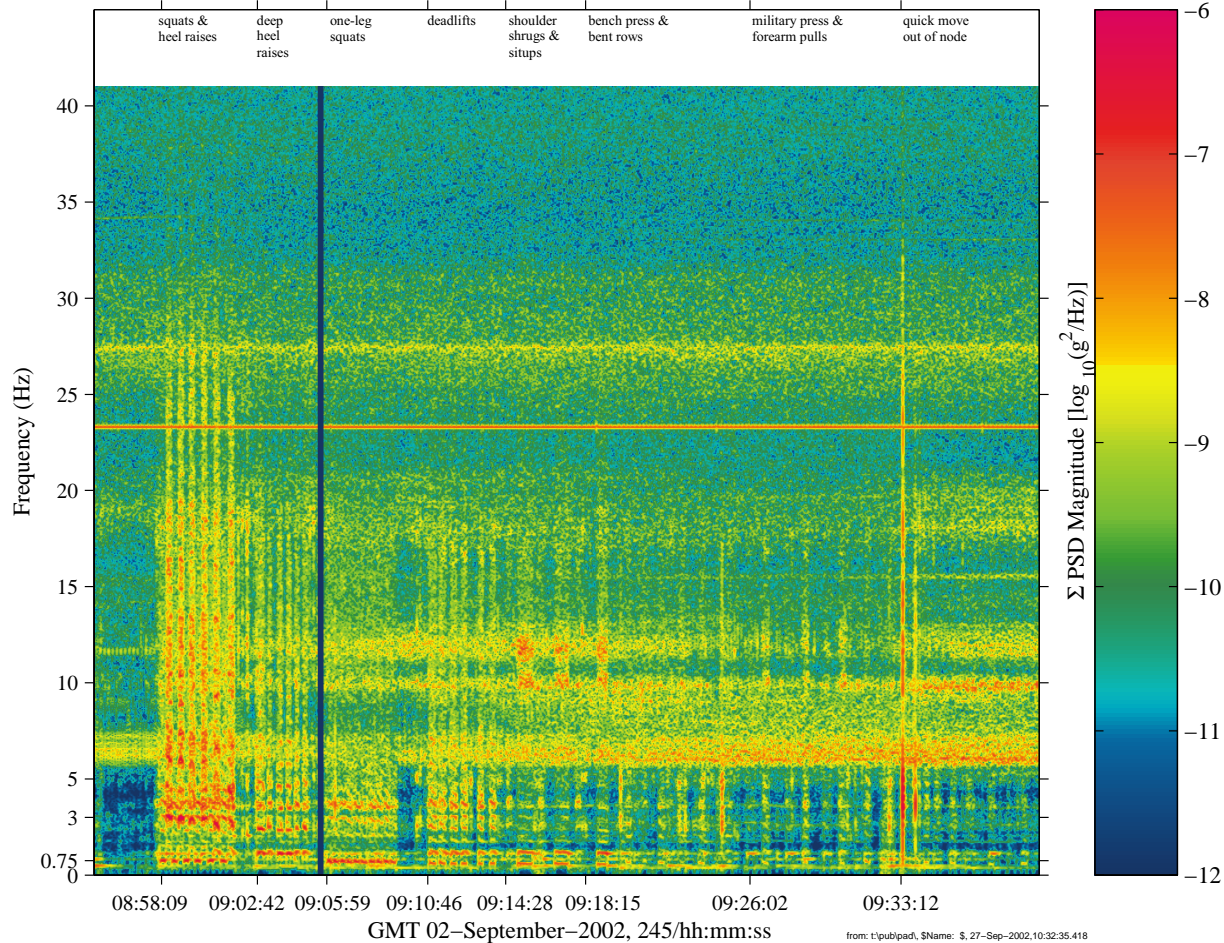
Regime:	Vibratory
Category:	Crew
Source:	Public Affairs Office (PAO) Event

# Resistive Exercise Device (RED) Qualify

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.061$  Hz, Nfft = 4096  
Temp. Res. = 0.820 sec, No = 3891

RED Exercise  
Start GMT 02-September-2002, 245/08:55:00.003

Increment: 5, Flight: UF2  
Sum  
Hanning  
Span = 45 minutes



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Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

### Notes:

- multi-purpose exercise device
- crank canisters to adjust resistance
- in the interim, it is hardmounted
- used routinely and located in the Z1 alcove of Node 1
- base plate parallel with Z1 hatch
- help crew preserve strength and bone mineral
- exercise types: squats, heel raises, deadlifts, bench press, upright rows, bent rows



Regime:	Vibratory
Category:	Crew Activity
Source:	Resistive Exercise Device (RED)

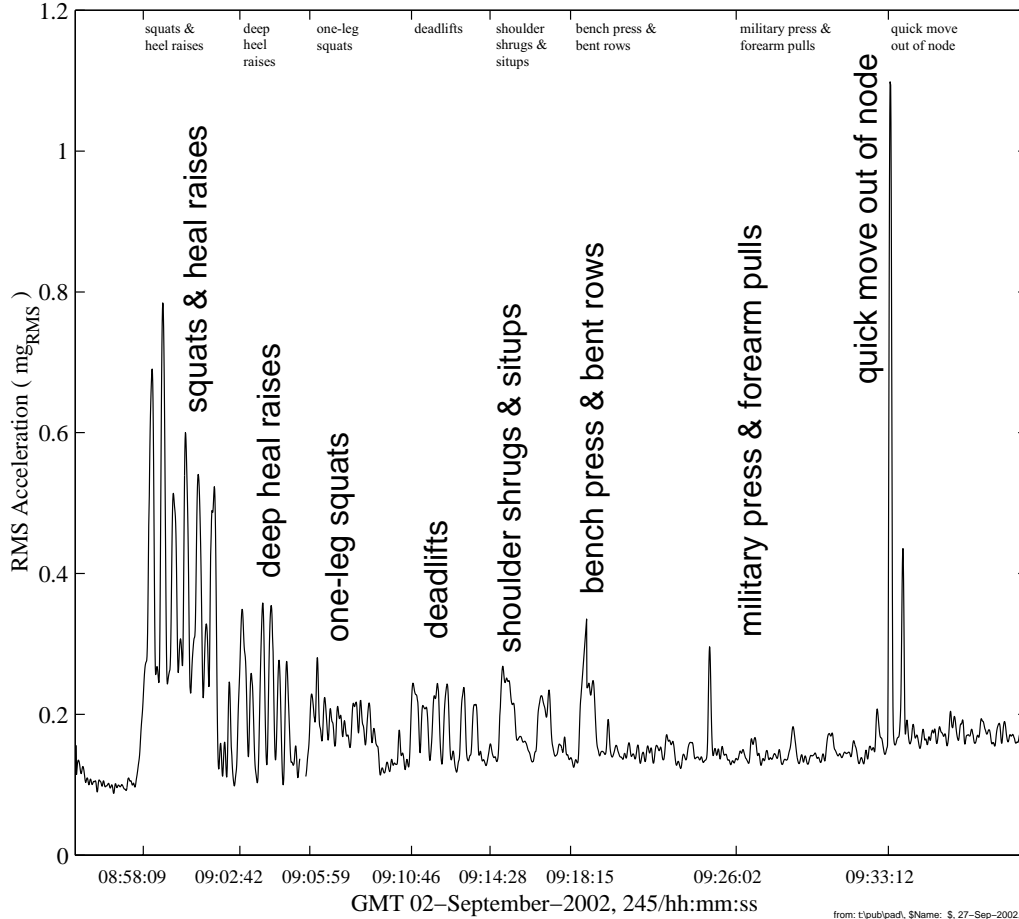
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# Resistive Exercise Device (RED) Quantify

