Herschel/Planck

INSTRUMENT INTERFACE DOCUMENT

PART B

INSTRUMENT "SPIRE"

Name		Signature
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1	**Herschel/Planck Project Team**	**ESA**
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1	**Herschel** SPIRE	**Univ.Cardiff/RAL**
1	**ESA Project Scientist**	**ESTEC**

Document Change Record

Issue-Rev	Date	Version	Pages affected
1-0	01/09/2000	Initial Issue for ITT	New Document
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2-1	13/02/2001	Unpublished version	According to SCI/PT/MM-11440 And DCN .. Includes HP-SP-RAL-ECR-005, 06, 07, 12, 14. ECR 9 and 10 not agreed.
2.2	01/06/2002	PDR version	According to agreed changes published in Minutes of convergence meeting HP-ASPI-MN-1346

1 INTRODUCTION

The purpose of the Instrument Interface Documents (IIDs) is to define and control the overall interface between each of the Herschel/Planck scientific instruments and the Herschel/Planck spacecraft.

The IIDs consist of two parts, IID-A and IID-B. There is one part A, covering the interfaces to all Herschel and Planck instruments, and one IID-B per instrument:

- The IID-A describes the implementation of the instrument requirements in the design of the spacecraft and will be a result of the spacecraft design activities performed by the Contractor.
- Each IID-B defines in its ‘interface’ section (chapter 5) the requirements of the instrument and the resources to be provided by the spacecraft. In its ‘performance’ section (last section of chapter 4) it defines the scientific performance requirements of the instrument as part of the scientific mission requirements and as agreed between the Principal Investigators and ESA.

After issue 2/0 by ESA, the Contractor will be responsible for maintenance and configuration control of the IIDs in agreement with, and after approval by, the Instruments Principal Investigators and ESA.

In case of conflict between the contents of the IID-A and the IID-Bs, the agreement or definition in the IID-B shall take precedence.

The IIDs will not cover any of the interfaces of the Instrument Control Centres (ICCs for Herschel), the Data Processing Centres (DPCs for Planck) or the Herschel Science Centre (HSC).

2 APPLICABLE/REFERENCE DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD 1	Herschel/Planck Instrument Interface Document Part A. (Ref.SCI-PT-IIDA-04624)
AD 2	OIRD Herschel/Planck Operations Interface Requirements Document SCI-PT-RS-07360.
AD 3	Herschel-SIRD Herschel Science-operations Implementation Requirements Document SCI-PT-03646.
AD4	SPIRE Management Plan (SPIRE-RAL-PRJ-000029)
AD5	Product Assurance Requirements for the Herschel/Planck Scientific Instruments (SCI-PT-RQ-04410)

2.2 REFERENCE DOCUMENTS

RD 1	Caldwell, M., Richards, A., Swinyard, B., Straylight Analysis - PHOT, SPIRE-RAL-NOT-000144.
RD 2	Rutherford Appleton Laboratory, SPIRE Product Assurance Plan APIRE-RAL-PRJ-000017.
RD 3	Swinyard. B , Power profiles for SPIRE operating modes, RAL-NOT-000068.
RD 4	SPIRE Instrument AIV Plan, SPIRE-RAL-Doc-PRJ-000410
RD 5	SPIRE Data ICD, SPIRE-RAL-PRJ-001078
RD 6	SPIRE Operating Modes, SPIRE RAL-PRJ-000320
RD 7	Herschel Alignment Plan, Annex to IID-A
RD 8	SPIRE Thermal Configuration Control Document, SPIRE-RAL-PRJ-000560
RD 9	Herschel SPIRE Harness Definition, SPIRE-RAL-PRJ-000608

2.3 LIST OF ACRONYMS

AD	Applicable Document
AO	Announcement of Opportunity
AVM	Avionics Verification Model
BSM	Beam Steering Mechanism
CCE	Central Check-Out Equipment
CDMS	Command and Data Management Subsystem
CQM	Cryogenic Qualification Model
CVV	Cryostat Vacuum Vessel
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
EGSE	Electrical Ground Support Equipment
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
Herschel	Far InfraRed and Submillimetre Telescope (FIRST)
FM	Flight Model

FOV	Field Of View
FTS	Fourier Transform Spectrometer
GSE	Ground Support Equipment
HIFI	Heterodyne Instrument for the Far Infrared
HSC	Herschel Science Centre
IA	Interactive Analysis
ICC	Instrument Control Centre
ICD	Interface Control Document
IID	Instrument Interface Document
ISO	Infrared Space Observatory
JFET	Junction Field Effect Transistor
KAL	Keep Alive Line
LOU	Local Oscillator Unit (HIFI)
MGSE	Mechanical Ground Support Equipment
MOC	Mission Operations Centre
NEP	Noise Equivalent Power
OBS	On Board Software
OGSE	Optical Ground Support Equipment
OIRD	Operations Interface Requirements Document
OTF	On-Target Flag
PACS	Photoconductor Array Camera and Spectrometer (Herschel)
PFM	Proto Flight Model
QLA	Quick Look Analysis (software)
RAM	Random Access Memory
RD	Reference Document
RF	Radio Frequency
ROM	Read Only Memory
RTA	Real Time Assessment (software)
S/C	Spacecraft
SCOS	Spacecraft Control and Operations System
SIRD	Science –Operations Implementation Requirements Document
SPIRE	Spectral Photometer Imaging Receiver
SPU	Signal Processing Unit
SRD	Software Requirements Document
SVM	Service Module
TBC	To be confirmed
TBD	To be determined
TBW	To be written

3 KEY PERSONNEL AND RESPONSIBILITIES

3.1 KEY PERSONNEL

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3.2 RESPONSIBILITIES

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ATC, Edinburgh	Beam steering mechanism
CEA, Grenoble	^{3}He cooler
CEA, SAp, Paris	Detector Readout and Control Unit (DRCU); ICC DAPSAS Centre;
DESPA, Paris	FTS expertise and design support
GSFC, Maryland	FTS Expertise and design support;
IAS, Paris	Ground Calibration support
ICSTM, London	ICC UK DAPSAS Centre
IFSI, Rome	Digital Processing Unit (DPU) and related On-board S/W
JPL/Caltech, California	Bolometer arrays and associated cold readout electronics
LAM, Marseille	Optics; FTS mechanism
MSSL, Surrey	Focal Plane Unit Structure
University of Wales, Cardiff	Focal plane array testing; filters, dichroics, beam dividers
RAL, Oxfordshire	Project management and Project Office; AIV and ground calibration facilities; ICC Operations Centre
Stockholm Observatory	Instrument simulator; DRCU Simulator
University of Padua	Provision of ICC Operations Staff
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4 INSTRUMENT DESCRIPTION

4.1 INTRODUCTION

For low background direct detection at wavelengths longer than around 200 μm, the most sensitive detectors are cryogenic bolometers operating at temperatures in the 0.1 - 0.3 K range.

SPIRE (Spectral & Photometric Imaging REceiver) is a bolometer instrument comprising a three-band imaging photometer covering the 200-500 μm range and an imaging Fourier Transform Spectrometer (FTS) with a spectral resolution of at least 0.4 cm^{-1} (corresponding to $\lambda/\Delta\lambda$ = 100 at 250 μm, covering wavelengths between 200 and 670 μm. The detectors are bolometer arrays cooled to 300 mK using a ^{3}He refrigerator. The photometer is optimised for deep photometric surveys, and can observe simultaneously the same field of view of 4 x 8 arcminutes in all three bands.

Figure 4.1 Spire in Herschel

4.2 SCIENTIFIC RATIONALE

The wavelength range 200 - 700 μm is largely unexplored. The thermal emission from many astrophysical sources peaks in this part of the spectrum, including comets, planets, star-forming molecular cloud cores, and starburst galaxies. The short submillimetre region is also rich in atomic and molecular transitions which can be used to probe the chemistry and physical conditions in these sources.

Wavelengths between 200 and 350 μm are not observable from the ground and have not be observed by ISO. Between 350 μm and 700 μm, some low transparency submillimetre windows allow some observations to be made with difficulty from the ground, but with far lower sensitivity than can be achieved from space.

One of the most important scientific projects for the Herschel mission is to investigate the statistics and physics of galaxy formation at high redshift. This requires the ability to carry out deep photometric imaging at far-infrared and submillimetre wavelengths to discover objects, and the ability to follow up the survey observations with spectroscopy of selected sources. The Herschel SPIRE instrument is essential for this programme, and is being designed so as to be optimised for these extragalactic imaging and spectral surveys. Another key scientific project for SPIRE is a sensitive unbiased search for proto-stellar objects within our own galaxy. This will also be followed up by spectral observations using SPIRE, other Herschel instruments and ground-based facilities.

4.3 INSTRUMENT OVERVIEW

SPIRE contains a three-band imaging photometer and an imaging Fourier Transform Spectrometer (FTS), both of which use 0.3-K "spider-web" NTD germanium bolometers cooled by a ^{3}He refrigerator. The bolometers are coupled to the telescope by close-packed single-mode conical feedhorns. The photometer and spectrometer are not designed to operate simultaneously. The field of view of the photometer is 4 x 8 arcminute, the largest that can be achieved given the location of the SPIRE field of view in the Herschel focal plane and the size of the telescope unvignetted field of view. Three photometer arrays provide broad-band photometry ($\lambda/\Delta\lambda \approx 3$) in wavelength bands centred on 250, 350 and 500 μm. The 250, 350 and 500 μm arrays have 149, 88, and 43 detectors respectively, making a total of 280. The field of view is observed simultaneously in all three bands through the use of fixed dichroic beam-splitters. Spatial modulation can be provided either by a Beam Steering Mirror (BSM) in the instrument or by drift scanning the telescope across the sky, depending on the type of observation. An internal thermal calibration source is available to provide a repeatable calibration signal for the detectors. The FTS uses novel broadband intensity beam dividers, and combines high efficiency with spatially separated input ports. One input port covers a 2.6-arcminute diameter field of view on the sky and the other is fed by an on-board calibration source which serves to null the thermal background from the telescope and to provide absolute calibration. Two bolometer arrays are located at the output ports, one covering 200-300 μm and the other 300-670 μm. The FTS will be operated in continuous scan mode, with the path difference between the two arms of the interferometer being changed by a constant-speed mirror drive mechanism. The spectral resolution, as determined by the maximum optical path difference, will be adjustable between 0.04 and 2 cm^{-1} (corresponding to $\lambda/\Delta\lambda$ = 1000 - 20 at 250 µm wavelength).

The focal plane unit has three separate temperature stages at nominal temperatures of 4 K, 2 K (provided by the Herschel cryostat) and 300 mK (provided by SPIRE's internal cooler). The main 4-K structural element of the FPU is an optical bench panel which is supported from the cryostat optical bench by stainless steel blade mounts. The photometer and spectrometer are located on either side of this panel. The majority of the optics are at 4 K, but the detector arrays and final optics are contained within 2-K enclosures. The ^{3}He refrigerator cools all of the five detector arrays to 0.3 K. Two JFET preamplifier modules (one for the photometer an one for the FTS) are attached to the optical bench close to the 4-K enclosure, with the JFETs heated internally to their optimum operating temperature of ~ 120 K.

The SPIRE warm electronics consist of two boxes with direct connection to the FPU, the Detector Control Unit (DCU) and the Focal Plane Control Unit (FCU) (together these boxes are termed the Detector Readout and Control Unit (DRCU)) plus a Digital Processing Unit (DPU) with interfaces to the other two boxes and the spacecraft data handling system. The DCU provides bias and signal conditioning for the detector arrays and cold readout electronics and reads out the detector signals. The FCU controls the FPU mechanisms and the ^{3}He cooler and handles housekeeping measurements. The DPU acts as the interface to the spacecraft, including instrument commanding and formats science and housekeeping data for telemetry to the ground.

4.4 HARDWARE DESCRIPTION

The SPIRE instrument consists of:

HSFPU Focal Plane Unit (FPU):
This interfaces to the cryostat optical bench, and the 4-K and 2-K temperature stages provided by the cryostat. Within the unit, further cooling of the detector arrays to a temperature of around 300 mK is provided by a ^{3}He refrigerator which is part of the instrument.

HSJFP JFET box for the photometer detectors
This box is mounted on the optical bench next to the photometer side of the FPU and contains JFET preamplifiers for the detector signals. The JFETs operate at around 120 K, and are thermally isolated inside the enclosure.

HSJFS JFET box for the spectrometer detectors
This box is mounted on the optical bench next to the spectrometer side of the FPU and contains JFET preamplifiers for the detector signals. The JFETs operate at around 120 K, and are thermally isolated inside the enclosure.

HSDCU Detector Read-out and Control Unit (on Herschel SVM)
A warm analogue electronics box for detector read-out analogue signal processing, multiplexing, A/D conversion, array sequencing, mechanism control, temperature sensing and general housekeeping and ^{3}He refrigerator operation.

HSFCU Focal Plane Control Unit (on Herschel SVM)
A warm analogue electronics box for mechanism control, temperature sensing and general housekeeping and ^{3}He refrigirator operation.

HSDPU Digital Processing Unit (on Herschel SVM)
A warm digital electronics box for signal processing and instrument commanding and interfacing to the spacecraft telemetry.

HSWIH Warm interconnect harness (on Herschel SVM)
Harness making connections between the electronics boxes.

4.5 SOFTWARE DESCRIPTION

The OBS will carry out the following functions:

- Read and log housekeeping data
- Control and monitor the instrument mechanisms and internal calibration sources
- Carry out pre-defined observing sequences
- Implement pre-defined procedures on detection of instrument anomalies

The on-board software (OBS) will be written in "C" (TBC) language and will be designed to allow the instrument to operate in an autonomous fashion for 48 hours as required in the IID-A. The basic implication of this requirement is that there must be the facility to store enough commands for a 48 observing programme and enough mass memory on the satellite to store 48 hours of instrument telemetry. More sophisticated autonomy functions may include the on-board analysis of scientific or housekeeping data and the ability to react on the basis of that analysis. The type of automatic operation undertaken following such an analysis may range from the raising of a warning flag to the switching over to a redundant sub-system or the switching off of a defective sub-system. All autonomy functions will require extensive evaluation and test before they are implemented to avoid the possibility of instrument failure. No instrument autonomy mode will be implemented that will affect the satellite operation.

Memory load commands will be used to send single instructions to the instrument or to command pre-defined sequences of operations. The command words will be interpreted by the OBS according to a given algorithm and the relevant sequence of digital commands sent to the subsystems. Each command will be formed with a variable number of words having the following general structure: (i) a header describing the command function; (ii) the number of words to follow; (iii) the new values of the parameters, if any. There will be at least four types of commands: macro commands, subsystem commands, peek-and-poke commands; and spare commands. The macro commands define the timing and sequence of instrument operation. The subsystem commands allow the immediate control of each instrument subsystem. The peek-and-poke commands allow the down-link of RAM or ROM content as well as the ability up-link patches, new programmes or tables. There will also be the possibility to run new commands by up-linking the specific code in RAM recalled by the spare command.

A detailed description of the on-board software will be given in Chapter 5

4.6 OPERATING MODES

This section gives a brief description of the operating modes for the SPIRE instrument.

For latest information, refer to RD 6.

4.6.1 OFF Mode

All instrument sub-systems will be switched off - including the DPU and there will be no instrument telemetry.

4.6.2 Initialise (INIT) Mode

This is an intermediate mode between OFF and ON. This will be the mode the instrument enters after a power on or re-boot. In this mode only a limited sub-set of commands may be executed. This mode allows updates of DPU on-board software and/or tables to be carried out safely before they are used for instrument control.

4.6.3 ON Mode

The DPU will be switched on and can receive and interpret all instrument commands, but no other sub-systems will be switched on (including the DRCU). For engineering purposes it will be possible to command the instrument to switch on individual sub-systems from this mode. Full DPU housekeeping data will be telemetered.

4.6.4 Ready (REDY) Mode

The DPU and DRCU are powered on and the on-board software is ready to receive commands. No other sub-systems are switched on in this mode. DRCU housekeeping data will be telemetered.

4.6.5 Standby (STBY) Mode

The spacecraft may be pointed in an arbitrary direction (observing with another instrument for instance). The instrument will telemeter only housekeeping information, and perhaps some degraded science data -see below, at a rate very much lower than the full telemetry bandwidth. This is presently baselined to be the photometer detectors on and at 300 mK i.e. the cooler will have been recycled previous to entering STANDBY. All other sub-systems will be switched off.

4.6.6 Observe Mode (OBSV) Mode

There are two basic sub-modes for the observe mode Photometer and Spectrometer. The details of the OBSERVATIONS to be carried out in OBSERVE mode are given in section 4.7.

4.6.7 Cooler Recycle (CREC) Mode

The ^{3}He cooler requires recycling every 46 hours (TBC). During this time the instrument will be switched off except for vital housekeeping and cooler functions (TBC).

4.6.8 SAFE Mode

The instrument will be switched to SAFE mode in the event of any anomalous situation occurring whilst in autonomous operation. This will be with the DPU on having been rebooted from a restricted set of software stored in ROM.

4.7 OBSERVING MODES

The spacecraft will be pointed in a specific direction or, for mapping, will either slew slowly over a given region of the sky, or execute a raster pattern by movements of the telescope. The instrument will take scientifically meaningful data and use the full telemetry bandwidth. It is assumed that any calibrations required will also be done in the observe mode (TBC).

For latest information, refer to RD 6.

4.7.1 Photometer Observing Modes

The photometer can carry out essentially three kinds of observation: chopping, jiggling, and scanning, and it is envisaged that these will form the basis of three Astronomical Observation Templates (AOTs) to allow astronomers to specify their observations. The three kinds of observation are implemented as 6 (TBC) observing modes, named POFs (Photometer Observatory Functions), which are briefly described below. Provision is also made for additional POFs for peak-up and special engineering modes.

4.7.1.1 Observation: Point Source Photometry

POF1 Chop without jiggling:
This mode is for point source observations with reliable telescope pointing. The SPIRE Beam Steering Mechanism is used to chop between two positions on the sky at a frequency of typically 2 Hz. The telescope may optionally be nodded with a nod period of typically three minutes.

POF2 Seven-point jiggle map:
This mode is for point source observations for which the telescope pointing or the source co-ordinates are not deemed sufficiently accurate. The SPIRE BSM chops and also executes a seven-point map around the nominal position. Nodding is optional.

4.7.1.2 Observation: Jiggle Map

POF3 n-point jiggle map:
This mode is designed for mapping of extended sources. It is similar to POF2 except that the nominal value of n is 64 rather than 7. It produces a fully sampled map of a 4 x 4 arcminute area.

POF4 Raster map:
This is the same as POF3 except that maps of large regions can be built up by using the telescope rastering capability.

4.7.1.3 Observation: Scan Map

POF5 Scan map without chopping:
This mode is used for mapping areas much larger than the SPIRE field of view. The SPIRE BSM is inactive, and the spacecraft is scanned continuously across the sky to modulate the detector signals.

POF6 Scan map with chopping:
This mode is the same as POF5 except that the SPIRE BSM implements chopping. It allows for the possibility of excess 1/f noise by permitting signal modulation at frequencies higher that POF5.

4.7.1.4 Others

POF7 Photometer peak-up (TBD):
This mode allows the necessary pointing offsets to be determined in order to allow implementation of POF1 rather than POF2. The observation itself is the same as POF3. On completion, the SPIRE DPU computes the offsets between the telescope pointed position and the source peak emission, and sends this information to the spacecraft, which can then implement the necessary pointing corrections.

POF8 Operate photometer calibrator:
The SPIRE photometer internal calibrator is energised with a pre-determined sequence and the corresponding detector signals are recorded.

POF9 Special engineering/commissioning modes (TBD).

4.7.2 Spectrometer Observing Modes

There are two kinds of spectrometer observation: point source and fully sampled map. The latter is carried out by repeating the former at a number of separate pointing using the SPIRE BSM (or, alternatively the spacecraft in RASTER Pointing mode). These are implemented as two Spectrometer Observatory Functions (SOFs):

SOF1: Point source spectrum
SOF2: Fully sampled spectral map

In all cases, the telescope pointing and/or Beam Steering Mirror position are kept fixed while the FTS mirror is scanned a predetermined number of times to generate interferograms from which the source spectrum can be derived.

4.7.3 Other Modes

4.7.3.1 Photometer Serendipity

During spacecraft slews scientifically useful information can be obtained without the necessity of using the focal plane chopper - essentially these are rapid scan maps. The chopper and spectrometer mechanisms will be switched off in this mode. Accurate pointing information will be required from the AOCS to reconstruct the slew path in the data analysis on the ground.

4.7.3.2 Photometer Parallel

When observations are being made with PACS, scientifically useful data may be obtainable from the photometer, albeit with degraded sensitivity and spatial resolution. In this mode a science data packet will be telemetered alongside the standard housekeeping data. The chopper and spectrometer mechanisms will be switched off in this mode. The feasibility and scientific desirability of this mode is TBD.

4.7.4 Real-Time Commanding

During ground contact it may be necessary to command the instrument in real time and analyse the resultant data on the ground in near real time for instrument testing and debugging purposes. In this case the full telemetry bandwidth will be required for the duration of the instrument test in question. It is not anticipated that this will occur frequently.

4.7.5 Commissioning/calibration Mode

During the commissioning and performance verification phases of mission operations, many housekeeping and other health check parameters will be unknown or poorly defined. This mode allows the limits on selected health check parameters to be ignored by whatever real time monitoring systems are in place on the spacecraft/instrument.

4.7.6 FPU operations at Ambient Temperature

TBD. It is anticipated that functional checks will be possible for mechanisms and housekeeping lines. The detectors will not function at ambient temperature. Limited verification of the readout electronics may be possible.

4.7.7 FPU Orientation

During ground tests the FTS mechanism can only operate when the FPU is on its side. In addition, there is a restriction on the orientation of the ^{3}He cooler during recycling.

4.8 INSTRUMENT REQUIREMENTS AND PERFORMANCE SPECIFICATION

4.8.1 Scientific Requirements

The scientific performance requirements for SPIRE are summarised in the SPIRE *Scientific Requirements Document* as follows:

Requirement SRD-R 1: The photometer should be capable of diffraction-limited extragalactic blind surveys of at least 60 sq. deg. of the sky, to 1-σ detection limit of 3 mJy in all bands with an observing time of six months or less.

Requirement SRD-R 2: The photometer should be capable of a galactic survey covering 1 deg. sq. to a 1-σ depth of 3 mJy at 250 µm within an observing time of one month or less.

Requirement SRD-R 3: Maximising the mapping speed at which confusion limit is reached over a large area of sky is the primary science driver. This means maximising sensitivity and field-of-view (FOV) but NOT at the expense of spatial resolution.

Requirement SRD-R 4: The photometer observing modes should provide a mechanism for telemetering undifferenced samples to the ground.

Requirement SRD-R 5: The photometer should have an observing mode that permits accurate measurement of the point spread function.

Requirement SRD-R 6: Optical field distortion should be less than 10% across the photometer field of view.

Requirement SRD-R 7: The photometer field of view shall be at least 4 x 4 arcminutes, with a goal of 4 x 8 arcminutes.

Requirement SRD-R 8: For 2Fλ feedhorns, crosstalk shall be less than 1% (goal 0.5%) for adjacent detectors and 0.1% or less (goal 0.05%) for all non-adjacent detectors in the same array; for 0.5Fλ pixels, the requirement is 5% (goal 2%) to adjacent detectors and 0.1% (goal 0.05%) to all others. (Note: This requirement is under review).

Requirement SRD-R 9: The maximum available chop throw shall be at least 4 arcminutes; the minimum shall 10 arcseconds or less.

Requirement SRD-R 10: The rms detector NEP variation across any photometer array should be less than 20%.

Requirement SRD-R 11: The photometer dynamic range for astronomical signals shall be 12 bits or higher.

Requirement SRD-R 12: SPIRE absolute photometric accuracy shall be 15% or better at all wavelengths, with a goal of 10%.

Requirement SRD-R 13: The relative photometric accuracy should be 10% or better with a goal or 5%.

Requirement SRD-R 14: SPIRE photometric measurements shall be linear to 5% over a dynamic range of 4000 for astronomical signals.

Requirement SRD-R 15: For feedhorn detectors, the overlapping sets of three detectors at the three wavelengths should be co-aligned to within 2.0 arcseconds on the sky (goal is 1.0 arcsecond).

Requirement SRD-R 16: The spectrometer design shall be optimised for optimum sensitivity to point sources, but shall have an imaging capability with the largest possible field of view that can be accommodated.

Requirement SRD-R 17: The sensitivity of the FTS at any spectral resolution up to the goal value shall be limited by the photon noise from the Herschel telescope within the chosen passband.

Requirement SRD-R 18: The spectrometer dynamic range for astronomical signals shall be 12 bits or higher.

Requirement SRD-R 19: The FTS absolute accuracy shall be 15% or better at all wavelengths, with a goal of 10%.

Requirement SRD-R 20: The FTS shall be capable of making spectrophotometric measurements with a resolution of 2 cm^{-1}, with a goal of 4 cm^{-1}.

Requirement SRD-R 21: The width of the FTS instrument response function shall be uniform to within 10% across the field of view.

Requirement SRD-R 22: The maximum spectral resolution of the FTS shall be at least 0.4 cm^{-1} with a goal of 0.04 cm^{-1}.

Requirement SRD-R 23: The SPIRE photometer shall have an observing mode capable of implementing a 64-point jiggle map to produce a fully sampled image of a 4 x 4 arcminute region.

Requirement SRD-R 24: The photometer observing modes shall include provision for 5-point or 7-point jiggle maps for accurate point source photometry.

Requirement SRD-R 25: The photometer shall have a "peak-up" observing mode capable of being implemented using the beam steering mirror.

4.8.2 Instrument Performance Estimates

4.8.2.1 Assumptions

The sensitivity of SPIRE has been estimated under the assumptions listed in Table 4.1.

Telescope temperature (K)	80		
Telescope emissivity	0.04		
Telescope used diameter (m) (1)	3.29		
No. of observable hours per 24-hr period	21		
Photometer			
Bands (µm)	250	350	500
Numbers of detectors	139	88	43
Beam FWHM (arcsec.)	17	24	35
Bolometer DQE (2)	0.6	0.7	0.7
Throughput	λ^2		
Bolometer yield	0.8		
Feed-horn/cavity efficiency (3)	0.7		
Field of view (arcmin.) Scan mapping Field mapping	4 x 8 4 x 4		
Overall instrument transmission	0.3		
Filter widths ($\lambda/\Delta\lambda$)	3.3		
Observing efficiency (slewing, setting up, etc.)	0.9		
Chopping efficiency factor	0.45		
Reduction in telescope background by cold stop (4)	0.8		
FTS spectrometer			
Bands (µm)	200-300	300-670	
Numbers of detectors	37	19	
Bolometer DQE	0.6	0.7	
Feed-horn/cavity efficiency	0.70		
Field of view diameter (arcmin.)	2.6		
Max. spectral resolution (cm^{-1})	0.04		
Overall instrument transmission	0.15		
Signal modulation efficiency	0.5		
Observing efficiency	0.8		
Electrical filter efficiency	0.8		

Table 4.1: Assumptions for SPIRE Performance Estimation

Notes:

The telescope secondary mirror is the pupil stop for the system, so that the outer edges of the primary mirror are not seen by the detectors. This is important to make sure that radiation from highly emissive elements beyond the primary reflector does not contribute stray light.
The bolometer DQE (Detective Quantum Efficiency) is defined as : $[NEP_{ph}/ NEP_{Total}]^2$, where NEP_{ph} is the photon noise NEP due to the absorbed radiant power and NEP_{Total} is the overall NEP including the contribution from the bolometer noise.
This is the overall absorption efficiency of the combination of feed-horn, cavity and bolometer element.
A fraction of the feedhorn throughput falls outside the solid angle defined by the photometer 2-K cold stop and is thus terminated on a cold (non-emitting) surface rather than on the 4% emissive 80-K telescope. This reduces the background power on the detector.

The background power levels on the SPIRE detectors dominated by the telescope emission), and the corresponding photon noise limited NEP values are given in Table 4.2.

		Photometer band			**FTS band (µm)**	
		250	350	500	200-300	300-670
Background power/detector	pW	3.9	3.2	2.0	6.0	11
Background-limited NEP	W $Hz^{-1/2}$ x 10^{-17}	8.1	6.1	4.5	10	11
Total NEP (inc. detector)	W $Hz^{-1/2}$ x 10^{-17}	10	7.3	5.4	12	14

Table 4.2: Background Power and Photon Noise Levels

The estimated sensitivity levels for SPIRE are summarised in Table 4.3. The figures quoted are the nominal values, with an overall uncertaintyof around 50% to take into account uncertainties in instrument parameters, particularly feedhorn efficiency, detector DQE, and overall transmission efficiency. The pixel size will be increasingly mis-matched to the diffraction spot size. The trade-off between wavelength coverage and sensitivity of the long-wavelength FTS band must be studied in detail. At the moment, we estimate an effective loss of efficiency of a factor of two at 670mm, and scale linearly for wavelengths between 400 and 670 mm. Performance beyond 400 mm may have to be compromised to maintain the desired sensitivity below 400 mm.

