SPIRE-ESA-DOC-000275

HERSCHEL / PLANCK

Interface Instrument Document - Part B SPIRE

(IID-B SPIRE)

SCI-PT-IIDB/SPIRE-02124

Product Code : 112 000

Written by	***Responsibility-Office -Company***	***Date***	***Signature***
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LIST OF REFERENCE REQUIREMENTS

DISTRIBUTION LIST

Distribution in electronic format (Adobe PDF)

Qty	Organisation	Institute
1	Herschel/Planck Project Team	ESTEC (Noordwijk)
1	Prime Contractor	Alcatel Alenia Space France (Cannes)
1	SVM Contractor	Alcatel Alenia Space Italy (Torino)
1	H-EPLM Contractor	EADS Astrium GmbH (Friedrichshafen)
1	Herschel SPIRE	Univ.Cardiff/RAL
1	ESA Project Scientist	ESTEC (Noordwijk)

A0 . DOCUMENT CHANGE RECORD

Issue-Rev	Date	VERSION	Pages affected
1-0	01/09/2000	Initial Issue for ITT	New Document
2-0	31/07/2001	Issue for SRR	Complete Revision: Renaming of HERSCHEL by Herschel. Changes maked by change bars (including editorial changes).
2-1	13/02/2001	Unpublished version	According to SCI/PT/MM-11440 And DCN ..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
3.0	23/09/2003	Not signed issue	According to changes by SPIRE CR & all comments & changes as here under (*), and minutes of IF& IIDB Meetings: H-P-ASP-MN-3513 and H-P-ASP-MN-3668
3.1	02/12/2003	Not signed issue	According to comments & changes by H-P-ASP-MN-3923, H-P-ASP-MN-3961
3.11	07/01/2004	New Issue for ESA CCB - Not signed issue	According ASP CCB #41
3.2	01/03/2004	New Issue for PLM CDR version – Signed issue	According ESA CCB SCI-PT-MM-024070,
3.3	21/06/2004	New Issue for System CDR version	According: ESA CCB SCI-PT-MM-024070, several SPIRE IIDB 3.3 inputs, H-P-MN-5081, and Sections & pages as here under (***)
4	01/04/2006	New signed issue	Sections & pages as here under (*) SPIRE CRs applied as here under (**)

A0.1 (*) Issue 4 changes versus issue 3.3:

- This Section 0, DISTRIBUTION LIST and DOCUMENT CHANGE RECORD, List of Reference Requirements added
- General in all sections 1 to 10:
  - Changes in pages format and number (but not highlighted)
  - Changes versus issue 3.3 are only highlighted (coloured text and or change bar)
- Section 2.1, AD7: Replaced by ASED-TN-0097 "Alignment Methods, Plan & Results"
- Section 2.2: Updated Title and missing ref# added to RD 9, RD 10, RD 11 and RD 14. New RD added: RD 29 to RD 35.
- Section 3.2, Paola Andreani: TBD changed to 3441
- Section 4.6.8: "Only one (single) command is required by SPIRE to go to safe mode." is added in last line
- Section 4.7: "TBC" is deleted after "observe mode"
- Section 4.7.1: "as 6 (TBC)" is replaced by "as a number of"
- Section 4.7.1.4: "TBD" is deleted on first line, and TBD is replaced by "will be defined after the PFM test programme".
- Section 4.7.3.2, in the 2 last sentences: "chopper and ", and last sentence "The feasibility and scientific desirability of this mode is TBD" are deleted
- Section 4.7.6: "TBD" is deleted on first line
- Section 5.1: Reference requirements added (0270 and 0280)
- Section 5.2: figure 5.2-1 is updated with SPIRE_Block_Diagram_6.0
- Section 5.4.1: figure 5.4-1 is updated
- Section 5.4.1.1: figure 5.4-4 is updated
- Section 5.5, Table 5.5-1: Reference requirement added (0300), mass values are updated, column comment is added, note (**) is deleted
- Section 5.6.1.2:
  - "The 3 Level-0 straps are provided by SPIRE, the H-EPLM contractor shall supply the 2 Level-1 and the 2 Level-3 straps" is added before paragraph "SPIRE JFET L3 I/F with electrical insulation"
  - Reference requirements added (0360 and 0370)
  - paragraph SPIRE JFET L3 I/F with electrical insulation: in 2d sentence "40mm x 12mm" is replaced by "40mm x 10mm"; in 2d bullet "AD3-1" is replaced by "AD1"; "Ref to "2 JFET" and "6 JFET" ICD's in Annex 1" is added after 4th bullet
- Section 5.6.3: Reference requirements added (0400 and 0410)
- Section 5.7: figure 5.7-1 is updated
- Section 5.7.1.3: Reference requirement added (0420)
- Section 5.7.1.4: Reference requirement added (0430)
- Section 5.7.3: Reference requirement added (0440 and 0450)
- Section 5.7.5.3: Reference requirement added (0460)
- Section 5.8: Reference requirement added (0470)
- Section 5.9.3: Reference requirement added (0490)
- Section 5.9.6.1, Table 5.9-4: column "Long Peak BOL/EOL" is removed
- Section 5.9.6.4: Reference requirement added (0510)
- Section 5.10:

  - in 1st paragraph "(SPIRE-RAL-PRJ-000608)" is added after "RD-19", 2d paragraph "The function … in Annex 5)" is deleted
  - 3rd "External to the CVV … Faraday shield "and 4th paragraph "Internal to the CVV … closed shield " are deleted and replaced by "All harnesses shielding and overshielding implementation shall be in accordance with RD-19 (SPIRE-RAL-PRJ-000608, issue 1.2.1 or higher)"
  - 5th paragraph: "is consistent with" is replaced by "should be consistent with"
  - 6th paragraph: "in the SPIRE HDD, are given in Annex 6" is replaced by "in RD-19 (SPIRE HDD), are given in RD- 35"
  - Reference requirements added (0520 and 530)
- Section 5.10.1:
  - 1st paragraph: ", Issue 1.1 and updated pages, for harness bundles 4 and 6, identified by «SPIRE HDD 1.1 Deltas», ref SPIRE-RAL-NOT-001819, given in Annex 5:" is deleted
  - 2d paragraph: "the requirements specified in Annex 3 (Summary of SPIRE cryoharness wiring functions)" is replaced by "RD-19 (SPIRE-RAL-PRJ-000608, issue 1.2.1 or higher)"
  - Reference requirement added (0540)
  - "Figure 5.10-1 is for information only, details given in RD 19" is added under Figure 5.10-1
- Section 5.10.3: Reference requirements added (0550 and 0560)
- Section 5.10.4.3: Reference requirements added (0570, 0580 and 0590)
- Section 5.11.3, Reference HP-SPIRE-REQ-0200: replaced by new tex "When using telescope scan mode, information will be made available to the SPIRE project to enable determination of the start of scan with a precision better than 10ms with respect to the S/C clock"
- Section 5.11.4: last line is added "Safe mode: only one (single) command is required by SPIRE to go to safe mode."
- Section 5.12.2: Reference requirements added (0600 and 0620)
- Section 5.12.3: Reference requirement added (0630)
- Section 5.13.1: Reference requirement added (0640)
- Section 5.13.2: Reference requirement added (0650)
- Section 5.14: New text added
- Section 5.14.3:
  - Reference requirement added (0660)
  - Table 5.14-1: in row PSU "131 kHz TBC" is replaced by "200 kHz"; and note under table is deleted
- Section 5.15.1.2:
  - Above 100 K: dT/dt 20 K/hour is changed by 5 K/hour and Note 1 is added
  - Above and Below 100 K: delta T max from L0 to L1 and from L1 to L2 are added
  - Reference requirements added (0700 and 0710)
  - Note "Reference sensors used for cool down and warm up rate monitoring … will be described and fixed in on going procedures " is added at end of section
- Section 5.15.1.3: Reference requirement added (0720)
- Section 5.15.3.1: Reference requirement added (0740)
- Section 5.16.1.2:
  - paragraph This model comprises the following units: 2 bullets (Spectrometer & Photometer JFET) added after 1st bullet
  - paragraph Connector savers, safe plugs, covers etc:: in 2d bullet "JFETS" added after "CQM"
  - List of equipment necessary to perform EQM/PFM test programme and table 5.16.1-1 is added at end of section

- Section 5.16.1.3:
  - All text and note 1 after 1st paragraph “Initially it will be delivered … *schedule and financial aspects*” is deleted
  - paragraph This model comprises the following units: 2 bullets (Spectrometer & Photometer JFET) added after 1st bullet
  - paragraph Connector savers, safe plugs, covers etc::
    - in 1st bullet: “with the PFM for WU only” is replaced by “fitted to all units”
    - in 2d bullet “PFM in the active connectors only” is replaced by “JFETS bias lines. Note these connectors will not be fitted with savers as well as safe plugs, as these will be subject to very limited mate/demate cycles at S/C level”
- Section 7.1: All text is replaced by “Integration is described in the SPIRE structure assembly, integration and handling plan RD32”
- Section 7.1.3: Reference requirement added (0770)
- Section 7.2: Reference requirement added (0780), and “and by the SPIRE instrument group” is added
- Section 7.2.3: All text is replaced by “See RD33 (QM thermal test specification (SPIRE-RAL-NOT-002319)”
- Section 7.2.4:
  - ”AD 13 (HP-2-ASED-PL-0021_2_0” and “AD 14 (HP-2-ASED-PL-0031_1_0” are changed to “AD 14 (HP-2-ASED-PL-0021_3_1 draft” and “AD 13 (HP-2-ASED-PL-0031_2_0”, and table 7.2-1 is updated.
  - Note “Concerning FM tests … FM IST Test specification” and “Herschel Integrated Satellite Test Procedure” to be issued “ is added under table 7.2-1
- Section 9.8: new column “Shock” is added in table 9.8-1 (Verification matrix)
- Annex 1 is re-organised in 2 sub-sections, and updated with:
  - Annex 1-1: Note is added “Concerning mass and power (dissipation and load) the tables of sections 5.5 and 5.9 take precedence on values indicated (or not) in all these ICD’s”
  - Annex 1-1: Table of drawings configuration is updated according ICD pack issue 14 and new DPU FM ICD (ICD to be officially agreed with HR-SP-RAL-ECR-089)
  - Annex 1-1: All sections 1 (ASED comments) and 2 (SPIRE answer) are deleted
  - Annex 1-2: All drawings updated with SPIRE-IID-B_pack_Oct_Iss13 and new DPU FM ICD
- Annex 2: Note is added “SPIRE reduced TMM Issue 2.5 should be updated by SPIRE”
- Previous Annexes 3 (Summary of SPIRE cryoharness wiring functions), 5 (SPIRE HDD 1.1 Deltas) and 6 (Making SPIRE ESD Safe)are deleted
- Annex “DESCRIPTION OF THE OPERATIONS OF THE 3HE SORPTION COOLER” number is changed to 3 (against 4). All occurrences (see, ref to) of Annex 4 in present document are changed to Annex 3 (in sections 5.7.1.2, 5.7.1.3, 5.9.1)

A0.2 (**) Status of SPIRE CRs versus IIDB 3.3 : applied or not to issue 4

See Changes of issue 4 versus 3.3 here before

CR ref HR-SP-RAL-	**Subject of SPIRE CR**	**Status & Comments**
ECR-089	New DPU FM ICD, with black coating and some IF changes	**Applied in Annex 1 with caveat** Impact to be evaluated by AAS-I (black coating and cold case temperature)

A0.3 (***) Issue 3.3 changes versus issue 3.2:

- This Section 0
- General in all sections 1 to 10:
    - All figures and tables previously with no name and number are named, and some tables and figures have new numbers
    - Old notes or comment asking for update highlighted in yellow when still not fixed
    - Changes in pages format and number (but not highlighted)
    - Changes versus issue 3.2 are only highlighted (coloured text and or change bar)
- Section 2.2: RD 22 to 27 added (IID-B input-ESawyer 4/6/04)
- Section 2.2: added RD 28 SPIRE Warm electronic integration plan, SPIRERAL-DOC-001132, Issue 0.1, 10/01/02»
- Section 4.6.7: first sentence changed by «The ^{3}He cooler will be recycled every 48 hours»
- Section 5.1, in last sentence: «(TBD, SPIRE to provide a TN)» replaced by «see annex 6 of present IIDB» added
- Section 5.2.1, Figure 5.2.1: Spire Block Diagram – updated to version 5.8
- Section 5.3.1.1: «Spire specific SVM panel picture » is named «Figure 5.3-2»
- Section 5.4.2: Figure 5.4-3 changed and renamed 5.4-2
- Section 5.4.3: Figure 5.4-4 changed and renamed 5.4-3
- Section 5.4.4-1: Figure 5.4-6 is renamed 5.4-4
- Section 5.4.4-2: Figure 5.4-7 is renamed 5.4-5
- Section 5.4.4-3: Figure 5.4-8 changed and renamed 5.4-6, Note under figure is removed
- Section 5.5: table is named « Table 5.5-1: SPIRE Units mass & dimension», dimensions values deleted (only ref to annex 1), note added « Concerning units nominal mass, this table takes precedence to any mass value indicated in drawings of Annex 1»
- Section 5.6.1.2: updated as minutes H-P-ASP-MN-5081:
    - In L3 electrical insulation, remove "and Kapton on the JFET rack I/F. The impact of the Kapton tape at the JFET I/F belongs to the SPIRE thermal budget"
    - figure 5.6-1 replaced by figure in mail from J.Delderfield 9/3/04
    - All text & figure 5.6-2 below «SPIRE level 1 electrical insulation» is removed and replaced by: "SPIRE L1 Electrical insulation is done internal to the FPU. See FPU ICD in Annex 1"
- Section 5.6.3: "TBD devices" replaced by "Tie bases and wrap as defined in IIDA Annex 10"
- Section 5.7: issue 2.3 removed from reference to reduced TMM
- Section 5.7.1: note removed
- Section 5.7.1.3: Table 5.7-2(On ground temperatures & heat flows) is removed, only the 2 last column "non operating temperatures" kept as table moved in §5.7.1.4
- Section 5.7.1.4: note (*) added (baking of 80°C for 72 h plus the ramp-up and ramp down), and table *Table 5.7-2* « SPIRE FPU Non operating temperatures» added
- Section 5.7.3: table named « Table 5.7-3: SPIRE WU temperatures»
- Section 5.7.3, note under table, all 4th bullet " Spire units will be ... for such systems, TBC» is removed
- Section 5.7.5.1: table named « Table 5.7.5-1: SPIRE Instrument Temperature Sensors »
- Section 5.7.5.3: table named « Table 5.7.5-2: SPIRE Satellite Temperature Sensors »
- Section 5.7.5.3, table, 2d row T225: Accuracy «0.001K» is changed by «0.008K»
- Section 5.7.5.3, all notes under table after : «… information only» are removed
- Section 5.9.1: table named «Table 5.9-1: Power dissipation inside cryostat»

- Section 5.9.1, note under table changed by: « for information only, refer to SPIRE RTMM in Annex 2»
- Section 5.9.3: table named «Table 5.9-2: Power dissipation on the SVM », and « When operating in spectrometry … losses in the HSFCU are TBD « is removed under table
- Section 5.9.3, under table : note added « This table takes precedence to any power dissipation value indicated in drawings of Annex 1 »
- Section 5.9.5: table named «Table 5.9-3: Power status versus instrument modes »
- Section 5.9.6.1: table named «Table 5.9-4: Power load on main bus», and note added » SPIRE to update the tables «
- Section 5.9.6.2: full new section (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)
- Section 5.9.6.4.1: figure named « Figure 5.9-1: HSDPU Power Input Circuit Configuration», and added « Note: Power Input Circuit Configuration is given for information only»
- Section 5.9.6.4.2: full new section, text and figure 5.9-2 (SPIRE CR 74v1), and added « Note: Power Input Circuit Configuration is given for information only»
- Section 5.10, after last sentence «All relevant details of the termination connectors … given in Annex 6 (Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028)» is added
- Section 5.10.1: issue and date after «HDD 1.1 Delta, ref SPIRE-RAL-NOT-001819» are deleted.
- Section 5.10.4.2: figure named « Figure 5.10-4 : DPU's 1553B interface to the Herschel S/C»
- Section 5.10.4.2: full section and all requirements deleted, no more Master Clock (SPIRE CR 72v2)
- Section 5.10.4.3: text added and changed as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.11.1.1: table named «Table 5.11-1: Housekeeping and science data rates »
- Sections 5.11.1.1: text changed and added, values in table, text and notes changed as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.11.1.2: «TBC» is removed after «200 kbps»
- Section 5.11.1.3: «100kbps» is replaced by « the maximum packet generation rate» and «TBC» is removed after « once per second » (as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»)
- Section 5.11.3: req 0190 changed, text added and figure changed & named «Figure 5.11-1» (SPIRE CR 72v2)
- Section 5.12.2, after: …1.5 arcsec r.m.s.: «TBC» is changed by «goal»
- Section 5.12.3, after: …0.1 second: «TBC» is changed by «TBC, to be relaxed»
- Section 5.13.3: full new section, req 0240 deleted, req 0250 & 0260 changed (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)
- Section 5.13.5: full new section (E.Sawyer input §5.9.6.2 & §5.13.3 to 5_11-06-04)
- Section 5.14.3: table named « Table 5.14-1: SPIRE Frequency Plan»
- Section 5.15.1: full new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.1: full new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.2: Above 50 K changed by 100K and TBC removed, Below 100 K req added, «50 mBar/hour (TBC)» changed by «50 mBar/min», last sentence «As a goal … 100 mbar/h» is deleted (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.3: partially new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.1.4: TBW replaced by RD 23 (E.Sawyer input §5.15_11-06-04)
- Section 5.15.2.1: reduced new section. (E.Sawyer input §5.15_11-06-04)
- Section 5.15.2.2: TBW replaced by RD 23 (E.Sawyer input §5.15_11-06-04)
- Section 5.15.3.1: reduced new section (E.Sawyer input §5.15_11-06-04)
- Section 5.15.3.2: « are given in document TBW» is replaced by «will be supplied with the instrument EIDP» (E.Sawyer input §5.15_11-06-04)
- Section 5.16: Notes 1 & 2 deleted

- Section 5.16.1: full new section, with new sub-sections 5.16.1.1 to 5.16.1.4, and new 5.16.1.5 Hardware matrix with tables 5.16-1 to 5.16-7 (E.Sawyer input_04-06-04: but with added text and note), and as «Comments on IID-B 3.3 draft1, E Sawyer 13/7/04»
- Section 5.16.2: partially new section (E.Sawyer input_04-06-04)
- Section 5.16.3: partially new section (E.Sawyer input_04-06-04)
- Section 5.16.4: full new section (E.Sawyer input_04-06-04)
- Section 5.16.6: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.7: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.8: full reduced new section (E.Sawyer input_04-06-04)
- Section 5.16.9: TBD is removed (E.Sawyer input_04-06-04)
- Section 5.16.10: TBD is removed (E.Sawyer input_04-06-04)
- Section 5.16.11: : TBD are removed, RD 7 added (E.Sawyer input_04-06-04)
- Section6.1: full new section (E.Sawyer input_04-06-04)
- Section6.2: full reduced new section, previous description is deleted (E.Sawyer input_04-06-04)
- Section 7: Note deleted
- Section 7.1.1: full reduced new section (E.Sawyer input_04-06-04))
- Section 7.1.3: full reduced new section (E.Sawyer input_04-06-04)), «see RD 28» added
- Section 7.1.4: full new section (E.Sawyer input_04-06-04)
- Section 7.2.1: new title, full reduced new section, with all tables 7.2-1 deleted (E.Sawyer input_04-06-04)
- Section 7.2.2: partially new section (E.Sawyer input_04-06-04)
- Section 7.2.3: only ref to RD 24 (E.Sawyer input_04-06-04)
- Section 7.2.4: added new section 7.2.4 « EQM and PFM tests list» with new table 7.2-1
- Section 9.1: First sentence « Further details can be found in RD25 (SPIRE Instrument Qualification Requirements)» is added (E.Sawyer input_04-06-04)
- Section 9.2: partially new section (E.Sawyer input_04-06-04)
- Section 9.3: full new section (E.Sawyer input_04-06-04), but with added text
- Section 9.4: full new section (E.Sawyer input_04-06-04)
- Section 9.5: full new section (E.Sawyer input_04-06-04),
- Section 9.6: full new section (E.Sawyer input_04-06-04)
- Section 9.7: full new section (E.Sawyer input_04-06-04)
- Section 9.8: added new section 9.8, with new Table 9.8-1 »SPIRE Verification matrix» (E.Sawyer input_04-06-04)
- Annex 1: New front page (configuration and comments) and new ICD pack 11 (CR 68v1) included
- Annex 2: New SPIRE RTMM v2.5 included, with new diagram on front page
- Annex 3: no changes
- Annex 4: Some typos are corrected (^{3}He and μW)
- Annex 5: new issue 4, dated 08/07/04 of document HDD 1.1 Deltas SPIRE-RAL-NOT-001819
- Annex 6: new annex with document «Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028, draft 02, 18 june 04»

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 is the result of a specific instrument's design activity. In its 'interface' section (chapter 5) are defined 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

All Applicable Documents hereafter are available (with IIDA) on ASP ftp site :

ftp://ftp.hp-instruments.as-b2b.com/industry_to_instruments\IIDs\IID-A\Applicable and Reference documents\

AD 1 Herschel/Planck Instrument Interface Document Part A.
SCI-PT-IIDA-04624

AD 2 Product Assurance Requirements for Herschel/Planck Scientific Instruments
SCI-PT-RQ-04410

AD 3 Herschel/Planck Operations Interface Requirements Document OIRD
SCI-PT-RS-07360.

AD 4 Herschel Science-operations Implementation Requirements Document - SIRD
SCI-PT-03646

AD 5 Herschel/Planck Packet Structure Interface Control Document - PSICD
SCI-PT-ICD-07527

AD 6 Telescope specification / Herschel
SCI-PT-RS-04671

AD 7 Alignment Methods, Plan & Results
HP-2-ASED-TN- 0097 (Annex of AD1)

AD 8 Software standard
ECSS E 40 B

2.2 REFERENCE DOCUMENTS

All Reference Documents hereafter are available on ESA livelink:

http://www.rssd.esa.int/llink/livelink?func=ll&objId=26764&objAction=browse&sort=name

RD 1 SPIRE Instrument Design Description
SPIRE-RAL-PRJ-000620

RD 2 SPIRE Instrument Requirements Document (IRD)
SPIRE-RAL-PRJ-000034

RD 3 SPIRE Data ICD
SPIRE-RAL-PRJ-001078 (covers both telemetry and command data)

RD 4 SPIRE Management Plan
SPIRE-RAL-PRJ-000029

RD 5 SPIRE Science Requirements Document (SRD)
SPIRE-UCF-PRJ-000064

RD 6 SPIRE Instrument AIV Plan
SPIRE-RAL-DOC -000410

RD 7 SPIRE Product Assurance Plan
SPIRE-RAL-PRJ-000017.

RD 8 SPIRE Block Diagram
SPIRE-RAL-DWG-000646

RD 9 SPIRE product tree
SPIRE-RAL-PRJ-000030

RD 10 Instrument Work Breakdown Structure (WBS inside RD4)
SPIRE-RAL-PRJ-000031

RD 11 SPIRE Science Implementation plan
SPIRE-RAL-PRJ-000018

RD 12	SPIRE Grounding and Screening Philosophy SPIRE-RAL-PRJ-000624
RD 13	SPIRE CRYOGENIC INTERFACE THERMAL MATHEMATICAL MODEL (ITMM) SPIRE-RAL-PRJ-000728
RD 14	FEA of SPIRE structure MSSL-Technote-SPIRE-9
RD 15	Spire Straylight References SPIRE-RAL-NOT-001124
RD 16	Swinyard. B , Power profiles for SPIRE operating modes RAL-NOT-000068
RD 17	SPIRE Operating Modes SPIRE RAL-PRJ-000320
RD 18	SPIRE Thermal Configuration Control Document SPIRE-RAL-PRJ-000560
RD 19	Herschel SPIRE Harness Definition SPIRE-RAL-PRJ-000608
RD 20	Spire requirements on Cryostat Apertures SPIRE-RAL-NOT-01242
RD 21	Matching SPIRE - HOB Decentre and tilt amplitudes to the Photometer pupil alignment budget SPIRE-RAL-NOT-000754
RD 22	The Instrument EGSE for Herschel Integrated System Tests SPIRE-RAL-NOT-001463
RD 23	SPIRE FPU Handling and Integration Procedure SPIRE-RAL-PRC-001923
RD 24	EQM test plan SPIRE-RAL-DOC-001905
RD 25	SPIRE Instrument Qualification Requirements SPIRE-RAL-PRJ-000592
RD 26	Calibration Requirements Document SPIRE-RAL-PRJ-001064
RD 27	SPIRE CQM Instrument Level EMC Test Specification SPIRE-RAL-NOT-001681
RD 28	SPIRE Warm electronic integration plan SPIRE-RAL-DOC-001132
RD 29	SPIRE System interface FMECA SPIRE-RAL-PRJ-001260
RD 30	Interface FMECA qualification status report for CDR SPIRE-RAL0NOT-002087
RD 31	FDIR procedure definition SPIRE-RAL-PRJ-001978
RD 32	SPIRE structure assembly, integration and handling plan MSSL-SPIRE-SP011.04
RD 33	EQM thermal test specification SPIRE-RAL-NOT-002319
RD 34	BDA Sub Systen Specification Document SPIRE-JPL-PRJ-000456
RD 35	Making SPIRE ESD Safe SPIRE-RAL-NOT-002028

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

INSTITUTE	RESPONSIBILITIES
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, System and Thermal Engineering; AIV and ground calibration facilities; ICC Operations Centre
Stockholm Observatory	Instrument simulator; DRCU Simulator
University of Padua	Provision of ICC Operations Staff
University of Saskatchewan	OGSE Fourier Spectrometer + Science Support

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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.

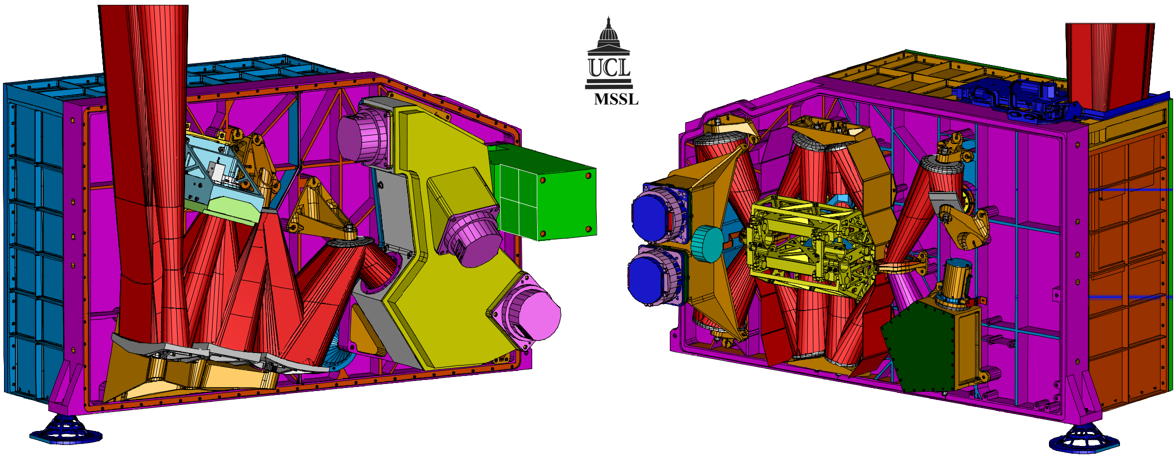


Figure 4-1: Two halves of Spire: photometer shown on left, spectrometer on the right"

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 Control Unit (on Herschel SVM) A warm analogue electronics box for detector read-out analogue signal processing, multiplexing, A/D conversion, and array sequencing.
HSFCU	Focal Plane Control Unit (on Herschel SVM) A warm analogue electronics box for mechanism control, temperature sensing, general housekeeping and ^{3}He refrigerator operation. It conditions secondary power both for itself and for the DCU.
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 SPIRE electronics boxes.

4.5 SOFTWARE DESCRIPTION

The SPIRE OBS will carry out the following functions:

- Read and log housekeeping data and packetise the data that these produce.
- 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» 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.

Commands defined in RD5 and conforming to AD5 will be sent via a HERSCHEL 1553 bus to the active HSDPU. The Spire OBS in the HSDPU will verify and then interpret these commands. Many will result in a sequence of internal digital commands which are then sent with appropriate timings to the HSDCU and/or the HSFCU.

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 17.

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 will be recycled every 48 hours. 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.

Only one (single) command is required by SPIRE to go to safe mode.

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.

For latest information, refer to RD 17.

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 a number of 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:

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 (will be defined after the PFM test programme").

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 spectrometer mechanisms will be switched off in this mode.

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

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.

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:

1 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.

2 The bolometer DQE (Detective Quantum Efficiency) is defined as :[NEPph/ NEPTotal]^2, where NEPph is the photon noise NEP due to the absorbed radiant power and NEPTotal is the overall NEP including the contribution from the bolometer noise.

3 This is the overall absorption efficiency of the combination of feed-horn, cavity and bolometer element.

4 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 (μm)			**FTS band (μm)**	
		250 μm	350 μm	500 μm	200-300 μm	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.

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° x 1° scan map	1.8	1.7	1.9

Line spectroscopy Δσ = **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 Δσ **= 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

Table 4.3: SPIRE Estimated Sensitivity

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

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)

Reference **HP-SPIRE-REQ-0270**

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

Table 5.1-1: SPIRE project codes

*

The HSFCU is a physical unit containing three functions, the HSSCU and the HSMCU meaning the HS Sub-System Control Unit and the HS Mechanisms' Control Unit respectively, plus the HSPSU that provides secondary power to all parts of the Spire DRCU..

[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.

Reference **HP-SPIRE-REQ-0280**

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

HSSxx are the SVM cryoharnesses between the SVM 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 cryoharnesses located inside the cryostat, between the vacuum connectors and the HS Cryogenic units.

The HSIxx, HSSxx and HSCxx are all considered to be "Cryoharness" and are not provided by the Spire instrument.

The two F harnesses (FPU sub-system F harness) between JFETs and FPU (HSFPU-HSJFP and HSFPU-HSJFS) are provided by SPIRE with the instrument units.

"ESA's contractor will also provide any safing plugs needed (see annex 6 of present IIDB) for the cryoharness"

#

5.2 INTERFACE LOCATIONS

All of the above may be visualised by means of the block diagram, shown in figure 5.2.1 (see RD 8). 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, electrical interfaces are at the connector planes.

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)

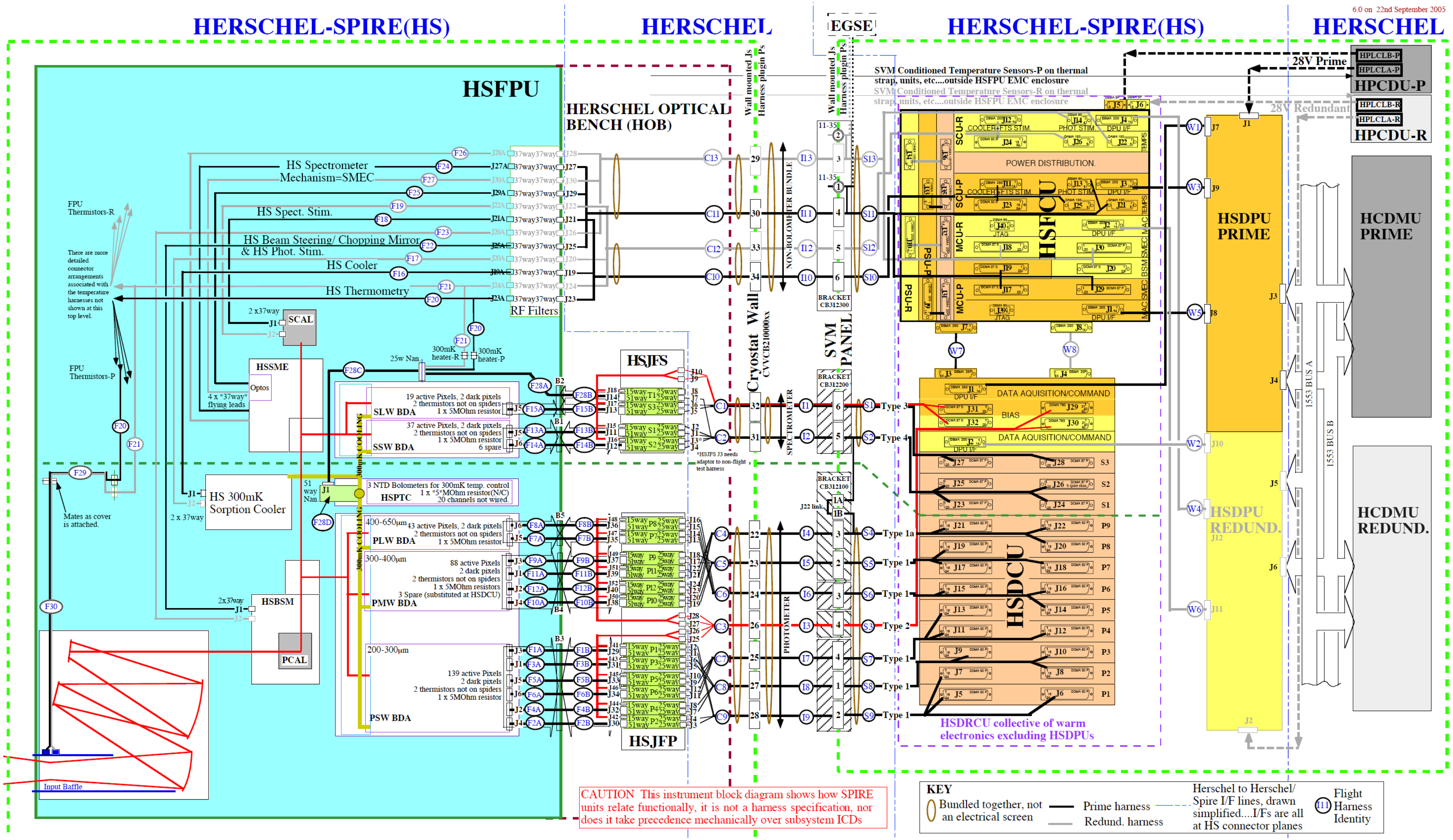


Figure 5.2.1 : Spire Block Diagram – version 6.0

5.3 LOCATION AND ALIGNMENT

Figure 5.3-1 shows 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.

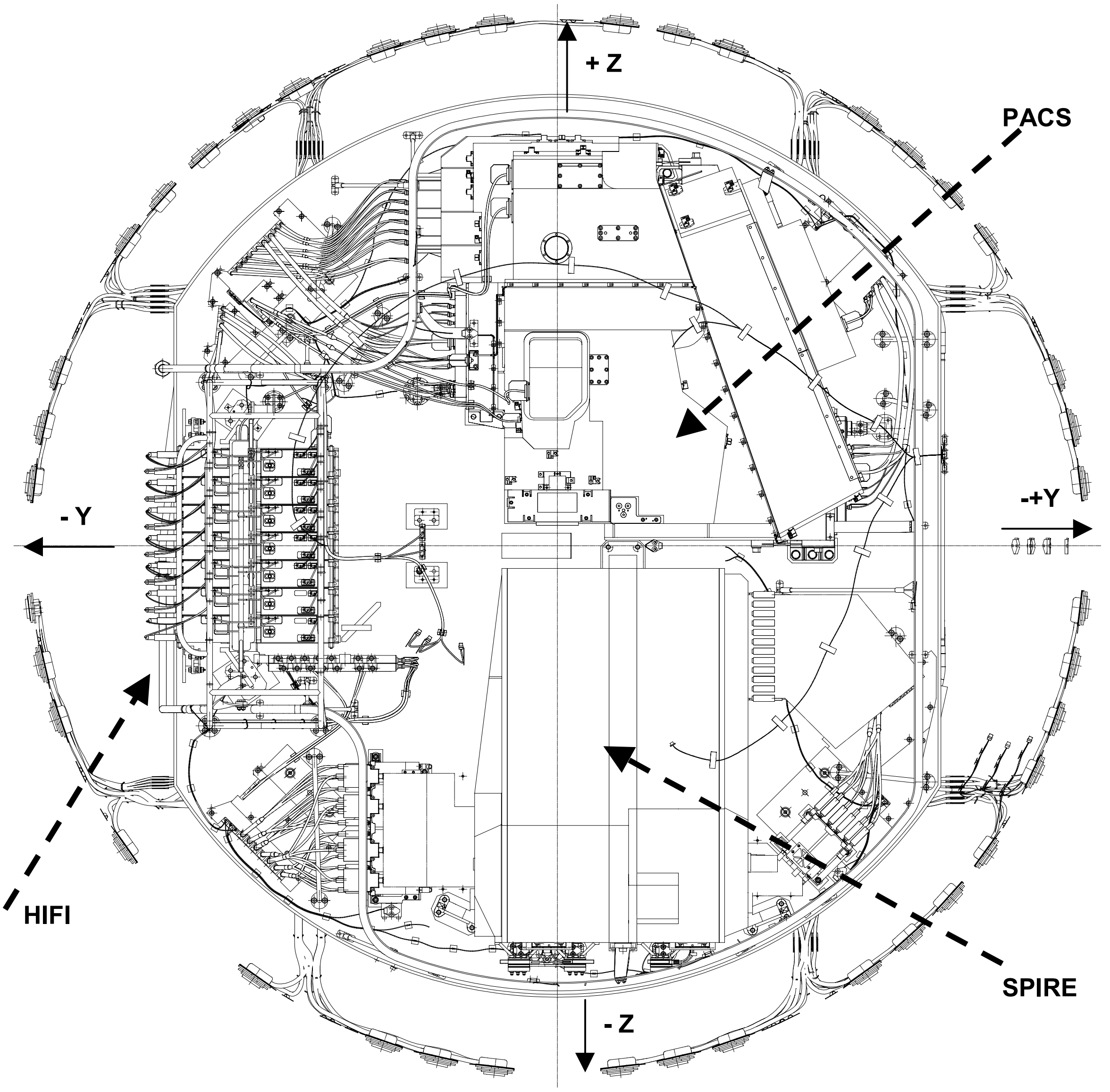


Figure 5.3-1: The Herschel Focal Plane, top view towards –X

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 128 way connectors. 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.

The picture here under shows the Spire specific SVM panel

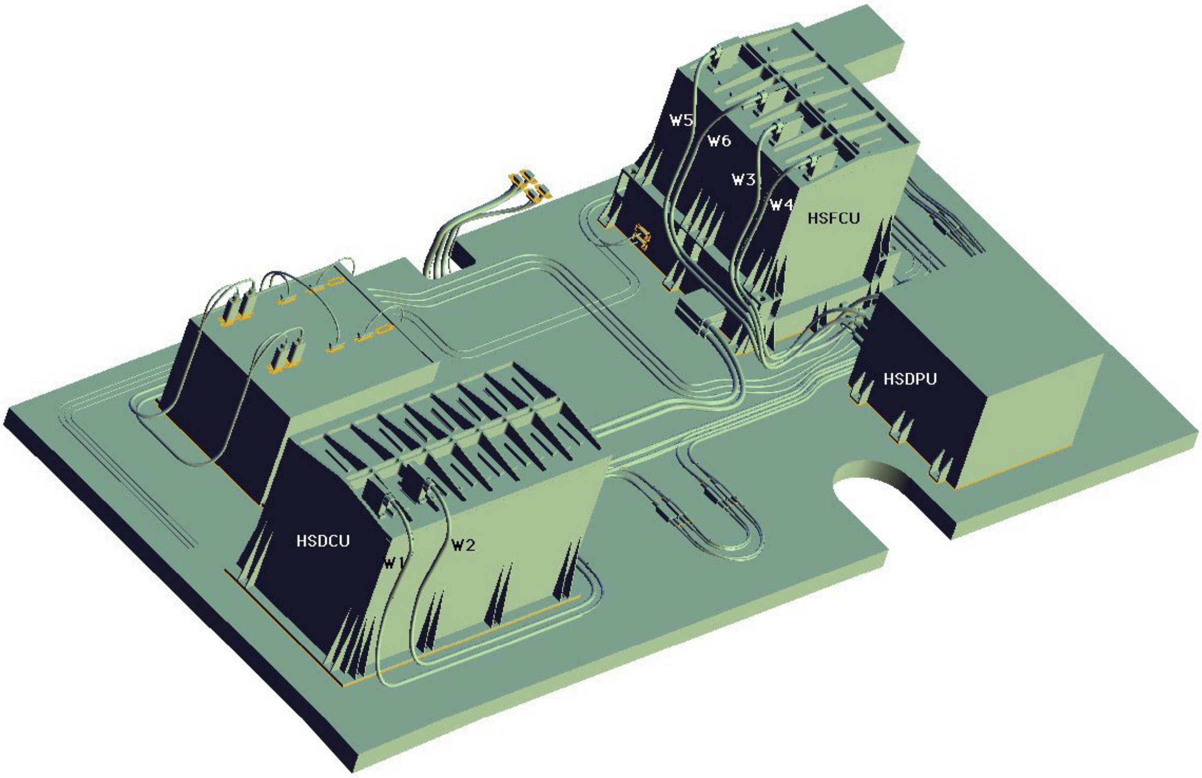


Figure 5.3-2: SPIRE specific SVM panel picture

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 AD7. This defines an error budget for how well the alignment has to be achieved, as well as how stable it then has to remain.

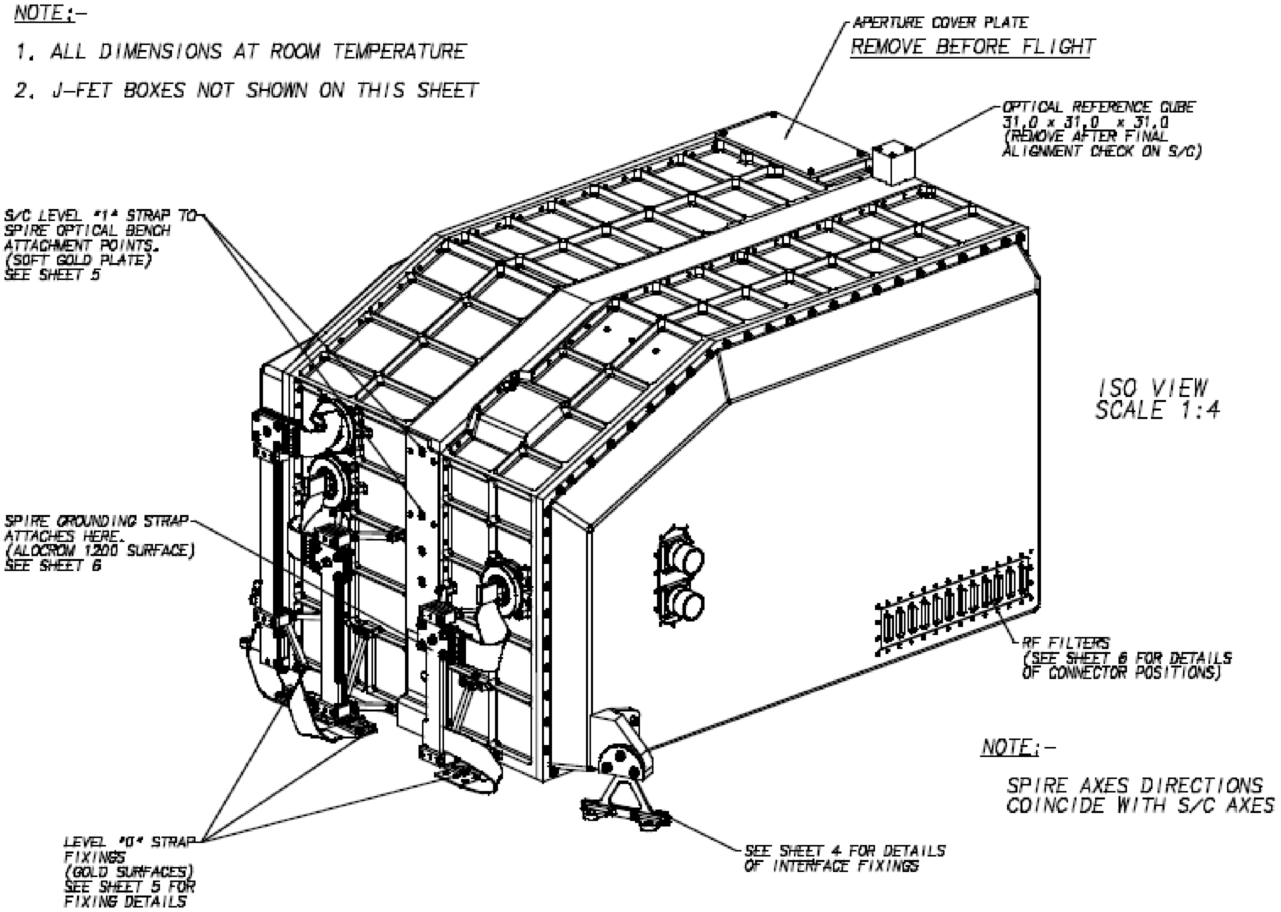
5.4 EXTERNAL CONFIGURATION DRAWINGS

These are included for readability only.

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.



Note: figure extracted from Interface Drawing, Issue 20, Sheet1

Figure 5.4-1 : HSFPU overall view

5.4.2 HSJFS

The figure here after provides an isometric view of the Spire Spectrometer JFET rack. More detailed drawings can be found in Annex 1.

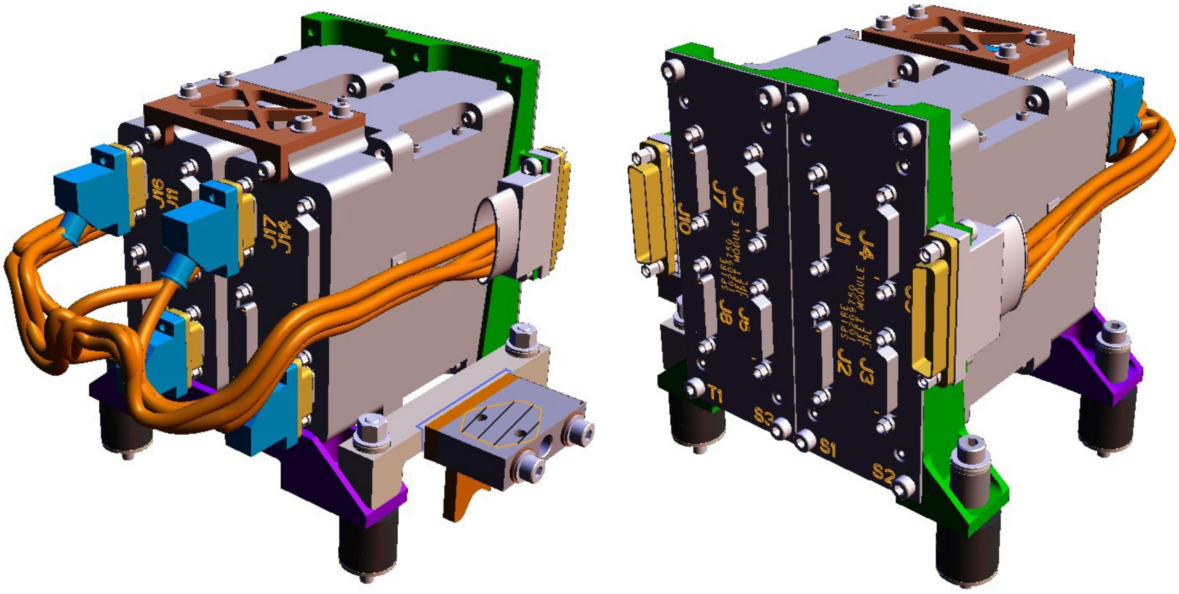


Figure 5.4-2 : SPIRE Spectrometer JFET rack external configuration

5.4.3 HSJFP

The figure here after provides an isometric view of the Spire Photometer JFET rack. More detailed drawings can be found in Annex 1.

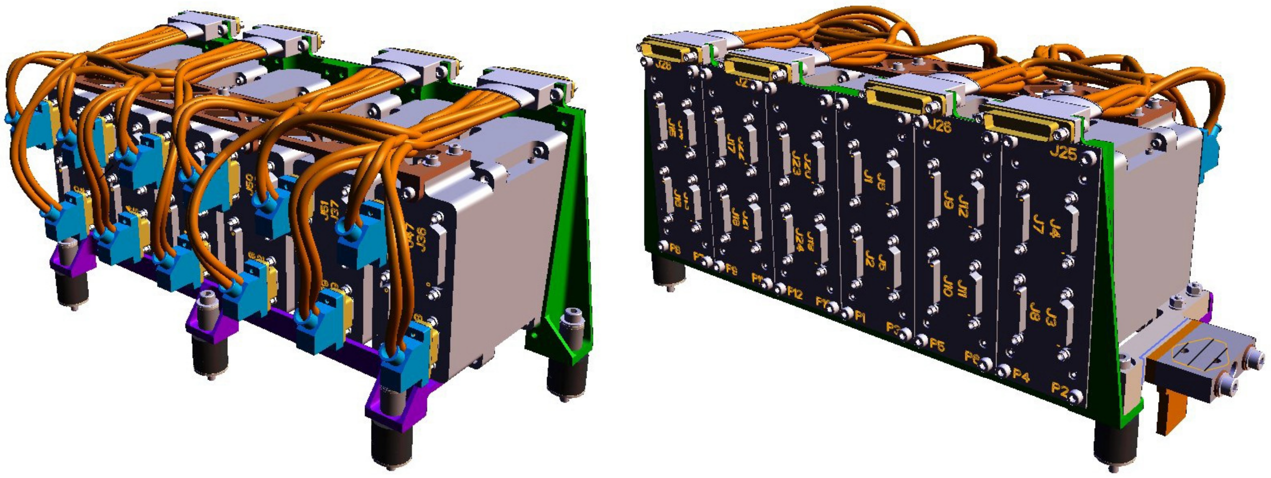


Figure 5.4-3 : SPIRE Photometer JFET rack external configuration

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

The figure here after shows an isometric view of the Spire Digital Processing Unit More detailed drawings can be found in Annex 1.

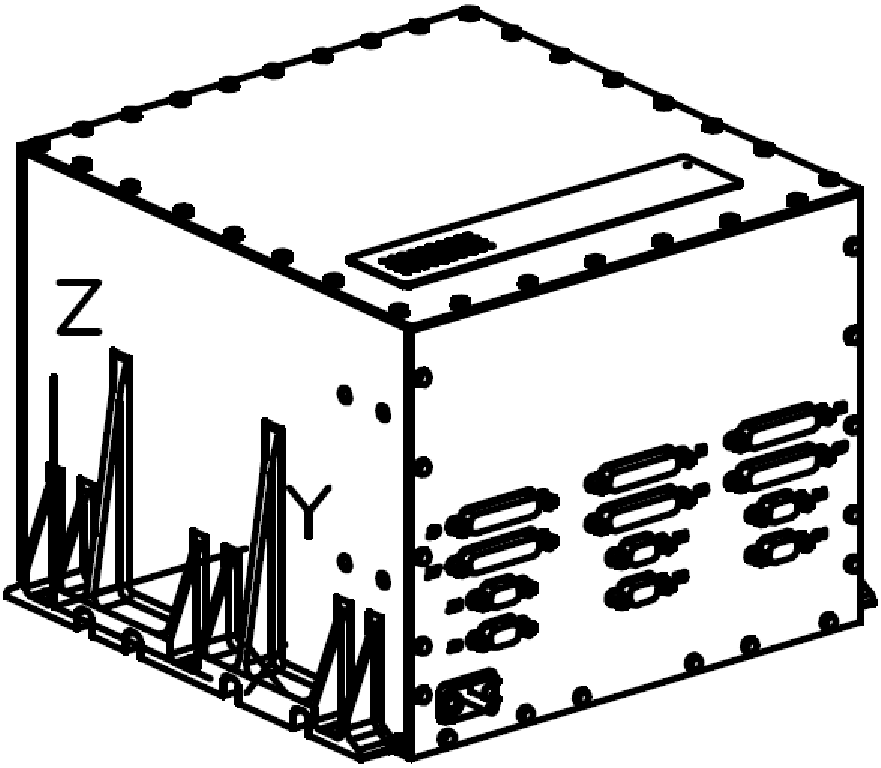


Figure 5.4-4 Isometric view of the DPU

5.4.4.2 HSDCU

The figure here after shows an isometric view of the Spire Detector Control Unit. More detailed drawings can be found in Annex 1.

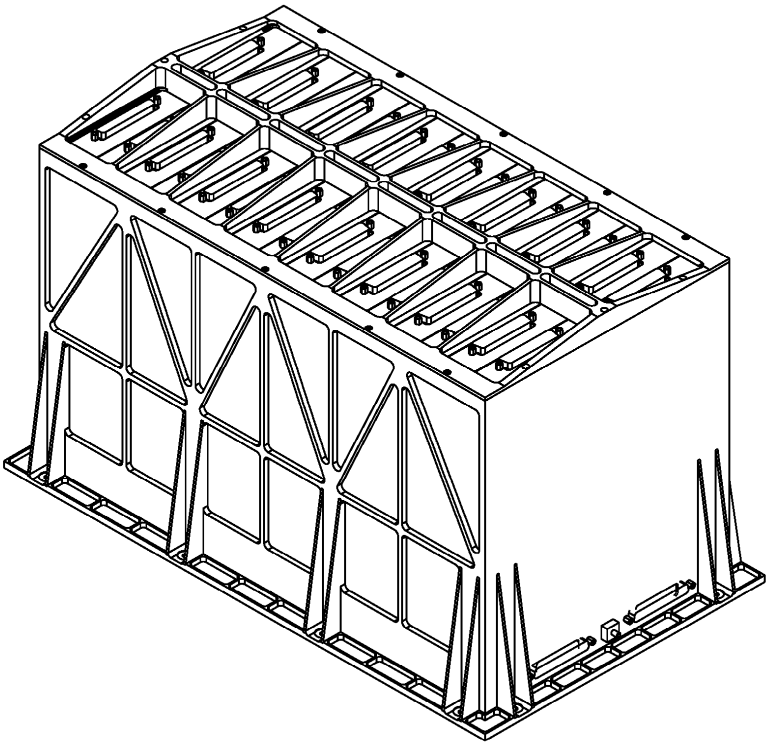


Figure 5.4-5 : HSDCU external configuration

5.4.4.3 HSFCU

The figure here after shows an isometric view of the Spire FPU Control Unit.

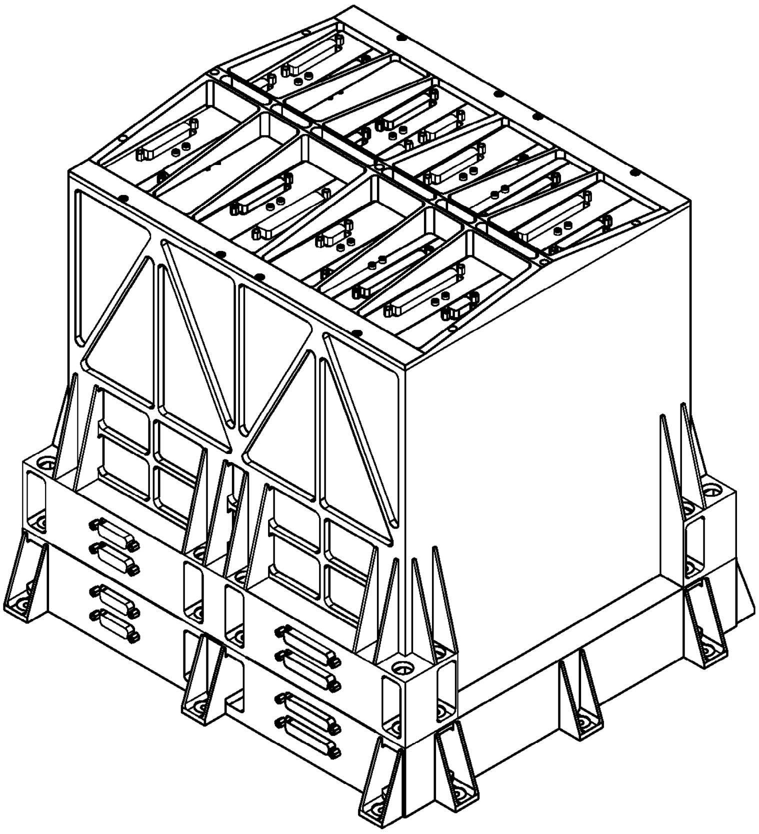


Figure 5.4-6 : HSFCU external configuration

5.5 SIZES AND MASS PROPERTIES

Reference **HP-SPIRE-REQ-0300**

Project Code	Instrument Unit	Dimenions (mm) including feet	New Estimate/ Nominal Mass of FM (kg)	Allocated Mass (kg)	Comment on new mass
HSFPU	HS Focal Plane Unit (*)	Non-rectangular. See Annex 1	45.0	47.2	Based on weighed FM with QM SMEC, no significant change expected
HSJFP	HS JFET Rack Photometer	See Annex 1	2.73	2.8	Weighed FM
HSJFS	HS JFET Rack Spectrometer	See Annex 1	1.0	1.0	Weighed FM
		Total SPIRE OB Units	**48.73**	**51.0**	
HSFCU	HS FPU Control Unit	See Annex 1	16.48	15.0	Weighed QM No change for FM expected
HSDCU	HS Detector Control Unit	See Annex 1	16.96	15.5	Weighed QM No change for FM expected
HSDPU	HS Digital Processing Unit	See Annex 1	7.23	7.0	Latest estimate
HSW1-8	HS Warm Inter-unit Harness	WIH layout is described in IIDA Annex 8	1.5	1.5	Manufactured not complete
		Total SPIRE SVM Units	**42.17**	**39.0**	
		SPIRE Instrument Total	**90.9**	**90.0**	

(*): HSFPU includes attached flying leads and any FPU thermal strap supports.

The ICD drawings, with all dimensions, for all these items are in Annex 1, in SPIRE-RAL-DWG-001409

Note: Concerning units nominal mass, this table takes precedence to any mass value indicated in drawings of Annex 1

Table 5.5-1: SPIRE Units mass & dimension

#

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 microvibrations 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

SPIRE requires the following thermal straps:

- 3 Level-0 thermal straps
- 2 Level-1 thermal straps
- 2 Level-3 thermal straps

The mechanical I/F geometry, fixing torque, mechanical load cases, etc. for each of these straps is as baselined in the IID-A. See section 5.4 for positions on Spire and section 5.7 for more details.

The HERSCHEL to Spire interfaces for the L0 straps are at three standardised points just above the HOB plate. For information, inside SPIRE, these thermal straps will be steadied by non-metallic supports 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.

The 3 Level-0 straps are provided by SPIRE, the H-EPLM contractor shall supply the 2 Level-1 and the 2 Level-3 straps.

SPIRE JFET L3 I/F with electrical insulation

Reference **HP-SPIRE-REQ-0360**

The SPIRE JFET L3 thermal strap interface shall be implemented as shown in the figure 5.6-1 below.

#

Reference **HP-SPIRE-REQ-0370**

The shape of the L3 thermal strap shall have a T-shaped end bracket (40mm x 10mm). The requirement for the two L3 straps are as follows:

- Bolt hole tolerance ∅6.00-6.05mm
- Bolt spacing 25mm +/-0.1 according to AD1
- Gold plated on both I/F sides > 10microns
- Flatness <0.05, roughness <0.4mircrons

Ref to "2 JFET" and "6 JFET" ICD's in Annex 1

#

SPIRE will provide all needed clamping and fixation parts, which will be equipped by SPIRE with an electrical insulation. The H-EPLM Contractor shall supply a T-shaped end-bracket of the flexible link for each JFET rack (i.e. 2-JFET and 6-JFET) as shown below. SPIRE will provide the clamp block with insulated bushes. The arrangement is shown in the figure 5.6-1 below.

