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		Ref.Nr.:	**FP-071 / 1999**
		Datum/Date:	**25.10.1999**
Cc:		**Seite/page:**	**1 von/of 1**

Subject: **FIRST Cryostat Study-Update of Instrument Interfaces**

Ref.:

Dear Sirs,

please find attached the minutes of meeting of the progress meeting # 1.

Best regards

Dornier Satellitensysteme GmbH

i.V. Moßbacher   i.A. Schupp

Attachment: 31 pages

Minutes of Meeting

Besprechungsprotokoll

Daimler-Benz Aerospace
Dornier

Dornier Satellitensysteme GmbH

Subject Thema: FIRST – Update of Instrument Interfaces – Progress Meeting #1

Location Ort: DSS / OTN

Date Datum: 20. Oct. 1999

Distribution Verteiler

Participants Teilnehmer	**Organ.**				
Wim van Leeuwen	SRON	N. Gradmann	DSS	A. Wagner	RIASS DASA
Henri Aarts	SRON	G. Pilbratt	ESTEC	B. Roßbacher	DSS
Nick Whyborn	SRON	B. Guillaume	ESTEC	J. Schupp	DSS
T. Passvogel	ESTEC	B. Gröger	DASA	H. Peitzker	DSS
B. SWINYARD	RAL.	R. Graue	KT		
M GRIFFIN	QMW	K. Moritz	DSS		
N. Geis	MPE	A. Hauser	DSS		
R. Katterloher	MPE	B. Collaudin	ESA		
		H. Peitzker	DSS		

Agreements, Statements Vereinbarungen, Feststellungen

Action verantwortlich

Status of AI from Study kick-off:
AI-1 closed; AI 2 till AI-7
still open

Meeting agenda proposed by Estec, ref. SCI-PT/IF1/07165 is agreed

Signatures Unterschriften

Date Datum

Page Seite 1 **of** von 9

Action
verantwortlich

2. Introduction / Results of IID-B Review

see DSS-handout

PACS: principle instrument configuration (mass, shape of housing etc..) is not yet available

page 7 of handout: PACS prefers Model 2 to be taken into account

page 10 (of handout):
HIFI confirms that 2.1 mW conduction from 4.3K to 1.7K-level occurs in the Off-state too

page 9: the 4.5 mW at the 1.7K-level correspond to the average of 48h

page 5 (SPIRE):
Heatload figures will be updated by SPIRE. They are lower by about a factor of 5 for one detector configuration.

AI-01
SPIRE
closed during meeting, see Annex-01

Action
verantwortlich

Mechanical Analysis of Optical Bench

page 17: the preliminary design loads should be the same as for the instruments; ESTEC to check the design limit loads

AI-05
ESTEC
05. Nov. 99

One main result is that an aluminium sandwich structure does not fulfill the 100 Hz eigen-frequency requirement. Search for solutions shall not be limited to sandwich structures.

Optical Bench Thermal Concepts

HIFI has not to be thermally insulated.

Page 30: ~~SPIRE will provide comments (update of figures / complete design data~~

(item covered by AI-07)

The SPIRE cover is made of aluminium with tbd coating.

page 31: The Dissipation for the detector arrays shall read 1.0 mW (instead of 0.8 mW). The temperature requirement 2.2 K. The aperture size is $0.002\ mm^2$, shall have an emissivity of 0.4.
No MLI around the box shall be considered in the thermal model.

Signatures Unterschriften	Date Datum	Page Seite 4 of von

	Action verantwortlich
4. Optical Interfaces	
SPIRE provides beam pattern sections wrt cryostat openings (see Annex- of this MoM)	see Annex-7
Requested input from other instruments is already covered by AI's of KoS-off	see Annex-4 for definition of cut planes
5. Optical Bench Design Concepts	
see handout;	
The interface locations of the cooling straps at the instruments have been roughly defined in the meeting (see Annex-5)	
The instrument fixation accuracies required at present are considered far too stringend (see Annex-6). Estec to reconsider necessity of requirements	AI-08 ESTEC PM#2
It is agreed that the level 1 He-tubing loop can be moved from the bottom to the top of the optical Bench	

Action
verantwortlich

7. Critical Inputs needed

see handout;

HIFI shall define the thermal radiation generated by the relatively warm parts of the oscillator beam.

The possibility to shield the local oscillator beam shall be considered.

It shall be investigated above what frequency level the required 15 g level applicable to the instruments can be reduced. AI-12 ESTEC 05. Nov. 99

PS for level Definition

	Action verantwortlich
Definition of level 1 temperatures:	
SPIRE: less than 6 K	
PACS: less than 4.3 K	
HIFI: less than 6 K	
Definition of level 2 temperatures:	
SPIRE:	
PACS: less than 15 K	
HIFI: less than 20 K	
The instruments are asked to conform the listed values	AI-13 SPIRE / PACS / HIFI
Definition of level 0 temperatures:	PM #2
SPIRE less than 2 K	
PACS less than 1.75 K	
HIFI less than 2 K	

Signatures Unterschriften	**Date** Datum	**Page** Seite 9 **of** von 9

Updated Thermal Budgets

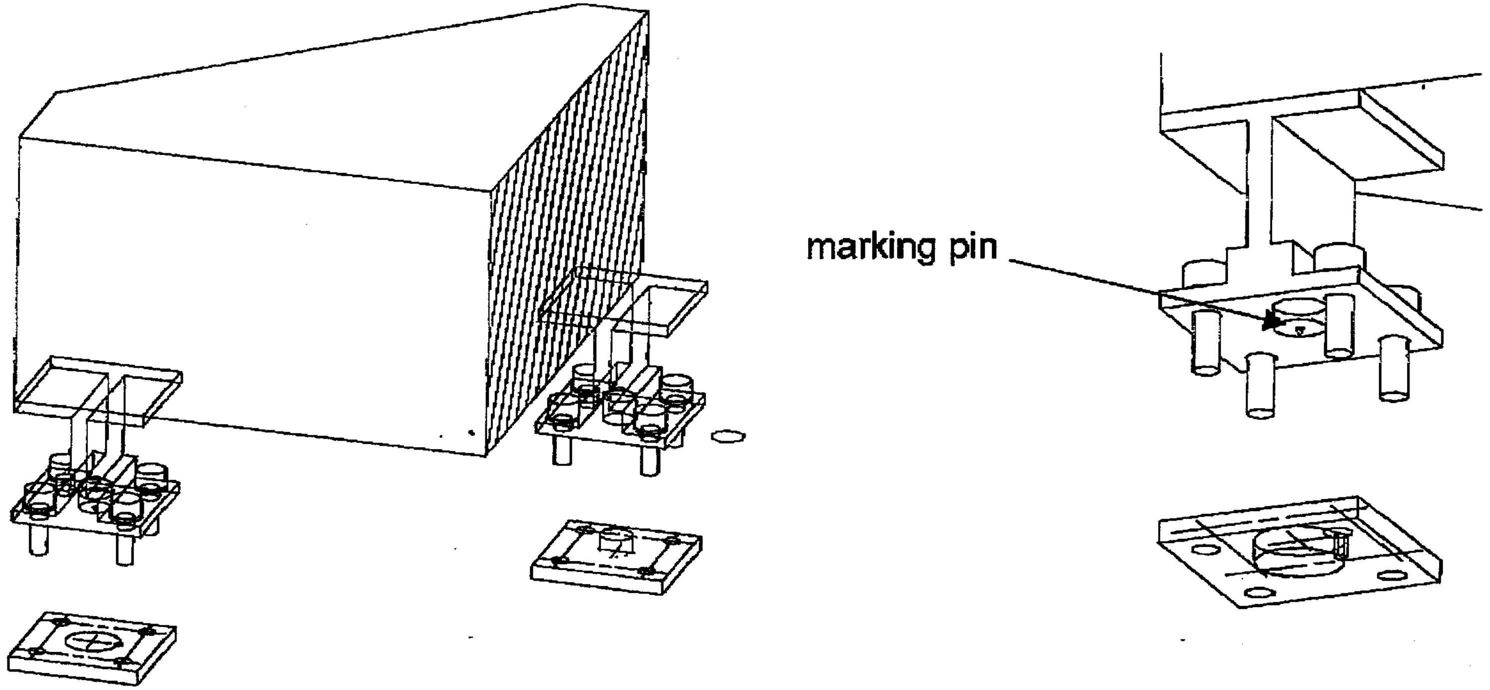
GSFC arrays (4x8 arcminutes FOV)

