FIRST Focal Plane Commonality Meeting
QMW London April 7, 8 1999

DRAFT AGENDA

Day 1: April 7

13.00 Introduction and review of the agenda Griffin

Then BRIEF presentations by the three instrument teams (about 15 min per instrument: 45 - 60 min per topic):

13.30 Stray light etc.
- Stray light model(s)
- Black materials
- LO window
- Etc.

SPIRE: Richards/Ade
PACS :
HIFI :

14.30 Filters/dichroics

SPIRE: Ade
PACS :
HIFI :

15.30 On-board calibration sources

SPIRE: Griffin
PACS :
HIFI :

16.30 Systems engineering/commonality issues
- Internal wiring and connectors
- Temperature sensors
- Contamination requirements
- EMC modelling and analysis
- Cold vibration test facility
- Ionising radiation testing

SPIRE: Cunningham
PACS :
HIFI :

17.30 Discussion and definition of the agenda for Day 2

18.00 End Day 1

Day 2: April 8

~~10.00~~ 09.00 **Mechanisms**

- Requirements/specifications
- Plans for implementation/procurement
- Mechanism position measurement

SPIRE: Cunningham/Swinyard
PACS : Renotte
HIFI : Wildemann

10.00 **Thermal/mechanical engineering**

- FPU structural designs
- Materials - properties testing procurement
- Thermal strap implementation
- ^{3}He coolers

SPIRE: Swinyard
PACS : Geis
HIFI : Kruizinga/van Baren

11.00 - 13.00 - Splinter meetings

1.	**Filters etc.**	(Ade)	**Physics 601**
2.	**Mechanisms**	(Swinyard)	**Physics 112**
	Alignment Working Group (12.00 – 16.00)		**Main Conf. Room**

13.00 **Lunch**

14.00 - 15.00 **Splinter meetings (continued)**

2.	**Stray light**	(Richards)	**Physics 601**
3.	**EMC**	(Griffin)	**Physics 112**

15.30 **Conclusions/actions/future plans**

16.00 - 16.30 **Meeting ends**
Visit QMW lab. for those who have the time

FIRST Focal Plane Commonality Meeting, 7 April 1999

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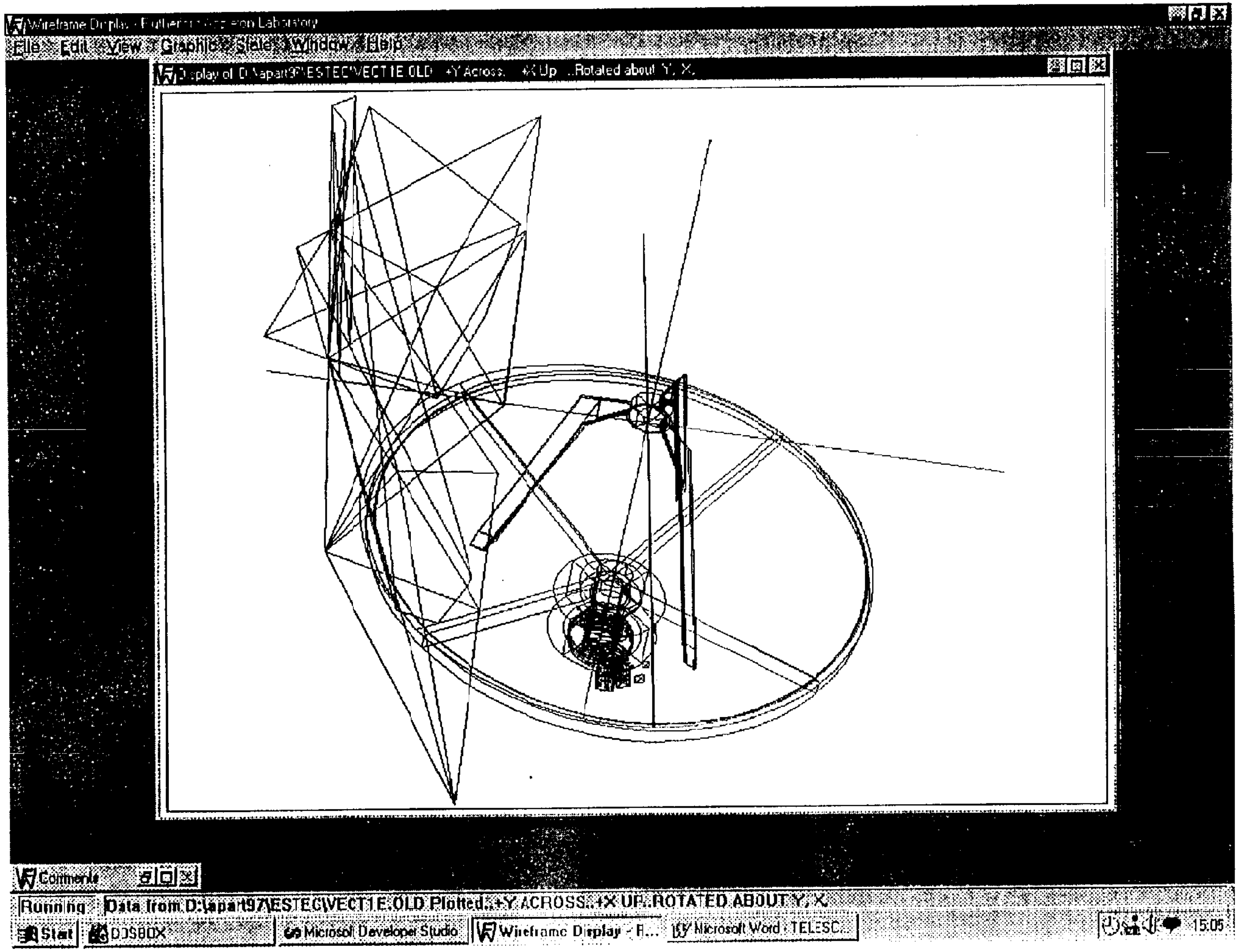
FIRST FPU Commonality Meeting
QMW, April 7, 8 1999

Aims of the meeting

- Review FPU technologies of common interest to the three FIRST instruments
- Initiate exchange of information, ideas, expertise
- Explore any possibilities for collaboration and cost reduction

STRAY LIGHT

TONY RICHARDS



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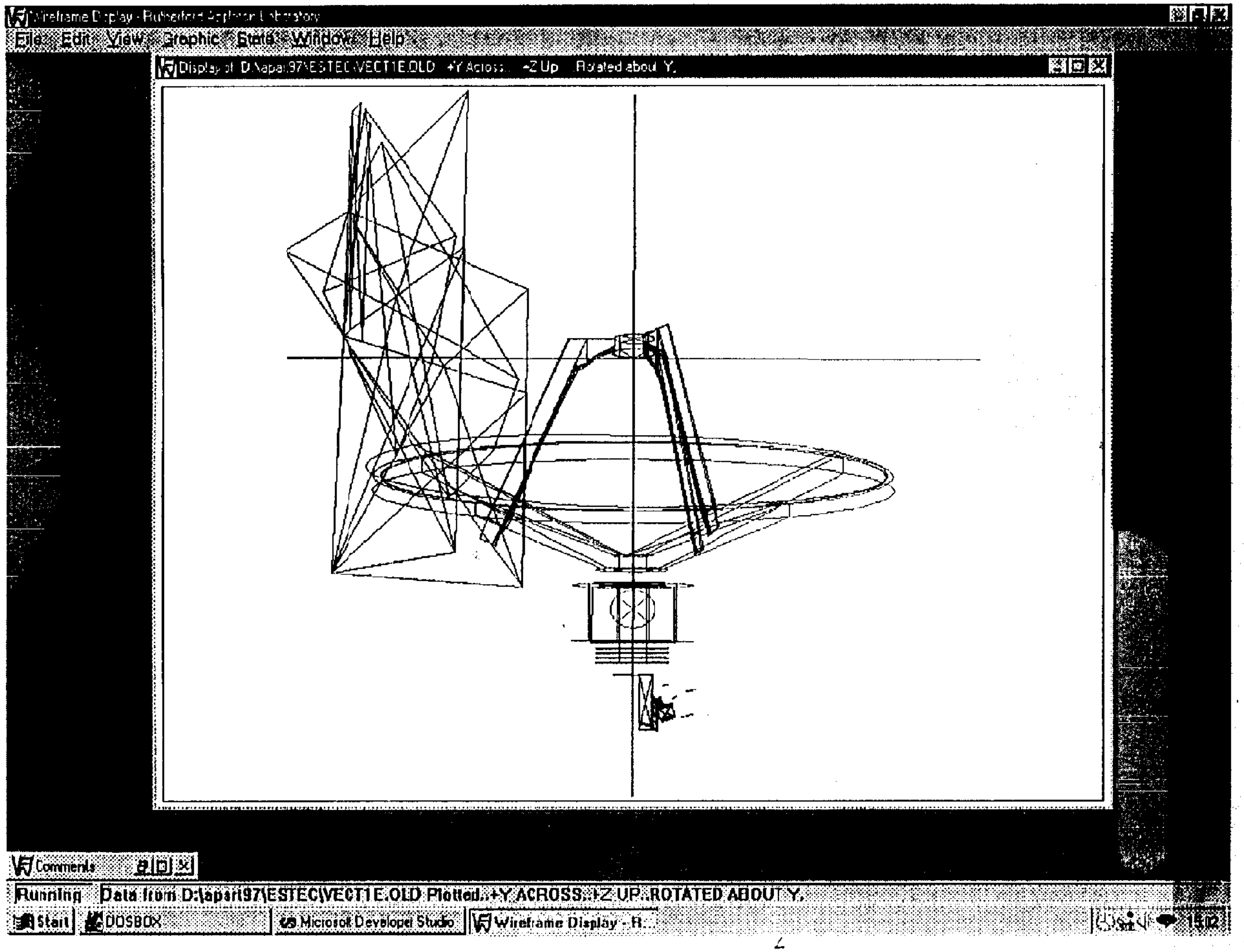

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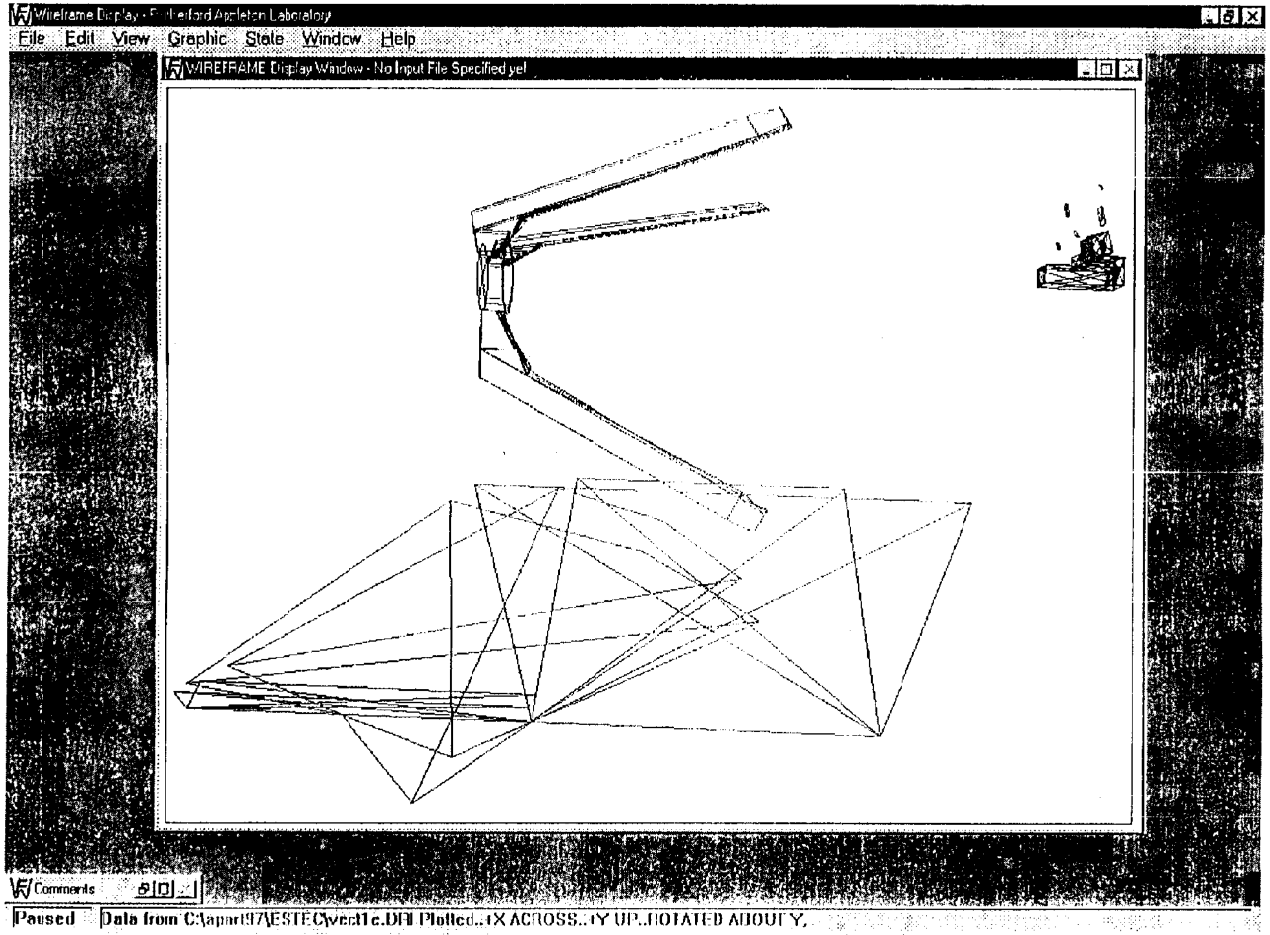

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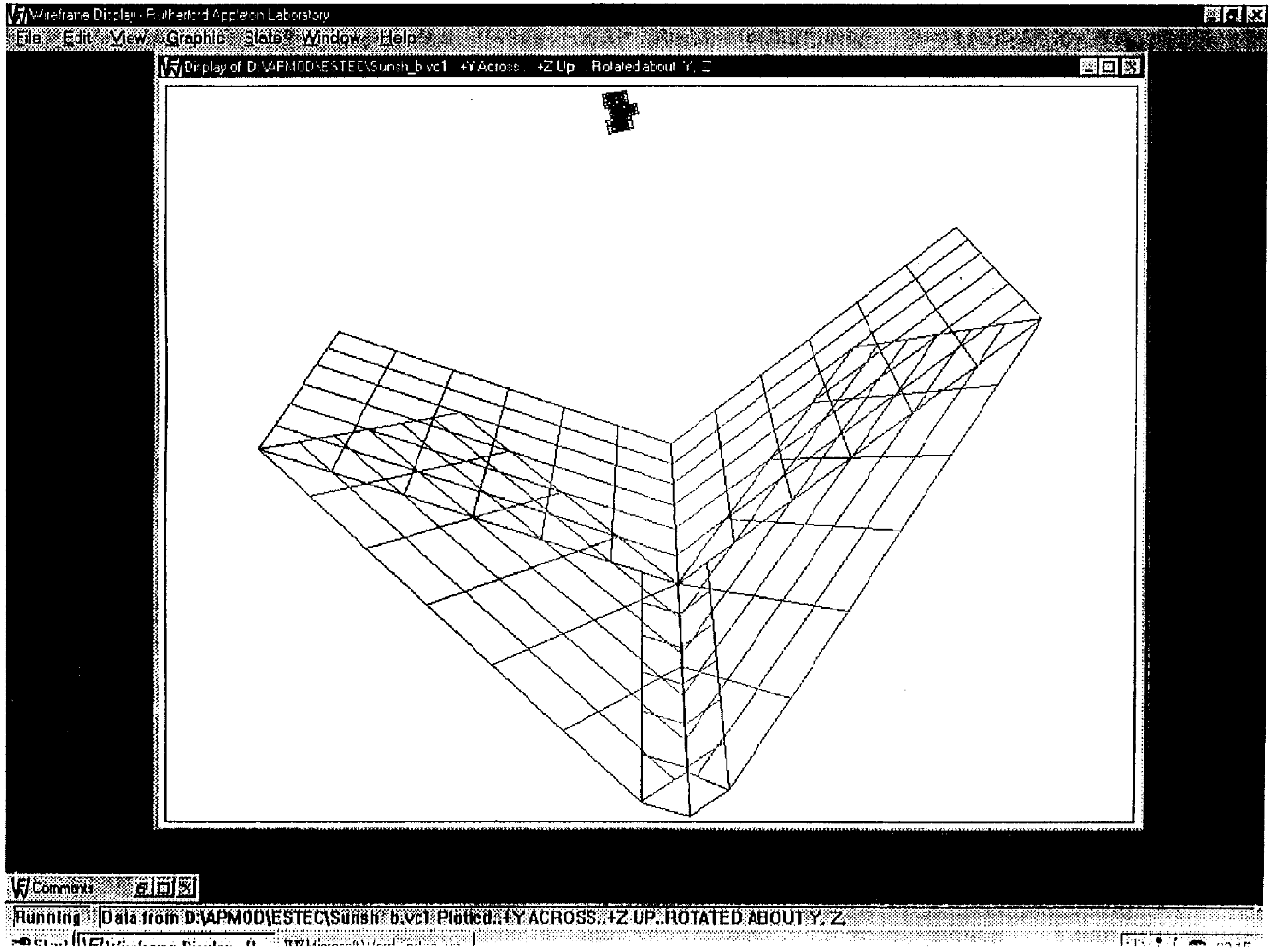

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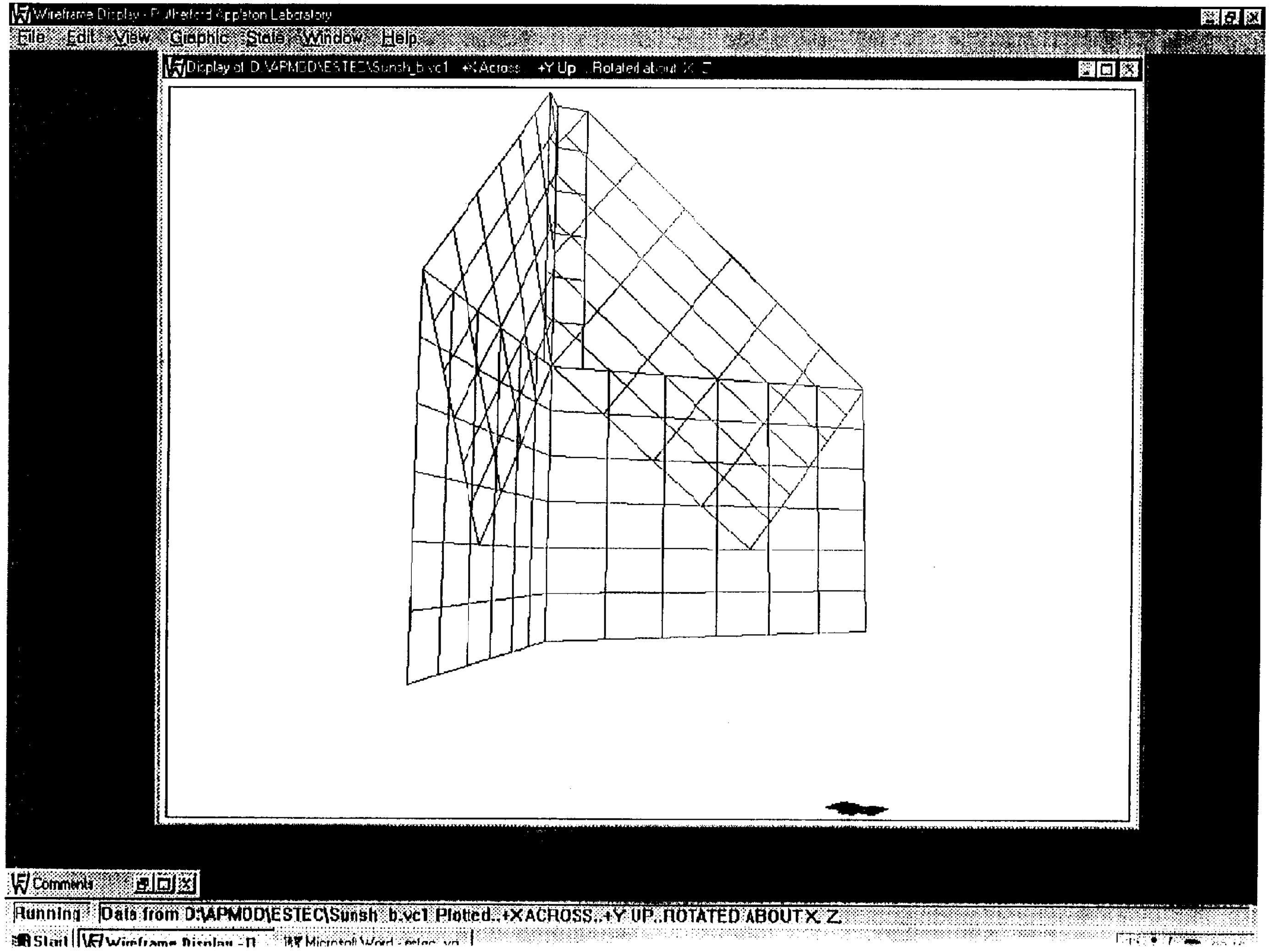

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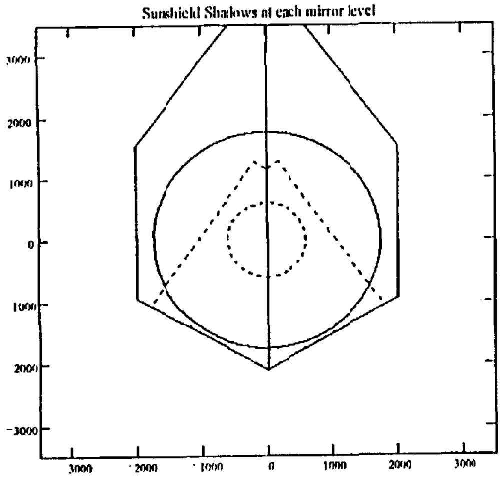
SHADOWING EFFECT OF THE SUNSHIELD

source elevation from boresight = 65 degrees

source azimuth = -Y direction



SHADOWING EFFECT OF THE SUNSHIELD

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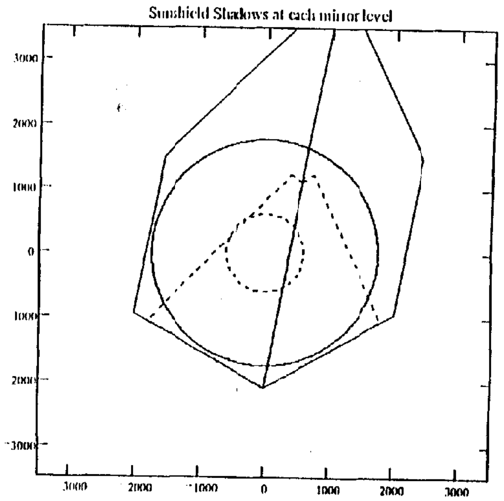
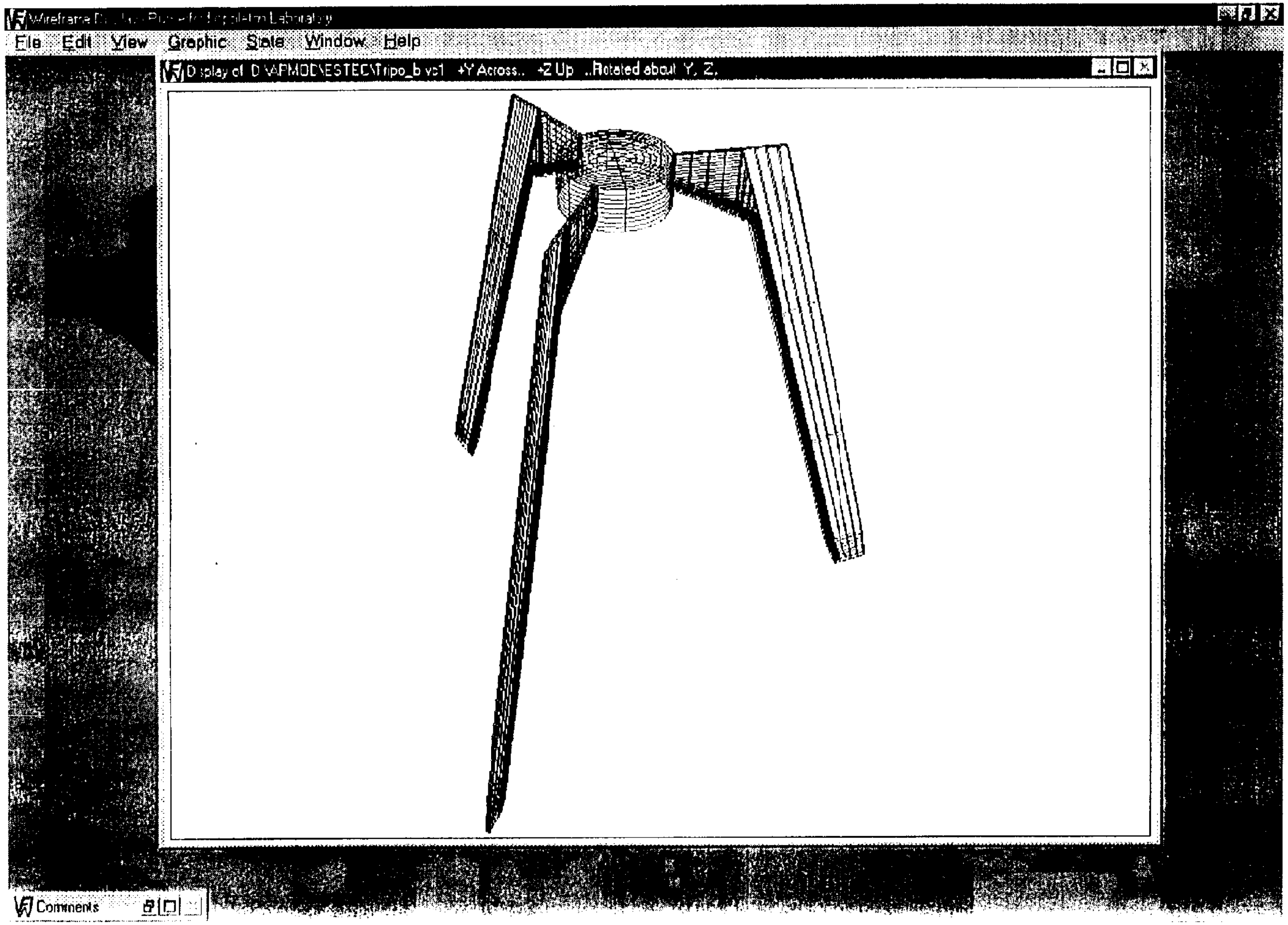
source azimuth = 10 degrees from -Y direction

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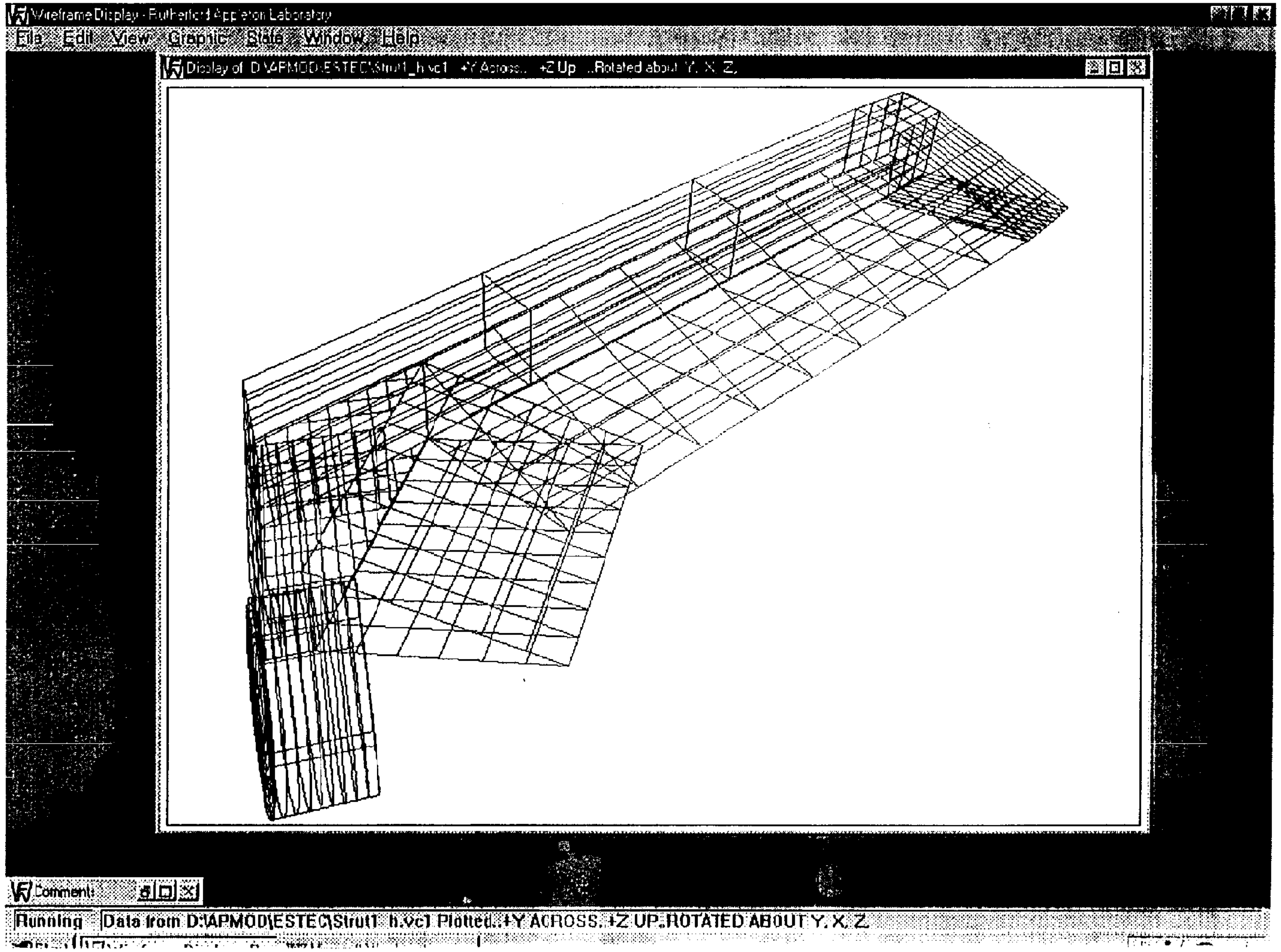
Comments



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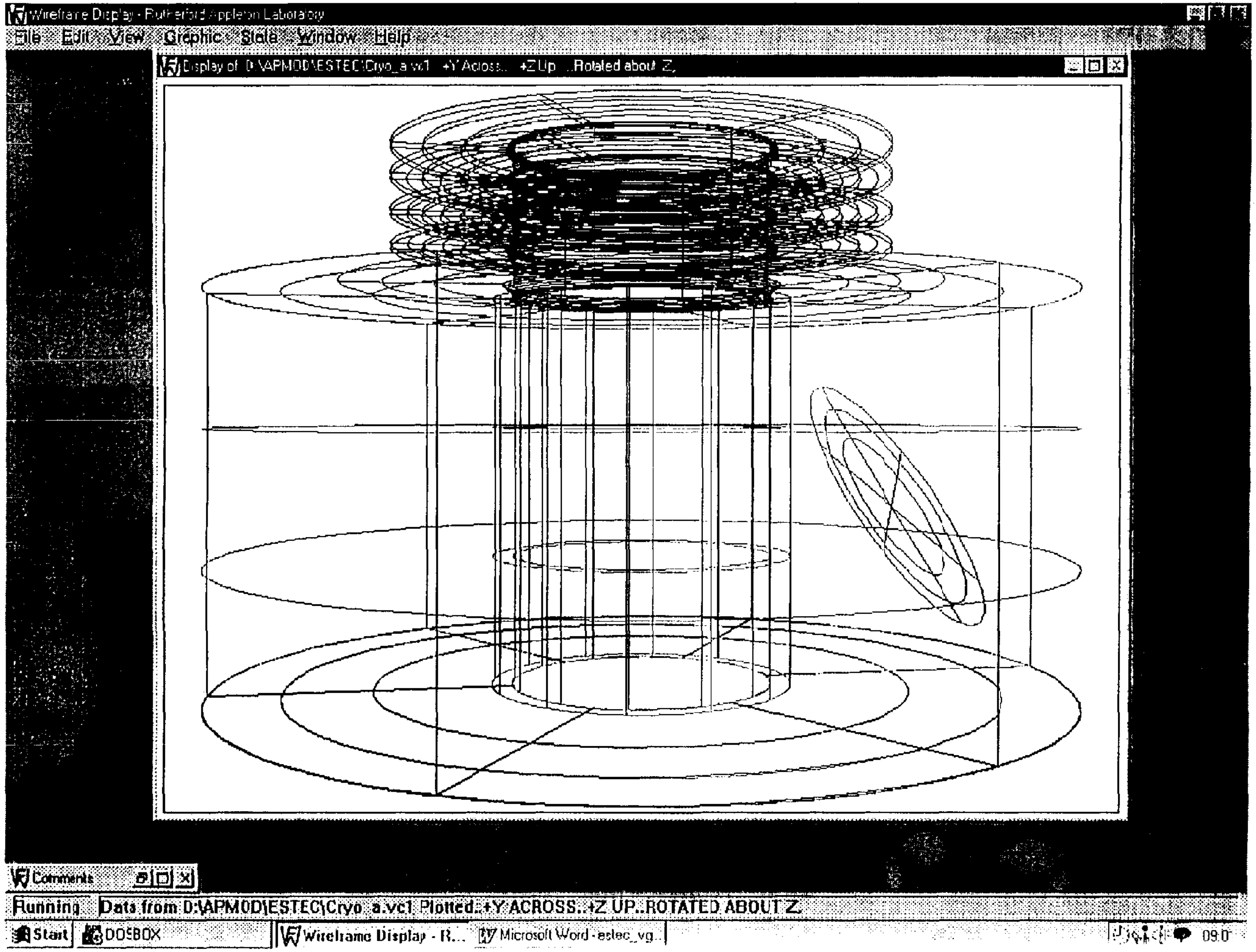

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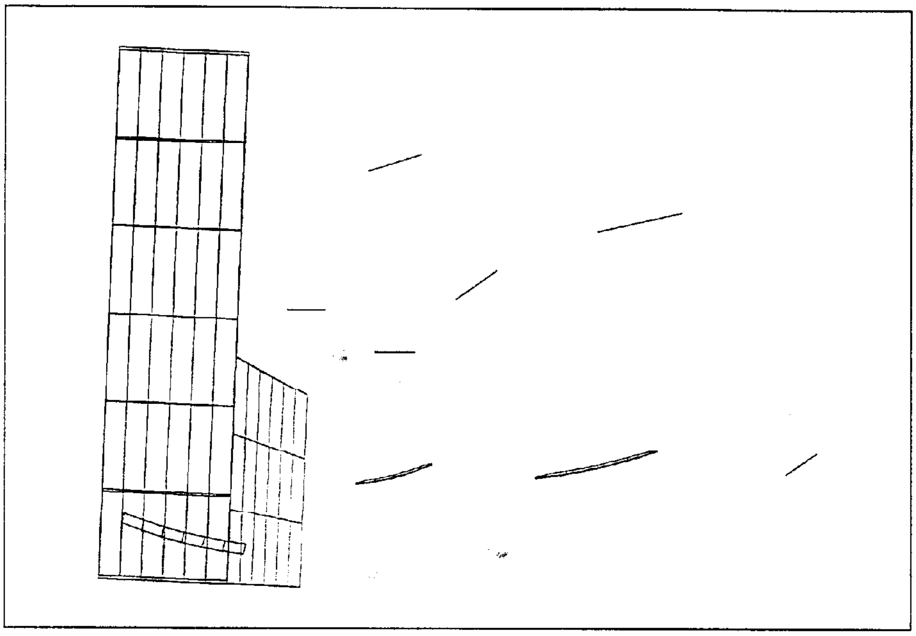


Figure 37 Y-Z plot of '15K' structure added to APART model

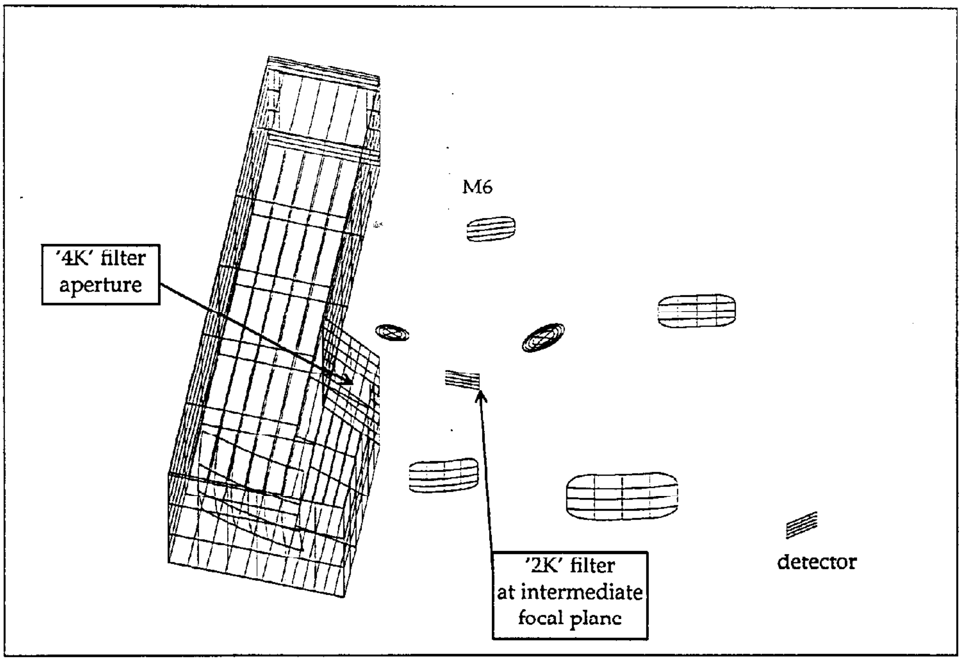


Figure 38 Isometric plot of '15K' structure showing relationship to optical surfaces