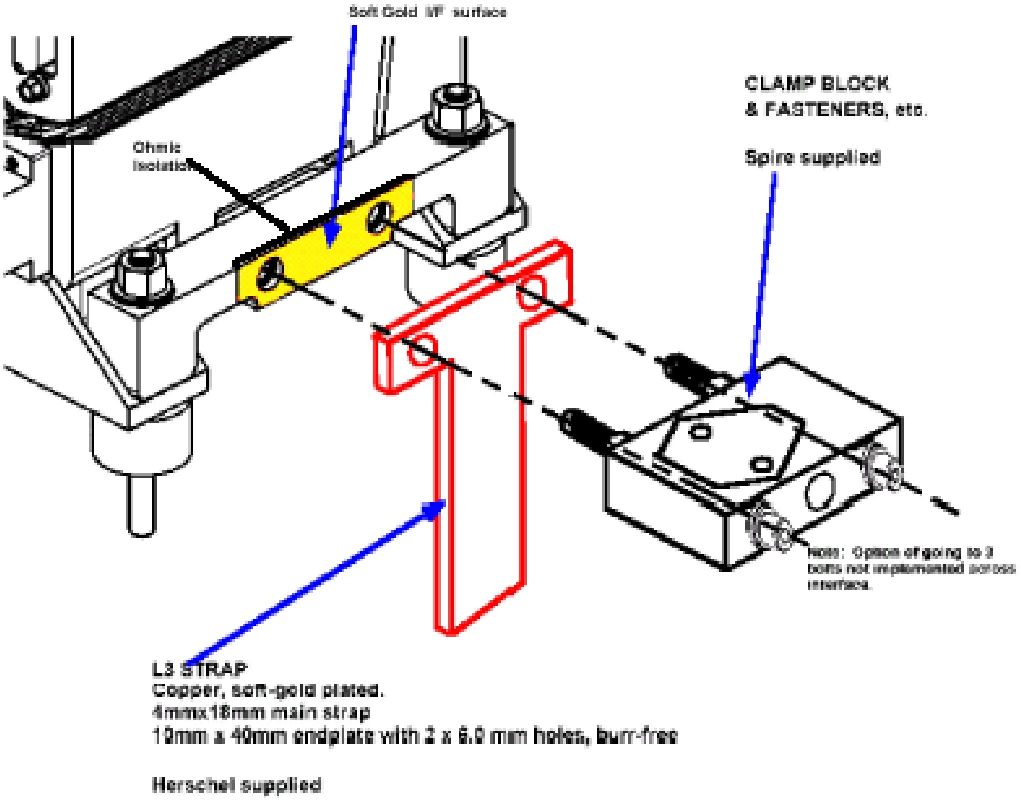


Figure 5.6-1: SPIRE JFET L3 interface including electrical insulation

SPIRE L1 electrical insulation I/F

SPIRE L1 Electrical insulation is done internal to the FPU. See FPU ICD in Annex 1

5.6.2 Outside Cryostat

NA

5.6.3 On SVM

Reference **HP-SPIRE-REQ-0400**

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 (ref Annex 1).

#

Reference **HP-SPIRE-REQ-0410**

The Spire warm harness will be attached to the SVM via tie bases and wrap as defined in IIDA Annex 10 and provided by Industry.

#

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.

The SPIRE reduced TMM is given in Annex 2 of present IIDB.

SPIRE heat flow diagram is given by the figure here under:

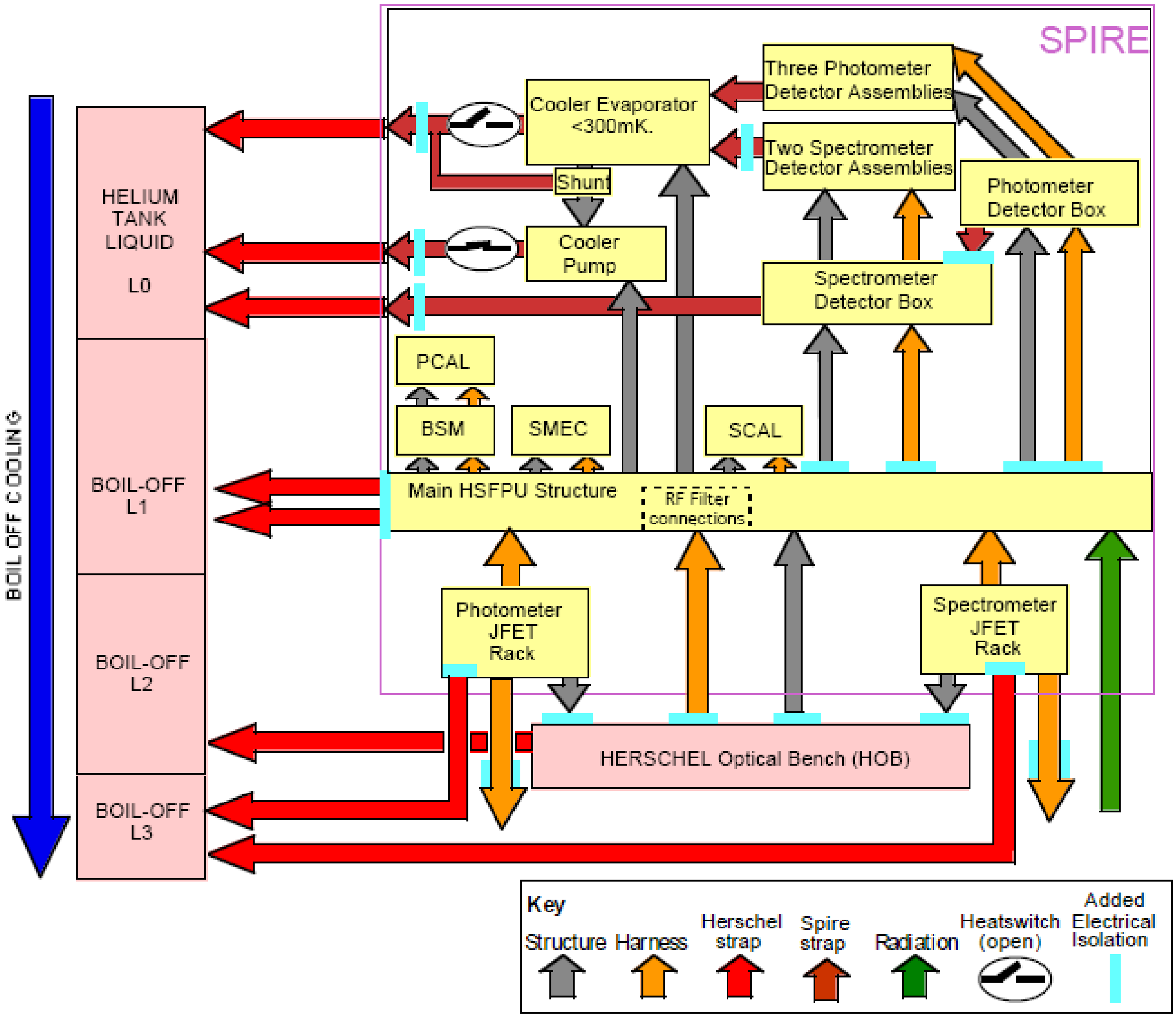


Figure 5.7-1: SPIRE heat flow diagram

5.7.1 Inside the cryostat

5.7.1.1 Description of the thermal interfaces

Spire uses 4 thermal stages to run 300mK detectors inside a ^{4}HeII cryostat. These link into levels provided by the Herschel cryostat. An overview of the Spire system is as follows, drawn with the heat switches associated with its 300mK cooler set as for an observing mode.

Electrical insulation is not shown here for electrical purposes but rather because where high thermal conduction is needed it adds to the design challenge. The radiative loads on Spire, shown in green, potentially come from warm baffles «seen» off-axis up the optical beam aperture. The arrow for external harness loads on the JFETs is not joined to anything specific as this depends on design decisions taken by Astrium.

Spire has two detector optical box structures, one housing the photometer detectors and one the spectrometer's. They mount on thermally isolating mounts inside the HSFPU and, to minimise the heat leak to the 300mK detectors themselves, link to the lowest available temperature, the L0 cryostat liquid sink. The spectrometer box has an external L0 interface and the photometer is then linked from it internally to the HSFPU, so together they only require one external I/F strap to L0.

As shown above in figure 5.7-1, there are two other L0 interfaces associated with the 300mK sorption cooler which is described below.

Not shown in the above overview are the small thermal loads on the Spire side of the I/F on the three L0 straps, due to their necessary mechanical support to the FPU.

The main HSFPU mountings to the HOB are also designed to be thermally isolating, so that the HSFPU can run at L1 whilst the HOB itself is at L2. The HOB tends to warm the HSFPU, which is why the structure and harness heat flow arrows are as shown.

When operational, JFET racks have a comparatively high dissipation. Fortunately, within reason, it is actually advantageous to run them a little warm. They therefore attach further up the boil-off line sequence to L3. Note that Spire plans to only power one rack at a time, either spectrometer or photometer and, depending on which is the more thermally demanding mode to operate in, their order on the L3 pipe is significant. Due to gas flow, the earlier can heat the later (with a heat path back into the FPU) but not visa versa.

To provide the required overall thermal balance boundary, the cryostat's inner instrument shield forms an enclosure at level 2, and the effective temperature seen from the surface of the HSFPU, integrated over an outward hemisphere, needs to be well specified.

5.7.1.2 Description of Operation and Interfaces for the ^{3}He Cooler

The Sorption Cooler interfaces and operation are described in Annex 3

5.7.1.3 Thermal requirements

Two major thermal requirements for SPIRE are its sorption minimum cooler cycle time of 48h, and its detector temperature of < 310mK.

Reference **HP-SPIRE-REQ-0420**

The table below shows the required operating temperatures and design heat flows at the thermal interfaces of the instrument unit with the cryostat or parts thereof :

	In-Orbit thermal requirements			
	SPIRE FPU thermal I/F	**Max I/F Temp @ Max Heat Load**		**Cooler State**
		Requirement	**Goal**	
L0	Detector Box	2 K @ 4 mW	1.71 K @ 1 mW	Operating
	Cooler Pump	2 K @ 2 mW	2 K @ 2 mW	Operating
		10 K @ 500 mW peak	10 K @ 500 mW peak	Recycling
	Cooler Evaporator	1.85 K @ 15 mW	1.75 K @ 15 mW	Recycling
L1		5.5 K @ 15 mW	3.7 K @ 13 mW	Operating
L2	Optical bench / FPU legs	12 K @ no load	8 K @ no load	Operating
L3	HSJFP (JFET Photometer)	15 K @ 50 mW	15 K @ 50 mW	-
	HSJFS (JFET Spectrometer)	15 K @ 25 mW	15 K @ 25 mW	-
-	Instrument shield (eq. Radiative temperature)	16 K @ -	16 K @ -	-

Notes: Assuming a He² tank temperature of 1.7 K

Sorption Cooler Recycling phase is composed of 2 phases in sequence, see Annex 3 for information

Table 5.7-1: In-Orbit thermal requirements

#

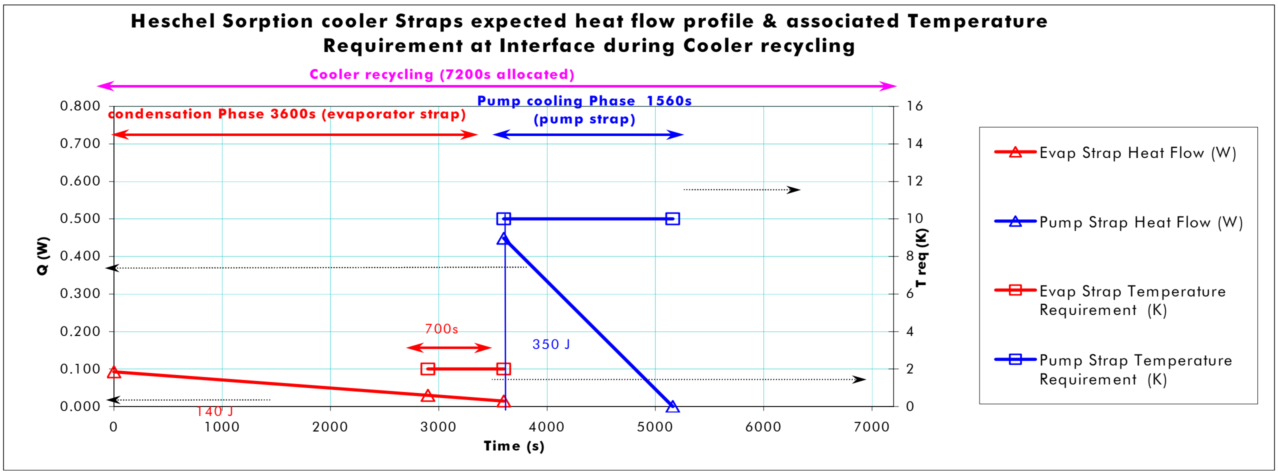


Figure 5.7.2: Expected heat profiles on evaporator and Pump strap, during recycling

5.7.1.4 Worst case temperatures

Reference **HP-SPIRE-REQ-0430**

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.

(*): The units must withstand a baking of 80°C for 72 h plus the ramp-up and ramp down operations. Taking into account the ramp-up and ramp down operations between room temperature and 80°C, the complete bake-out duration will be about 2 weeks (IID-A, § 5.15.2.5)

SPIRE FPU Thermal I/F		**Non operating temperatures**	
		Max continuous Temp	**Bake out Temp (72h max)**
L0	SPIRE SM Detector enclosure (814)	60 °C	80 °C
	SPIRE Cooler Pump strap (node 815)	60 °C	80 °C
	SPIRE Cooler Evaporator strap (node 816)	60 °C	80 °C
L1	SPIRE L1- FPU structure (two straps) (node 800)	60 °C	80 °C
L2	SPIRE L2 (Optical bench / FPU legs)		80 °C
L3	SPIRE L3 HSJFP, HSJFS		80 °C

Table 5.7-2: SPIRE FPU Non operating temperatures

#

5.7.2 Outside the Cryostat

NA

5.7.3 On the SVM

Reference **HP-SPIRE-REQ-0440**

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

Table 5.7-3: SPIRE WU temperatures

Notes: Acceptance temperature range is from 5 °C below min. to 5 °C above max. operating temp.
Qualification temperature range is from 10 °C below min. to 10 °C above max. operating temp.

#

Reference **HP-SPIRE-REQ-0450**

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

#

5.7.4 On the Planck Payload Module

NA

5.7.5 Temperature channels

5.7.5.1 Instrument Temperature Sensors

For information 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 HSFPU SPIRE conditioned housekeeping temperatures. The below table is consistent with RD19.

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	PTC_Ch1	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_2	PTC_Ch2	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
300mK Plumbing Cntrl_3	PTC_Ch3	NTD Ge Thermistor	0.2 K>5 K	0.05mK	0.2mK
HSFPU EMC filters	EMCFIL	CX-1030	3K>100K	25mK	50mK
Spectrometer 2K box	T_SL0	CX-1030	1K>10K	2mK	2mK
Photometer 2K box	T_PL0	CX-1030	1K>10K	2mK	2mK
M3,5,7 Optical SubBench	T_SUB	CX-1030	3K>100K	25mK	50mK
HSFPU Input Baffle	T_BAF	CX-1030	3K>80K	5mK	5mK
BSM/SOB I/F	T_BSMS	CX-1030	3K>80K	5mK	5mK
HS Spect. Stimulus Flange	T_SCST	CX-1030	1K>50K	10mK	10mK
Sorption Pump	T_CPHP	CX-1030	1K>50 K	10mK	10mK
Evaporator	T_CEV	CX-1030	0.2 K>5 K	1mK	1mK
Sorption Pump Heat Switch	T_CPHS	CX-1030	1K>50K	10mK	10mK

Location IN HSFPU	Acronym	Sensor Type	Temp. Range	Resol.	Acc.
Evaporator Heat Switch	T_CEHS	CX-1030	1K>50K	10mK	10mK
Thermal Shunt	T_CSHT	CX-1030	0.2 K>5 K	1mK	1mK
HS Spect. Stim 4%	T_SCL4	CX-1030	3K>80K	5mK	5mK
HS Spect. Stim 2%	T_SCL2	CX-1030	3K>80K	5mK	5mK
BSM	T_BSMM	CX-1030	3K>20K	10mK	10mK
SMEC	T_FTSM	CX-1030	3K>20K	10mK	10mK
SMEC/SOB I/F	T_FTSS	CX-1030	3K>100K	25mK	50mK

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

Table 5.7.5-1: SPIRE Instrument Temperature Sensors

5.7.5.2 Shutter Temperature Sensors

The SPIRE shutter has been removed. Temperature sensors are therefore not required

5.7.5.3 Satellite Temperature sensors

Reference **HP-SPIRE-REQ-0460**

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.

			CCU Measurement		**EGSE Measurement**	
Position	**Type (1)**	**Name (1)**	**Range**	**Accuracy**	**Range**	**Accuracy**
On Instrument Shield, close to SPIRE	C100	T213	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L0; Cooling Strap 5; to "SPIRE SM Detector enclosure"	C100	T225	1.6K - 2.0K	± < 0.001K	1.6K - 2.0K	± < 0.008K
L0; Cooling Strap 6; to "SPIRE Cooler Pump HS"	C100	T226	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L0; Cooling Strap 7; to "SPIRE Cooler Evaporator HS"	C100	T227	1.5K - 2.2K	± < 0.01K	1.5K - 2.2K	± < 0.01K
L1; on Ventline upstream strap 4 to "SPIRE Optical Bench"	C100	T235	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L1; on Ventline downstream strap 4 to "SPIRE Optical Bench"	C100	T236	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
L3; on Ventline to JFET-Phot	C100	T246	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L3; on Ventline to JFET-Spec	C100	T247	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
L1; on Strap 4 on SPIRE FPU side	C100	T248	2.0K - 10.0K	± 0.01K	2.0K – 10.0K	± 0.01K
On Spire JFET-Spec (Pos on Structure or L3 strap)	PT1000	T249			13K – 370K	± 1K
On Spire JFET-Spec (Pos on Structure or L3 strap)	C100	T250	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
On Spire JFET-Phot (Pos on Structure or L3 strap)	PT1000	T251			13K – 370K	± 1K
On Spire JFET-Phot (Pos on Structure or L3 strap)	C100	T252	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (center)	PT1000	T253			13K – 370K	± 1K
OB Plate near SPIRE foot (center)	C100	T254	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (-z+y)	PT1000	T255			13K – 370K	± 1K
OB Plate near SPIRE foot (-z+y)	C100	T256	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K
OB Plate near SPIRE foot (-y-z)	C100	T258	3.0K - 20.0K	± 0.1K	3.0K – 20.0K	± 0.1K

(1): Type and name for information only

Table 5.7.5-2: SPIRE Satellite Temperature Sensors

#

5.8 OPTICAL INTERFACES

\# Reference **HP-SPIRE-REQ-0470**

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-15.

The dimensions of the Spire optical beam stayout envelopes are defined in the HSFPU ICD annexed to the IID-B. These are simplified inclusive shapes, detailed ones can be found in RD-20

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 is the allowance required for beam diffraction.

The figure 5.8-1 here under takes into account the removing of SPIRE shutter

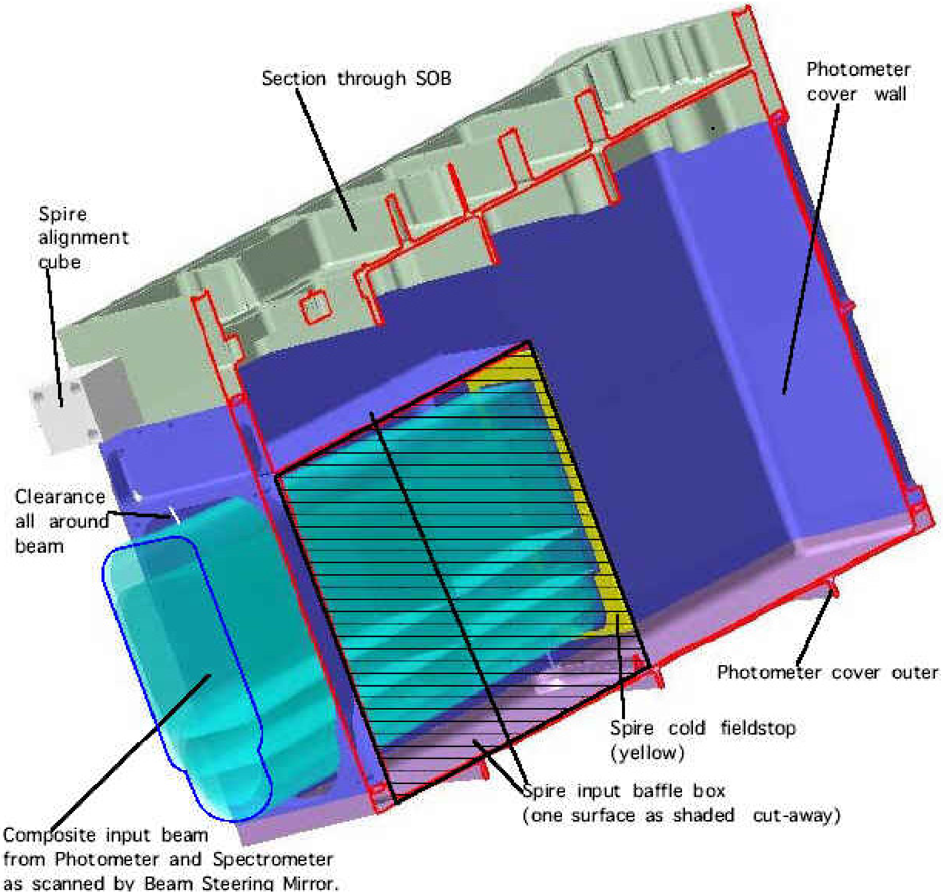


Figure 5.8-1 Spire optical beam envelope as it leaves the HSFPU

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 vary according to the operational mode of the instrument, as described in section 5.9.5.

Component	Dissipation. at component level (mW)
Photometer Cal	0.033
Spectrometer Cal	1.5
300 mK Cooler *	1.8
BSM / Photometry	3
BSM / Spectroscopy	0.2
SMEC / Photometry	0
SMEC / Spectroscopy	3.2
JFETS / Photometry	42
JFETS / Spectrometry	14

* Recycling is a special case, see section 5.7 and Annex 3.

Table 5.9-1: Power dissipation inside cryostat

Note: dissipation values of this table are for information only, refer to SPIRE RTMM in Annex 2 of present IIDB

5.9.2 Power outside the Cryostat

NA

5.9.3 Power on the SVM

Reference **HP-SPIRE-REQ-0490**

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) :

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**	

Table 5.9-2: Power dissipation on the SVM

Note: This table takes precedence to any power dissipation value indicated in drawings of Annex 1

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

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.

Table 5.9-3: Power status versus instrument modes

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:

Reference **HP-SPIRE-REQ-0020**

The SVM shall provide the allocated power budget as defined hereafter.

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	
Observing	95.3 W	95.3 W	
Parallel	95.3 W	95.3 W	
Serendipity	95.3 W	95.3 W	
Standby	95.3 W	95.3 W	
Cooler Recycle	95.3 W	95.3 W	
On	15.3 W	15.3 W	
Off	0 W	0 W	

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.

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.

Table 5.9-4: Power load on main bus

*

5.9.6.2 Power Nominal Turn-on.

This sequence takes the SPIRE instrument from its OFF configuration to the REDY configuration. In this final configuration the instrument is ready to be switched into either operational mode (Photometry or Spectrometry) or to perform a cooler recycle.

OFF to INIT:

Having checked that SPIRE is all unpowered, the spacecraft shall power on HSDPU (Prime).

The DPU will check its health and, if its status is OK, shall issue a TM(5,2) event packet indicating its readiness to accept commands. (In the event that an anomaly is found the DPU shall issue TM(5,4) event packets indicating the problem.)

INIT to DPU_ON:

A TC(8,4) command 'Force Boot' is sent to the DPU to load the On Board Software from EEPROM and start its execution. The result of this is the generation of TM(3,25) Nominal and Critical Housekeeping reports, which indicate that the OBS is configured to MODE=0x0000.

At this time 3 TM(5,1) event packets will also be generated indicating that the SPIRE DRCU subsystems are not responding to commands from the DPU - this is normal as the DRCU is not yet powered on.

DPU_ON to DRCU_ON:

Telecommands are sent to the DPU to stop collection of housekeeping data from the DRCU subsystems during power on. The stream of Nominal and Critical housekeeping TM packets will be interrupted at this time.

The spacecraft is commanded to power on the HSFCU (Prime).

Telecommands are sent to the DPU to restart collection of housekeeping data from the DRCU. The stream of Nominal and Critical housekeeping TM packets will be restarted at this time. Additional TM(5,1) event packets will be generated indicating that the DRCU subsystems are now responding to commands from the DPU, and the Nominal and Critical Housekeeping telemetry will indicate nominal operation.

The configuration MODE parameter is set by telecommand to 0x0100.

DRCU_ON to REDY:

Telecommands are sent to the instrument to:

- Switch on the DC and AC (Sub-K) temperature channels
- Power on the Cooler Sorption Pump Heat Switch
- Boot up the MCU DSP
- Set the MODE parameter to 0x0200

The affect of these commands is reflected in the housekeeping data.

5.9.6.3 Interface circuits

Reference **HP-SPIRE-REQ-0030**

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.

Reference **HP-SPIRE-REQ-0040**

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

Reference **HP-SPIRE-REQ-0050**

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

*

Reference **HP-SPIRE-REQ-0060**

Both DPUs may be powered 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.

*

Reference **HP-SPIRE-REQ-0510**

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

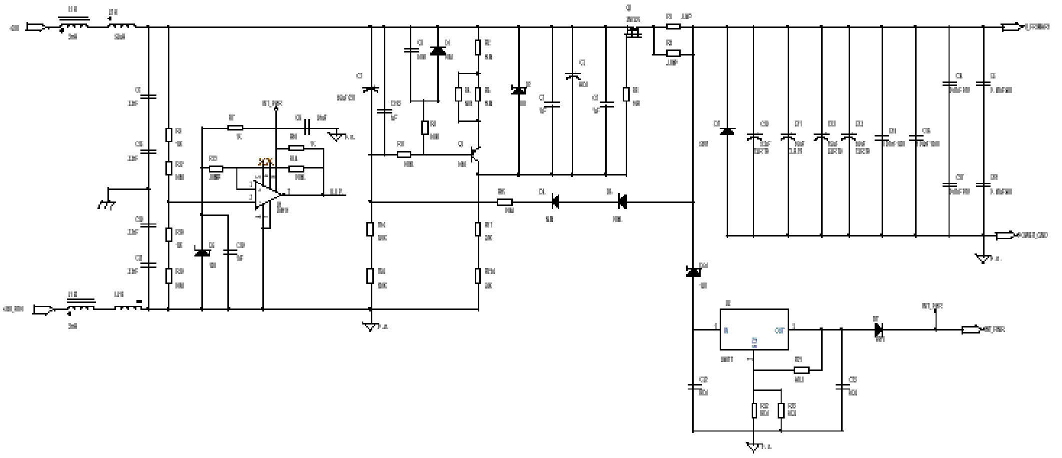
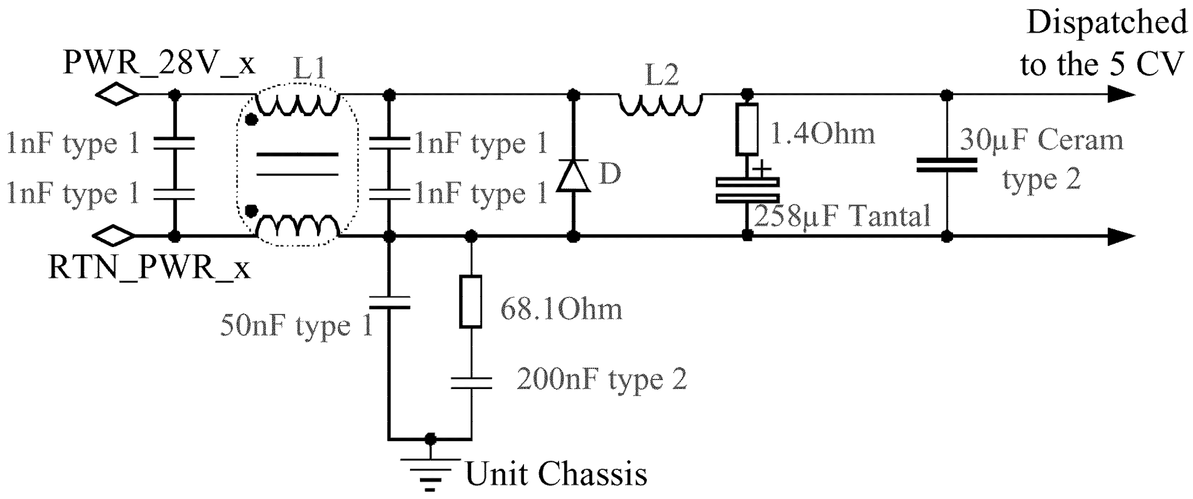


Figure 5.9-1: HSDPU Power Input Circuit Configuration

Note: This HSDPU Power Input Circuit Configuration is given for information only

5.9.6.4.2 HSFCU Power Input Circuit Configuration



On the schematic, «_x» signifies «_P» for nominal Board (J05) or «_R» for redundant. (J06).

L1 : common mode inductance , the value is : 210 µH.

L2 : differential mode inductance , the value is : 170 µH no load, 150 µH for nominal current (2.8 A), 140 µH for maximum current (4.2 A)

D is composed of four 1N5811 rectifiers, connected in series / parallel.

Figure 5.9-2: HSFCU Power Input Circuit Configuration

Note: This HSFCU Power Input Circuit Configuration is given for information only

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

Spire provides the SVM interconnect harnesses wired as per RD-19 (SPIRE-RAL-PRJ-000608), and suitable for routing/installation on the SVM as illustrated in the IID-A as regards length, connector back-shells, etc. This is illustrated in figure 5.3-2 *(as in section 5.3.1.1)*.

Reference **HP-SPIRE-REQ-0520**

Herschel provides the «cryoharness» between the warm Spire units and the cryogenic ones on the HOB inside the CVV. Figure 5.2.1illustrates how these are all in three sections, S, I and C.

#

Reference **HP-SPIRE-REQ-0530**

All harnesses shielding and overshielding implementation shall be in accordance with RD-19 (SPIRE-RAL-PRJ-000608, issue 1.2.1 or higher).

#

This implementation should be consistent with the grounding drawing figure 5.10-2

All relevant details of the termination connectors, not included in RD19 (SPIRE HDD), are given in RD35 (Making SPIRE ESD Safe, SPIRE-RAL-NOT-002028)

5.10.1 Harness and Connectors

Reference **HP-SPIRE-REQ-0540**

The cryoharness interface pinout shall be compliant with RD-19 (SPIRE-RAL-PRJ-000608, issue 1.2.1 or higher).

The Spire harnesses shall be compliant with RD-19 (SPIRE-RAL-PRJ-000608, issue 1.2.1 or higher).

#

Figure 5.10-1 below gives an overview of the 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.

The two F harnesses (FPU sub-system F harness) between JFETs and FPU (HSFPU-HSJFP and HSFPU-HSJFS) are provided by SPIRE with the instrument units.

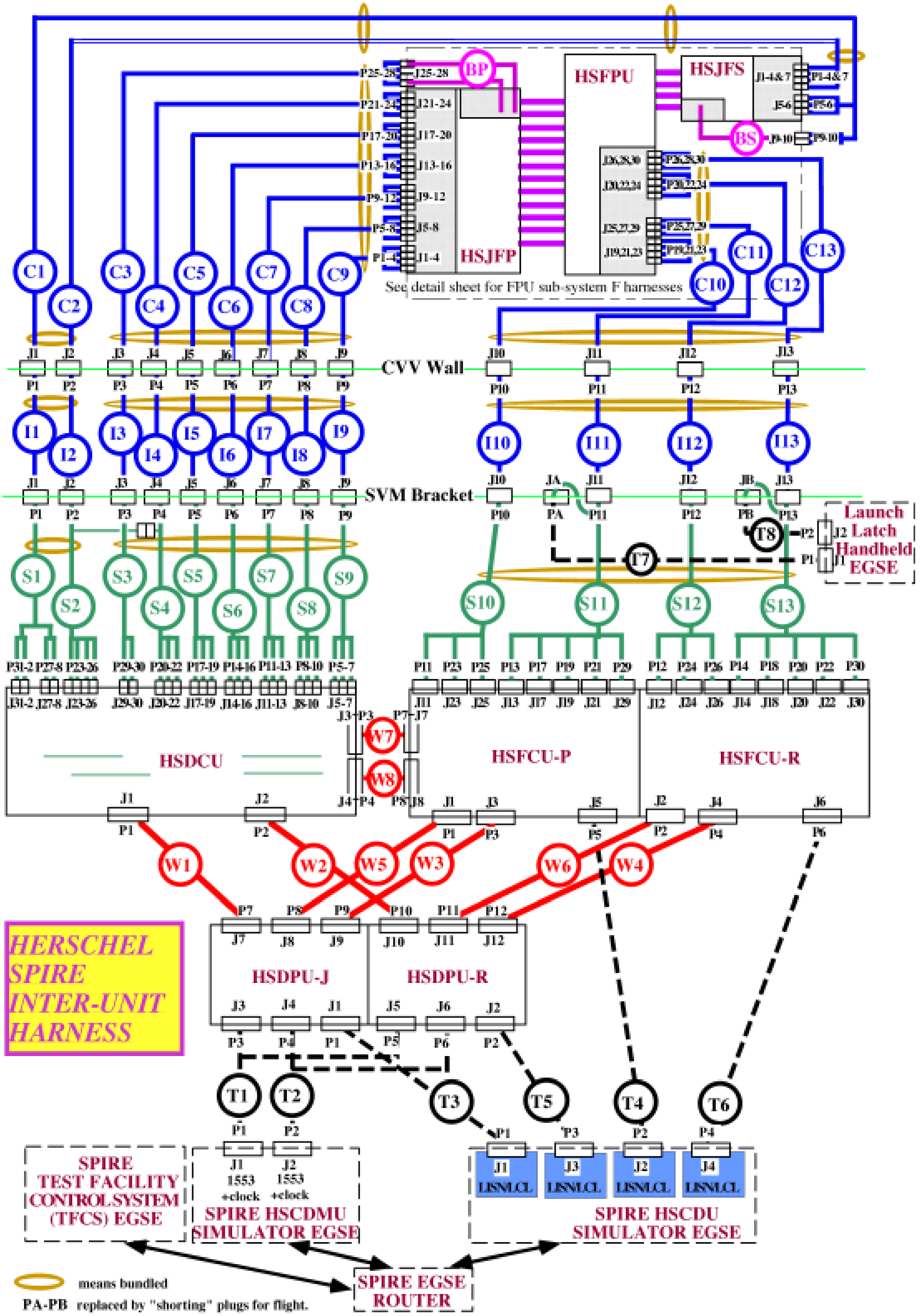


Figure 5.10-1 : SPIRE harness layout

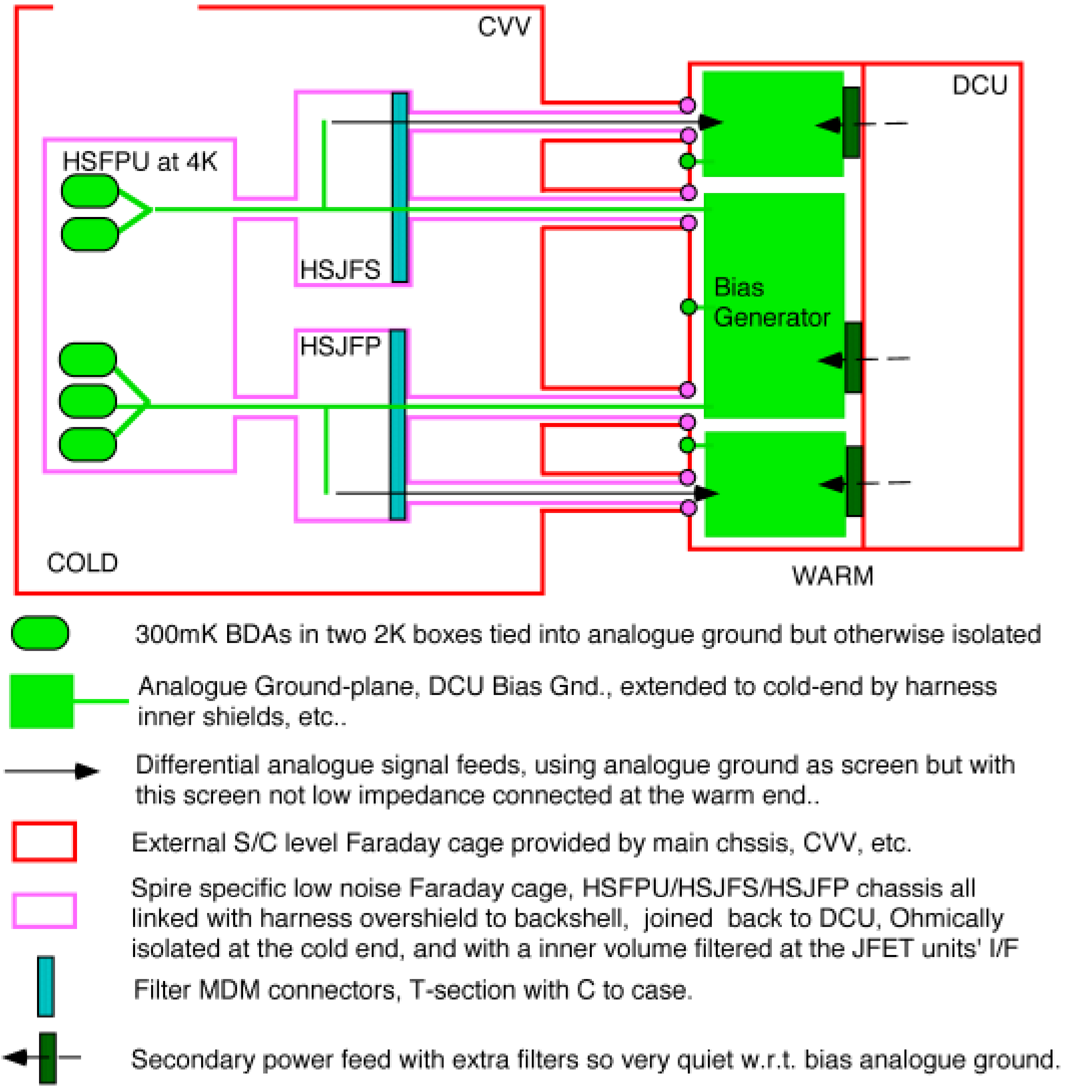
Figure 5.10-1 is for information only, details given in RD 19

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 figures 5.10-2 and 5.10-3 below is for information.

The mechanical implementation of thermal straps insulation is described in section 5.6.1.2



300mK BDAs in two 2K boxes tied into analogue ground but otherwise isolated

Analogue Ground-plane, DCU Bias Gnd., extended to cold-end by harness inner shields, etc..

Differential analogue signal feeds, using analogue ground as screen but with this screen not low impedance connected at the warm end..

External S/C level Faraday cage provided by main chssis, CVV, etc.

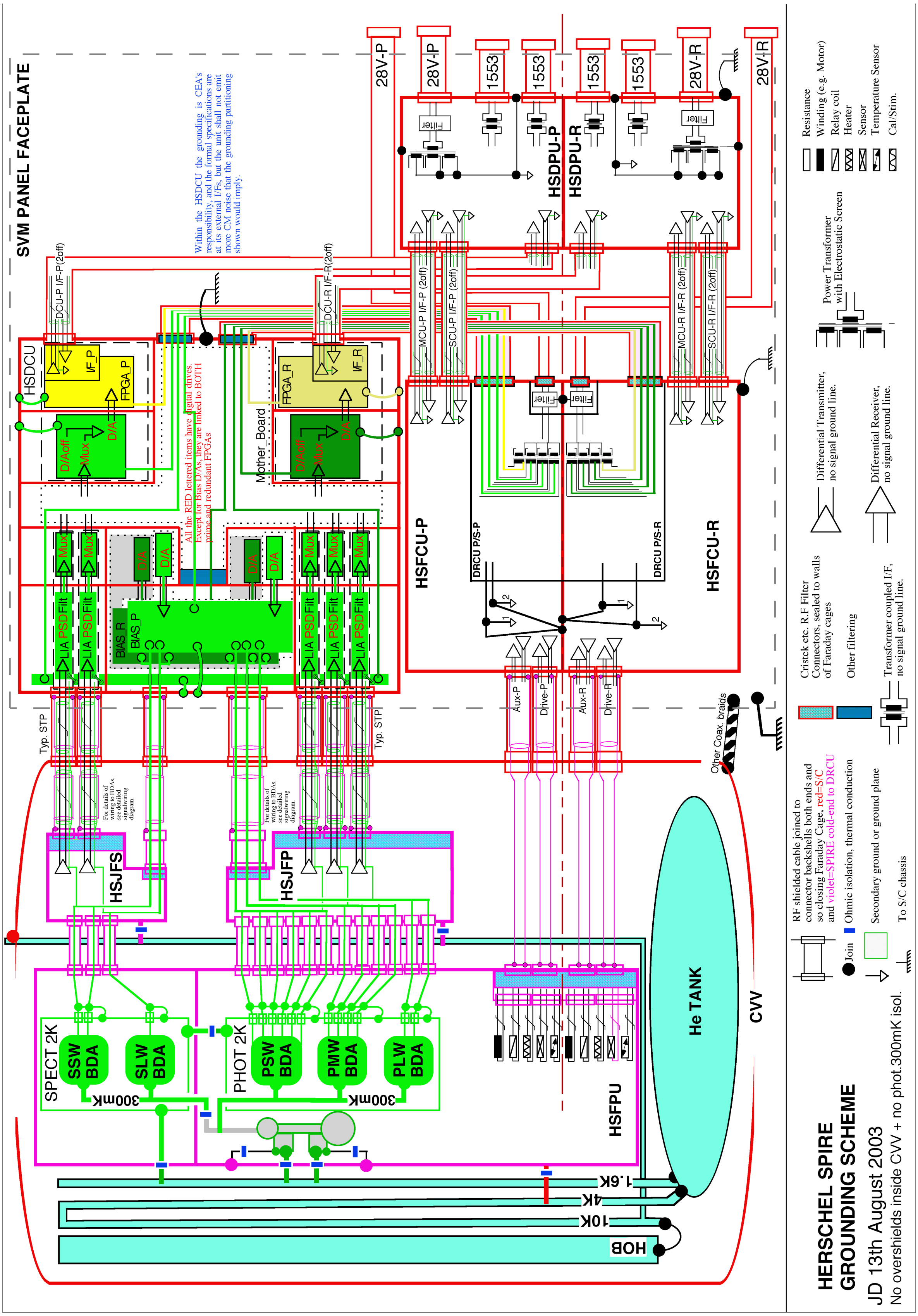
Spire specific low noise Faraday cage, HSFPU/HSJFS/HSJFP chassis all linked with harness overshield to backshell, joined back to DCU, Ohmically isolated at the cold end, and with a inner volume filtered at the JFET units' I/F

Filter MDM connectors, T-section with C to case.

Secondary power feed with extra filters so very quiet w.r.t. bias analogue ground.

Figure 5.10-2 : SPIRE Simplified 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.



Within the HSDCU the grounding is CEA's responsibility, and the formal specifications are at its external I/Fs, but the unit shall not emit more CM noise that the grounding partitioning shown would imply.

All the RED lettered items have digital drives. Except for Bias D/As, they are linked to BOTH prime and redundant FPGAs

For details of wiring to BDAs, see detailed signalwiring diagram.

For details of wiring to BDAs, see detailed signalwiring diagram.

HERSCHEL SPIRE GROUNDING SCHEME
JD 13th August 2003
No overshields inside CVV + no phot.300mK isol.

Figure 5.10-3 : SPIRE Grounding scheme

5.10.3 Bonding

Reference **HP-SPIRE-REQ-0550**

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.

The DRCU decreases interface inductance by using conductive interface gasket, see Annex 1

Reference **HP-SPIRE-REQ-0560**

A bonding strap is connected to each SPIRE SVM mounted unit.

#

5.10.4 Electrical Signal Interfaces

5.10.4.1 1553 Data Buses

Reference **HP-SPIRE-REQ-0070**

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.

---

*

Reference **HP-SPIRE-REQ-0080**

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

---

*

Reference **HP-SPIRE-REQ-0090**

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.

---

*

Reference **HP-SPIRE-REQ-0100**

Connector use is as follows:

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

---

*

The DPU’s 1553B interface to the Herschel S/C is configured as follows (figure 5.10-4) inside each SPIRE HSDPU :

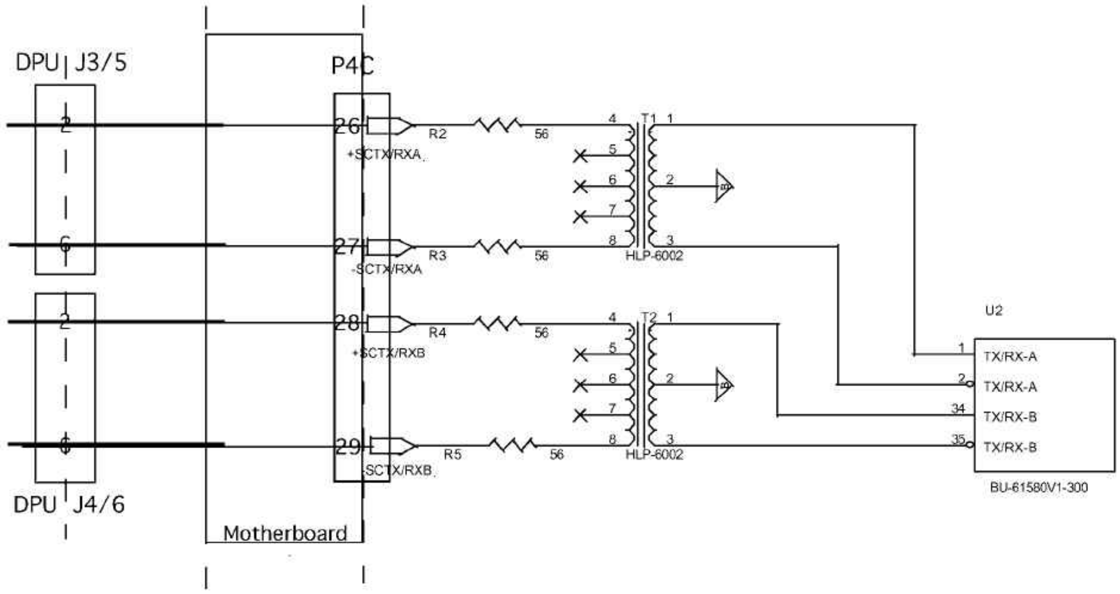


Figure 5.10-4 : DPU’s 1553B interface to the Herschel S/C

5.10.4.2 Master Clock

NA (no more Master Clock)

5.10.4.3 Launch Latch confirmation

Reference **HP-SPIRE-REQ-0570**

Spire has one cryogenic mechanism, the SMEC, which is fitted with a launch lock device to retain the mechanism during launch and ground handling. This launch lock should be maintained in the locked position except during specific on ground test sequences and once in orbit. The latching of this mechanism will need to be confirmed after launch stack integration. All functions are Prim, and Redundant.

#

Reference **HP-SPIRE-REQ-0580**

After transportation to Kourou, and the last operation of SPIRE prior to launch, hand-held Spire provided EGSE will require cable access to the two connectors JA and JB shown in the Harness configuration drawing.

This EGSE will be small and light and require no external power supply. A detailed procedure will be supplied by SPIRE.

If the latch is found to be un-latched, the instrument shall be powered up and the latch re-latched by command.

#

Reference **HP-SPIRE-REQ-0590**

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

#

5.11 DATA HANDLING

5.11.1 Telemetry

5.11.1.1 Telemetry rate

The table below gives the estimated telemetry rates in the different SPIRE modes, excluding event packets. For observing modes, the Data Rate value gives the maximum continuous data rate during an observation (the average data rate will be less due to the limited data rate used during configuration periods) and the Packet Rate gives the number of telemetry packets generated by the instrument per second (fractions indicate a packet is generated at a frequency of less than one per second, i.e.2/3 indicates two packets are generated every 3 seconds). The data rates include both instrument data and the TM packet overheads.

Description	Data Rate (Kbps)	Packet Rate (packets/s)
Housekeeping data rate (non prime)	1.9	1/2 + 1/4
Housekeeping data rate (prime)	6.5	1 +1/2
Science data rate: Photometer only	110.7	20 + 1/16 + 4/3
Science data rate: Spectrometer only	119.5	12 + 3 +1/16 + 1/3
Science data rate: Parallel mode	50.0	10 + 1/11
Science data rate: Serendipity mode	99.3	20 + 1/11

Table 5.11-1: Housekeeping and science data rates

Notes:

- Any increase in telemetry rate would have science benefits.
- The total data rate allocation of 130Kbps is a limit on the average including orbit recycling/commanding

Reference **HP-SPIRE-REQ-0150**

SPIRE requires an average of 126 kbps of TM data rate during operations, and 2.0 kbps when in non-prime mode.

*

5.11.1.2 Data-bus rate

Reference **HP-SPIRE-REQ-0160**

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 the maximum packet generation rate.

\# Reference **HP-SPIRE-REQ-0170**

In order to prevent data overflow in this Spire data storage, the HCDMU shall request packets from Spire at least as frequently as once per second .

\# *

5.11.2 S/C housekeeping

\# Reference **HP-SPIRE-REQ-0180**

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

Reference **HP-SPIRE-REQ-0190**

The S/C shall provide Spire with a timing synchronisation typically every second to allow cross reference or synchronisation of the Spire clock to the spacecraft clock.

*

Reference **HP-SPIRE-REQ-0200**

When using telescope scan mode, information will be made available to the SPIRE project to enable determination of the start of scan with a precision better than 10ms with respect to the S/C clock.

*

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 on figure here after.

Considering Spire Data Timings figure:

1. The DPU has an internal free-running 1MHz. crystal clock that runs continuously from when its power quality becomes correct at power turn on. This drives a counter that continuously synchronously increments and rolls over every ~71.6 minutes. The CDMU sends an asynchronous spacecraft time value message every second across the1553 S/C bus followed by a «seconds» marker message at that spacecraft time. At this time, the DPU stores the spacecraft time and the current value of its internal counter. For approximately the next second, i.e. until it has determined the next spacecraft time and counter value pair, the DPU determine times to label Spire data as the stored spacecraft time incremented by the delta between the value of its counter corresponding to this time and the value of its counter when the data were sampled.

The DPU controls the Spire DRCU by passing commands across the Spire internal Slow Speed Interface, sending all commands simultaneously to all three DRCU command interfaces. At appropriate intervals, it sends a DRCU counter reset command. At the time of the end of the transmission of each such command, the DPU assigns a time to this event as described and puts the result in Spire's housekeeping telemetry.

2. The DRCU's two units, the HSDCU and the HDFCU, both have command input buffers that handle the Slow Speed Interface a single command at a time. Each interface receives a 312.5KHz. clock from the DPU as part of the Slow Speed electrical protocol and this is used to increment DRCU internal counters, the values of which are then routinely used in the DRCU to label the science data sent to the DPU. Each counter will be reset to zero within 6μsec(TBC) of the end of the receipt of a counter reset command, and then immediately starts incrementing again on the next edge of the 312.5KHz. clock. It is the responsibility of the SPIRE command timeline to reset the DRCU counters sufficiently frequently that they do not overflow (i.e. at least every 229 minutes). [Note: It has to be ensured that the DPU sends commands to the DRCU sufficiently timespaced that each can be fully obeyed before the next is sent].

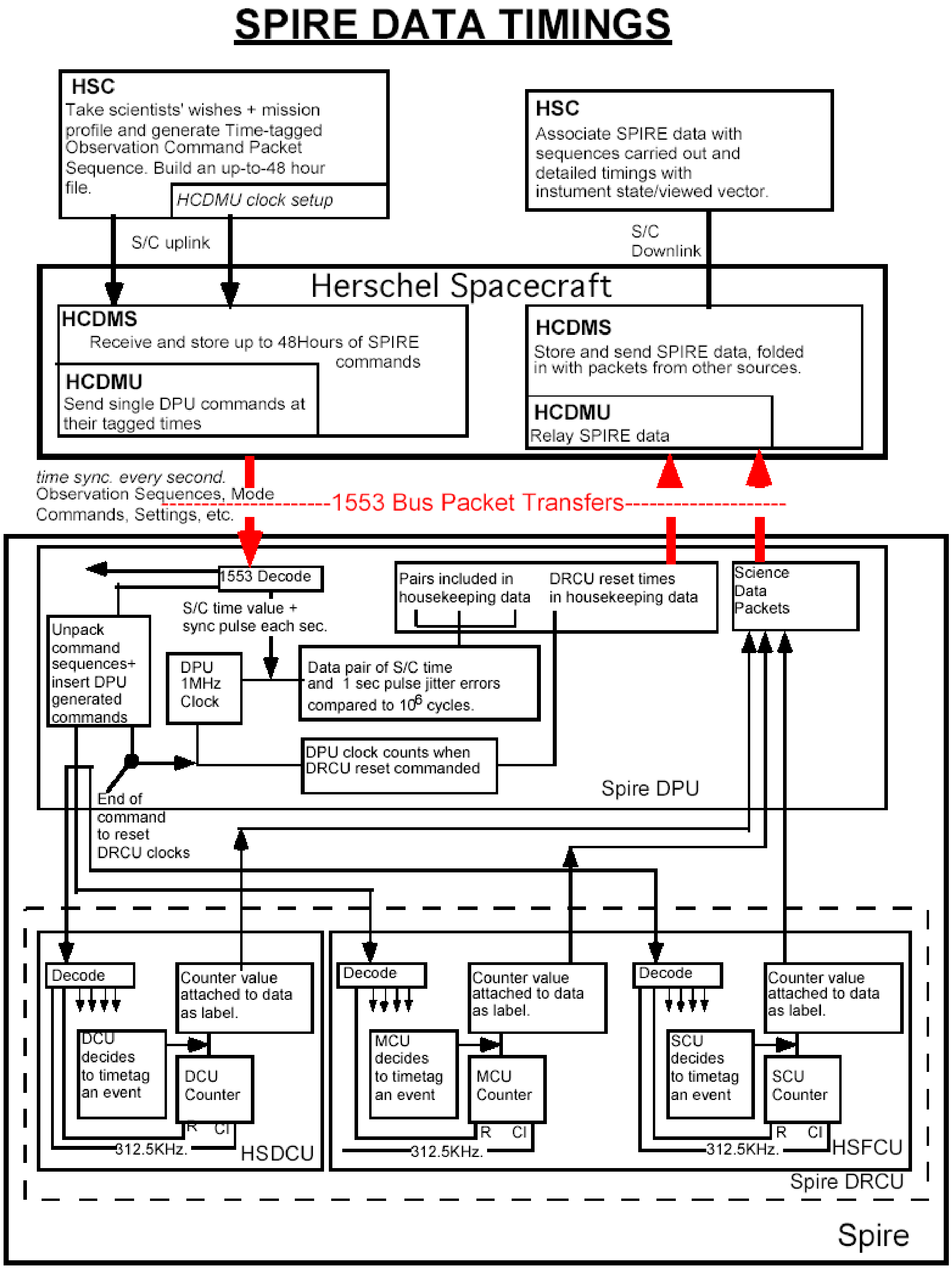


Figure 5.11-1: SPIRE Data Timings

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.

Reference **HP-SPIRE-REQ-0210**

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

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Reference **HP-SPIRE-REQ-0220**

The maximum telecommand packet length is 256 octets.

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*

Reference **HP-SPIRE-REQ-0230**

All Spire telecommands are defined in document RD3.

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Safe mode: only one (single) command is required by SPIRE to go to safe mode.

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 (TM(5,1) 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 transition time between the 2 position for 4 arcmin apart shall be less than 32s.
- 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 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 2 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

Reference **HP-SPIRE-REQ-0600**

The Spire instrument requires an absolute pointing error of better than 1.5 arcsec r.m.s. (goal), 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.

Reference **HP-SPIRE-REQ-0620**

Spire requires to be able to deduce where Herschel is pointing to 0.1 of its smallest pixel IFOV.

#

5.12.3 On-Target Flag (OTF)

Reference **HP-SPIRE-REQ-0630**

For pointed observations, SPIRE requires, an On-Target Flag. It will be provided in the spacecraft telemetry, and will specify the acquisition time to a precision of better than 0.1 second (TBC, to be relaxed). 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

Reference **HP-SPIRE-REQ-0640**

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.

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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.

Reference **HP-SPIRE-REQ-0650**

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

All S/C Autonomy functions are defined in the SPIRE FDIR (SPIRE-RAL-PRJ-001978). They are used either following detection of a problem with the instrument by the S/C - see the SOFDIR (H-P-1-ASPI-SP-0209) - or following receipt of an event packet from the SPIRE instrument.

Reference **HP-SPIRE-REQ-0250**

The S/C must be capable of taking predefined action when a particular event packet is received from the SPIRE instrument. Examples of the action to be taken are:

- Switching off the power to the SPIRE instrument (HPFCU and/or HSDPU)
- Stopping/restarting the current instrument sub-schedule
- Inhibiting commands to the instrument
- Sending fixed command sequences to the instrument

*

Reference **HP-SPIRE-REQ-0260**

The S/C must be capable of receiving and identifying SPIRE Event Reports (PUS Service Type 5, Subtypes 1, 2 and 4) that will alert the S/C of anomalies detected by the SPIRE DPU autonomy monitoring software.

*

5.13.4 Instrument Autonomy Housekeeping Packet Definition

N.A.

5.13.5 Instrument Event Packet Definition

All event packets are described in the SPIRE Data ICD (SPIRE-RAL-PRJ-001078).

This section details only those instrument event packets which have been identified as requiring action by the S/C.

All events are sent as TM(5,2) 'Exception Reports' (See PS_ICD) with

- APID = 0x0500
- SID = 0x0520
- Parameters A contains the Observation ID and Building Block ID
- Parameters B is not used

The event packets therefore have the following format:

<table>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td colspan="11">0x500</td></tr>
<tr><td>1</td><td>1</td><td colspan="14">Sequence Count</td></tr>
<tr><td colspan="16">Length=25</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="16">Time</td></tr>
<tr><td colspan="16">Event ID</td></tr>
<tr><td colspan="16">0x0520</td></tr>
<tr><td colspan="16">Observation ID</td></tr>
<tr><td colspan="16">Building Block ID</td></tr>
<tr><td colspan="16">Event Sequence Counter</td></tr>
<tr><td colspan="16">Checksum</td></tr>
</table>

Event IDs :

The following event IDs have been identified:

- 0xC000 DRCU Anomaly
  The DPU has detected an unrecoverable anomaly in the DRCU.
- 0xC010 DPU Anomaly
  The DPU has detected an unrecoverable anomaly in the DPU.
- 0xC100 Observation Anomaly
  The DPU has detected a problem during an observation.
- 0xC110 Observation Corrected
  The DPU has corrected an observation anomaly

5.14 EMC

The SPIRE instrument is particularly susceptible to EMI due to the fact that the signal to noise ratio of the detector signal is very low for faint astronomical sources. To achieve the required sensitivity dictated by the instrument science requirements, the detector signals need to be integrated for long periods of time. Excess EMI noise on the detector signals will degrade the SNR and lengthen the time required to conduct the observations.

The detector signal can be degraded due to two separate but related effects: (1) direct coupling of DM and or CM EMI voltages into the detector, front-end electronics (JFET Modules) , harness and back-end electronics (DCU), and (2) direct coupling of DM EMI current into the detector inducing I^2R heating of the bolometer. This I^2R heating results in a false detector signal output indistinguishable from the real astronomical signal. These two signal degradation modes are common to all bolometric detection systems.

The overall noise budget for the instrument is contained in the BDA SSSD. This noise budget contains a budget entry for EMI together with the other detector and readout noise sources broken down for each detector array. Due to the fact that: (1) many of the noise sources in the budget are strongly temperature dependent and (2) the detectors must be at operating temperature for I^2R heating effects to be detectable, any EMC testing on the detectors must be carried out with the instrument at the nominal flight operating temperature.

