SUBJECT: **Herschel/SPIRE Instrument Cold Workmanship Vibration Test Report**
FM acceptance

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CHANGE RECORD

ISSUE SECTIONS REASON FOR CHANGE

1.0	all	First Issue
2.0	4	X axis changed to Z (typo)
	7.4	Details of applied notch added
	9	Conclusions added

Table of contents

1. SCOPE

This document lists the acceptance test results of the cold workmanship vibration test of the Herschel SPIRE instrument flight model (FM). This test was carried out as the flight model SMEC had now been fitted.

This is now the full flight standard.

2. DOCUMENTS

AD (1)	Instrument Interface Document, part A	IID-A, issue 3
AD (2)	Technote 9 Random Vibration SPIRE February 2003 issue 3.doc	
AD (3)	Instrument Interface Drawing	5264-300 sheet 1 to 7, issue 18
AD (5)	As built status	SPIRE-RAL-DOC-002326 issue 2.6
AD (7)	HERSCHEL : SPIRE STM QUALIFICATION	AIV-2003-027-VIB
AD (8)	TRR minutes of meeting	SPIRE-RAL-MOM-002710
AD (9)	Cold vibration test plan	SPIRE-RAL-PRC-002597, issue 2
AD (10)	Cold vibration test procedure	SPIRE-RAL-PRC-002598, issue 2
AD (11)	SPIRE FPU Handling and integration procedure	SPIRE-RAL-PRC-001923
AD (12)	Cryo-vibration test report SPIRE FM 1	RP-CSL-CRYOV-06007, version 1
AD(13)	Instrument cold vibration test report	SPIRE-MSS-REP-002596
AD(14)	Cryo vibration test report (CSL)	RP-CSL-CRYOV-06007
AD(15)	PFM Electrical Interface Checkout	SPIRE-RAL-NOT-002318v10

3. DEFINITIONS

3.1. Abbreviations

AD	Applicable Document
BSM	Beam steering mirror
CQM	Cold Qualification Model
EM	Engineering Model
FM	Flight Model
ICD	Interface Control Document
PFM	Proto-Flight Model
STM	Structural Thermal Model
S/C	Spacecraft
TBC	To be confirmed
TBD	To be defined
TRB	Test Review Board
TRR	Test Readiness Review
TML	Total Material Loss
VCD	Verification Control Document
VCM	Volatile Condensable Material

4. TEST PHILOSOPHY

The test item is the FM model of the SPIRE instrument as it will be flown, the instrument was acceptance tested with a non flight SMEC in December 2005. This test is a workmanship test carried out after fitting of the FM SMEC. It is tested in one axis only (X) at acceptance levels for acceptance duration.

AD(5) As built configuration list applies.

5. TEST OBJECTIVES

- To carry out a workmanship test on the SPIRE instrument.
- The test sequence was dictated by the cryo-vibration facility. It consisted of:
  - Cool down
  - complete X-axis tests
  - Warm up

6. FIXTURE

The fixture for this cold vibration test was provided for by CSL

7. TEST REQUIREMENTS

7.1. SUMMARY

Resonance search, and random vibration tests were carried out in X axis only. Resonance searches and intermediate random tests were performed before the instrument was subjected to acceptance level runs.

7.2. Fixture qualification runs

Runs on just the bare fixture were carried out to prove that the fixture (and cold vibration facility) behaviour was suitable for the test. This was carried out before the instrument test. Test was successful.

7.3. Resonance search

A resonance search was performed before and after the random tests.

7.4. Random vibration test

See AD(14) for all response curves.

As stated in AD(9) the acceptance levels were defined as follows.

X axis

Frequency Range Hz	Qualification level
20-100	+3dB/Oct
100-150	0.032 g^2/Hz
150-300	0.0128g^2/Hz
300-2000	-12 dB/Oct
Global	2.8 g-rms