Table 4.3: SPIRE **Estimated Sensitivity**

Photometry				
λ µm		250	350	500
ΔS(5-σ; 1-hr) mJy	Point source (7-point) ode)	2.5	2.6	2.9
	4’ x 4’ jiggle map	8.8	8.7	9.1
	4’ x 8’ scan map	7.3	7.2	7.5
Time (days) to map 1 deg.^{2} to 3 mJy 1-σ	1^o x 1^o scan map	1.8	1.7	1.9

Line spectroscopy $\Delta\sigma$ = **0.04 cm^{-1}**				
λ µm		200	400	670
ΔS (5-σ; 1-hr) W m^{-2} x 10^{-17}	Point source	3.4	3.9	7.8
	2.6’ map	9.0	10	21

Low-resolution spectrophotometry $\Delta\sigma$ = **1 cm^{-1}**				
λ µm		200	400	670
ΔS (5-σ; 1-hr) mJy	Point source	110	130	260
	2.6’ map	300	350	700

Note: For the FTS, limiting flux density is inversely proportional to spectral resolution (Δσ). Limiting line flux is independent of spectral resolution (for an unresolved line).

These estimated sensitivity levels are comparable to the figures in the SPIRE proposal.

5 INTERFACE WITH SATELLITE

Spacecraft resource allocations are based on present knowledge.

5.1 IDENTIFICATION AND LABELLING

Each individual instrument unit is allocated two unique identification codes:

- a *project code* which is the normal reference used for routine identification in correspondence and technical descriptive material.
- a *spacecraft code* finalised by the spacecraft contractor in accordance with the computerised configuration control system to be implemented, and used in particular for connector and harness identification purposes. All of these have now been given a working designation anyway as work has progressed. The *project code* shall form part of the spacecraft code. (See IID-A section 5.1)

The project codes allocated to this instrument are:

Project code	Instrument unit	Location	Temperature
HSDPU	Digital Processing Unit	On SVM	Warm
HSFCU	FPU Control Unit	On SVM	Warm
HSDCU	Detector Control Unit	On SVM	Warm
HSJFS	JFETs (Spectrometer)	See section 5.3	Cryogenic
HSJFP	JFETs (Photometer)	See section 5.3	Cryogenic
HSFPU	Focal Plane Unit	See section 5.3	Cryogenic
HSWIH	Warm interconnect harness	See section 5.10	Warm

The HSFCU is a physical unit containing two functions, the HSSCU and the HSMCU meaning the HS Sub-System Control Unit and the HS Mechanisms' Control Unit respectively.

[Documentation may refer to a DRCU or Detector Readout and Control Unit. This is no longer a single unit and the term refers collectively to the HSDCU plus the HSFCU.]

There are four groups of harnesses at instrument interface level,

- HSWxx,
- HSIxx
- HSSxx
- HSCxx

where xx represents a number.

The HSWxx are Warm harnesses between Warm HS units on the SVM.

HSSxx are the cryoharnesses between the Connector brackets and the HS Warm Units.

The HSIxx are Intermediate cryoharnesses, which are external to the cryostat, and are situated between the vacuum connectors and the connector bracket on the SVM.

The HSCxx are cryogenic harnesses located inside the cryostat, between the vacuum connectors and the HS Cryogenic units.

5.2 INTERFACE LOCATIONS

All of the above may be visualised by means of the block diagram, shown in figure 5.2.1. The Herschel to Herschel-Spire electrical interfaces are in several "planes" shown by dashed blue lines, the categories between each line being labelled along the top. This diagram is for information only, and shall not represent any requirement on the spacecraft.

Note that, to be precise, these electrical interfaces are at the connector planes.

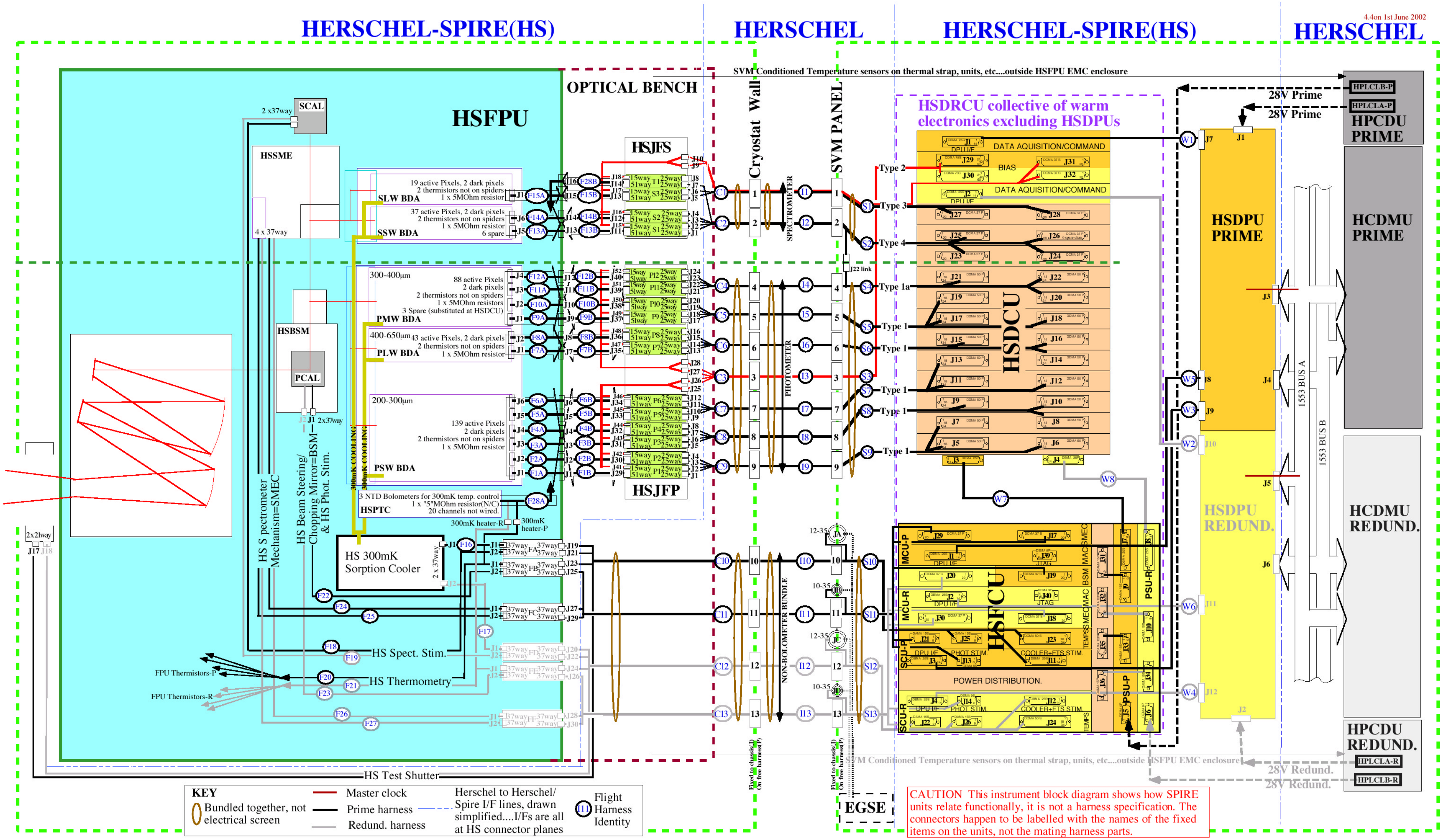

HERSCHEL-SPIRE(HS)
HERSCHEL
HERSCHEL-SPIRE(HS)
HERSCHEL
4.4on 1st June 2002
HSFPU
OPTICAL BENCH
Cryostat Wall
SVM PANEL
SVM Conditioned Temperature sensors on thermal strap, units, etc....outside HSFPU EMC enclosure
HSDRCU collective of warm electronics excluding HSDPUs
HSDCU
HSFCU
HSDPU PRIME
HSDPU REDUND.
HCDMU PRIME
HCDMU REDUND.
HPCDU PRIME
HPCDU REDUND.
28V Prime
28V Redund.
1553 BUS A
1553 BUS B
HSJFS
HSJFP
SLW BDA
SSW BDA
PMW BDA
PLW BDA
PSW BDA
HSPTC
HSSME
HSBSM
PCAL
SCAL
HS 300mK Sorption Cooler
HS S pectrometer Mechanism=SMEC
HS Beam Steering/ Chopping Mirror=BSM & HS Phot. Stim.
HS Spect. Stim.
HS Thermometry
HS Test Shutter
FPU Thermistors-P
FPU Thermistors-R
SPECTROMETER
PHOTOMETER
NON-BOLOMETER BUNDLE
EGSE
KEY
Bundled together, not electrical screen
Master clock
Prime harness
Redund. harness
Herschel to Herschel/ Spire I/F lines, drawn simplified....I/Fs are all at HS connector planes
Flight Harness Identity
CAUTION This instrument block diagram shows how SPIRE units relate functionally, it is not a harness specification. The connectors happen to be labelled with the names of the fixed items on the units, not the mating harness parts.

Figure 5.2.1 : Spire Block Diagram – version 4.4

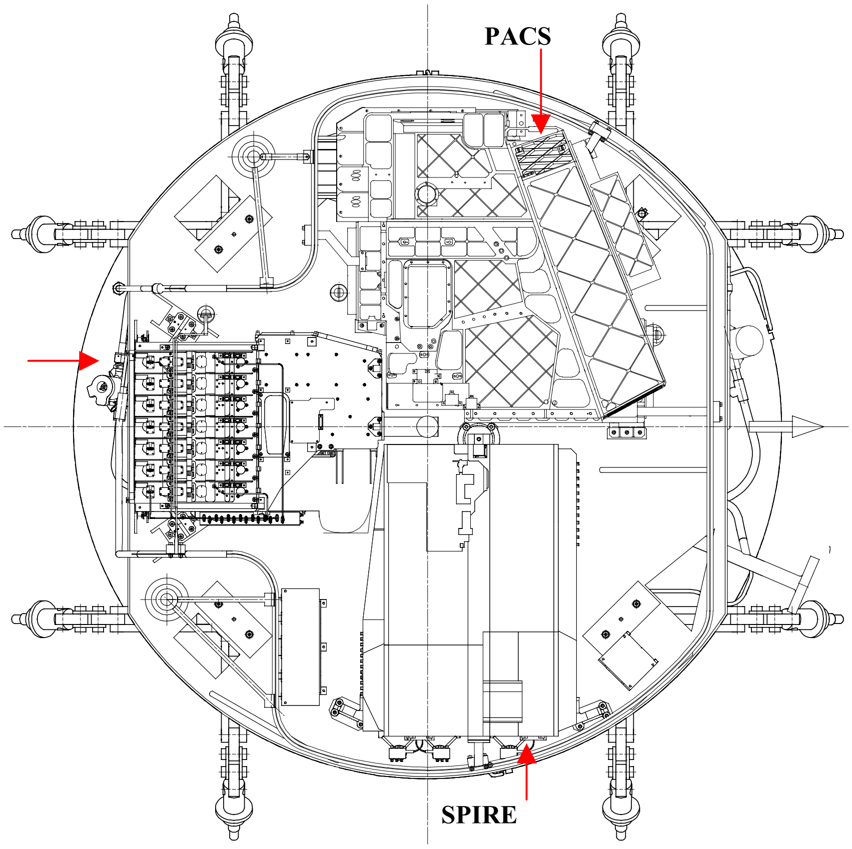
5.2.1 MECHANICAL COORDINATE SYSTEM

The unit specific x,y,z origin definitions are shown in the External Configuration Drawings. (see section 5.4)

5.3 LOCATION AND ALIGNMENT

Figures 5.3-1 and 5.3-2 show the concept of the location of the three Herschel Focal Plane Units (FPUs) for HIFI, PACS and Spire on the Optical Bench (OB) inside the cryostat. The Spire FPU has two nearby JFET racks. This accommodation may be subject to detailed evolution.

INCORPORER



INSERT HIFI

Figure 5.3-1: The Herschel Focal Plane, top view towards -X

Replace with ASED fig.

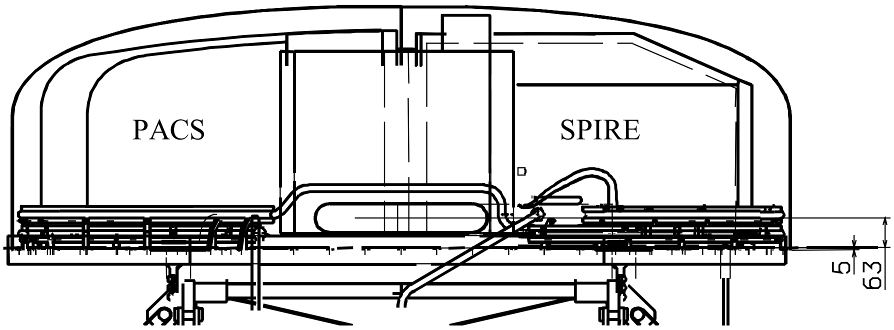


Figure 5.3-2: The Herschel Focal Plane, side view towards +Y

5.3.1 Instrument Location

The locations of the Spire units are as listed in section 5.1. Spire has no units supported on the outside of the Herschel cryostat or on the Planck Module. There are no critical alignment requirements on the Spire JFET boxes.

5.3.1.1 Location of units on the SVM

There are no specific requirements for the location of Spire units on the SVM, except that the HSDCU and HSFCU need optimised harness routing towards the Spire quadrant of cryostat 100way connectors. ESA is asked to advise the Spire Instrument consortium of harness and unit position definitions and 100way type at the earliest date, for comment and for them be recorded herein. The length of the instrument provided harness between the HSDCU and the HSFCU is critical. As a goal, the location of these two units on the SVM should enable this length to be kept below 0.8m.

5.3.2 Instrument Alignment on the HOB

Spire has no critical alignment and/or alignment stability requirements except for those of the HSFPU.

The HSFPU has an externally viewable alignment cube as shown on its ICD. Both the cube's angular alignment and the position of the HSFPU box' feet w.r.t. its internal optics will have been established at instrument level to a defined tolerance before delivery to ESA.

The mechanical process of mounting Spire on the HOB so that it is aligned to the Herschel telescope (when both are at operating temperature) is worked through in RD 7. This defines an error budget for how well the alignment has to be achieved, as well as how stable it then has to remain.

5.4 EXTERNAL CONFIGURATION DRAWINGS

These are included for readibility only. They are all controlled Spire drawings at their latest issue. The fully configured detailed interface drawings are provided in annex 1.

5.4.1 HSFPU

An overview of the HSFPU is provided below in Figure 5.4-1. More detailed drawings of the SPIRE focal plane and JFET units, showing their relationship to the Herschel focal plane, the cryostat radiation shield and the diameter of the HOB, can be found in Annex 1. The location of both of the JFET racks will need to be optimised to provide short cable lengths to the detectors in the FPU (the reason for their existence) and good routing from their opposite faces for the cryoharness feeds.

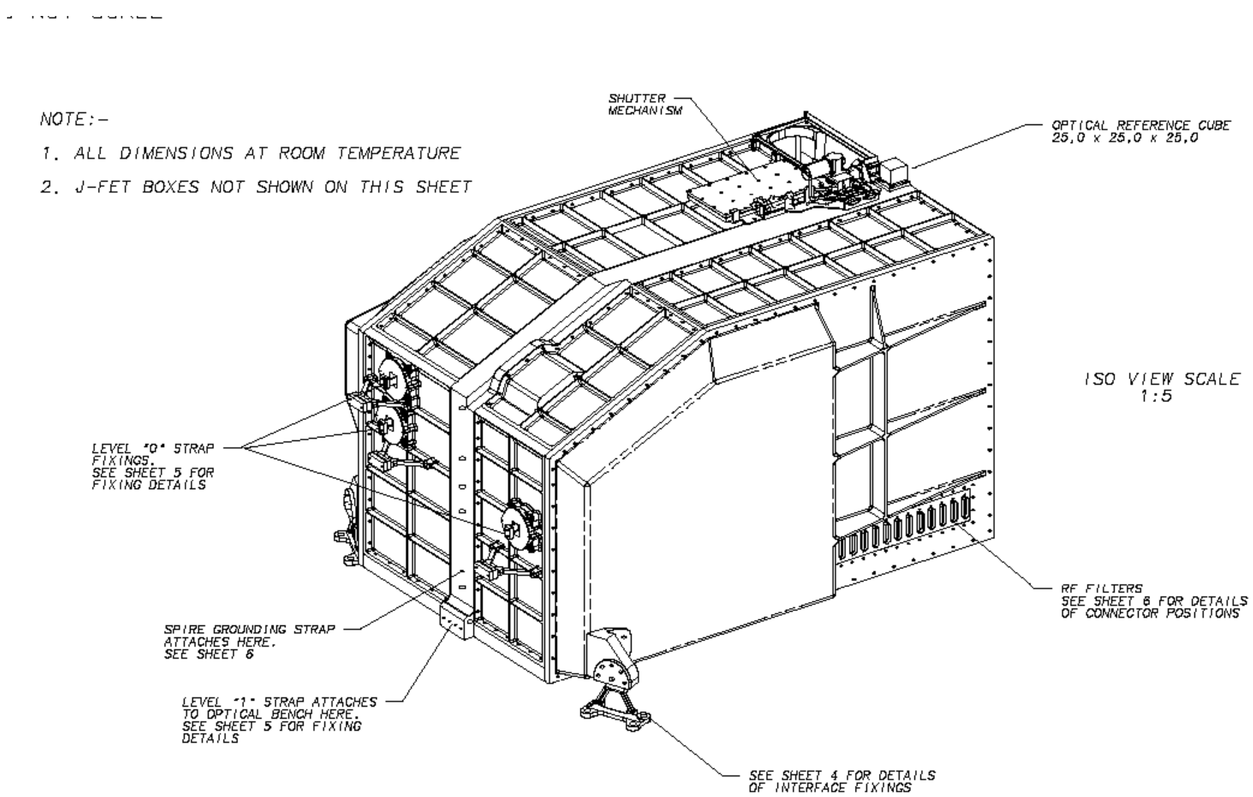


Figure 5.4-1 : HSFPU overall view

5.4.2 HSJFS

Figure 5.4-3 provides an isometric view of the Spire Spectrometer JFET rack. More detailed drawings can be found in Annex 1.

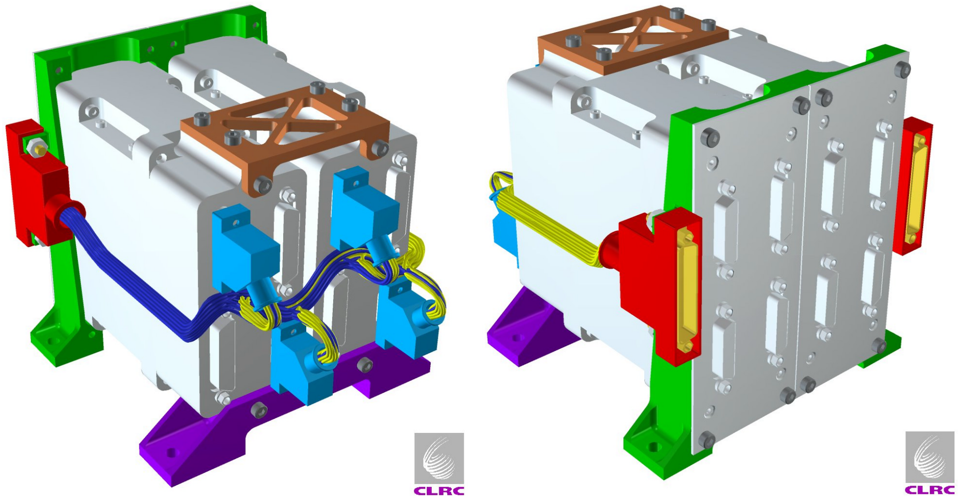


Figure 5.4-3 : SPIRE Spectrometer JFET rack external configuration

5.4.3 HSJFP

Figure 5.4-4 provides an isometric view of the Spire Photometer JFET rack. More detailed drawings can be found in Annex 1.

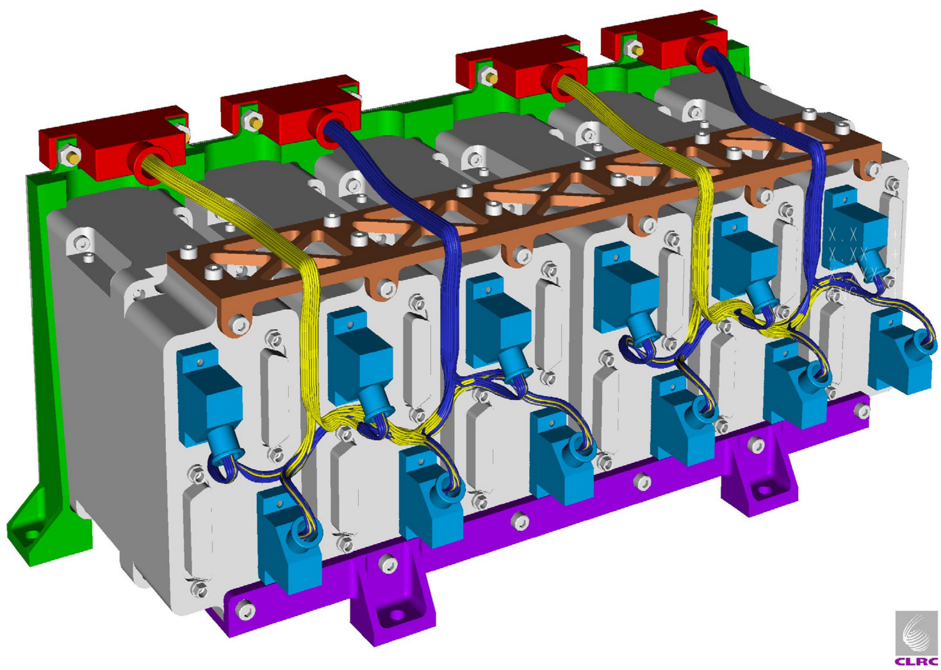


Figure 5.4-4 : SPIRE Photometer JFET rack external configuration

5.4.4 SVM Mounted Units.

Drawings of the layout of the SPIRE Warm Units on the SVM are provided in the corresponding section of the IIDA.

The following sub-sections provide an overview of the warm units, whereas detailed interface drawings can be found in Annex 1.

5.4.4.1 HSDPU

Figure 5.4-6 shows an isometric view of the Spire Digital Processing Unit More detailed drawings can be found in Annex 1.

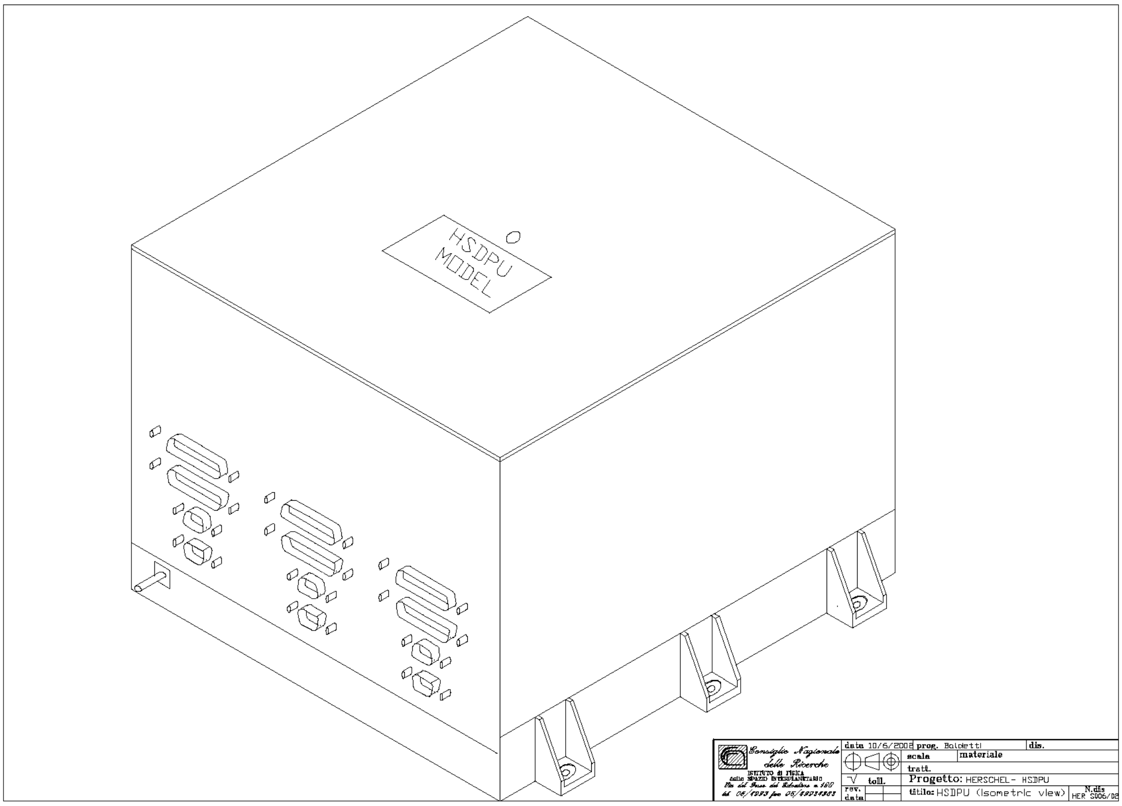


Figure 5.4-6 Isometric view of the DPU

5.4.4.2 HSDCU

Figure 5.4-7 shows an isometric view of the Spire Detector Control Unit. More detailed drawings can be found in Annex 1.

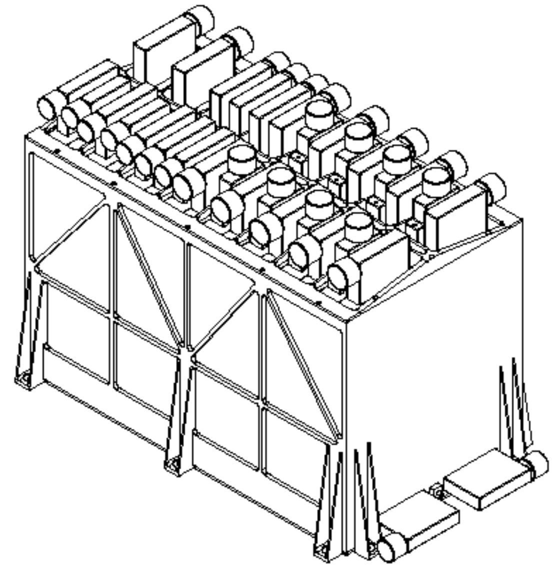


Figure 5.4-7 : HSDCU external configuration

5.4.4.3 HSFCU

Figure 5.4-8 shows an isometric view of the Spire FPU Control Unit.

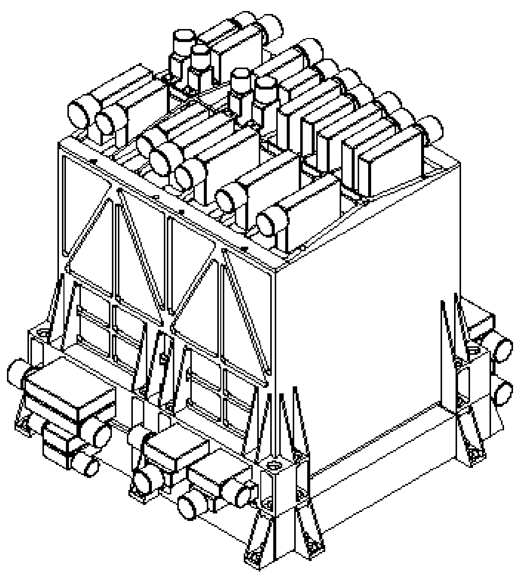


Figure 5.4-8 : HSFCU external configuration

5.5 SIZES AND MASS PROPERTIES

The mass budget is a mission critical item and no possibility is foreseen to negotiate any higher values for the allocated totals shown in bold in the following table:

Project Code	Instrument Unit	Dimenions (mm) incl. feet, & Drawing References.	Nominal Mass without margins (kg)	Allocated Mass (kg)
FSFPU	HS Focal Plane Unit	Non-rectangular, see section 5.4. drawing refs. : 5264 / 300 sheets 1,2 … 6.	45.5	46.3
FSJFP	HS JFET Rack Photometer	270.5 x 104 x 114 TBC 6 JFET Assembly – KE2896 – 30/11/01.	3.0	3.3
FSJFS	HS JFET Rack Spectrometer	108.5 x 91 x 104 TBC 2 JFET Assembly – KE2897 – 30/11/01.	1.2	1.4
		Total OB Units	**49.7**	**51.0**
FSFCU	HS Digital Processing Unit	374 X 4091 X 330 SPIR-MX-5200 000 A – 12/01/02.	14.3	15.0
FSDCU	HS Detector Control Unit	494 X 289 X 305 SPIR-MX-5100 000 A – 11/01/02.	15.4	15.5
FSDPU	HS Digital Processing Unit	274 X 258 X 194 HER S003/02 – 10/02/02.	7.0	7.0
FSW1-8	HS Warm Inter-unit Harness		1.5	1.5
		Total SVM Units	**38.2**	**39.0**
		Instrument Total	**87.9**	**90.0**

Dimensions are given as Length x Width x Height, the first two applying parallel to the mounting surface.

Dimensions including mounting feet, excluding connectors

5.6 MECHANICAL INTERFACES

Note: Electrical and thermal characteristics conferred by these mechanical interfaces are covered in the appropriate sections, not here.

5.6.1 Inside cryostat

The Focal Plane Unit, the HSFPU, has 3 supporting feet to the Optical Bench. The details of this mechanical interface will be such as to allow the unit alignment and alignment-stability requirements to be fulfilled.