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.061$  Hz, Nfft = 4096  
Temp. Res. = 0.820 sec, No = 3891

RED Exercise,  $0 < f < 30$  Hz  
Start GMT 02-September-2002, 245/08:55:00.003

Increment: 5, Flight: UF2  
Sum  
Hanning  
Span = 45 minutes



Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

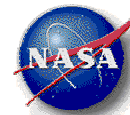
### Notes:

The interval RMS figure shown spans the entire RED exercise period and covers the frequency range below 30 Hz. This period consisted of several exercise types as annotated in the figure. Several of these types were analyzed for the frequency range below 10 Hz as tabulated below:

Type	Maximum ( $\mu g_{RMS}$ )	GMT Start 02-Sep-2002, 245/
baseline (no RED)	60	08:55:00
squats	301	08:58:09
heel raises	691	08:58:26
deep heel raises	336	09:02:42
deadlifts	206	09:10:46
bench/bent rows	222	09:20:21
one-leq squats	255	09:05:59



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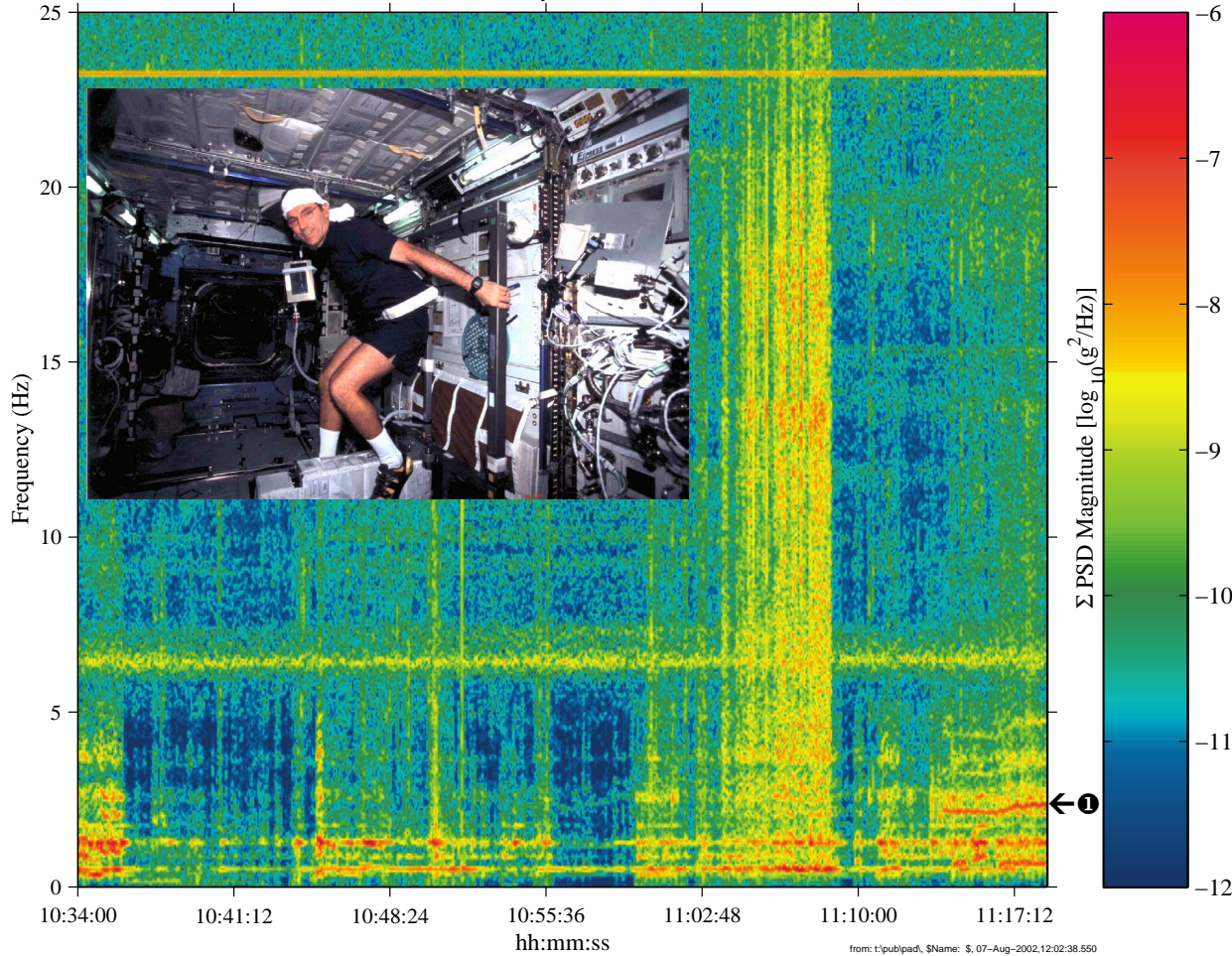
Regime:	Vibratory
Category:	Crew Activity
Source:	Resistive Exercise Device (RED)

# Cycle Ergometer with Vibration Isolation System (CEVIS) QUALIFY

sams2, 121f05 at LAB1O1, ER2, Upper Z Panel:[185.17 38.55 149.93]  
62.5 sa/sec (25.00 Hz)  
 $\Delta f = 0.061$  Hz, Nfft = 1024  
Temp. Res. = 4.096 sec, No = 768

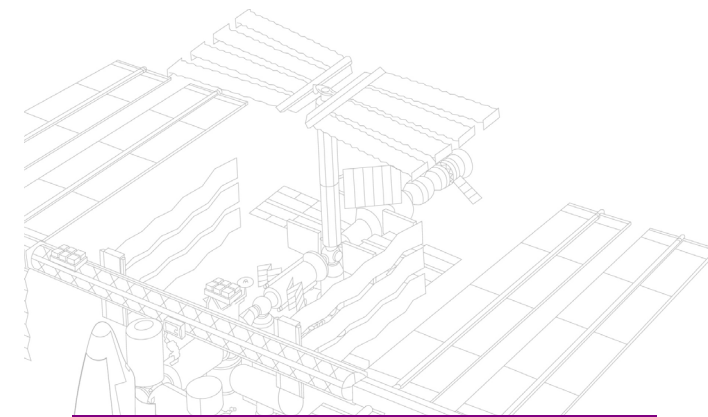
Increment: 4, Flight: UF1  
Sum  
Hanning, k = 656  
Span = 44.71 minutes

CEVIS Exercise Period  
Start GMT 01-January-2002, 001/10:34:00.009



Data Description	
Sensor	SAMS, 121f05 62.5 sa/sec (25.00 Hz)
Location	LAB1O1, ER2, Light Tray
Inc/Flight	Increment: 4, Flight: UF1
Plot Type	spectrogram

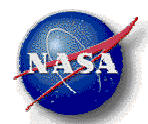
**Notes:**  
The CEVIS exercise device is located in the US Lab at LAB1P3. The narrowband peak at about 2.5 Hz marked on the lower right of the spectrogram is the pedaling frequency for this CEVIS exercise period. For Shuttle ergometer exercise, the pedaling signature was accompanied by that of shoulder sway with frequency around half the pedal rate. On the ISS for this CEVIS exercise period, the shoulder sway signature is obscured by structural modes that fall in the same frequency range.