EMI can couple into the detector system via either CS or RS paths. The following elements have been incorporated into the design of the instrument to ensure immunity of the instrument against EMI:

- The entire detector system is enclosed within a Faraday cage comprised of, (1) the chassis of the DCU, (2) the overshield of the instrument cryoharness, (3) the FPU and JFET modules.
- The analogue ground reference for the detectors has a single star point at the chassis of the DCU which minimises EMI currents within the detector elements causing I^2R heating
- The cryoharnesses entering the FPU and JFET modules enter through filtered MDM connectors which attenuate high frequency EMI voltages and improve the overall integrity of the FPU/JFET faraday cage
- The detector signals are readout differentially (with an associated system CMRR specification) to lower the susceptibility to common mode pickup
- Differential JFET amplifiers lower the output impedance of the detectors thereby reducing the susceptibility of the cryoharness to EMI

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

Reference **HP-SPIRE-REQ-0660**

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
	LVDTexcitation	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	200 kHz					Free running - ± 10% - internal to unit

Table 5.14-1: SPIRE Frequency Plan

#

5.15 Transport and Handling Provisions

5.15.1 Focal Plane Unit

The FPU is a delicate optical instrument and should be handled with extreme care at all time.

Contamination of the optical surfaces within the instrument is prevented by the aperture cover. This cover should remain in place unless it is necessary to remove it.

The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk at all times when the FPU is not attached to a rigid plate. When it is attached to a rigid plate i.e. the HOB or its transport plate then it is tolerant of loads from vibration, lateral expansion, thermal tests, etc.

The SPIRE instrument contains very sensitive detectors that are susceptible to damage by Electro static discharge.

On delivery all connectors will be protected by covers or shorting plugs as appropriate.

When handling, all personnel shall wear anti static protection (wrist straps or other suitable method). When the FPU is not connected electrically to the warm electronics, the chassis is isolated from ground.

5.15.1.1 Transport Container

The Spire FPU (HSFPU) will be transported in a purpose built container that provides environmental protection; the inner bagging or container shall be opened only in the Herschel cleanroom.

The transport container is fitted with shock recorders. The HSFPU transport container is described in RD23.

5.15.1.2 Cooling and Pumping restrictions

Reference **HP-SPIRE-REQ-0700**

During cryostat warm-up or cool-down phases:

Temperatures:

- Above 100 K:
    - the rate of temperature change dT/dt shall not exceed 5 K/hour (Note 1).
    - delta T max from L0 to L1 shall not exceed 30K
    - delta T max from L1 to L2 shall not exceed 20K

    Note 1: tests have shown that higher rates will permanently damage the SMEC
- Below 100K:
    - the rate of temperature change dT/dt shall not exceed 50 K/hour.
    - delta T max from L0 to L1 shall not exceed 70K
    - delta T max from L1 to L2 shall not exceed 50K

#

Reference **HP-SPIRE-REQ-0710**

The rate of depressurisation/pressurisation dP/dt shall not exceed 50 mBar/min

#

Note: Reference sensors used for cool down and warm up rate monitoring of L0 and L2 on FM will be chosen in satellite sensors (see Table 5.7.5-2). As there are no available adequate (versus full temperature range) Satellite Temperature sensors to measure L1, reference sensors used for L1 cool down and warm up rate monitoring on FM will be chosen in Instrument Temperature Sensors (see Table 5.7.5-1).

The corresponding instrument mode and sensors used will be described and fixed in on going procedures.

5.15.1.3 Mechanism positions

Reference **HP-SPIRE-REQ-0720**

For reasons of possible damage caused by vibration during transport, the spectrometer mechanism (SMEC) will be transported in its launch-latched state

\#

There are no limitations on any other mechanism

5.15.1.4 Unpacking Procedure

The procedure for removing and installing the HSFPU from its transport container is given in document RD 23

5.15.2 JFET/Filter Boxes

5.15.2.1 Transport Container

The Spire JFET/Filter Boxes (HSFTP/S) will be transported in the same container as the FPU.

5.15.2.2 Unpacking Procedure

The procedure for removing and installing the HSFTP/S from its transport container is given in document RD 23

5.15.3 Electronics Units

5.15.3.1 Transport Container

Reference **HP-SPIRE-REQ-0740**

The Spire warm electronics units (HSDPU; HSFCU; HSDCU, HSWIH) will be transported in a purpose built container that provides environmental protection. Containers to be opened only in class 100 000 clean conditions.

\#

The transport containers are fitted with shock recorders .

5.15.3.2 Unpacking Procedure

The procedures for removing and installing the Spire from warm electronics units their transport containers will be supplied with the instrument EIDP

5.16 DELIVERABLE ITEMS

5.16.1 Instrument Models.

5.16.1.1 AVM – The Avionics Model

This is an electrical model of the SPIRE instrument and will allow the electrical and software interfaces between the SPIRE instrument and the spacecraft to be validated. This will include the capability of testing the SPIRE autonomy functions and any exchange of information required between the spacecraft and SPIRE for any SPIRE operational mode.

This model comprises the following units:

- DPU (AVM1)
- DRCU simulator
- Test harness

The DPU will have the full functionality of the flight version but it will be built with commercial grade parts and will not have redundant systems fitted. It will be identical in external form and fit to the flight unit.

The DRCU simulator will be a computer with interface cards to the DPU that is capable of receiving commands from the DPU and returning realistic data to mimic the operation of the DCU, FCU, cold FPU and JFET boxes.

A test harness will be supplied by SPIRE to connect the DPU and DRCU simulator

NOTE. The DPU AVM1 is the same unit as used in the CQM.

5.16.1.2 CQM - Cryogenic Qualification Model

This is a model of the instrument that will be used to characterise and verify the instrument scientific performance with functionally representative cold sub-systems and warm electronics units. Not all the cold FPU units will be functional, see below. The purpose of the CQM is to verify that the design of the PFM will be capable of meeting the instrument level performance requirements and that the instrument is compatible with integration into the Herschel satellite.

This model comprises the following units:

- FPU (CQM)
- Spectrometer JFET assembly
- Photometer JFET assembly
- DPU (AVM1)
- DCU (QM1)
- FCU (QM1)
- Power supply (bench power supply)
- WIH
- Fixings etc.

JFET fixation hardware:

- Isolation washers, special screws and studs

Thermal strap fixation hardware:

- L3:
  - Pressure plates 2-off
- L1:
  - Screws and isolating bushes:

  - ➢ M8 2off,
  - ➢ M3 4off

  (these screws will be prepared for wire locking)
- Wire for locking above screws.
- M4 non isolating bushes for the vent line end of the strap 16 off

Connector savers, safe plugs, covers etc

- Savers will not be supplied with the CQM JFETS
- Safe plugs will be supplied fitted to the CQM in the active connectors only.
- Aperture cover (red tag item)
- Alignment cube.

Note1: according IIDA section 5.10.1.2 « Flight-quality connectors shall be protected against frequent mating/demating operations by connector savers. These savers shall be supplied with the instrument»

The FPU will be as per the PFM with the following exceptions:

Only the PLW detector will be fitted, all other detectors will be mass thermal dummies.

The SMEC (spectrometer mechanism) will be a non functioning structural/thermal dummy.

The BSM (beam steering mechanism) will be a non functioning structural/thermal dummy.

Only the PLW JFET will be fitted, the other JFETs will be mass thermal dummies.

The thermal isolating supports on both the FPU and the detector boxes will be stainless steel whereas it is planned to fit CFRP supports for improved thermal isolation to the PFM.

The DPU will have the full functionality of the flight version but it will be built with commercial grade parts and will not have redundant systems fitted. It will be identical in external form and fit to the flight unit.

The DCU and FCU (which together form the DRCU) will not be form and fit compatible with the PFM. They will be built using commercial or MIL spec components and will have the functionality of the PFM, but no redundancy will be incorporated.

The power supply is required to power the FCU as no DC/DC converter will be available for this model.

This power supply is a mains powered (220-240v 50 Hz) and its approximate dimensions are 550x550x350 mm (LWH), its mass is 45Kg.

Note 2: Concerning AVM/QM, if connectors layout is not identical to FM , the instrument shall deliver with AVM/QM unit all necessary devices (like extensions, ...) in order to connect the FM-like Cryo and SVM harnesses (or QM baseline specific cryo-harness when exist) to the concerned AVM/QM unit.

List of equipment necessary to perform EQM/PFM test programme.

Not listed above:

Equipment	Supplied by	Remarks
Specialised tools	SPIRE	Any non standard tools, e.g. non metric spanners etc will be supplied by SPIRE, all interface fasteners are metric
28v power supply	ASED	for DPU
Break out box	SPIRE	For testing JFETs and BDAs
Mulit meter	SPIRE	For testing JFETs and BDAs And continuity/isolation tests
Shorting plugs	ASED	For cryo harness when warm units not connected
Connection to crane	ASED	From small shackle on SPIRE MGSE to crane hook
HYDRA set	ASED	For fine lifting adjustment

Table 5.16.1-1: List of equipment necessary to perform EQM/PFM test programme

5.16.1.3 PFM- Proto-Flight Model

This will be the model that is intended for flight, built to full flight standards.

This model comprises the following units:

- FPU
- Spectrometer JFET assembly
- Photometer JFET assembly
- DPU
- DCU
- FCU
- WIH
- Fixings etc.

JFET fixation hardware:

- Isolation washers, special screws and studs

Thermal strap fixation hardware:

- L3:
  - Pressure plates 2-off
- L1:
  - Screws and isolating bushes:
    - M8 2off,
    - M3 4off

    (these screws will be prepared for wire locking)
  - Wire for locking above screws.
  - M4 non isolating bushes for the vent line end of the strap 16 off

Connector savers, safe plugs, covers etc

- Savers will be supplied fitted to all units
- Safe plugs will be supplied fitted to the JFETS bias lines. Note these connectors will not be fitted with savers as well as safe plugs, as these will be subject to very limited mate/demate cycles at S/C level.
- Aperture cover (red tag item)
- Alignment cube.

Note 2: according IIDA section 5.10.1.2 « Flight-quality connectors shall be protected against frequent mating/demating operations by connector savers. These savers shall be supplied with the instrument»

5.16.1.4 FS – Flight Spare

The flight spare cold FPU will be made from the refurbished CQM. The flight spare warm electronics will consist of spare electronics cards/modules/harness.

5.16.1.5 Hardware deliverable matrix

The SPIRE Hardware deliverable matrix is given by the following tables:

Unit: HSFPU **Subsystem /component**	**AVM**	**CQM**	**PFM**
Structure/baffles/wiring standoffs etc	none	Flight Representative structural components	Flight
L0 straps	none	Detector boxes –protoflight design Cooler –protoflight design	Flight
Mirrors	none	All mirrors fitted - protoflight design	Flight
Filters	none	CFIL-1 – flight representative PFIL-2 – flight representative PFIL-3 – flight representative PDIC-1 – flight representative PDIC-2 – flight representative SFIL-2-- flight representative SBS-1- not fitted SBS-2- mass dummy SFIL-3-S- flight representative SFIL-3-L - flight representative	Flight
Beam steering mirror	none	STM	Flight
^{3}He Cooler	none	Flight representative (CQM)	Flight
300 mK thermal straps and supports	none	Flight representative with 0.29 mm Kevlar on “in line” mounts	Flight
300 mK Thermal control system	none	Not fitted	Flight
Photometer LW array	none	Flight representative (CQM)	Flight
Photometer MW array	none	Unsuspended STM	Flight
Photometer SW array	none	Unsuspended STM	Flight
SMEC	none	STM	Flight
Spectrometer SW array	none	Unsuspended STM	Flight
Spectrometer LW array	none	Unsuspended STM	Flight
Photometer Calibrator	none	CQM	Flight
Spectrometer Calibrator	none	CQM	Flight
FPU RF Filters	none	Flight representative box and connectors	Flight
Thermometry	none	Flight representative	Flight
FPU internal harnesses	none	Flight representative	Flight

Table 5.16-1: HSFPU Hardware Matrix

Unit: HSJFP Subsystem /component	AVM	CQM	PFM
JFET Structure	none	Flight representative	Flight
JFET Modules	none	One 48 channel module flight representative Rest STMs	Flight
JFET Backharness	none	Flight representative	Flight
JFET/FPU Harness	none	Flight representative	Flight

Table 5.16-2: HSJFP Hardware Matrix

Unit: HSJFS Subsystem /component	AVM	CQM	PFM
JFET Structure	none	Flight representative	Flight
JFET Modules	none	Both STM	Flight
JFET Backharness	none	Flight representative	Flight
JFET/FPU Harness	none	Flight representative	Flight

Table 5.16-3: HSJFS Hardware Matrix

Unit: HSDCU Subsystem /component	AVM	CQM (QM1)	PFM QM2	PFM
DCU Structure	Simulator only	Non Flight representative	Flight representative	Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	48 LIA-P channels functional DPU interface functional no redundancy	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight

Table 5.16-4: HSDCU Hardware Matrix

Unit: HSFCU Subsystem /component	**AVM**	**CQM**	**PFM QM2**	**PFM**
FCU Structure		Non Flight representative	Flight representative	Flight
MCU		QM1 Fitted		Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	Flight representative (no redundancy)	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight
SCU		QM1 Fitted	Flight representative	Flight
Electrical Interfaces	Simulator only	Flight representative	Flight representative	Flight
Functionality	Simulator only	Flight representative (no redundancy)	Flight representative	Flight
Electrical Component Level	NA	Commercial/industrial	MIL spec	Flight
PSU		Not fitted – replaced by EGSE "Power Bench"	Flight	Flight
Electrical Interfaces	Simulator only	N/A	Flight	Flight
Functionality	Simulator only	N/A	Flight	Flight
Electrical Component Level	NA	N/A	Flight	Flight

Table 5.16-5: HSFCU Hardware Matrix

Unit: HSDPU Subsystem /component	**AVM (AVM1)**	**CQM**	**PFM**
DPU Structure	Flight representative	Flight representative	Flight
Electrical Interfaces	Flight representative	Flight representative	Flight
Functionality	Flight representative-No redundancy	Flight representative-No redundancy	Flight
Electrical Component Level	Commercial/industrial	Commercial/industrial	Flight

Table 5.16-6: HSDPU Hardware Matrix

Unit: HSWIH Subsystem /component	**AVM**	**CQM**	**PFM**
WIH Mechanical form	Test leads to connect DPU to simulators	Flight representative	Flight
Electrical Interfaces		Flight representative	Flight
Functionality		Flight representative (no redundancy required)	Flight
Electrical Component Level	Commercial/industrial	Flight representative	Flight

Table 5.16-7: HSWIH (Warm interconnect harness) Hardware Matrix

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.

A full description of EGSE can be found in RD22 (The Instrument EGSE for Herschel Integrated System Tests)

Deliverables:

- FPU electrical simulator, including simulation of the HSFTP/S (JFET/Filter Boxes), to enable integration of the HSDCU,HSDPU, HSFCFU and HSWIH
- Quick Look Facility to enable testing of the instrument at system level. This will interface to the S/C test environment
- Common instrument EGSE

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. Further details can be found in RD 23 (SPIRE FPU Handling and Integration Procedure)

MGSE ICD is given in annex 1.

Deliverables:

- Transport containers
  - FPU and JFETs
  - DPU
  - DCU
  - FCU
- FPU handling/lifting frames
  - FPU on transportation baseplate
  - FPU on its own

5.16.4 Optical Ground Support Equipment (OGSE)

The SPIRE FPU will be supplied with an alignment cube to allow an alignment check on the HOB to be carried out

This SPIRE alignment cube can be removed and replaced such that the alignment is still valid

Deliverables:

- Alignment cube : included in FPU ICD in Annex 1

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 an identical system to that 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.

5.16.8 Instrument Software Simulator

An instrument software simulator will be produced

5.16.9 Test Reference Data

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

5.16.10 Instrument Characterisation Data

The Spire instrument characterisation data will be delivered in the 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 (AD3)
- Instrument database – this will be delivered in the form generated during instrument and system level testing.
- Each instrument model will be delivered with an End Item Data Package in accordance with RD 7 (SPIRE PA Plan)

6. GROUND SUPPORT EQUIPMENT

6.1 MECHANICAL GROUND SUPPORT EQUIPMENT

MGSE is required to ensure safe handling of all instrument components during assembly integration and test procedures. Further details can be found in RD 23 (SPIRE FPU Handling and Integration Procedure).

A list of MGSE supplied equipment can be found in section 5.16.3 of present IIDB

6.2 ELECTRICAL GROUND SUPPORT EQUIPMENT

After delivery of the Herschel instruments to industry they will be integrated on to the payload/spacecraft and tested as part of the verification activities of the integrated system. Instrument testing requires the participation of the instrument teams in order to verify the correct operation of their instrument and to do this they will use a set of equipment delivered and integrated into the system-level test system. This equipment has been labelled the 'Instrument Station' in earlier documentation, even though it will consist of several workstations and associated peripherals. To clarify this situation, the equipment is now called the Instrument EGSE (IEGSE).

The SPIRE EGSE is fully described in RD 22 (The Instrument EGSE for Herschel Integrated System Tests)

A list of EGSE supplied equipment can be found in section 5.16.2 of present IIDB

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

A common EGSE system has been 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 SPIRE by ESA and its handover to the Contractor.

7.1 Integration

Integration is described in the SPIRE structure assembly, integration and handling plan RD32.

7.1.1 HPLM Integration

Integration of the SPIRE FPU onto the HPLM is described in RD23

7.1.2 PPLM Integration

NA

7.1.3 SVM Integration

Reference **HP-SPIRE-REQ-0770**

The SVM warm units shall be first integrated as panels, and the SPIRE units linked by warm Spire warm harness. See RD 28

#

7.1.4 Herschel/Planck Integration

Precautions listed in RD23 to be taken into account during all activities

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.

Reference **HP-SPIRE-REQ-0780**

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 and by the SPIRE instrument group.

#

7.2.1 EQM Testing (SPIRE CQM)

Details of testing at EQM level can be found in RD24 (EQM test plan), and its associated applicable/reference documents

7.2.2 PFM Testing

The PFM system level test procedures for SPIRE will be based on those carried out on the EQM. A separate document will be issued by SPIRE. 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, as for the CQM testing.

7.2.3 Thermal on ground Test

See RD33 (QM thermal test specification (SPIRE-RAL-NOT-002319)

7.2.4 EQM and PFM tests list

The list of TRS (test requirement sheets) of table here after is extracted from applicable documents of IIDA: AD 13 (HP-2-ASED-PL-0021_2_0 - Instrument testing at HPLM EQM level), and AD 14 (HP-2-ASED-PL-0031_1_0 - Instrument testing at HPLM FM level)

Instrument testing on PLM EQM Level HP-2-ASED-PL-0021		Instrument testing on PLM PFM & S/C Level HP-2-ASED-PL-0031	
TRS ref	**TRS title**	**TRS ref**	**TRS title**
11.1.1	Instrument EGSE Check Out SPIRE	10.1.3	Instrument EGSE Check Out SPIRE
11.2.5	SPIRE Short Functional Test Warm	10.2.5	SPIRE Short Functional Test Warm
11.2.6	SPIRE Short Functional Test Cold	10.2.6	SPIRE Short Functional Test Cold
11.3.9	SPIRE Cooler Recycle	10.3.9	SPIRE Cooler Recycle
11.3.11	SPIRE Ambient Background Verification	10.3.10	SPIRE Ambient Background Verification
11.3.10	SPIRE Photometer Chop Mode	10.3.11	SPIRE Photometer Mode
		10.3.12	SPIRE Spectrometer Mode
11.3.12	SPIRE PACS/SPIRE Parallel Mode	10.3.13	SPIRE PACS/SPIRE Parallel Mode
11.4.3	SPIRE Integrated Module Test	10.4.3	SPIRE Integrated Module Test/IST
11.5.3	SPIRE EMC Test	10.5.3	SPIRE EMC Test
		10.6.3	SPIRE TB/TV Test
		10.7.3	SPIRE SVT Test

Table 7.2-1: SPIRE Instrument testing

Note: Concerning FM tests, AD 14 (HP-2-ASED-PL-0031_1_0 - Instrument testing at HPLM FM level) and table 7.2-1 will be superseded and updated by on going “Herschel Instruments FM IST Test specification” and “Herschel Integrated Satellite Test Procedure” to be issued.

7.3 Operations

Covered in other applicable documentation as follows:

AD3	Herschel/Planck Operations Interface Requirements Document (OIRD)
AD 4	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’ (AD2).

Details are to be found in SPIRE Product Assurance Plan (RD7).

9. DEVELOPMENT AND VERIFICATION

9.1 General

Further details can be found in RD25 (SPIRE Instrument Qualification Requirements)

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 HCSS.
- 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 bythe SPIRE instrument will as described in RD6 (SPIRE AIV Plan). The instrument models to be produced are:

- AVM - Avionics Model. (*)
- SM - Structural Model
- AM – Alignment Model
- CQM - Cryogenic Qualification Model. (*)
- PFM 1 - Proto Flight Model , build 1
- PFM 2 - Proto Flight Model, build 2 (*)
- FS - Flight Spare. (*)

See section 5.16.1 for more details

Only models marked (*) are delivered to ESA or their contractor.

9.3 Mechanical Verification

Subsystems will be mechanically verified by a combination of analysis and test.

Qualification model subsystems will be subjected to vibration tests at ambient and cold temperatures at qualification levels and durations. At sub-system level only, cold testing in all three axis may not be possible, in that case the most sensitive axis or the axis with the highest input will be used.

Subsystem test levels will be derived from analysis of the FPU which will be refined after vibration tests on the SM and CQM models.

The FPU will be verified by a combination of analysis and test.

Vibration testing will be carried out on the structural model (SM) at ambient temperature at RAL, and on the CQM at cryogenic temperature in the dedicated facility at CSL.

The PFM FPU will also be subjected to a cold vibration test.

Test levels will be agreed between the SPIRE project and ESA before the test.

Warm electronics boxes will be vibrated at ambient temperature only, as specified in AD 1 (IIDA).

9.4 Thermal Verification

FPU

An extensive programme of thermal analysis will be performed at FPU level and combined with the Herschel cryostat model.

The thermal design will be validated by testing in a purpose built test cryostat at RAL. This facility will be able to simulate an environment close to that of the spacecraft in orbit.

Warm units

These will be subjected to a traditional thermal vacuum test programme using qualification temperatures on the qualification models and acceptance temperatures on the flight models, as specified in AD 1 (IIDA)

9.5 Verification of Scientific Performance

Extensive testing and calibration will be carried out in the test facility.

Each model will be subjected to a set of tests as described in that model test specification.

This will result in all criteria as specified in the RD2 being verified.

Full calibration as described in RD26 (Calibration Requirements Document), will be carried out on the flight model.

9.6 Electrical Testing

Electrical functional and performance testing will be carried out on units at subsystem and instrument levels.

All interfaces will be verified at subsystem and instrument level.

9.7 EMC Testing

Details of EMC testing can be found in RD27, CQM Instrument Level EMC Test Specification.

9.8 Verification matrix

The SPIRE Verification matrix Is given by the table 9.8-1 here after:

Model	Unit	Vibration	Shock	Thermal	Performance	Functional	Electrical interface	Mechanical interface	EMC
AVM	DPU (AVM1)	no	no	no	yes	yes	yes	no	no
SM	FPU	Warm only	no	no	no	no	no	no	no
AM	FPU	no	no	no	Warm and cold alignment verification	no	no	no	no
CQM	FPU	Ambient and cold Qual	no	yes	Yes limited to PLW detector channel	yes	yes	yes	Limited radiated susceptibility testing with FPU in the test cryostat
	JFET	Ambient and cold Qual	no	yes	Yes limited to PLW detector channel	yes	yes	Yes	
	DPU (AVM1)	no	no	no	Yes	Yes	yes	No	
	FCU (QM1)	no	no	no	Yes	Yes	yes	No	
	DCU (QM1)	no	no	no	yes	yes	yes	No	
QM	DPU (QM)	Qual	yes	TV qual	yes	yes	yes	yes	yes
non	FCU (QM2)	Qual	yes	TV qual	yes	yes	yes	yes	yes
deliverable	DCU (QM2)	Qual	yes	TV qual	yes	yes	yes	yes	yes
PFM	FPU	Acceptance cold	no	Yes	yes	yes	yes	yes	Limited radiated susceptibility testing with FPU in the test cryostat
	JFET	Acceptance cold	no	Yes	yes	yes	yes	yes	
	DPU	acceptance	no	TV acceptance	yes	yes	yes	yes	
	FCU	acceptance	no	TV acceptance	yes	yes	yes	yes	
	DCU	acceptance	no	TV acceptance	yes	yes	yes	yes	

Table 9.8-1: SPIRE Verification matrix

10. MANAGEMENT, PROGRAMME, SCHEDULE

All relevant information can be found in the SPIRE Management Plan, RD4.

A1 . ANNEX 1: SPIRE UNITS ICD

A1.1 Drawings configuration and Industry comments

Note: Concerning mass and power (dissipation and load) the tables of sections 5.5 and 5.9 take precedence on values indicated (or not) in all these ICD's

From SPIRE-RAL-DWD-001409 - Issue 14 – February 2006

Unit	CR (*)	Drawing ref/number	Issue	Date	Notes & Comments
DPU FM	089	20-SPIRE-00.02	/	24/01/06	New FM (previous ICD was AVM/QM). Coating is Black anodise. See here after (**) notes and added notes on drawing (Thermal Ref Foot, Contact surface). ICD thermal Impact to be evaluated by AAS-I (black coating and cold case temperature)
DCU	NA	SPIR-MX-5100 000	G	08/2004	Changes versus iss E: only added informations (base plate height 4mm, position Xp-Zp of on top connectors, position Xp 470mm of fixation hole)
FCU	NA	SPIR-MX-5200 000	K	08/2004	Changes versus iss J: only added informations (base plate height 4mm, position Xp of on top connectors, position Xp 350mm of fixation hole)
DPU QM/AVM	NA	HER S005/03	4	23-02-03	No change versus IIDB 3.3 and 3.2 (Idem since ICD pack issue 8). This ICD is no more used as FM ICD.
DCU QM1	NA	SPIR-MX-5101 000	A	02/12/02	No change versus IIDB 3.3, Same drw as in pack iss 11
FCU QM1	NA	SPIR-MX-5201 000	C	08/09/03	No change versus IIDB 3.3, Same drw as in pack iss 11
FPU (SPIRE IF)	NA	A1 5264 300 sheets 1 to 7	20	08/09/05	Changes versus ICD iss 19: see change list, agreed by ASED
2 JFET	NA	0-KE-0104-360	L	05/08/05	Changes versus iss K: see change list, agreed by ASED
6 JFET	NA	0-KE-0104-350	J	05/08/05	Changes versus iss H: see change list, agreed by ASED

Unit	CR (*)	Drawing ref/number	Issue	Date	Notes & Comments
MGSE	NA	A1 5264 404 sheet 4, sheet 6 and sheet 7	3 9 9	26/03/04 23/09/05 23/09/05	3 new sheets agreed by ASED

(*) SPIRE CR's HR-SP-RAL-ECR-xxx versus SPIRE IIDB 3.3

Table A1-1: SPIRE Drawings configuration

Notes (**): Changes of DPU FM ICD 20-SPIRE-00.02_24/01/06 versus AVM/QM ICD HER S005/03 (was FM applicable in IIDB 3.3):

Mechanical Ref Foot changed vs AVM, but Thermal Ref Foot (TRP) remains as on AVM ICD, that is the foot near connectors wall (note added in drawing).

X and Y axis are inverted in FM vs AVM (Y_AVM= -X_FM and X_AVM = Y_FM)

Contact surface value and shape changed, total surface contact is changed from 64428 mm^2 to about 70500 mm^2 (8000 + 62500) :

Lateral feet walls contact added with a surface of 8000 mm^2

New base plate surface is about 62500 mm^2

That gives total surface contact of about 70500 mm^2 (note added in drawing)

The assembly tolerance shall ensure the proper full feet walls + base plate contact (ref IIDA section 5.7.3). This tolerance will be measured on FM DPU and provided by SPIRE in order to confirm the final obtained total surface contact.

The length of the base in contact with the SVM panel, measured from the connector panel to the back panel, is not indicated on the DPU FM drawing (was indicated 258 mm on DPU AVM ICD).

This length is confirmed by SPIRE to be 257.5 mm on FM.

A1.2 Set of drawings SPIRE-RAL-DWD-001409

All ICD's, drawings and associated change records are attached here after

CCLRC Rutherford Appleton Laboratory	SPIRE INTERFACE DOCUMENT.	Doc#:SPIRE-RAL-DWG-001409 Issue: 14 Date: February 2006 Page 1 of 26

Forms Annex 1 to SCI-PT-IIDB/SPIRE-02124

Subject: **SPIRE MECHANICAL INTERFACE DRAWINGS**

PREPARED BY: J. DELDERFIELD ………………………… **Date:** ………………

APPROVED BY: ERIC SAWYER pp M.GRIFFIN………………… **Date:** … … … … … … .

Issue Drawing Change List

The detailed changes for each drawing are shown just before the drawing.

Issue 2. Update to status as of 8th October 2002

Issue 3 Update to status as of 1st November 2002
FCU, DCU & Cryogenic ICDs changed, see changelists where provided

Issue 4 Update to status as of 24/2/03. JFET drawing versions raised.

Issue 5 Updated as to status of 27th March 2003. Non-AVM DPU ICD included. JFET ICDs updated.

Issue 6 Small errors on JFET ICDs fixed.

Issue 7 New versions of FPU and JFET ICDs, see their individual change lists.

Issue 8. DRCU “QM1” I/F drawings added, red-lined with NCR information. 2Module JFET updated but changes are all internal to unit.

Issue 9. Incorporate updated FM FCU and DCU drawings, including their change control sheets.
DRCU QM1 drawings amended to be like the hardware.

Issue10…Version 19 of Cryogenic unit I/F drawing inserted, implementing latest L0 straps. For detailed change control see drawing’s change list included herein.

Issue 11...Omitted connectors and unit ref. holes clarified in QM1 DRCU ICDs
JFET unit drawing minor corrections, see drawings’ change lists included herein
Append SPIRE cryogenic integration MGSE drawing sheets.

Issue 12...All drawings now represent FM build…see individual change lists except for DPU and MGSE for which these have failed to be produced

Issue13 Change not for DPU ICD generated.

Issue14 Yet another DPU update and re-insertion of QM1 DPU drawing for completeness.

Changes to DPU ICD

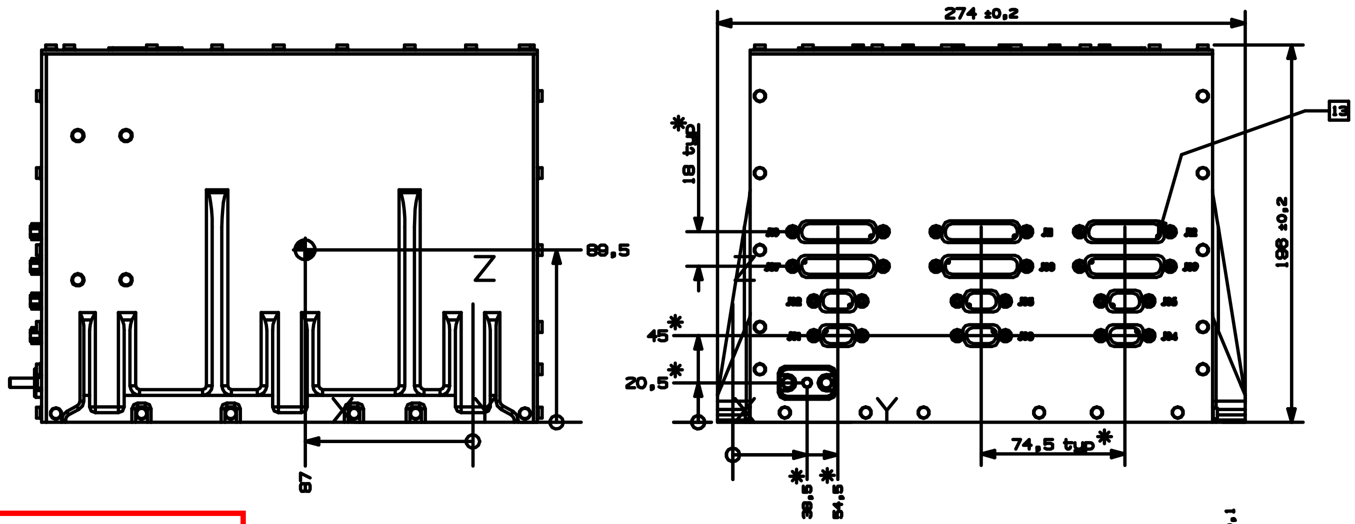
from 23/2/03 issue to 10-SPIRE-00.02 21/3/05 in issue 13

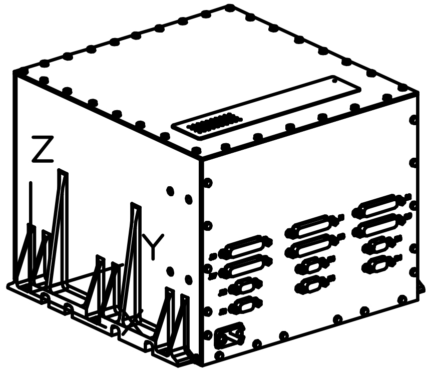
1. C. of G. moved in Z direction from 77.4 to 85
2. Tolerances on hole positions added.
3. Moments of inertia updated
4. Details of bonding stud added
5. Details of mounting foot added
6. Re-dimensioned from reference hole.
7. 3D view added
8. Mass changed from 7.177Kg +/- 200g to 7.23Kg +/- 5%.
9. Surface roughness of base added
10. Material changed from Anticorodal 6082 to AL 7075 T7351
11. Surface treatment changed from Alodine 1200 to Black anodise.
12. Connector torque added.

from 10-SPIRE-00.02 21/3/05 to 20-SPIRE-00.02 24/01/06 in issue 14.

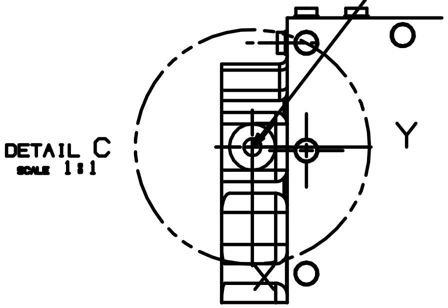
1. To align with GA's PFM documentation, the drawing number changed from 10-xxx to 20-xxx
2. New issue of the Identification Label (and with it also venting holes). The size of the ID Plate increased to provide a grid over the venting slots to prevent insertion of material into the box
3. SPIRE from J07 to J12 functions corrected
4. Engraving has been identified as per manufacturer's drawing instead of signing it with label
5. Mounting Surface calculated value modified due to thermal and mechanical considerations
6. Power dissipation value has been corrected (was 27.85 W now 14.6 W)
7. Mass evaluation has been adapted
8. Notes have been modified or deleted (where not needed), e.g. Chotherm note has been removed
9. Dimension and tolerances made consistent with the tolerances in the mechanical test procedure, without changing the overall interfaces and ICD envelope..
10. Tolerances (+0.2/-0) added to the mounting holes dimensions.

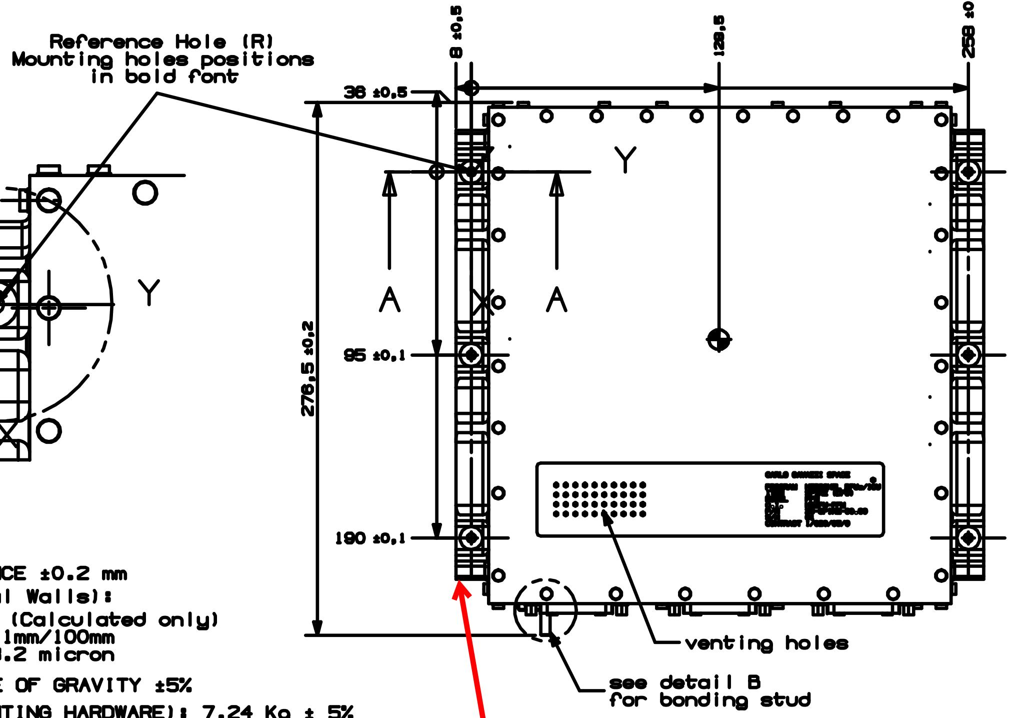
See added notes in Annex 1-1 and in FM drawing



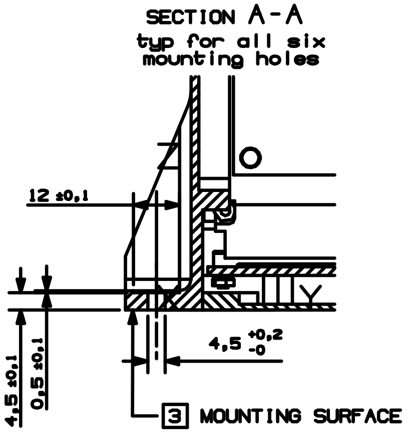


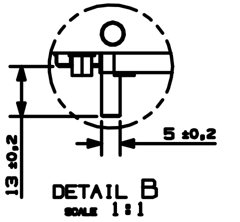
Total contact surface value is about 70500 mm² (including base plate surface of about 62500 mm²)





Thermal Ref Foot (TRP) (as on AVM ICD)





CONNECTORS TABLE

ID	P/N	Function
J01	3401002 01B DEMA9P NMBF0	from DPU Prime to PDU Prime
J02	3401002 01B DEMA9P NMBF0	from DPU Red. to PDU Red.
J03	3401002 01B DEMA9S NMBF0	from DPU Prime to Bus A Prime
J04	3401002 01B DEMA9S NMBF0	from DPU Prime to Bus B Prime
J05	3401002 01B DEMA9S NMBF0	from DPU Red. to Bus A Red.
J06	3401002 01B DEMA9S NMBF0	from DPU Red. to Bus B Red.
J07	3401002 01B DBMA25P NMBF0	from DPU Prime to DCU Prime
J08	3401002 01B DBMA25P NMBF0	from DPU Prime to MCU Prime
J09	3401002 01B DBMA25P NMBF0	from DPU Prime to SCU Prime
J10	3401002 01B DBMA25P NMBF0	from DPU Red to DCU Red.
J11	3401002 01B DBMA25P NMBF0	from DPU Red to MCU Red.
J12	3401002 01B DBMA25P NMBF0	from DPU Red to SCU Red.

NOTES:

1. OVERALL DIMENSION:
   X : 276.5 mm
   Y : 274 mm
   Z : 196 mm
2. GENERAL ASSEMBLY TOLERANCE ±0.2 mm

[3] MOUNTING SURFACE (Lateral Walls):
CONTACT AREA: 8000 mm² (Calculated only)
FLATNESS: less than 0.1mm/100mm
ROUGHNESS: less than 3.2 micron

4. ⊕ INDICATES THE CENTRE OF GRAVITY ±5%
5. MASS (NOT INCLUDING MOUNTING HARDWARE): 7.24 Kg ± 5%
6. EMISSIVITY: > 0.8 (OUTER WALLS)
7. POWER DISSIPATION: MAX 14.6 W ± 0.5 W
8. MATERIALS:
   WALLS : AL 7075 T7351 QQ-A-250/12 or EQUIVALENT
   BONDING STUD : AISI 316 PASSIVATION ACCORDING TO QQ-P-35
9. MAX TORQUE ON BONDING STUD M5: 4 Nm
10. MAX TORQUE ON CONNECTORS: 0.3 Nm
11. SURFACE TREATMENT:
    WALLS : BLACK ANODIZE ACCORDING TO MIL-A-8625 TYPE III CLASS 2
    BASEPLATE : ALODINE 1200 MIL-C-5541 CLASS 3
12. NO EIGEN MODES WITH FREQUENCY LOWER THAN 140Hz AND EFFECTIVE ASSOCIATED MASS HIGHER THAN 5% PRESENT IN INSTALLED CONFIGURATION (Analysis Results)

[13] • INDICATES CONNECTOR PIN 1

14. * DIMENSION INDICATED FOR INFORMATION ONLY AND NOT SUBJECTED TO VERIFICATION

FILE MODEL: herschel_assy_rev8
FILE DRAWING: pfm_icd_spire_dwg

REV	DRAWN	DATE	MEC CHECK	DATE	EL CHECK	DATE	SYST ENG	DATE	PA	DATE	CoC	DATE	CHANGE AUTHORITY
/	AM	24-01-08											

UNLESS OTHERWISE SPECIFIED DIMENSIONS AND TOLERANCES ARE IN mm
IDENTIFICATION MARKING PER

DASH NUMBER	NEXT ASSY
-01	20-SPIRE-00.00

APPLICATION

DRAWING TITLE
HERSCHEL SPIRE (DPU)
INTERFACE CONTROL DOCUMENT

CARLO GAVAZZI SPACE
SCALE N.A.
PROJECTION
GEN. TOLERANCES PER ISO 2768-N.A.
SPECIAL N.A. √
CARLO GAVAZZI

SIZE A2
CAGE CODE
DRAWING NUMBER 20-SPIRE-00.02
REV /
SHEET 1 OF 1

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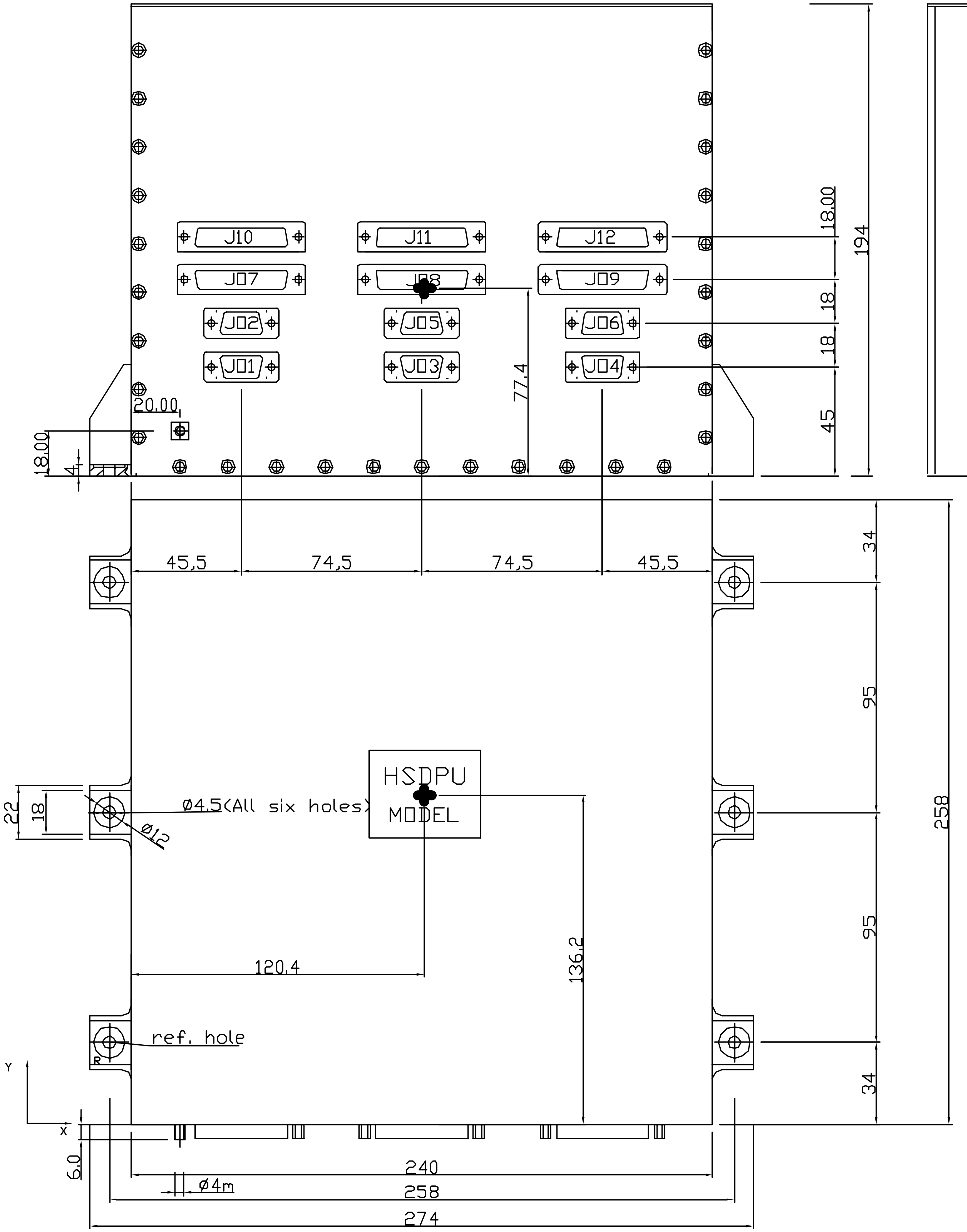
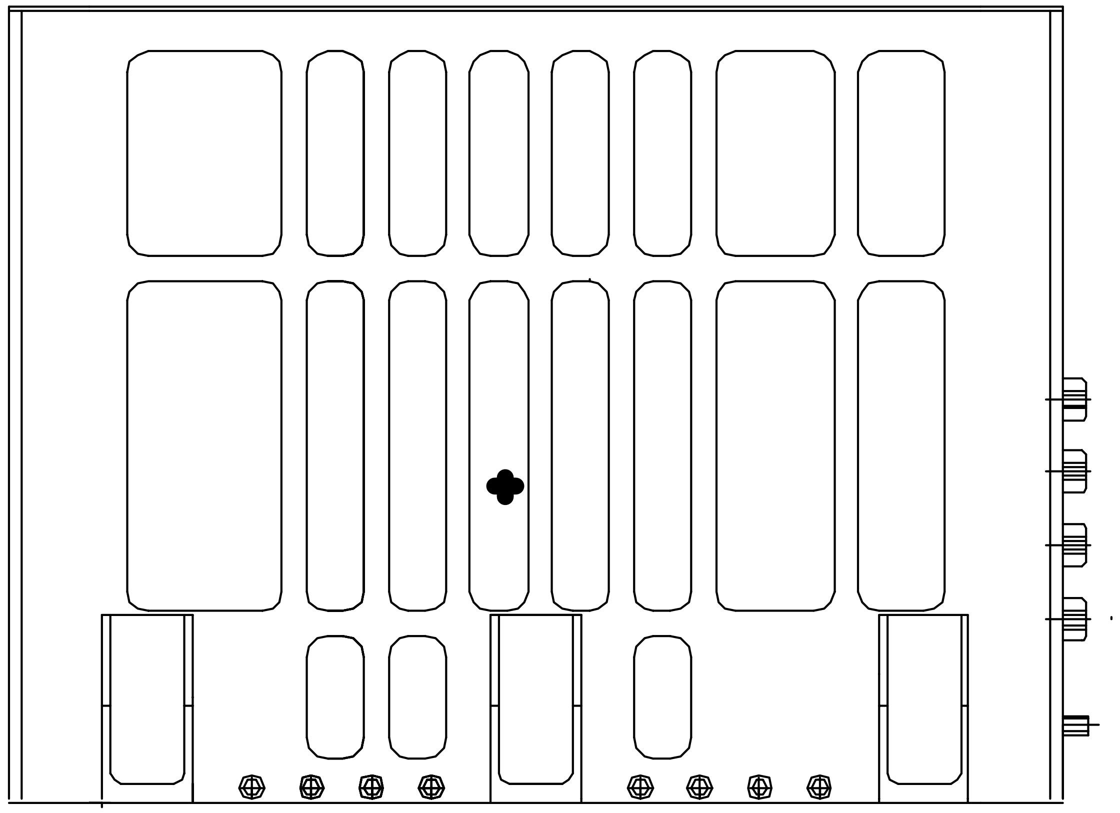




GENERAL TOLERANCE± 1mm
WEIGHT 7.177 Kg ±200g
DIMENSION 274 X 258 X 194mm3
CENTRE OF GRAVITY (E): X=120,4; Y=136,2;
Z=77,4
MOMENT OF INERTIA (E): $Jx=6,23X10^{-2}$ Kgm^2
$Jy=5.73X10^{-2}$ Kgm^2
$Jz=7.70X10^{-2}$ Kgm^2
CASING MATERIAL: ANTICORODAL 6082
SURFACE TREATMENT: ALODINE 1200:
alfa solar = 0,604
R-solar = 0,396
epsilon IR = 0,172
R-IR = 0,828
THERMAL CAPACITANCE: 7.177J/°C (E)
CONTACT AREA OF BASEPLATE PLUS FEET64428mm2
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.

ONLY FOR
QM1

UPDATED: 23/02/2003 P. Baldetti (rev. 4)
UPDATED: 10/02/2002 P. Baldetti (rev. 3)
UPDATED: 16/01/2002 P. Baldetti UPDATED: 29/01/2002 P. Baldetti

Consiglio Nazionale
delle Ricerche
ISTITUTO di FISICA
dello SPAZIO INTERPLANETARIO
Via del Fosso del Cavaliere n.100
tel. 06/4993 fax 06/49934383

data 5/04/2001	**prog.** Baldetti		**dis.**
	scala	**materiale**	
	tratt.		
√ **toll.**	**Progetto:** HERSCHEL- HSDPU		
rev. 4 **data** 23/02/03	**titilo:** HSDPU		**N.dis** HER S005/03

HERSCHEL Spire	**List of changes** **SPIR-MX-5100 000** **Rev. E to Rev G**	cea DSM-DAPNIA SAp SAp-SPIRE-QA-0188-04 Date : 03/09/2004 Page: 1/1

List of changes

Document identification

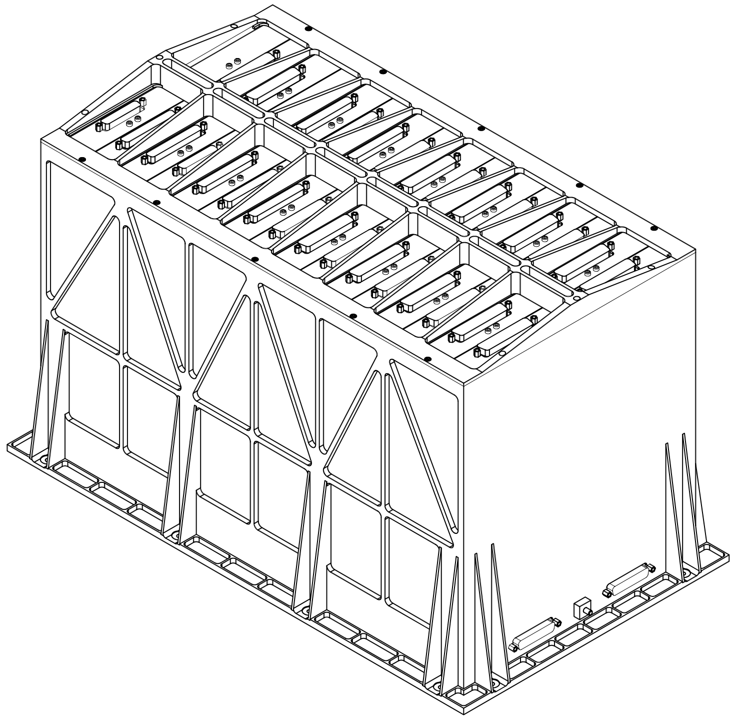
Document n°		SPIR-MX-5100 000
Title of document		SPIRE DCU Electronic box mechanical i/f drawing
Changes	From rev.	Rev. E (01/2004)
	To rev.	Rev. G (08/2004)

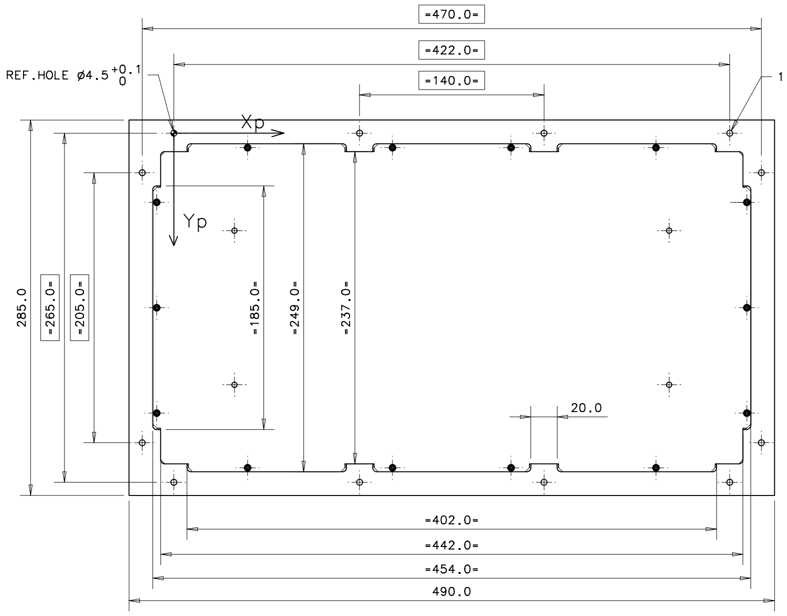
Nota : rev F has not been released.

Detail of changes

Description	Associated RFD / ECR (if any)	Status
No changes introduced, only added follwing informations : - base plate height 4mm ("Coupe partielle A-A") - position of top connectors on Xp and Zp - position of fixation hole on Xp (470mm)	--	--

	Position	Name	Signature
Prepared by	PA manager	J. Fontignie	09/09/04
Verified by	Mechanical Designer	T. Tourrette	27/09/04
Approved by	Project manager	J.L. Auguères	28.09/04

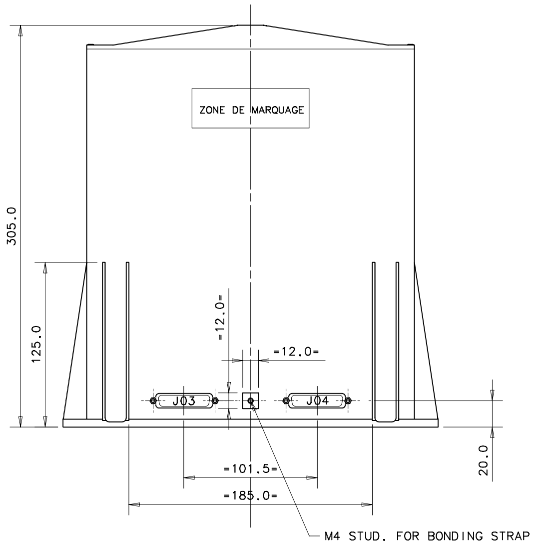


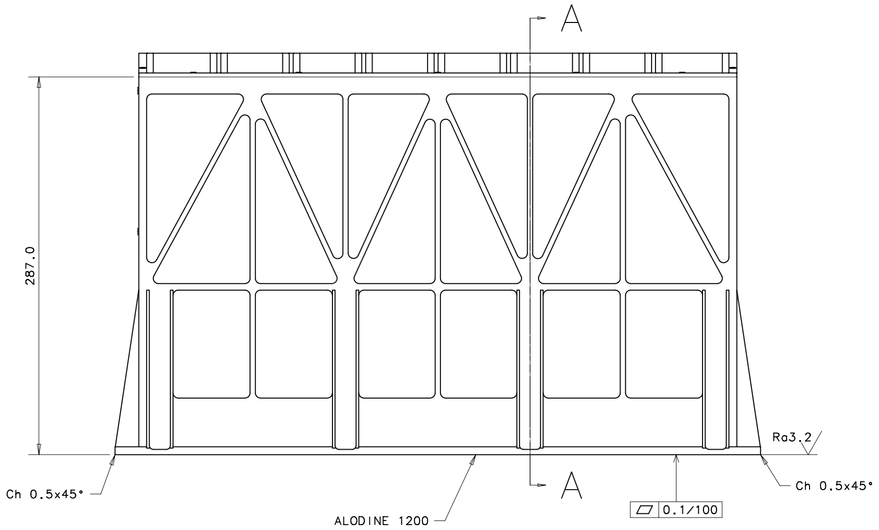


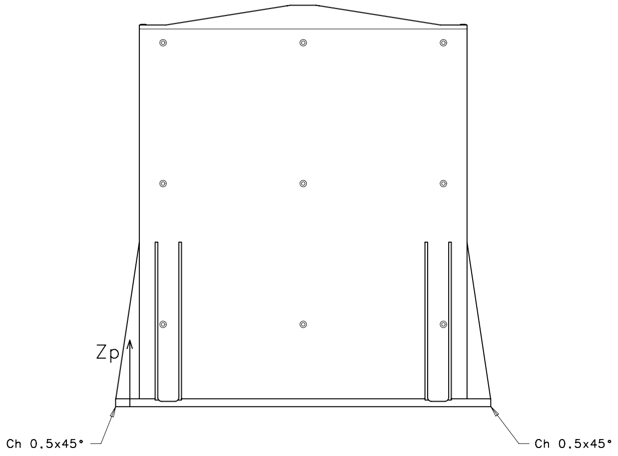
CONNECTORS					
IDENT	TYPE	FUNCTIONS	IDENT	TYPE	FUNCTIONS
J01	DBMA 25S	DAQ_IF_M/DPU_M	J17	DDMA 50P	LIA_P_7/FPU
J02	DBMA 25S	DAQ_IF_R/DPU_R	J18	DDMA 50P	LIA_P_7/FPU
J03	DBMA 25P	DCU/PSU_M	J19	DDMA 50P	LIA_P_8/FPU
J04	DBMA 25P	DCU/PSU_R	J20	DDMA 50P	LIA_P_8/FPU
J05	DDMA 50P	LIA_P_1/FPU	J21	DDMA 50P	LIA_P_9/FPU
J06	DDMA 50P	LIA_P_1/FPU	J22	DDMA 50P	LIA_P_9/FPU
J07	DDMA 50P	LIA_P_2/FPU	J23	DCMA 37P	LIA_S_1/FPU
J08	DDMA 50P	LIA_P_2/FPU	J24	DCMA 37P	LIA_S_1/FPU
J09	DDMA 50P	LIA_P_3/FPU	J25	DCMA 37P	LIA_S_2/FPU
J10	DDMA 50P	LIA_P_3/FPU	J26	DCMA 37P	LIA_S_2/FPU
J11	DDMA 50P	LIA_P_4/FPU	J27	DCMA 37P	LIA_S_3/FPU
J12	DDMA 50P	LIA_P_4/FPU	J28	DCMA 37P	LIA_S_3/FPU
J13	DDMA 50P	LIA_P_5/FPU	J29	DDMA 78S	BIAS_M/FPU
J14	DDMA 50P	LIA_P_5/FPU	J30	DDMA 78S	BIAS_R/FPU
J15	DDMA 50P	LIA_P_6/FPU	J31	DCMA 37S	BIAS_M/FPU
J16	DDMA 50P	LIA_P_6/FPU	J32	DCMA 37S	BIAS_R/FPU

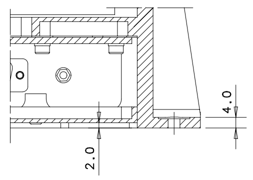
NOTES

MATERIAL AL 6082
CENTRE OF GRAVITY REFERRED TO REFERENCE HOLE
X=213.2mm Y=132.4mm Z=157.9mm
MOMENTS OF INERTIA REFERRED TO CENTRE OF GRAVITY
JXp=0.471 Kg.m2 JYp=0.250 Kg.m2 JZp=0.444 Kg.m2
CONTACT AREA MOUNTING FEET=28180mm2
THERMAL COATING AND BLACK ANODISING ESA.PSS.703
SURFACE EMISSIVITY >0.85
TORQUE VALUE FOR CONNECTOR FIXATION SCREWS=
- MALE=0.3mN
- FEMALE=0.45mN
SPECIFIC HEAT 1170 J/Kg.°K
ESTIMATED MASS=14442g

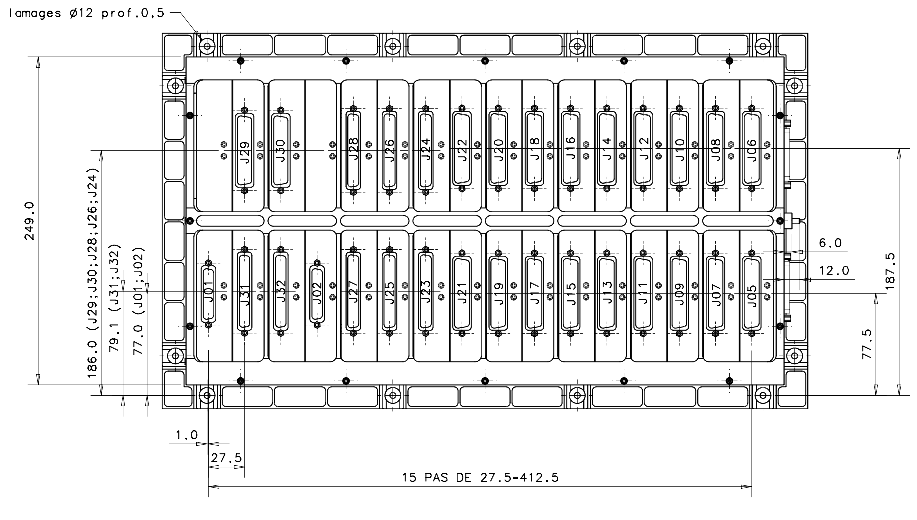




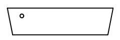




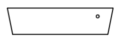
COUPE PARTIELLE A-A
ECHELLE:1/1



CONNECTOR TYPE P



CONNECTOR TYPE S



indice	Modifications	Date	Dessiné par	Vérifié par	Approuvé par
G	Mise à jour	08/04	DHENAIN		
F	Mise à jour	06/04	DHENAIN		
E	Mise à jour	01/04	DHENAIN		
D	Ajout coupe A-A	10/02	DHENAIN		
C	Mise à jour	09/02	DHENAIN		
B	Mise à jour	06/02	DHENAIN		
A	Origine	11/01	DHENAIN	......	......

