Filters

Subsystem Specification Document

SPIRE Ref.: SPIRE-QMW-PRJ-000454
Cardiff Ref.: HSO-CDF-SP-002
Issue: 2.0

Prepared by: Peter Hargrave
Last Modified on: 23 August 2001
Approved by:

Distribution list

Update history

Date	Version	Remarks
03 April 2000	Draft 1.0	First draft. No detailed design available.
14 July 2000	Issue 1.0	First issue
19 April 2001	Issue 1.1	Revised & updated for IIDR
23 August 2001	Issue 1.2	Revised filter bands
7/9/01	2.0	First configuration controlled issue.

List of Acronyms

Term	Meaning	Term	Meaning
AD	Applicable Document	IR	Infrared
ADC	Analogue to Digital Converter	IRD	Instrument Requirements Document
AIV	Assembly, Integration and Verification	IRTS	Infrared Telescope in Space
AME	Absolute Measurement Error	ISM	Interstellar Medium
AOCS	Attitude and Orbit Control System	JFET	Junction Field Effect Transistor
APART	Arizona's Program for the Analysis of Radiation Transfer	ISO	Infrared Space Observatory
APE	Absolute Pointing Error	LCL	Latching Current Limiter
ASAP	Advanced Systems Analysis Program	LIA	Lock-In Amplifier
ATC	Astronomy Technology Centre, Edinburgh	LVDT	Linear Variable Differential Transformer
AVM	Avionics Model	LWS	Long Wave Spectrometer (an instrument used on ISO)
BDA	Bolometer Detector Array	MAC	Multi Axis Controller
BFL	Back Focal Length	MAIV	Manufacturing, Assembly, Integration and Verification
BRO	Breault Research Organization	MCU	Mechanism Control Unit = HSMCU
BSM	Beam Steering Mirror	MGSE	Mechanical Ground Support Equipment
CBB	Cryogenic Black Body	M-P	Martin-Puplett
CDF	Cardiff, Department of Physics & Astronomy	NEP	Noise Equivalent Power
CDMS	Command and Data Management System	NTD	Neutron Transmutation Doped
CDMU	Command and Data Management Unit	OBS	On-Board Software
CDR	Critical Design Review	OGSE	Optical Ground Support Equipment
CEA	Commissariat a l'Energie Atomique	OMD	Observing Modes Document
CMOS	Complimentary Metal Oxide Silicon	OPD	Optical Path Difference
CoG	Centre of Gravity	PACS	Photodetector Array Camera and Spectrometer
CPU	Central Processing Unit	PCAL	Photometer Calibration source
CQM	Cryogenic Qualification Model	PFM	Proto-Flight Model
CVV	Cryostat Vacuum Vessel	PID	Proportional, Integral and Differential (used in the context of feedback control loop architecture)
DAC	Digital to Analogue Converter	PLW	Photometer, Long Wavelength
DAQ	Data Acquisition	PMW	Photometer, Medium Wavelength
DCU	Detector Control Unit = HSDCU	POF	Photometer Observatory Function
DDR	Detailed Design Review	PROM	Programmable Read Only Memory
DM	Development Model	PSW	Photometer, Short Wavelength
DPU	Digital Processing Unit = HSDPU	PUS	Packet Utilisation Standard
DSP	Digital Signal Processor	RAL	Rutherford Appleton Laboratory,
DQE	Detective Quantum Efficiency	RD	Reference Document
EDAC	Error Detection and Correction	RMS	Root Mean Squared
EGSE	Electrical Ground Support Equipment	SCAL	Spectrometer Calibration Source
EM	Engineering Model	SCUBA	Submillimetre Common User Bolometer Array
EMC	Electro-magnetic Compatibility	SED	Spectral Energy Distribution
EMI	Electro-magnetic Interference	SMEC	Spectrometer Mechanics
ESA	European Space Agency	SMPS	Switch Mode Power Supply
FCU	FCU Control Unit = HSFCU	SOB	SPIRE Optical Bench
FIR	Far Infrared	SOF	Spectrometer Observatory Function
FIRST	Far Infra-Red and Submillimetre Telescope	SPIRE	Spectral and Photometric Imaging Receiver
FOV	Field of View	SRAM	Static Random Access Memory
F-P	Fabry-Perot	SSSD	SubSystem Specification Document
FPGA	Field Programmable Gate Array	STP	Standard Temperature and Pressure
FPU	Focal Plane Unit	SVM	Service Module
FS	Flight Spare	TBC	To Be Confirmed
FTS	Fourier Transform Spectrometer	TBD	To Be Determined
FWHM	Full Width Half maximum	TC	Telecommand
GSFC	Goddard Space Flight Center	URD	User Requirements Document
HK	House Keeping	UV	Ultra Violet
HOB	Herschel Optical Bench	WE	Warm Electronics
HPDU	Herschel Power Distribution Unit	ZPD	Zero Path Difference
HSDCU	Herschel-SPIRE Detector Control Unit		
HSDPU	Herschel-SPIRE Digital Processing Unit		
HSFCU	Herschel-SPIRE FPU Control Unit		
HSO	Herschel Space Observatory		
IF	Interface		
IID-A	Instrument Interface Document - Part A		
IID-B	Instrument Interface Document - Part B		
IMF	Initial Mass Function		

Table of Contents

1. Scope

This specification defines the requirements and specifications applied to the performance, design, qualification and interfaces of the SPIRE Filters subsystem. It is applicable to the STM, the CQM, the PFM and the FS as described in this document.

2. Documents

2.1. Applicable documents

All applicable documents are listed in the AD chapter of the CIDL (HSO-CDF-LI-029).

2.2. Reference documents

3. Subsystem Description

3.1. Design philosophy and overview

The first filter in the chain, situated on the 4-K box, should reflect back to the sky as much unwanted high frequency radiation as possible. Filters on lower temperature shields should then reject radiation from higher temperature boxes and shields. Strategic placement of filters will enable us to:

- Define the spectral passbands.
- Minimise the thermal loading on the ^{3}He fridge, 2-K and 4-K stages by rejecting short wavelength thermal energy.
- Minimise stray light getting to the detectors.
- Maximise the in-band spectral transmission.