APART-CALCULATED TRANSFERS FROM PRIMARY HOLE AND CRYOSTAT FORWARD FACING SURFACES TO M3 AND DETECTOR

TRANSFER		SOURCE	COLLECTOR	SOURCE		COLLECTOR		TRANSFER TIME	SOURCE SMALL AVERAGE	COLLECTOR SMALL AVERAGE	TOTAL GCF	AZIMUTH
				PI	Z	PI	Z					
403	TRANSFR	173.02	210.05	12	-10	12	-10	2.73 S	0.000	0.000	1.869E-09	0.000
404	TRANSFR	174.02	210.05	9	-9	12	-10	1.27 S	0.000	0.000	6.406E-09	0.000
405	TRANSFR	171.02	210.05	12	-10	12	-10	2.83 S	0.000	0.000	1.072E-09	0.000
406	TRANSFR	148.02	210.05	9	-9	12	-10	2.75 S	0.000	0.000	8.715E-09	0.000
407	TRANSFR	166.02	210.05	9	-9	12	-10	1.33 S	0.000	0.000	4.530E-09	0.000
408	TRANSFR	146.02	210.05	9	-10	12	-10	2.20 S	0.000	0.000	5.169E-09	0.000
409	TRANSFR	147.02	210.05	9	-9	12	-10	1.27 S	0.000	0.000	4.358E-09	0.000
410	TRANSFR	144.02	210.05	9	-10	12	-10	2.05 S	0.000	0.000	3.777E-09	0.000
411	TRANSFR	145.02	210.05	9	-9	12	-10	1.28 S	0.000	0.000	4.243E-09	0.000
412	TRANSFR	142.02	210.05	9	-10	12	-10	2.02 S	0.000	0.000	3.676E-09	0.000
413	TRANSFR	143.02	210.05	9	-9	12	-10	1.25 S	0.000	0.000	4.125E-09	0.000
414	TRANSFR	140.02	210.05	9	-10	12	-10	1.94 S	0.000	0.000	2.573E-09	0.000
415	TRANSFR	141.02	210.05	9	-9	12	-10	1.26 S	0.000	0.000	4.029E-09	0.000
416	TRANSFR	152.02	210.05	9	-5	12	-10	0.86 S	0.000	0.000	6.898E-10	0.000
417	TRANSFR	155.02	210.05	9	-5	12	-10	0.83 S	0.000	0.000	7.163E-10	0.000
418	TRANSFR	158.02	210.05	9	-5	12	-10	0.82 S	0.000	0.000	7.454E-10	0.000
419	TRANSFR	161.02	210.05	9	-5	12	-10	0.80 S	0.000	0.000	7.770E-10	0.000
420	TRANSFR	118.02	299.15	9	1	12	-10	1.48 S	0.000	0.000	5.176E-09	0.000
421	TRANSFR	119.02	299.15	9	-9	12	-10	10.62 S	0.000	0.000	3.759E-10	0.000
422	TRANSFR	173.02	299.15	12	-10	12	-10	7.98 S	0.000	0.000	4.222E-10	0.000
423	TRANSFR	174.02	299.15	9	-9	12	-10	6.26 S	0.000	0.000	1.434E-09	0.000
424	TRANSFR	171.02	299.15	12	-10	12	-10	7.90 S	0.000	0.000	2.399E-10	0.000
425	TRANSFR	148.02	299.15	9	-9	12	-10	11.74 S	0.000	0.000	1.950E-09	0.000
426	TRANSFR	166.02	299.15	9	-9	12	-10	6.46 S	0.000	0.000	1.012E-09	0.000
427	TRANSFR	146.02	299.15	9	-10	12	-10	8.30 S	0.000	0.000	1.155E-09	0.000
428	TRANSFR	147.02	299.15	9	-9	12	-10	6.21 S	0.000	0.000	9.734E-10	0.000
429	TRANSFR	144.02	299.15	9	-10	12	-10	7.56 S	0.000	0.000	8.435E-10	0.000
430	TRANSFR	145.02	299.15	9	-9	12	-10	6.21 S	0.000	0.000	9.479E-10	0.000
431	TRANSFR	142.02	299.15	9	-10	12	-10	7.56 S	0.000	0.000	8.212E-10	0.000
432	TRANSFR	143.02	299.15	9	-9	12	-10	6.29 S	0.000	0.000	9.216E-10	0.000
433	TRANSFR	140.02	299.15	9	-10	12	-10	7.01 S	0.000	0.000	5.744E-10	0.000
434	TRANSFR	141.02	299.15	9	-9	12	-10	6.26 S	0.000	0.000	9.002E-10	0.000
435	TRANSFR	152.02	299.15	9	-5	12	-10	5.61 S	0.000	0.000	1.541E-10	0.000
436	TRANSFR	155.02	299.15	9	-5	12	-10	5.57 S	0.000	0.000	1.600E-10	0.000
437	TRANSFR	158.02	299.15	9	-5	12	-10	5.56 S	0.000	0.000	1.666E-10	0.000
438	TRANSFR	161.02	299.15	9	-5	12	-10	5.53 S	0.000	0.000	1.734E-10	0.000

APART Analysis Results

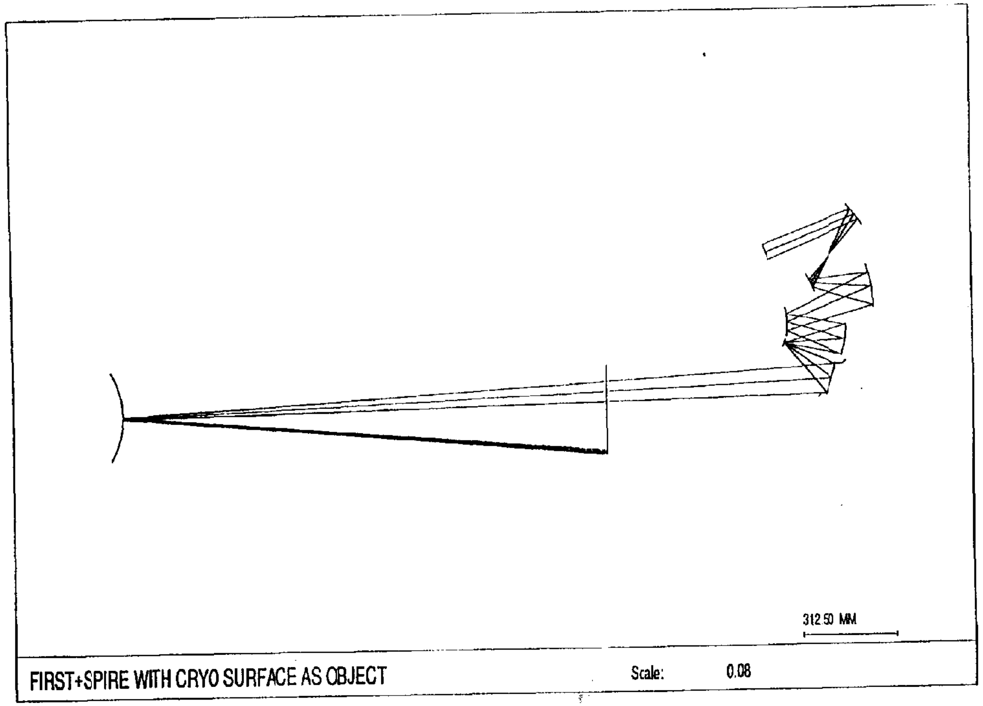
TABLE OF CALCULATED TRANSFERS FROM FORWARD-FACING FPU APERTURES AND APERTURE SURROUNDS TO THE SPIRE DETECTOR

TRANSFER		SOURCE	COLLECTOR	SOURCE		COLLECTOR		TRANSFER TIME	SOURCE SMALL AVERAGE	COLLECTOR SMALL AVERAGE	TOTAL GCF	AZIMUTH
				PI	Z	PI	Z					
6	TRANSFR	109.02	299.15	9	-9	12	-10	11.28 S	0.000	0.000	2.440E-09	0.000
7	TRANSFR	199.02	299.15	9	-9	12	-10	11.27 S	0.000	0.000	2.437E-09	0.000
8	TRANSFR	209.02	299.15	9	-3	12	-10	3.29 S	0.000	0.000	2.455E-09	0.000
9	TRANSFR	60.02	299.15	9	-6	12	-10	7.41 S	0.000	0.000	2.600E-09	0.000
10	TRANSFR	100.02	299.15	9	-6	12	-10	7.34 S	0.000	0.000	2.438E-09	0.000
11	TRANSFR	191.02	299.15	9	-6	12	-10	7.30 S	0.000	0.000	2.432E-09	0.000
12	TRANSFR	200.02	299.15	9	-6	12	-10	7.30 S	0.000	0.000	2.456E-09	0.000

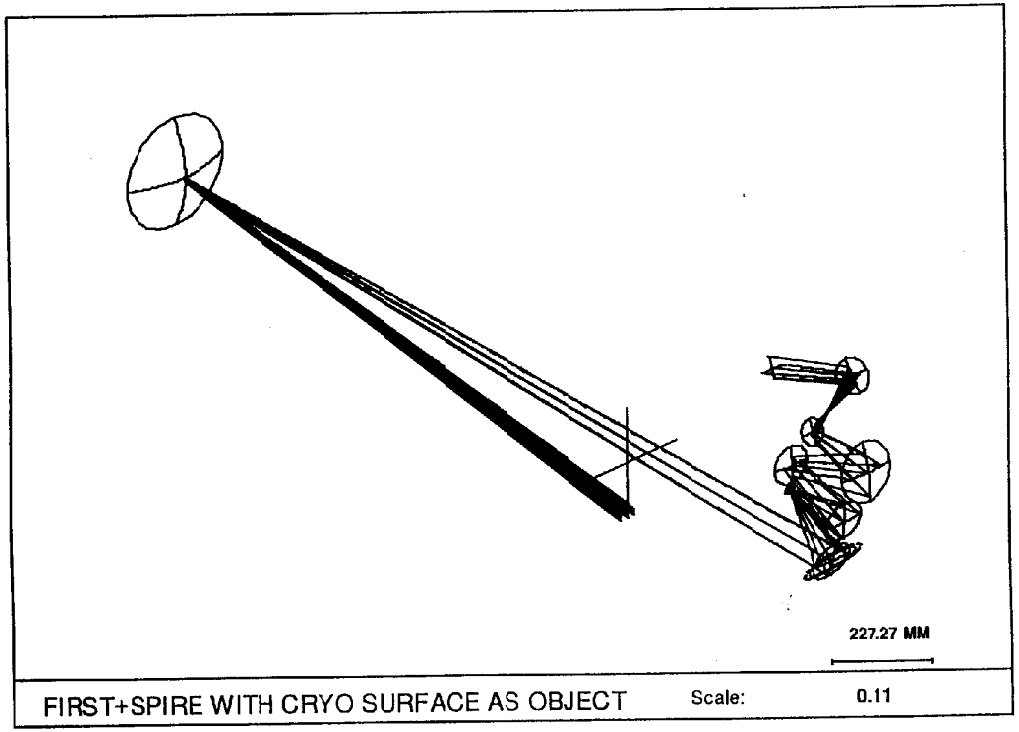
TABLE OF CALCULATED TRANSFERS SPIRE MIRORS TO THE SPIRE DETECTOR

TRANSFER		SOURCE	COLLECTOR	SOURCE		COLLECTOR		TRANSFER TIME	SOURCE SMALL AVERAGE	COLLECTOR SMALL AVERAGE	TOTAL GCF	AZIMUTH
				PI	Z	PI	Z					
13	TRANSFR	210.06	299.15	12	-10	12	-10	3.68 S	0.000	0.000	1.373E-06	0.000
14	TRANSFR	266.08	299.15	12	-10	12	-10	7.16 S	0.000	0.000	6.456E-05	0.000
15	TRANSFR	268.10	299.15	12	-10	12	-10	8.65 S	0.019	0.000	3.544E-06	0.000
16	TRANSFR	270.12	299.15	12	-10	12	-10	3.96 S	0.000	0.000	2.182E-05	0.000
17	TRANSFR	273.14	299.15	12	-10	12	-10	2.80 S	0.000	0.000	1.129E-05	0.000
18	TRANSFR	274.15	299.15	12	-10	12	-10	1.24 S	0.000	0.000	3.321E-05	0.000

One example of the SPIRE detector's view of a cryostat surface illustrated using CODEV



The SPIRE detector's view of a cryostat surface illustrated using CODEV, from another viewpoint



APART Thermal Emission Results, 200μ - 300μ waveband

```
PERCENT OF POWER CONTRIBUTED  BY EACH OBJECT AS A FUNCTION  OF EACH LEVEL

                     OBJECTS/              LEVEL
                                         0        1
                10 LEG#1 BODY          0.05     0.01
                12 LEG#1,EDG.FAC#1     0.28     0.00
                13 LEG#1,EDG.FAC#2     0.28     0.00
                14 STRUT#1,INNER SE    0.00     0.00
                15 STRUT#1,OUTER SE    0.00     0.00
                16 STRUT#1,EDG.FAC#    0.10     0.00
                17 STRUT#1,EDG.FAC#    0.10     0.00
                20 LEG#2 BODY          0.06     0.00
                22 LEG#2,EDG.FAC#1     0.23     0.05
                23 LEG#2,EDG.FAC#2     0.26     0.00
                24 STRUT#2,INNER SE    0.00     0.00
                25 STRUT#2,OUTER SE    0.00     0.00
                26 STRUT#2,EDG.FAC#    0.08     0.01
                27 STRUT#2,EDG.FAC#    0.09     0.00
                30 LEG#3 BODY          0.06     0.00
                32 LEG#3,EDG.FAC#1     0.26     0.00
                33 LEG#3,EDG.FAC#2     0.23     0.05
                34 STRUT#3,INNER SE    0.00     0.00
                35 STRUT#3,OUTER SE    0.00     0.00
                36 STRUT#3,EDG.FAC#    0.09     0.00
                37 STRUT#3,EDG.FAC#    0.08     0.01
                60 OUT.DUM.PACS.APE    0.03     0.00
                69 PACS APERT.SURRN    0.05     0.03
               100 OUT.DUM.HIFI.APE     0.04     0.00
               109 HIFI APERT.SURRN     0.05     0.03
               119 PM HOLE WALL         0.07     6.72
               120 PRIMARY MIRROR      44.57    38.33
               129 SECONDARY MIRROR    49.52    43.79
               140 SHLD0 TO TEL         0.00     0.00
               141 SHLD0 EDGE           0.00     0.00
               142 SHLD1 TO TEL         0.03     0.00
               143 SHLD1 EDGE           0.00     0.00
               144 SHLD2 TO TEL         0.06     0.00
               145 SHLD2 EDGE           0.00     0.00
               146 SHLD3 TO TEL         0.13     0.00
               147 SHLD3 EDGE           0.00     0.00
               148 CVV UPPER CONE       0.08     0.00
               166 CVV INNER EDGE       0.00     0.00
               171 CVV OUTER SURF       0.55     0.00
               173 CAVITY CAP OUT.S     1.41     0.00
               174 CRYOCOVER HOLEED     0.00     0.00
               191 OUT.DUM.DUMMY.AP     0.01     0.00
               199 DUMMY APERT.SURR     0.02     0.00
               200 OUT.DUMMY FPU.AP     0.03     0.00
               209 FPU APERT.SURROU     0.05     0.03
               210 M3 MIRROR            1.05    10.92
               266 M4,ASTOP1            0.00     0.02
               268 M5                   0.00     0.00
               270 M6                   0.00     0.00
               273 M7                   0.00     0.00
               274 M8                   0.00     0.00

            TOTAL POWER(WATT)        2.40E-9   3.6E-11
```

APART Thermal Emission Results, 200µ - 300µ waveband

```
TOP 10 PROPAGATION PATHS AND THEIR PERCENT CONTRIBUTIONS FOR CYCLE  1

      1  48.69%  129.03-->299.15
            *SECONDARY MIRR* DETECTOR *

      2  43.90%  120.02-->299.15
            *PRIMARY MIRR *  DETECTOR *

      3   1.39%  173.02-->299.15
            *CRYO.OUT.FACE*  DETECTOR *

      4   1.04%  210.06-->299.15
            *SPIRE.M3 MIRR*  DETECTOR *

      5   0.54%  171.02-->299.15
            *CVV.OUT.FACE *  DETECTOR *

      6   0.33%   44.01-->129.01 129.03-->299.15
                *SUNSHADE*SECONDARY MIRRO* DETECTOR*

      7   0.33%   43.01-->129.01 129.03-->299.15
                *SUNSHADE*SECONDARY MIRRO* DETECTOR*

      8   0.28%   43.01-->120.01 120.02-->299.15
                *SUNSHADE*PRIMARY MIRRO* DETECTOR*

      9   0.28%   44.01-->120.01 120.02-->299.15
                *SUNSHADE*PRIMARY MIRRO* DETECTOR*

      10   0.16%   12.01-->299.15
         *TRIPOD LEG EDGE* DETECTOR*
```

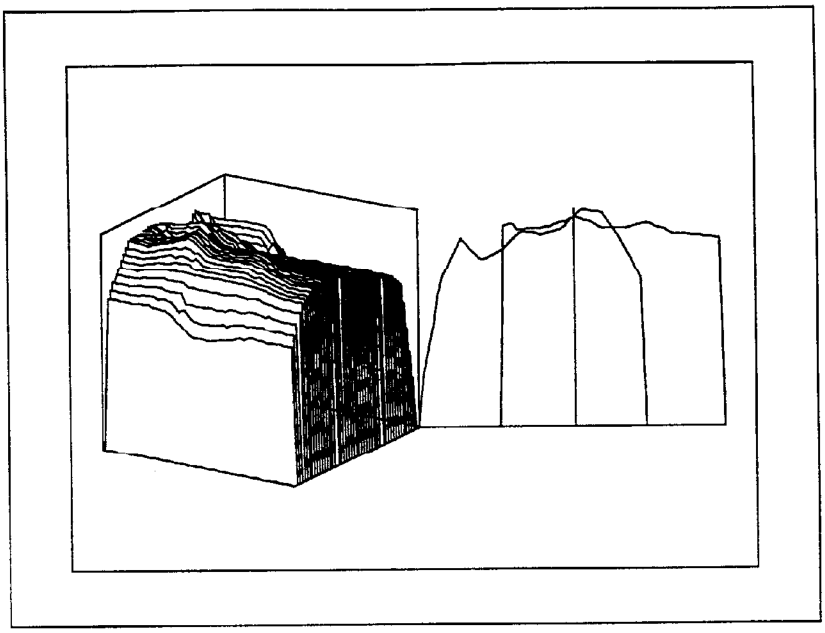
APART Thermal Emission Results, 200μ - 300μ waveband
(NO PRIMARY, SECONDARY OR M3 EMISSION)

```
PERCENT OF POWER CONTRIBUTED  BY EACH OBJECT AS A FUNCTION   OF EACH LEVEL
                       OBJECTS/                    LEVEL
                                     0        1        2
           10 LEG#1 BODY            1.10     0.01     0.00
           12 LEG#1,EDG.FAC#1       5.75     0.00     0.00
           13 LEG#1,EDG.FAC#2       5.75     0.00     0.00
           14 STRUT#1,INNER SE      0.01     0.00     0.00
           15 STRUT#1,OUTER SE      0.00     0.00     0.00
           16 STRUT#1,EDG.FAC#      2.03     0.00     0.00
           17 STRUT#1,EDG.FAC#      2.03     0.00     0.00
           20 LEG#2 BODY            1.13     0.00     0.00
           22 LEG#2,EDG.FAC#1       4.80     0.05     0.00
           23 LEG#2,EDG.FAC#2       5.39     0.00     0.00
           24 STRUT#2,INNER SE      0.05     0.00     0.00
           25 STRUT#2,OUTER SE      0.01     0.00     0.00
           26 STRUT#2,EDG.FAC#      1.74     0.01     0.00
           27 STRUT#2,EDG.FAC#      1.79     0.00     0.00
           30 LEG#3 BODY            1.13     0.00     0.00
           32 LEG#3,EDG.FAC#1       5.39     0.00     0.00
           33 LEG#3,EDG.FAC#2       4.80     0.05     0.00
           34 STRUT#3,INNER SE      0.05     0.00     0.00
           35 STRUT#3,OUTER SE      0.01     0.00     0.00
           36 STRUT#3,EDG.FAC#      1.79     0.00     0.00
           37 STRUT#3,EDG.FAC#      1.74     0.01     0.00
           60 OUT.DUM.PACS.APE      0.63     0.00     0.00
           69 PACS APERT.SURRN      1.10     0.00     0.00
          100 OUT.DUM.HIFI.APE      0.75     0.00     0.00
          109 HIFI APERT.SURRN      1.02     0.00     0.00
          119 PM HOLE WALL          1.41     6.86   100.00
          120 PRIMARY MIRROR        0.00    39.09     0.00
          129 SECONDARY MIRROR      0.00    44.66     0.00
          140 SHLD0 TO TEL          0.03     0.00     0.00
          141 SHLD0 EDGE            0.01     0.00     0.00
          142 SHLD1 TO TEL          0.52     0.00     0.00
          143 SHLD1 EDGE            0.00     0.00     0.00
          144 SHLD2 TO TEL          1.25     0.00     0.00
          145 SHLD2 EDGE            0.00     0.00     0.00
          146 SHLD3 TO TEL          2.66     0.00     0.00
          147 SHLD3 EDGE            0.00     0.00     0.00
          148 CVV UPPER CONE        1.64     0.00     0.00
          166 CVV INNER EDGE        0.00     0.00     0.00
          171 CVV OUTER SURF       11.38     0.00     0.00
          173 CAVITY CAP OUT.S     29.05     0.00     0.00
          174 CRYOCOVER HOLEED      0.00     0.00     0.00
          191 OUT.DUM.DUMMY.AP      0.13     0.00     0.00
          199 DUMMY APERT.SURR      0.34     0.00     0.00
          200 OUT.DUMMY FPU.AP      0.58     0.00     0.00
          209 FPU APERT.SURROU      1.01     0.00     0.00
          210 M3 MIRROR             0.00     9.24     0.00
          266 M4,ASTOP1             0.00     0.00     0.00
          268 M5                    0.00     0.00     0.00
          270 M6                    0.00     0.00     0.00
          273 M7                    0.01     0.00     0.00
          274 M8                    0.01     0.00     0.00

          TOTAL POWER(Watt)      1.2E-10  3.6E-11  1.1E-16
```

APART Thermal Emission Results, 200µ - 300µ waveband
(NO PRIMARY, SECONDARY OR M3 EMISSION)

```
TOP 10 PROPAGATION PATHS AND THEIR PERCENT CONTRIBUTIONS FOR CYCLE  1

     1  22.23%  173.02-->299.15
         *CRYO.OUT.FACE*  DETECTOR *

     2   8.71%  171.02-->299.15
         *CVV.OUT.FACE *  DETECTOR *

     3   5.23%   44.01-->129.01 129.03-->299.15
             *SUNSHADE*SECONDARY MIRRO* DETECTOR*

     4   5.23%   43.01-->129.01 129.03-->299.15
             *SUNSHADE*SECONDARY MIRRO* DETECTOR*

     5   4.51%   43.01-->120.01 120.02-->299.15
             *SUNSHADE*  PRIMARY MIRRO* DETECTOR*

     6   4.51%   44.01-->120.01 120.02-->299.15
             *SUNSHADE*  PRIMARY MIRRO* DETECTOR*

     7   2.54%   12.01-->299.15
       *TRIPOD LEG#1 EDGE* DETECTOR*

     8   2.54%   13.01-->299.15
       *TRIPOD LEG#1 EDGE* DETECTOR*

     9   2.49%   32.02-->299.15
       *TRIPOD LEG#1 EDGE* DETECTOR*

     10   2.49%   23.02-->299.15
       *TRIPOD LEG#1 EDGE* DETECTOR*
```

Typical Stray Energy Distribution on the SPIRE detector



The other methods to give fully general diffraction analysis are Electromagnetic, used in mm-wave antenna design (e.g. GRASP©).

For systems which are quasi-optical with clipping/aberrating components larger than approx. 20 wavelengths, ray-based methods have the following advantages (ref.2):

- more quickly treat a train of many components.
- more explicitly treat off-axis (FOV) aberrations, and relate them to the optical design & optimisation criteria.
- More easily exchange system model with other codes, e.g. CAD & APART.

Ref.1 "Modelling the effect of multiple beam clipping in sub-mm instruments ISO-LWS & FIRST-SPIRE" SPIE Vol.3426 p.313

Ref.2 "Test of a ray-trace method ... " Int. J. of IR & mm-waves. Feb.99.

Long-wave optics analysis of beam patterns & low-angle stray-light.

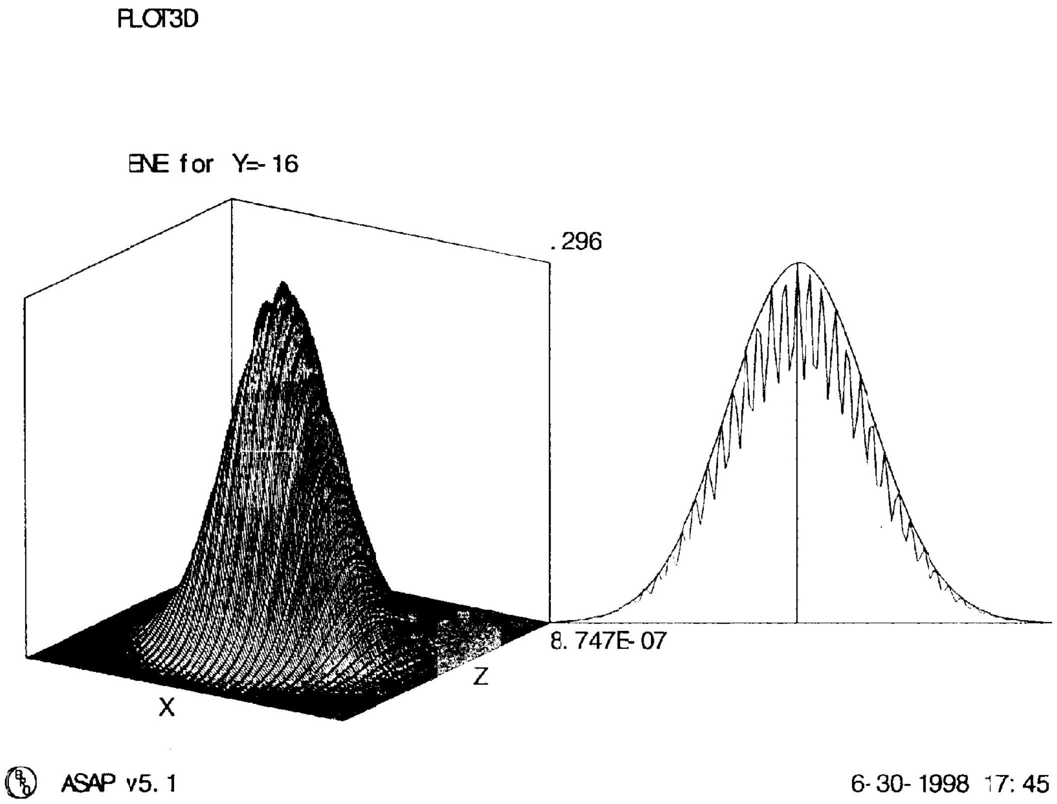
A ray-based method (employing the software package ASAP©) is used to numerically analyse the beam pattern throughout the instrument (Ref.1). This includes :

- Beam-mode treatment.
- Beam-clipping (edge-diffraction), in plane of component.
- geometric aberrations.

The performances of interest are clipping-induced **stray-light backgrounds** and final beam pattern (instrument far-field **angular response function**.)

The method is complementary to that of APART in that it covers **low off-axis angle** (currently up to < 10 x Airy radius) , where GTD (geometric theory of diffraction) is not valid.

Interferogram at detection-plane.



BLACK MATERIALS

PETER ADE

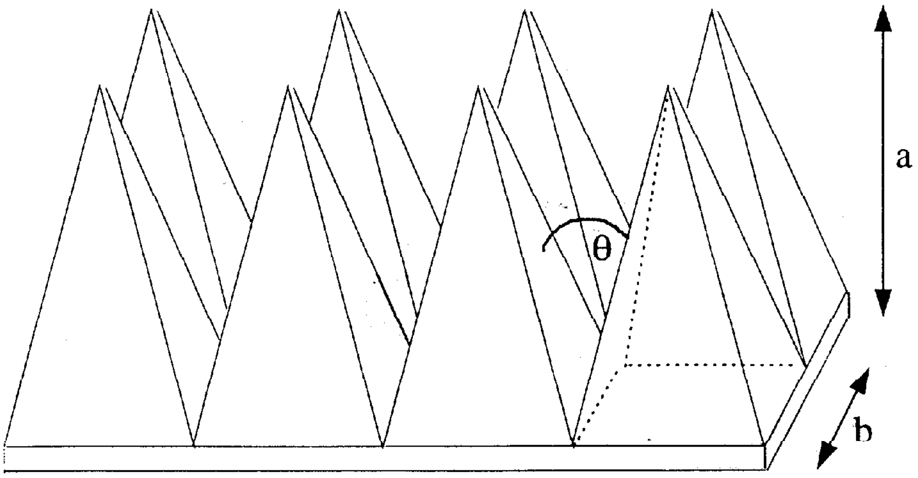
Uses:

- absorption of radiation from stray reflections within optical systems (particularly at apertures)
- provision of calibration sources in a variety of spectroscopic systems

Samples tested:

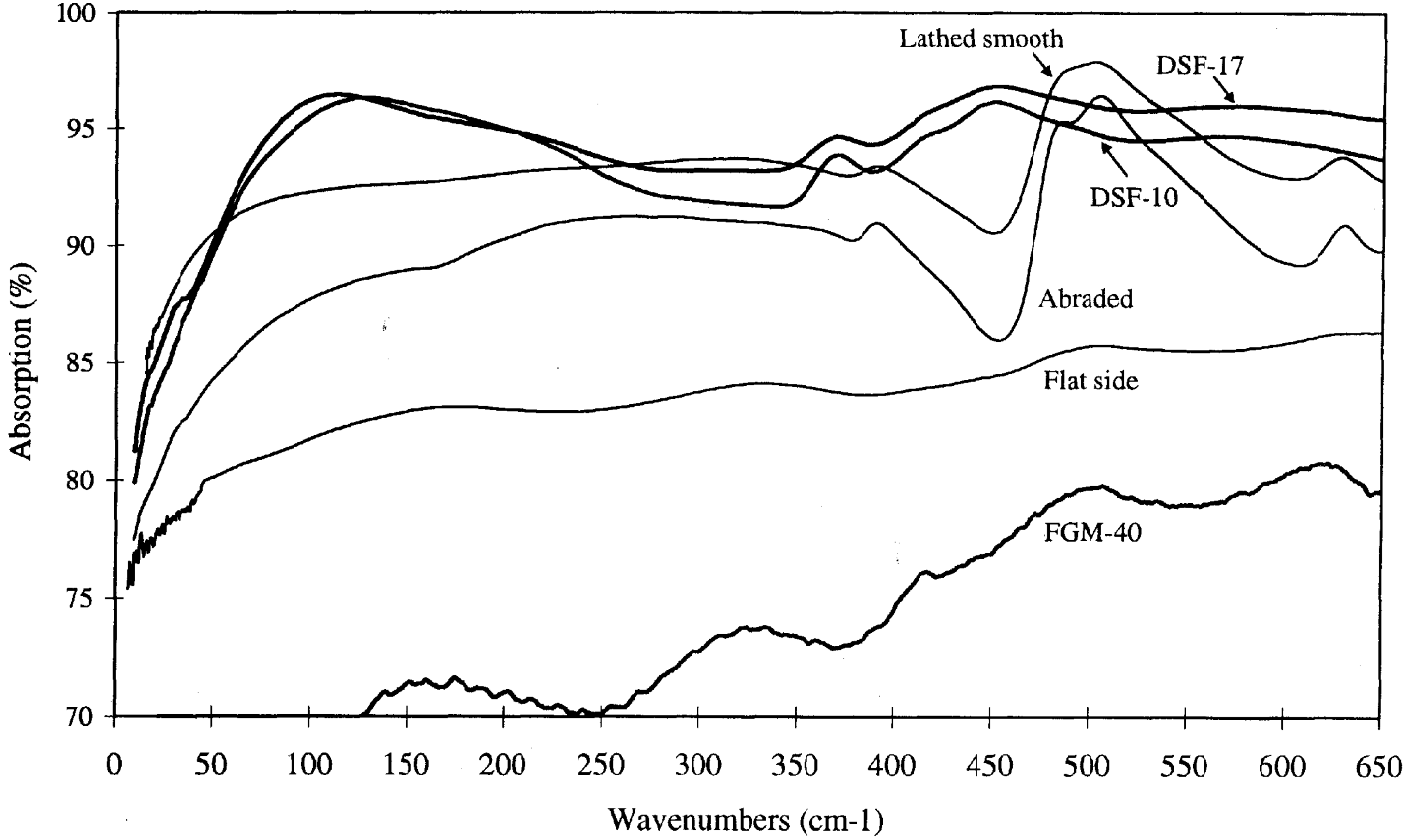
- Epotek 920 epoxy
- DSF-10 Eccosorb
- DSF-17 Eccosorb
- FGM-40 Eccosorb
- AN72 Eccosorb

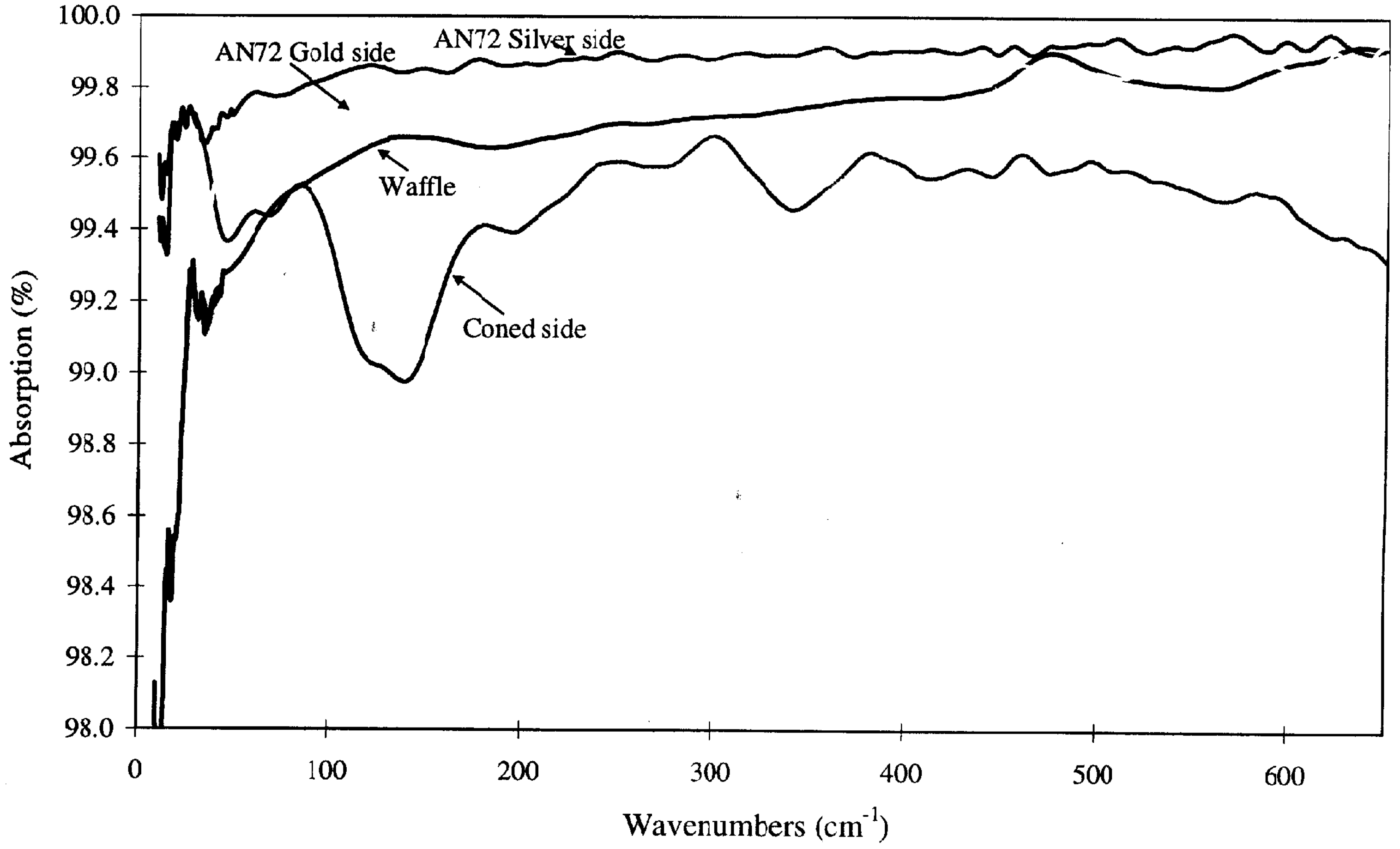
- emissivity ~1
- high thermal conductivity
- suitable for applying to cold metallic surfaces (aperture plate, radiation shield or reference source)
- ease of moulding
- durability at all temperatures from 1.5 to 400 K (non-flaking)
- low outgassing

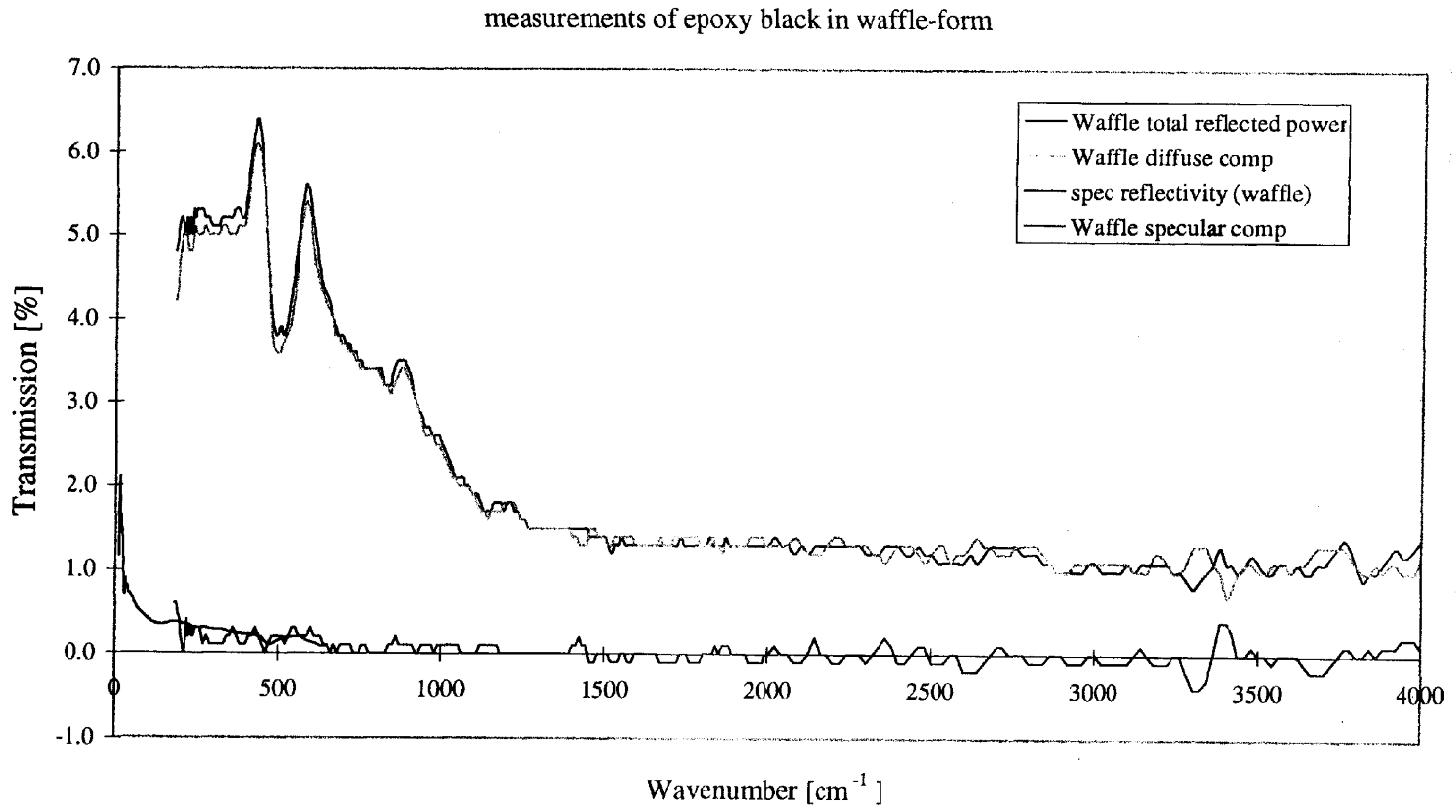


Where: a = 1.5 mm, b =0.9 mm, θ = 31°.

An angle of 31° is used to allow multiple reflections (up to 5 incidence reflections) with near on axis radiation.


