SPIRE

SHUTTER USAGE FORECAST

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Author: J.K. Taylor

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1 SCOPE OF THIS DOCUMENT

This document outlines the anticipated cold usage of the SPIRE shutter subsystem in the integrated SPIRE PFM and the pre-launch Herschel configurations (PLM and S/C).

The integration, testing and operations schedules for SPIRE and Herschel are not yet well defined. Accordingly, the information presented in this document is subject to revision.

2 Documents

2.1 Governing documents

These documents, of the issue shown, describe instrument qualification procedures to which the shutter must conform:

Table 1: Governing documents.

	Title	Document No.	Date
GD-1	FIRST/Planck Instrument Interface Document Part A	SCI-PT-IIDA-04624 Current issue 1/1	20 Dec 2000
GD-2	FIRST/Planck Instrument Interface Document Part B 'SPIRE'	SCI-PT-IIDB/SPIRE-02124 Current issue 1/0	01 Sep 2000
GD-3	Design Requirements for the SPIRE Shutter Subsystem	SPIRE-USK-NOT-000826 Current Issue 0.2	27 Aug 2001
GD-4	Instrument Qualification Requirements Document	SPIRE-RAL-PRJ-000592 Current Issue 1.1	29 Mar 2001
GD-5	Instrument AIV Plan	SPIRE-RAL-PRJ-000410 Current Issue 2.1	29 Mar 2001
GD-6	SPIRE Schedule, 12 April 2001	N/A	12 Apr 2001
GD-7	SPIRE Calibration Requirements Document	To Be Written	N/A
GD-8	SPIRE Operations Requirements Document	To Be Written	N/A

Subsequent issues of GD-7 and GD-8, or revised issues of GD-1 through GD-6 , shall not automatically impose or change requirements for the shutter. Rather, a subsequent issue of this document will reflect or contain updated requirements negotiated between the SPIRE Project and the CSA.

2.2 Reference documents

These documents provide useful background information, but do not contain any information regarding shutter usage at the SPIRE or Herschel level:

Table 2: Reference documents.

	Title	Document No.	Date
RD-1	SPIRE Design Description	SPIRE-RAL-PRJ-000620 Current Issue 0.1 (DRAFT)	12 Apr 2001
RD-2	Instrument Requirements Document	SPIRE-RAL-PRJ-000034 Current issue 1.0	23 Nov 2000

3 ABBREVIATIONS

AD	Applicable Document
AIV	Assembly Integration and Verification
BOL	Beginning of Life
CDMS	Command and Data Management System
CSA	Canadian Space Agency
CVV	Cryostat Vacuum Vessel
ESA	European Space Agency
FPU	Focal Plane Unit
FSDPU	First-SPIRE Digital Processing Unit
FSDRCU	First-SPIRE Detector Readout and Control Unit
GD	Governing Document
GSE	Ground Support Equipment
HIFI	Heterodyne Instrument for the Far Infrared
HOB	Herschel Optical Bench
ILT	Instrument Level Testing
PACS	Photodetector Array Camera and Spectrometer
PFM	Proto-Flight Model
PLM	Payload Module
RAL	Rutherford Appleton Laboratory
RD	Reference Document
S/C	Spacecraft
SPIRE	Spectral and Photometric Imaging Receiver
TBC	To Be Confirmed
TBD	To Be Determined
TBW	To Be Written
USK	University of Saskatchewan

4 SHUTTER RATIONALE

In the Herschel flight configuration, the background flux on the SPIRE detectors will be dominated by thermal emission from the telescope. The telescope is defined in GD-1. The relevant thermophysical parameters are:

- temperature: 80±10K
- BOL emissivity: 0.02 - 0.04

In pre-launch configurations the background flux must be simulated so that the instrument can be operated and tested under flight-like conditions (Figure 1).

