End Item Data Package (EIDP)

SPIRE - 300mK strap supports- PFM

SPIRE Ref.: SPIRE-UCF-
Cardiff Ref.: HSO-CDF-EIDP-072 Issue 1.0
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Change Record

Issue	Section	Date	Changes
1.0		23/07/04	First issue

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SECTION 01 - Shipping Documents

SECTION 02 - Transportation, Packing, Handling & Integration Procedures

Handling

- Inspection may be carried out in class-100 clean air cabinet.
- The light baffle covers must not be removed unless an authorised member of Cardiff personnel is present.
- Outer surface may be cleaned using a clean-room wipe impregnated with iso-propyl alcohol.
- The light baffle may only ever be placed on a bench in the orientation shown in Figure 1. Any other orientation may damage the Kevlar cords, and this must be avoided at all costs.

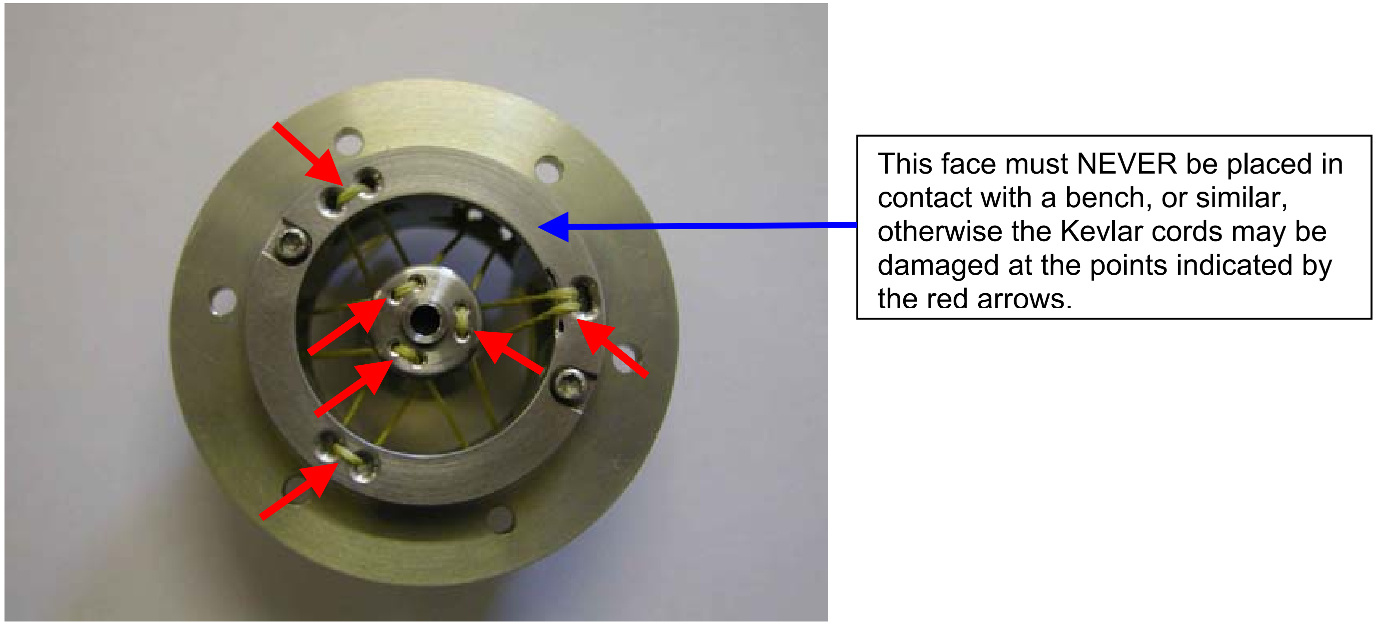


Figure 1 The light baffles may only be placed on a bench in the orientation shown here. On no account must the face indicated by the blue arrow be placed in contact with any surface. N.B. The image shown above is of an STM unit, NOT a flight model design assembly.

Storage

- The 300mK strap support assemblies must be stored in the transport container provided.

- Store in a dark place. Exposure to light should be kept to a minimum wherever possible.

Installation

- The 300mK strap support assemblies should be installed by trained MSSL or RAL technicians, according to the MSSL integration procedure.
- If any part of the 300mK strap system has to be forced or bent in order to fit through the light baffles or supports, integration should be halted, an NCR should be raised, and Cardiff should be informed immediately.

SECTION 03 - Certificate of Conformance

Cardiff University Astronomy Instrumentation Group hereby certifies that the following equipment,	
Spacecraft / Project:	**Herschel**
Instrument:	**SPIRE**
Model:	**PFM**
Subsystem:	**300mK Strap Support System**
Serial No:	**LTS-PFM-100, LTS-PFM-200, LTS-PFM-300, LTS-PFM-400**
As described in this End Item Data Package: **HSO-CDF-EIDP-072**	
Complies with the requirements set out in: **SPIRE-RAL-PRJ-000034**	

Responsible Authority		***Signature***
Cardiff Product Assurance	Dr I.Walker	
Cardiff SPIRE Management	Dr P.Hargrave	

SECTION 04 - Qualification Status List / Compliance Matrix

Test	Status	Applicable document / Test reference	Test Institute
Dimension and tolerances to specification	Compliant		UWC
Visual inspection (internal & external)	Passed	Lab book – "300mK log – 1"	UWC
Mass	Requirements document is only in draft form (0.1), and out-of date. A change request will be placed against this document.	SPIRE-RAL-PRJ-001323 STRAP-REQ-05 "285g (includes mass of photometer and spectrometer straps & stray light baffles)"	
Thermal / vacuum cycles	Passed	Lab book – "300mK log – 1"	UWC
Power consumption	N/A		
Vibrations 300K	Passed	AIV-2003-008-VIB, AIV-2003-091-VIB	RAL
Vibrations 4K	Passed	AIV-2003-008-VIB, AIV-2003-091-VIB	RAL
Environmental condition - Vacuum $3x10^{-1}$mBar	Passed	Lab book – "300mK log – 1"	UWC
Differential pressure (a pumping-out rate of 10mB/sec)	Compliant	Lab book – "300mK log – 1"	UWC
Pre-bake out (not exceeding 80˚C)	Completed	Lab book – "300mK log – 1"	UWC
Outgassing	Compliant	By analysis – not tested.	
Cleanliness checks, by visual inspection.	Passed	Lab book – "300mK log – 1"	UWC
Degradation due to high energy radiation.	Compliant	By analysis – not tested	

Compliance with IRD and 300mK Strap System Requirements

There are no specific requirements in the IRD for the 300mK strap supports.
Requirements stated below, which are relevant to the 300mK supports are stated in “300mK Strap System requirements”, SPIRE-RAL-PRJ-001323 draft 0.1.

<table>
<tr><th>Requirement ID</th><th>Description</th><th>Value</th><th>Compliant?</th></tr>
<tr><td>IRD-COOL-R01</td><td>Temperature at the detectors</td><td>The ^{3}He cooler, in conjunction with the associated 300 mK architecture, shall maintain all bolometer detector assemblies at less than 310 mK – goal 300 mK.</td><td>This requirement is not complete. The base temperature achievable depends heavily on the level-0 temperature, and the resulting parasitic heat load to the 300mK system.
There is no specific requirement on the parasitic heat load, or more correctly, the thermal conductance, of the support system as a function of level-0 temperature.</td></tr>
<tr><td>IRD-COOL-R08</td><td>Hold time</td><td>Minimum 46 hours</td><td>This requirement places design constraints on the cooler, the 300mK support system, and the overall thermal design of SPIRE.</td></tr>
<tr><td>IRD-COOL-R10</td><td>Mechanical interface</td><td>Preferred interface is with the instrument common structure</td><td>Compliant</td></tr>
<tr><td>STRAP-REQ-02</td><td>Strap support and stray light baffles parasitic heat load</td><td>Maximum of 2μW</td><td>Parasitic load depends on level-0 temperature. According to data from Duband, we are compliant, according to Ventura, we are not.
<table>
<tr><th rowspan="2">Level-0 temperature</th><th colspan="2">Parasitic load to cooler tip from 300mK strap suspension (μW)</th></tr>
<tr><th>Duband model</th><th>Ventura model</th></tr>
<tr><td>1.8K</td><td>1.42</td><td>2.65</td></tr>
<tr><td>2.0K</td><td>1.87</td><td>3.54</td></tr>
</table></td></tr>
<tr><td>STRAP-REQ-04</td><td>Accomodation</td><td>The 300-mK Strap system is to be supported entirely from the Level-0 Photometer and Spectrometer Detector Boxes.</td><td>Compliant</td></tr>
<tr><td>STRAP-REQ-05</td><td>Mass</td><td>285g (includes mass of photometer and spectrometer straps & stray light baffles)</td><td>Not compliant.
Requirements document is only in draft form (0.1), and out-of date.
The mass of the assemblies has been accepted by the project.
A change request will be placed against this document.</td></tr>
<tr><td>STRAP-REQ-06</td><td>First mode of vibration</td><td>>300Hz, goal >400Hz</td><td>This requirement is for the whole system, including the bus-bar, and can only be checked by analysis followed by system level vibration in SPIRE. MSSL are responsible for this analysis.</td></tr>
<tr><td>STRAP-REQ-07</td><td>Qualification level random vibration loads</td><td>0.5g^2/Hz 100Hz – 400Hz, 6dB/octave roll-off below & above this</td><td>Compliant</td></tr>
<tr><td>STRAP-REQ-08</td><td>Qualification level sine vibration loads</td><td>40g between 5Hz and 110 Hz</td><td>Compliant</td></tr>
</table>

STRAP-REQ-17	Stray light baffling effectiveness	The photometer and spectrometer stray light baffles are to provide at least four reflections for the shortest optical path between the level-1 environment and the level-0 environment inside the detector boxes.	Not compliant. It is possible for a photon to penetrate the inside of the detector box from the level-1 environment following three reflections. Increasing the effectiveness of the light trap would compromise the safety of the system, making a thermal short from 300mK to level-0 more likely. The fewer reflections are not such an issue, as the whole light trap is coated with a high emissivity coating.
STRAP-REQ-18	Stray light baffle opacity	The photometer and spectrometer stray light baffles are to be opaque (99.9%) in the wavelengths 0.5μm to 670μm	Compliant.

SECTION 05 - Top Level Drawings (Inc. Family Tree)

Hardware tree

The hardware tree for the 300mK is shown in Figure 2. Note that the part numbers are given by the general form “LTS-XXX-nnn”, where “XXX” is the model designation (CQM, PFM etc) and “nnn” is the number given in the hardware tree (LTS stands for “Low Temperature System”). For instance, the part number for the 300mK flight model adjustable capstan for photometer support A is “LTS-PFM-108”.

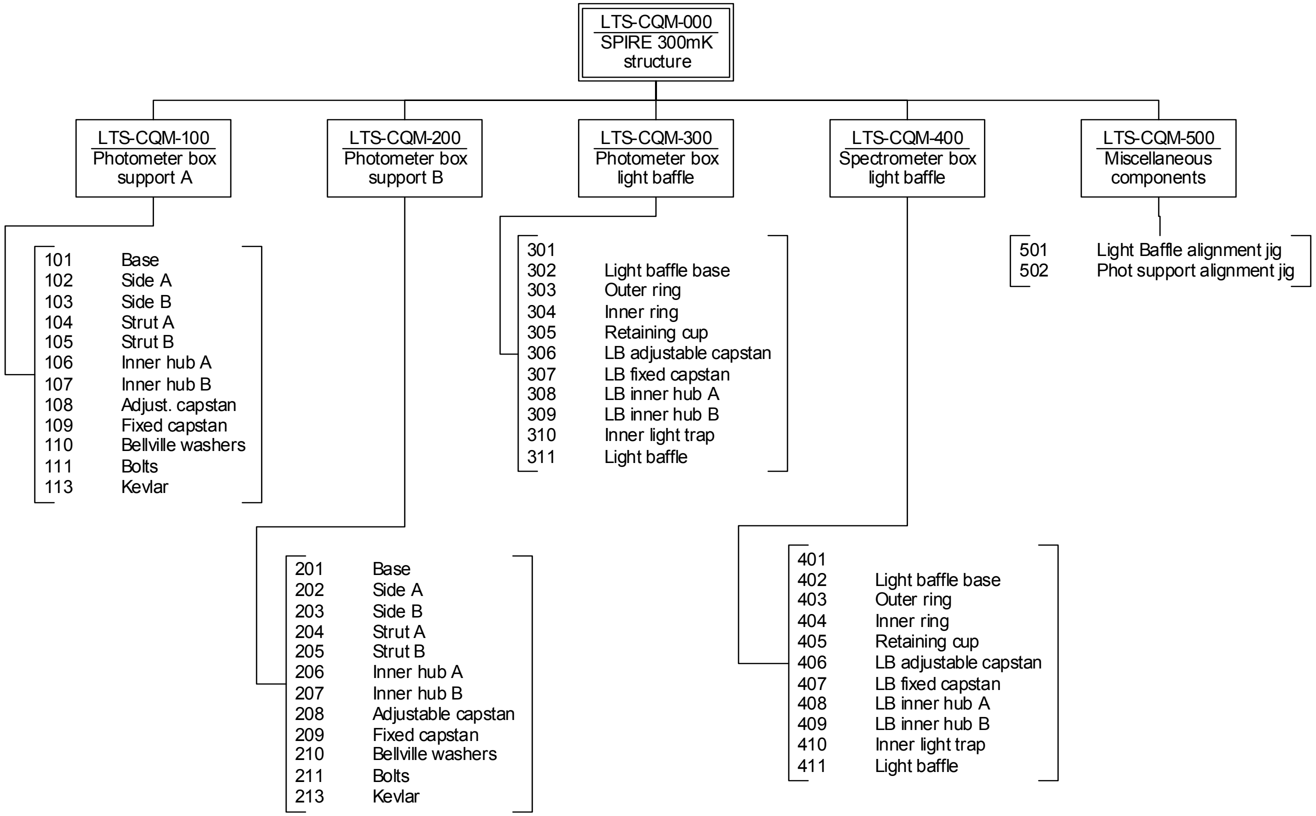


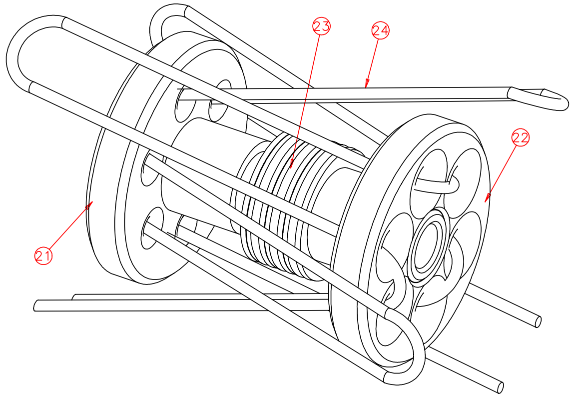
Figure 2 Hardware tree for 300mK support system

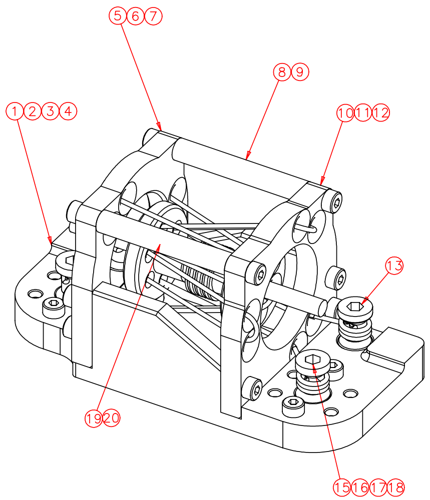
TOP LEVEL DRAWING LIST

Note that the drawings below, although labelled CQM, CQM2, are the drawings used for flight model manufacture.

Drawing No.	Title
LTS-CQM-100/200	Photometer Support (Figure 3) Issue 1.0
LTS-CQM2-300/400	300mK Light Baffle (Figure 4) Issue 1.0

CLEAN & BREAK ALL SHARP EDGES





ITEM NO.	DRAWING No.	DESCRIPTION	No. OFF	REMARKS
24	N/D	UNWOVEN KEVLAR CORD.	A/R	
23	N/D	BELLEVILLE SPRING WASHER	12	PT. NO. S105204
22	LTS-CQM-107/207	INNER HUB B	1	ST. STEEL
21	LTS-CQM-106/206	INNER HUB A	1	ST. STEEL
20	N/D	HELICOIL SCREWLOCK INSERTS 256 UNC x 1.5D	2	PT. NO. 3585-02 CNX.129
19	LTS-CQM-204/205	STRUT B	1	ST. STEEL
18	N/D	HELICOIL SCREWLOCK INSERTS 256 UNC x 1.5D	24	PT. NO. 3585-02 CNX.129
17	N/D	BELLEVILLE SPRING WASHER	2	PT. NO. D6-20
16	N/D	SCREW, 2-56UNC CP HD. 6.35 LG.	2	ST. STEEL
15	LTS-CQM-108/208	ADJUSTABLE CAPSTAN	2	ST. STEEL
14	N/D	ø2.0mm DOWEL x 10.0 LG.	2	ST. STEEL
13	LTS-CQM-109/209	FIXED CAPSTAN	2	ST. STEEL
12	N/D	BELLEVILLE SPRING WASHER	5	PT. NO. D6-20
11	N/D	SCREW, 2-56UNC CP HD. 6.35 LG.	5	ST. STEEL
10	LTS-CQM-202/203	SIDE B	1	ST. STEEL
9	N/D	HELICOIL SCREWLOCK INSERTS 256 UNC x 1.5D	2	PT. NO. 3585-02 CNX.129
8	LTS-CQM-104/105	STRUT A	1	ST. STEEL
7	N/D	BELLEVILLE SPRING WASHER	5	PT. NO. D6-20
6	N/D	SCREW, 2-56UNC CP HD. 6.35 LG.	5	ST. STEEL
5	LTS-CQM-102/103	SIDE A	1	ST. STEEL
4	N/D	HELICOIL SCREWLOCK INSERTS 256 UNC x 1.5D	13	PT. NO. 3585-02 CNX.129
3	N/D	BELLEVILLE SPRING WASHER	4	PT. NO. D6-20
2	N/D	SCREW, 2-56UNC CP HD. 6.35 LG.	4	ST. STEEL
1	LTS-CQM-101/201	MAIN BASE	1	AL-6082

CONTRACT NO.	AMENDMENT
APPROVALS	DATE
DRAWN BJK	15.09.03
CHECKED BY: IT	16.09.03
APPROVED BY: PCH	17.09.03
ISSUE	1

MATERIAL & SPEC : AS LISTED

FINISH: AS LISTED — ESTD WT. 100.0g

QUANTITY: 2 — ACTL WT. 110.0g

SCALE 2:1

DIMENSIONS IN MM

TOLERANCES UNLESS OTHERWISE STATED
LINEAR +/- 0,10
ANGULAR +/- 0,15°

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CAD FILE
CONFIGURED-DOCUMENTS/300mK/PFM-BUILD/MANUFACTURE/ARCHIVE FILE

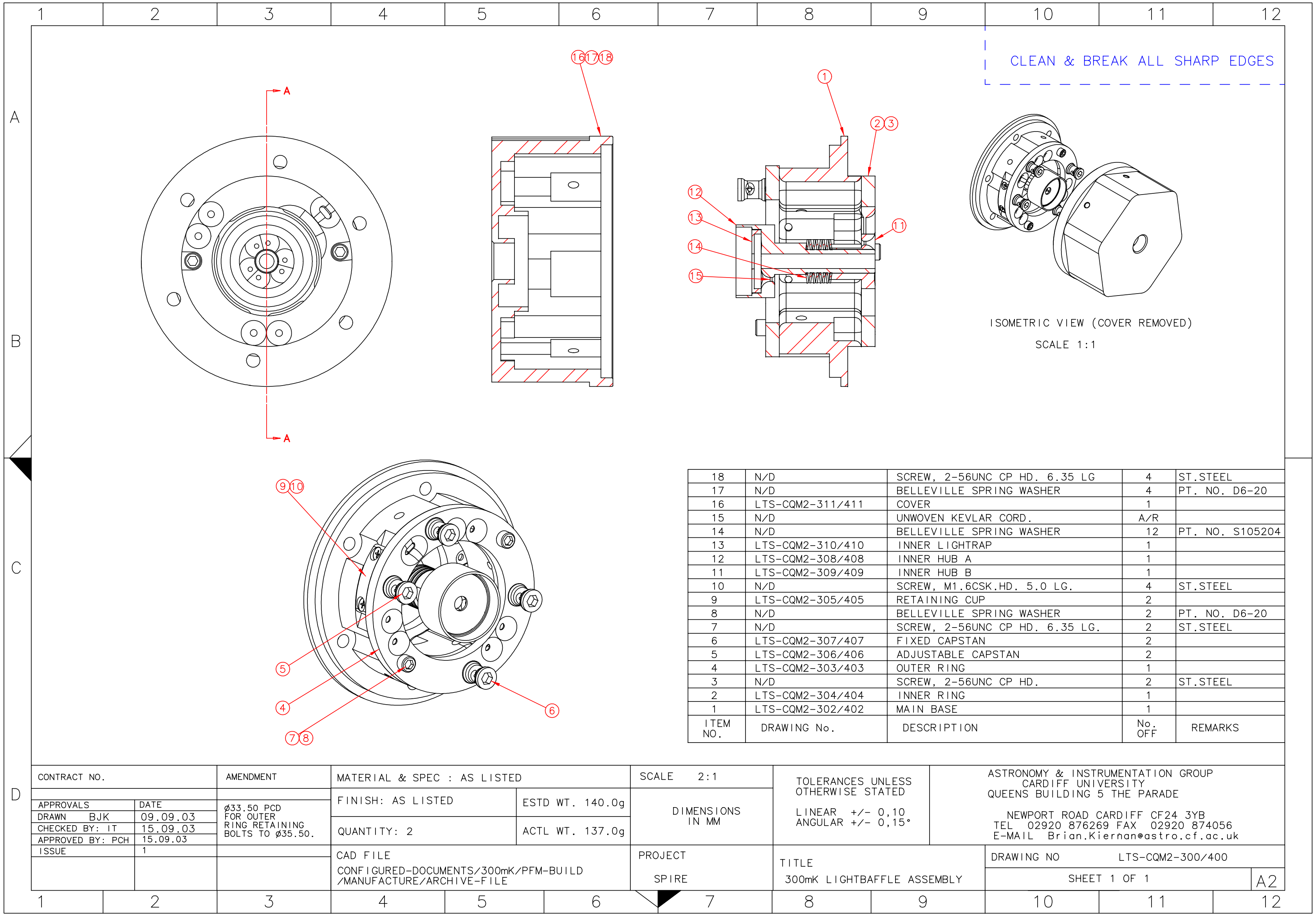
PROJECT SPIRE

TITLE PHOTOMETER SUPPORT ASSEMBLY

DRAWING NO LTS-CQM-100/200

SHEET 1 OF 1 — A2

Figure 3 Photometer support assembly



ITEM NO.	DRAWING No.	DESCRIPTION	No. OFF	REMARKS
18	N/D	SCREW, 2-56UNC CP HD. 6.35 LG	4	ST.STEEL
17	N/D	BELLEVILLE SPRING WASHER	4	PT. NO. D6-20
16	LTS-CQM2-311/411	COVER	1	
15	N/D	UNWOVEN KEVLAR CORD.	A/R	
14	N/D	BELLEVILLE SPRING WASHER	12	PT. NO. S105204
13	LTS-CQM2-310/410	INNER LIGHTRAP	1	
12	LTS-CQM2-308/408	INNER HUB A	1	
11	LTS-CQM2-309/409	INNER HUB B	1	
10	N/D	SCREW, M1.6CSK.HD. 5.0 LG.	4	ST.STEEL
9	LTS-CQM2-305/405	RETAINING CUP	2	
8	N/D	BELLEVILLE SPRING WASHER	2	PT. NO. D6-20
7	N/D	SCREW, 2-56UNC CP HD. 6.35 LG.	2	ST.STEEL
6	LTS-CQM2-307/407	FIXED CAPSTAN	2	
5	LTS-CQM2-306/406	ADJUSTABLE CAPSTAN	2	
4	LTS-CQM2-303/403	OUTER RING	1	
3	N/D	SCREW, 2-56UNC CP HD.	2	ST.STEEL
2	LTS-CQM2-304/404	INNER RING	1	
1	LTS-CQM2-302/402	MAIN BASE	1	

Figure 4 Light baffle assembly

SECTION 06 - Interface Drawings

INTERFACE DRAWING LIST

Note that the drawings below, although labelled CQM, CQM2, are the drawings used for flight model manufacture.

Drawing No.	Title	Notes
LTS-CQM-ICD-100/200	300mK support interface	Issue 1.0 (Figure 5)
LTS-CQM2-ICD-300/400	Light baffle interface	Issue 2. (Figure 6)

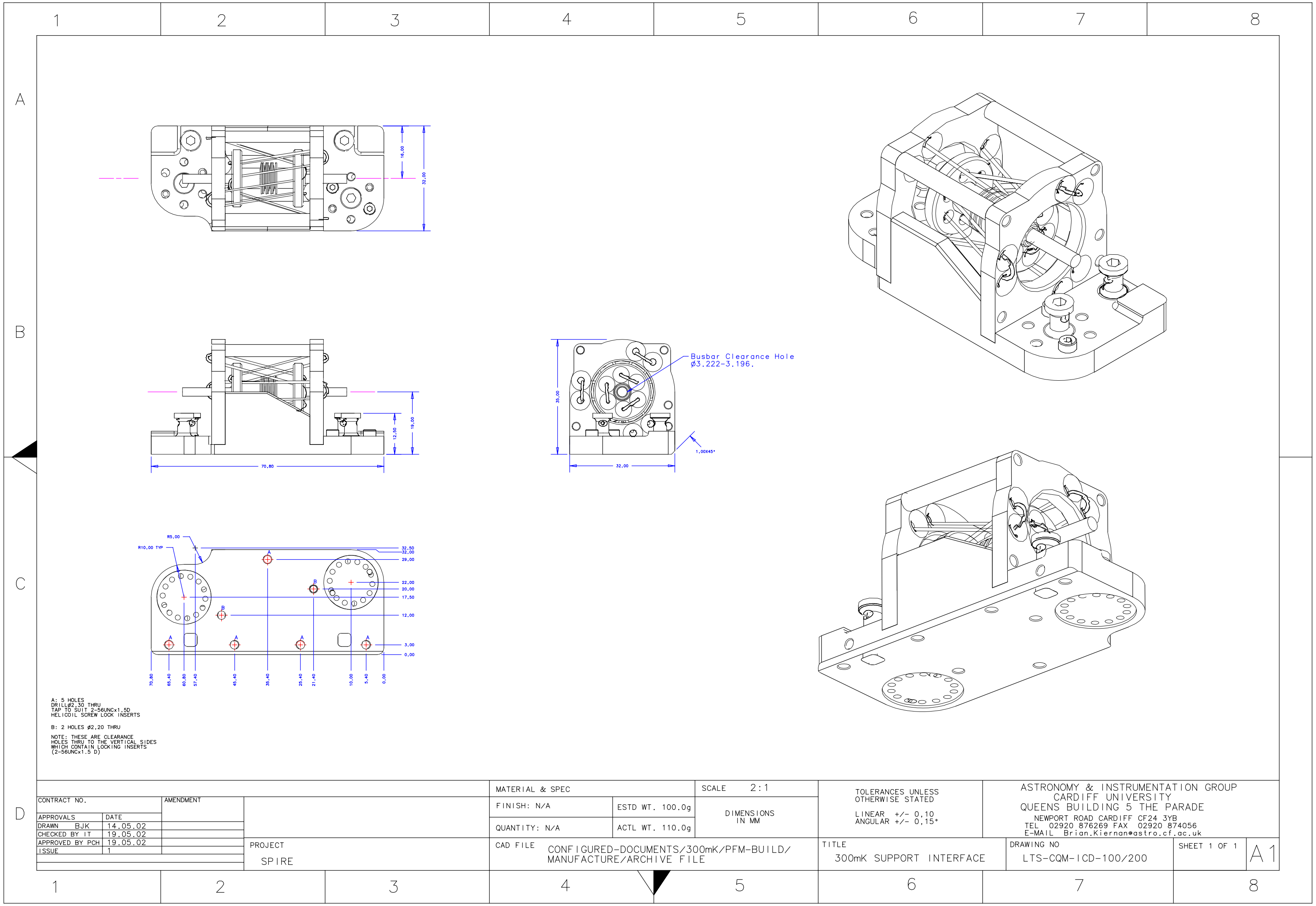


Figure 5 Photometer support A and B interface drawing

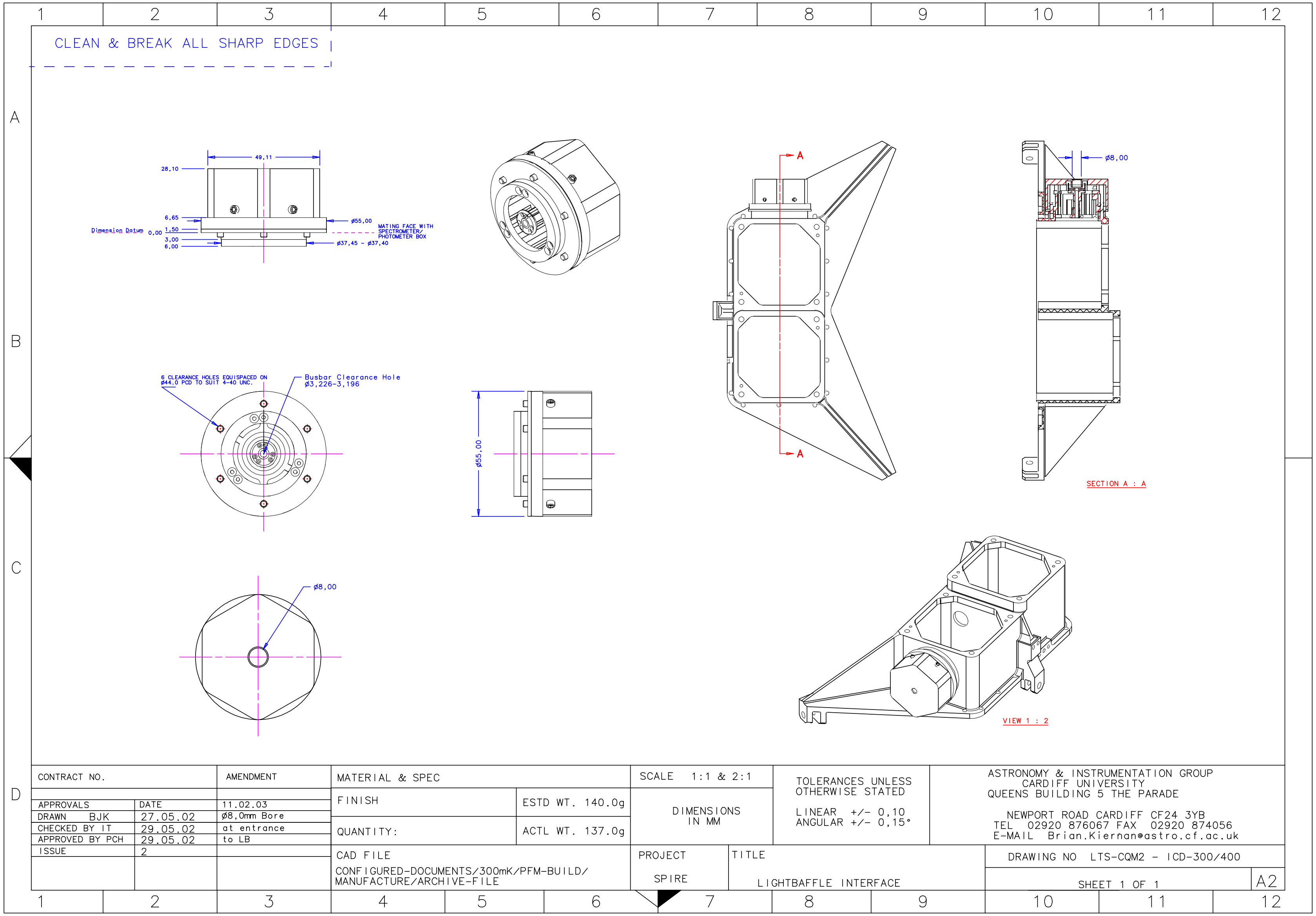


Figure 6 Light baffle A and B interface drawing

SECTION 07 - Functional, Block & Mechanical Drawings

Component drawings are given in this section.

FUNCTIONAL & BLOCK DRAWING LIST

Drawing No.	Title

MECHANICAL COMPONENT DRAWING LIST

Note that the drawings below, although labelled CQM, CQM2, are the drawings used for flight model manufacture.