100
95
90
85
80
75
70
Absorption (%)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Wavenumbers (cm-1)
Lathed smooth
DSF-17
DSF-10
Abraded
Flat side
FGM-40


AN72 Gold side
AN72 Silver side
Waffle
Coned side
Absorption (%)
100.0
99.8
99.6
99.4
99.2
99.0
98.8
98.6
98.4
98.2
98.0
0
100
200
300
400
500
600
Wavenumbers (cm^{-1})


measurements of epoxy black in waffle-form
Waffle total reflected power
Waffle diffuse comp
spec reflectivity (waffle)
Waffle specular comp
Transmission [%]
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0
500
1000
1500
2000
2500
3000
3500
4000
Wavenumber [cm^{-1}]

BLACK MATERIALS

KLAAS WILDEMAN

Absorbing coatings for sub-millimeter radiation

M. Carmen Diez and Tjeerd O. Klaassen
Department of Applied Physics, TU Delft
and
Kees Smorenburg and V. Kirchner
TNO Technisch Physische Dienst TU Delft
and
Klaas Wildeman,
SRON, Groningen

Project supported by:

Netherlands agency for aerospace programmes (NIVR)

Experimental set-up

- Source: optically pumped far-infrared laser
- Wavelength: $50 \leq \lambda \leq 2000 \mu m$
- Specular reflection and BRDF : $\Omega = 2.10^{-3} sr$
- Room temperature
- Cryogenic temperature facility (10 K) under construction.

Samples

Aluminum substrate with binder and filler material.

Binder: Stycast 2850 FT + 24 LV catalyst

Near future:
Cardinal 6450
(Solar Chem Black)

Filler: SiC grains; 125 -1000 μm
Al_2O_3 grains
porous (volcanic) grains

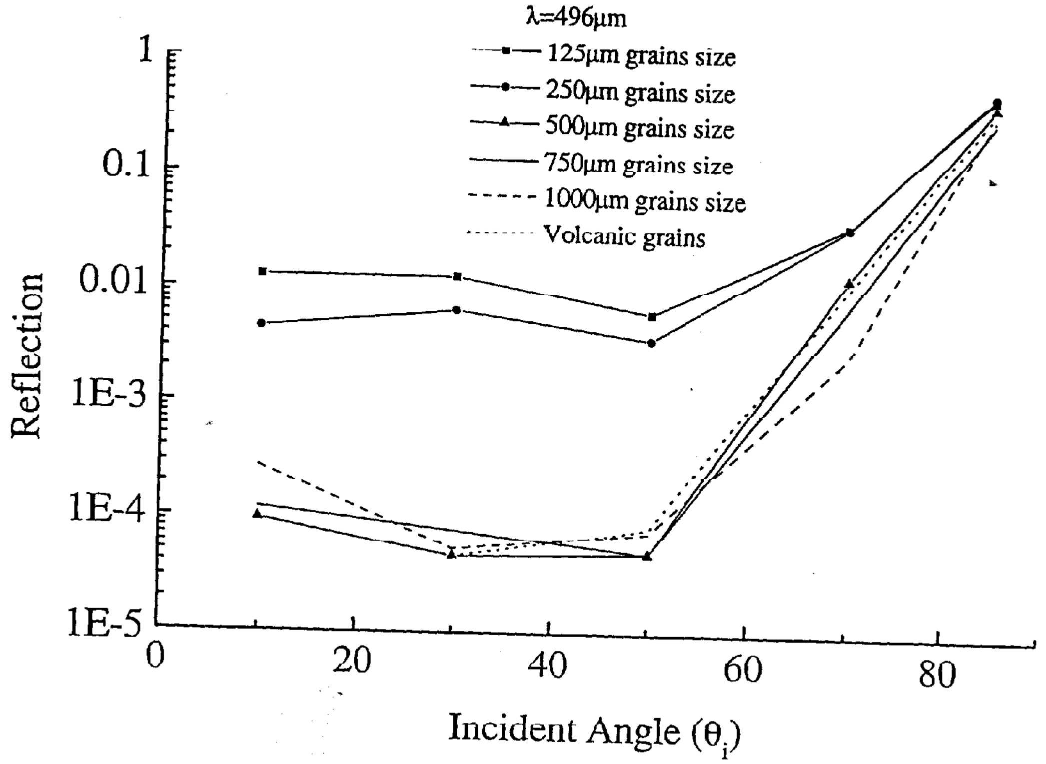
Near future:
Duocel SiC foam
Duocel Aluminum foam
RVC (Reticulated Vitreous Carbon)

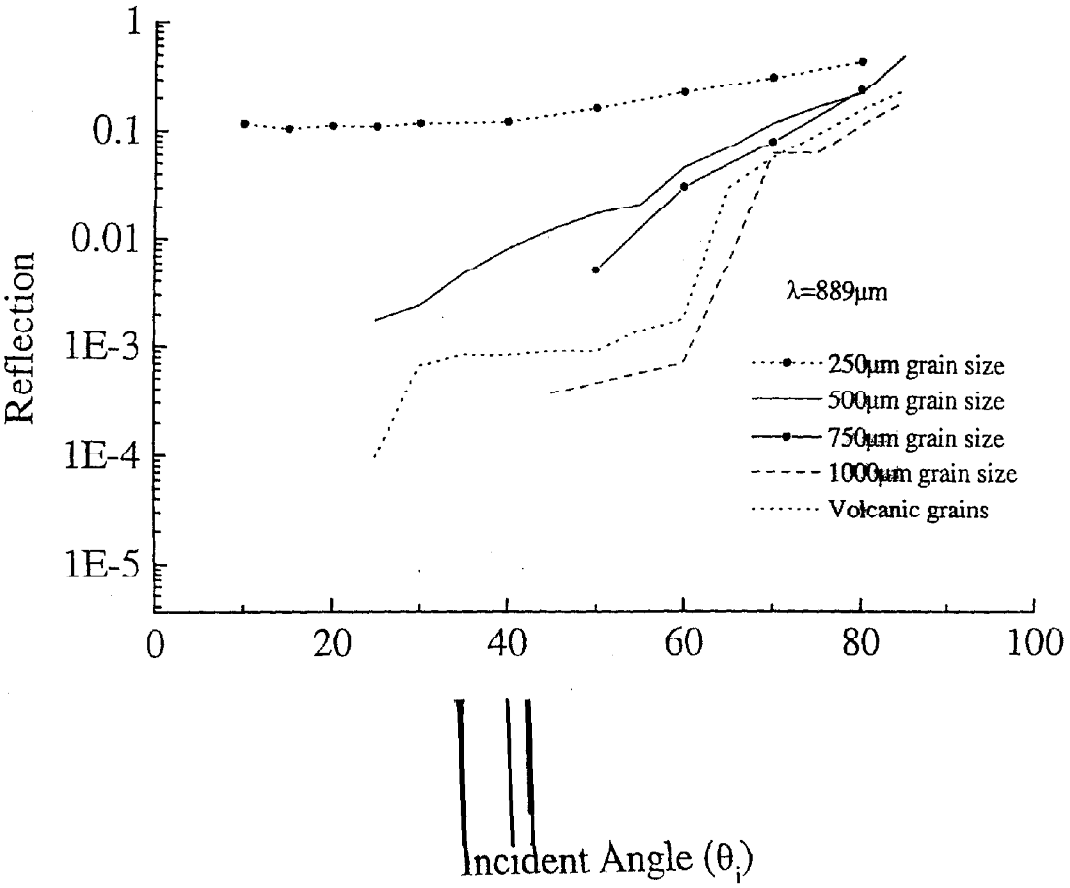
Experimental results

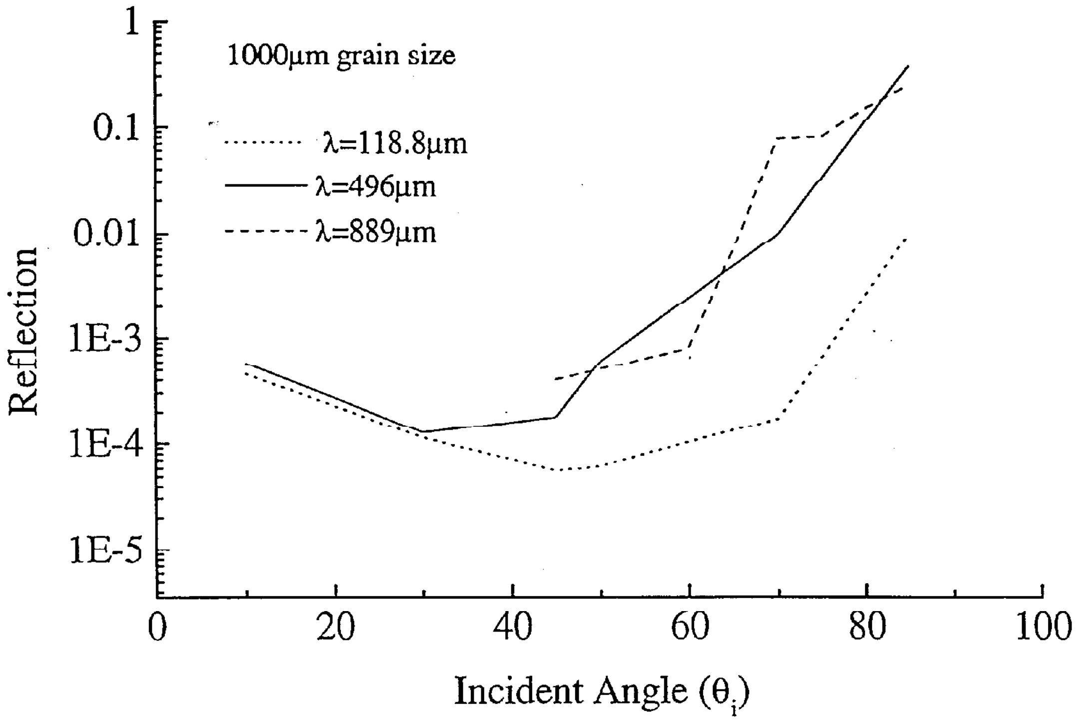
- $\lambda = 118$, 184, 496 and 889 μm.
- BRDF as a function of angle of incidence θ_i
- Specular reflection as a function of θ_i.

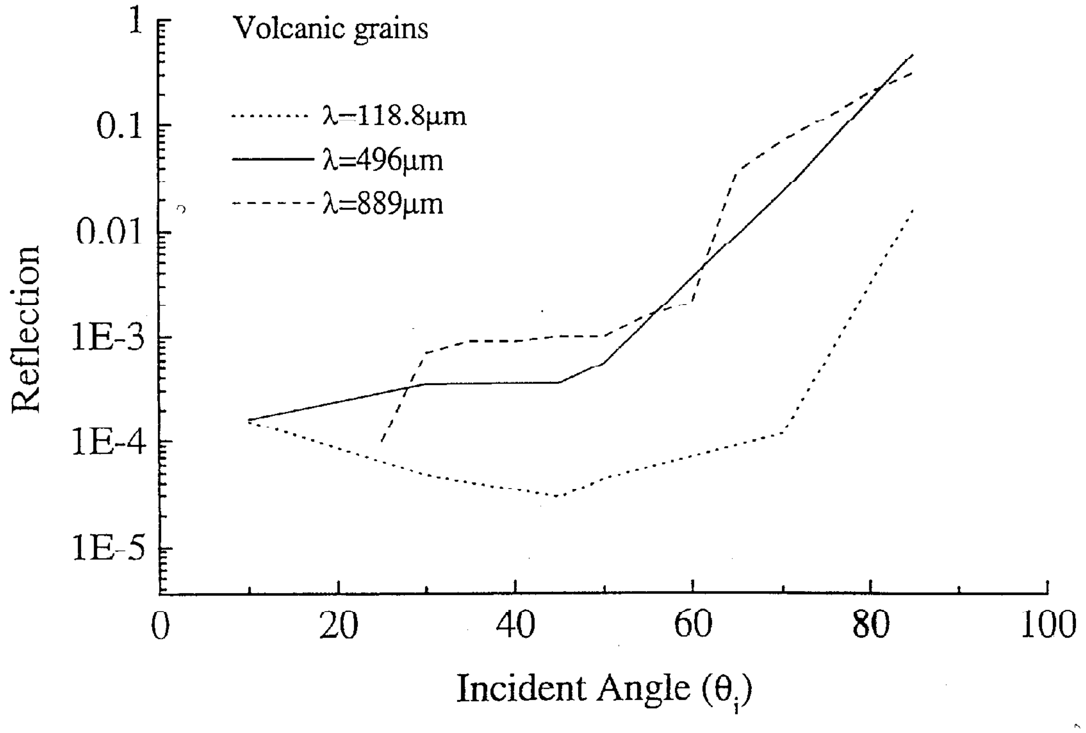
General trends

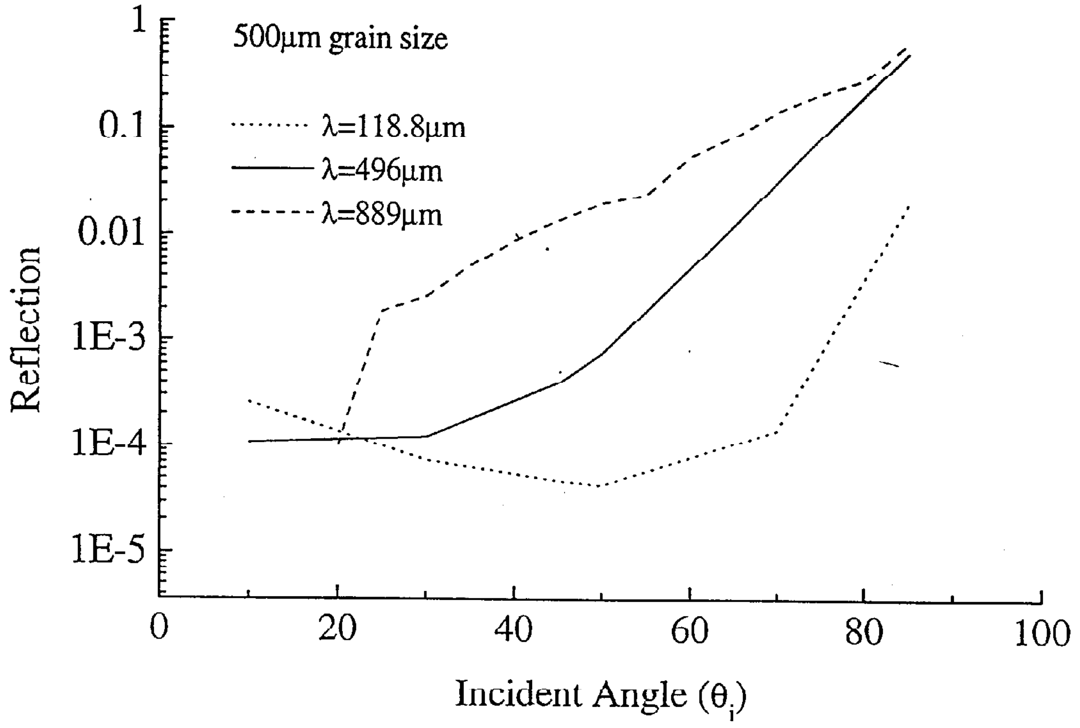
- Specular reflection increases with wavelength.
- Specular reflection increases with angle of incidence.
- Large specular reflection for $\theta_i \geq 80^0$.
- Surface roughness to obtain diffuse reflection.
- BRDF of the order of $1 - 2.10^{-2} sr^{-1}$.
- Total diffuse reflectance of the order of 5%.

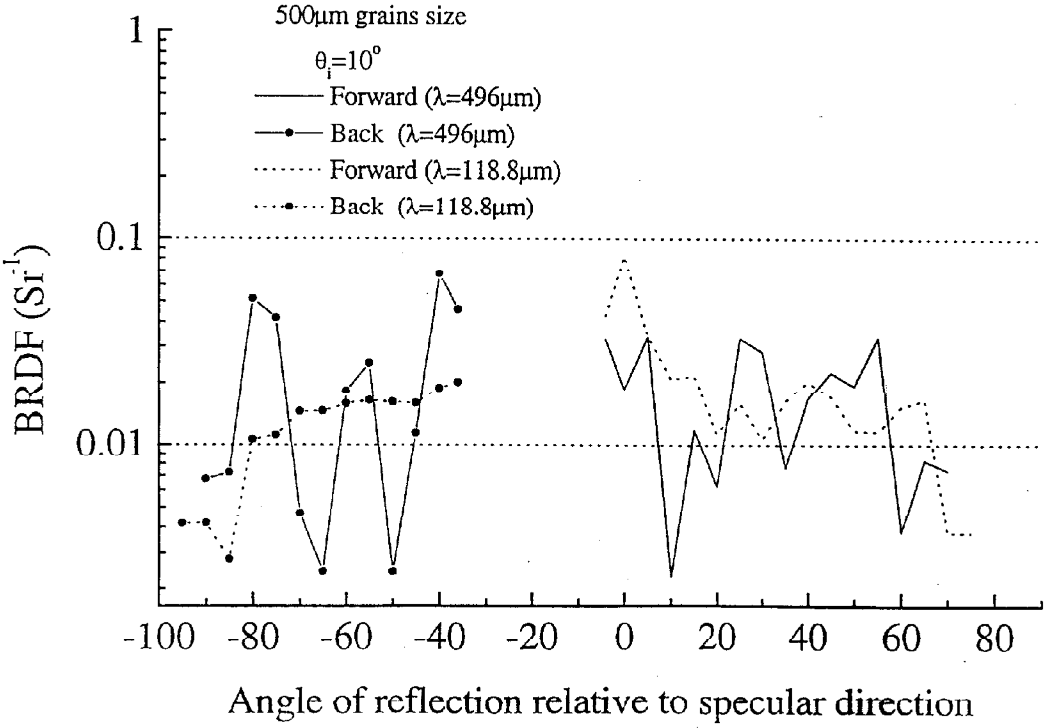

λ=496μm
125μm grains size
250μm grains size
500μm grains size
750μm grains size
1000μm grains size
Volcanic grains
Reflection
1
0.1
0.01
1E-3
1E-4
1E-5
0
20
40
60
80
Incident Angle (θi)


λ=889μm
250μm grain size
500μm grain size
750μm grain size
1000μm grain size
Volcanic grains
Reflection
1
0.1
0.01
1E-3
1E-4
1E-5
0
20
40
60
80
100
Incident Angle (θi)


1000μm grain size
λ=118.8μm
λ=496μm
λ=889μm
Reflection
1
0.1
0.01
1E-3
1E-4
1E-5
0
20
40
60
80
100
Incident Angle (θi)

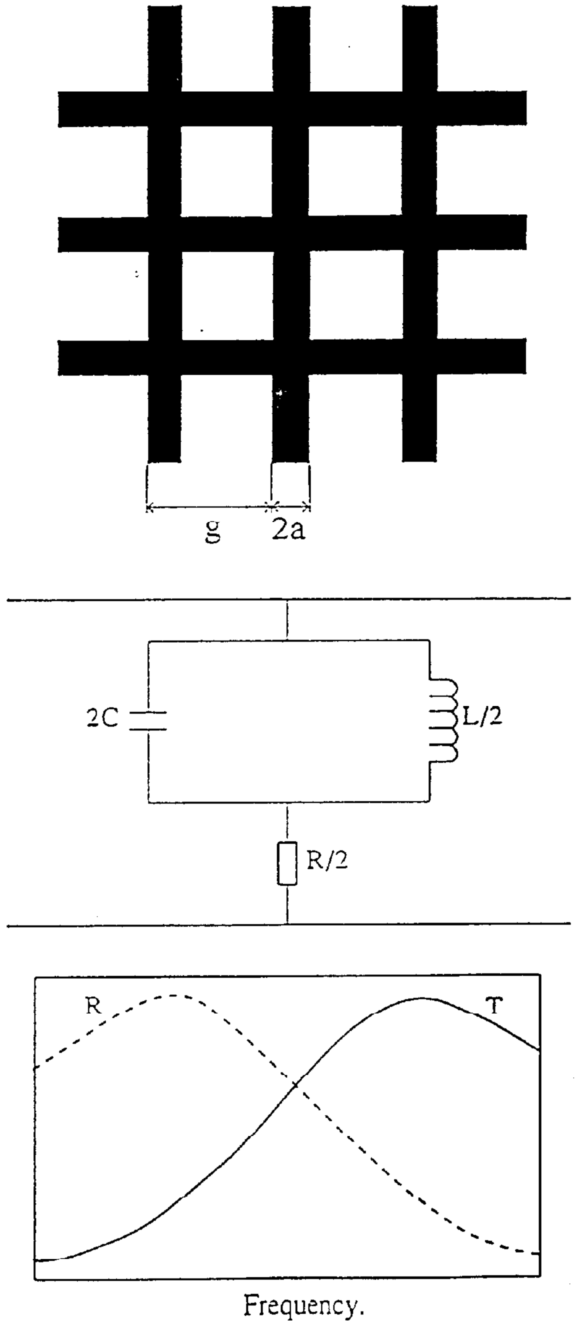

Volcanic grains
λ=118.8μm
λ=496μm
λ=889μm
Reflection
1
0.1
0.01
1E-3
1E-4
1E-5
0
20
40
60
80
100
Incident Angle (θi)


500µm grain size
λ=118.8µm
λ=496µm
λ=889µm
Reflection
1
0.1
0.01
1E-3
1E-4
1E-5
0
20
40
60
80
100
Incident Angle (θi)

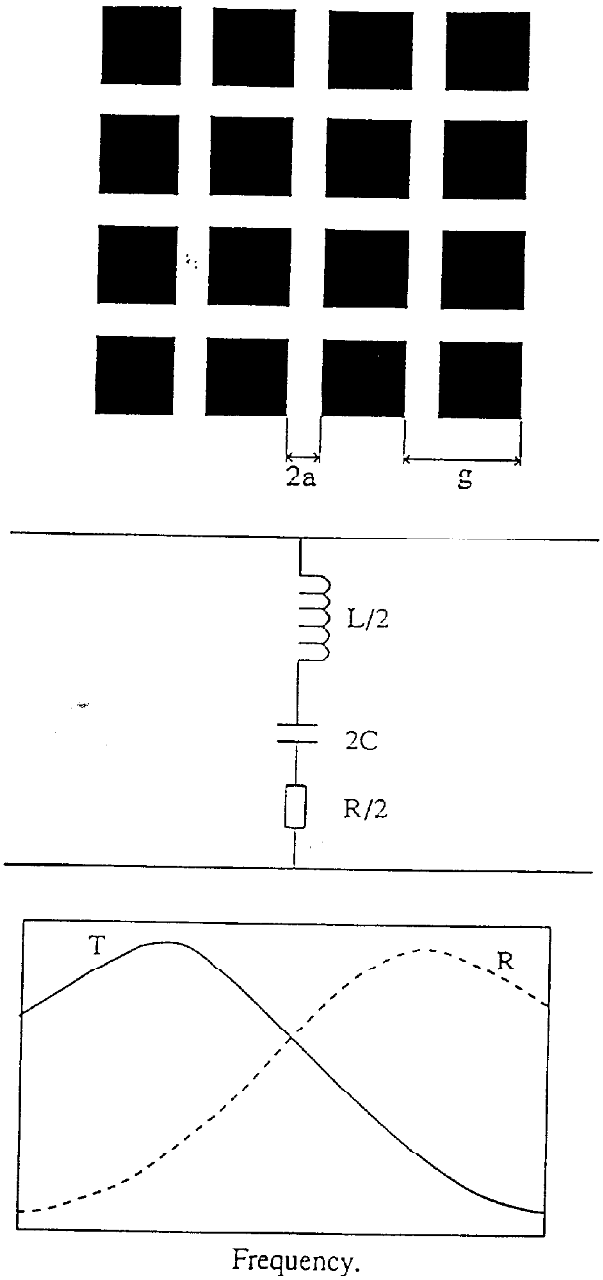

500µm grains size
θi=10°
Forward (λ=496µm)
Back (λ=496µm)
Forward (λ=118.8µm)
Back (λ=118.8µm)
BRDF (Sr-1)
1
0.1
0.01
-100
-80
-60
-40
-20
0
20
40
60
80
Angle of reflection relative to specular direction

FILTERS AND DICHROICS

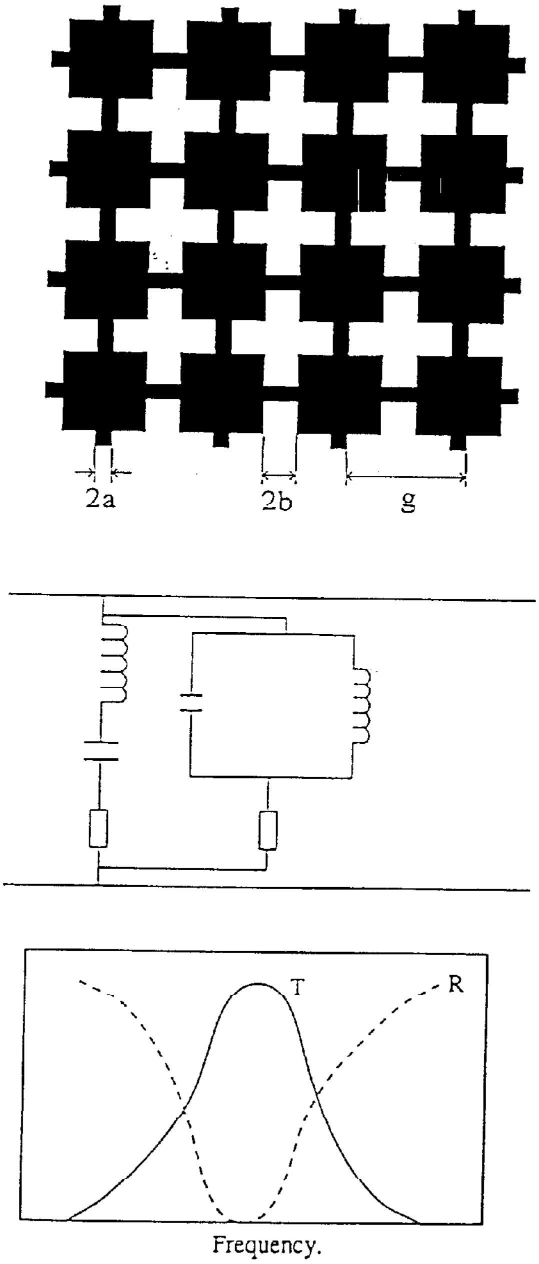
PETER ADE



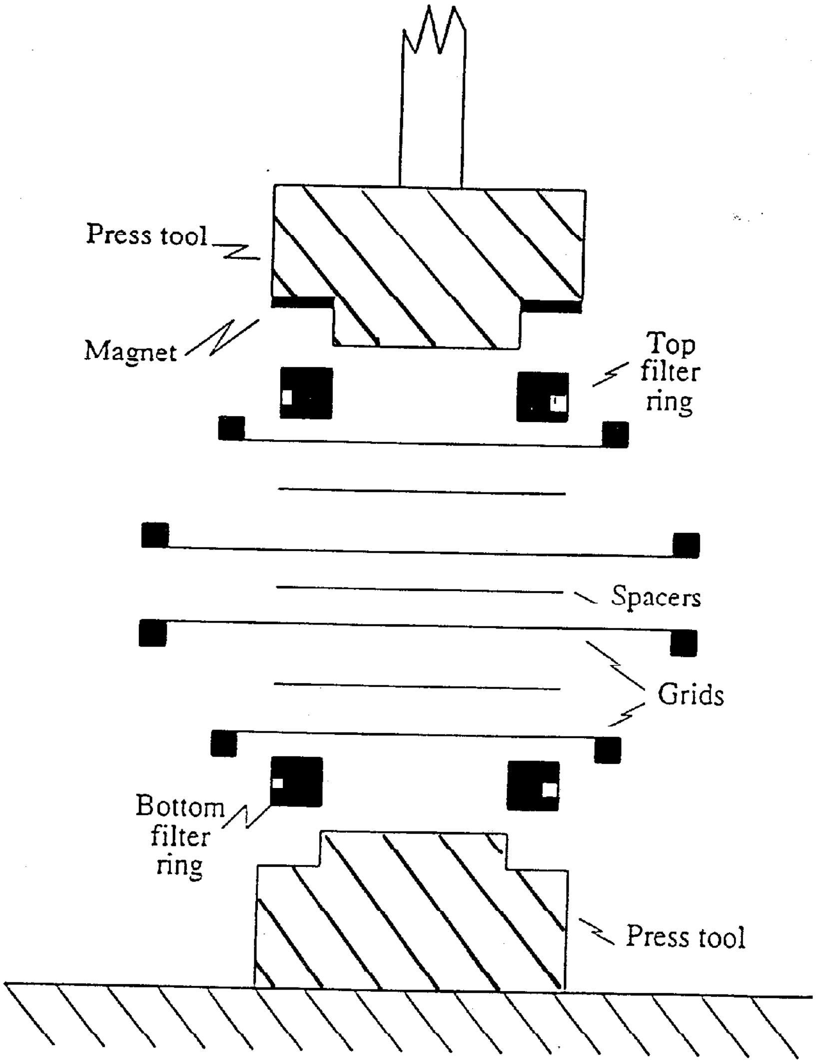
Geometry, equivalent circuit representation and idealised spectral performance of the inductive mesh.



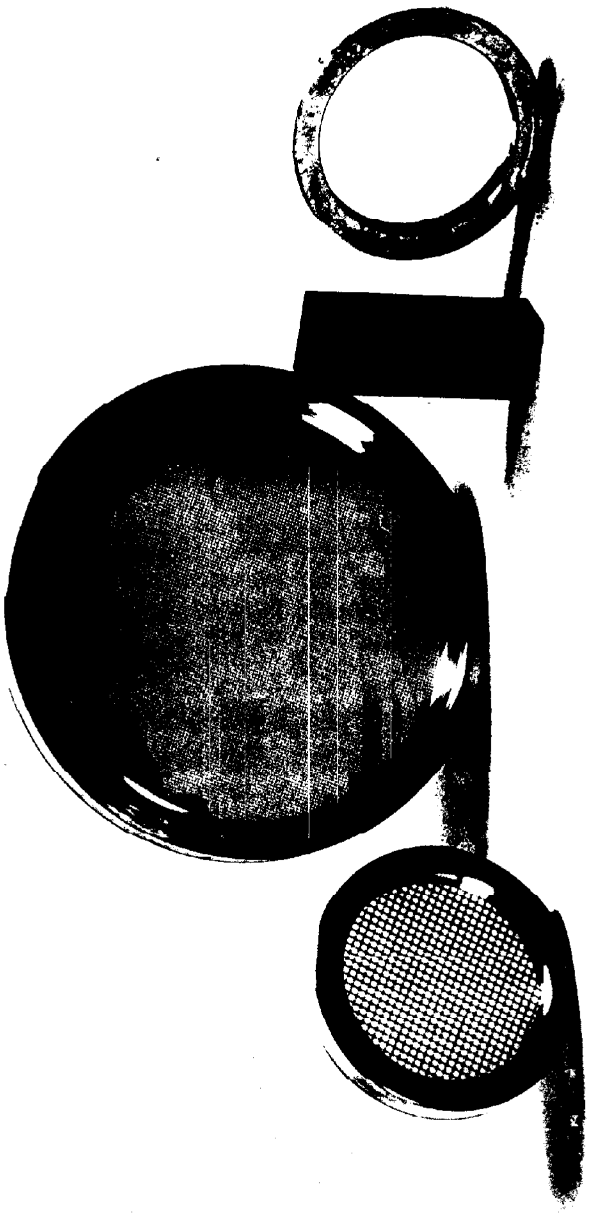
Geometry, equivalent circuit representation and idealised spectral performance of the capacitative mesh.

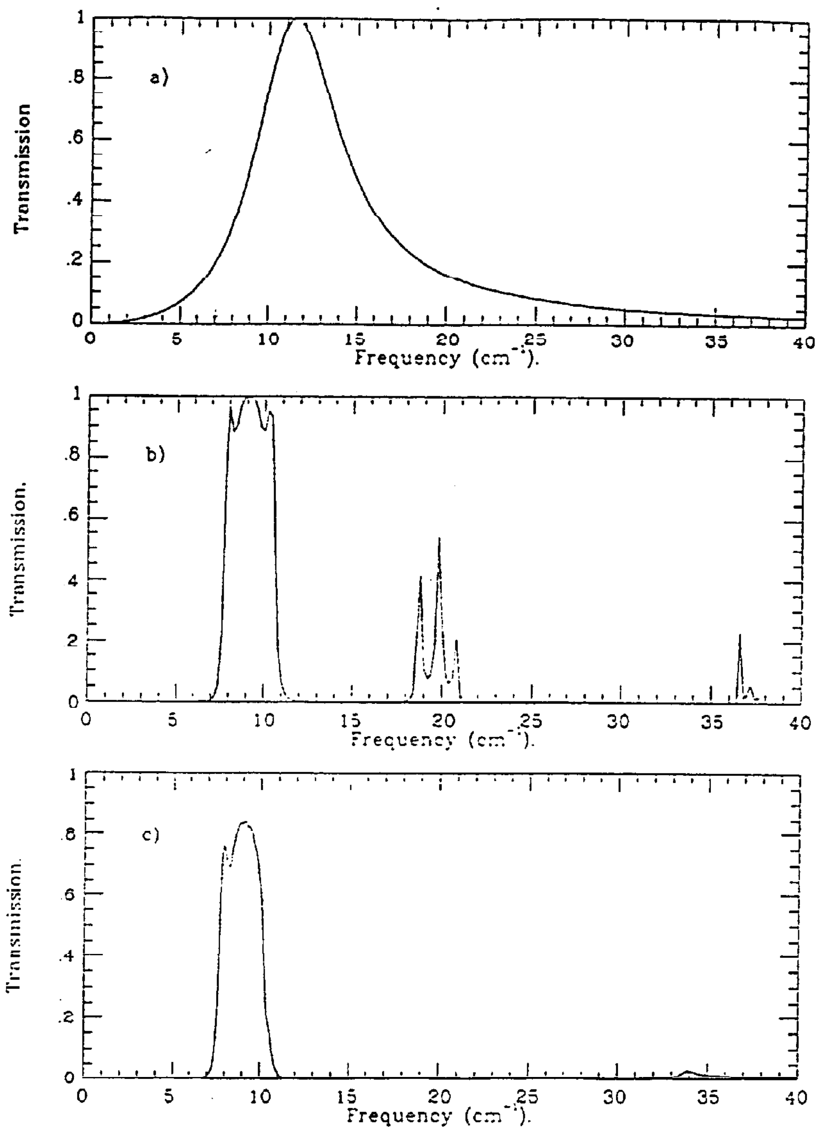


Geometry, equivalent circuit representation and idealised spectral performance of the resonant mesh.

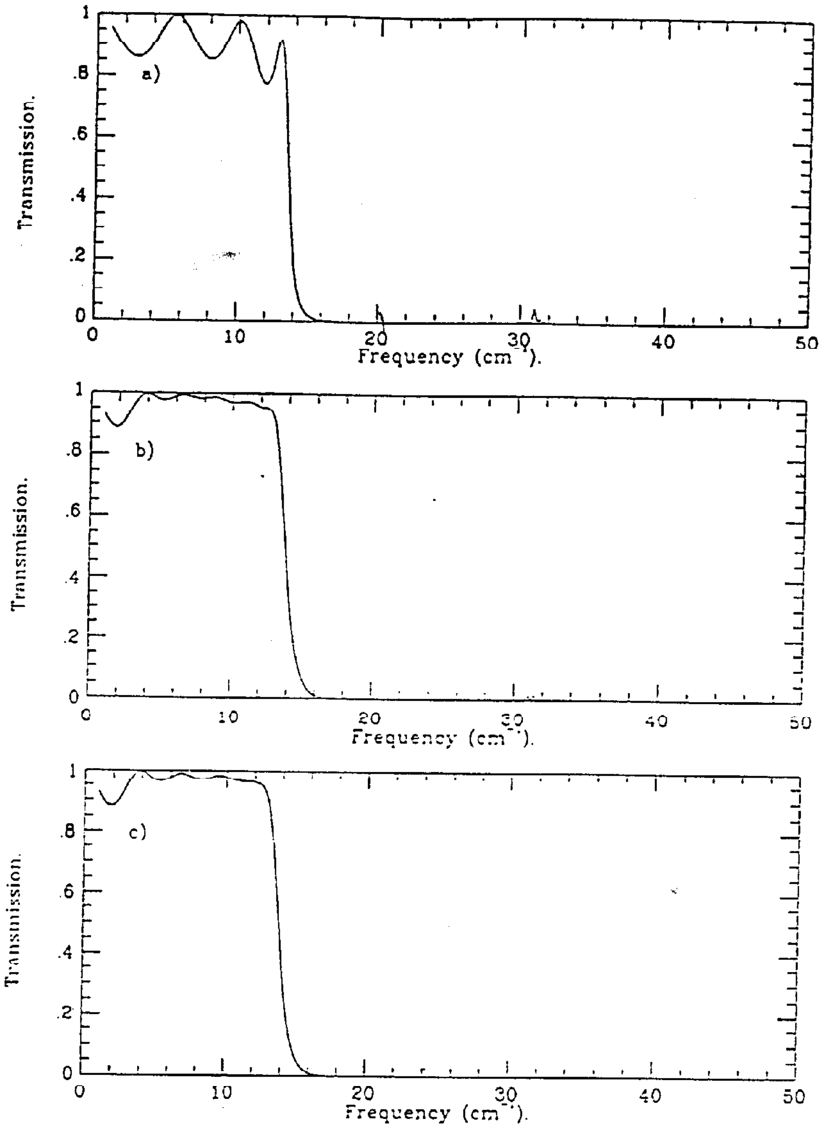


A schematic diagram showing the assembly of a metallic mesh filter stack.