The Spire JFET racks will also mechanically interface directly to the Optical Bench.

5.6.1.1 Microvibrations

Spire's mechanisms (SMEC and BSM) are sensitive to μ-vibrations between 0.03 Hz and 300 Hz, with the potential effect of displacing the SMEC suspended mirrors from their optical positions. The bolometers, as they are accommodated, probably have a similar susceptibility to HOB-driven microvibrations. This is potentially due to harness flexure /capacitance changes, rather than to movements of the detector elements themselves.

Spire needs knowledge of the level of the microvibration-induced forces on the HSFPU at its HOB interface, in order to ensure they can be mitigated. The expected levels of input acceleration are to be provided by ESA/Alcatel, over the frequency range between 30 Hz and 300 Hz.

5.6.1.2 Thermal Straps

The mechanical I/F geometry, fixing torque, etc. for each of these straps is as baselined in the IIDA. See section 5.4 for positions on Spire and section 5.7 for more details. Note that the HERSHEL to Spire interfaces for the L0 straps are at three simple strap to strap clamp points just above the HOB. For information, inside SPIRE, these thermal straps will be steadied by non-metallic Spire provided A-frames on the outside of the FPU, designed to minimise the forces the straps can apply to thermal lead-throughs, but not be Ohmic shorts. Separate supports are needed to minimise cross-coupling between the two sorption cooler straps.

5.6.2 Outside Cryostat

NA

5.6.3 On SVM

The three units mounted on the SVM will each have attachment points for fixation to the equipment platform, as shown in their External Configuration Drawings. Interface flatnesses, fasteners and tightening torques are all defined on these drawings.

The Spire warm harness will be attached to the SVM or to agreed points on the outsides of the units via TBD ESA provided hold-down ties.

5.6.4 On Planck Payload Module

NA

5.6.5 Cooler valves and piping

NA

5.7 THERMAL INTERFACES

The cryogenic interfaces are the most important category of interfaces for Spire 's success, and the most complicated. They would provide the most gain to science performance from being improved.

5.7.1 Inside the cryostat

ESA, SPIRE and Industry recognise that the definition of the thermal interface between the SPIRE FPU and the Herschel Cryostat is an open issue that requires urgent settlement. However, in the midst of various analyses both on Industry and SPIRE side, no convergence was found prior to this issue 2.1 of the SPIRE IID-B.

Two major thermal requirements for SPIRE are its sorption minimum cooler cycle time of 48h, and its cold tip temperature of < 290mK.

The following paragraphs (5.7.1 to 5.7.1.2) are a statement of the SPIRE requirements on the Herschel system. However, industry can not commit to the requirements below, but is investigating refining its design with these as objectives. A number of technical options have been identified, both on satellite and SPIRE instrument sides, which need to be analysed to converge to an interface definition. An objective is to meet both the cryostat lifetime and SPIRE thermal requirements. This shall be settled and formalised via the regular Change Request process.

Make apparent where begins and stops the IID-B 1.0 part

Until convergence is reached, Industry is contractually committed to the following interface (as per SPIRE IID-B 1.0 para 5.7.1, repeated below) :

The various instrument stages require 3 different temperatures. This will be achieved by strapping the stages to various “cold” parts of the cryostat. These cryostat parts are:

- Level 0: The He II tank for temperatures at the 1.7 K level
- Level 1: Strap to the He ventline at about 4K
- Level 2: Strap to the He-ventline at about 10 K

The table below shows the required operating temperatures at the interface of the instrument unit with the cryostat or parts thereof :

Project Code	Operating		Start-up	Switch-off	Non-Operating	
	Min. K	Max. K	Deg. C	Deg. C	Min. C	Max. C
FSFPU (L_1 Enclosure)	N/A	6	TBD ***	TBD ***	TBD ***	+60 * +80 **
FSFPU (dedicated ^{3}He cooler strap)	N/A	2 ****	TBD ***	TBD ***	TBD ***	+60 * +80 **
FSFPU (L_0 Enclosure)	N/A	2	TBD ***	TBD ***	TBD ***	+60 * +80 **
FSFTB	N/A	15	TBD ***	TBD ***	TBD ***	+60 * +80 **

* Continuous temperature limit.
** Short-duration temperature limit for bake-out during a maximum of 72 hours.
*** Certain sub-systems may not be able to be operated above 20 K.
**** For sorption cooler recycling see 5.7.1.1

The various instrument stages require straps to 3 different temperature levels. An indicative overview of the heatflows in the system is given in Figure 5.7-1 :

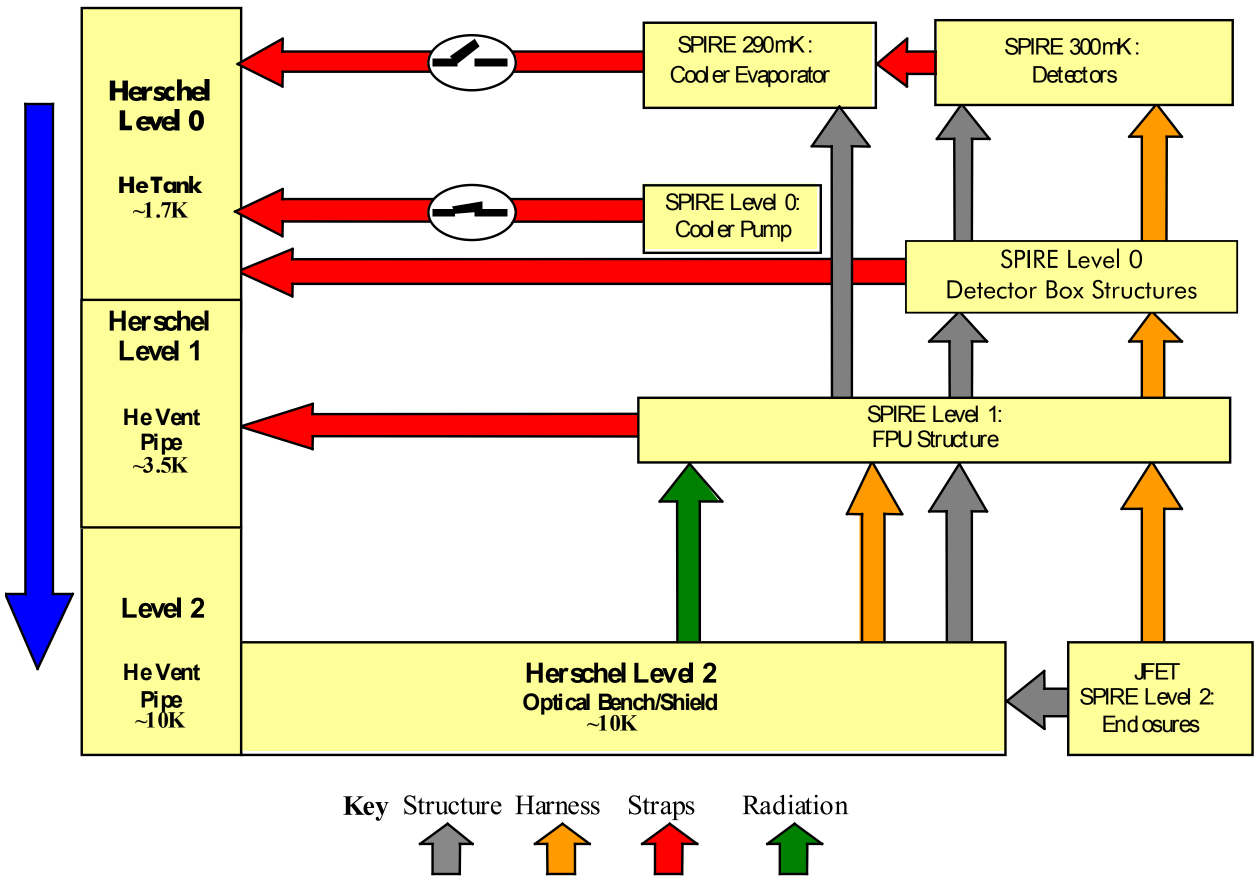


Figure 5.7-1: Heat-flows overview inside the Cryostat

5.7.1.1 Reasons for Spire Level 0 interfaces

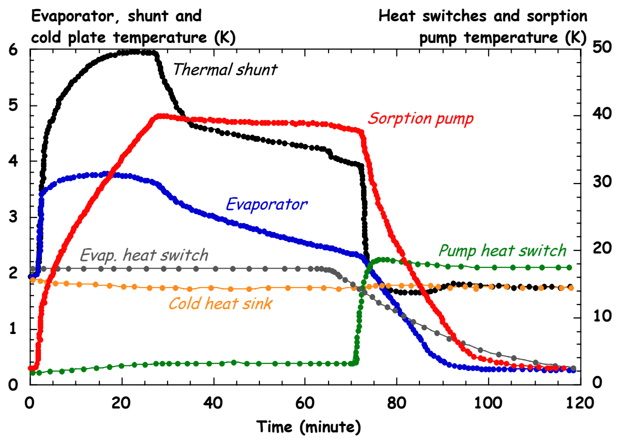
The Spire ^{3}He cooler has three operating phases: condensation; cool-down; low temperature. The combination of the first two is called re-cycling or re-generation.

First the sorption pump is heated to ~40K and the evaporator's heat-switch ON to conduct heat to the HPLM Helium II tank, so the ^{3}He condenses back into the cooler's evaporator. A temperature of the evaporator during this phase maximises the recycling efficiency (i.e. ratio of Liquid ^{3}He to condensed ^{3}He), a factor in maximising its subsequent 300mK hold time. The sorption cooler manufacturer stipulates a conductance of >0.1Watts/Kelvin between the HPLM Helium II tank and the sorption cooler evaporator heat-switch I/F.

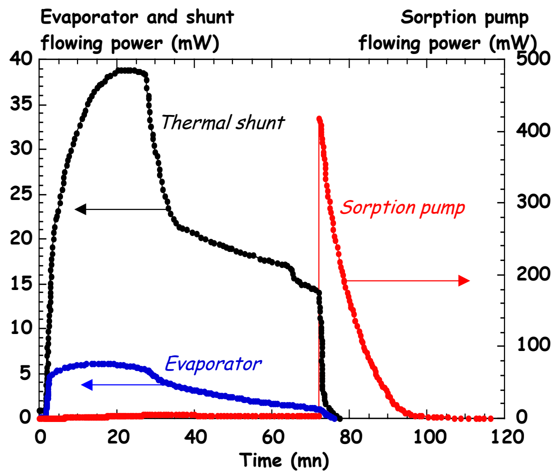
At the end of the condensation phase of the cooler's regeneration, the heat switch on the sorption pump is turned ON and the switch on the evaporator is turned OFF. There is a substantial (~450mW) peak power from the sorption pump to the cryostat as it is re-cooled. The design of HPLM Helium II cryostat should be such that this peak power and associated energy does not have any significant impact, such as cryogen surface film breakage. During this phase, the evaporator strap shall be below 2K, to avoid re-evaporating the condensed 3He.

These operating modes mean that the Pump Strap and the Evaporator straps must be sufficiently insulated from each other. There are thus two straps from the cooler, one for the sorption pump and one for the evaporator. In this way, during normal operation, the temperature of the evaporator strap will remain at T_{bath}+DeltaT (as small as possible), leading to a good condensation efficiency and less ^{3}He lost during the cooldown from 1.7 K to 0.3K.

Spire plans to operate the Sorption cooler to fit in with the HERSCHEL mission, namely a 48hour cycle comprising 46 hours of cold operation and 2 hours of recycling. An indicative overview of this two hours recycling is shown in the following diagrams :



Temperatures (not at I/F)



Heatflows

Note that the cooler has an internal heat shunt between its pump and evaporator, but the braid from this uses a common external cooler I/F with the evaporator heatswitch.

Spire has two 1.8K optical box structures on isolating mounts inside the HSFPU. As shown in the overall scheme above, these provide a low temperature mounting for the detector assemblies. The photometer box and the spectrometer box are thermally linked internally to the FPU, and provide just one instrument external strap I/F to level 0.

5.7.1.2 Requirements on Strap I/F temperatures

3 thermal strap interfaces at Level 0.
The thermal interface applies at the mechanical positions shown in section 5.4, namely Spire supported connections of the type described in IID-A fig 5.7.1.2. located near –X end of the HSFPU's –Z face.

HPLM will have three thermal links from these I/Fs to Helium II tank which shall provide at least the following cooling at an I/F temperature of **1.8K** :

Strap	Max Heatflow	Lifetime Heatflow Operating	Lifetime Heatflow Non-Operating
Detector Enclosures	5 mW	3.0 mW	1.0 mW
Cooler Pump	2 mW	1.8 mW	0.25 mW
Cooler Evaporator	1 mW	0.6 mW	0.25 mW

The lifetime heat flows are the values which should be used to estimate the Herschel cryostat lifetime (taking into account averaging during Spire operation).

At the end of the condensation phase, the cooler connects its 40K pump back to the level 0 pump strap via a gas switch. The heat pulse from the pump can be approximated to a triangular pulse (Max 450mW, duration 1560s, =Energy 350J), similar in shape to that shown in the figure above. During this pulse, the pump strap interface is allowed to rise up to 10K, but the evaporator strap interface shall remain below 2K.

A thermal strap of 0.1W/K is recommended for the evaporator strap, and 0.05W/K for the pump strap. The detector strap must be also 0.05W/K for a tank at 1.7K.

1 thermal strap interfaces at Level 1.

At least the following cooling at the Spire I/F shall be provided

Strap	Temperature	Heatflow
HSFPU SOB	**4.5 K**	**13 mW**

The HOB interfaces at Level 2.

At least the following cooling at the **Spire** I/F shall be provided

Interface	Temperature	Heatflow
Three HSFPU Feet	12 K	-10 mW
HSJFP rack feet	12 K	50 mW
HSJFS rack feet	12 K	25 mW

Notes: i. Only one of the HSJFP or HSJFS operates at this effective power at any one time
ii. The –10mW indicates that the HSFPU is tending to cool the HOB; this value is subject to change
iii. **Spire** has proposed that the 12K value of the HOB I/F be reduced to 10K, a value that would improve instrument thermal accommodation and appears to be consistent with cryostat thermal models. This has been discussed but not agreed.

No HSJFS or HSJFP level 2 straps are listed because the present design uses direct mounting conduction to the HOB, so they are not fitted

The level 2 to level 1 non-bolometer ESA-provided cryo-harness shall not input more than 0.2mWatts into the HSFPU.

To provide the required overall thermal balance boundary, since the inner instrument shield is nominally black at level 2, the effective temperature seen from any point on the surface of the HSFPU when integrated over an outward hemisphere shall not exceed 16K. This surface of course includes the areas around Spire's input aperture.

5.7.1.3 Worst case temperatures

The cryogenic units must withstand the full thermal environment given in the IIDA, including repeated max. 72hr. 80°C bake-outs and indefinite 60°C soak.

5.7.2 Outside the Cryostat

NA

5.7.3 On the SVM

The table below shows the required operating temperatures at the interface of the instrument unit with a mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. ^{0}C	Max. ^{0}C	^{0}C	^{0}C	Min. ^{0}C	Max. ^{0}C
HSDPU	- 15	+ 45	- 30	+ 50	- 35	+ 60
HSFCU	- 15	+ 45	- 30	+ 50	- 35	+ 60
HSDCU	- 15	+ 45	- 30	+ 50	- 35	+ 60

Note:

Acceptance temperature range is from 5 ^{0}C below min. to 5 ^{0}C above max. operating temp.
Qualification temperature range is from 10 ^{0}C below min. to10 ^{0}C above max. operating temp.

During nominal operation in-flight, the SVM units will not move at more than 3K/hour.

Spire units will be thermally joined over their base mounting I/Fs to the panel skins which will help stabilise the temperature of un-powered sections and absorb dissipated heat when powered by conduction. The units have an alochromed aluminium general surface finish. If it is found that other arrangements are needed, such as low temperature limit thermostated heaters, these shall be external and Herschel furnished. If details are determined on time-scales that can be accommodated, Spire will build in minimal necessary mounting arrangements for such systems, TBC.

5.7.4 On the Planck Payload Module

NA

5.7.5 Temperature channels

5.7.5.1 Instrument Temperature Sensors

The table below shows the measurement of instrument cryogenic temperatures. These data are available in DPU science packets (unless otherwise indicated) via whichever is powered of the prime and redundant sides of the Spire electronics. They may also be included in some housekeeping. packets.

Each Prime/Redundant side uses different, electrically isolated sensors and will therefore have subtlety differing electrical to temperature calibrations. Note that the accuracy columns that follow refer to the performance of the complete system including cryoharness and electronics, not the sensors alone. "Resolutions" and "Accuracy" will need to be further defined as they are actually temperature dependant.

Cernox sensors type CX-1030 are used for all Spire conditioned housekeeping temperatures. The below table is consistent with Spire Wiring Definition.

Location IN HSFPU	**Acronym**	**Sensor Type**	**Temp. Range**	**Resol.**	**Acc.**
PSW BDA_1	T_PSW_1	NTD Ge Thermistor*	0.2 K>5 K	0.5mK	2mK
PSW BDA_2	T_PSW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PMW BDA_1	T_PMW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PMW BDA_2	T_PMW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PLW BDA_1	T_PLW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
PLW BDA_2	T_PLW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SSW BDA_1	T_SSW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SSW BDA_2	T_SSW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SLW BDA_1	T_SLW_1	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
SLW BDA_2	T_SLW_2	NTD Ge Thermistor	0.2 K>5 K	0.5mK	2mK
300mK Plumbing Cntrl_1	TBD	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_2	TBD	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_3	TBD	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
JFET temps (6off? TBD)	TBD	HeaterThermistor?	10K>120K	0.5K	1K
HSFPU Opt. Bench (HOB)	TBD	CX-1030	3K>100K	25mK	50mK
Spectrometer 2K box	TBD	CX-1030	1K>10K	2mK	2mK
Photometer 2K box	TBD	CX-1030	1K>10K	2mK	2mK
M3,5,7 Optical SubBench	TBD	CX-1030	3K>100K	25mK	50mK
HSFPU Input Baffle	TBD	CX-1030	3K>80K	5mK	5mK
BSM/SOB I/F	TBD	CX-1030	3K>80K	5mK	5mK
HS Spect. Stimulus Flange	TBD	CX-1030	1K>50K	10mK	10mK
Sorption Pump	TBD	CX-1030	0.2 K>5 K	1mK	1mK
Evaporator	TBD	CX-1030	0.2 K>5 K	1mK	1mK
Sorption Pump Heat Switch	TBD	CX-1030	1K>50K	10mK	10mK
Evaporator Heat Switch	TBD	CX-1030	1K>50K	10mK	10mK
Thermal Shunt	TBD	CX-1030	0.2 K>5 K	1mK	1mK
HS Spect. Stim 4%	TBD	CX-1030	3K>80K	5mK	5mK
HS Spect. Stim 2%	TBD	CX-1030	3K>80K	5mK	5mK
BSM	TBD	CX-1030	3K>20K	10mK	10mK
SMEC	TBD	CX-1030	3K>20K	10mK	10mK
SMEC/HOB I/F		CX-1030	3K>100K	25mK	50mK

*NTD Ge Thermistor is equivalent to a detector element, but it is not mounted on an isolating web.

5.7.5.2 Shutter Temperature Sensors

Handled by EGSE, not FCU/DPU, and therefore included here only for completeness. Not available for flight.

Location IN HSFPU	Acronym	Sensor Type	Temp. Range	Resol-ution	Acc.
Shutter Vane-A	TBD	CX-1070, TBC	3K>80K	5mK	10mK
Shutter Vane -B *	TBD	CX-1070, TBC	3K>80K	5mK	10mK
Shutter Actuator-A *	TBD	CX-1070, TBC	3K>120K	25mK	500mK
Shutter Actuator-B *	TBD	CX-1070, TBC	3K>120K	25mK	500mK

5.7.5.3 Satellite Temperature sensors

In addition to the Spire conditioned temperature channels, Spire requires that Herschel itself shall monitor the temperatures of certain locations on the cryostat and SVM. These are given in the table below.

Location	Sensor Type	Temp. Range	Acronym	Resol-ution*	Acc.
Level 0 Strap A to cooler	ESA TBD	1.5K to 90°C	TBD	10-500mK	50mK
Level 0 Strap B to cooler	ESA TBD	1.5K to 90°C	TBD	10-500mK	50mK
Level 0 Strap to HSFPU 1.8k boxes	ESA TBD	1.5K to 90°C	TBD	10-500mK	50mK
Level 1 strap to HSFPU	ESA TBD	1.5K to 90°C	TBD	10-500mK	50mK
HSJFS mounting temperature	ESA TBD	1.5K to 90°C	TBD	10-500mK	1K
HSJFP mounting temperature	ESA TBD	1.5K to 90°C	TBD	10-500mK	1K
HOB at HSFPU centre foot	ESA TBD	1.5K to 90°C	TBD	10-500mK	1K
HOB at HSFPU +Y foot	ESA TBD	1.5K to 90°C	TBD	10-500mK	1K
HOB at HSFPU -Y foot	ESA TBD	1.5K to 90°C	TBD	10-500mK	1K
Centre SPIRE SVM panel.	ESA TBD	-80 to 90°C	TBD	0.4K	1K

* Lower values for resolution and accuracy apply at bottom end of range, higher when hot and the absolute value of the requirement is much less stringent. The temperature of an item should be determined (accuracy+ resolution errors) to 2% of its absolute value in Kelvin, TBC

The precise number and location of these sensors shall be confirmed after thermal modelling.

Herschel shall check temperatures are within range, and for instance not empower SVM units outside of their rated operating ranges.

5.8 OPTICAL INTERFACES

The cryostat and baffle structures shall be compatible with the SPIRE beam.

5.8.1 Straylight

The instrument straylight model and its conclusions related to alignment etc. are described in RD-1.

For information, Figure 5.8-1 illustrates the SPIRE optical beam envelope viewed as it passes out of the HSFPU, showing the contributions from the photometer and the spectrometer. The differing beams result from the extremes of the BSM's jiggle and chop displacements. The beam envelope formed is the geometric optical beam passing through the Spire cold stop. The 6mm clearance around the beam, at the level of the shutter frame, is the allowance required for beam diffraction.

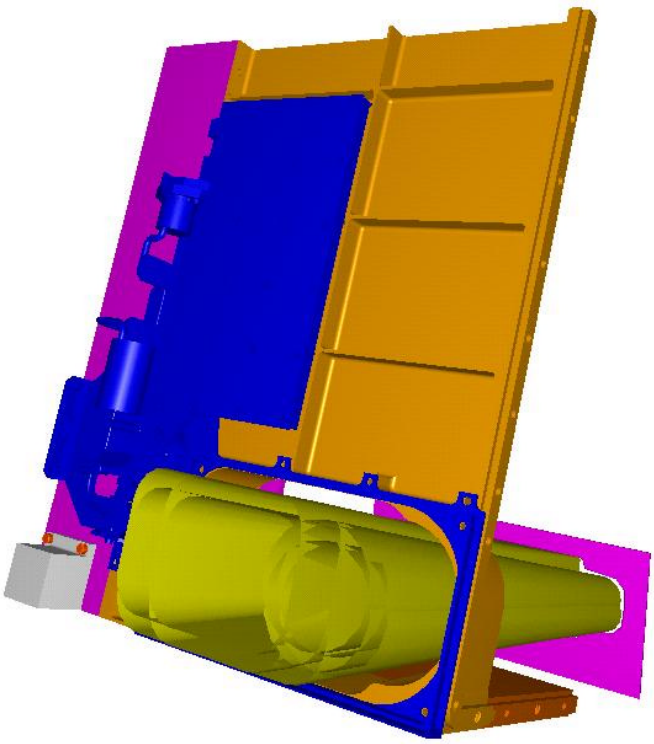


Figure 5.8-1 Spire optical beam envelope as it leaves the HSFPU

The spectrometer's almost circular used beams are the farther from HERSCHEL field centre, and lie to the side of the semi-rectangular beams of the photometer. FOV switching is not used within SPIRE to boresight the photometer and the spectrometer; both are illuminated simultaneously by the HERSCHEL telescope.

5.9 POWER

The thermal design and thermal model is still under evaluation at system level, with industry and ESA project. The values given in 5.9.1 reflect the current known status.

5.9.1 Power inside the cryostat

The SPIRE components which dissipate power inside the cryostat are described in the Table below. It should be noted that the individual component dissipations can vary according to the operational mode of the instrument, as described in section 5.9.5.

Component	Max. at	Mean at	Max in harness	Mean in harness

	component level (mW)	component level (mW)	(mW)	(mW)
Photometer Cal	4	0.1		
Spectrometer Cal	5	2		
300 mK Cooler *	1.42	1.22		
BSM / Photometry	4	4		
BSM / Spectroscopy	4	1		
SMEC / Photometry	9.5	4.6		
SMEC / Spectroscopy	9.5	1.6		
JFETS / Photometry	42	42		
JFETS / Spectrometry	14.1	14.1		

* Recycling is a special case, see section 5.7.1.

5.9.2 Power outside the Cryostat

NA

5.9.3 Power on the SVM

The following table shows the heat dissipation (in Watts) of the warm electronic units mounted on the SVM. Note that the power passed through to the Cryoharness and the HSFPU is negligible, such that the dissipation values given here are the same as those corresponding to the unit power loads on the bus (Section 5.9.6.1) :

Project Code	Instrument Unit	Dissipation	Comment
HSDPU	HS Digital Processing Unit	15.3 W	
HSFCU	HS FPU Control Unit	42.9 W	Includes power cond. losses
HSDCU	HS Detector Control Unit	37.0 W	Lower in spectrometer Mode
HSWIR	HS Warm Inter-unit Harness	0.1 W	
	Total	**95.3 W**	

The above dissipations are essentially independent of observing mode, with the exception that the baseline is to power EITHER the spectrometer OR the photometer bolometer systems at any one time. The above figures are based on the higher dissipation values expected with *photometer* operation. When operating in spectrometry mode, the reduction in HSDCU power requirements and the associated reduction in conditioning losses in the HSFCU are TBD.

The baseline is to empower either prime or redundant modules of Spire. The instrument will therefore appear to the S/C as simply cold redundant.

5.9.4 Power on Planck Payload Module

NA

5.9.5 Power versus Instrument Operating Modes

The table below shows the status of the instrument subsystems in the various instrument modes.

Unit	Subsystem	Recycle	Off	On	Standby / Parallel / Serendipity	Observing	
						Photom.	Spectro.
HSFPU	Detector Bias	OFF	OFF	OFF	ON	ON	ON
	Photometer Cal Source	OFF	OFF	OFF	OFF	X	OFF
	Spect. Cal Source	OFF	OFF	OFF	OFF	OFF	ON
	Cooler	ON	OFF	OFF	ON	ON	ON
	BSM	OFF	OFF	OFF	ON	ON	ON
	FTS Mechanism	OFF	OFF	OFF	OFF	OFF	ON
HSFTB	JFET amplifiers	OFF	OFF	OFF	ON	ON	ON
HSFCU + HSDCU	Read-out electronics & mechanism drive electronics	ON	OFF	OFF	ON	ON	ON
HSDPU	Digital Processing Unit	ON	OFF	ON	ON	ON	ON

LEGEND	
ON :	Operational
OFF :	Inactive
X :	Either ON or OFF depending on instrument configuration.

5.9.6 Supply Voltages

5.9.6.1 Load on main-bus

The total power load Spire places on the 28V main-bus is defined In the Spire Budgets' Document. The following is an extracted summary:

The "average" and "peak" power values correspond to "worst-case" conditions, i.e. taking into account the specified supply bus voltage range : 26V and 29V.

Spire Operating Mode	[1] Max. Ave. BOL	[1] Max. Ave. EOL	[1] Long Peak BOL / EOL
Observing	95.3 W	95.3 W	TBD
Parallel	95.3 W	95.3 W	TBD
Serendipity	95.3 W	95.3 W	TBD
Standby	95.3 W	95.3 W	TBD
Cooler Recycle	95.3 W	95.3 W	TBD
On	15.3 W	15.3 W	TBD
Off	0 W	0 W	0

Project Code	Instrument Unit	Mean load per LCL
HSDPU	HS Digital Processing Unit	15.3 W [2]
HSFCU	HS FPU Control Unit	80.0 W [3]

[1] The "average" and "peak" power values correspond to "worst-case" conditions, i.e. taking into account the specified supply bus voltage range : 26V ~ 29V. The average "with-margin", and peak "with-margin" total power loads are also to be provided. Power requirements cannot be accepted until assumed margins are clearly stated.

[2] The **maximum** associated "Long Peak" load on this LCL is understood to be the mean value (above) X 1.20, i.e. 18.5 W.

[3] The **maximum** associated "Long Peak" load on this LCL is understood to be the mean value (above) X 1.20, i.e. 96 W.

5.9.6.2 Power Nominal Turn-on.

Having checked that Spire is all unpowered, the HPCDU shall empower an HSDPU (P or R).

This DPU checks its health and sends a status packet on the active 1553 bus. If its status is OK, the HCDMU commands the HPCDU to turn on the corresponding HSFCU module (P or R).

Note that turning on the HSFCU has the automatic subsidiary effect of turning on the non-redundant DCU, but this unit is not seen directly via a S/C interface.

5.9.6.3 Interface circuits

The HSDPU and the HSFCU receive both primary and redundant 28V feeds. The configuration is shown in figure 5.2.1, and the connectors are HSDPU J1-2 and HSFCU J5-6.