Regime:	Vibratory
Category:	Crew
Source:	Cycle Ergometer with Vibration Isolation System (CEVIS)



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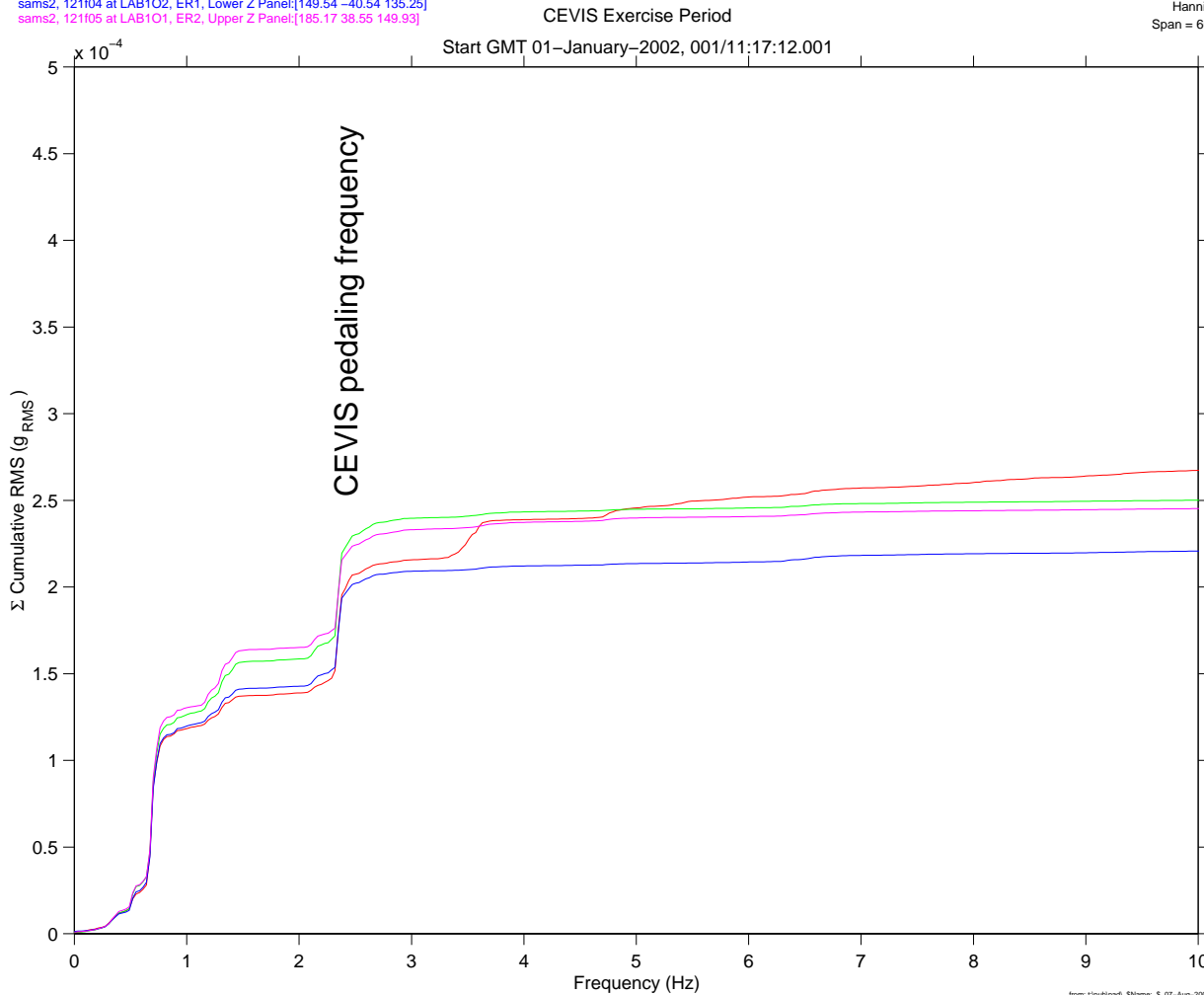
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# Cycle Ergometer with Vibration Isolation System (CEVIS) QUANTIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
sams2, 121f03 at LAB1O1, ER2, Lower Z Panel:[191.54 -40.54 135.25]  
sams2, 121f04 at LAB1O2, ER1, Lower Z Panel:[149.54 -40.54 135.25]  
sams2, 121f05 at LAB1O1, ER2, Upper Z Panel:[185.17 38.55 149.93]

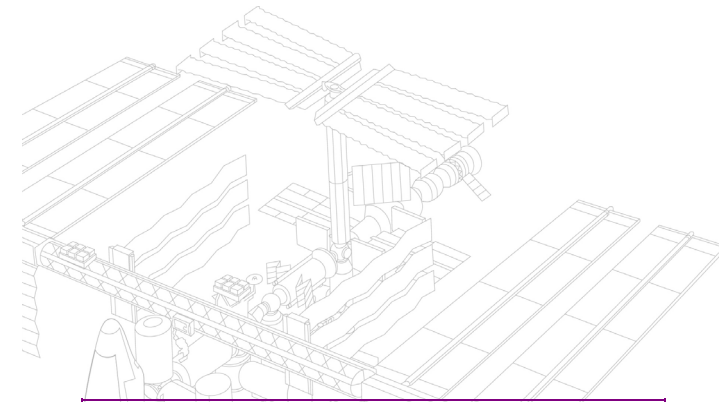
Increment: 4, Flight: UF1  
Sum  
Hanning, k = 2  
Span = 60.00 sec.



Data Description	
Sensor	see upper left of figure
Location	see upper left of figure
Inc/Flight	Increment: 4, Flight: UF1
Plot Type	cumulative RMS

### Notes:

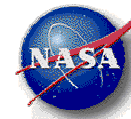
To quantify the impact of a CEVIS exercise period from four sensor locations, the cumulative RMS acceleration versus frequency curves shown in the figure were computed. The legend at the upper left shows which trace was computed for each of the different sensors. The curves in this figure all step up about  $70 \mu\text{g}_{\text{RMS}}$  at the pedaling frequency, but vary to some degree across the rest of the acceleration spectrum below 10 Hz. The variability is expected as the SAMS sensors used for the analysis were distributed throughout ER1 and ER2 as indicated by the legend.



