Contents:

This SPIRE structure subsystem description gives an outline of the design of the instrument together with the compliance of this design with the various requirements as stated in the instrument requirements documents and the instrument interface document part A and B. Furthermore all interfacing subsystems are listed together with the applicable ICD's. This for downwards compatibility and traceability.

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File name and location: D:\SPIRE\Documents\Subsystem Description\SPIRE Structure Subsystem Specification Document 1.0.doc

Revision Record:

	Date	Brief description of change
0.1	4 June 2000	Creation of the document
1.0	13 June 2000	Official issue

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1. Scope of the document

This specification defines the requirements applied to the performances, the design and the qualification of the SPIRE structure. It is applicable to the STM, CQM, PFM and the FS.

2. Documents

2.1. Reference documents

ID	Title	Author	Reference	Date
RD1	Instrument Requirements Document	B. M. Swinyard	SPIRE-RAL-PRJ-000034, issue 0.30	May 2000
RD2	Instrument Interface Document part A	H. Schaap/ A. Heske	PT-IID-A-04624, issue 0-2	15/02/2000
RD3	Instrument Interface Document part B	C. Cunningham B. Swinyard	PT-SPIRE-02124, issue 0-4	15/02/2000
RD4	SPIRE Product Tree	K. King	SPIRE-RAL-PRJ-00030, issue 1	September 1999
RD5	FIRST SPIRE Optical Alignment Plan	Origne, K. Dohlen	LOOM.KD.SPIRE.2000.001-1	3/1/2000
RD6	SPIRE Sub-system Budget allocations	-	-	-
RD7	Conceptual design for the 300 mK thermal strap	B. Swinyard	Technote, issue .00	24/05/2000
RD8	A stray-light baffle design for thermal strap entry ports	A. Richards	SPIRE-RAL-NOT-000344, issue 1	2 March 2000
RD9	SPIRE Instrument CQM requirements	B. Swinyard	SPIRE-RAL-NOT-000389, issue 0.1	18/04/2000
RD10	ESA fax	B. Guillaume	SCI-PT/IFI/07222	05/11/99
RD11	SPIRE Subsystem Block Diagram	B. Swinyard K. King	SPIRE-RAL-NOT-000391	26/04/2000

2.2. Applicable documents

ID	Title	Author	Reference	Date
AD1	Structure Design and Development Plan	B. Winter	SPIRE-MSS-PRJ-000426, issue 0.1	02-06-2000
AD2	SPIRE structure/Optics ICD	D. Pouliquen B. Winter	SPIRE-MSS-PRJ-000293, issue 0.3	06-06-200
AD3	ICD 1.1/1.5.2 structure/FTS mechanism	D. Pouliquen B. Winter	SPIRE-MSS-PRJ-000298, issue 0.2	-
AD4	ICD 1.1/1.2.1 structure/Filters	P. Hargrave B. Winter	SPIRE-MSS-PRJ-000331, issue 0.-	-
AD5	ICD 1.1/1.3 structure/cooler	L. Dubant B. Winter		
AD6				

2.3. Applicable drawings

ID	Title	Author	Reference	Date
DR1	Provisional SPIRE/FIRST Interface	J. Coker	A1-5264-300, issue 6, Snapshot in appendix A	30/05/00
DR2				

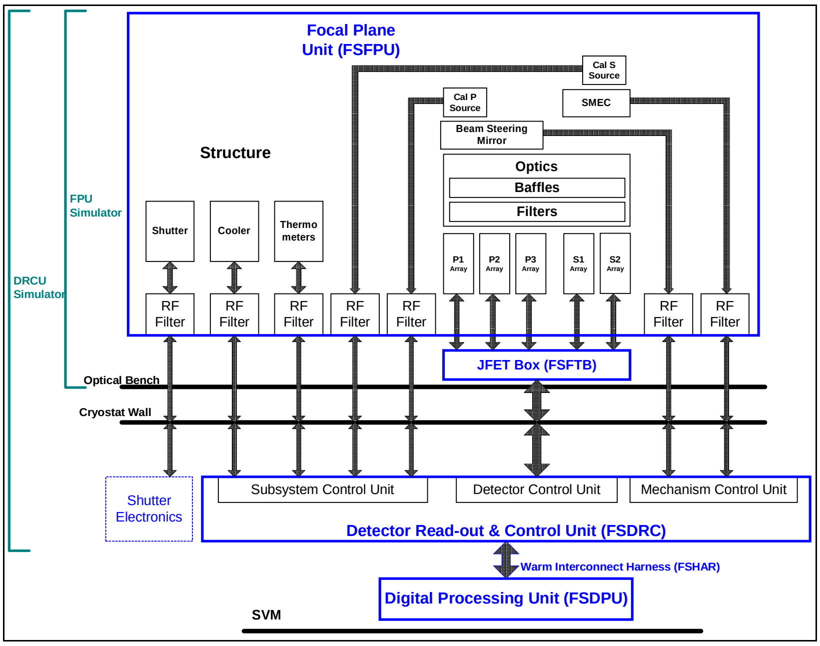
2.4. Glossary

AD	Applicable Document	Level 0	Cryostat level 0 temperature is ~ 2 K (RD1)
ATC	Astronomy Technology Centre	Level 1	Cryostat level 1 temperature is ~ 4 K (RD1)
BSM	Beam Steering Mechanism	Level 2	Cryostat level 2 temperature is ~9-11 K (RD1)
CDR	Critical Design Review	MGSE	Mechanical Ground Support Equipment
CEA	Commissariat à l' Energie Atomique	MSSL	Mullard Space Science Laboratory
CNES	Centre National des Etudes Spatiales	NA	Not Applicable
CoG	Centre of Gravity	OGSE	Optical Ground Support Equipment
CQM	Cryogenic Qualification Model	PFM	ProtoFlight Model
FIRST	Far Infra Red Space Telescope	QMW	Queen Mary and Westfield college
FS	Flight Spare	RAL	Rutherford Appleton Laboratories
FTS	Fourier Transform Spectrometer	SOB	SPIRE Optical Bench
GSFC	Goddard Space Flight Center	SMEC	Spectrometer MEChanism
I/F	Interface	SPIRE	Spectro and Photometric Image REceiver
JFET	Junction Field Effect Transistor	TBC	To Be Confirmed
JPL	Jet Propulsion Laboratory	TBD	To Be Defined
LAM	Laboratoire d'Astronomie Marseille	TBI	To Be Issued

3. Subsystem description

3.1. Design

The SPIR structure is part of the SPIRE FPU, its place within the FPU is outlined in the block diagram hereafter.