The layout of filters on SPIRE is shown schematically by Figure 1 and Figure 2.

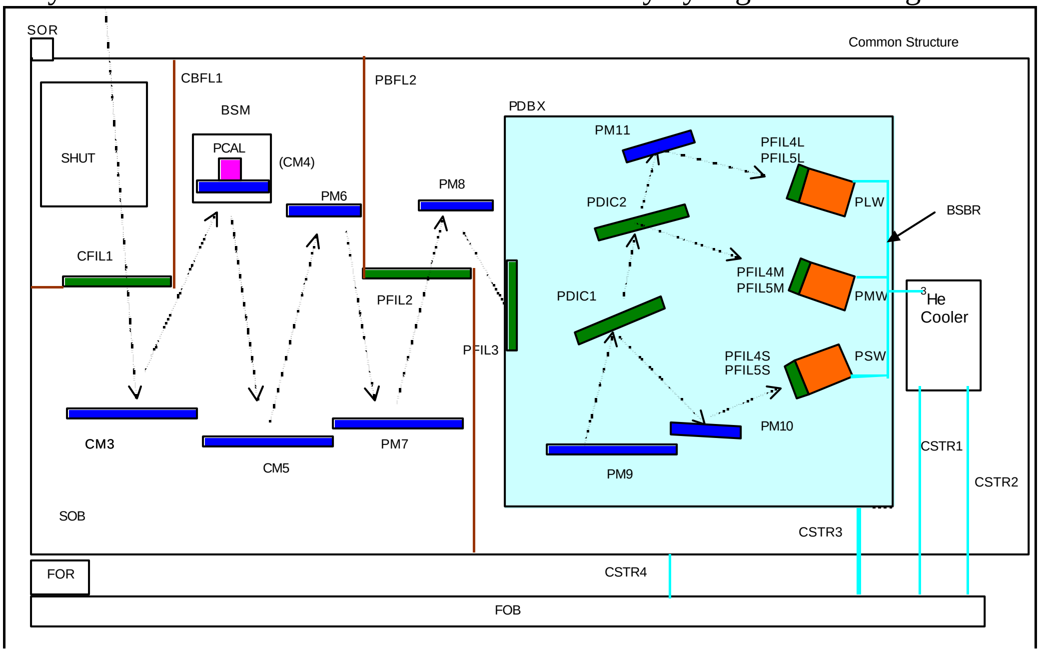

Figure 1 Topology of photometer side of SPIRE. Filters and dichroics are shown in green.

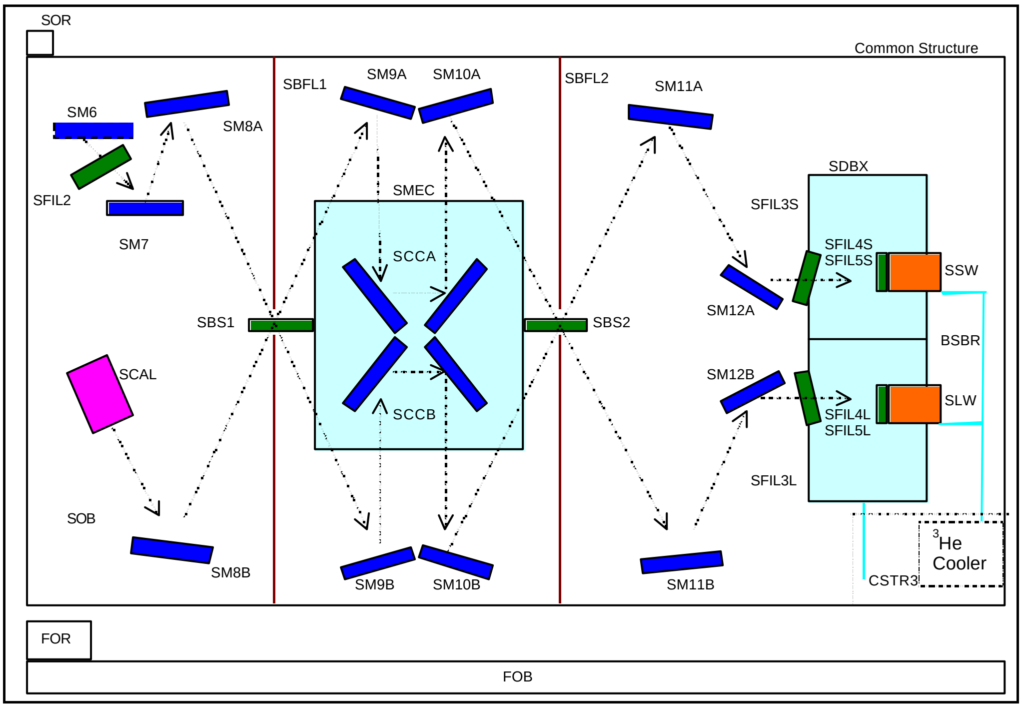

Figure 2 Topology of spectrometer side of SPIRE. Filters and beam splitters are shown in green.

3.2. Photometer filtering scheme

A summary of the photometer filter requirements is shown in Table 1.
The full specifications of each filter component are detailed in section 4.

3.2.1. Comments on filtering scheme

These comments are also valid for the spectrometer filters.

Thickness:- The dimension shown in the column is the thickness of the filter itself, not including any mounting rings.

Size:- The numbers in this column define the minimum clear aperture (MCA) required. A single number represents the diameter of a circular aperture, and two numbers are the sides of a rectangular aperture.

Assumptions:-
For blocking filters, the 90 % and 10 % edges are within 5 % of the 50 % transmission point. 2 % blocking is achieved at $10cm^{-1}$ away from the 50 % point. For the dichroics, the 50 % point in reflection is separated by 0.6 cm^{-1} from the 50 % point in transmission.