Table 8.5-2: X axis input definition random acceptance

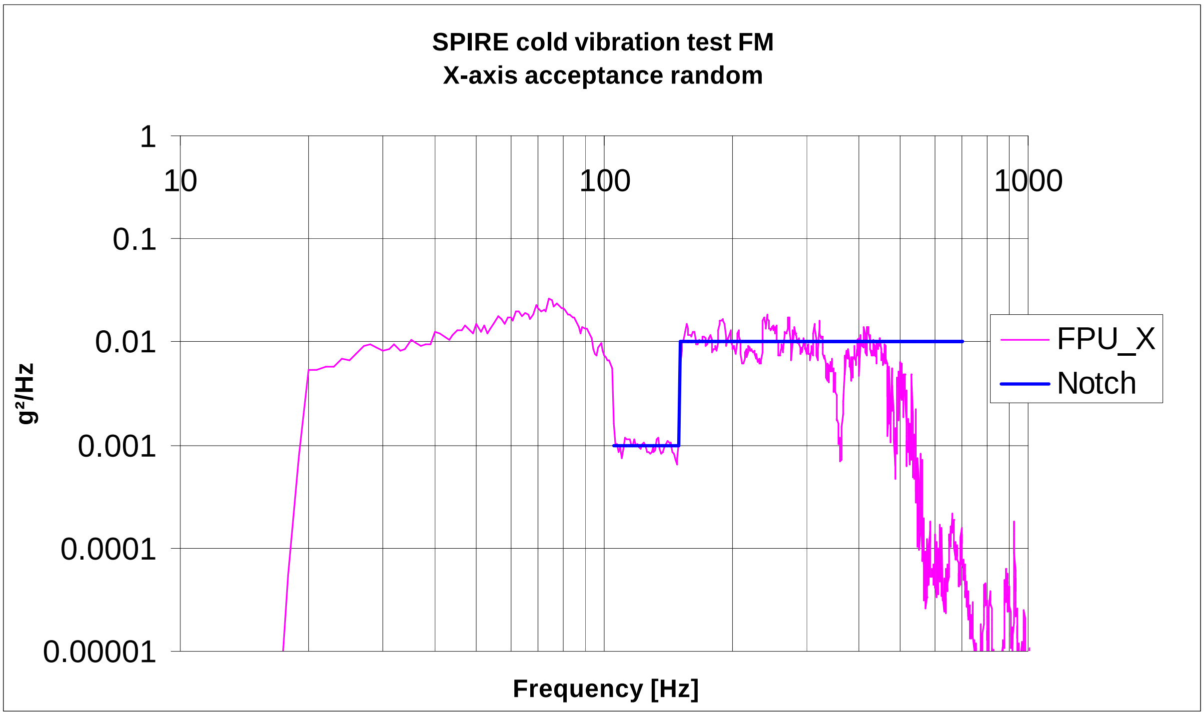
Test duration 1 minute

Input definition (control)

For each test the input was specified via the average response of the accelerometers located on the shaker table near the feet of the instrument. For all tests this was the average over 3 accelerometers.

Notching

The notching was performed on the FPU_X accelerometer in line with the instrument test in January 2006. As defined in AD (9)



Response measured in January 2006.

The control followed the input specification with a notch level specified on the top of the FPU (FPU_X):

Notch Channel	Frequency range	Level
FPU_X	110-150 Hz	0.001 g²/Hz
FPU_X	150-600 Hz	0.01 g²/Hz

Force Notching

No direct force notching was used, only a predefined notch on the top accelerometer, copied from the cold FM vibration test in January 2006.

7.5. Measurement of subsystem levels

N.A.

7.6. Post test inspection

On removal of the instrument from the cryostat an interface checkout was performed (AD15) All systems checked out OK with the exception of the SMEC, which was found to be in an unlatched condition. HR-SP-RAL-NCR-159 was raised. The latch was relatched for transport back to RAL.

7.7. Main resonance frequencies found

Main frequencies		Hz	
X-axis			
Warm	Cold CQM	COLD FM Jan 06	COLD FM Sep 06
176	158	145	159
206	193		
219	212	207	204
314	300	300	300

8.7-1: Main frequencies (X-axis)

The listed frequencies are from the warm STM test, the cold CQM test and the cold FM test (Jan and Sep 2006). There are a few things that are different between the warm and the cold STM test. First of all the instrument mass went up with about 12%, but this is countered by the increase in stiffness due to the lower temperatures (typically 5% to 10%). The rest is the influence of the coupled vibration with the CSL shaker, which in general lowers the frequencies or clusters modes. The cold FM test has again slightly lower frequencies due to the slightly more flexible A-frames. The original stainless steel A-frames (CQM) were replaced by CFRP re-engineered frames (FM). The main X response frequencies are at 205 Hz and at 300 Hz, the others are cross-coupled modes.