Temp. Stage	Item	Loads in mW (all TBC)			
		St'by	OFF	PHOT	SPEC
"15-K"		0	0	0	0
"4-K"	Wires	2.7	2.7	2.7	2.7
	Radiation	0.6	0.6	0.6	0.6
	Mechanisms & Calibrators	0.0	0.0	4.1	7.4
	Structure	2.0	2.0	2.0	2.0
	Total	5.3	5.3	9.4	12.7
"2-K"	Wires	0.36	0.36	0.36	0.36
	Dissipation	0.0	0.0	0.5	0.2
	Cooler	3.0	3.0	3.0	3.0
	Structure	1.0	1.0	1.0	1.0
	Total	4.36	4.36	4.86	4.56

Annex - 2/1

Position Alignment Proposal

- use of a common drilling jig for OB and experiments, or
- adaptation of the hole pattern as done by ISO



Annex 2/2

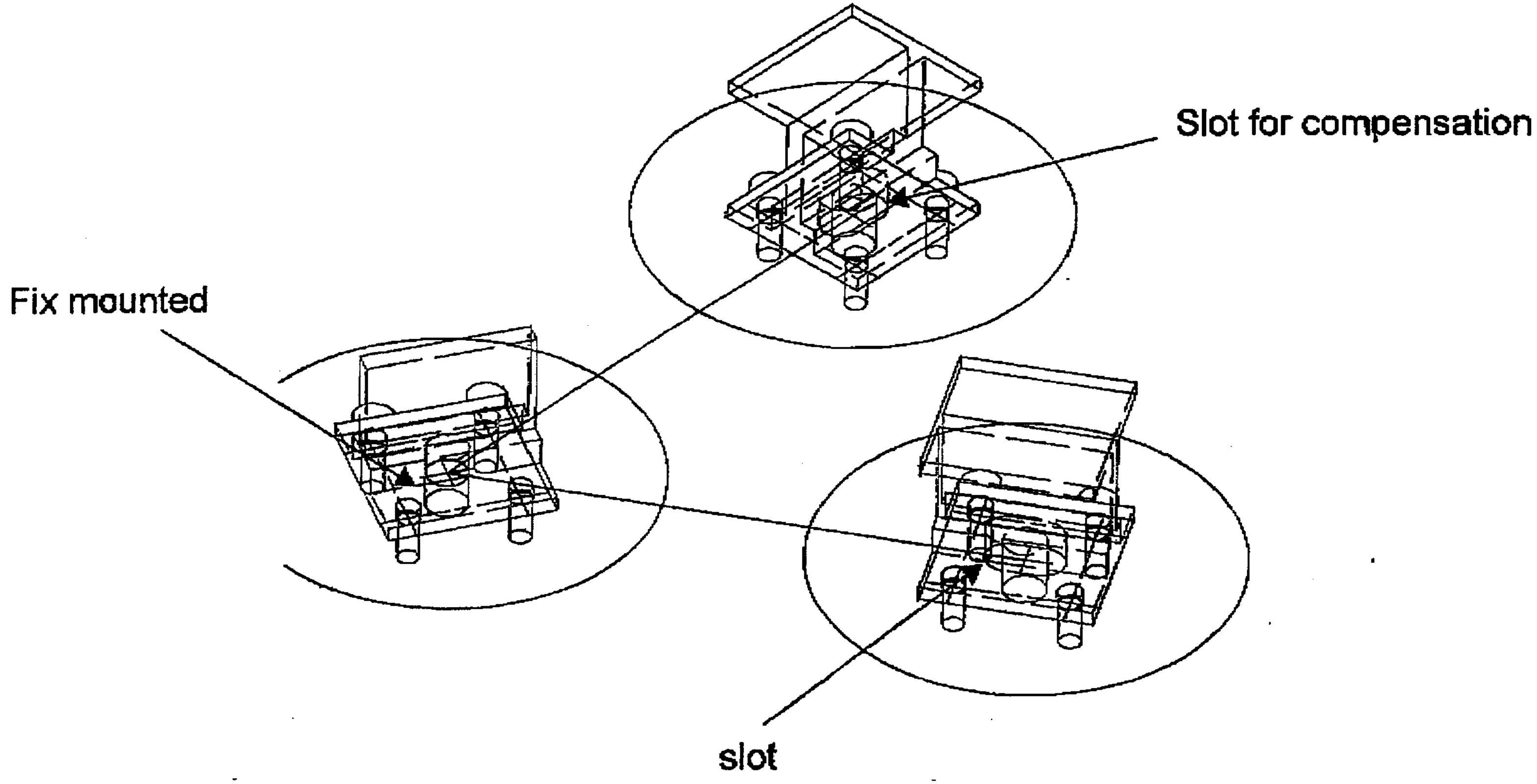
Compensation of Thermal Displacement -Proposal

- general principle:
  - one fixed mounted bracket
  - two flexible for compensation
- the fixed part can be a flange or bracket
- the floating can be:
  - slotted hole
  - flexible element
  - sliding on bolt
  - struts
- one axis flexibility in the direction of deformation is sufficient

Annex 2 / 3

Compensation of Thermal Displacement continuation

Slotted holes



Annex 2/4

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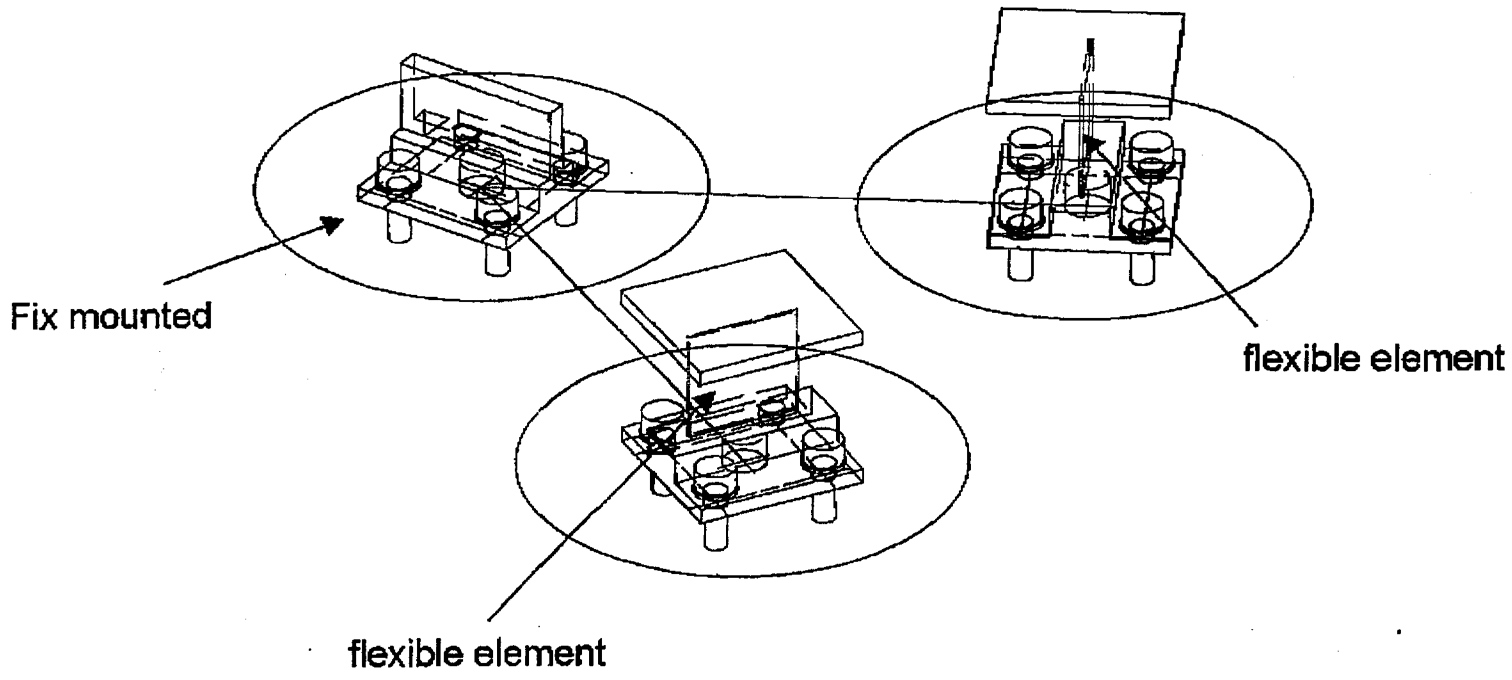
Space Infrastructure