Drawing No.	Title	Notes
LTS-CQM-101/201	PHOTOMETER SUPPORT BASE	
LTS-CQM-102/103-202/203	PHOTOMETER SUPPORT: SIDES A & B	
LTS-CQM-104/105-204/205	PHOTOMETER SUPPORT: STRUT A & B	
LTS-CQM-106/206	PHOTOMETER SUPPORT: INNER HUB A	
LTS-CQM-107/207	PHOTOMETER SUPPORT: INNER HUB B	
LTS-CQM-108/208	PHOTOMETER SUPPORT: ADJUSTABLE CAPSTAN	
LTS-CQM-109/209	PHOTOMETER SUPPORT: FIXED CAPSTAN	
LTS-CQM2-302/402	300mK LIGHTBAFFLE MAIN BASE	2 SHEETS
LTS-CQM2-303/403	300mK LIGHTBAFFLE OUTER RING	
LTS-CQM2-304/404	300mK LIGHTBAFFLE INNER RING	
LTS-CQM2-305/405	300mK LIGHTBAFFLE RETAINING CUP	
LTS-CQM2-306/406	300mK LIGHTBAFFLE ADJUSTABLE CAPSTAN	
LTS-CQM2-307/407	300mK LIGHTBAFFLE FIXED CAPSTAN	
LTS-CQM2-308/408	300mK LIGHTBAFFLE INNER HUB A	
LTS-CQM2-309/409	300mK LIGHTBAFFLE INNER HUB B	
LTS-CQM2-410/510	300mK LIGHTBAFFLE INNER LIGHT TRAP	
LTS-CQM2-411/511	300mK LIGHTBAFFLE COVER	2 SHEETS

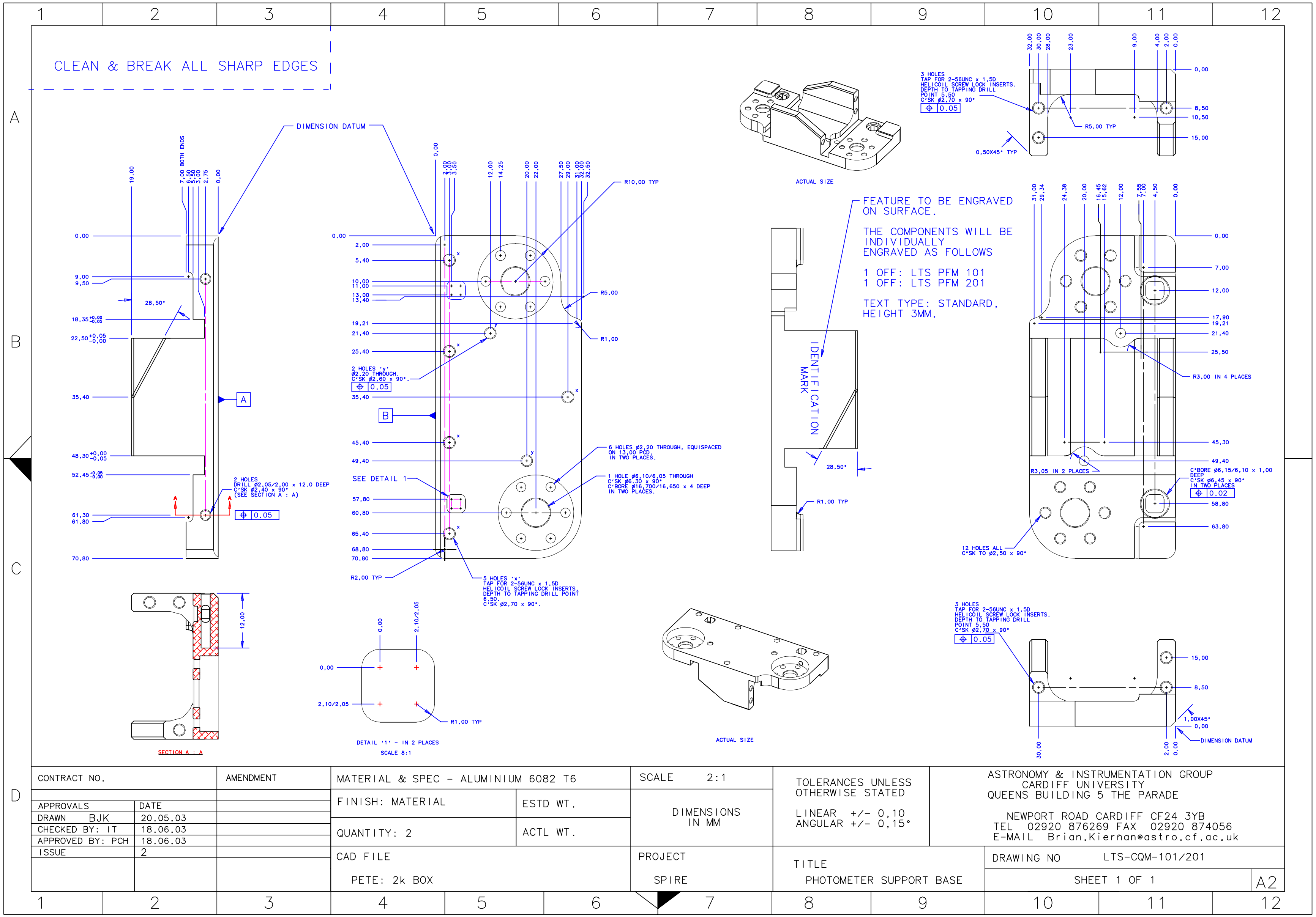


Figure 7 Photometer support base

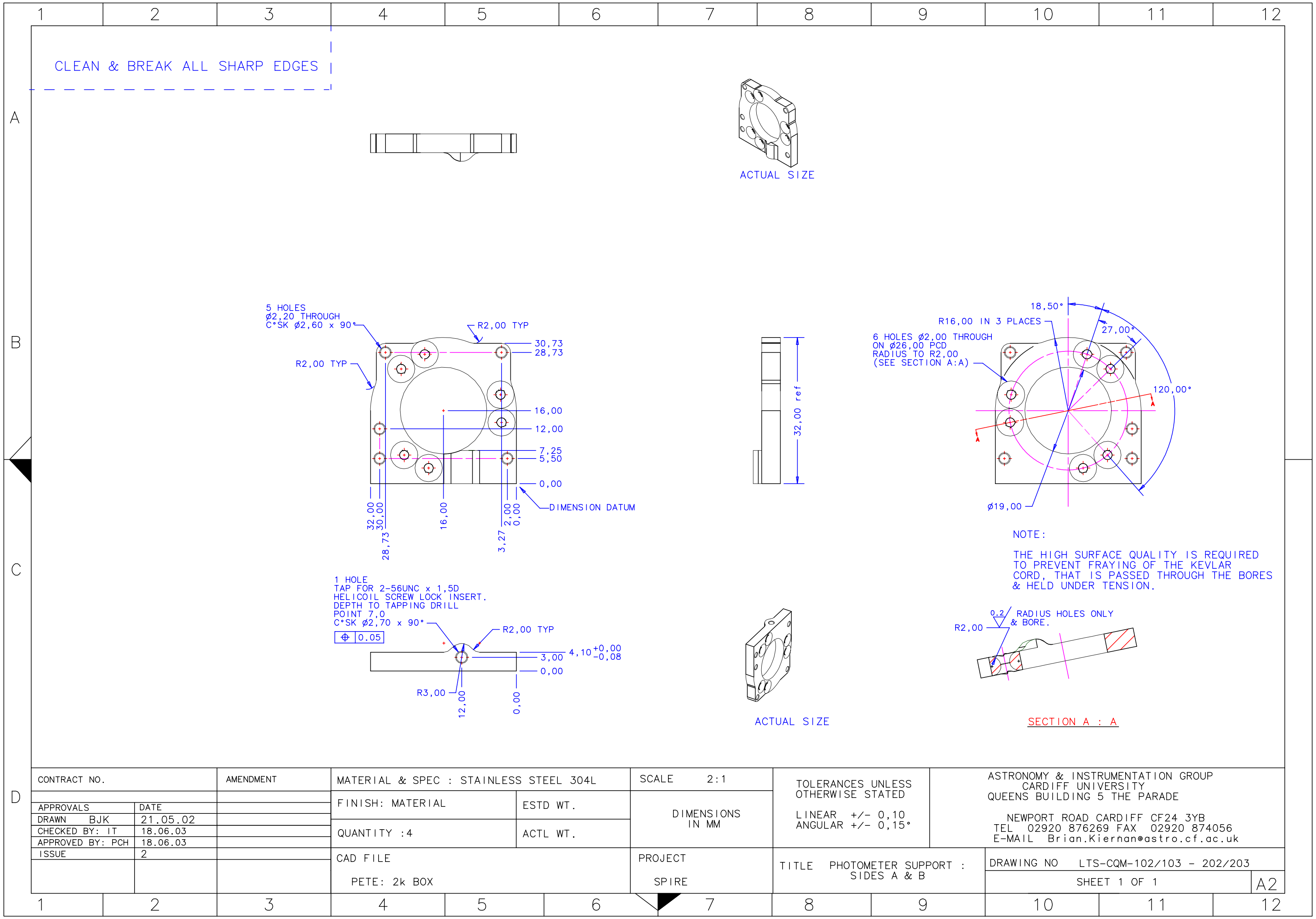


Figure 8 Photometer support sides A & B

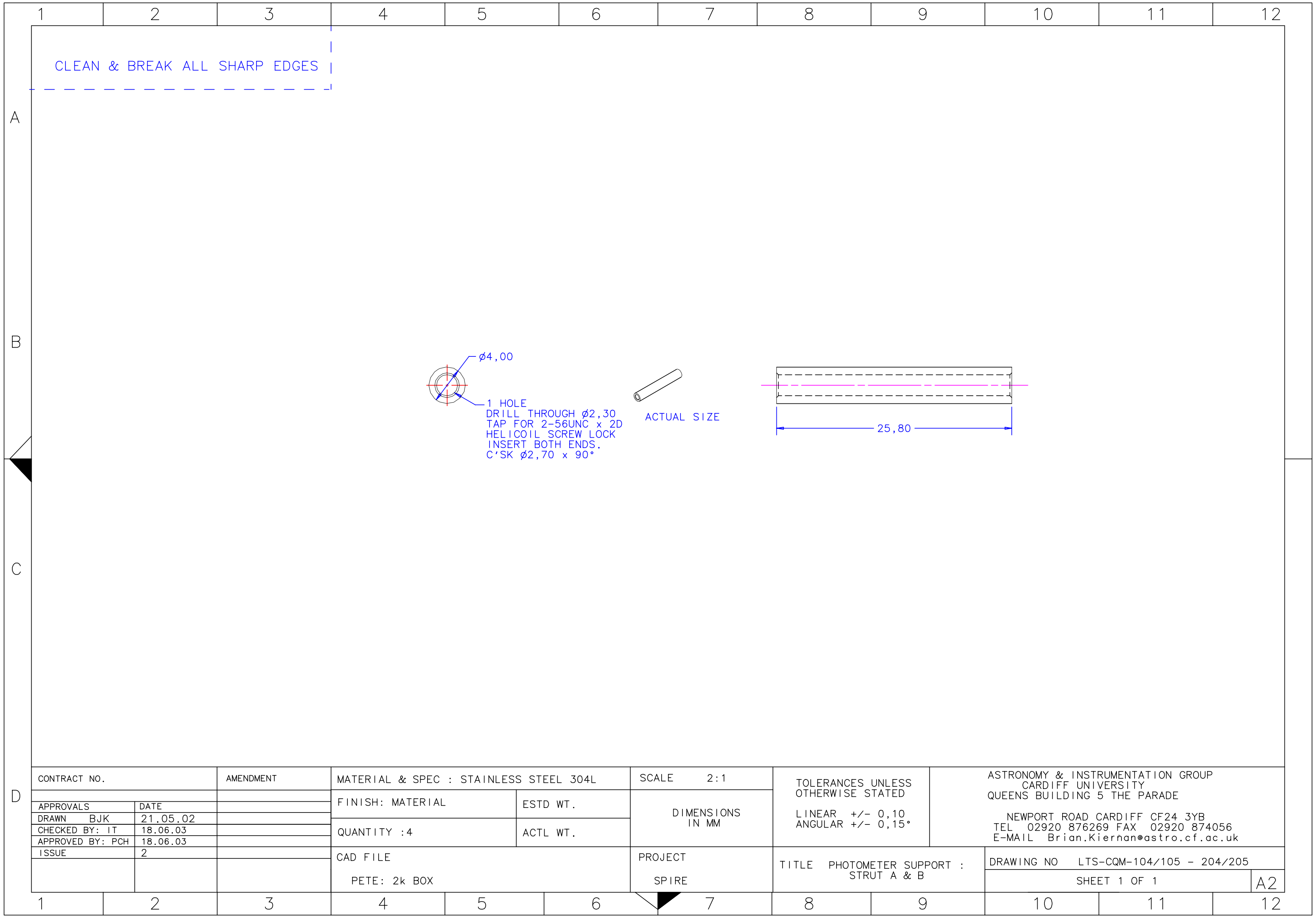


Figure 9 Photometer support strut A & B

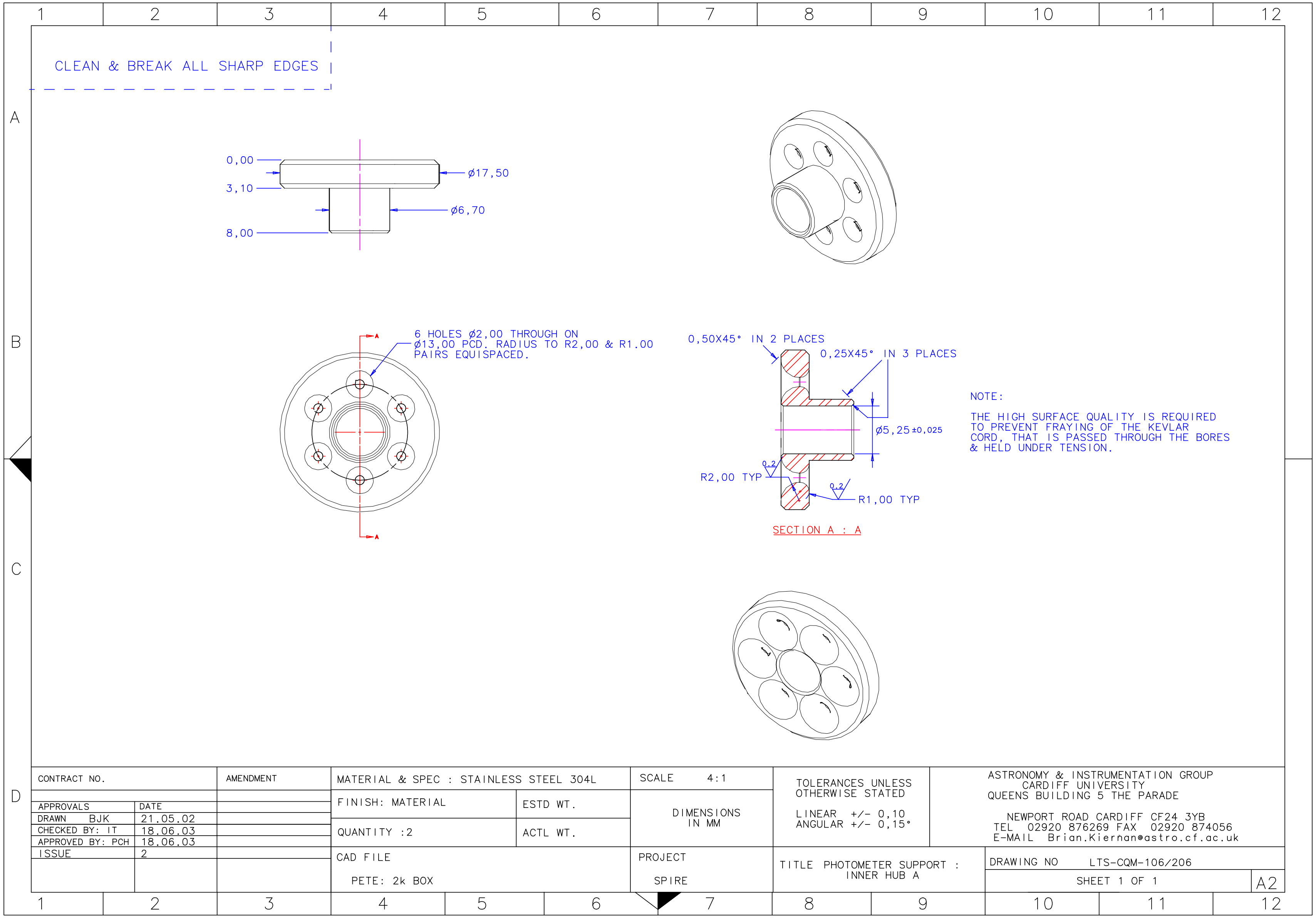


Figure 10 Photometer support inner hub A

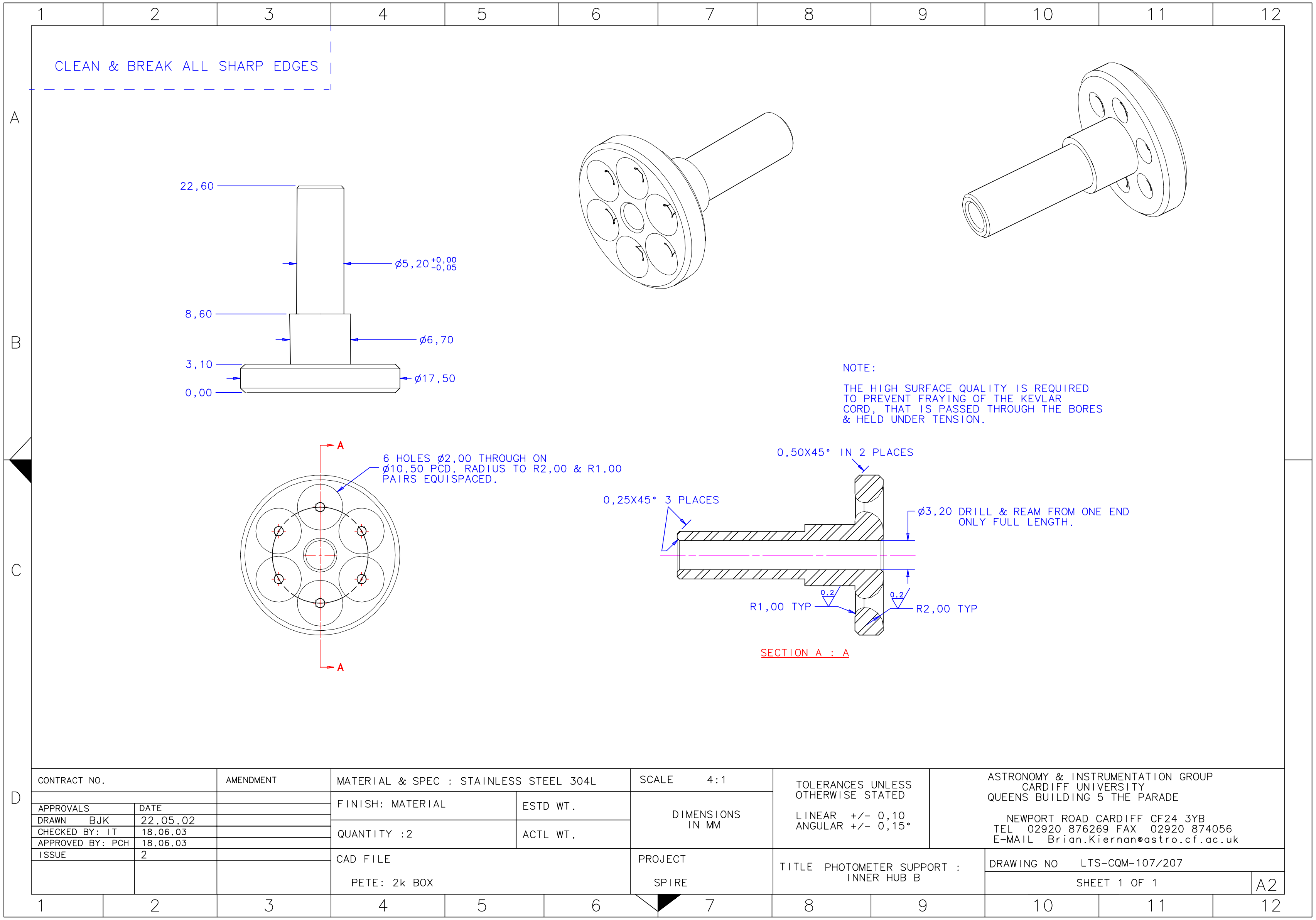


Figure 11 Photometer support inner hub B

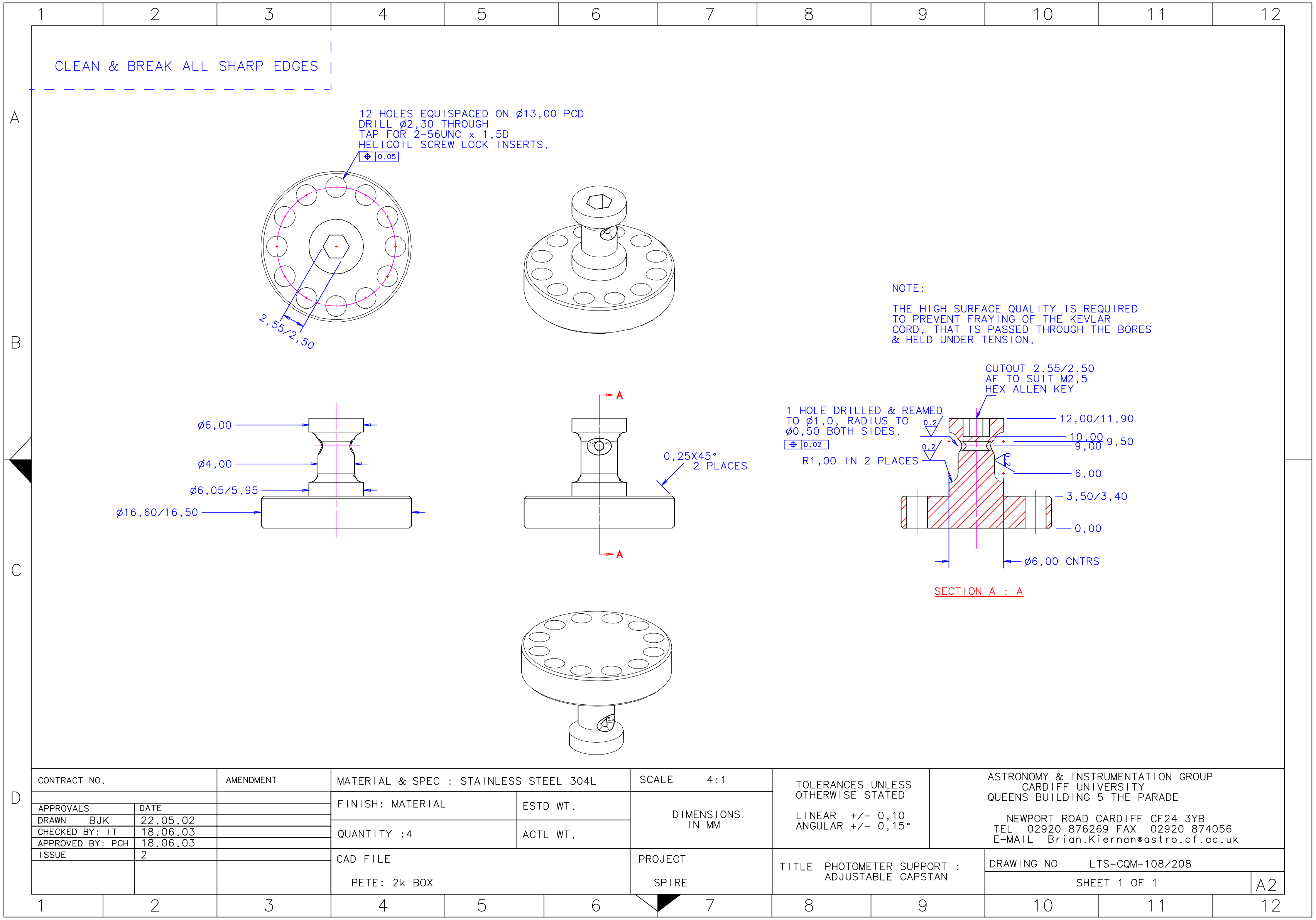


Figure 12 Photometer support adjustable capstan

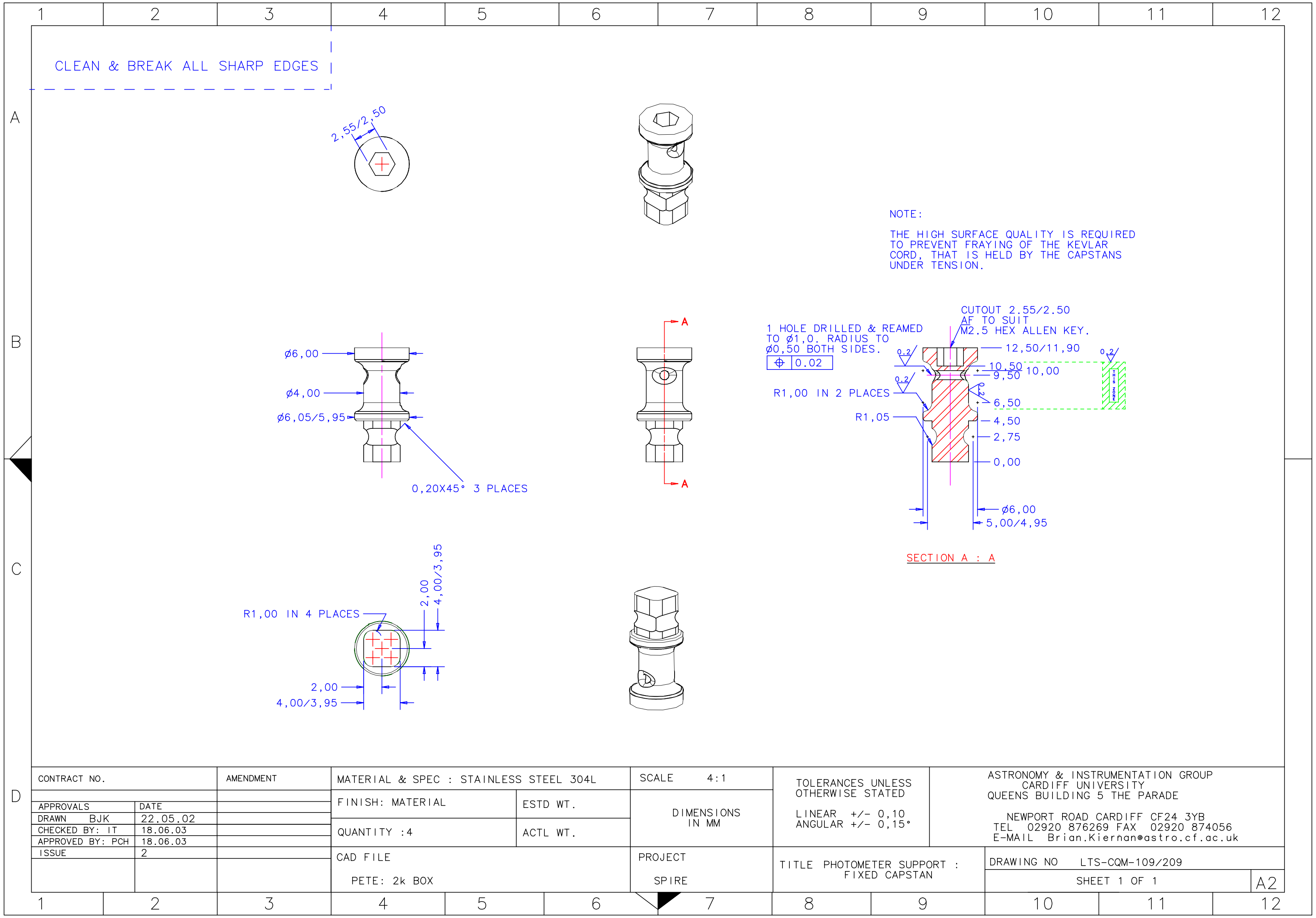
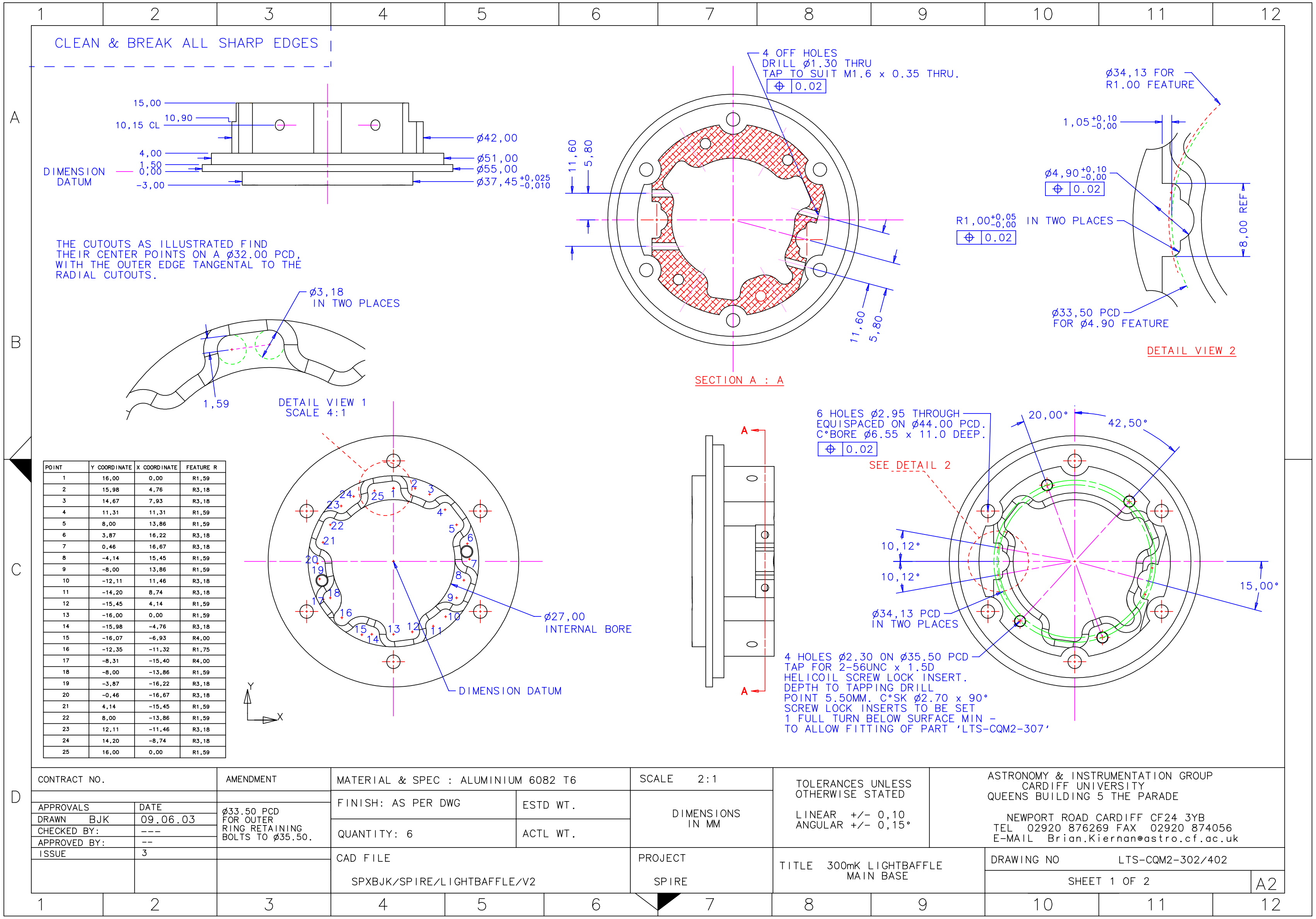


Figure 13 Photometer support fixed capstan



POINT	Y COORDINATE	X COORDINATE	FEATURE R
1	16,00	0,00	R1,59
2	15,98	4,76	R3,18
3	14,67	7,93	R3,18
4	11,31	11,31	R1,59
5	8,00	13,86	R1,59
6	3,87	16,22	R3,18
7	0,46	16,67	R3,18
8	-4,14	15,45	R1,59
9	-8,00	13,86	R1,59
10	-12,11	11,46	R3,18
11	-14,20	8,74	R3,18
12	-15,45	4,14	R1,59
13	-16,00	0,00	R1,59
14	-15,98	-4,76	R3,18
15	-16,07	-6,93	R4,00
16	-12,35	-11,32	R1,75
17	-8,31	-15,40	R4,00
18	-8,00	-13,86	R1,59
19	-3,87	-16,22	R3,18
20	-0,46	-16,67	R3,18
21	4,14	-15,45	R1,59
22	8,00	-13,86	R1,59
23	12,11	-11,46	R3,18
24	14,20	-8,74	R3,18
25	16,00	0,00	R1,59

