SPIRE Calibrators subsystem specification

Issue 1.0

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Update

Date	Version	Remarks
03 April 2000	Draft 1.0	First draft. No detailed design available.
14 July 2000	Issue 1.0	First issue

Host system	Windows NT 4.0
Word Processor	Microsoft Word 2000
File	F:\Projects\First\Spire\Management\Development_plans\Spire Filters subsystem specification.doc

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1. Scope of the document

This document describes the specifications for the photometer and spectrometer calibration sources for SPIRE. Detailed designs for these components do not exist at present, so this document, in it's present draft, is limited to a presentation of conceptual designs. This document covers (or will cover):-

- The instrument requirements on the calibrators
- The performance specifications and design drivers for the photometer and spectrometer calibrators
- The manufacturing procedures and QC/QA
- Risk analysis and testing procedures

The issue of calibrator mounting and integration is covered by document AD2, and work breakdown and scheduling is covered by document AD3

2. Documents

2.1. Applicable documents

	Title	Author	Reference	Date
AD1	Instrument Requirements Document	B.M.Swinyard	SPIRE-RAL-PRJ-000034 Issue 0.30	May 2000
AD2	Interface control documents – Photometer calibrator/chopper Spectrometer calibrator/structure	P.Hargrave, C.Cunningham, B.Winter	SPIRE/ICD/1.5/1.6.1 SPIRE/ICD/1.1/1.6.2	
AD3	SPIRE instrument – Calibrators subsystem development plan	P.Hargrave		April 2000

2.2. Glossary

AD	Applicable Document		
		MGSE	Mechanical Ground Support Equipment
CDR	Critical Design Review	MSSL	Mullard Space Science Laboratory
		NA	Not Applicable
CoG	Center of Gravity	OGSE	Optical Ground Support Equipment
CQM	Cryogenic Qualification Model	PFM	ProtoFlight Model

3. Subsystem description

At the time of writing this draft, the calibrator subsystem is still under development.

3.1. Photometer calibrator

The purpose of the photometer calibrator is to provide a repeatable signal for monitoring of detector health and responsivity for ground testing and in-flight operation. The calibrator is not required to provide absolute calibration, but may be useful as part of the overall calibration scheme. The baseline design consists of a thermal source inside an integrating cavity, the body of which will be at 4-K. The cavity will have a light pipe output with a 1-mm diameter aperture, as shown in figure (1). The calibrator will be located behind the beam steering mirror (M4) at an image of the telescope secondary mirror, as shown in figure (2). The calibrator will form an integral part of the beam steering mirror subsystem. The fraction of M4 area obscured will be 0.2%. The limit on the calibrator aperture is set by the ratio of the telescope secondary to primary mirror diameters.