Spécifications particulières

tolérances générales		
Indice de rugosité général XXXX		SOUS-TRAITANT
Tol.ang.:±XX°		
Casser les angles vifs		

Matière: Traitement thermique:	Protection		
	Echelle 1/2	Poids	Niveau qualité

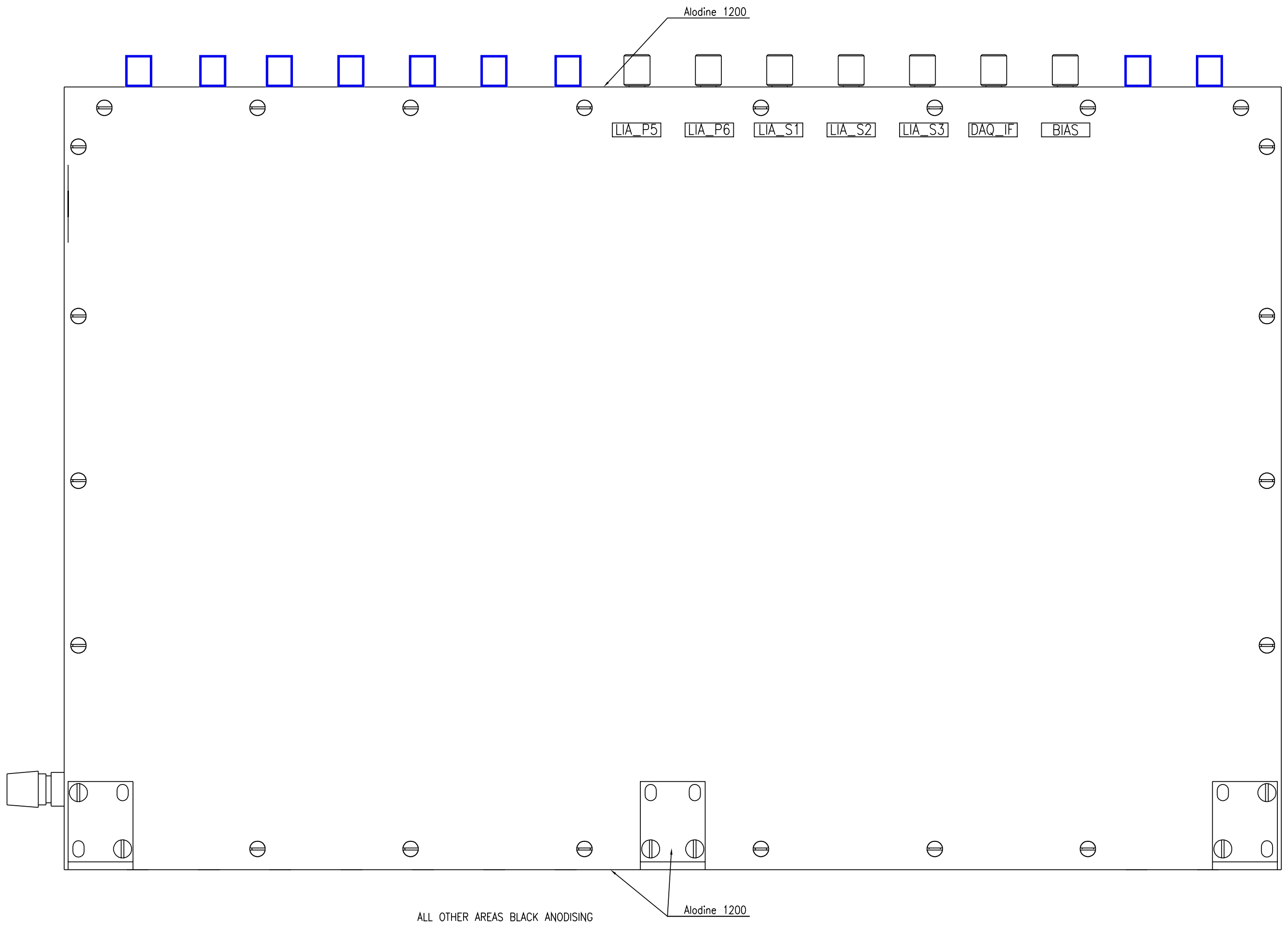
SPIRE
HSDCU ELECTRONIC BOX
MECHANICAL INTERFACE CONTROL DRAWING

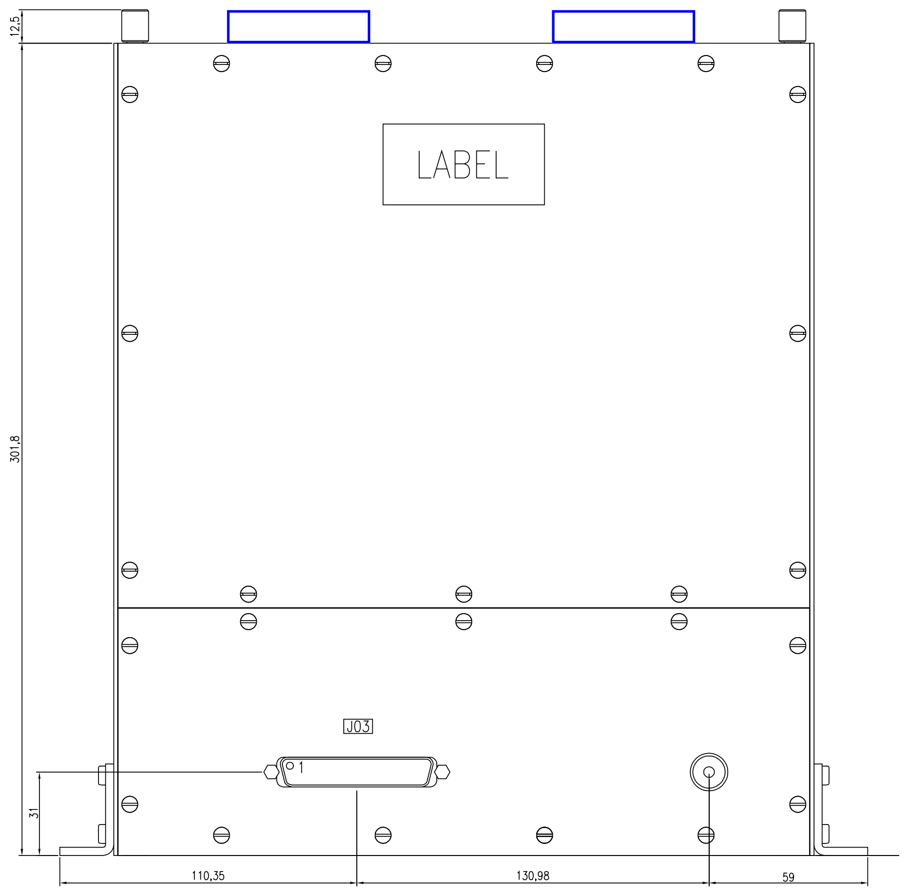
Il n'est permis d'utiliser ce dessin qu'avec licence spéciale ou autorisation expresse - loi du 11 mars 1957

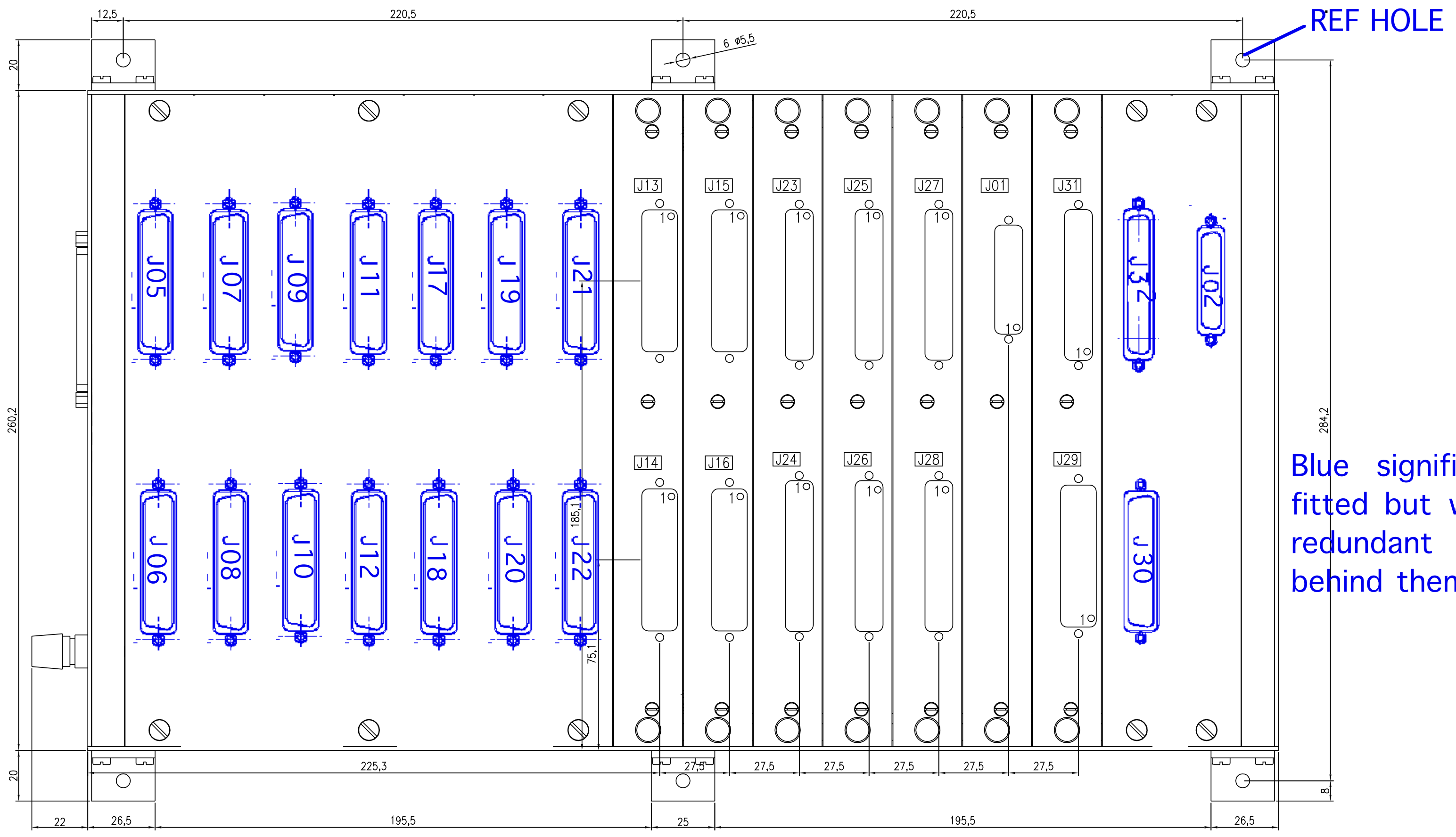
SAP/GERES
Tel:01.69.08.78.25
01.69.08.59.76
Fax:01.69.08.79.96

COMMISSARIAT A
L'ENERGIE ATOMIQUE
C.E.N SACLAY

A0 SPIR-MX-5100 000 G

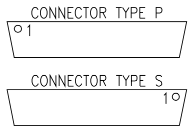






Blue signifies connectors fitted but without redundant side electronics behind them.

CONNECTORS					
IDENT	TYPE	FUNCTION	IDENT	TYPE	FUNCTION
J01	DBMA 25S	DAQ_IF_M/DPU	J24	DCMA 37P	LIA_S_1/FPU
J03	DBMA 25P	DCU/PSU_M	J25	DCMA 37P	LIA_S_2/FPU
J13	DDMA 50P	LIA_P_5/FPU	J26	DCMA 37P	LIA_S_2/FPU
J14	DDMA 50P	LIA_P_5/FPU	J27	DCMA 37P	LIA_S_3/FPU
J15	DDMA 50P	LIA_P_6/FPU	J28	DCMA 37P	LIA_S_3/FPU
J16	DDMA 50P	LIA_P_6/FPU	J29	DDMA 78S	BIAS_M/FPU
J23	DCMA 37P	LIA_S_1/FPU	J31	DCMA 37S	BIAS_M/FPU



ONLY FOR QM1

CEA /SAP 91191 GIF/YVETTE Cedex	MATIERE : Alu 2017A TRAITEMENT : Alodine 1200	PROTECTION : DESSINE : SREE DATE : 02/12/02 VERIFIE : VISA :

ECHELLE : 3/4
TOLERANCES GENERALES : ±0.2
Ra1.6

DESIGNATION
ICD HS DCU/QM1

SRIR-MX-5101 000 A 0 A1

List of changes
SPIR-MX-5200 000
Rev. J to Rev K

SAp-SPIRE-QA-0187-04
Date : 03/09/2004
Page: 1/1

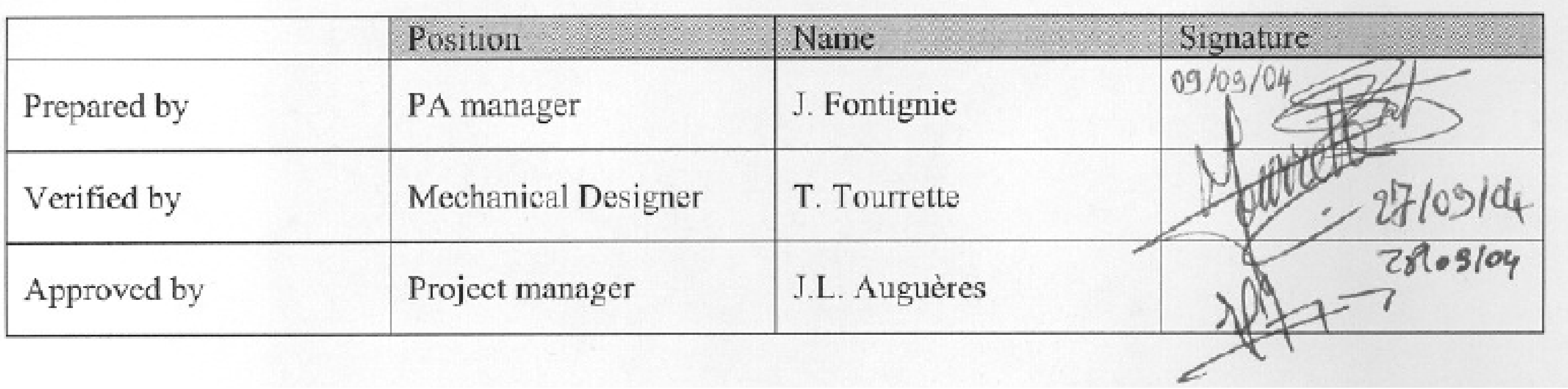
List of changes

Document identification

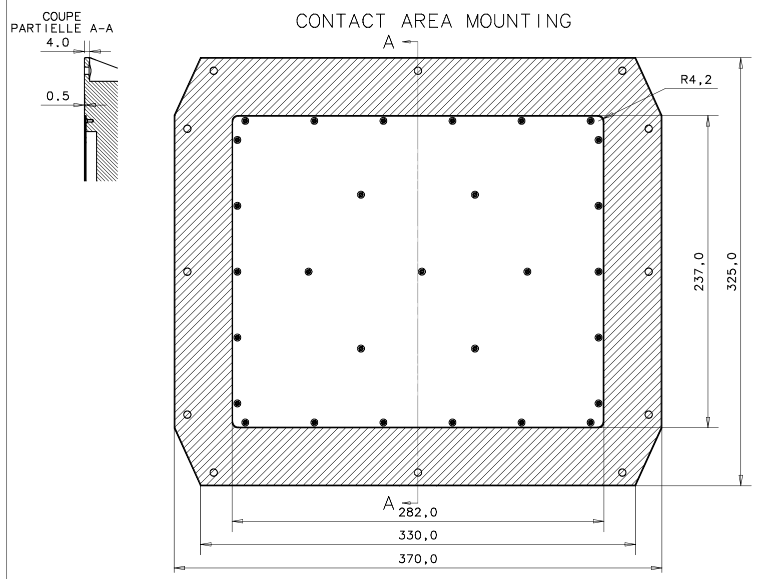
Document n°	SPIR-MX-5200 000
Title of document	SPIRE FCU Electronic box mechanical i/f drawing
Changes From rev.	Rev. J (01/2004)
To rev.	Rev. K (08/2004)

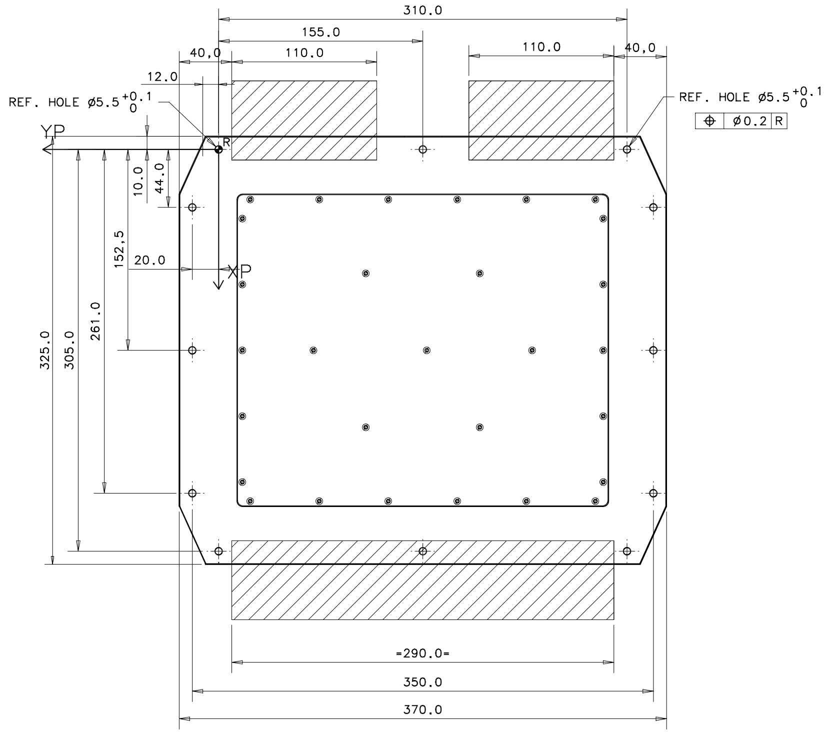
Detail of changes

Description	Associated RFD / ECR (if any)	Status
No changes introduced, only added follwong informations : - base plate height 4mm ("Coupe partielle A-A") - enhanced readability of top connectors position on Xp - position of fixation hole on Xp (350mm)	--	--



	Position	Name	Signature
Prepared by	PA manager	J. Fontignie	09/09/04
Verified by	Mechanical Designer	T. Tourrette	27/09/04
Approved by	Project manager	J.L. Augueres	28.09/04





NOTES

MATERIAL AL 6082

CENTRE OF GRAVITY REFFERED TO REFERENCE HOLE

X=148.8mm Y=-153mm Z=138.5mm

MOMENTS OF INERTIA REFERRED TO CENTRE OF GRAVITY

JX=0.338 Kg.m2 JY=0.318 Kg.m2 JZ=0.282 Kg.m2

CONTACT AREA MOUNTING FEET=51656mm2

THERMAL COATING AND BLACK ANODISING ESA.PSS.703

SURFACE EMISSIVITY >0.85

TORQUE VALUE FOR CONNECTOR FIXATION SCREWS=

-MALE=0.3mN

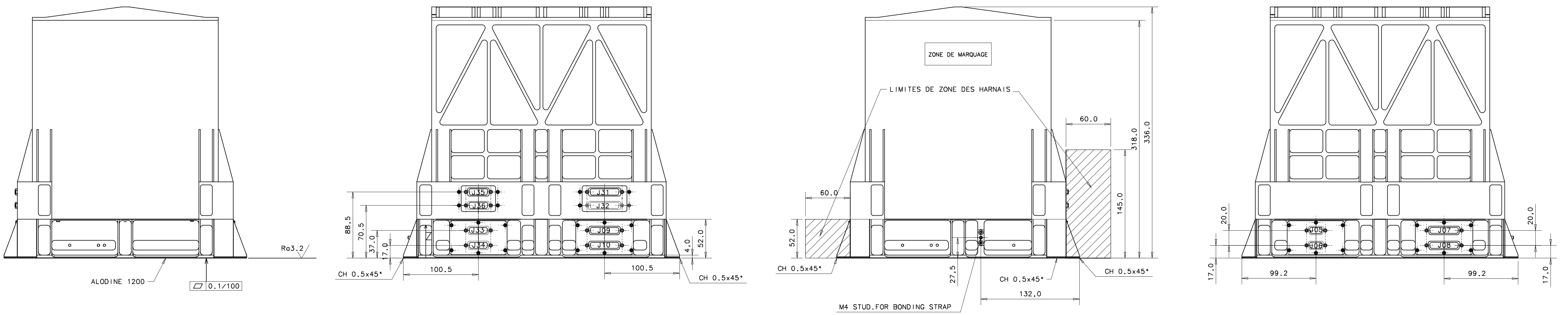
-FEMALE=0.45mN

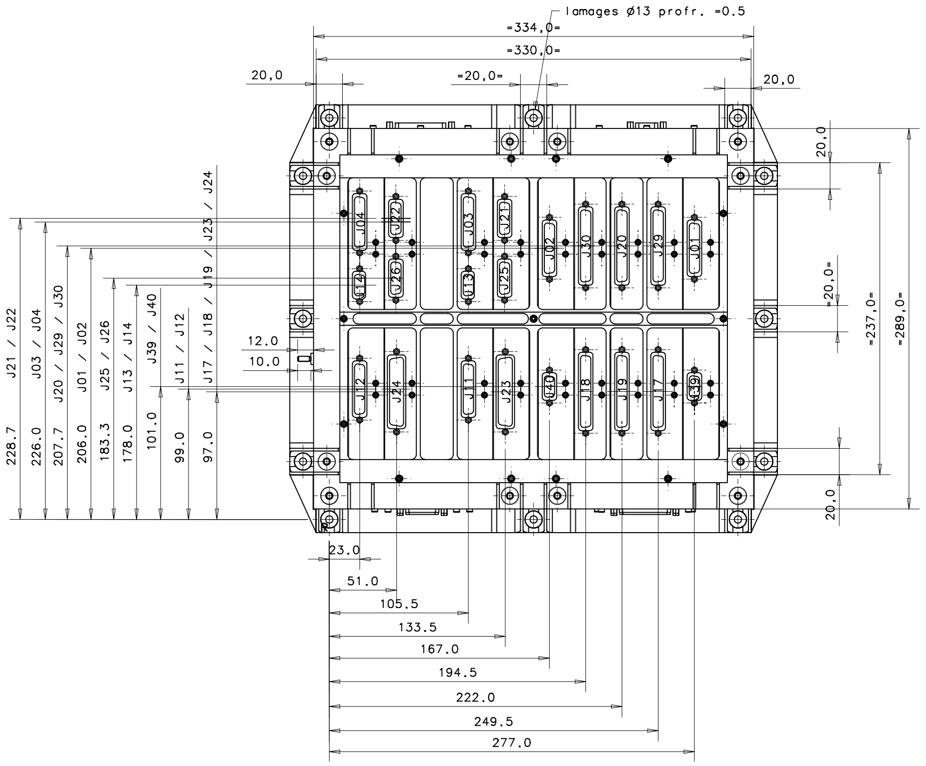
ESTIMATED MASS=16254g

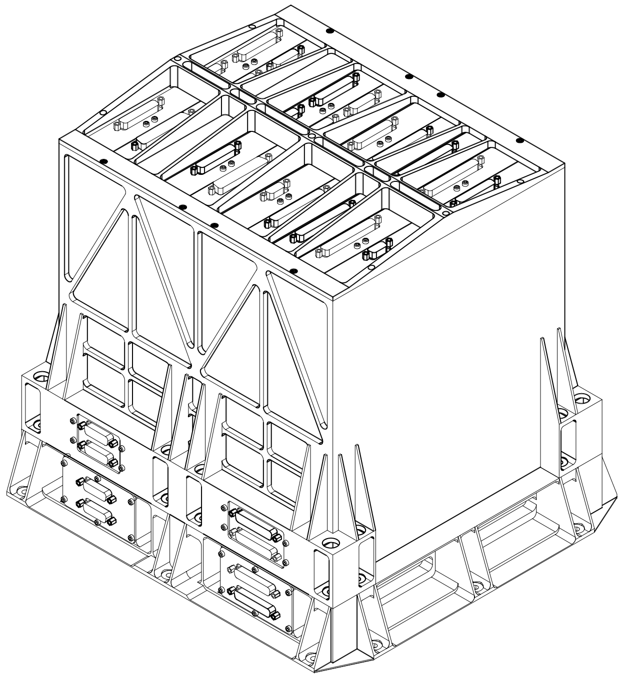
CP=1170j/kg.°K

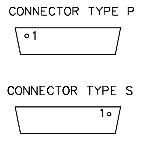
CONNECTORS

IDENT	TYPE	INTERFACE NAME	IDENT	TYPE	INTERFACE NAME
J01	DBMA 25S	MAC-M/DPU-M	J21	DAMA 15S	TEMP-M/FPU-TS-1-M
J02	DBMA 25S	MAC-R/DPU-R	J22	DAMA 15S	TEMP-R/FPU-TS-1-R
J03	DBMA 25S	CCHK-IF-M/DPU-M	J23	DDMA 50S	TEMP-M/FPU-TS-2-M
J04	DBMA 25S	CCHK-IF-R/DPU-R	J24	DDMA 50S	TEMP-R/FPU-TS-2-R
J05	DEMA 9P	PSU-M/PCDU-M	J25	DAMA 15S	TEMP-M/FPU-MEC-TS-M
J06	DEMA 9P	PSU-R/PCDU-R	J26	DAMA 15S	TEMP-R/FPU-MEC-TS-R
J07	DBMA 25S	PSU-M/DCU	J27	NA	NA
J08	DBMA 25S	PSU-R/DCU	J28	NA	NA
J09	DBMA 25S	PSU-M/MCU-M	J29	DCMA 37P	SMEC-M/FPU-SMECm-2-M
J10	DBMA 25S	PSU-R/MCU-R	J30	DCMA 37P	SMEC-R/FPU-SMECm-2-R
J11	DBMA 25S	CCHK-IF-M/FPU-COOL-CAL-M	J31	DBMA 25P	MCU-M/PSU-M
J12	DBMA 25S	CCHK-IF-R/FPU-COOL-CAL-R	J32	DBMA 25P	MCU-R/PSU-R
J13	DEMA 9S	CCHK-IF-M/FPU-PH-STIM-M	J33	DAMA 15S	PSU-M/SCU-M
J14	DEMA 9S	CCHK-IF-R/FPU-PH-STIM-R	J34	DAMA 15S	PSU-R/SCU-R
J15	NA	NA	J35	DAMA 15P	SCU-M/PSU-M
J16	NA	NA	J36	DAMA 15P	SCU-R/PSU-R
J17	DCMA 37S	SMEC-M/FPU-SMECm-1-M	J37	NA	NA
J18	DCMA 37S	SMEC-R/FPU-SMECm-1-R	J38	NA	NA
J19	DCMA 37S	BSM-M/FPU-BSM-M	J39	DEMA 9S	MAC-H/JTAG
J20	DCMA 37S	BSM-R/FPU-BSM-R	J40	DEMA 9S	MAC-R/JTAG









indice	Modifications	Date	Dessiné par	Vérifié par	Approuvé par
K	Mise à jour	08/04	DHENAIN		
J	Mise à jour	01/04	DHENAIN		
I	Modif position CdG	12/03	DHENAIN		
H	Mise a jour	11/03	DHENAIN		
G	Mise a jour	04/03	DHENAIN		
F	Mise à jour	10/02	DHENAIN		
E	Mise à jour connecteurs	09/02	DHENAIN		
D	Mise a jour	07/02	DHENAIN		
C	Mise a jour	06/02	DHENAIN		
B	Mise a jour	05/02	DHENAIN		
A	Origine	12/01	DHENAIN	......	......

Spécifications particulières

tolérances générales

Indice de rugosité général

Tol.ang.:

Casser les angles vifs

SOUS-TRAITANT

Matière:

Traitement thermique:

Protection

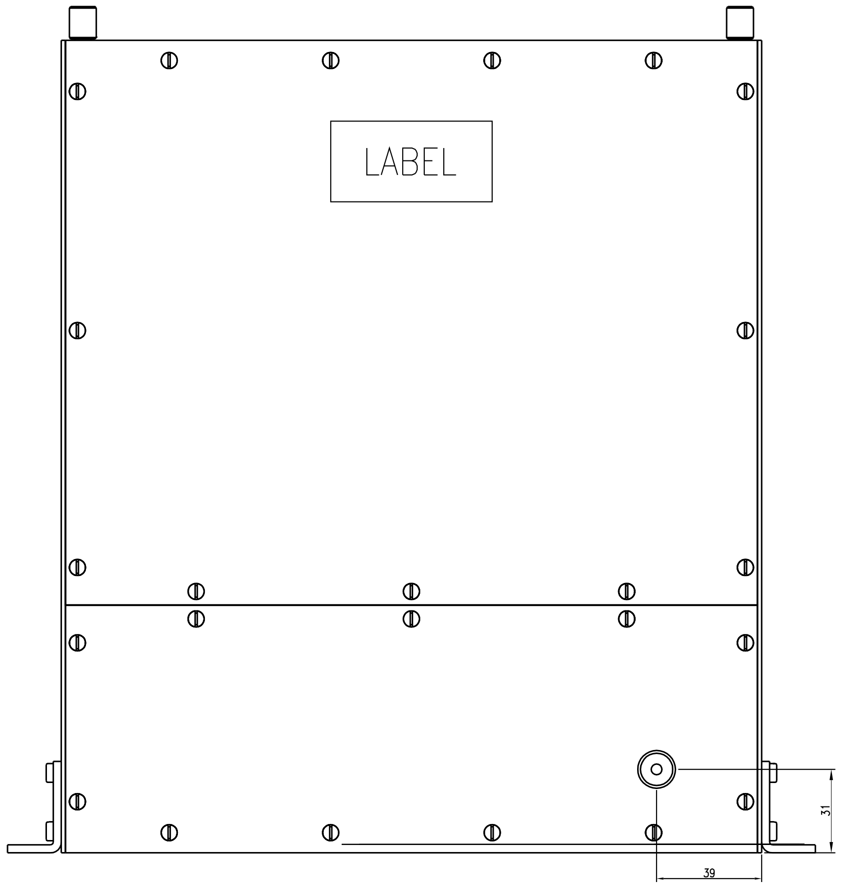
Echelle	Poids	Niveau qualité
1/2		

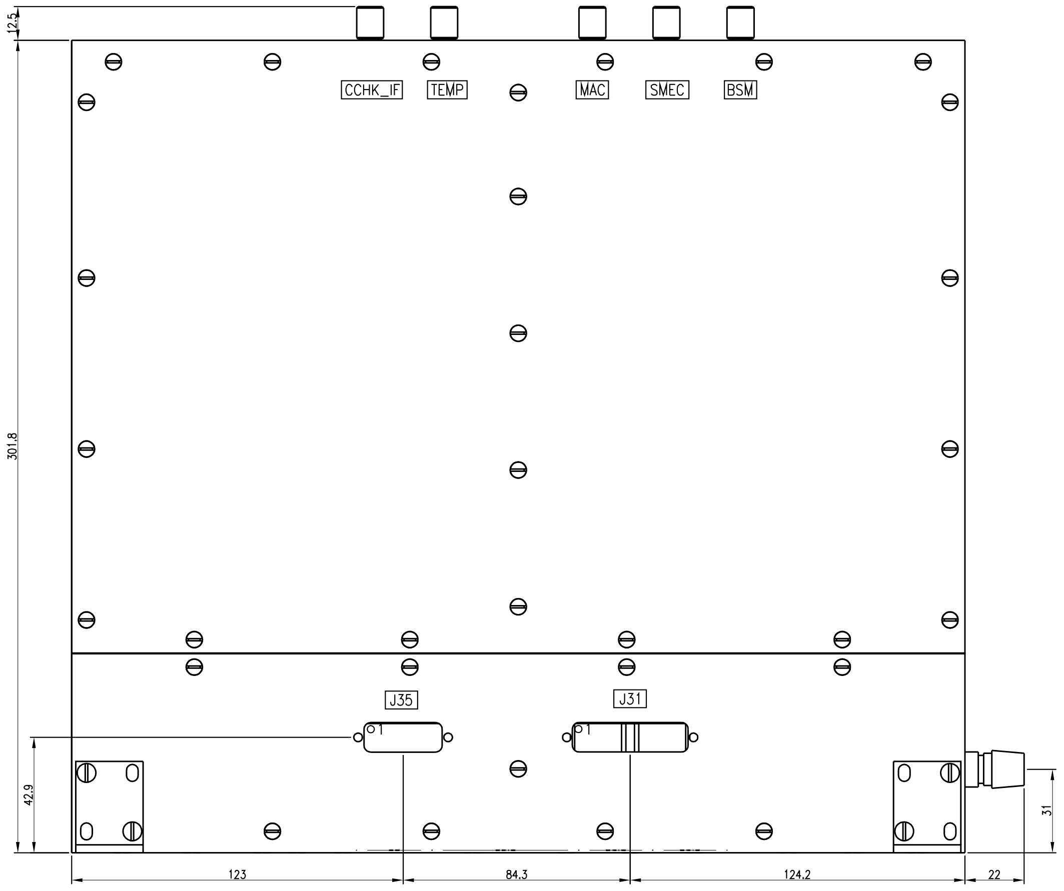
SPIRE
FCU ELECTRONIC BOX
MECHANICHAL INTERFACE CONTROL DRAWING

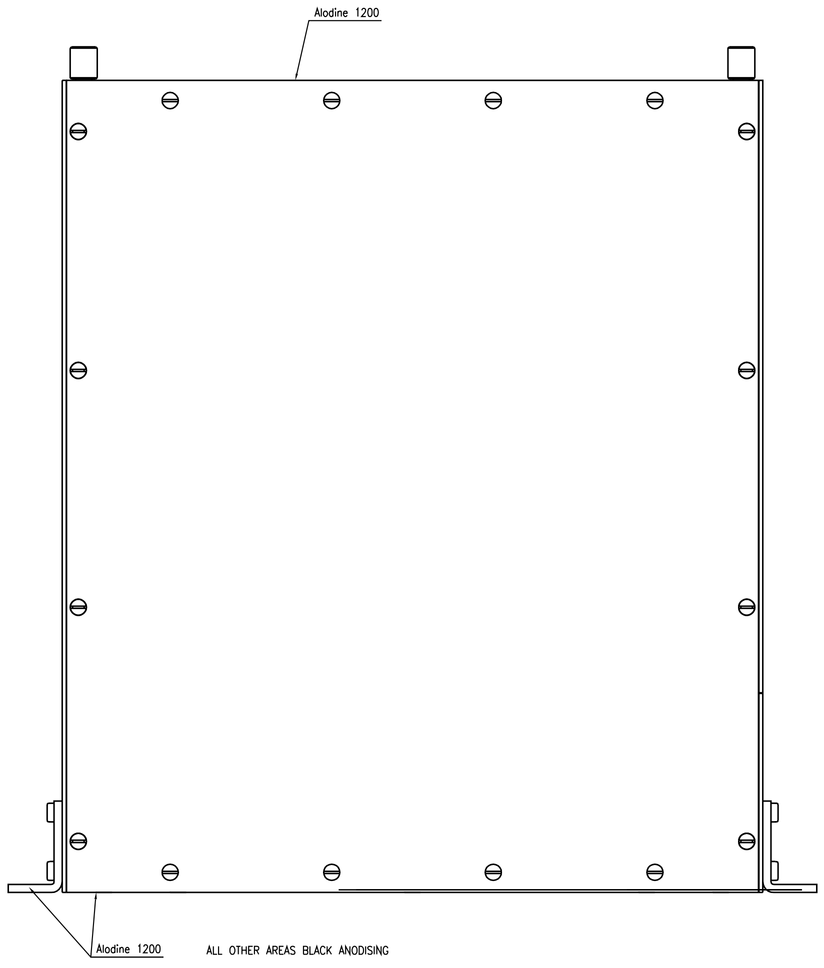
SAP/GERES
Tel:01.69.08.78.25
01.69.08.59.76
Fax:01.69.08.79.96

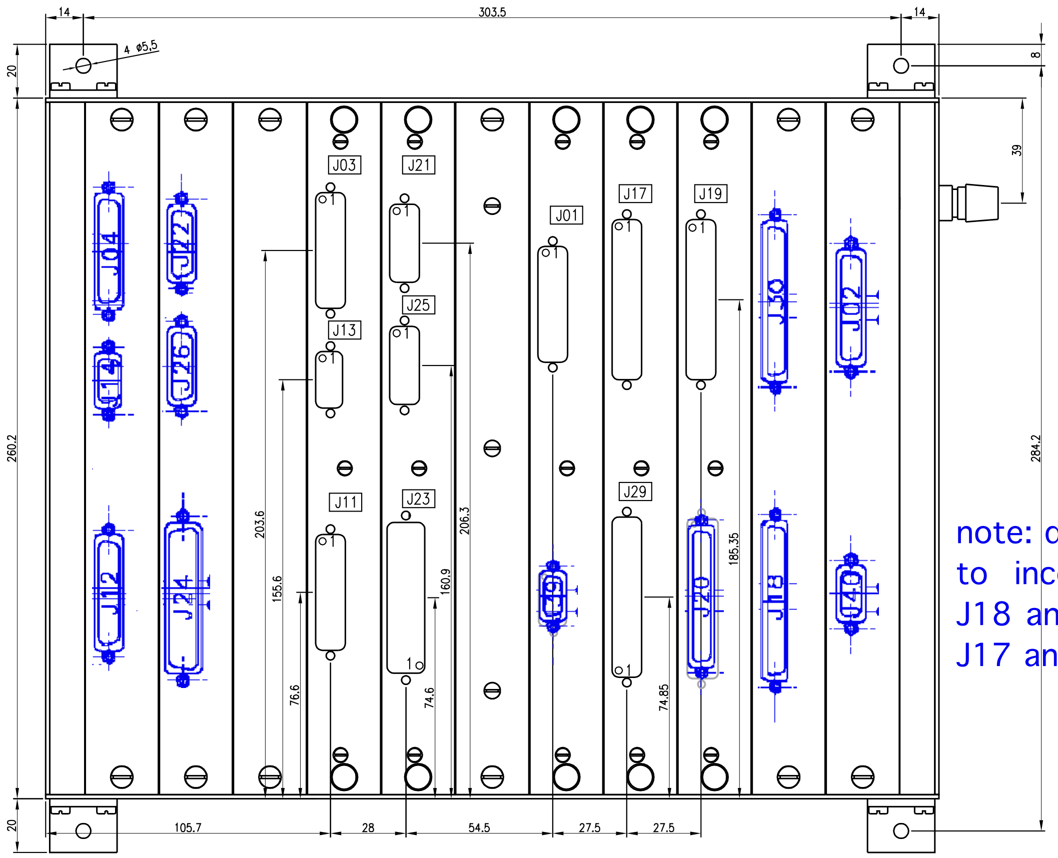
COMMISSARIAT A
L'ENERGIE ATOMIQUE
C.E.N SACLAY

A0 SPIR-MX-5200 000 K









ONLY FOR QM1

Blue signifies connectors fitted but without redundant side electronics behind them.

note: do not intend to incorrectly transpose J18 and J30 just because J17 and J39 are swapped!

CONNECTORS					
IDENT	TYPE	FUNCTION	IDENT	TYPE	FUNCTION
J01	DBMA 25S	MAC/DPU	J21	DAMA 15S	TEMP/FPU-TS-1
J03	DBMA 25S	CCHK-IF/DPU	J23	DDMA 50S	TEMP/FPU-TS-2
J11	DBMA 25S	CCHK-IF/FPU-COOL-CAL	J25	DAMA 15S	TEMP/FPU-MEC-TS
J13	DEMA 9S	CCHK-IF/FPU-PH-STIM	J29	DCMA 37P	SMEC/FPU-SMECm-2
J17	DCMA 37S	SMEC/FPU-SMECm-1	J31	DBMA 25P	MCU/PSU
J19	DCMA 37S	BSM/FPU-BSM	J35	DAMA 15P	SCU/PSU

CEA /SAP
91191 GIF/YVETTE Cedex

MATIERE : Alu 2017A
TRAITEMENT : ALODINE 1200
PROTECTION :
DESSINE : SREE
DATE : 08/09/03
VERIFIE :
VISA :

ECHELLE : 3/4
TOLERANCES GENERALES : ±0.2
Ra1.6

DESIGNATION
ICD HS FCU/QM1

SPIR-MX-5201 000 C
0
A1

UCL

MSSL

SPIRE – STRUCTURE INTERFACE DRAWING ISSUE 20 AND MODIFICATION SHEET

Document Number: MSSL/SPIRE/SP005.05 ……30 September 2005

ISSUE 20

SHEET	MODIFICATION
All Sheets	Drawing redrawn due to loss of Computer File
All Sheets	Main Instrument Mounts replaced with CFRP mounts
All Sheets	Details of the Level 1 Thermal Interface added
All sheets	The PFM spectrometer level 0 strap replaed the CAM spec strap.
Sheet 1	Addition of dimension between end of L0 straps and the centre line pf the fixed cone mount
Sheet 1	Addition of dimension at bottom of Evaporator L0 strap (4.5 mm)
Sheet 3	Addition of dimension from centre of fixed cone mount to the First Optical Datum
Sheet 6	Addition of pictorial view and cross section of the Level 1 thermal interface

ISSUE 19

SHEET	MODIFICATION
All Sheets	Level ‘0’ Cold Straps and relevant Dimensions updated.
All Sheets	JFETS and relevant dimensions updated.
1	Mass Properties updated.
1	Dim 202.00 (HOB datum to SPIRE focal plane) “CRYOGENIC” added.
1	Note “SPIRE AXES ETC” - word “DIRECTIONS” added.
1	Level ‘0’ Straps – max rads. added.
3	Optical Beams note added.
3	Optical beam dims note “STAY OUT AREA” note modified.
4	“+ RUNNING TORQUES” added to interface torque figures.
4	Temperature sensor holes added.
5	Notes wrt Level ‘0’ interfaces to S/C modified/deleted/added.
5	Torques for Level ‘0’ straps deleted – note “TORQUE AS SPECIFIED BY ASTRIUM” added.
5	Level ‘1’ fixings torques – “+ RUNNING TORQUES” added.
5	Temp sensor/Level ‘0’ fixings modified
6	JFET Harness zone dimensions modified.
7	PACS & HIFI labelled.

ISSUE 18

SHEET	MODIFICATION
1	Mass properties updated to the latest sub system estimates/measured masses. No mass received for the harnesses (A guess in the model)
1	No weighed masses for Busbar Supports, Light traps, SCAL (Cardiff), SMEC (LAM) and SOB Harness, Photo BDA, Spectro BDA (Techdata)
1	Notes, “Work in Progress” referring to BDA connector panels deleted
1	Note WRT Aperture cover added
1	Notes WRT surface finish at L0 and L1 interfaces added
1	Aperture cover added
1	BDA connector flanges updated
2	Pictorial changes WRT BDA connector flanges ad aperture cover to reflect sheet 1
3	Pictorial changes WRT BDA connector flanges ad aperture cover to reflect sheet 1
4	Pictorial changes WRT BDA connector flanges ad aperture cover to reflect sheet 1
5	Surface roughness on L0 straps added with “BY VISUAL INSPECTION ONLY” note
5	Gold finish on L0 straps
5	Surface roughness and Alochrom 1200 finish note added for L1 straps
5	M4 Torques were 1.26 Nm
6	“Work in progress” notes wrt BDA connector panels deleted
6	Note reminding that M4 grounding hole does not have a locking insert fitted added
6	Dims to BDA connectors added
7	Pictorial changes WRT BDA connector flanges ad aperture cover to reflect sheet 1

ISSUE 17

SHEET	MODIFICATION
1	RF Filter Connector numbers added
1,2,3	Cryostat hole diameter was 270mm
1	Spire axes coincident with Spacecraft axes – note added
1	Reference cube to be dismounted after installation on spacecraft – note added
1	Dimension to ‘A’ Frame top pin centre added
1,3	Redundant dimensions deleted
1	Level 1 grounding strap positions moved and applicable note modified (Reference HR-SP-RAL-ECR-034v1)
1	‘Alternative Level 1’ note deleted
2	Beams removed bottom LH view
3	Optical reference cube note modified – reference to A3/5264/305-6 added
3	Beam angle added (Bottom LH view)
3	‘Cryogenic’ added to two dimensions
ALL	‘UNLESS OTHERWISE SPECIFIED’ added to note wrt. ‘ALL DIMENSIONS AT ROOM TEMPERATURE’
3	Dimension to top of reference cube added
3	Note stating U/S of SOB is Yu & Zu Optical Datum Deleted
4	Front mounting cone centre – positional tolerances added
4	SPIRE interface bolt material and torques added
5	Level ‘O’ cold strap interfaces modified. Bolt types, torques and Belleville types added.
7	Beam clearance dimension 0.92 reviewed
1	Note WRT clearance between FPU and Inner Shield Added
1,2,3	Cryostat Inner shield updated
5	“Stay Out” zone around Level ‘0’ straps added

ISSUE 16

SHEET	MODIFICATION
2	JFET note modified.
1	Dimensions over Blade Mounts added.
1	‘Zu’ axis added. Spacecraft co-ordinates note added.
1	“Optical Datum Pin” note deleted.
4	Mounting referencing hole added (fixed mounting).
2	Section description note changed.
3	10 mm mechanical clearance zone deleted.
3	Shaded optical beams extended.
3	Note wrt. Beam dimensions added.
3	Reference cube angular mounting ad absolute accuracy note added.
4	Floating details removed.
4	Alignment of HOB wrt. Herschel to permit Spire to be aligned.
5	Unit axes added.
5	Cold Straps detail deleted (saved on new drawing A1/5264/300A).
5	JFET thermal Interfaces note added. External to MSSL note added.
5	HSFPU thermal finishes added. Note wrt. JFET thermal interfaces added.
6	Electrical isolation note wrt. Cold straps added.
1	Mass updated. Moments of Inertia added.
4	FPU mounting cone interface holes modified.
4	Contact area of FPU interface Vespel insulators added.
4	Note wrt. HOB flatness and tilt to Herschel X Axis added.
5	Detail of FPU internal Level ‘0’ straps deleted – Now on drawing A1/5264/300A
6	JFET harness “Stay Out” zones added.
7	FPU cone to PACS clearance dimension added.
ALL	BDA- Obsolete harness feedthroughs deleted.
2	Addition of RF Filter connector numbers

DRAWING No.		
A1	5264	300 sht1

USED ON HERSCHEL

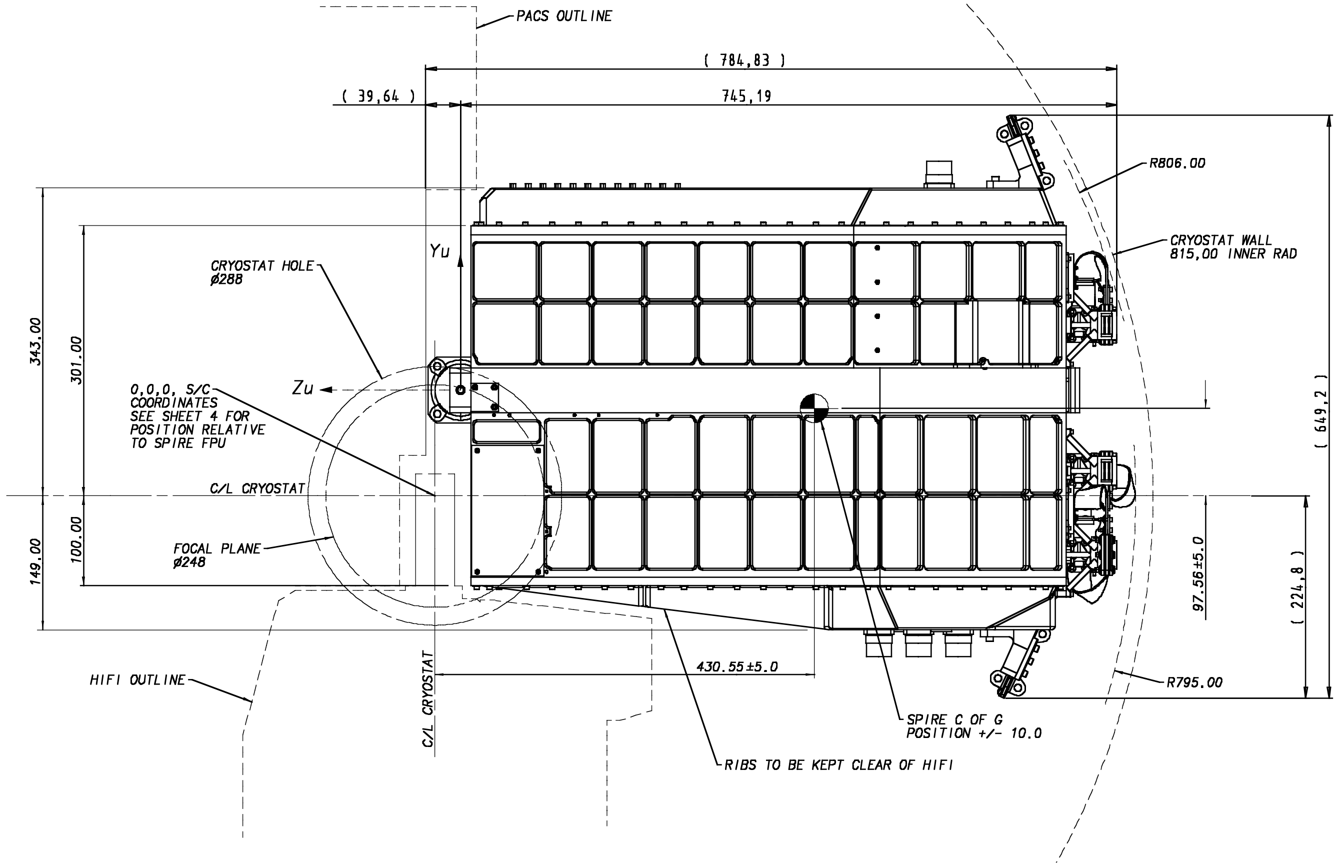
THIRD ANGLE PROJECTION

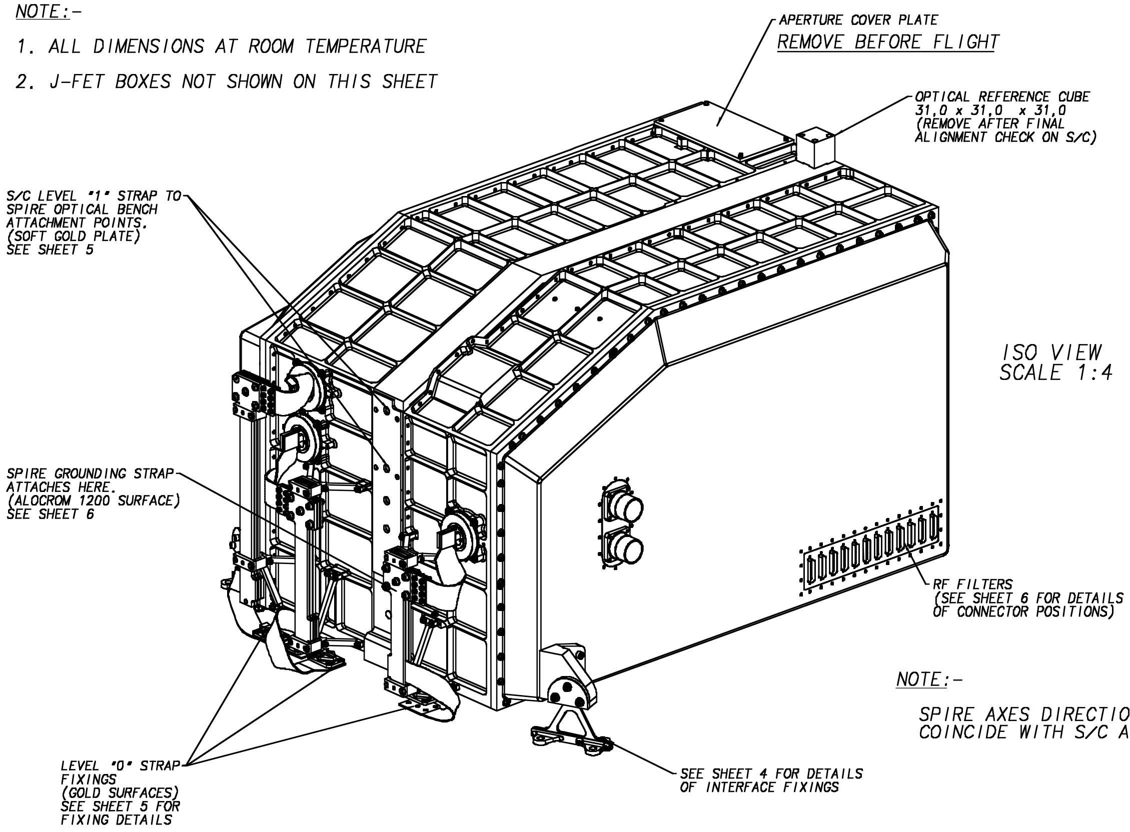
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

NOTE:-

1. ALL DIMENSIONS AT ROOM TEMPERATURE
2. J-FET BOXES NOT SHOWN ON THIS SHEET





ISO VIEW
SCALE 1:4

NOTE:-

SPIRE AXES DIRECTIONS COINCIDE WITH S/C AXES

MOMENTS OF INERTIA ABOUT CG:-

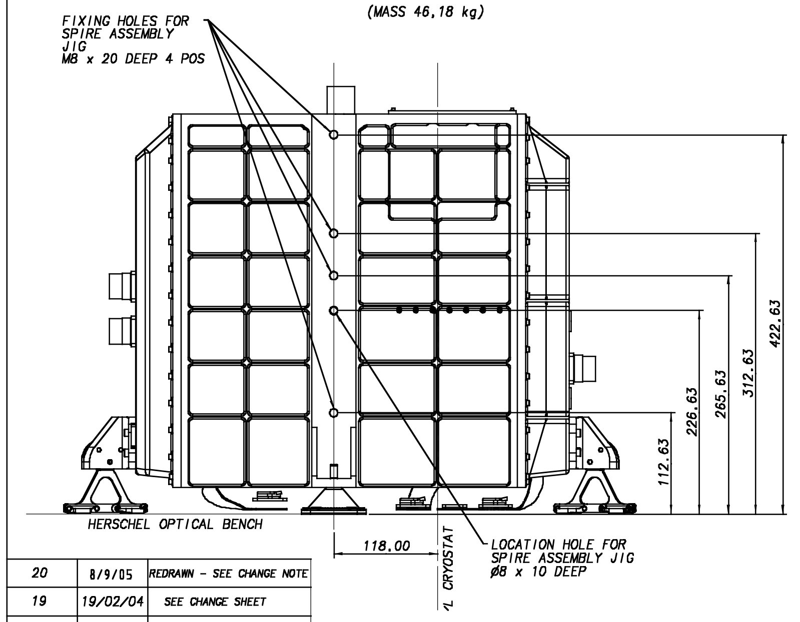
(NOTE:- ALL MASS PROPERTIES EXCLUDE JFETS, EXTERNAL FPU HARNESSES AND ASTRIUM SUPPLIED LEVEL "0" INTERFACE PARTS)

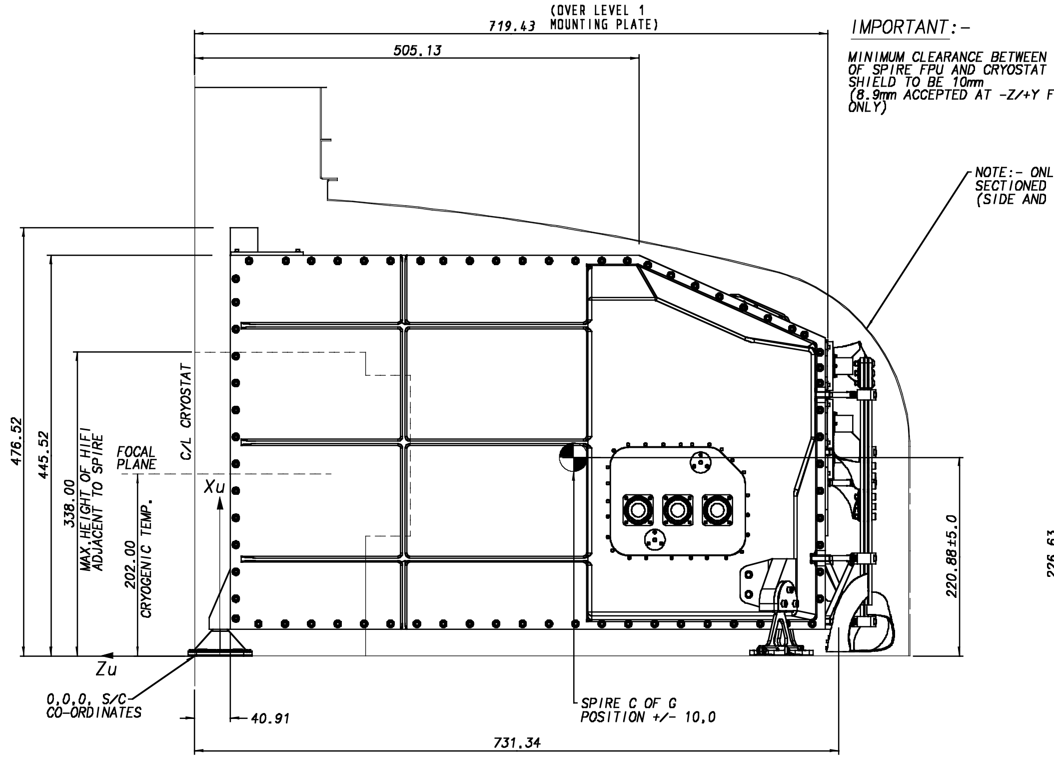
Ixx = 3,056 kg m^2
Iyy = 3,008 kg m^2
Izz = 1,559 kg m^2