Definition of tolerance:-
% transmission is with respect to the peak
Blocking, B, refers to blocking at <2 %.
50 % edge has a tolerance of ± 1 % in frequency.
10 % and 9 0% edges shall be within the values specified.

In-band transmission:-

The overall transmission of the filter stack has a design value of >60 %, averaged over the central 50 % of the band.

50% bands (μm) as determined by these filters:

				$\lambda/\Delta\lambda$	λ_o	
P/SW	208.3	-	300.3	2.77	254	But waveguide cut-off limits it to 291.7
P/MW	305.8	-	420.2	3.17	363	Waveguide cut-off is set at 420.0
P/LW	431.0	-	583.3	3.33	507	Note: 583.3 is set by waveguide cut-off

50% bands (μm) as specified in feedhorn design

				$\lambda/\Delta\lambda$	λ_o	
P/SW	208.3	-	291.7	3.00	250	OK
P/MW	306.0	-	420.1	3.18	363	OK
P/LW	416.7	-	583.3	3.00	500	Band defined by the current filters/dichroics is narrower. Options: keep bandwidth of 3.3 or else open out LW waveguide.

Table 1 Photometer filters and dichroics.

Name	Location	Temp.	Filter type	Edges			Function T = Transmit B = Block; R = Reflect		Comments	Size (mm)	Thickness (microns)
				Trans.	cm-1	μm					
CFIL1	Input filter on Level-1 box	Level 1 (5 K)	Low-pass edge	90% 50% 10%	60.0 100.0 105.0	166.7 100.0 95.2	T B	15 - 50 cm-1 666.7 - 200 μm 110.0 - UV cm-1 90.91 - UV μm	Thermal blocker. Common to Photometer and FTS.	135 x 67	118.24
PFIL2	At baffle between PM7 and PM8	Level 1 (5 K)	Low-pass edge	90% 50% 10%	60.0 90.0 94.5	166.7 111.1 105.8	T B	15 - 50 cm-1 666.7 - 200 μm 99.5 - UV cm-1 100.5 - UV μm	Thermal blocker.	76	131.38
PFIL3	At 2K cold stop	Level 0 (2 K)	Low-pass edge	90% 50% 10%	57.0 60.0 63.0	175.4 166.7 158.7	T B	15 - 50 cm-1 666.7 - 200 μm 68.0 - UV cm-1 147.1 - UV μm	Thermal blocker.	TBD	197.07
PDIC1	After PM9	Level 0 (2 K)	Low-pass edge (dichroic)	90% 50% 10%	31.1 **32.7** 34.3	321.9 **305.8** 291.2	T R	15 - 32.7 cm-1 666.7 - 306 μm 33.3 - 50 cm-1 **300** - 200 μm	Dichroic. Reflects onto P/SW and transmits to P/MW and P/SW.	80	361.60
PDIC2	After PDIC1	Level 0 (2 K)	Low-pass edge (dichroic)	90% 50% 10%	22.0 **23.2** 24.4	453.7 **431.0** 410.5	T R	15 - 23.2 cm-1 666.7 - 431 μm 23.8 - 50 cm-1 **420.2** - 200 μm	Dichroic. Reflects onto P/MW and transmits to P/LW.	72	509.67
PFIL4S	Over SW array	300 mK	Low-pass edge	90% 50% 10%	47.5 50.0 52.5	210.5 200.0 190.5	T B	33.9 - 50.0 cm-1 295 - 200 μm 57.5 - UV cm-1 173.9 - UV μm	Blocker.	25 x 50	236.49
PFIL5S	Over SW array	300 mK	Low-pass edge	90% 50% 10%	45.6 48.0 50.4	219.3 208.3 198.4	T B	33.9 - 48.0 cm-1 295 - **208** μm 55.4 - UV cm-1 180.5 - UV μm	SW array edge definer .	25 x 50	246.34
PFIL4M	Over MW array	300 mK	Low-pass edge	90% 50% 10%	40.9 43.0 45.2	244.8 232.6 221.5	T	23.8 - 43.0 cm-1 420.2 - 233 μm	Blocker	25 x 50	274.98
PFIL5M	Over MW array	300 mK	Low-pass edge	90% 50% 10%	31.4 33.0 34.7	319.0 303.0 288.6	T	23.8 - 33.0 cm-1 420.2 - 303 μm	MW array edge definer. Baseline: not implemented – already defined by PDIC1.	25 x 50	358.31
PFIL4L	Over LW array	300 mK	Low-pass edge	90% 50% 10%	28.5 30.0 31.5	350.9 333.3 317.5	T B	15 - 23.2 cm-1 666.7 - 431 μm 36.5 - UV cm-1 274 - UV μm	Blocker	25 x 50	394.14
PFIL5L	Over LW array	300 mK	Low-pass edge	90% 50% 10%	22.0 23.2 24.4	453.7 431.0 410.5	T B	15 - 23.2 cm-1 666.7 - 431 μm 29.4 - UV cm-1 340.6 - UV μm	LW array edge definer. Baseline: not implemented – already defined by PDIC2.	25 x 50	509.67
PFIL6L	Over LW array.	300 mK	High-pass edge	90% 50% 10%	16.3 17.2 18.1	612.0 581.4 553.7	T B	17.2 - 23.9 cm-1 581.4 - 418 μm 0 - 15.8 cm-1 TBD - 633 μm	Baseline: not implemented – defined by waveguide cut-on.	25 x 50	687.46