Block Diagram 3.1-1: SPIRE system

The SPIRE instrument consists of a monocoque shell holding an bending stiff optical bench. This optical bench supports a photometer and a spectrometer. All parts of these two measurement devices are mounted on the optical bench. The instrument is mounted on the FIRST optical bench via three interfaces. Two A-frames and a conical fixed point. These interfaces ensure a controlled contraction of the instrument when it is cooled down. The optical bench panel is on one side mounted on the fixed point, the side closest to the optical axis of the telescope. The two A-frames are mounted on the two corners the furthest away from the fixed point. The bending flexible direction of the A-frames is pointing towards the fixed point. Making the whole suspension kinematic.

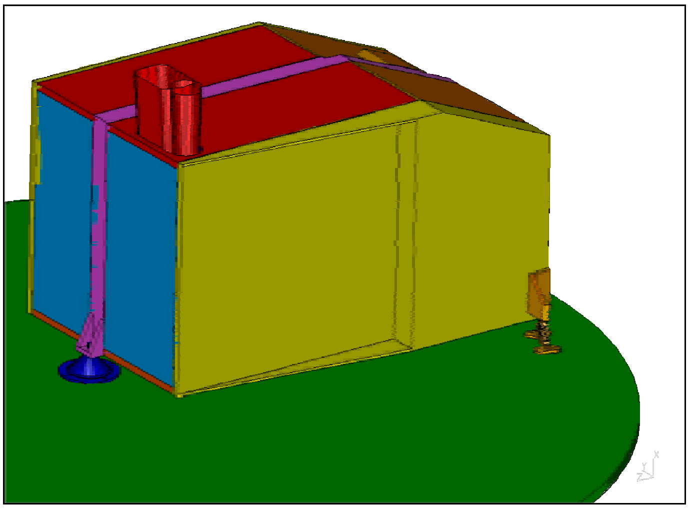


Figure 3.1-1: View of the outside of the instrument – Common Structure + Mounting

The instrument is divided into different temperature zones. The reason for this is the relative high interface temperature of the FIRST optical bench and the low operating temperature of the detectors inside the instrument. The interface temperature is 6-9 Kelvin where the operating temperature of the detectors is 0.3 Kelvin. The temperature zones in between are the temperature of the monocoque structure with the optical bench at ~4 Kelvin and the boxes holding the detectors, filters and dichroics at ~2 Kelvin.

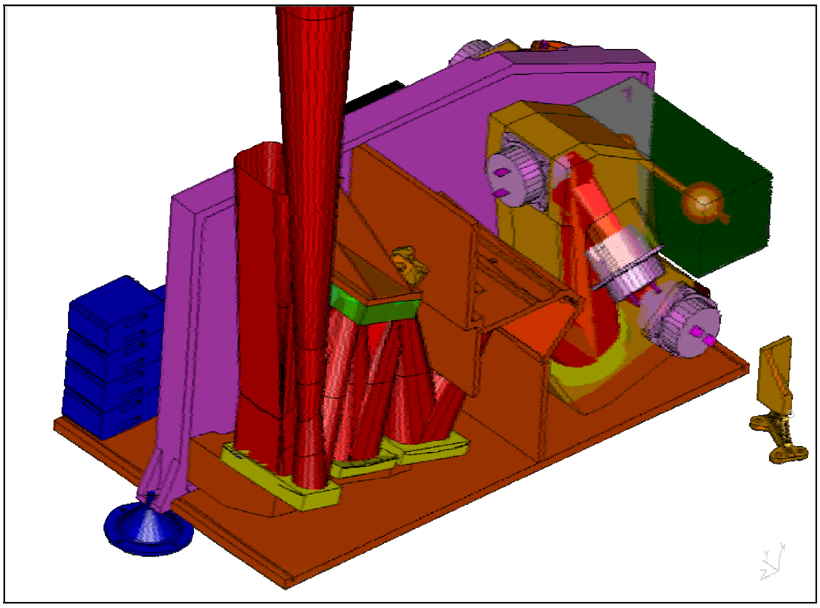


Figure 3.1-2: View of the inside of the instrument – photometer side, cover taken off

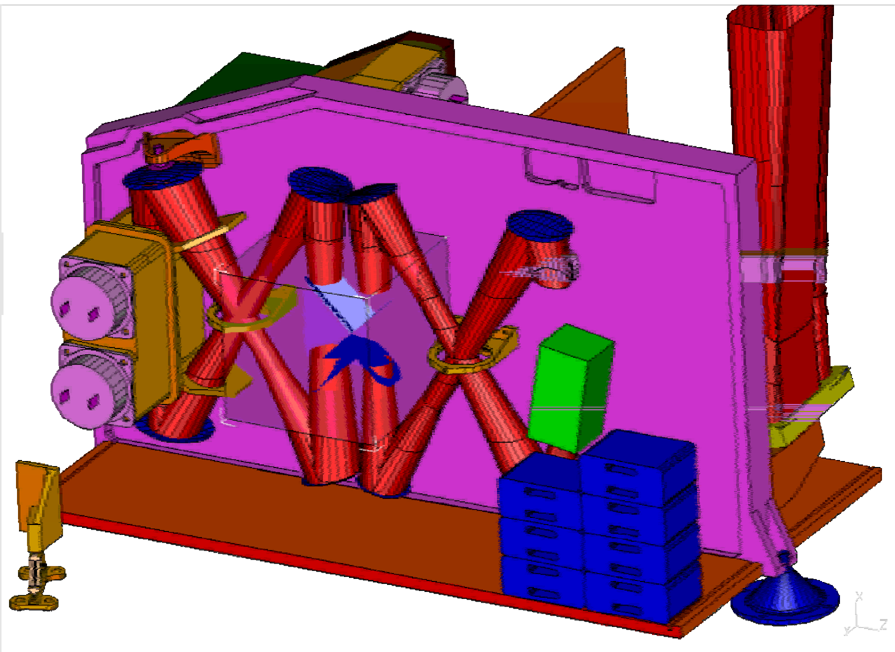


Figure 3.1-3: View of the inside of the instrument – spectrometer side, cover taken off