Figure 14 300mK light baffle main base – sheet 1

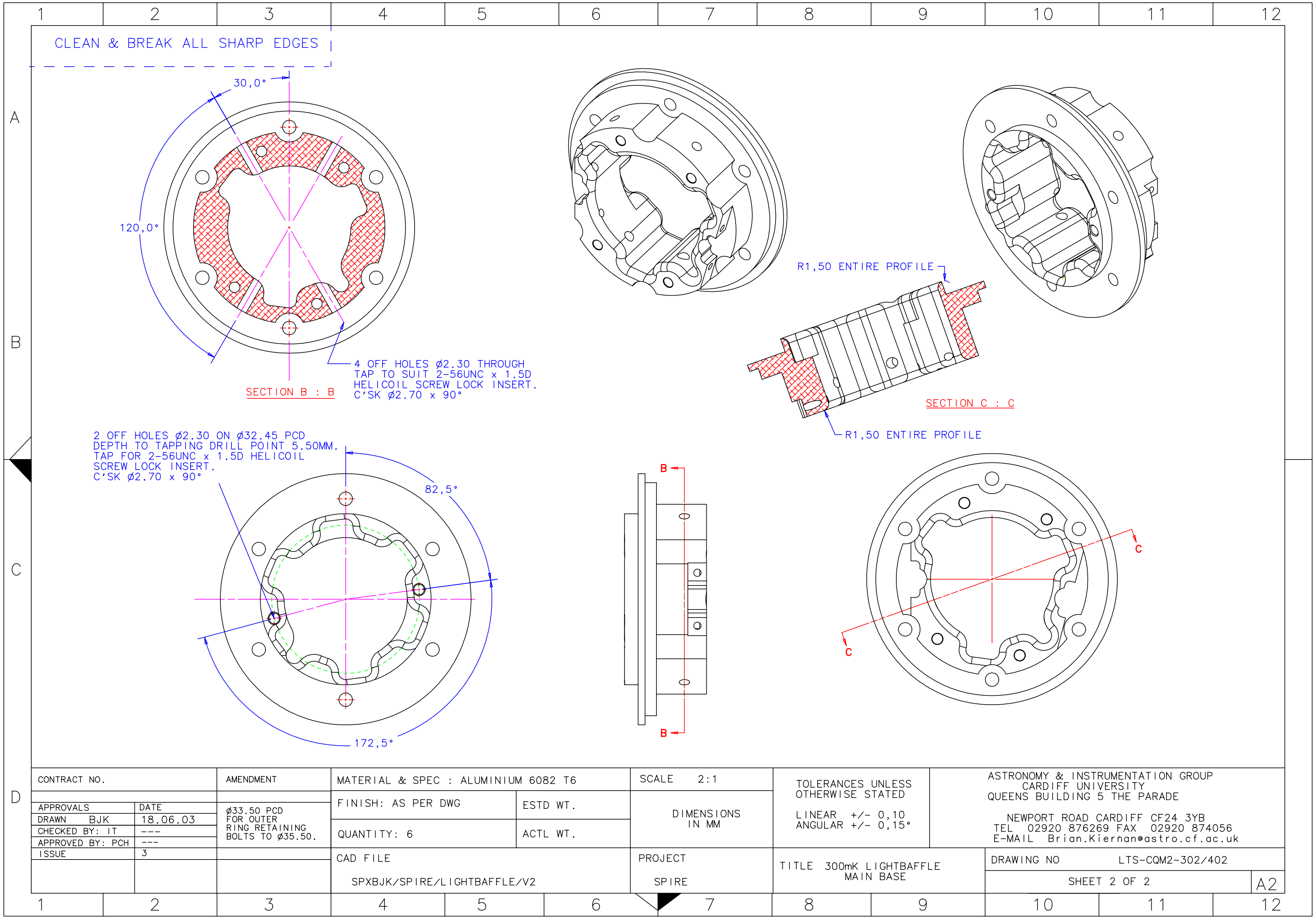


Figure 15 300mK light baffle main base – sheet 2

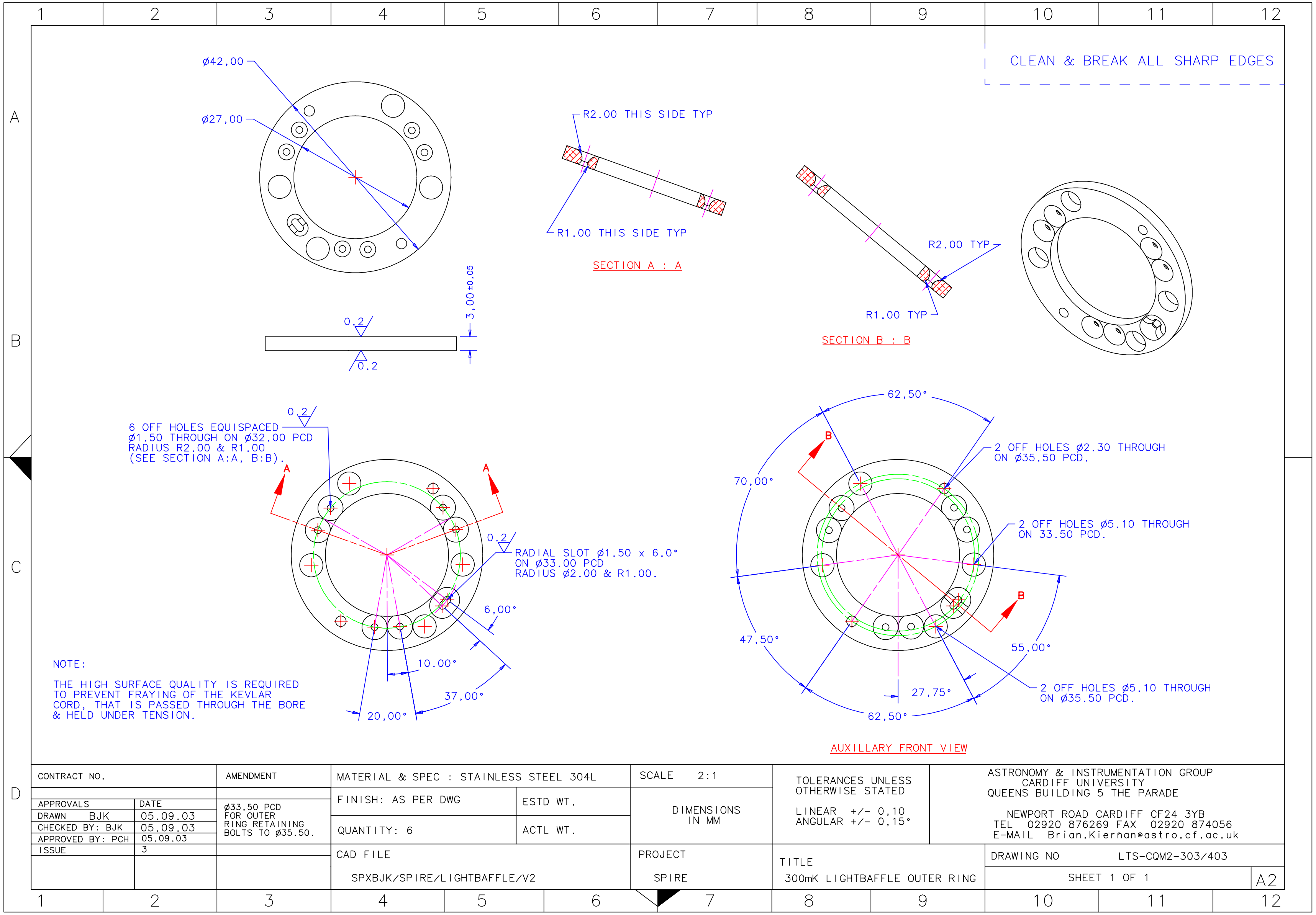


Figure 16 300mK light baffle outer ring

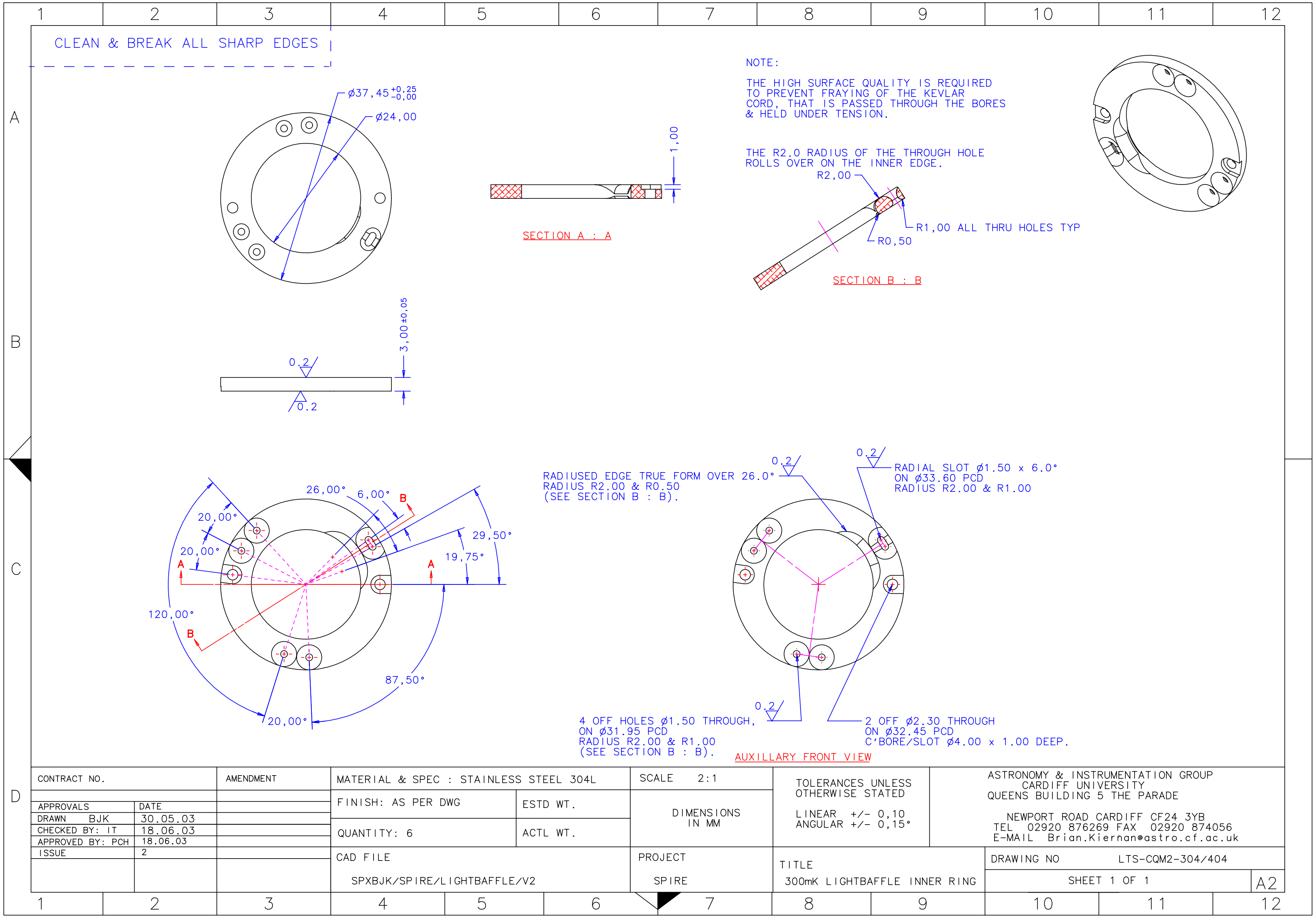


Figure 17 300mK light baffle inner ring

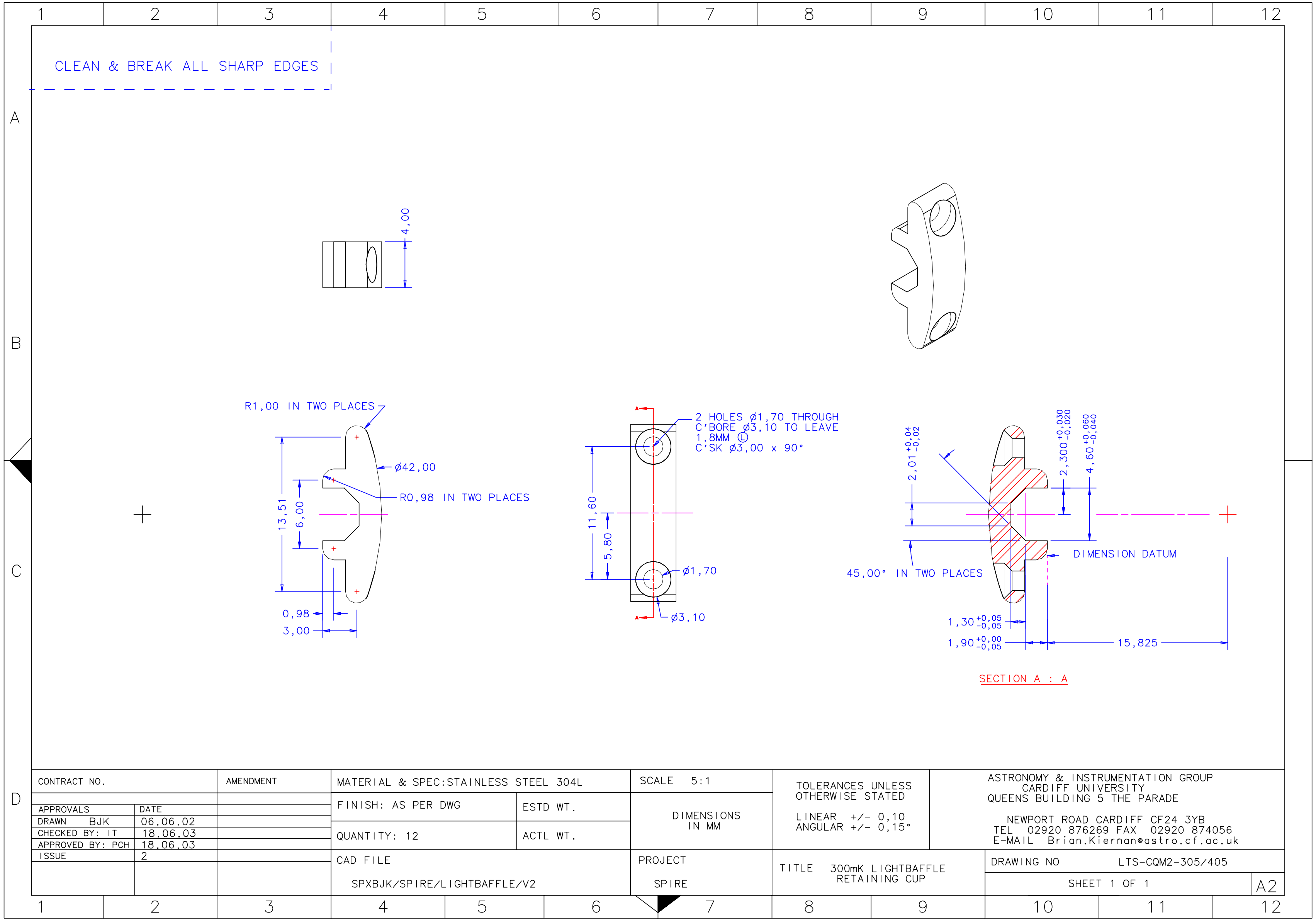


Figure 18 300mK light baffle retaining cup

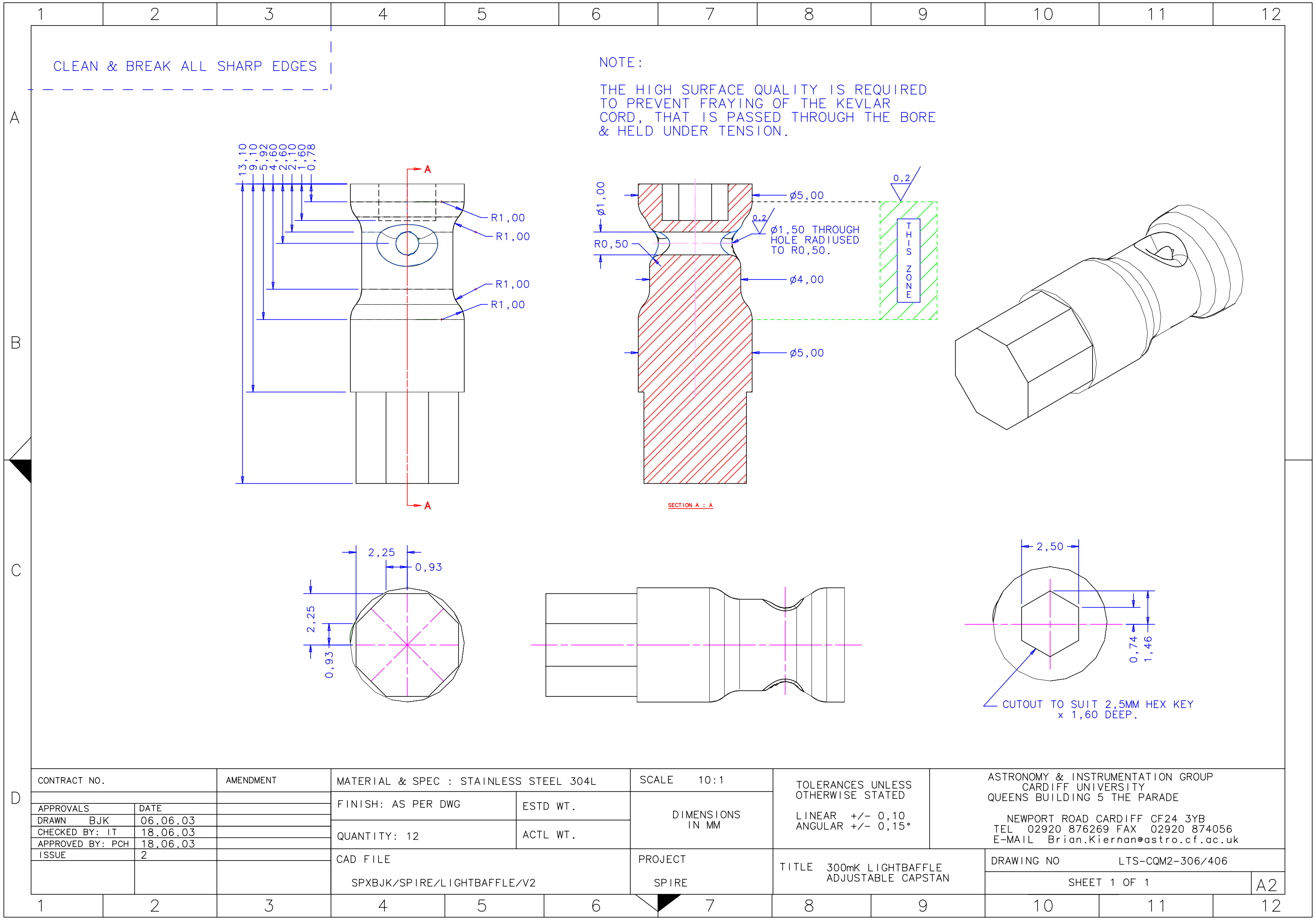


Figure 19 300mK light baffle adjustable capstan

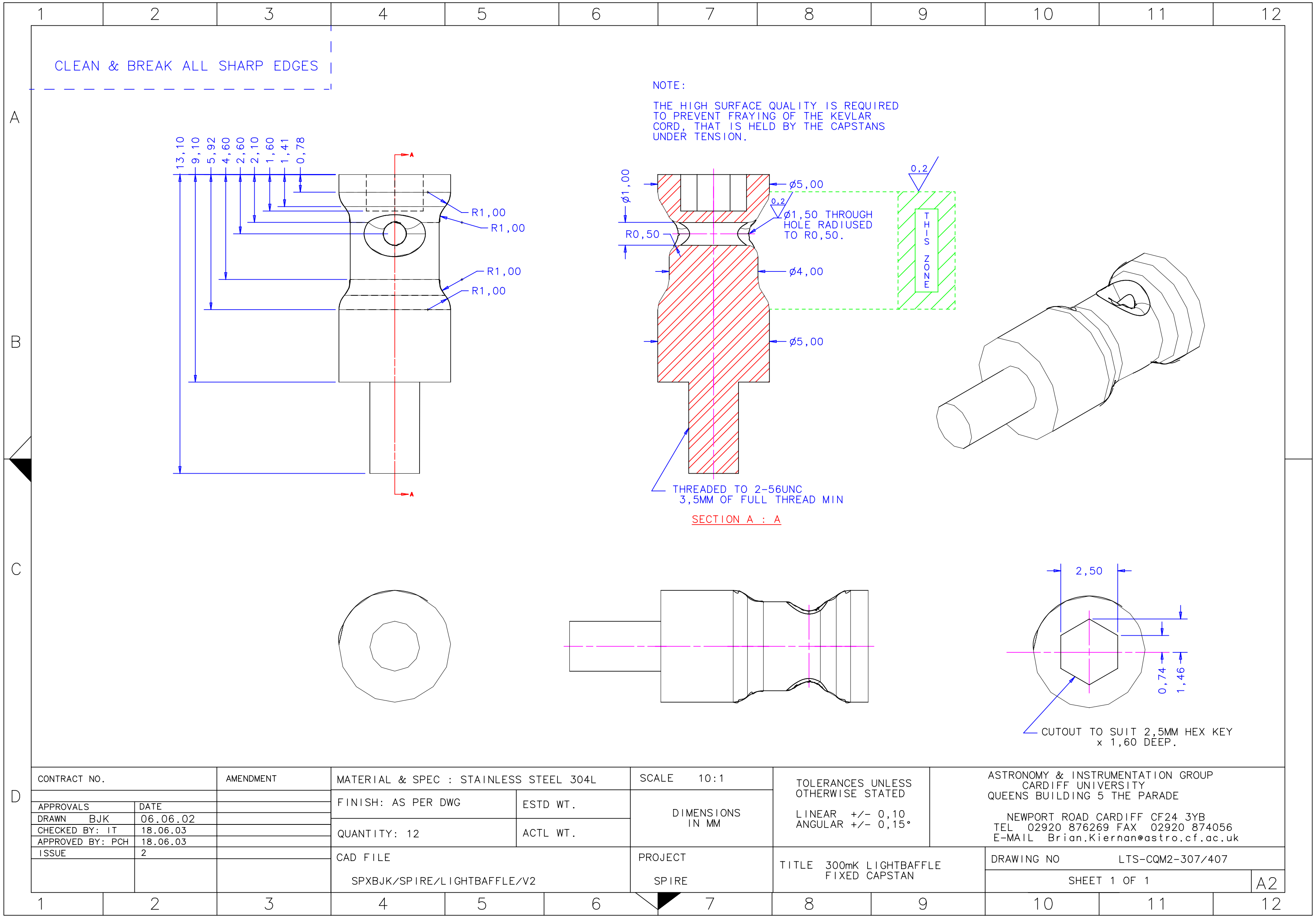


Figure 20 300mK light baffle fixed capstan

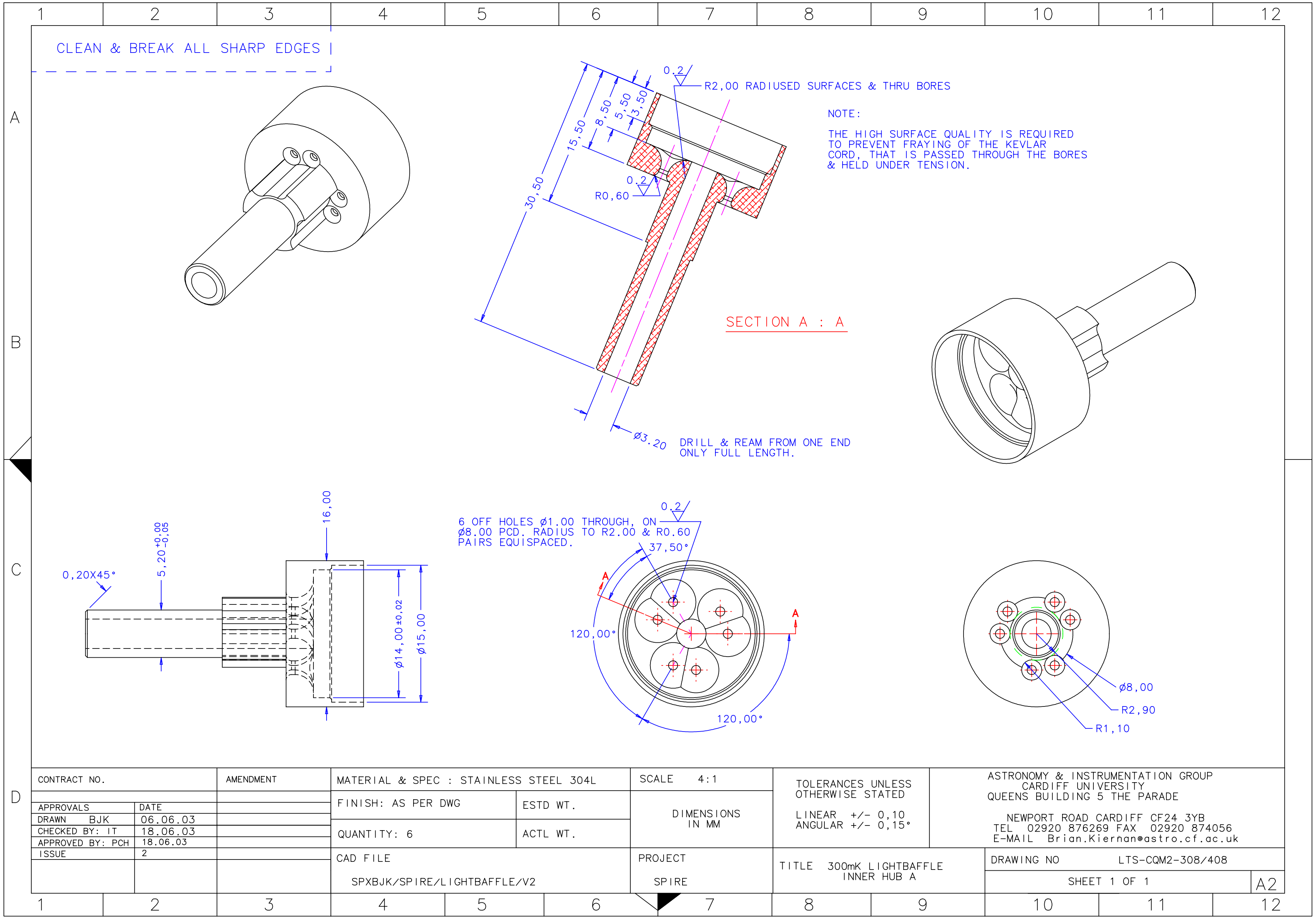


Figure 21 300mK light baffle inner hub A

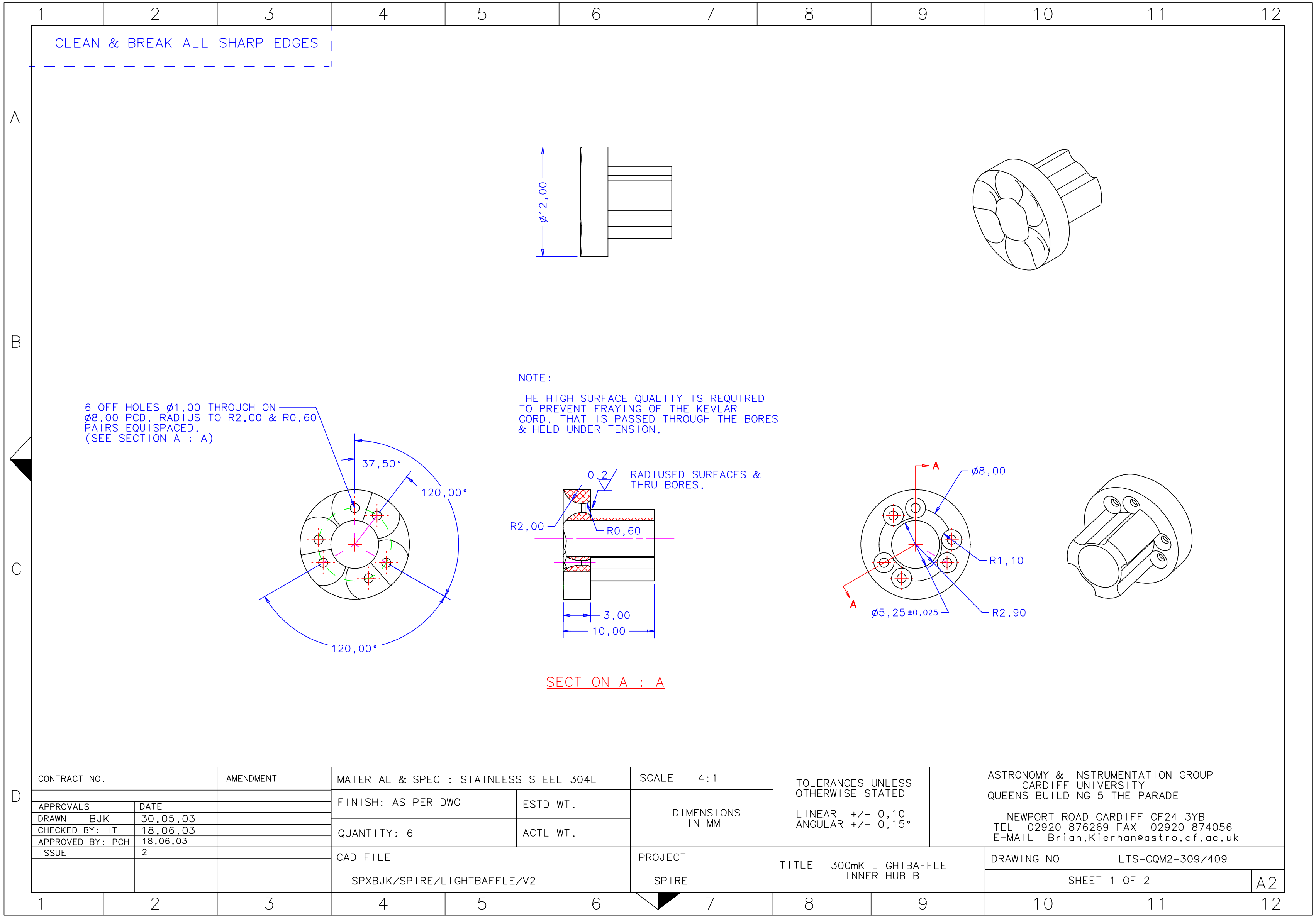


Figure 22 300mK light baffle inner hub B

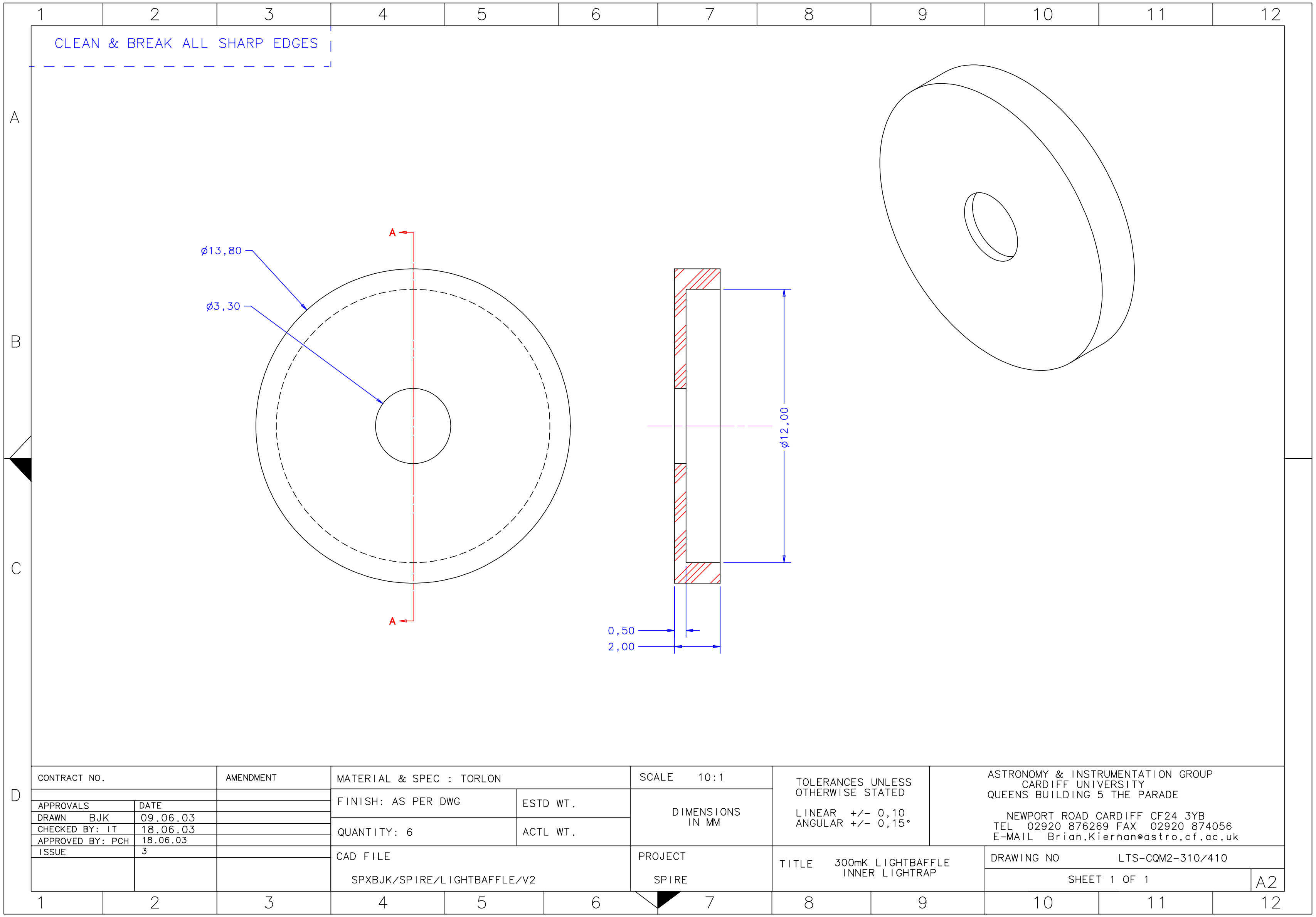
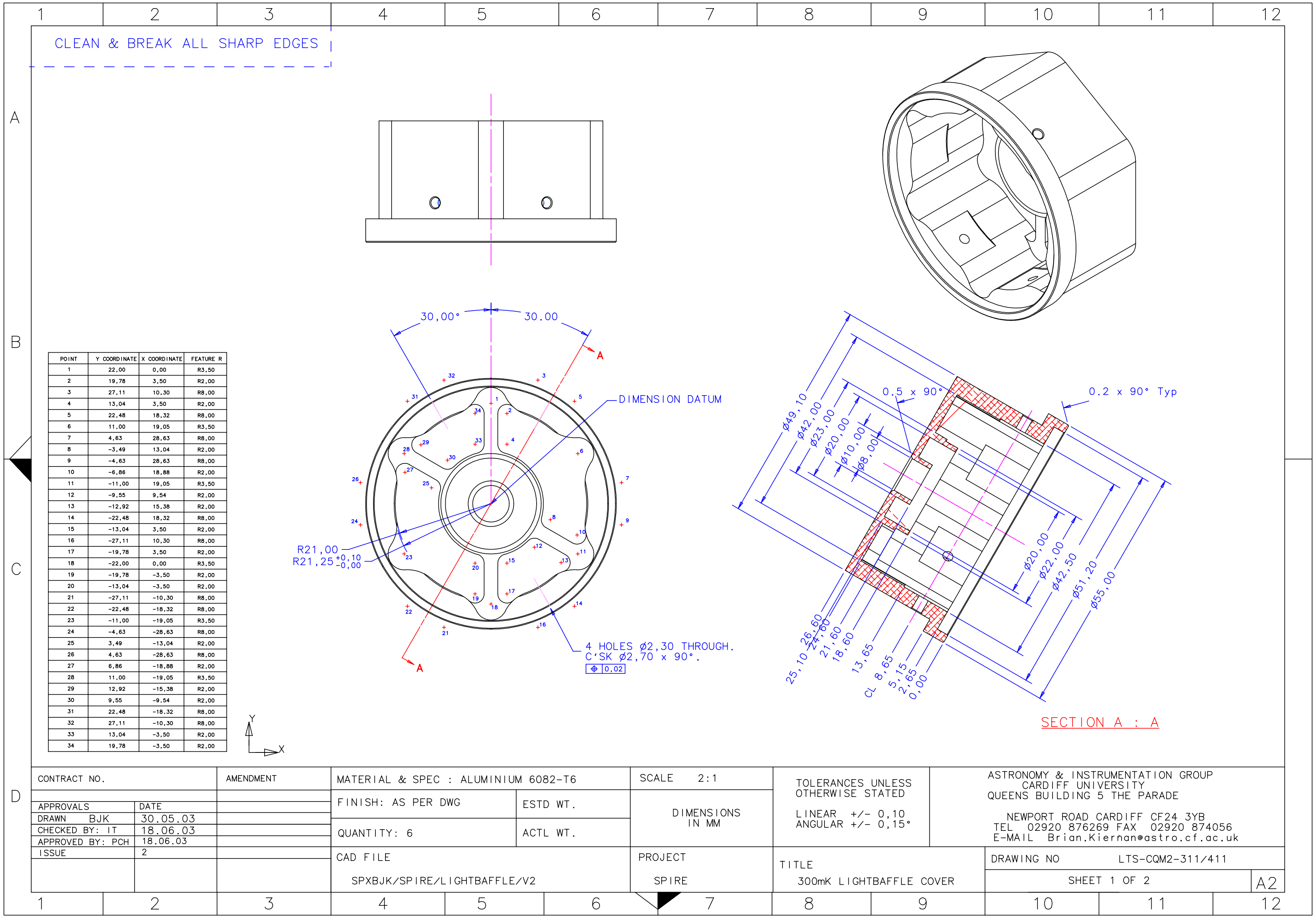


Figure 23 300mK light baffle inner light trap



POINT	Y COORDINATE	X COORDINATE	FEATURE R
1	22,00	0,00	R3,50
2	19,78	3,50	R2,00
3	27,11	10,30	R8,00
4	13,04	3,50	R2,00
5	22,48	18,32	R8,00
6	11,00	19,05	R3,50
7	4,63	28,63	R8,00
8	-3,49	13,04	R2,00
9	-4,63	28,63	R8,00
10	-6,86	18,88	R2,00
11	-11,00	19,05	R3,50
12	-9,55	9,54	R2,00
13	-12,92	15,38	R2,00
14	-22,48	18,32	R8,00
15	-13,04	3,50	R2,00
16	-27,11	10,30	R8,00
17	-19,78	3,50	R2,00
18	-22,00	0,00	R3,50
19	-19,78	-3,50	R2,00
20	-13,04	-3,50	R2,00
21	-27,11	-10,30	R8,00
22	-22,48	-18,32	R8,00
23	-11,00	-19,05	R3,50
24	-4,63	-28,63	R8,00
25	3,49	-13,04	R2,00
26	4,63	-28,63	R8,00
27	6,86	-18,88	R2,00
28	11,00	-19,05	R3,50
29	12,92	-15,38	R2,00
30	9,55	-9.54	R2,00
31	22,48	-18.32	R8,00
32	27,11	-10,30	R8,00
33	13,04	-3,50	R2,00
34	19,78	-3,50	R2,00