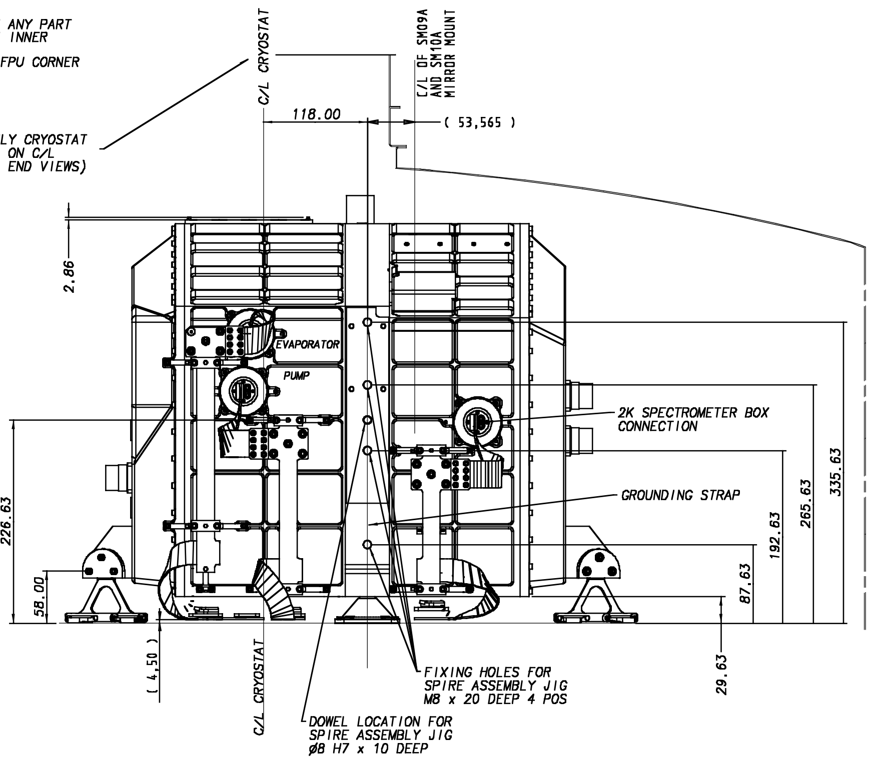
(MASS 46,18 kg)

IMPORTANT:-

MINIMUM CLEARANCE BETWEEN ANY PART OF SPIRE FPU AND CRYOSTAT INNER SHIELD TO BE 10mm (8.9mm ACCEPTED AT -Z/+Y FPU CORNER ONLY)







	ISSUE	DATE	AMENDMENT
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	19	19/02/04	SEE CHANGE SHEET
	18	4/07/03	SEE CHANGE SHEET
	17	16/10/02	SEE CHANGE SHEET
CHECKED	16	28/08/02	MODIFICATIONS AND CHANGE SHEET CREATED DRAWING UPDATED TO ISSUE 16 THERE-ON
	15	27/04/01	THERMAL STRAP INTERFACE MODIFIED. LEVEL 1 STRAP FIXING HOLES MOVED
TRACED PGC	14	23/11/01	CENTRE OF GRAVITY ADDED TO SHT.1. J-FET DESIGN UPDATED, STAY OUT HOLES REMOVED
	13	19/11/01	UPDATED RFI FILTER & PHOT CONNECTORS ADDED. FOCAL PLANE & 'A' FRAME MOUNT DIM ADDED. SHEET 7 ADDED
DRAWN AJC	1	24/11/01	

NOTE:-

SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH	MATERIAL & SPEC.	TOLERANCES UNLESS OTHERWISE STATED -
ALOCROM 1200 AL PARTS GOLD PLATED AREAS ON COPPER PARTS (ST.STEEL PARTS NATURAL)	AS LISTED	LINEAR +/- 0.10 ANGULAR +/- 0°15'
ESTD WT. 45,63kg (NO CONT) SEE NOTE SHT.1		
ACTL WT.	DIMENSIONS IN mm	SCALE 1:4

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE

SPIRE INTERFACE
(GENERAL DIMENSIONS)

DRAWING No		
A1	5264	300 sht1

SHEET 1 OF 7

DRAWING No.
A1 5264 300 sht2

USED ON
HERSCHEL

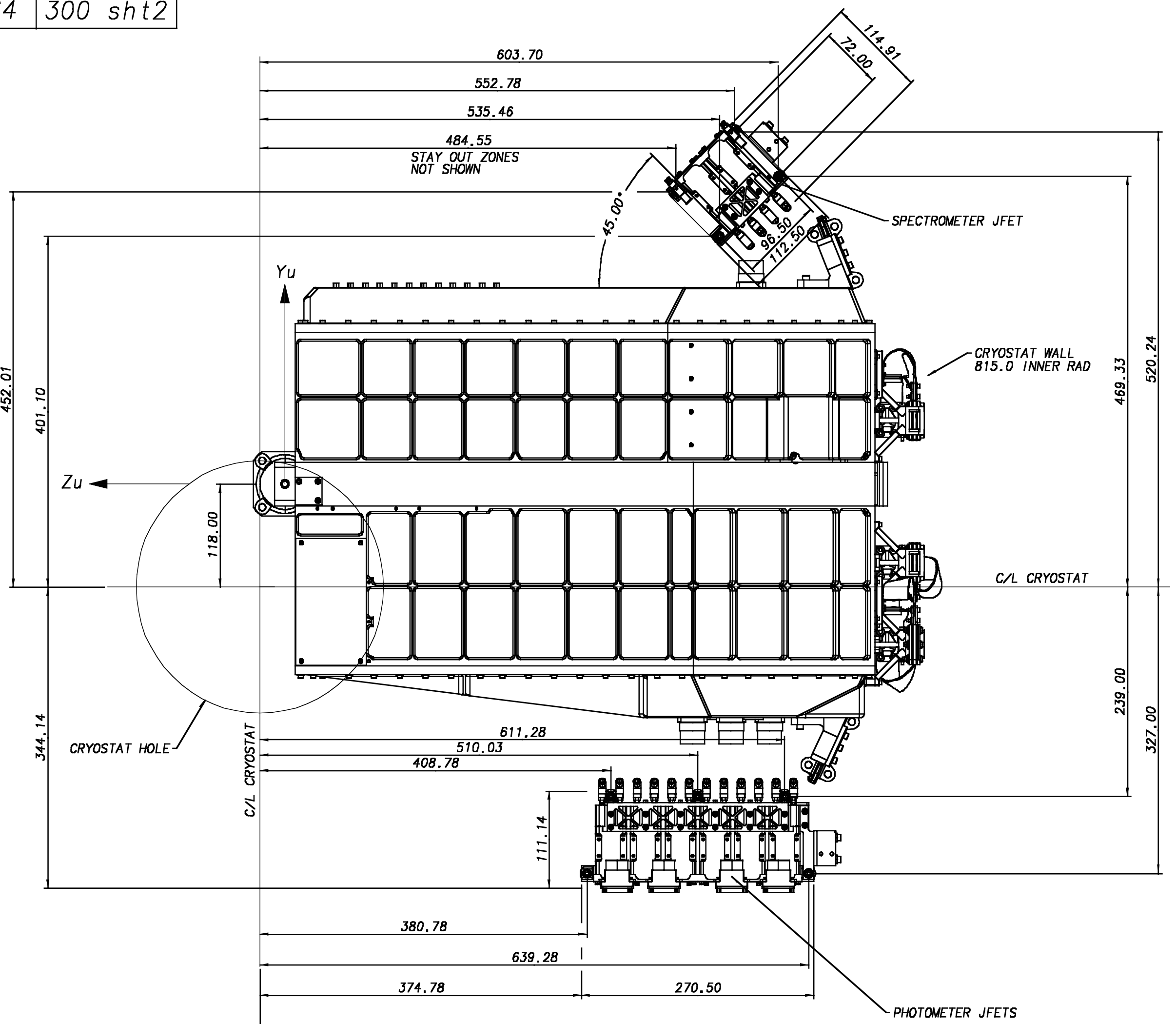
THIRD ANGLE PROJECTION

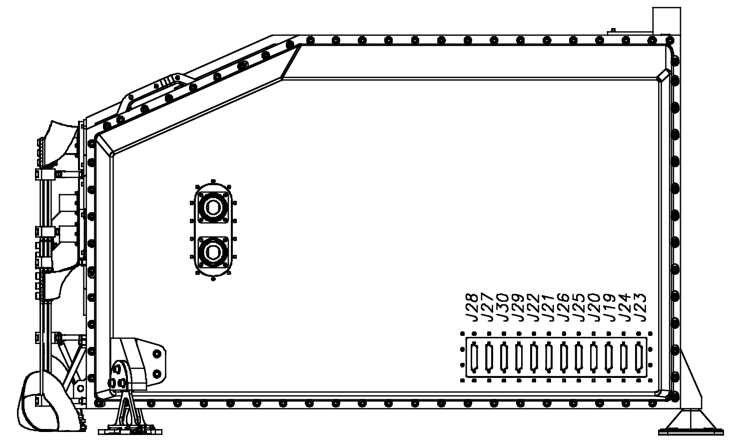
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

NOTE:-

ALL DIMENSIONS AT ROOM TEMPERATURE

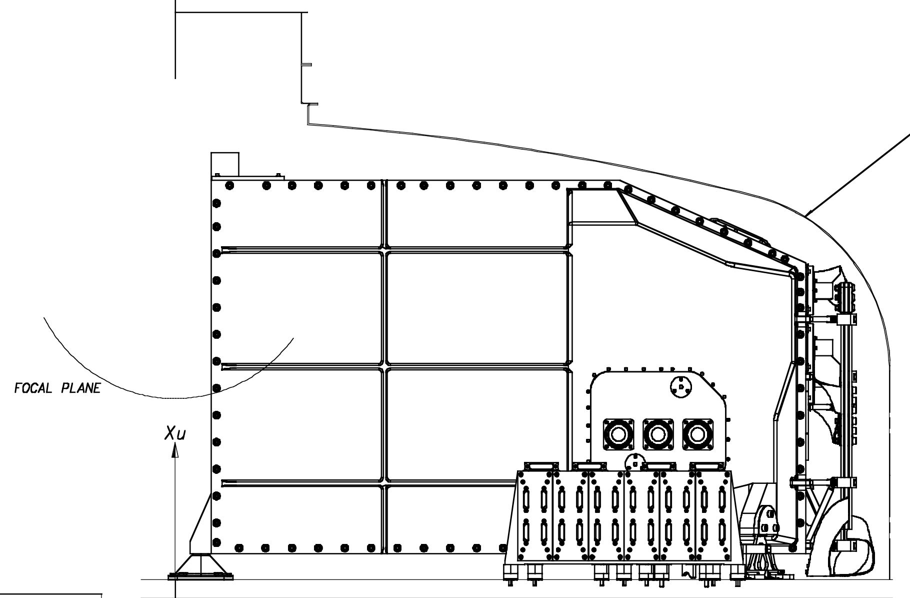




SPECTROMETER SIDE

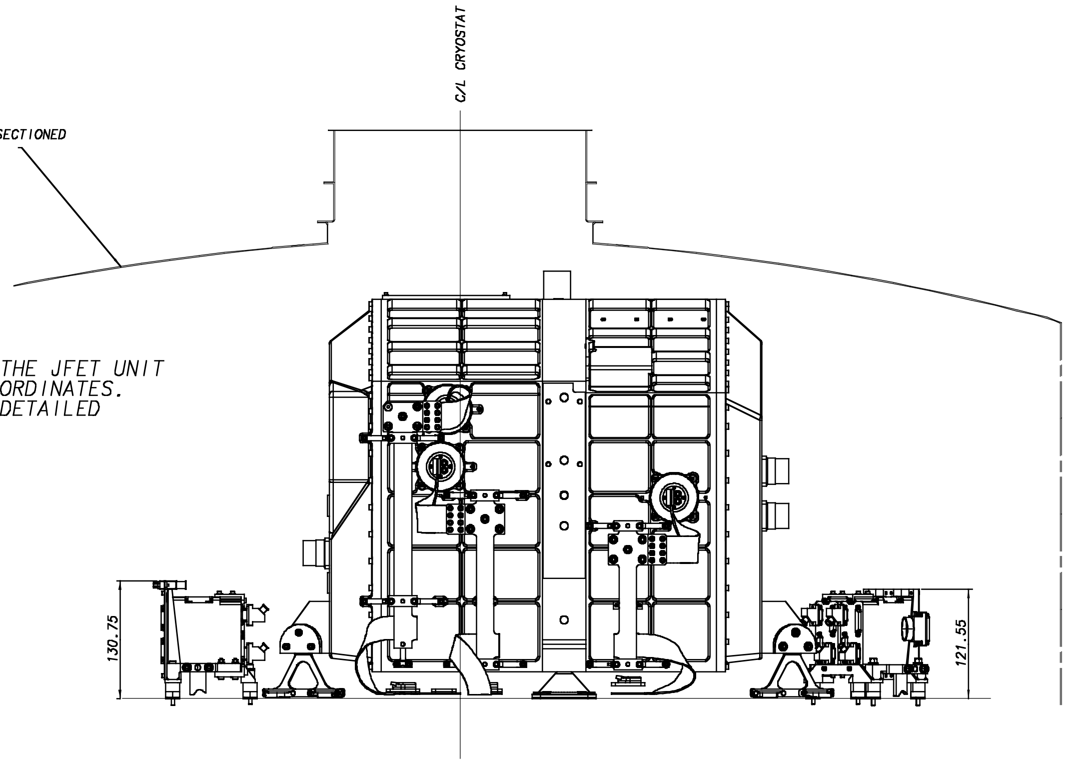
(VIEWED IN -Yu DIRECTION)

ONLY CVV INSTRUMENT SHIELD SECTIONED ON C/L (SIDE AND END VIEWS)



PHOTOMETER SIDE

NOTE:-
THIS DRAWING REFERENCES THE JFET UNIT MOUNTINGS TO HOB S/C CO-ORDINATES. THE JFETS HAVE SEPARATE DETAILED INTERFACE DRAWINGS



ISSUE	DATE	AMENDMENT
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13	19/11/01	UPDATED RFI FILTER & PHOT CONNECTORS ADDED, FOCAL PLANE & 'A' FRAME MOUNT DIM ADDED. SHEET 7 ADDED
1	24/11/01	

CHECKED

TRACED
PGC

DRAWN
AJC

NOTE:-
SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH
ALOCROM 1200
(ST.STEEL PARTS
NATURAL)

ESTD WT. 45,63kg (NO CONT) SEE NOTE SHT.1

ACTL WT.

MATERIAL & SPEC.
AS LISTED

DIMENSIONS IN mm

TOLERANCES UNLESS OTHERWISE STATED -
LINEAR +/- 0.10
ANGULAR +/- 0°15'

SCALE 1:4

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE INTERFACE
(J-FET POSITIONS)

DRAWING No
A1 5264 300 sht2

SHEET 2 OF 7

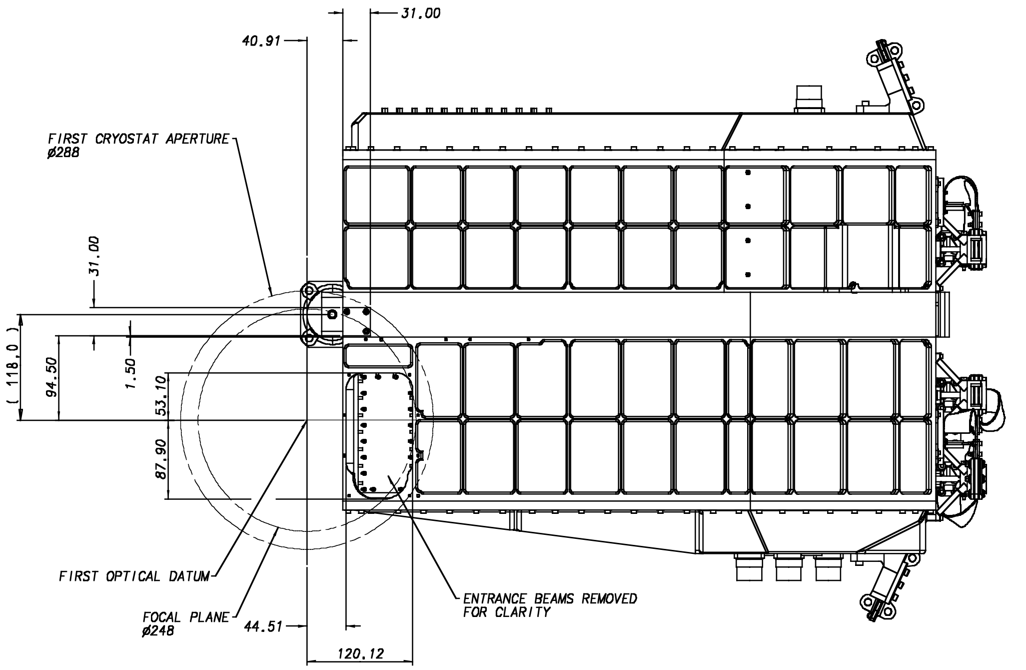
DRAWING No.		
A1	5264	300 sht3

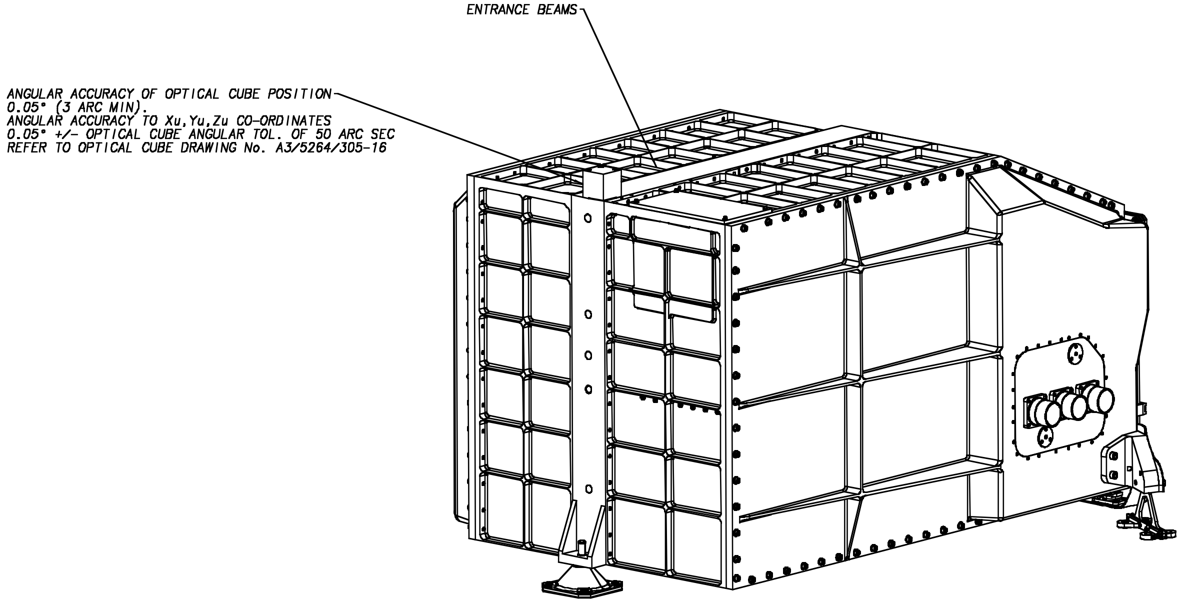
THIRD ANGLE PROJECTION

DO NOT SCALE

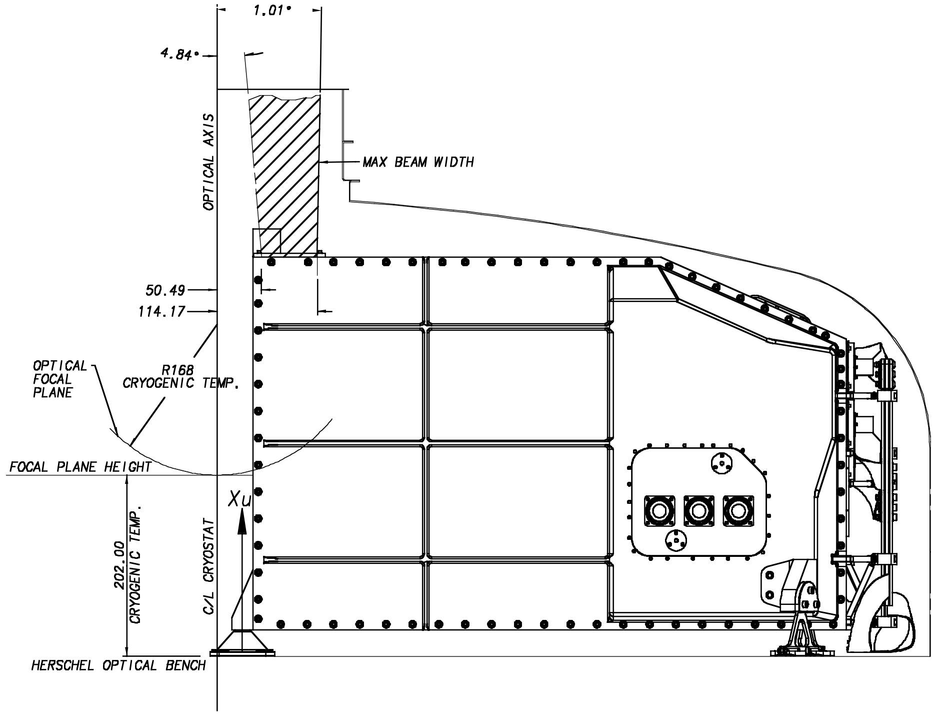
REMOVE ALL BURRS & SHARP EDGES

USED ON
HERSCHEL



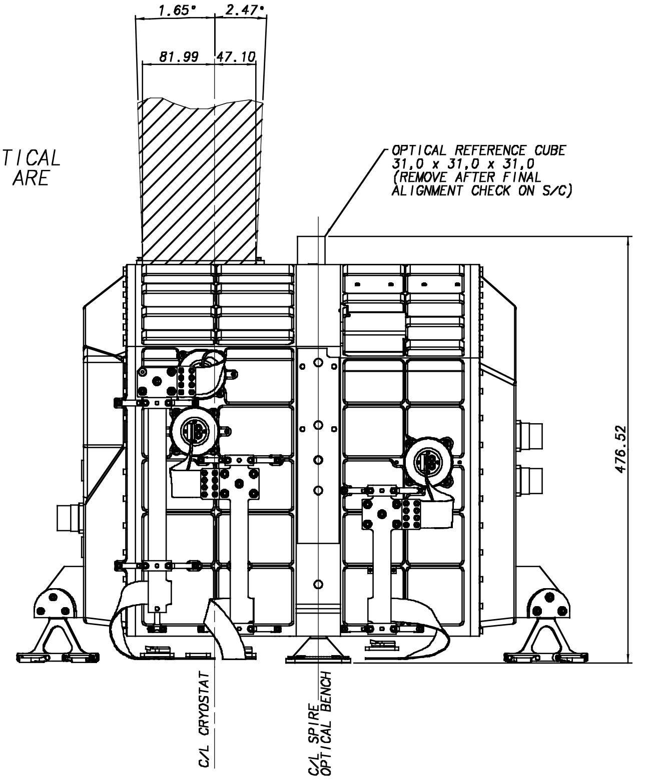


ANGULAR ACCURACY OF OPTICAL CUBE POSITION 0.05° (3 ARC MIN).
ANGULAR ACCURACY TO Xu,Yu,Zu CO-ORDINATES 0.05° +/- OPTICAL CUBE ANGULAR TOL. OF 50 ARC SEC
REFER TO OPTICAL CUBE DRAWING No. A3/5264/305-16



OPTICAL BEAM DIMENSIONS:-

ONLY DIMENSIONS DEFINING THE VOLUME FOR THE OPTICAL BEAMS WHICH SHALL REMAIN FREE FROM OBSTRUCTION ARE SHOWN.
REFER TO IID-B FOR MORE DETAILED INFORMATION



NOTE:-

1. ALL DIMENSIONS AT ROOM TEMPERATURE UNLESS OTHERWISE SPECIFIED

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DRAWN AJC	1	24/11/01	

NOTE:-

SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH ALOCROM 1200 (ST.STEEL PARTS NATURAL)	MATERIAL & SPEC. AS LISTED	TOLERANCES UNLESS OTHERWISE STATED - LINEAR +/- 0.10 ANGULAR +/- 0°15'
ESTD WT. 45.63kg (NO CONT) SEE NOTE SHT.1		
ACTL WT.	DIMENSIONS IN mm	SCALE 1:4

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE	DRAWING No		
SPIRE INTERFACE (OPTICAL DETAILS)	A1	5264	300 sht3

SHEET 3 OF 7

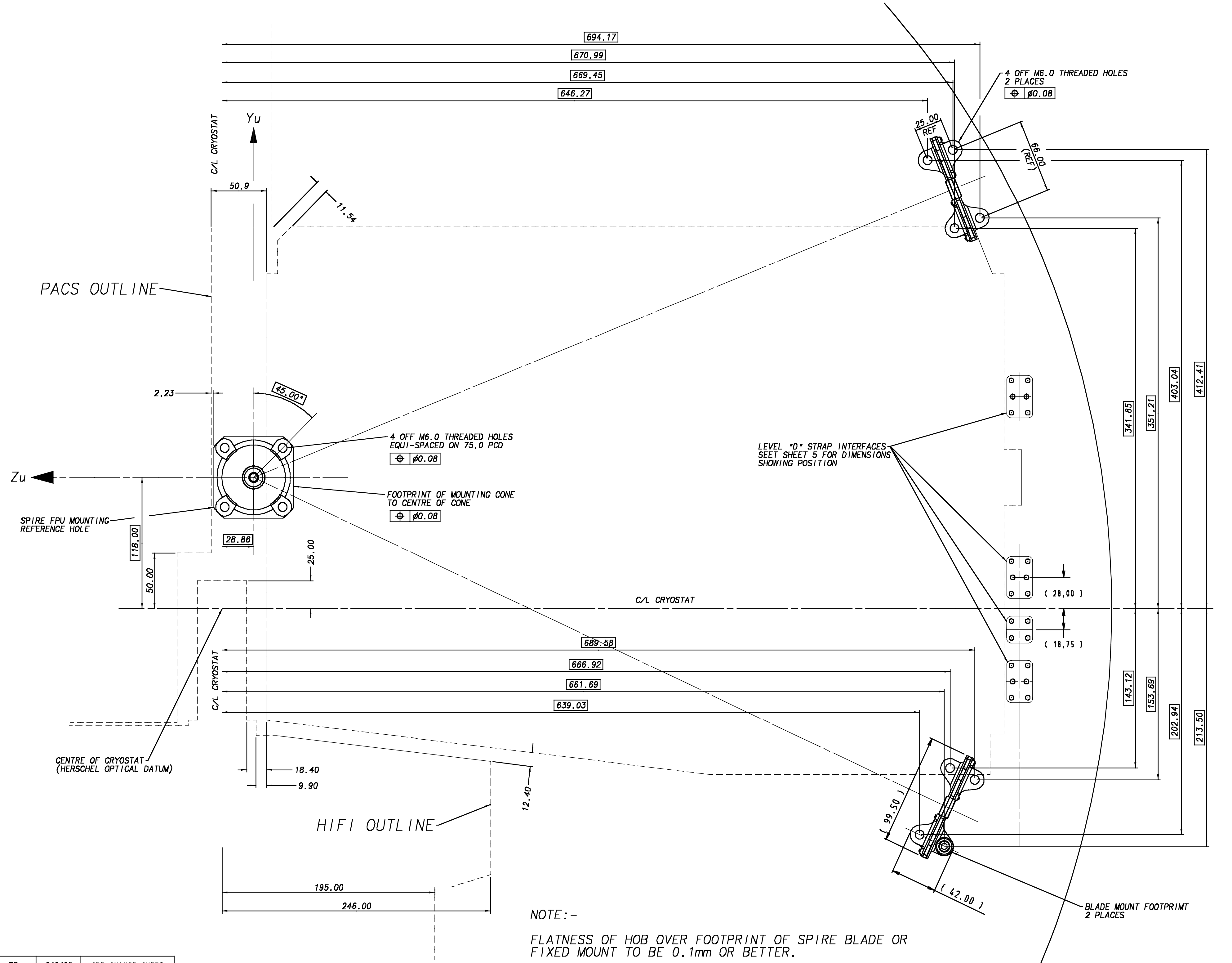
DRAWING No.
A1 5264 300 sht4

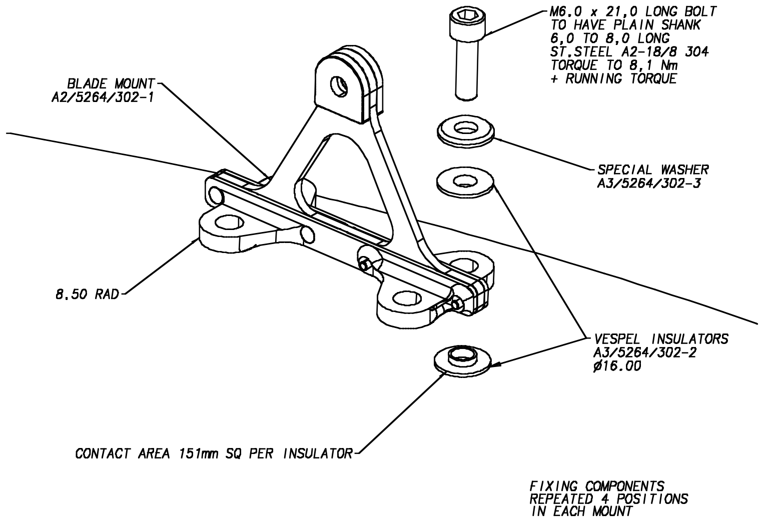
THIRD ANGLE PROJECTION

DO NOT SCALE

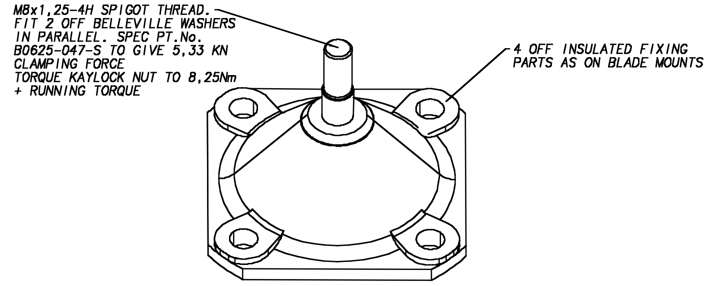
REMOVE ALL BURRS & SHARP EDGES

USED ON
HERSCHEL





DETAIL OF BLADE MOUNT FIXINGS
SCALE 1:1



DETAIL OF FIXED MOUNTING
SCALE 1:1

NOTE:-

FLATNESS OF HOB OVER FOOTPRINT OF SPIRE BLADE OR FIXED MOUNT TO BE 0.1mm OR BETTER.

MAX.TILT OF HOB FROM HERSCHEL X AXIS TO BE 5 ARC.MIN. TO ENABLE SPIRE FPU TO BE MACHINED OR SHIMMED INTO ALIGNMENT (IF REQUIRED).

NOTE:-

1. ALL DIMENSIONS AT ROOM TEMPERATURE

	ISSUE	DATE	AMENDMENT
	20	8/9/05	SEE CHANGE SHEET
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	17	16/10/02	SEE CHANGE SHEET
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DRAWN AJC	1	24/11/01	

NOTE:-

SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH
ALOCROM 1200
(ST.STEEL PARTS
NATURAL)

ESTD WT. 45,63kg (NO CONT) SEE NOTE SHT.1

ACTL WT.

MATERIAL & SPEC.
AS LISTED

DIMENSIONS IN mm

TOLERANCES UNLESS OTHERWISE STATED -
LINEAR +/- 0.10
ANGULAR +/- 0°15'

SCALE 1:2 & 1:1

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE INTERFACE
(INTERFACE FIXING DETAILS)

DRAWING No
A1 5264 300 sht4

SHEET 4 OF 7

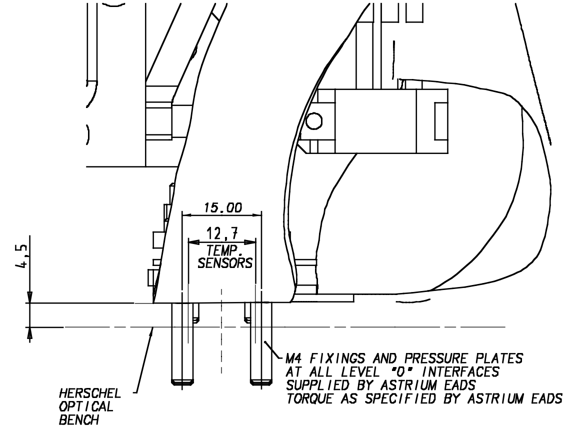
DRAWING No.		
A1	5264	300 sht5

USED ON
HERSCHEL

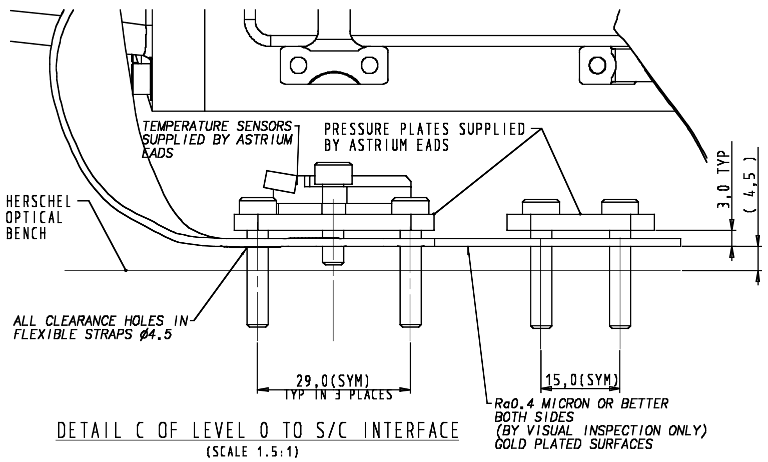
THIRD ANGLE PROJECTION

DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES



DETAIL "B" OF LEVEL "0" TO S/C INTERFACE
(SCALE 1.5:1)



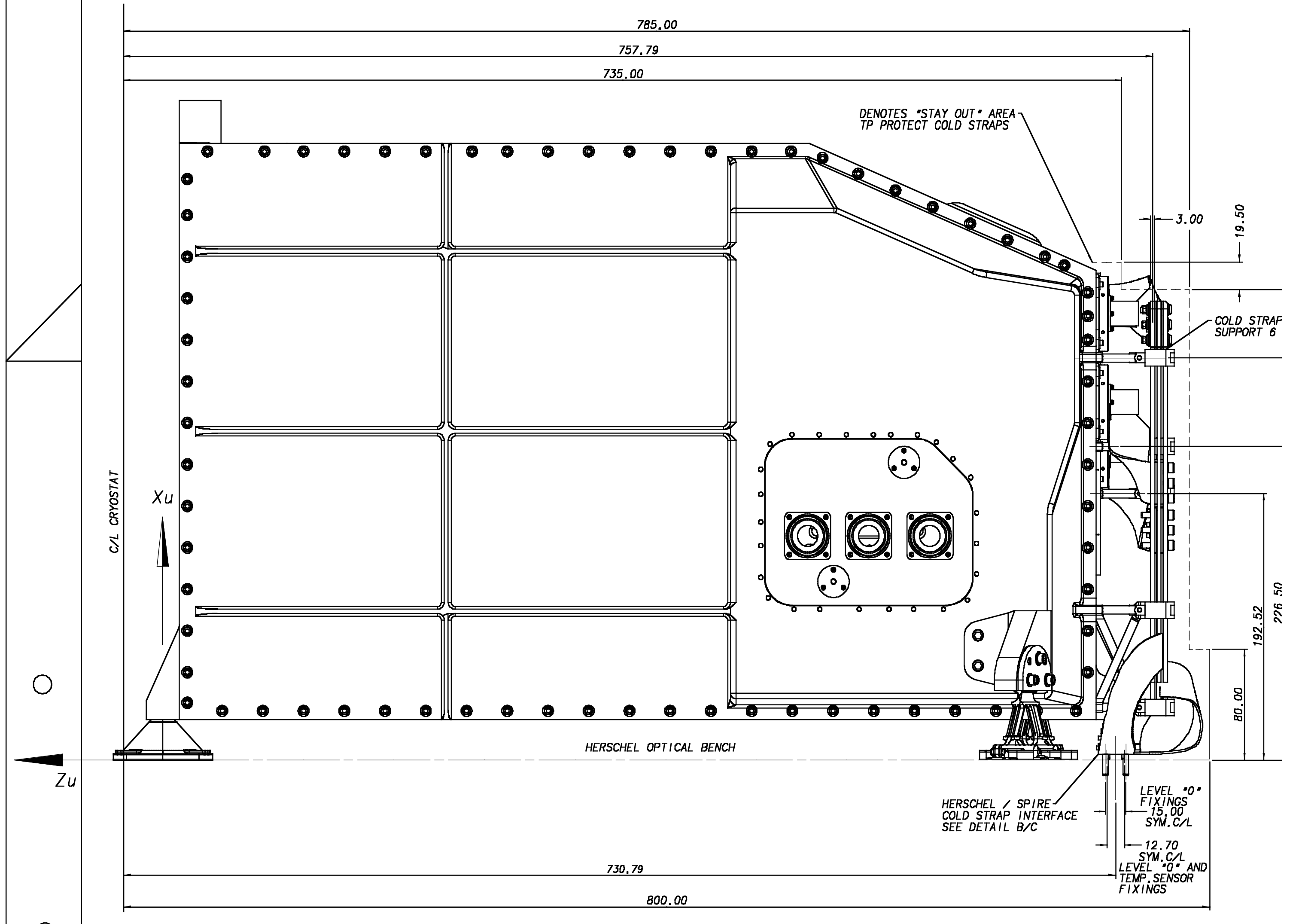
DETAIL C OF LEVEL 0 TO S/C INTERFACE
(SCALE 1.5:1)

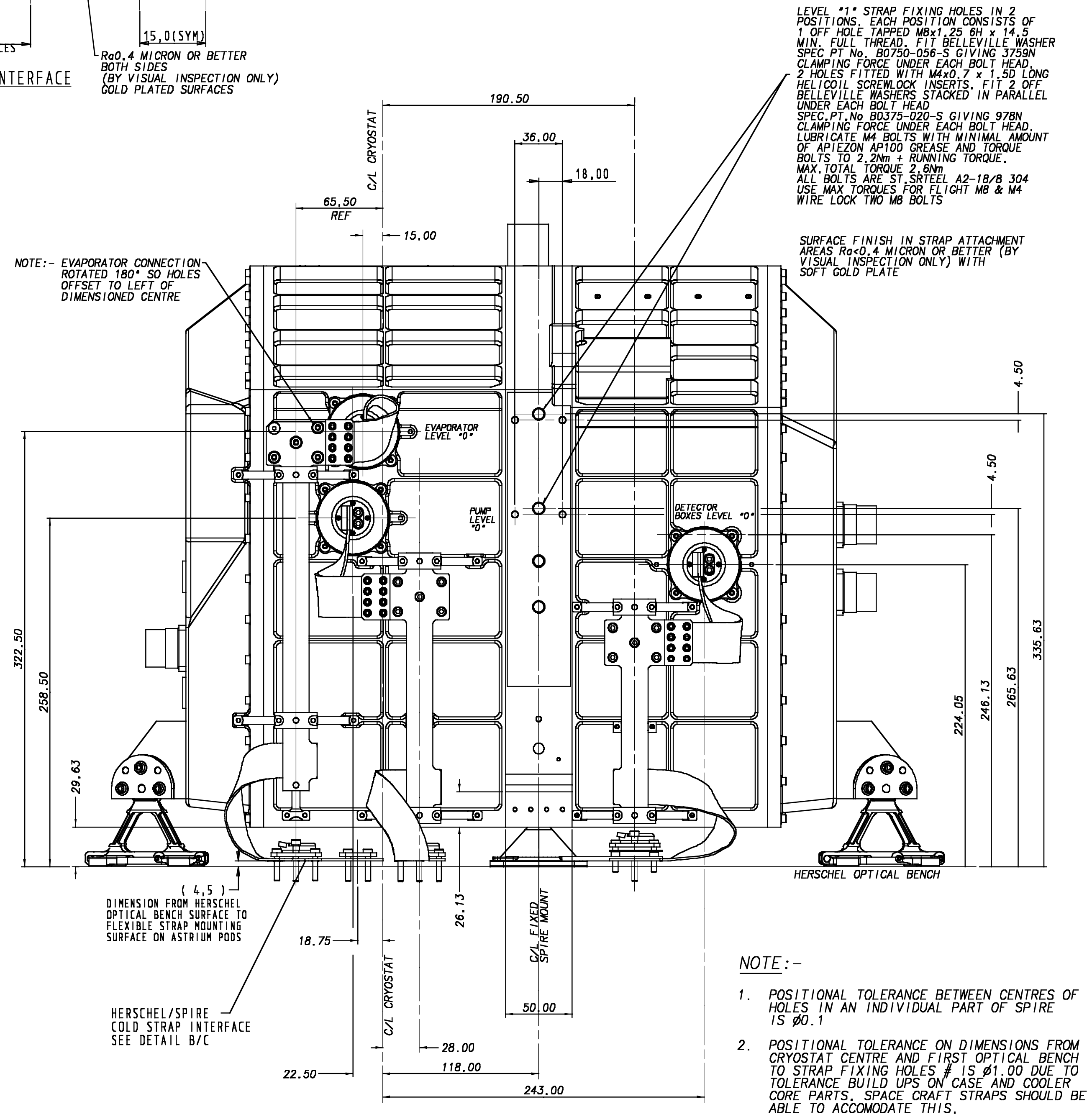
HSFPU EXTERNAL FINISHES:-

INSTRUMENT CASE AND EXTERNAL COVERS. BLADE AND FIXED MOUNTING.	ALOCROM 1200 NATURAL ST.STEEL & CARBON FIBRE
EXTERNAL FIXINGS, COLD STRAPS	NATURAL ST.STEEL GOLD PLATED

NOTE:-

ANY THERMAL INTERFACE PROVISIONS NEEDED FOT THE JFET UNITS ARE SHOWN ON INTERFACE DRAWINGS RELATING TO THOSE UNITS.





NOTE:-

1. POSITIONAL TOLERANCE BETWEEN CENTRES OF HOLES IN AN INDIVIDUAL PART OF SPIRE IS ø0.1
2. POSITIONAL TOLERANCE ON DIMENSIONS FROM CRYOSTAT CENTRE AND FIRST OPTICAL BENCH TO STRAP FIXING HOLES # IS ø1.00 DUE TO TOLERANCE BUILD UPS ON CASE AND COOLER CORE PARTS. SPACE CRAFT STRAPS SHOULD BE ABLE TO ACCOMODATE THIS.

	ISSUE	DATE	AMENDMENT
	20	8/9/05	SEE CHANGE SHEET
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DRAWN AJC	1	24/11/01	

NOTE:-

SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

NOTE:-

ALL DIMENSIONS AT ROOM TEMPERATURE

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH	MATERIAL & SPEC.	TOLERANCES UNLESS OTHERWISE STATED -
ALOCROM 1200 AND SOFT GOLD PLATE (ST.STEEL PARTS NATURAL)	AS LISTED	LINEAR +/- 0.10 ANGULAR +/- 0°15′
ESTD WT. 45,63kg (NO CONT) SEE NOTE SHT.1		
ACTL WT.	DIMENSIONS IN mm	SCALE 0.45:1 & 2:1

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE INTERFACE
(THERMAL STRAP CONNECTIONS)

DRAWING No		
A1	5264	300 sht5

SHEET 5 OF 7

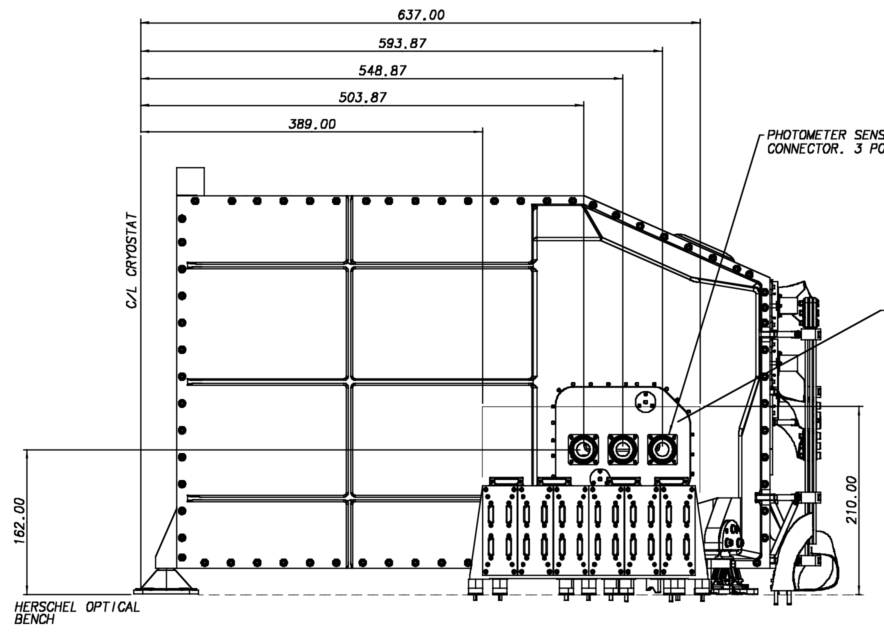
DRAWING No.
A1 5264 300 sht6

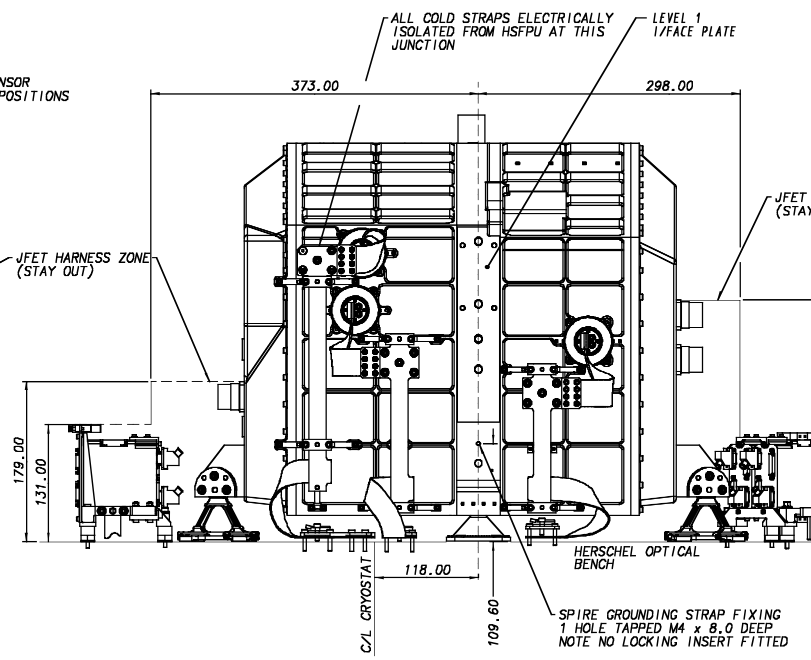
THIRD ANGLE PROJECTION

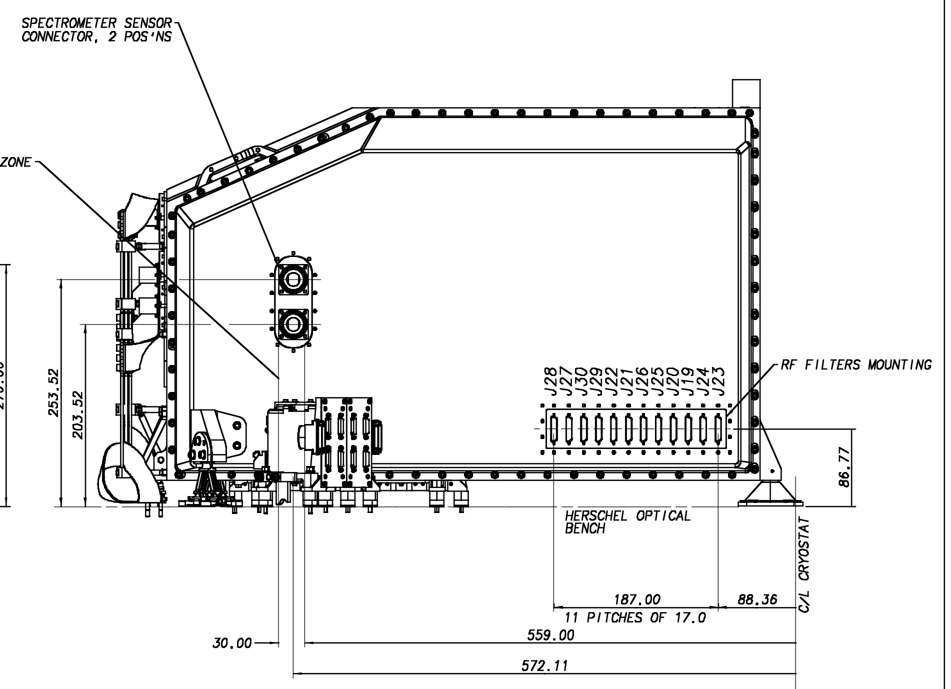
DO NOT SCALE

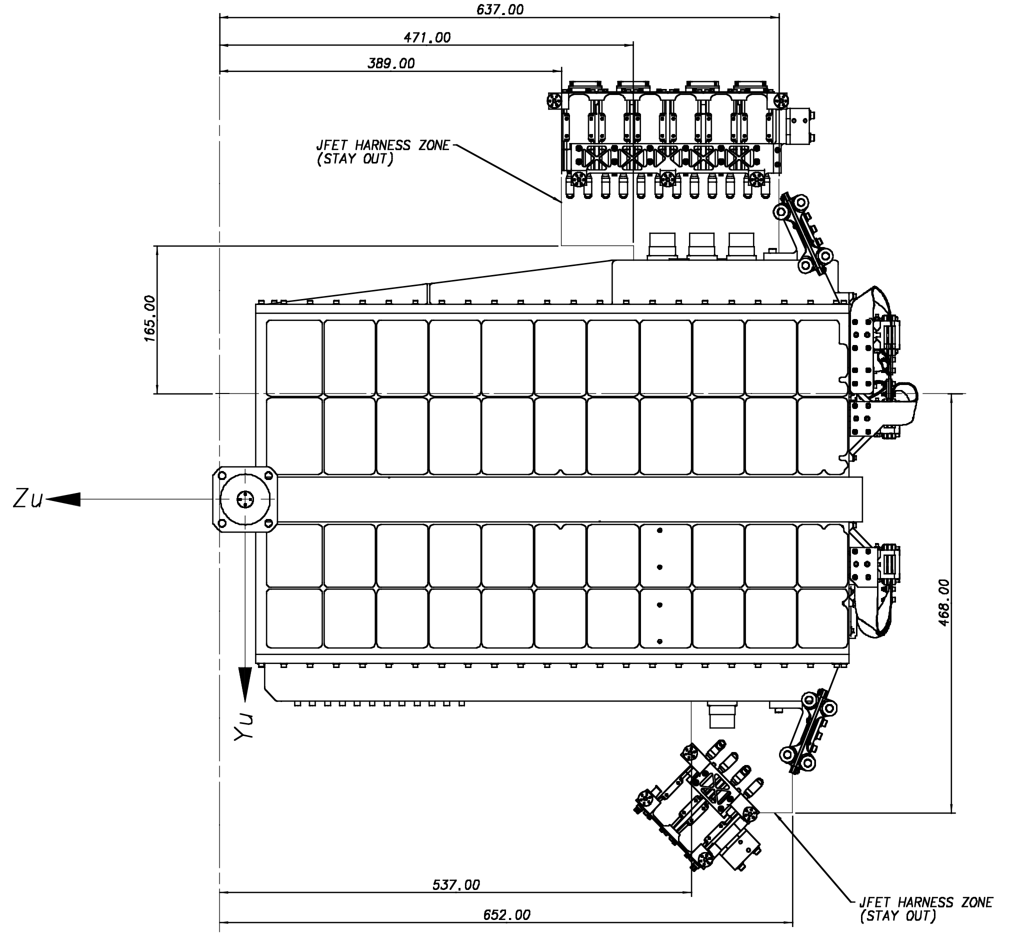
REMOVE ALL BURRS & SHARP EDGES

USED ON
HERSCHEL



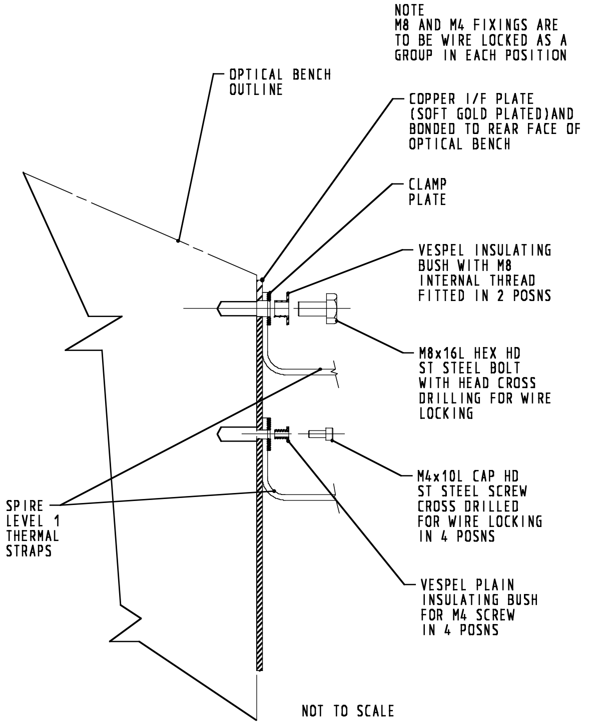






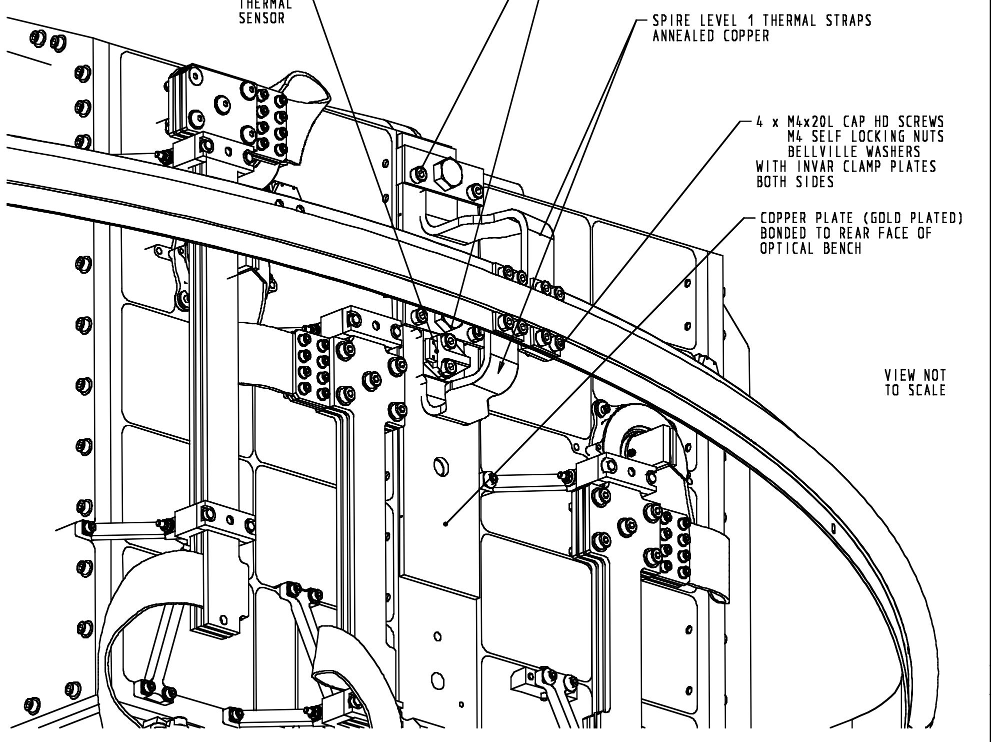
VIEW ON Xu (UNDERSIDE OF SPIRE)

NOTE
M8 AND M4 FIXINGS ARE TO BE WIRE LOCKED AS A GROUP IN EACH POSITION



NOT TO SCALE

PICTORIAL VIEW OF
LEVEL 1 THERMAL STRAPS
(FROM SPIRE INTERFACE mar 2002 (ASSY)
CONFIG-DWG SHEET 5)



VIEW NOT TO SCALE

NOTE:-
1. ALL DIMENSIONS AT ROOM TEMPERATURE

	ISSUE	DATE	AMENDMENT
	20	13/02/05	REDRAWN-SEE CHANGE SHEET
	19	19/02/04	SEE CHANGE SHEET
	18	4/07/03	SEE CHANGE SHEET
	17	16/10/02	SEE CHANGE SHEET
CHECKED	16	28/08/02	MODIFICATIONS AND CHANGE SHEET CREATED DRAWING UPDATED TO ISSUE 16 THERE-ON
	15	27/04/01	THERMAL STRAP INTERFACE MODIFIED. LEVEL 1 STRAP FIXING HOLES MOVED
TRACED PGC	14	23/11/01	CENTRE OF GRAVITY ADDED TO SHT.1. J-FET DESIGN UPDATED. STAY OUT HOLES REMOVED
	13	19/11/01	UPDATED RFI FILTER & PHOT CONNECTORS ADDED. FOCAL PLANE & 'A' FRAME MOUNT DIM ADDED. SHEET 7 ADDED
DRAWN AJC	1	24/11/01	

NOTE:-
SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH	MATERIAL & SPEC.	TOLERANCES UNLESS OTHERWISE STATED -
ALOCROM 1200 AL PARTS SELECTIVE GOLD PLATE ON COPPER PARTS (ST.STEEL PARTS NATURAL)	AS LISTED	LINEAR +/- 0.10 ANGULAR +/- 0°15'
ESTD WT. 45.63kg (NO CONT) SEE NOTE SHT.1		
ACTL WT.	DIMENSIONS IN mm	SCALE 1:4