The monocoque shell also serves as RF-attenuator/shield. For this all openings/seams in the instrument need to be closed such that the instrument works as a Faraday cage attenuating the RF radiation sufficiently in the specified frequency bands. For the signal and control wiring filters will be used to ensure proper operation/functionality of the electronics. An example of an RF-seal to be used in between the joints of the common structure panels is shown in figure 3.1-4

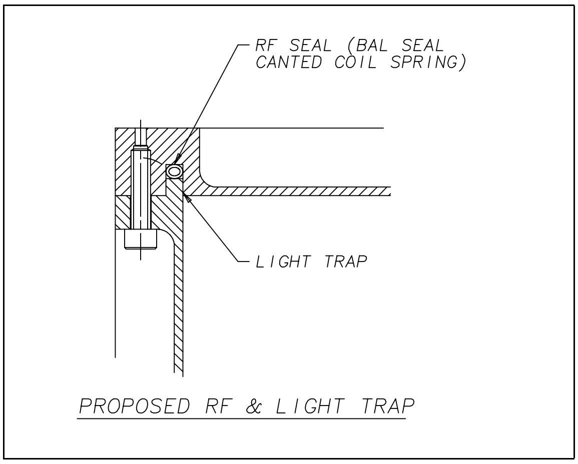


Figure 3.1-4

The straylight will be attenuated as much as possible by utilising filters, black material, labyrinths and baffles where needed. The joints will have a small tight labyrinth as shown in figure 3.1-4. At the entry of the instrument the incoming IR beam will be filtered, excluding as much as possible the unwanted wave lengths. Inside the instrument (4 K environment) the beam will pass baffles, filters and finally, after being reflected via mirrors, end inside the detector boxes falling onto the detector noses.

The proposed stray-light baffles around the thermal straps entering the common structure or the detector boxes will look like the one outlined in figure 3.1-5. (See for more details RD7 and RD8).

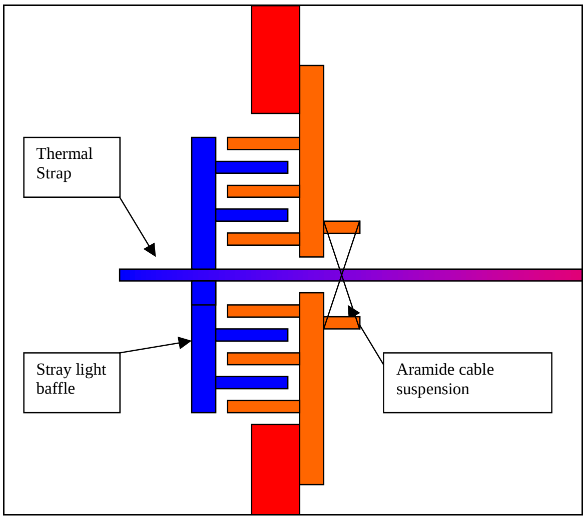


Figure 3.1-5: Outline of the stray-light baffle concept for thermal straps.

The various parts of the instrument will be connected with thermal straps to heat sinks inside the cryostat (~2 K and ~4 K). The detectors, mounted on the detector boxes, will be cooled using a helium-3 fridge.

The instrument will be electrically isolated from the FIRST optical bench. The thermal straps will be electrically isolated from the cryostat. Se for an outline of the baseline grounding scheme figure 3.1-6.

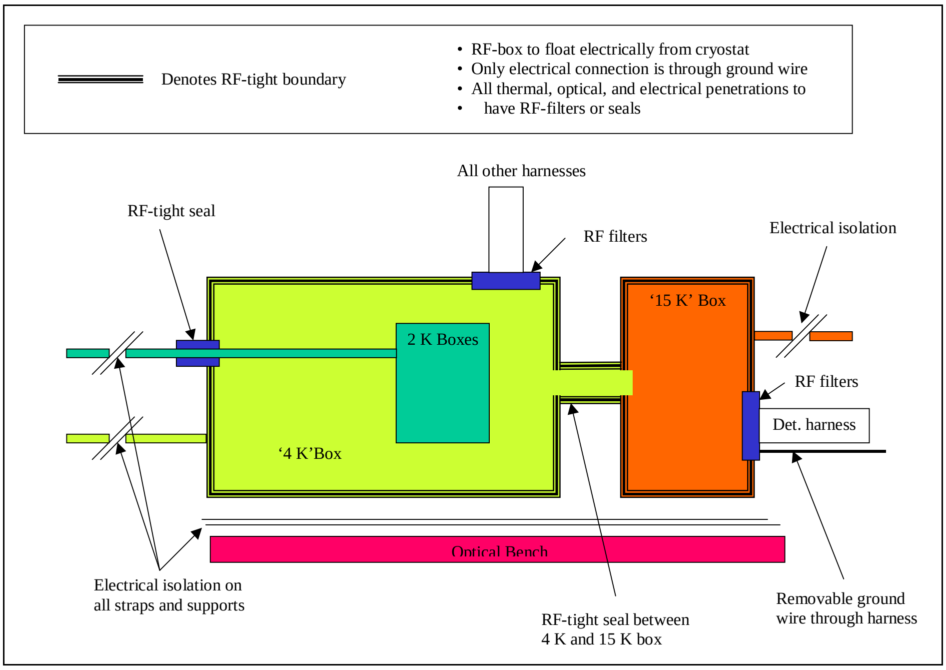


Figure 3.1-6: SPIRE baseline grounding scheme.