8. REJECTION AND RETEST

No test run was rejected or a re-test performed. Several attempts were made to continue an aborted low level sine-sweep. But because of the inherent problem of the shaker (flexibility of the table mounting) it was decided to accept sweeps up to 500 Hz as a minimum, but all sweeps were successful up to 2000 Hz.

9. CONCLUSIONS

The tests specified in AD(9) were carried out. The FPU behaved as expected

9.1. Problems encountered

9.1.1. SMEC unlatching

The Spectrometer mechanism (SMEC) which was found to be in an unlatched at the end of the test. This was discovered during the electrical meaurements of the latch status line. It was then verified by tipping the FPU to listen for the sound of the mechanisn running into its' end stop. HR-SP-RAL-NCR-159 was raised. The latch was relatched for transport back to RAL.

9.1.2. Overtest

After the test it was discovered that the input spectrum had been specified incorrectly which resulted in an over test in the region 80 to 100Hz.

Appendix A – Intrumentation specification

The instrumentation consisted of CSL provided cryogenic accelerometers at the following locations

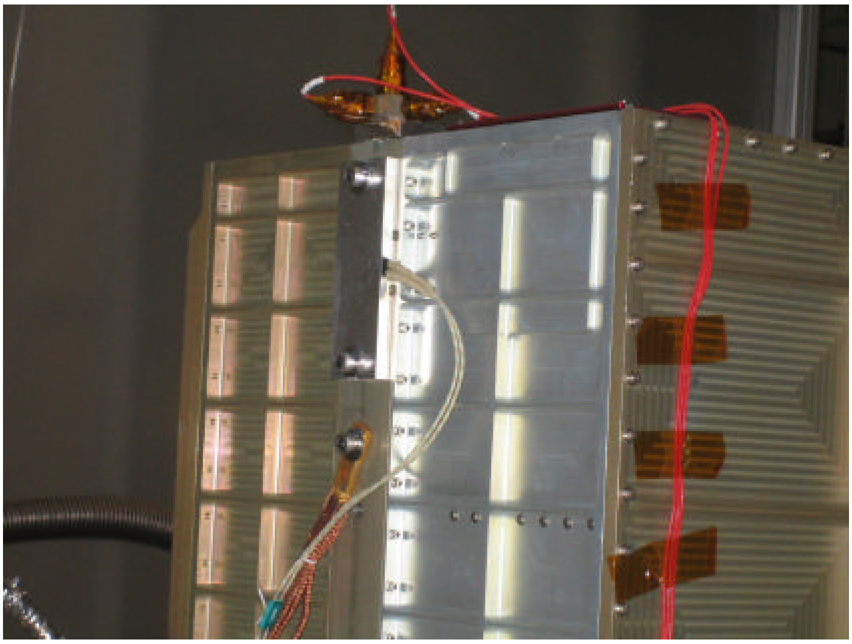
- At each mounting point of the instrument (interface with vibration fixture for control, 3 tri-ax cold-vibration accelerometers in total)
- Top of the optical bench in instrument coordinates: FPU X,Y and Z (tri-ax co-aligned with S/C coordinates)

The implemented instrumentation:

The numbering used during the tests was as follows (only accelerometers mounted in/on the instrument are listed):

Accelerometer allocation

Location	**Type**	**Code**	**Axis**
FPU top of optics bench over cone	7724	FPUX	X
FPU top	7724	FPUY	Y
FPU top	7724	FPUZ	Z



A-3: Triax on SOB outside (FPU)

Additionally provided by the facility were accelerometers located at each interface point measuring out of plane at each interface point and in plane at two locations for each direction.

The instrument instrumentation was limited since the instrument will not be opened/disassembled again, which excludes the use of internal monitor accelerometers.