Their S/C power interfaces circuits shall be designed not to generate unwanted interactions with LCL switching limiters. Instrument power circuits are shown in sections 5.9.6.4.1 & .2.

The HPCDU shall telemeter the Spacecraft's LCL current to a resolution of better than 25mA or 1/256 of (trip x 1.5), whichever is the larger. The stated resolution, to be provided by the current telemetry, does imply any particular level of current measurement *accuracy.*

5.9.6.4 LCL fault conditions

The S/C shall not allow simultaneous powering of both FCUs, even in the event of a single point LCL failure.

Both DPUs may be powered simultaneously but only under LCL fault conditions. To permit this, other design features must be present. The unwanted although powered DPU shall be kept in-active by not commanding the inactive unit, and neither HCDMU shall turn on the corresponding HSFCU. To permit commanding the DPUs to work like this, each HSDPU uses a different 1553 bus address.

The Herschel platform shall monitor that LCL's are behaving correctly. With certain timing restrictions, it shall regularly check that an "off" LCL is passing less than a minimum current, and that an "on" LCL is passing a current between a minimum and a maximum that depends on circuit. It shall re-check this before and after implementing a command to change an LCL's state. The formal status of the functionality of LCLs [working, stuck on, stuck open-circuit, dubious, etc.] shall be stored somewhere in the Herschel commanding system (probably on the ground?) to stop any attempt to switch a failed LCL without specific over-ride .

An open-circuit LCL is not a particularly difficult case to consider as it would just preclude the use of one side of Spire.

5.9.6.4.1 HSDPU Power Input Circuit Configuration

Insert drawing as supplied by SPIRE

TBW

5.9.6.4.2 HSFCU Power Input Circuit Configuration

TBW

5.9.7 Keep Alive Line (KAL)

Because Spire should not be switched-on/off frequently, a KAL will not be implemented.

5.10 CONNECTORS, HARNESS, GROUNDING, BONDING

5.10.1 Harness and Connectors

Spire harnesses shall be as defined in RD9. Harness length details are to be incorporated in RD9, but may not be available at the time of issue of the present document. For information, the following data has been extracted from RD9. It should however be noted that any electrical requirements of Spire, which may be implicitly represented by Figure 5.10-1, are accepted ONLY when such requirements are expressed in the text of the present document.

Figure below gives an overview of the Spire harness layout.

Update drawing to have right acronyms,

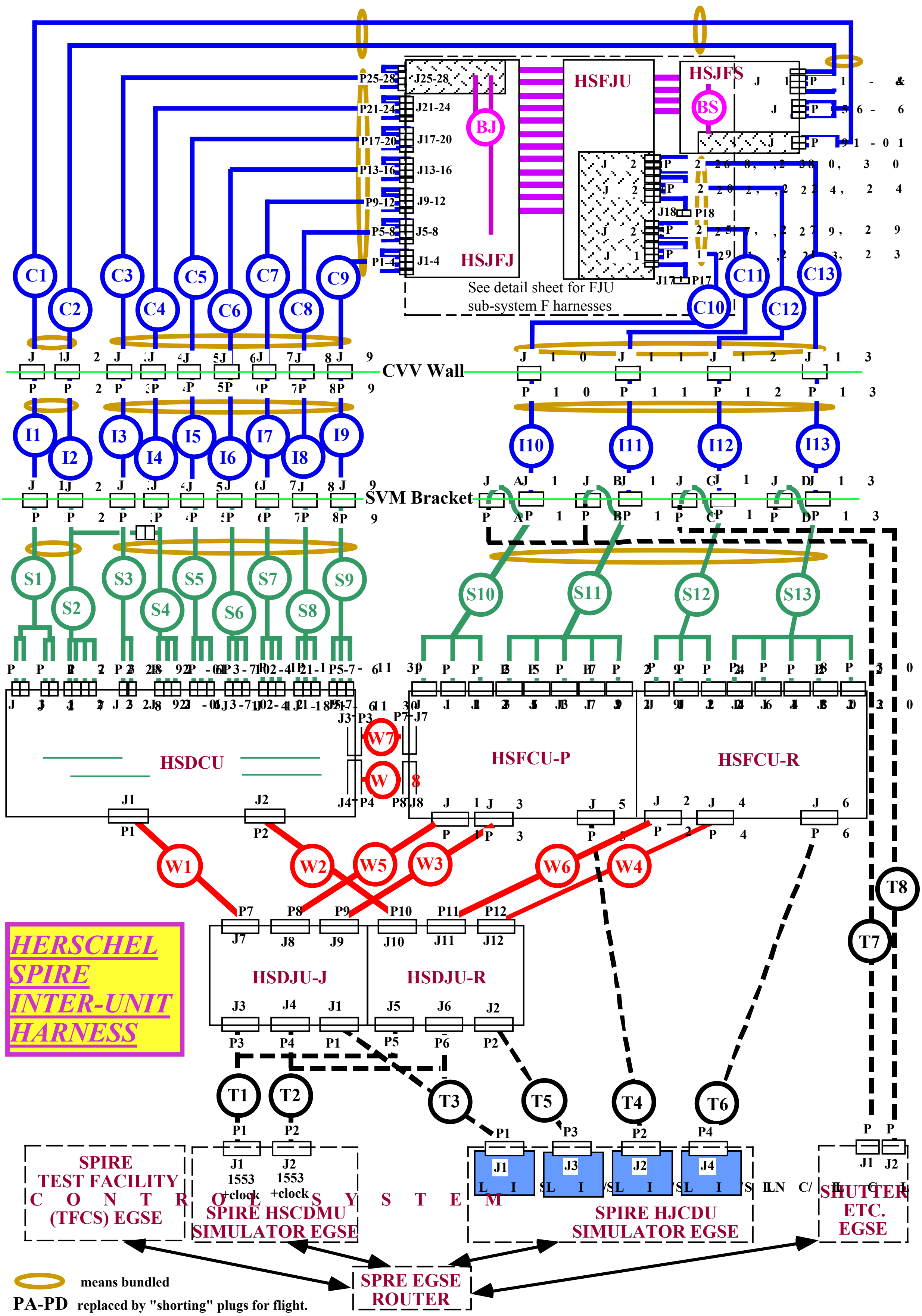


Figure 5.10-1 : SPIRE harness layout

Note that the Cryo-harness, i.e. series C, I and S, are ESA provided and not Spire flight H/W, whilst the T series apply only for instrument test and are not Spire flight items.

Requirements for the SPIRE cryo harness, series C, I and S as agreed with industry, are given in the tables below.

Internal Harness – Data taken from ECR-029 / TBC Remove ECR ref, TBC, add headers and page number

Name	128 Way Connector	FPU/JFS/JFP Connector Label	FPU/JFS/JFP Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
C1	CVV 1	HSJFS J5	MDM 25 P	HSJFS P5	MDM 25 S	Bolometer signals from JFS (SLW 1-12)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type 3						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J6	MDM 25 P	HSJFS P6	MDM 25S	Bolometer signals from JFS (SLW 13-24)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J9	MDM 37 S	HSJFS P9	MDM 37P	300-mK TC Bias	2	1	STP	200	1000pF	0.08uH	3.20E-08	8.00E-09	10
						300-mK Ground wire	1	0	S	50	1000pF	0.08uH	0	0	10
						300-mK JFET Bias	2	1	STP	100	1000pF	0.08uH	5.00E-03	2.00E-04	10
						SLW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	9.60E-08	2.40E-08	10
						SLW JFET Bias	4	2	STP	100	1000pF	0.08uH	2.50E-03	6.00E-04	10
						SLW Ground wire	1	0	S	50	1000pF	0.08uH	0	0	10
						SSW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	1.20E-03	4.80E-08	10
						SSW JFET Bias	4	2	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						SSW Ground Wire	1	0	S	50	1000pF	0.08uH	0	0	10
						300-mK TC JFET Heater	2	1	STP	200	1000pF	0.08uH	1.90E-03	4.80E-04	10
						SLW JFET Heater	2	1	STP	200	1000pF	0.08uH	3.30E-03	8.30E-04	10
						SSW JFET Heater	2	1	STP	200	1000pF	0.08uH	6.70E-03	1.70E-03	10
		HSJFS J10	MDM 37 S	HSJFS P10	MDM 37P	300-mK TC Bias	2	1	STP	200	1000pF	0.08uH	3.20E-08	8.00E-09	10
						300-mK Ground wire	1	0	S	50	1000pF	0.08uH	0	0	10
						300-mK JFET Bias	2	1	STP	100	1000pF	0.08uH	5.00E-03	2.00E-04	10
						SLW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	9.60E-08	2.40E-08	10
						SLW JFET Bias	4	2	STP	100	1000pF	0.08uH	2.50E-03	6.00E-04	10
						SLW Ground wire	1	0	S	50	1000pF	0.08uH	0	0	10
						SSW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	1.20E-03	4.80E-08	10
						SSW JFET Bias	4	2	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						SSW Ground Wire	1	0	S	50	1000pF	0.08uH	0	0	10
						300-mK TC JFET Heater	2	1	STP	200	1000pF	0.08uH	1.90E-03	4.80E-04	10
						SLW JFET Heater	2	1	STP	200	1000pF	0.08uH	3.30E-03	8.30E-04	10
						SSW JFET Heater	2	1	STP	200	1000pF	0.08uH	6.70E-03	1.70E-03	10
						FPU Faraday Shield Link#			#	50		0.01uH			
C2	CVV 2	HSJFS J7	MDM 25 P	HSJFS P7	MDM 25S	Bolometer signals from JFS (300mK TC 1-3)	8	1	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type4						Anti-cross talk ground wires.	4	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J1	MDM 25 P	HSJFS P1	MDM 25S	Bolometer signals from JFS (SSW 1-8)	16	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	4	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J2	MDM 25 P	HSJFS P2	MDM 25S	Bolometer signals from JFS (SSW 9-20)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J3	MDM 25 P	HSJFS P3	MDM 25S	Bolometer signals from JFS (SSW 21-32)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	4	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFS J4	MDM 25 P	HSJFS P4	MDM 25S	Bolometer signals from JFS (SSW 33-44)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C3		HSJFP J25	MDM 37 S	JFP P25	MDM 37P	PSW JFET Bias	12	6	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
Type2						PSW Ground	1	0	S	50	1000pF	0.08uH	0	0	10
						PSW Bolometer Bias	6	3	STP	200	1000pF	0.08uH	3.80E-07	9.60E-08	10
						PSW Heater	6	3	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
		HSJFP J27	MDM 37 S	JFP P27	MDM 37P	PMW JFET Bias	8	4	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						PMW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	3.80E-07	9.60E-08	10
						PMW Ground	1	0	S	50	1000pF	0.08uH	0	0	10
						PMW JFET Heater	4	2	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
						PLW JFET Heater	2	1	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
						PLW JFET Bias	4	2	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						PLW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	1.90E-07	4.80E-08	10

Internal Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	FPU/JFS/JFP Connector Label	FPU/JFS/JFP Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements			Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
										R (W)	C(pF)	L(uH)			
						PLW Ground	1	0	S	50	1000pF	0.08uH	0	0	10
		HSJFP J26	MDM 37 S	JFP P26	MDM 37P	PSW JFET Bias	12	6	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						PSW Ground	1	0	S	50	1000pF	0.08uH	0	0.00E+00	10
						PSW Bolometer Bias	6	3	STP	200	1000pF	0.08uH	3.80E-07	9.60E-08	10
						PSW Heater	6	3	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
		HSJFP J28	MDM 37 S	JFP P28	MDM 37P	PMW JFET Bias	8	4	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						PMW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	3.80E-07	9.60E-08	10
						PMW Ground	1	0	S	50	1000pF	0.08uH	0.00E+00	0.00E+00	10
						PMW JFET Heater	4	2	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
						PLW JFET Heater	2	1	STP	200	1000pF	0.08uH	3.80E-03	9.60E-04	10
						PLW JFET Bias	4	2	STP	100	1000pF	0.08uH	5.00E-03	1.20E-03	10
						PLW Bolometer Bias	4	2	STP	200	1000pF	0.08uH	1.90E-07	4.80E-08	10
						PLW Ground	1	0	S	50	1000pF	0.08uH	0.00E+00	0.00E+00	10
						FPU Faraday Shield Link#			#	50		0.01uH			
C4	CVV 4	HSJFP J21	MDM 25 P	HSJFP P21	MDM 25S	Bolometer signals from JFP (PMW 1-12)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J22	MDM 25 P	HSJFP P22	MDM 25S	Bolometer signals from JFP (PMW 13-24)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J23	MDM 25 P	HSJFP P23	MDM 25S	Bolometer signals from JFP (PMW 25-36)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J24	MDM 25 P	HSJFP P24	MDM 25S	Bolometer signals from JFP (PMW 37-48)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C5	CVV 5	HSJFP J17	MDM 25 P	HSJFP P17	MDM 25S	Bolometer signals from JFP (PMW 49-60)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J18	MDM 25 P	HSJFP P18	MDM 25S	Bolometer signals from JFP (PMW 61-72)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J19	MDM 25 P	HSJFP J19	MDM 25S	Bolometer signals from JFP (PMW 73-84)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J20	MDM 25 P	HSJFP J20	MDM 25S	Bolometer signals from JFP (PMW 85-96)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C6	CVV 6	HSJFP J13	MDM 25 P	HSJFP P13	MDM 25S	Bolometer signals from JFP (PLW 1-12)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J14	MDM 25 P	HSJFP P14	MDM 25S	Bolometer signals from JFP (PLW 13-24)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J15	MDM 25 P	HSJFP P15	MDM 25S	Bolometer signals from JFP (PLW 25-36)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J16	MDM 25 P	HSJFP P16	MDM 25S	Bolometer signals from JFP (PLW 37-48)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C7	CVV 7	HSJFP J9	MDM 25 P	HSJFP P9	MDM 25S	Bolometer signals from JFP (PSW 1-12)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J10	MDM 25 P	HSJFP P10	MDM 25S	Bolometer signals from JFP (PSW 13-24)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J11	MDM 25 P	HSJFP P11	MDM 25S	Bolometer signals from JFP (PSW 25-36)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J12	MDM 25 P	HSJFP P12	MDM 25S	Bolometer signals from JFP (PSW 37-48)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			

Internal Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	FPU/JFS/JFP Connector Label	FPU/JFS/JFP Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
C8	CVV 8	HSJFP J5	MDM 25 P	HSJFP P5	MDM 25S	Bolometer signals from JFP (PSW 49-60)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J6	MDM 25 P	HSJFP P6	MDM 25S	Bolometer signals from JFP (PSW 61-72)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J7	MDM 25 P	HSJFP P7	MDM 25S	Bolometer signals from JFP (PSW 73-84)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J8	MDM 25 P	HSJFP P8	MDM 25S	Bolometer signals from JFP (PSW 85-96)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA	in12-ax	500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C9	CVV 9	HSJFP J1	MDM 25 P	HSJFP P1	MDM 25S	Bolometer signals from JFP (PSW 97-108)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
Type1						Anti-cross talk ground wires.	12	NA		500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J2	MDM 25 P	HSJFP P2	MDM 25S	Bolometer signals from JFP (PSW 109-120)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA		500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J3	MDM 25 P	HSJFP P3	MDM 25S	Bolometer signals from JFP (PSW 121-132)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA		500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
		HSJFP J4	MDM 25 P	HSJFP P4	MDM 25S	Bolometer signals from JFP (PSW 133-144)	24	3	12-ax	500	1000pF	0.08uH	1.00E-09	5.00E-10	0.1
						Anti-cross talk ground wires.	12	NA		500	1000pF	0.08uH	0.00E+00	0.00E+00	0.1
						FPU Faraday Shield Link#			#	50		0.01uH			
C10	CVV 10	HSFPU J19	MDM 37 S	HSFPU P19	MDM 37P	Sorption Pump Heater	4	0	TQ	10			2.50E-02	6.30E-03	
Aux-P						Heat switch heaters	8	0	TQ	50			1.50E-03	3.80E-04	
						Various cooler thermistors	20	5	STQ	1000			1.00E-06	1.00E-06	
		HSFPU J21	MDM 37 S	HSFPU P21	MDM 37P	Spectrometer Stimulus Thermistors	12	3	STQ	1000			1.00E-06	1.00E-06	
						Spectrometer Stimulus Heater 4%	4	0	TQ	30			9.00E-03	2.30E-03	
						Spectrometer Stimulus Heater 2%	4	0	TQ	30			7.00E-03	1.80E-03	
		HSFPU J23	MDM 37 S	HSFPU P23	MDM 37P	FPU Thermometry	24	6	STQ	1000			1.00E-06	1.00E-06	
						300mK Thermal Control Heater	4	1	STQ	30			2.00E-03	5.00E-04	
		HSFPU J17	MDM21 S	HSFPU P17	MDM21P	Shutter Vane Position Sensor	2	1	STP	1000			1.00E-02	0	
						Shutter Latch Position Sense	2	1	STP	1000			1.00E-02		
						Shutter Temperature Sensor Bias	2	1	STP	1000			1.00E-05		
						Shutter Temperature Signals	3	1	STT	1000			1.00E-06	0	10
						Shutter Latch Drive/Heaters	3	1	STT	10			1.50E-01	0	
						Shutter Motor Drive	3	1	STT	10			1.50E-01	0	
						FPU Faraday Shield Link#			#	50		0.01uH			
C11	CVV 11	HSFPU J25	MDM 37 S	HSFPU P25	MDM 37P	BSM Chopper Sensors	3	1	STT	1000			1.00E-06	1.00E-06	0.4
						BSM Chopper Sensors	2	1	STP	1000			1.00E-06	1.00E-06	
Drive-P						BSM Jiggle Sensors	3	1	STT	1000			1.00E-06	1.00E-06	
						BSM Jiggle Sensors	2	1	STP	1000			1.00E-06	1.00E-06	
						BSM Temperature	4	1	STQ	1000			1.00E-06	1.00E-06	
						Photometer Stimulus Heater	4	2	STP	10			7.00E-03	1.80E-03	
						BSM Launch latch sense	2	1	STP	1000			1.00E-03	0	
						BSM Launch latch solenoid	2	1	STT	10			3.50E-02	0	
						BSM Chop motor drive	4	1	STQ	10			3.00E-02	1.00E-02	
						BSM Jiggle motor drive	4	1	STQ	10			4.00E-02	2.50E-03	
		HSFPU J27	MDM 37 S	HSFPU P27	MDM 37P	SMEC Thermometry	8	2	STQ	1000			1.00E-06	1.00E-06	
						SMEC LVDT Primary	2	1	STP	5			5.00E-03	3.54E-03	5
						SMEC LVDT Secondary	4	2	STP	50			5.00E-05	3.54E-05	15
						SMEC Launch Latch	4	2	STP	5			4.00E-01	0.00E+00	15
						SMEC Launch Latch (Rob.)	4	2	STP	5			4.00E-01	0.00E+00	15
						SMEC Launch Latch Confirm	4	2	STP	5			1.00E-03	0.00E+00	15
		HSFPU J29	MDM 37 S	HSFPU P29	MDM 37P	SMEC Drive Coil	2	1	STP	5			1.00E-01	4.00E-02	15
						SMEC Drive (Rob.)	2	1	STP	5			1.00E-01	4.00E-02	15

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	FPU/JFS/JFP Connector Label	FPU/JFS/JFP Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements			Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
										R (W)	C(pF)	L(uH)			
						SMEC Drive coil voltage sensor	2	1	STP	500			1.00E-05	1.00E-05	15
						SMEC Position sensor supplies	2	1	STP	100			1.00E-03	1.00E-03	5
						SMEC LED Power	2	1	STP	100			1.00E-03	8.00E-04	5
						SMEC Position sensor photodiodes	6	3	STP	1000			2.00E-05	2.00E-05	5
						SMEC Position sensor photodiodes FB	6	3	STP	1000			1.00E-05	1.00E-05	5
						FPU Faraday Shield Link#			#	50		0.01uH			
C12	CVV 12	HSFPU J20	MDM 37 S	HSFPU P20	MDM 37P	Sorption Pump Heater	4	0	TQ	10			2.50E-02	0	
Aux-R						Heat switch heaters	8	0	TQ	50			1.50E-03	0	
						Various cooler thermistors	20	5	STQ	1000			1.00E-06	0	
		HSFPU J22	MDM 37 S	HSFPU P22	MDM 37P	Spectrometer Stimulus Thermistors	12	3	STQ	1000			1.00E-06	0	
						Spectrometer Stimulus Heater 4%	4	0	TQ	30			9.00E-03	0	
						Spectrometer Stimulus Heater 2%	4	0	TQ	30			7.00E-03	0	
		HSFPU J24	MDM 37 S	HSFPU P24	MDM 37P	FPU Thermometry	24	6	STQ	1000			1.00E-06	0	
						300mK Thermal Control Heater	4	1	STQ	30			2.00E-03	0	
		HSFPU J18	MDM21 S	HSFPU P18	MDM21P	Vane Position Sensor	2	1	STP	1000			1.00E-02	0	
						Latch Position Sense	2	1	STP	1000			1.00E-02	0	
						Temperature Sensor Bias	2	1	STP	1000			1.00E-05	0	
						Temperature Signals	3	1	STT	1000			1.00E-06	0	10
						Latch Drive/Heaters	3	1	STT	10			1.50E-01	0	
						Motor Drive	3	1	STT	10			1.50E-01	0	
						FPU Faraday Shield Link#			#	50		0.01uH			
C13	CVV13	HSFPU J26	MDM 37 S	HSFPU P26	MDM 37P	BSM Chopper Sensors	3	1	STT	1000			1.00E-06	0	0.4
Drive-R						BSM Chopper Sensors	2	1	STP	1000			1.00E-06	0	
						BSM Jiggle Sensors	3	1	STT	1000			1.00E-06	0	
						BSM Jiggle Sensors	2	1	STP	1000			1.00E-06	0	
						BSM Temperature	4	1	STQ	1000			1.00E-06	0	
						Photometer Stimulus Heater	4	2	STP	10			7.00E-03	0	
						BSM Launch latch sense	2	1	STP	1000			1.00E-03	0	
						BSM Launch latch solenoid	2	1	STT	10			3.50E-02	0	
						BSM Chop motor drive	4	1	STQ	10			3.00E-02	0	
						BSM Jiggle motor drive	4	1	STQ	10			4.00E-02	0	
		HSFPU J28	MDM 37 S	HSFPU P28	MDM 37P	SMEC Thermometry	8	2	STQ	1000			1.00E-06	0	
						SMEC LVDT Primary	2	1	STP	5			5.00E-03	0	5
						SMEC LVDT Secondary	4	2	STP	5			5.00E-05	0	15
						SMEC Launch Latch	4	2	STP	5			4.00E-01	0	15
						SMEC Launch Latch (Rob.)	4	2	STP	5			4.00E-01	0	15
						SMEC Launch Latch Confirm	4	2	STP	5			1.00E-03	0	15
		HSFPU J30	MDM 37 S	HSFPU P30	MDM 37P	SMEC Drive Coil	2	1	STP	5			1.00E-01	0	15
						SMEC Drive (Rob.)	2	1	STP	5			1.00E-01	0	15
						SMEC Drive coil voltage sensor	2	1	STP	500			1.00E-05	0	15
						SMEC Position sensor supplies	2	1	STP	100			1.00E-03	0	5
						SMEC LED Power	2	1	STP	100			1.00E-03	0	5
						SMEC Position sensor photodiodes	6	3	STP	1000			2.00E-05	0	5
						SMEC Position sensor photodiodes FB	6	3	STP	1000			1.00E-05	0	5
						FPU Faraday Shield Link#			#	50		0.01uH			
# There are three options			a. Several wires from CVV connector contacts to FPU system backshells as presently instructed by Alcatel												
to implement these links:			b. A >80% overshield braid joined to FPU system backshells, isolated from CVV and tailed on to CVV connector contacts												
				to be compliant with SPIRE's grounding scheme, be the same as the Calibration harness, and as required by SPIRE											
			c. A >80% overshield braid joined to FPU system backshells, isolated from CVV except where joined to the CVV connector backshells,												
				with FPU Faraday Shield link contacts left unpopulated.											

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	DRCU Connector Label	DRCU Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
I1/S1	CVV 1	DCU J27	DCMA37 P	DCU P27	DCMA 37S	Bolometer signals from JFS (SLW 1-12)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
Type3						SLW Ground	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J28	DCMA37 P	DCU P28	DCMA 37 S	Bolometer signals from JFS (SLW13-24)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
						SLW Ground	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J31	DCMA 37S	DCU P31	DCMA 37 P	300-mK TC Bias	2	1	STP	100	1500pF	0.08uH	3.20E-08	8.00E-09	10
						300-mK Ground wire	1	0	S	50	1500pF	0.08uH	0	0	10
						300-mK JFET Bias	2	1	STP	100	1500pF	0.08uH	5.00E-03	2.00E-04	10
						SLW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	9.60E-08	2.40E-08	10
						SLW JFET Bias	4	2	STP	100	1500pF	0.08uH	2.50E-03	6.00E-04	10
						SLW Ground wire	1	0	S	50	1500pF	0.08uH	0	0	10
						SSW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	1.20E-03	4.80E-08	10
						SSW JFET Bias	4	2	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						SSW Ground Wire	1	0	S	50	1500pF	0.08uH	0	0	10
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0
						300-mK TC JFET Heater	2	1	STP	200	1500pF	0.08uH	1.92E-03	4.81E-04	10
						SLW JFET Heater	2	1	STP	200	1500pF	0.08uH	3.33E-03	8.33E-04	10
						SSW JFET Heater	2	1	STP	200	1500pF	0.08uH	6.67E-03	1.67E-03	10
		DCU J32	DCMA 37S	DCU P32	DCMA 37 P	300-mK TC Bias	2	1	STP	100	1500pF	0.08uH	3.20E-08	8.00E-09	10
						300-mK Ground wire	1	0	S	50	1500pF	0.08uH	0	0	10
						300-mK JFET Bias	2	1	STP	100	1500pF	0.08uH	5.00E-03	2.00E-04	10
						SLW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	9.60E-08	2.40E-08	10
						SLW JFET Bias	4	2	STP	100	1500pF	0.08uH	2.50E-03	6.00E-04	10
						SLW Ground wire	1	0	S	50	1500pF	0.08uH	0	0	10
						SSW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	1.20E-03	4.80E-08	10
						SSW JFET Bias	4	2	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						SSW Ground Wire	1	0	S	50	1500pF	0.08uH	0	0	10
						FPU Faraday Shield Link	1	9	S	50	1500pF	0.08uH	0	0	10
						300-mK TC JFET Heater	2	1	STP	200	1500pF	0.08uH	1.92E-03	4.81E-04	10
						SLW JFET Heater	2	1	STP	200	1500pF	0.08uH	3.33E-03	8.33E-04	10
						SSW JFET Heater	2	1	STP	200	1500pF	0.08uH	6.67E-03	1.67E-03	10
		Shields*				RF Overshield			>80%			0.01			
I2/S2	CVV 2	DCU J23	DCMA37 P	DCU P23	DCMA 37 S	Bol.signals from JFS (SSW 1-8, 300mK TC 1-3#)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
Type4						FPU Faraday Shield Link	1	0	Single	50	1500pF	0.08uH	0.0	0.0	0.1
		DCU J24	DCMA37 P	DCU P24	DCMA 37 S	Bolometer signals from JFS (SSW 9-20)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
						SSW Ground Wire	1	0	Single	50	1500pF	0.08uH	0.0	0.0	0.1
		DCU J25	DCMA37 P	DCU P25	DCMA 37 S	Bolometer signals from JFS (SSW21-32)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
						FPU Faraday Shield Link	1	0	Single	50	1500pF	0.08uH	0.0	0.0	0.1
		DCU J26	DCMA37 P	DCU P26	DCMA 37 S	Bolometer signals from JFS(SSW 33-44)	24	12	STP	500	1500pF	0.08uH	1.00E-09	5.00E-10	0.1
						SSW Ground Wire	1	0	Single	50	1500pF	0.08uH	0.0	0.0	0.1
		Shields*				RF Overshield			>80%			0.01			
I3/S3	CVV 3	DCU J29	DDMA 78S	DCU P29	DDMA 78 P	PSW JFET Bias	12	6	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
Type2						PSW Ground	1	0	S	50	1500pF	0.08uH	0	0	10
						PSW Bolometer Bias	6	3	STP	100	1500pF	0.08uH	3.84E-07	9.60E-08	10
						PSW Heater	6	3	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0
						PMW JFET Bias	8	4	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						PMW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	3.84E-07	9.60E-08	10
						PMW Ground	1	0	S	50	1500pF	0.08uH	0	0	10
						PMW JFET Heater	4	2	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						PLW JFET Heater	2	1	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						PLW JFET Bias	4	2	STP	1000	1500pF	0.08uH	5.00E-03	1.20E-03	10
						PLW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	1.92E-07	4.80E-08	10