Compensation of Thermal Displacement continuation

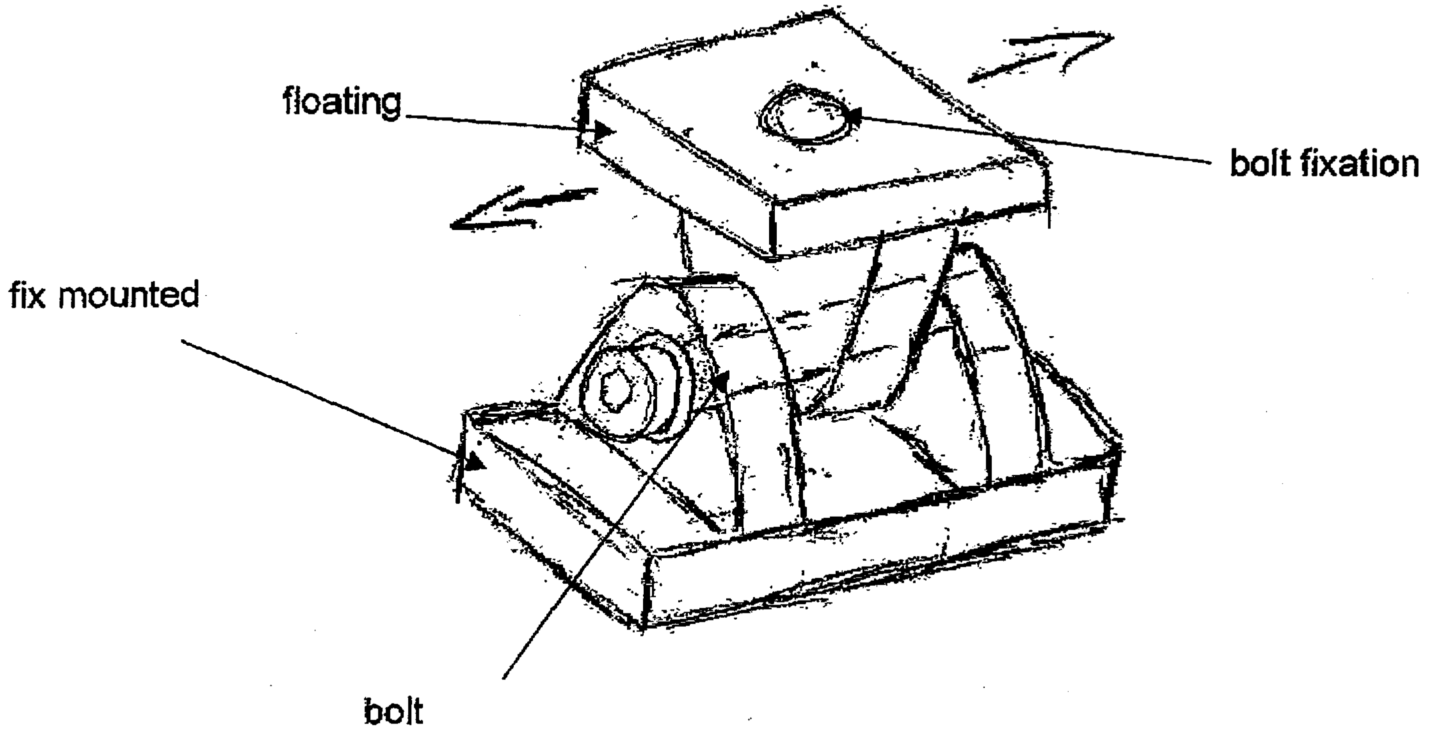
Flexible Element



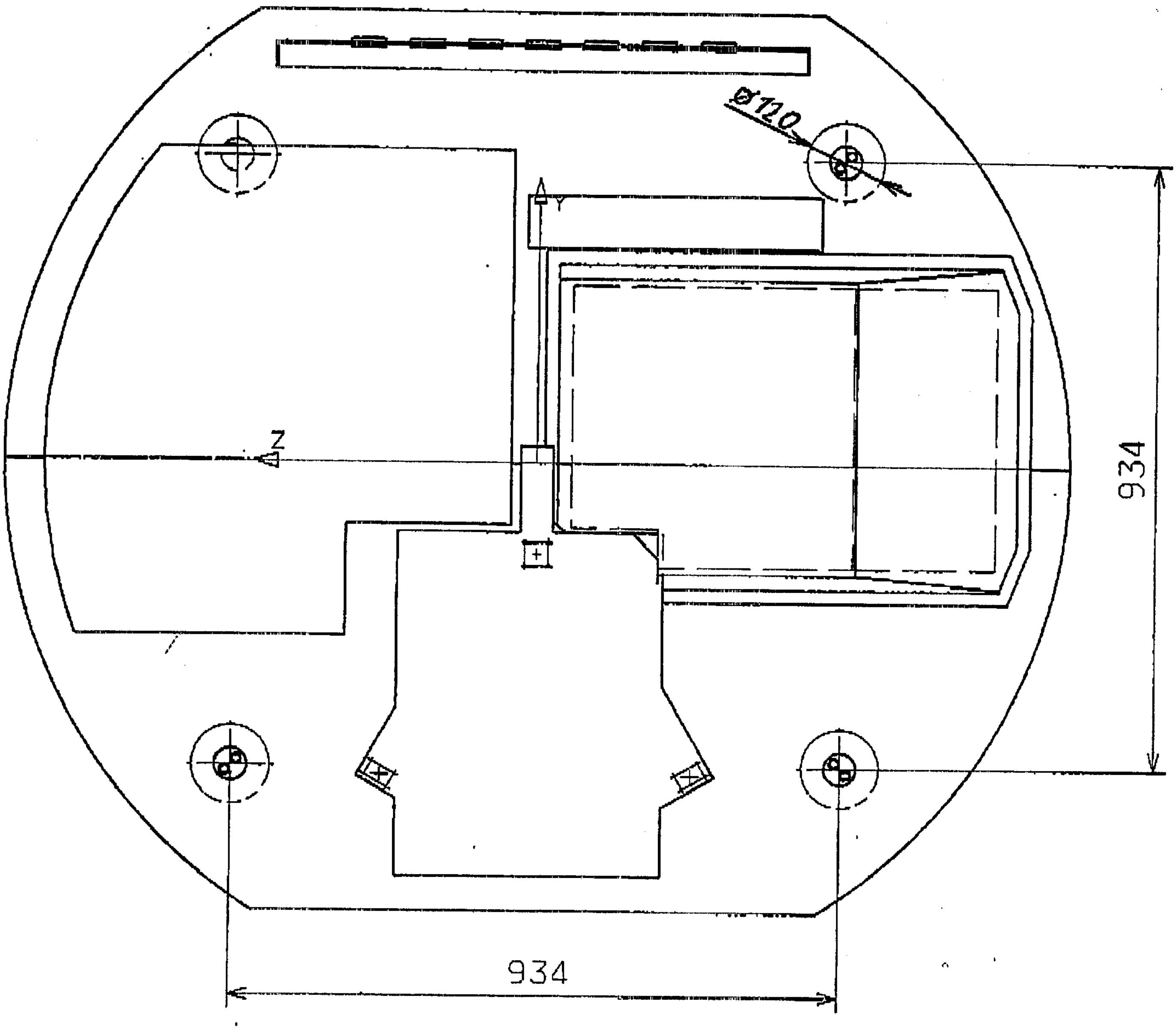
Annex 2/5

Compensation of Thermal Displacement continuation

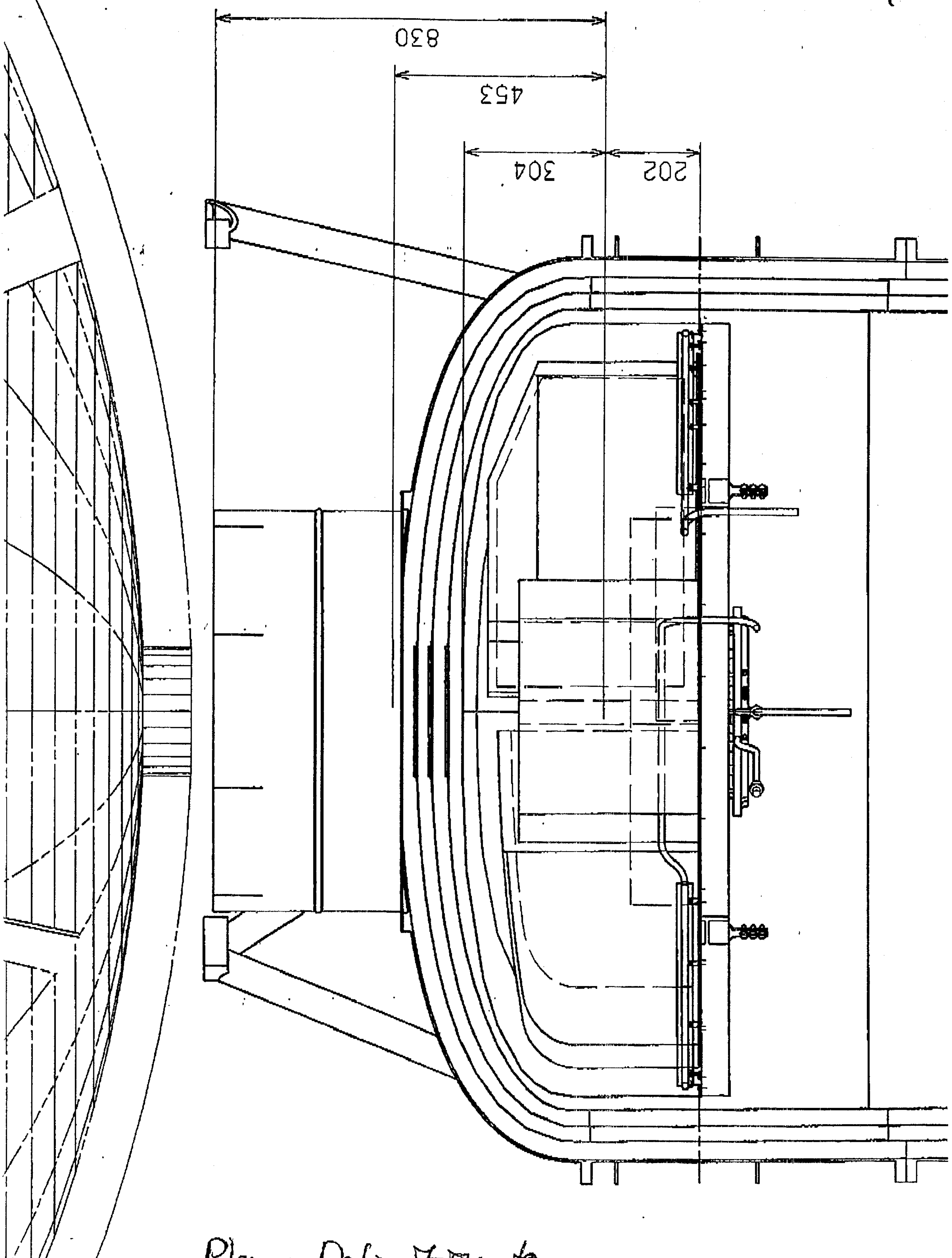
Sliding on bolt



Annex-3



Annex-4



Plane Definition to define optical beam cut-outs

Annex-5

FIRST

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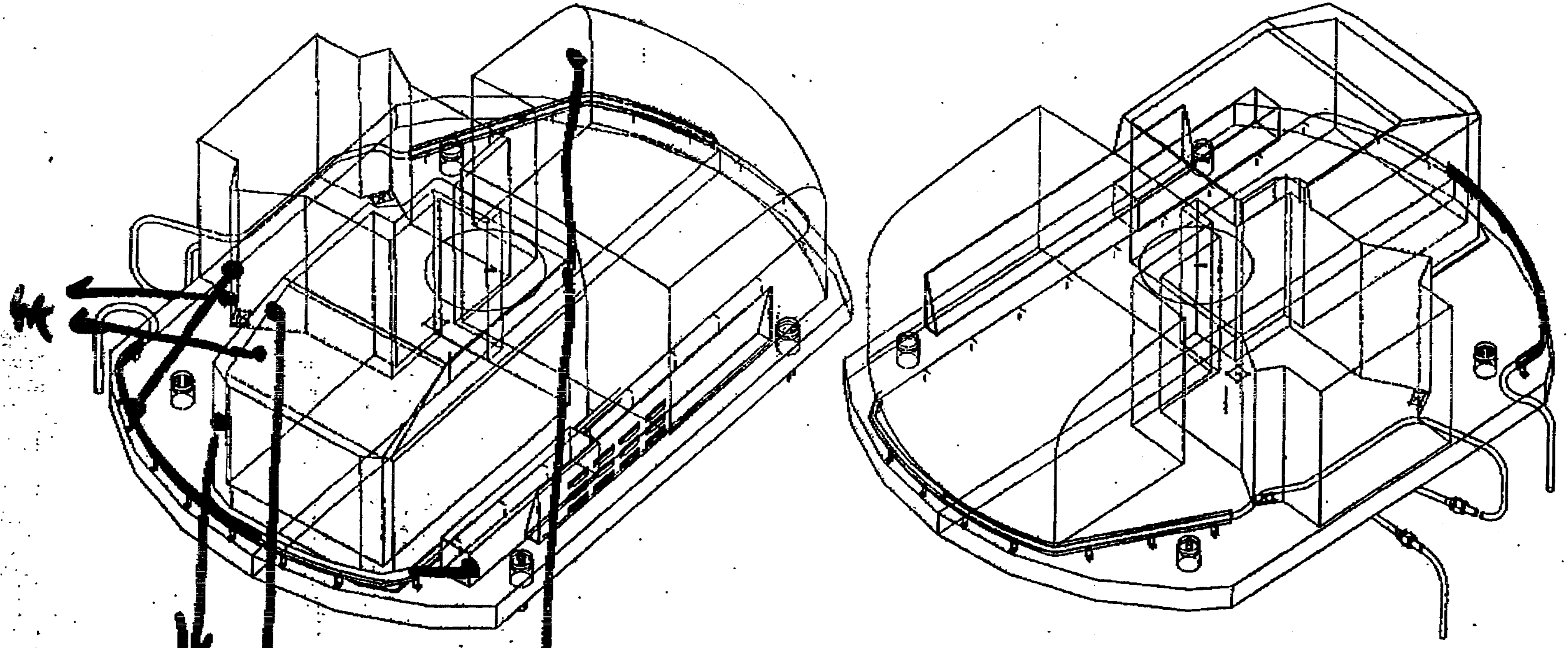
Space Infrastructure

Optical Bench Layout



Annex-6

Experiment Fixation Accuracy

- ~~Expected alignment accuracy:~~
  - ~~OB center wrt. beam:~~
    - ~~± 0,1 mm~~
- ~~required thermal stability values of OB:~~
  - ~~experiment reference point to OB center~~
    - ~~± 0,05 mm in plane~~
  - ~~experiment reference point to other fixation points~~
    - ~~± 0,05 mm in plane~~
  - out of plane:
    - ± 0,05 mm internal experiment
    - ± 0,1 mm between experiments

Annex - F

SPIRE	Technical Note SPIRE instrument beam sections in the cryostat space	Ref: SPIRE-RAL-NOT-000301 Issue: 1 Date: 29 September 1999 Page: 1 of 6

SUBJECT: **SPIRE instrument beam sections in the cryostat space**

PREPARED BY: **A G Richards**

KEYWORDS: **beams, cross-sections**

COMMENTS: **This document presents data on the expected size of the SPIRE instrument beams at various distances forwards of the instrument within the space presently occupied by the cryostat.**

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1. INTRODUCTION

In order to help the cryostat contractors tailor the cryostat apertures to fit around the beams defining the active views out of the FIRST focal plane instruments, this note presents some of the relevant data obtained for the SPIRE photometer and spectrometer. We present 2-D plots showing beam cross-sections at three places between SPIRE and the front of the space allotted to the cryostat. This graphical data can be supplemented on request with the original data that allows reconstruction of the beam boundaries at any plane in the beam path. IGES files can also be produced showing representations of the beam boundaries in 3 dimensions in any convenient co-ordinate reference frame.