3.3. Spectrometer filtering scheme

Table 2 Spectrometer filters and beam dividers

Name	Location	Temp.	Filter type	Edges			Function T = Transmit B = Block; R = Reflect		Comments	Size (mm)	Thickness (mm)
				Trans	cm-1	mm					
CFIL1	Input filter on Level-1 box	Level 1 (5 K)	Low-pass edge	90% 50% 10%	60.0 100.0 105.0	166.7 100.0 95.2	T B	15 - 50 cm-1 667 - 200 µm 110 - UV cm-1 90.9 - UV µm	Thermal blocker. Common to Photometer and FTS.	135 x 67	118.24
SFIL2	At pupil in SOB	Level 1 (5 K)	Low-pass edge	90% 50% 10%	60.0 90.0 94.5	166.7 111.1 105.8	T B	15 - 50 cm-1 667 - 200 µm 100 - UV cm-1 100 - UV µm	Thermal blocker. Identical to PFIL2.	30	131.38
SBS1	After SM8A	Level 1 (5 K)	Beam divider		15.0 50.0	666.7 200.0	Requirement is 4RT> 90% over quoted range.			38	236.49
SBS2	After SM10A	Level 1 (5 K)	Beam divider		15.0 50.0	666.7 200.0	Requirement is 4RT> 90% over quoted range.		Identical design to SBS1.	38	236.49
SFIL3S	After SM12A	At Level 0 SW cold stop (2 K)	Low-pass edge	90% 50% 10%	66.5 70.0 73.5	150.4 142.9 136.1	T B	31.2 - 51.3 cm-1 321 - 195 µm 78.5 - UV cm-1 127 - UV µm	Blocker	40	168.92
SFIL4S	Over SW array	300 mK	Low-pass edge	90% 50% 10%	57.0 60.0 63.0	175.4 166.7 158.7	T B	31.2 - 51.3 cm-1 321 - 195 µm 68 - UV cm-1 147 - UV µm	Blocker	16	197.07
SFIL5S	Over SW array	300 mK	Low-pass edge	90% 50% 10%	50.0 52.6 55.2	200.1 190.1 181.1	T B	31.7 - 52.6 cm-1 315 - 190 µm 60.2 - UV cm-1 166 - UV µm	Band defining edge. The half-power point is set to yield a 90% point at 50cm-1 or less.	16	224.80
SFIL6S	Over SW array	300 mK	High-pass edge	90% 50% 10%	32.3 30.8 29.3	309.2 324.7 341.8	T B	30.8 - 52.6 cm-1 325 - 190 µm 0 - 24.3 cm-1 #### - 412 µm	Baseline: not implemented – HP edge defined by waveguide cut-off.	16	383.91
SFIL3L	After SM12B	At Level 0 LW cold stop (2 K)	Low-pass edge	90% 50% 10%	57.0 60.0 63.0	175.4 166.7 158.7	T B	14.9 - 32.3 cm-1 671 - 309 µm 68.0 - UV cm-1 147 - UV µm	Blocker	40	197.07
SFIL4L	Over LW array	300 mK	Low-pass edge	90% 50% 10%	40.9 43.0 45.2	244.8 232.6 221.5	T B	14.9 - 32.3 cm-1 671 - 309 µm 50.2 - UV cm-1 199 - UV µm	Blocker	20	274.98
SFIL5L	Over LW array	300 mK	Low-pass edge	90% 50% 10%	31.7 33.4 35.1	315.2 299.4 285.1	T B	14.9 - 31.7 cm-1 671 - 315 µm 40.1 - UV cm-1 250 - UV µm	Band defining edge. Required overlap between bands requires 90% trans. at 315 um	20	354.02
SFIL6L	Over LW array.	300 mK	High-pass edge	90% 50% 10%	14.9 14.2 13.5	670.7 704.2 741.3	T B	14.9 - 32.9 cm-1 671 - 304 µm 0 - 12.5 cm-1 #### - 800 µm	Baseline: not implemented – HP edge defined by waveguide cut-off. Required 90% LW band edge is 670 µm.	20	832.70

4. Specification of filter components

This section lists the specifications for the SPIRE filters. All interface details are contained in the filters ICD (HSO-CDF-ICD-012).

4.1. Common filter

4.1.1. CFIL1

This filter covers the entrance aperture to the SPIRE 4-K box, and will be rectangular in format. It is a common input filter for both the photometer and spectrometer.

Table 3 CFIL1 details

Type	Hot Pressed
Dimensions	135x67 mm MCA, outer dimensions TBC
Interface	Clamp ring
Mass	5 g TBC
Spectral characteristics	LPE 100 cm^{-1}
Comments	

4.2. Photometer filters

4.2.1. PFIL2

This filter covers an aperture in the baffle, PBFL2, in the photometer box, and is only seen by the photometer detectors. A general mounting sketch is shown in Figure 3.

Table 4 PFIL2 details

Type	Hot Pressed
Dimensions	76 mm MCA
Interface	Clamp ring
Mass	3 g TBD
Spectral characteristics	LPE 90 cm^{-1}
Comments	

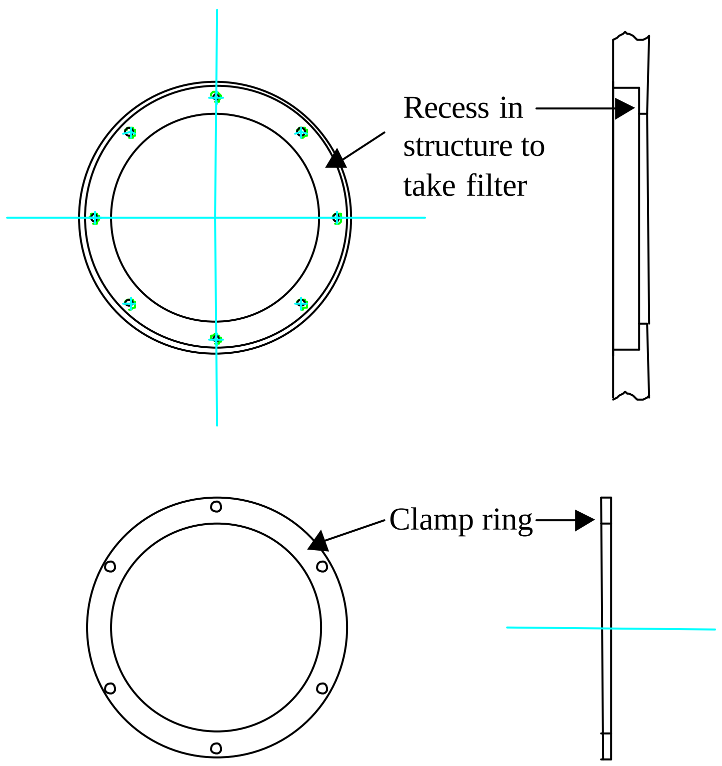

Figure 3 Sketch showing the mounting concept to be used for all circular hot-pressed filter components. Detailed drawings for all hot-pressed filters and mounts are in progress at the time of writing of this issue.