Figure 24 300mK light baffle cover - sheet 1

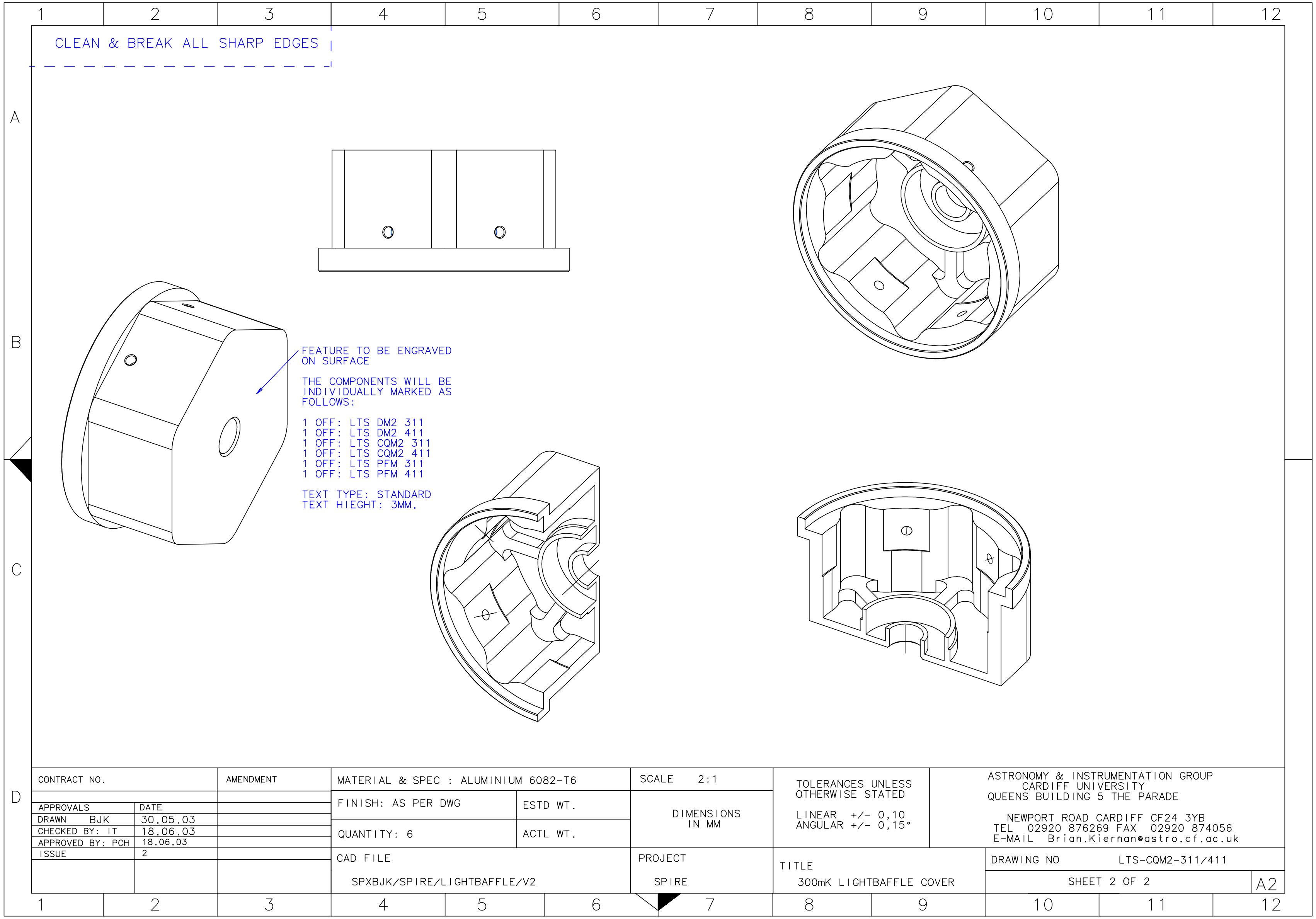


Figure 25 300mK light baffle cover – sheet 2

SECTION 08 – Electrical Circuit Diagrams

N/A

SECTION 09 - As Built Configuration Items Status List

Item	Reference / batch number / serial number	Quantity	Assembly / Location	Manufacturer / supplier	C of C #	Notes
BASE	LTS-PFM-101	1	**PHOTOMETER SUPPORT A LTS-PFM-100**	EMEC	23654 / 29472	
SIDE A	LTS-PFM-102	1		TMC	13755	
SIDE B	LTS-PFM-103	1		TMC	13755	
STRUT A	LTS-PFM-104	1		TMC	13755	
STRUT B	LTS-PFM-105	1		TMC	13755	
INNER HUB A	LTS-PFM-106	1		TMC	13755	
INNER HUB B	LTS-PFM-107	1		TMC	13755	
ADJUSTABLE CAPSTAN	LTS-PFM-108	1		TMC	13755	
FIXED CAPSTAN	LTS-PFM-109	1		TMC	13755	
BELLVILLE WASHERS	Part#3105204	12		PTC	Batch #19135	
BOLTS 2-56 X 1/4		2		PTC	17953	
BOLTS 2-56 X 5/16		8		PTC	13734	
KEVLAR				CFILT		
BASE	LTS-PFM-201	1	**PHOTOMETER SUPPORT B LTS-PFM-200**	EMEC	23654 / 29472	
SIDE A	LTS-PFM-202	1		TMC	13755	
SIDE B	LTS-PFM-203	1		TMC	13755	
STRUT A	LTS-PFM-204	1		TMC	13755	
STRUT B	LTS-PFM-205	1		TMC	13755	
INNER HUB A	LTS-PFM-206	1		TMC	13755	
INNER HUB B	LTS-PFM-207	1		TMC	13755	

ADJUSTABLE CAPSTAN	LTS-PFM-208	1		TMC	13755	
FIXED CAPSTAN	LTS-PFM-209	1		TMC	13755	
BELLVILLE WASHERS	Part#3105204	12		PTC	Batch #19135	
BOLTS 2-56 X 1/4		2		PTC	17953	
BOLTS 2-56 X 5/16		8		PTC	13734	
KEVLAR						
LIGHT BAFFLE BASE	LTS-PFM-302	1	**PHOTOMETER BOX LIGHT BAFFLE LTS-PFM-300**	EMEC	23654 / 29472	
OUTER RING	LTS-PFM-303	1		TMC	13755	
INNER RING	LTS-PFM-304	1		TMC	13755	
RETAINING CUP	LTS-PFM-305	1		TMC	13755	
LB ADJUSTABLE CAPSTAN	LTS-PFM-306	1		TMC	13755	
LB FIXED CAPSTAN	LTS-PFM-307	1		TMC	13755	
LB INNER HUB A	LTS-PFM-308	1		TMC	13755	
LB INNER HUB B	LTS-PFM-309	1		TMC	13755	
INNER LIGHT TRAP	LTS-PFM-310	1		TMC	13755	
LIGHT BAFFLE	LTS-PFM-311	1		EMEC	23654 / 29472	
BOLTS – 2-56 X 1/4		4		PTC	17953	
BOLTS – 2-56 X 5/16		4		PTC	13734	
BELLVILLE WASHERS	Part#3105204	12		PTC	Batch #19135	
KEVLAR				CFILT		
LIGHT BAFFLE BASE	LTS-PFM-402		**SPECTROMETER BOX LIGHT BAFFLE LTS-PFM-400**	EMEC	23654 / 29472	
OUTER RING	LTS-PFM-403			TMC	13755	
INNER RING	LTS-PFM-404			TMC	13755	
RETAINING CUP	LTS-PFM-405			TMC	13755	
LB ADJUSTABLE CAPSTAN	LTS-PFM-406			TMC	13755	
LB FIXED CAPSTAN	LTS-PFM-407			TMC	13755	
LB INNER HUB A	LTS-PFM-408			TMC	13755	
LB INNER HUB B	LTS-PFM-409			TMC	13755	

INNER LIGHT TRAP	LTS-PFM-410			TMC	13755	
LIGHT BAFFLE	LTS-PFM-411			EMEC	23654 / 29472	
BOLTS – 2-56 X 1/4		4		PTC	17953	
BOLTS – 2-56 X 5/16		4		PTC	13734	
BELLVILLE WASHERS	Part#3105204	12		PTC	Batch #19135	
KEVLAR						
Photometer support & light baffle – Assembly drawings and ICDs	300mK-PFM-top-level-DRAWINGS.doc		\\SPIRE\Cardiff_workpackages\Configured_Documents\300mK\PFM-BUILD\Manufacture			
Photometer support – Component drawings	300mK-SUPPORT-PFM-components.doc		\\SPIRE\Cardiff_workpackages\Configured_Documents\300mK\PFM-BUILD\Manufacture			
Light baffle – component drawings	300mK_Light-Baffle-PFM-components.doc		\\SPIRE\Cardiff_workpackages\Configured_Documents\300mK\PFM-BUILD\Manufacture			
300mK support system EIDP	HSO-CDF-EIDP-078		\\SPIRE\CARDIFF-WORKPACKAGES\deliverables\shipped\300mK\PFM\EIDP			
300mK support PFM design description	HSO-CDF-DD-038 issue 3.0					
Inspection record	Photographs		\\SPIRE\Cardiff_workpackages\Configured_Documents\300mK\PFM-BUILD\LTS-PFM-inspection \\SPIRE\Cardiff_workpackages\Configured_Documents\300mK\PFM-BUILD\LTS-PFM-inspection\COMPONENTS			

Suppliers & manufacturers:-

TMC	PTC	EMEC	CFILT
The Machining Centre, Pembroke Lane, Milton Village, Abingdon, Oxon, OX14 4EA 01235 831343	Precision Technology Supplies LTD, The Birches Industrial Estate, Imberhorne Lane, East Grinstead, West Sussex. RH19 1XZ 01342 410758	Electro-mec (Reading) LTD, 28 Portman Road, Reading, Bershire, England. RG30 1EA 0118 958 2035	Cousin Filterie, 8 rue Abbé Bonpain, BP 6 Wervicq Sud, 59558 Comines Cedex France

SECTION 10 – Serialised Components List
See above

SECTION 11 - List of Waivers
No waivers.

SECTION 12 - Copies of Waivers
N/A

SECTION 13 - Operations Manual
No operating manual is supplied.

13.1 PFM 300mK strap support system overview
Refer to Appendix A –Subsystem Design Description – HSO-CDF-DD-038 issue 3.0.

SECTION 14 - Historical Record

The following table contains *brief* historical details of the manufacture, assembly and testing of the PFM 300mK strap support system
A *full* historical record of every stage of manufacture for each component is traceable at UWC, in both hard copy log-book format and on a Microsoft Access database.

Date	Event	Notes
28/07/03	PFM aluminium components delivered	
07/08/03	PFM aluminium components accepted	
15/08/03	Stainless steel components delivered	
20/08/03	Stainless steel components rejected – sent back for re-work / re-build	Machining quality not to drawing spec.
02/09/03	Stainless steel components accepted	
08/03/04	Photometer support assembly	
10/03/04	Light baffle assembly	
11/03/04	Thermal shock cycles – supports & baffles	
04/05/04	Thermal cycle #1 to 4K	
10/05/04	Thermal cycle #2 to 4K	
04/05/04	Monitoring period starts	
22/07/04	Monitoring period ends	
08/07/04	Pre-delivery inspections	
22/07/04	Final cleaning & bakeout	
	Delivery to RAL	

SECTION 15 - Logbook / Diary of Events

Not provided – available from subsystem provider upon request.

SECTION 16 - Operating Time / Cycle Record

Post assembly, the four PFM assemblies (LTS-PFM-100/200/300/400) underwent five thermal shock cycles (350K – 77K – 350K) over the course of two days (11th/12th March 2004) as part of the Kevlar conditioning procedure.

They subsequently underwent two controlled thermal cycles to 4K, with a 6Hr soak at 4K before warming up.

- Cycle #1 – 4th May 2004
- Cycle #2 – 10th May 2004

SECTION 17 – Connector Mating Record

N/A

SECTION 18 – Age Sensitive Items Record

N/A

SECTION 19 – Pressure Vessel History / Test Record

N/A

SECTION 20 - Calibration Data Record

N/A

SECTION 21 - Temporary Installation Record

N/A

SECTION 22 - Open Work / Deferred Work / Open Tests

Ongoing monitoring of DM assemblies.

SECTION 23 - List of Non-Conformance Reports

Number	Non-Conformance Details	Status	Raised Date
HR-SP-RAL-NCR-038	Failure of Kevlar cord on CQM1 photometer light baffle after STM warm shake	Major. Closed – CQM2 design used for CQM & PFM	April 2003

SECTION 24 - Copies of Non-Conformance Reports

NCR number HR-SP-RAL-NCR-038 is attached below.
The minutes from the resulting MRB are also attached, after the NCR.

Rutherford Appleton Laboratory	NON-CONFORMANCE REPORT (NCR)	PRODUCT ASSURANCE Space Science and Technology Department

NCR Number:	HR-SP-RAL-NCR-038v2

Spacecraft / Project	HERSCHEL	**Originator's Name**	Doug Griffin	
Experiment / Model	SPIRE	**Signature**	[signature]	
Sub-System	Structure	**Date**	6th May 03	
Assembly	300-mK Strap	**Level** (Highlight if applicable)	Major	**Minor**
Sub-Assembly	Photometer SLB			
Item		**NRB Reference**		
Serial Number				

NCR Occurred During (Highlight if applicable)	Manufacture	**Inspection**	Test	Integration	Other

NCR Title	**300-mK Thermal Short during STM Programme**

NCR Description

It was observed that the ∅3mm copper bus-bar that passes through the Photometer Detector Box was misaligned. An Ohmmeter measured a resistance of 15Ohm between the bus-bar and the Photometer Detector Box which indicated that a short had occurred.

It was noted that there was a degree of misalignment of the bus-bar during integration.

The structure had undergone a warm random vibration test.

The link between the Stray-light baffle and the cooler was not present.

Attachments:

1 – Image of the partially assembled SLB prior to the vibration test

2 – Image of the SLB after the vibration test

Cause of NCR

Undetermined: It is unclear if the misalignment was increased during the vibration test as quantitative measurements were not made during initial integration

Disposition / Corrective Action

1. De-integrate the components from the Instrument and inspect for signs of mechanical interference during the test. **Action: RAL/MSSL/Cardiff**
   a. This action has been completed. Figures 3 and 4 indicate the precise location within the stray-light baffle where the cord commenced to fail.
2. Create an alignment budget for the 300-mK SLB and Supports. **Action: Cardiff**
3. Insert into 300-mK Integration Procedure an inspection point for measuring the misalignment. **Action: MSSL/Cardiff**

Item 1-Doug to issue a check list to cover Key integration Point including this one.

Items 2 & 3 no longer valid Delete. NCR Closed

Document or Drawing Affected (Title, Number & Issue)

	PA Manager (Or Deputy)	**Project Manager (Or Deputy)**	**Date**
NCR CLOSED (Signatures Required)	[signature] Digitally signed by Eric Clark Date: 2004.06.14 10:10:00 +01'00'	[signature]	Digitally signed by Eric Sawyer Date: 2004.06.17 11:00:12 +01'00'

Rutherford Appleton Laboratory	NON-CONFORMANCE REPORT (NCR)	PRODUCT ASSURANCE Space Science and Technology Department

NCR Number:	HR-SP-RAL-NCR-038

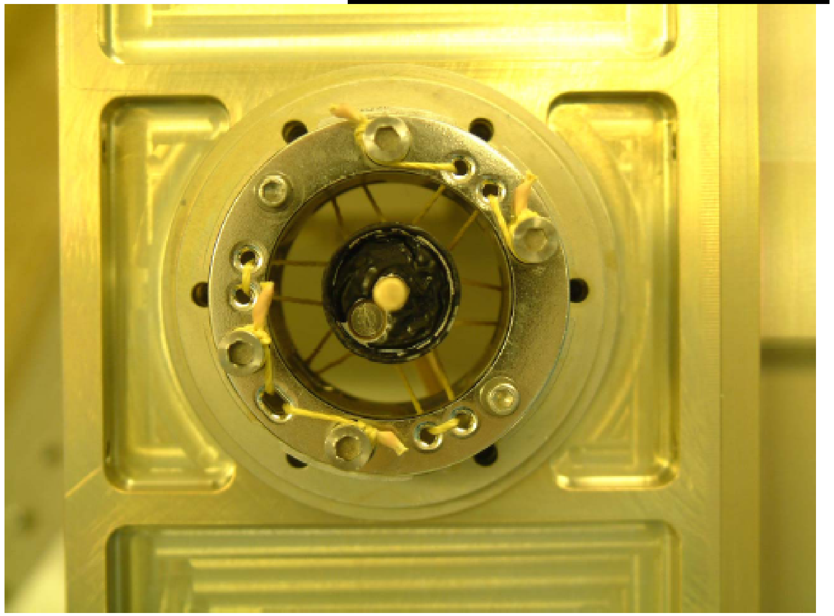


Figure 1 - Image of the SLB prior to the Warm Vibration

Figure 2 - Image of the outside of the SLB after warm vibration. This view is partially obscured by the presence of the cooler.

Rutherford Appleton Laboratory | NON-CONFORMANCE REPORT (NCR) | PRODUCT ASSURANCE Space Science and Technology Department

NCR Number:	HR-SP-RAL-NCR-038

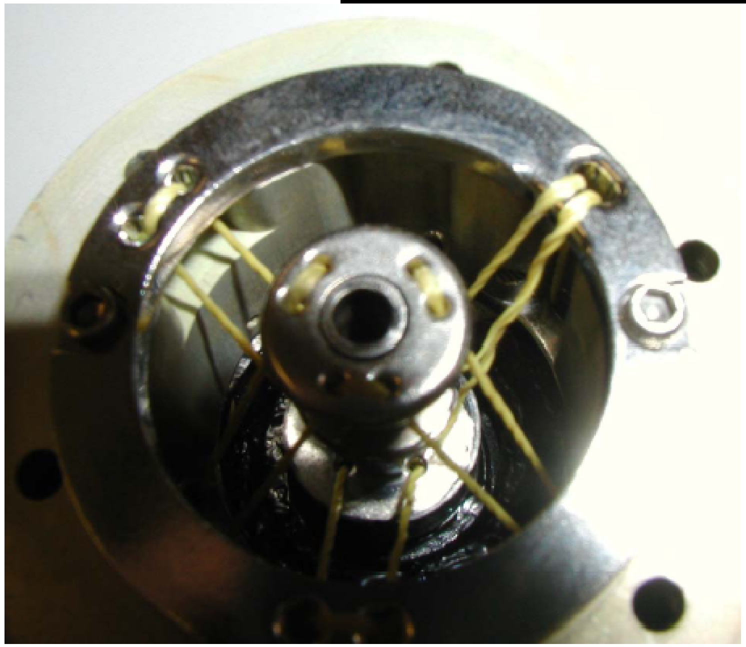


Figure 3 - View of the partially failed Kevlar cord

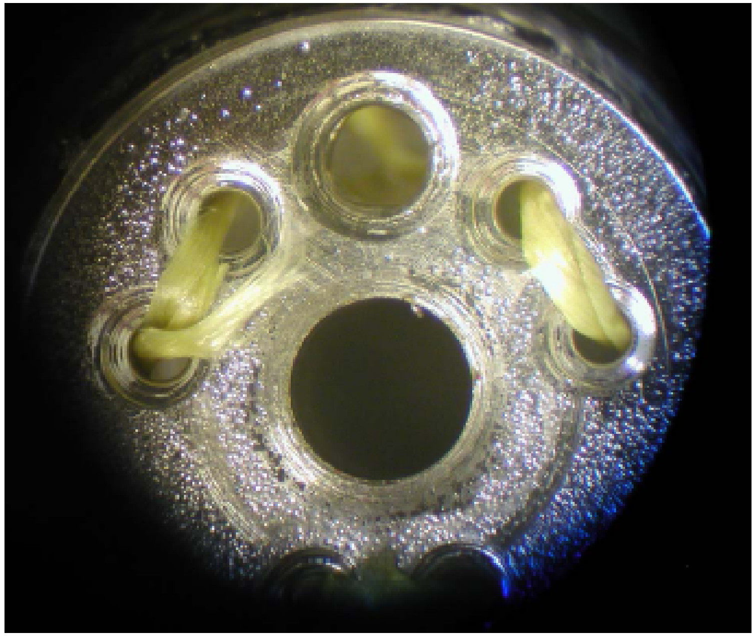


Figure 4 - View of the cord fraying around the tight bend radius.

MRB minutes – following NCR number HR-SP-RAL-NCR-038

300-mK STM vibration Kevlar failure MRB

Summary by Pete of his document of May 8

- Unit was central when delivered from Cardiff
- Before vibration: not exactly central but not touching by visible inspection.
- After vibration: not touching on visible inspection outside but touching inside as measured electrically.
- Kevlar cord visibly damaged - two of three cords broken - asymmetry leading to misalignment
- Black coating undamaged
- Close inspection showed cord failure as radiused hole - badly machined with slight discontinuity instead of smoothly radiused transition from one hole to another
- Signs of minor Kevlar fibre abrasion on inner hub - scuffing during handling? - but this is not the failure mode. Handling and jigging procedures may be revised.
- Unit was originally designed for lower preloads - bends are too tight for higher preload now being used to prevent the Kevlar from slipping and make the unit stiff.
- Manufacturers used ball-ended cutter but profiled cutter was requested.- will be addressed at rebuild - processes will be specified and inspected.

Proposed Redesign (presentation by Pete)

- Kevlar diameter 0.5 mm to be retained (needed to accommodate the pre-load)
- Larger radiused holes (4-mm dia bend) on both the inner and outer parts (even though inner part is less critical) with some rerouting of the Kevlar
- No change to interfaces or volume envelope
- Small (advantageous) increase in Kevlar angles
- 1-mm radiused sections where Kevlar exits
- Disk thickness will be increased from 2 mm to 3 mm
- Disk now to be threaded instead of using a locked screw - still to be detailed

Options - keep existing design or redesign?

- Berend: It was a workmanship/inspection failure, but approve of redesign to provide more margin.
- Doug: Agree.
- Bruce: Agree provisionally, but need to inspect the spectrometer baffle unit. Danger of bringing in unforeseen phenomena in a new design - e.g., will it slip more?
- Berend: New design should slip less.

- Doug: Larger radiused hole should reduce compressing stress if the cord goes over a raised feature.
    - *Note: Inspection of spectrometer side light baffle support by Berend later in the day showed it to exhibit no anomalies*.

Conclusions

- Failure is attributed to sharp edges at radiused holes (workmanship/inspection) combined with too-small radiused holes (vulnerability to such workmanship errors)
- Very careful inspection will be needed of the new units

Proposed plan (assuming redesign goes ahead)

- Already slipped by a few days wrt Pete's plan as distributed in the note.
- Review of drawings of new unit after ~ 1 week preparation - internal Cardiff review but to be circulated to MSSL
- 4-week manufacture (est.) - MIPS need to be included in the plan.
- Six sets of outer rings and central hubs to be procured
- A few days needed for acceptance - RAL Talysurf machine to be used.
- Assemble DM2 to all procedures for unit-level test (mid-July) at MSSL
- Pete's plan has CQM delivery end July
- Cold shake with analogue of photometer 2-K box at RAL would be ideal next test.
- PLW BDA goes in 20 July - so there's no time for this cold test.
- 2-K box would need 400-mm envelope - too big for the cryostat.
- John: Note that Kevlar touching other side of radiused hole needs to be considered in the new design.
- Non-Cardiff effort needed to implement the recovery plan:
    - MSSL: support from for review of drawings, warm shake, definition of integration and handling procedures
    - RAL: Talysurf facility; manufacturing/advice (John Spencer's team)
- Doug: Suggest implementing an imbalance in the warm shake to make the test more severe.
- Action: Pete to updated plan to include the following, timetabled appropriately:
    - Document handling procedures and review with MSSL (Chris)
    - Provide (by repolishing/inspection and choice of the best units) a unit of the existing design as well as a fallback.
    - Test how much torque needed to misalign and restore the alignment of the unit.
    - Include workmanship shake of the unit that goes into the CQM

MRB to be reconvened before installation of new unit into the CQM.

SECTION 25 - Test Reports

Vibration test report

Warm and cold vibration testing was carried out to full qualification levels on the DM versions of the 300mK support system. These components were built in the same batch as the PFM components, and assembled to the same procedure.
The test report (AIV-2003-091-VIB) is attached as Appendix D

Post-assembly monitoring

Post-assembly, the PFM deliverables were monitored over the course of three months, at two-week intervals. The monitoring consisted of:-

- Visual inspection of the Kevlar
- Metrology of the suspended hubs
- Alignment of the suspended hub

Suspended hub metrology

Figure 26 The dimensions marked “A” and “B” are used for monitoring hub extension as a function of time for the photometer supports and light baffles respectively

Hub alignment

Hub alignment was checked by fitting the alignment caps to each module. These caps form a close fit between the bodies and the suspended hubs, and any difficulty in re-fitting them would indicated a hub mis-alignment.

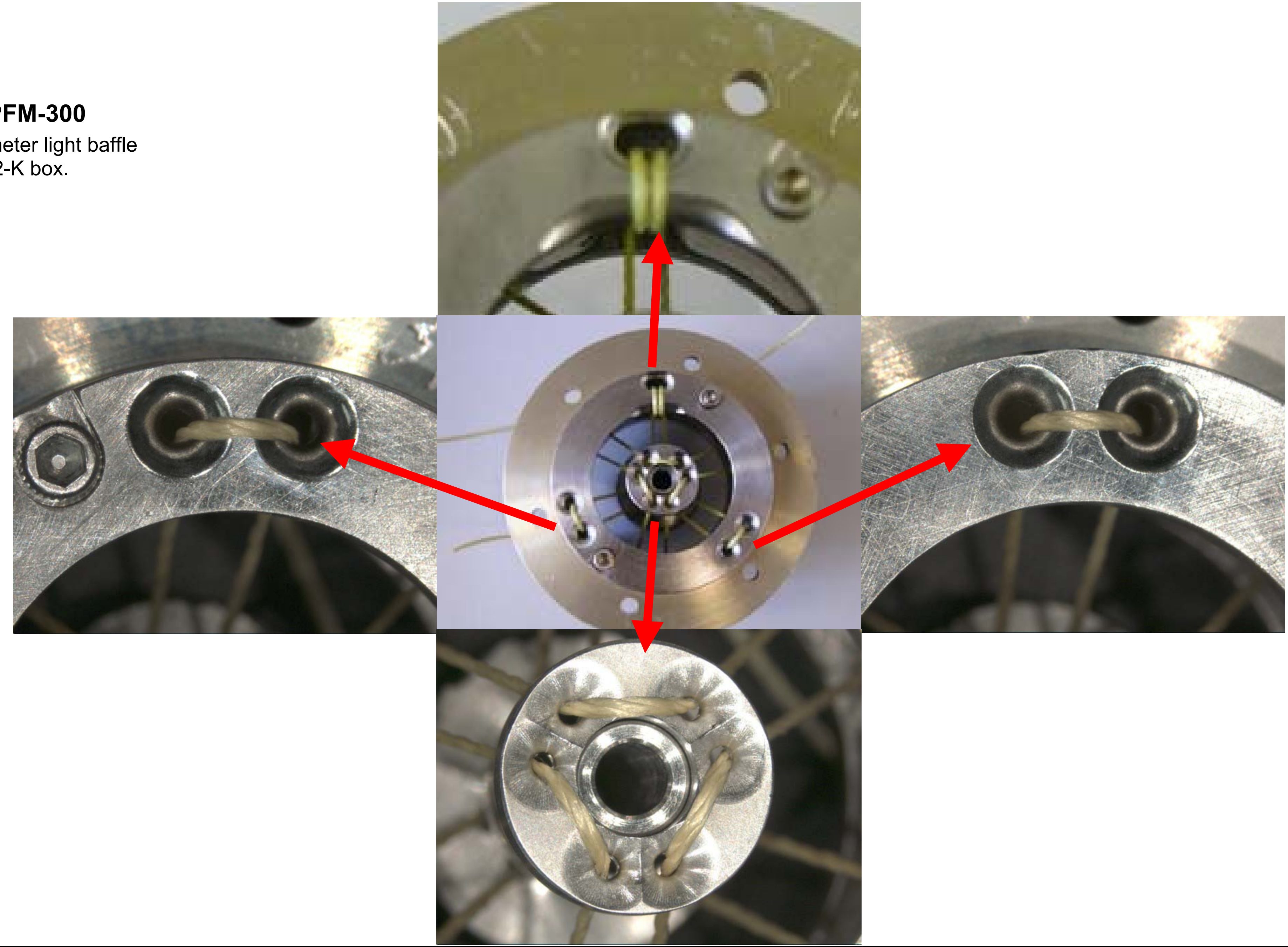
Monitoring results

Date	LTS-PFM-100		LTS-PFM-200		LTS-PFM-300		LTS-PFM-400		Checked by:
	Hub length (mm ±0.05 mm)	Cap fit?	Hub length (mm ±0.05 mm)	Cap fit?	Hub length (mm ±0.1 mm)	Cap fit?	Hub length (mm ±0.1 mm)	Cap fit?	
04/05/04	15.78	Yes	15.57	Yes	22.20	Yes	22.71	Yes	P.Hargrave
18/05/04	15.80	Yes	15.61	Yes	22.27	Yes	22.79	Yes	P.Hargrave
31/05/04	15.81	Yes	15.61	Yes	22.28	Yes	22.80	Yes	P.Hargrave
18/06/04	15.80	Yes	15.61	Yes	22.26	Yes	22.78	Yes	P.Hargrave
06/07/04	15.81	Yes	15.60	Yes	22.25	Yes	22.81	Yes	P.Hargrave
22/07/04	15.81	Yes	15.61	Yes	22.29	Yes	22.80	Yes	P.Hargrave

Pre-delivery inspection

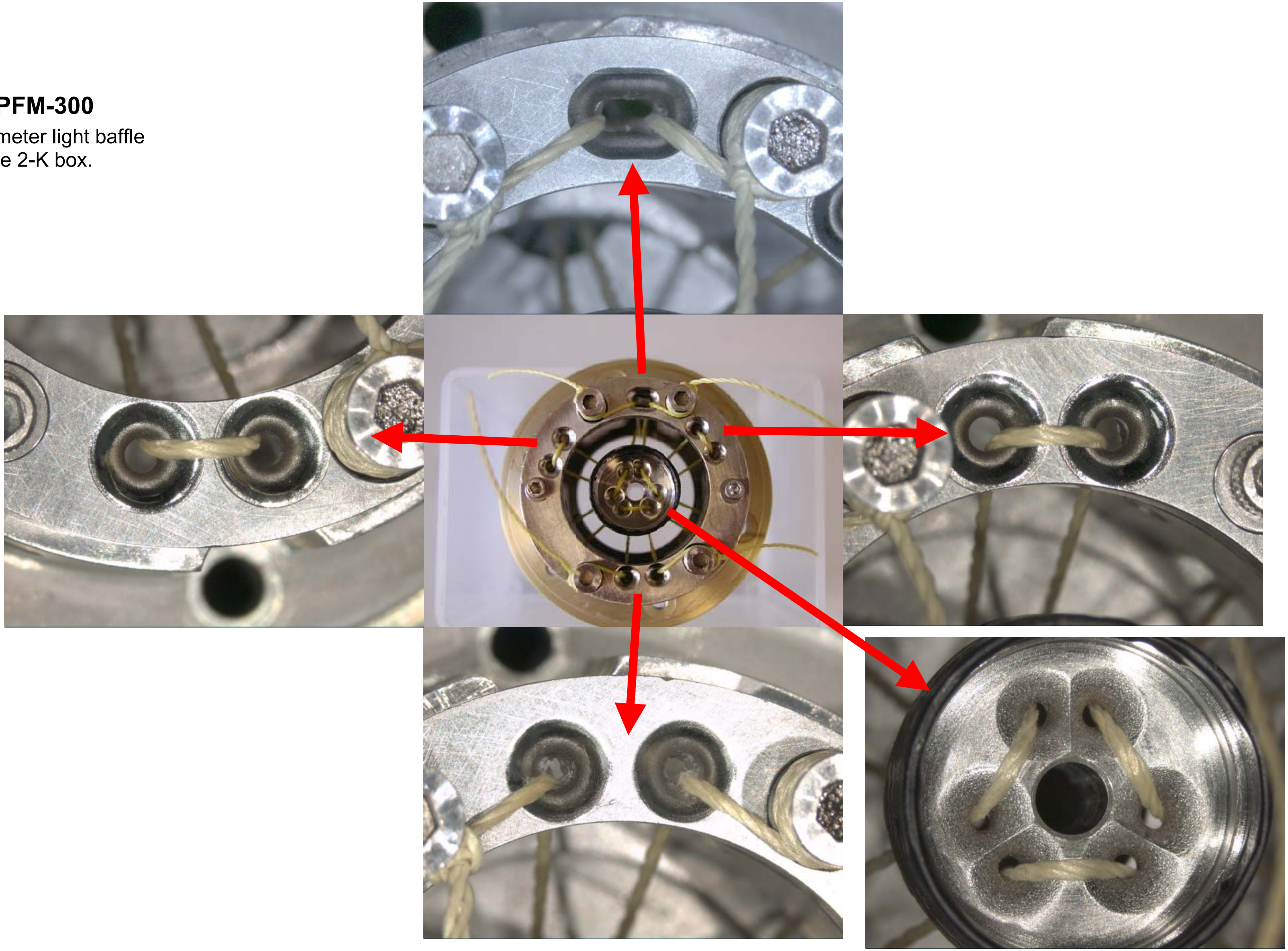
All Kevlar routings were photographically recorded prior to delivery, as shown on the next six pages.

LTS-PFM-300
Photometer light baffle
Inside 2-K box.



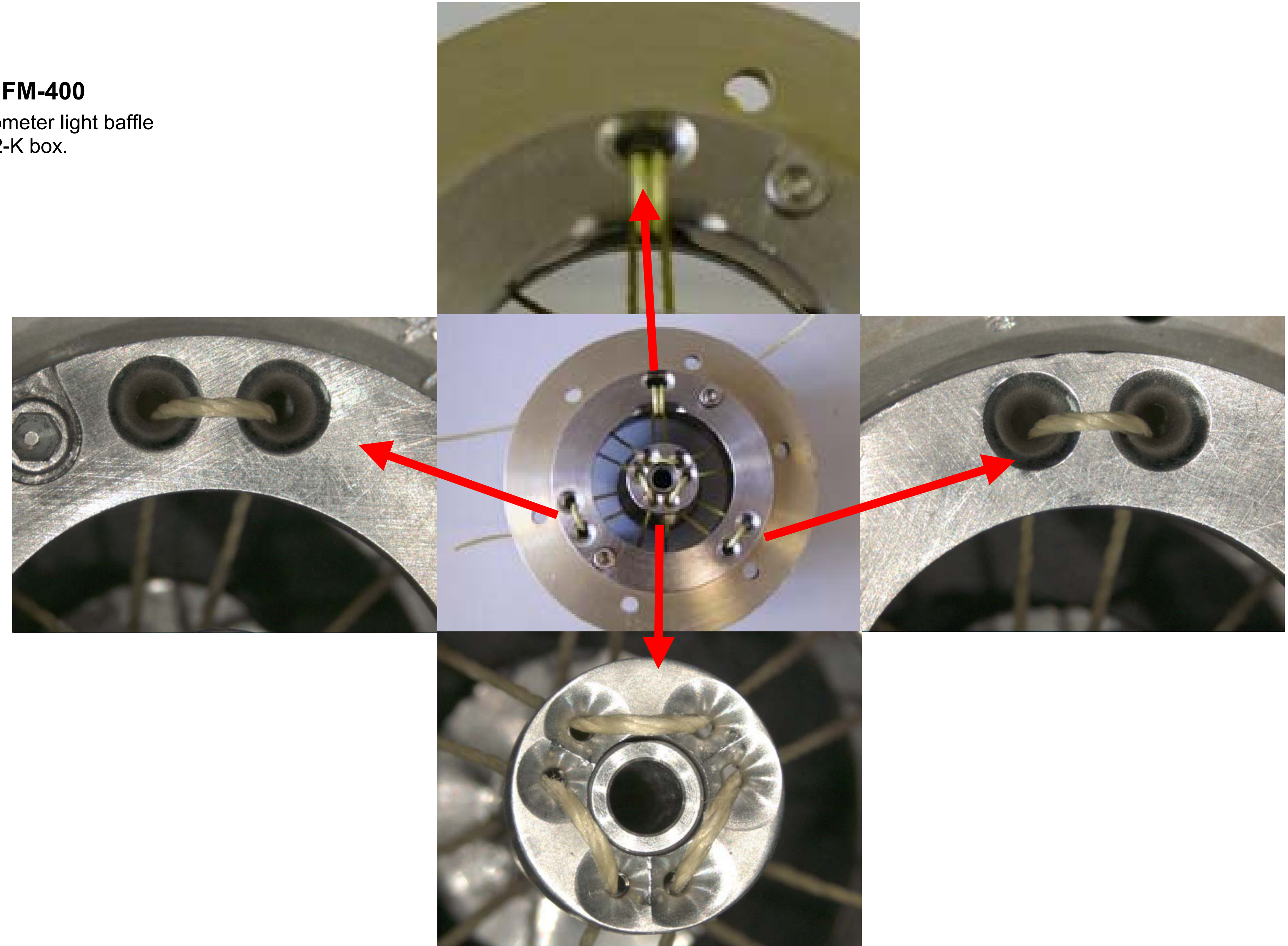
LTS-PFM-300

Photometer light baffle
Outside 2-K box.