The SPIRE structure consists of the following components:

1. Common structure
2. Fixed point suspension
3. Blade suspension (two blades)
4. SPIRE optical bench panel (SOB, magenta –panel in figure 3.1-1 to 3)
5. Stray light baffles
6. Detector boxes, one for the spectrometer and one for the photometer
7. Mirror supports
8. Beam splitter supports
9. Mounting provisions for detectors (magneta
10. Mounting provisions for filters and dichroics
11. Mounting provision for FTS mechanism
12. Mounting provision for ^{3}He cooler
13. Mounting provision for BSM
14. Mounting provision for calibration source
15. Mounting provision for shutter
16. Mounting provisions for thermal straps
17. Mounting provisions for routing harness
18. Mounting provisions for filters
19. RF-seal (attenuation) for Common Structure
20. I/F to JFET box
21. Application of thermal finishes
22. Application of black material
23. Mounting provision for RF-filter box (blue boxes in figure 3.1-3)

Hereafter the topology of the optical lay-out of the instrument is given. First, the photometer side of the instrument, followed by the spectrometer side.

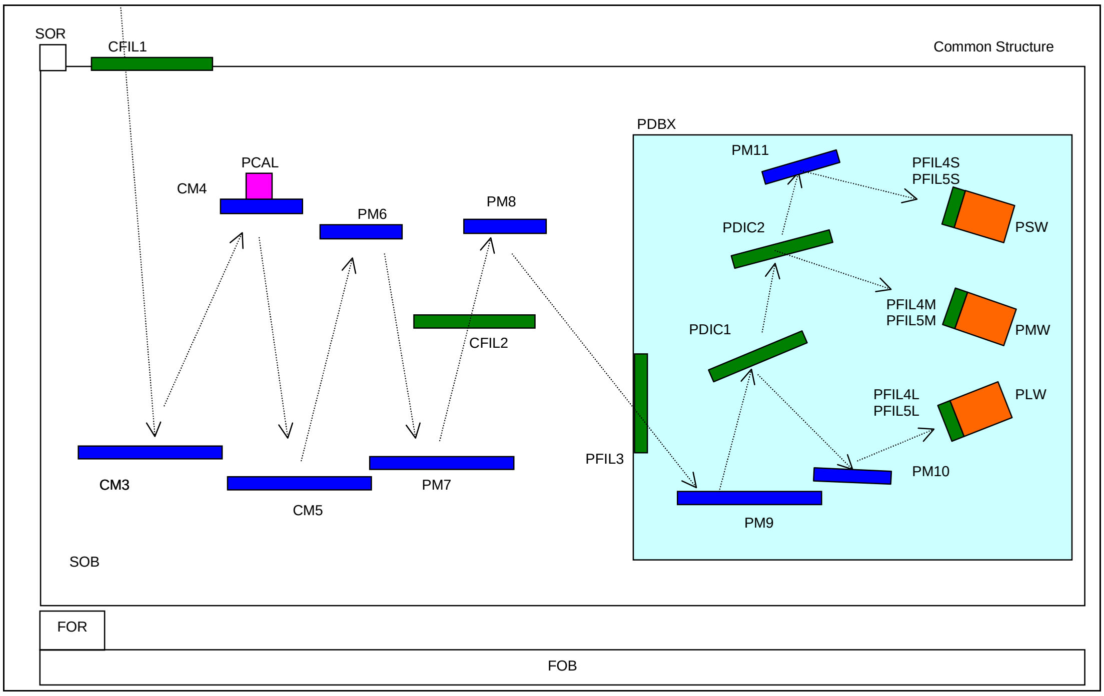


Figure 3.1-7: Photometer topology

Where :

CFIL1	Common Filter 1
CFIL2	Common Filter 2
CM3-5	Common Mirror 3-5
FOB	First Optical Bench
FOR	First Optical Reference
PCAL	Photometer CALibrationsource
PDBX	Photometer Detector BoX
PDIC1	Photometer DIChroic 1
PDIC2	Photometer DIChroic 2
PFIL3	Photometer FILter 3 (entrance PDBX)
PFIL4L/5L	Photometer FILter 4 and 5 at nose PLW
PFIL4M/5M	Photometer FILter 4 and 5 at nose PMW
PFIL4S/5S	Photometer FILter 4 and 5 at nose PSW
PLW	Photometer Long Wave detector
PM6-11	Photometer Mirror 6 to 11
PMW	Photometer Medium Wave detector
PSW	Photometer Short Wave detector
SOB	Spire Optical Bench Panel
SOR	Spire Optical Reference

Not included in the overview are the shutter, baffles and the cooler.