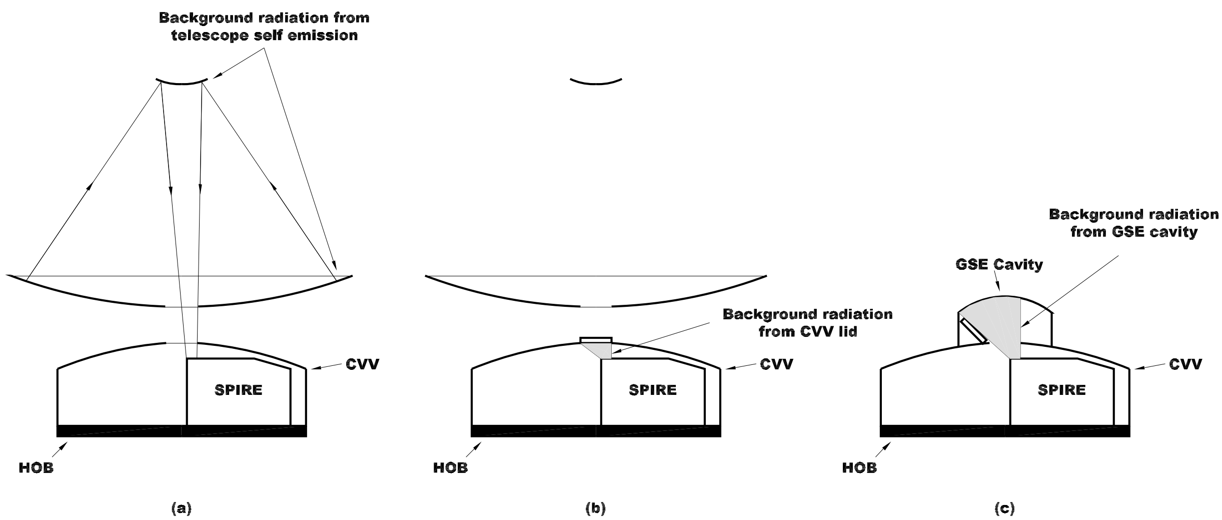

Figure 1: **Background Radiation - Herschel Configurations.** (a) In orbit, the lid will be open and the background flux will be dominated by thermal emission from the telescope; (b) in spacecraft tests, the lid will be closed and the background flux is potentially high enough to saturate the detectors; (c) use of a GSE cavity is TBC for Herschel PLM PFM testing.

The shutter will also be useful during SPIRE instrument level testing (ILT). The shutter is designed to:

1. reject incident flux;
2. simulate the background flux from the Herschel telescope.

The design requirements for the shutter are defined in GD-3. There are three pre-launch configurations to consider:

1. SPIRE ILT (Instrument Level Testing)
2. Herschel PLM (Payload Module)
3. Herschel S/C (Spacecraft)

5 SPIRE INSTRUMENT LEVEL TESTING

The primary objectives of the SPIRE ILT are:

1. to simulate the thermal environment in which the instrument will operate; and
2. to provide a telescope simulator and calibration sources to allow cold verification of the instrument specifications and its calibration.

It is also desirable to test shutter performance and detected vane flux during this level of testing.

5.1 Instrument Orientation

The SPIRE $+y$ axis is earth-facing in the RAL test cryostat to be used for SPIRE ILT (Figure 2). In this orientation, vane motion is in the plane of the gravitational force, $\vec{F}_g$, and the shutter will be required to operate against a maximum $1g$ acceleration (GD-3). The RAL cryostat is stationary. No tilting of the instrument during SPIRE ILT is required for FTS operation or adsorption cooler recycling.

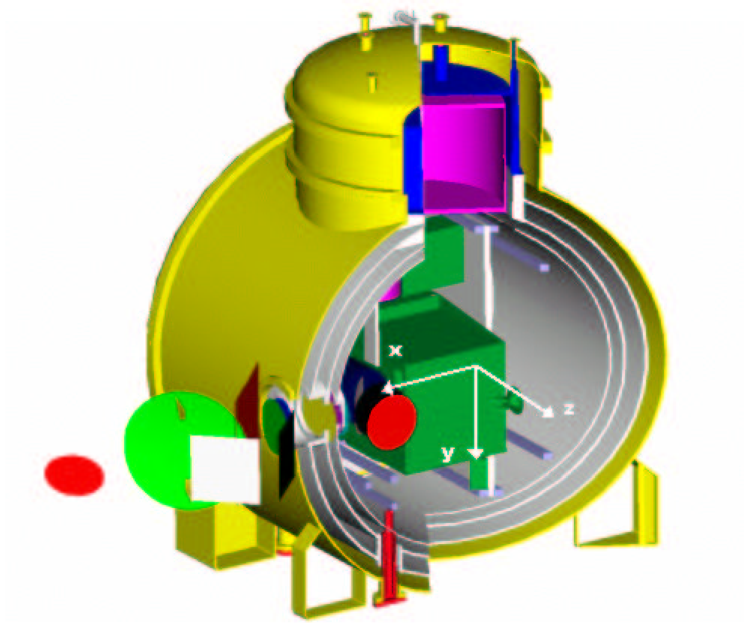

Figure 2: **SPIRE orientation - SPIRE ILT.** The $+y$ axis will be earth-facing during instrument level testing.