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	DRCU Connector Label	DRCU Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements			Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
										R (W)	C(pF)	L(uH)			
						PLW Ground	1	0	S	50	1500pF	0.08uH	0	0	10
		DCU J30	DDMA 78S	DCU P30	DDMA 78 P	PSW JFET Bias	12	6	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						PSW Ground	1	0	S	50	1500pF	0.08uH	0.00E+00	0.00E+00	10
						PSW Bolometer Bias	6	3	STP	100	1500pF	0.08uH	0.0	0.0	10
						PSW Heater	6	3	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0.0	0.0	0
						PMW JFET Bias	8	4	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						PMW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	3.84E-07	9.60E-08	10
						PMW Ground	1	0	S	50	1500pF	0.08uH	0	0	10
						PMW JFET Heater	4	2	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						PLW JFET Heater	2	1	STP	200	1500pF	0.08uH	3.85E-03	9.62E-04	10
						PLW JFET Bias	4	2	STP	100	1500pF	0.08uH	5.00E-03	1.20E-03	10
						PLW Bolometer Bias	4	2	STP	100	1500pF	0.08uH	1.92E-07	4.80E-08	10
						PLW Ground	1	0	S	50	1500pF	0.08uH	0	0	10
		Shields*				RF Overshield			>80%			0.01			
I4/S4	CVV 4	DCU J20	DDMA 50 P	DCU P20	DDMA 50 S	16 ch. PMW (1-16)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	1	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J21	DDMA 50 P	DCU P21	DDMA 50 S	16 ch. PMW (17-32)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	1	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J22#	DDMA 50 P	DCU P22	DDMA 50 S	16 ch. PMW (33-48)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	1	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I5/S5	CVV 5	DCU J17	DDMA 50 P	DCU P17	DDMA 50 S	16 ch. PMW (49-64)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J18	DDMA 50 P	DCU P18	DDMA 50 S	16 ch. PMW (65-80)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J19	DDMA 50 P	DCU P19	DDMA 50 S	16 ch. PMW (81-96)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I6/S6	CVV 6	DCU J14	DDMA 50 P	DCU P14	DDMA 50 S	16 ch. PLW (1-16)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J15	DDMA 50 P	DCU P15	DDMA 50 S	16 ch. PLW (17-32)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J16	DDMA 50 P	DCU P16	DDMA 50 S	16 ch. PLW (33-48)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I7/S7	CVV 7	DCU J11	DDMA 50 P	DCU P11	DDMA 50 S	16 ch. PSW (1-16)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J12	DDMA 50 P	DCU P12	DDMA 50 S	16 ch. PSW (17-32)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J13	DDMA 50 P	DCU P13	DDMA 50 S	16 ch. PSW (33-48)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	DRCU Connector Label	DRCU Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I8/S8	CVV 8	DCU J8	DDMA 50 P	DCU P8	DDMA 50 S	16 ch. PSW (49-64)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J9	DDMA 50 P	DCU P9	DDMA 50 S	16 ch. PSW (65-80)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J10	DDMA 50 P	DCU P10	DDMA 50 S	16 ch. PSW (81-96)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I9/S9	CVV 9	DCU 5	DDMA 50 P	DCU P5	DDMA 50 S	16 ch. PMW (97-112)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J6	DDMA 50 P	DCU P6	DDMA 50 S	16 ch. PMW (113-128)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J7	DDMA 50 P	DCU P7	DDMA 50 S	16 ch. PMW (129-144)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I10/S10	CVV 10	JA	12/35	Blanking cover		Shutter Vane Position Sensor	2	1	STP	1000			1.0E-02	0	
Aux-P		On SVM Bracket not DRCU				Shutter Latch Position Sense/Confirm	2	1	STP	1000			1.0E-02	0	10
						Shutter Temperature Sensor Bias	2	1	STP	1000			1.0E-05		
						Shutter Temperature Signals	3	1	STT	1000			1.0E-06		
						Shutter Latch Drive/Heaters	3	1	STT	10			1.5E-01	0	
						Shutter Motor Drive	3	1	STT	10			1.5E-01	0	
		FCU J11	DBMA 25 S	FCU P11	DBMA 25 P	Sorption Pump Heater	4	0	TQ	10			2.50E-02	6.25E-03	
						Heat switch heaters	8	0	TQ	50			1.50E-03	3.75E-04	
						300mK Thermal Control Heater	4	1	STQ	100			2.00E-03	5.00E-04	
						Spectrometer Stimulus Heater 4%	4	0	TQ	30			9.00E-03	2.25E-03	
						Spectrometer Stimulus Heater 2%	4	0	TQ	30			7.00E-03	1.75E-03	
		FCUJ23	DDMA 50 S	FCU P23	DAMA 50 P	FPU Thermometry A	44	11	STQ	1000			1.00E-06	1.00E-06	
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	
		FCUJ25	DAMA 15 S	FCU P25	DAMA 15 P	FPU Thermometry B	12	3	STQ	1000			1.00E-06	1.00E-06	
		Shields*				RF Overshield			>80%			0.01			
I11/S11	CVV 11	JB on SVB	10/35	Blanking cover		Mechanisms Launch Lock Confirm	6	3	STP	1000			0	0	
Drive-P		FCU J21	DAMA 15 S	FCU P21	DAMA 15 P	FPU Thermometry C	12	3	STQ	1000			1.00E-06	1.00E-06	
		FCU J19	DCMA 37 S	FCU P19	DCMA 37 P	BSM Chop/Jiggle Sensors	4	2	STP	1000			1.00E-06	1.00E-06	0.4
						BSM Chop/Jiggle Sensors	6	2	STT	1000			1.00E-06	1.00E-06	
						BSM Launch latch sense	2	1	STP	1000			1.00E-03	0.00E+00	
						BSM Launch latch solenoid	2	1	STP	10			3.50E-02	0.00E+00	
						BSM Chop motor drive	4	1	STQ	10			3.00E-02	1.00E-02	
						BSM Jiggle motor drive	4	1	STQ	10			4.00E-02	2.50E-03	
		FCU J29	DCMA 37 P	FCU P29	DCMA 37 S	SMEC LVDT Primary	2	1	STP	5			5.00E-03	2.50E-03	
						SMEC LVDT Secondary	4	2	STP	50			5.00E-05	5.00E-05	
						SMEC Launch Latch1	4	2	STP	5			4.00E-01		
						SMEC Launch Latch1 Confirm	2	1	STP	5			1.00E-03		
						SMEC Launch Latch2	4	2	STP	5			4.00E-01		
						SMEC Launch Latch2 Confirm	2	1	STP	5			1.00E-03		
		FCU J17	DCMA 37 S	FCU P17	DCMA 37 P	SMEC Drive Coil	2	1	STP	5			1.00E-01	4.00E-02	
						SMEC Drive Coil (Rob.)	2	1	STP	5			1.00E-01	4.00E-02	

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	DRCU Connector Label	DRCU Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I8/S8	CVV 8	DCU J8	DDMA 50 P	DCU P8	DDMA 50 S	16 ch. PSW (49-64)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J9	DDMA 50 P	DCU P9	DDMA 50 S	16 ch. PSW (65-80)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J10	DDMA 50 P	DCU P10	DDMA 50 S	16 ch. PSW (81-96)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I9/S9	CVV 9	DCU 5	DDMA 50 P	DCU P5	DDMA 50 S	16 ch. PMW (97-112)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
Type1						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J6	DDMA 50 P	DCU P6	DDMA 50 S	16 ch. PMW (113-128)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		DCU J7	DDMA 50 P	DCU P7	DDMA 50 S	16 ch. PMW (129-144)	32	16	STP	500	1500pF	0.08uH	1.00E-09	5E-10	0.1
						Ground Wire	2	0	S	50	1500pF	0.08uH	0	0	0.1
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	0.1
		Shields*				RF Overshield			>80%			0.01			
I10/S10	CVV 10	JA	12/35	Blanking cover		Shutter Vane Position Sensor	2	1	STP	1000			1.0E-02	0	
Aux-P		On SVM Bracket not DRCU				Shutter Latch Position Sense/Confirm	2	1	STP	1000			1.0E-02	0	10
						Shutter Temperature Sensor Bias	2	1	STP	1000			1.0E-05		
						Shutter Temperature Signals	3	1	STT	1000			1.0E-06		
						Shutter Latch Drive/Heaters	3	1	STT	10			1.5E-01	0	
						Shutter Motor Drive	3	1	STT	10			1.5E-01	0	
		FCU J11	DBMA 25 S	FCU P11	DBMA 25 P	Sorption Pump Heater	4	0	TQ	10			2.50E-02	6.25E-03	
						Heat switch heaters	8	0	TQ	50			1.50E-03	3.75E-04	
						300mK Thermal Control Heater	4	1	STQ	100			2.00E-03	5.00E-04	
						Spectrometer Stimulus Heater 4%	4	0	TQ	30			9.00E-03	2.25E-03	
						Spectrometer Stimulus Heater 2%	4	0	TQ	30			7.00E-03	1.75E-03	
		FCUJ23	DDMA 50 S	FCU P23	DAMA 50 P	FPU Thermometry A	44	11	STQ	1000			1.00E-06	1.00E-06	
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	
		FCUJ25	DAMA 15 S	FCU P25	DAMA 15 P	FPU Thermometry B	12	3	STQ	1000			1.00E-06	1.00E-06	
		Shields*				RF Overshield			>80%			0.01			
I11/S11	CVV 11	JB on SVB	10/35	Blanking cover		Mechanisms Launch Lock Confirm	6	3	STP	1000			0	0	
Drive-P		FCU J21	DAMA 15 S	FCU P21	DAMA 15 P	FPU Thermometry C	12	3	STQ	1000			1.00E-06	1.00E-06	
		FCU J19	DCMA 37 S	FCU P19	DCMA 37 P	BSM Chop/Jiggle Sensors	4	2	STP	1000			1.00E-06	1.00E-06	0.4
						BSM Chop/Jiggle Sensors	6	2	STT	1000			1.00E-06	1.00E-06	
						BSM Launch latch sense	2	1	STP	1000			1.00E-03	0.00E+00	
						BSM Launch latch solenoid	2	1	STP	10			3.50E-02	0.00E+00	
						BSM Chop motor drive	4	1	STQ	10			3.00E-02	1.00E-02	
						BSM Jiggle motor drive	4	1	STQ	10			4.00E-02	2.00E-02	
		FCU J29	DCMA 37 P	FCU P29	DCMA 37 S	SMEC LVDT Primary	2	1	STP	5			5.00E-03	2.50E-03	
						SMEC LVDT Secondary	4	2	STP	50			5.00E-05	5.00E-05	
						SMEC Launch Latch1	4	2	STP	5			4.00E-01		
						SMEC Launch Latch1 Confirm	2	1	STP	5			1.00E-03		
						SMEC Launch Latch2	4	2	STP	5			4.00E-01		
						SMEC Launch Latch2 Confirm	2	1	STP	5			1.00E-03		
		FCU J17	DCMA 37 S	FCU P17	DCMA 37 P	SMEC Drive Coil	2	1	STP	5			1.00E-01	4.00E-02	
						SMEC Drive Coil (Rob.)	2	1	STP	5			1.00E-01	4.00E-02	

External Harness – Data taken from ECR-029 / TBC

Name	128 Way Connector	DRCU Connector Label	DRCU Connector Type	Mating Harness Conn.Label	Mating Harness Conn.Type	Description	# Conductors excl. shlds	# Inner Shields	Implementation	Max. Impedance Requirements R (W)	C(pF)	L(uH)	Max.Current in A per Conductor	Av. Curent in A per Conductor	Max. Volts
						SMEC Drive coil voltage sensor	2	1	STP	500			1.00E-05		
						SMEC Position sensor supplies	4	2	STP	100			1.00E-03		
						SMEC Position sensor photodiodes	6	3	STP	1000			2.00E-05		
						SMEC Position sensor photodiodes FB	6	3	STP	1000			1.00E-05		
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	
		FCU J13	DEMA 9 S	FCU P13	DEMA 9P	P-Cal Heater	4	2	STP	10			7.00E-03	1.75E-03	
		Shields*				RF Overshield			>80%			0.01			
I12/S12	CVV 12	JC	12/35	Blanking cover		Shutter Vane Position Sensor	2	1	STP	1000			1.00E-02	0	
Aux-R		On SVM Bracket not DRCU				Shutter Latch Position Sense/Confirm	2	1	STP	1000			1.00E-02	0	10
						Shutter Temperature Sensor Bias	2	1	STP	1000			1.00E-05		
						Shutter Temperature Signals	3	1	STT	1000			1.00E-06		
						Shutter Latch Drive/Heaters	3	1	STT	10			1.50E-01	0	
						Shutter Motor Drive	3	1	STT	10			1.50E-01	0	
		FCU J12	DBMA 25 S	FCU P12	DBMA 25 P	Sorption Pump Heater	4	0	TQ	10			2.50E-02	0	
						Heat switch heaters	8	0	TQ	50			1.50E-03	0	
						300mK Thermal Control Heater	4	1	STQ	100			2.00E-03	0	
						Spectrometer Stimulus Heater 4%	4	0	TQ	30			9.00E-03	0	
						Spectrometer Stimulus Heater 2%	4	0	TQ	30			7.00E-03	0	
		FCUJ24	DDMA 50 S	FCU P24	DDMA 50 P	FPU Thermometry A	44	11	STQ	1000			1.00E-06	0	
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	
		FCUJ26	DAMA 15 S	FCU P26	DAMA 15 P	FPU Thermometry B	12	3	STQ	1000			1.00E-06	0	
		Shields*				RF Overshield			>80%			0.01			
I13/S13	CVV 13	JD on SVB	10/35	Blanking cover		Mechanisms Launch Lock Confirm	6	3	STP	1000			0.00E+00	0	
Drive-R		FCU J22	DAMA 15 S	FCU P22	DAMA 15 P	FPU Thermometry C	12	3	STQ	1000			1.00E-06	0	
		FCU J20	DCMA 37 S	FCU P20	DCMA 37 P	BSM Chop/Jiggle Sensors	4	2	STP	1000			1.00E-06	0	0.4
						BSM Chop/Jiggle Sensors	6	2	STT	1000			1.00E-06	0	
						BSM Launch latch sense	2	1	STP	1000			1.00E-03	0	
						BSM Launch latch solenoid	2	1	STP	10			3.50E-02	0	
						BSM Chop motor drive	4	1	STQ	10			3.00E-02	0	
						BSM Jiggle motor drive	4	1	STQ	10			4.00E-02	0	
		FCU J30	DCMA 37 P	FCU P30	DCMA 37 S	SMEC LVDT Primary	2	1	STP	5			5.00E-03	0	
						SMEC LVDT Secondary	4	2	STP	5			5.00E-05	0	
						SMEC Launch Latch1	4	2	STP	5			4.00E-01	0	
						SMEC Launch Latch1 Confirm	2	1	STP	5			1.00E-03	0	
						SMEC Launch Latch2	4	2	STP	5			4.00E-01	0	
						SMEC Launch Latch2 Confirm	2	1	STP	5			1.00E-03	0	
		FCU J18	DCMA 37 S	FCU P18	DCMA 37 P	SMEC Drive Coil	2	1	STP	5			1.00E-01	0	
						SMEC Drive Coil (Rob.)	2	1	STP	5			1.00E-01	0	
						SMEC Drive coil voltage sensor	2	1	STP	500			1.00E-05	0	
						SMEC Position sensor supplies	4	2	STP	100			1.00E-03	0	
						SMEC Position sensor photodiodes	6	3	STP	1000			2.00E-05	0	
						SMEC Position sensor photodiodes FB	6	3	STP	1000			1.00E-05	0	
						FPU Faraday Shield Link	1	0	S	50	1500pF	0.08uH	0	0	
		FCU J14	DEMA 9S	FCU P14	DEMA 9P	P-Cal Heater	4	2	STP	10			7.00E-03	0	
		Shields*				RF Overshield			>80%			0.01			

5.10.2 Grounding

To fulfil Spire's grounding requirements, the HSFPU and both of the JFET racks need to be electrically isolated from the Optical Bench, at their mechanical mounting points. The same applies to the bolometer system harness screens.

SPIRE grounding diagram provided in the figure below is for information only, and shall not represent any requirements on the spacecraft.

Update figure if available

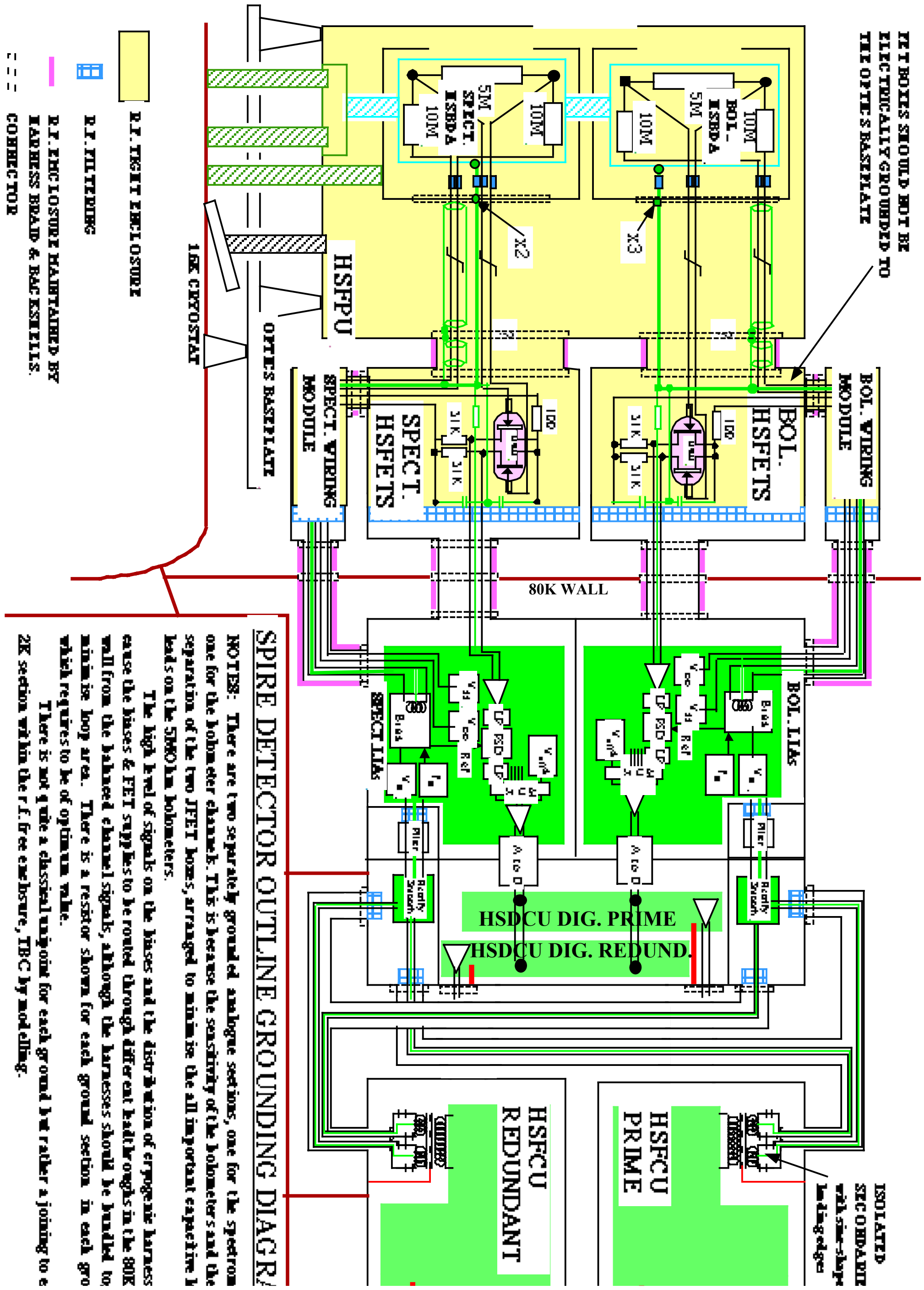


Figure 5.10-2 : SPIRE Grounding scheme

The Spire FCU itself and the DPU use a "standard" ESA-type secondary power system, whereas the DCU/FPU and FCU supply sections shown above are an optimised system w.r.t. minimising the overall bolometer analogue ground noise. The FCU powers the DCU, keeping the latter free of conditioning noise. The FCU driven items in the FPU, see figure 5.2.1, are considered less critical and will all be Ohmically grounded in the FCU.

5.10.3 Bonding

It is understood that Herschel bonding applies to harness shields used to maintain closed Faraday cages. Bonded interfaces shall not be used as routine current return paths.

We note that presently all Warm Electronics units rely in conductivity via their mechanical mounting feet to S/C. Spire would much prefer a formal S/C aluminium strap bonding tree, coupled by controlled straps to all equipment, and will therefore provide a bonding strap mounting point on each SVM mounted unit to permit this.

5.10.4 Electrical Signal Interfaces

5.10.4.1 1553 Data Buses

The 4 interfaces to the two (prime and redundant) buses between the Spire instrument DPUs and the CDMU shall conform to MIL-STD-1553B, with the CDMU controlling the bus.

The 4 Spire interfaces shall have unique bus addresses, consistent with Herschel properly controlling the use of Prime and Redundant equipment.

A long stub configuration shall be used for each of the 4 interfaces, one transformer for each stub in the bus wiring and one in the instrument I/F.

Connector use is as follows:

DPU Connector	Prime Bus	Redundant Bus
Prime DPU	J3	J4
Redundant DPU	J5	J6

5.10.4.2 Master Clock

Herschel shall supply 2 differential signal lines of 2^{17}Hz. master clock signals. They are therefore supplied unground-referenced. These are shown as brown lines in figure 5.2.1.

Electrical interface details are standard digital differential receiver, through DPU connectors J3 and 5, i.e. bundled with primary 1553 bus.

This shall be supplied to both powered and un-powered Spire HSDPUs.

Note that Herschel arranges the OR-ing of the functions over Prime and Redundant CDMU so that Spire is unaffected by which one is active.

S/C wide synchronisation of dc-dc converters, will NOT be implemented.

5.10.4.3 Launch confirmation

Spire has three cryogenic mechanisms: BSM; SMEC; shutter. It is baselined that each will need to be launch-locked and that their latching will need to be confirmed after launch stack integration. All functions are Prime and Redundant.

During launch preparations, hand-held Spire provided EGSE will require cable access to the four connectors JA-JD shown in the Harness Configuration drawing.

Connector blanking plugs PA-PD that inter-connect connector contacts as defined by Spire will be HERSCHEL provided and fitted whenever the EGSE is not connected, which includes in flight.

Until timing and physical access details for the days before launch are better defined, industry cannot confirm that this section's requirements can be met or provide details of the access that can be afforded to Spire

5.11 DATA HANDLING

5.11.1 Telemetry

5.11.1.1 Telemetry rate

The instrument produced “raw” housekeeping and science data rates, given for information purposes, are as follows:

Description	**Data rate (Kbps)**
Housekeeping data rate (non-prime)	2.1
Housekeeping data rate (prime)	2
Science data rate: Photometer only	93.6
Science data rate: Spectrometer only	97.4
Science data rate: Parallel mode	10
Science data rate: Serendipity mode	87

Any increase in telemetry rate would have science benefits. Note that the data rate allocation of 100Kbps is a limit on the average including orbit recycling/commanding periods

5.11.1.2 Data-bus rate

For the purpose of possible (up to 5 minutes) higher instrument data-rates, the bus interconnecting the instrument and the HCDMU shall have the capability of handling a telemetry rate of > 200 kbps. This will allow for the rapid emptying of Spire on-board data storage units at the end of each observation, thus keeping overheads due to data transfer to a minimum.

5.11.1.3 Data Packets

Spire is capable of buffering 10 seconds of data at 100kps. In order to prevent data overflow in this Spire data storage, the HVDMU shall request packets from Spire at least as frequently as once per second(TBC).

5.11.2 S/C housekeeping

The S/C should be capable of collecting and range checking the following instrument parameters every minute. It shall provide a data packet to the ground that includes these housekeeping values, together with any range violations and any actions taken thereon.

Voltages to instrument

Currents to instrument

Power status – i.e. which Spire units are on i.e. HSDPU and HSDRC.

Requested temperatures in Section 5.7.5.2.

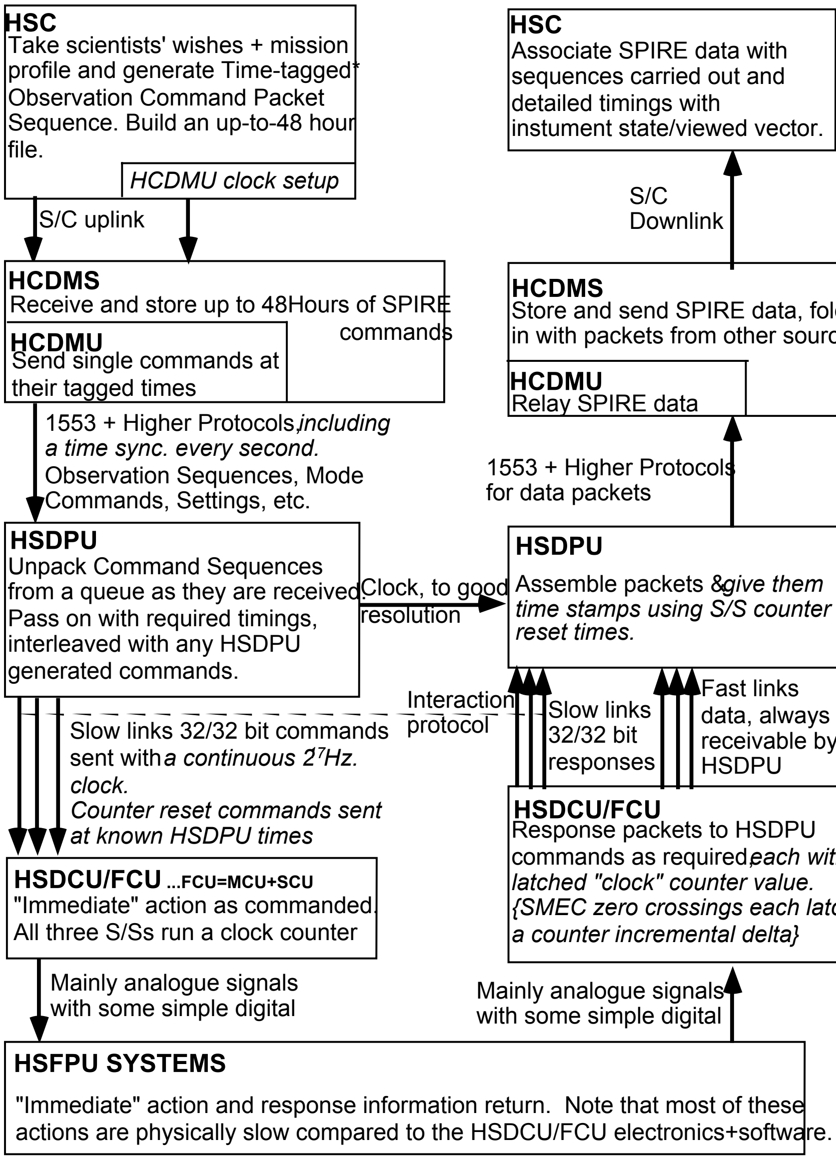
5.11.3 Timing and synchronisation signals

The S/C shall provide Spire with a timing synchronisation at least once per 24 hours to allow cross reference or synchronisation of the Spire clock to the spacecraft clock.

Spire requires to be able to deduce where Herschel is pointing to 0.1 of its smallest pixel IFOV. So when using the telescope scan mode, a “start of scan” indication will be sent be to the DPU to give a timing precision of better than 5 milliseconds, although the actual UT of the pulse only needs to be within one second of its planned time. This is required so that the Spire data can be located in time and correctly ground processed to link to Herschel attitude; it is not required for the operation of the Spire instrument.

The Spire instrument typically works by its DPU unpacking S/C commands to a lower level, and sending those lower level commands to the DCU and FCU with timings that they can guarantee to keep up with. There is a minimum of handshaking on internal interfaces and, for instance, the DPU has to be ready to receive science data packets from the DPU and FCU whenever they reasonably send them. In these internal data packet headers are counter values permitting accurate datation of all values back to sequence start pulses sent from the DPU. The scheme can be viewed as:

SPIRE DATA TIMINGS



*This process uses known worst case timings for SPIRE operation + margin to ensure that the plan can be implemented and timed starts will not slip.

Note that for the above scheme to work, either the DCU/MCU/SCU need to have no input FIFOs, or the DPU needs to know that they are empty and a reset will go straight through, or these units need to check for the reset pulse in hardware before feeding other packets into a FIFO. TBD.

5.11.4 Telecommand

It is assumed that the observation schedule for each 24 hour period will be uplinked during the data transfer and commanding phase (DTCP). It is further assumed that the correct receipt of all Spire commands is verified by the S/C during the DTCP.

The maximum rate of sending command packets from the CDMS to the Spire instrument is less than 10 per second.

The maximum telecommand packet length is 256 octets.

All Spire telecommands are defined in document AD (tbd).