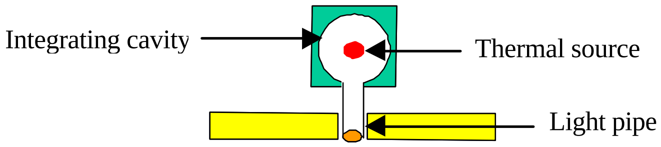

Figure 1 Conceptual design of photometer calibrator

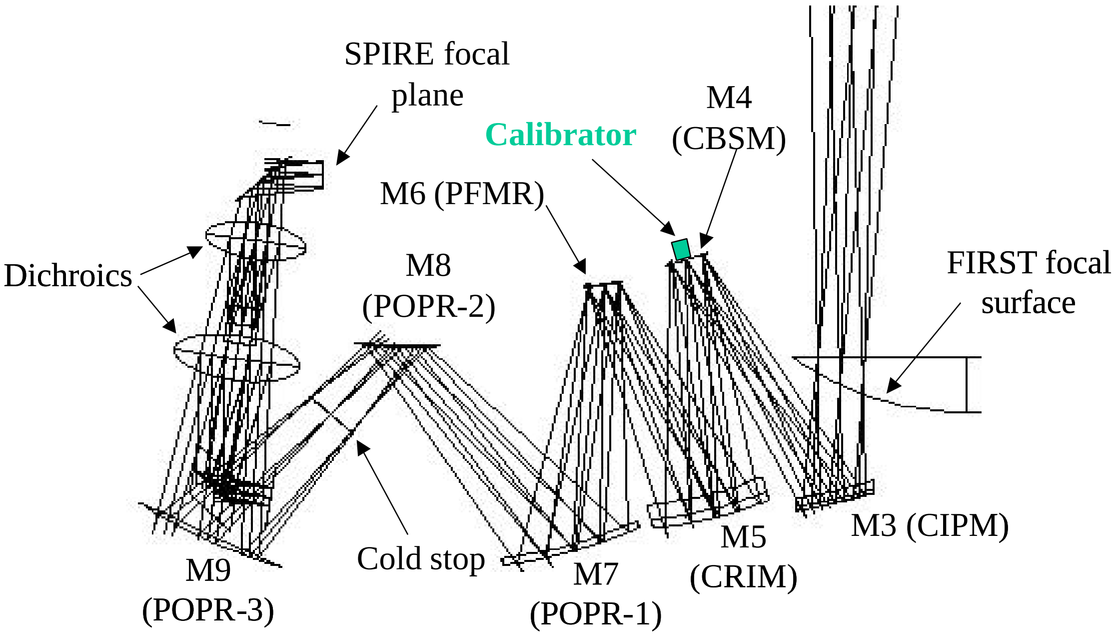

Figure 2 Location of photometer calibrator (PCAL)

3.2. Spectrometer calibrator

The purpose of the spectrometer calibrator is to null the telescope emission by mimicking its spectrum and brightness in the second input port of the FTS. The telescope is assumed to be at 80-K with overall wavelength-independent emissivity $\varepsilon = 0.04$. The overall emissivity of the system is assumed to be uncertain by a factor of 2 (actual value will not be known before launch). The baseline design, shown in figure (3), is the use of a heated black plate (or possibly a metallised film), together with a “hot” source in an integrating cavity with light pipe, to uniformly illuminate the pupil. A possible alternative design is a thermal source with Winston Cone optic to present uniform illumination across the pupil as shown in figure (4). A neutral density filter will be used to dilute the emission. The calibrator will be located at the second input port to the FTS, at an image of the telescope pupil (diameter = 30 mm) as shown in figure (5).