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE INTERFACE

DRAWING No
A1 5264 300 sht6

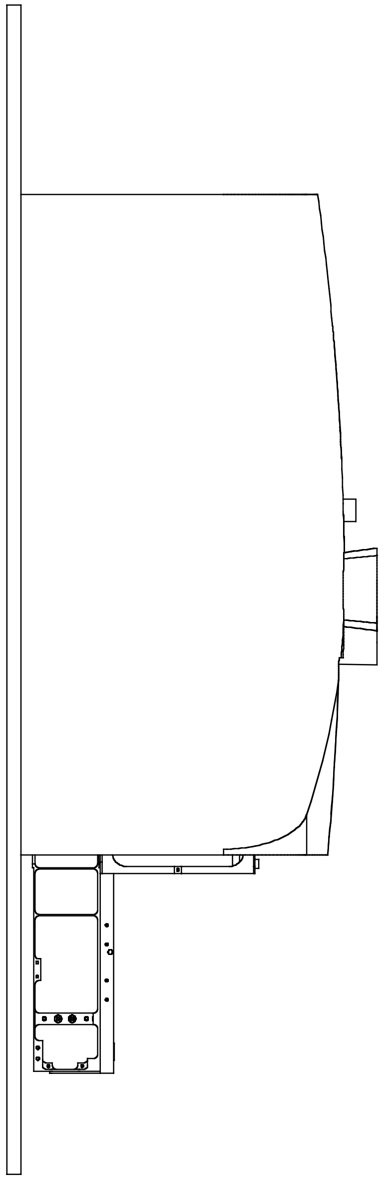
DRAWING No.		
A1	5264	300 sht7

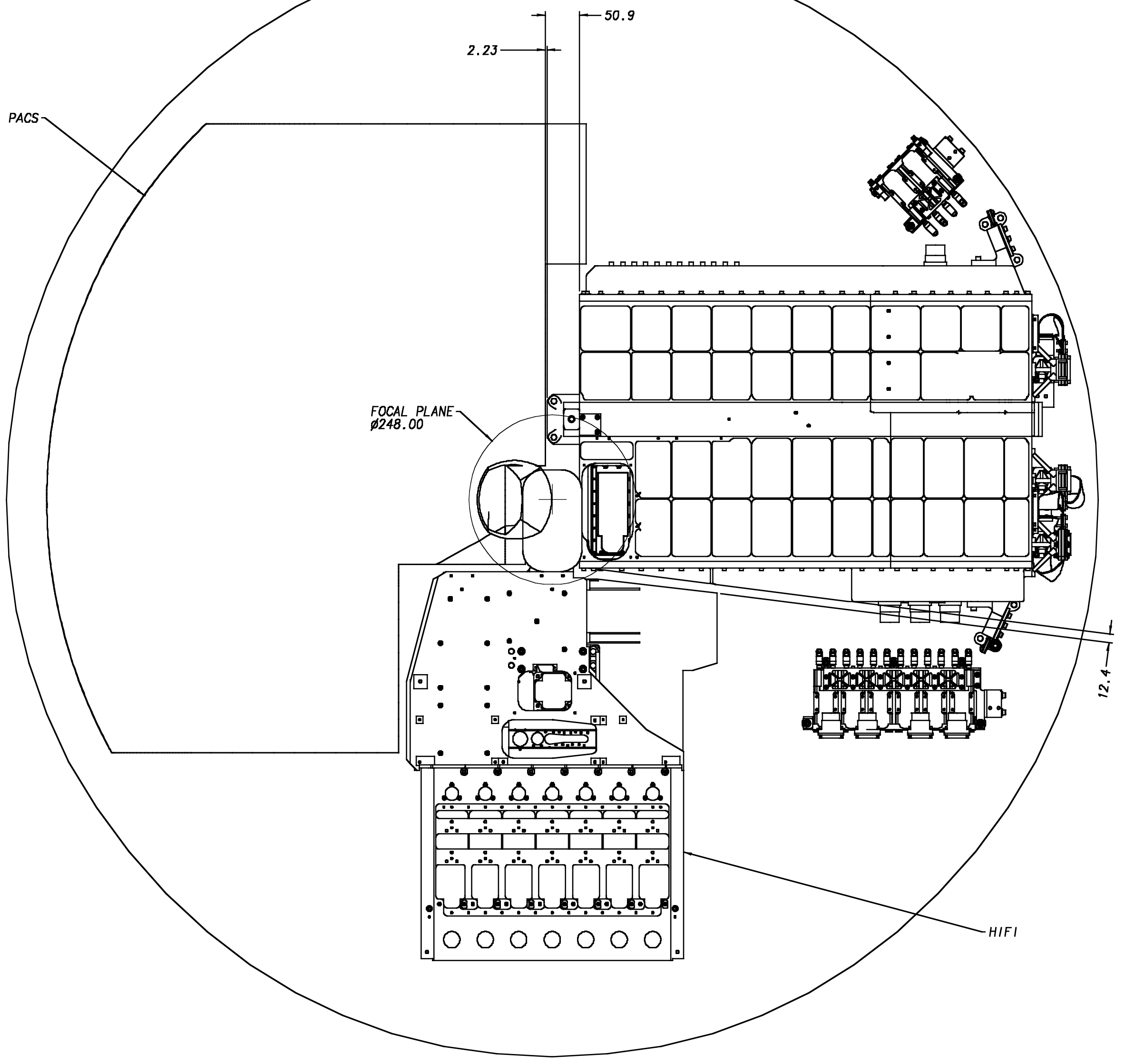
THIRD ANGLE PROJECTION

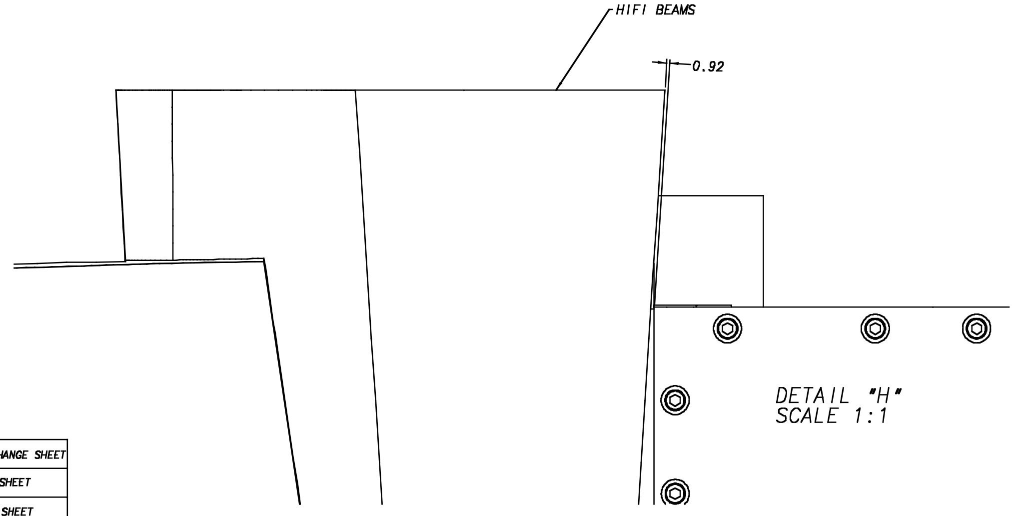
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

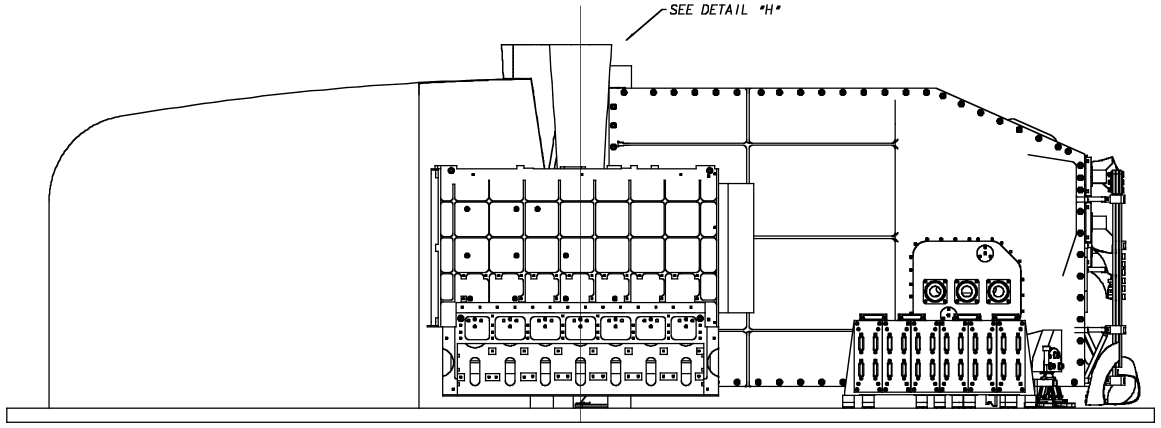
USED ON
HERSCHEL







DETAIL "H"
SCALE 1:1



	ISSUE	DATE	AMENDMENT
	20	8/9/05	REDRAWN-SEE CHANGE SHEET
	19	19/02/04	SEE CHANGE SHEET
	18	4/07/03	SEE CHANGE SHEET
	17	16/10/02	SEE CHANGE SHEET
CHECKED	16	28/08/02	MODIFICATIONS AND CHANGE SHEET CREATED DRAWING UPDATED TO ISSUE 16 THERE-ON
	15	27/04/01	THERMAL STRAP INTERFACE MODIFIED. LEVEL 1 STRAP FIXING HOLES MOVED
TRACED PGC	14	23/11/01	CENTRE OF GRAVITY ADDED TO SHT.1. J-FET DESIGN UPDATED, STAY OUT HOLES REMOVED
	13	19/11/01	UPDATED RFI FILTER & PHOT CONNECTORS ADDED, FOCAL PLANE & 'A' FRAME MOUNT DIM ADDED. SHEET 7 ADDED
DRAWN AJC	1	24/11/01	

NOTE:-

SEE CHANGE SHEET FOR DETAILS OF CHANGES MADE FROM ISSUE 16 ONWARDS

SPIRE INTERFACE mar 2002 (ASSEMBLY MODEL)

COMPUTER FILE

PROTECTIVE FINISH	MATERIAL & SPEC.	TOLERANCES UNLESS OTHERWISE STATED -
ALOCROM 1200 (ST.STEEL PARTS NATURAL)	AS LISTED	LINEAR +/- 0.10 ANGULAR +/- 0°15'
ESTD WT. 45,63kg (NO CONT) SEE NOTE SHT.1		
ACTL WT.	DIMENSIONS IN mm	SCALE

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE INTERFACE
(PACS & HIFI OPTICAL & CLEARANCES)

DRAWING No		
A1	5264	300 sht7

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 3 of 6

KE-2952

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-360

DRAWING TITLE: 2 JFET RACK INTERFACE DRAWING

Date: 12-Mar-2003

NCR/ECR:

Modification Description:

1. Thermal standoff positional dimensions changed to basic dimensions.
2. Thermal strap interface dimensions added
3. Note 3 modified to clarify that stud is set to depth then nut is torqued to 2.1Nm.
4. Height of JFET rack dimension added.
5. Note 8 added regarding the protrusion and trimming of the parylene coating
6. Annotation moved (next to balloon) stating that the KE-0104-357 and 358 should not be confused (as they have different lengths of parylene coating).
7. Typos fixed
8. Unit mounting hole size and positional accuracy added

Issue raised to:	G	By:	Iain Gilmour

Date: 20-May-2003

NCR/ECR:

Modification Description:

Added note to size of tapped holes for attachment of cooling strap (L-1/2)

2 HOLES M4x0.7 1.5D LG HELICOIL
FASTENER TO ENGAGE 1.5d
TORQUE NOT TO EXCEED 2.5Nm

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2952

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 4 of 6

KE-2952

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-360

DRAWING TITLE: 2 JFET RACK INTERFACE DRAWING

Issue raised to:	H	By:	Kevin Burke

Date: 13-Oct-2003

NCR/ECR:

Modification Description:

1. Reflects new thermal standoff design with additional bush and upper and lower feet washers. Subsequent dimensions in X direction updated to new interface plane. New parts added to Parts List.
2. Reflects new harness layout which simulates actual physical layout. Micro-D 15 way connector added to harness representation. Micro-D 37 way elliptical entry backshells replace standard circular entry versions. Mass of harness increased from 110g to 205g.
3. L3 strap and interface assembly added. Views updated to show interface details and L3 strap hole definition.
4. Mass of JFET modules reduced from 305g to 260g.
5. Kapton tape removed from fastener and stand-off interfaces (note 7 deleted).
6. Moments of inertia updated along with C of G position.
7. Kapton tape note removed from L3 interface area.
8. Incorrectly specified M2.5 x 8 long fasteners used to fasten JFET modules to front plate replaced with M3 x 8 long.
9. Temperature sensor interface shown on both sides of the L3 interface sub-assembly.
10. Distance between S/C connector I/F and rear of JFET harness increased due to addition of 15-way connectors to JFET harness.
11. New dimensions applied to L3 interface area.
12. Connector fasteners and nuts added to spacecraft connectors.

Issue raised to:	I	By:	Dave Smart

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2952

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 5 of 6

KE-2952

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-360

DRAWING TITLE: 2 JFET RACK INTERFACE DRAWING

Date: 12-Nov-2003

NCR/ECR:

Modification Description:

1. Harness re-routed to show clearance required to access connectors on the rear of the JFETS. Reference to note 6 added.
2. Harness tie down parts added.
3. Note 8 added concerning the pre-fitting of the M4 fasteners prior to the assembly of the harness.

Issue raised to:	J	By:	Dave Smart

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2952

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 6 of 6

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MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-360

DRAWING TITLE: 2 JFET RACK INTERFACE DRAWING

Date: 10-Mar-2004

NCR/ECR:

Modification Description:

1. Note 9 and leaders added indicating 3mm jackscrew length below the mating plane.
2. Label added to Part 23836-10209722 (JFET) to indicate orientation:

SPIRE

10209750

JFET MODULE

JPL

(NOTE: 10209750 is the JPL part number, 10209722 is the JPL ICD drawing number. JD wishes to leave the ProE part name as 23836-10209722)

Issue raised to:	K	By:	Dave Smart

Date: 05-Aug-2005

NCR/ECR:

Modification Description:

1. Note added to describe removal of Carbon Whiskers and coating with D222a

RAISED TO ISSUE L

Issue raised to:	L	By:	Sam Tobin

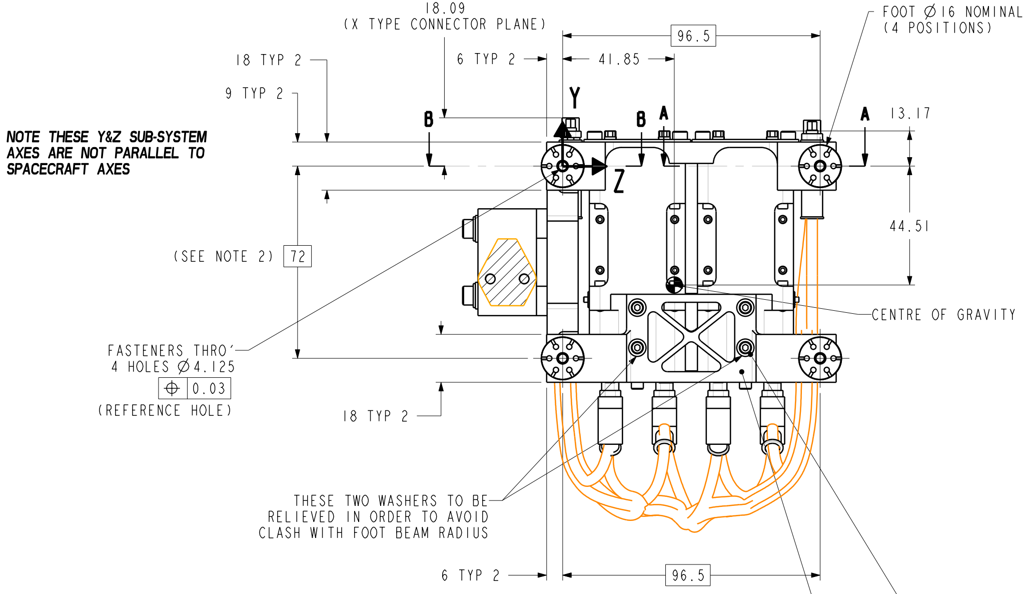
SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

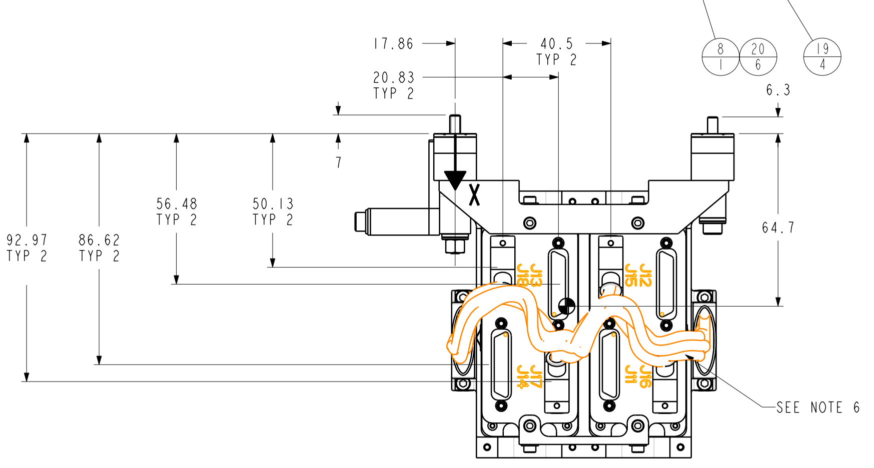
KE-2952

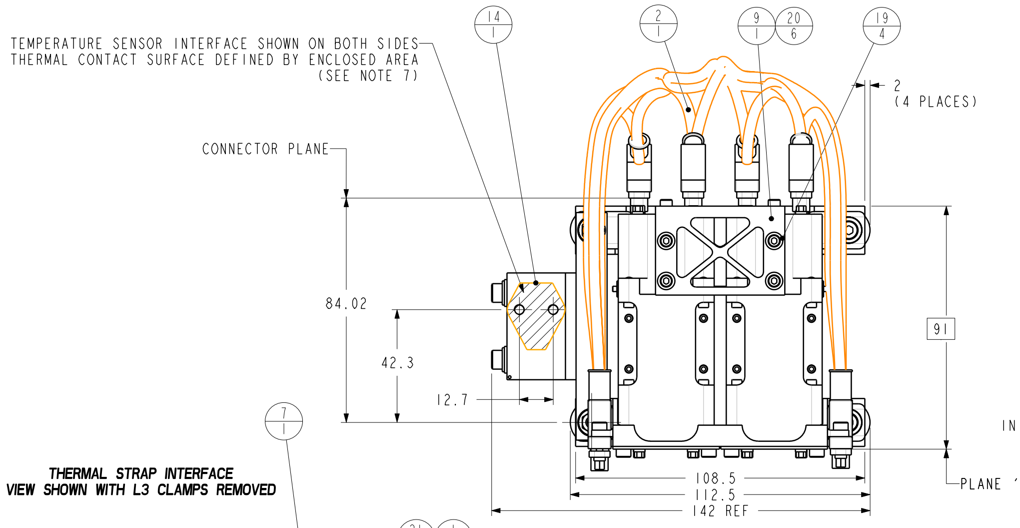
A 0-KE-0104-360-L

PROJECTION

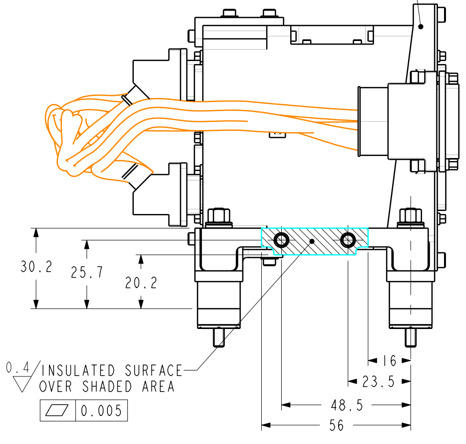
THIS DRAWING CONFORMS TO B.S.308

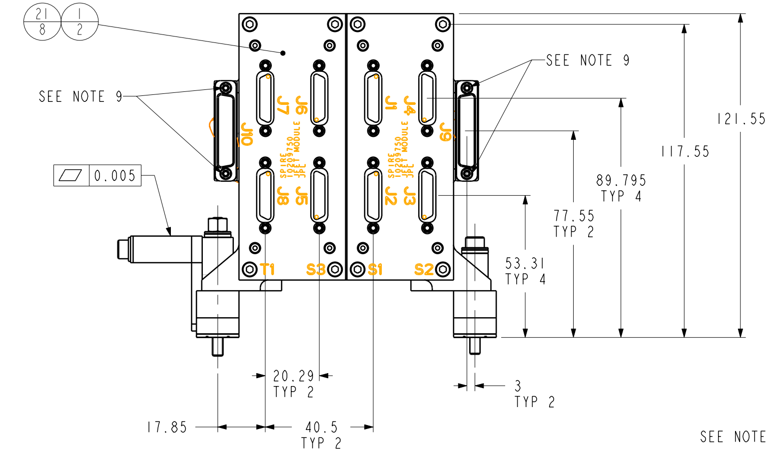


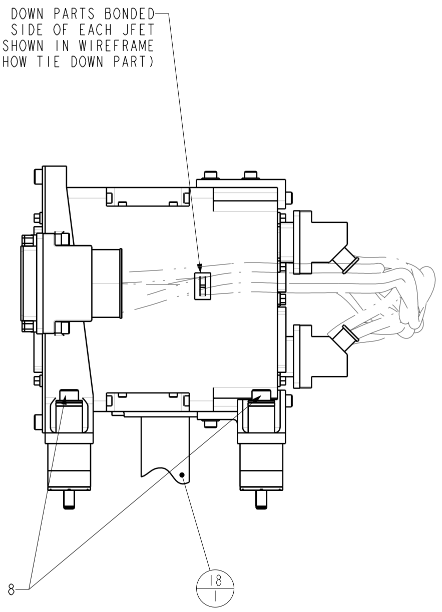


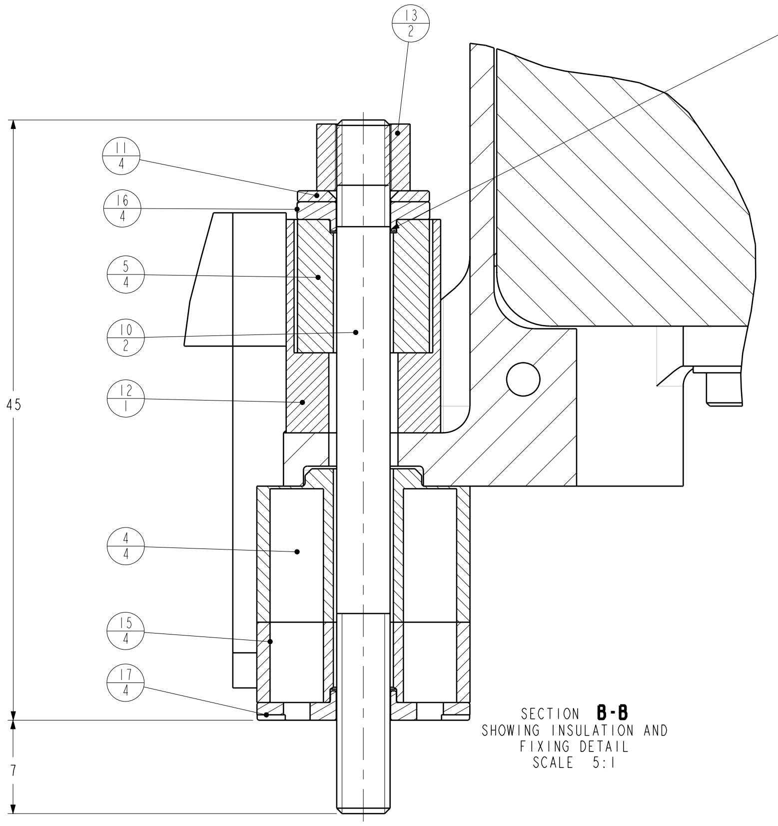


THERMAL STRAP INTERFACE
VIEW SHOWN WITH L3 CLAMPS REMOVED

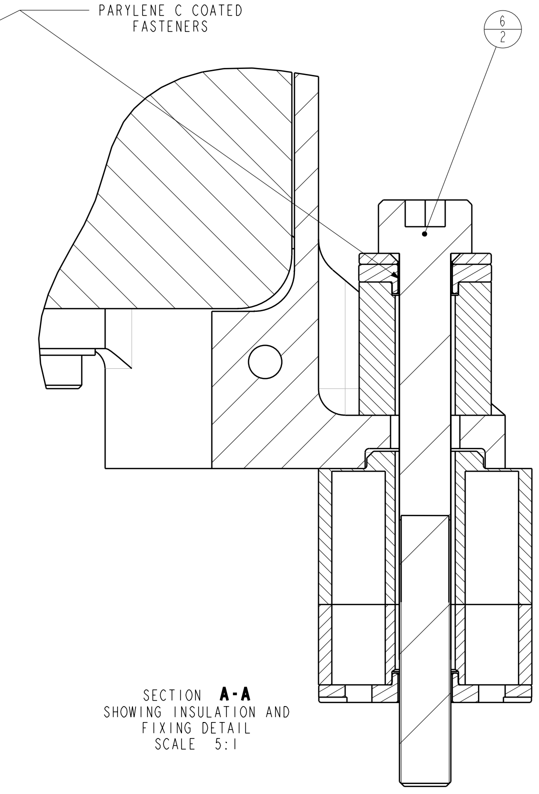








SECTION **B-B**
SHOWING INSULATION AND
FIXING DETAIL
SCALE 5:1



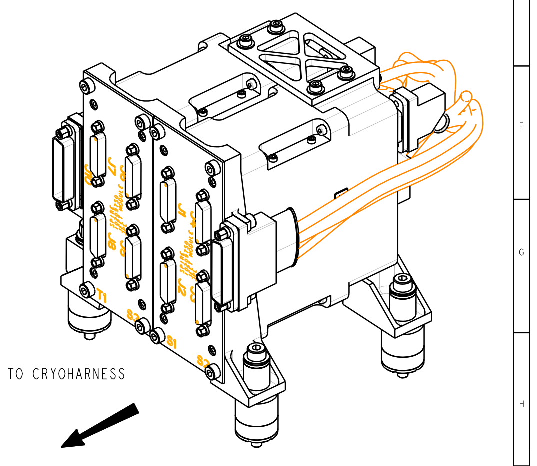
SECTION **A-A**
SHOWING INSULATION AND
FIXING DETAIL
SCALE 5:1

CONNECTOR TABLE

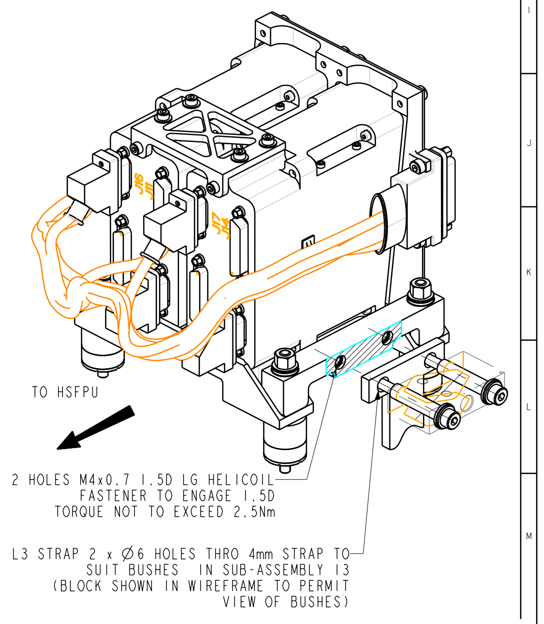
LABEL	TYPE	FUNCTION
J1	ALL MDM25P	ALL SIGNAL FEEDS TO CRYOHARNESS
J2		
J3		
J4		
J5		
J6		
J7		
J8		
J9	MDM37S	BIAS WIRES FROM CRYOHARNESS
J10		
J11	ALL MDM51P	SIGNALS IN FROM DETECTORS
J12		
J13		
J14		
J15	ALL MDM15P	BIAS FEEDS INTO MODULES
J16		
J17		
J18		

MOMENTS OF INERTIA (Kg.mm^2) WITH RESPECT TO C OF G	
I_{xx}	1.71e+03
I_{yy}	1.94e+03
I_{zz}	2.31e+03

ITEM	PART NO.	DESCRIPTION	QTY	MASS/ITEM	TOTAL MASS	COMMENTS
1	23836-10209722	JFET MODULE	2	260.00	520.00	JPL SUPPLY
2	2JFET_HARNESS	BACKHARNESS (10209784_1)	1	216.95	216.95	JPL SUPPLY
3	HARNESS_CLIP		2			
4	KE-0104-354	STEPPED THERMAL STANDOFF	4	1.70	6.80	
5	KE-0104-355	TOP THERMAL STANDOFF	4	0.87	3.47	
6	KE-0104-358	M4 BOLT (PARYLENE C COATED 26.5mm)	2	4.70	9.39	
7	KE-0104-361	FRONT PLATE - 2 JFET	1	48.01	48.01	
8	KE-0104-362	REAR FOOT BEAM - 2 JFET	1	33.69	33.69	
9	KE-0104-363	REAR TOP BEAM - 2 JFET	1	8.62	8.62	
10	KE-0104-365	M4 STUD (PARYLENE C COATED)	2	5.08	10.16	
11	KE-0104-367	THERMAL STANDOFF WASHER	4	0.39	1.55	
12	KE-0104-368	THERMAL STRAP ASSY - 2 JFET	1	23.28	23.28	
13	KE-0104-386	M4 NUT (5mm LONG)	2	1.31	2.62	
14	KE-0104-393	L3 INTERFACE ASSY	1	64.18	64.18	
15	KE-0104-397	THERMAL STANDOFF BUSH	4	0.94	3.76	
16	KE-0104-398	FOOT UPPER WASHER	4	0.14	0.55	
17	KE-0104-399	FOOT LOWER WASHER	4	0.34	1.35	
18	L3_STRAP_A	L3 STRAP	1	N/A		HERSCHEL SUPPLY
19	M2-5_WASHER	WASHER	8	0.11	0.86	S/STEEL BS970/1501 304S 11/15/31
20	M2-5_X_8LG_CPHD_SKT_SS	FASTENER	12	0.58	6.93	S/STEEL BS3506-1:1998 A2-70
21	M3_X_8LG_CPHD_SKT__SS	FASTENER	8	0.74	5.95	S/STEEL BS3506-1:1998 A2-70
				ASSEMBLY MASS	968.13 GRAMS	



PARTIALLY EXPLODED 3D VIEW
SHOWING THERMAL STRAP INTERFACE
VIEW SHOWN WITH L3 CLAMPS REMOVED



NOTES:-

1. BOND ITEM 15 TO 4 PRIOR TO ASSEMBLY.
   BOND ITEMS 16 & 14 TO 3 PRIOR TO ASSEMBLY.
   ITEMS 3 & 4 TO BE PERMANENTLY GLUED TO MATING SURFACES.
2. TO ATTAIN THE CORRECT MOUNTING INTERFACE DIMENSION, AND TO COMPENSATE FOR ACTUAL JFET MODULE SIZES, THE FOLLOWING PROCEDURE MUST BE FOLLOWED:
   PARTS 1 ARE TO BE MOUNTED TO PART 6. MEASURE FROM THE TOP OF PARTS 1 SHOWN AS PLANE 'C' TO THE TAIL END FACE OF PARTS 6, NOTING THE TWO VALUES.
   MACHINE RAISED PADS ON PART 7 TO REMOVE (VALUE - 87.7). PADS ON ITEM 8 WILL ALSO NEED MACHINING IF TRIAL ASSEMBLY OF RACK ON FLAT SURFACE SHOWS GAPS BEFORE FASTENERS ARE TIGHTENED.
3. ITEMS 6 TO BE TORQUED TO 2.1 Nm ABOVE LOCKING INSERT RUNNING TORQUE.
   ITEMS 13 TO BE TORQUED TO 2.1 Nm WITH STUD SET TO DEPTH SHOWN IN HOB LOCKING INSERT.
4. UNIT SHOWN FITTED WITH BACK-HARNESS MATING TO J9 - J10 & J15 - J18 BECAUSE THIS WILL BE FITTED BEFORE ITEM IS INTEGRATED TO HOB.
5. HEAT CAPACITY AT RT = 700 JOULES / KELVIN.
6. FITTED BACKHARNESS TO AFFORD OPEN ACCESS TO 51 WAYS AS SHOWN.
7. AFFIX ONE SENSOR WITH LONG BOLTS AND THEN THE OTHER ON THE REVERSE WITH NUTS
8. ITEMS 6 AND 11 TO BE PRE-FITTED BEFORE ITEM 2 IS FITTED
9. ONLY 3mm JACKSCREW LENGTH GUARANTEED BELOW THE MATING PLANE
10. INNER SURFACES OF PARTS 4, 5 AND 15 TO BE CLEAN OF CARBON WHISKERS AND OVERCOATED WITH D222A AFTER ASSEMBLY.

L	05-Aug-05	KE-2952.	D. SMART	Digitally signed by Sam Tobin Date: 2005.08.05 13:56:48 +01'00'	2005.08.08 10:13:17 +01'00'	ISSUED
ISSUE	DATE	MOD. No.	DRN. BY	CHKD.	APPD.	STATUS

TOLERANCES UNLESS STATED ±0.2 mm ±0.3 °	**FINISH** CLEAN **REMOVE ALL BURRS**	**ORIGINAL SCALE** 1:1 **DO NOT SCALE**
MATERIAL & SPEC. SEE DETAILS	**SURFACE TEXTURE µM** SEE DETAILS ✓ **UNLESS STATED**	0 50mm

USED ON

CENTRAL LABORATORY OF THE RESEARCH COUNCILS

TITLE

2 JFET RACK
INTERFACE DRAWING

SPIRE

A 0-KE-0104-360-L

1 OF 1

A 0-KE-0104-360-L

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 3 of 6

KE-2953

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-350

DRAWING TITLE: 6 JFET RACK INTERFACE DRAWING

Date: 12-Mar-2003

NCR/ECR:

Modification Description:

1. Thermal standoff positional dimensions changed to basic dimensions.
2. Thermal strap interface dimensions added
3. Note 8 added regarding the protrusion and trimming of the parylene coating
4. Typos fixed
5. 2 off thermal strap standard washers replaced with Belleville washers, BOM updated to this effect.

6. Unit mounting hole size and positional accuracy added

Issue raised to: E By: Iain Gilmour

Date: 20-May-2003

NCR/ECR:

Modification Description:

1. Note Associated with tapped holes in the Thermal Strap Interface, first line modified for clarity to read:
   2 HOLES M4x0.7 1.5D LG HELICOIL

Issue raised to: F By: Kevin Burke

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2953

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 4 of 6

KE-2953

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-350

DRAWING TITLE: 6 JFET RACK INTERFACE DRAWING

Date: 13-Oct-2003

NCR/ECR:

Modification Description:

1. Reflects new thermal standoff design with additional bush and upper and lower feet washers. Subsequent dimensions in X direction updated to new interface plane. New parts added to Parts List.
2. Reflects new harness layout which simulates actual physical layout. Micro-D 15 way connector added to harness representation. Micro-D 37 way elliptical entry backshells replace standard circular entry versions. Mass of harnesses increased from 165g to 270g.
3. L3 strap and interface assembly added. Views updated and added to show interface details and L3 strap hole definition.
4. Mass of JFET modules reduced from 305g to 260g.
5. Kapton tape removed from fastener and stand-off interfaces (note 7 deleted).
6. Moments of inertia updated along with C of G position.
7. Fastener for thermal strap assembly changed to non parylene coated M4 x 45mm long.
8. Kapton tape note removed from L3 interface area.
9. Incorrectly specified M2.5 x 8 long fasteners used to fasten JFET modules to front plate replaced with M3 x 8 long.
10. Temperature sensor interface shown on both sides of the L3 interface sub-assembly.
11. Distance between S/C connector I/F and rear of JFET harness increased due to addition of 15-way connectors to JFET harness. Dimension between S/C connector plane and rear face of JFET module added.
12. New dimensions applied to L3 interface area.
13. Connector fasteners and nuts added to spacecraft connectors.

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2953

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 5 of 6

KE-2953

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-350

DRAWING TITLE: 6 JFET RACK INTERFACE DRAWING

Issue raised to: G By: Dave Smart

Date: 10-Mar-2004

NCR/ECR:

Modification Description:

1. Note 8 and leaders added indicating 3mm jackscrew length below the mating plane.
2. Label added to Part 23836-10209722 (JFET) to indicate orientation:

SPIRE

10209750

JFET MODULE

JPL

(NOTE: 10209750 is the JPL part number, 10209722 is the JPL ICD drawing number. JD wishes to leave the ProE part name as 23836-10209722)

Issue raised to: H By: Dave Smart

Date: 05-Aug-2005

NCR/ECR:

Modification Description:

1. Note added to describe removal of Carbon Whiskers and coating with D222a

RAISED TO ISSUE J

Issue raised to: J By: Sam Tobin

SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

KE-2953

SSTD Rutherford Appleton Laboratory	**Space Product Assurance Form** ***Mechanical Design Office***	Doc.No. :ISO9:FORM/MECH/006 Issue : 2 Date : 21/12/2001 Page : 6 of 6

KE-2953

MODIFICATION SHEET

THE CENTRAL LABORATORY OF THE RESEARCH COUNCILS RUTHERFORD APPLETON LABORATORY

DRAWING NUMBER: KE-0104-350

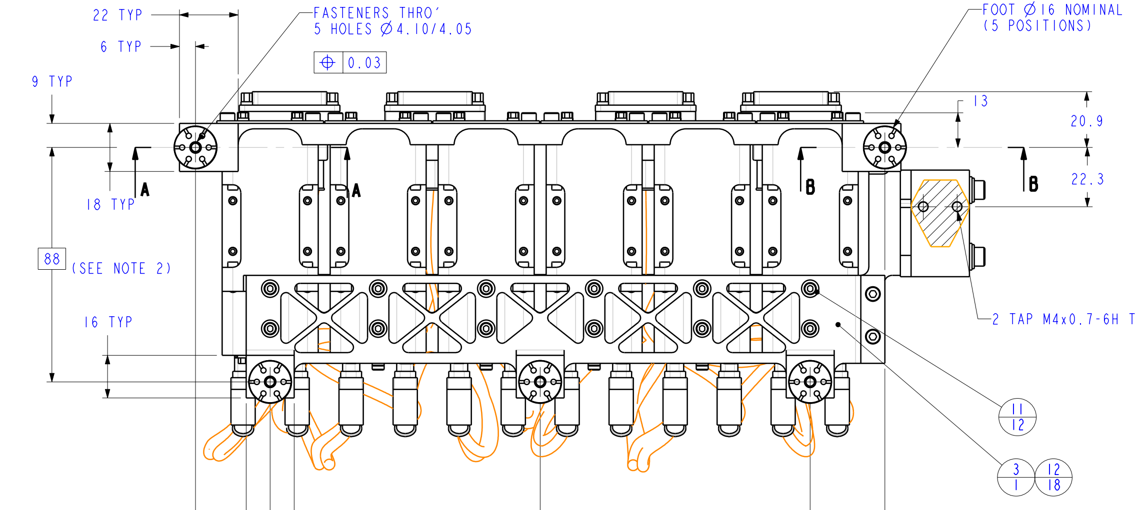
DRAWING TITLE: 6 JFET RACK INTERFACE DRAWING

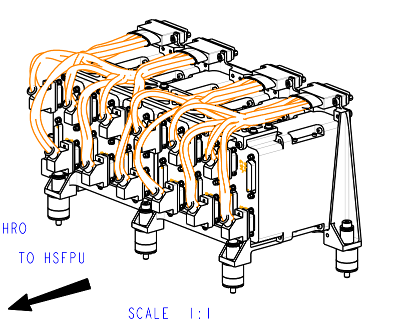
SUPERSEDED ISSUES OF ALL DRAWING HARD COPIES TO BE DESTROYED

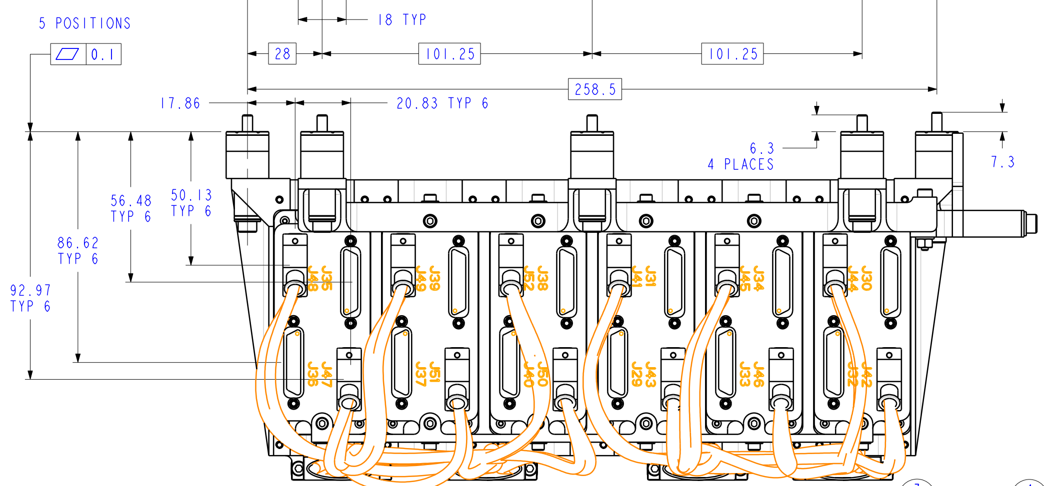
KE-2953

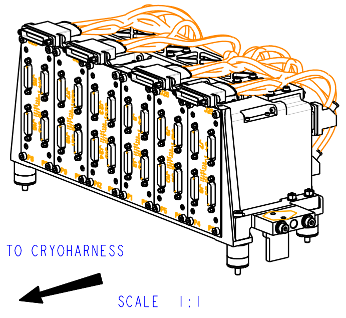
PROJECTION

THIS DRAWING CONFORMS TO B.S.308

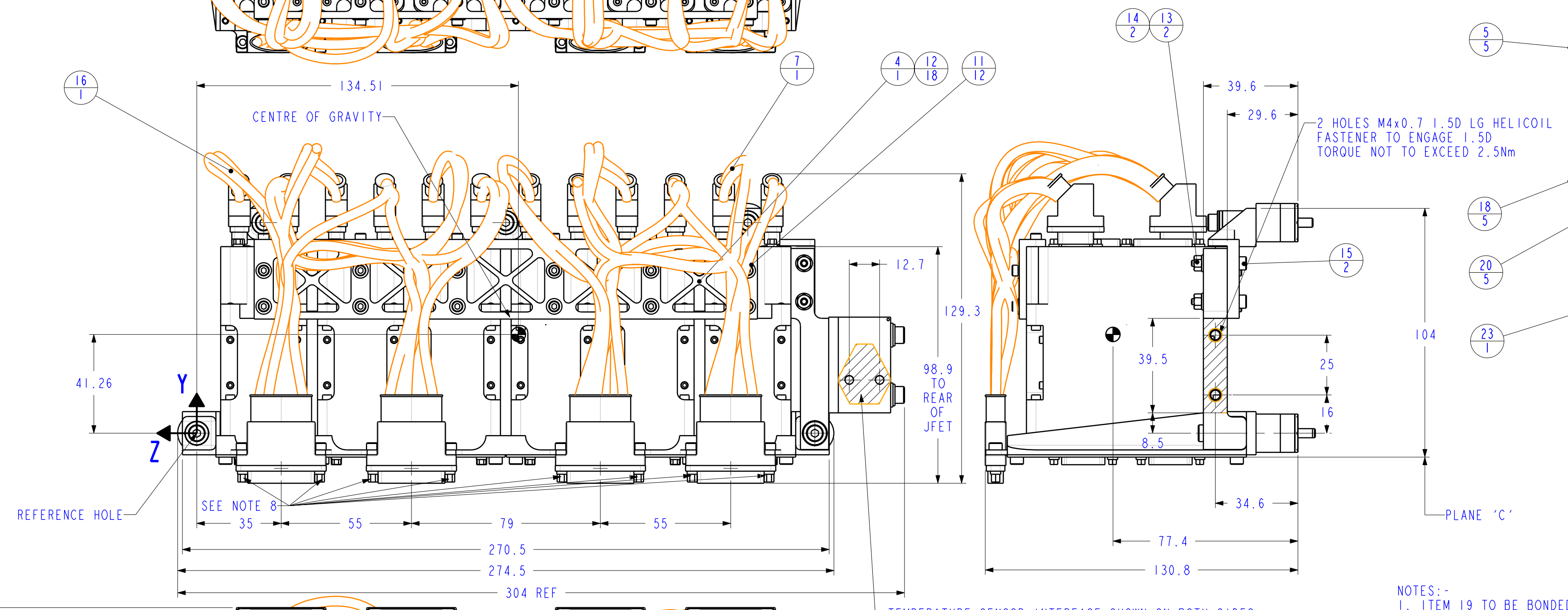


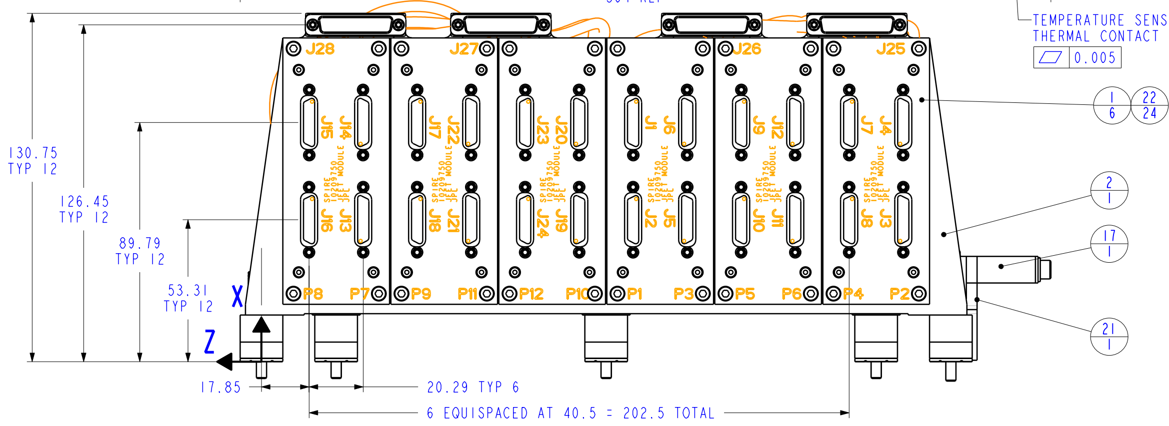


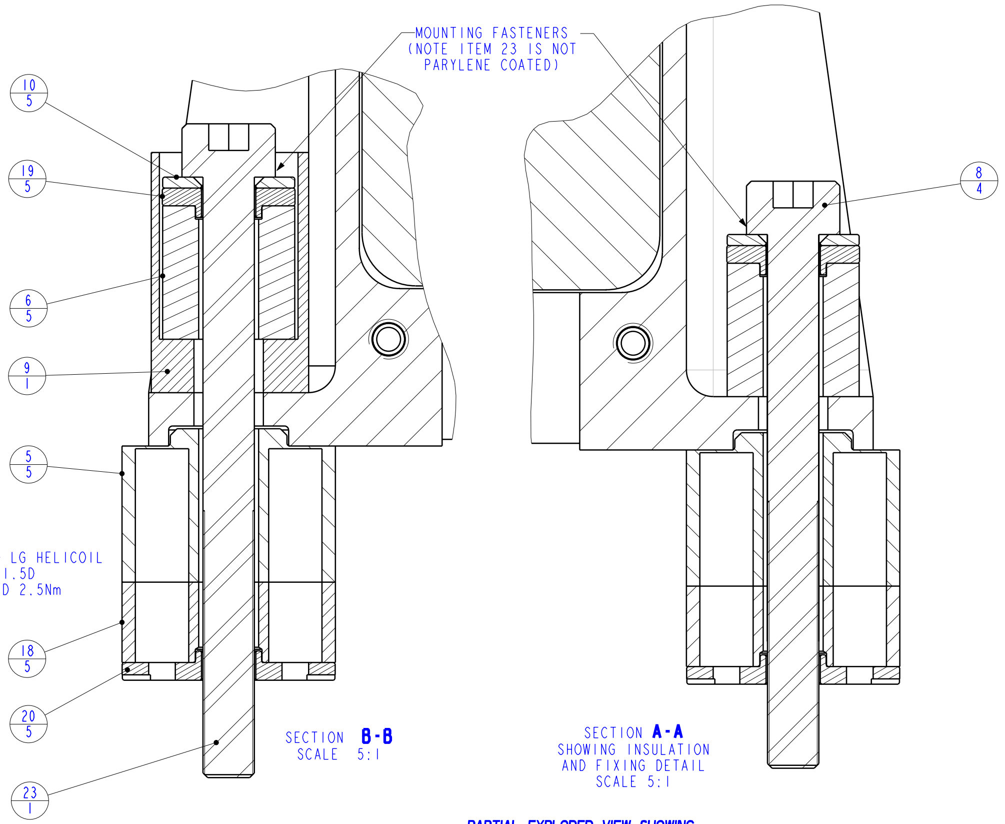




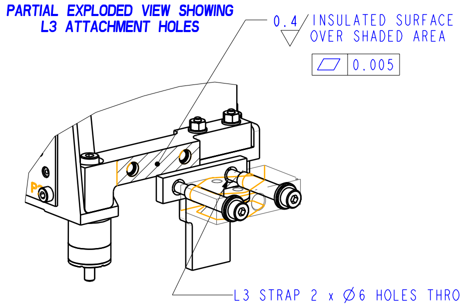
THERMAL STRAP INTERFACE
VIEW SHOWN WITH L3 CLAMPS REMOVED







PARTIAL EXPLODED VIEW SHOWING
L3 ATTACHMENT HOLES



MOMENTS OF INERTIA (Kg.mm²) WITH RESPECT TO C OF G	
I_{xx}	1.70e+04
I_{YY}	1.66e+04
I_{zz}	4.73e+03

ITEM	PART NO.	DESCRIPTION	QTY	MASS/ITEM	TOTAL MASS	COMMENTS
1	23836-10209722	JFET MODULE	6	260.00	1560.00	JPL SUPPLY
2	KE-0104-351	FRONT PLATE 6 JFET	1	128.66	128.66	
3	KE-0104-352	REAR FOOT BEAM - 6 JFET	1	69.55	69.55	
4	KE-0104-353	REAR TOP BEAM - 6 JFET	1	32.56	32.56	
5	KE-0104-354	STEPPED THERMAL STANDOFF	5	1.70	8.50	
6	KE-0104-355	TOP THERMAL STANDOFF	5	0.87	4.34	
7	10209785_1	BACKHARNESS (10209785_1)	1	265.65	265.65	JPL SUPPLY
8	KE-0104-358	M4 BOLT (PARYLENE C COATED 26.5mm)	4	4.70	18.78	
9	KE-0104-359	THERMAL STRAP ASSY - 6 JFET	1	23.76	23.76	
10	KE-0104-367	THERMAL STANDOFF WASHER	5	0.39	1.94	
11	M2-5_WASHER	WASHER	24	0.11	2.57	S/STEEL BS970/1501 304S 11/15/31
12	M2-5_X_8LG_CPHD_SKT_SS	FASTENER	36	0.58	20.79	S/STEEL BS3506-1:1998 A2-70
13	M3_NUT	NUT	2	0.48	0.97	S/STEEL BS6105 A2-50 DIN 912
14	58-3205	BELLEVILLE WASHER	2	0.17	0.33	BELLEVILLE SPRINGS LTD, BATCH 17415
15	M3_X_20LG_CPHD_SKT_SS	FASTENER	2	1.26	2.52	S/STEEL BS3506-1:1998 A2-70
16	10209786_1	BACKHARNESS (10209786_1)	1	267.70	267.70	JPL SUPPLY
17	KE-0104-393	L3 INTERFACE ASSY	1	64.18	64.18	
18	KE-0104-397	THERMAL STANDOFF BUSH	5	0.94	4.70	
19	KE-0104-398	FOOT UPPER WASHER	5	0.14	0.69	
20	KE-0104-399	FOOT LOWER WASHER	5	0.34	1.69	
21	L3_STRAP_B	L3 STRAP	1	N/A		HERSCHEL SUPPLY
22	M3_X_8LG_CPHD_SKT__SS	FASTENER	24	0.74	17.86	S/STEEL BS3506-1:1998 A2-70
23	M4_X_45LG_CPHD_SKT_SS	FASTENER	1	5.15	5.15	S/STEEL BS3506-1:1998 A2-70
				ASSEMBLY MASS	2502.88 GRAMS	

CONNECTOR TABLE

LABEL	TYPE	FUNCTION
J1	ALL MDM25P	ALL SIGNAL FEEDS TO CRYOHARNESS
J2		
J3		
J4		
J5		
J6		
J7		
J8		
J9		
J10		
J11		
J12		
J13		
J14		
J15		
J16		
J17		
J18		
J19		
J20		
J21		
J22		
J23		
J24		
J25	MDM37S	BIAS WIRES FROM CRYOHARNESS
J26		
J27		
J28		
J29	ALL MDM51P	SIGNALS IN FROM DETECTORS
J30		
J31		
J32		
J33		
J34		
J35		
J36		
J37		
J38		
J39		
J40		
J41	ALL MDM15P	BIAS FEEDS INTO MODULES
J42		
J43		
J44		
J45		
J46		
J47		
J48		
J49		
J50		
J51		
J52		

NOTES:-

1. ITEM 19 TO BE BONDED TO ITEM 6 PRIOR TO ASSEMBLY.
   ITEMS 20 & 18 TO BE BONDED TO ITEM 5 PRIOR TO ASSEMBLY
   ITEMS 5 & 6 TO BE PERMANENTLY GLUED TO MATING SURFACES.
2. TO ATTAIN THE CORRECT MOUNTING INTERFACE DIMENSION, AND TO COMPENSATE FOR ACTUAL JFET MODULE SIZES, THE FOLLOWING PROCEDURE MUST BE FOLLOWED:
   PARTS 1 ARE TO BE MOUNTED TO PART 2. MEASURE FROM THE TOP OF PARTS 1 SHOWN AS PLANE 'C' TO THE TAIL END FACE OF PARTS 2, NOTING THE SIX VALUES.
   MACHINE RAISED PADS ON PART 3 TO REMOVE (VALUE - 87.7). PADS ON ITEM 4 WILL ALSO NEED MACHINING IF TRIAL ASSEMBLY OF RACK ON FLAT SURFACE SHOWS GAPS BEFORE FASTENERS ARE TIGHTENED.
3. ITEMS 22 AND 8 TO BE TORQUED TO 2.1 Nm ABOVE LOCKING INSERT RUNNING TORQUE.
4. UNIT SHOWN FITTED WITH BACK-HARNESS MATING TO J25-28 & J41-52 BECAUSE THIS WILL BE FITTED BEFORE ITEM IS INTEGRATED TO HOB.
5. HEAT CAPACITY AT RT = 2100 JOULES / KELVIN.
6. FITTED BACKHARNESS TO AFFORD OPEN ACCESS TO 51 WAYS AS SHOWN.
7. AFFIX ONE SENSOR WITH LONG BOLTS AND THEN THE OTHER ON THE REVERSE WITH NUTS
8. ONLY 3mm JACSCREW LENGTH GUARANTEED BELOW MOUNTING PLANE
9. INNER SURFACES OF PARTS 5, 6 AND 18 TO BE CLEAN OF CARBON WHISKERS AND OVERCOATED WITH D222A AFTER ASSEMBLY.

J	05-AUG-05	KE-2953.	D. SMART	Digitally signed by Sam Tobin Date: 2005.08.05 13:56:29 +01'00'	2005.08.08 10:12:21 +01'00'	ISSUED
ISSUE	DATE	MOD. No.	DRN. BY	CHKD.	APPD.	STATUS

TOLERANCES UNLESS STATED ±0.2 mm ±0.3 °	**FINISH** CLEAN **REMOVE ALL BURRS**	**ORIGINAL SCALE** 1:1 **DO NOT SCALE**
MATERIAL & SPEC. SEE DETAILS	**SURFACE TEXTURE µM** SEE DETAILS ✓ **UNLESS STATED**	0 50mm

USED ON

CENTRAL LABORATORY OF THE RESEARCH COUNCILS

TITLE

6 JFET RACK
INTERFACE DRAWING

SPIRE

A 0-KE-0104-350-J 1 OF 1

DRAWING No.			
A1	5264	404	SHT 4

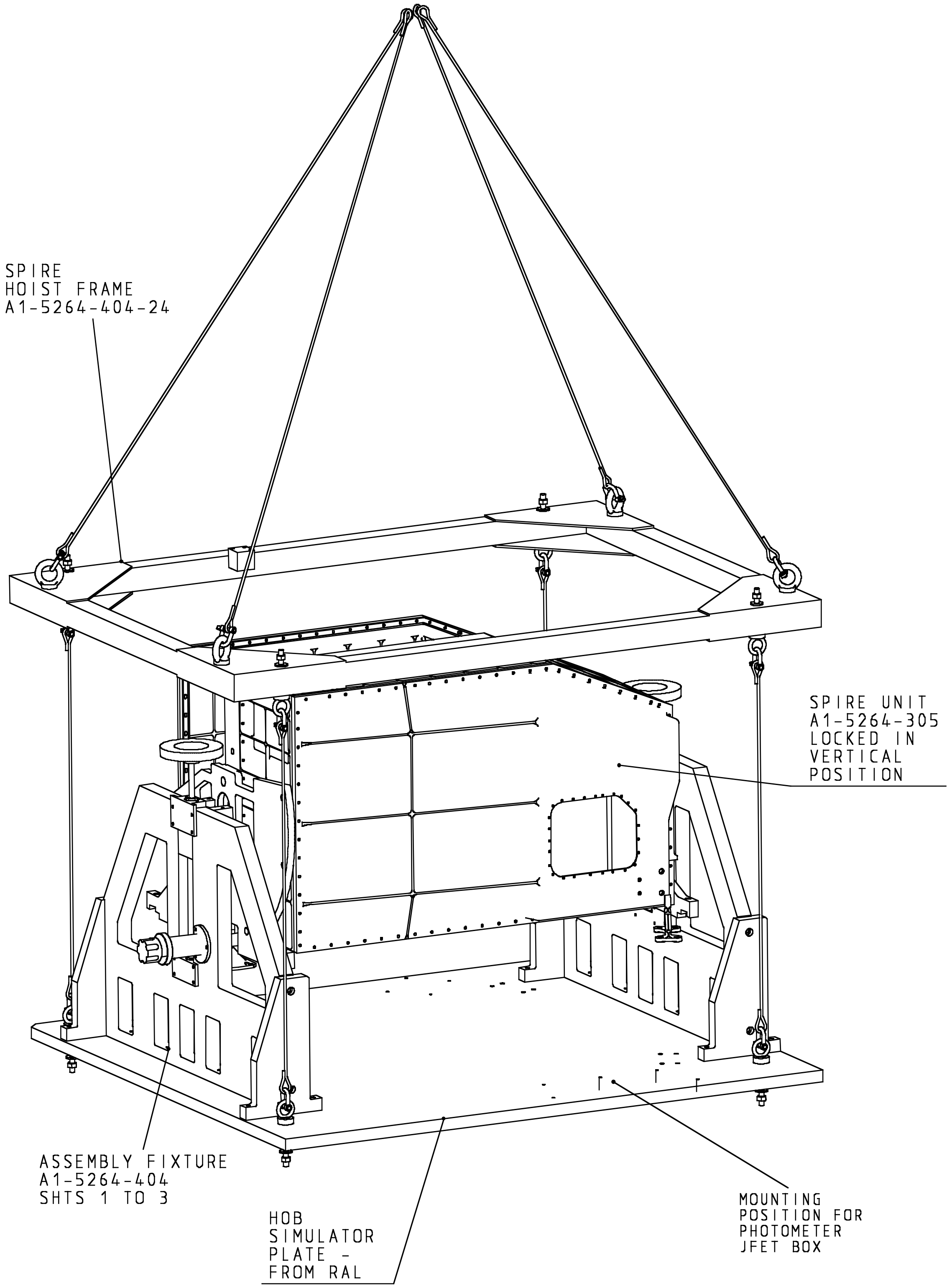
USED ON
SPIRE
MGSE

THIRD ANGLE PROJECTION

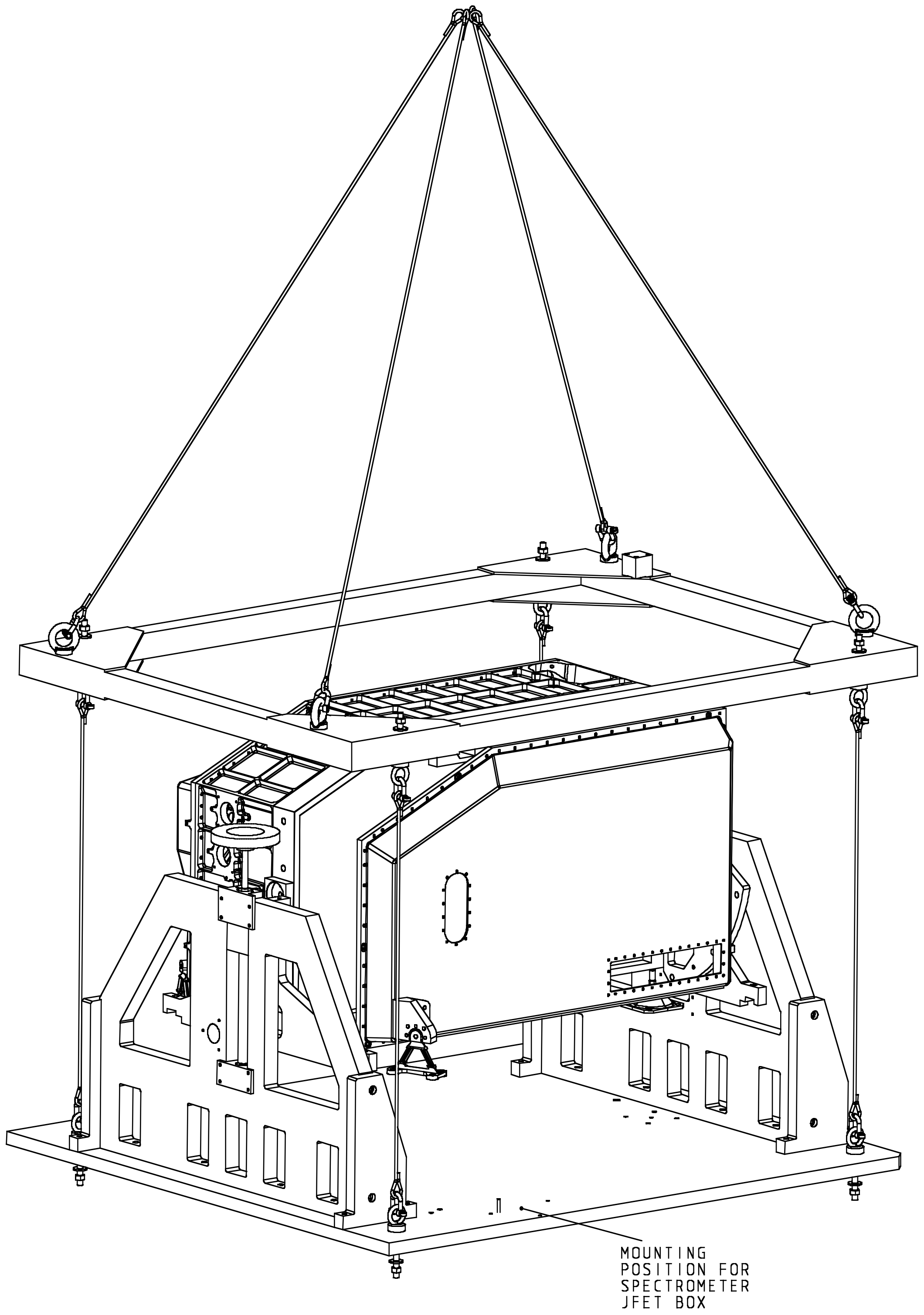
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

NOTES
1 SEE SHEET 5 FOR FRAME DETAILS AND PARTS LIST



VIEW TAKEN FROM HOIST-FRAME-KIT CONFIG2-HOIST-SPIRE



VIEW TAKEN FROM HOIST-FRAME-KIT CONFIG2-HOIST-SPIRE

	ISSUE	DATE	AMENDMENT
CHECKED			
TRACED	3	26/3/04	M10 PLAIN NUTS REPLACED WITH M10 NYLOC NUTS
	2	28/3/03	
DRAWN PMB	1	2/10/02	

COMPUTER FILE DRAWING A1-5264-404-sht4and5
ASSEMBLY HOIST-FRAME-KIT
CONFIG1 AND 2

PROTECTIVE FINISH

ESTD WT.