5.2 Integration, Testing and Operations

Table 3: SPIRE Instrument Level Integration and Testing.

Sequence	Duration	Remarks
SPIRE PFM Integration	105d	2 days outlined for shutter integration
SPIRE PFM Test Readiness Review	1d	
		continued on next page

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SPIRE PFM Verification
• PFM Instrument Cold Tests I
  – Cool down (4d)
  – Interface checks (2d)
  – Cold Functional Tests I (5d)
  – Pre-vibration performance tests (5d)
  – Warm up (4d)
  – Warm Functional Tests II (1d)
• PFM cold vibration (34d)
• PFM Instrument Cold Tests II
  – Cool down (3d)
  – Cold Functional Tests II (3d)
  – Post-vibration performance tests (5d)
	66 days	**Potential shutter usage:**
		• Cold Functional Tests I:
		  – vane cycles: 1
		  – latch cycles: 1
		• Pre-vibration performance checks:
		  – vane cycles: 1
		  – latch cycles: 1
		• Cold vibration:
		  – latch cycles: 1
		• Cold Functional Tests II:
		  – vane cycles: 1
		  – latch cycles: 1
		• Post-vibration performance tests:
		  – vane cycles: 1
		  – latch cycles: 1

SPIRE PFM Warm Electronics Integration	19d	To be completed in parallel with conclusion of PFM verification

SPIRE PFM Instrument Calibration
• Integrate PFM WE into test facility (2d)
• Cold Functional Test III (2d)
• Warm electronics thermal range tests (5d)
• Calibration (30d)
• Cold Functional Test IV (3d)
• Warm up (4d)
	46d	**Potential shutter usage:**
		• Cold Functional Tests III:
		  – vane cycles: 1
		  – latch cycles: 1
		• Calibration:
		  – vane cycles: 5
		• Cold Functional Tests IV:
		  – vane cycles: 1
		  – latch cycles: 1

6 HERSCHEL LEVEL TESTING OF THE SPIRE INSTRUMENT

The shutter rationale is based on its use during pre-launch SPIRE operation in both the Herschel PLM and S/C configurations. Successful shutter operation during these phases is critical.

6.1 Instrument Orientation

The SPIRE $-x$ axis is earth-facing for the Herschel PLM and S/C AIV phases (Figure 3). In this orientation, the motion of the vane is perpendicular to Earth's gravitational force, $\vec{F}_g$. However, testing of the SPIRE FTS mechanism will require a $+90°$ tilt of the Herschel PLM (or S/C) about the z-axis. The $90°$ tilt results in shutter vane motion in the plane of $\vec{F}_g$. Again, the shutter shall be required to operate against a maximum acceleration of $1g$ (GD-3).

Secondly, Helium sorption cooler recycling needs to be performed at an angle of $15°$ or more (sorption pump above evaporator) during ground testing. The position and orientation of the cooler within the SPIRE instrument will require that the Herschel PLM (or S/C) be tilted by $+15°$ about the z-axis for SPIRE Helium sorption cooler recycling. The cooler requires recycling every 46 hours (TBC). During this time SPIRE will be switched off except for vital housekeeping and cooler functions. The position of the shutter vane during cooler recycling is currently undefined.

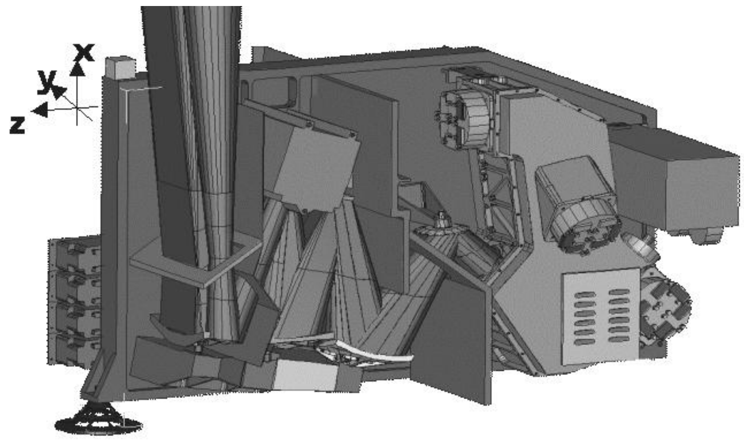

Figure 3: **SPIRE orientation - Herschel.** A 90° tilt about the z-axis will be required for testing of the SPIRE FTS.