5.12 ATTITUDE AND ORBIT CONTROL/POINTING

5.12.1 Attitude and orbit control

For information, Spire has the following **instrument** pointing modes:

- Peak up mode. The ACMS pointing ability quoted in the IID-A (3.7 arcsec APE – see also section 5.12.2) will not be good enough to prevent unacceptable signal loss when observing point sources with the photometer or spectrometer. The Spire beam steering mirror will be used to perform a cruciform raster over the observation target and the offset between the required pointing and the actual pointing of the telescope will be provided via an ACMS Data Packet from the Spire instrument to the S/C. The S/C will then adjust the pointing accordingly.
- Nodding mode. If the telescope temperature stability time constant proves to be short compared with a typical pointed observation with Spire; then the telescope must be capable of being pointed to another fixed position on the sky between 10 arcsec and 4 arcmin from the original pointing in an arbitrary direction with respect to the spacecraft axes. The settling time at each re-pointing must be less than 10 seconds
- Line scan mode. To map large areas of the sky, the telescope must be capable of being scanned up to 20 degrees at a constant rate in an arbitrary orientation with respect to the spacecraft axes. The rate of scan must be variable between 0.1 arcsec/sec and 60 arcsec per second. It is expected that the RPE will be maintained in the orthogonal direction during the scan. The S/C must be capable of reaching any scan speed up to the maximum within 20 seconds of the observation commencing.
- Raster mode. To finely sample the Spire FOV the instrument beam steering mirror will be used to step the FOV across the sky in an arbitrary direction. The step size will be between 1.7 (to be agreed, current value is 2) arcsec and 30 arcsec. The beam steering mirror can also be used to chop a portion of the Spire FOV at a rate up to 2 Hz.
- The S/C is specified as being able to perform its own raster mode, i.e. stepping the FOV of the overall Herschel telescope view to follow predetermined patterns. This is acknowledged to be much less efficient than using the internal Beam Steering Mirror (BSM), but is needed as a backup in the event of Spire BSM failure. The spacecraft shall be capable of performing a rectangular raster with steps of between 1.7 and 30 arcsec in any arbitrary orientation with respect to the S/C axes.
- To map extended regions using the spectrometer, the Spire instrument will use the Herschel telescope Normal Raster Mode. The instrument may perform fine sampling of each raster pointing using its internal BSM.

5.12.2 Pointing

The Spire instrument requires an absolute pointing error of better than 1.5 arcsec r.m.s. (TBC), and a relative pointing error of better than 0.3 arcsec r.m.s. per minute.

This is achieved by the peak up mode in case the pointing goal values are not fully achieved by the S/C.

5.12.3 On-Target Flag (OTF)

SPIRE agreed during the convergence meeting not to request this, given the information is provided on ground, and the IID-A specifies how.

For pointed observations, within about a second of an acquisition being achieved an On-Target Flag will be provided from the platform to Spire as a message on the1553 bus, specifying the acquisition time to a precision of better than 0.1 second. This is required for the correct processing of the Spire data on the ground; it is not required for Spire operations.

5.13 ON-BOARD HARDWARE/SOFTWARE AND AUTONOMY FUNCTIONS

5.13.1 On-board hardware

There is a single on-board computer in each of the prime and redundant SPIRE HSDPUs. Each HSDPU shall have a different 1553 address. The HSDPUs have the only non-hard-coded on-board software used in SPIRE.

5.13.2 On-board software

It is assumed that the Spire warm electronics will remain powered during all operational phases. The DPU will download baseline software from ROM during power up but some additional software may be required (TBD) to be unlinked before observations commence, either patches or whole modules/objects.

No single instrument command nor any sequence of instrument commands will constitute a hazard for the instrument so the HSDPU is required to trap out any such situations. For the same reason, the HSDPU shall ensure its own correct function, at least as far as checking memory function in the background, check-summed read only areas, and an inhibitable SEU safing capability.

5.13.3 Autonomy functions

The S/C must be capable of automatic monitoring all Spacecraft Housekeeping parameters, i.e. the parameters listed in section 5.7.5.3 when the S/C is not in ground contact.

The S/C must be capable of taking predefined action – e.g. switching off the power to the Spire instrument - when an error or hard limit is detected in the SPIRE S/C housekeeping.

The S/C must be capable of receiving and interpreting Spire “Event Data” packets that will alert the S/C of errors or hard limits detected by the Spire DPU autonomy monitoring software. Again the S/C must be capable of taking the appropriate pre-defined action on detecting an error alert in the Spire Event Data.

5.13.4 Instrument Autonomy Housekeeping Packet Definition

N.A.

5.13.5 Instrument Event Packet Definition

TBD

5.14 EMC

5.14.1 Conducted Emission/Susceptibility

None to be found under required test conditions

5.14.2 Radiated Emission/Susceptibility

None to be found under required test conditions

5.14.3 Frequency Plan

The original specification for Spire to have all its internal oscillators for signal/power synchronised to S/C sync. signals has been dropped.

The Spire frequencies are arranged to minimise noise problems in the bolometer sub-system's highly sensitive analogue sections, and are provided in the following table.

SPIRE Unit	Frequency Source - subsystem	Frequency Range		Wave-form	Signal level(s)		Comments
		Lower	Upper				
DCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422 – Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	10 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	Bolometer Bias	50 Hz	300 Hz	Sine	0	100 mV	Differential – Highly sensitive signal
	T/C Bias	50 Hz	300 Hz	Sine	0	500 mV	Differential – Highly sensitive signal
MCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422- Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	40 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	DSP Clock	20 MHz		Rect		5 V	Master clock / 2 Internal to unit
	LVDT excitation	2.5 kHz		Sine		3 V	Differential +/- 20 %
	DAC change	3.0 kHz	10 kHz	Rand.		10 V	Internal to unit
	Position encoder	0	2.5 kHz	Sine		3 mV	Differential 250 Hz at nominal speed
SCU	Cmd IF Clock	312 kHz		Rect.	0	5 V	Differential RS422- Continuous
	Data IF Clock	1MHz	2.5 MHz	Rect	0	5 V	Differential RS422
	Master Clock	10 MHz		Rect		5 V	Crystal Oscillator – Internal to unit
	300 mK TS Bias	20 Hz		Rect		6 mV	Tr/Tf = 1ms Highly sensitive signal
	Photo Stimulus	0	5 Hz	Rect			
PSU	DC/DC switching frequency	131 kHz TBC					Free runing - ± 10% - internal to unit

5.15 Transport and Handling Provisions

5.15.1 Focal Plane Unit

For reasons of possible damage caused by vibration during transport, environmental testing and launch, mechanisms shall be transported in their launch-latched state.

5.15.1.1 Transport Container

The Spire FPU (HSFPU) will be transported in a clean hermetically sealed container to be opened only in class 100 clean conditions (TBC) with less than 50% humidity (TBC).

The maximum shock the HSFPU can sustain in any direction is (TBD). The transport container is fitted with shock recorders and internal humidity monitors. The HSFPU transport container is shown in figure TBD.

5.15.1.2 Cooling and Pumping restrictions

During cryostat warm-up or cool-down phases the rate of temperature change dT/dt shall not exceed 10 K/hour (TBC). The rate of depressurisation/pressurisation dP/dt shall not exceed 50 mBar/minute (TBC).

5.15.1.3 Mechanism positions

For reasons of possible damage caused by vibration during transport, environmental testing and launch, mechanisms shall be placed in the TBD position. This position is shown in table TBD.

5.15.1.4 Unpacking Procedure

The procedure for removing and installing the HSFPU from its transport container is given in document TBW

5.15.2 JFET/Filter Boxes

5.15.2.1 Transport Container

The Spire JFET/Filter Boxes (HSFTP/S) will be transported in a clean hermetically sealed container to be opened only in class 100 clean conditions (TBC) with less than 50% humidity (TBC).

The maximum shock the HSFTP/S can sustain in any direction is (TBD). The transport container is fitted with shock recorders and internal humidity monitors. The HSFTP/S transport container is shown in figure TBD.

5.15.2.2 Unpacking Procedure

The procedure for removing and installing the HSFTP/S from its transport container is given in document TBW

5.15.3 Electronics Units

5.15.3.1 Transport Container

The Spire warm electronics units (HSDPU; HSFCU; HSDCU, HSWIH) will be transported in clean hermetically sealed containers to be opened only in class 100 000 clean conditions (TBC) with less than 75% humidity (TBC).

The maximum shock any of the warm electronics units can sustain in any direction is (TBD). The transport containers are fitted with shock recorders and internal humidity monitors. The Spire warm electronics transport containers are shown in figure TBD.

5.15.3.2 Unpacking Procedure

The procedures for removing and installing the Spire from warm electronics units their transport containers are given in document TBW

5.16 DELIVERABLE ITEMS

5.16.1 Instrument Models.

The model philosophy to be adopted for the AIV of the Herschel Spire instrument will be in accordance with the Spire Development Plan and Model Philosophy, AD (tbd).

In outline, the instrument models to be produced are:

AVM – The Avionics Model shall permit us "…to validate electronics and software for its interface with the S/C, including anything that exchanges information with, for example, the AOCS. In addition all tasks relevant to Spire autonomy shall be verified." This requires a DPU in at least form, fit and function plus a simulator of the DRCU and cold FPU – collectively termed the DRCU Simulator. As the schedule demands that this model will be delivered almost simultaneously with the CQM, it is planned to use the CQM DPU in the AVM.

CQM - Cryogenic Qualification Model. For both the cold FPU and the warm electronics it is assumed that this is built to flight standards, but not necessarily using flight quality electronic components. The performance capabilities of the instrument may be less than the proto-flight model - i.e. fewer pixels in the focal plane arrays, but it will mimic as exactly as possible the thermal, electrical and mechanical properties of the flight instrument and will be capable of under going the full environmental qualification programme

PFM – Proto-Flight Model. This will be the model that is intended for flight, built to full flight standards. The PFM will therefore undergo environmental test to qualification levels for acceptance times (TBD) - this applies to both the warm electronics boxes and the cold FPU. A CQM qualification review will determine if in fact the PFM has needed sufficient updates that full re-qualification is needed in some respects.

FS – Flight Spare. The flight spare cold FPU will be made from the refurbished CQM (TBC). The flight spare warm electronics will consist of spare electronics cards/modules/harness.

5.16.2 Electrical Ground Support Equipment (EGSE)

Electrical Ground Support Equipment (EGSE) will be needed to provide Spire instrument level monitoring during instrument integration with the S/C and system level testing.

Deliverables:

FPU electrical simulator, including simulation of the HSFTP/S, to enable integration of the HSDCU,HSDPU, HSFCFU and HSWIH

TBD EGSE for integration of the HSFPU

Quick Look Facility to enable testing of the instrument at system level. This will interface to the S/C test environment

5.16.3 Mechanical Ground Support Equipment (MGSE)

MGSE is required to ensure safe handling of all instrument components during assembly integration and test procedures.

Deliverables:

- Transport containers
- Instrument to cryostat integration jigs/equipment
- Plus TBD

5.16.4 Optical Ground Support Equipment (OGSE)

OGSE is required to carry out alignment procedures with the telescope.

Deliverables:

- Instrument optics primary alignment and alignment verification jigs/equipment
- Plus TBD

5.16.5 System Test Software

Will be based on the Quick Look Facility - computers and software that allow the monitoring in near real time of the instrument housekeeping parameters and instrument data. This is the basic facility to be used for the ICC operations monitoring for the monitoring of the instrument in-orbit. The same facility with enhanced capabilities will be used for the ground tests and in-orbit check out of the instrument.

5.16.6 Hardware for the Observatory Ground Segment

Quick Look Facility for the Mission Operations Centre for instrument in-flight commissioning. This will consist of TBD workstations etc….and must be identical to the system used for instrument system level testing.

5.16.7 Software for the Observatory Ground Segment

The software for the Quick Look Facility will be delivered to the MOC for instrument in-flight commissioning.

Plus TBD.

5.16.8 Instrument Software Simulator

TBD

5.16.9 Test Reference Data

The Spire instrument test reference data will be delivered in the TBD form generated during instrument and system level testing.

5.16.10 Instrument Characterisation Data

The Spire instrument characterisation data will be delivered in the TBD form generated during instrument and system level testing.

5.16.11 Technical Documentation

The following documents will be delivered:

Instrument User Manual following the requirements laid down in the OIRD (AD2)

Instrument database – this will be delivered in the TBD form generated during instrument and system level testing.

Each instrument model will be delivered with an Acceptance Data Package consisting of TBD…a good way to end a document.

6 GROUND SUPPORT EQUIPMENT

6.1 MECHANICAL GROUND SUPPORT EQUIPMENT

TBD

6.2 ELECTRICAL GROUND SUPPORT EQUIPMENT

In agreement with all the other instruments of Herschel/Planck the SPIRE EGSE will be implemented using SCOS2000.

In order to achieve the benefits of smooth transition between different mission phases and maximum reuse of resources, this system will also be used during instrument-level testing, system level tests and in the operational phases of the mission. In particular, the interface between the EGSE and the MOC during the Commissioning and Performance Verification phases (and, for Herschel only, contingency activities during the normal operations phase) will be the same as that between the EGSE and the CCE. This interface, concerning telemetry, telecommanding, the instrument database and procedures will follow the standard defined by SCOS 2000 i.e.

Telemetry:
The SPIRE EGSE will be supplied with all telemetry packets from the satellite (or its simulator) in real time.

This telemetry interface will conform to the SCOS2000 telemetry ICD (ref: TBD).

Telecommanding:
The SPIRE EGSE will not require any commanding capability through the CCE. Instrument commanding will be implemented in the CCE in line with the methods of operation of the MOC.

Databases:
SPIRE will deliver the instrument database to the Prime Contractor through the standard SCOS2000 database interface mechanism (ref: TBD).

SPIRE expects the Prime Contractor to deliver the full satellite database through the same interface. This will allow checking of the correct implementation of the instrument database in the satellite database and allow the display and monitoring of S/C parameters during tests/operations at the system level.

Test procedures:
Test procedures, including command sequences, will be delivered in an agreed format (e.g. flow diagrams and descriptions) to the Prime Contractor who will be responsible for their implementation in the CCE.

Archive data:

It shall be possible to retrieve test data from the CCE off-line.

6.3 COMMONALITY

Taking into account that it is a fundamental design goal of the Herschel/Planck mission that commonality should be pursued to the maximum extent possible, the Herschel instrument teams have been actively engaged in investigating such possibilities.

6.3.1 EGSE

It has been agreed that a common EGSE system could be developed as a collaborative effort between instrument groups.

In addition, it has been agreed that this system would be applicable at various times during all the phases of the mission listed below:

- Subsystem Level Testing
- Instrument Level Testing
- Module and System Level Testing
- In-orbit instrument commissioning
- Performance Verification
- Routine operations

In the interests of minimising the cost and maximising the reliability of such a system through the different phases the EGSE will:

- be based on SCOS 2000 – this system will be used in the ground segment by the MOC for controlling the satellite. The cost of the system (essentially free), its proven use in similar situations for other space projects and the support provided by ESOC, contribute to a cheaper and more reliable system.

- use the same interfaces between the EGSE and other systems, in order to improve reliability through reuse throughout the mission.

- Provide a constant implementation of the
  - Man Machine Interfaces
  - Data Archiving and Distribution facilities
  - On-board Software Management
  - On-board Maintenance (e.g. Software Development Environment, Software Validation Facility)

- Common User Language (for Test procedures and in-orbit operations)

6.3.2 Instrument Control and Data Handling

All three Herschel instruments are using the same supplier (IFSI) for their on-board control and data handling hardware and software systems, which interface to the spacecraft. This has ensured commonality in the areas of;

- on-board microprocessors

- instrument internal interfaces

- On-board Programming language
- Software Development Environments
- Software Validation Facilities

In addition, the on-board software provides commonality in its non instrument-specific functions. A common instrument commanding scheme has also been agreed and will be implemented by the instrument teams.

6.3.3 Other areas

Other areas of possible commonality will be addressed by working groups set up as and when necessary. These may cover:

- Follow up on Herschel Common Science System data archive activities
- A common approach to IA/QLA systems

7 INTEGRATION, TESTING AND OPERATIONS

Information in this chapter covers all instrument-related activities after the acceptance of the instruments by ESA and handover to the Contractor.

7.1 Integration

Procedures detailing the individual integration steps will be prepared and reviewed in due time.

7.1.1 HPLM Integration

It is anticipated that the SPIRE Focal Plane Unit (HSFPU) and the SPIRE JFET box (HSFTB) will be integrated separately onto the Herschel optical bench. Electrical and RF-shield connections (TBD) will be made between the boxes after mechanical integration with the Herschel optical bench.

This applies to both the CQM and PFM units.

7.1.2 PPLM Integration

NA

7.1.3 SVM Integration

TBD

7.1.4 Herschel/Planck Integration

TBD

7.2 Testing

After completion of the integration, be it at the level of the FPLM, PPLM, SVM or Herschel/Planck, a series of verification tests will be carried-out.

Each test will be defined in detail in a test procedure to be written by the Contractor, based on instrument group inputs. It will be reviewed and approved by the Herschel/Planck project group.

7.2.1 CQM Testing

Overview

The detailed system level test procedures for the SPIRE CQM are TBW. An indication of the type of testing anticipated for the SPIRE CQM is given below:

- FPU integration procedures
- Optical alignment procedures
- Integration with CCE
- Test of checkout procedures to be done for PFM
- Test of parallel operation with PACS
- Functional checks using standard test procedures
- Thermal balance tests under representative conditions. This will include cooler recycle and some mechanism operations.
- Test switching sequences between all modes. Check length of time required to change modes – including waiting for thermal environment to stabilise.
- Test thermal dissipation in each “operating mode”.
- Straylight checks with GSE fitted or with final shield blanked off. This is an extreme test as the other shields will be at higher temperatures than expected in flight.
- EMC test of conducted susceptibility only.

Test Environment

In order to carry out these tests the SPIRE instruments expects the CQM test environment to be as follows:

The cryostat will give flight representative temperatures at thermal interfaces.
Under nominal conditions it is expected that the cryostat will have a large gas flow with the CVV at ambient temperature – the heat lift will therefore be greater than expected in space. A configuration should be made possible to allow a gas flow nearer to that expected in-flight.
The cryostat shields will be warmer – possibly much warmer than flight.
The radiation environment will not be representative without some GSE in place. Notably the cryostat lid will be at a minimum of ~300 K
A configuration with the final radiation shield blanked off is being considered – this will give a lower background than expected in space.
A representative telecommanding and data handling environment will be provided by the Prime Contractor/ESA and the Instrument will provide a quick look facility.
The nominal orientation of the cryostat means that the SPIRE **FTS mechanism is in the wrong orientation and cannot be operated unless the cryostat is tilted through 90 degrees about the S/C Z-axis.**
The cooler will not recycle unless the cryostat is tilted to at least 17 degrees about the S/C Z-axis.

Detailed Sequencing

Sequence	Duration [days]	Objective	Requirements	Remarks
Instrument Test SPIRE	3			
SPIRE Functional Test	~1.5			
1		SPIRE switch on procedure, including validation of connection between EGSE and instrument, memory load and dump		SPIRE will be switched to the ON mode
2		Validate function of HSDPU		At the end of this SPIRE will be switched to REDY mode
3		Validate function of HSDRCU		
4		Verify function of cooler thermistors and heaters		
5		Verify function of mechanisms (Shutter (if fitted); BSM; FTS - see note)	To operate the SPIRE FTS mechanism the cryostat will need to be tilted over to 90 degrees about the Z axis.	
6		Cooler recycle	To recycle the SPIRE cooler the cryostat will need to be rotated about the Z-axis by at least 17 degrees	

Sequence	Duration [days]	Objective	Requirements	Remarks
7		Verify function of bolometers, detector readouts, thermal control heaters and temperature sensors		To do this properly will require either the use of the PLM GSE; the use of the SPIRE internal shutter or blanking the final shield within the cryostat
8		Verify function of Calibration sources		
9		Verify SPIRE Autonomy functions		
10		Verify SPIRE to CDMS interfaces and telemetry rates		This to include S/C switching SPIRE to SAFE mode in event of an anomaly
11		Validation of SPIRE deactivation (=shut-down) procedure		SPIRE will be switched to OFF mode
SPIRE Performance Test	~1.5			
1		Validation of SPIRE activation sequence and switch to SPIRE ready Mode		Takes SPIRE from OFF to REDY
2		Cooler recycle	Cryostat needs to be orientated correctly - see above	
3		Validation of SPIRE switching to standby mode		SPIRE switched to standby
4		Switch SPIRE to photometer OBSERVE		SPIRE switched to one of the photometer observe modes and placed in most straylight sensitive condition - shutter closed?
5		Cryostat background measurement	This requires GSE or blanked off shield	
6		EMI tests		Test for induced noise from whatever source in quiescent conditions
7		Conducted susceptibility		Inject EMC through supply lines

Sequence	Duration [days]	Objective	Requirements	Remarks
8		Test SPIRE HSFPU thermal behaviour in photometer observe mode		Run through typical photometer observing sequence in most "thermally intensive" mode - this will include operation of calibrators and BSM.
9		Switch SPIRE to spectrometer OBSERVE	Cryostat needs to be orientated correctly (see above). Test of how long it takes to switch modes.	
10		Test SPIRE HSFPU thermal behaviour in spectrometer observe mode		Run through typical spectrometer observing sequence - this will include operation of calibrators.
SPIRE AOT Test				
1		Test SPIRE photometer POFs		Details TBD - generates test data sets for interface checks with FINDAS and processing software etc
2		Test SPIRE spectrometer POFs		Ditto
SPIRE/PACS parallel Operation				
1		SPIRE switched to standby mode PACS as prime instrument		Details TBD
SPIRE Shutdown				
1		SPIRE switched from standby to OFF		If all tests are done contiguously then this only need happen once. If not then will need to have appropriate shut down and start up sequences at the beginning of each test period.

Table 7.2-1: Outline test sequence for the **SPIRE** CQM integrated in the CQM PLM.

7.2.2 PFM Testing

The PFM system level test procedures for SPIRE are TBW. It is expected that they will be for instrument and system verification and validation purposes only as the CQM testing will have addressed all fundamental operational issues. The sequencing and test environment requirements for the PFM testing will be the same, or very similar (TBC), as for the CQM testing shown in table 7.2-1.

7.3 Operations

Covered in other applicable documentation as follows:

AD 2	Herschel/Planck Operations Interface Requirements Document (OIRD)
AD 3	Herschel Science-operations Implementation Requirements Document (Herschel-SIRD)

7.4 Commonality

The SPIRE system level integration and test programme is compatible with that laid out in the IID-A chapter 7.

8 PRODUCT ASSURANCE

The instrument will comply with the 'Product Assurance Requirements for Herschel/Planck Scientific Instruments' (AD5).

Details are to be found in SPIRE Product Assurance Plan (RD2).

9 DEVELOPMENT AND VERIFICATION

9.1 GENERAL

These are guidelines that will be followed in constructing the instrument AIV programme:

- The instrument will be fully tested in compliance with the satellite level AIV plans as set out in the IID part A and reference documents therein.

- The AIV flow will be designed to allow the experience gained on each model to be fed into both the design and construction of the next model and into the AIV procedures to be followed for the next model.

- A cold test facility to house the instrument will be constructed that will represent as nearly as possible the conditions and interfaces within the Herschel cryostat.

- The instrument Quick Look Facility and commanding environment will be the same or accurately simulate the in-flight environment to facilitate the re-use of test command scripts and data analysis tools during in-flight operations.

- The EGSE and instrument Quick Look Facility will interface to FINDAS.

- Personnel from the ICC will be used to conduct the instrument functional checkout to allow an early experience of the instrument operations and to facilitate the transfer of expertise from the ground test team to the in-flight operations team.

- A more detailed description of the system level AIV sequence is given in reference document RD4. This document will form the basis of the *Herschel* SPIRE *Instrument Test Plan,* which will provide the baseline instrument test plans and detailed procedures and will be submitted to ESA for approval.

- Detailed procedures for the sub-system level AIV will be produced by all sub-system responsible groups.

- Sub-systems will undergo individual qualification or acceptance programmes before integration into the instrument.

- Sub-systems will be operationally and functionally checked at the appropriate level before integration into the instrument.

9.2 MODEL PHILOSOPHY

The model philosophy to be adopted for the AIV of the SPIRE instrument will be in accordance with the requirements of the Herschel IID part A. The instrument models to be produced are:

- AVM – Avionics Model.
- CQM - Cryogenic Qualification Model.
- PFM - Proto Flight Model.
- FS - Flight Spare.

See section 5.16.1 for more details

9.3 MECHANICAL VERIFICATION

TBD

9.4 THERMAL VERIFICATION

TBD

9.5 VERIFICATION OF SCIENTIFIC PERFORMANCE

TBD

9.6 ELECTRICAL TESTING

TBD

9.7 EMC TESTING

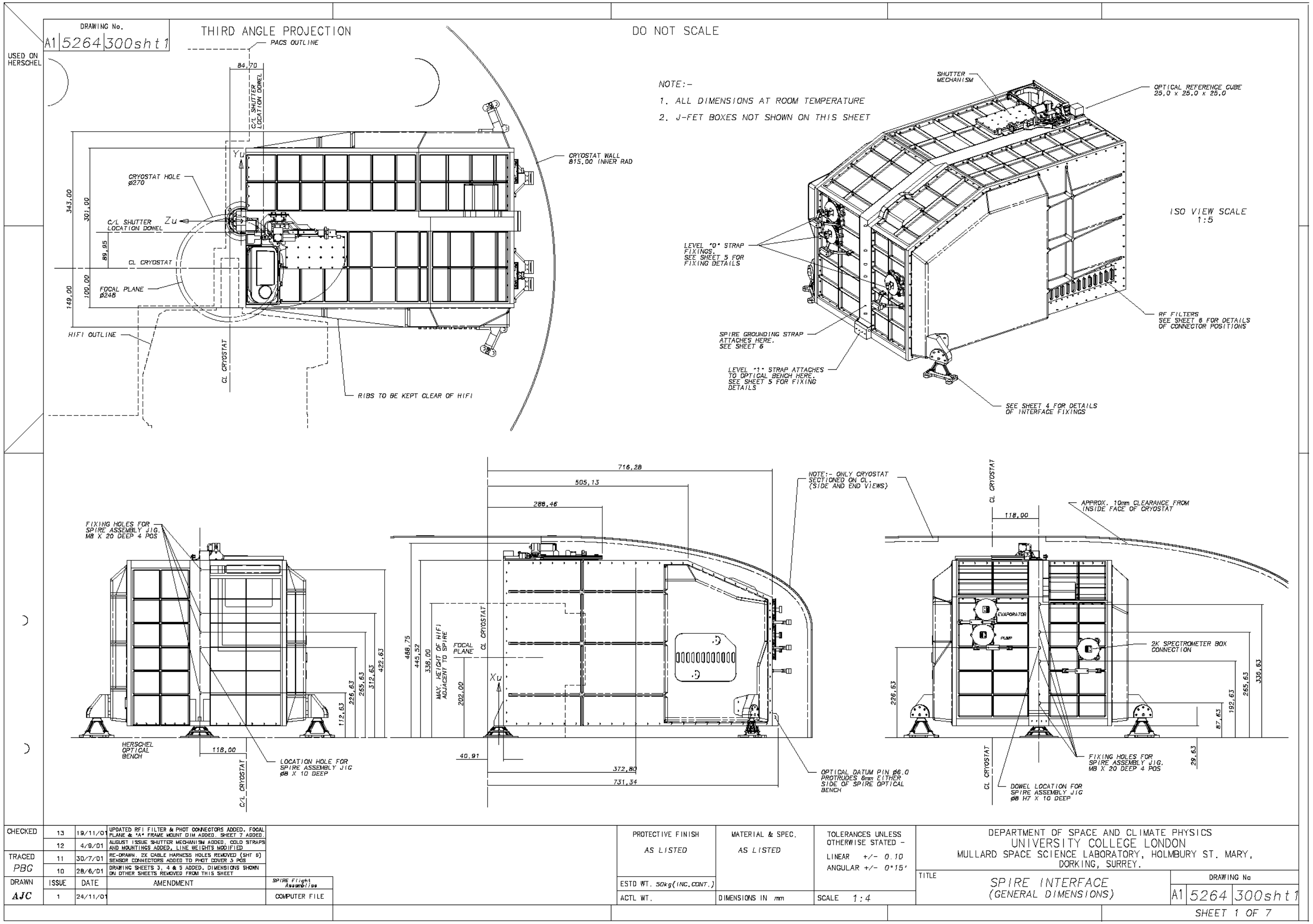
TBD

10 MANAGEMENT, PROGRAMME, SCHEDULE

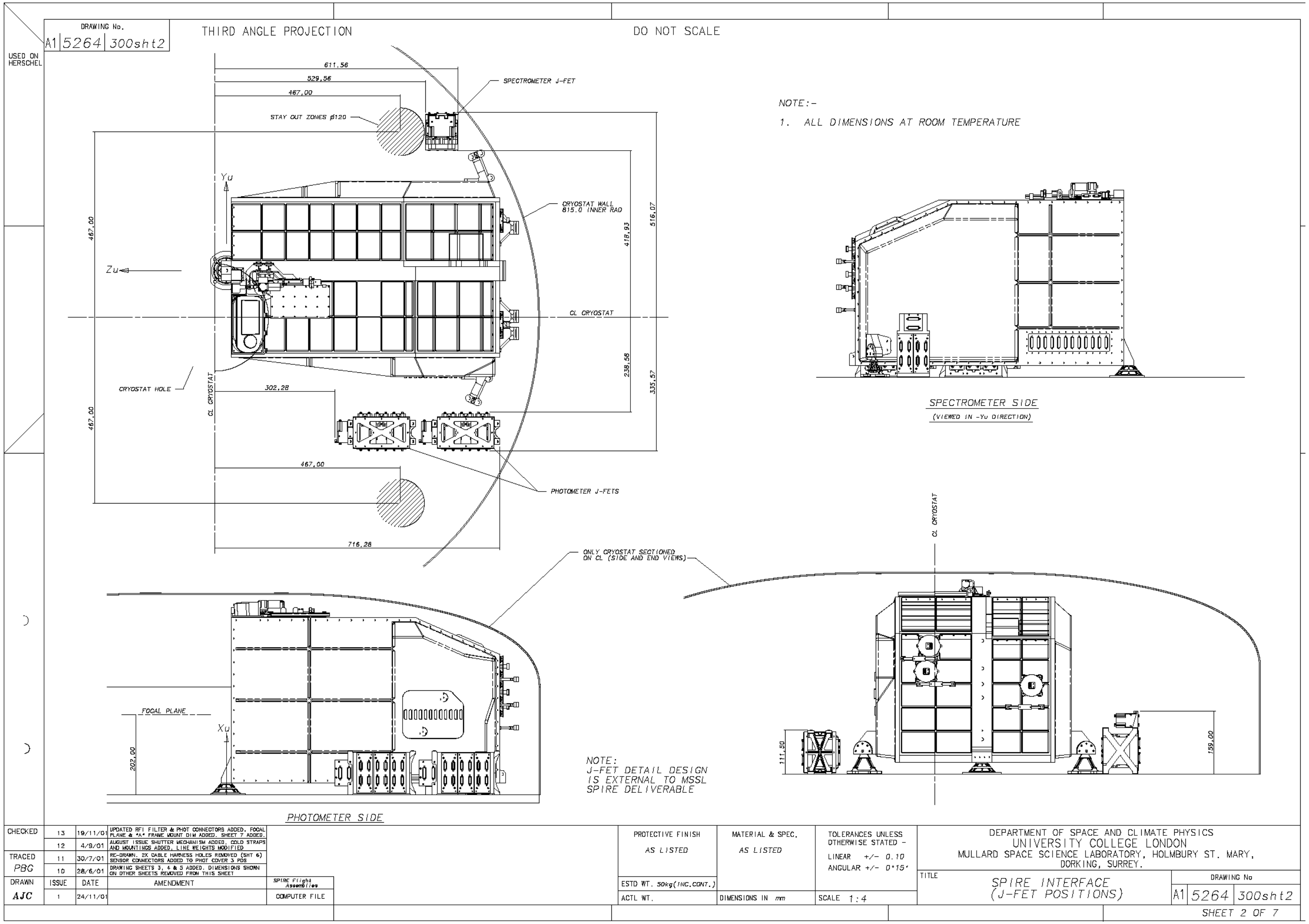
All relevant information can be found in the SPIRE Management Plan, AD4.