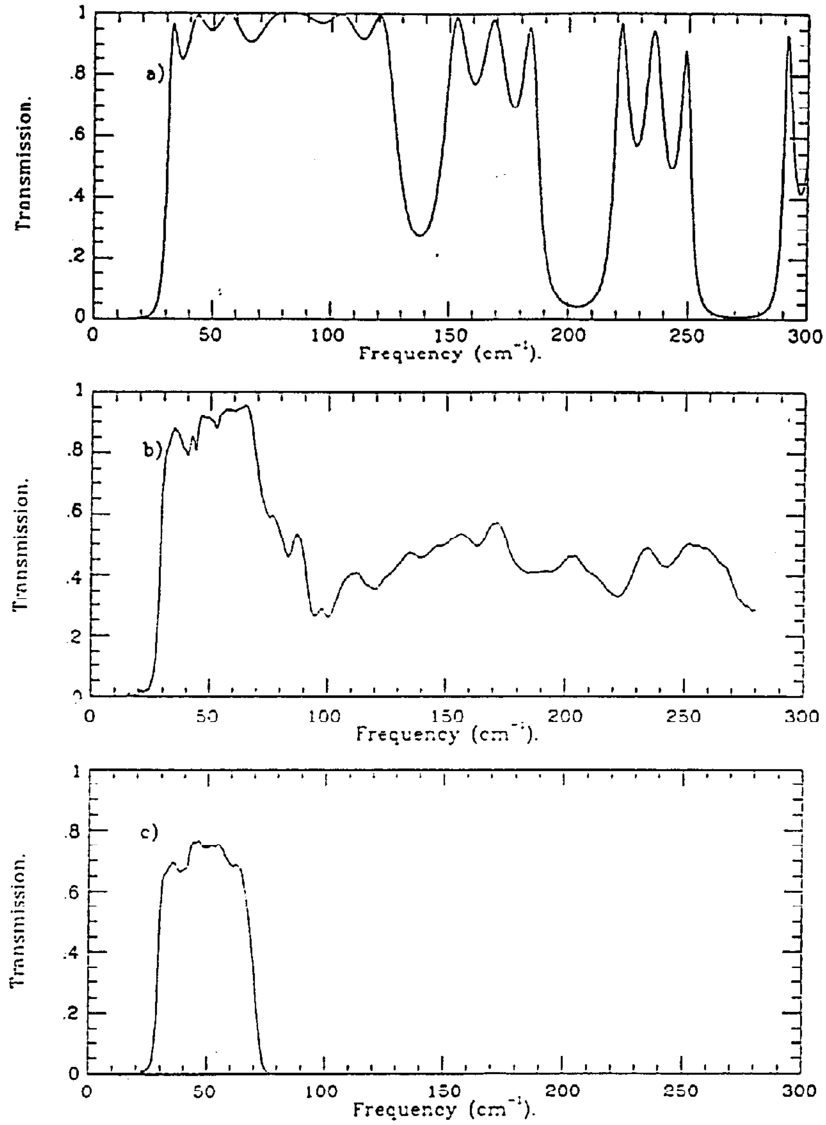




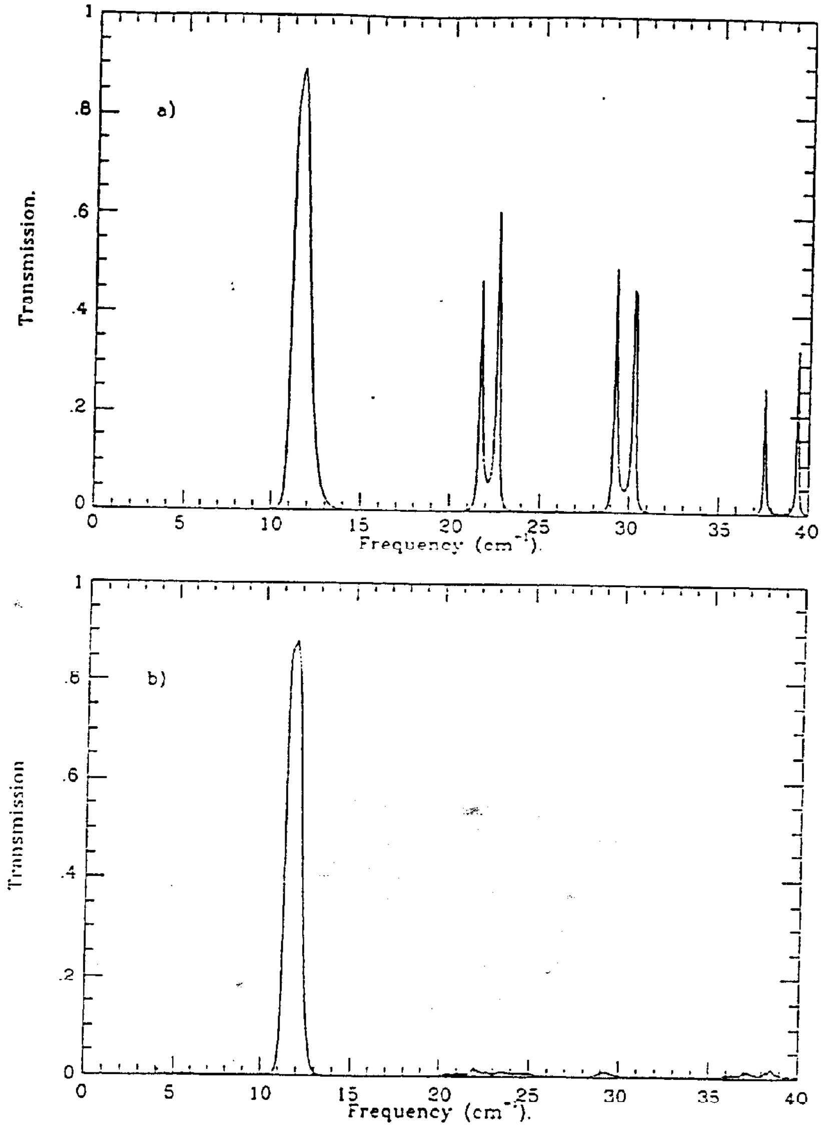
Spectral performance of: a) Single R480 mesh, b) R610-R610-R610-R610 (mesh separation = 283μm) and c) A real filter (built as b).



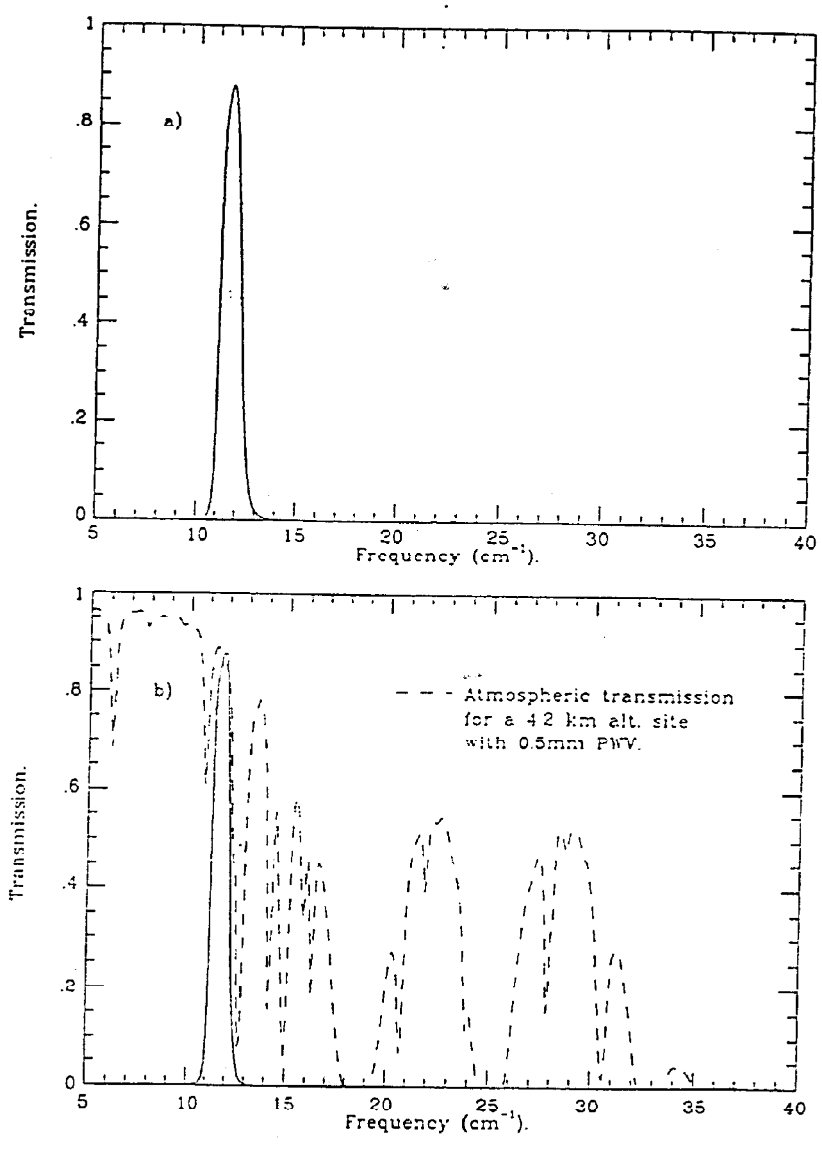
Spectral performance of a) Four grid edge filter, b) Eight grid edge filter and c) Eight grid edge filter with 'de-tuned' first pair.



Spectral performance of a) Modelled I130–I120–I120–I130 (mesh separation = 70μm), b) Real filter of same design and c) A combination low- and high-pass filter giving a broad pass-band.

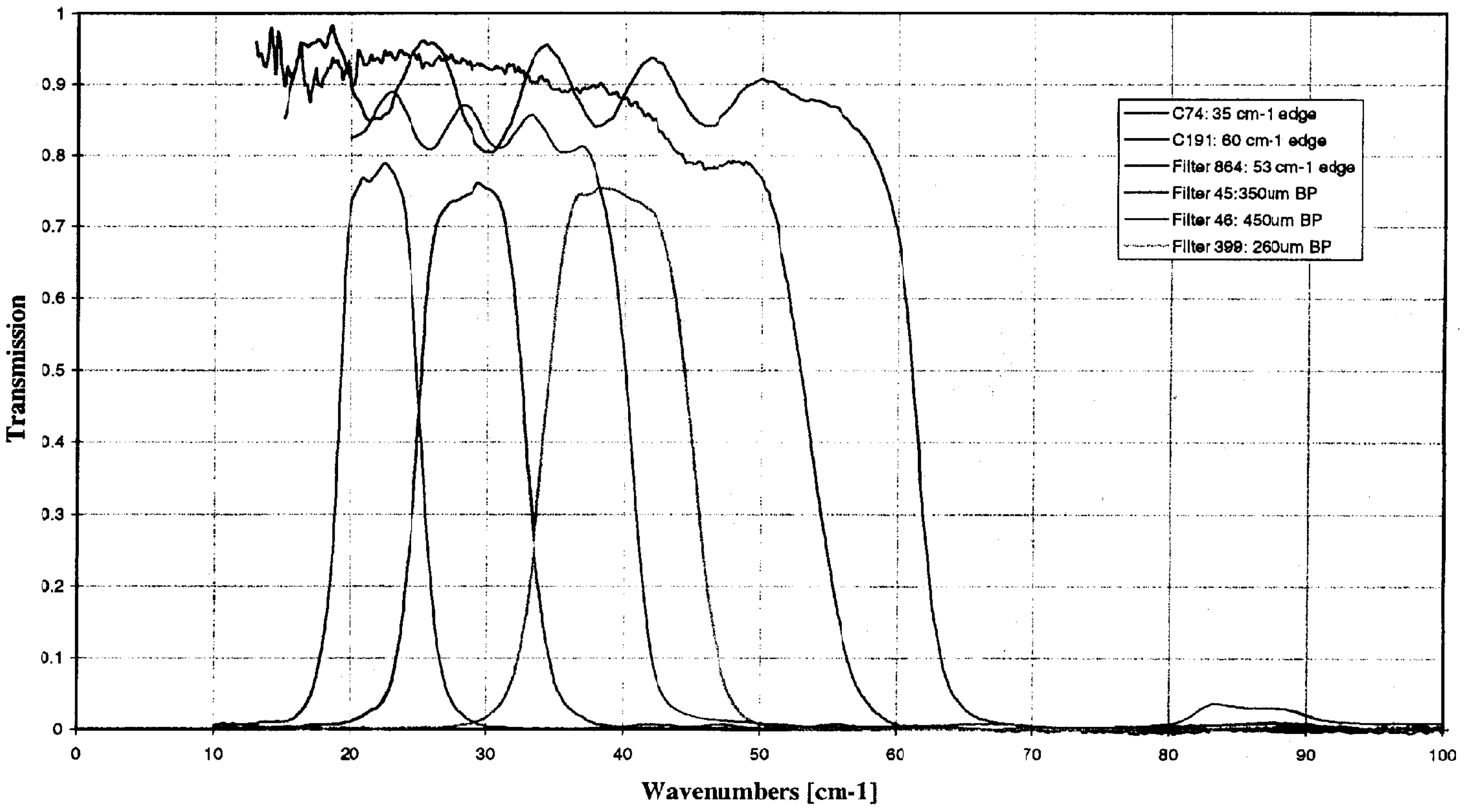


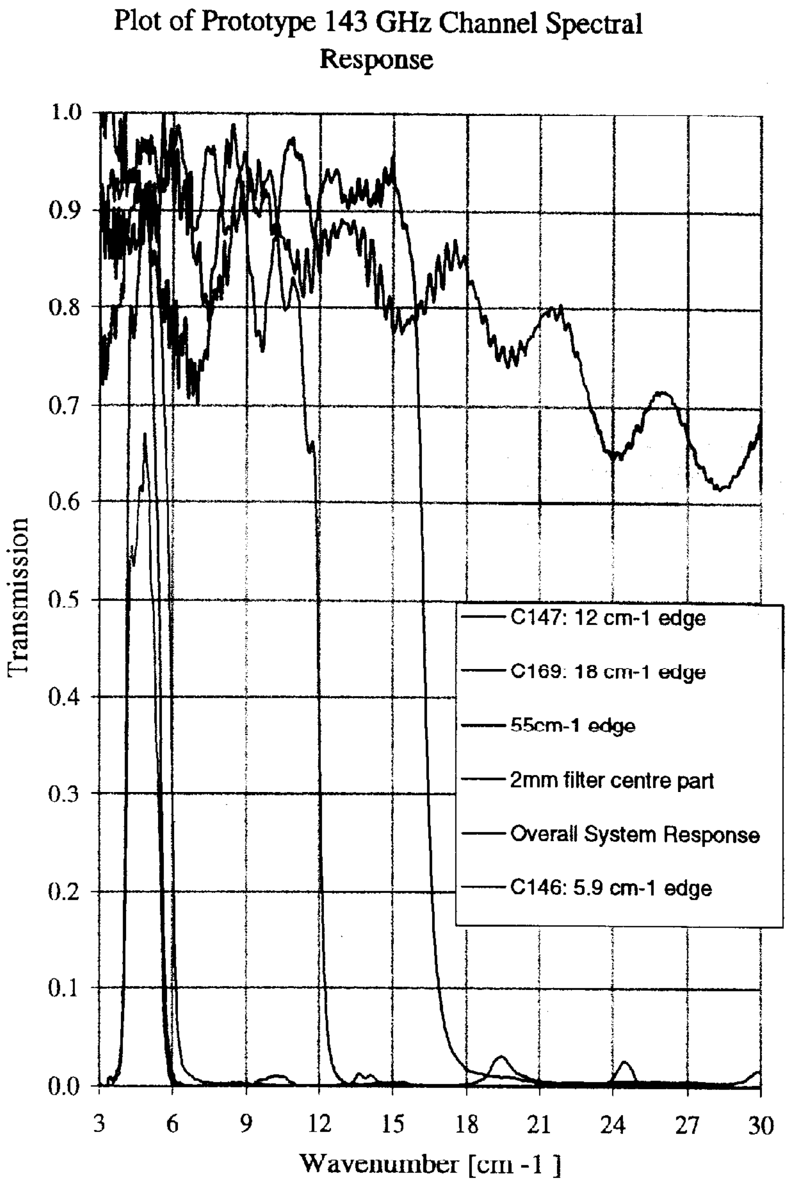
Performance of an R480-I288-I90-I288-R480 combination: a) Modelled and b) Manufactured device.

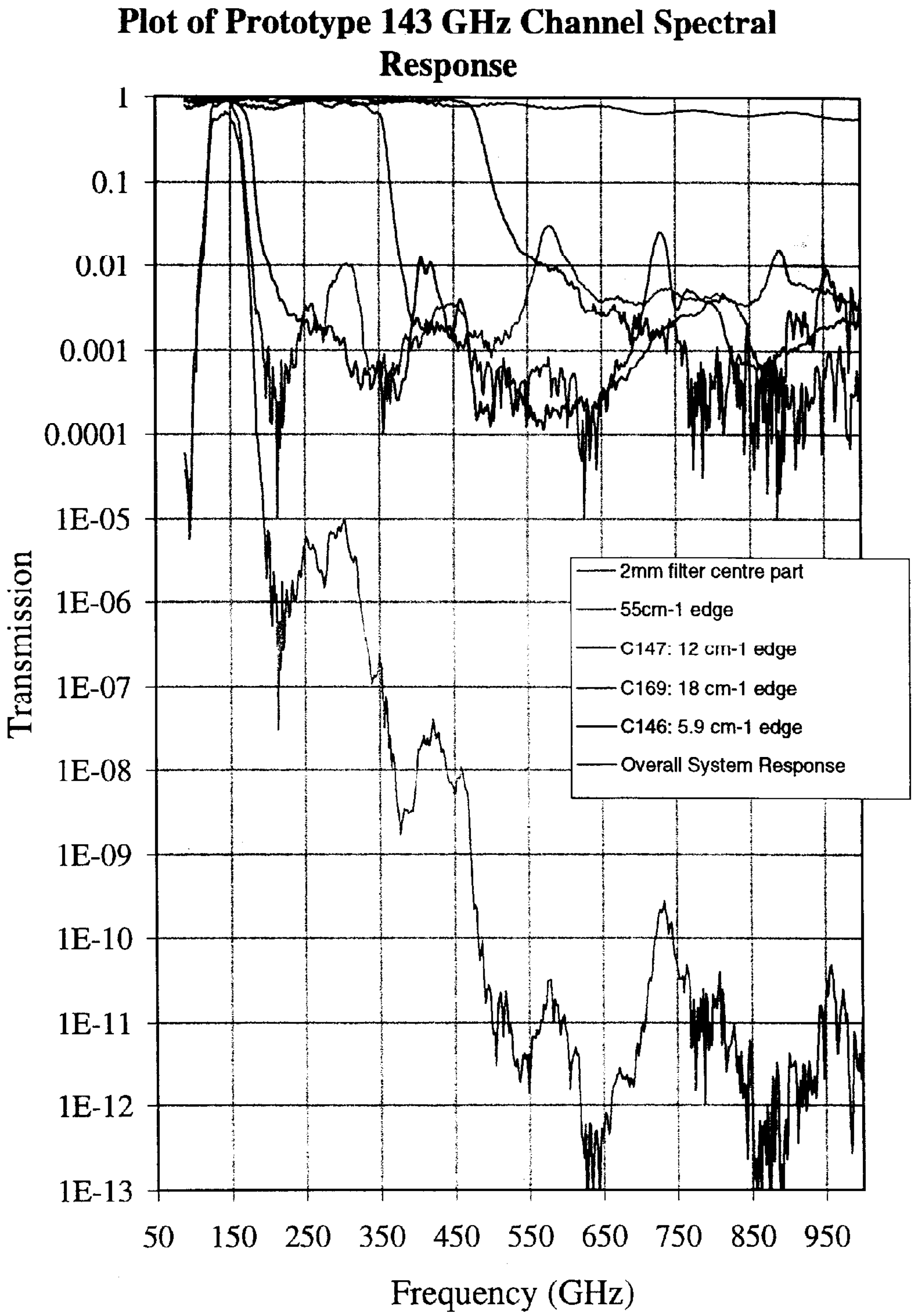


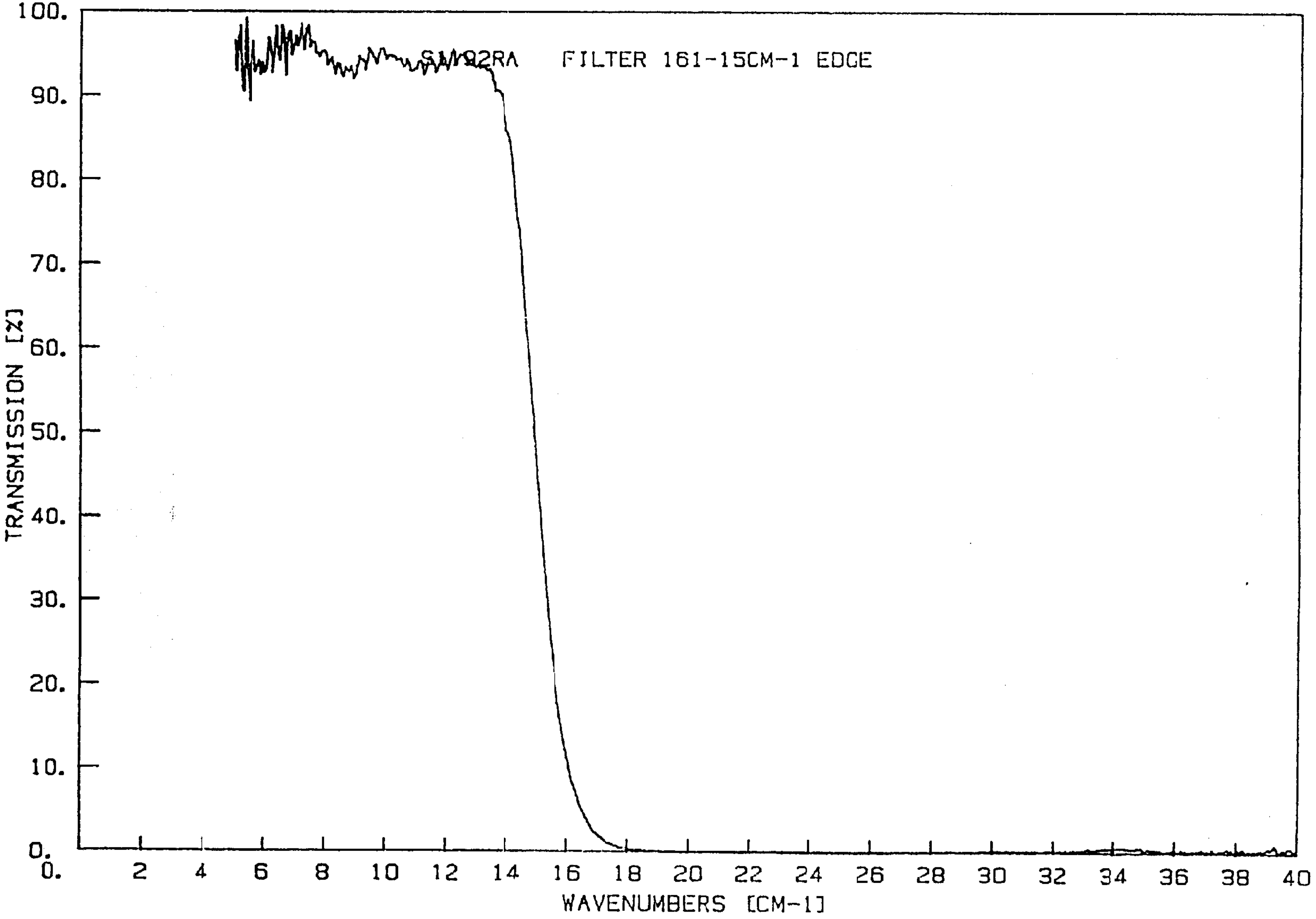
Spectral performance of a) Modelled capacitative blocked DHWFP and b) Real filter to same design as a).

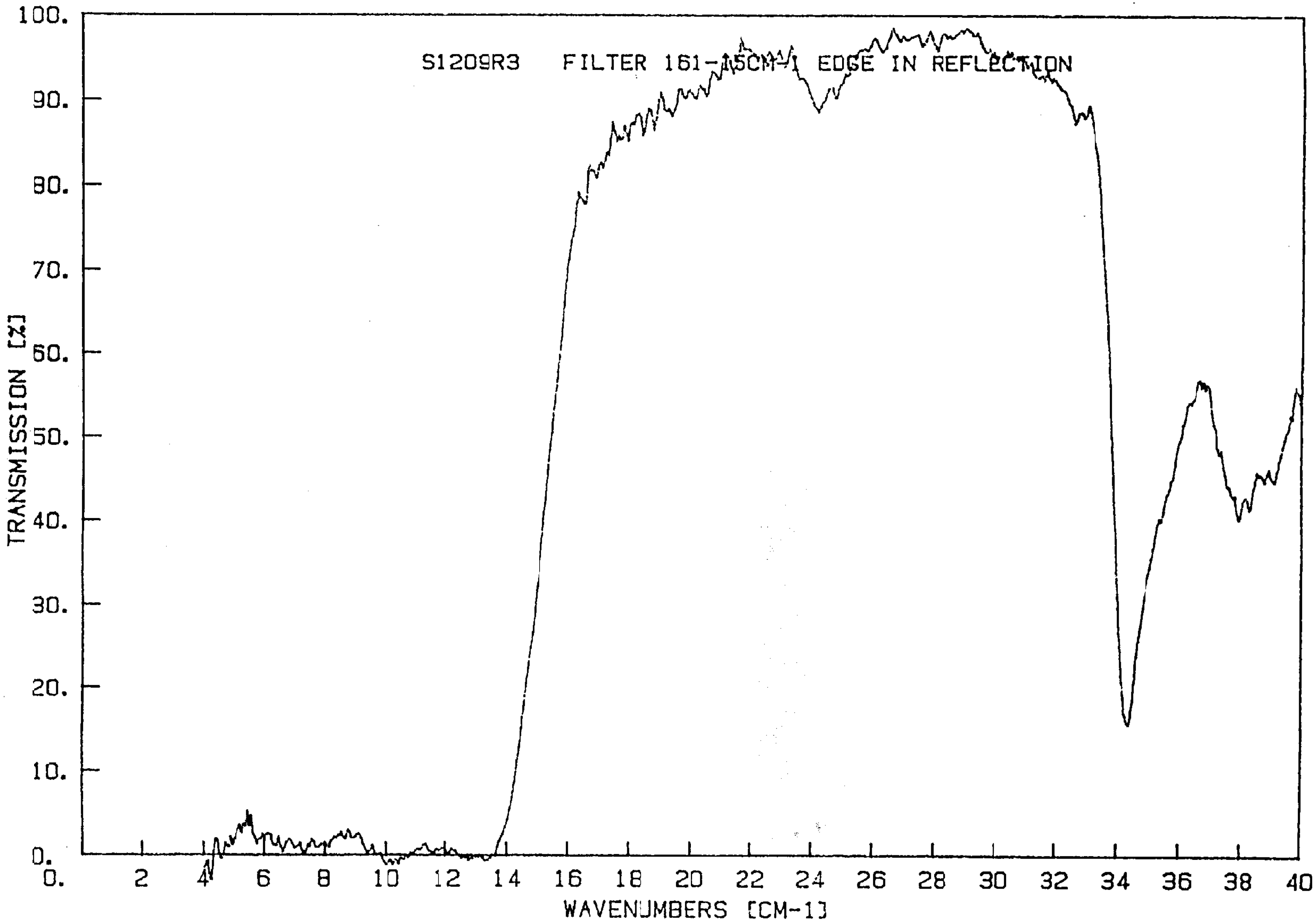
BACUS filters

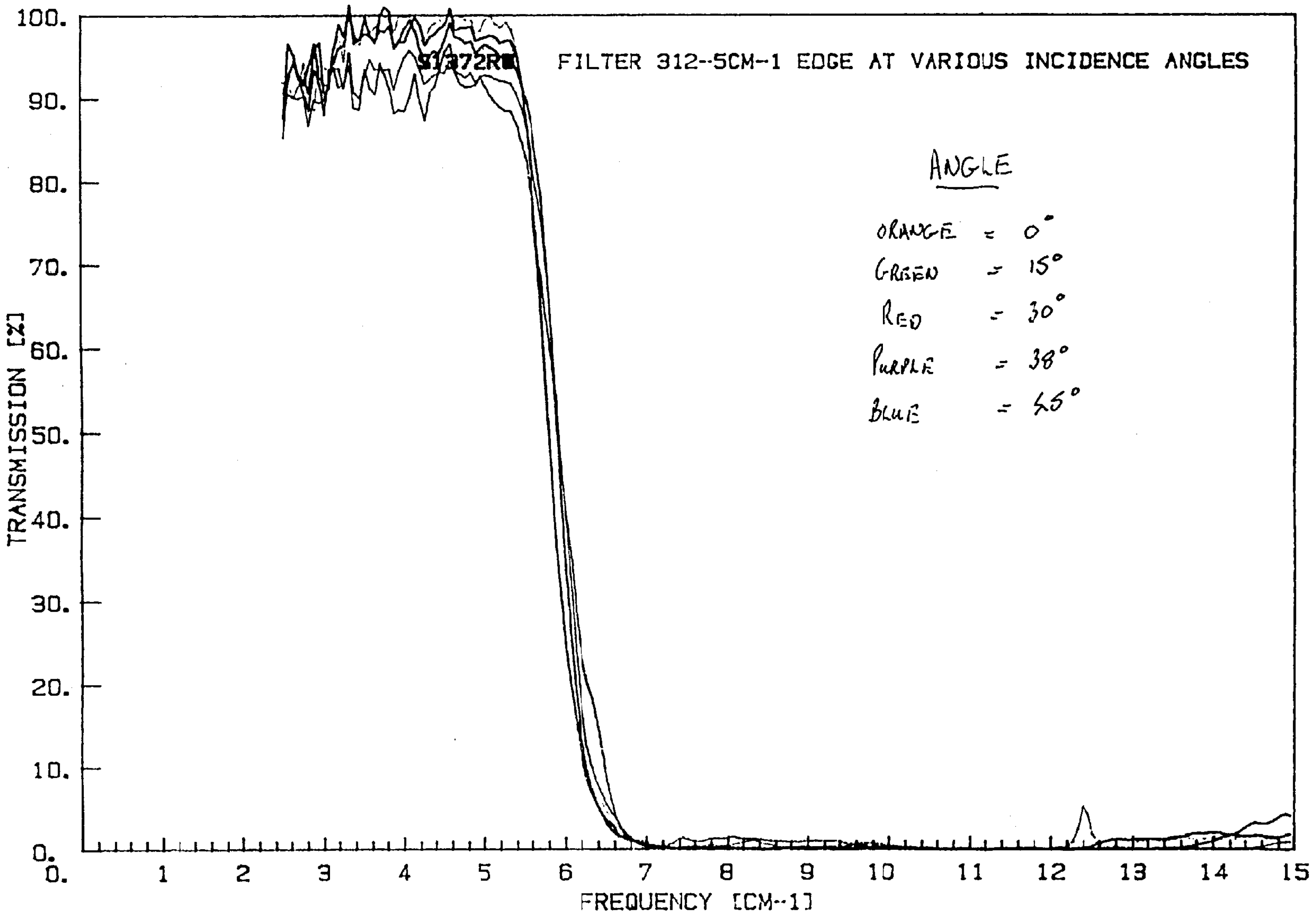



Plot of Prototype 143 GHz Channel Spectral Response
Transmission
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3
6
9
12
15
18
21
24
27
30
Wavenumber [cm -1]
C147: 12 cm-1 edge
C169: 18 cm-1 edge
55cm-1 edge
2mm filter centre part
Overall System Response
C146: 5.9 cm-1 edge


Plot of Prototype 143 GHz Channel Spectral Response
1
0.1
0.01
0.001
0.0001
1E-05
1E-06
1E-07
1E-08
1E-09
1E-10
1E-11
1E-12
1E-13
Transmission
50
150
250
350
450
550
650
750
850
950
Frequency (GHz)
2mm filter centre part
55cm-1 edge
C147: 12 cm-1 edge
C169: 18 cm-1 edge
C146: 5.9 cm-1 edge
Overall System Response

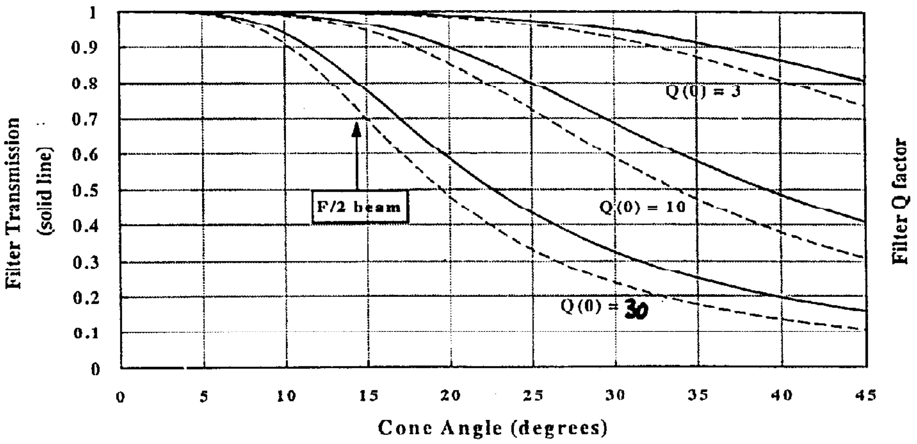

SAM92RA FILTER 161-15CM-1 EDGE
TRANSMISSION [%]
100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
0.
0.
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
WAVENUMBERS [CM-1]


S1209R3 FILTER 161-15CM-1 EDGE IN REFLECTION
TRANSMISSION [%]
100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
0.
0.
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
WAVENUMBERS [CM-1]


S1372R
FILTER 312--5CM-1 EDGE AT VARIOUS INCIDENCE ANGLES
ANGLE
ORANGE = 0°
GREEN = 15°
RED = 30°
PURPLE = 38°
BLUE = 45°
TRANSMISSION [%]
100.
90.
80.
70.
60.
50.
40.
30.
20.
10.
0.
0.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
FREQUENCY [CM-1]

FILTER SUMMARY

- At submillimetre wavelengths we can make to specification bandpass, highpass and lowpass filters
- The best performance is obtained for filters using free space gaps between the elements
- Good performance can only be achieved for hot pressed dielectric filled filters over limited spectral ranges
- The hot pressed filters are particularly convenient when space is at a premium (no room for bulky mounting rings in array systems or on radiation shields)
- Because the out of band radiation from a low pass filter is reflected they are ideal for use as dichroics or for rejecting high frequencies whilst achieving thermal balance within the overall system
- The use of high Q bandpass or edge filters in converging beams needs careful design



INTERNAL CALIBRATORS

MATT GRIFFIN

SPIRE INTERNAL CALIBRATION SOURCES

1. Photometer calibrator

Purpose
- Repeatable signal for monitoring of detector health and responsivity.
- Not required to provide absolute calibration (but may be useful)

Location
- Centre of SPIRE chopping/beam steering mirror (M4 = image of telescope pupil).
- Calibrator located behind the mirror.
- Light pipe connects the aperture (1 mm) to integrating cavity in which the thermal source is mounted.
- Beam steering mirror shall be switched off when the calibrator is operating.

Baseline Design
- Thermal source located at centre of chopping/beam steering mirror M4
  Option 1: Development of micromachined IR calibrators used on SIRTF IRAC
  Option 2: Modification of thermal sources used on ISO LWS

Institutes
- NASA Goddard (manufacture)
- QMW(evaluation, calibration)

SPIRE INTERNAL CALIBRATION SOURCES

Requirements for photometer calibrator

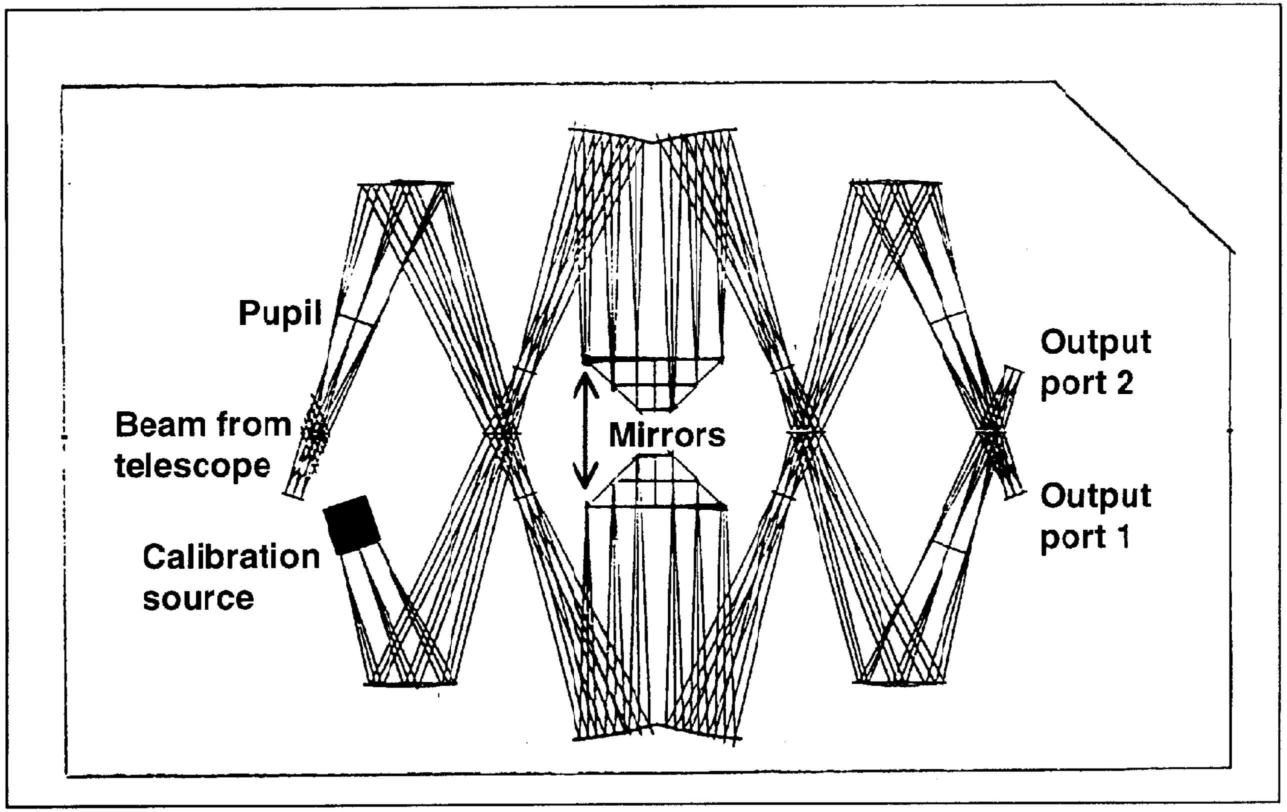
• Mass	< 20 g
• Volume envelope	30 x 15 x 10 mm
• Power dissipation	< 2 mW when operating at nominal temperature
• Radiated power:	Requirement : εT = 20 - 80 K Nominal operation : εT = 40 K
• Speed of response	Requirement: 150 ms Goal : 30 ms
• Repeatability	RMS better than 1% over 20 operations
Aging	Less than 10% over lifetime of mission
• Operation	Nominally flashed for 5 - 10 seconds every hour
• No. of operations	Total number of operations in flight: (4.5*365*22 hours)(0.33 SPIRE usage)(0.5 Photometer usage) ≈ 6,000 Assume 100% margin (for ground testing, PV phase, etc), giving 12,000
• Operating voltage	< 28 V (including voltage drop along cryoharness)
• Redundancy	Goal: Cold redundancy for the active element

SPIRE INTERNAL CALIBRATION SOURCES

2. Spectrometer calibrator

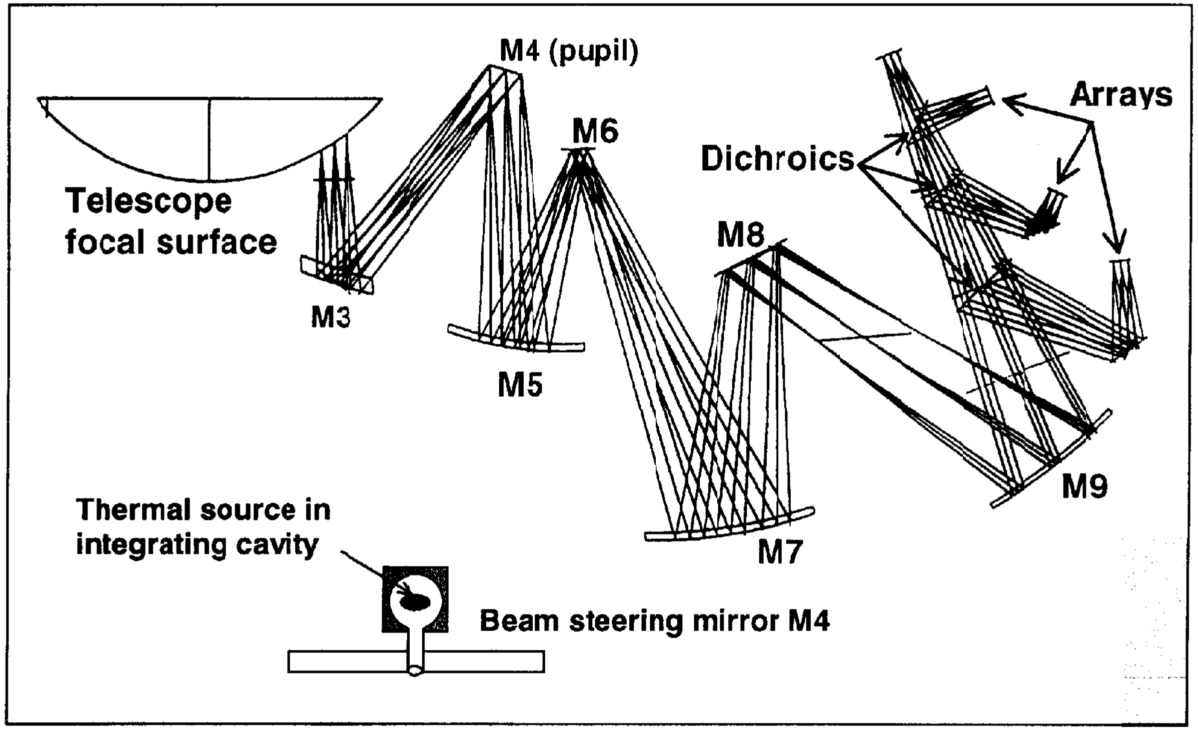
Purpose	• Null the telescope emission by mimicking its spectrum and brightness in the second input port of the FTS • Telescope is assumed to be at 80-K with λ-independent $\varepsilon = 0.04$ • Overall emissivity of the system is assumed to be uncertain by a factor of 2 (actual value will not be known before launch)
Location	• At second input port to the FTS, at an image of the telescope pupil (diameter = 30 mm)
Baseline Design	• Thermal source with Winston Cone optic to present uniform illumination across the pupil and • Neutral density filter to dilute the emission. Option 1: Development of micromachined IR calibrators used on SIRTF IRAC Option 2: Modification of thermal sources used on ISO LWS Option 3: Adjustable temperature black plate + ND filter
Operation	• Continuous operation while the FTS is operating (nominally 50% of SPIRE time) • FTS will normally be operated for long periods (1 hr).
Institutes	• NASA Goddard (manufacture) • QMW(evaluation, calibration)

SPIRE INTERNAL CALIBRATION SOURCES



SPIRE FTS optics

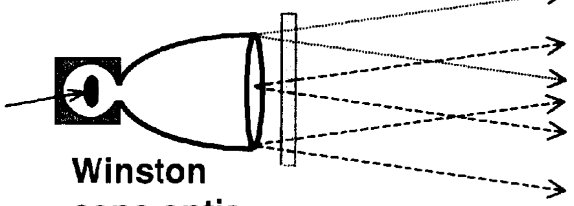
SPIRE INTERNAL CALIBRATION SOURCES



SPIRE photometer optics

SPIRE INTERNAL CALIBRATION SOURCES

FTS calibrator design concept:



Coping with uncertainty in the telescope emission:

Calibrator must be designed to operate correctly in the case of total emissivities in the range 2 - 8%. This can be accommodated by designing for a range of operating temperatures:

⇒ Design for Nominal operation with T = 80 K, 4% ND
Operation up to 120 K
If ε_{tel} higher than expected, operate at higher temperature
If ε_{tel} lower than expected, operate at lower temperature

SPIRE INTERNAL CALIBRATION SOURCES

Requirements for spectrometer calibrator

• Mass	< 200 gm
• Volume envelope	50 x 50 x 70 mm (TBC)
• Power dissipation	Requirement (Goal) < 5 mW (2 mW) when operating at nominal temp.
• Radiated spectrum	Requirement (Goal): Null the central maximum to accuracy of 5% (2%) [TBC] Replicate the dilute 80-K spectrum of the telescope to an accuracy of better than 20% (5%) [TBC] over 200-400 μm.
• Beam pattern	Between f/5 and f/4 at 90% points
• Uniformity	Uniform brightness across the pupil to TBD%
• Speed of response	N/A - operation is DC
• Settling time	Output stable to within 2% within 5 minutes of switch-on [TBC]
• Repeatability	Drift less than 15% over lifetime of mission
• Operation	Switched on continuously at nominal power while FTS is operating Typical duration: assume 1 hour
• No. of operations	Total number of operations in flight: (4.5*365*22 hours)(0.33 SPIRE usage)(0.5 Spectrometer usage) ≈ 6,000 Assume 100% margin (for ground testing, PV phase, etc), giving 12,000
• Operating voltage	< 28 V (including voltage drop along cryoharness)
• Redundancy	Requirement: Cold redundancy for the active element

INTERNAL CALIBRATORS

ALBRECHT POGLITSCH

Instrument Design/Development Status (cont.)