6.2 Integration, Testing and Operations

Only the major steps of the Herschel PLM and S/C PFM testing are currently defined. The timeline is TBD. Table 4 outlines the integration and test sequence for Herschel.

Table 4: Herschel Integration and Test Sequence.

Herschel PLM PFM Testing	
Sequence	**Remarks**
Integration	Interface verification, mounting of FPUs
Alignment check	Pre-alignment of optical bench prior to cool-down
Evacuation and bakeout	Parallel activity: mount GSE cavity TBC
Alignment check	
Cool-down of the system, 100% fill at He I temperature	Cryostat cover closed
Cold alignment check	
He II Production, 100% fill at He II temperature	Parallel activities: • electrical connection to warm electronic units • integrate FM external cryostat harness • exchange GSE cavity (TBD)
Integrated module test	
Close cryostat cover, remove GSE cavity	
Warm to He I temperatures	Prepare for transport to S/C AIV facility

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Herschel S/C PFM Testing	
Complete integration	
Alignment and cryostat refilling	Cryostat filling includes: • top-up with He I • He II production, 100% fill at He II temperatures
Integrated satellite test	Cryostat cover closed
System validation test	
Vibration test and acoustic noise test	
EMC test	
Thermal vacuum and thermal balance test	
Prepare system for the carrier test program	

On the following page Table 5 details the SPIRE testing and operations which will take place in both the Integrated Module Test (Herschel PLM PFM) and the Integrated Satellite Test (Herschel S/C PFM) phases.

Table 5: SPIRE Test Sequence - Herschel Configurations **(TBD)**.

<table>
<tr><th>Sequence</th><th>Duration</th><th>Remarks</th></tr>
<tr><td>SPIRE Functional Test
• SPIRE switch on procedure
• validate function of FSDPU
• validate function of FSDRCU
• verify function of cooler thermistors and heaters
• verify function of mechanisms
– to operate FTS the cryostat will need to be tilted by 90° about the Z-axis
• cooler recycle
– to recycle the cooler the cryostat will need to be tilted by ≥ 15° about the Z-axis
• verify function of bolometers, detector readouts, thermal control heaters and temperature sensors
• verify function of calibration sources
• verify SPIRE autonomy functions
• verify SPIRE to CDMS interfaces and telemetry rates
• validation of SPIRE shutdown procedure</td><td>1.5d</td><td>Predicted FPU structure temperature: $5.6K - 6.2K$

Potential shutter usage:
• functional test of mechanisms:
– vane cycles: 1
– latch cycles: 1
• functional test of bolometers, detector readouts, and calibration sources:
– vane cycles: 1</td></tr>
<tr><td>SPIRE Performance Test
• validate SPIRE activation sequence (READY mode)
• cooler recycle
• switch to STANDBY mode
• switch to PHOTOMETER OBSERVE mode
– SPIRE switched to one of the photometer observe modes and placed in the most straylight sensitive condition
• background measurement
• EMI tests
• conducted susceptibility test
• test SPIRE FSFPU thermal behaviour in most ‘thermally intensive’ photometer mode
• switch to SPECTROMETER OBSERVE mode
• test SPIRE FSFPU thermal behaviour in most ‘thermally intensive’ spectrometer mode
• test SPIRE photometer POFs
• test SPIRE spectrometer POFs
• switch to STANDBY (PACS parallel test TBD)
• switch to OFF</td><td>1.5d</td><td>Predicted FPU structure temperatures:
• PHOTOMETER OBSERVE: $6.2K$
• SPECTROMETER OBSERVE: $5.6K$

Potential shutter usage:
• PHOTOMETER OBSERVE:
– vane cycles: 1
• background measurement:
– vane cycles: 1
• SPECTROMETER OBSERVE:
– vane cycles: 1</td></tr>
</table>

7 SUMMARY

Referring to Tables 3 and 5, the anticipated number of shutter vane cold cycles is 21. The anticipated number of shutter latch cold cycles is 9. This is representative of the current test schedules for SPIRE and Herschel.

It is probable that additional tests will be scheduled as the project matures. It is also possible that unforeseen tests, and the repetition of scheduled tests, will become necessary. To safely account for these additional procedures, shutter design should be based on an anticipated shutter usage of 100 cold cycles for both the shutter latch and vane.