Regime:	Vibratory
Category:	Crew
Source:	Cycle Ergometer with Vibration Isolation System (CEVIS)



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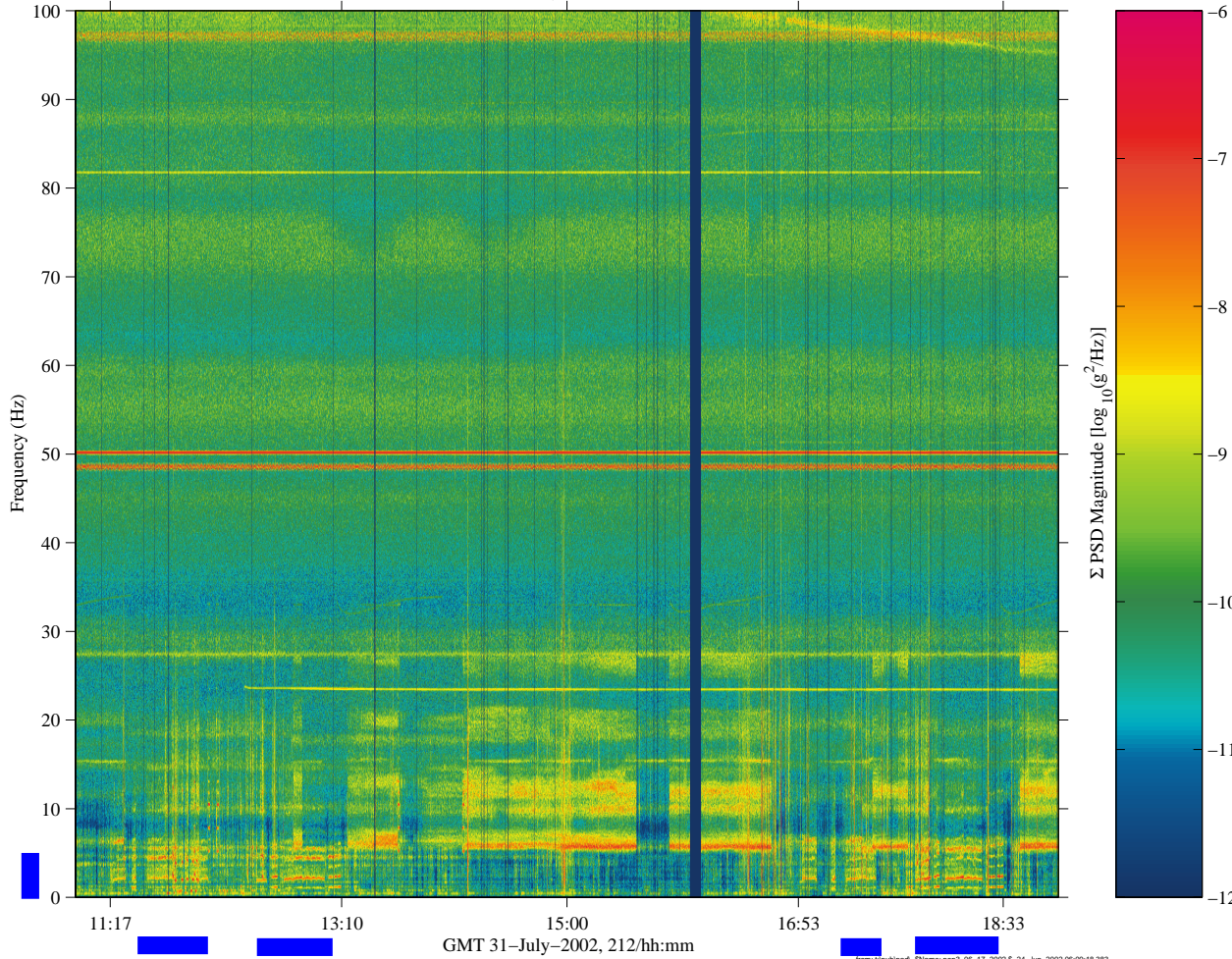
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# Veloped (Velo) Exercise QUALIFY

sams2, 121f02 at LAB102, ER1, Drawer 1:[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

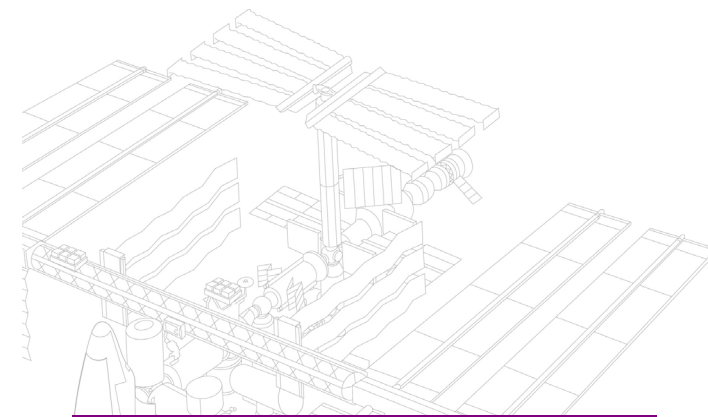
Velo Exercise  
Start GMT 31-July-2002, 212/11:00:00

Increment: 5, Flight: UF2  
Sum  
Hanning, k = 3393  
Span = 8 hours



Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB102, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	spectrogram

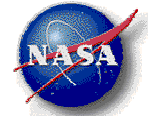
**Notes:**  
The abbreviation velo is short for veloped, a Russian bicycle exercise device – the abbreviation velo is to veloped like bike is to bicycle. Two distinct periods that show **velo exercise** are seen in the figure **below about 5 Hz from 11:17 to 13:10 and from 16:53 to 18:33**. For these periods, both the **pedal rate signature at about 2.2 Hz** and the **shoulder sway at half that rate** are evident.