4.2.2. PFIL3

This filter covers the 2-K cold stop in the photometer.

Table 5 PFIL3 details

Type	Hot Pressed
Dimensions	TBD
Interface	Clamp ring
Mass	3 g TBC
Spectral characteristics	LPE 60 cm^{-1}
Comments	

4.2.3. PDIC1

This is the first dichroic in the photometer chain. It is essential that this component remains flat upon cooling, and so it has to be mounted on a substantial ring. An assembly drawing for PDIC1 is shown in Figure 4. This drawing is awaiting approval at the time of writing this document.

Table 6 PDIC1 details

Type	Hot Pressed (TBD), Ring mounted
Dimensions	80mm MCA, 94 mm o/d, 13.5 mm depth
Interface	3-point mounting ring
Mass	287 g TBC
Spectral characteristics	LPE 32.7 cm^{-1} (to give a HPE in reflection of 33.3 cm-1)
Comments	The mass of this component may be reduced after prototype tests have been completed. This component must remain flat, and therefore needs a substantial ring mount.

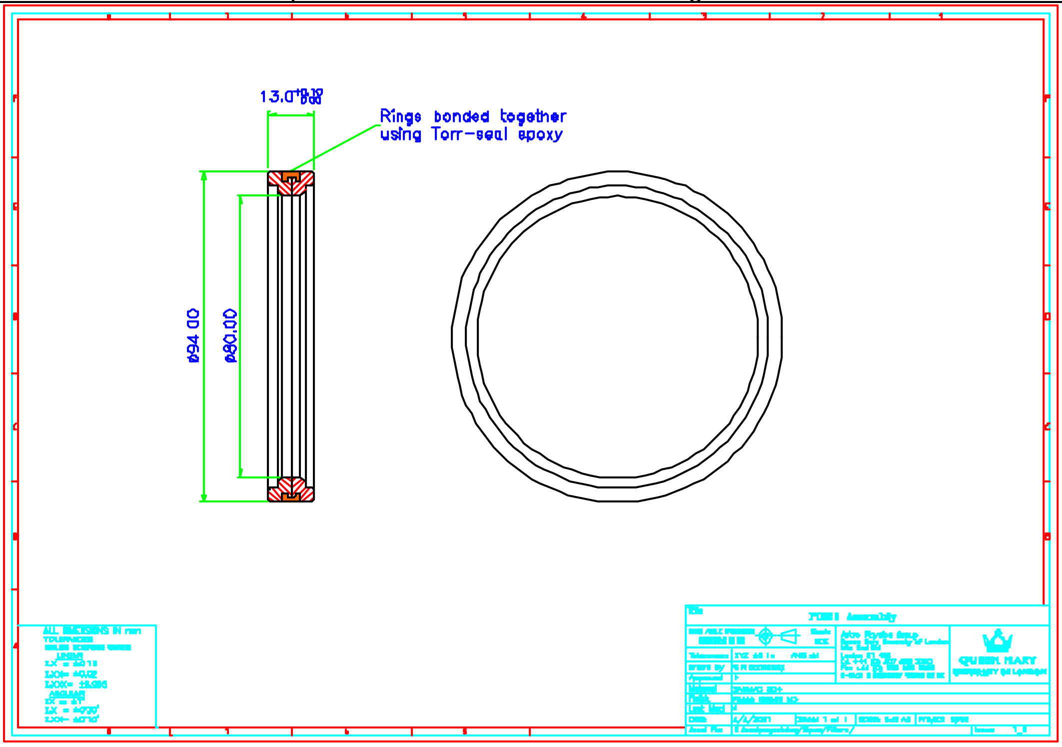

Figure 4 Assembly drawing for PDIC1

4.2.4. PDIC2

This is the second dichroic in the photometer chain. It is essential that this component remains flat upon cooling, and so it has to be mounted on a substantial ring. An assembly drawing for PDIC2 is shown in Figure 5. This drawing is awaiting approval at the time of writing this document.

Table 7 PDIC2 details

Type	Hot Pressed (TBD), Ring mounted
Dimensions	75 mm i/d, 90 mm o/d (MCA=72mm)
Interface	3-point mounting ring
Mass	250 g TBC
Spectral characteristics	LPE 23.2 cm^{-1} (to give a HPE in reflection of 23.8 cm-1)
Comments	The mass of this component may be reduced after prototype tests have been completed. This component must remain flat, and therefore needs a substantial ring mount.