11 Annex 1 : Spire Interface drawings

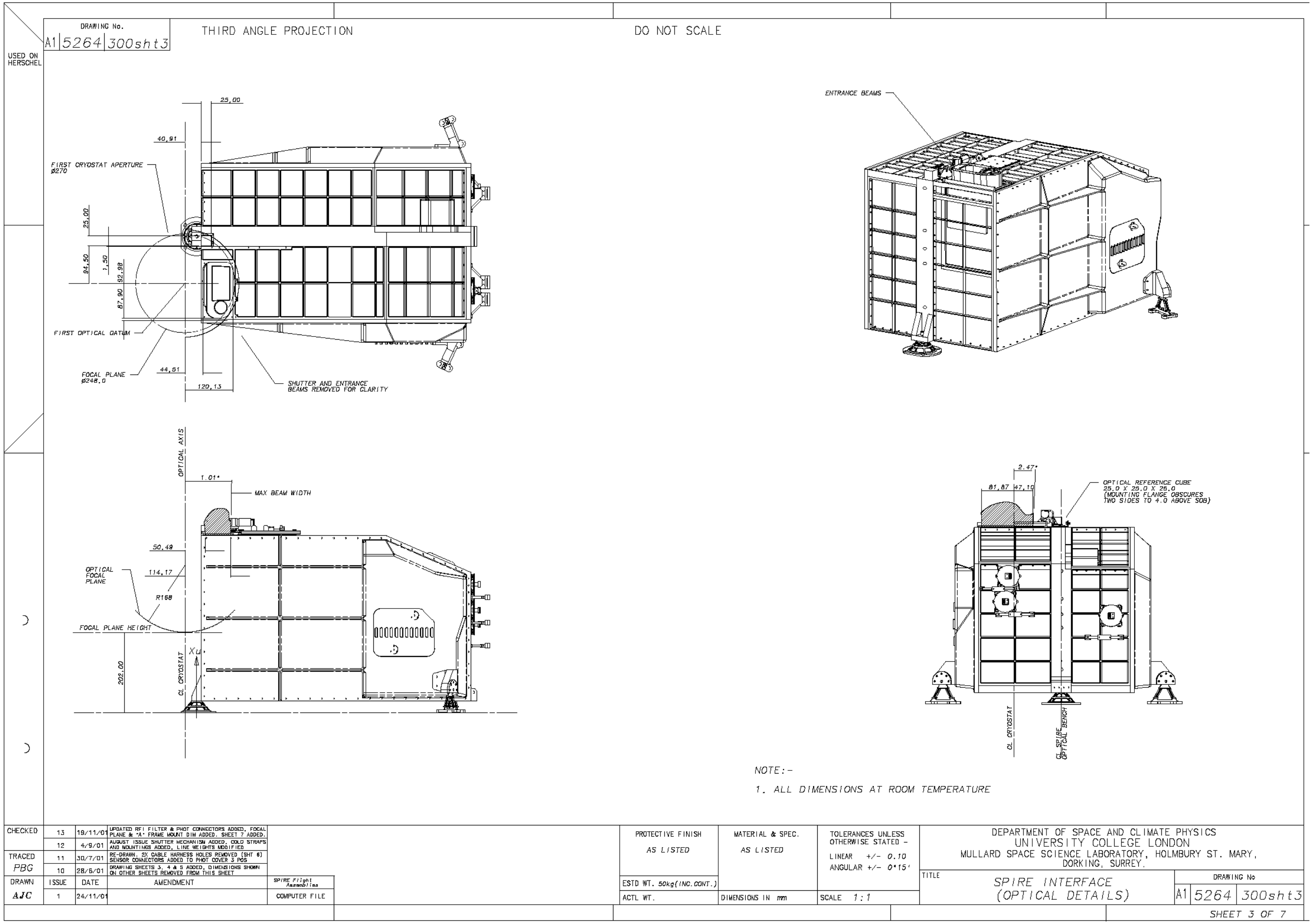
HSFPU : Sheet 1/7



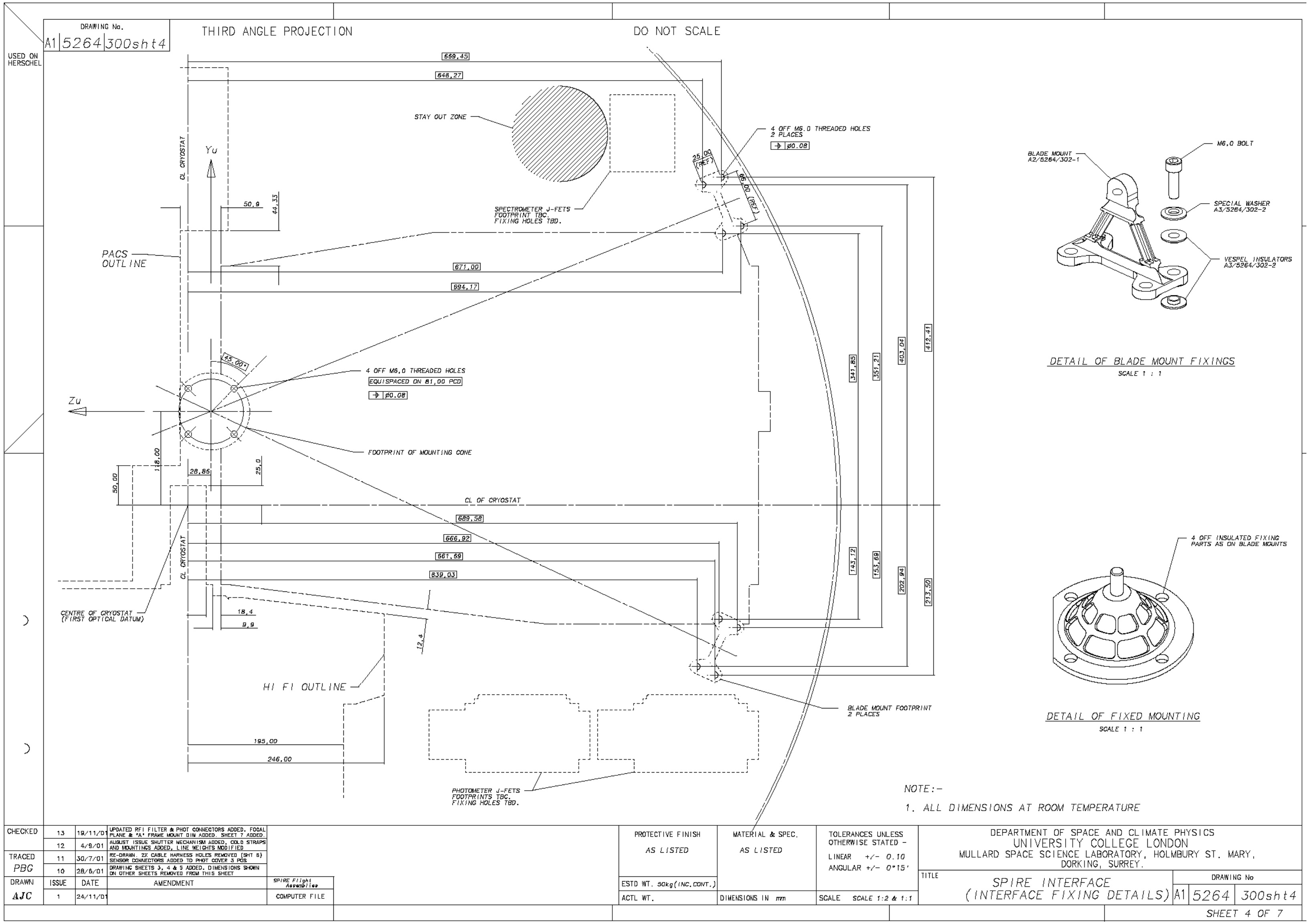
HSFPU : Sheet 2/7



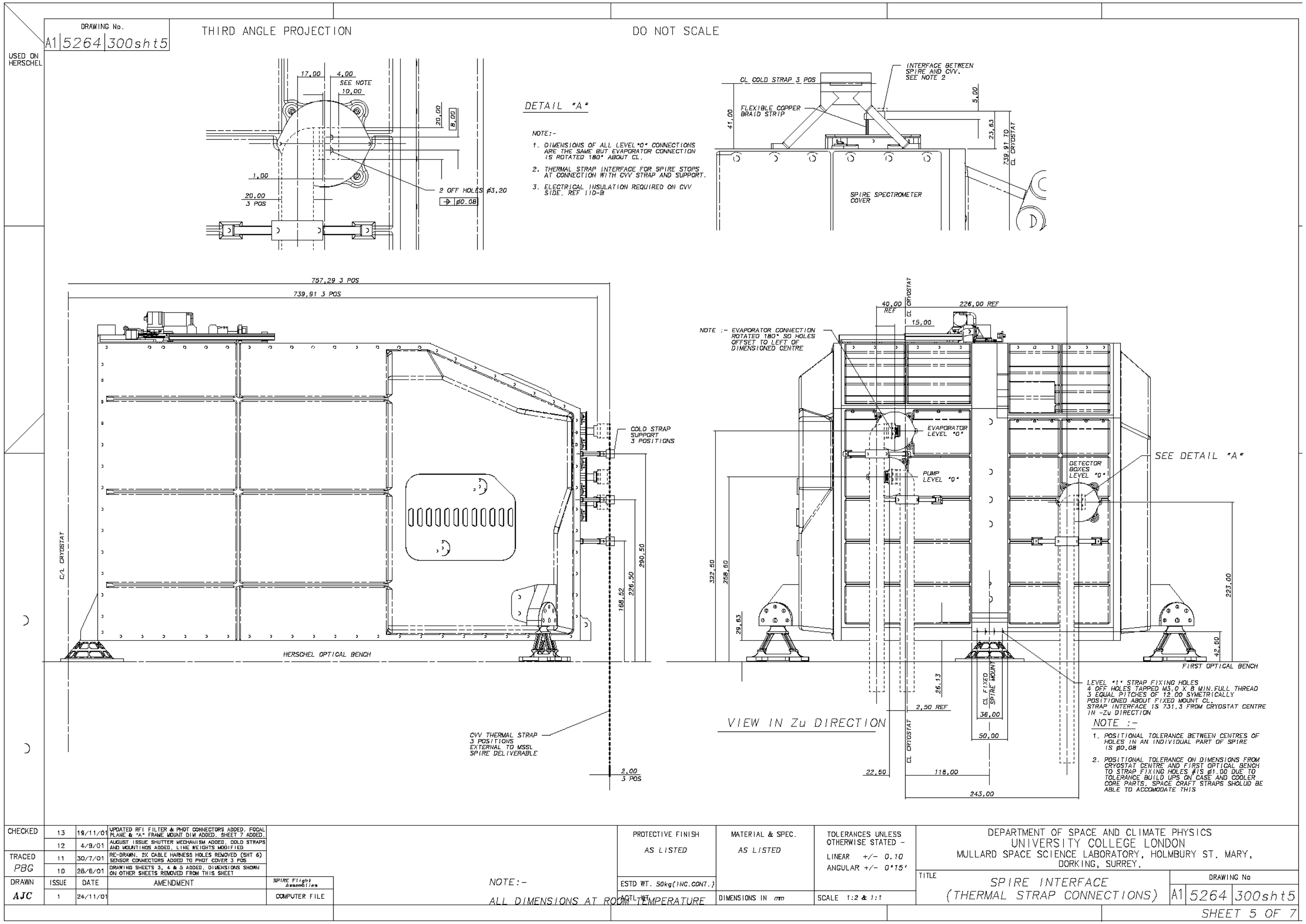
HSFPU : Sheet 3/7



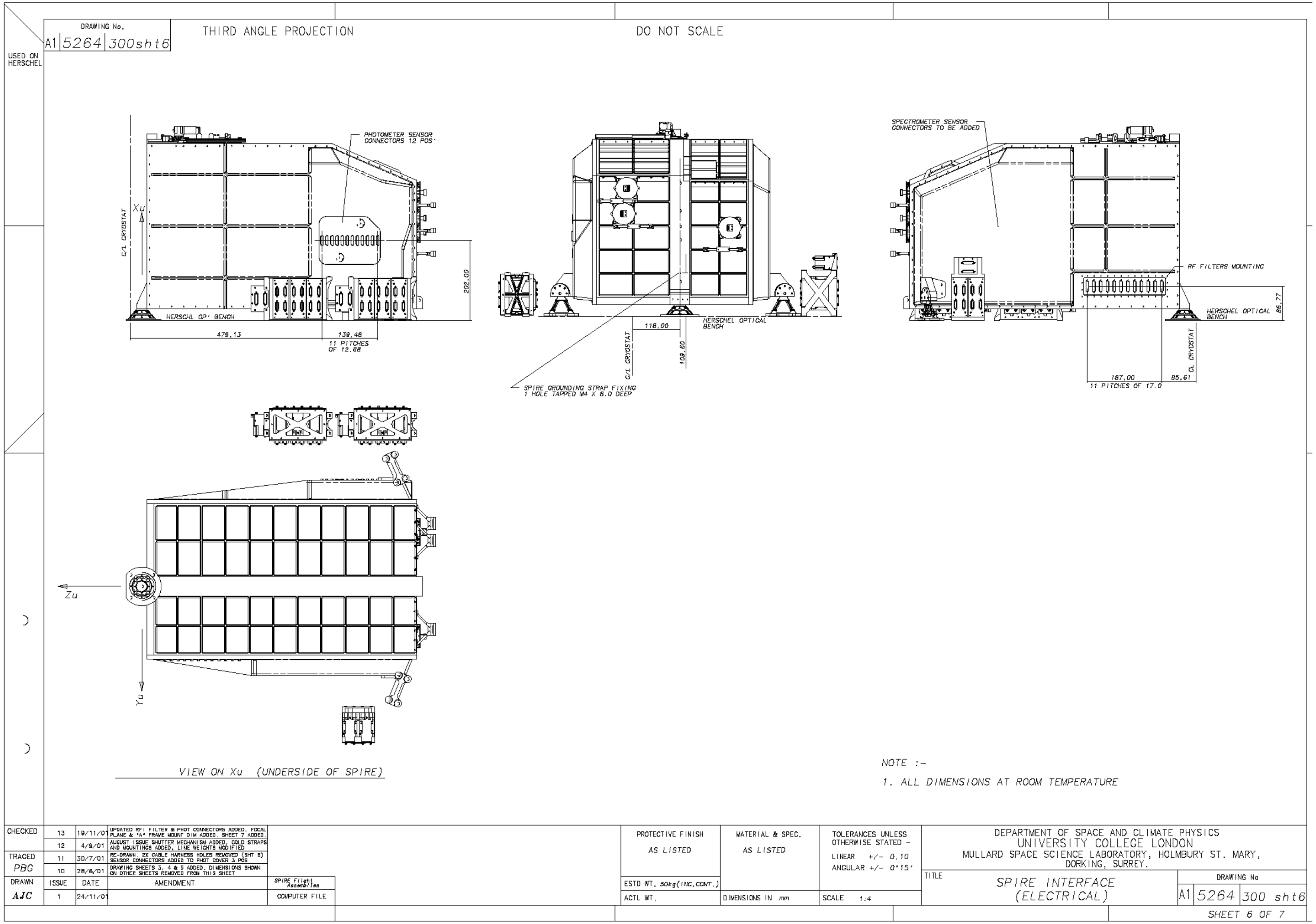
HSFPU : Sheet 4/7



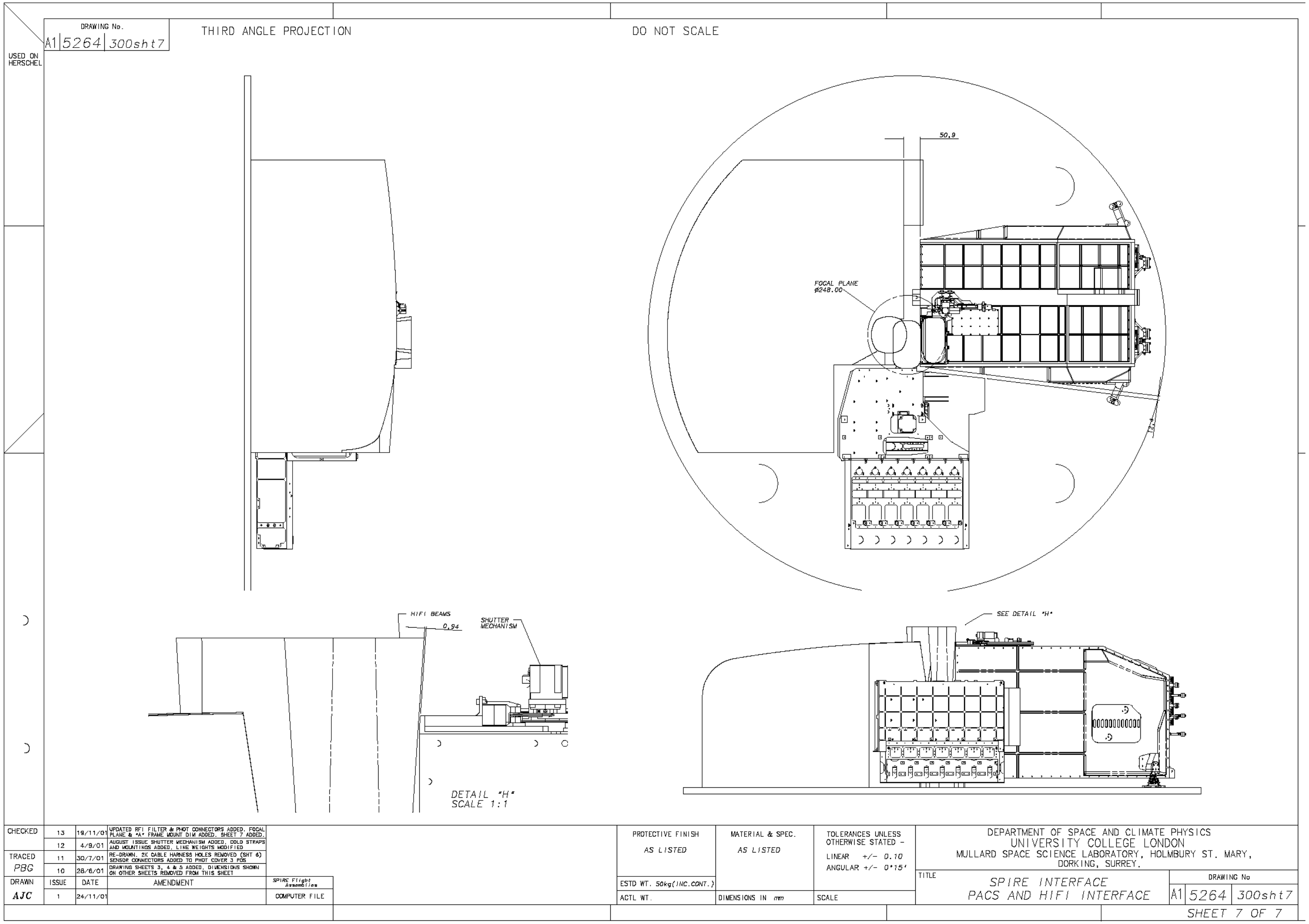
HSFPU : Sheet 5/7



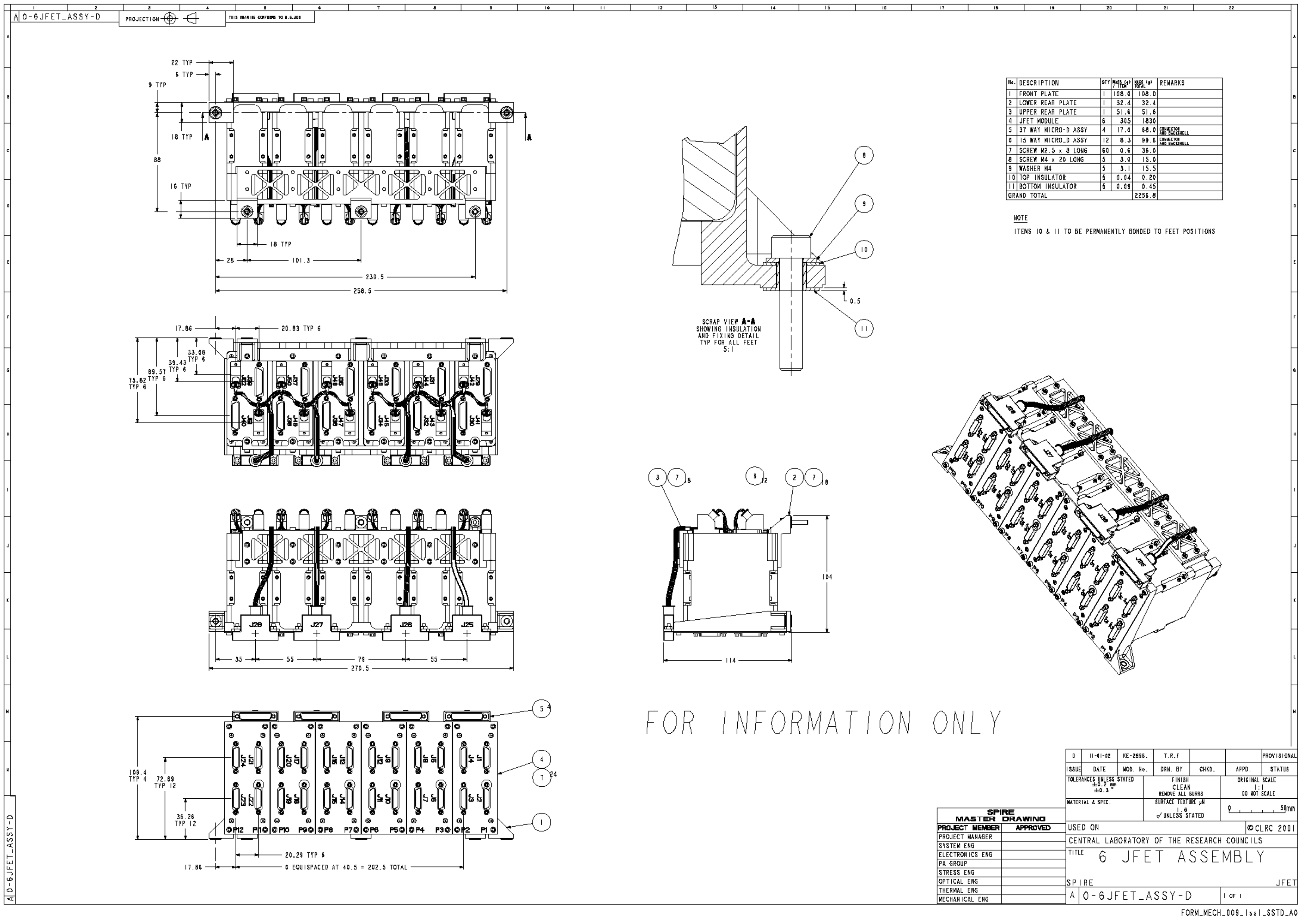
HSFPU : Sheet 6/7



HSFPU : Sheet 7/7

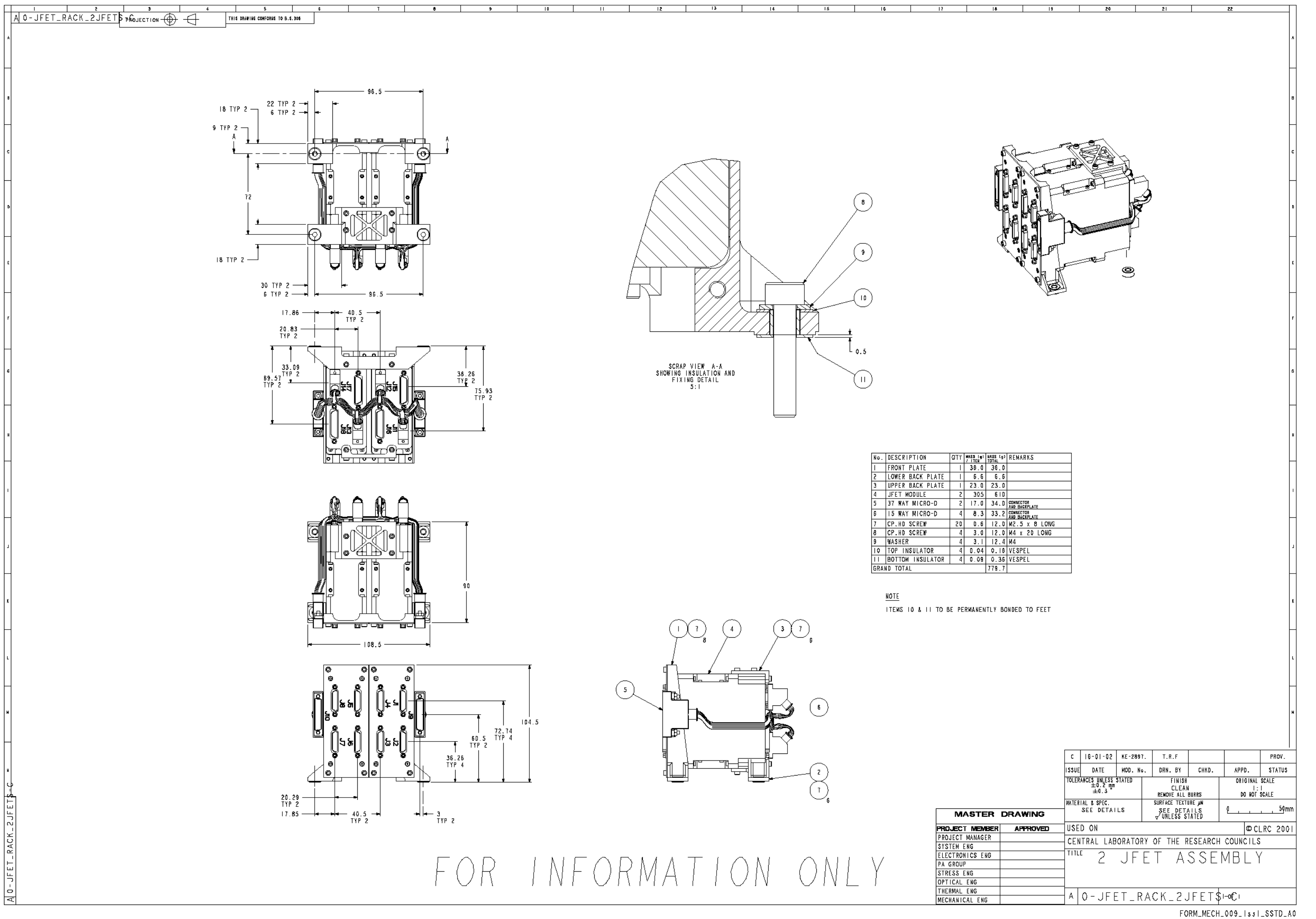


HSJFS (Spectrometer JFET)