ACTL WT.

MATERIAL & SPEC.

DIMENSIONS IN mm

TOLERANCES UNLESS OTHERWISE STATED -
LINEAR +/- 0.10
ANGULAR +/- 0°15'

SCALE NTS

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE SPIRE LIFTING HOIST
GENERAL ARRANGEMENT

DRAWING No			
A1	5264	404	SHT 4

DRAWING No.			
A1	5264	404	SHT 6

USED ON
SPIRE
MGSE

THIRD ANGLE PROJECTION

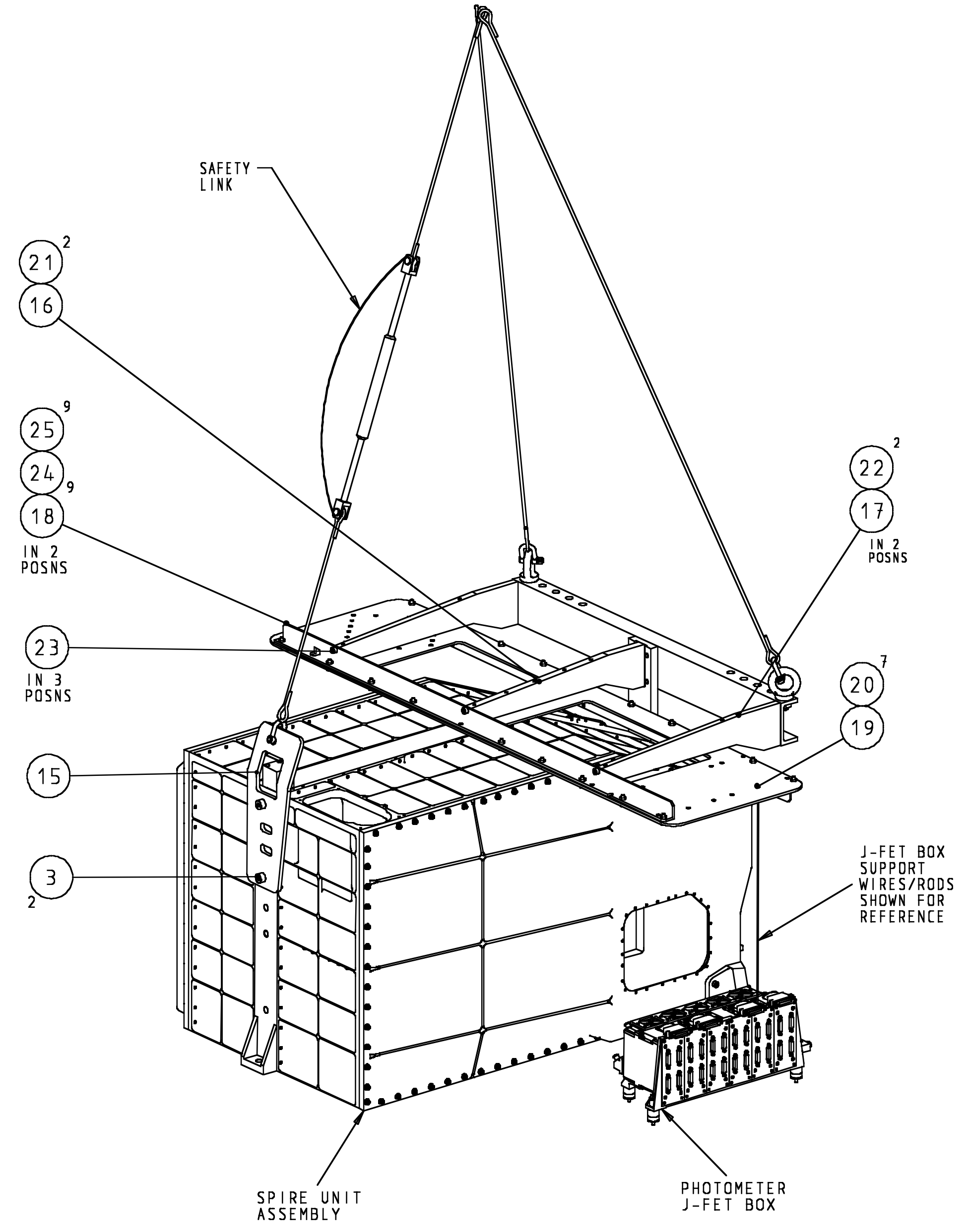
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

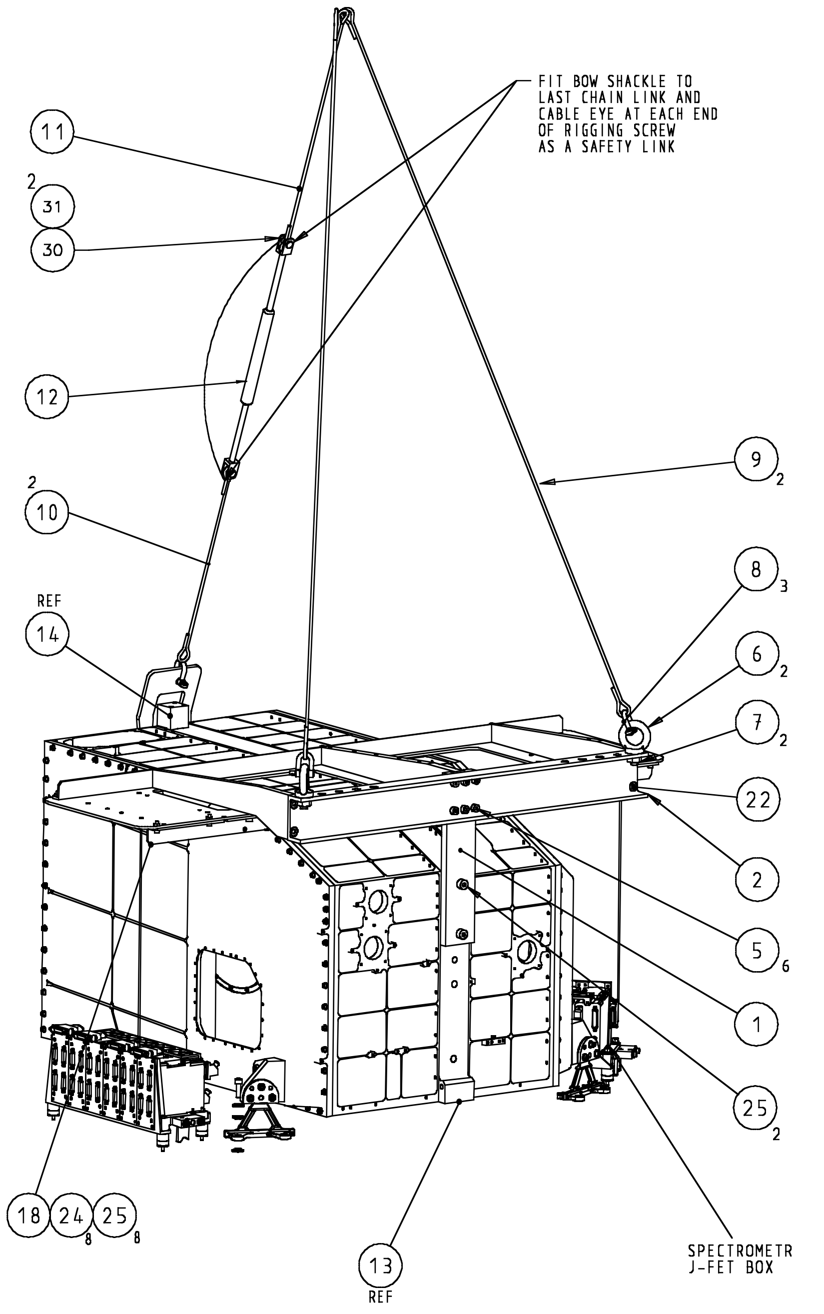
NOTES
1 DIMENSIONS ARE NOMINAL AND MAY VARY DUE TO MANUFACTURING TOLERANCES

NOTE
1 SEE SHEET 7 FOR SPIRE INSTALLATION LIFTING REFERENCE DIMENSIONS

2 PLEASE NOTE THAT BILL OF MATERIALS IS GENERATED FROM THE CORRESPONDING ASSEMBLY MODEL EXCEPT FOR ITEMS 30 AND 31



VIEW SCALE 0.2 : 1



VIEW SCALE 0.2 : 1

Item	Part #	Name	Qty
31	KEY-	BOW SHACKLE	2
30	KEY-	CHAIN	0.5M
29	KE-0104-350_ASM	KE-0104-350_ASM	1
28	KE-0104-360_ASM	KE-0104-360_ASM	1
27	REFERENCE	PHOT COVER ASSEMBLY	1
26	REFERENCE	SPEC COVER ASSEMBLY	1
25		NUT-M4-NYLOC-ST-STL	17
24	ST STL	SCR-M4x12L-CAP-HD	17
23		SCR-M5x12L-CAP-HD	3
22		SCR-M6x20L-CSK-SKT-HD	4
21		SCR-M5x20-SKT-CSK-HD	2
20		SCR-M5x20-SKT-BUTT-HD	7
19	5264-404-37	yoke	1
18	5264-404-39	yoke-stiffener	2
17	5264-404-38	yoke-support-fillet	2
16	5264-404-36	yoke-center-support	1
15		front-lift-strap-2	1
14	REFERENCE	reference cube	1
13	REFERENCE	dummy-SOB	1
12	ANGLIA-HANDLING	RIGGING-SCREW-M12-JAW-JAW-CLOSED	1
11	5264-404-35	hoist-cable-split	1
10	A3-5264-404-36	hoist-cable-short-2	1
9	A3-5264-404-22	hoist-cable-long	2
8	KEY-927A078N	shackle-STD	3
7		NUT-M10-NYLOC-ST-STL	2
6	ANGLIA-HANDLING-ST-STL	shoulder-eyebolt-M10	2
5	ST STL	SCR-M6x20L-CAP-HD	6
4	ST STL	SCR-M8x25L-CAP-HD	2
3	ST STL	SCR-M8x20L-CAP-HD	2
2	5264-404-16	rear-lift-channel	1
1	A3-5264-404-15	rear-lift-plate	1

	ISSUE	DATE	AMENDMENT	ISSUE	DATE	AMENDMENT
CHECKED	5	2/2/04	SUPPORT PLATE FOR JFET BOXES ADDED			
	4	28/1/04	ASSEMBLY JIG PARTS REMOVED DUE TO SPACE LIMITATIONS	9	23/9/05	ITEMS 30 AND 31 ADDED/SHEET 8 ADDED
TRACED	3	8/8/03	FRONT LIFT BRACKET REPLACED WITH FRONT LIFT STRAP	8	15/7/05	ITEM BALLOONS REDEFINED
	2	28/3/03		7	17/5/05	UPDATED FOR M12 RIGGING SCREW AND NEW SPLIT CABLES
DRAWN				6	29/3/04	BOM ADDED
PMB	1	2/10/02				

COMPUTER FILE SPIRE-LIFT (ASSEMBLY)
3 CONFIGURATIONS
A1-5264-404-SHT 6 / 7 and 8(dwg)

PROTECTIVE FINISH

ESTD WT.

ACTL WT.

MATERIAL & SPEC.

DIMENSIONS IN *mm*

TOLERANCES UNLESS OTHERWISE STATED -
LINEAR *+/- 0.10*
ANGULAR *+/- 0°15'*

SCALE SEE VIEWS

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE LIFTING FOR INSTALLATION

DRAWING No			
A1	5264	404	SHT 6

DRAWING No.		
A1 5264	404	SHT 7

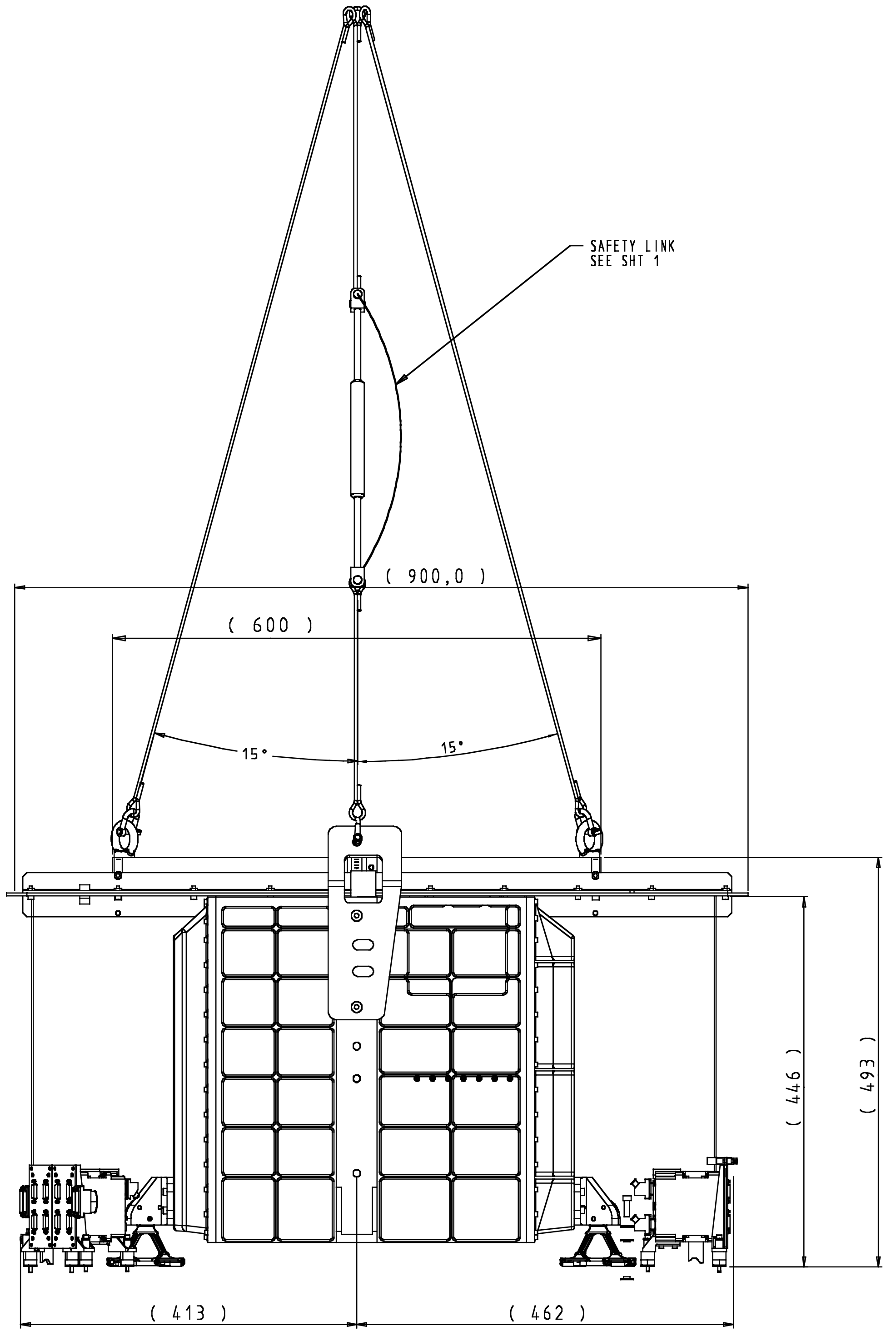
USED ON
SPIRE
MGSE

THIRD ANGLE PROJECTION

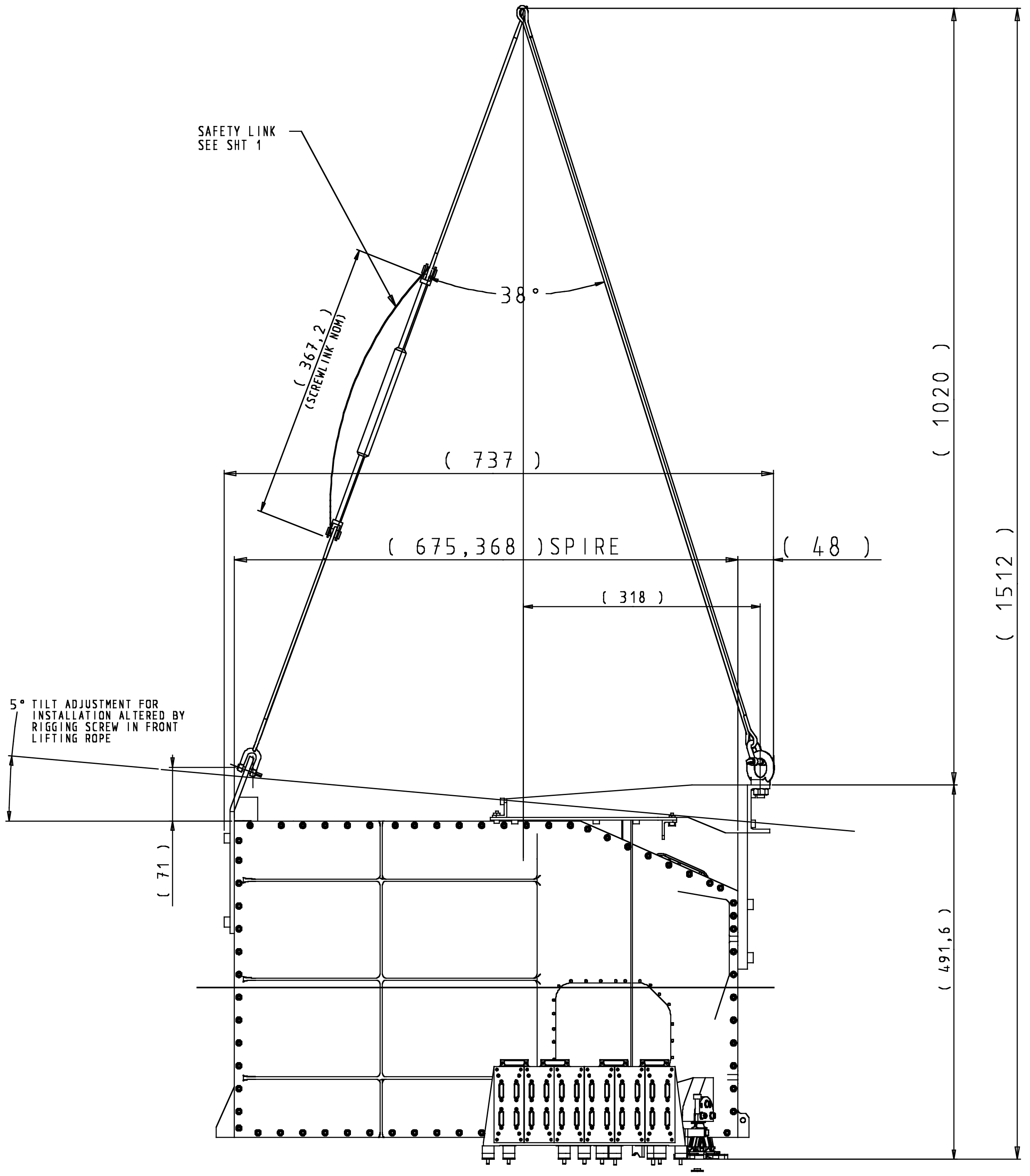
DO NOT SCALE

REMOVE ALL BURRS & SHARP EDGES

NOTES
1 DIMENSIONS ARE NOMINAL AND MAY VARY DUE TO MANUFACTURING TOLERANCES



VIEW SCALE 0.25:1



VIEW SCALE 0.25:1

	ISSUE	DATE	AMENDMENT	ISSUE	DATE	AMENDMENT
CHECKED	5	2/2/04	SUPPORT PLATE FOR JFET BOXES ADDED			
	4	28/1/04	ASSEMBLY JIG PARTS REMOVED DUE TO SPACE LIMITATIONS	9	23/9/05	ITEMS 30 AND 31 ADDED/SHEET 8 ADDED
TRACED	3	8/8/03	FRONT LIFT BRACKET REPLACED WITH FRONT LIFT STRAP	8	15/7/05	ITEM BALLOONS REDEFINED
	2	28/3/03		7	17/5/05	UPDATED FOR M12 RIGGING SCREW AND NEW SPLIT CABLES
DRAWN PMB	1	2/10/02		6	29/3/04	BOM ADDED

COMPUTER FILE SPIRE-LIFT (ASSEMBLY)
3 CONFIGURATIONS
A1-5264-404-SHT 6 / 7 and 8(dwg)

PROTECTIVE FINISH

ESTD WT.

ACTL WT.

MATERIAL & SPEC.

DIMENSIONS IN *mm*

TOLERANCES UNLESS OTHERWISE STATED –
LINEAR +/– *0.10*
ANGULAR +/– *0°15′*

SCALE SEE VIEWS

DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.

TITLE
SPIRE LIFTING FOR
INSTALLATION

DRAWING No		
A1 5264	404	SHT 7

A2 . ANNEX 2: SPIRE REDUCED TMM

SPIRE Reduced TMM Issue 2.5

Note : SPIRE reduced TMM Issue 2.5 should be updated by SPIRE, but new TMM issue was not available when issuing the present IIDB issue 4.

The SPIRE reduced TMM Issue 2.5 diagram is given by the figure here under:

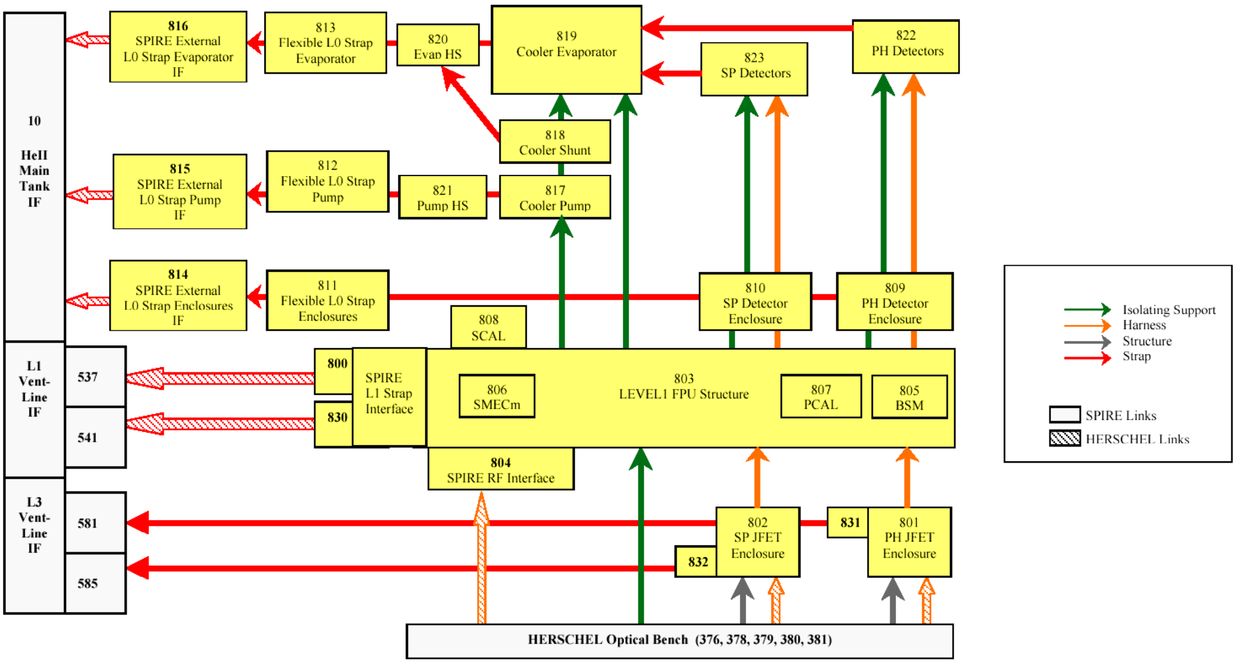


Figure 1: SPIRE ITMM OVERVIEW

The SPIRE reduced TMM Issue 2.5 is given by the pages here after:

```
#          SPIRE Interface Thermal Model
#
#
#  Filename:      spirntrm25.d
#
#  Author:        AS Goizel
#  Email:         a.goizel@rl.ac.uk
#
#  Issue:         2.5
#  Created:       02.02.2004
#
#  Esatan Version: 8.7
#
##############################################################################
#
#  Before pre-processing the SPIRE ITMM, select the following options:
#
#  - Select the level of margin to be applied on the mechanisms internal
#    dissipation with the variable "margin_fac" in the $CONSTANTS Block
#    (1.0 is default value)
#
##############################################################################
#
# List of Changes:
#
# 06.12.02 - Issue 2   - Baseline SPIRE ITMM.
# 20.01.03 - Issue 2.1 - Change in SPIRE external and flexible L0 Strap
#                        Dimensions (Overall condutance of L0 straps changed
#                        from 200 mW/K to 150 mW/K.
# 03.03.03 - Issue 2.2 - SCAL (node 808) dissipation applied to FPU (node 803)
#                        for average mode.
#                      - Few GL links declared in VARS1 rather than in GL Block
#                        to allow for esatan Sun/PC platforms compatibility.
#                      - Changes in VARS to allow better setup of the evaporator,
#                        node (819) and heat-switches status according to the
#                        type of analysis (no need to select the analysis mode
#                        anymore).
# 27.03.03 - Issue 2.3 - SCAL dissipation down to 2 mW
#                      - busbar update
#                      - BDA update
#                      - vespel on L1 foot supports for elec iso
#                      - L1 additional IF node for double L1 strap
#                      - 2 additional nodes for L3 strap attachment
#                      - L3 JFETs isolation supports updated
# 07.04.03 - Issue 2.4 - Heat Switch Actuation Updated to account for a
#                        30 sec delay.[error in model file - 07/01/04]
#
# 02.02.04 - Issue 2.5 - Cooler recycling profiles updated to obtain more accurate
#                        energy levels on Pump and Evaporator straps during recycling.
#                      - SCAL Power Dissipation changed back to 1.5mW.
#                      - Average case adjusted according to reflect the two first updates.
#                      - 300mK system Kelvar support cord diameter adjusted to 0.5mm diamter
```

```
#               - Detectors Harness adjsuted according JPL test data
#               - Evaporator Kevlar cord back to 0.29 mm diameter.
#               - Level 1 and Level 0 support conductance rduced by factor 4
#               - F-harnesses Length adjusted to FM hardware
#               - New Level 0 straps and supports design
#               - New JFET supports design
#               - For transient runs, the following capacities have been set
#                 to zero: 800,830,831,832,805,806,807,808,811,812,813,814,
#                 815,816,818,820,821
#               - $VARIABLES1/timeline analysis: selection of dissipation
#                 profiles done via control variable "SPSUBMD" (no longer
#                 via TIMEN),to have access from within HERSCHEL mainmodel
#
##############################################################################
# This file has NOT been formatted as a deliverable for Astrium
##############################################################################


$MODEL SPIRNTRM
#======



$NODES
#======

#Level 2

 D801  = 'PH_JFET_ENCLOSURE',          T = 10.0D0,   C = SHCAL(T801)*2.348D0;
 D802  = 'SP_JFET_ENCLOSURE',          T = 10.0D0,   C = SHCAL(T802)*0.81342D0;


#Level 1

 D800  = 'L1 Strap IF1 @ SOB',         T =  5.0D0,   C = SHCCU(T800)*1.0D-3; # assumption

 D803  = 'FPU_OPTICAL_BENCH',          T =  4.0D0,   C = SHCAL(T803)*26.75D0;
 D804  = 'RF_FILTER_BOXES',            T =  4.0D0,   C = SHCAL(T804)*1.465D0;
 D805  = 'BSM',                        T =  4.0D0,   C = SHCAL(T805)*1.1D0;
 D806  = 'SMECm',                      T =  4.0D0,   C = SHCAL(T806)*1.043D0;
 D807  = 'PH_CALIB',                   T =  4.0D0,   C = SHCAL(T807)*0.03D0;
 D808  = 'SPEC_CALIB',                 T =  4.0D0,   C = SHCAL(T808)*0.0002041D0;


#Level 0

 D809    =    'PH_DETECTOR_ENCLOSURE',                    T    =    1.8D0,        C    =
(SHCAL(T809)*3.56D0)+(SHCSS(T809)*0.114)+(SHCINV(T809)*0.192D0)+(SHCSI(T809)*0.048D0);

 D810    =    'SP_DETECTOR_ENCLOSURE',                    T    =    1.8D0,        C    =
(SHCAL(T810)*1.468D0)+(SHCSS(T810)*0.076)+(SHCINV(T810)*0.128D0)+(SHCSI(T810)*0.032D0);

 D811 = ' L0 Enclosure Flexible Strap',     T = 1.8D0,    C = SHCCU(T811)*164.D-3;
 D812 = ' L0 Pump Flexible Strap',          T = 1.8D0,    C = SHCCU(T812)*159.D-3;
```

```
  D813 = ' L0 Evap Flexible Strap',             T = 1.8D0,    C = SHCCU(T813)*152.D-3;

  D814 = ' L0 Enclosure External Strap',         T = 1.8D0,    C = SHCCU(T814)*462.D-3;
  D815 = ' L0 Pump External Strap',              T = 1.8D0,    C = SHCCU(T815)*516.D-3;
  D816 = ' L0 Evaporator External Strap',        T = 1.8D0,    C = SHCCU(T816)*701.D-3;


  D817 = 'COOLER_PUMP',                          T =  1.8D0,   C = 0.150D0*SHCTI(T817)+SHCHAR(T817)+0.00081D0*3000.0D0;
  D818 = 'COOLER_SHUNT',                         T =  1.8D0,   C = SHCTI(T818)*0.01D0;
  B819 = 'COOLER_EVAP',                          T =  0.29D0,  C = SHCTI(T819)*0.084D0;

  D820 = 'COOLER_EVAP_HS',                       T =  1.8D0,   C = SHCTI(T820)*0.074D0;
  D821 = 'COOLER_PUMP_HS',                       T =  1.8D0,   C = SHCTI(T821)*0.074D0;


# 300 mK Level

  D822 = 'PH_DETECTORS',                         T =  0.3D0,   C = (SHCINV(T822)*0.435D0) + (SHCCU(T822)*0.709D0);
  D823 = 'SP DETECTORS',                         T =  0.3D0,   C = (SHCINV(T823)*0.281D0) + (SHCCU(T823)*0.254D0);

# New L1 and L3 interface nodes

  D830 = 'L1 Strap IF2 @ SOB',                   T =  5.0D0,   C = 0.0D0; # assumption
  D831 = 'PH_L3 IF',                             T =  10.0D0,  C = 0.0D0; # assumption
  D832 = 'SP_L3 IF',                             T =  10.0D0,  C = 0.0D0; # assumption



$CONDUCTORS
#======

##########################################################################
################################################################
#                              SPIRE Interface Definition with HERSCHEL                              #
##########################################################################
################################################################
#
# The following conductive links need to be integrated into HERSCHEL with the appropriate node numbers
#
#  SPIRE / HERSCHEL--------- MATERIAL ------------- X-SECTION ----------- LENGTH
#
#GL(SPIRE:801, 378) = 4.*1.1*0.00666*CNDFNC(3,SPIRE:K_CFRP_T300);        #Isolating Supports
#GL(SPIRE:801, 379) = 1.*1.1*0.00666*CNDFNC(3,SPIRE:K_CFRP_T300);        #Isolating Supports
#GL(SPIRE:801,9361) = 1.;                                               #Harness to CVV;
#GL(SPIRE:831, 581) = 1./((2./0.4)+1./(0.0667D-3 * CNDFNC(1, TLCU, 1)));  #L3 strap
#
#GL(SPIRE:802, 380) = 3.*1.1*0.00666*CNDFNC(3,SPIRE:K_CFRP_T300);        #Isolating Supports
#GL(SPIRE:802, 379) = 1.*1.1*0.00666*CNDFNC(3,SPIRE:K_CFRP_T300);        #Isolating Supports
#GL(SPIRE:802,9381) = 1.;                                               #Harness to CVV;
#GL(SPIRE:832, 585) = 1./((2./0.4)+1./(0.0667D-3 * CNDFNC(1, TLCU, 1)));  # L3 strap
#
#GL(SPIRE:803, 376) = 0.25 / (1.0/(CNDFNC(3,SPIRE:K_SSTEEL) * 1.5914D-3) + 1.0D0/(604.0D-
6*CNDFNC(3,SPIRE:K_VES)/0.001D0)); #L1 Cone Support (effective xsect)
```

```
#GL(SPIRE:803, 381) = 0.25 / (1.0/(CNDFNC(3,SPIRE:K_SSTEEL) * 1.6370D-3) + 2.0D0/(604.0D-
6*CNDFNC(3,SPIRE:K_VES)/0.001D0)); #L1 A-Frame Supports with correl factor
#
#GL(SPIRE:804,9301) = k_8*FCAB( SP11SST,SP11BRAS,SP11PTFE,SP11CCU,SP11SIMO,SP11CUBE,SP11CUMN, SP11L1/6.,
T:SPIRE:804 ,T9301); #HERSCHEL RF Filter Harness;
#GL(SPIRE:804,9341) = 1.;
#
#GL(SPIRE:814, 10 ) = k_40* 1.583/(1./0.075 + 1./0.4);        # SPIRE enclosure L0 Interface at HeII Tank - 1.583 fac needed to reach
the 0.1 W/K
#GL(SPIRE:815, 10 ) = k_40* 2.25 /(1./0.05  + 1./0.4);        # SPIRE pump L0 Interface at HeII Tank      - 2.25  fac needed to reach the
0.1 W/K
#GL(SPIRE:816, 10 ) = 3.0 * k_40* 1.25 /(1./0.1 + 1./0.4);    # SPIRE evap L0 Interface at HeII Tank      - 3.75  fac needed to reach the
0.3 W/K
#
#GL(SPIRE:800, 537) = 1./((2./(k_43* 0.4))+1./(k_41* 0.0909D-3 * CNDFNC(1, TLCU, 1))); # SPIRE 20 x 1.0 x 220 mm (SPIRE
ECR009)/HERSCHEL L1 strap1
#GL(SPIRE:830, 541) = 1./((2./(k_43* 0.4))+1./(k_41* 0.0909D-3 * CNDFNC(1, TLCU, 1))); # SPIRE 20 x 1.0 x 220 mm (SPIRE
ECR009)/HERSCHEL L1 strap2
#
# The following files includes the radiative couplings of SPIRE with HERSCHEL
#
#       $INCLUDE "spire_gr.d"
#
######################################################################################
####################################################################



######################################################################################
####################################################################
#                                SPIRE INTERNAL CONDUCTIVE COUPLINGS                               #
######################################################################################
####################################################################

# SPIRE Level 3 Strap Interface
#-----------------------------------

GL( 801 ,  831 )  =  0.138 ;   # Electrical Isolation
GL( 802 ,  832 )  =  0.138 ;   # Electrical Isolation


# Level 2 to 1 Harness
#--------------------

   # Photometer  ------------------------------------ 12 axs -------------- STT -----------------RF screen -----------
GL(   801,   803   )  =  CNDFNC(3,K_MANGANIN) * (5.47D-8 *  320.33D0 + 1.37D-8 * 53.388D0) ;
GL(   801,   803   )  =  CNDFNC(3,K_TEF)      * (4.38D-7 *  320.33D0 + 1.1D-7  * 53.388D0) ;
GL(   801,   803   )  =  CNDFNC(3,K_SSTEEL)   * (1.95D-7 *  320.33D0 + 1.95D-7 * 53.388D0 + 192.0D0 * 5.027D-9 * 53.388D0) ;
GL(   801,   803   )  =  CNDFNC(3,K_TEF)      * (7.54D-7 *  320.33D0 + 7.54D-7 * 53.388D0) ;


   # Spectrometer  ------------------------------------ 12 axs -------------- STT -----------------RF screen -----------
GL(   802,   803   )  =  CNDFNC(3,K_MANGANIN)  * (5.47D-8 *  55.726D0 + 1.37D-8 * 9.872D0) ;
GL(   802,   803   )  =  CNDFNC(3,K_TEF)       * (4.38D-7 *  55.726D0 + 1.1D-7  * 9.872D0) ;
GL(   802,   803   )  =  CNDFNC(3,K_SSTEEL)    * (1.95D-7 *  55.726D0 + 1.95D-7 * 9.872D0 + 192.0D0*5.027D-9 * 9.872D0) ;
GL(   802,   803   )  =  CNDFNC(3,K_TEF)       * (7.54D-7 *  55.726D0 + 7.54D-7 * 9.872D0) ;
```

```
# Level 1
#--------

GL(  803,  804  )  =  6.0D0*CNDFNC(3,M4COND_up);                #Mechanisms and Calib sources to Level 1 SOB
GL(  803,  805  )  =  4.0D0*CNDFNC(3,M4COND_up);
GL(  803,  806  )  =  4.0D0*CNDFNC(3,M4COND_up);
GL(  803,  808  )  =  CNDFNC(3,K_TOR) * 5.30D-06       /  0.02D0 ;   #single SCAL source
GL(  805,  807  )  =  4.0D0*CNDFNC(3,M4COND_up);


# Level 1 to Level 0
#------------------


   # Photometer
GL(  803,  809  )  =  0.25*CNDFNC(3,K_SSTEEL)      *  45.96D-06      /  0.0346D0;   #L1-L0 ph enclosure Cone supports effective A
GL(  803,  809  )  =  0.25*CNDFNC(3,K_SSTEEL)      *  2.0D0*25.0D-06   /  0.0362D0;   #L1-L0 ph enclosure A-Frame supports
   # ---------------------------------------------- 12 axs ----------------- STT --------
GL(  803,  809  )  =  CNDFNC(3,K_MANGANIN)  * (5.47D-8 *  316.417D0 + 1.37D-8  * 52.736D0) ;
GL(  803,  809  )  =  CNDFNC(3,K_TEF)       * (4.38D-7 *  316.417D0 + 1.1D-7   * 52.736D0) ;
GL(  803,  809  )  =  CNDFNC(3,K_SSTEEL)    * (1.95D-7 *  316.417D0 + 1.95D-7  * 52.736D0) ;
GL(  803,  809  )  =  CNDFNC(3,K_TEF)       * (7.54D-7 *  316.417D0 + 7.54D-7  * 52.736D0) ;

   # Spectrometer
GL(   803,  810   )  =   0.25*CNDFNC(3,K_SSTEEL)      *  3.0D0*10.38D-06  /  0.0346D0;   #L1-L0 sp enclosure supports effective A/L
   # ---------------------------------------------- 12 axs ----------------- STT --------
GL(  803,  810  )  =  CNDFNC(3,K_MANGANIN)  * (5.47D-8 *  121.93D0 + 1.37D-8  * 22.7D0) ;
GL(  803,  810  )  =  CNDFNC(3,K_TEF)       * (4.38D-7 *  121.93D0 + 1.1D-7   * 22.7D0) ;
GL(  803,  810  )  =   CNDFNC(3,K_SSTEEL)   * (1.95D-7 *  121.93D0 + 1.95D-7  * 22.7D0) ;
GL(  803,  810  )  =   CNDFNC(3,K_TEF)      * (7.54D-7 *  121.93D0 + 7.54D-7  * 22.7D0) ;


# 300mK System
#-------------

  # Photometer
GL(  809,  822  )  =  CNDFNC(3,K_KEV29)       *  0.00025 * 3.0;               #Ph BDA Supports
GL(  809,  822  )  =  (12.+1.)* 1.17 * 0.286D-06;                        #L0 to 300mK ph harness + 1 PTC
GL(  809,  822  )  =  CNDFNC(3,K_KEV29)       *  7.068D-06       /  0.025D0;   #ph enclosure busbar feedthru

  # Spectrometer
GL(  810,  823  )  =  CNDFNC(3,K_KEV29)       *  0.00025 * 2.0;               #Sp BDA Supports
GL(  810,  823  )  =  3.0 * 1.17 * 0.286D-06;                          #L0 to 300mK sp harness
GL(  810,  823  )  =  CNDFNC(3,K_KEV29)       *  2.356D-06       /  0.025D0;   #sp enclosure busbar feedthru


# 3He COOLER
#-----------
```

```
  # Shunt
GL( 817, 818  ) =  CNDFNC(3,K_TI6AL4V)     * 6.41D-06       / 0.038D0;   #pump-shunt tube
GL( 818, 819  ) =  CNDFNC(3,K_TI6AL4V)     * 6.41D-06       / 0.06D0;    #shunt-evap tube
GL( 818, 820  ) =  CNDFNC(3,K_HPCU1)        * 5.00D-06       / 0.05D0;    #shunt strap

GL( 819, 803  ) =  CNDFNC(3,K_KEV29)       * 16. * 6.605D-08  / 0.031D0;   #evap conducted parasitic
GL( 817, 803  ) =  CNDFNC(3,K_KEV29)       * 16. * 1.963D-07  / 0.037D0;   #pump conducted parasitic



  # Evap
GL( 819, 820  ) =  CNDFNC(3,K_TI6AL4V)     * 2.2305D-06      / 0.05D0;    #evap heat switch conducted parasitic
GL( 819, 820  ) =  HS_EVAP_GAS;                                #evap heat switch He cond
GR( 819, 820  ) =  0.1D0              * 0.6619D-03;              #evap HS radiation parasitic

GL( 820, 803  ) =  CNDFNC(3,K_TI6AL4V)     * 1.16D-05       / 0.027D0;   #evap heat switch support from L1

  # Pump
GL( 821, 817  ) =  CNDFNC(3,K_TI6AL4V)     * 2.2305D-06      / 0.05D0;    #pump heat switch conducted parasitic
GL( 821, 817  ) =  HS_PUMP_GAS;                                #pump heat switch He cond
GR( 821, 817  ) =  0.1D0              * 0.6619D-03;              #pump HS radiation parasitic

GL( 821, 803  ) =  CNDFNC(3,K_TI6AL4V)     * 1.16D-05       / 0.027D0;   #pump heat switch support from L1




# SPIRE Level 0 Straps Architecture
#----------------------------------



#                    |    Main Strap       | Bottom Flex
GL( 814 ,  811   ) =    1./(1./(1.4876D-3*L0_Cu)+1./(0.380D-3*L0_Cu)); # SPIRE L0 enclosure strap
GL( 815 ,  812   ) =    1./(1./(1.1613D-3*L0_Cu)+1./(0.390D-3*L0_Cu)); # SPIRE L0 pump strap
GL( 816 ,  813   ) =    1./(1./(0.7347D-3*L0_Cu)+1./(0.332D-3*L0_Cu)); # SPIRE L0 evap strap

# SPIRE Internal L0 Flexible Straps
#                  |  IF |     Adaptor     |   Top Flex     | Bolted IF|     elec iso    |
GL( 811 ,  810 )  =   1./(1./0.2+1./(1.998D-3*L0_Cu)+1./(0.375D-3*L0_Cu)+1./(4.*0.4)+1./(4.*4.5*3.4*0.025));   #L0 enclosure
GL( 812 ,  821 )  =   1./(1./0.4+1./(1.998D-3*L0_Cu)+1./(0.400D-3*L0_Cu)+1./(4.*0.4)+1./(4.*4.5*3.4*0.025));   #L0 pump
GL( 813 ,  820 )  =   1./(1./0.4+1./(1.998D-3*L0_Cu)+1./(0.428D-3*L0_Cu)+1./(4.*0.4)+1./(4.*4.5*3.4*0.025));   #L0 evaporator



  # L0 Strap Supports off SOB
GL( 811 ,  803 )   =   CNDFNC(3,K_TOR)*(2.0D0*2.0D0*0.006D0*0.006D0/0.03375D0 + 0.006D0*0.006D0/0.070D0); #2 supports
per strap, 1 bipod and 1 tripod
GL( 812 ,  803 )   =   CNDFNC(3,K_TOR)*(2.0D0*2.0D0*0.006D0*0.006D0/0.03375D0 + 0.006D0*0.006D0/0.070D0); #2 supports
per strap, 1 bipod and 1 tripod
GL( 813 ,  803 )   =   CNDFNC(3,K_TOR)*(2.0D0*2.0D0*0.006D0*0.006D0/0.03375D0 + 0.006D0*0.006D0/0.070D0); #2 supports
per strap, 1 bipod and 1 tripod


 # SPIRE Internal L0 Strap between the spectrometer and the photometer enclsoures
```

```
  #                   |Al/Cu  IF|           Strap            |  elec iso    |
GL( 810,  809 )  = 1./(1./0.2+1.0D0/(L0_Cu*9.0E-06/0.198D0)+1./(1.66*0.025));

  # SPIRE Internal 300mK Straps to the cooler cold tip
GL( 822,  819 )  = U;    #cooler-ph detector strap effective A
GL( 823,  819 )  = U;    #cooler-sp detector strap effective A



# SPIRE Level 1 Strap Interface
#---------------------------------

  # Level 1 strap electrical insulation joint conductance - Copper/Epoxy/Copper Joint with 13 cm2 contact area
  # The 0.425 factor has been added to achieve a sensible SOB mean Temperature
GL( 803 ,  800 )  =  (0.425) * 0.107;
GL( 803 ,  830 )  =  (0.425) * 0.107;


$CONSTANTS
#======


$CHARACTER


    GPLTO = 'O'; # initialize switch for phase to be run (global constant) For integratin within Herschel
                  #  indicates the phase to be run; initialisation only
                  #  GPLTO is read from control file control.ctl:
                  # 'G'   Ground life time
                  # 'X'   Ground Testing, steady-state, venting from HOT, HTT closed
                  # 'P'   Precooling/ground autonomy/launch autonomy
                  # 'L'   Launch
                  # 'T'   Transfer
                  # 'O'   Orbit


    MODE           = 'SWITCH_OFF';

    HS_EVAP_STATE     = 'OFF';
    HS_PUMP_STATE     = 'OFF';


$INTEGER

    IMODE = 0;   # initialize switch for dissipation mode (global constant) For integration within Herschel
                  # IMODE is read from control file control.ctl:
                  #-2  IID-A
                  #-1  no dissipation
                  # 0   Orbit average steady state
                  # 1   Orbit Mode 1  steady state (PACS Spec.)
                  # 2   Orbit Mode 2  steady state (PACS Phot.)
                  # 3   Orbit Mode 3  steady state (SPIRE Phot.)
                  # 4   Orbit Mode 4  steady state (SPIRE Spec.)
```

```
                # 5   Orbit Mode 5  steady state (HIFI On)
                # 6   Orbit Mode 6  steady state (PACS Phot. & SPIRE Phot.)


    SPSUBMD = 0;  # kw: initialize switch for dissipation sub-mode for SPIRE timeline

$REAL

    # To Be Selected by the user before pre-processing the model
    # Margin factor applied on the SPIRE Mechanisms Internal dissipation
    #
    margin_fac = 1.0D0;


    PI = 3.141592654D0;

    L0_Cu = 2000.0D0;    # Baseline For Copper Thermal Conductivity [W/mK]


    #POWERS
    #
    q_jfet_phot       = 0.0420D0;
    q_jfet_spec       = 0.0141D0;

    q_peak_phot_calib = 0.004D0;
    q_mean_phot_calib = 0.000033D0;

    q_peak_spec_calib = 0.0072D0;
    q_mean_spec_calib = 0.00525D0;
    q_hold_spec_calib = 0.0015D0;

    q_peak_phot_bsm   = 0.003D0;
    q_mean_phot_bsm   = 0.0019D0;

    q_peak_phot_bsm2  = 0.0002D0;
    q_mean_phot_bsm2  = 0.0002D0;

    q_peak_spec_mech  = 0.0032D0;
    q_mean_spec_mech  = 0.00205D0;
    q_min_spec_mech   = 0.0009D0;


    q_pump_nom       = 0.0014D0;            # nominal value
    q_pump_add       = 0.0D0;               # low temp phase cooler average thermodynamic loads for 30microW load ~50xQevap (ref LD at IBDR)

    q_pump0         = 0.300D0;            #heat pump initially 300mW for 5 mins to 16K - then desorption
    q_pump1         = 0.130D0;            #heat pump 150mW for 35 mins to 45K
    q_pump2         = 0.025D0;            #then 25mW for 30 mins to maintain at 45K - ref: thermal summit - LD

    q_evap_rec1      = 0.055D0;
    q_evap_rec2      = 0.010D0;

    q_evap_hs       = 0.0008D0;           #ref LD at Thermal Summit plus mail 27-9-00
```

```
    q_pump_hs        = 0.0004D0;            #ref LD at Thermal Summit plus mail 27-9-00


    # Average Load Definition
    #
    q_pump_avr     = 0.000448D0;
    q_evap_avr     = 0.0003247D0;
    q_pump_hs_avr  = 0.000129D0;
    q_evap_hs_avr  = 0.000000D0;

    q_pcal        = 0.000011D0;
    q_bsm         = 0.000424D0;
    q_smecm        = 0.000328D0;
    q_scal        = 0.000240D0;
    q_pjfet_avr    = 0.006722D0;
    q_sjfet_avr    = 0.002257D0;


    #Heat Switch Gas Conductance - Calculated in $VARIABLES1
    #
    HS_PUMP_GAS       = 0.0D0;
    HS_EVAP_GAS       = 0.0D0;


    # Cooler Heat Loads - Calculated in $VARIABLES1
    #
    Photo_load         = 0.0D0;            # in microwatts
    Spectro_load       = 0.0D0;            # in microwatts
    Parasitic_load     = 0.0D0;            # in microwatts - Evap only
    Tot_Cooler_load    = 0.0D0;             # in microwatts


$CONTROL

    RELXCA = 0.0D0;
    NLOOP  = 0;
    TABS   = 0.0D0;
    OUTINT = 0.0D0;
    TIMEND = 0.0D0;
    DTIMEI = 0.0D0;



$ARRAYS
#======


$REAL

##############################################################################
########################
# SPIRE Material Specific Heat (J/kg/K)
```

```
#####################################################################################
#########################
#
# SPECIFIC HEAT - Aluminium
#
SHCAL1(2,19)=
1.1,     0.1332,
2.0D0,   0.1148,
4.0D0,   0.2830,
10.D0,   1.40D0,
15.D0,   3.84D0,
18.D0,   6.49D0,
19.D0,   7.62D0,
20.D0,   8.90D0,
21.D0,  10.30D0,
22.D0,  11.90D0,
23.D0,  13.70D0,
24.D0,  15.70D0,
25.D0,  17.80D0,
27.D0,  22.60D0,
30.D0,  31.50D0,
50.D0,  142.00D0,
100.D0, 481.00D0,
200.D0, 797.00D0,
300.D0, 902.00D0;
#
SHCHAR1(2,5)=
20.0D0, 0.9218D0,
30.0D0, 1.2738D0,
40.0D0, 1.6038D0,
50.0D0, 1.9162D0,
60.0D0, 2.2176D0;
#
# SPECIFIC HEAT - Copper
#
SHCCU1(2,10)=
0.2D0,     0.0006D0,
0.3D0,     0.0006D0,
1.0D0,     0.012D0,
4.0D0,     0.091D0,
10.0D0,    0.86D0,
20.0D0,    7.7D0,
50.0D0,    99.0D0,
100.0D0,   250.0D0,
200.0D0,   360.0D0,
300.0D0,   390.0D0;
#
#  SPECIFIC HEAT - Invar
#
SHCIN1(2,10)=
0.2D0,     0.096D0,
0.3D0,     0.096D0,
1.0D0,     0.24D0,
4.0D0,     0.57D0,
```

```
10.0D0,    3.1D0,
20.0D0,    12.0D0,
50.0D0,    120.0D0,
100.0D0,   310.0D0,
200.0D0,   440.0D0,
300.0D0,   470.0D0;
#
#  SPECIFIC HEAT - Silicon
#
SHCSI1(2,10)=
0.2D0,     0.000001D0,
0.3D0,     0.000001D0,
1.0D0,     0.000066D0,
4.0D0,     0.017D0,
10.0D0,    0.28D0,
20.0D0,    8.5D0,
50.0D0,    79.0D0,
100.0D0,   260.0D0,
200.0D0,   560.0D0,
300.0D0,   710.0D0;
#
#  SPECIFIC HEAT - Titanium
#
SHCTI1(2,10)=
0.2D0,     0.0071D0,
0.3D0,     0.0071D0,
1.0D0,     0.071D0,
4.0D0,     0.317D0,
10.0D0,    1.26D0,
20.0D0,    7.0D0,
50.0D0,    99.2D0,
100.0D0,   300.0D0,
200.0D0,   465.0D0,
300.0D0,   522.0D0;
#
#  SPECIFIC HEAT - Stainless Steel
#
SHCSS1(2,10)=
0.2D0,     0.02D0,
0.3D0,     0.020D0,
1.0D0,     0.090D0,
4.0D0,     0.382D0,
10.0D0,    1.24D0,
20.0D0,    4.5D0,
50.0D0,    55.0D0,
100.0D0,   216.0D0,
200.0D0,   384.0D0,
300.0D0,   447.0D0;
#
#
##########################################################################
########################
# SPIRE Material Thermal Conductivity (W/mK)
```

```
###############################################################################
#########################
#
# High Purity Aluminium 99.999% un-annealed
# Curve fitted to SRON measurments
#
K_HPAL59(2,7)=
1.0D0, 3802.0D0,
2.0D0, 5319.0D0,
3.0D0, 6836.0D0,
4.0D0, 8353.0D0,
5.0D0, 9870.0D0,
6.0D0, 11387.0D0,
7.0D0, 12904.0D0;
#
# Brass
#
K_BRASS(2,15) =
0.1D0,   0.065D0,
0.2D0,   0.13D0,
0.3D0,   0.20D0,
0.4D0,   0.28D0,
0.5D0,   0.32D0,
0.6D0,   0.39D0,
0.7D0,   0.43D0,
0.8D0,   0.50D0,
1.0D0,   0.7D0,
4.0D0,   3.0D0,
10.0D0,  10.0D0,
40.0D0,  37.0D0,
80.0D0,  65.0D0,
150.0D0, 85.0D0,
300.0D0, 120.0D0;
#
# CFRP T300 : High Tensile - Parallel
#           Unidirectional
#
K_CFRP_T300(2,23)=
7.0D0, 0.0350D0,
10.0D0, 0.0451D0,
20.0D0, 0.0982D0,
30.0D0, 0.1820D0,
40.0D0, 0.2730D0,
50.0D0, 0.4000D0,
60.0D0, 0.5640D0,
70.0D0, 0.7570D0,
80.0D0, 1.0200D0,
90.0D0, 1.3000D0,
100.0D0, 1.6100D0,
110.0D0, 1.9400D0,
120.0D0, 2.2800D0,
130.0D0, 2.6100D0,
140.0D0, 2.9800D0,
150.0D0, 3.1500D0,
```

```
160.0D0, 3.6000D0,
170.0D0, 3.9000D0,
180.0D0, 4.2300D0,
190.0D0, 4.4600D0,
200.0D0, 4.5900D0,
250.0D0, 5.0000D0,
300.0D0, 5.5000D0;
#
# Constantan - 60% Cu - 40% Ni&55% Cu - 45% Ni
#
K_CONSTANTAN(2,26) =
0.1D0,    0.006D0,
0.4D0,    0.02D0,
1.0D0,    0.1D0,
4.0D0,    0.8D0,
5.0D0,    1.2D0,
6.0D0,    1.6D0,
7.0D0,    2.0D0,
8.0D0,    2.5D0,
9.0D0,    3.0D0,
10.0D0,   3.5D0,
15.0D0,   6.3D0,
20.0D0,   8.5D0,
30.0D0,   12.0D0,
40.0D0,   14.0D0,
50.0D0,   15.0D0,
60.0D0,   16.0D0,
70.0D0,   16.5D0,
80.0D0,   17.0D0,
140.0D0,  17.5D0,
150.0D0,  17.8D0,
160.0D0,  18.0D0,
180.0D0,  18.2D0,
190.0D0,  18.5D0,
200.0D0,  19.0D0,
250.0D0,  21.0D0,
300.0D0,  22.5D0;
#
# COPPER OFHC
# Applicable range : 2-300K
#
K_OFHC(2,22) =
0.0D0,    0.0D0,
0.3D0,    16.7D0,
1.0D0,    55.7D0,
2.0D0,    111.6D0,
3.0D0,    168.2D0,
4.0D0,    225.8D0,
6.0D0,    344.4D0,
8.0D0,    467.7D0,
10.0D0,   593.4D0,
12.0D0,   716.7D0,
14.0D0,   832.0D0,
```

```
15.0D0,   884.9D0,
16.0D0,   934.1D0,
17.0D0,   979.2D0,
20.0D0,   1088.3D0,
30.0D0,   1189.0D0,
40.0D0,   1030.6D0,
50.0D0,   801.1D0,
75.0D0,   475.3D0,
100.0D0,  431.1D0,
200.0D0,  430.8D0,
300.0D0,  430.9D0;
#
# Copper - CG-OFC ultra high purity
#
K_HPCU1(2,10) =
0.2D0,    100.0D0,
0.3D0,    100.0D0,
1.0D0,    400.0D0,
4.0D0,    1500.0D0,
10.0D0,   3600.0D0,
20.0D0,   4400.0D0,
50.0D0,   1300.0D0,
100.0D0,  550.0D0,
200.0D0,  420.0D0,
300.0D0,  420.0D0;
#
# Helium 3
#
He3(2,24)=
0.3D0,  0.003D0,
1.0D0,  0.0075D0,
2.0D0,  0.0117D0,
3.0D0,  0.0128D0,
4.0D0,  0.0135D0,
5.0D0,  0.016132188D0,
10.0D0, 0.022801491D0,
15.0D0, 0.028331647D0,
20.0D0, 0.033272474D0,
25.0D0, 0.037823528D0,
30.0D0, 0.042087113D0,
35.0D0, 0.046125065D0,
40.0D0, 0.049978604D0,
45.0D0, 0.053677057D0,
50.0D0, 0.057242285D0,
55.0D0, 0.060691168D0,
60.0D0, 0.064037101D0,
65.0D0, 0.067290951D0,
70.0D0, 0.070461696D0,
75.0D0, 0.073556864D0,
80.0D0, 0.076582854D0,
100.0D0,0.088094754D0,
200.0D0,0.136670461D0,
300.0D0,0.176908476D0;
```

```
#
# Kapton
#
K_KAPT(2,9)=
0.30D0,  0.00037D0,
1.0D0,   0.00110D0,
4.0D0,   0.0047D0,
10.0D0,  0.015D0,
20.0D0,  0.031D0,
50.0D0,  0.064D0,
100.0D0, 0.100D0,
200.0D0, 0.150D0,
300.0D0, 0.170D0;
#
# KEVLAR 29 THREAD
#
K_KEV29(2,40) =
0.1D0,   0.0000760D0,
0.2D0,   0.000249D0,
0.3D0,   0.000498D0,
0.4D0,   0.000814D0,
0.5D0,   0.00119D0,
0.6D0,   0.00163D0,
0.7D0,   0.00212D0,
0.8D0,   0.00266D0,
0.9D0,   0.00326D0,
1.0D0,   0.00390D0,
1.1D0,   0.00459D0,
1.2D0,   0.00533D0,
1.3D0,   0.00611D0,
1.4D0,   0.00693D0,
1.5D0,   0.00780D0,
1.6D0,   0.00871D0,
1.7D0,   0.00966D0,
1.8D0,   0.0107D0,
1.9D0,   0.0117D0,
2.0D0,   0.0128D0,
3.0D0,   0.0165D0,
3.5D0,   0.0209D0,
4.0D0,   0.0256D0,
4.5D0,   0.0307D0,
5.0D0,   0.0361D0,
6.0D0,   0.0478D0,
7.0D0,   0.0607D0,
8.0D0,   0.0745D0,
9.0D0,   0.0893D0,
10.0D0,  0.1051D0,
15.0D0,  0.1962D0,
20.0D0,  0.3055D0,
30.0D0,  0.45D0,
40.0D0,  0.60D0,
50.0D0,  0.72D0,
60.0D0,  0.80D0,
```

```
70.0D0,  1.00D0,
100.0D0, 1.20D0,
200.0D0, 3.50D0,
300.D0,  10.00D0;
#
# MANGANIN
#
K_MANGANIN(2,16) =
0.1D0,    0.00143D0,
0.4D0,    0.0122D0,.0D0,    0.0503D0,
2.0D0,    0.147D0,
3.0D0,    0.275D0,
4.0D0,    0.429D0,
6.0D0,    0.803D0,
8.0D0,    1.253D0,
9.3D0,    1.568D0,
10.0D0,   1.727D0,
20.0D0,   3.71D0,
40.0D0,   7.02D0,
50.0D0,   8.39D0,
100.0D0,  13.18D0,
200.0D0,  17.81D0,
300.0D0,  22.13D0;
#
# AL to AL CONTACT
#
M4COND_up(2,19)=
0.0D0,    0.0D0,
2.0D0,    0.0019D0,
4.0D0,    0.0045D0,
6.0D0,    0.0075D0,
8.0D0,    0.0108D0,
10.0D0,   0.0142D0,
20.0D0,   0.0338D0,
30.0D0,   0.0562D0,
40.0D0,   0.0805D0,
50.0D0,   0.1064D0,
60.0D0,   0.1336D0,
70.0D0,   0.1620D0,
80.0D0,   0.1914D0,
90.0D0,   0.2218D0,
102.5D0,  0.26D0,
150.0D0,  0.26D0,
200.0D0,  0.26D0,
250.0D0,  0.26D0,
300.0D0,  0.26D0;
#
# STAINLESS STEEL
#
K_SSTEEL(2,35) =
0.1D0,   0.01D0,
0.2D0,   0.03D0,
0.3D0,   0.04D0,
```

```
0.5D0,   0.08D0,
0.7D0,   0.11D0,
1.0D0,   0.08D0,
4.0D0,   0.24D0,
5.0D0,   0.32D0,
6.0D0,   0.40D0,
7.0D0,   0.48D0,
8.0D0,   0.58D0,
9.0D0,   0.66D0,
10.0D0,  0.77D0,
15.0D0,  1.30D0,
20.0D0,  1.90D0,
30.0D0,  3.25D0,
40.0D0,  4.50D0,
50.0D0,  5.75D0,
60.0D0,  6.75D0,
70.0D0,  7.50D0,
80.0D0,  8.25D0,
90.0D0,  9.00D0,
100.0D0, 9.50D0,
110.0D0, 10.00D0,
120.0D0, 10.50D0,
130.0D0, 10.75D0,
140.0D0, 11.00D0,
150.0D0, 11.50D0,
160.0D0, 11.75D0,
170.0D0, 12.00D0,
180.0D0, 12.25D0,
190.0D0, 12.50D0,
200.0D0, 13.00D0,
250.0D0, 14.00D0,
300.0D0, 15.00D0;
#
# Teflon
#
K_TEF(2,8)=
0.1D0,   0.00002D0,
0.4D0,   0.00040D0,
1.0D0,   0.00400D0,
2.0D0,   0.02000D0,
4.0D0,   0.05000D0,
10.0D0,  0.10000D0,
40.0D0,  0.20000D0,
400.0D0, 0.266D0;
#
# Torlon
#
K_TOR(2,19)=
0.1D0,   4.05005D-06,
2.0D0,   0.002777831D0,
3.0D0,   0.006723336D0,
4.0D0,   0.012587841D0,
5.02D0,  1.61D-02,
```

```
7.06D0,  1.69D-02,
10.12D0, 1.93D-02,
15.22D0, 2.60D-02,
20.32D0, 3.63D-02,
24.91D0, 4.85D-02,
30.01D0, 6.53D-02,
35.11D0, 8.57D-02,
40.21D0, 1.10D-01,
44.8D0,  1.34D-01,
49.9D0,  1.65D-01,
55.0D0,  0.1986D0,
100.0D0, 0.2367D0,
200.0D0, 0.3213D0,
293.0D0, 0.4000D0;
#
# Ti6Al4V
#
K_TI6AL4V(2,17)=
0.2D0,    0.006D0,
0.3D0,    0.006D0,
0.5D0,    0.014D0,
1.0D0,    0.043D0,
1.5D0,    0.082D0,
2.0D0,    0.130D0,
3.0D0,    0.197D0,
4.0D0,    0.253D0,
10.0D0,   0.68D0,
20.0D0,   1.32D0,
35.0D0,   2.12D0,
50.0D0,   2.75D0,
100.0D0,  4.00D0,
150.0D0,  5.00D0,
200.0D0,  5.80D0,
250.0D0,  6.60D0,
300.0D0,  7.60D0;
#
# Vespel
#
K_VES(2,15)=
0.1D0,   0.0001D0,
0.3D0,   0.00045D0,
1.0D0,   0.0018D0,
2.0D0,   0.0042D0,
4.0D0,   0.0096D0,
5.0D0,   0.0126D0,
8.0D0,   0.0223D0,
10.0D0,  0.0292D0,
15.0D0,  0.0477D0,
117.0D0, 0.047D0,
144.0D0, 0.06D0,
200.0D0, 0.085D0,
255.0D0, 0.11D0,
297.0D0, 0.129D0,
```

```
311.0D0, 0.136D0;
#
#
################################################################################
################################
# Interfaces Conductance Arrays (W/K)
################################################################################
################################
#
K_BDA_IF(2,9)=
0.2D0, 0.02612821D0,
0.3D0, 0.044D0,
0.4D0, 0.072531529D0,
0.5D0, 0.100757013D0,
0.6D0, 0.131798133D0,
0.7D0, 0.165394811D0,
0.8D0, 0.201346469D0,
0.9D0, 0.239492371D0,
1.0D0, 0.2797D0;
#
# Note: no electrical isolation included
K_Cooler_IF(2,11)=
0.3D0,   0.040D0,
0.35D0,  0.050501804D0,
0.4D0,   0.065540111D0,
0.45D0,  0.082481565D0,
0.5D0,   0.101315412D0,
5.0D0,   0.4D0,
6.0D0,   0.5D0,
10.0D0,  0.8D0,
15.0D0,  1.0D0,
50.0D0,  1.0D0,
300.0D0, 1.0D0;
#
K_RClamp_IF(2,11)=
0.3D0,   0.045499027D0,
0.35D0,  0.05423604D0,
0.4D0,   0.063149483D0,
0.45D0,  0.072220102D0,
0.5D0,   0.081432686D0,
5.0D0,   0.4D0,
6.0D0,   0.5D0,
10.0D0,  0.8D0,
15.0D0,  1.0D0,
50.0D0,  1.0D0,
300.0D0, 1.0D0;
#
K_TwoPart_IF(2,11)=
0.3D0,   0.0258D0,
0.35D0,  0.030256894D0,
0.4D0,   0.035655411D0,
0.45D0,  0.04121141D0,
0.5D0,   0.046911174D0,
5.0D0,   0.4D0,
```

```
6.0D0,   0.5D0,
10.0D0,  0.8D0,
15.0D0,  1.0D0,
50.0D0,  1.0D0,
300.0D0, 1.0D0;
#
K_CuCu_IF(2,14)=
0.0D0,   0.0D0,
1.0D0,   0.08D0,
2.0D0,   0.16D0,
3.0D0,   0.24D0,
4.0D0,   0.32D0,
5.0D0,   0.40D0,.0D0,   0.48D0,
7.0D0,   0.56D0,
8.0D0,   0.64D0,
9.0D0,   0.72D0,
10.0D0,  0.8D0,
15.0D0,  1.0D0,
50.0D0,  1.0D0,
300.0D0, 1.0D0;
#
K_Cu_Sty_Cu_IF(2,5)=
0.3D0,  0.002051712D0,
0.35D0, 0.002919785D0,
0.4D0,  0.003963589D0,
0.45D0, 0.005190051D0,
0.5D0,  0.006605504D0;
#
Cu_E_Cu(2,3)=
1.5D0, 0.0045D0,
2.0D0, 0.0055D0,
4.0D0, 0.009D0;
#
##############################################################################
#########################



$SUBROUTINES
#======


      DOUBLE PRECISION FUNCTION SHCAL(X)
      DOUBLE PRECISION X
      SHCAL = INTRP1 (X,SHCAL1,1)
      RETURN
      END

      DOUBLE PRECISION FUNCTION SHCHAR(X)
      DOUBLE PRECISION X
      SHCHAR = INTRP1 (X,SHCHAR1,1)
      RETURN
      END
```

```
      DOUBLE PRECISION FUNCTION SHCCU(X)
      DOUBLE PRECISION X
      SHCCU = INTRP1 (X,SHCCU1,1)
      RETURN
      END

      DOUBLE PRECISION FUNCTION SHCINV(X)
      DOUBLE PRECISION X
      SHCINV = INTRP1 (X,SHCIN1,1)
      RETURN
      END

      DOUBLE PRECISION FUNCTION SHCSI(X)
      DOUBLE PRECISION X
      SHCSI = INTRP1 (X,SHCSI1,1)
      RETURN
      END

      DOUBLE PRECISION FUNCTION SHCTI(X)
      DOUBLE PRECISION X
      SHCTI = INTRP1 (X,SHCTI1,1)
      RETURN
      END

      DOUBLE PRECISION FUNCTION SHCSS(X)
      DOUBLE PRECISION X
      SHCSS = INTRP1 (X,SHCSS1,1)
      RETURN
      END


     SUBROUTINE SSOPMD(ISWITCH) LANG = MORTRAN
#     =========================================
     INTEGER ISWITCH
#
     SELECT CASE ISWITCH

       CASE -1   # PACS Off, SPIRE and HIFI off

         MODE = 'SWITCH_OFF'

         QI801 = 0.0        # Photometer JFET
         QI802 = 0.0        # Spectrometer JFET
         QI805 = 0.0        # BSM
         QI806 = 0.0        # SMECm
         QI807 = 0.0        # PCAL
         QI808 = 0.0        # SCAL
         QI817 = 0.0        # PUMP
         QI818 = 0.0        # SHUNT
         QI819 = 0.0        # EVAP
         QI820 = 0.0        # HS EVAP
         QI821 = 0.0        # HS PUMP
```

```
CASE 0   # Average Power dissipation for Steady State

  MODE = 'SWITCH_ON'

  QI801 = q_pjfet_avr         # Photometer JFET
  QI802 = q_sjfet_avr         # Spectrometer JFET
  QI805 = q_bsm               # BSM
  QI806 = q_smecm               # SMECm
  QI807 = q_pcal              # PCAL
  #
  # Please note that due to instability problem the power dissipation has been applied to SOB (803)
  # instead of the Spectrometer Calibration Source (808)
  QI808 = 0.0       # q_scal
  QI803 = q_scal    # Heat dissipation applied to SOB instead
  #
  QI817 = q_pump_avr          # PUMP
  QI820 = q_evap_hs_avr        # q_evap_hs_avr - removed as Evap HS assumed closed for avr case, HS EVAP
  QI821 = q_pump_hs_avr        # HS PUMP

  QI813 = q_evap_avr          # EVAP


CASE 1   # PACS in Spectrometer Mode, SPIRE and HIFI off

  MODE = 'SWITCH_OFF'

  QI801 = 0.0        # Photometer JFET
  QI802 = 0.0        # Spectrometer JFET
  QI805 = 0.0        # BSM
  QI806 = 0.0        # SMECm
  QI807 = 0.0        # PCAL
  QI808 = 0.0        # SCAL
  QI817 = 0.0        # PUMP
  QI818 = 0.0        # SHUNT
  QI819 = 0.0        # EVAP
  QI820 = 0.0        # HS EVAP
  QI821 = 0.0        # HS PUMP


CASE 2   # PACS in Photometer mode, HIFI and SPIRE off

  MODE = 'SWITCH_OFF'

  QI801 = 0.0        # Photometer JFET
  QI802 = 0.0        # Spectrometer JFET
  QI805 = 0.0        # BSM
  QI806 = 0.0        # SMECm
  QI807 = 0.0        # PCAL
  QI808 = 0.0        # SCAL
  QI817 = 0.0        # PUMP
  QI818 = 0.0        # SHUNT
  QI819 = 0.0        # EVAP
```

```
  QI820 = 0.0          # HS EVAP
  QI821 = 0.0          # HS PUMP

CASE 3   # PACS off, SPIRE Photometer mode, HIFI off

  MODE = 'SWITCH_ON'

  QI801 = q_jfet_phot          # Photometer JFET
  QI802 = 0.0                # Spectrometer JFET
  QI805 = q_peak_phot_bsm      # BSM
  QI806 = 0.0                # SMECm
  QI807 = q_mean_phot_calib    # PCAL
  QI808 = 0.0                # SCAL
  QI817 = q_pump_nom           # PUMP
  QI818 = 0.0                # SHUNT
  QI819 = 0.0                # EVAP
  QI820 = 0.0                # HS EVAP
  QI821 = q_pump_hs          # HS PUMP


CASE 4   # PACS off, SPIRE Spectrometer mode, HIFI off

  MODE = 'SWITCH_ON'

  QI801 = 0.0                # Photometer JFET
  QI802 = q_jfet_spec          # Spectrometer JFET
  QI805 = q_mean_phot_bsm2     # BSM
  QI806 = q_peak_spec_mech     # SMECm
  QI807 = q_mean_phot_calib    # PCAL

  #QI808 = q_hold_spec_calib    # SCAL
  QI803 = q_hold_spec_calib    # SCAL

  QI817 = q_pump_nom           # PUMP
  QI818 = 0.0                # SHUNT
  QI819 = 0.0                # EVAP
  QI820 = 0.0                # HS EVAP
  QI821 = q_pump_hs            # HS PUMP


CASE 5   # PACS off, SPIRE off, HIFI on

  MODE = 'SWITCH_OFF'

  QI801 = 0.0          # Photometer JFET
  QI802 = 0.0          # Spectrometer JFET
  QI805 = 0.0          # BSM
  QI806 = 0.0          # SMECm
  QI807 = 0.0          # PCAL
  QI808 = 0.0          # SCAL
  QI817 = 0.0          # PUMP
  QI818 = 0.0          # SHUNT
  QI819 = 0.0          # EVAP
```

```
        QI820 = 0.0          # HS EVAP
        QI821 = 0.0          # HS PUMP


      CASE 6   # PACS in Photometer mode, SPIRE in Photometer Mode, HIFI off

        MODE = 'SWITCH_ON'

        QI801 = q_jfet_phot          # Photometer JFET
        QI802 = 0.0                  # Spectrometer JFET
        QI805 = q_peak_phot_bsm      # BSM
        QI806 = 0.0                  # SMECm
        QI807 = q_mean_phot_calib    # PCAL
        QI808 = 0.0                  # SCAL
        QI817 = q_pump_nom           # PUMP
        QI818 = 0.0                  # SHUNT
        QI819 = 0.0                  # EVAP
        QI820 = 0.0                  # HS EVAP
        QI821 = q_pump_hs            # HS PUMP


#
      CASE ELSE
        WRITE (*,*) 'Illegal dissipation mode: ', ISWITCH
        STOP
    END SELECT
#
    RETURN
    END




$INITIAL
#======



      # Apply margin factor to internal mechanism dissipation

      q_jfet_phot        = q_jfet_phot        * margin_fac
      q_jfet_spec        = q_jfet_spec        * margin_fac

      q_peak_phot_calib  = q_peak_phot_calib  * margin_fac
      q_mean_phot_calib  = q_mean_phot_calib  * margin_fac

      q_peak_spec_calib  =  q_peak_spec_calib * margin_fac
      q_mean_spec_calib  =  q_mean_spec_calib * margin_fac
      q_hold_spec_calib  =  q_hold_spec_calib * margin_fac

      q_peak_phot_bsm    = q_peak_phot_bsm    * margin_fac
      q_mean_phot_bsm    = q_mean_phot_bsm    * margin_fac
```

```
    q_peak_phot_bsm2   = q_peak_phot_bsm2   * margin_fac
    q_mean_phot_bsm2   = q_mean_phot_bsm2   * margin_fac

    q_peak_spec_mech   = q_peak_spec_mech   * margin_fac
    q_mean_spec_mech   = q_mean_spec_mech   * margin_fac
    q_min_spec_mech    = q_min_spec_mech    * margin_fac

    q_evap_hs          = q_evap_hs          * margin_fac
    q_pump_hs          = q_pump_hs          * margin_fac


    q_pump_avr         = q_pump_avr         * margin_fac
    q_evap_avr         = q_evap_avr         * margin_fac
    q_evap_hs_avr      = q_evap_hs_avr      * margin_fac
    q_pump_hs_avr      = q_pump_hs_avr      * margin_fac
    q_pcal             = q_pcal             * margin_fac
    q_bsm              = q_bsm              * margin_fac
    q_smecm            = q_smecm            * margin_fac
    q_scal             = q_scal             * margin_fac
    q_pjfet_avr        = q_pjfet_avr        * margin_fac
    q_sjfet_avr        = q_sjfet_avr        * margin_fac



$VARIABLES1
#==========


    GENMOR
    # kw: GLs defined here because of PC-ESATAN restrictions for "long" lines in $CONDUCTORS

    GL( 822, 819 ) = 1.0D0/(1.0D0/(CNDFN3(T822,T819,K_HPCU1)*(0.003*0.003)/0.10D0)+
  &                  1.0D0/(CNDFN3(T822,T819,K_HPCU1)*(0.0132*0.003)/0.025D0)+
  &                  1.0D0/(CNDFN3(T822,T819,K_Cooler_IF)))
    GL( 823, 819 ) = 1.0D0/(1.0D0/(CNDFN3(T823,T819,K_HPCU1)*(0.003*0.003)/0.22D0)+
  &                  1.0D0/(CNDFN3(T823,T819,K_Cu_Sty_Cu_IF))+
  &                  1.0D0/(CNDFN3(T823,T819,K_Cooler_IF)))



    # Cooler instrument loads (in microwatts)
    #
    Photo_load      = ((GL(822,819)*(T822-T819)) * 1000000.0D0)
    Spectro_load    = ((GL(823,819)*(T823-T819)) * 1000000.0D0)
    Parasitic_load  = ((GL(803,819)*(T803-T819) + GL(820,819)*(T820-T819) + GL(818,819)*(T818-T819))*1000000.0D0)
    Tot_Cooler_load = (Photo_load + Spectro_load + Parasitic_load)


    # "Missing" Pump Internal Power Dissipation
    #
    q_pump_add = ((50.0D0 * Tot_Cooler_load ) / 1000000.0D0) - q_pump_nom
```

```
# Update the Heat Switches and Evaporator Status according to SPIRE Mode ON or OFF
#
IF (MODULE.EQ.'SOLVIT' .OR. MODULE.EQ.'SOLVT2' .OR. MODULE.EQ.'SOLVSM' .OR. MODULE.EQ.'SOLVFM')   THEN


  IF (MODE.EQ.'SWITCH_ON') THEN

    # During SPIRE Operation :
    # - The evaporator node 819 is always a boundary node at 0.29K
    # - The pump HS is ON
    # - The evaporator HS is OFF

    CALL STATST('N819','B')
    T819 = 0.29D0

    HS_EVAP_STATE = 'OFF'
    HS_PUMP_STATE = 'ON'


    # No power dissipation is currently defined for the node 812 within the ISWITCH Function because this
    # node is used as an "arithmetic" node to compensate for the "missing" power dissipation of the pump.
    # QI812 is updated at each iteration according to the current total cooler load (ie - only when SPIRE is in
    # operation).
    #  The next two lines are used to update QI8012 during the Steady-State Analysis,  but a similar approach
    #  is used in Transient Analysis.
    #

    QI812 = q_pump_add


    IF (IMODE.EQ.0) THEN
      QI812 = 0.33D0 * 0.041 * 0.047 + 0.33D0 * 0.96875 * q_pump_add
    ELSE
    ENDIF


  ELSE

    # SPIRE in OFF Mode :
    # - The evaporator node 819 is always a diffuse node
    # - The pump HS is OFF
    # - The evaporator HS is OFF

    CALL STATST('N819','D')

    HS_EVAP_STATE = 'OFF'
    HS_PUMP_STATE = 'OFF'

    QI812 = 0.0

  ENDIF
```

```
ELSE IF (MODULE.EQ.'SLFWBK' .OR. MODULE.EQ.'SLFRWD' .OR. MODULE.EQ.'SLGEAR' .OR. MODULE.EQ.'SLGRDJ')   THEN


 # Set the following Heat capacitance to zero
 C800 = 0.
 C830 = 0.
 C831 = 0.
 C832 = 0.
 C805 = 0.
 C806 = 0.
 C807 = 0.
 C808 = 0.
 C811 = 0.
 C812 = 0.
 C813 = 0.
 C814 = 0.
 C815 = 0.
 C816 = 0.
 C818 = 0.
 C820 = 0.
 C821 = 0.


 # Start Transient Analysis with 48 hrs of PACS Operation
 # SPIRE in OFF Mode
 IF (SPSUBMD.EQ.-1) THEN

 CALL STATST('N819','D')

 HS_EVAP_STATE = 'OFF'
 HS_PUMP_STATE = 'OFF'

 QI801 = 0.0D0         # Photometer JFET
 QI802 = 0.0D0         # Spectrometer JFET
 QI805 = 0.0D0         # BSM
 QI806 = 0.0D0         # SMECm         QI807 = 0.0D0          # PCAL
 QI808 = 0.0D0         # SCAL
 QI812 = 0.0D0         # Additional "Pump" Power Dissipation
 QI817 = 0.0D0         # PUMP
 QI818 = 0.0D0         # SHUNT
 QI819 = 0.0D0         # EVAP
 QI820 = 0.0D0         # HS EVAP
 QI821 = 0.0D0         # HS PUMP


 # SPIRE in Average Mode
 ELSE IF (SPSUBMD.EQ.0) THEN

 CALL STATST('N819','B')
 T819 = 0.29D0
```

```
HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'
QI812 = q_pump_add

CALL SSOPMD(0)


# Start SPIRE Recycling after 48 hrs of PACS Operation
ELSE IF (SPSUBMD.EQ.1) THEN

#CALL STATST('N819','D') - isn't this needed?

HS_EVAP_STATE = 'ON'
HS_PUMP_STATE = 'OFF'

QI801 = 0.0D0       # Photometer JFET
QI802 = 0.0D0       # Spectrometer JFET
QI805 = 0.0D0       # BSM
QI806 = 0.0D0       # SMECm
QI807 = 0.0D0       # PCAL
QI808 = 0.0D0       # SCAL
QI812 = 0.0D0       # Additional "Pump" Power Dissipation
QI817 = 0.0D0       # PUMP
QI818 = 0.0D0       # SHUNT
QI819 = 0.0D0       # EVAP
QI820 = q_evap_hs    # HS EVAP
QI821 = 0.0D0       # HS PUMP


# First Phase of Condensation Period
ELSE IF (SPSUBMD.EQ.2) THEN

HS_EVAP_STATE = 'ON'
HS_PUMP_STATE = 'OFF'

QI801 = 0.0D0         # Photometer JFET
QI802 = 0.0D0         # Spectrometer JFET
QI805 = 0.0D0         # BSM
QI806 = 0.0D0         # SMECm
QI807 = 0.0D0         # PCAL
QI808 = 0.0D0         # SCAL
QI812 = 0.0D0         # Additional "Pump" Power Dissipation
QI817 = q_pump0         # PUMP
QI818 = 0.9D0*q_evap_rec1    # SHUNT
QI819 = 0.1D0*q_evap_rec1    # EVAP
QI820 = q_evap_hs       # HS EVAP
QI821 = 0.0D0         # HS PUMP


# First Phase of Condensation Period
ELSE IF (SPSUBMD.EQ.22) THEN
```

```
HS_EVAP_STATE = 'ON'
HS_PUMP_STATE = 'OFF'

QI801 = 0.0D0              # Photometer JFET
QI802 = 0.0D0              # Spectrometer JFET
QI805 = 0.0D0              # BSM
QI806 = 0.0D0              # SMECm
QI807 = 0.0D0              # PCAL
QI808 = 0.0D0              # SCAL
QI812 = 0.0D0              # Additional "Pump" Power Dissipation
QI817 = q_pump1              # PUMP
QI818 = 0.9D0*q_evap_rec1    # SHUNT
QI819 = 0.1D0*q_evap_rec1    # EVAP
QI820 = q_evap_hs           # HS EVAP
QI821 = 0.0D0              # HS PUMP

# Second Phase of Condensation Period
ELSE IF (SPSUBMD.EQ.3) THEN

HS_EVAP_STATE = 'ON'
HS_PUMP_STATE = 'OFF'

QI801 = 0.0D0             # Photometer JFET
QI802 = 0.0D0             # Spectrometer JFET
QI805 = 0.0D0             # BSM
QI806 = 0.0D0             # SMECm
QI807 = 0.0D0             # PCAL
QI808 = 0.0D0             # SCAL
QI812 = 0.0D0             # Additional "Pump" Power Dissipation
QI817 = q_pump2             # PUMP
QI818 = 0.9D0*q_evap_rec2   # SHUNT
QI819 = 0.1D0*q_evap_rec2   # EVAP
QI820 = q_evap_hs          # HS EVAP
QI821 = 0.0D0             # HS PUMP


# Set all dissipations to OFF
ELSE IF (SPSUBMD.EQ.4) THEN

HS_EVAP_STATE = 'ON'
HS_PUMP_STATE = 'OFF'

QI801 = 0.0D0            # Photometer JFET
QI802 = 0.0D0            # Spectrometer JFET
QI805 = 0.0D0            # BSM
QI806 = 0.0D0            # SMECm
QI807 = 0.0D0            # PCAL
QI808 = 0.0D0            # SCAL
QI812 = 0.0D0            # Additional "Pump" Power Dissipation
QI817 = 0.0D0            # PUMP
QI818 = 0.0D0            # SHUNT
QI819 = 0.0D0            # EVAP
QI820 = q_evap_hs         # HS EVAP
```

```
QI821 = 0.00D0          # HS PUMP


# Switch evap OFF and pump ON
ELSE IF (SPSUBMD.EQ.5) THEN

HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'

QI801 = 0.0D0          # Photometer JFET
QI802 = 0.0D0          # Spectrometer JFET
QI805 = 0.0D0          # BSM
QI806 = 0.0D0          # SMECm
QI807 = 0.0D0          # PCAL
QI808 = 0.0D0          # SCAL
QI812 = 0.0D0          # Additional "Pump" Power Dissipation
QI817 = 0.0D0          # PUMP
QI818 = 0.0D0          # SHUNT
QI819 = 0.0D0          # EVAP
QI820 = 0.00D0          # HS EVAP
QI821 = q_evap_hs        # HS PUMP



# Wait for the cooler to reach 290 mK
ELSE IF (SPSUBMD.EQ.6) THEN


CALL STATST('N819','B')

 IF (T819.GT.0.29D0) THEN

   T819 = T819 - (DTIMEU*0.00175D0)  # 0.00175K/sec is the evaporator approximated cooldown rate during recycling

   QI812 = 0.0D0          # Additional "Pump" Power Dissipation
   QI817 = 0.0D0          # PUMP
   QI818 = 0.0D0          # SHUNT
   QI819 = 0.0D0          # EVAP
   QI821 = q_evap_hs       # HS PUMP

 ELSE

   T819 = 0.29D0

   QI812 = q_pump_add      # Additional "Pump" Power Dissipation
   QI817 = q_pump_nom      # PUMP
   QI818 = 0.0D0          # SHUNT
   QI819 = 0.0D0          # EVAP
   QI821 = q_pump_hs       # HS PUMP


 END IF
```

```
HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'

QI801 = 0.0D0          # Photometer JFET
QI802 = 0.0D0          # Spectrometer JFET
QI805 = 0.0D0          # BSM
QI806 = 0.0D0          # SMECm
QI807 = 0.0D0          # PCAL
QI808 = 0.0D0          # SCAL
QI820 = 0.0D0          # HS EVAP



# End of SPIRE Recycling - Evaporator Node is now a Boundary Node at 0.29K
# Start of SPIRE Operation in Spectrometer MODE - 12 hrs in SMECm R=1000
#
ELSE IF (SPSUBMD.EQ.7) THEN

CALL STATST('N819','B')
T819 = 0.29D0

HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'

QI801 = 0.0              # Photometer JFET
QI802 = q_jfet_spec         # Spectrometer JFET
QI805 = q_mean_phot_bsm2     # BSM
QI806 = q_peak_spec_mech     # SMECm
QI807 = q_mean_phot_calib    # PCAL

#QI808 = q_mean_spec_calib    # SCAL
QI803 = q_hold_spec_calib    # SCAL

QI812 = q_pump_add          # Additional "Pump" Power Dissipation
QI817 = q_pump_nom          # PUMP
QI818 = 0.0              # SHUNT
QI819 = 0.0D0              # EVAP
QI820 = 0.0D0              # HS EVAP
QI821 = q_pump_hs           # HS PUMP


# Spectrometer Mode - 12 hrs in SMECm R=10
#
ELSE IF (SPSUBMD.EQ.8) THEN

CALL STATST('N819','B')
T819 = 0.29D0

HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'

QI801 = 0.0              # Photometer JFET
QI802 = q_jfet_spec         # Spectrometer JFET
```

```
QI805 = q_mean_phot_bsm2     # BSM
QI806 = q_min_spec_mech      # SMECm
QI807 = q_mean_phot_calib    # PCAL

#QI808 = q_mean_spec_calib    # SCAL
QI803 = q_hold_spec_calib    # SCAL

QI812 = q_pump_add           # Additional "Pump" Power Dissipation
QI817 = q_pump_nom           # PUMP
QI818 = 0.0D0                # SHUNT
QI819 = 0.0D0                # EVAP
QI820 = 0.0D0                # HS EVAP
QI821 = q_pump_hs            # HS PUMP




# Change of Operation Mode for Photometer Mode - 11.5 hrs with BSM in chopping mode
#
ELSE IF (SPSUBMD.EQ.9) THEN


CALL STATST('N819','B')
T819 = 0.29D0

HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'

QI801 = q_jfet_phot          # Photometer JFET
QI802 = 0.0                  # Spectrometer JFET
QI805 = q_mean_phot_bsm      # BSM
QI806 = 0.0                  # SMECm
QI807 = q_mean_phot_calib    # PCAL
QI808 = 0.0                  # SCAL
QI812 = q_pump_add           # Additional "Pump" Power Dissipation
QI817 = q_pump_nom           # PUMP
QI818 = 0.0                  # SHUNT
QI819 = 0.0                  # EVAP
QI820 = 0.0                  # HS EVAP
QI821 = q_pump_hs            # HS PUMP



# SPIRE Operation
# Photometer Mode - 11 hrs with BSM in scanning mode
#
ELSE IF (SPSUBMD.EQ.10) THEN

CALL STATST('N819','B')
T819 = 0.29D0

HS_EVAP_STATE = 'OFF'
HS_PUMP_STATE = 'ON'
```

```
    QI801 = q_jfet_phot          # Photometer JFET
    QI802 = 0.0               # Spectrometer JFET
    QI805 = q_peak_phot_bsm      # BSM
    QI806 = 0.0               # SMECm
    QI807 = q_mean_phot_calib    # PCAL
    QI808 = 0.0               # SCAL
    QI812 = q_pump_add           # Additional "Pump" Power Dissipation
    QI817 = q_pump_nom           # PUMP
    QI818 = 0.0D0              # SHUNT
    QI819 = 0.0D0              # EVAP
    QI820 = 0.0D0              # HS EVAP
    QI821 = q_pump_hs            # HS PUMP

    END IF


  ENDIF


    #Heat switch temp dependant couplings due Helium when ON, or 0W/K when OFF:

    IF (HS_PUMP_STATE.EQ.'ON') THEN
     HS_PUMP_GAS              =              1./(1./(0.00061D0*INTRP1(((T821+T817)/2.0D0),He3,1)/0.0001D0)+1.0/(1.6265D-
5*INTRP1(((T821+T817)/2.0D0),K_OFHC,1)/0.048D0))

       IF (HS_PUMP_GAS.GT.0.04) THEN
         HS_PUMP_GAS = 0.04
       ELSE
       ENDIF

    ELSE IF (HS_PUMP_STATE.EQ.'OFF') THEN
     HS_PUMP_GAS = 0.0D0
    ENDIF


    IF (HS_EVAP_STATE.EQ.'ON') THEN
     HS_EVAP_GAS              =              1./(1./(0.00061D0*INTRP1(((T819+T820)/2.0D0),He3,1)/0.0001D0)+1.0/(1.6265D-
5*INTRP1(((T819+T820)/2.0D0),K_OFHC,1)/0.048D0))

       IF (HS_EVAP_GAS.GT.0.04) THEN
         HS_EVAP_GAS = 0.04
       ELSE
       ENDIF

    ELSE IF (HS_EVAP_STATE.EQ.'OFF') THEN
     HS_EVAP_GAS = 0.0D0
    ENDIF


$VARIABLES2
#=========
```

```
$EXECUTION
#=========


$OUTPUTS
#=======


$ENDMODEL
#=======
```