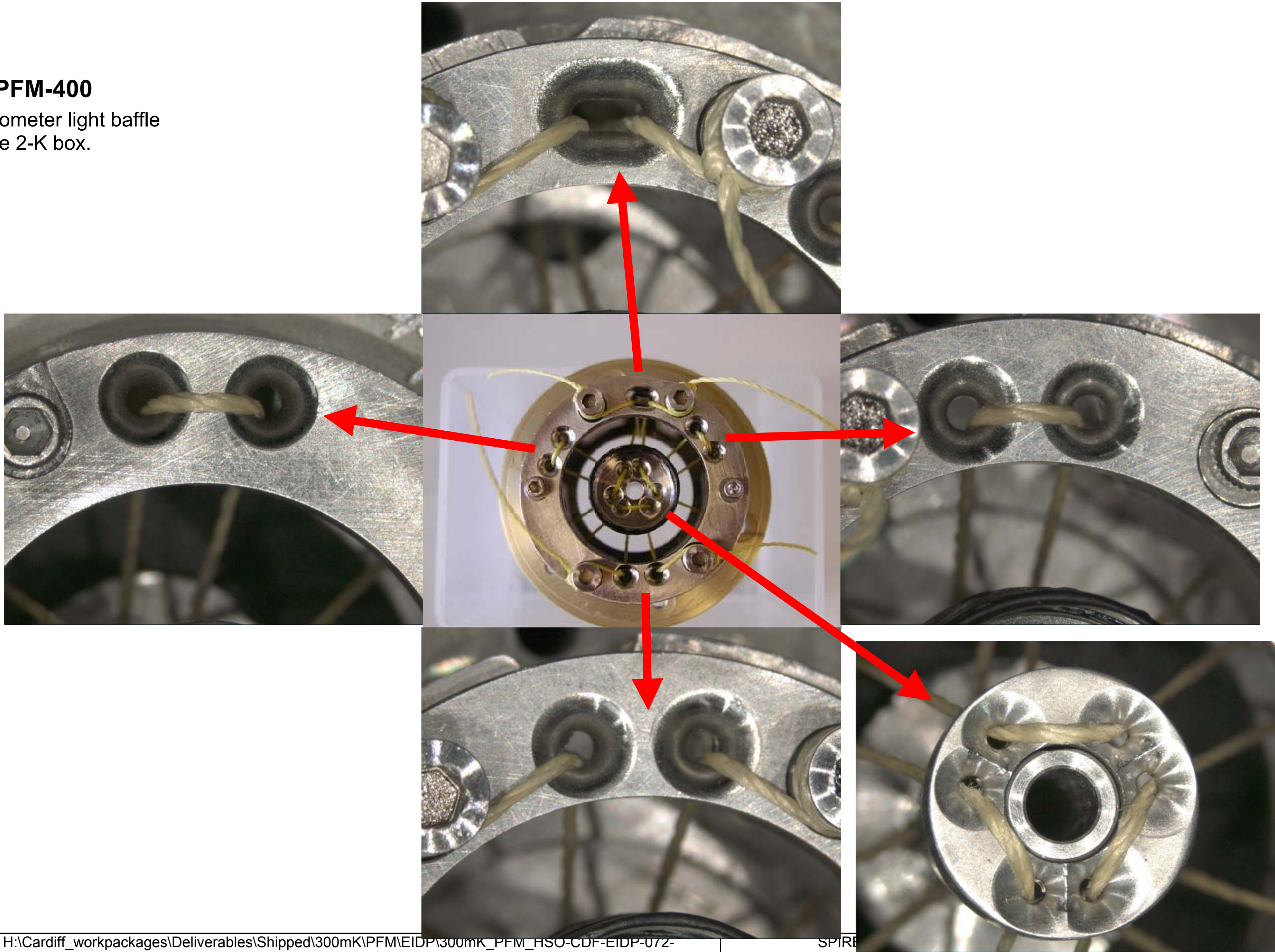
LTS-PFM-400

Spectrometer light baffle
Inside 2-K box.



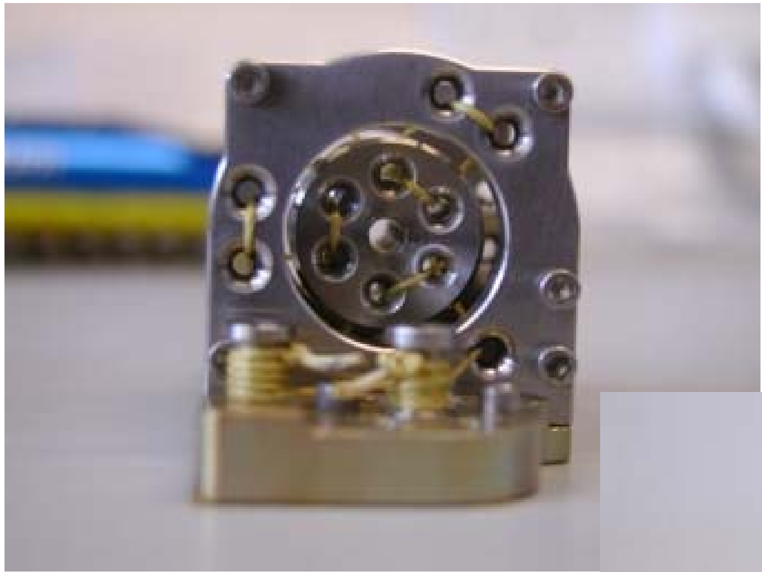
LTS-PFM-400

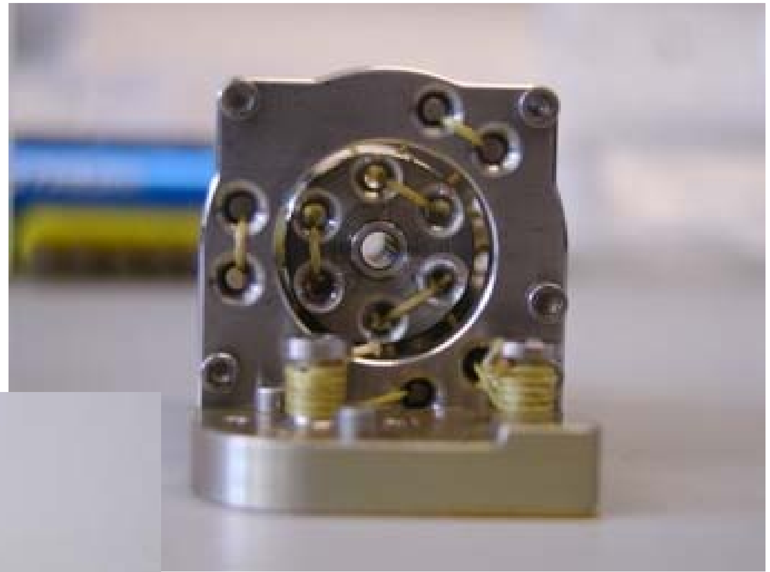
Spectrometer light baffle
Outside 2-K box.



LTS-PFM-100

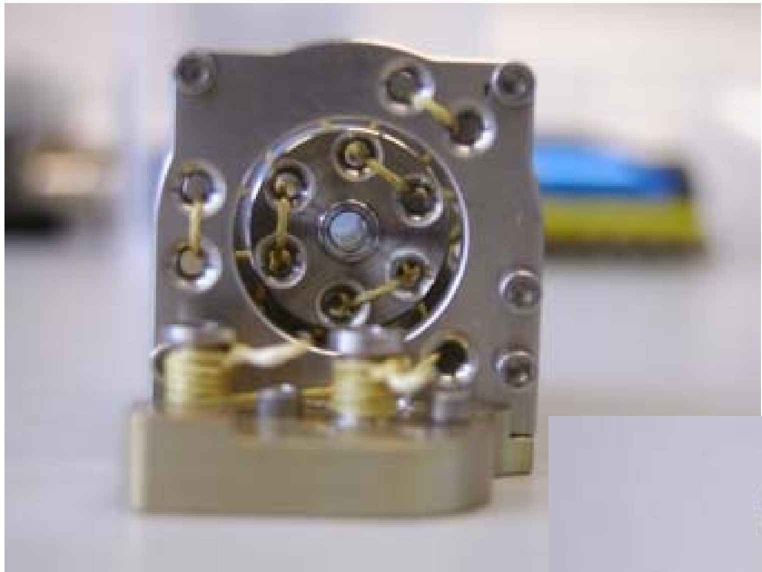
Photometer support A

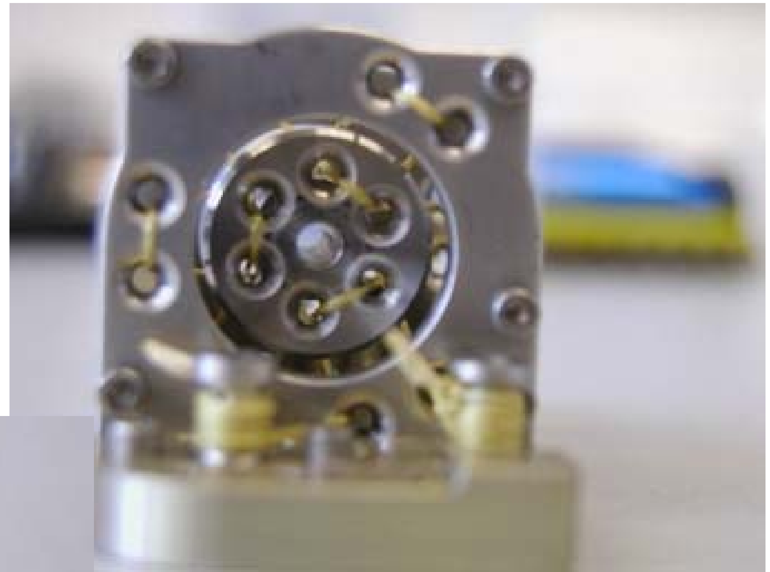




LTS-PFM-200

Photometer support B





SECTION 26 – Assembly record

08/03/04 – Photometer supports (LTS-PFM-100, LTS-PFM-200) assembled according to photometer support assembly procedure – HSO-CDF-PR-044
10/03/04 – Light baffles (LTS-PFM-300, LTS-PFM-400) assembled according to light baffle assembly procedure – HSO-CDF-RP-045

SECTION 27 - Reference List of EIDP's

Associated

Title (Listed in alphabetical order)	**ID** (Serial No.)	**Acronym**	**Document No.**	**Issue**	**Date**
MSSL PFM Structure EIDP			MSSL/SPIRE/PA012.01		

Lower Level

Title (Listed in alphabetical order)	**ID** (Serial No.)	**Acronym**	**Document No.**	**Issue**	**Date**

SECTION 28 - Mass Records

Assembly	Final measured mass (g)
LTS-PFM-100 – PHOTOMETER SUPPORT A	109.3
LTS-PFM-200 – PHOTOMETER SUPPORT B	109.6
LTS-PFM-300 – PHOTOMETER LIGHT BAFFLE	137.3
LTS-PFM-400 – SPECTROMETER LIGHT BAFFLE	137.0

SECTION 29 - Cleanliness Statement

Statement

The PFM 300mK strap support assemblies (LTS-PFM-100, -200, -300, -400) have been cleaned, assembled and tested within a class 1000 clean room to meet the requirements of the Cardiff PA plan (HSO-CDF-PL-007).

Signature Not Verified

Digitally signed by Peter Hargrave
DN: cn=Peter Hargrave, o=Cardiff University, ou=Astrophysics Instrumentation, c=GB
Date: 2004.07.27 17:29:37 +01'00'

Signed ……………………………………………Peter Hargrave, Technical Manager, Cardiff-SPIRE deliverables.

Signed ……………………………………………Ian Walker, Programme Manager, Cardiff AIG.

Date ……………..

Extra Information

A dedicated Herschel-Planck clean room is available in the Cardiff AIG labs, class 1 000, with class 100 laminar flow cabinets.
Cleanliness has been checked and logged on a regular (approx weekly) basis.
For cooldown tests (thermal cycles) the PFM assemblies were integrated to the Cardiff test dewar within the clean room annex (approx. Class 10,000 – exposure ~15 minutes per thermal cycle).

SECTION 30 - Other Useful Information

SECTION 31 - DPL/DML

Refer to the Cardiff-SPIRE PFM deliverables lists.

Cardiff-SPIRE-DML	HSO-CDF-LI-074
Cardiff-SPIRE-DMPL	HSO-CDF-LI-075
Cardiff-SPIRE-DPL	HSO-CDF-076

SECTION 32 – List of Appendices/Attachments

Appendix #	Title (Listed in alphabetical order)	Document No.	Issue	Date	Notes
A	300mK strap supports detailed design description	HSO-CDF-DD-038	3.0		
B	300mK photometer support assembly procedure	HSO-CDF-RP-044	1.0		
C	300mK light baffle assembly procedure	HSO-CDF-RP-045	1.0		
D	Vibration test report – Herschel: Cardiff components	AIV-2003-091-VIB		22/04/04	

References

Appendix A

300mK strap support system design description
HSO-CDF-DD-038 issue 3.0

End Item Data Package (EIDP)

SPIRE - 300mK strap supports- PFM

Document Ref.: SPIRE
Cardiff Ref.: HSO-CDF-DD-038
Issue: 3.0

Prepared by: Peter Hargrave
Last Modified on: 27 July 2004
Approved by:

Update history

Date	Version	Remarks
4th July 2002	1.0	DDR Release
7th February 2003	2.0	Delta-DDR Release. Includes detailed design of bus-bar assembly.
15th July 2004	3.0	Flight model design description

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1. Scope

This document describes the design of the Herschel-SPIRE 300mK strap support subsystem. This document release (3.0) describes in detail the design of the CQM (build 2), Flight Model and Flight Spare strap support system.

2. Documents

2.1. Applicable documents

	Title	Author	Reference
AD1	Instrument Requirements Document	B.M. Swinyard	SPIRE-RAL-PRJ-000034
AD2	SPIRE Thermal Configuration Control Document	S. Heys	SPIRE-RAL-PRJ-000560
AD3	SPIRE Structural Mechanical I/F	B. Winter	MSSL/SPIRE/SP004.12

2.2. Reference documents

	Title	Author	Reference
RD1	SPIRE 300-mK Strap System Development Plan	D. Griffin	SPIRE-RAL-PRJ-001317
RD2	A stray-light baffle design for thermal strap entry ports	A G Richards	SPIRE-RAL-NOT-000344
RD3	Herschel/SPIRE 300mK strap system requirements	D. Griffin	SPIRE-RAL-PRJ-001323
RD4	Herschel-SPIRE Interface Control Document (BDA ICD)		JPL Document D-21995
RD5	FEA of 300mK Thermal Strap System	B.Winter	MSSL-technote-SPIRE-18
RD6	300mK thermal interface test summary	I.Didschuns	Cardiff tech. note. HSO-CDF-RP-xxx

RD7	Black Coating BG1 – Application procedure	P.Hargrave	Cardiff issued procedure - HSO-CDF-PR-050 Black-non-SiC-HSO-CDF-PR-050.doc

3. Overview of 300mK strap system

The 300mK strap system links the ^{3}He cooler tip with all five detector arrays in the SPIRE instrument. The straps must have a high degree of thermal isolation from warmer structure while at the same time be able to withstand high levels of launch vibration with very high reliability. In order to fulfill these somewhat conflicting requirements, a Kevlar suspension system has been developed to support the 300mK straps. An additional complication is the fact that the thermal interfaces for the 300mK straps to the detectors are inside the Level-0 detector boxes at approximately 2K. The 300mK straps pass from the Level-1 (~4K) environment of the cooler tip, through the Level-0 detector box walls, into the ~2K environments of the photometer and spectrometer detector boxes. Therefore a light baffle has been developed, based on the Kevlar support idea, which supports the straps as they pass through the detector box walls, while at the same time providing a high degree of stray light attenuation.

4. Detailed Design Description

4.1. Design Drivers

4.1.1. Reliability

The 300mK strap system has the potential to provide a single point failure for the whole of the SPIRE instrument. All five detector arrays are linked via the 300mK straps to the single cooler tip. If any part of the strap system fails and produces a thermal short to the warmer structure, depending upon the severity of the short, all detectors may rise beyond any useful operating temperature. Therefore reliability has the utmost importance in the sub-system design, at the expense of any other design driver.

4.1.2. Thermal Isolation

The total budget allocated for parasitic heat load to the cooler from the 300mK strap system is 2.0μW. Analysis and preliminary thermal tests show that the design presented in this document for the suspension of the straps meets this requirement with reasonable margin.

4.1.3. Light Tightness

The detector arrays are mounted to the Level-0 detector boxes on the photometer and spectrometer. The 300mK strap/detector interface is on the front face of each BDA, i.e. on the inside of each Level-0 box. Therefore the 300mK straps must be brought from a Level-1 environment at approximately 4K, through the photometer and spectrometer box walls, into the ~2K environment. The feedthroughs must serve the dual purpose of providing thermally isolating support and a high level of stray light attenuation.
This design driver has lower priority than 4.1.1 (reliability) - mechanical integrity will not be compromised for the benefit of improved light-tightness (see RD2)

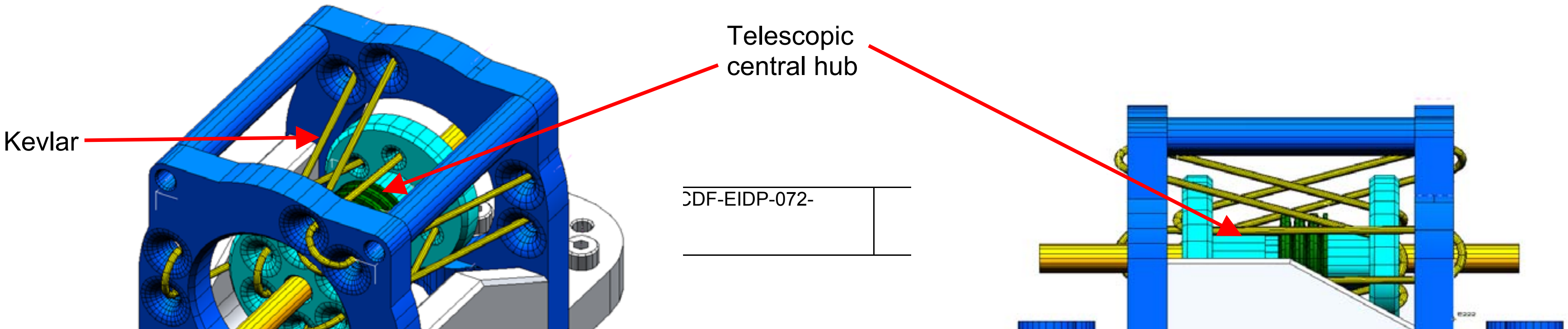
4.1.4. Stiffness

The first mode of the 300mK system should be as high as possible (RD3) in order to avoid transmitting additional mechanical loads to the BDAs or cooler tip.

4.2. Photometer Strap Suspension

There are two identical bus-bar supports within the photometer box. These supports provide a high degree of thermal isolation and mechanical strength by the use of Kevlar under tension, as shown in

Figure 27.



Fixed

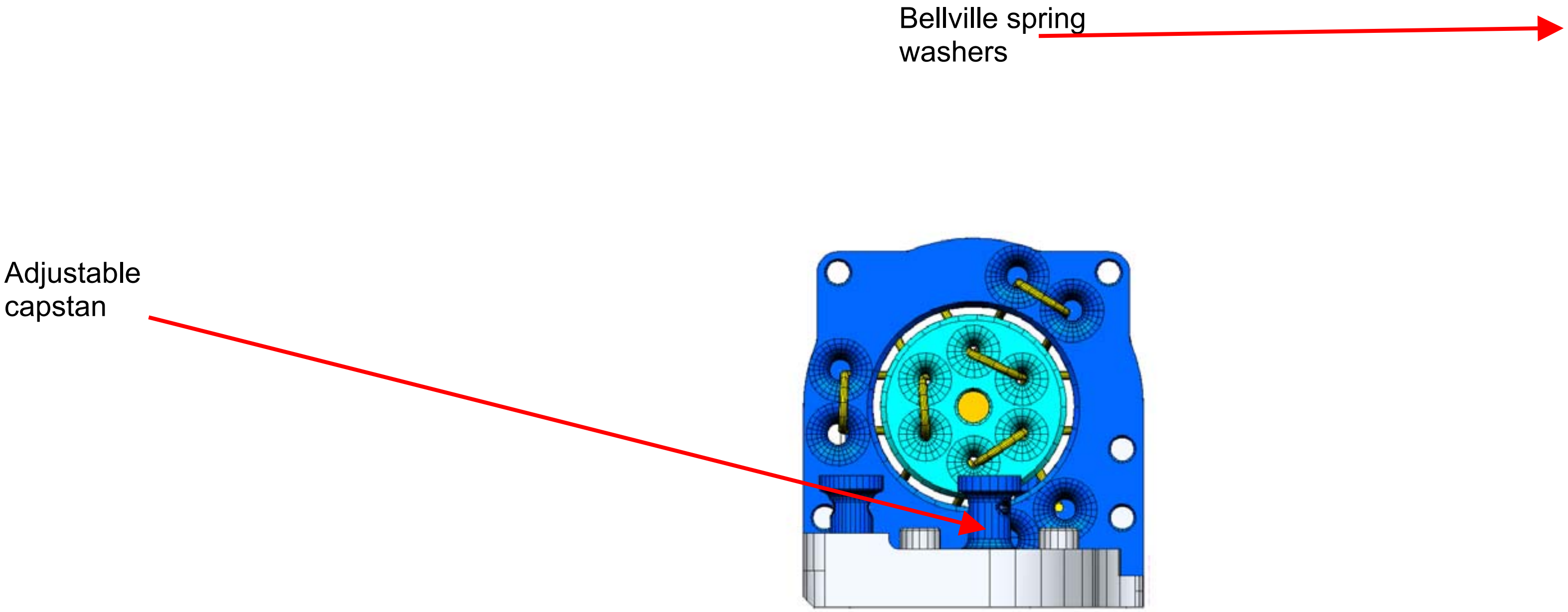
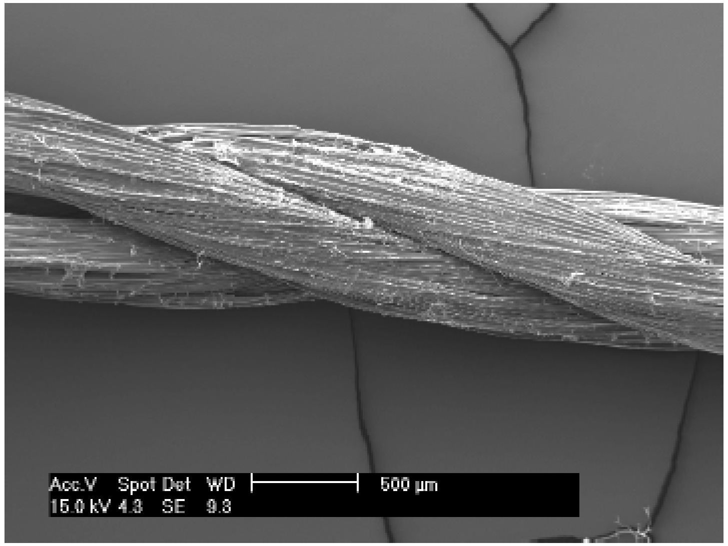


Figure 27 Views of a photometer 300mK strap support module

The main body of each support is bolted to the photometer box lid at 2K, and there is a central hub, which carries the 300mK bus-bar axially. This central hub is made in two sections; part of one section fits concentrically inside the other so that the whole hub can expand telescopically. A stack of Belleville spring washers between the hub sections is used to provide resistance to compression. The central hub assembly is compressed before the whole assembly is “laced” with the Kevlar. The Kevlar is pre-tensioned and terminated at two sets of capstans. Throughout this process, jigs are in place to ensure correct alignment of the central hub with respect to the support body. The compression of the central hub is then released and the alignment jigs are removed. The result is a well-aligned, modular, stiff thermal isolation unit, ready for integration with the rest of the 300mK strap system.

4.2.1. Kevlar type

The flight devices use Kevlar "ropes" of the type also qualified for use with the SPIRE and PACS ^{3}He coolers. The bulk material comes from Dupont de Nemours, and is formed into "ropes" by Cousin-Filterie, a company located in the north of France (Cousin filterie, 8 rue Abbé Bonpain, BP 6 Wervicq Sud, 59558 Comines Cedex). An example of this "rope" is shown in Figure 28.



Kevlar 11 (80°C baked)

Figure 28 Kevlar "rope" for 300mK strap suspension

For this application, we take advantage of the following properties of Kevlar:-

- High tensile strength
- High Young's modulus
- Low thermal conductivity at low temperature

A comparison between Nylon, stainless steel, Titanium Ta6V and Kevlar is shown in Table 1. As a first approximation the goal is to maximise the resonant frequencies (proportional to the square root of the Young's modulus "Y ")and the strength "σ ", and to minimise the thermal load (proportional to the integrated thermal conductivity "I " between say 0.3 and 2 K).

Table 1 Comparison of thermal isolation materials – extracted from Ref [1].

	Nylon	*Stainless*	*Titanium Ta6V*	*Kevlar 29*
σ (MPa)*	100	550	875	1600
Y (MPa)*	3 000	200 000	110 000	65 000
I (W/cm)	$5.9\ 10^{-5}$	$2\ 10^{-3}$	10^{-3}	$7\ 10^{-5}$
$\sigma.Y^{0.5}/I$	$0.9\ 10^{8}$	$1.2\ 10^{8}$	$2.9\ 10^{8}$	$58\ 10^{8}$

(*: mechanical properties at ambiant temperature)

Kevlar also has a few disadvantages which are accounted for in the design:-

- The fibres absorb moisture. All support and light baffle assemblies will be vacuum baked and stored in a dessicator when not in use, prior to integration with SPIRE.
- Although the tensile strength and modulus is high, compressive properties are relatively poor. This has been taken into account in the design of the capstans and the Kevlar routing.
- Kevlar is susceptible to “creep” which manifests itself as a small increase in length over a long time period.
- Kevlar has a small negative longitudinal thermal expansion coefficient – it gets slightly longer as it cools down. This point, and the previous one, is addressed by the design of the telescopic central hub. A stack of Belleville spring washers maintains tension by causing a slight increase in the length of the hub, which will compensate for any cord expansion,

4.2.2. Kevlar routing

The routing of the Kevlar is shown in Figure 29. Two independent cords are used, although this does not add redundancy. Both cords are needed to maintain tension. An important design feature of the support module is that the Kevlar cord is never threaded around a bend diameter less than 4mm. Duband [1] has shown that a bend diameter greater than 3mm is required for Kevlar passing around a pulley or capstan under tension if the full rated strength of the cords is to be achieved. In other words, below a diameter of 3mm, stress concentrations build up and weaken the Kevlar at these points, as shown in Figure 30.

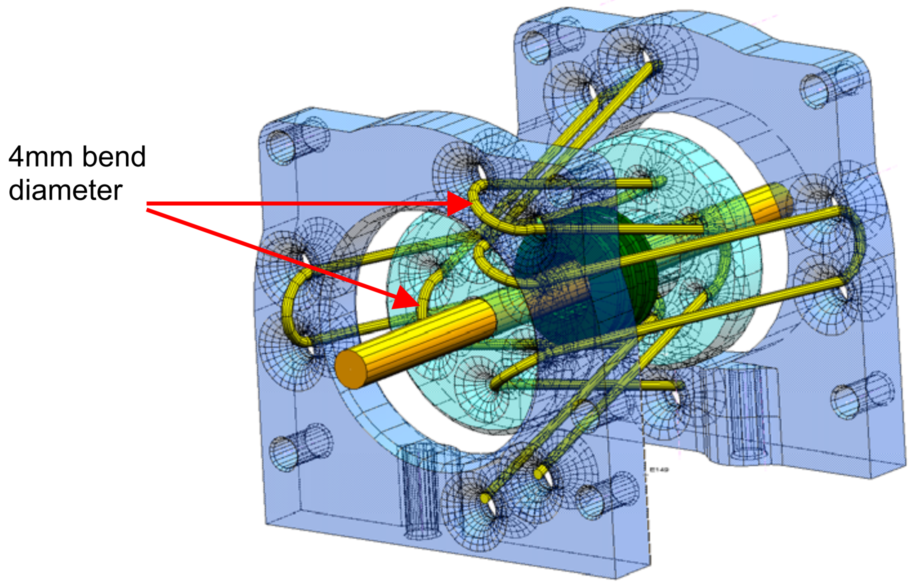


Figure 29 Kevlar routing for photometer bus-bar support

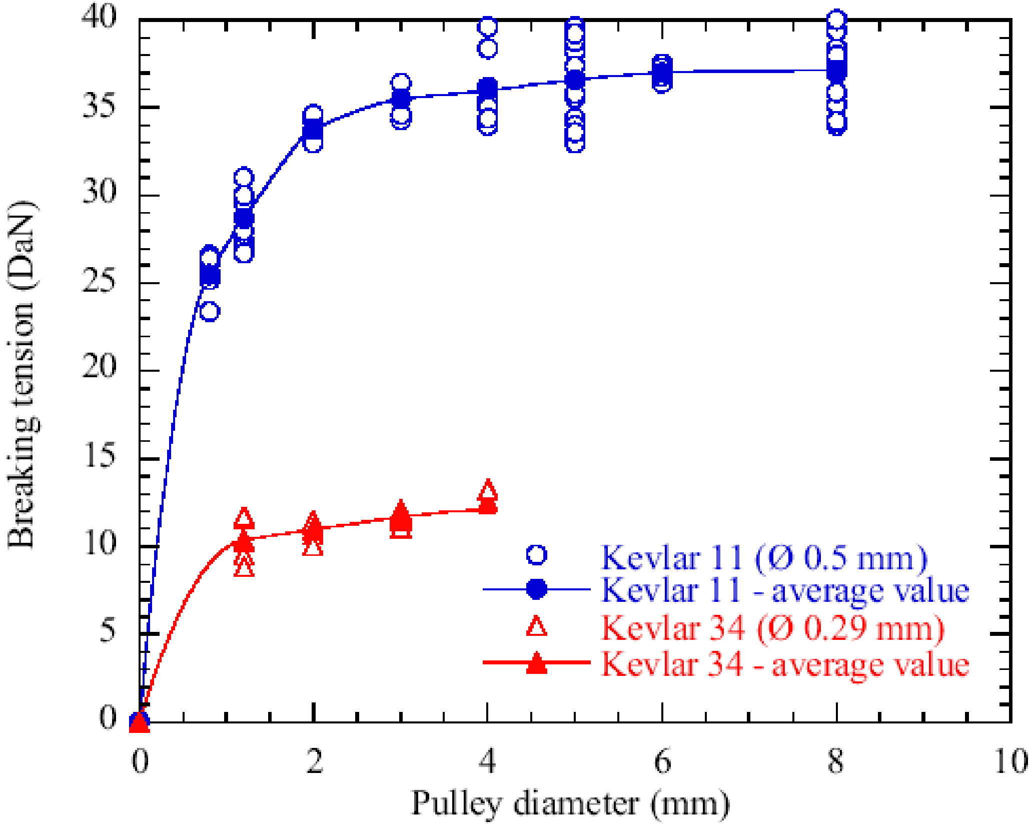


Figure 30 Kevlar breaking strength as a function of pulley diameter (from Ref. [1])

4.2.3. Capstans

Termination of the Kevlar was a potential problem. Any direct knot in the Kevlar must be avoided, as the fibres would tend to cut into each other and producing a weak spot at the knot. Duband [1] showed that the presence of a knot weakens the Kevlar by approximately 50%. Therefore this design employs capstans, again following the recommendations in Ref. [1]. The idea behind the capstan is that the "residual tension", proportional to the number of turns around the capstan, can be lowered to a level where a knot can be used without weakening the termination. This is shown by a simple experiment carried out by Duband. The Kevlar cord is permanently loaded on one side, then goes around a capstan by "n" turns, and is attached to a force transducer on the other side (Figure 31). Figure 32 shows how the remaining tension is affected by the number of turns around the capstan.

A second experiment used a capstan with a hole in which one end of the Kevlar cord is inserted and locked with a knot, and the cord then wound around the capstan by “n” turns. Figure 33 shows the breaking strength of this arrangement as a function of the number of turns around the capstan. These results show that a cord arrangement featuring at least 3 turns around the capstan allows the remaining tension at the end of the cord to be lowered to such a level where a knot may be safely employed. A concern is slippage of the cord around the capstan, effectively increasing the tension in the region of the knot. Duband has tested for this effect and found no increase in the “residual tension” after 4 days (using 3 capstan turns). A long term fatigue behaviour experiment has been started at SBT to test thoroughly for this, and other, effects.

Figure 31 Experimental arrangement for capstan tests.