Appendix B – Pre-Post sine and random comparison

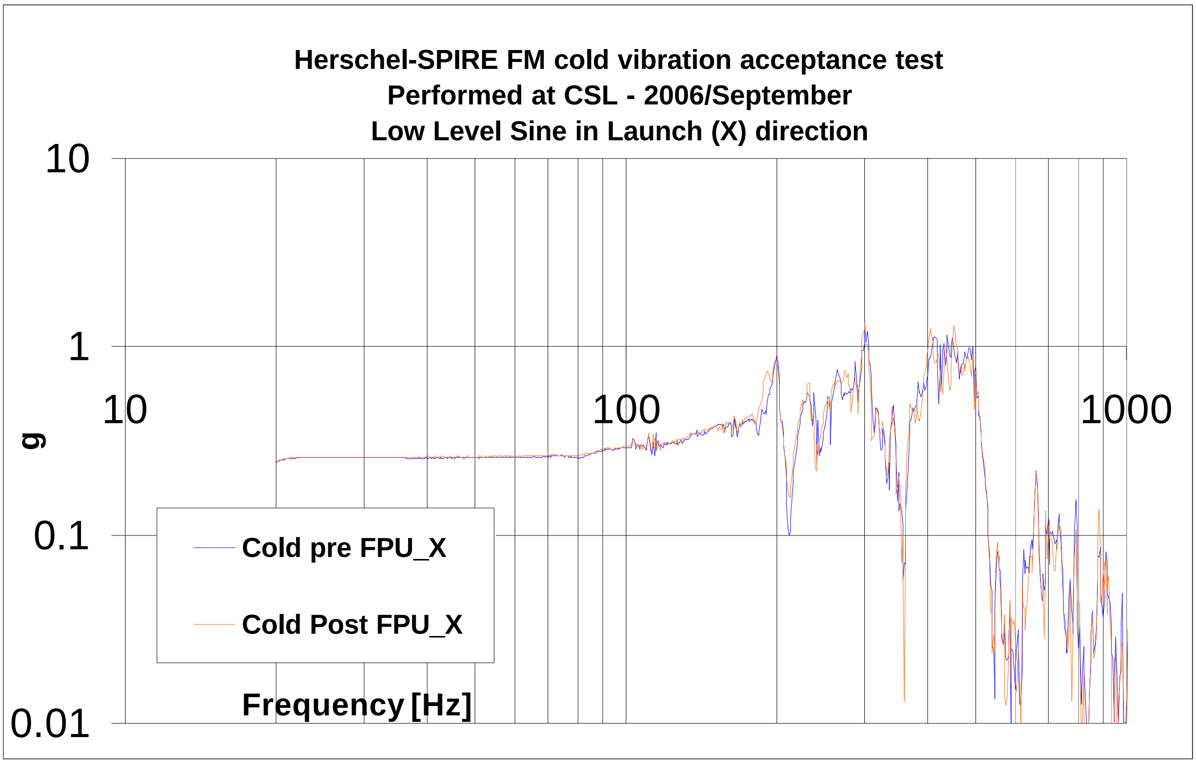


Figure B-1 pre-post comparison in launch direction (X)