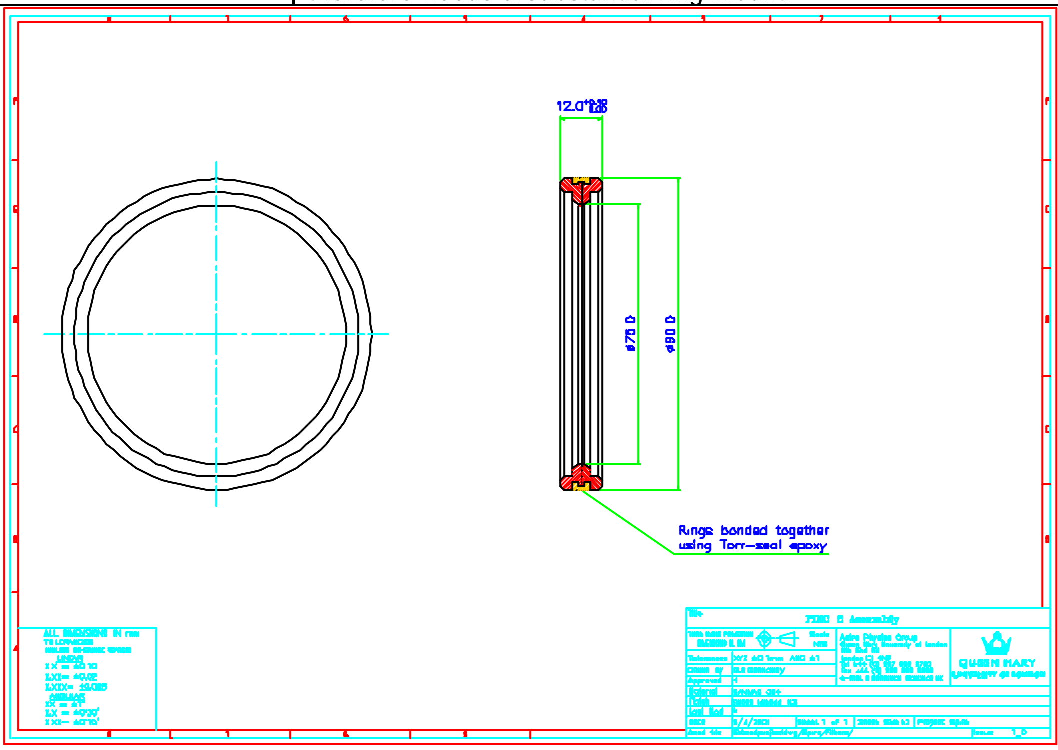

Figure 5 Assembly drawing for PDIC2

4.2.5. PFIL4S

This filter is fitted to the SW BDA at 300-mK. Blocker over SW array.

Table 8 PFIL4S details

Type	Hot Pressed
Dimensions	31x56 mm (25x50 mm MCA)
Interface	Clamp ring
Mass	1.5 g
Spectral characteristics	LPE 50 cm^{-1}
Comments	Clamps to detector module.

4.2.6. PFIL5S

This filter is fitted to the SW BDA at 300-mK. Low-pass edge-definer over SW array.

Table 9 PFIL5S details

Type	Hot Pressed
Dimensions	31x56 mm (25x50mm MCA)
Interface	Clamp ring
Mass	1.5 g
Spectral characteristics	LPE 48 cm^{-1}
Comments	Clamps to detector module.

4.2.7. PFIL4M

This filter is fitted to the MW BDA at 300-mK. Blocker over MW array.

Table 10 PFIL4M details

Type	Hot Pressed
Dimensions	31x56 mm (25x50 mm MCA)
Interface	Clamp ring
Mass	1.5 g
Spectral characteristics	LPE 43 cm^{-1}
Comments	Clamps to detector module.

4.2.8. PFIL5M – Baseline – not implemented as edge defined by PDIC1

This filter is fitted to the MW BDA at 300-mK. Low-pass edge-definer for MW array.

Table 11 PFIL5M details

Type	Hot Pressed
Dimensions	31x56mm (25x50mm MCA)
Interface	Clamp ring
Mass	1.5g
Spectral characteristics	LPE 33.0cm^{-1}
Comments	Clamps to detector module.

4.2.9. PFIL4L

This filter is fitted to the LW BDA at 300-mK. Blocker over LW array.

Table 12 PFIL4L details

Type	Hot Pressed
Dimensions	31x56 mm (25x50 mm MCA)
Interface	Clamp ring
Mass	1.5 g
Spectral characteristics	LPE 30 cm^{-1}
Comments	Clamps to detector module.

4.2.10. PFIL5L – Baseline – not implemented as edge defined by PDIC2

This filter is fitted to the LW BDA at 300-mK. Low-pass edge-definer for LW array

Table 13 PFIL5L details

Type	Hot Pressed
Dimensions	31x56mm (25x50mm MCA)
Interface	Clamp ring
Mass	1.5g
Spectral characteristics	LPE 23.2cm^{-1}
Comments	Clamps to detector module.

4.2.11. PFIL6L Baseline – not implemented, since high-pass edge defined by waveguide cut-on.

High-pass edge-definer over LW array.

Table 14 PFIL6L details

Type	Hot Pressed
Dimensions	31x56mm (25x50mm MCA)
Interface	Clamp ring
Mass	1.5g
Spectral characteristics	HPE 17.2cm^{-1}
Comments	Clamps to detector module. This filter may be needed to define the high-pass cut-on for the long wavelength channel (the dichroics define the HPE for the other two channels)

4.3. Spectrometer filters

4.3.1. SFIL2

This filter is positioned at the pupil in the SPIRE optical bench.

Table 15 SFIL2 details

Type	Hot Pressed
Dimensions	30 mm MCA, 36 mm o/d (TBC)
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 90 cm^{-1}
Comments	

4.3.2. SBS1

This component must remain flat, and therefore it shall be ring mounted. An assembly drawing is shown in Figure 6.