2. OPTICAL GEOMETRY AND RAYTRACING

The CODEV representations of the SPIRE instruments, which are presently in use at RAL, are versions identified as PH126B (photometer) and SP460C (spectrometer). These permit reverse ray tracing from the respective detectors (rectangular 4' x 8'for the photometer, circular 1 3' radius for the spectrometer) outwards to the telescope space. The present telescope model places the pole of the primary mirror surface 975 mm forwards of the telescope's axial back focus and the pole of the secondary 1720.3 mm further forwards of the primary. Therefore the model does NOT yet include the proposed 'thick' primary telescope model.

In order to be able to define each detector's active view, several points uniformly spaced around the edge of each detector (24 photometer, 8 spectrometer), together with one point in the centre of eachd detector, were taken as sources of 37 rays. One ray from each source point, the chief ray, was traced through the centre of the chosen entrance pupil-defining aperture (pupil stop), the other 36 from each source point being traced through points uniformly distributed around the boundary of the pupil stop. The (x,y,z) intersections of each ray with all relevant surfaces was output in a global co-ordinate system to an ASCII text file. The global co-ordinate system chosen was that centred on the location of the axial back focus of the telescope, 975 mm behind the pole of the primary mirror surface on the axis of symmetry of the telescope with +Z towards the focal plane instruments. The Z co-ordinate of the primary in this system is therefore Z= -975mm. The +Y direction is in the fold plane of the SPIRE photometer pointing towards the SPIRE entrance aperture.

The photometer has a two-axis steering mirror, M4, which is intended to displace the detector field of view by +- 2 arcminutes on the sky in a direction orthogonal to the fold plane (X direction) and by about +- 0.5 arc minutes on the sky parallel to the fold plane (Y direction). The rays were therefore traced through the photometer for several combinations of two-axis tilts that covered the extremes of each range, producing one data set for each combination of the two tilt angles. The photometer therefore has a range of active views that have eventually to be combined into a composite instrument view through the cryostat and telescope.

3. OUTPUT DATA AND PROCESSING

The data files containing ray intercept co-ordinates were used as input to MATHCAD analysis documents. Two parallel planes were selected in a relevant space between two of the surfaces at which intercepts were evaluated and listed and the boundaries of the beams from all object points were displayed so that a single boundary curve could be estimated and parameterised. Figure 3-1 is an example. This shows the boundaries of the 'views' from all 25 object points on the photometer detector for one combination of M4 tilts, together with an outer dashed line boundary, flagged with diamond symbols. This composite boundary has been sizeded to clear the overlapping boundaries by a positive margin of about 1 mm all round. It has been found possible to parameterise the beam between any two suitably chosen analysis planes by determining just two sets of composite boundary points, one in each of the planes, and just interpolating between ordered pairs of points (one from each plane) to any intervening plane. Thus boundary for the photometer beam at any plane located between axial locations approximately 100 and 1175 mm from the focal surface can be accurately determined using two suitably chosen sets of 41 points in each of these planes. This Z-range covers the space occupied by the cryostat and centre of the primary mirror.

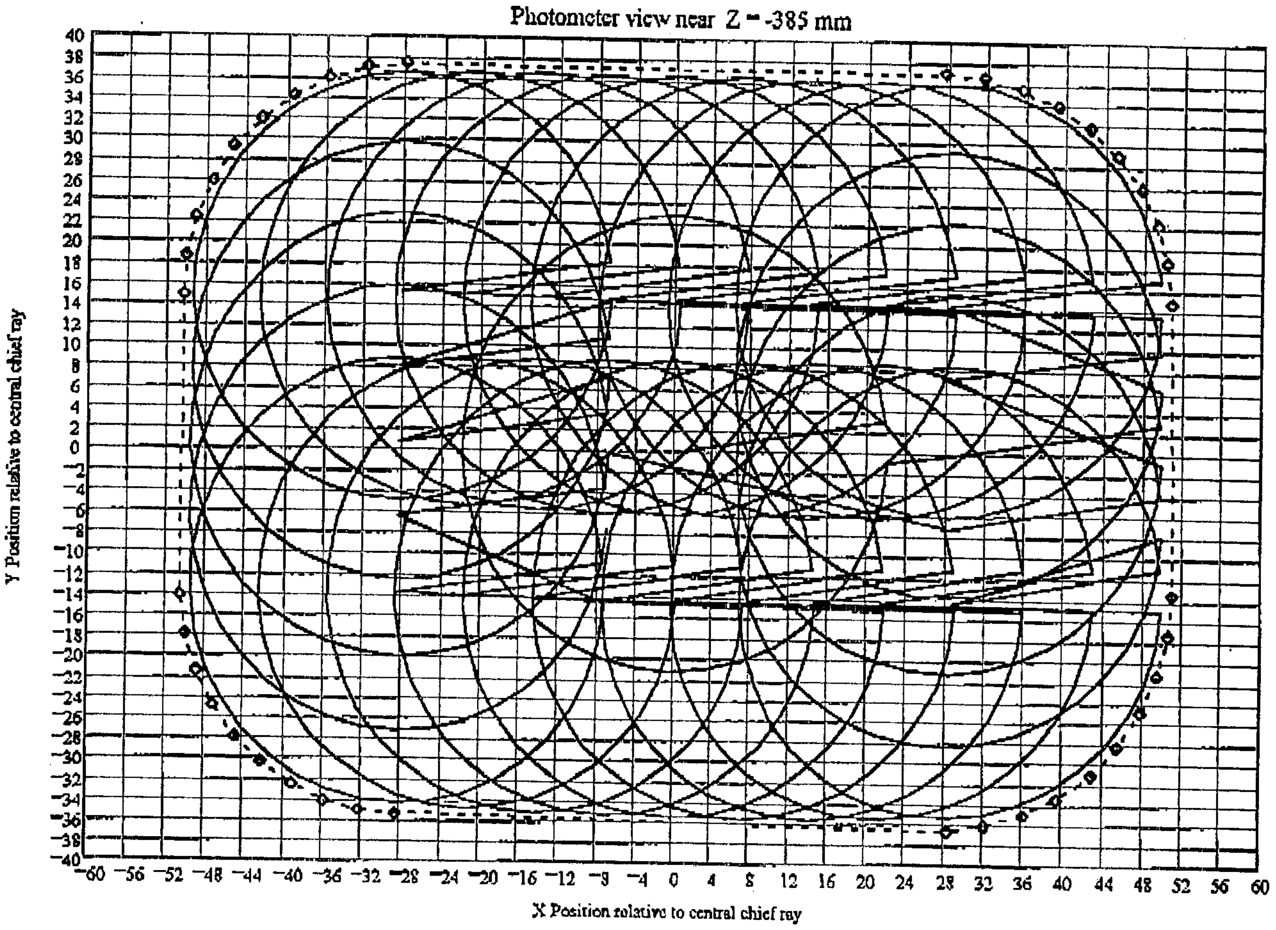

Figure 3-1 Photometer view approximately 385 mm forwards of telescope focal surface

As well as the two sets of 41 points used to define beam boundaries in two parallel planes, the MATHCAD analysis uses them to generate beam boundaries at intervening planes by interpolation. This data is converted to a convenient co-ordinate reference frame and then output in a suitable format to 3-D vector plot files. These plot files enable the beam to be visualised and they can also be converted into IGES files suitable for importing into a CAD system. Figure 3-2 shows such a visualisation of the beam, a section of which is represented by the dashed line in figure 3-1.