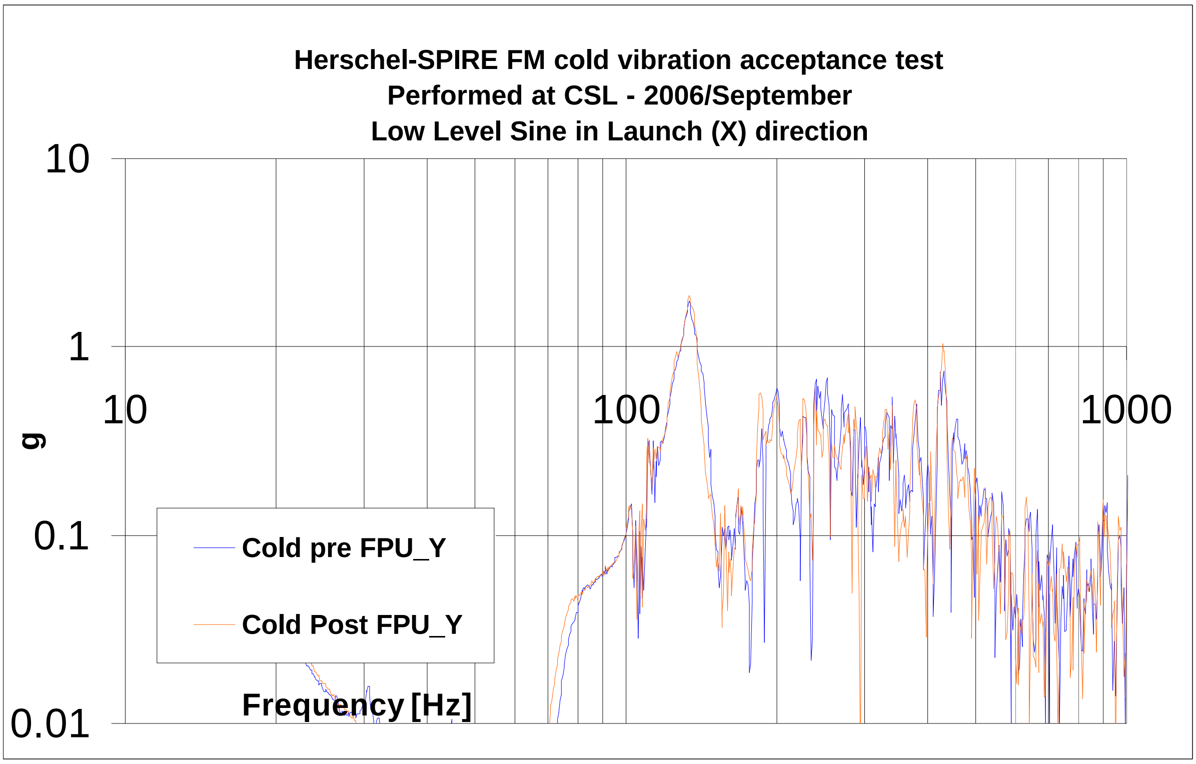


Figure B-2 pre-post comparison in lateral direction (Y)

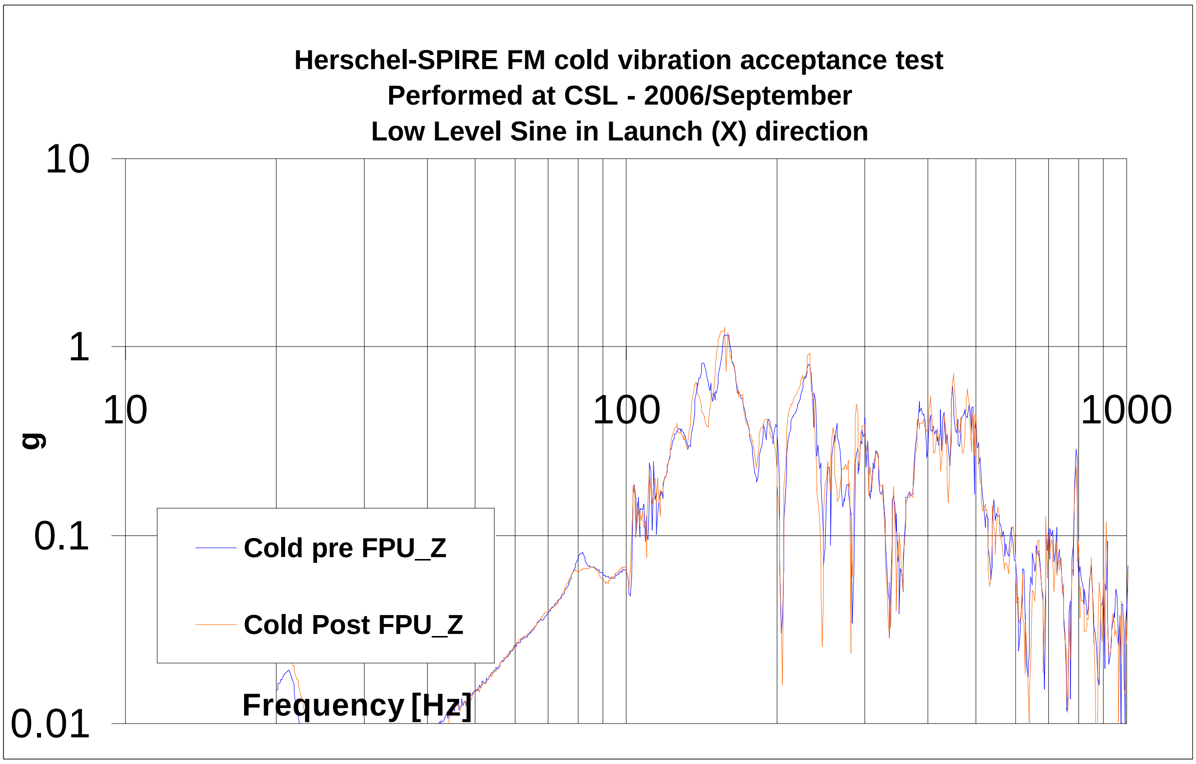


Figure B-3 pre-post comparison in lateral direction (Z)

Appendix C – Run list

See AD12 for a complete overview.