Table 16 SBS1 details

Type	Hot Pressed (TBC), Ring mounted
Dimensions	46 mm i/d, 56 mm o/d, 38 mm MCA (TBC)
Interface	3-point mounting ring
Mass	32 g
Spectral characteristics	15-50 cm^{-1} beam splitter
Comments	Size 5 ring

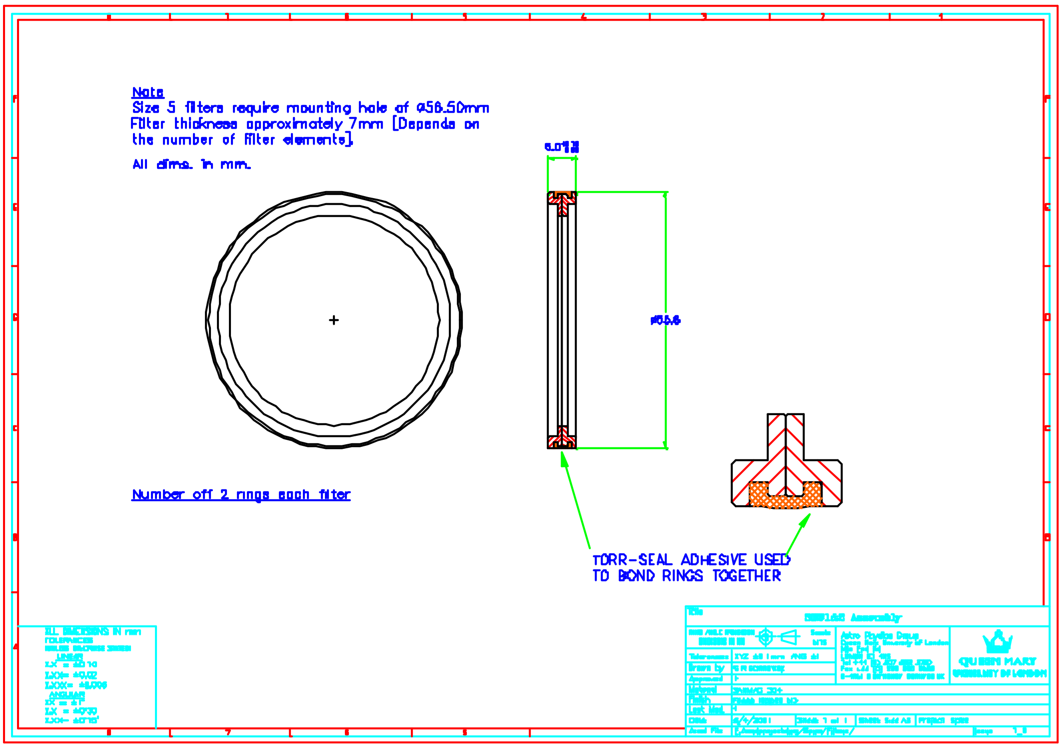

Figure 6 Assembly drawing of SBS1 and SBS2.

4.3.3. SBS2

This component must remain flat, and therefore it shall be ring mounted. An assembly drawing is shown in Figure 6. Mounted in opposition to SBS1 – critical.

Table 17 SBS2 details

Type	Hot Pressed (TBC), Ring mounted
Dimensions	46 mm i/d, 56 mm o/d, 38 mm MCA (TBC)
Interface	3-point mounting ring
Mass	32 g
Spectral characteristics	15-50 cm^{-1} beam splitter
Comments	Size 5 ring

4.3.4. SFIL3S

This filter covers the 2-K cold stop at the entrance to the SW side of the spectrometer detector box.

Table 18 SFIL3S details

Type	Hot Pressed
Dimensions	40 mm MCA, 43 mm o/d –
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 70 cm^{-1}
Comments	

4.3.5. SFIL4S

This filter is fitted to the SW spectrometer BDA at 300-mK.

Table 19 SFIL4S details

Type	Hot Pressed
Dimensions	16 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 60 cm^{-1}
Comments	Blocker

4.3.6. SFIL5S

This filter is fitted to the SW spectrometer BDA at 300-mK. Low-pass edge definer for the LW band. Filter designed to give the 90% power point at 50cm-1.

Table 20 SFIL5S details

Type	Hot Pressed
Dimensions	16 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 52.6 cm^{-1}
Comments	Edge definer

4.3.7. SFIL6S Baseline – not implemented, since high-pass edge defined by waveguide cut-on.

This filter is fitted to the SW spectrometer BDA at 300-mK. High-pass edge-definer for SW band.

Table 21 SFIL6S details

Type	Hot Pressed
Dimensions	16 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	HPE 30.8 cm^{-1}
Comments	Designed to allow for a 10um overlap between the SW and LW bands.

4.3.8. SFIL3L

This filter covers the 2-K cold stop at the entrance to the LW side of the spectrometer detector box.

Table 22 SFIL3L details

Type	Hot Pressed
Dimensions	40 mm MCA, TBD o/d
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 60 cm^{-1}
Comments	

4.3.9. SFIL4L

This filter is fitted to the LW spectrometer BDA at 300-mK.

Table 23 SFIL4L details

Type	Hot Pressed
Dimensions	20 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 43 cm^{-1}
Comments	Blocker

4.3.10. SFIL5L

This filter is fitted to the LW spectrometer BDA at 300-mK. Low-pass edge-definer for LW band.

Table 24 SFIL5L details

Type	Hot Pressed
Dimensions	20 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	LPE 33.4 cm^{-1}
Comments	Designed to allow for a 10 um overlap between the SW and LW bands.

4.3.11. SFIL6L Baseline – not implemented, since high frequency edge defined by waveguide cut-on.

This filter is fitted to the LW spectrometer BDA at 300-mK. High-pass edge definer for LW band.

Table 25 SFIL6L details

Type	Hot Pressed
Dimensions	20 mm MCA, o/d TBD
Interface	Clamp ring
Mass	1 g
Spectral characteristics	HPE 14.2 cm^{-1}
Comments	

5. Functional requirements

5.1. Technical constraints

Table 26 Performance requirements on the filters sub-system. These requirements are extracted from AD11. The requirements shown in red appeared in a previous version of AD11, and may now be obsolete (TBC).