- Calibration Sources
  - Two Calibration Source Concepts:
    1) Conventional Blackbody Radiator (12 mm aperture dia.)
    2) Ulbricht Sphere Radiator (12 mm aperture dia.)
  - Requirements:
    a Calibrators need to have flux similar to telescope, which is a graybody radiator at $\varepsilon \sim 5\ \%$, $T \sim 90$ K.
    b For flatfielding we need anisotropy $< 10^{-3}$ and homogeneity 10 mK.
    c Short term (1s) and long term (d) temperature stability have to be <2mK, 100 mK, resp.

PACS Blackbody Specification

Background

Two internal blackbodies (BB) are used for internal flux calibration and flatfielding of the detector arrays.

The PACS internal chopper is used to switch between the two.

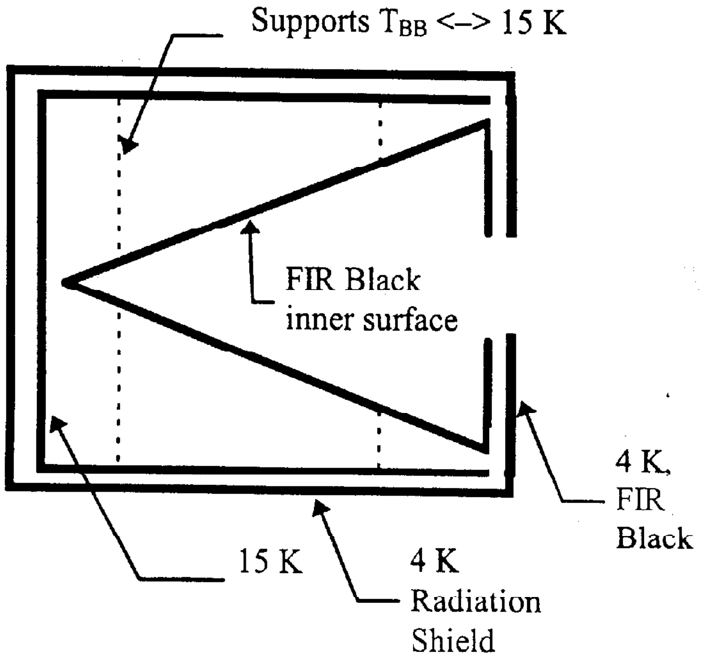
The BBs are located at the entrance pupil when calibrating. Optically, the illumination is equivalent to BBs sitting at the FIRST secondary mirror. Separate field mirrors at the entrance of PACS are used to image the BB openings onto the PACS chopper. The BBs have to illuminate both the pupil as well as the (combined spectrometer and photometer) field in a uniform manner.

The temperatures have to be adjusted such that their power spectral density is roughly comparable to that of the telescope emission in the currently detected band.

Technical Specification.

Temperature Range	**20-35 K**
Heat Load	**< 1 mW**
Short Term Temperature Stability (1 s)	**2 mK**
Long Term Temperature Stability (10 d)	**0.1 K**
Absolute Temperature Readout Accuracy	**0.1 K**
Thermal Time Constant when changing temperature	**15 min**
Emissivity (80-210 mm)	**> 95 %**
Flux Anisotropy (within ± 12° cone)	**$< 10^{-3}$**
Radiating Surface Temperature Inhomogeneity	**< 10 mK**
Circular Aperture dia.	**12 mm TBC**
He Temperature Baffle Stop	**FIR black, 4K**

Schematic View of Blackbody



BlackBody Dimensions

Wall thickness	1 mm
Cone diameter	30 mm
Cone Length	40 mm
Cone Weight	6.9979 g

Operating Conditions

Allowed Heat Load to 15 K level	0.001 W
Temperature difference 15k => T_BB	20 K
Conductivity	5E-05 W/K
C (Specific Heat)	0.01 J/gK (Al, 30K)

===>

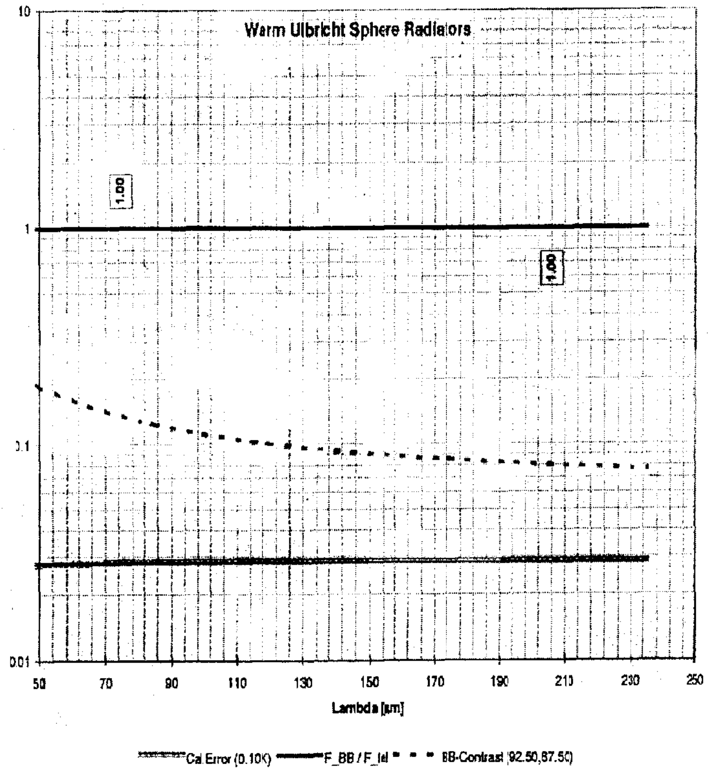
TimeConst = HeatLoad*SpecHeat/Conductivity **1400 s**

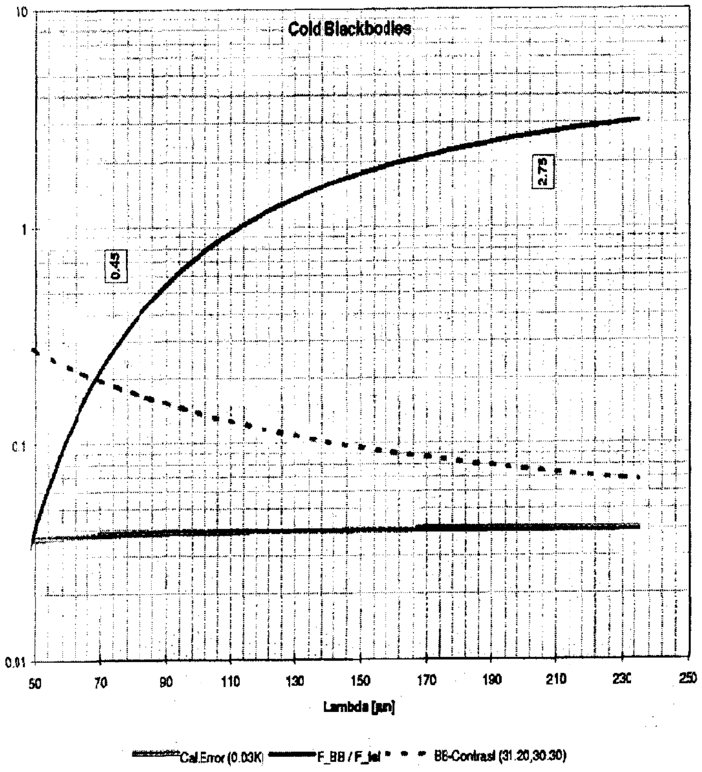
To match calibrator signal to telescope background, and to reach stable conditions according to the requirements *black body* calibrators would need many hours between observations in different wavelength regimes.

This is not acceptable from an operations point-of-view.

PACS BB Specs.xls

Comparison of calibration source concepts





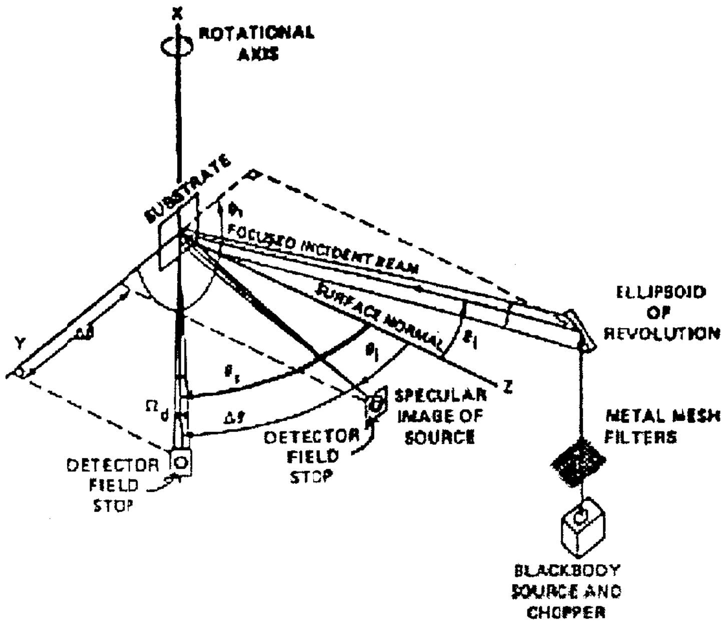


Figure 1. Schematic drawing of the NASA-Ames nonspecular reflectometer. For reflection in the plane of incidence, $\cos \phi_i = \cos \phi_s = 1$.

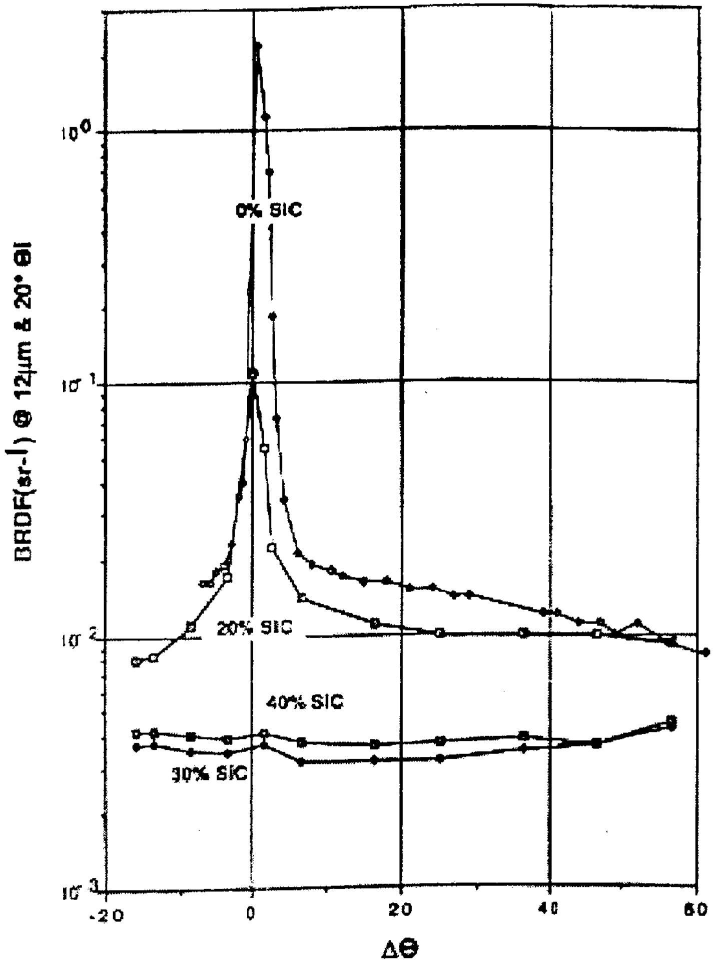


Figure 3. BRDFs at increasing loadings of SiC grit. These measurements were made at 12.5μm (in the restrahlen band of SiC) and 20° incidence. Note the non-linear change with SiC loading.

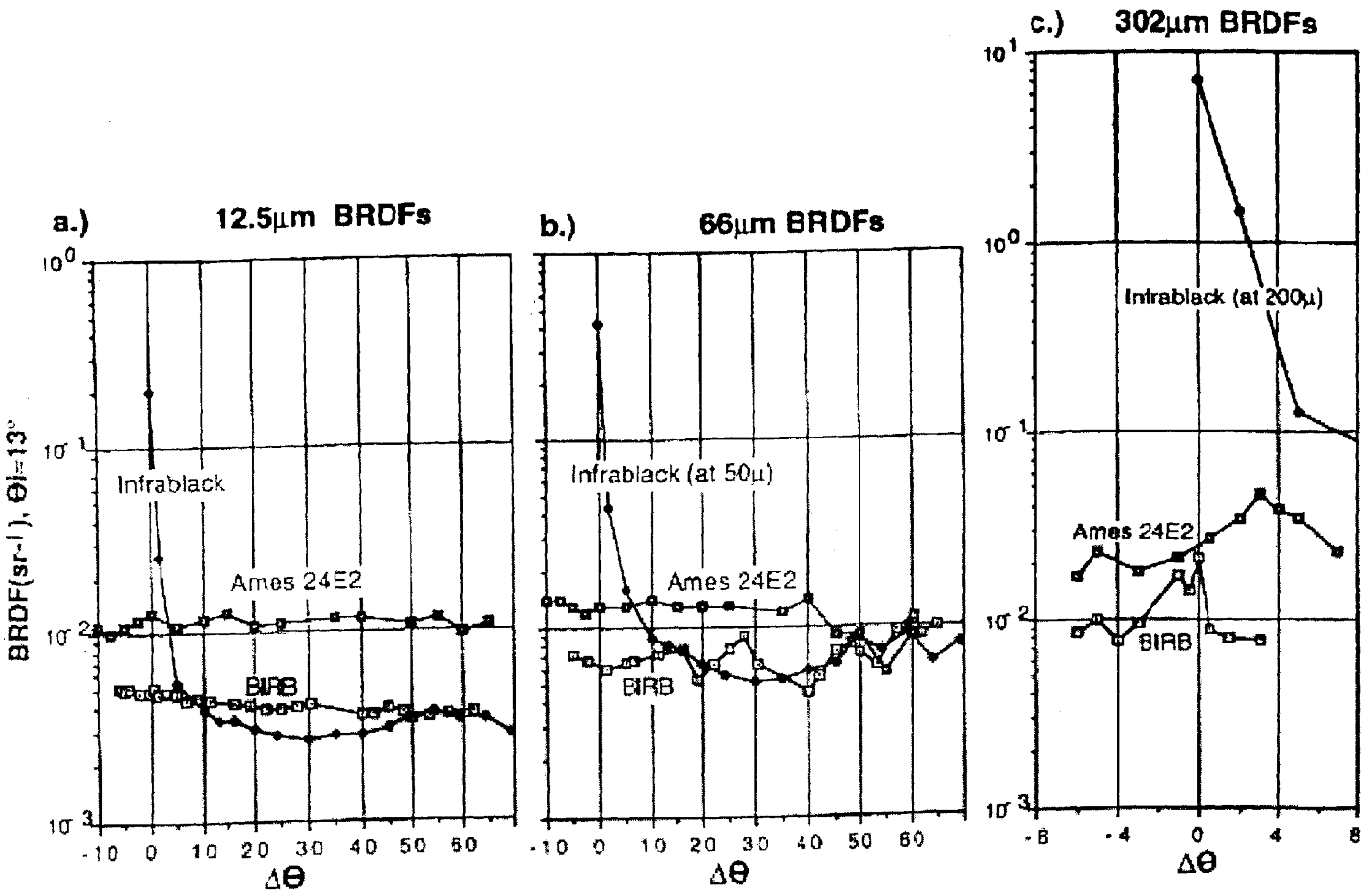


Figure 2(a,b,c). BRDFs at three separate wavelengths: 12.5, 66, and 302µm (except for Infrablack at 50 and 200µm). The specular direction is at or near ΔΘ = 0, and the incidence angle is ~13°.

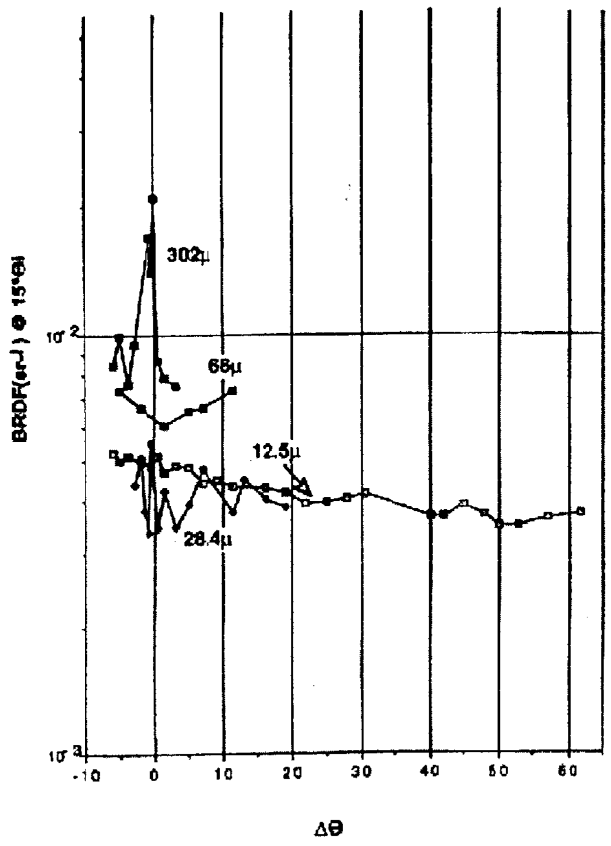


Figure 6. BRDFs of Ball IR Black at 15° incidence.

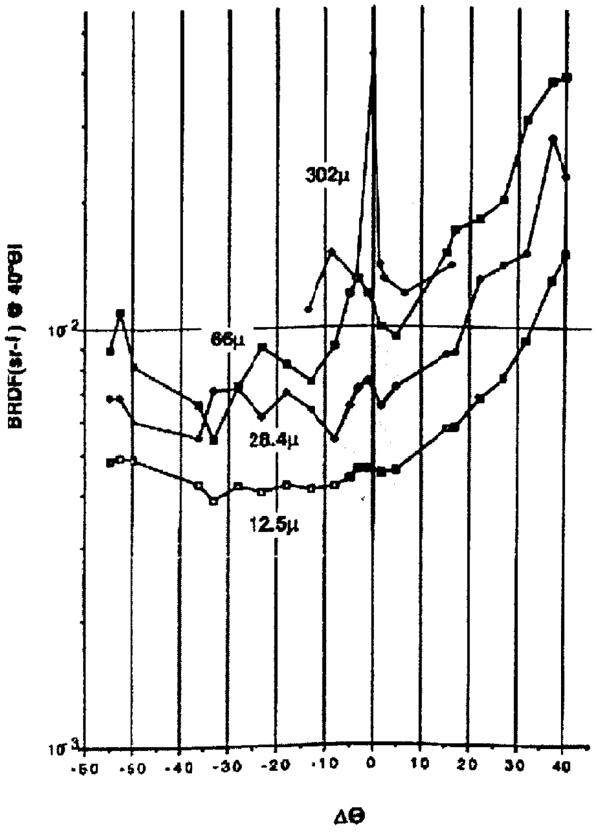


Figure 7. BRDFs of Ball IR Black at 40° incidence, except for 302μm at 20°.

Ulbricht Sphere Radiators

Integrating sphere to randomize and thin out the radiation field of a hot radiator to match the telescope flux.

• Temperature	~110 K (TBD)
• Heat Load	< 1 mW
• Stability	0.2 mK (1s); 10 mK (10d)
• Temp. accuracy	10 mK
• Time constant	~ 1 min (TBC)

The "source" is a Pt-100 resistor embedded in a meteal plate. This is sized and coated to give the correct flux level at the sphere output (this is after being affected by absorption due to multiple reflections, losses into large angles etc.).

The voltage drop from the heating current into the Pt-100 is used as the temperature readout (4-wire method).

Randomisation and smoothing of the emission pattern is achieved by forcing multiple (~ 10) internal reflections and by a roughened scatter plate as the final scattering surface (see figure).

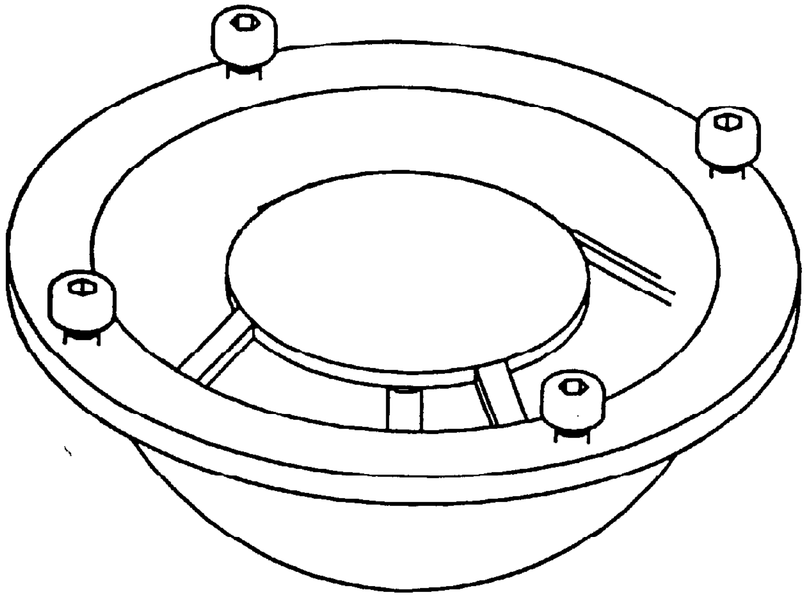


Figure 2.1.2: Inside of the integrating sphere with scatter plate

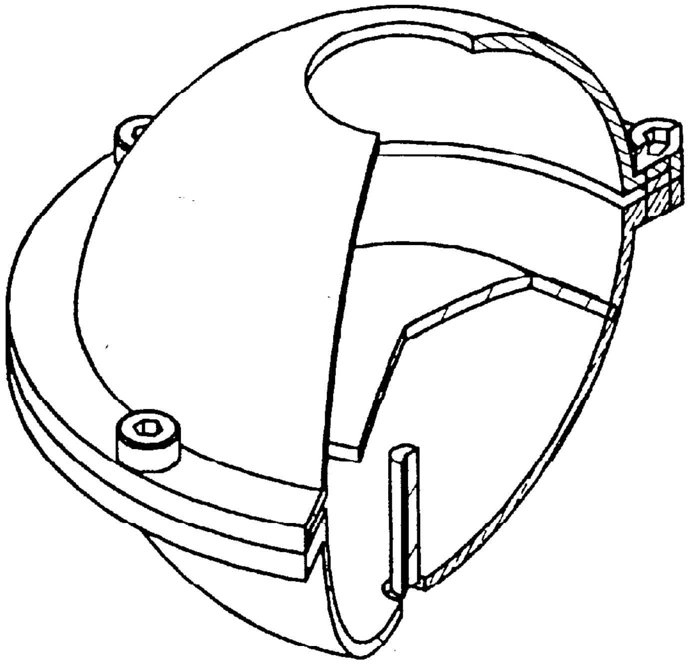


Figure 2.1.3: Cut through the lower half with scatter mirror and source

A trade off based on the ISO, IBSS experience and on a recent SOFIA study (NASA) has resulted in a preselection of the following candidate cryo coatings/paintings offering excellent IR absorption, even in the FIR spectral range:

- Herberts (critical due to particle loss), (Ref. CRISTA)
- AMES 24 E2 with MH 2200 (NASA)
- DeSoto (e.g. Ball Aerospace) Black (optimum FIR - scatter and absorption properties)
- Chemglaze/Aeroglaze Z306 (Ref.: IBSS,. XMM baffles) with average FIR performance
- Martin Marietta, Enhanced Black (poor cleaning properties)
- Infrablack (20-200 µm)
- 3M Black Velvet.

SYSTEMS ENGINEERING

COLIN CUNNIGNHAM

SPIRE

SPIRE Commonality Issues

Systems Engineering

Colin Cunningham

April

UK
Astronomy Technology Centre

Internal Wiring and Connectors

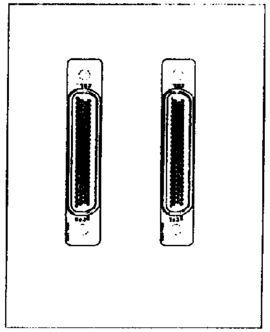
- We have around 1000 signal wires and 180 housekeeping wires
- Requirements:
    - Compact
    - Low thermal conductivity
    - Stiff to minimise microphonics
    - Low capacitance to ground
    - Low capacitance between signal pairs
    - Robust
    - Easy to assemble

Signal wiring issues:

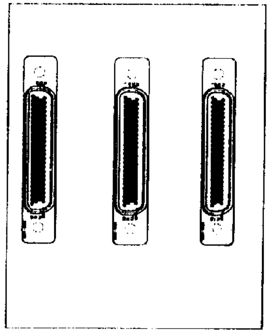
- **Inside FPU**
  - Connectors- 37, 51 or 100 way ?
  - Ribbon cables - Kapton or Woven?
- **Cold Interconnect Harness:** FPU to BAU, BAU to DRC and FPU to DRC (ESA responsible)
  - Connectors- 37, 51 or 100 way ?
  - We have agreement with ESA to use intermediate harness on optical bench to go from say 100w to 37w connectors on connector panel
  - Conventional wire bundles or Ribbon cables - Kapton or Woven?

Connector options:

61 detector array: 130 pins
2 x 100w MDM



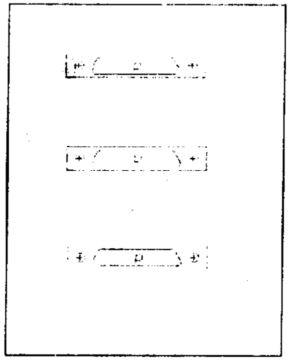
122 detector array: 255 pins
3 x 100w MDM



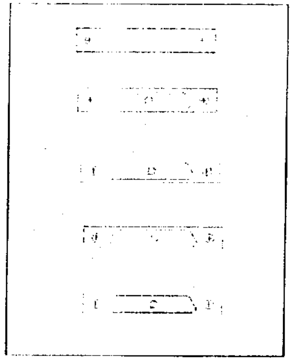
Typical space available: 95 x 75 mm

Connector options:

61 detector array: 130 pins
3 x 51w MDM



122 detector array: 255 pins
5 x 51w MDM



Using ESA-approved 37w MDMs will be even worse!

Connector Types

- MDM 37 way
- MDM 51 way
- MDM 100 way
  - ESA concerns about need to remove rubber seal
- ESA recommended 104 pin D-type?
- Others?

Temperature Sensors

Undecided what type, but requirements are:

- **0.2K to 5K Range: eg Germanium thermistors?**
- **1K or 3K to 300K: Silicon diodes?**
- **-40C to 80C (warm electronics) : Silicon diodes**

Contamination Requirements

No quantitative requirements yet –

Main Effects:

- MIRRORS – increased emmissivity
  – increased scatter → straylight

- DETECTORS – unknown, but
  may increase noise
  <u>or</u> reduce sensitivity

EMC Modelling and Analysis

EMC is a serious problem for bolometers

BRUTE FORCE:
FARADAY CAGE
RF FILTERS ON ALL LINES

MODELLING MAY BE USEFUL
– but bolometers susceptible to wide range of frequencies

Cold Vibration Test Facility

will be needed!

Ionisation radiation testing

Not a big problem For bolometers

- No memory effects
- Spikes can be easily modelled

PACS RADIATION TESTING

REINHARD KATTERLOHER

Ionising radiation testing

PACS has 2 × 16 × 25 = 800 detector elements

$0.1\ s^{-1}$ spike events expected

Tests using 1 or 2 detector modules (EM)
(s-Ge:Ga)

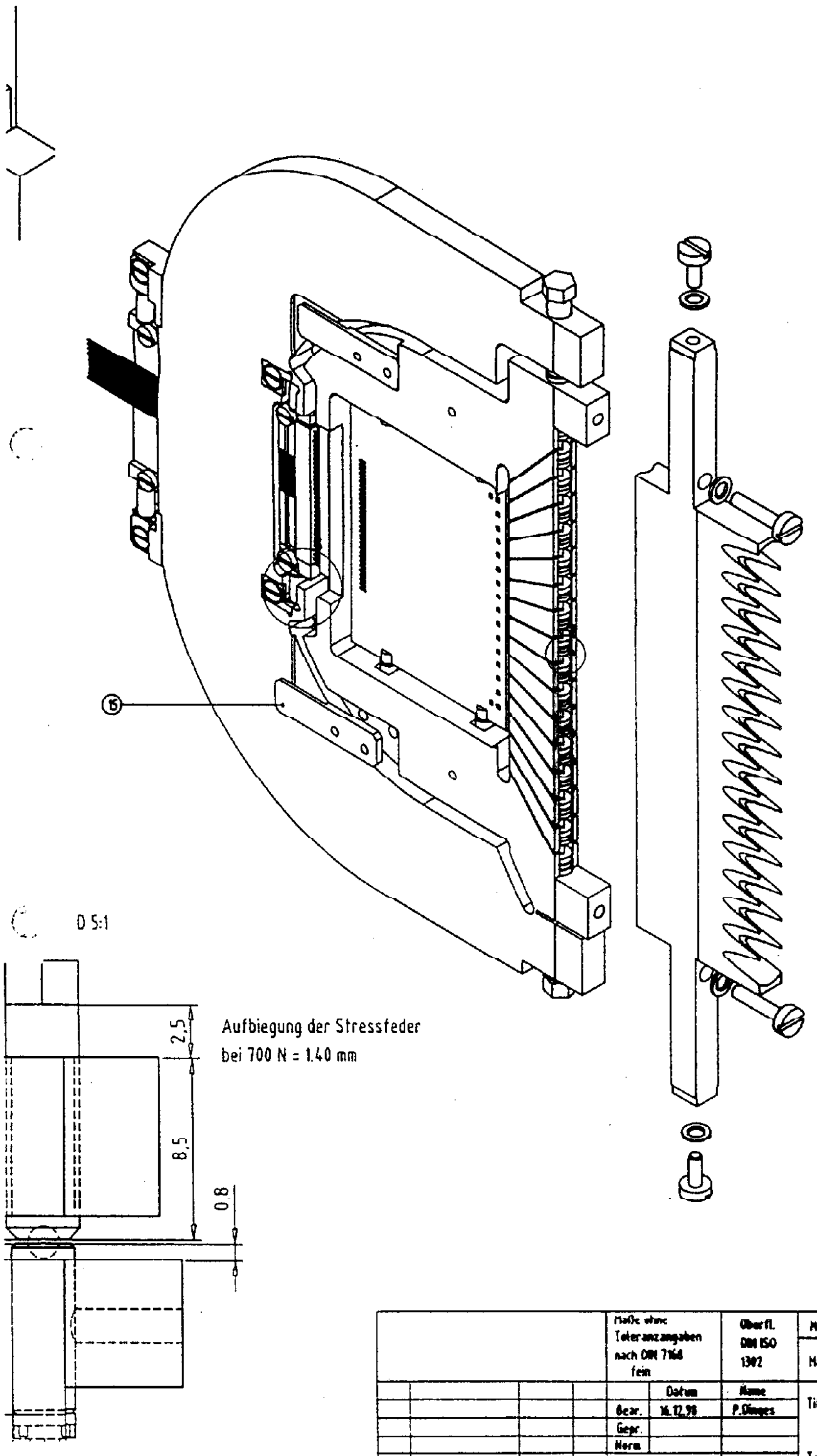
should start beginning of 2000
at PSI Zurich
using 100 MeV protons

Get information on detector settling
times and spike behaviour

→ impact on data preprocessing / ~~reduction~~ compressio.
→ optimise bias and shielding

Availability of cryo triax cables ?
(CRE shield driver)

MDM connectors ? MALCO ?