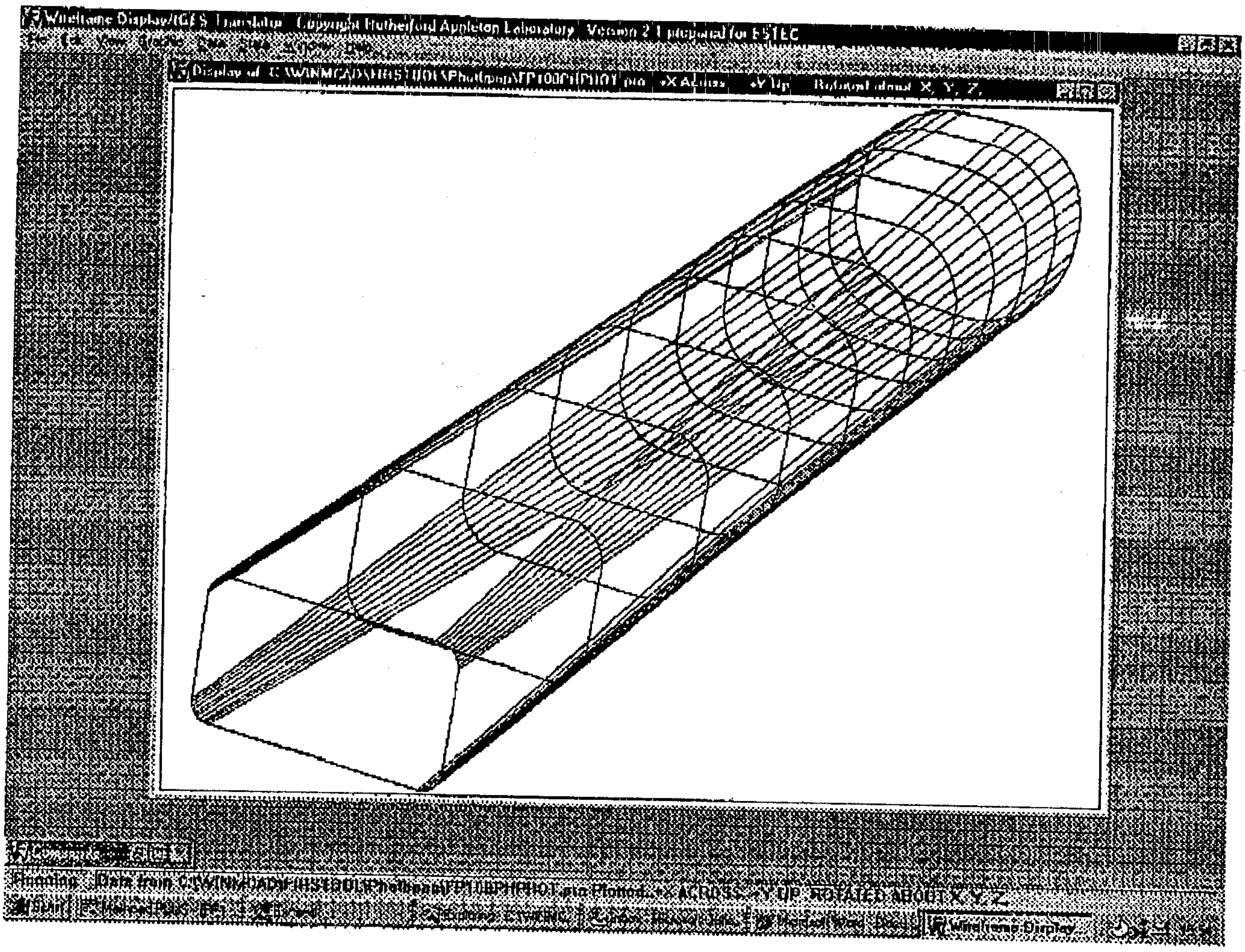

Figure 3-2 View of a 3-D representation of a composite photometer beam boundary

4. COMBINED BEAM SECTIONS

Figures 4-1, 4-2 and 4-3 show the combined boundaries of beams from both SPIRE instruments. The spectrometer beam is the roughly circular one to the left. This was produced for a single setting for the M4 mirror, in the centre of its range of tilts in both axes. Several overlapping boundaries are shown for the photometer, one for each of the four extreme pairs of tilt angles and two for the two extreme Y tilt values at the central 'zero' X tilt position. For the case where M4 tilts the photometer view away from the spectrometer FOV (X tilt), the beam representing the rightmost 2 arc minutes of the detector has been excluded. This reflects the fact that M3 will not be extended in that direction enough to cover more than the central 4 arc minute square when it is given a 2 arc minute tilt offset in this direction.

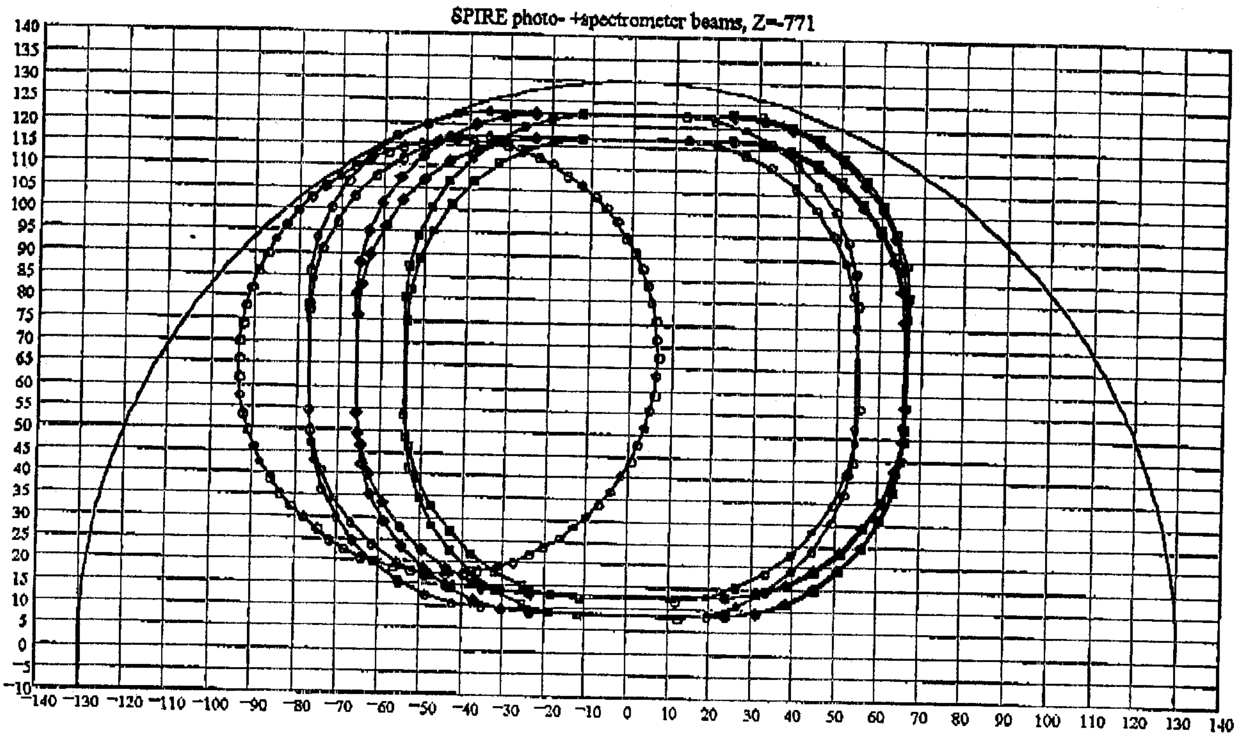

Figure 4-1 Composite beam boundaries at 771 mm forwards of the telescope axial focus