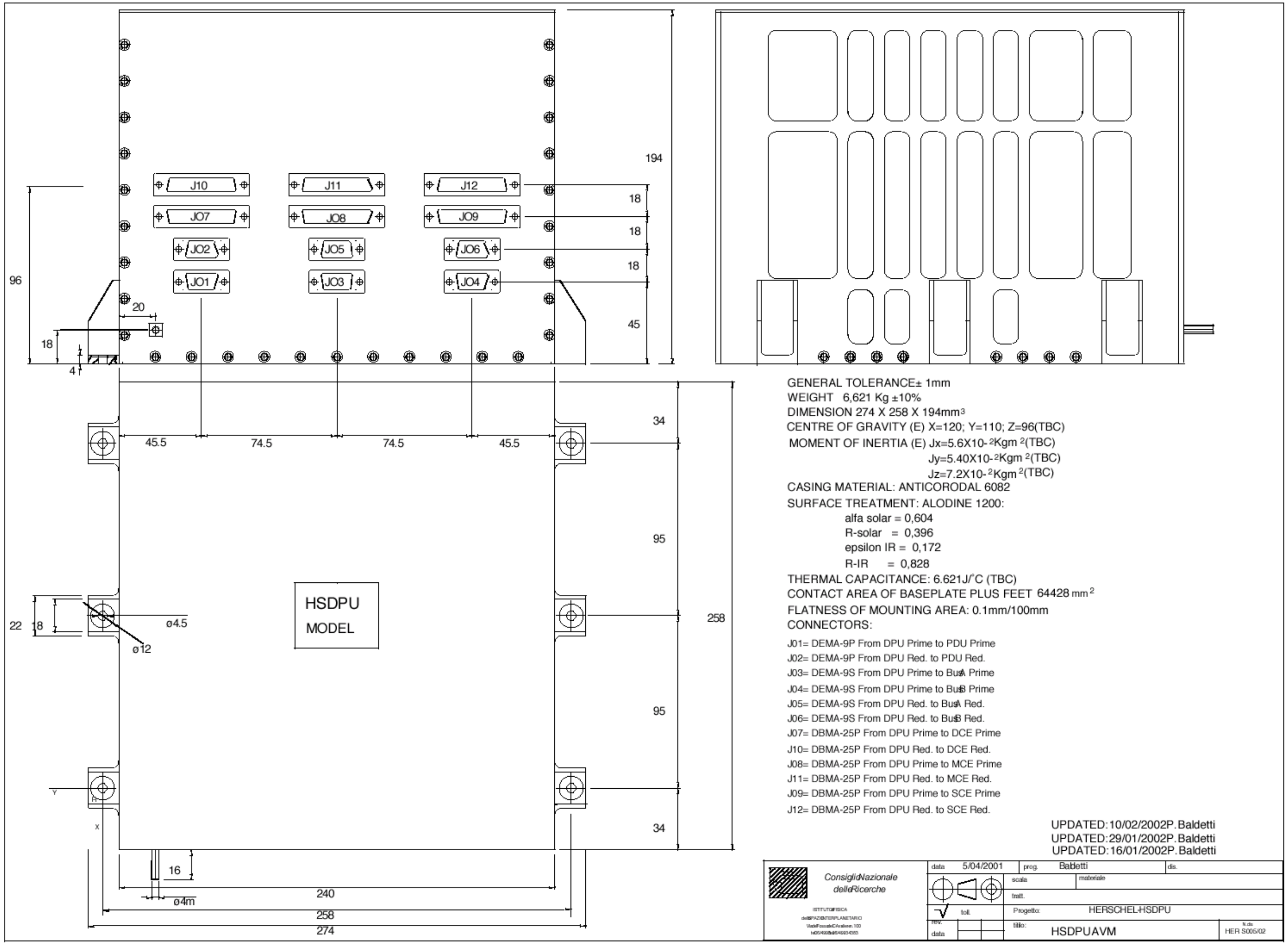
No.	DESCRIPTION	QTY	MASS (g) / ITEM	MASS (g) TOTAL	REMARKS
1	FRONT PLATE	1	108.0	108.0	
2	LOWER REAR PLATE	1	32.4	32.4	
3	UPPER REAR PLATE	1	51.6	51.6	
4	JFET MODULE	6	305	1830	
5	37 WAY MICRO-D ASSY	4	17.0	68.0	CONNECTOR AND BACKSHELL
6	15 WAY MICRO_D ASSY	12	8.3	99.6	CONNECTOR AND BACKSHELL
7	SCREW M2.5 x 8 LONG	60	0.6	36.0	
8	SCREW M4 x 20 LONG	5	3.0	15.0	
9	WASHER M4	5	3.1	15.5	
10	TOP INSULATOR	5	0.04	0.20	
11	BOTTOM INSULATOR	5	0.09	0.45	
GRAND TOTAL				2256.8	

HSJFP (Photometer JFET)

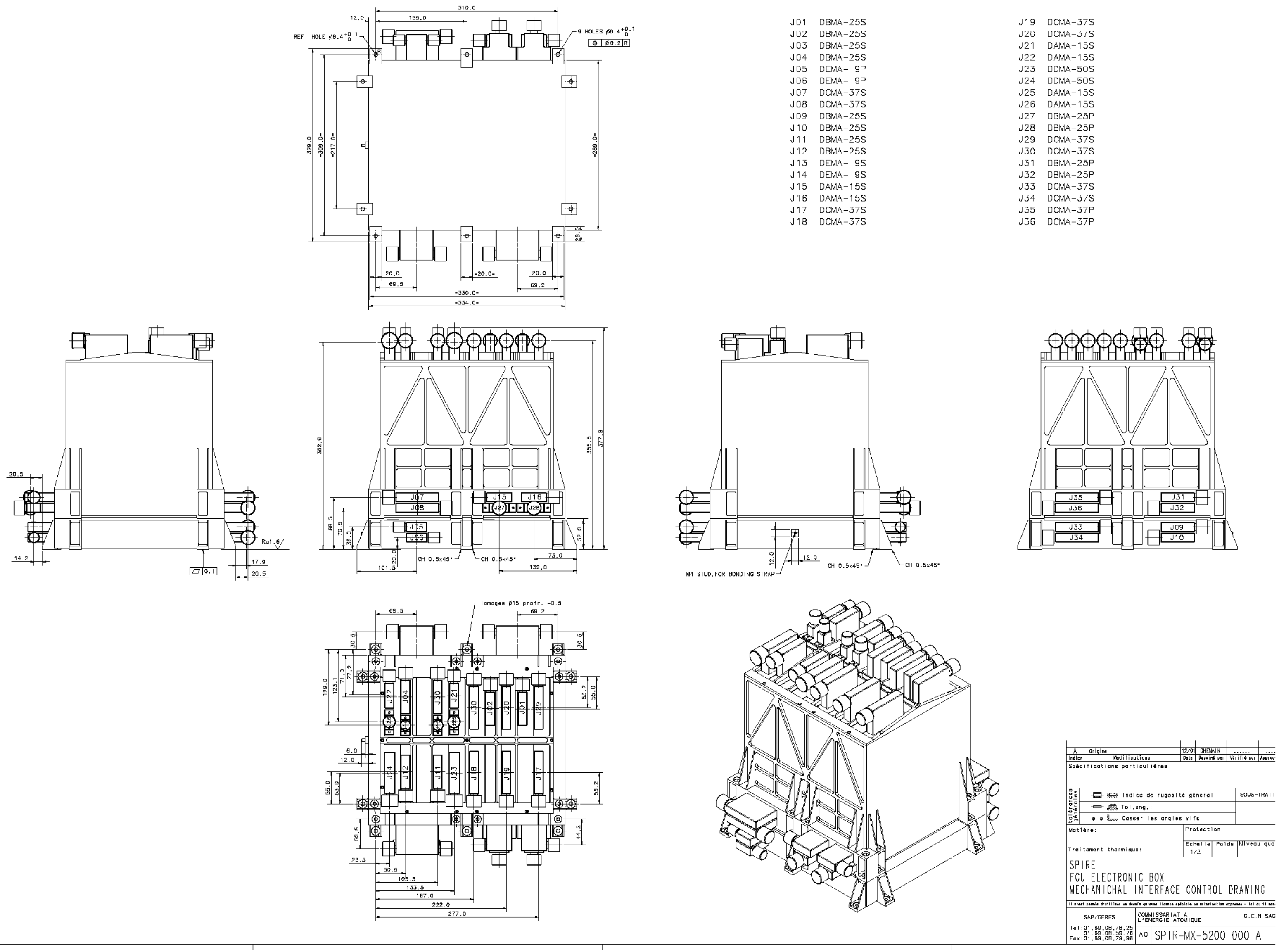


No.	DESCRIPTION	QTY	MASS (g) / ITEM	MASS (g) TOTAL	REMARKS
1	FRONT PLATE	1	36.0	36.0	
2	LOWER BACK PLATE	1	6.6	6.6	
3	UPPER BACK PLATE	1	23.0	23.0	
4	JFET MODULE	2	305	610	
5	37 WAY MICRO-D	2	17.0	34.0	CONNECTOR AND BACKPLATE
6	15 WAY MICRO-D	4	8.3	33.2	CONNECTOR AND BACKPLATE
7	CP.HD SCREW	20	0.6	12.0	M2.5 x 8 LONG
8	CP.HD SCREW	4	3.0	12.0	M4 x 20 LONG
9	WASHER	4	3.1	12.4	M4
10	TOP INSULATOR	4	0.04	0.16	VESPEL
11	BOTTOM INSULATOR	4	0.09	0.36	VESPEL
GRAND TOTAL				779.7	

HSDPU


J10
J11
J12
JO7
JO8
JO9
JO2
JO5
JO6
JO1
JO3
JO4
194
18
18
18
45
96
20
18
4
45.5
74.5
74.5
45.5
34
95
95
34
258
22
18
ø4.5
ø12
HSDPU
MODEL
Y
X
16
ø4m
240
258
274
GENERAL TOLERANCE± 1mm
WEIGHT 6,621 Kg ±10%
DIMENSION 274 X 258 X 194mm3
CENTRE OF GRAVITY (E) X=120; Y=110; Z=96(TBC)
MOMENT OF INERTIA (E) Jx=5.6X10-2Kgm 2(TBC)
Jy=5.40X10-2Kgm 2(TBC)
Jz=7.2X10-2Kgm 2(TBC)
CASING MATERIAL: ANTICORODAL 6082
SURFACE TREATMENT: ALODINE 1200:
alfa solar = 0,604
R-solar = 0,396
epsilon IR = 0,172
R-IR = 0,828
THERMAL CAPACITANCE: 6.621J/°C (TBC)
CONTACT AREA OF BASEPLATE PLUS FEET 64428 mm2
FLATNESS OF MOUNTING AREA: 0.1mm/100mm
CONNECTORS:
J01= DEMA-9P From DPU Prime to PDU Prime
J02= DEMA-9P From DPU Red. to PDU Red.
J03= DEMA-9S From DPU Prime to Bus A Prime
J04= DEMA-9S From DPU Prime to Bus B Prime
J05= DEMA-9S From DPU Red. to Bus A Red.
J06= DEMA-9S From DPU Red. to Bus B Red.
J07= DBMA-25P From DPU Prime to DCE Prime
J10= DBMA-25P From DPU Red. to DCE Red.
J08= DBMA-25P From DPU Prime to MCE Prime
J11= DBMA-25P From DPU Red. to MCE Red.
J09= DBMA-25P From DPU Prime to SCE Prime
J12= DBMA-25P From DPU Red. to SCE Red.
UPDATED:10/02/2002P.Baldetti
UPDATED:29/01/2002P.Baldetti
UPDATED:16/01/2002P.Baldetti
Consiglio Nazionale delle Ricerche
data 5/04/2001
prog. Baldetti
dis.
scala
materiale
tratt.
toll.
Progetto: HERSCHEL-HSDPU
rev.
data
titolo: HSDPUAVM
N.dis
HER S005/02

HSFCU


J01 DBMA-25S
J02 DBMA-25S
J03 DBMA-25S
J04 DBMA-25S
J05 DEMA- 9P
J06 DEMA- 9P
J07 DCMA-37S
J08 DCMA-37S
J09 DBMA-25S
J10 DBMA-25S
J11 DBMA-25S
J12 DBMA-25S
J13 DEMA- 9S
J14 DEMA- 9S
J15 DAMA-15S
J16 DAMA-15S
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J21 DAMA-15S
J22 DAMA-15S
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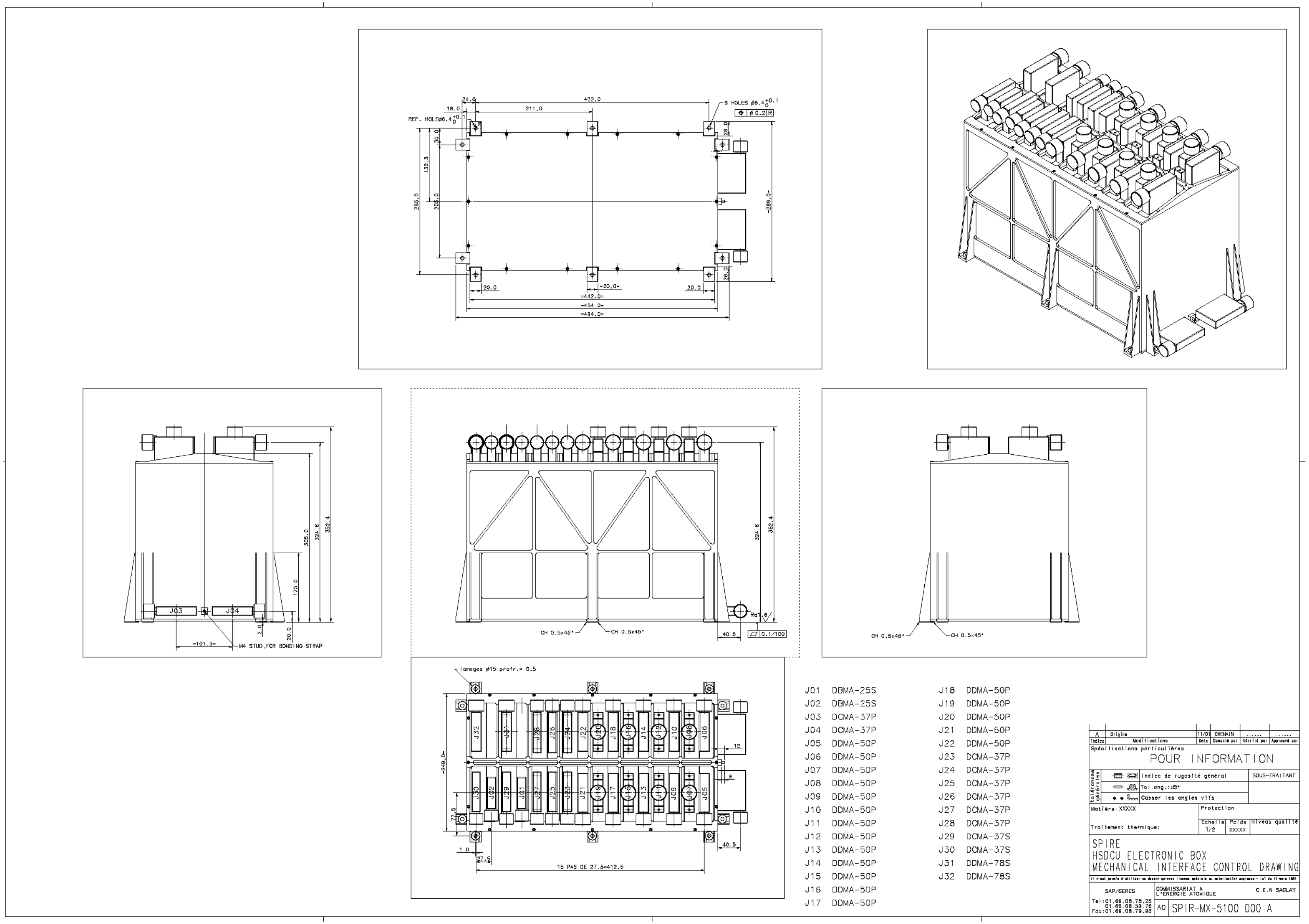
J28 DBMA-25P
J29 DCMA-37S
J30 DCMA-37S
J31 DBMA-25P
J32 DBMA-25P
J33 DCMA-37S
J34 DCMA-37S
J35 DCMA-37P
J36 DCMA-37P
REF. HOLE ø8.4
9 HOLES ø8.4
M4 STUD,FOR BONDING STRAP
CH 0.5x45°
lamages ø15 profr. ~0.5
A Origine 12/01 DHENAIN
Indice Modifications Date Dessiné par Vérifié par
Spécifications particulières
tolérances générales
Indice de rugosité général
Tol.ang.:
Casser les angles vifs
SOUS-TRAIT
Matière:
Traitement thermique:
Protection
Echelle 1/2
Poids
Niveau qua
SPIRE
FCU ELECTRONIC BOX
MECHANICHAL INTERFACE CONTROL DRAWING
SAP/GERES
Tel:01.69.08.78.25
01.69.08.59.76
Fax:01.69.08.79.96
COMMISSARIAT A L'ENERGIE ATOMIQUE
C.E.N SAC
A0
SPIR-MX-5200 000 A

HSDCU


J01 DBMA-25S
J02 DBMA-25S
J03 DCMA-37P
J04 DCMA-37P
J05 DDMA-50P
J06 DDMA-50P
J07 DDMA-50P
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J12 DDMA-50P
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J28 DCMA-37P
J29 DCMA-37S
J30 DCMA-37S
J31 DDMA-78S
J32 DDMA-78S
A Origine 11/01 DHENAIN
Indice Modifications Date Dessiné par Vérifié par Approuvé par
Spécifications particulières
POUR INFORMATION
tolérances générales
Indice de rugosité général
SOUS-TRAITANT
Casser les angles vifs
Matière: XXXXX
Protection
Traitement thermique:
Echelle 1/2
Poids XXXXX
Niveau qualité
SPIRE
HSDCU ELECTRONIC BOX
MECHANICAL INTERFACE CONTROL DRAWING
SAP/GERES
Tel:01.69.08.78.25
01.69.08.59.76
Fax:01.69.08.79.86
COMMISSARIAT A L'ENERGIE ATOMIQUE
C.E.N SACLAY
A0
SPIR-MX-5100 000 A

12 Annex 2 : SPIRE Reduced TMM

```
#
###################################################################################################
#
# I M P O R T E D   F P U   M O D E L   S E C T I O N            (SCI-PT/09948, dated
04.10.01)
###################################################################################################
#
#
#
#  SPIRE Instrument (from ESA but last zero in node number deleted)
#
   D 801 = 'SPIRE PM JFET ENCL  ', T =  4.D0,  C =  5.27D0*FCAL(T801);
   D 802 = 'SPIRE SM JFET ENCL  ', T =  4.D0,  C =  1.72D0*FCAL(T802);
   D 803 = 'SPIRE Optical Bench ', T =  4.D0,  C =  30.0D0*FCAL(T803);
   D 804 = 'SPIRE RF Filter Box ', T =  4.D0,  C = 1.465D0*FCAL(T804);
   D 805 = 'SPIRE Beam St. Mech ', T =  4.D0,  C =  1.10D0*FCAL(T805);
   D 806 = 'SPIRE SMECm         ', T =  4.D0,  C =  1.30D0*FCAL(T806);
   D 807 = 'SPIRE PM calibrator ', T =  4.D0;
   D 808 = 'SPIRE SM calibrator ', T =  4.D0;
   D 809 = 'SPIRE Shutter       ', T =  4.D0;
   D 810 = 'SPIRE PM Detector en', T =  2.D0,  C =  1.967D0*FCAL(T810)+0.306*FCSS(T810); #+Si
   D 811 = 'SPIRE SM Detector en', T =  2.D0,  C =  1.433D0*FCAL(T811)+0.160*FCSS(T811); #+Si
   D 812 = 'SPIRE PM Detectors  ', T =  2.D0,  C =  0.804D0*FCCU(T812)+0.435*FCSS(T812);
   D 813 = 'SPIRE SM detector   ', T =  2.D0,  C =  0.318D0*FCCU(T813)+0.281*FCSS(T813);
   D 816 = 'SPIRE Cooler Pump   ', T =  2.D0;
   D 817 = 'SPIRE Cooler shunt  ', T =  2.D0;
   D 818 = 'SPIRE Cooler evap   ', T =  2.D0;
   D 819 = 'SPIRE Cooler pump HS', T =  2.D0;
   D 820 = 'SPIRE Cooler evap HS', T =  2.D0;
#
#

###################################################################################################
#
# I M P L E M E N T E D   I / F   F P U - O B   S E C T I O N      (SCI-PT/09948, dated
04.10.01)
###################################################################################################
#
#
#
  GL(803,376) = 0.333D0*2.65D-3*INTRP1(.5*(T803+T376),TAB4,1);     #  SPIRE Stainless steel blades
  GL(803,381) = 0.667D0*2.65D-3*INTRP1(.5*(T803+T381),TAB4,1);     #  SPIRE Stainless steel blades
  GL(802,380)= 0.8; # SPIRE SM JFET ENCL, assumed
  GL(802,379)= 0.2; # SPIRE SM JFET ENCL, assumed
  GL(801,379)= 0.2; # SPIRE PM JFET ENCL, assumed
  GL(801,378)= 0.8; # SPIRE PM JFET ENCL, assumed
  GL(910,375) = 0.7;       # assumed
  GL(910,376) = 0.3;       # assumed
#
#
#   Harness and support inside SPIRE (from ESA TMM, but last zero in node number deleted)
# ----------------------------------------------------------------------------------
#
  GL(803,804) = 1.0;       # assumed
  GL(803,805) = 1.0;       # assumed
  GL(803,806) = 1.0;       # assumed
  GL(803,808) = 9.375D-5;
  GL(803,809) = 1.0;       # assumed
  GL(805,807) = 1.0;       # assumed
  GL(810,811) =   2.0D-5/0.19*INTRP1(.5*(T810+T811),TLCU,1);
  GL(810,812) = 1.752D-5/0.02*INTRP1(.5*(T810+T812),LKEV,1);
  GL(811,813) = 1.088D-5/0.02*INTRP1(.5*(T811+T813),LKEV,1);
  GL(812,818) = 7.07D-6/0.5418*INTRP1(.5*(T812+T818),TLCU,1);
  GL(813,818) = 7.07D-6/0.2103*INTRP1(.5*(T813+T818),TLCU,1);
  GL(816,817) = 6.41D-6/0.038*INTRP1(.5*(T816+T817),TAB6,1);
  GL(817,818) = 6.41D-6/0.038*INTRP1(.5*(T817+T818),TAB6,1);
  GL(817,820) = 5.D-6/0.05*INTRP1(.5*(T817+T820),TLCU,1);
  GL(818,820) = 0.28D-6; # Off state
  GL(819,816) = 16.0D-3; # On state
  GL(819,803) = 1.16D-5/0.027*INTRP1(0.5*(T819+T803),TAB6,1);
  GL(820,803) = 1.16D-5/0.027*INTRP1(0.5*(T820+T803),TAB6,1);
#
# Harness
#                           (      SST,   BRAS,   PTFE,     CCU,     VESP,    CUBE,    CUMN,       L,
T1,  T2)
  GL(803,810)  =       FCAB( 38.00D0,  0.0D0, 31.7D0,   0.0D0,   0.00D0,   0.0D0,  4.070D0,
0.025D0, T803,T810);
  GL(803,811)  =       FCAB( 30.12D0,  0.0D0, 7.92D0,   0.0D0,   0.00D0,   0.0D0,  1.020D0,
0.025D0, T803,T811);
```

```
  GL(810,812)  = 1.911D-5/0.03*INTRP1(0.5*(T810+T812),TLVESP,1)+2.16D-
7/0.03*INTRP1(0.5*(T810+T812),TLCUNI,1);
  GL(811,813)  = 3.885D-6/0.03*INTRP1(0.5*(T811+T813),TLVESP,1)+5.4D-
8/0.03*INTRP1(0.5*(T811+T813),TLCUNI,1);
#
#   Harness:  JFETs to SPIRE
#
  GL(801,803)  = FCAB(  9.51D0,  0.D0, 31.68D0,    0.D0,   0.00D0,   0.0D0,  4.070D0, 0.100D0,
T801,T803);
  GL(802,803)  = FCAB(  2.38D0,  0.D0,  7.92D0,    0.D0,   0.00D0,   0.0D0,  1.018D0, 0.100D0,
T802,T803);
#
# Radiation
  GR(801,803) = 0.003;
  GR(802,803) = 0.003;
#
#
#
#
####################################################################################################
#
# I M P O R T E D   F P U   M O D E L   S E C T I O N             (SCI-PT/09948, dated
04.10.01)
####################################################################################################
#
#
      SUBROUTINE MODEAVRG LANG = MORTRAN
#     ==================================
#
# Average Power dissipation for Steady State
#
# SPIRE
#
        QI801 = 1.2 * 49.000D-3 /6.0 + 0.75*SP5OHM*SP5L    # PM JFET
        QI802 = 1.2 * 14.1D-3   /6.0                       # SM JFET
        QI805 = 1.2 * 5.0D-3    /6.0                       # BSM
        QI806 = 1.2 * 2.4D-3    /6.0                       # SMECm
        QI807 = 1.2 * 0.1D-3    /6.0                       # PM cal
        QI808 = 1.2 * 2.0D-3    /6.0                       # SM cal
        QI816 = 758.0 * 1.2 /(46.*60.*60.)/3.              # Pump
        QI817 = 1.2 * 0.01D-3   /6.0                       # Shunt
        QI819 = 1.2 * 0.4D-3    /6.0                       # Pump HS
#
        QI804=  0.75*SP3OHM*SP3L
#
      RETURN
      END
#
      SUBROUTINE MODE1 LANG = MORTRAN
#     ===============================
#
# PACS in Spectrometer Mode, SPIRE and HIFI off
#
#
        QI801 = 0.0                                          # PM JFET
        QI802 = 0.0                                          # SM JFET
        QI805 = 0.0                                          # BSM
        QI806 = 0.0                                          # SMECm
        QI807 = 0.0                                          # PM cal
        QI808 = 0.0                                          # SM cal
        QI816 = 1.02D-03 * 1.2                               # Pump
        QI817 = 0.0                                          # Shunt
        QI819 = 0.0                                          # Pump HS
#
#
      RETURN
      END
#
      SUBROUTINE MODE2 LANG = MORTRAN
#     ===============================
#
# PACS in Photometer mode, HIFI and SPIRE off
#
#
        QI801 = 0.0                                          # PM JFET
        QI802 = 0.0                                          # SM JFET
        QI805 = 0.0                                          # BSM
        QI806 = 0.0                                          # SMECm
        QI807 = 0.0                                          # PM cal
        QI808 = 0.0                                          # SM cal
        QI816 = 1.02D-03 * 1.2                               # Pump
        QI817 = 0.0                                          # Shunt
        QI819 = 0.0                                          # Pump HS
#
```

```
      RETURN
      END
#
      SUBROUTINE MODE3 LANG = MORTRAN
#     ===============================
#
# PACS off, SPIRE Photometer mode, HIFI off
#
#
        QI801 = 1.2 * 30.000D-3                              # PM JFET
        QI802 = 1.2 * 0.0                                    # SM JFET
        QI805 = 1.2 * 4.0D-3                                 # BSM
        QI806 = 1.2 * 0.0                                    # SMECm
        QI807 = 1.2 * 0.1D-3                                 # PM cal
        QI808 = 1.2 * 0.0D-3                                 # SM cal
        QI816 = 1.2 * 1.02D-3                                # Pump
        QI817 = 1.2 * 0.005D-3                               # Shunt
        QI819 = 1.2 * 0.2D-3                                 # Pump HS
#
#
      RETURN
      END
#
      SUBROUTINE MODE4 LANG = MORTRAN
#     ===============================
#
# PACS off, SPIRE Spectrometer mode, HIFI off
#
#
        QI801 = 1.2 * 0.0                                    # PM JFET
        QI802 = 1.2 * 14.1D-3                                # SM JFET
        QI805 = 1.2 * 1.0D-3                                 # BSM
        QI806 = 1.2 * 2.4D-3                                 # SMECm
        QI807 = 1.2 * 0.0D-3                                 # PM cal
        QI808 = 1.2 * 2.0D-3                                 # SM cal
        QI816 = 1.2 * 1.02D-3                                # Pump
        QI817 = 1.2 * 0.005D-3                               # Shunt
        QI819 = 1.2 * 0.2D-3                                 # Pump HS
#
#
      RETURN
      END
#
      SUBROUTINE MODE5 LANG = MORTRAN
#     ===============================
#
# PACS off, SPIRE off, HIFI on
#
#
        QI801 = 0.0                                          # PM JFET
        QI802 = 0.0                                          # SM JFET
        QI805 = 0.0                                          # BSM
        QI806 = 0.0                                          # SMECm
        QI807 = 0.0                                          # PM cal
        QI808 = 0.0                                          # SM cal
        QI816 = 1.02D-03 *1.2                                # Pump
        QI817 = 0.0                                          # Shunt
        QI819 = 0.0                                          # Pump HS
#
#
      RETURN
      END

      SUBROUTINE MODE6 LANG = MORTRAN
#     ===============================
#
# PACS in Photometer mode, SPIRE in Photometer Mode, HIFI off
#
#
        QI801 = 1.2 * 30.000D-3                              # PM JFET
        QI802 = 1.2 * 0.0                                    # SM JFET
        QI805 = 1.2 * 4.0D-3                                 # BSM
        QI806 = 1.2 * 0.0                                    # SMECm
        QI807 = 1.2 * 0.0D-3                                 # PM cal
        QI808 = 1.2 * 0.0D-3                                 # SM cal
        QI816 = 1.2 * 1.02D-3                                # Pump
        QI817 = 1.2 * 0.005D-3                               # Shunt
        QI819 = 1.2 * 0.2D-3                                 # Pump HS
#
#
      RETURN
      END
```