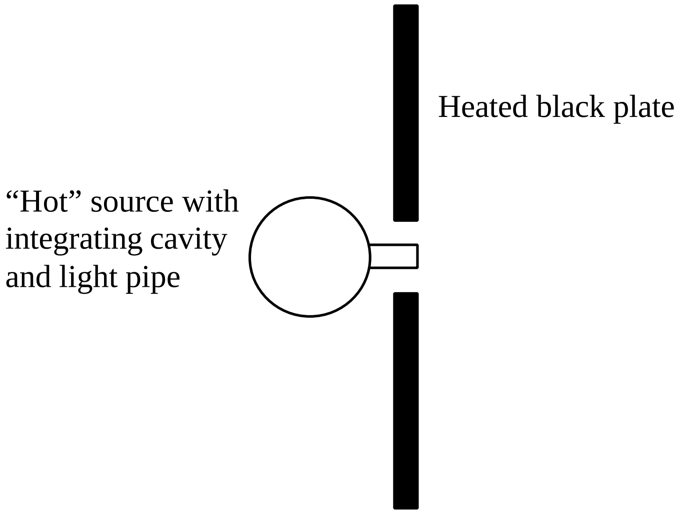

Figure 3 Baseline concept for spectrometer calibrator

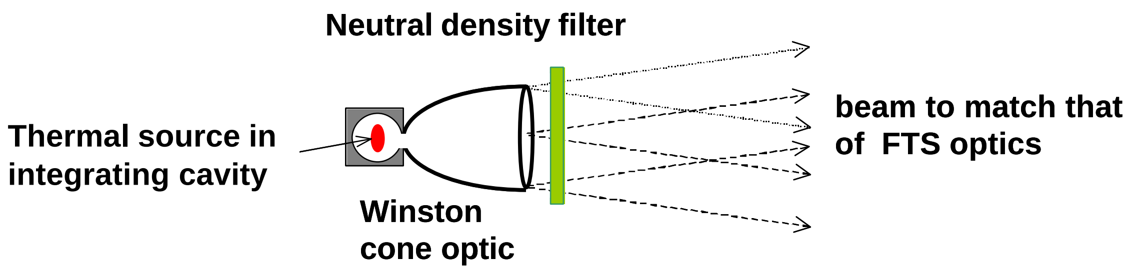

Figure 4 Alternative design of spectrometer calibrator

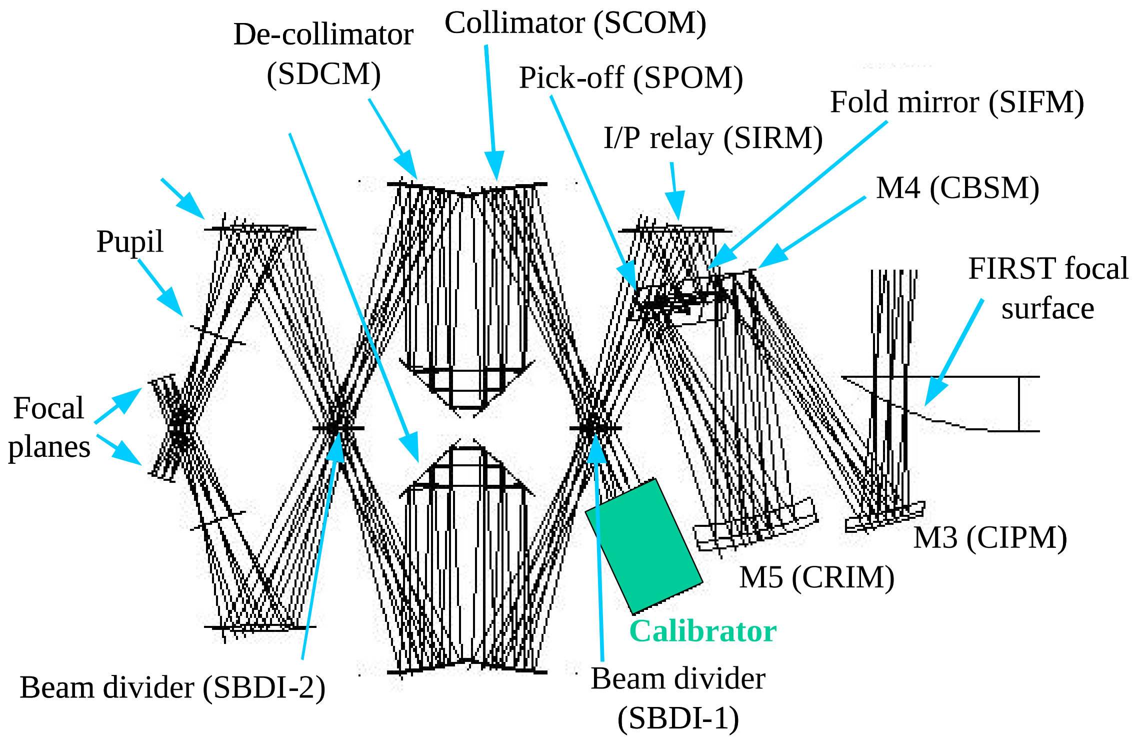

Figure 5 Location of spectrometer calibrator (SCAL)

3.3. Thermal sources

Two types of thermal source are under consideration for the photometer calibrator and for the hot source for the spectrometer calibrator.

1.1.1. Modified ISO style sources

Devices based on the design of the Infra Red Labs TRS sources, as used on ISO, can be manufactured in-house with improved reliability and reduced power dissipation. These are currently under development at QMW.

1.1.2. SIRTF/IRAC type devices

Micromachined Si devices have been developed by NASA/GSFC for use on SIRTF/IRAC. Further development and testing is needed for use on SPIRE. This is in progress at QMW.

4. Performance & System requirements

The performance and system requirements for PCAL and SCAL are listed below, and are extracted from AD1.

4.1. Photometer calibrator (PCAL) performance requirements

Requirement ID	***Description***	***Value***
IRD-CALP-R01	Nominal operating output	Equivalent to εT=40 K for 200<λ<700 mm
IRD-CALP-R02.	Operating range	4-80 K for 200<λ<700 mm commandable in 256 (TBC) steps
IRD-CALP-R03	Equivalent obscuration of aperture through BSM mirror	<0.2%. Actual size is referred to the telescope secondary mirror image at the position of the beam steering mirror.
IRD-CALP-R04	Speed of response	Requirement 150 ms. Goal 30 ms
IRD-CALP-R05	Repeatability	RMS better than 1% over 20 operations. Drift less than10% over lifetime of the mission.
IRD-CALP-R06	Operation	Nominally once per hour for no more than 10 seconds.
IRD-CALP-R07	Frequency	Continuously or pseudo continuously variable between 0 and 5 Hz.