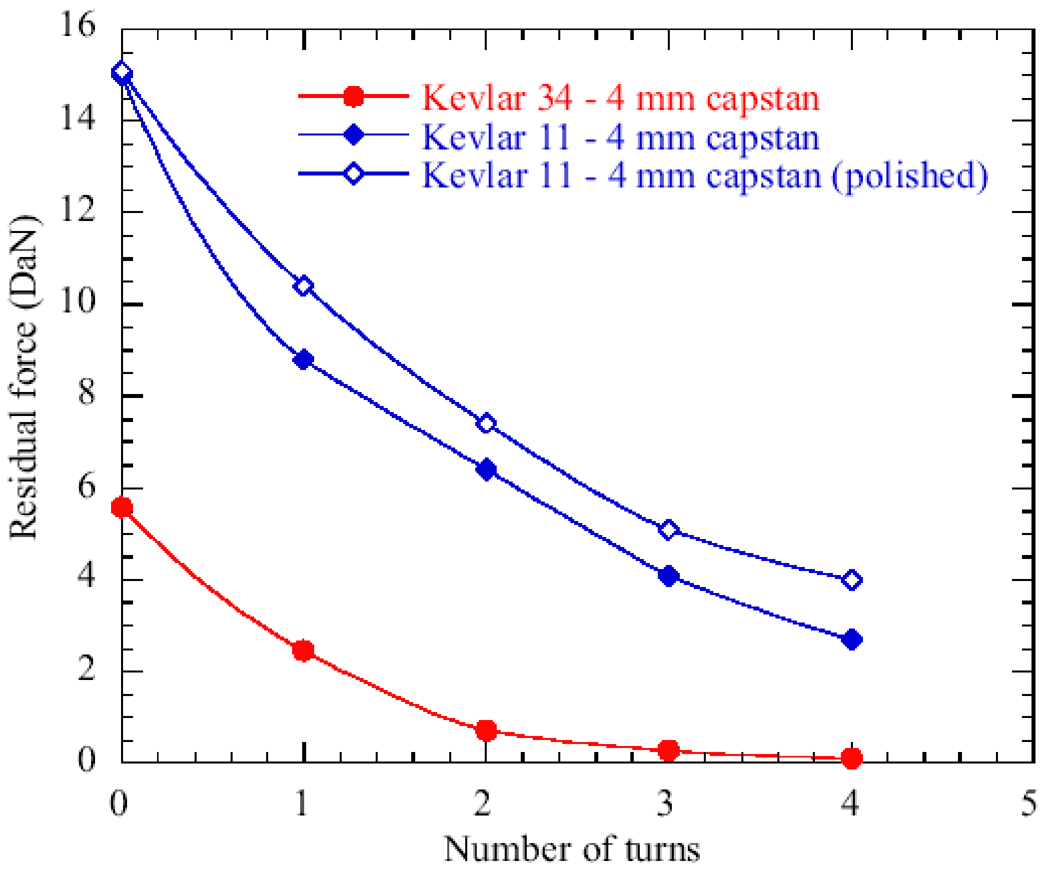


Figure 32 Residual force as a function of number of capstan turns

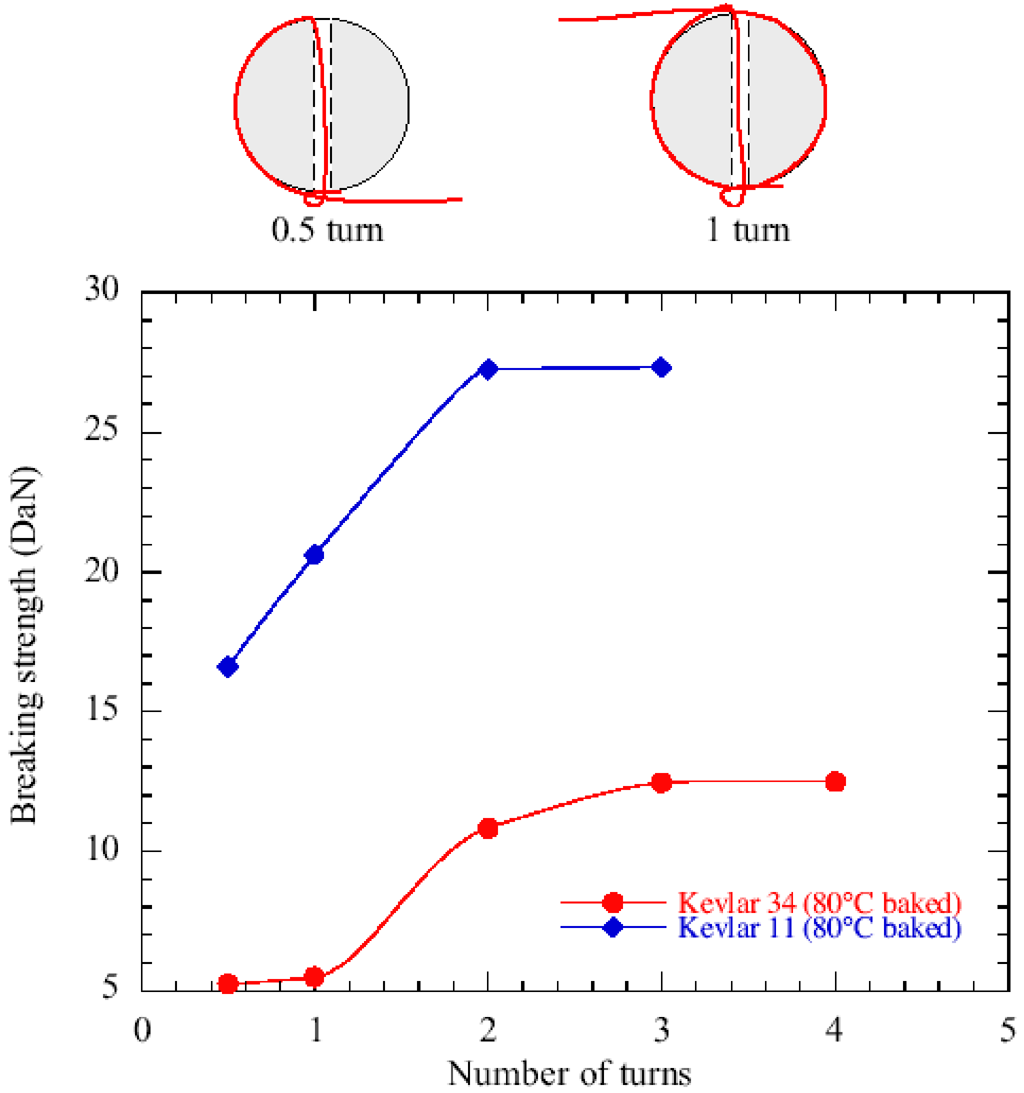


Figure 33 Breaking strength as a function of number of turns around capstan.

The knots used at the capstans are adjustable jam hitches, illustrated in Figure 34. This type of knot is used, as it tends to tighten under tension without imparting undue compressive stress on the Kevlar cord.

Figure 34 Details of knot used for terminating the Kevlar at capstans (Adjustable Jam Hitch).

4.2.3.1. Capstan details

For each support assembly, there are two Kevlar cords. Each cord employs two capstans. The cord run starts on a fixed capstan and ends on an adjustable capstan, details of which are shown in Figure 35.

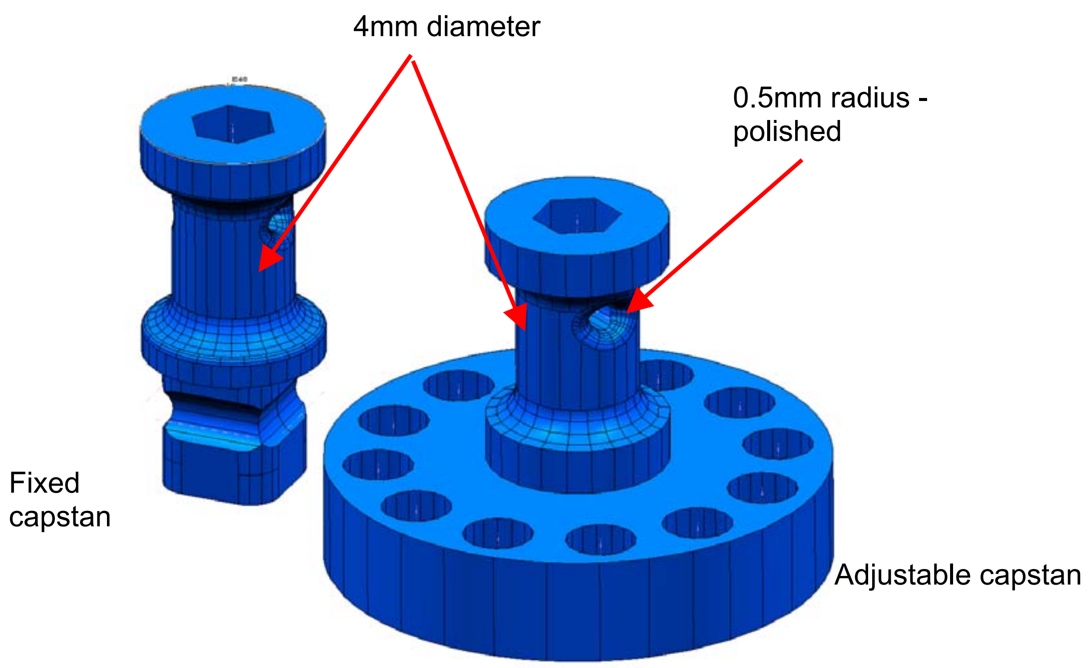


Figure 35 Details of capstans for photometer 300mK bus-bar supports.

The adjustable capstan has twelve threaded holes with locking inserts, and in combination with the six holes on the baseplate (two of which are used at any one time) provides adjustment steps of 7.5°. A minimum of four turns around each capstan is used for the Kevlar rope.

4.2.4. Hub assembly

The hub assembly consists of the two stainless steel parts of the hub itself, together with a stack of Belleville spring washers as shown in Figure 36 and Figure 37. The two hub parts interlock and one is able to slide over the other to form a telescopic hub.

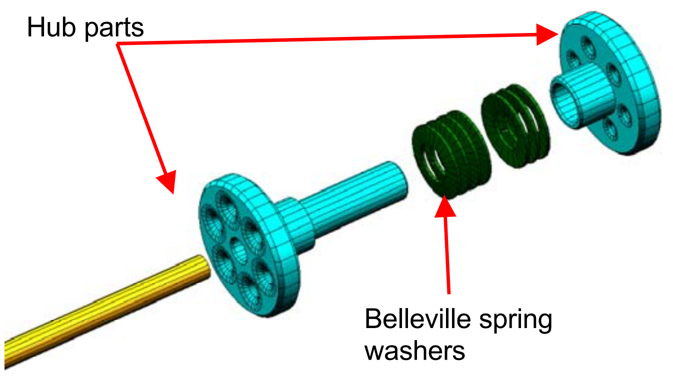


Figure 36 Exploded view of hub assembly

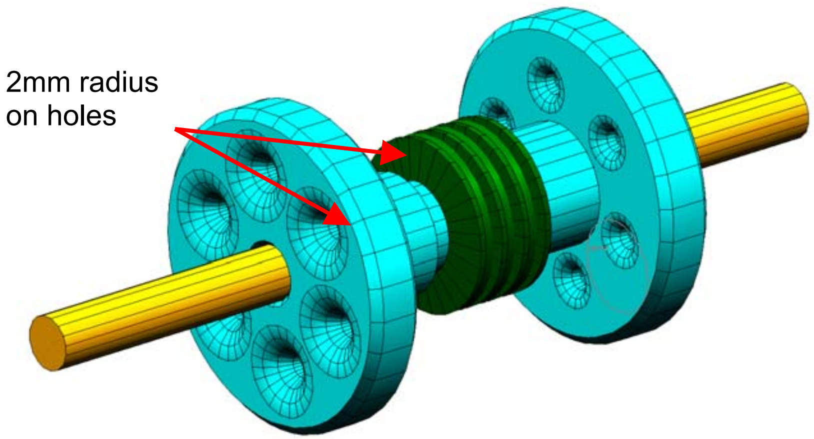


Figure 37 Hub assembly with bus-bar

4.2.4.1. Belleville spring washers

Stainless steel disc spring washers (Belleville springs LTD, Worcestershire) are employed to tension the Kevlar by forcing the central hub to expand. The spring washers can be stacked in various ways to obtain the desired range of deflection and restoring force, as shown in Figure 38.
The disc spring type selected for the telescopic hub is part number S105204, data for which is shown in Table 2.

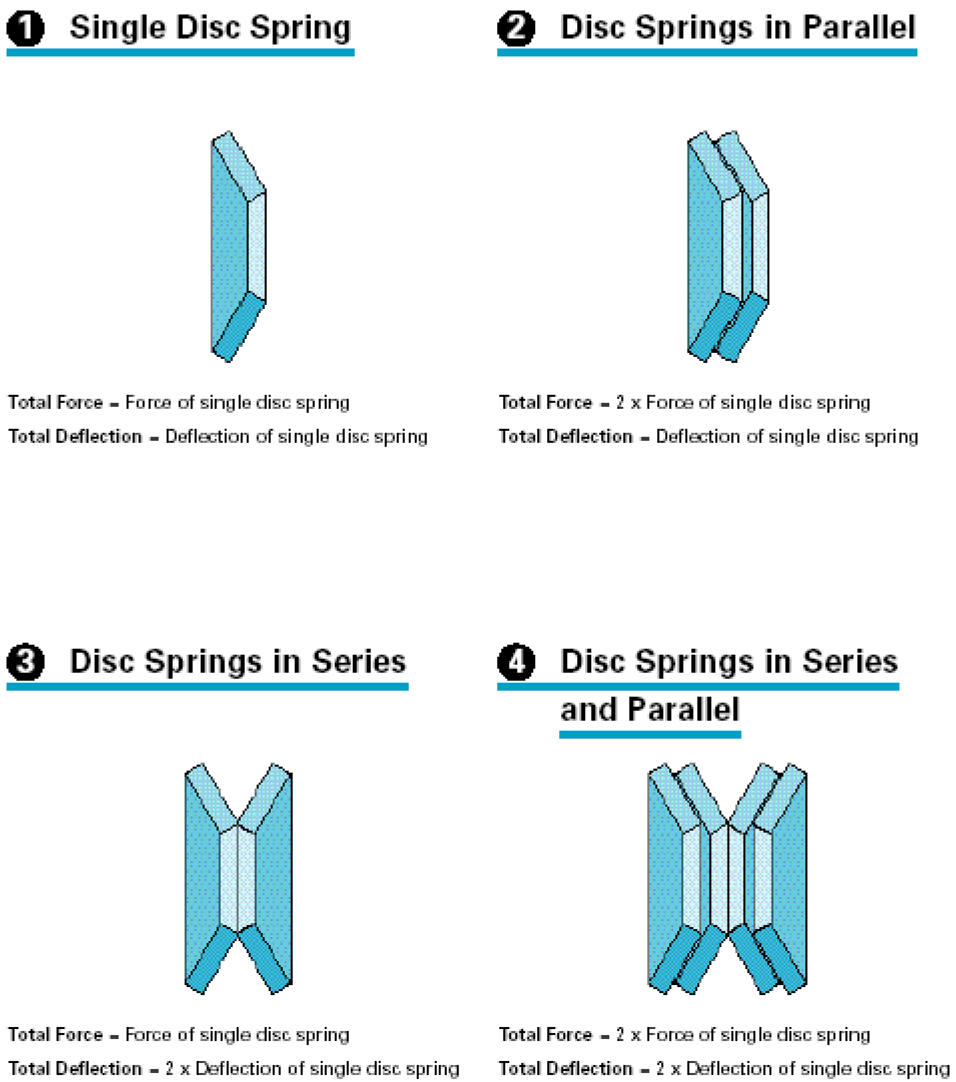


Figure 38 Options for stacking disc spring washers.

Table 2 Data for stainless steel disc springs for use in telescopic hub.

Stainless Disc Springs

Material: X12CrNi 17 7 (DIN 1.4310)

Code No.	Outer Dia. (De) mm	Inner Dia. (Di) mm	Thick. (t) mm	Cone Ht. (ho) mm	Overall Ht. (lo) mm	Cone Ht. / Thick. Ratio	Weight per 1000 pcs.	15% Defl.		30% Defl.		45% Defl.		60% Defl.		75% Defl.		90% Defl.	
								Defl. mm	Force N	Defl. mm	Force N	Defl. mm	Force N	Defl. mm	Force N	Defl. mm	Force N	Defl. mm	Force N
								Stress δII N/mm²	Stress δIII N/mm²	Stress δII N/mm²	Stress δIII N/mm²	Stress δII N/mm²	Stress δIII N/mm²	Stress δII N/mm²	Stress δIII N/mm²	Stress δII N/mm²	Stress δIII N/mm²	Stress δII N/mm²	Stress δIII N/mm²
S63203	6.0	3.2	.30	.15	.45	.50	.05	.02	25	.05	49	.07	70	.09	91	.11	110	.14	129
								183	252	387	490	612	714	858	924	1,125	1,121	1,413	1,304
S83205	8.0	3.2	.50	.20	.70	.40	.17	.03	72	.06	141	.09	206	.12	269	.15	330	.18	389
								276	229	572	448	889	655	1,226	851	1,584	1,036	1,962	1,210
S84202	8.0	4.2	.20	.25	.45	1.25	.06	.04	13	.08	22	.11	29	.15	33	.19	36	.23	38
								-6	233	20	445	79	636	170	806	294	954	451	1,081
S84203	8.0	4.2	.30	.25	.55	.83	.09	.04	30	.08	55	.11	76	.15	94	.19	109	.23	122
								91	284	215	548	371	789	560	1,010	782	1,210	1,036	1,388
S84204	8.0	4.2	.40	.20	.60	.50	.11	.03	45	.06	85	.09	124	.12	159	.15	193	.18	226
								183	247	387	481	612	702	857	908	1,124	1,102	1,411	1,281
S1052025	10.0	5.2	.25	.30	.55	1.20	.11	.05	18	.09	32	.14	42	.18	49	.23	53	.27	56
								2	217	34	414	96	592	188	751	309	890	461	1,010
S105204	10.0	5.2	.40	.30	.70	.75	.18	.05	51	.09	95	.14	132	.18	164	.23	193	.27	220
								114	275	258	531	432	767	636	984	870	1,181	1,134	1,359
S105205	10.0	5.2	.50	.25	.75	.50	.22	.04	69	.08	133	.11	192	.15	247	.19	300	.23	351
								183	245	387	477	612	695	857	899	1,123	1,090	1,411	1,268

4.2.4.2. Kevlar pre-tension and spring stacking options

There are many options for pre-tensioning the Kevlar by using different arrangements of spring washers, as shown in Table 3. In this table, D_T is the total stack deflection for an individual washer deflection of 75% or 90%, F is the restoring force from the stack, and T_K is the resulting tension in each Kevlar cable (twelve per support assembly). The predicted breaking stress for each Kevlar cable is around 500 N.

The hub is compressed such that the disc spring compression is ~90%, prior to suspending the hub on the Kevlar. This is achieved by using an M3 bolt and nut through the central axis, with the nut turned to a torque of 200Ncm. The Kevlar is then pulled taut to a fixed pre-load (60Ncm torque on adjustable capstan) and terminated at the capstans. Then the external compression of the hub is released, and the restoring force of the Belleville stack will fully tension the Kevlar. This tension is determined by the Belleville stacking arrangement, and the pre-compression applied.
For the CQM, flight model and flight spare assemblies, the hubs (both photometer supports and light baffles) were each loaded with twelve series-parallel stacked washers (stacking pattern = <<<>>><<<>>>).

Table 3 Options for adjusting the Kevlar pre-load using different Bellville spring washer configurations

Belleville spring configuration	Belleville deflection					
	75%			90%		
	D_T(mm)	F (N)	T_K(N)	D_T(mm)	F (N)	T_K(N)
8 series	*1.84*	*193*	*16.3*	*2.16*	*220*	*18.5*
8 series/parallel (4 pairs)	*0.92*	*386*	*32.5*	*1.08*	*440*	*37.1*
8 series/parallel (2 nests of 4)	*0.46*	*772*	*65.1*	*0.54*	*880*	*74.2*
12 series/parallel (4 nests of 3)	*0.92*	*579*	*48.8*	*1.08*	*660*	*55.6*

The Belleville configuration used for the CQM, PFM and FS photometer supports and light baffles is as indicated in the last row of Table 3, highlighted in blue. This should give a final tension in each Kevlar cable length of around 56 N (initial compression of 90%).

4.3. Light Baffles

All five detector array modules are mounted on the 2K photometer and spectrometer detector boxes. The feedhorn apertures look into the low-background 2K environments of these light-tight boxes. A low-pass edge filter covers the entrance apertures of these boxes. The detector interface for the 300mK strap is on the front face of each BDA, which means that the 300mK bus-bar must be brought into each 2K box while retaining a high level of light-tightness. Of course, there cannot be any direct contact between the 300mK components and the 2K boxes. Therefore a light-trap has been designed which provides a rigid support, a high degree of thermal isolation, and a reasonable level of stray light attenuation. General views of the assembled baffle are shown in Figure 39 and Figure 40 and an illustration of one of the baffles in place on the photometer 2K box is shown in Figure 41.

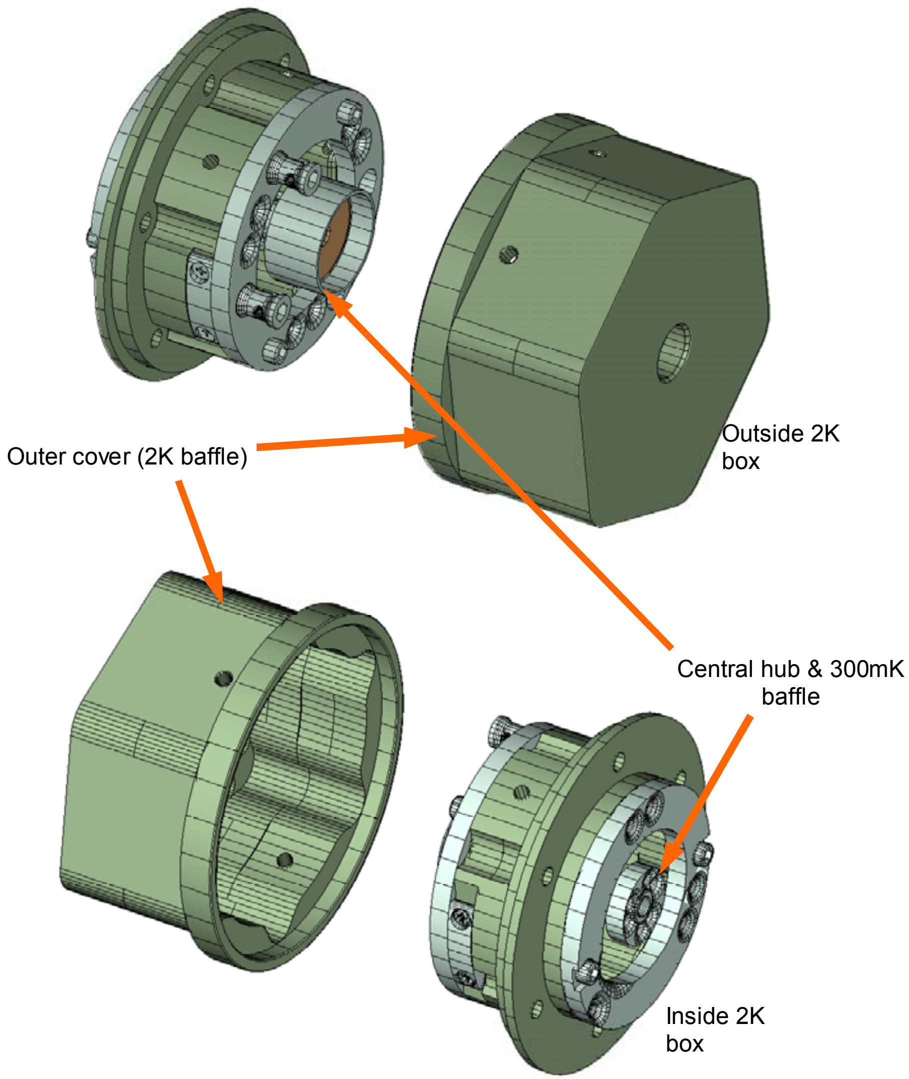


Figure 39 Views of the assembled light baffle (cover removed)

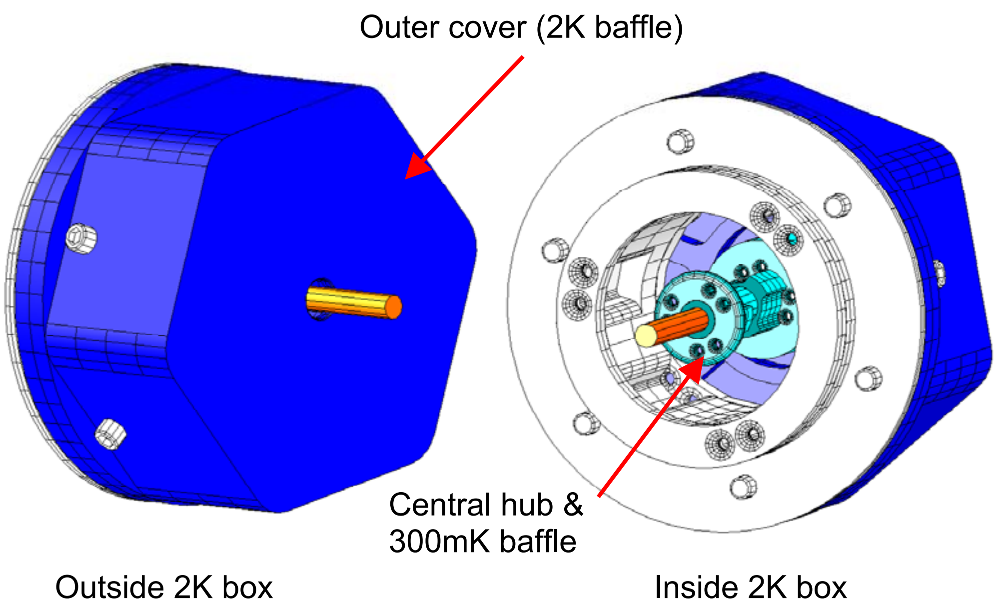


Figure 40 General views of the light baffle assembly

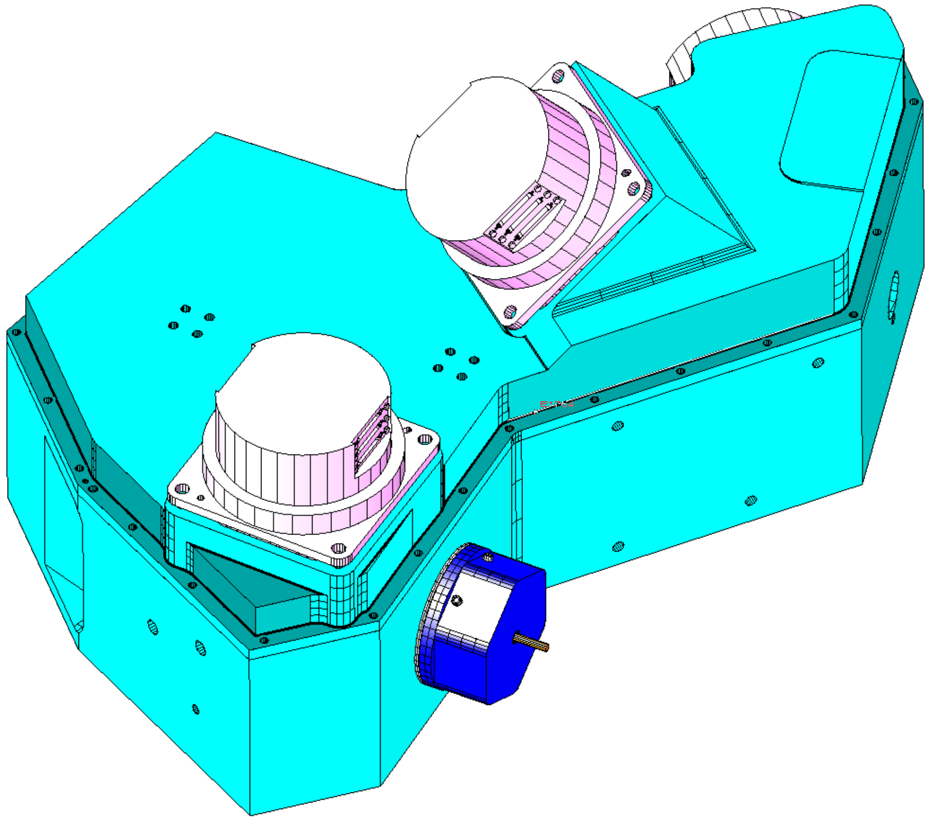


Figure 41 Light baffle in position on the photometer box spine. An identical baffle is employed on the spectrometer 2K box.

4.3.1. General assembly

The core of the light baffle assembly is essentially the same as the photometer bus-bar support. It employs a Kevlar suspension system with a Belleville-tensioned telescopic central hub. Concentric, overlapping tubular baffles form a light trap – one on the central hub (300mK section) and two on the light baffle cover at ~2K.

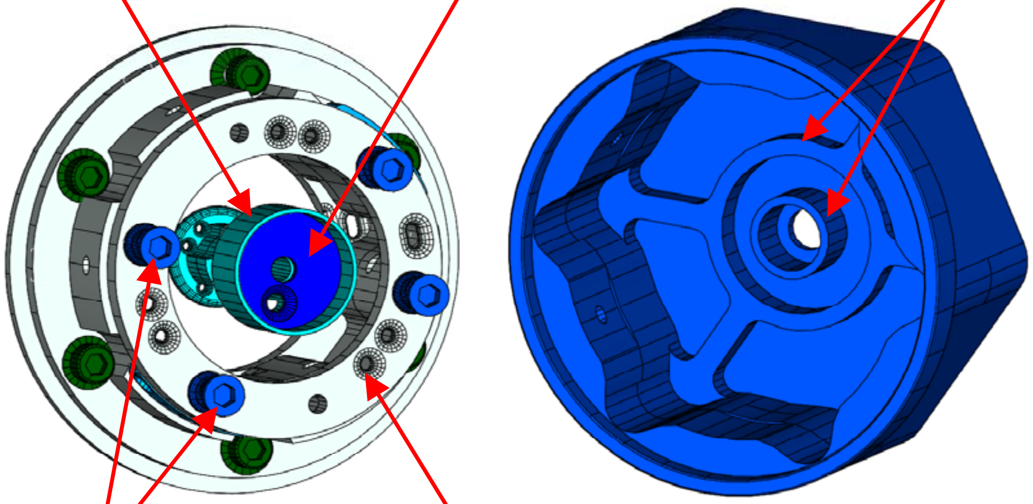


Figure 42 Light baffle assembly – outer cover removed. Baffle disc is used to cover Kevlar routing holes on central hub.

4.3.2. Light baffle design

In designing the light trap, efficacy of light attenuation was considered a less important design driver than avoidance of thermal shorts. Making the individual tube baffle sections tall, with small clearances between baffles (the way to optimize light attenuation – maximize number of photon "bounces") greatly increases the risk of a thermal short from 300mK to Level-0 by misalignment of the hub. Therefore, relatively short tube baffle sections with generous clearances between sections have been employed. Sectional views are shown in Figure 43 and Figure 44. The surfaces of the light trap, and the inside of the light baffle cover, are coated with a highly absorbent black coating which has been qualified at Cardiff for use on SPIRE (RD7). A stray light analysis of this arrangement will be carried out, and the level of light leakage will be tested experimentally on the DM devices (built at the same time as the CQM2 / PFM / FS devices).

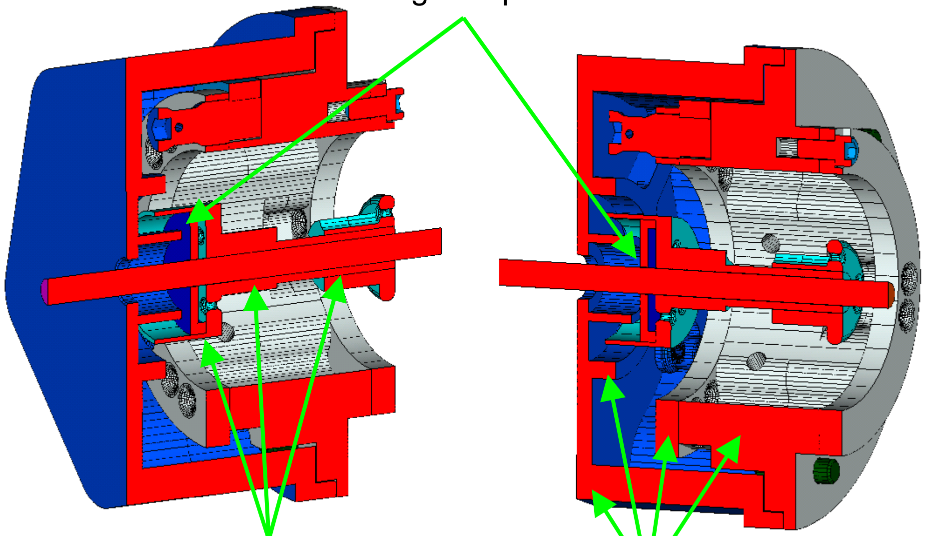


Figure 43 Sectional view of light baffle with bus-bar.

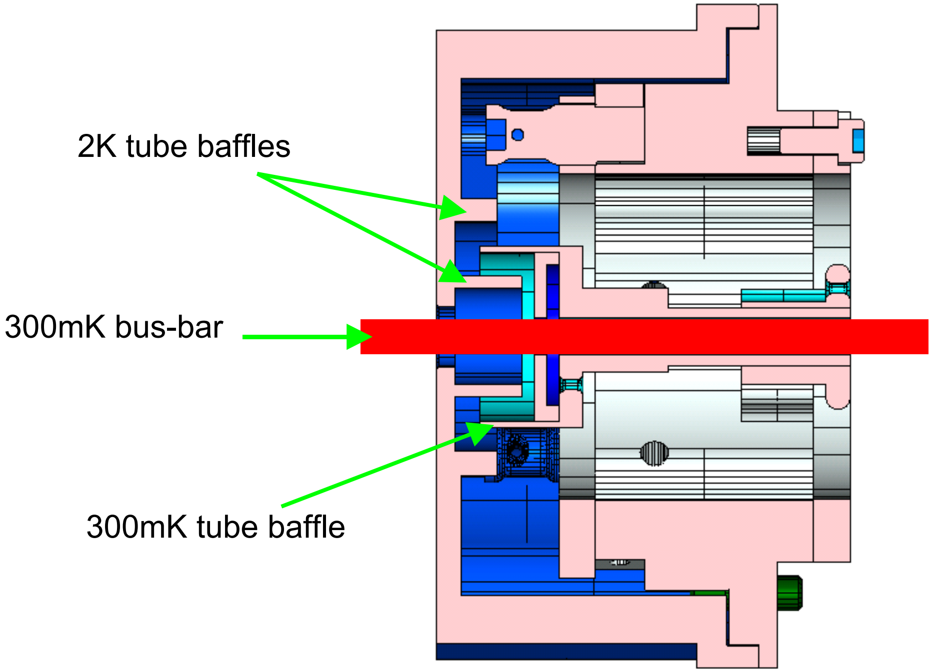


Figure 44 Sectional view showing details of light trap. Minimum clearance between 2K and 300mK structure is 2mm. Blue areas indicate where the black coating is applied.

4.3.3. Light attenuation requirements

The optical requirements on the stray light baffles are shown in Table 4.

Table 4 Optical requirements on stray light baffles – extracted from RD3

Requirement ID	Description	Value	Reference	Notes

Requirement ID	Description	Value	Reference	Notes
STRAP-Req-18	Stray-light baffling effectiveness	The Photometer and Spectrometer Stray-Light Baffles are to provide at least four reflections for the shortest optical path between the Level-1 environment outside the detector box and the Level-0 environment inside the detector boxes.	IRD-STRP-R06 IRD-STRS-R06. [AD1]	These requirements on the stray-light shielding in terms of attenuation have in terms of been changed into geometric requirements. See RD02
STRAP-Req-19	Stray-Light Baffle Opacity	The Photometer and Spectrometer Stray-Light Baffles are to be opaque (>99.9%) in the wavelengths 0.5μm to 670μm	IRD-STRP-R06 IRD-STRS-R06. [AD1]	Since the attenuation requirement in the IRD has been translated into a geometric requirement, the opacity of the stray light baffle needs to be specified as well.

4.3.3.1. STRAP-Req-18

Because of the greater emphasis put on ensuring adequate clearance between 300mK and Level-0 structure within the light trap, it may prove difficult to fulfill this requirement. A full stray light analysis of the baffles has yet to be carried out at the time of writing, but a naïve analysis shows the potential for a stray light path for which a photon would undergo only three bounces, as shown in Figure 45.

4.3.3.2. STRAP-Rep-19

This requirement for opacity of the light baffles in the wavelength range 0.5μm to 670μm will be easily met, as the baffle is manufactured from aluminium with a minimum thickness of 1mm. The reason for the 0.5μm lower limit is due to the emission of the LED used on the SMEC position sensor (peak at ~1μm).