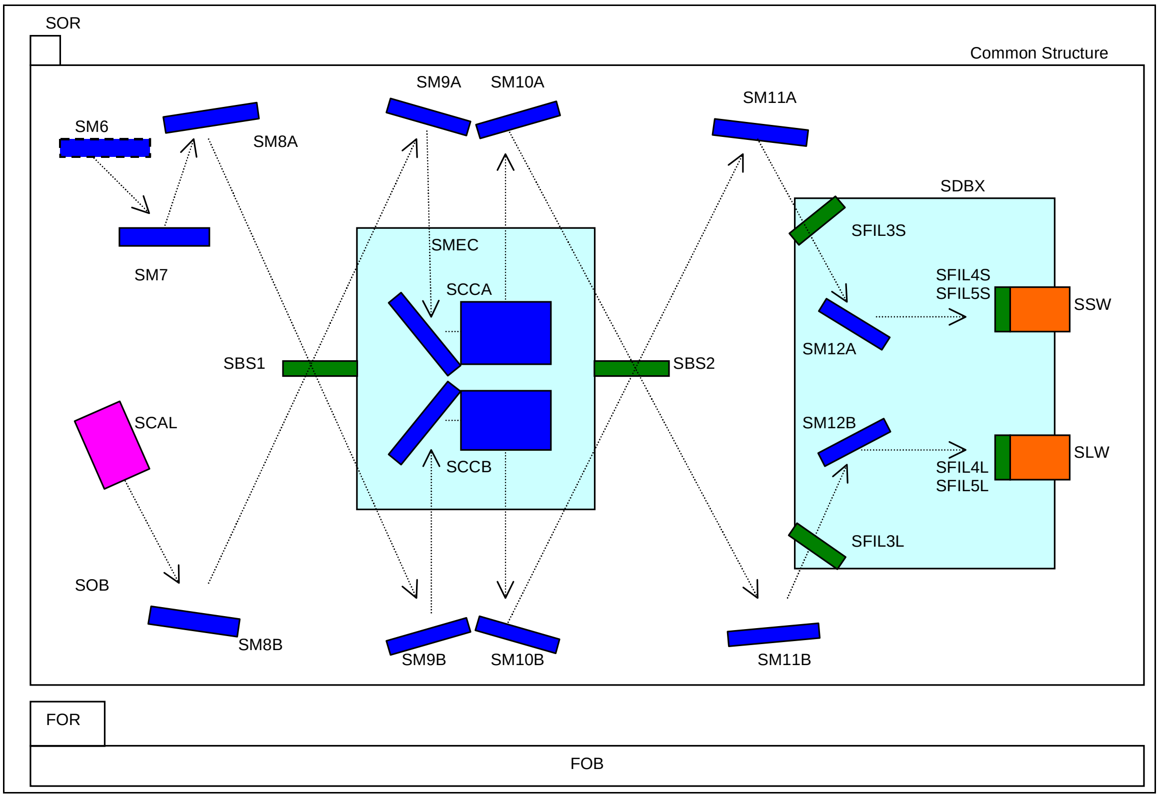


Figure 3.1-8: Spectrometer topology

Where:

FOB	First Optical Bench
FOR	Firs Optical Reference
SBS1	Spectrometer Beam Splitter 1
SBS2	Spectrometer Beam Splitter 2
SCCA	Spectrometer Corner Cube +X
SCCB	Spectrometer Corner Cube –X
SCAL	Spectrometer CALibration source
SDBX	Spectrometer Detector BoX
SFIL3L	Spectrometer FILter 3 (long wave)
SFIL3S	Spectrometer FILter 3 (short wave)
SFIL4L/5L	Spectrometer FILter at nose SLW
SFIL4S/5S	Spectrometer FILter at nose SSW
SM6-7	Spectrometer Mirror6-7
SM8A-12A	Spectrometer Mirror 8-12 +X chain
SM8B-12B	Spectrometer Mirror 8-12 –X chain
SMEC	Spectrometer MEChanism
SOB	Spire Optical Bench Panel
SOR	Spire Optical Reference

3.2. Mission profile

The SPIRE CQM structure will be subjected to several tests. These tests consist of an STM test, which is a structural test verifying the dynamic properties of the structure (stiffness, strength, mass), and the CQM test programme (requirements outlined in RD9):

Alignment verification warm
Alignment verification cold
Environmental tests (sine, random, thermal)

The parts will be baked out before integration.

After successfully, withstanding the qualification tests, the PFM will be constructed. The PFM will be subjected to the same tests as the CQM (except STM testing). After successfully withstanding the proto-qualification tests the PFM will be integrated in the spacecraft. Integrated in the spacecraft it will be subjected to the spacecraft proto-qualification programme. If these tests prove successful the spacecraft will be launched. More details can be found in AD1. The CQM model will be refurbished to act as a flight spare. The FS will be interchangeable with the PFM unit.

3.3. Product tree

Hereafter the parts as listed in the product tree (RD4) are listed.

ID	Product Item	Descriptor	STM	AVM	CQM	PFM	FS	RESP
1.1	Structure	STRC	x		X	x	x	**MSSL**
1.1	Common Structure (incl. Interface wit JFET and RF filter box and FIRST optical bench)	C4K	x		X	x	x	MSSL
1.1	Photometer detector box	PDBX	x		X	x	x	MSSL
1.1	Spectrometer detector box	SDBX	x		X	x	x	MSSL
1.1	Mounting provisions for thermal straps		x		X	x	x	MSSL
1.1	Mounting provision for thermal interface with level 0		x		X	x	x	MSSL
1.1	Mounting provision for thermal interface with level 1		x		X	x	x	MSSL
1.1	Mounting provisions for thermal straps from cooler to detectors		x		X	x	x	MSSL
1.1	Alignment reference mirror	SOR	x		X	x	x	MSSL
1.1.1.1	Structure thermistors	T_PDBX_1 T_PDBX_2 T_SDBX_1 T_SDBX_1 T_C4K_1 T_C4K_2	x		X	x	x	MSSL
1.2	Photometer mirror mounts		x		X	x	x	MSSL
1.2	Spectrometer mirror mounts		x		X	x	x	MSSL
1.2.1	Filters, Dichroics and beam splitters mountings		x		X	x	x	MSSL
1.2.2	Baffles	BAFF	x		X	x	x	MSSL
1.3	Cooler I/F	COOL	x		X	x	x	MSSL
1.4.1	Detector I/F		x		X	x	x	MSSL
1.4.2	Detector I/F		x		X	x	X	MSSL
1.5.2	SMEC I/F		x		X	x	X	MSSL
1.5.3	Shutter I/F		x		X	x	X	MSSL
1.6.2	Spectrometer calibration I/F		x		X	x	X	MSSL
1.7	JFET I/F		x		X	x	X	JPL/MSSL
1.7	RF I/F		x		X	x	X	JPL/MSSL
5.3	Mechanical ground support equipment	MGSE	x		X	x	X	MSSL
	Mathematical model structure	FEM						MSSL

A more detailed list of deliverables is part of the development plan (AD1)

4. Requirements

4.1. Functional requirements

4.1.1. Performance requirements

List of the required performances and general requirements. The requirements are taken from RD1. The mass requirements are listed in the budget allocations (RD6). The mass of the current baseline design meets the strict requirements as set out in section 3.4.3 of RD1.

IRD-SUBS-R03: The mass of the structure, including 20% contingency instrument is 32.6 kg

Included in this mass are the straylight baffles, mirror mounts, filter splitter and dichroic clamps/mounts. The straylight baffles are not strictly a part of the structure, nor are the various subsystem supports. However they will be deliverables and are therefore added to this mass budget. The budget does not include the fasteners required to mount the various subsystems in/on the common structure or one of the detector boxes. See for a more detailed mass allocation section 4.1.2, with the technical (implementation) requirements.