Below is a list of vibration runs and their identification code.

Run	Date	Time	Axis	Description
BNS04X.rsn	4/9/06	10.30	X	Resonance search
NIA03X.rrrn	4/9/06	10.56	X	-12 dB random
NIA04X.rrn	4/9/06	11.07	X	-6 dB random
NIA05X.rrn	4/9/06	11.15	X	Full level Random

Appendix D - Summary of events

Date	Activity
22/8/06	Delivery of SPIRE to CSL
24/8/06	Mount FPU on VTA in Y axis
25/8/06	Warm low level run
4/9/06	SPIRE cold, X axis test
5 to 10/9/06	Warm up
11/9/06	Remove SPIRE, Pack
13/9/06	Ship to RAL

Appendix E - Full level random responses

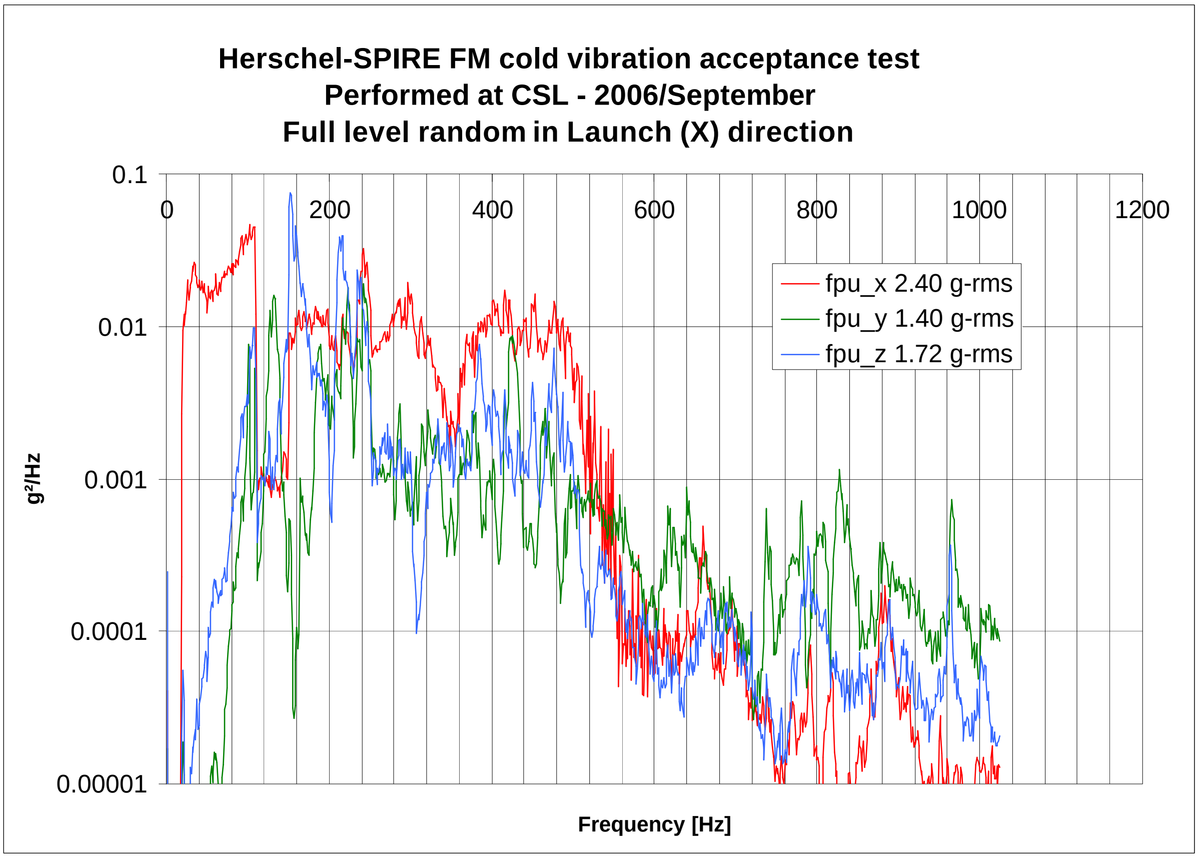


Figure E-1: Full level random, FPU responses (X-axis vibration)