Aufbiegung der Stressfeder
bei 700 N = 1.40 mm

				Maße ohne Toleranzangaben nach DIN 7168 fein		Oberfl. DIN ISO 1302	Maßstab: 2:1, 10:1 / Masse: Material:
					Datum	Name	Titel: Assembly stressing modul 5004-2110288-Issue1
				Bear.	16.12.98	P.Dinges	
				Gepr.			
				Norm			Teil:
				ANTEC Angewandte Neue Technologien GmbH			Projekt: FIRSA-Upgrading File: assembly stressing modul
Zus.	Änderung	Datum	Name	Tel. 06195 973237			Blatt 1 von 1

SPIRE BEAM STEERING MECHANISM

COLIN CUNNIGNHAM

SPIRE Commonality Issues

Beam Steering Mirror Mechanism

Colin Cunningham

Beam Steering Mechanism (Chopper)

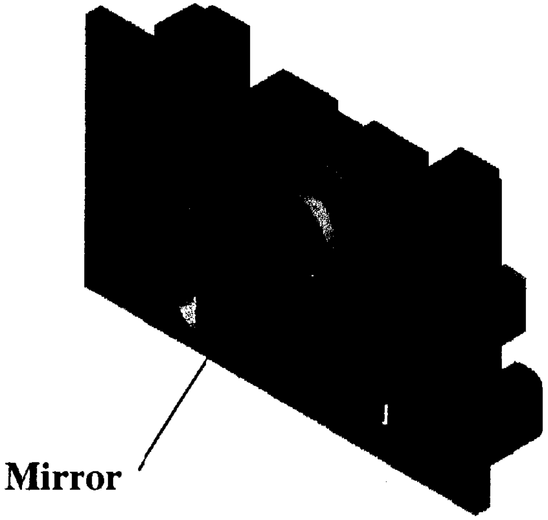
- Operating Modes:
  - Jiggle Mapping / Microstepping
    - To fill in gaps caused by undersampling using horns, or to improve signal-noise in so-called fully sampled maps made with filled arrays
  - Fine Pointing
    - ‘Peaking up’ mode may be needed for horn option, where satellite pointing accuracy of (3.7” requirement, 1.5” goal) may be inadequate for photometry
  - Chopping
    - May be needed to cancel the telescope background or to avoid 1/f noise
    - Frequency up to 5 Hz
  - Fast Jiggling
    - Possible observing mode, now being tested on SCUBA, where we jiggle at around 5 Hz

Preliminary BSM Requirements and Specification:

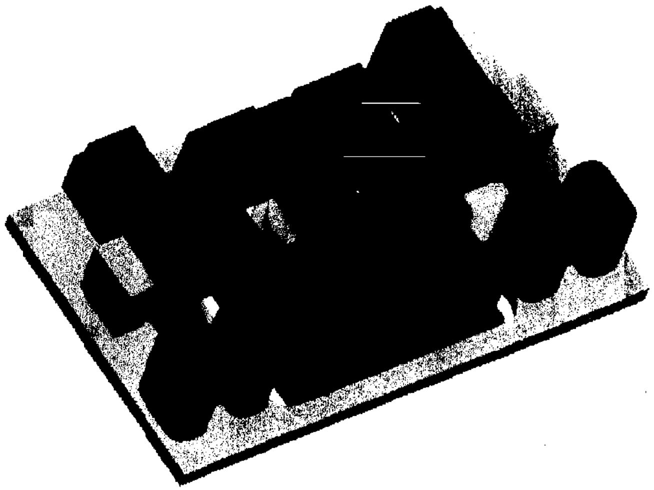
- **Requirements:**
  - 2-axes to allow jiggling & fine pointing
  - 1 of the axes has smaller amplitude, and lower speed requirements, except for fast jiggle
- **1st axis (chopping/jiggling/steering)**
  - Throw: 5 arcmin on sky, 6 degree at mirror (±3°)
  - Max Frequency: 5Hz
  - Duty Cycle 80% required, 90% goal
  - Accuracy/repeatability: 0.5 arcsec on sky
- **2nd Axis (steering/jiggling)**
  - Step size: 4.5 - 20 arcsec on sky, 5.4 - 24 arcmin at mirror
  - Max Frequency: 1Hz
  - Duty Cycle 80% required, 90% goal
  - Accuracy/repeatability: 0.5 arcsec on sky
- **2nd Axis (fast jiggling)**
  - As above, but frequency up to 5 Hz

Note: 1° at mirror = 50 arcsecs on sky (slightly different in two axes)

Proposed Design -based on ISOPHOT



Two Axis Flex Pivot System
Allows Steering in Both Axes



Implementation Plan

- Evaluation of ISOPHOT chopper -especially vibrations
- Model mechanism and control system
- Design and build prototype
- Life-testing, accuracy and dynamic measurement, EMC test
    - Expected life test to simulate 140 million cycles at 3-10 times normal operating frequency

Issues:

- Vibration Measurement & Modelling
- EMC especially for TES/SQUID option
- System design and modelling (parameters?)
- Performance data for flexures
- Motors
- Position sensors (differential field plates)
- Design of Drive and Read-out Electronics
- Life testing

PACS CHOPPER
ALBRECHT POGLITSCH

Max-Planck-Institut für Astronomie Heidelberg

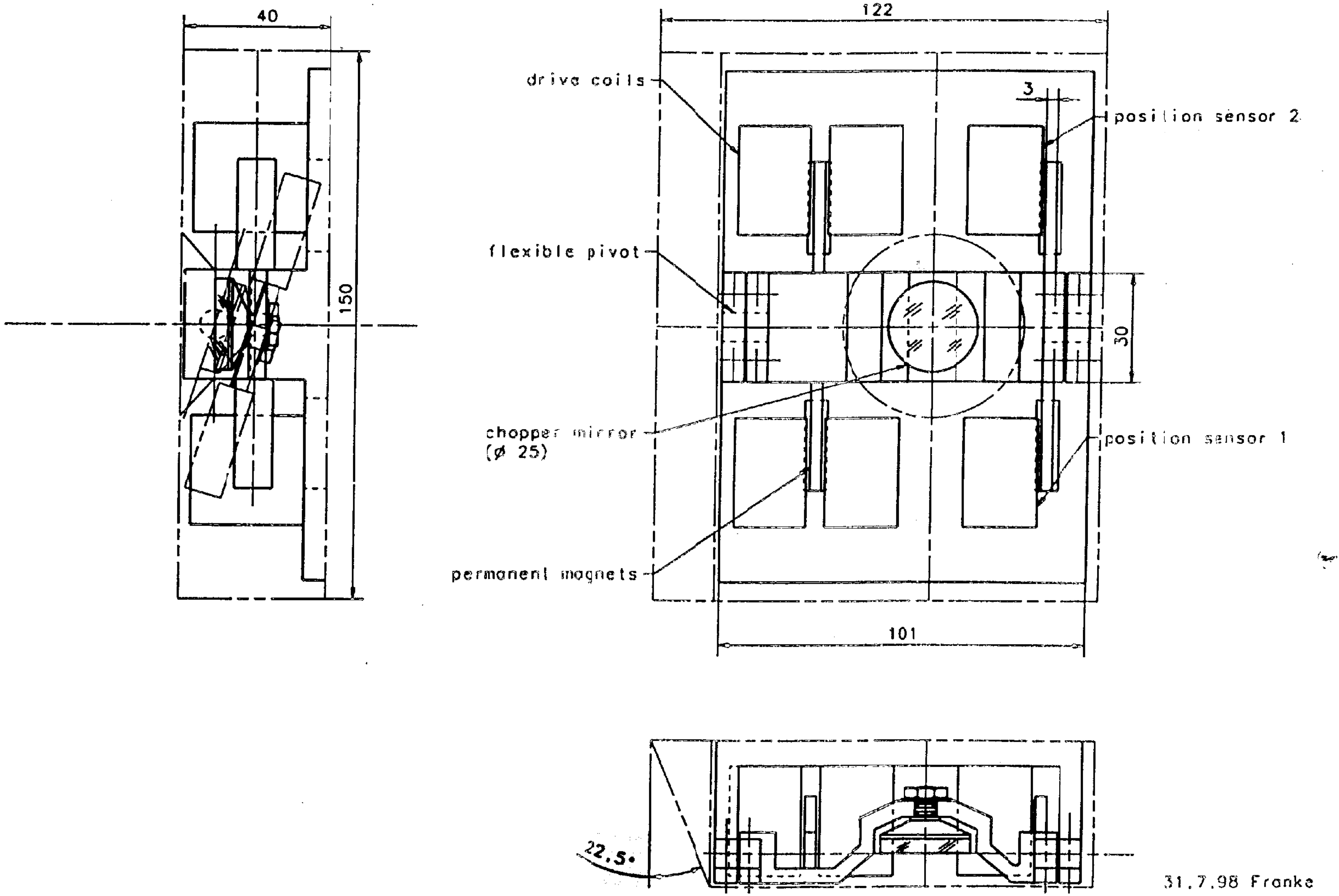
PACS Focal Plane Chopper

Specifications:*

♦ Size of unit (max):	150 x 122 x 40 mm^3
♦ Mass:	≤ 600g
♦ Mirror Size:	25mm diameter
♦ Chopper throw:	Observation ± 8,9° , accuracy ± 1arcmin Calibration ± 17,8°, accuracy ± 3arcmin (≈ 2% of operating time)
♦ Modulation functions:	Rectangular, sawtooth ...
♦ Frequency range:	0 ... 10Hz, duty cycle ≥ 80% (goal)
♦ Heat dissipation:	≤ 5 mW at 10Hz (8Hz min), ± 8,9° throw
♦ Failsafe position:	center ± 1arcmin, central axis to be maintained if axis breaks
♦ Operational environment:	Vacuum, 15K
♦ Vibration loads:	?g sinus, ?g random
♦ Operational life time:	5 years, 50% operation (≈ 800Mio cycles)

*preliminary and incomplete

PACS/FIRST Focal Plane Chopper (Project #9801)

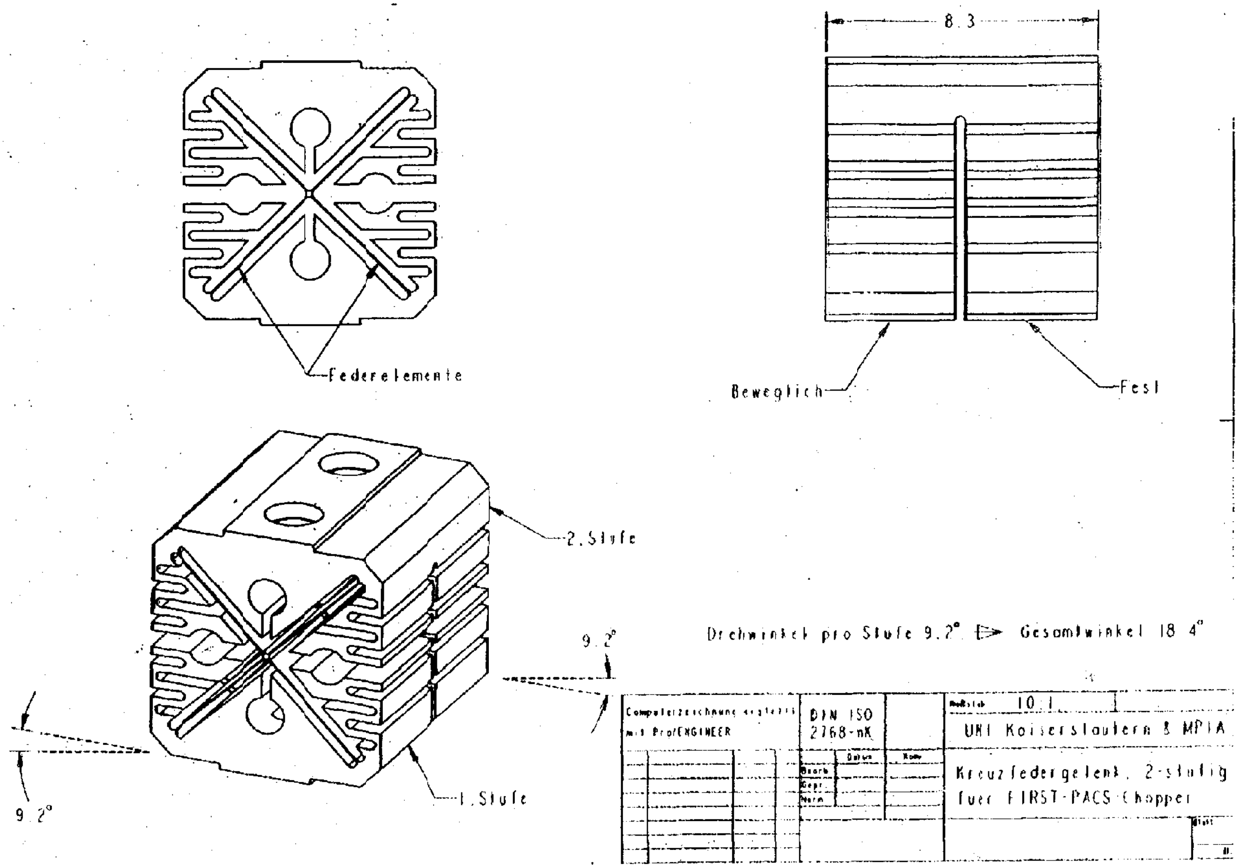


31.7.98 Franke

Instrument Design/Development Status (cont.)

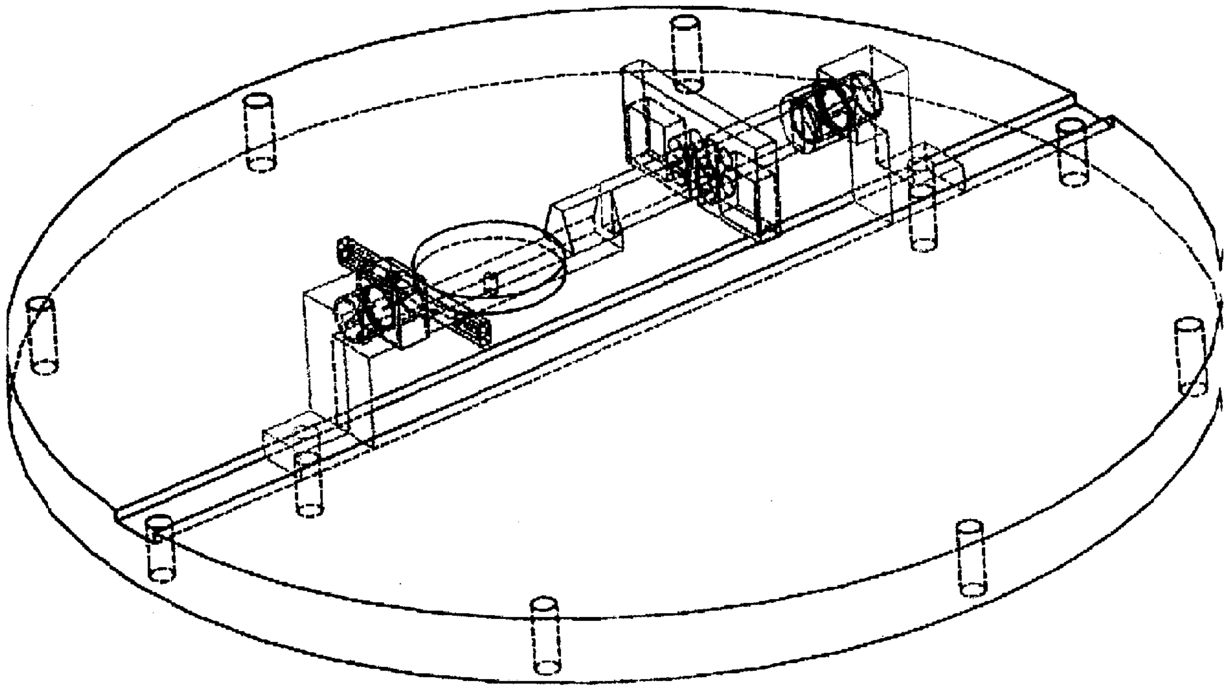
- Chopper
  - Refined design of flexural pivots at Univ. of Kaiserslautern, compensation of differential thermal shrinking
  - Large chop angle to be achieved by interlocking flex pivots
  - CuBe selected as material
  - Spark erosion selected as fabrication technique
  - First tests of chopper prototype carried out at 77 K. Problems with transient stress in (steel) flex pivot during cooldown identified. New design/material should overcome these problems

PACS Flexural Pivot Design



Max-Planck-Institut für Astronomie Heidelberg

PACS-Chopper Prototype, mechanical setup



December 1998

PACS GRATING

ETIENNE RENOTTE

CSL- Liege (B)
Etienne Renotte
[erenotte@ulg.ac.be]

PACS GRATING ASS'Y

SPECS:
Throw : 40° (±20°)
Accuracy: 4''
Stabilisation time : ~ 30 ms.

GRATING: 300 x 80 mm², flat within 4 μm, 8.5 li/mm

BRACKET: I/F FPU structure, accomodates pivots

PIVOTS: Flexures vs. Ball bearings
↳ never rotates over full race !
↳ not suited respect to { 40° throw ! / variable spring effects !

⇒ current baseline is to use ball-bearings
- MoS_2 dry lubricant ?
- ceramic balls ?

ACTUATOR:
current baseline : DC torquer developed by
F.U. Berlin (Low Temp. Lab.)
Flew on GIRL, CRISTA...
Major drawback : Mass (1.6 kg !)

POSITION SENSOR :

- capacitive ? ← preferred, but to be developed...
- LVDT ?
- Inductosyn ?
- ...

LAUNCH LOCK :

TBD

(We likely need one ...)

ISSUES :

- Mass
- Lifetime test at LHe temperature
- Performance test " " "
- Vibration test " " "
- Alignment
- Grating strap to 4K Level

...

SPIRE FTS MECHANISM
BRUCE SWINAYRD

SPIRE FTS MECHANISM

THROW: −0.3 +3.2 cm

STEP SIZE: 5 − 50 μm

MEASUREMENT ACCURACY : 0.1 μm

VELOCITY STABILITY : ~1%

MAXIMUM VELOCITY: 0.1 cm/s

POWER DISSIPATION: <5 mW

MASS : < 1 Kg.

⇒ MEASUREMENT SYSTEM IDENTIFIED
  ⇒ HIEDENHAIN MOIRÉ FRINGE
  ⇒ LED'S TESTED @ 4 K AND WORK O.K.

⇒ POSSIBLE STRUCTURAL SOLUTION FROM GSFC BEING DEVELOPED FOR JAPANESE SATELLITE

⇒ MOTOR NOT YET IDENTIFIED:

POSSIBILITIES ARE:

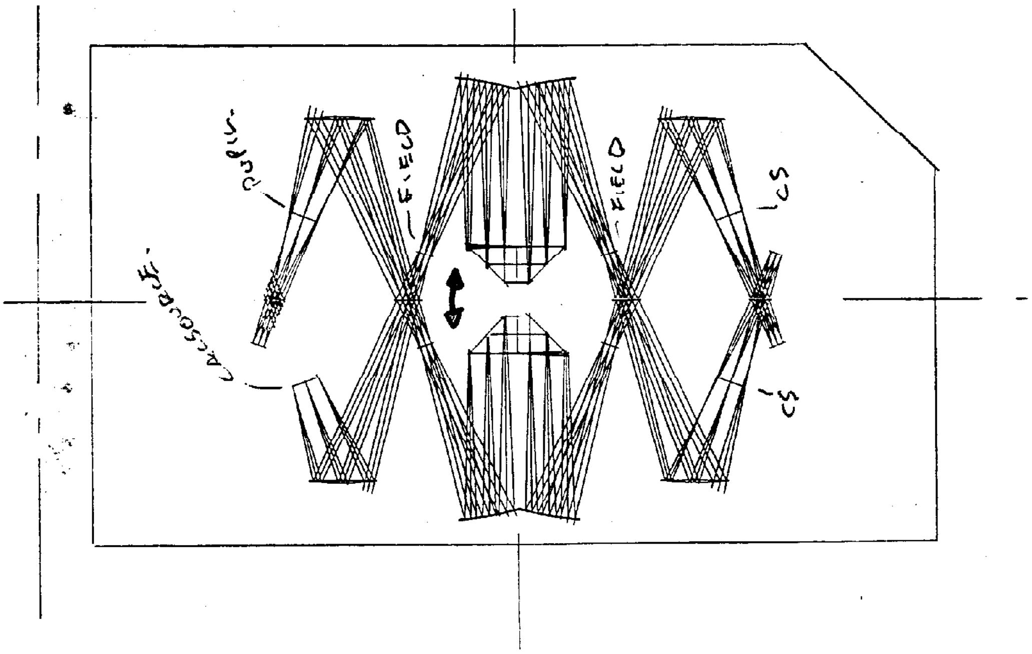
ISO TYPE GRATING MOTOR

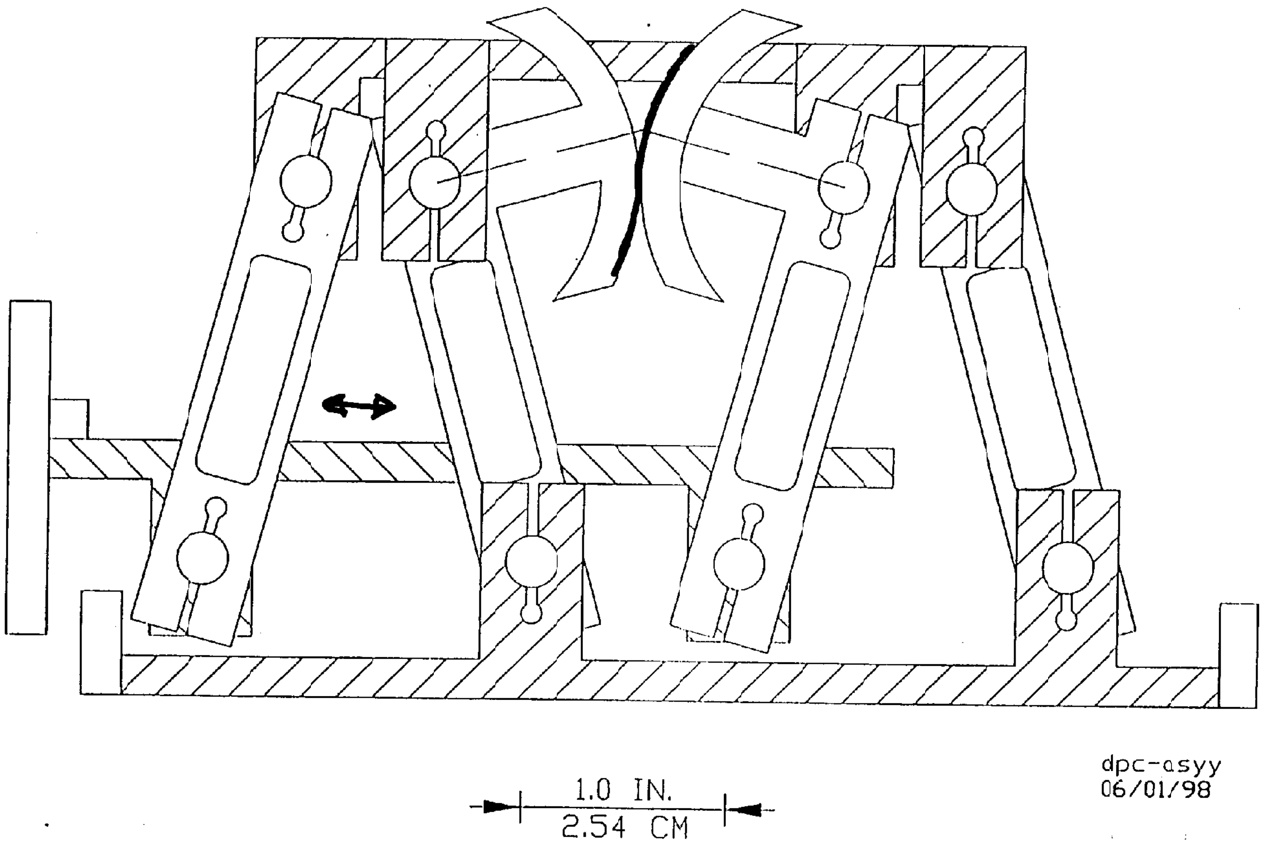
CSL MOTOR DESIGNED FOR MIR FTS

CIRS MOTOR

SPIRE FTS

RAPID SCANNING MACH-ZENHDER

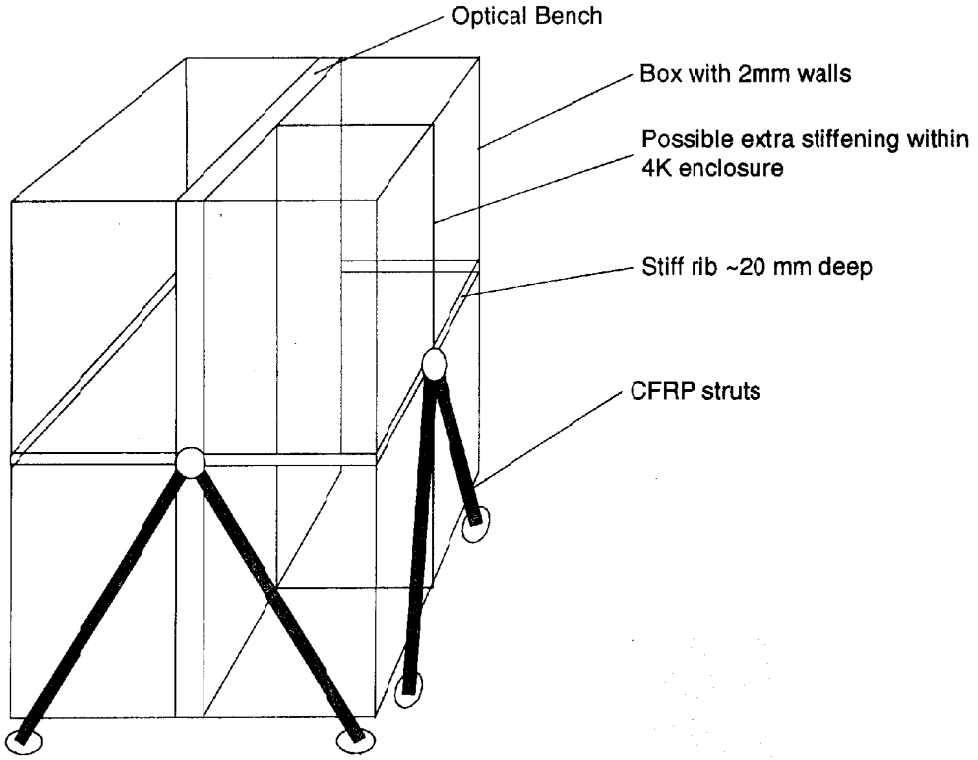


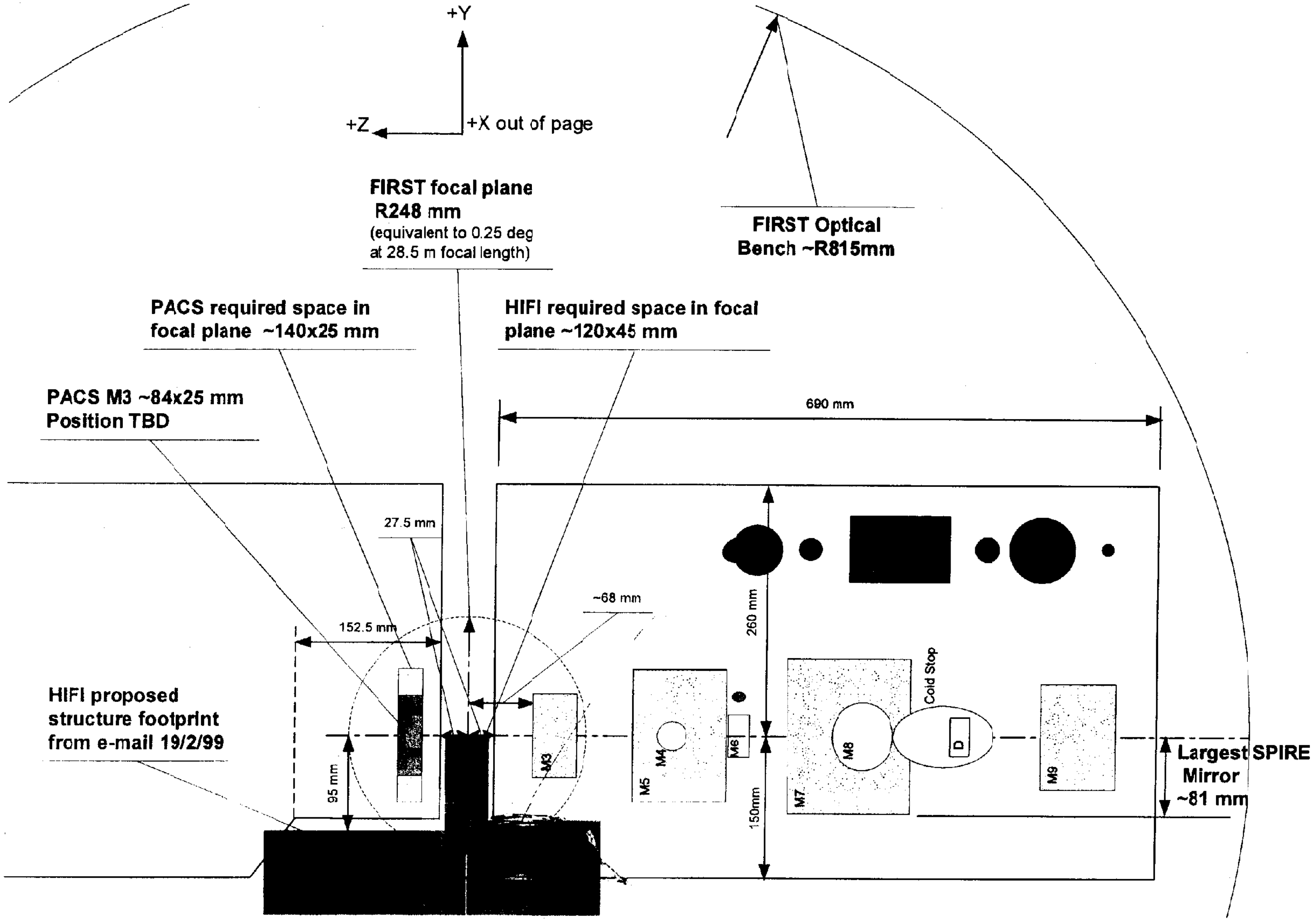

1.0 IN.
2.54 CM
dpc-asyy
06/01/98

SPIRE
STRUCTURE/THERMAL

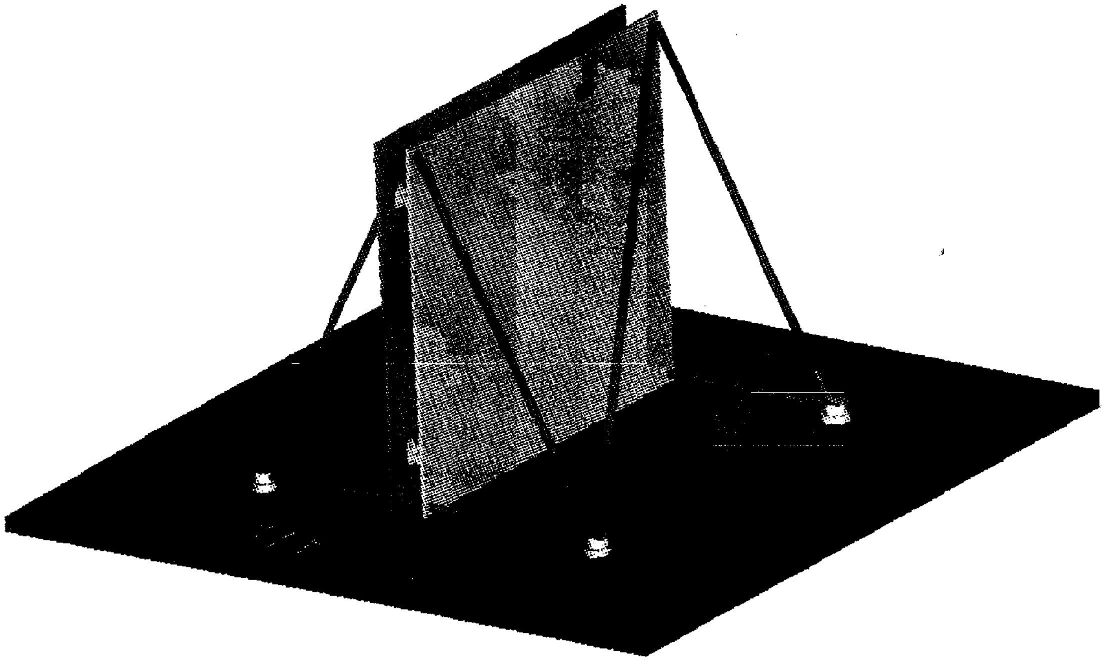
BRUCE SWINYARD

SPIRE FPU STRUCTURE CONCEPT

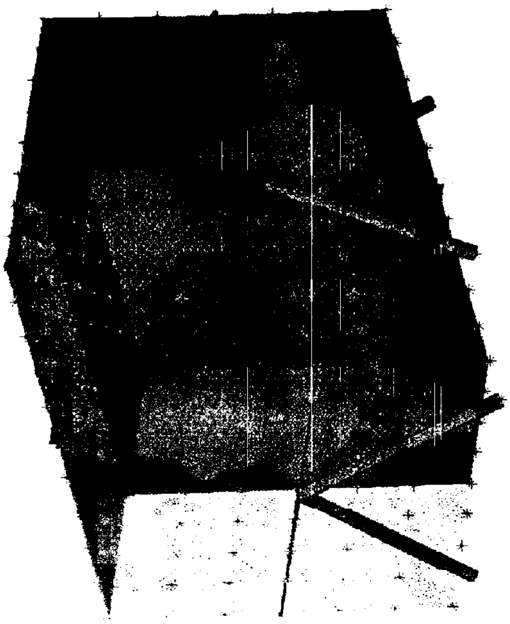



+Y
+Z
+X out of page
FIRST focal plane
R248 mm
(equivalent to 0.25 deg
at 28.5 m focal length)
FIRST Optical
Bench ~R815mm
PACS required space in
focal plane ~140x25 mm
HIFI required space in focal
plane ~120x45 mm
PACS M3 ~84x25 mm
Position TBD
690 mm
27.5 mm
~68 mm
152.5 mm
260 mm
150mm
95 mm
Cold Stop
D
M3
M4
M5
M6
M7
M8
M9
HIFI proposed
structure footprint
from e-mail 19/2/99
Largest SPIRE
Mirror
~81 mm

CONFIGURATION 1:



SPIRE FPU STRUCTURE CONCEPT



FE Model of SPIRE FPU (rotated 90 degrees)

PACS
STRUCTURE/THERMAL

NORBERT GEIS

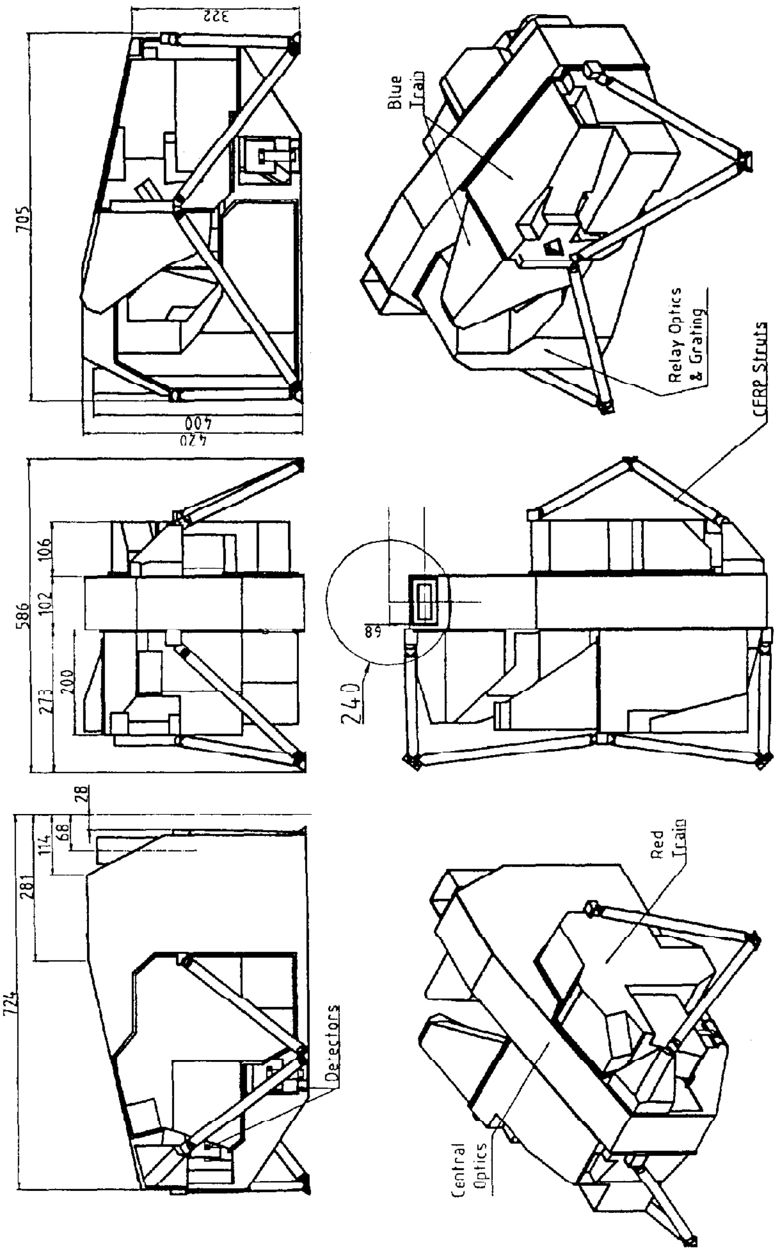
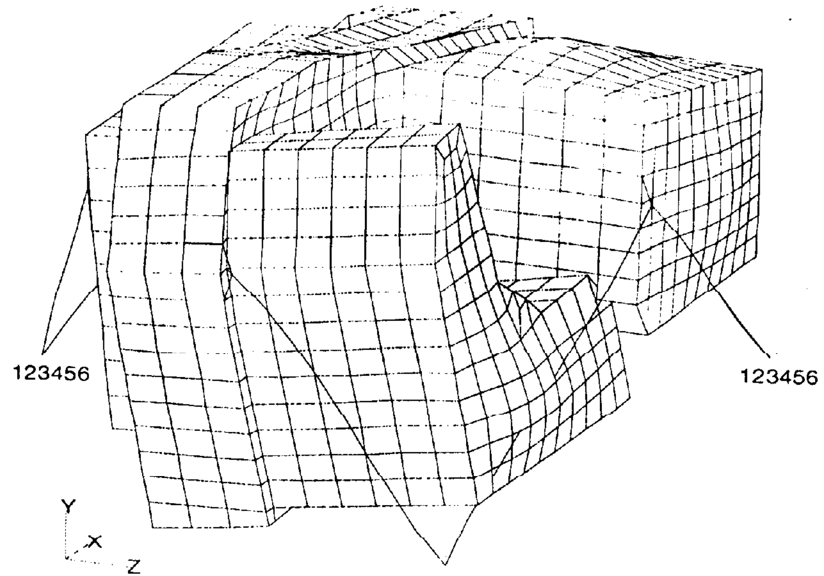
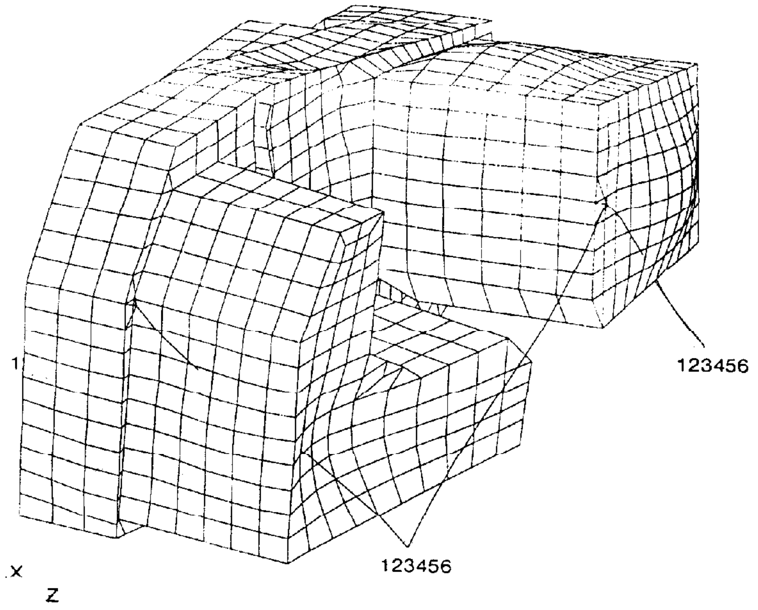


Fig. 2-1 PAX-1 Housing



Output Set: Mode 1 74.60042 Hz
Deformed(0.342): Total Translation



Output Set: Mode 2 95.21122 Hz
Deformed(0.33): Total Translation

Fig. 2-6 First and second fundamental mode of the PAX-1

- The computed fundamental modes fulfil the estimated requirements with a good margin. The dedicated effective masses corresponding to be fundamental modes are given in table 2.1-2. The first lateral and axial mode shapes are shown in figure 2-6.

Fundamental modes	Analysis [Hz]	Requirements [Hz]
- 1st lateral	74.6	>40 (tbc)
- 2nd lateral	95.2	>70 (tbc).

Effective Masses up to 200Hz

Mode	Freq.	Tx	Ty	Tz	Rx	Ry	Rz
Num.	[Hz]	eff.Mass %	eff.Mass %	eff.Mass %	eff.Mass %	eff.Mass %	eff.Mass %
1	74.600	0.256	8.589	**63.152**	7.202	**30.321**	3.368
2	95.211	**13.536**	1.783	7.285	9.609	**38.288**	6.084
3	99.971	**57.212**	6.366	3.732	5.001	2.910	0.151
4	139.416	0.000	1.927	0.951	2.843	0.008	2.430
5	140.563	0.172	0.206	1.142	3.241	0.295	0.117
6	147.900	0.008	2.913	1.339	3.136	0.953	2.054
7	154.011	0.423	1.981	1.428	2.066	0.026	1.222
8	156.696	0.833	1.385	0.239	1.099	0.257	0.732
9	164.513	1.642	6.624	0.583	1.079	0.000	3.325
10	168.010	0.439	0.051	0.173	0.434	0.758	0.053
11	172.068	0.120	0.118	0.002	0.099	0.001	0.020
12	175.360	0.751	7.747	0.111	0.137	0.070	1.866
13	181.523	0.760	0.010	4.767	13.220	3.005	1.741
14	199.859	2.040	6.991	1.652	1.214	0.003	8.057
	total:	78.192	46.690	86.557	50.382	76.895	31.218
	Mass total:	42.2	42.2	42.2	3.08	7.46	8.43

Table 2.1-2 Fundamental frequencies and effective masses

Adequate mounting provisions are considered in our design.

2.1.3.3 PAX-1 Suspension

2 x 3 struts are configured to establish the isostatic suspension and additionally a thermal decoupling of the instrument from the optical bench. The conductivity is a major source for the heat load of 4.3 K level, but the length/cross section ratio of the struts is designed as a compromise between thermal and mechanical requirements. Composites materials are offering the best performance in terms of stiffness, strength and minimized thermal conductivity. The proposed concept is given in figure 2-3.

Mechanical Concept (tbc)

- Struts length: 290-400 mm
- Diameter: 20-30 mm
- Wall thickness: 1.5 - 2 mm
- I/F to external H/W : Titanium fittings with 4 x M5 screw holes (tbc)
- I/F fitting / strut: glue (tbd) with safety bolt
- Total mass: 2.4 kg (tbc)

Flexural pivots (metallic joints) are considered at the outer fittings to avoid irregular forces to the suspension of the PAX-1 housing.