Regime:	Vibratory
Category:	Crew
Source:	Veloped (Velo) Exercise



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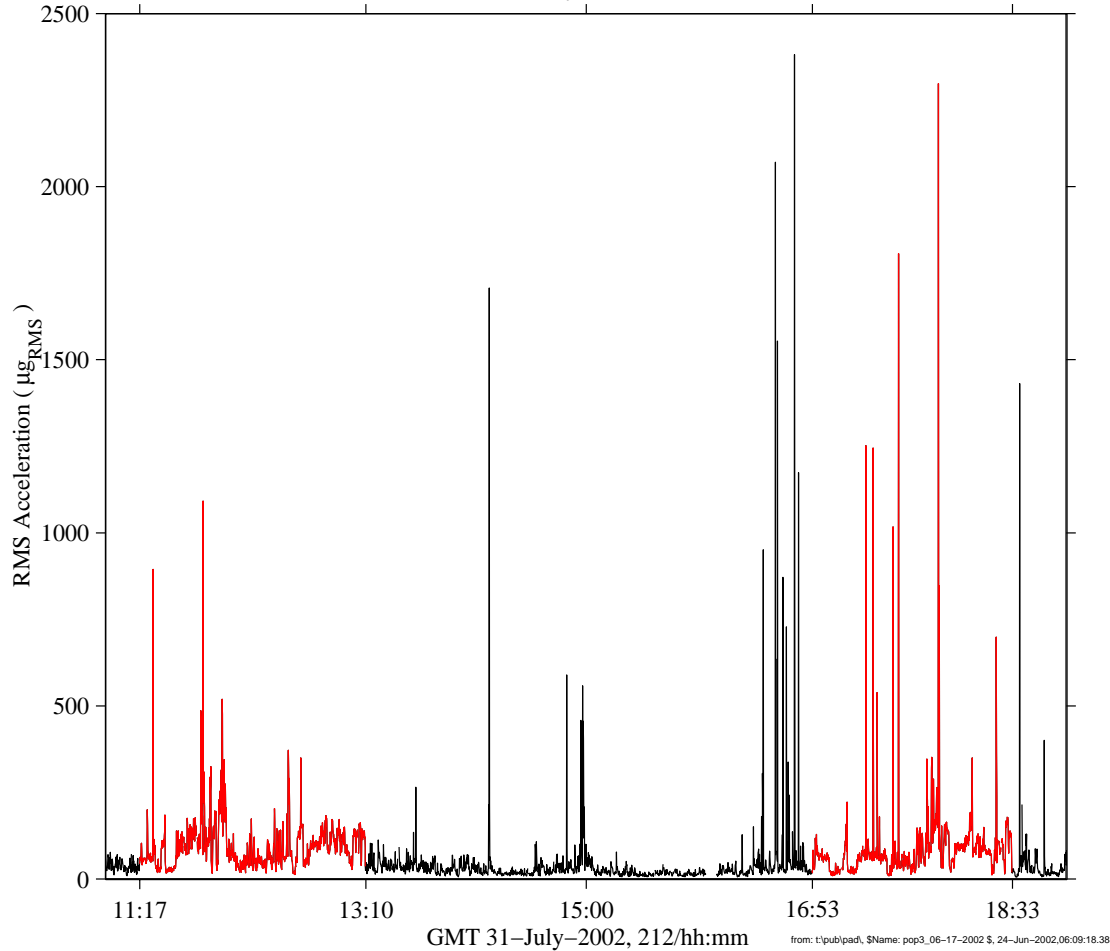
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## Velosiped (Velo) Exercise QUANTIFY

sams2, 121f02 at LAB1O2, ER1, Drawer 1:[128.73 -23.53 144.15]  
 250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
 Temp. Res. = 8.192 sec, No = 0

Velo Exercise,  $0 < f < 5$  Hz  
 Start GMT 31-July-2002, 212/11:00:00

Increment: 5, Flight: UF2  
 Sum  
 Hanning, k = 3393  
 Span = 8 hours

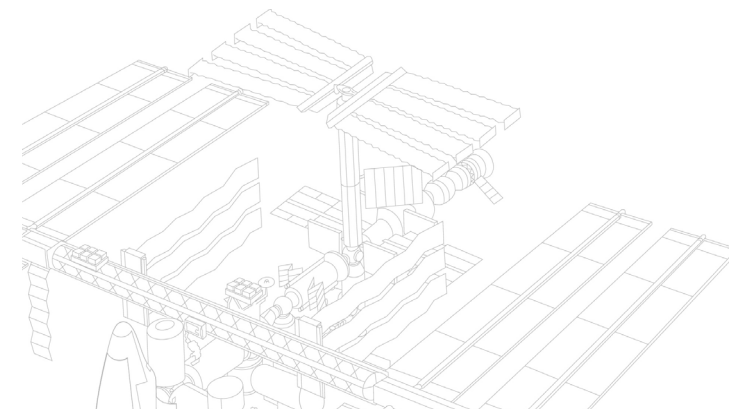


Data Description	
Sensor	SAMS, 121f02 250.0 sa/sec (100.00 Hz)
Location	LAB1O2, ER1, Drawer 1
Inc/Flight	Increment: 5, Flight: UF2
Plot Type	interval RMS

**Notes:**

This figure shows that the RMS acceleration values below 5 Hz during the velo exercise periods (shown in red) are noticeably above baseline for this 8-hour period. Statistics computed from these data show:

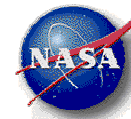
Velo exercise periods' median: 74.1  $\mu\text{g}_{\text{RMS}}$   
 Non-velo median: 23.8  $\mu\text{g}_{\text{RMS}}$



Regime:	Vibratory
Category:	Crew
Source:	Velosiped (Velo) Exercise



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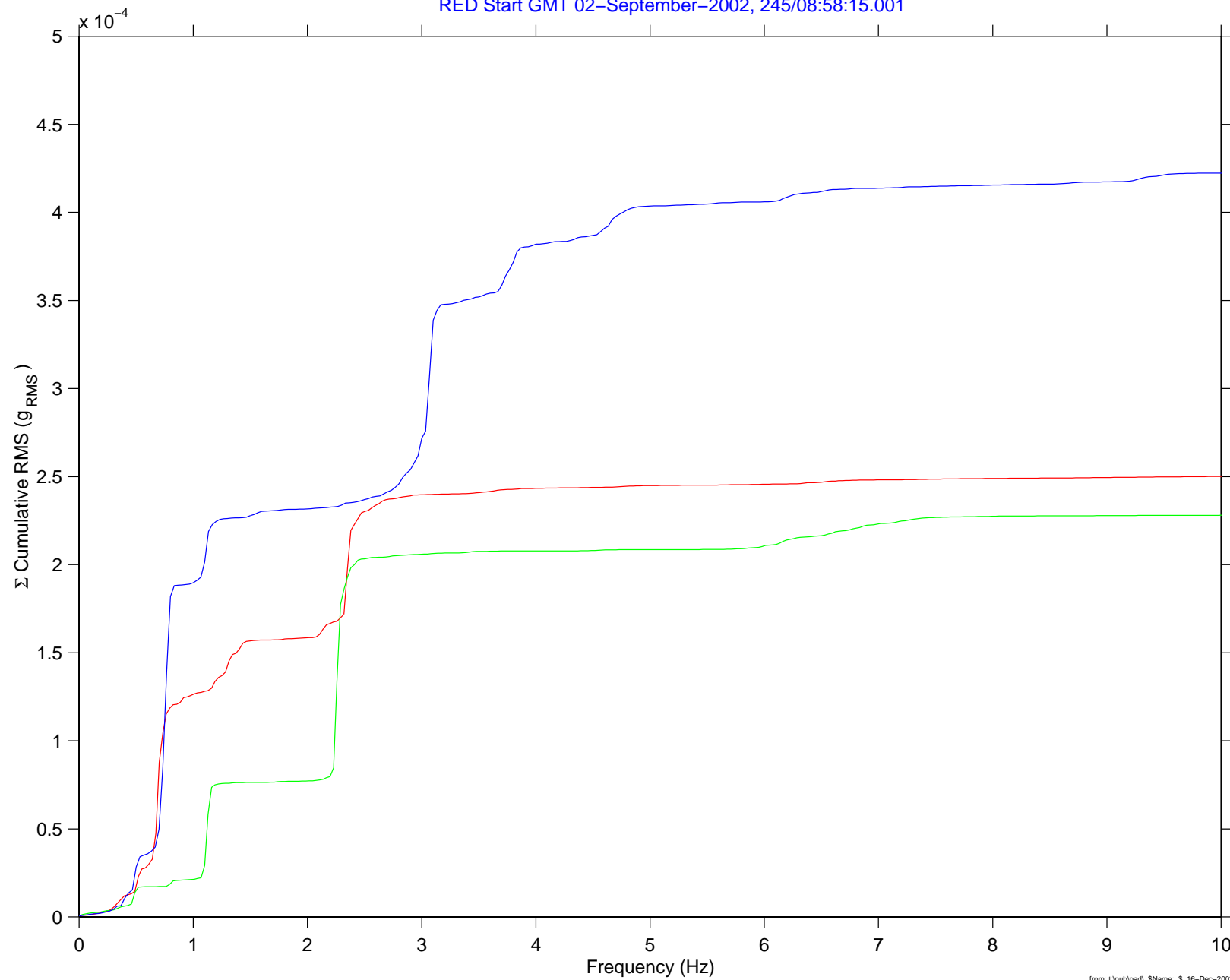
sams2, 121f03 at LAB1O1, ER2, Lower Z Panel:[191.54 -40.54 135.25]  
 250.0 sa/sec (100.00 Hz)