The instrument and common structure requirements are listed hereafter.

ID	Description	Value	Source	Compliant
IRD-STRC-R01	Alignment ot the instrument w.r.t. FIRST optical axis	The common structure shall allow the alignment of the instrument and the telescope axis to within +/- 2.5 mm (TBC) lateral, TBD arcmin rotational about any axis.	RD1/table 3.5.-1	TBC
IRD-STRC-R02	Attenuation of RF by Common Structure	The covers as fitted on the instrument will attenuate all frequencies lower than 8 GHz by TBD dB.	RD1/table 3.5.-1	TBC
IRD-STRC-R03	Items required support from the Common Structure	Photometer and common subsystems, Spectrometer	RD1/table 3.5.-1	Yes
IRD-STRC-R04	Optics and associated sub-system alignment	Specified in RD5	RD1/table 3.5.-1	TBC
IRD-STRC-R05	Surface finish of the Common Structure cover	The inside and the outside of the box shall have a finish with a low emissivity. At least less than $\varepsilon = 0.2$. Parts may be blackened as part of stray light control.	RD1/table 3.5.-1	Yes
IRD-STRC-R06	Pumping port	The total effective pumping conductance of the common structure shall be ≥7.8 l/s	RD1/table 3.5.-1	TBC
IRD-STRC-R07	Thermometry	See 3.3/1.1.1.1	RD1/table 3.5.-1	Yes
IRD-STRC-R08	Attenuation of radiation from cryostat	Requirement $<2x10^{-5}$	RD1/table 3.5.-1	TBC
IRD-STRC-R09	First natural frequency	The structures eigenfrequency shall be above 100 Hz (req.) and preferably above 120 Hz (goal)	RD1/table 3.5-2	Yes
IRD-STRC-R10	Instr. mechanical interface	The I/F will be directly to the FIRST optical bench. The instrument will be in direct thermal contact	RD1/table 3.5-2	Yes
IRD-STRC-R11	-			
IRD-STRC-R12	Grounding	All parts of the SPIRE structure shall be electrically connected one to another. Resistance to be no more than 0.1 **Ω** (TBC)	RD1/table 3.5-2	TBC
IRD-STRC-R13	Electrical isolation from FIRST	All parts of the SPIRE structure shall be electrically isolated from the FIRST optical bench and cryostat. Resistance to	RD1/table 3.5-2	TBC

		be greater than TBD **Ω**		
IRD-STRC-R14	Thermal isolation	The conductance from the level 2 to level 1 stage is required to be no more than 6 mW (TBC) assuming level 2 is 9 K and level 1 is 4 K.	RD1/table 3.5-2	Yes

Table 4.1.1-1: Structure

Photometer detector box structure requirements

ID	Description	Value	Source	Compliant
IRD-STRP-R01	Items supporting	The photometer detector box shall support the level 0 optics, dichtoics, filter, detectors, and thermal strap for detectors	RD1/table 3.5-3	Yes
IRD-STRP-R02	Optics and filter alignment	See RD5	RD1/table 3.5-3	TBC
IRD-STRP-R03	Array module alignment	See RD5	RD1/table 3.5-3	TBC
IRD-STRP-R04	Surface finish	The outside of the box shall have a finish with a low emissivity. At least ε = 0.2. The inside shall have a low reflective finish on all non-optical surfaces..	RD1/table 3.5-4	Yes
IRD-STRP-R05	Pumping port	The total effective pumping conductance of the detector box shall be ≥ 5.6 l/s	RD1/table 3.5-4	TBC
IRD-STRP-R06	Attenuation from common structure	Requirement: $5x10^{-7}$ with a goal of $5x10^{-8}$	RD1/table 3.5-4	TBC
IRD-STRP-R07	First natural frequency	The first eigenfrequency of the photometer detector box on its mounts shall be greater than 100 Hz, with a goal of 150 Hz	RD1/table 3.5-4	Yes
IRD-STRP-R08	-			
IRD-STRP-R09	Thermal isolation	The conductance from the common structure to the detector box shall be less than 0.75 mW. (TBC)	RD1/table 3.5-4	TBC

Table 4.1.1-2: Photometer detector box

Spectrometer detector box structure requirements

ID	Description	Value	Source	Compliant
IRD-STRS-R01	Items supporting	The photometer detector box shall support the level 0 optics, filter, detectors, and thermal strap for detectors	RD1/table 3.5-4	Yes
IRD-STRS-R02	Optics and filter alignment	See RD5	RD1/table 3.5-4	TBC
IRD-STRS-R03	Array module alignment	See RD5	RD1/table 3.5-4	TBC
IRD-STRS-R04	Surface finish	The outside of the box shall have a finish with a low emissivity. At least ε = 0.2. The inside shall have a low reflective finish on all non-optical surfaces..	RD1/table 3.5-4	Yes
IRD-STRS-R05	Pumping port	The total effective pumping conductance of the detector box shall be ≥ 5.6 l/s	RD1/table 3.5-4	TBC
IRD-STRS-R06	Attenuation from common structure	Requirement: $5x10^{-7}$ with a goal of $5x10^{-8}$	RD1/table 3.5-4	TBC
IRD-STRS-R07	First natural frequency	The first eigenfrequency of the photometer detector box on its mounts shall be greater than 100 Hz, with a goal of 150 Hz	RD1/table 3.5-4	Yes
IRD-STRS-R09	Thermal isolation	The conductance from the common structure to the detector box shall be less than 0.75 mW. (TBC)	RD1/table 3.5-4	TBC

Table 4.1.1-3: Spectrometer detector requirements

4.1.2. Technical requirements

The following co-ordinate system as reference to the cryostat shall be taken into account (RD3). See also DR1 and appendix A.