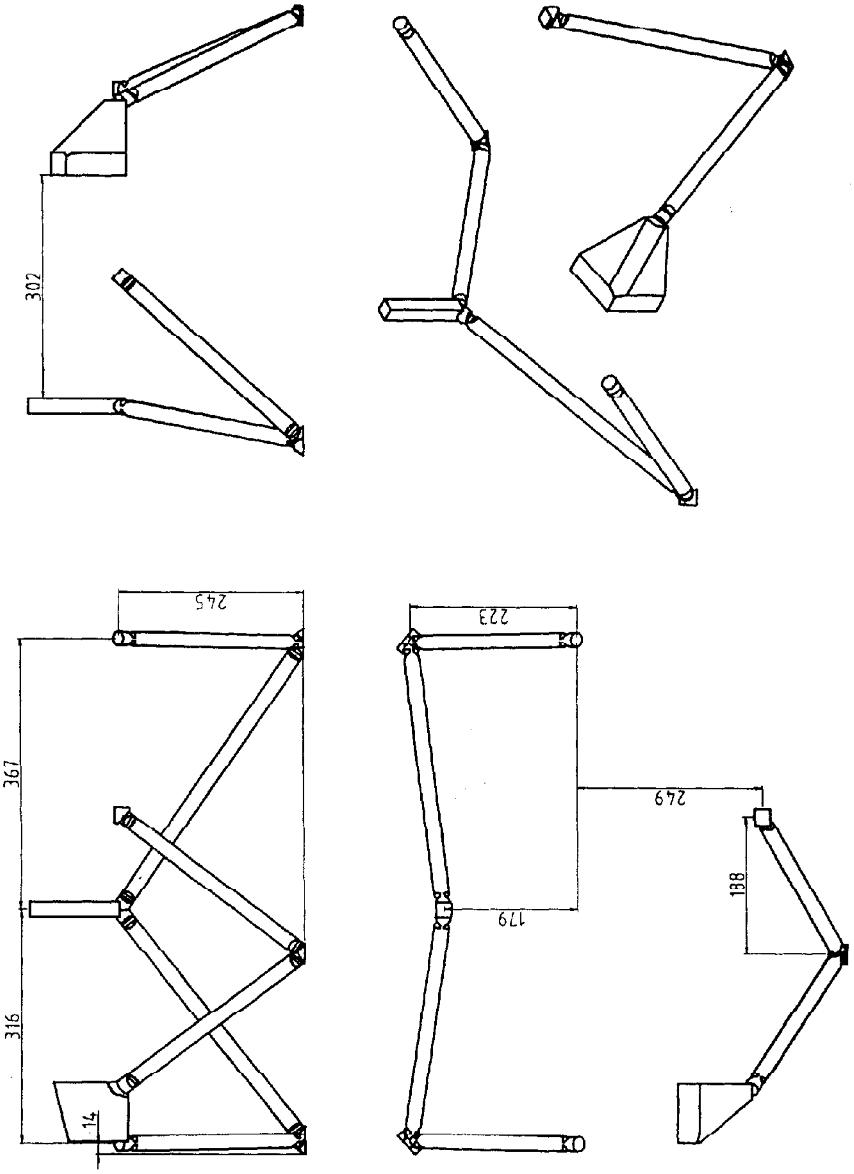


Fig. 2-3 Struts

Physical Properties Requirements (tbc)

- Layout: unidirectional or bidirectional
- E-Modulus: 120 GPa
- Tensile strength: 600 MPa (first ply failure)
  1200 MPa (ultimate failure)
- G-Modulus: >10 GPa
- Lambda (10K): <0.2 W/mK

Material

The following materials are proposed:

- Baseline: CFRP T300
- Alternatives:
  - CFRP M40A
  - GFRP
- Fittings: Titanium (tbc)

As resin system we suggest a system from Ciba Geigy (Araldite LY-556/HY-918/DY-970) extensively used in space applications ,even for cryogenic temperatures (4K). A wet filament winding process applying those materials is proposed as baseline

Conclusions:

- CFRP T300 was preselected according to the optimum (i.e. minimum) heat conductivity at cryogenic temperatures compared with the other candidate materials (data derived from exhausting material test within the frame of GIRL and ISO)

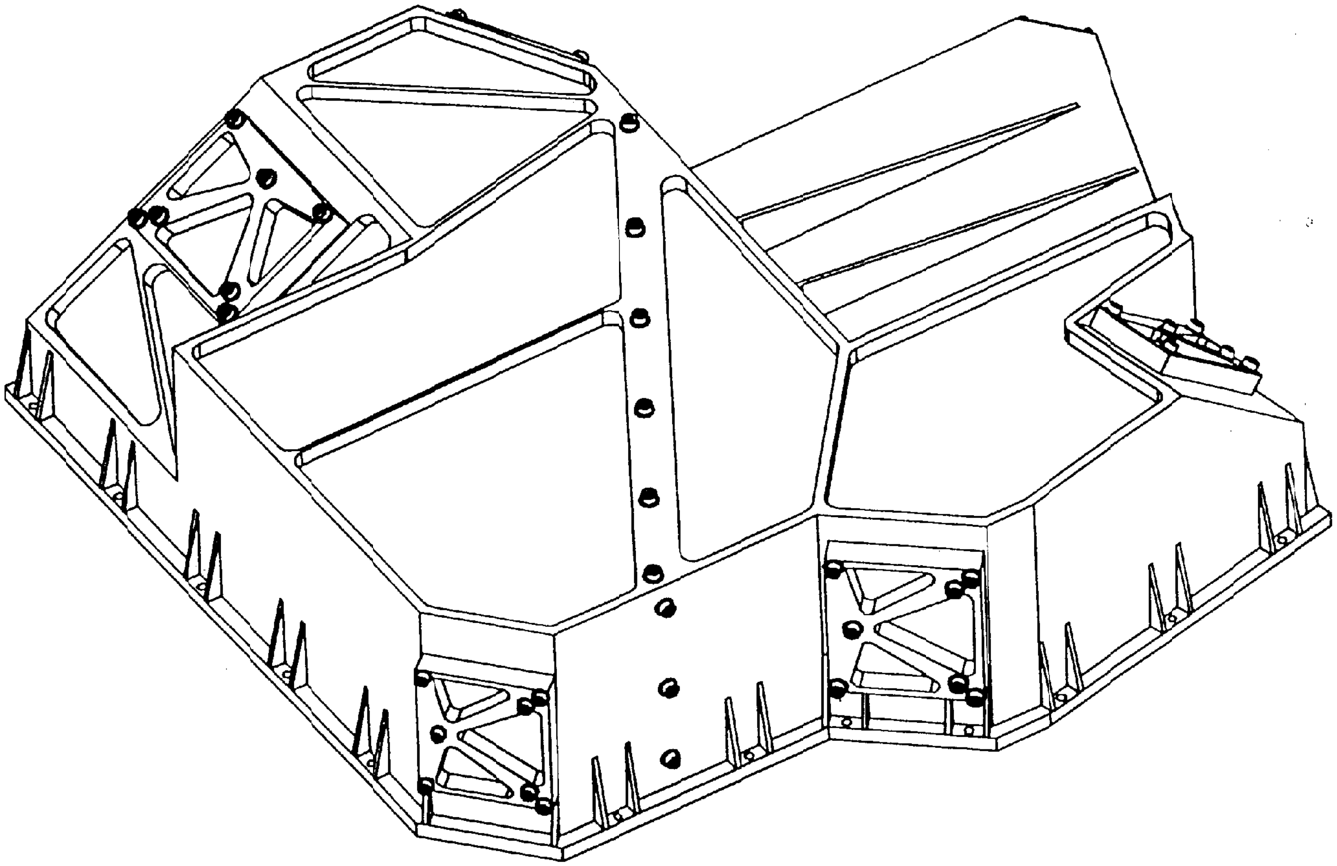


Fig. 2-2 Red photometer train Substructure

The optical items are attached by adjustable interfaces, as necessary. Usually lateral,

2.2.2 Thermal Hardware

2.2.2.1 Thermal Links

The proposed thermal links between the dedicated items of the Focal Plane Unit arrays and the cryostat cold plates with different temperature levels are summarized in table 2.2.-3

Tab. 2.2-3 Thermal Links

Interconnection	Hardware	Function
Detector blocks, detector array to 4.3 K housing	3 Kevlar straps (50 mm)	I
Detector block to 1.7 K He II piping	1 Copper strap	C
Detector wires to 4.3 K housing	TBD	I
FPU housing to 4.3 K heat sink	3 Copper straps	C
FPU housing to optical bench	6 CFRP struts (tbc)	I
Wires (detector, sensors) to 15 K heat sink	tbd	I
Chopper motor to 15 K heat sink	Copper strap	C
Chopper motor to FPU housing	Thermal washers	I
Grating device to 15 K heat sink	Copper strap	C

I : Thermal insulation, C : High Thermal Conductivity

Table 2.2-1 Heat loads

Heat Sink	FPU Cooling Budget (mW)	PAX-1 Cooling Budget (mW)		Comments
		Allocated	Estimated	
1.7 K	2.5	0.6*	0.6*	acceptable
4.3 K	10	9.7**	6.0**	**improved**
15 K	25	12.5***	12.5***	acceptable

*Wiring conduction: 0.5 mW

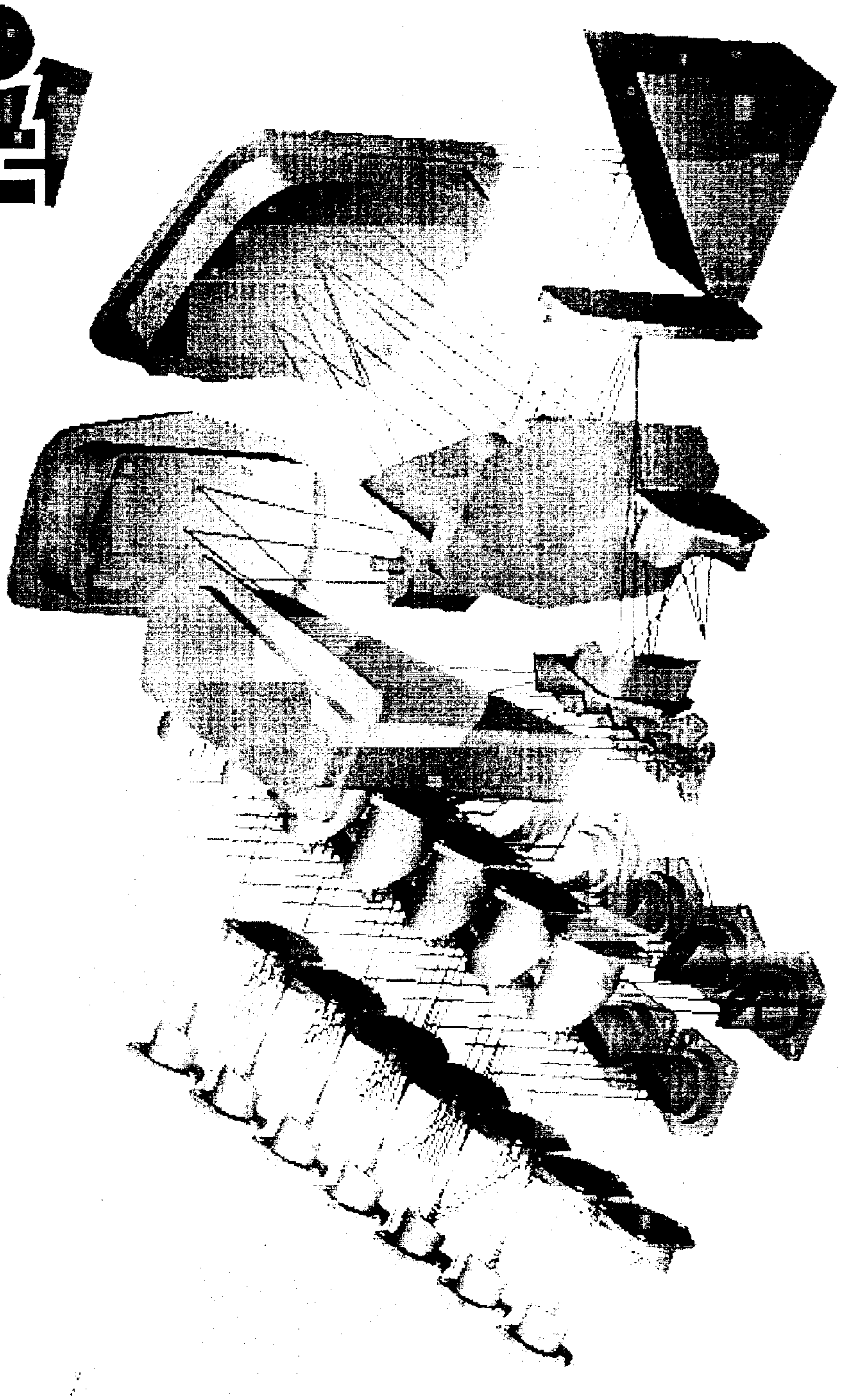
** Wiring conduction: 0.7 mW, wiring dissipation: 0.5 mW, CRE/BB/Flip mirror: 2.5mW (tbc- see AD 4)

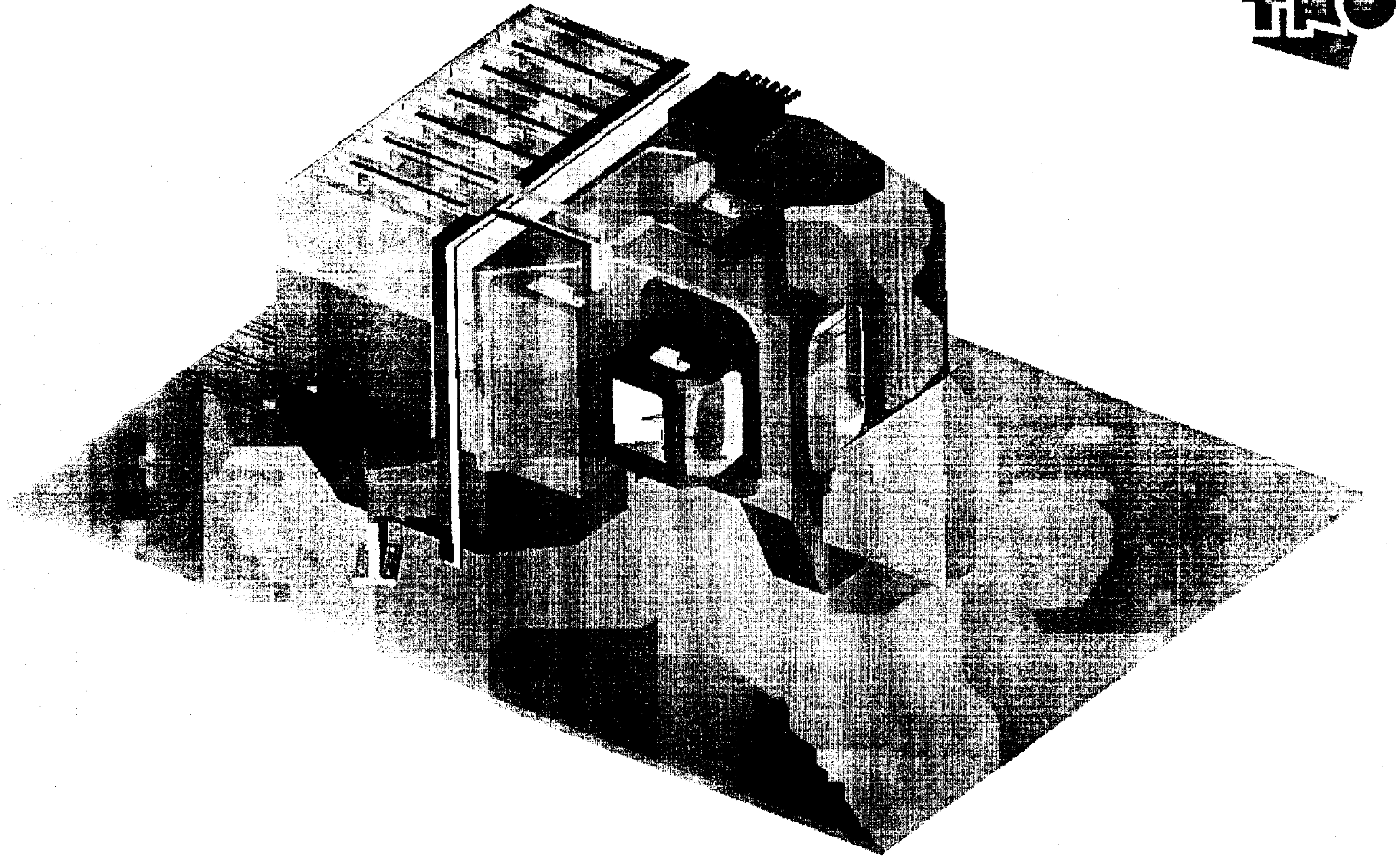
***Chopper/grating drive : 12 mW. 15 -300 K harness not considered

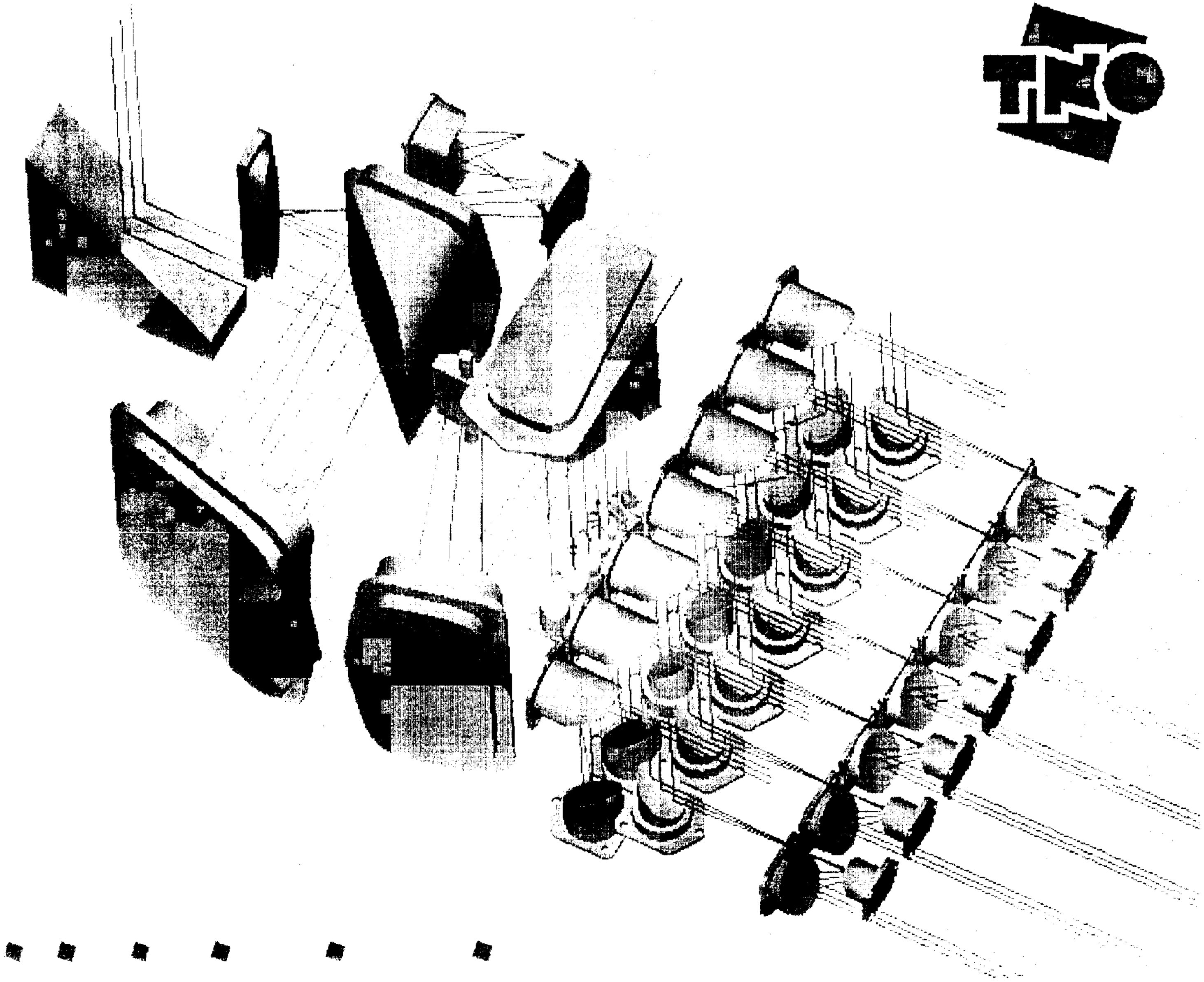
The internal dissipation sources considered within the detailed thermal model (see figure 2-7) were derived from AD5. The thermal model, consisting of 48 nodes for substructures, struts, MLI, dissipation sources, etc. and further nodes for boundary conditions (heat sinks etc.), represents the current mechanical and thermal design and provides a good confidence

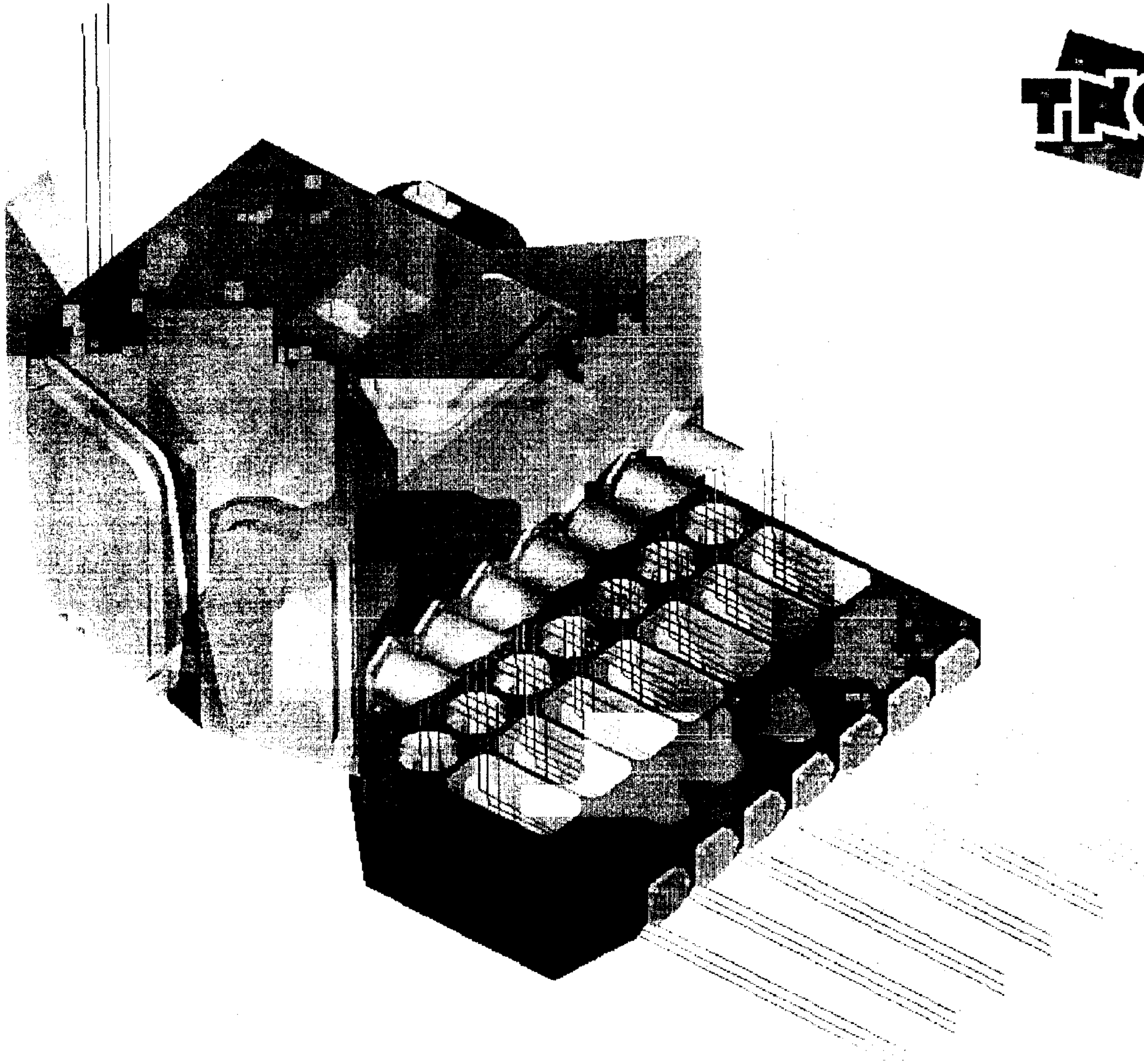
HIFI
STRUCTURE/THERMAL

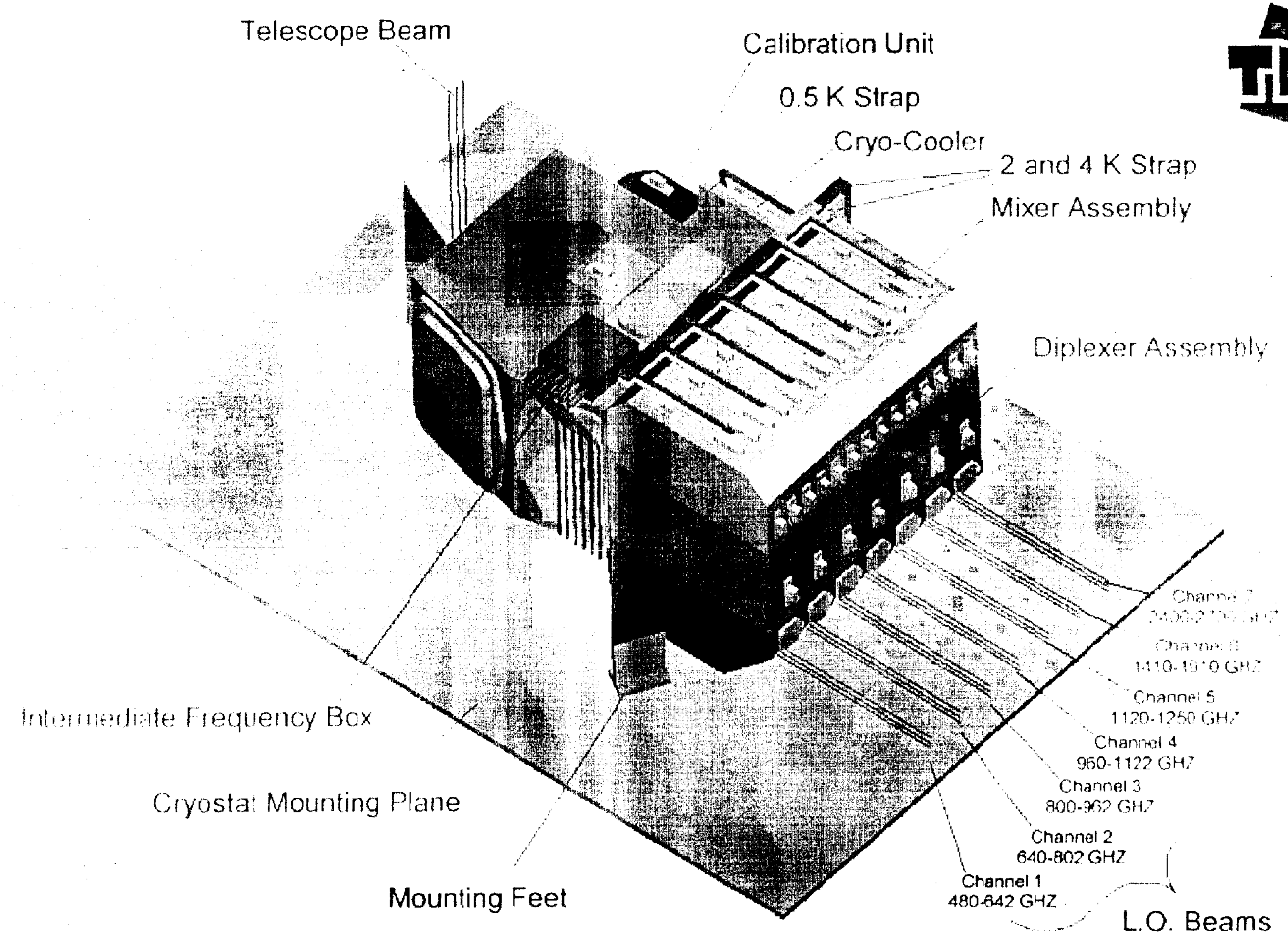
J Kruizinga
Coen van Baren










Telescope Beam
Calibration Unit
0.5 K Strap
Cryo-Cooler
2 and 4 K Strap
Mixer Assembly
Diplexer Assembly
Intermediate Frequency Box
Cryostat Mounting Plane
Mounting Feet
Channel 7
[illegible]
Channel 6
1410-1910 GHZ
Channel 5
1120-1250 GHZ
Channel 4
960-1122 GHZ
Channel 3
800-962 GHZ
Channel 2
640-802 GHZ
Channel 1
480-642 GHZ
L.O. Beams

HIFI mixer console preliminary design

Console design

- Support of mixer and isolator
- Thermally isolating the mixer (2K) via 4K level from 15K housing by stainless steel tubes
- Thermal strap attachment to 2K and 4K level

Requirements

- Vibration qualification levels @ 4K
  Sine vibration: 15g up to 100 Hz (sweep rate 2 oct/min, all axes)
  Random: 7.3g RMS (2 min, all axes)

- Thermal
  Maximum conductivity: in accordance with thermal budget on 2K level, but a factor of 2 above 4K maximum loads

- Mechanical stability

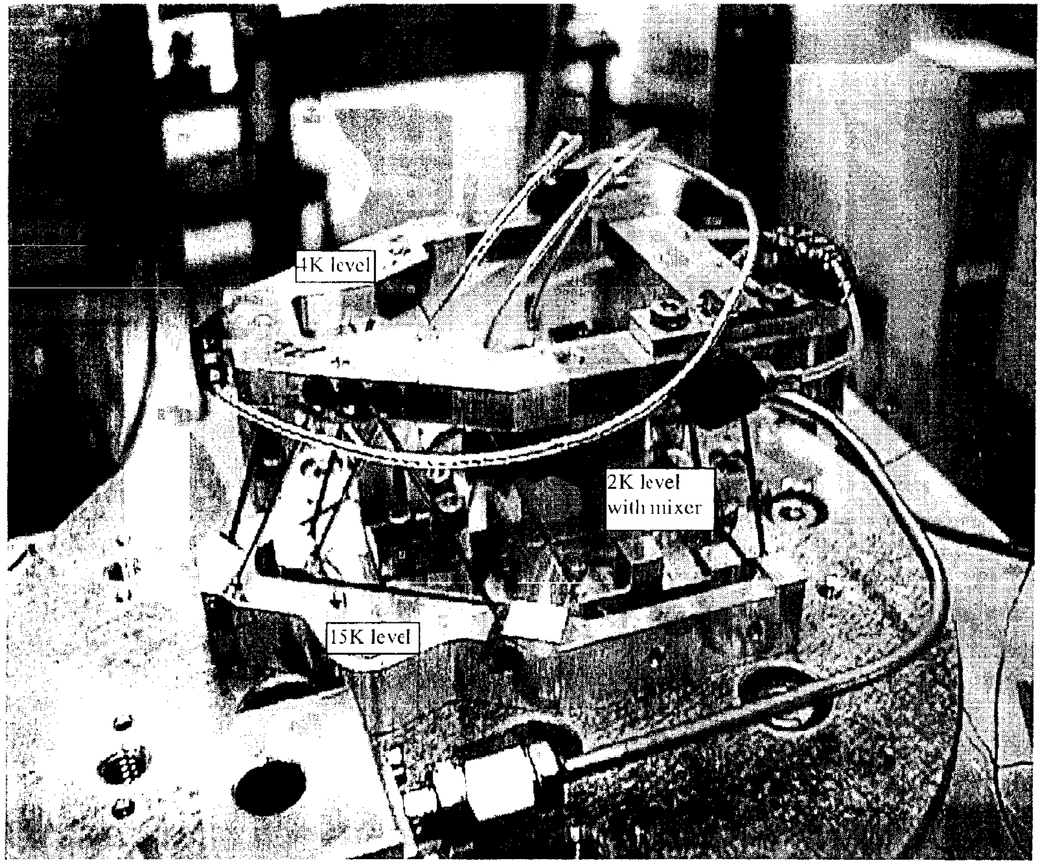
Requirements:	pre/post vibration	TBD
	cool down stability	0.1 mm shift
		2 arcmin tilt
		20 arcmin roll

Tests performed

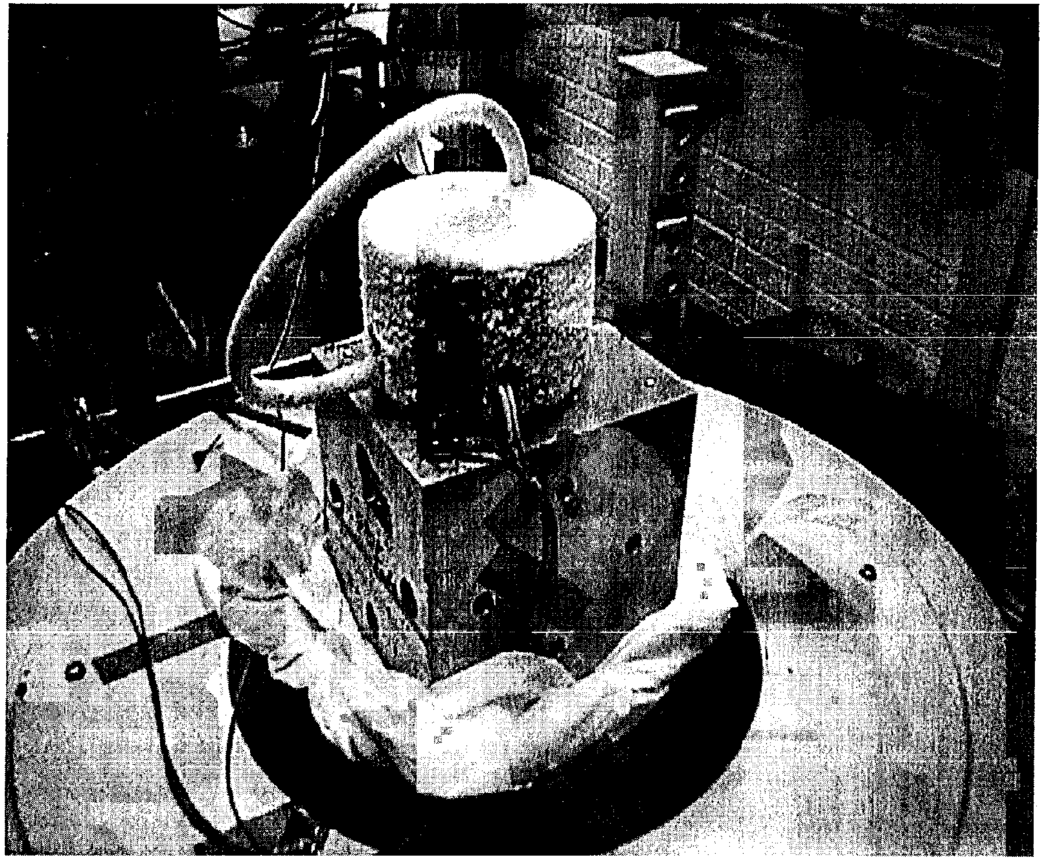
- Mixer console with mixer dummy mass
- Vibration test at 77K at qualification level passed successfully
- First resonance frequency 319 Hz (for mixer mass of 34 grams)
- Measured acceleration on mixer dummy 61g RMS
- Pre- and post qualification alignment shift of 21 arcsecs
- Thermal balance test to determine conductivity through support
  Total conduction (14 consoles) 0.36 mW on 2K level and 9.2 mW on 4K level
  Thermal analytical model matches measurements reasonably well

Future developments

- Cold test at 4K to determine alignment stability during cool down from 300K to 4K
- The design can be optimized based on
    - Present test data (Q-factors measured allow thinner rods, factor of 2 less conduction TBD)
    - New mixer assembly housing layout with lower mass
    - Integrating to mixers on one platform
    - Development of isolator with lower mass (TBC)
- Research and tests with other low conductivity materials (Vespel)

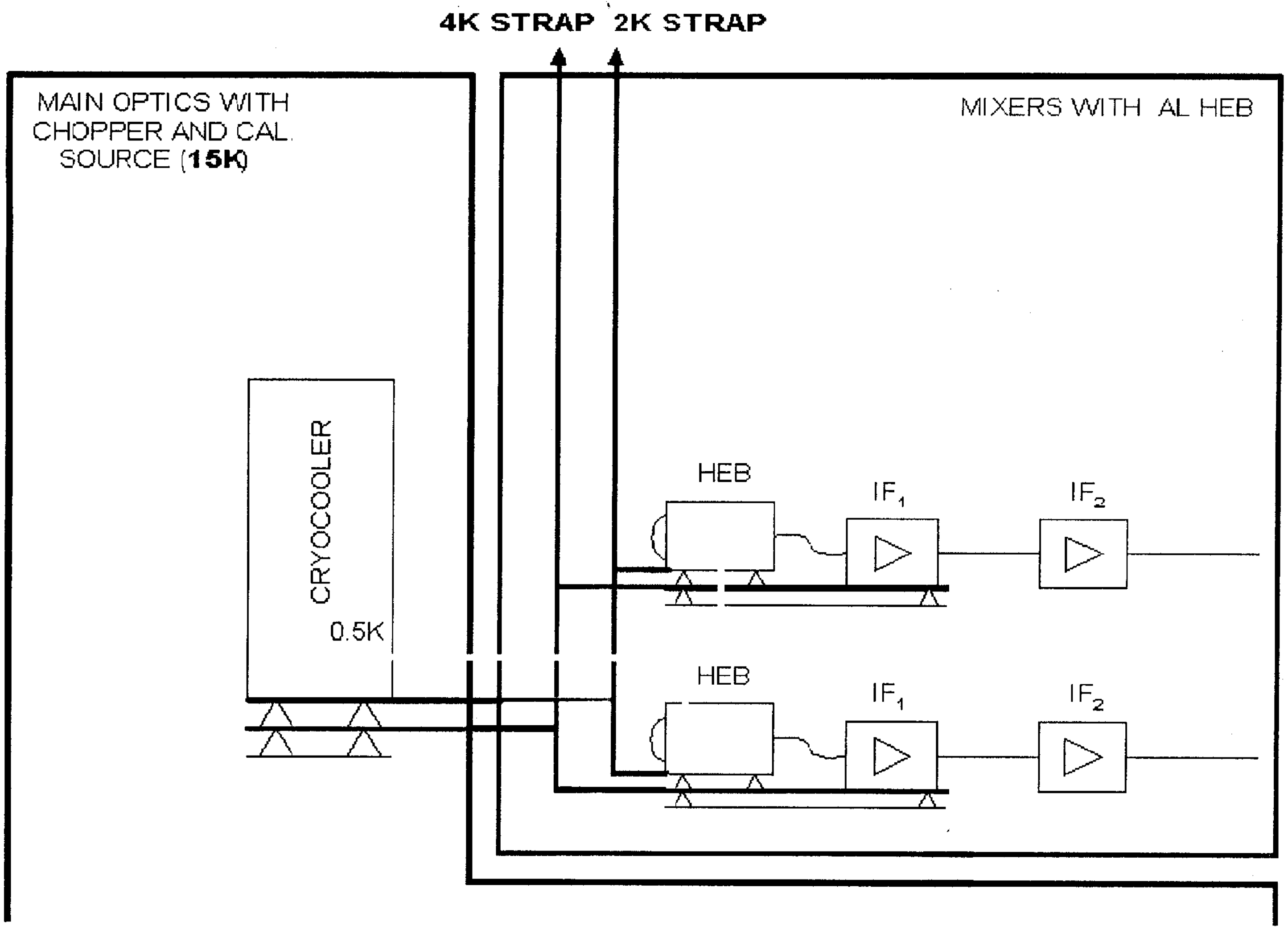


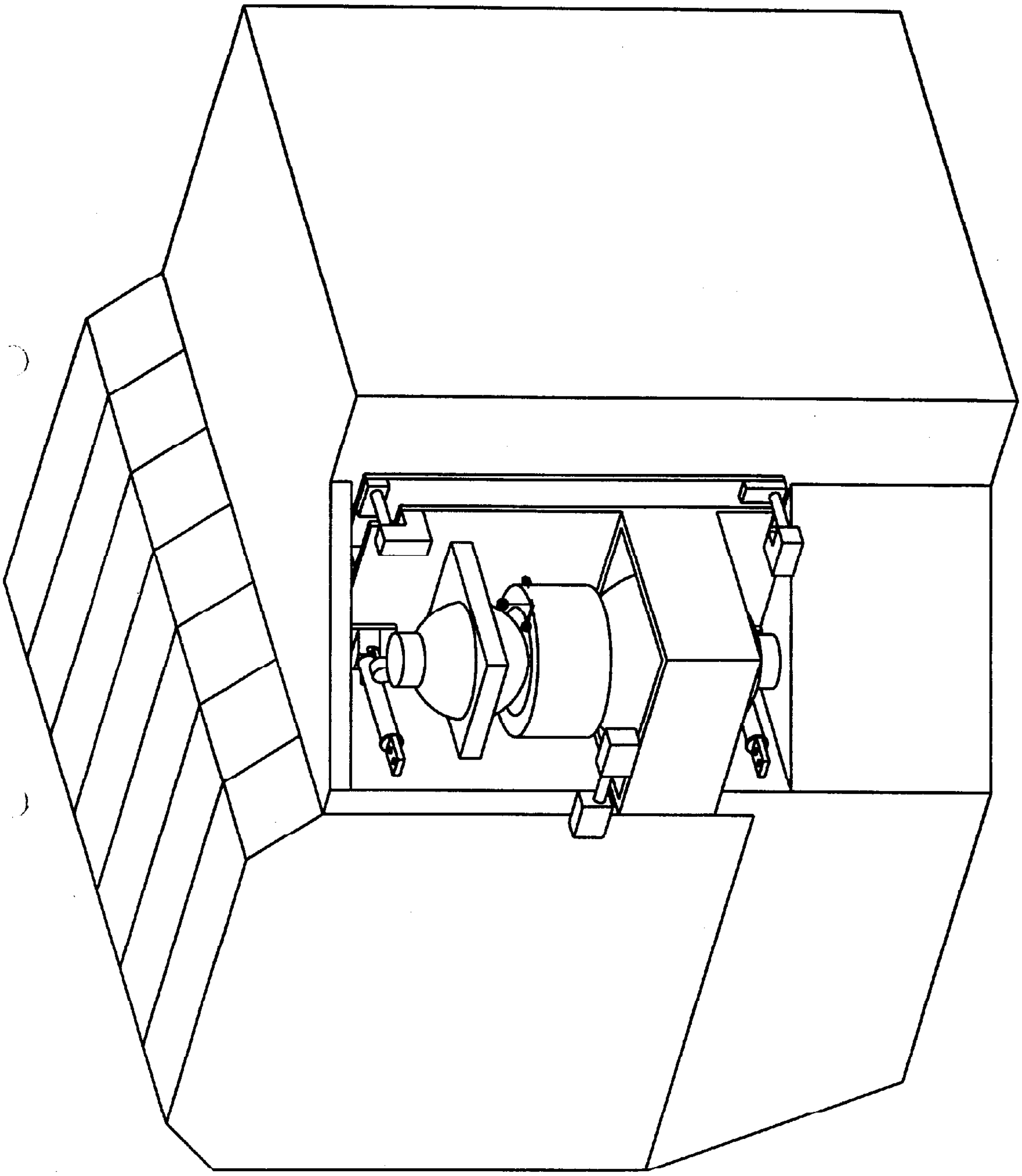
Mixer console development model



Vibration test setup at 77K

FPU (15K)
THERMAL DESIGN (1)