A3 . ANNEX 3: DESCRIPTION OF THE OPERATIONS OF THE 3HE SORPTION COOLER

Description of the Operation of the ^{3}He Sorption Cooler

The ^{3}He cooler is produced for Spire and PACS by SBT/CEA, Grenoble, who own the intellectual information in this annex. The cooler is specified in SBT documents HSO-SBT-SP-001-3-3 and HSO-SBT-TNS-2; its interfaces internal to Spire are controlled via HSO-SBT-ICD-012-1-3.

The cooler's internal thermal configuration is as follows:

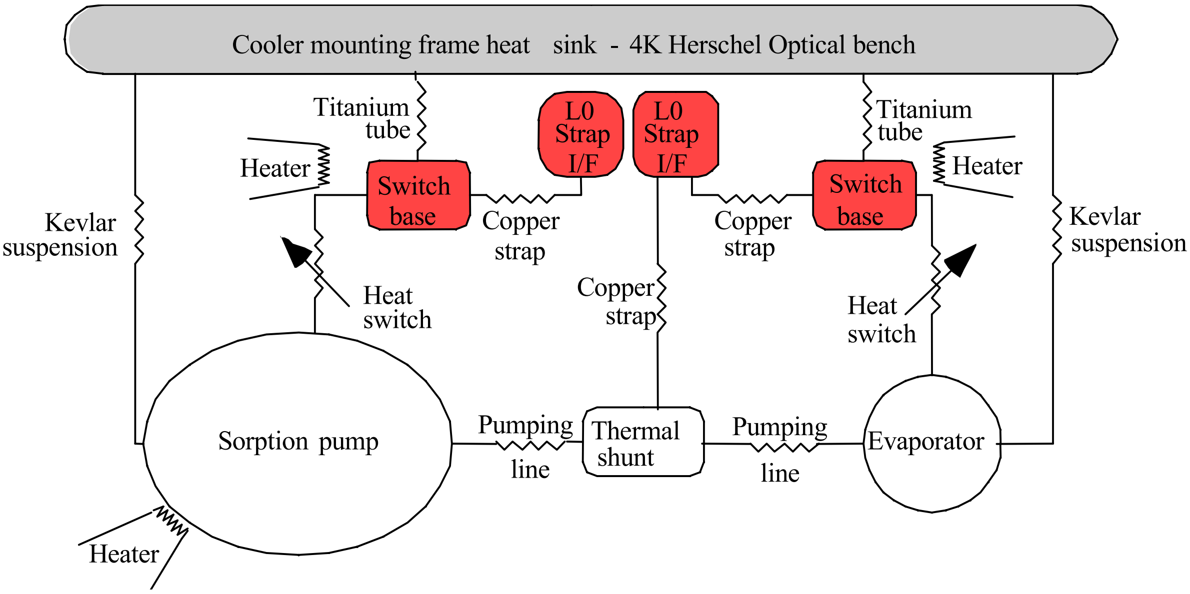


Figure 1: SPIRE Sorption cooler

The cooler is hermetically closed and does not have a lifetime limited by its cryogen boil-off. However it cannot cool continuously but rather it needs to be re-generated regularly. This regeneration energy cycle is a small but significant contribution to the total dissipation within the Herschel cryostat.

When operational, Spire runs a 48 hour ^{3}He cooler cycle, 46 hours with Spire's detectors cooled to «300mK» and 2 hours recycling. This fits in with Herschel ground commanding periods.

When at «300mK», the temperature at the cooler's evaporator is to a very good approximation a single valued function of gross applied load on its evaporator, i.e. available/net cooling power PLUS the cooler's internal parasitics. The cooling is simply due to the physical process of evaporation along the cooler's «pumping line» geometry(see above figure). The function is shown below in figure 2) which is derived by offsetting curves of tip temperature v. load that have been measured at different L1 and hence parasistics. A puzzling factor is that the TRP 4 litre contract showed this characteristic to be independent of attitude but under test the function for the 6 litre units shows some dependency on attitude.

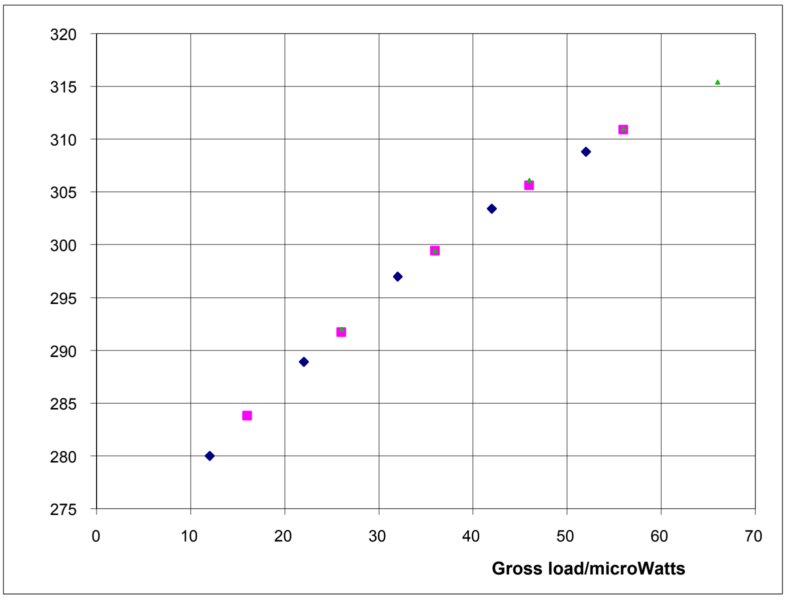


Figure 2: Evaporator temperature vs <u>total</u> load

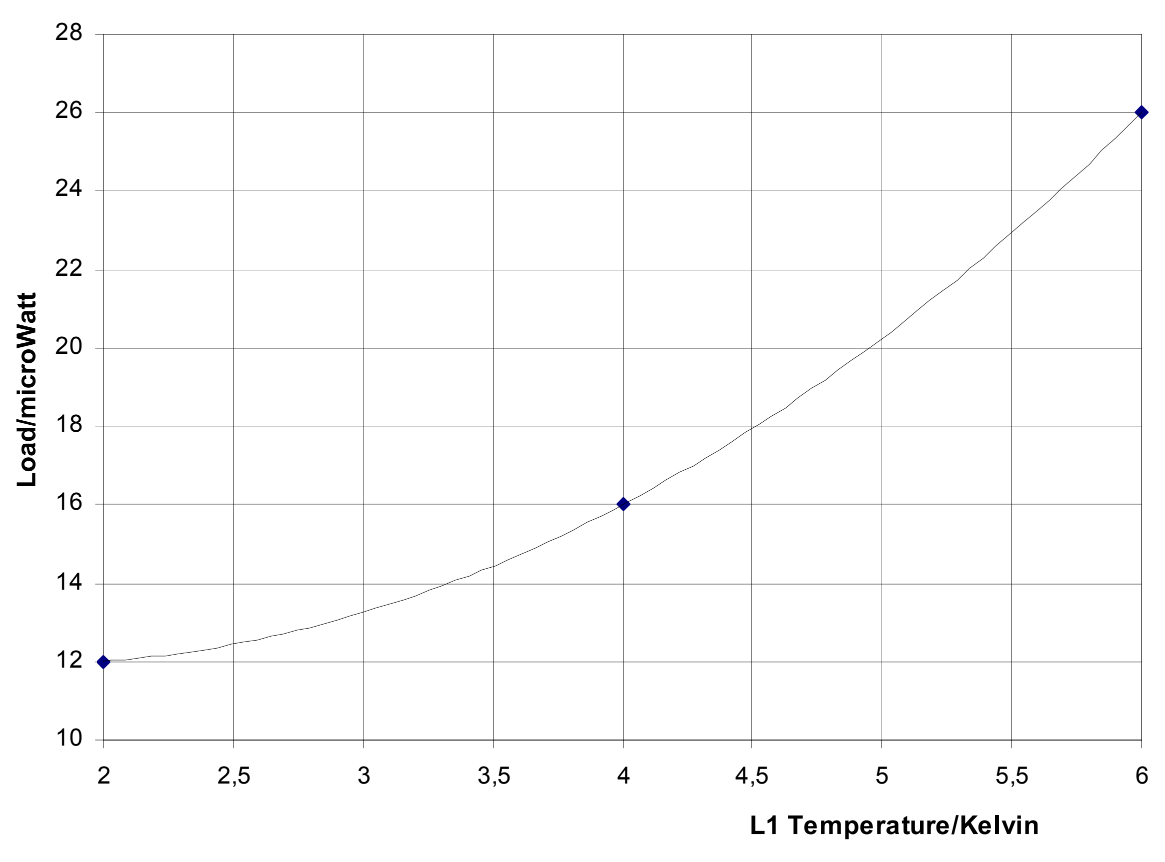


Figure 3: Cooler parasitic loads vs level 1 temperature

The baseline parasitic of 280mK shown in figure 2 of 12microwatts for L1 = 2K is indirectly derived, but the data plotted in figure 3 are the shifts needed to superimpose the curves at different L1 in 2a, They suggest a stronger dependence of cooler parasitics on L1 temperature than is often assumed.

Contributions to the cooler's internal evaporator parasitics are heat-switch off-state leakage to L0, tube conduction to the thermal shunt, wiring conduction, and Kevlar suspension leakage to L1, presuming the lack of unwanted effects inside the cooler. For details see Annex 3.

In the 46hr. operating/observing mode only the sorption pump sieve heat-switch heater is on. The following confirms a sieve switch-over temperature of 12-13K.

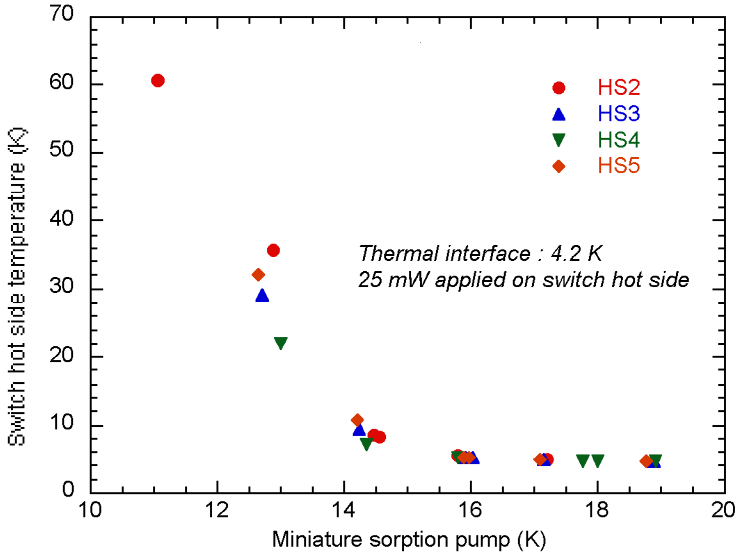


Figure 4: Heat switch "switching temperature" (vs switch pump temperature)

The power needed to raise the switch's sieve to ~14K is ~200 μW. To have margin, ~400 μW has been demonstrated to run the pump switch and to speed up the switch-over phase the sieve is heated at 800 μW for an initial limited time.

As helium evaporates, heat is pumped. There is an amplification factor between the heat load at the evaporator and the resulting adsorption heat load on the pump which is sunk down the turned-on pump switch and its strap. The following curves are from an experiment to measure this.

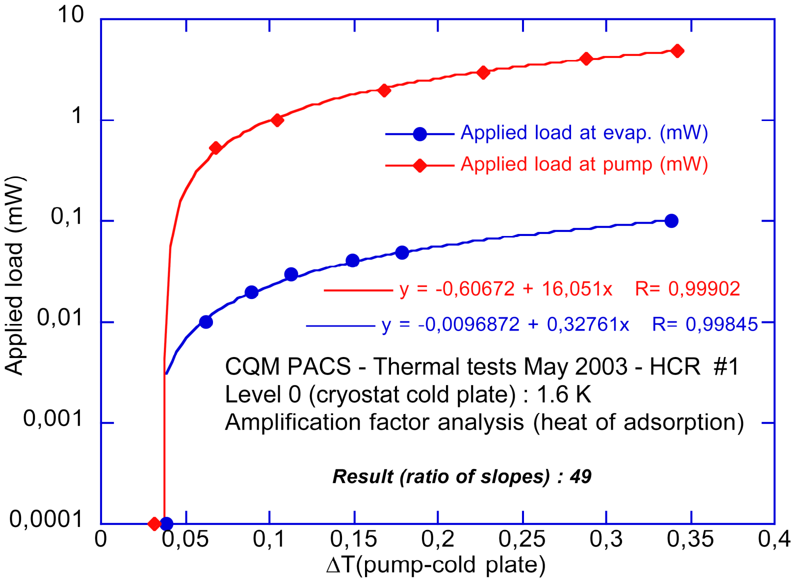


Figure 5 : Measurement of adsorption heat on pump vs heat applied on evaporator

A ratio between these heat loads of 46-49 is typical for ^{3}He coolers, and such a test result shows that the cooler is pumping properly according to the expected thermodynamics.

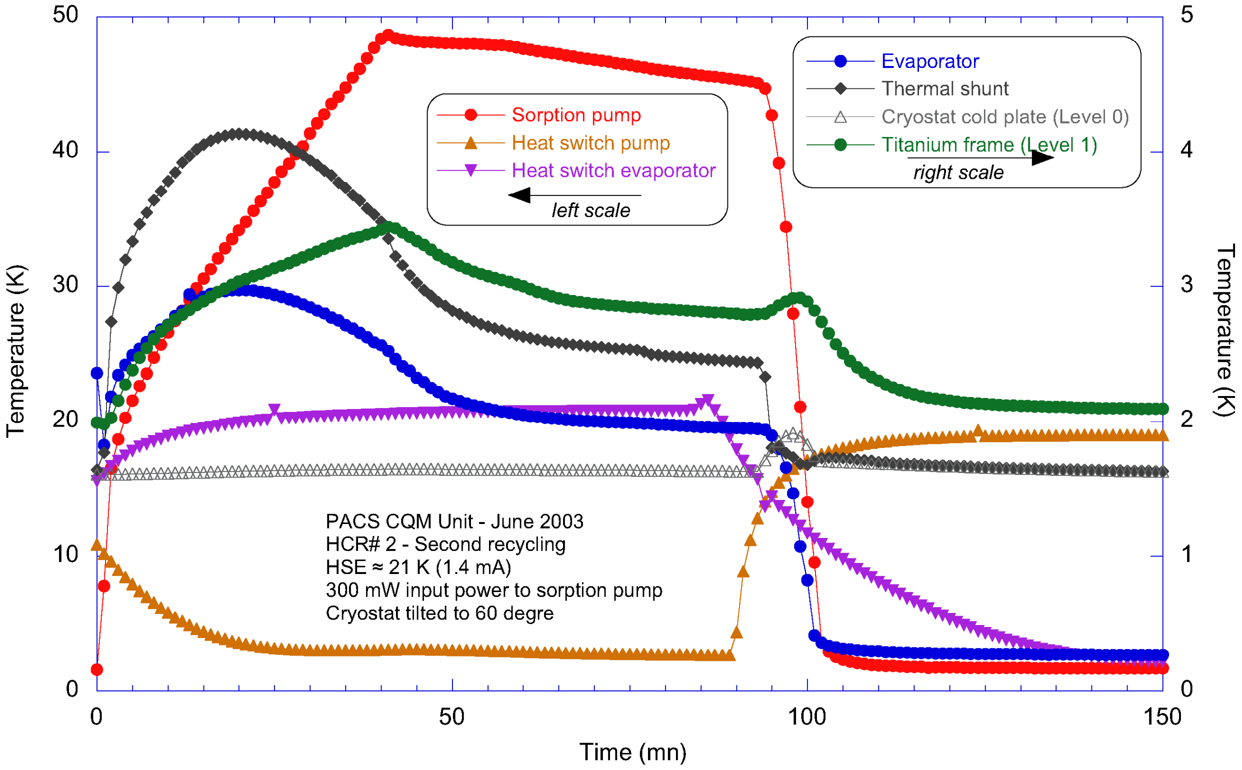
In practise the whole system must be able to cope with the 2 hour recycling heat mode. This is in many respects is more demanding than the 46hour hold-time.

During the first phase of recycling, i.e. condensation, the evaporator heat-switch is closed and the pump's switch opened. The evaporator strap needs extremely low thermal impedance and 800W heat-switch sieve power is baselined. The cooler's sorption pump is heated to 40-45K and a lower power is then used to keep it hot. Condensation occurs in the evaporator. Almost all the cooler's ^{3}He charge needs to be condensed so Spire can meet the hold-time for its subsequent 46 hours at 300mK. The temperature of the evaporator itself at the end of condensation is critical. This is a parameter internal to Spire, even being internal to one of its subsystems, and it needs to be <2K for the last few minutes of this phase. We may need to apply 1mW to the evaporator's heat-switch sieve the end of the condensation phase to help to achieve this <2K

During this condensation phase the shunt has to extract nearly all the heat from the hot gas travelling from the pump to the evaporator; it should typically stay below 6K. More than >80% of the enthalpy of the hot gas should be thus removed. throughout the condensation phase. The overall shunt strap actually needs a tuned conductance because during the condensation phase its temperature needs to go and stay above Tevap to avoid ^{3}He condensing on it instead of in the evaporator.

At the end of the condensation phase there is a cooling phase when and the cooler heat switches are swapped over to their normal (operating) positions: the pump switch is on and the evaporator's off. Timings for this have to be optimised by test. This cooler requires that its pump and evaporator have separate straps back to Herschell's main ^{4}HeII because otherwise the heat-pulse that occurs at this switch-over could heat the evaporator and waste much of the available ^{3}He liquid charge.

Recycling of a flight type 6 litre coolers is sdhown below, but with a warning that it has been obtained at unit level with 200mW/K conductances for both the straps from the cooler heatswitch interfaces (which are not Spire/Herschel Interfaces) to the ^{4}HeII (at <1.7K). When later results with flight type conductances are available, these results will need updating. For instance when the cooler is accommodated inside Spire the 350J pump power spike is likely to peak at only ~500mW and of course therefore to last longer.



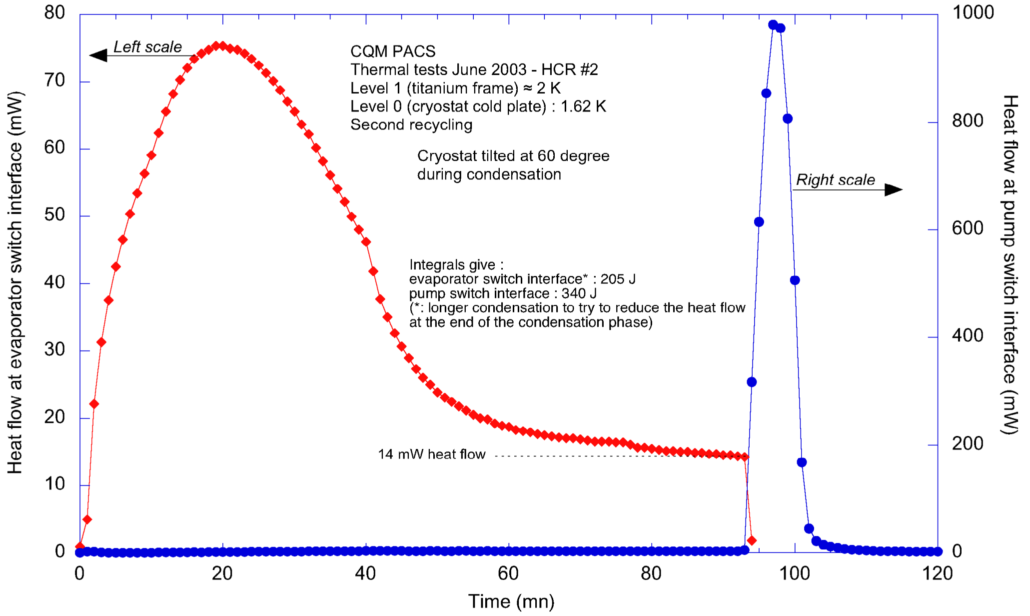


Figure 6: Cooler Recycling: Characteristics above and estimated heat-flows below

We see that during test, and probably in flight also, the cooler's titanium frame alters temperature during re-cycling. This is even with the cooler chassis fixed all along one side (PACS style) to the L1 test plate.

Generally the faster the whole regeneration process the better, both in terms of the minimising the total single recycle energy and in terms of the fraction of time available for science. By searching for efficient operation, in Spire we have set the initial pump heater power to 300mW. If the heat shunt and evaporator strap could take the load as a high flow-rate of warm ^{3}He leaves the pump, we could heat the pump with some 600mW to 40K very quickly, keep it there for just a few minutes, turn off and let everything cool down again, which would achieve a very energy efficient regeneration. In practise, strap impedance both limits the initial power that can be applied and causes us to need to wait an appreciable time before the evaporator comes back down to <2K, the point at which «cool down» can be commenced.

The time taken for the 6 litre flight cooler's sorption pump to be heated up to ~40-45K is expected to be ~30minutes. SBT/CEA have put considerable effort into developing the heat straps inside the cooler to cut down the wait time for evaporator itself to get back down to <2K at the end of the condensation phase.

The shunt and the evaporator share an L0 strap, the latter via a heat-switch. The energy to be transported during recycling from the evaporator itself is expected to be 50 Joules with the profile shown, peaking at a power of 45mW. However the total energy through this strap per cycle is ~205 Joules when the shunt's contribution is also added in, peaking at 75mW. Although evaporator power may drop to <2mW at the end of the condensation phase, there is still ~13mW from the shunt added into the strap to give a total power along it of ~15mW.

Achieving the 46 hours lifetime requires a minimised total load on the 300mK evaporator, and also on the cooler achieving its full 6 litre latent heat energy rating. Spire should only place an external load on the cooler such that the total load remains below ~29μWatts

Not achieving an evaporator temperature of <2K at the end of the condensation phase would cause an unacceptable reduction in the amount of condensed helium in the evaporator available for next operation phase. This is computed to be:

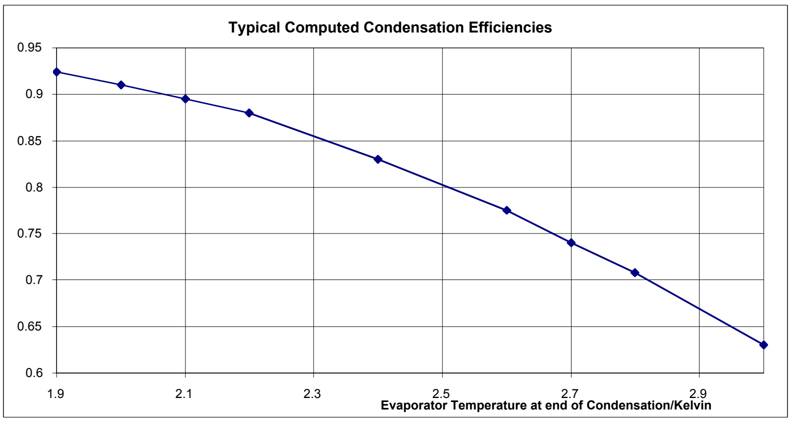


Figure 7 : Estimated Condensation efficiency (% ^{3}He liquefied) vs evaporator temperature

A fraction of the ^{3}He charge is expended cooling both itself and the evaporator/detectors down to 300mK, which is taken as the end of recycling. This leaves an amount of ^{3}He available to keep the Spire 300mK section cooled for the next 46 hrs. The evaporator temperature at the end of the previous phase is again critical to minimising He usage for this pre-cooling process, and <2K is required.

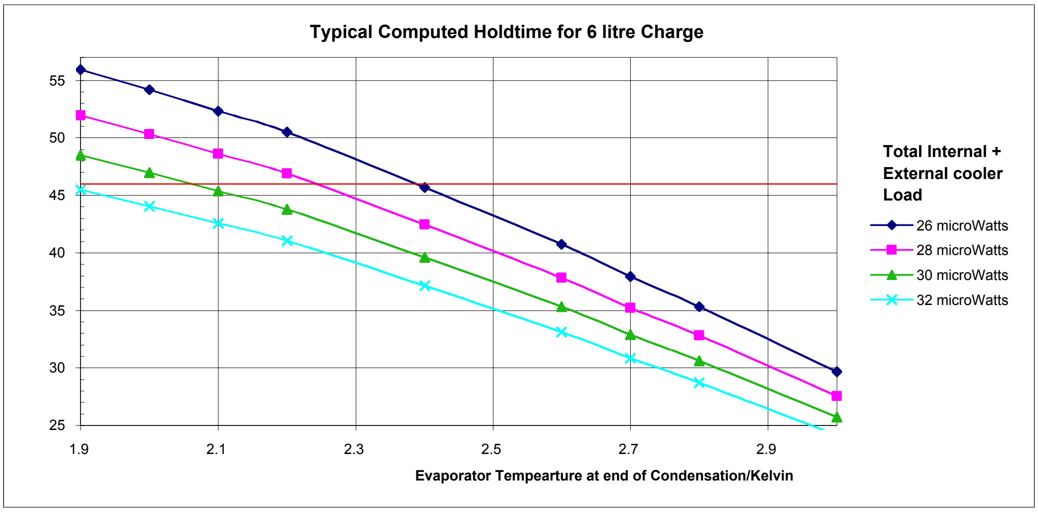


Figure 8 : Cooler hold time ve evaporator temperature at end of condensation, and average total load on evaporator.

Figure 8 is the same as one from the IHDR but with the above condensation efficiencies also included.

These curves are an approximation in that they ignore the small extra demands on the cooler from all loads during the 2K to 300mK cooldown and the heat capacity during this period of all 300mK components besides that of the helium itself. However, these effects are small and the approximation is good.

Note:

There is one cooler variation still under consideration by **Spire**. The requirement that the evaporator itself be <2K at the end of the condensation phase [typically 1.85K at the cooler's heat-switch interface inside the instrument] is sufficiently challenging to achieve that we were considering putting the shunt on the pump's strap rather than on the evaporator's, see thermal overview drawing at the start of this section. This would avoid ~15mWatts from the shunt travelling down the evaporator strap at this stage in the recycling, thus avoiding its contribution to the temperature drop along the strap. Caveat: it's not clear yet if this alteration has other significant disadvantageous side-effects, and the project has seriously run out of time to put such a change into the programme.

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