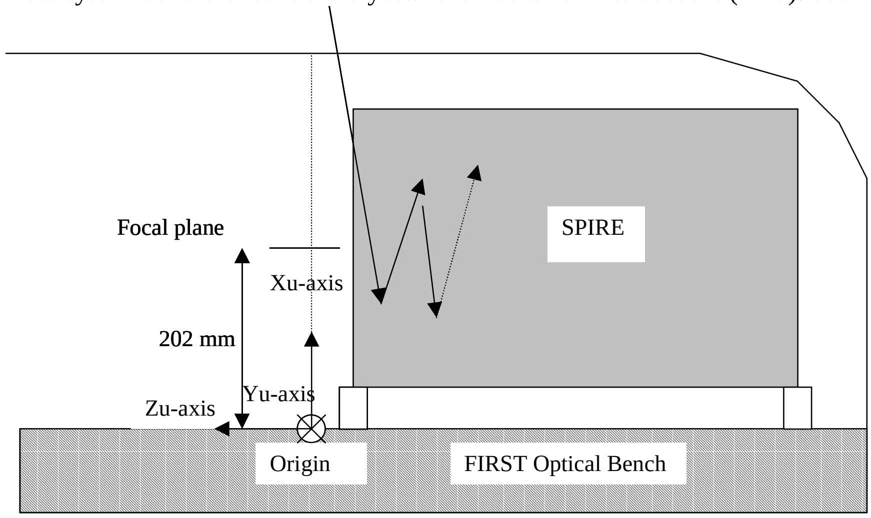


Figure 4.1.2-1 Cryostat reference co-ordinate system.

The following local co-ordinate system shall be taken into account for the SOB mounted subsystems. See also DR1 and appendix A. The origin lies on the optical bench datum point. This is visible and reachable both before, during and after integration. It will however not be visible from outside the spacecraft cryostat. As optical reference an optical alignment cube will be used, mounted on top of the optical bench, outside the common structure, closest to the spacecraft optical axis and visible from outside the cryostat. The advantage of the datum point on the optical bench is that all co-ordinates inside the instrument are positive. Both the co-ordinate systems, are co-aligned with the S/C co-ordinate system, only the origins differ.

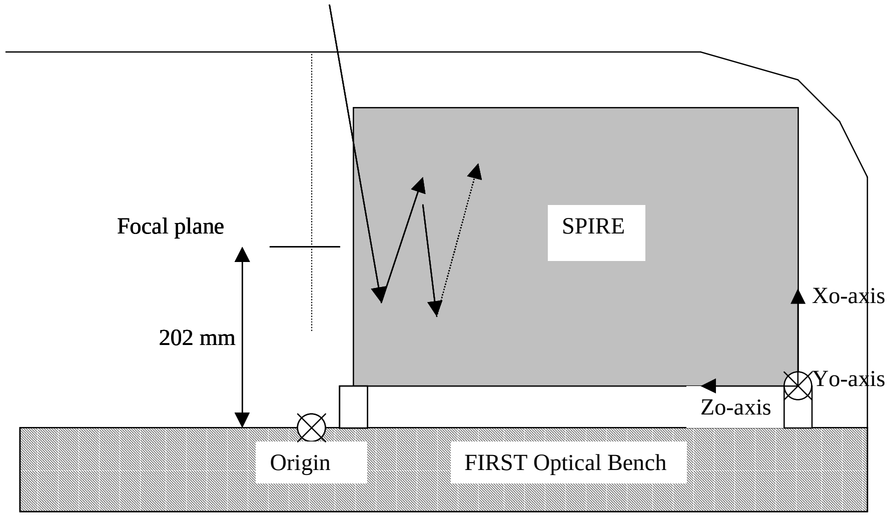


Figure 4.1.2-2 Spire optical bench reference co-ordinate system.

For the current baseline design the following mass distribution holds:

SPIRE – structure				
Contingency taken into account: 20%				
	Nett	Contg.	Total	
Photometer cover	7.43	1.49	8.92	[kg]
Spectrometer cover	5.69	1.14	6.82	[kg]
Optical bench	7.10	1.42	8.52	[kg]
Mounting common structure	0.57	0.11	0.69	[kg]
RF-attenuation	0.25	0.05	0.30	[kg]
Phot. det. box	1.58	0.32	1.89	[kg]
Spect. det. box	1.10	0.22	1.32	[kg]
Mounts, Clamps Phot.	1.04	0.21	1.17	[kg]
Mounts, Clamps Spect.	1.06	0.21	1.42	[kg]
Straylight Baffles	1.38	0.28	1.66	[kg]
total	27.20	5.44	32.64	[kg]
Excluding:	Thermal straps			
	Harness wiring			
	RF-filter boxes			
	JFET I/F structure			
	Spect. Cal.			
	Shutter			
	Cooler I/F			
	Straylight baffles (around straps)			

Table 4.1.2-1: Mass distribution SPIRE structure and related

Implementation requirements still to be defined:

Thermal flow characteristic through A-frame and fixed point suspension. (RD3, section 5.9.1.2, total 6 mW)
Thermal flow characteristic through detector box suspension. (RD3, section 5.9.1.2, total 1 mW)

4.2. Operational requirements

4.2.1. Operational Safety

N.A.

4.2.2. Lifetime

Expected integrated lifetime is 9 years, including on orbit life, TBC

4.2.3. Operating modes

N.A.

4.2.4. Telemetry

NA

4.2.5. Telecommands

NA

4.3. Interface requirements

The interface with the FIRST optical bench is given by ja1-5264-300, pictured in appendix A.

Hereafter all subsystem interfaces and the applicable ICD's are listed. The ICD's contain the interface drawings

ICD	Part name	ICD	Other party
1.1 - 1.2	Mirrors/Optics	AD2	LAS
1.1 - 1.5.2	FTS mechanism	AD3	LAS
1.1 - 1.2.2	Straylight attenuation	TBI	RAL
1.1 - 1.2.1	Filters, splitters & dichroics	AD4	QMW
1.1 - 1.4.1/2	Detectors	TBI	JPL
1.1 - 1.5.1	BSM	TBI	ATC
1.1 - 1.6.1	Calibration source Photometer	TBI	QMW?
1.1 - 1.6.2	Calibration source Spectrometer	TBI	QMW?
1.1 - 1.5.3	Shutter mechanism	TBI	UoS
1.1 - 1.3	He^3 Cooler	AD5	CEA-Grenoble
1.1 - ?	Thermal hardware	TBI	?