CEVIS Start GMT 01-January-2002, 001/11:17:12.001

Velo Start GMT 31-July-2002, 212/12:50:00.001

RED Start GMT 02-September-2002, 245/08:58:15.001

Span = 1 min.



from: t:\pub\pad\, SName: \$, 16-Dec-2002,12:53:58.984

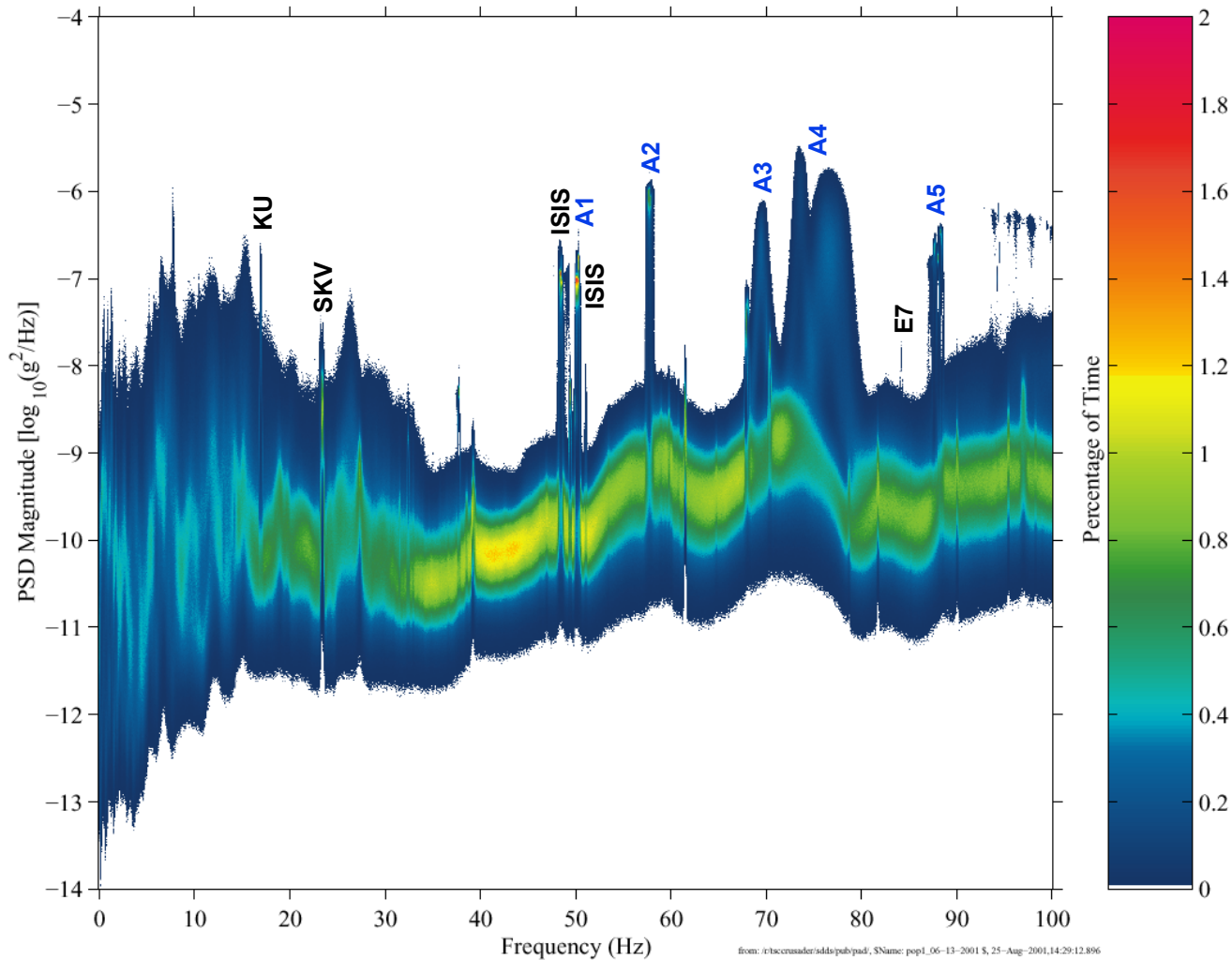


# Increment 2 PCSA

mams, hirap at LAB102, ER1, Lockers 3,4:[138.68 -16.18 142.35]  
1000.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 8192  
Temp. Res. = 8.192 sec, No = 0

MAMS HiRAP

Increment: 2, Flight: 7A  
Sum  
hanning, 262209 PSDs  
Total of 596.7 hours



## LEGEND:

- KU: Shuttle's Ku-band antenna dither during docked operations
- SKV: air conditioner in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
- A1: ADVASC fan
- A2: ADVASC pump
- A3\*: ADVASC blower
- A4\*: ADVASC blower
- A5\*: ADVASC fan
- \* frequency shift/smear
- E7: EXPPCS 7<sup>th</sup> harmonic