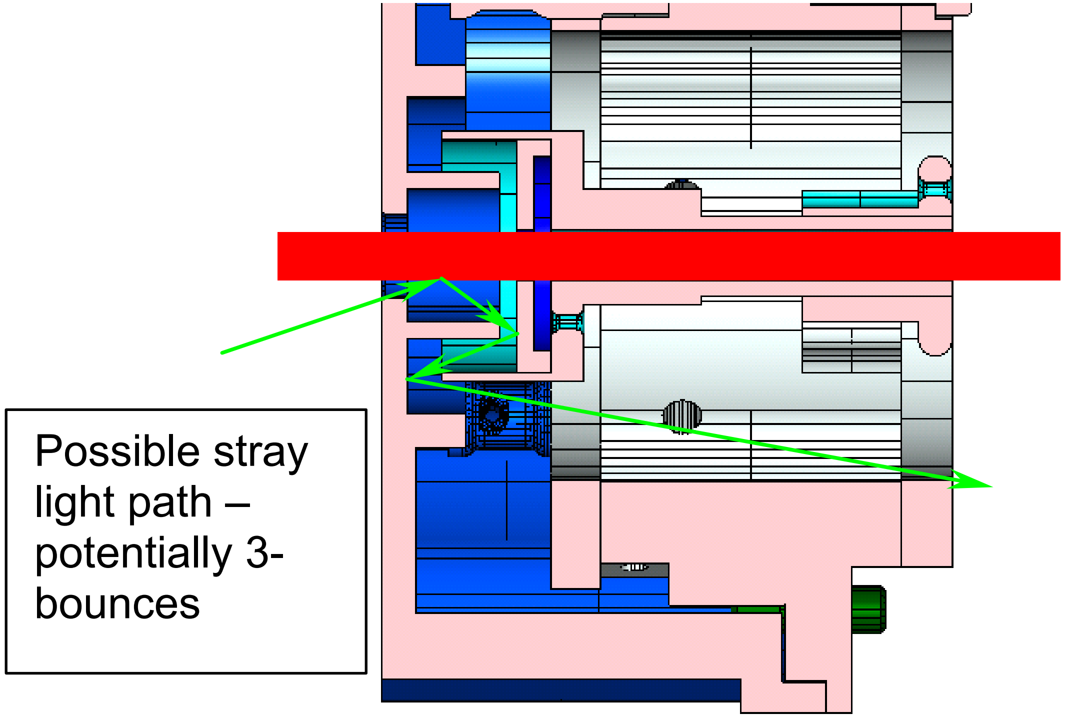


Figure 45 Potential for a “3-bounce” stray light path – unconfirmed.

4.3.4. Light baffle capstans

The Kevlar is terminated on capstans of a similar design to those used for the photometer bus-bar supports. There is a lower range of angular adjustment on the adjustable capstan, due to severe space constraints.

4.4. Mechanical analysis

A full FEA analysis of the 300mK strap system has been carried out, and may be found in RD5.

4.5. *Thermal analysis*

A thermal model of the Kevlar suspension systems has been produced as a design tool in order to ascertain the level of parasitic heat load to the cooler as a function of Kevlar geometry. A summary of the results for the design presented in this document follows.

4.5.1. Assumptions

- Kevlar type
  - 291 Tex – effective cross-sectional area of $1.97 \times 10^{-7} m^2$
- Kevlar Conductivity
  - Model run for two conductivity estimates
    - Duband [2]
    - Ventura [3]
  - Venturas data gives the more pessimistic result, and Dubands 300mK conductivity estimate was extrapolated from 2K data. Therefore Venturas data is used for estimation of parasitics.
- Kevlar geometry
  - Individual cable length (between Level-0 and 300mK) – 25mm
  - 48 cables from Level-0 to 300mK – twelve per support/light baffle – two photometer strap supports and two light baffles (one each for photometer and spectrometer boxes)
- Level-0 temperature – For estimation of parasitics, a Level-0 temeperature of 2K has been assumed, although in flight, it could be as low as 1.8K [AD2].

4.5.2. Results

The results from this model are shown in Table 5 and Figure 46. The graph plotted in Figure 46 is derived using the Ventura model, which gives the more pessimistic result.

Table 5 Parasitic heat load estimates as a function of Level-0 temperature.

Level-0 temperature	Parasitic load to cooler tip from 300mK strap suspension (μW)	
	Duband model	Ventura model
1.8K	1.42	2.65
2.0K	1.87	3.54

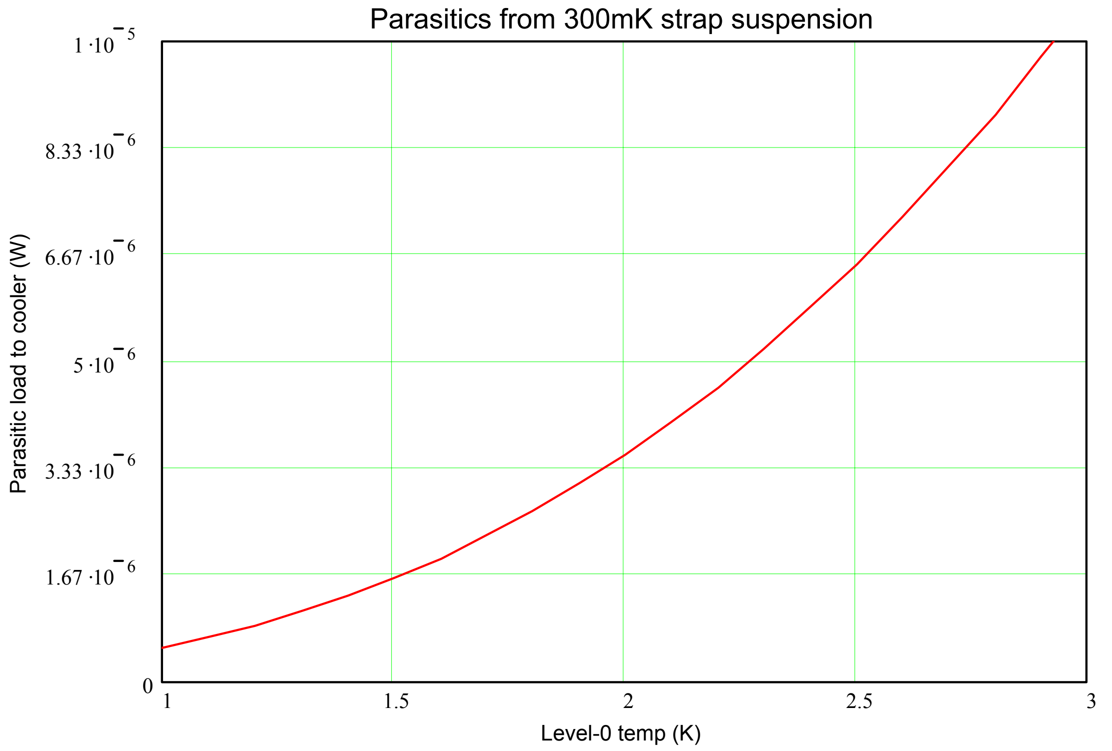


Figure 46 Total parasitics to cooler tip from strap suspension, as a function of Level-0 temperature (from Ventura model).

4.6. Photometer strap support system overview

The 300mK strap system is under MSSL control. This section gives an overview of how the 300mK supports and light baffles are used in the strap system.

The photometer strap assembly consists of several components. The best situation from a thermal perspective would be have the entire strap assembly formed out of one piece of copper, to minimize the number of thermal interfaces. However, this is obviously impractical due to cost and integration limitations. Therefore the strap system has been designed to allow reasonable integration and ease of manufacture, while keeping the number of thermal interfaces to a minimum.
This means that the photometer strap assembly is split into six components, as illustrated in Figure 47. All components of the strap assembly are manufactured from 99.999% copper (gold-plated), and are identified as follows:-

1) Feed from cooler tip to outside of light baffle.
2) Light baffle feed-through and section 1 of bus-bar – 3mm diameter copper rod.
3) Compliant link to PSW BDA – 1mm dia. copper.
4) Compliant link to PMW BDA – also serves as clamp to section 2 of bus-bar.
5) Section 2 of bus-bar – fed through both photometer strap supports – 3mm dia. copper rod.
6) Compliant link to PLW BDA.

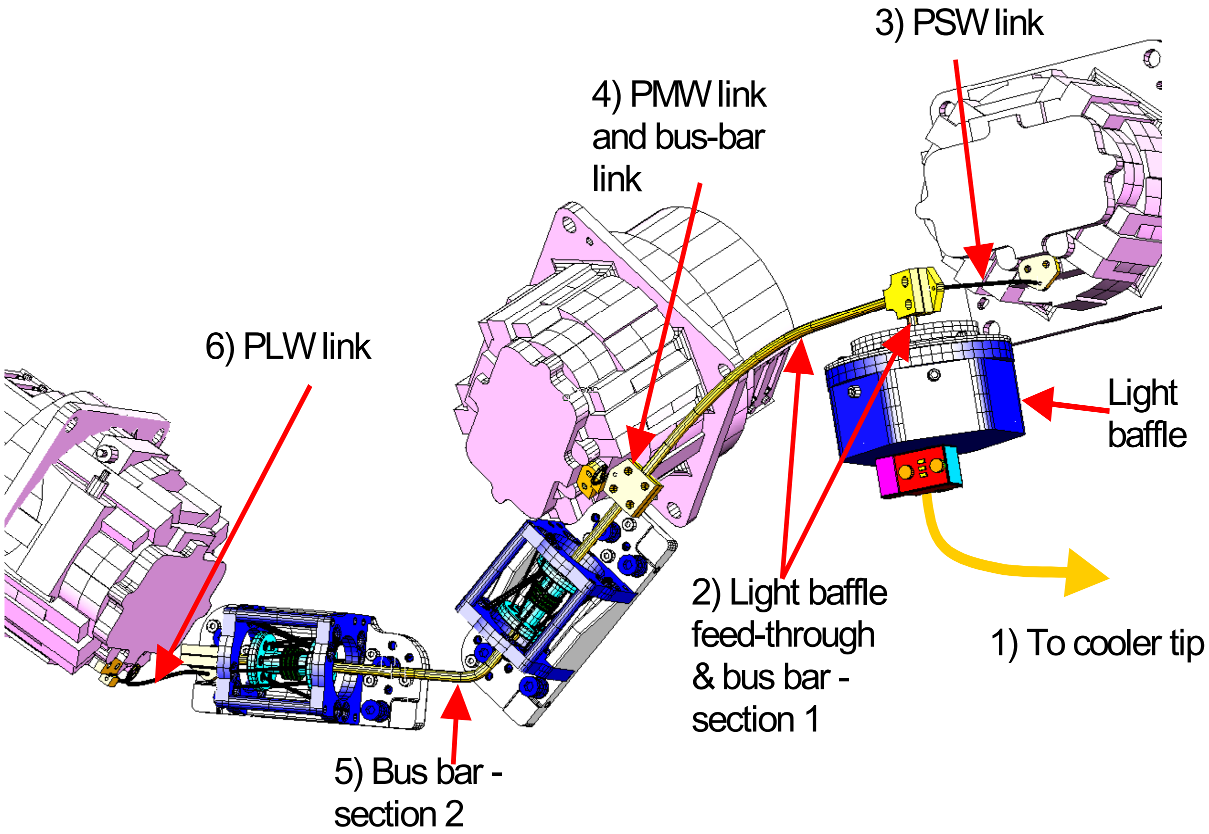


Figure 47 Overview of photometer strap assembly

4.7. Spectrometer strap assembly

4.7.1. System overview

Space is extremely restricted within the Level-0 spectrometer detector box. Views of the 300mK system within this box are shown in Figure 48 - Figure 51. Space restrictions force us to provide additional support for the SLW BDA strap from the SSW BDA clamp, as shown in Figure 50.
The SSW and SLW straps are manufactured from two 1mm diameter gold-plated copper wires, which are permanently fixed (brazed) into interface plates on one end, and into the light baffle feed-through on the other.
The feed from the cooler tip passes through the optical bench and clamps to the spectrometer strap light baffle feed-through. Electrical isolation for this strap will be implemented at the cooler tip.

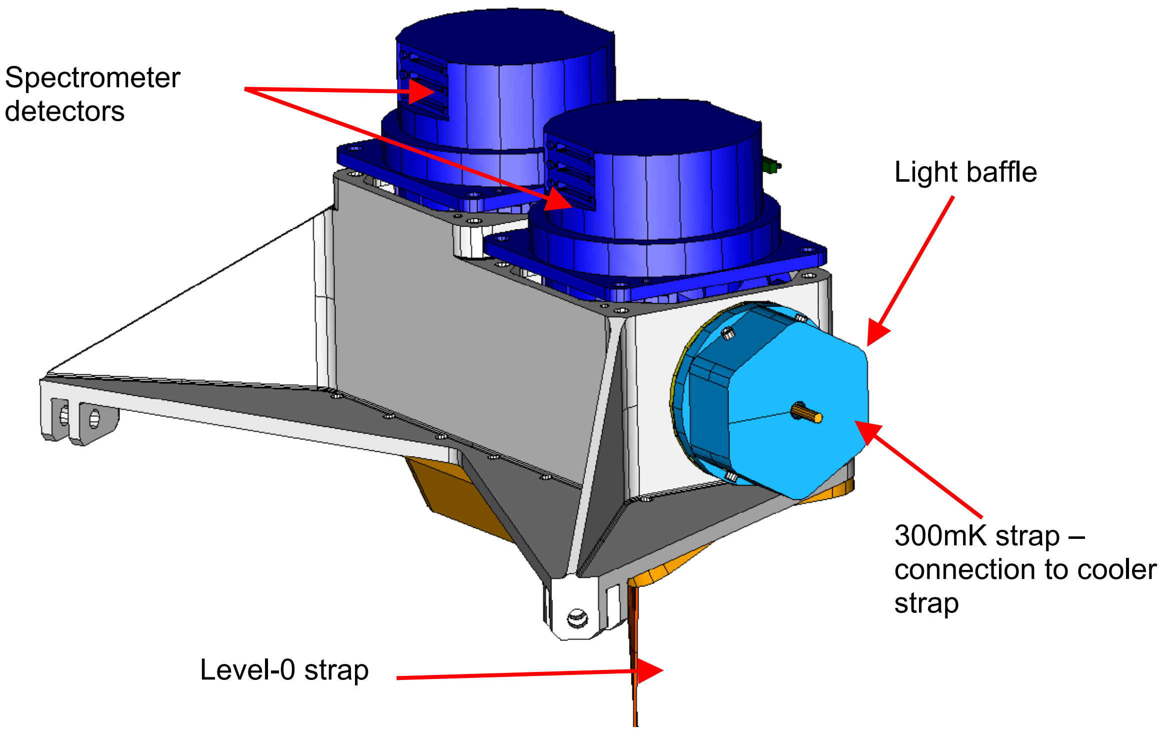


Figure 48 General view of spectrometer Level-0 box with light baffle

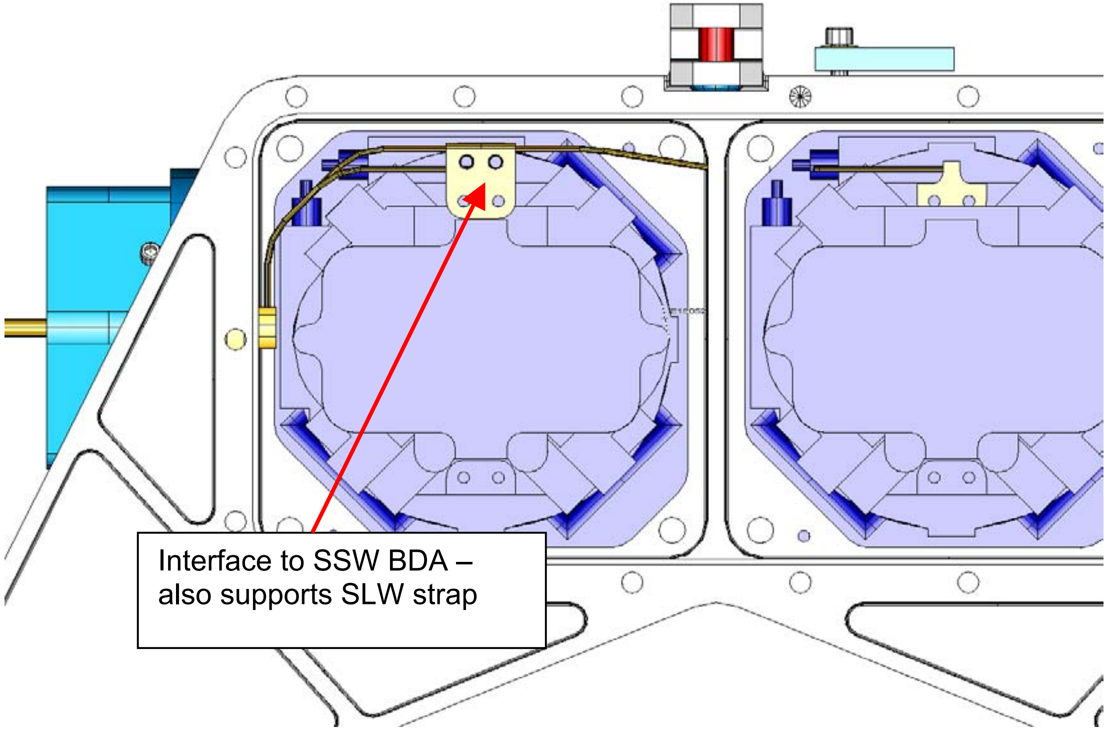


Figure 49 Details of spectrometer 300mK strap routing inside Level-0 box

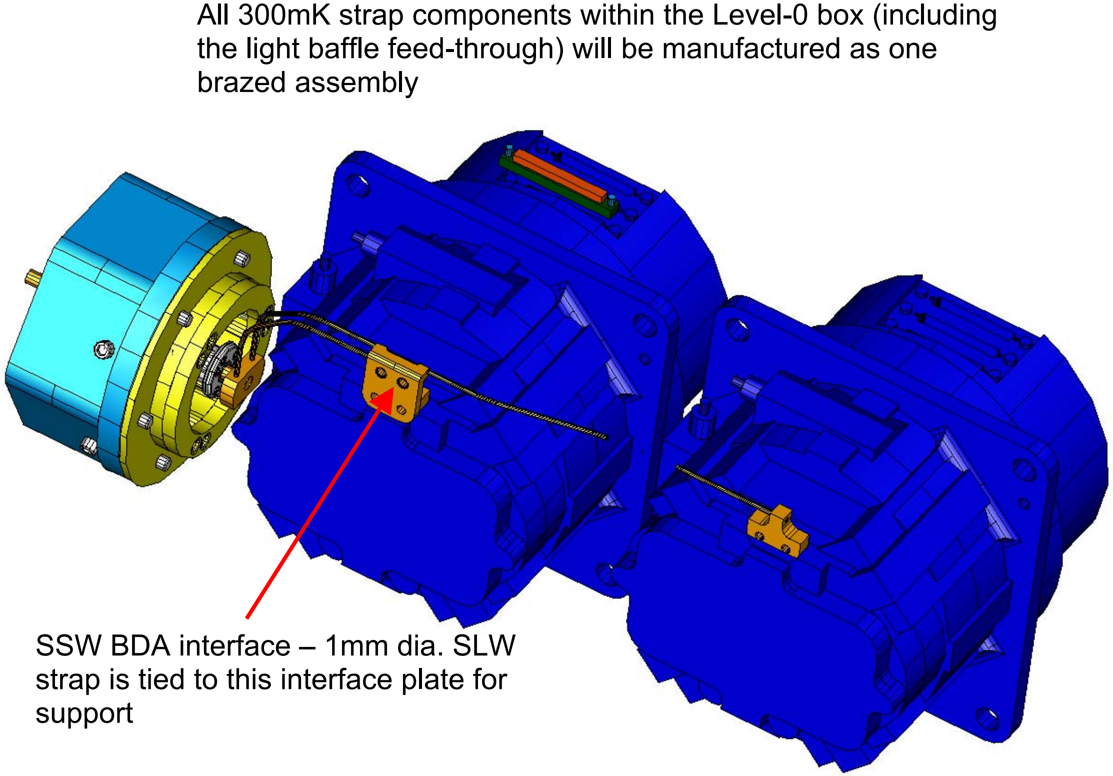


Figure 50 Spectrometer 300mK straps - box removed.

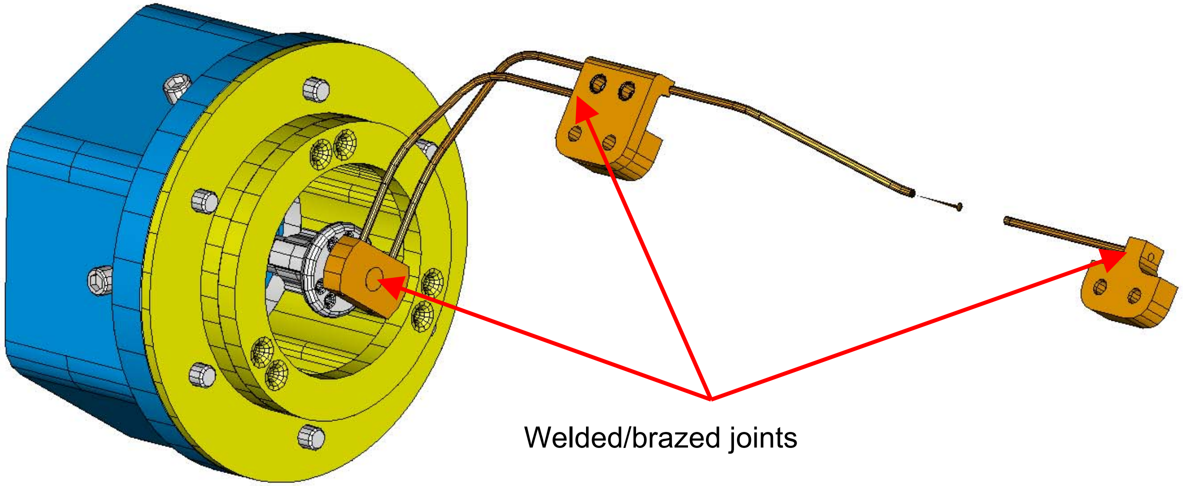


Figure 51 Details of spectrometer 300mK straps

4.8. Axial constraint of bus-bars

The design of the photometer and spectrometer bus-bar assemblies is such that when assembled, they are fully constrained axially by the photometer supports and light baffles. The hubs are constrained by stainless steel bushes. These bushes only contact the inner hub part, and so do not impede any expansion of the hub, which may take place upon cooling, or as compensation for Kevlar creep. The method employed for constraint at the light baffles is illustrated in Figure 52.

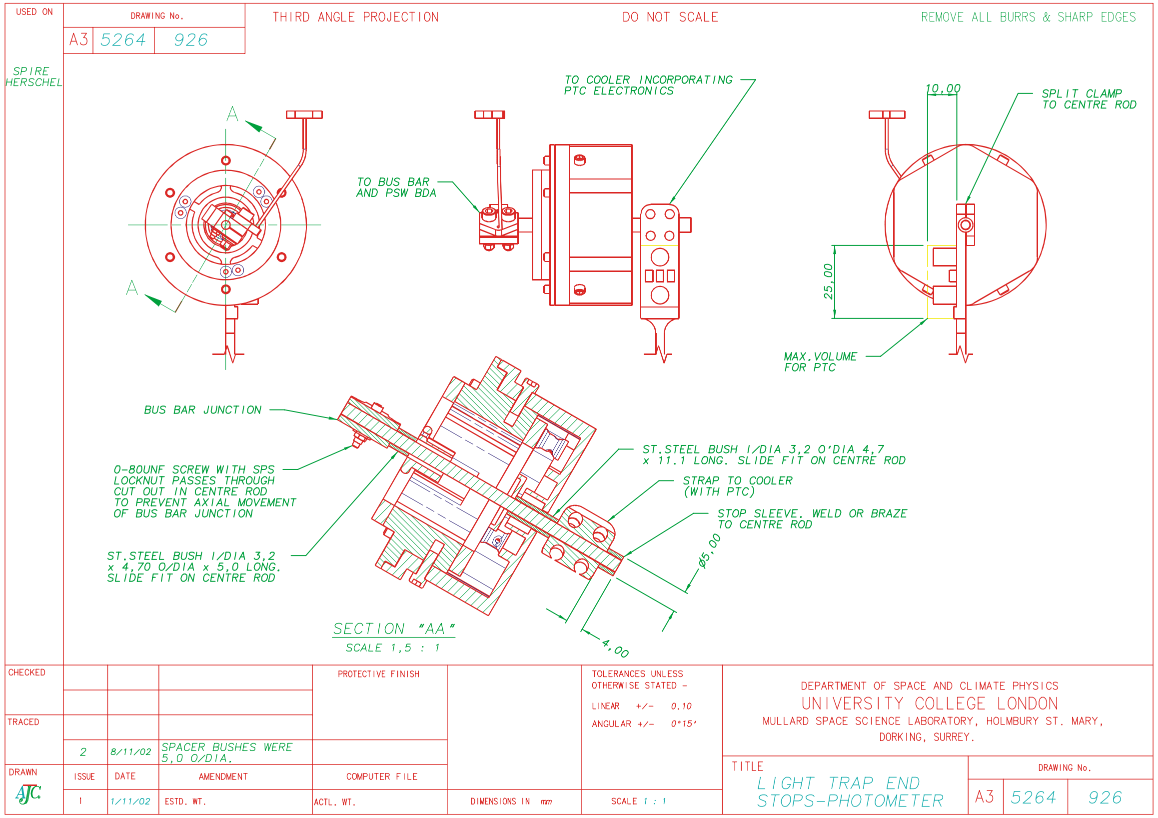


Figure 52 Axial constraint for thermal strap as it passes through the light baffles

The photometer bus-bar is additionally constrained inside the photometer box by the internal bus-bar supports, as shown in Figure 53.

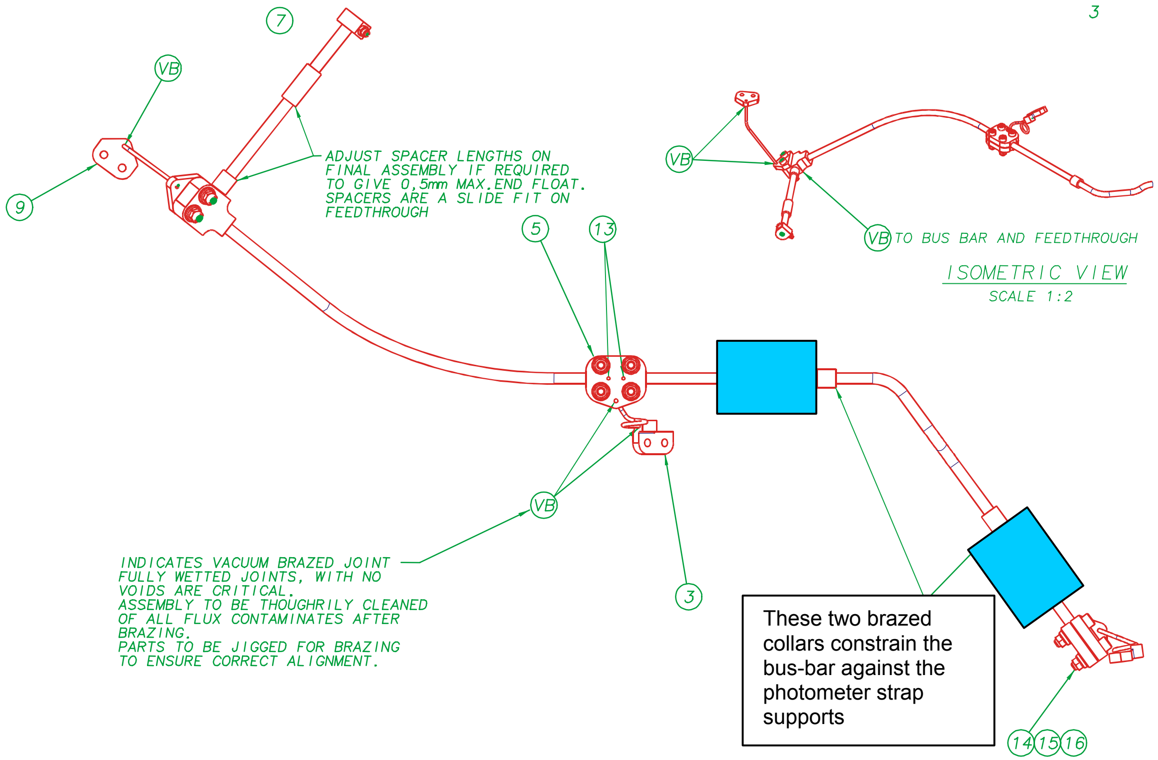


Figure 53 Detail of photometer bus-bar assembly showing method of axial constraint.

5. References

1. "Experimental characterization of Kevlar 29". TNS4, Issue 0 Rev. 1. L. Duband
2. Duband et al - Cryogenics 33, no6 643-64
3. Ventura et al – Cryogenics 40 (2000) 489-491

Appendix B

300mK photometer strap support assembly procedure HSO-CDF-RP-044

End Item Data Package (EIDP)

SPIRE - 300mK strap supports- PFM

SPIRE Ref.:
Cardiff Ref.: HSO-CDF-PR-044
Issue: 1.0

Prepared by: Peter Hargrave
Last Modified on: 27 July 2004
Approved by:

Update history

Date	Version	Remarks
08/02/03	1.0	First Issue for DDR

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APPENDIX D **131**

1. Scope

This document presents the assembly procedure for the 300mK photometer thermal strap supports. Note that this document will soon be updated with step-by-step photographs of the entire assembly sequence.

2. Documents

2.1. Applicable documents

All applicable documents are listed in the AD chapter of the CIDL (HSO-CDF-LI-029).

2.2. Reference documents

3. 300mK Photometer Bus-Bar Support Assembly Procedure

3.1. Check components against drawings

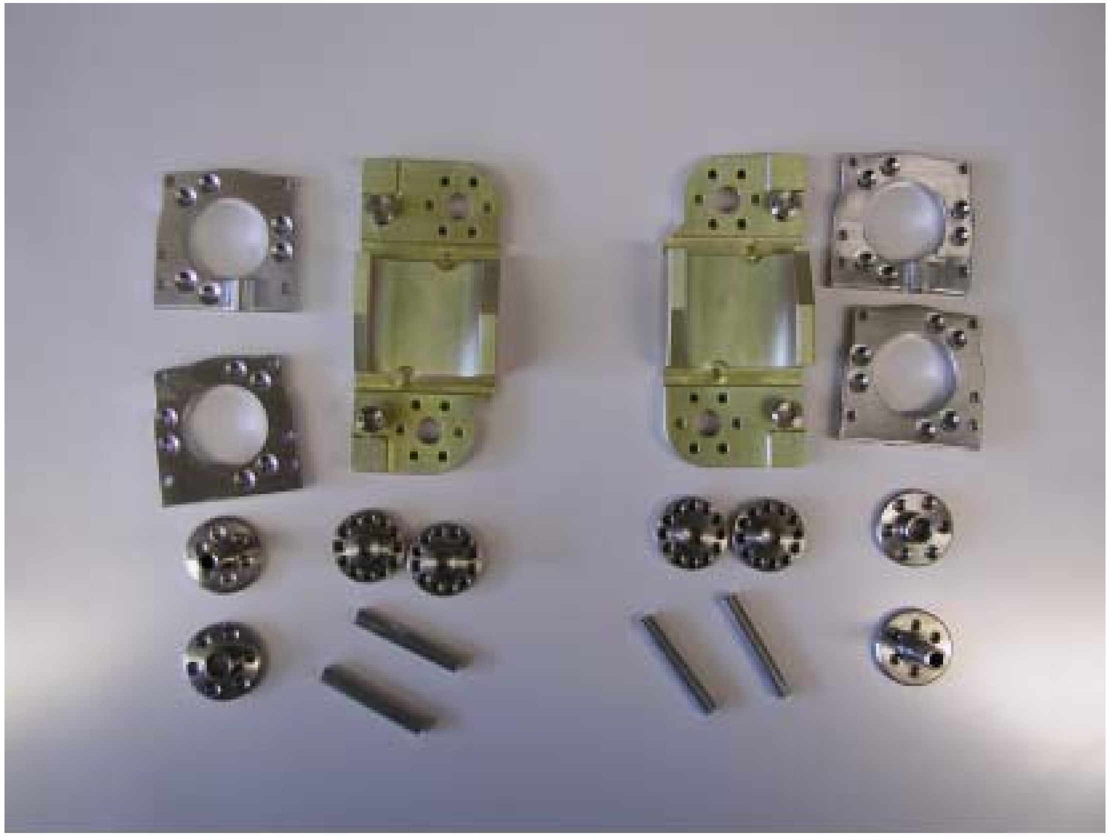

Figure 54 Components required for photometer support assembly (fixed capstans already fitted)

3.2. Assemble photometer support base

Assemble the photometer support base as shown in Figure 55.

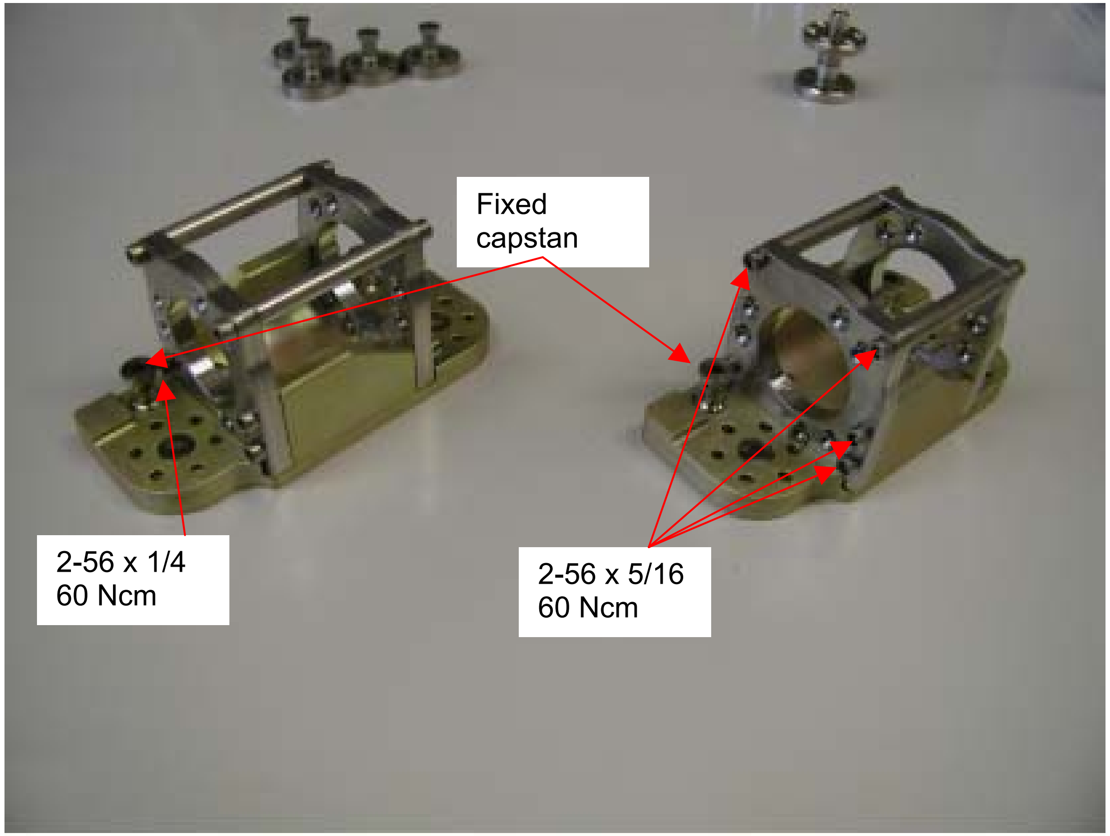

Figure 55 Photometer support frames assembled

3.3. Assemble & compress hub

3.3.1. Hub preparation

Stack Belleville spring washers on central hub assembly as shown in Figure 56. A total of twelve Belleville washers are used in this arrangement. Stainless steel disc spring washers (Belleville springs LTD, Worcestershire) are used, part number S105204.