4.2. Photometer calibrator (PCAL) system requirements

Requirement ID	***Description***	***Value***
IRD-CALP-R08	Interface	The calibrator will be integrated into the beam steering mechanism.
IRD-CALP-R09	Volume envelope	30 x 15 x 10 mm
IRD-CALP-R10	Thermal isolation	The temperature of the surrounding structure (including the beam steering mirror) shall rise by no more than 1 K after 10 seconds when the calibrator is operated unmodulated at nominal power output.
IRD-CALP-R11	Operating temperature	4-K
IRD-CALP-R12	Cold power dissipation	Less than 2 mW when operated unmodulated at nominal power output.
IRD-CALP-R13	Warm power dissipation	Less than TBD W when operated unmodulated at nominal power output
IRD-CALP-R14	Operating voltage	Less than 28 V at input power level of 5 mW
IRD-CALP-R15	Redundancy	Cold redundancy for the thermal source

4.3. Spectrometer calibrator (SCAL) performance requirements

Requirement ID	***Description***	***Value***
IRD-CALS-R01	Radiated spectrum	Null the central maximum to accuracy of 5% (goal 2%) [TBC] Replicate the dilute spectrum of the telescope to an accuracy of better than 20% (goal 5%) [TBC] over 200-400 mm.
IRD-CALS-R02	Beam pattern	Replicate the appropriate beam pattern at the second input port pupil image
IRD-CALS-R03	Adjustability	Zero - maximum in 256 steps
IRD-CALS-R04	Uniformity	The uniformity of the intensity from the calibration source across the second input port pupil image shall be better than TBD%
IRD-CALS-R05	Repeatability and drift	The output intensity of the calibration source shall drift by no more than 1% over one hour of continuous operation. The absolute change in the output intensity of the source shall be no more than 15% over the mission lifetime
IRD-CALS-R06	Operation	The calibration source shall be capable of continuous operation for periods of up to 2 hours with no loss of operational performance.
IRD-CALS-R07	Number of operations	The calibration source shall be capable of up to 12000 operational cycles

4.4. Spectrometer calibrator (SCAL) system requirements

Requirement ID	***Description***	***Value***
IRD-CALS-R08	Operating voltage	No more than 28 V DC
IRD-CALS-R09	Power dissipation in the focal plane	No more than 5 mW with a goal of 2 mW
IRD-CALS-R11	Envelope	50x50x70 mm (TBC)
IRD-CALS-R12	Thermal isolation	The surrounding structure of the calibrator shall rise in temperature by no more than TBD K after one hour of continuous operation
IRD-CALS-R13	Operating temperature	4 K
IRD-CALS-R14	Redundancy	Fully redundant systems shall be provided for the active elements.

5. Technical requirements – to be completed

These requirements are design dependent. This section will be completed once the final designs are available.
Typical list:

- Axis reference system
- Alignment constraint
- Field view
- Dimensions
- Center of gravity, mass, inertia
- Stiffness
- Dynamic perturbations emitted by the subsystem
- Power consumption

- EMC emitted by the product

6. Operation – to be completed once design finalised

6.1. Reliability

6.2. Lifetime

6.3. Environment

6.4. Alignment

6.5. Stability

6.6. EMI

6.7. Attitude disturbance

6.8. Safety

6.9. Operating modes

6.10. Telemetry

6.10.1. Telecommands

7. Design & construction – to be completed

7.1. Interface requirements

7.2. Reference axes

7.3. Design philosophy

7.4. Configuration

7.5. Cleanliness

7.6. Venting

7.7. Accessibility and servicing

7.8. Materials

7.9. Finishes

7.10. Processes

7.11. Standard & commercial parts

7.12. Standard specification

7.13. Part identification

7.14. Interchangeability

7.15. Electrical

7.16. High energy particle shielding

7.17. Resource budget

8. Test & Calibration – to be completed

More detail can be found in AD3.

8.1. Functional test

8.2. Performance test

8.3. Verification requirements

- Mathematical modelling
- Functional tests
- Qualification tests

- Acceptance tests
- Life tests

8.4. Mechanical environment test

8.5. System dynamic test

8.6. Thermal vacuum performance test

8.7. Life test

9. Logistical requirements – to be completed

9.1. Handling equipment & procedures

9.2. Transit equipment & procedures

9.3. Protection equipment & procedures

9.4. Ancillary equipment & procedures