Table 4.3-1: ICD list

4.4. Design and manufacture requirements

4.4.1. Design requirements

The key baseline design requirements and implementation are the following

1 -Stiffness

In order to provide for the required stiffness the baseline design of the structure consists of a monocoque structure with a central stiff optical bench panel. In principle all sub-systems are mounted on the optical bench panel. In order to comply with the sine vibration input specification the design goal set for the structure is to reach an first natural frequency of 120 Hz or higher. Because of the uncertainty taken into account for the frequency prediction of 10% the baseline design should have its predicted first natural frequency of at least 133 Hz. Furthermore the various sub-systems need to be decoupled (dynamically) as much as possible. The eigenfrequency of the SOB should be at least 20 % higher than the first overall natural frequency (160 Hz). The minimal eigenfrequency of all subsystems and detector boxes should be at least 25% higher (200 Hz).

2 - Thermal

The structure will be thermally isolated from the FIRST optical bench as much as possible. Assuming a 6 K interface load and a 4 K structure temperature the maximum heat flow through the mounting of the structure should be less than 2 mW.

3 - Electrical

The structure will be electrical isolated from the FIRST optical bench. This to allow for controlled grounding of the structure and its various subsystems. The thermal straps routed along various locations within the structure will be electrically isolated from the structure.

4.4.2. Design rules

No specific design rules as yet.

4.4.3. Manufacture requirements

TBD

4.5. Logistic requirements

RD2, 5.15.1.1: For all deliverable units, transport containers shall be provided.

1. Each model will have its transportation container and handling frame. Only one set of integration tools is required. (If applicable) Since the FS will be a refurbished CQM model, only two sets of transportation containers and handling frames are required. One for the CQM/FS and one for the PFM.
2. The subsystem will be transported from MSSL to RAL, and from RAL to ESTEC (TBC)
3. The container shall be vacuum tight, be purged and slightly overpressured with dry nitrogen gas.
4. The instrument will be mounted using shock absorber supports
5. Shock recorders shall be mounted at TBD location
6. IID-B shall list size and mass of the container as well as the overall mass including the instrument package

4.6. Environment requirements

These requirements describe the environment the structure needs to be able to sustain during its life. Life includes all ground operations and tests, launch and all on orbit operations. For the structure it is assumed that the warm vibration test, followed by the CQM qualification programme envelopes the worst case environment for the structure. Therefore the structure

4.6.1. Natural environment

This is the description of the natural environment around the subsystem during its life.

#	Parameter	Value	IRD	Note
EN1	Vacuum	Less than 10-4 Pa		In operation
EN2	Operating temperature	during system qualif and on orbit = 4K		
EN3	Storage and handling temperature Humidity Cleanliness	-20 to +30 °C Less than 45% TBD		Overall, on ground In clean room In clean room
EN4	Radiations	Less than 3.5 kRAD		On orbit

4.6.2. Operating environment

N.A.

4.7. Verification requirements

RD1 lists in section 2.6 the verification requirement for the instrument. They are repeated hereafter and the compliance is indicated.

ID	Description	Response	Compliant
IRD-VER-01	STM verification: stiffness and strength of the structure	STM sine vibartion test (warm)	yes
IRD-VER-R02	AVM verification	Not applicable	-
IRD-VER-R03	CQM verification 1 correct operation (all operating modes) at cryogenic temperatures 3 thermal dissipation 6 Straylight	1 Cryogenic test 3 Cryogenic test 6 Cryogenic test	1 yes 3 yes 6 yes
IRD-VER-R04	PFM and FS same as for CQM verification (structure)	Cryogenic test	yes

Prior to the STM and CQM test, mathematical models will be used to verify the strength and stiffness of the proposed structure. The mechanical tests will be simulated for as far as the software allows doing that. The principle loads will be derived from these analyses and forwarded to all subsystems, if required, via the ICD.

At present the draft mechanical environment requirements as issued by ESA (RD10) are listed hereafter. These apply for the structure subsystems as a whole. Not for the subsystems individual.

Mechanical environment

Quasi-Static

The qualification levels are **provisional**, copied from the qualification loads of ISO.

Quasi Static levels	Case 1	Case 2	Case 3	Case 4
x-direction	22.5 g (TBC)	22.5 g (TBC)	-	-
y-direction	3 g (TBC)	-	6 (TBC)	-
z-direction	-	3 g (TBC)	-	6 (TBC)

Table 2.4-1: Qualification levels for quasi static vibration

Sine

The sine vibration environment qualification loads taken from ESA fax, SCI-PT/IFI/07222, d.d. 05/11/99. These are the input acceleration at the base of the SPIRE instrument. The sweep rate is 2.0 oct/min (TBC) RD2 echo's this fax and adds the low level sweep to the specification.

Sine vibration levels	Frequency range	Input at base (QUAL)
X-direction	5-18 Hz 18-70 Hz 70-100 Hz	22 mm (peak-peak) 15 g 7.5
Y-direction	5-18 Hz 18-50 Hz 50-100 Hz	22 mm (peak-peak) 15 g 7.5
Z-direction	5-18 Hz 18-50 Hz 50-100 Hz	22 mm (peak-peak) 15 g 7.5

Table 2.4-2: Qualification levels for sine vibration

For all axis the a signature run of 0.5 g from 5.0 to 2000 Hz will be performed as the first and the last sweep. RD3, table 9.5.3.3.2-2.

Random

The qualification levels are **provisional**, copied from the qualification loads of ISO.

Random vibration levels	Frequency range	Input at base (QUAL.)
X-direction	5 – 150 Hz 150-700 Hz 700 – 2000 Hz	+6 dB Hz 0.04 g^2/Hz -3 dB
Y-direction	5 – 150 Hz 150-700 Hz 700 – 2000 Hz	+6 dB Hz 0.04 g^2/Hz -3 dB
Z-direction	5 – 150 Hz 150-700 Hz 700 – 2000 Hz	+6 dB Hz 0.04 g^2/Hz -3 dB

Table 2.4-3: Qualification levels for random vibration

Appendix A

Interface drawing SPIRE-FIRST