Requirement ID	***Description***	***Value***
IRD-PHOT-R01	Nominal pass band	250 mm, 350 mm and 500 mm (TBC) $\lambda/\Delta\lambda$ = 3
IRD-SPEC-R01	Wavelength range	Band 1 = 200-300mm, 31.15 - 50.0cm^{-1} (TBC) Band 2 = 300-670mm, 14.9 - 32.15cm^{-1} (TBC)
IRD-OPTP-R05	Throughput	The throughput of the photometer mirrors, filters, dichroics and baffles shall be greater than 0.27 (TBC) over the instrument waveband. This includes losses due to manufacturing defects; surface finish and alignment tolerances.
IRD-OPTP-R07	Out-of-band radiation	The end to end filtering of the photometer shall control the out of band radiation to be no more than

		10^{-3} for 50 cm-1 to 200 cm^{-1} 10^{-6} for 200 cm-1 to 1000 cm^{-1} 10^{-9} for 1000 cm^{-1} to 100000 cm^{-1} of the in-band telescope background radiation.
IRD-OPTS-R05	Throughput	The theoretical throughput of the spectrometer mirrors; filters; beam splitters and baffles shall be greater than 0.2 (TBC) over the total instrument waveband (TBC) including all losses due to manufacturing defects; surface finish and alignment tolerances.
IRD-OPTS-R07	Balancing of ports	In order that the two output ports shall have the same performance and to facilitate accurate compensation of the zero path difference maximum, the beam splitters shall have 2RT equal to $R^2 + T^2$ to within 90% (TBC) over the waveband of the instrument.
IRD-OPTS-R08	Out-of-band radiation	The end-to-end filtering of the spectrometer shall control the out of band radiation to be no more than 10^{-3} for 50 cm^{-1} to 200 cm^{-1} 10^{-6} for 200 cm^{-1} to 1000 cm^{-1} 10^{-9} for 1000 cm^{-1} to 100000 cm^{-1} of the in-band telescope background radiation.

6. Design, manufacture & test requirements

6.1. Design requirements

Cardiff University design procedures shall be followed.

6.2. Product assurance plan

The deliverables from the filters, beam splitters and dichroics work-package will comply with the SPIRE product assurance plan (AD12) and with the Cardiff internal product assurance plan (AD30).

6.3. Parts, materials and processes

6.3.1. General

The workmanship and materials used shall be, or shall be shown to be compatible in any future build, of a standard consistent with flight hardware. The number of materials, mechanical parts types, and processes shall be minimized. Materials and mechanical parts that have been successfully used in similar space applications shall be preferred. Standard processes or known processes previously used in space applications shall be preferred. Material justification shall prove the hardware structural integrity during the design life.

6.3.2. Materials, processes and mechanical parts approval and listing

All MPM meeting the requirements of this document shall be approved by submitting to SPIRE PA the Declared Materials List. If these requirements are not met, a RFA shall be submitted to ESA. A Declared Materials List (DML) shall be drawn up, according to the requirements of ECSS-Q- 70 § 3.1.3. Materials with limited-life characteristics and non-metallic materials shall be highlighted. Mechanical parts shall be included in the DML as a separate group. Process details shall also be included in the DML for the appropriate material. Critical processes shall be highlighted.

6.3.3. Cleanliness

All filters will be assembled in class 100 conditions.

6.3.4. Finish

Surface finish shall prevent deterioration from exposure to the environment. Mechanical parts made of stainless steel shall be passivated.

6.3.5. Outgassing

PSS-01-702 shall be used as a guideline.

6.3.6. Materials selection

ESA and NASA guidelines will be followed. No materials will be used that have not already been flown on previous space missions.

6.3.7. Processes

The use of existing ESA documents shall be maximized where appropriate. Critical processes shall be identified and reported to TBD through a critical process list or the DML.

7. Operational requirements

7.1. Safety

N/A

7.2. Lifetime

The lifetime of the filters shall be at least 5 years in orbit and 5 years on ground.

7.3. Operating modes

N/A

8. Interface requirements

All 4-K and 2-K filters interface with the SPIRE structure, and the interface is defined in the Filters ICD (AD28).
All 300-mK filters interface with the BDAs. This interface is still to be defined.

9. Logistic requirements

9.1. Storage

The filters shall not suffer any performance degradation following storage in a dry nitrogen atmosphere for a period of up to 5 years.
Storage temperatures shall be in the range +5°C to +30°C.

9.2. Handling

Ring mounted components (beam splitters and dichroics) must only be handled and installed by suitably trained staff from the Cardiff filter group. Suitably trained staff may handle other filter components, following procedures specified by Cardiff (TBW).

9.3. Transportation

TBW

9.4. ESD precautions

N/A

10. Environmental requirements

These requirements are imposed by the environment the subsystem will encounter during its life.

10.1. Shock

A working figure of 50g static acceleration loads in all three axes is assumed for all filter components. The actual levels are TBD.

10.2. Vibration

TBD

10.3. Vacuum level

Less than 10^{-4} Pa TBC

10.4. Vacuum outgassing

Less than TBC

10.5. Temperature

The filters will perform to specification at their intended temperatures, depending on their position in SPIRE (4-K box, 2-K box or 300-mK detectors).

10.6. Magnetic fields

N/A

10.7. Survival temperature

The filters, beam splitters and dichroics shall remain unaffected by exposure to temperatures of 80°C for periods of up to 72 hours.

10.8. Radiation environment

Look up ISO & Cassini figures – estimate change for L2 environment

11. Verification requirements

The filters development plan (RD2) contains more detail on the actual tests to be carried out. The tables below show how each of the functional and operational requirements in this document are to be demonstrated for each of the filter sets for the SPIRE models.

11.1. Performance requirements

Test T
Measurement M (Spectroscopy – FIR – UV)
Analysis A
Inspection I

Requirement ID	***Description***	***CQM***	***PFM***	***FS***
IRD-PHOT-R01	Nominal pass band	M	M	M
IRD-SPEC-R01	Wavelength range	M	M	M
IRD-OPTP-R05	Throughput	M	M	M
IRD-OPTP-R07	Out of band radiation	M	M	M
IRD-OPTS-R05	Throughput	M	M	M
IRD-OPTS-R07	Balancing of ports	M	M	M
IRD-OPTS-R08	Out of band radiation	M	M	M

11.2. System Requirements

To be written.