HIFI mechanical/thermal engineering

FPU design

- See figures

Materials

- Standard materials:
    - Aluminium FPU housing
    - Thermal insulating supports for mixers:
      At present stainless steel tubing
      Other materials (Vespel) under research
    - Thermal insulating supports for strapping and cryocooler:
      Vespel is serious option

- Testing of critical components
    - Thermal properties in 4K cryostat
    - Vibration tests in 77K (LiN) test set up

- Procurement
    - Usage of standard material facilitates procurement

Thermal strap implementation

- Type of strapping
    - Dimensions (TBD)
    - Materials (Cu?)
    - Routing (From each mixer assy box (7x) to one thermal bus on top of the COA)
    - Strap supports on FPU (0.5 K straps supported via 2K and 4K to 15K housing)
    - Exchange of strapping engineering data (between S/C, SPIRE, PACS and HIFI)

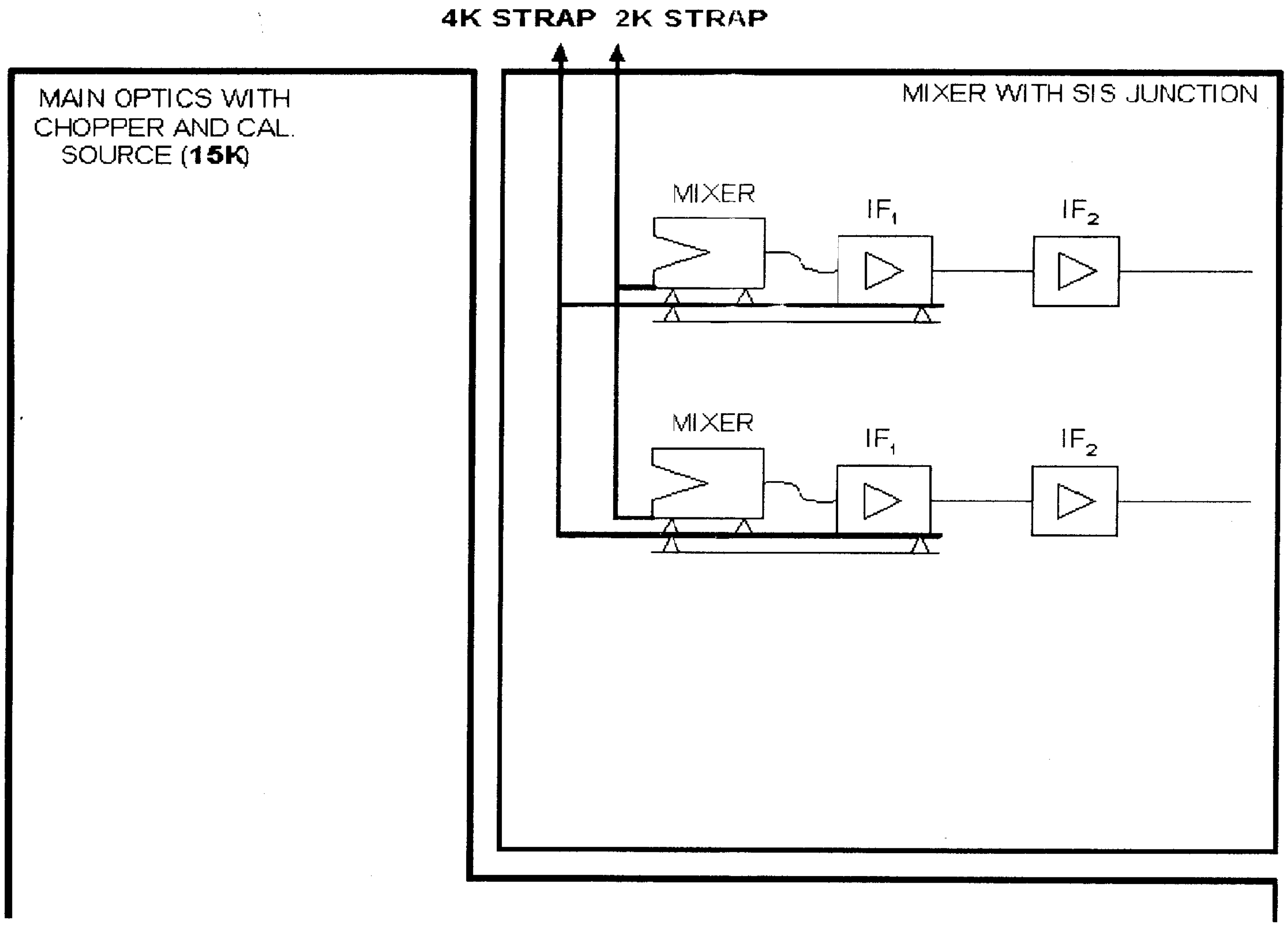
- Location of I/F points
    - Strapping of HIFI FPU thermal bus will come down on cryocooler side (TBD)
    - Present FPU design shows some space available under the COA (Common Optics Assembly)

- Definition of I/F to S/C thermal straps
    - Type of material (gold plated copper?, filler material?)
    - Electrical insulation necessary (yes?)
    - Type of connection (bolted?)

He-3 cooler

- Option: FPU to use the cooler design for SPIRE
- No deviations from SPIRE design that needs requalification of unit
- Possibly minor design changes to fit and support unit in FPU
- Envelope 200 x 100 x 100 mm fits in FPU design
- Thermal load to cooler is TBD (affects recycling period only)

FPU (15K)
THERMAL DESIGN (1)



HIFI MECHANISMS
KLAAS WILDEMAN

CHOPPER.

- 1 Hz; < 80% duty cycle; mirror size 40 ∅ mm.
- ~ ± 5° (10° pp) (*)
- LIFETIME ~ 30 mill cycles
- Design based on SWS - ISO

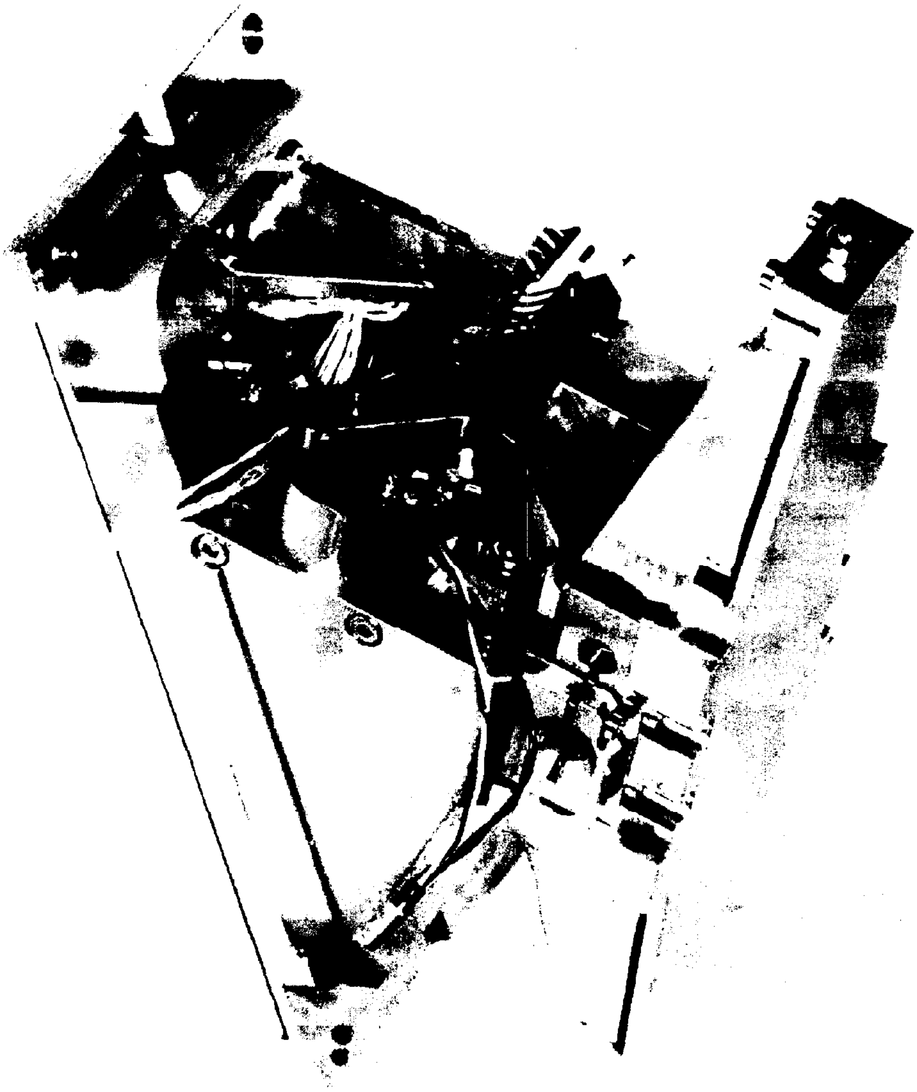
DIPLEXER MECHANISMS.

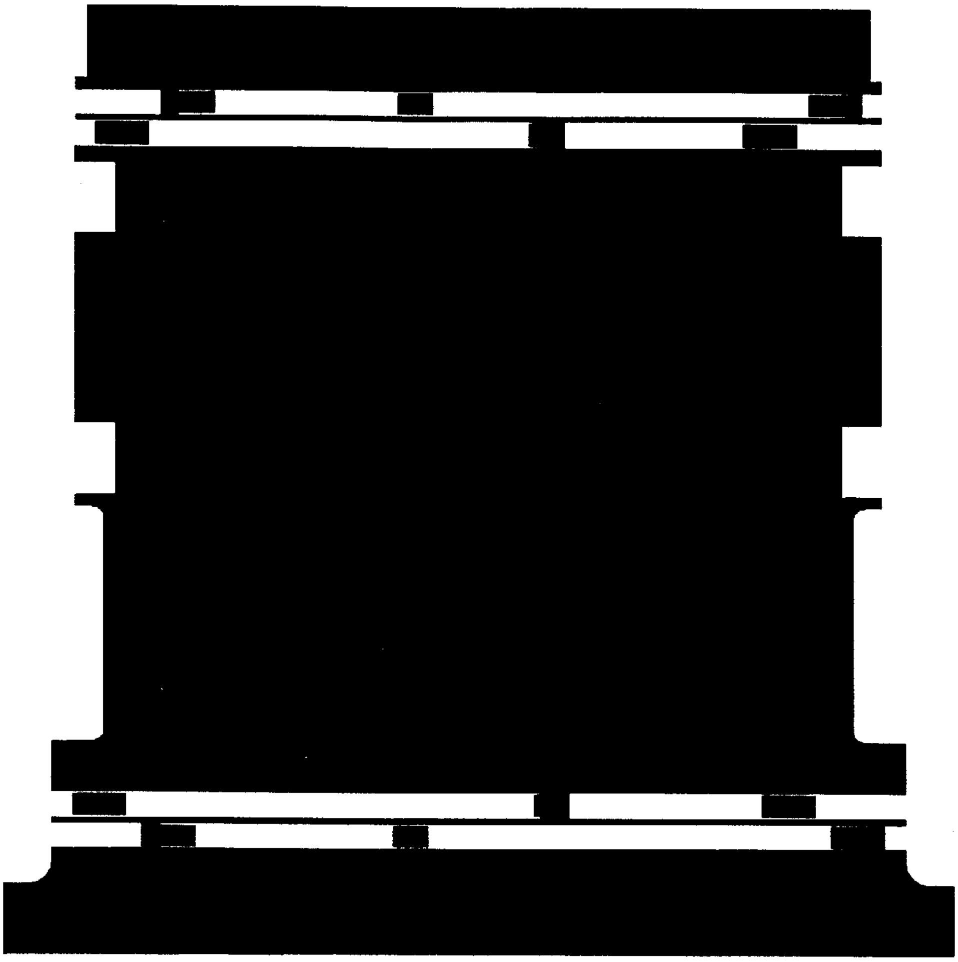
- Travel ± 200 µm
- Pos. reproducibility ~ 1 µm.

Read-out

- LVDT? → Power dissipation
- Cap sensor?

(*) Normal operation < ± 2.5°
Calibration ≃ 7° to one side.
Failure mode in operational position.





From: K.J. Wildeman

Summary and conclusions on page 5.

The scanning mechanism in the SWS has a separate friction free position-sensing device: an ac energised linear variable differential transformer (lvdt). A schematic drawing of the lvdt is shown in figure 1.

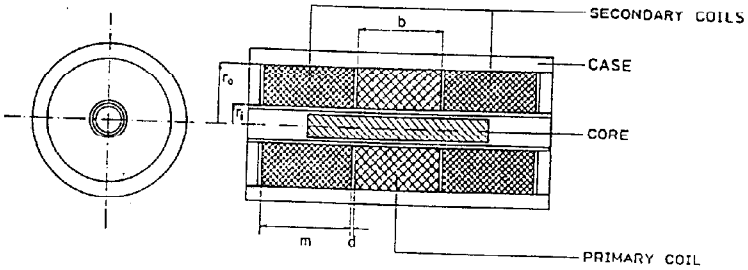


Figure 1: Schematic drawing of the lvdt.

The lvdt is a transformer type position-sensing device, operating on a variable coupling between the primary and two secondary coils working in push-pull. The core is the moving part.

It is well known from experience in the past that lvdt's are suitable for operation at temperatures of a few kelvin. Effects of low temperature on properties of the lvdt are determined by the applied materials for the case and the core. Especially the relation between output and temperature and the losses at low temperature - important for devices inside a cryostat - depend on type of case materials.

Table 2: Losses in the ROG13/2(armco). The input voltage U is 1 volt; the frequency is 5 kHz.

T (K)	5.5	77	300
I (input current in mA)	2.40	2.18	1.52
R (ohmic resistance of prim coil in ohm)	2.11	24.4	180
e (is U-IR, in volt)	0.995	0.947	0.726
Pcu (ohmic losses in microwatt)	12	116	416
Pi (iron losses in microwatt)	647	614	366
Pi at e is one volt (in microwatt)	654	684	693

Table 3: Losses in the SM3(420). The input voltage U is 1 volt; the frequency is 5 khz.

T (K)	5.5	77	300
I (input current in mA)	2.87	2.82	2.44
R (ohmic resistance of prim. coil in ohm)	0.56	9.4	70.3
e (is U-IR, in volt)	0.9984	0.9735	0.828
Pcu (ohmic losses; in microwatt)	5	75	418
Pi (iron losses; in microwatt)	760	756	504
Pi at e is one volt (in microwatt)	726	798	734

The relation between iron losses and frequency for a segmented case.

For the SM3 the relation between frequency and iron losses is measured for a standard case, for a case of 4 segments and for a case of 16 segments. The material of the case is AISI 420. For these measurements the primary current is 2 mA (current source). A case made out of 4 segments reduces the iron losses by about 30%. Cases made out of more than 4 segments are not advantageous (figure 5).

The sensitivity of the lvdt was not affected by segmenting the case.

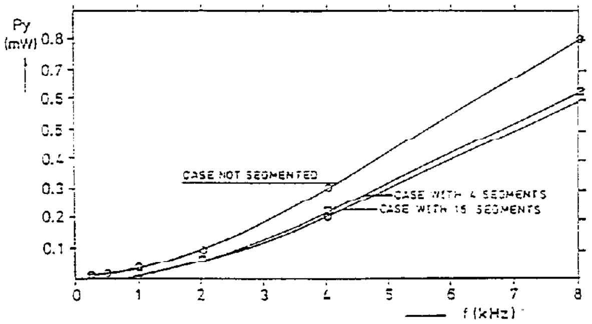


Figure 5: Relation between iron losses and frequncy for a non-segmented and segmented case of a SM3(420) at 300 K. The input current is 2 mA.

SPIRE ^{3}He COOLER

BRUCE SWINYARD

Logo Will Go Here	SPIRE	**Ref:** **SPIRE-RAL-NOT-nnnn**
	Provisional Cooler Requirements B. Swinyard	**Issue: .00** **Date: 07/04/99** **Page: 1 of 3**

Introduction:

This document outlines the SPIRE instrument requirements on the detector cooling system. The cooling system comprises the ^{3}He sorption cooler; the thermal links between the cooler cold tip and the detectors; the associated thermometry and any active temperature control circuitry. Most, but not all, of the requirements apply to the cooler.

The requirements set out here come from discussions between B. Swinyard, L. Duband, B. Collaudin and M. Griffin. Any comments or queries should be addressed to B. Swinyard (B.M.Swinyard@rl.ac.uk)

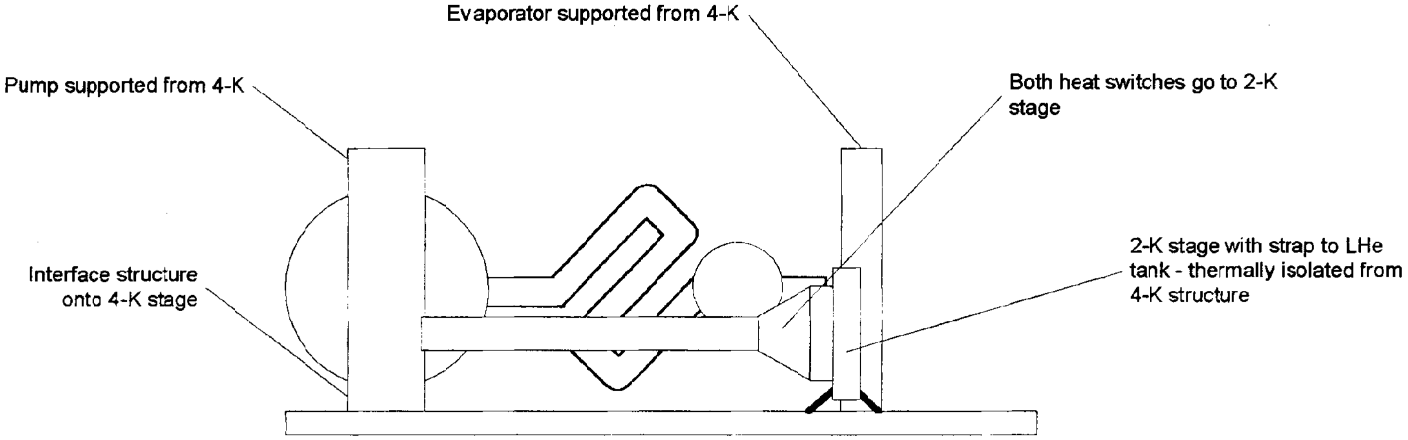
Provisional Instrument Requirements:

Temperature at the detectors	Nominal 300 mK
Operating temperature control	Desirable to be able to vary the temperature of the detectors up to 320 mK and below 300 mK *if this is permitted by the temperature drop across the thermal link.* The evaporator cold tip temperature can be varied by heating the sorption cooler. Electronic control shall be provided to do this in the flight electronics.
Temperature drop across thermal link between detectors and evaporator cold tip	Maximum of 25 mK
Temperature drift	The temperature of the evaporator cold tip should not drift by more than 10 mK/h
Temperature fluctuations at the evaporator cold tip	No more than 150 nK $Hz^{-1/2}$ in a frequency band from 0.1-100 Hz.
System low frequency temperature stability with active temperature control	TBD nK at 0.015 Hz at a maximum power dissipation of TBD μW
Heat lift at detectors	Minimum of 10 μW at 300 mK
Hold time	Minimum 46 hours
Recycle time	Maximum 2 hours
Thermal interface	Pumped liquid helium tank at 1.8 K for both sorption pump and evaporator
Thermal load onto He bath during cold operation	Maximum 1 mW
Time averaged thermal load onto He bath for 48 hour cycle	Maximum 3 mW (includes 20% margin)
Mass – including support structure	0.6 kg (includes 20%) margin (this will be revisited if more mass is required to mount the cooler from 4-K)
Maximum envelope	200x100x100 mm
Mechanical interface	Preferred interface is with the instrument 4-K structure – sketches below indicate how this might be achieved.
Preferred orientation	Horizontal with long axis along S/C Y-axis and evaporator at – Y end (see sketch)
Thermometers	Thermometers shall be provided on the cooler as set out in the table below. The absolute temperature measurement on the evaporator cold tip shall be 0.5% (<1.5 mK) with a resolution

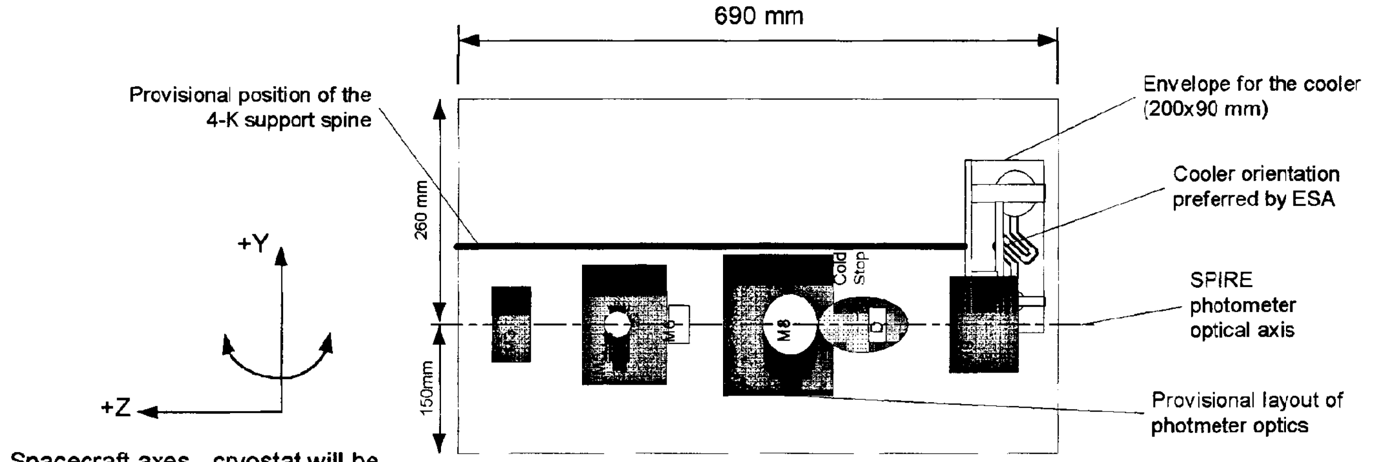
	of TBD mK. Thermometers of the same specification shall also be provided on each detector array
Sorption pump heater	The baseline design has a heater resistance of 400 Ω implying a current of up to 20 mA for recycling. It is desirable that this heater resistance is increased so that the allowable resistance of the cryo-harness wiring can, in turn, be increased. The maximum resistance of the heater that can be driven by 28 V is about 5 kΩ.
Gas gap heat switches	It is noted that these are a potential single point failure in the instrument operation. Provision of some redundancy (i.e. doubling them up) is desirable *but not at the expense of severe limitations on the cooler performance.*
Ground Operation	The cooler must be capable of full operation on the ground, including recycling, when the instrument is in its normal orientation i.e. +Y horizontal and +X vertical and pointing skyward. Further it must be capable of operating with the instrument rotated to up to 90° about the S/C Y-axis (see sketch)

ID	Instrument: SPIRE 4.3-K to 300-K interface Signal definition	Name	No. of Cond.	No. of shields	Max. allowed Res. (Ω)	Current (A)	Duty Cycle (t*T)	Max. Line Volt (V)	Remarks
14	Pump heater (main)	PH_M	2	0	10 TBC	1.4E-2	0.014	TBD	Br. AWG38
15	Pump heater (red.)	PH_R	2	0	10 TBC	0.0E+0	0	TBD	Br. AWG38
16	Pump therm. (main)	PT_M	4	1	1000	1.0E-5	1	TBD	SST AWG38
17	Pump therm. (red.)	PT_R	4	1	1000	1.0E-5	1	TBD	SST AWG38
18	Evap. therm. (main)	ET_M	4	1	1000	1.0E-5	1	TBD	SST AWG38
19	Evap. therm. (red.)	ET_R	4	1	1000	1.0E-5	1	TBD	SST AWG38
20	Pump heat SW heater (main)	PHSWH_M	2	0	10 TBC	2.0E-3	0.96	TBD	Br. AWG38
21	Pump heat SW heater (red.)	PHSWH_R	2	0	10 TBC	0.0E+0	0	TBD	Br. AWG38
22	Evap. heat SW heater (main)	EHSWH_M	2	0	10 TBC	2.0E-3	0.04	TBD	Br. AWG38
23	Evap. heat SW heater (red.)	EHSWH_R	2	0	10 TBC	0.0E+0	0	TBD	Br. AWG38
24	Pump heat SW therm. (main)	PHSWT_M	4	1	1000	1.0E-5	1	TBD	SST AWG38
25	Pump heat SW therm. (red.)	PHSWT_R	4	1	1000	1.0E-5	1	TBD	SST AWG38
26	Evap. heat SW therm. (main)	EHSWT_M	4	1	1000	1.0E-5	1	TBD	SST AWG38
27	Evap. heat SW therm. (red.)	EHSWT_R	4	1	1000	1.0E-5	1	TBD	SST AWG38
	TOTAL		44	8					

Wiring table from IID-B



Arrangement for mounting cooler from 4-K stage

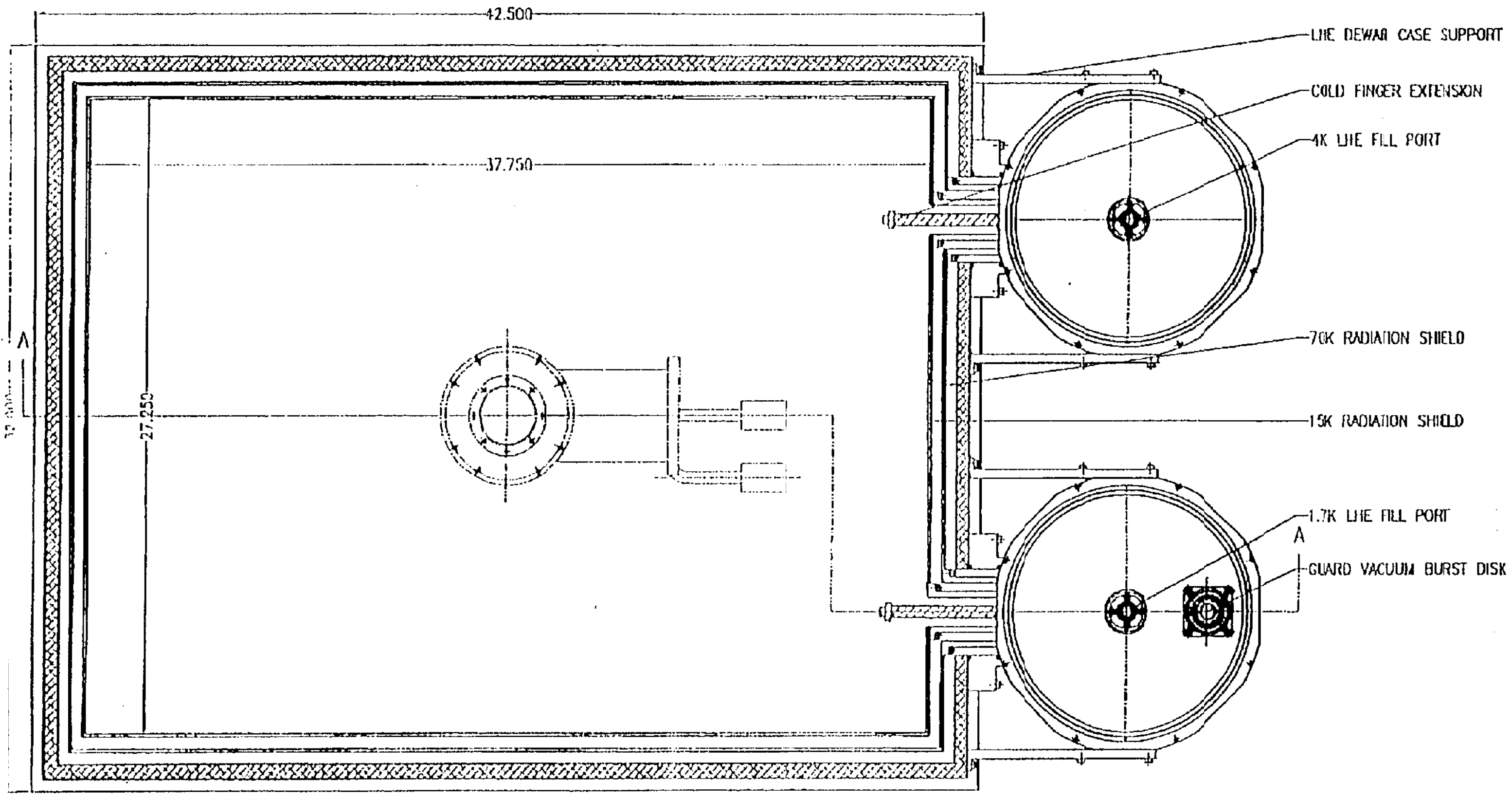


Spacecraft axes - cryostat will be rotated to up to 90° around y-axis during ground testing

Provisional postioning of the cooler within SPIRE

HIFI CALIBRATION FACILITY

WILLEM LUINGE



SECTION VIEW D-D

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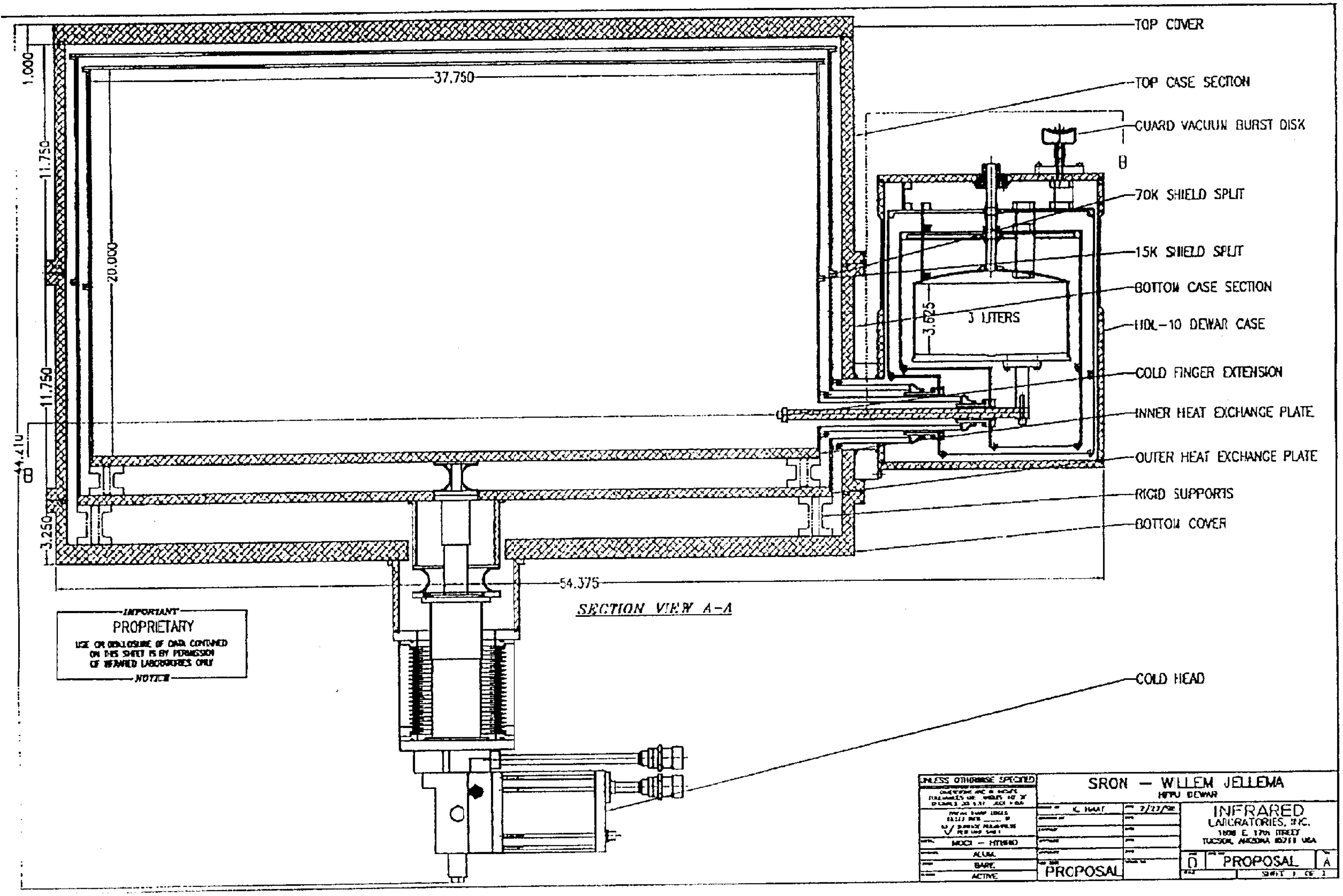
SHEET 2 OF 3


TOP COVER
TOP CASE SECTION
GUARD VACUUM BURST DISK
B
70K SHIELD SPLIT
15K SHIELD SPLIT
BOTTOM CASE SECTION
3 LITERS
3.625
HDL-10 DEWAR CASE
COLD FINGER EXTENSION
INNER HEAT EXCHANGE PLATE
OUTER HEAT EXCHANGE PLATE
RIGID SUPPORTS
BOTTOM COVER
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SECTION VIEW A-A
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SHEET 1 OF 1

SPLINTER MEETING REPORTS

FILTERS (Peter Ade)

MECHANISMS (Colin Cunningham)

EMC (Matt Griffin)

Stray light (Tony Richards)

FIRST Commonality Meeting

Filters, Dichroics, F-P meshes, LO windows, FTS beamdividers etc.

SPIRE – QMW responsible for all filter, dichroics and FTS beamdividers.

Design, prototyping and manufacture all done in-house.

Action: QMW need to define filter requirements.

HIFI –

Identified requirements :

F-P meshes

Low loss LO window – A/R coated (surface pyramids) silicon proposed
NIR emission could be a problem (ESA responsibility)

HEB (Hot Electron Bolometers) will need short wavelength blocking even if A/R quartz is used

He3 system will require thermal load on 0.3K cold finger to be small – need out of band radiation rejected.

whyborn
Action: Nick ~~Wybourn~~e needs to consider if QMW help will be requested.

PACS – looking for QMW assistance

Identified requirements :

Dichroics – for ~ 70 cm^{-1} and 90 cm^{-1} (Low or High pass?)

Blocker filters for 15 K, 4 K and 2 K boxes.

Blocker filters (stray light filters) on baffles inside final optics box and a final blocker on the front of each array. Diameters up to 100 mm.

Order sorting (Band pass filters) may be needed on grating detector array.

Action: QMW need to see optics layout and optical design to comment on overall filtering strategy. Choice of high pass versus low pass will effect optical design.

Summary of Mechanisms Splinter

- **Motors: Potential commonality for SPIRE, PACS and HIFI choppers.**
    - Question on power dissipation: ohmic / eddy currents
    - Question on need for coil shorting at launch
- **Position sensors: common to SPIRE & PACS choppers**
    - MAY be possible to use Moiré fringe type for PACS grating
    - Capacitive sensors will need input to frequency plan
- **Flex Pivots: could be common for SPIRE, PACS and HIFI**
    - SPIRE does not need travel than ISOPHOT types, but could use new spark eroded CuBe types if available in time
- **Test facilities: Ken King will send info on RAL cold vibration set-up**
- **Concern that phasing of PDRs will prevent commonality being exploited fully**

Summary of Structure splinter

- CFRP struts:
  - We will pool test or evaluation results
  - Will investigate common procurement
- 0.3K Coolers will be identical
- Low temp supports could be common
- Compatibility of materials: share knowledge
- Covers
- Thermal straps: light tightness
- E-mail list for Mechanism & Structure people will be set up by Ken King

EMC Splinter Meeting Summary

Matt Griffin

1. ESA will get internal EMC experts to make preliminary assessment of EMC issues for FIRST based on all information available (esp. inputs from instruments)

2. SPIRE will produce first draft Frequency Plan for IID-B
    - Frequencies radiated
    - Frequencies to which we are sensitive
    - Includes low-frequency magnetic fields

3. Frequencies already identified as important:

    60 kHz (TBC) and harmonics from DC-DC converters
    8 GHz from X-band transponders (may not be completely off during observation)

4. ISO EMC spec can be used as a starting point (e.g., for test levels or calculating electric and magnetic field attenuation of the cryostat
    SPIRE will convert to pdf and put on DMS

5. No formal EMC group to be set up just yet, but issue should be reviewed at ESA-instrument technical meetings

6. Question for HIFI: will the LO be completely off during SPIRE/PACS observations?

    HFI answer – yes.

Stray Light Splinter Meeting Summary

Tony Richards report (as noted by MJG)

- Only SPIRE has APART software. SPIRE is willing to analyse PACS input optics – only requires some small modifications to whats being done for SPIRE. Norbert and Tony to liaise on this.
- Detailed APART analysis is time consuming and would have resource implications at RAL if it is required.
- All instruments need good characterisation of the thermal inputs.

  A thermal filter in front of the field mirror could cause scattering into the beam – this needs analysis/measurement. Tjeerd Klassens can do BRDF measurements on a sample – Peter Ade and Tjeerd to liaise on this.
- PACS and SPIRE should be able to meet the spec. that stray light at the detector focal plane be less than 10% of the telescope background
- HIFI requirements for the centre of the secondary should be clarified
- TPD have ASAP and will investigate HIFI standing wave effects
- Thermal transients and gradients are a potential problem for the instruments – the susceptibility should be quantified.