## NOTE:

- the axis box for this plot matches next slide

selected periods from  
~ 30-May-2001 to 20-Aug-2001

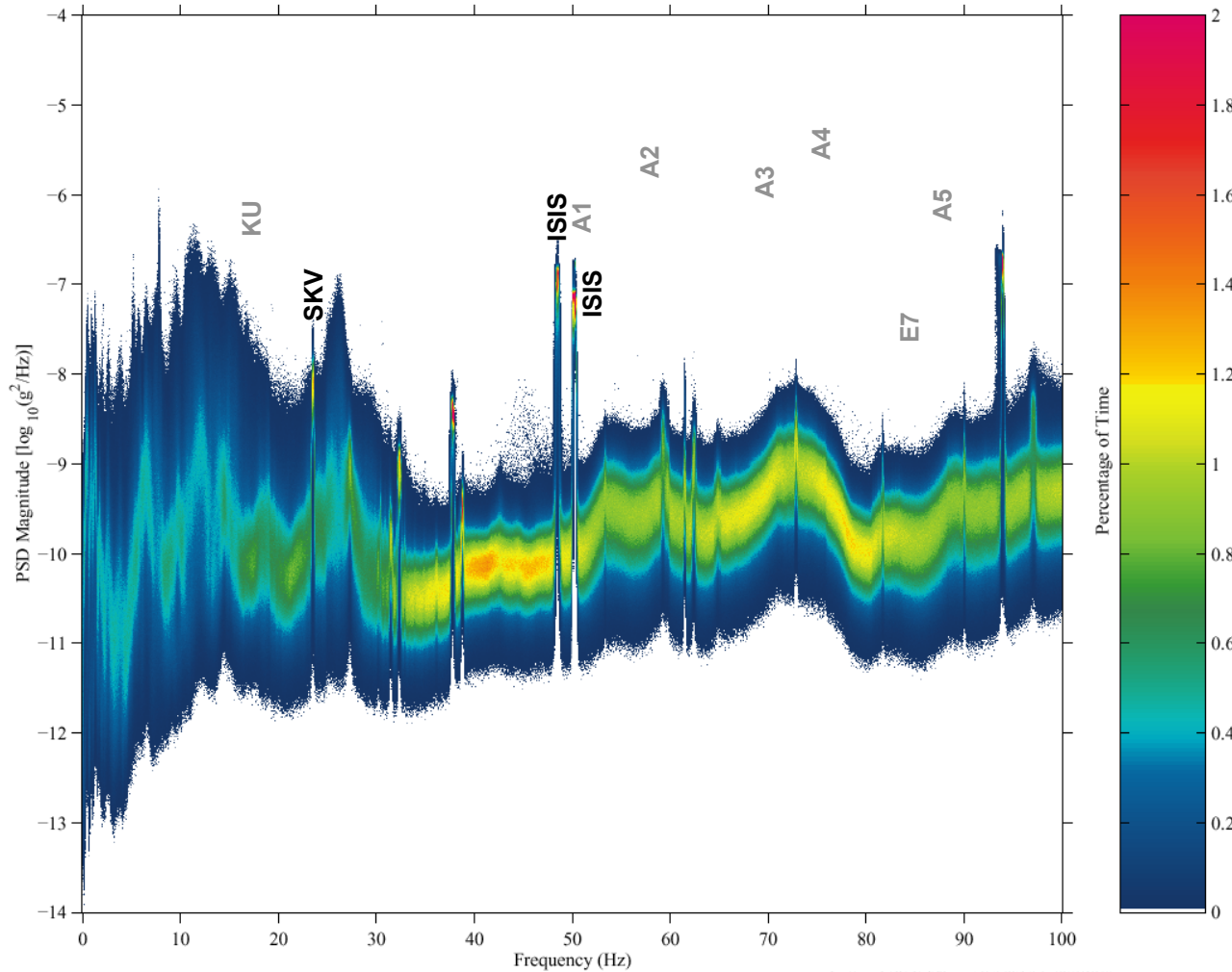
see p. 43 of PIMS Inc. 2 report  
for more details

# Increment 3 PCSA

mams, hirap at LAB102, ER1, Lockers 3,4 [138.68 -16.18 142.35]  
1000.0 sa/sec (100.00 Hz)  
Af = 0.122 Hz, Nfft = 8192  
Temp. Res. = 8.192 sec, No = 0

MAMS HiRAP

Increment: 3, Flight: 7A.1  
Sum  
hanning, 102694 PSDs  
Total of 233.7 hours



## LEGEND:

- KU: **No** Shuttle's Ku-band antenna dither because no docked operations
- SKV: air conditioner in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
  - higher frequency fan overlaps vacated ADVASC (A1) fan disturbance at ~50Hz
- A1-A5: **No** ADVASC
- E7: **No** EXPPCS

## NOTE:

- the axis box for this plot matches previous slide

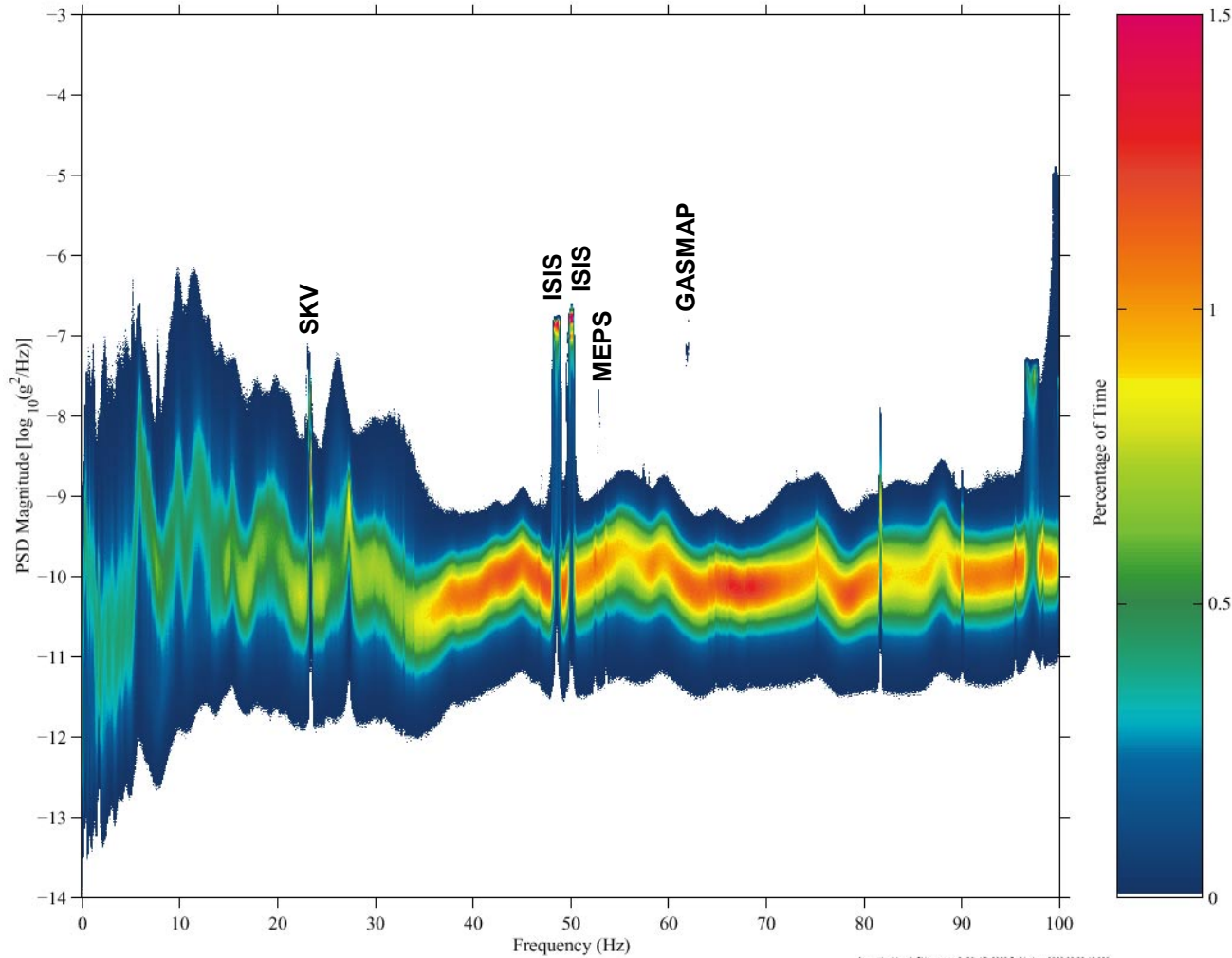
selected periods from  
~ 21-Aug-2001 to 30-Aug-2001  
see p. 108 of PIMS Inc. 3 report  
for more details