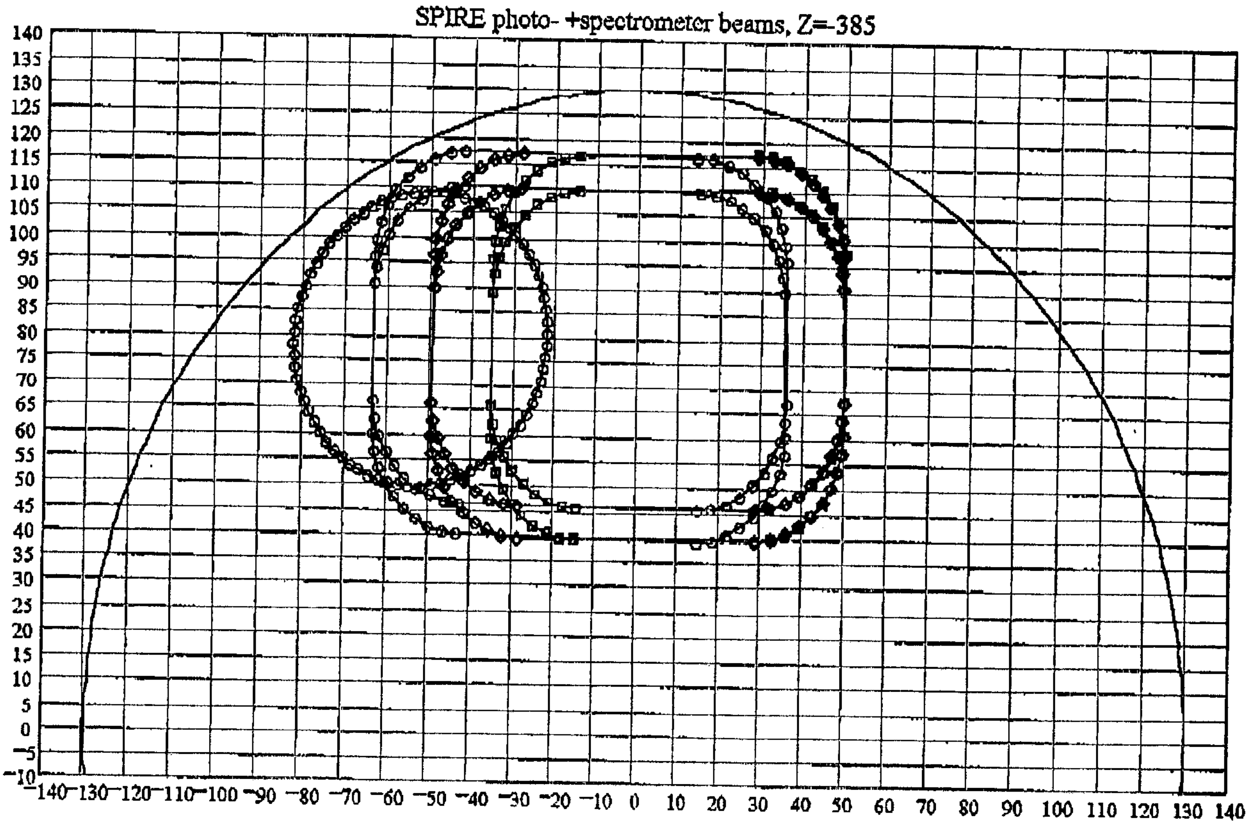

Figure 4-2 Composite beam boundaries at 385 mm forwards of the telescope axial focus

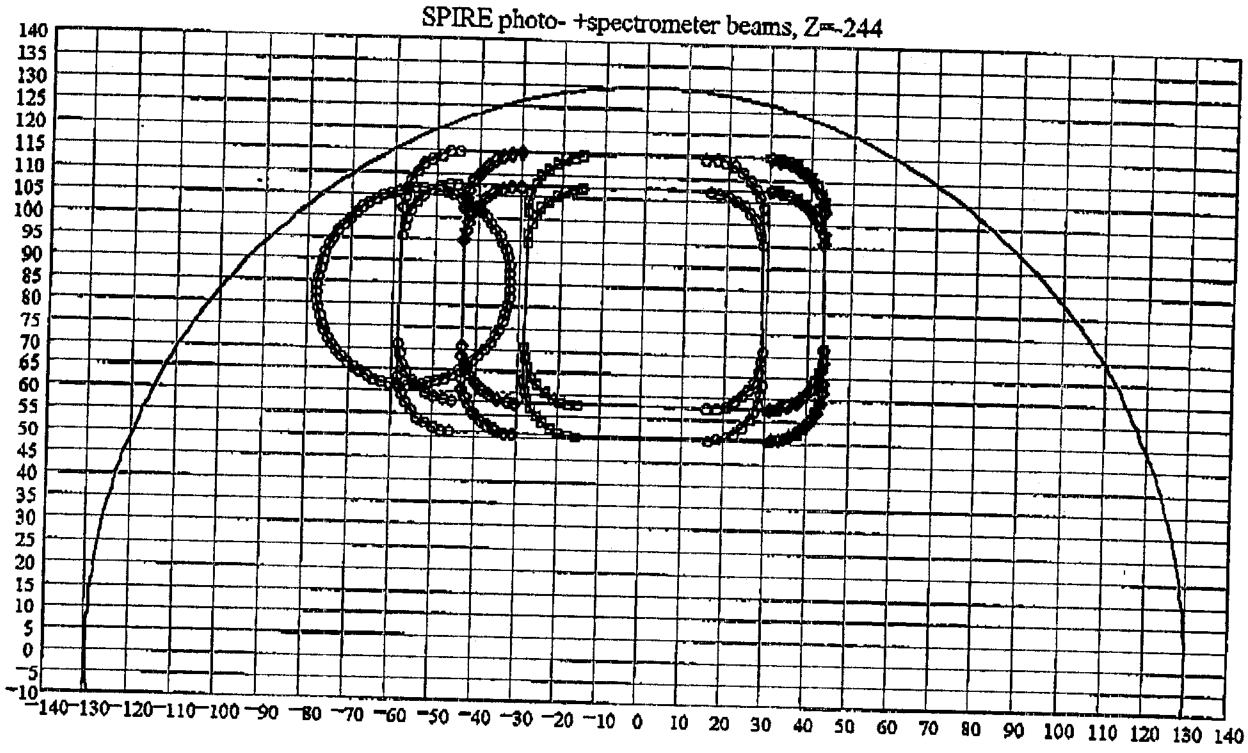

Figure 4-3 Composite beam boundaries at 244 mm forwards of the telescope axial focus

The Z co-ordinates chosen for the illustrated sectional planes (-771, -385 and -244 mm) represent respectively the approximate locations of the front opening to the cryostat, the cryostat vent closure plate and the rearmost heat shield nearest the focal plane instruments. These dimensions reflect the cryostat design that existed at the time of the original FIRST payload module study. The 130 mm radius semi-circular boundary drawn on each figure represents the size of the openings in all the cryostat shields that are included in the cryostat model presently used for straylight analysis. All dimensions shown in the figures are in millimetres.

5. REQUESTS FOR FURTHER DATA

Please e-mail me at A.G.Richards@RL.AC.UK if the text data files referred to above are needed and I will endeavour to satisfy your requirements.

Annex - 8

S **HIFI**	**TECHNICAL NOTE**	**Hifi no.: SRON-G/FPU/TN1999-003** **Inst.no.: HIFI - FPU** **Issue: 1** **Date: June 23, 1999** **Category: -**

Title: Thermal budget of the HIFI-FPU

Prepared by: K.J. Wildeman/C. van Baren date: June 23, 1999

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Table of Contents

S HIFI	TECHNICAL NOTE	Hifi no.: SRON-G/FPU/TN1999-003 Inst.no.: HIFI - FPU Issue: 1 Date: June 23, 1999 Category: -

1. Introduction:

This note is a reaction on action item AI-HIFI-23. "Provide a detailed break down on thermal budget in the FPU". It presents the thermal budget of the FPU based on a preliminary analysis and present (preliminary) design.

2. Comments to the table

- The overall thermal load of the FPU to the S/C cryogenic system appears to be within the HIFI proposal thermal budget for the 1.7K strap, but not for the 4.3K level assuming the FPU is at 15K.
- The main contribution to the thermal load is the parasitic loss (conduction) through the mechanical supports of the mixers and straps on the instrument. Presented figures reflect the use of Vespel tubes (3 mm outer diameter and 100 micron wall thickness) for the support. The critical parameter is the buckling of the tubes, which limits the wall thickness for a given mass of 100 grams of mixer + isolator. Further reduction of these parasitic losses will be difficult using this technique. These figures are based on mechanical analysis only, tests will be performed on short notice. Preliminary results resonance frequency for 100 gr mass approx. 150Hz.
- If the FPU temperature is reduced from 15K to 10K the parasitic losses to the 4K level will be reduced with a factor of 0.38, in which case these losses are within the HIFI proposed budget.

In the table below the reduction factor is given for several FPU temperatures:

FPU temperature	Reduction factor of parasitic losses to 4.3K level (w.r.t values in the tables on page 3 and 4)
15K	1 (-0%)
12K	0.59
11K	0.48
10K	0.38
9K	0.29
4K	0 (-100%)

- A preliminary design shown in fig.1 (page 9) has a "moving" mass of approx. 150 gr including mixer, isolator and console parts, which has to be supported by the vespel tubes.

  The total mass of a complete mixer console including base plate will be approx. 200 gr.

- The thermal straps are stacked (0.3K to 1.7K to 4.3K strap) to reduce the losses to a minimum. The strapping on the FPU assumes a rigid strap (with a high stiffness to mass ratio) in order to minimize the number of vespel supports. To increase the frequency of the strap on its supports it may be necessary to use kevlar tension cords.
- The data presented here is based on mechanical analysis of single components, the analysis of the complete thermal system of mixer consoles with strapping has not yet been performed.
- The radiation contribution of the focal plane dome, at 20K, to the FPU at 15K assumes a black dome surface and a FPU surface with an epsilon of 0.1
- The local oscillator ports are at 80K. These ports radiate thermally into the FPU. In the next tables it is assumed that this heat is absorbed in the 15K FPU optical components completely. However this is still uncertain. If all radiation is reflected 100% towards the mixer units the extra heat load to the 1.7K level is 2.1 mW and to the 0.3K level 0.8 mW (800 microW!).
- The IF cable from the mixers to the first stage amplifiers has the second largest contribution. A trade off between performance of the cable (signal attenuation) and thermal losses is necessary. In the analysis a stainless steel coax cable has been suggested with no copper clad, of which the attenuation is probably not acceptable. A coax with a copper clad has factors higher parasitic loss. Other possibilities are the use of superconducting niobium with low thermal conductivity. This is presently under investigation.
- Amplifier dissipation depends strongly on type and number of stages. This is under development.
- For the HEB mixers: the support has not been designed yet. There is an agreement that JPL will design the mixer (0.3K) with support, which is mounted directly to the 1.7K platform. Using kevlar suspension cords the parasitic losses of 1 microWatt seem to be feasible. Creep effects of the cords, detector position stability and repeatability are major concerns here.
- The signal connection between the HEB mixer (0.3K) and the isolator (1.7K) cannot been done by a standard coax cable due to high conduction. A niobium microstrip supported of a kapton film is a solution. A trade off between strip dimensions, signal attenuation en thermal losses to reach an optimum has to be done.

- Heater power to increase SIS junction temperature to TBD K (temporarily action for annealing purposes) not yet included in this technical note.

3. HIFI FPU Thermal Analysis Results

Loads on S/C thermal system

SIS mixers operating:

	0.3K	1.7K	4.3K	15K
2 mixers		0,01		
2 IF amplifiers				20,00
Magnet bias wire			1,10	
Mechanisms.(chopper + diplexers)				4,00
Calibrator				2,00
Cryocooler				
Total load dissipation	0	0,01	1,10	26,00

Mixer support		0,72	3,60	
IF Preamp support				
Cold strap support		0,40	0,60	
IF cable		0,48	2,20	
Mixer bias wire		0,04	0,14	
Sensor wire		0,00	0,06	
IF bias wire		0,04	0,14	
Magnet wire			1,10	
Cryocooler wire		0,00	0,01	
Cryocooler support			0,30	
Heatswitch support		0.41		
Total load conduction	0	2,09	8,06	8,15

Radiation from 15K housing internally		0,10	0,10	-0,20
Radiation from focal plane dome to FPU				0,40
Radiation from LO port to mixers		0,00		2,87
Total load radiation	0	0,10	0,10	3,07

Overall [illegible]	0	2,20	7,26	20,92
Proposed by HIFI [illegible]	[illegible]	4,10	4,30	21,00
Instr. I/F Doc. Part A, total 3 FP instr's		2,50	10,00	25,00
	microW	mW	mW	mW

S **HIFI**	**TECHNICAL NOTE**	**Hifi no.: SRON-G/FPU/TN1999-003** **Inst.no.: HIFI - FPU** **Issue: 1** **Date: June 23, 1999** **Category: -**

HEB mixers operating:

	0.3K	1.7K	4.3K	15K
2 mixers	1			
2 IF amplifiers				20,00
Magnet bias wire				
Mechanisms.(chopper + diplexers)				4,00
Calibrator				2,00
Cryocooler		2,40		
Total load /dissipation	1	2,40	0,00	26,00

Mixer support		0,72	3,60	
Mixer support	1,0			
IF Preamp support				
Cold strap support	3,0	0,40	0,60	
IF cable (microstrip for 1.7K -> 0.3K)	2,0	0,48	2,20	
Mixer bias wire	1,0	0,08	0,14	
Sensor wire	1,0	0,00	0,06	
IF bias wire		0,04	0,14	
Magnet wire			1,10	
Cryocooler wire		0,00	0,01	
Cryocooler support			0,30	
Heatswitch support		0,41		
Total load conduction	8,0	2,12	6,02	8,15

Radiation from 15K housing internally	0,33	0,10	0,10	-0,20
Radiation from focal plane dome to FPU	1,03			0,40
Radiation from LO port to mixers	0,00	0,00		2,87
Total load radiation	1,35	0,10	0,10	3,07

Overall	10,4	4,62	6,12	20,82
Proposed by HIFI	10*	6,50	3,20	21,00
Instr. I/F Doc. Part A total 3 FP instr's	[illegible]	2,50	10,00	25,00
	microW	mW	mW	mW

* Cryogenic sorption cooler technical requirements for engineering model (ESA contract).

Cooling power budget 10 microW at 0.3K detector temperature for 48 hrs.

** If all 80K radiation from two LO ports will be passed through without losses to the 0.3K mixers this load is 0.8 mW on the mixers

Preliminary design option of mixer console

Fig. 1a and 1b Preliminary design option of mixer console using vespel tubes. Mixer and isolator are supported on the 1.7K level via 4.3K level to

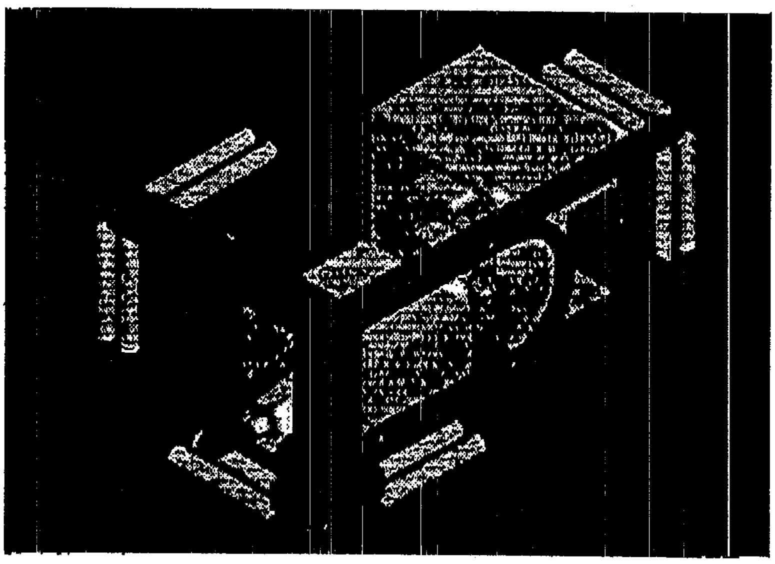

Fig. 1a

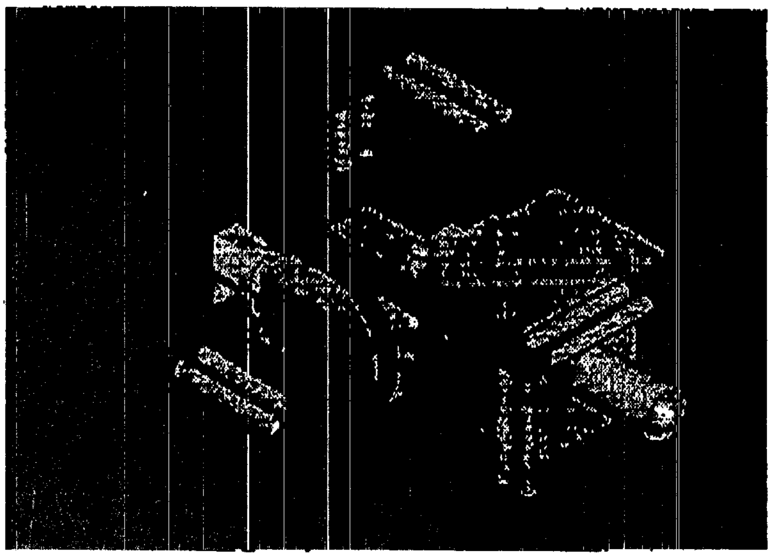

Fig. 1b