# Increment 5 PCSA - Data Set #7

sams2, 121f02 at LAB1Q2, ER1, Drawer 1.[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

SAMS 121f02  
GMT 16-Jun-2002 through 08-Oct-2002  
SKIP 29-Jun-2002, 12-Sep-2002, 24-Sep-2002

Increment: 5, Flight: UF2  
Sum  
hanning, 827287 PSDs  
Total of 1882.5 hours



## LEGEND:

- SKV: air conditioner in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
- GASMAP: Gas Analysis System for Metabolic Analysis of Physiology pump & fan
- MEPS: Microencapsulation Electrostatic Processing System [fan(s)]

## NOTE:

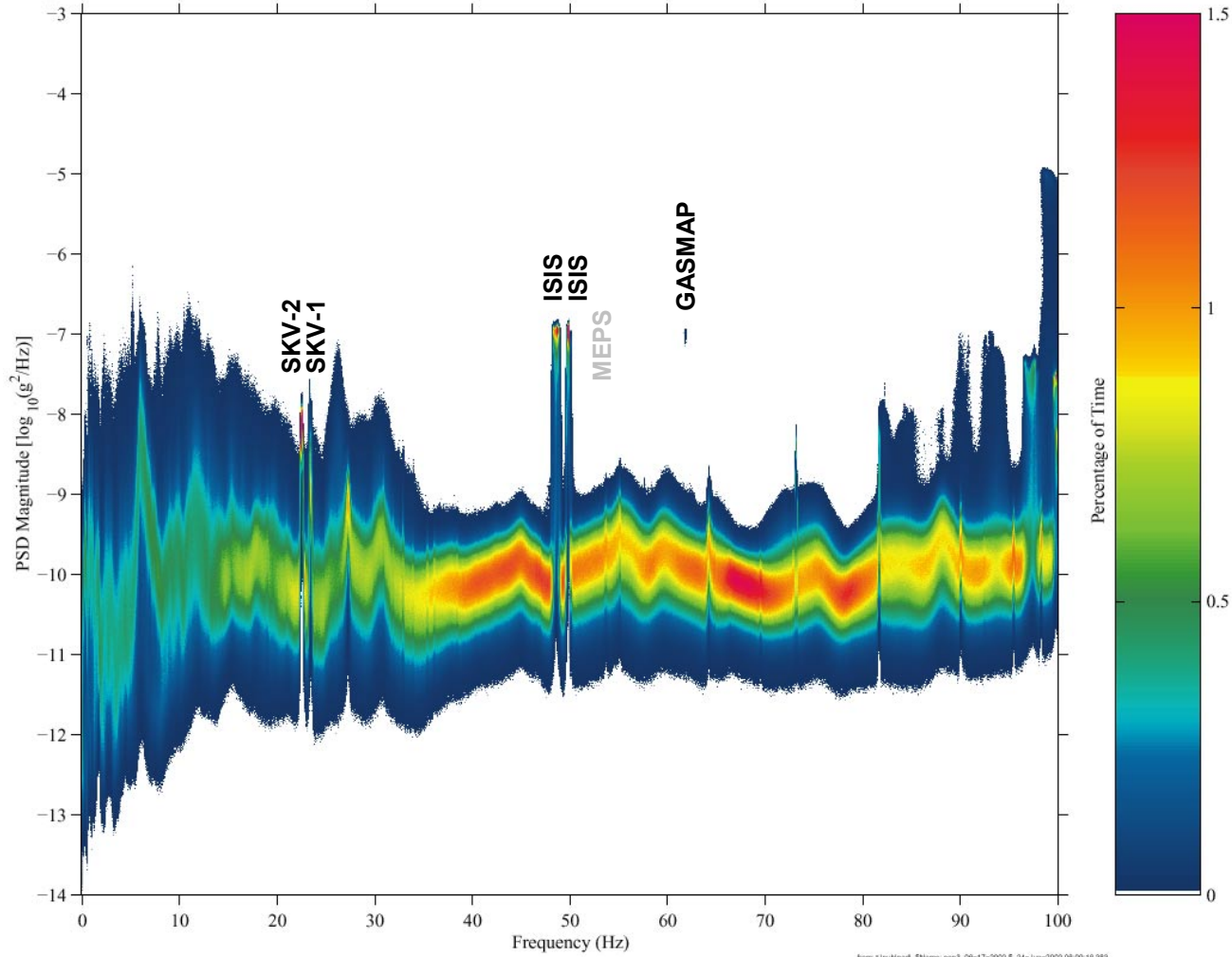
- the axis box for this plot matches next slide

# Increment 5 PCSA - Data Set #8

sams2, 121f02 at LAB1O2, ER1, Drawer 1.[128.73 -23.53 144.15]  
250.0 sa/sec (100.00 Hz)  
 $\Delta f = 0.122$  Hz, Nfft = 2048  
Temp. Res. = 8.192 sec, No = 0

SAMS 121f02  
GMT 17-Oct-2002 through 24-Nov-2002  
SKIP 01-Nov-2002

Increment: 5, Flight: UF2  
Sum  
hanning, 350011 PSDs  
Total of 796.5 hours



## LEGEND:

- SKV-1, SKV-2: air conditioners in Russian Service Module
- ISIS: International Subrack Interface Standard drawer fans
- GASMAP: Gas Analysis System for Metabolic Analysis of Physiology pump & fan
- MEPS: **No** Microencapsulation Electrostatic Processing System [fan(s)]

## NOTE:

- the axis box for this plot matches previous slide