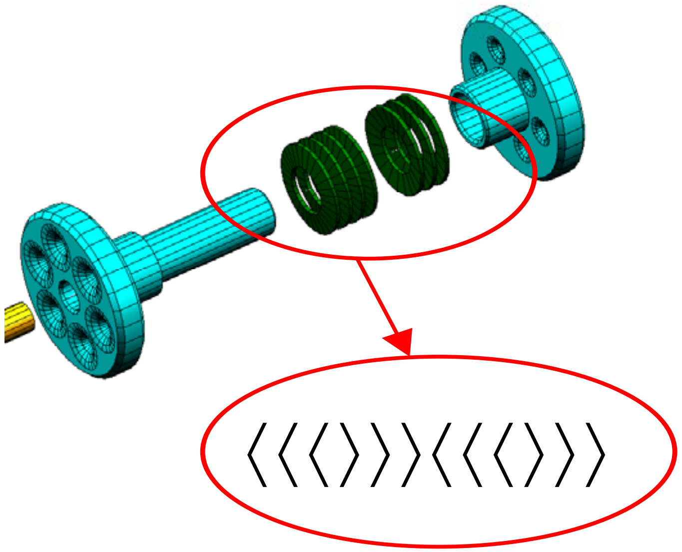

Figure 56 Stacking arrangement of Belleville spring washers on central hub.

3.3.2. Hub alignment & compression

Insert M3 bolt, align hub components, and fully compress hub by applying a torque of 200Ncm to the M3 nut, as shown in Figure 57 and Figure 58. Note the use of the hub compression tool, LTS-GSE-001. When the hub is "fully compressed" in this manner, the resultant compression of the Belleville spring stack is ~90%. The compression force in this situation is approximately 932N.

KIP – Note the distance between the inner faces, indicated in Figure 57

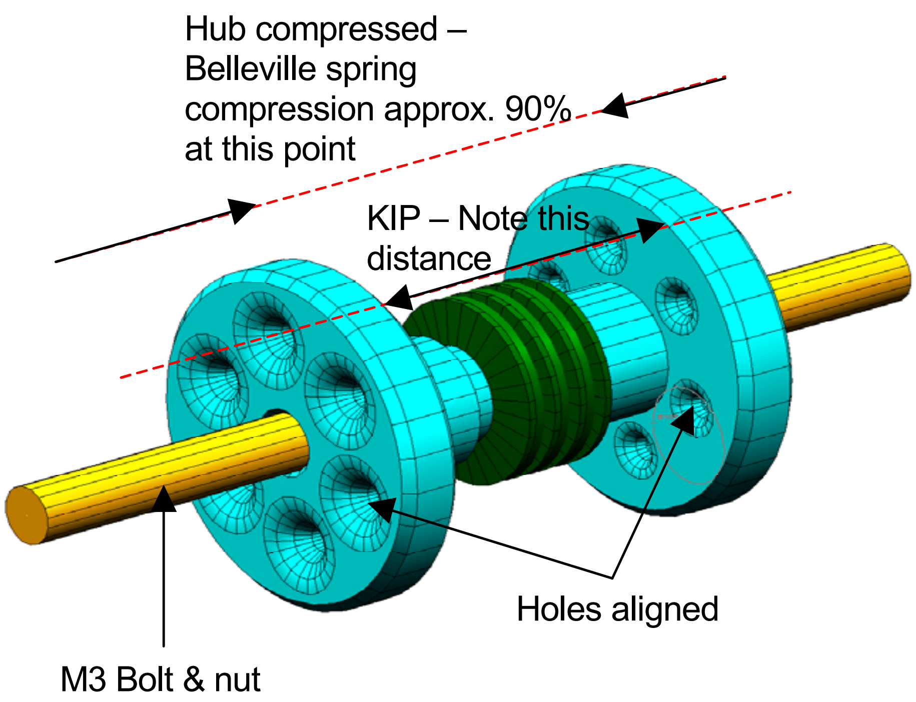

Figure 57 Alignment and compression of central hub assembly.

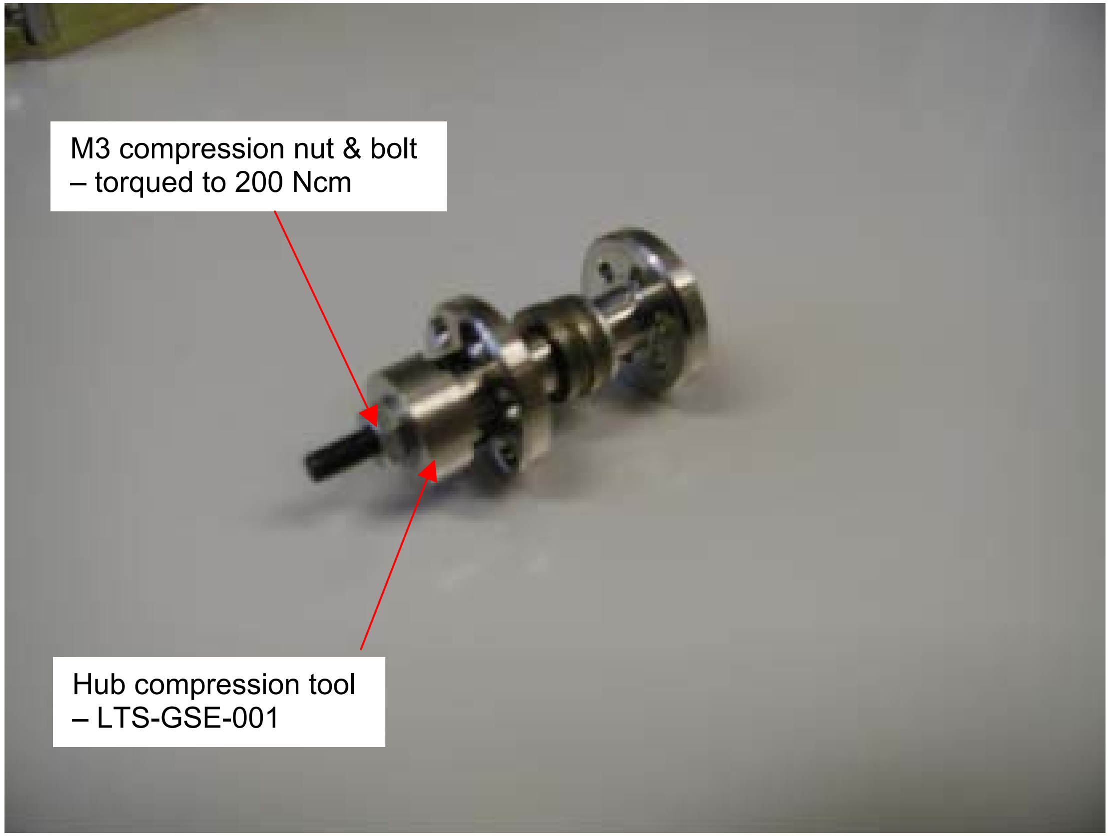

Figure 58 Compression of central hub, using M3 nut & bolt, and compression tool.

3.4. Kevlar Lacing

The photometer support system employs two individual Kevlar cords to support the central hub. These cords work in opposition to maintain tension. The routing for the cords is symmetric, as shown in Figure 63, and therefore the lacing procedure is the same for each cord.

3.4.1. Cord preparation

The Kevlar cord (Kevlar 11, Cousin Filterie) is cut to >30cm length, and the ends are sealed with GE varnish. This sealing is purely to contain the fibres and hence aid lacing. No section of cord treated with GE varnish will be in the final assembly.

3.4.2. Starting at fixed capstan

The Kevlar is tied to the fixed capstan (Figure 59 & Figure 60) using an adjustable jamming hitch, as shown in Figure 61. The Kevlar is then wrapped around the capstan at least four times, as shown in Figure 62. For convenience while lacing the rest of the structure, the Kevlar-wrapped capstan is temporarily wrapped with Kapton tape to prevent the Kevlar coils from spilling off the capstan.

3.4.3. Kevlar lacing

The Kevlar is laced according to Figure 63. This cord will be terminated on the adjustable capstan on the same side of the assembly as the starting capstan, but only after the second cord is laced and the alignment caps are in place (see later). The second cord is laced in the same way as the first, starting from the fixed capstan on the other side of the assembly, and following steps 3.4.1 to 3.4.3.

Figure 59 Kevlar tied and wrapped around fixed capstan, temporarily held with Kapton tape.

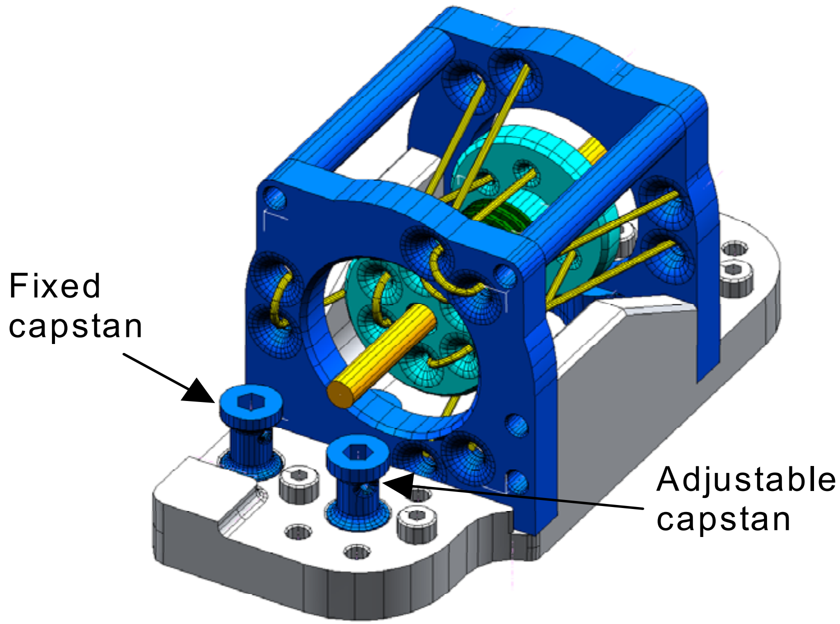

Figure 60 Support overview, showing capstans

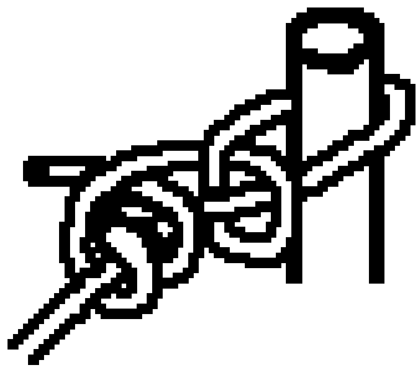

Figure 61 Detail of knot used to tie Kevlar to capstans.

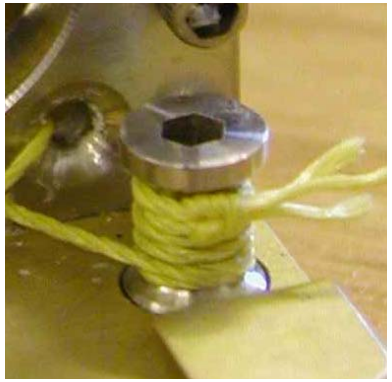

Figure 62 Details of Kevlar wrapping around fixed capstan at start of run.

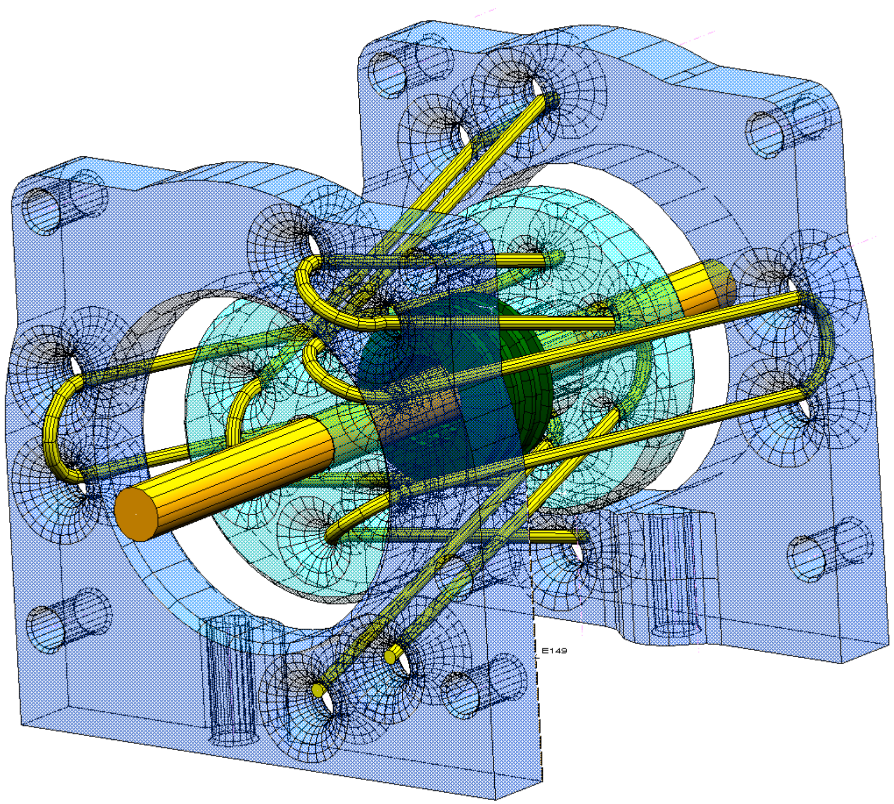

Figure 63 Kevlar routing

3.4.4. Hub alignment

With the Kevlar cords laced, but un-terminated on the adjustable capstans, the alignment caps are placed on the support assembly to hold the central hub aligned with respect to the support structure. A view of the support assembly with an alignment cap in place is shown in Figure 64.

3.4.5. Termination on adjustable capstans

With the alignment caps in place, the two free ends of Kevlar cord, one on each side of the assembly, are pulled hand tight. The ends of the cords are then tied to their respective adjustable capstans using an adjustable jam hitch (Figure 61), leaving 3cm of “slack” Kevlar. This is to ensure that there is enough slack to allow at least four turns of cord around the adjustable capstan. Each adjustable capstan is then turned, carefully winding the slack cord onto it, ensuring that no cord is overlapping another. Finally, the initial pre-tension is set by winding each capstan to a torque of 60±5Ncm and locking the capstan with two bolts, as shown in Figure 65. Note that the central hub compression has NOT been released at this point. The temporary kapton tape should be removed from the fixed capstans, and the excess cord on all capstans trimmed to leave 10mm cord free.

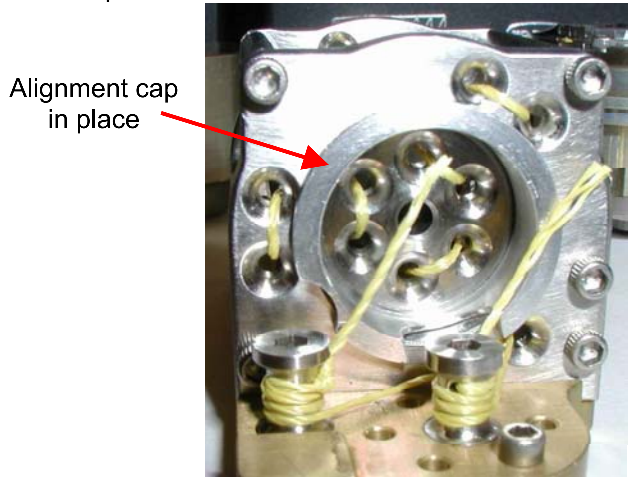

Figure 64 View of support assembly showing one of the alignment caps in place.

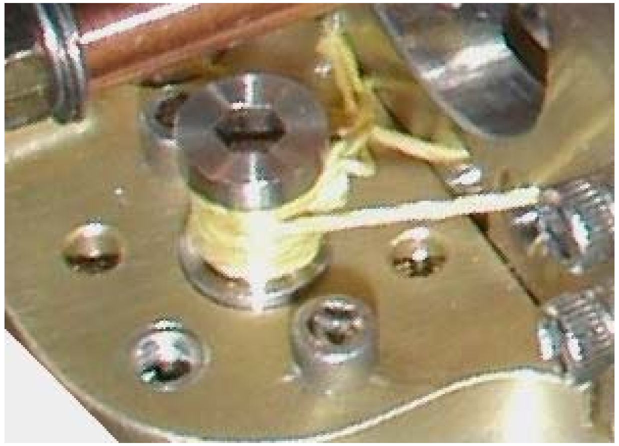

Figure 65 Kevlar terminated on adjustable capstan

3.4.6. Kevlar pre-conditioning

Experiments at JPL have indicated a benefit from pre-conditioning of Kevlar cords by baking under tension. Additionally, there is a significant amount of friction between the cords and the radiused holes through which the cords pass. This friction can lead to small differences in the tensions in individual Kevlar runs which could potentially lead to slight misalignment of the central hub. Therefore, the following procedure is followed, with the alignment caps in place throughout:-

- Thermal shock of entire assembly – immerse in liquid nitrogen for 10 minutes
- Bake out entire assembly at 80°C for 24 hours. The Kevlar is under relatively low tension from the torque applied to the adjustable capstans in step 3.4.5.

Figure 66 Assembled hub prior to hub compression release

3.4.7. Final tensioning and conditioning

The compression of the central hub can now be released by removing the axial M3 nut & bolt. Care should be taken to avoid twisting the hub when undoing the bolt. Note that the alignment caps should still be in place throughout this procedure.
The whole assembly should then undergo the following thermal shock cycle 3 times:-

- Immersion in liquid nitrogen for 10 minutes
- Bake at 80°C for 4 hours

A=The assembly should then undergo a final 24 hour vacuum bake at 80°C.

The alignment caps can now be removed.

KIP – Note the new distance between the hub inner faces, as indicated in Figure 57

Appendix C

Light baffle assembly procedure.
HSO-CDF-PR-045

Appendix D

Vibration test report.

AIV-2003-091-VIB

SST DEPARTMENT

VIBRATION TEST FACILITY

REPORT REF: AIV-2003-091-VIB

HERSCHEL : CARDIFF COMPONENTS

RUTHERFORD APPLETON LABORATORY
Vibration Facility
Chilton, Didcot,
Oxfordshire OX11 OQX

Tel: 44 (0) 1235 446617

CONTENTS

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ANNEX A: ACCELEROMETER PLOT FIGURES 1 – 5

ANNEX B: COOLDOWN/WARM UP GRAPH

1) TEST ITEM DESCRIPTION

The test items consisted of :-

- Scal-B - nominal flight spare, reduced power option - SCAL-FS-000-FLIGHT COMPONENT
- Pcal DM – lifetest source in DM structure – non-flight, but flight replica
- 300mK System – 1 photometer support & 1 light baffle – both DM, but flight replica. Configuration as per previous shake.
- 2 additional Pcal sources (in sealed chambers). One mica device, one sapphire device.
- Beam divider in CQM Mount (flight replica)
- Black tiles
- Representative hot-pressed filter material in SPIRE-type mount

Testing would be carried out on the head of the shaker within the Cryostat.

2) TEST SPECIFICATION

The components were to be tested to Spire Qualification levels. A sine survey was to be initially carried out at ambient temperature/atmospheric pressure. A further sine survey followed by a random and post random sine survey would be carried out at sub 10 Kelvin/ Vacuum. A final sine survey at ambient temperature/atmospheric pressure would be undertaken.

A single axis accelerometer was to be used for monitoring.

SINE SURVEY TEST

One sweep @ 0.25g from 10 Hz to 2000 Hz at 2 octaves per minute.

RANDOM

FREQUENCY (Hz)	TEST LEVEL
20 - 100	+3 dB/oct
100 – 138.5	0.06 g^2 / Hz
138.5 - 170	0.06 – 0.7 g^2 / Hz
170 - 200	0.7 g^2 / Hz
200 - 220	0.7 – 0.1 g^2 / Hz
220 - 300	0.1 g^2 / Hz
300 - 2000	-9 dB/oct

Overall Test Level = 8.0 g rms. for 30 Seconds

3) ACCELEROMETER CALIBRATION STATUS

SINGLE AXIS - ENDEVCO 2272 & B&K 4393

SERIAL NUMBER	CALIBRATION PC/g	Date	SIGNAL CONDITIONER
A66B	12.67	11/03/04	ENDEVCO 2775A
YG32	13.77	11/03/04	
1434587	3.16	N/A	

NOTE

Due to the temperature effects, a reduction of 10% in the sensitivity values was used during all cold testing.

See test summary for details on S/N 1434587

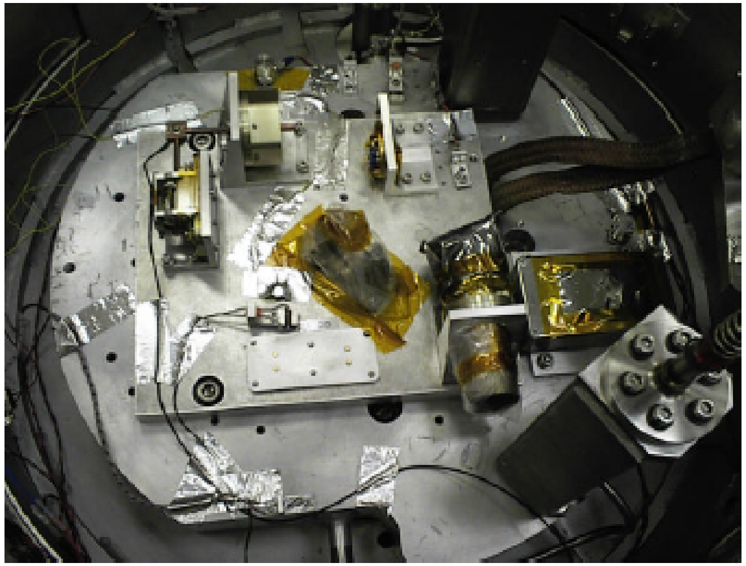
Signal Conditioners: Endevco 2775A
Calibrated on: September 2002

4) CLEANLINESS

Approved cleanroom gloves to be worn when handling the test items.

5) FIXTURE DETAILS

FIXTURE CONFIGURATION



A view of the test items mounted on their vibration fixture. The control strategy implemented involved taking the average response from the two accelerometers attached to the fixture.

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6) TEST SUMMARY

Test Dates: 23 March 2004 to 25 March 2004

Observers: Dr. Peter Hargrave and Facility Staff

Organisation : Cardiff University

CHANNEL ALLOCATION:

CONTROL:-

Channel No.	Accelerometer Type/Serial No.	Testing Axis	Mounting Position
1	Endevco A66B	N/A	Fixture
2	Endevco YG32	N/A	Fixture

MONITORING:-

Channel No.	Accelerometer Type/Serial No.	Testing Axis	Mounting Position
3	B&K 1434587	N/A	300mK Busbar

NOTE

Accelerometer B&K 1434587 was an uncalibrated unit, which was not specified to have a working temperature range at the low temperatures it would be subjected too. As such the data collected should only be viewed as an indication of frequency response. The amplitude data has no relevance.

ACTION	DATE	TIME
Pumpdown Started	23/03/04	16:45
Cooldown Started	23/03/04	21:30
Cold Vib. Testing	24/03/04	11:30
Start Warm Up	24/03/04	12:00
Ambient Testing	25/03/04	08:40
Test Item Removed	25/03/04	11:00

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ACCELEROMETER TEST PLOTS

ATMOSPHERIC/AMBIENT TEST CONDITIONS 23/03/04

RUN 00002 SINE SURVEY *FIG 1*

COLD TEST CONDITIONS 24/03/04

RUN 00003 SINE SURVEY *FIG 2*

RUN 00001 RANDOM *FIG 3*

RUN 00005 SINE SURVEY *FIG 4*

ATMOSPHERIC/AMBIENT TEST CONDITIONS 25/03/04

RUN 00006 SINE SURVEY *FIG 5*

7) CONCLUSION

The test items were subjected to the Spire Qualification levels of vibration. On inspection, post vibration testing, it was discovered that 3 of the 4 fasteners securing the photometer support to the fixture were loose. These had been torqued too 0.2 NM prior to testing.

A visual inspection revealed no further problems with any other components.

FACILITY OPERATOR: -

Digitally signed by
Dave Rippington
Date: 2004.04.22
15:28:12 +01'00'

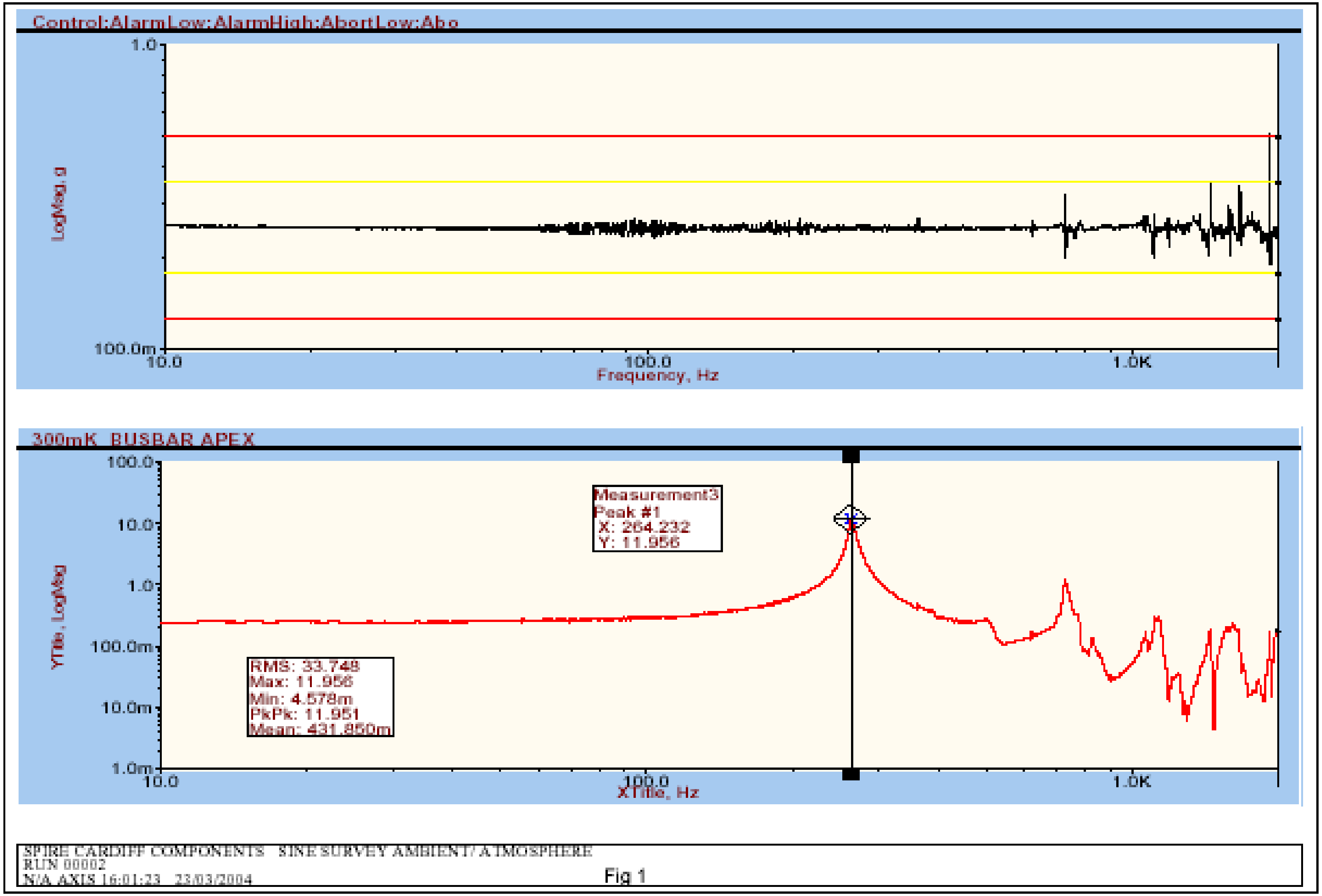
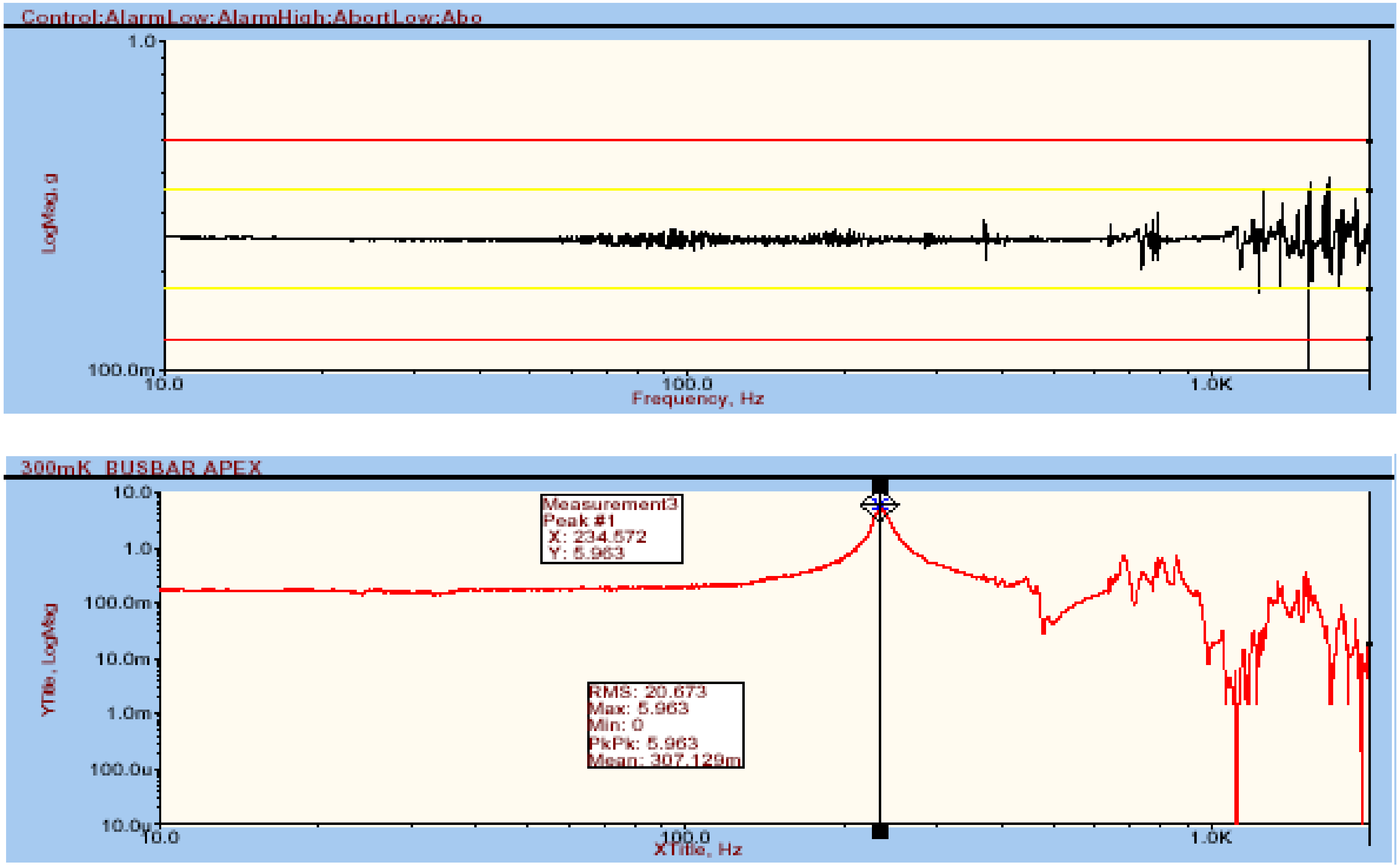
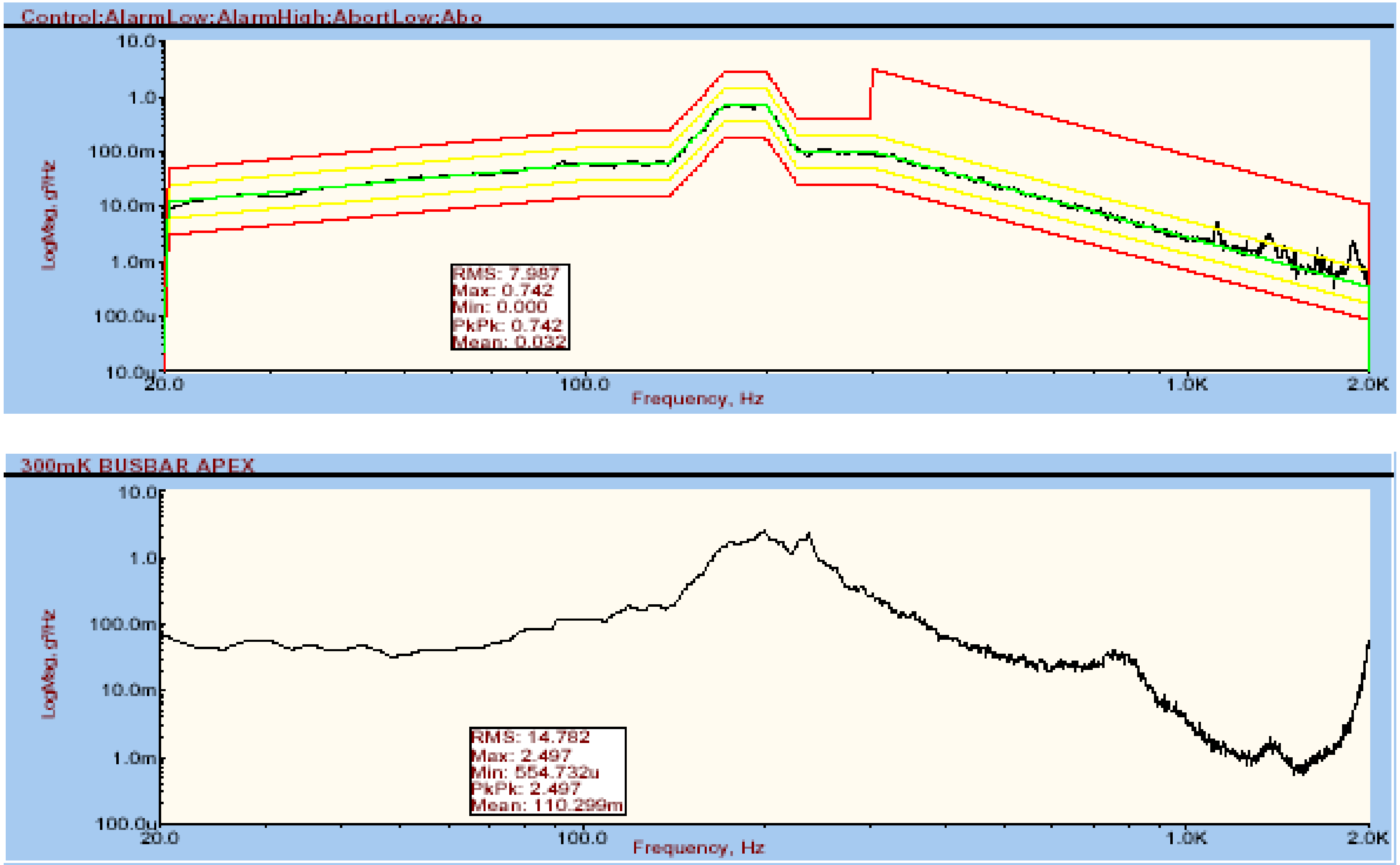

Control:AlarmLow:AlarmHigh:AbortLow:Abo
1.0
100.0m
LogMag, g
10.0
100.0
1.0K
Frequency, Hz
300mK BUSBAR APEX
100.0
10.0
1.0
100.0m
10.0m
1.0m
YTitle, LogMag
Measurement3
Peak #1
X: 264.232
Y: 11.956
RMS: 33.748
Max: 11.956
Min: 4.578m
PkPk: 11.951
Mean: 431.850m
XTitle, Hz
SPIRE CARDIFF COMPONENTS SINE SURVEY AMBIENT/ ATMOSPHERE
RUN 00002
N/A AXIS 16:01:23 23/03/2004

Fig 1



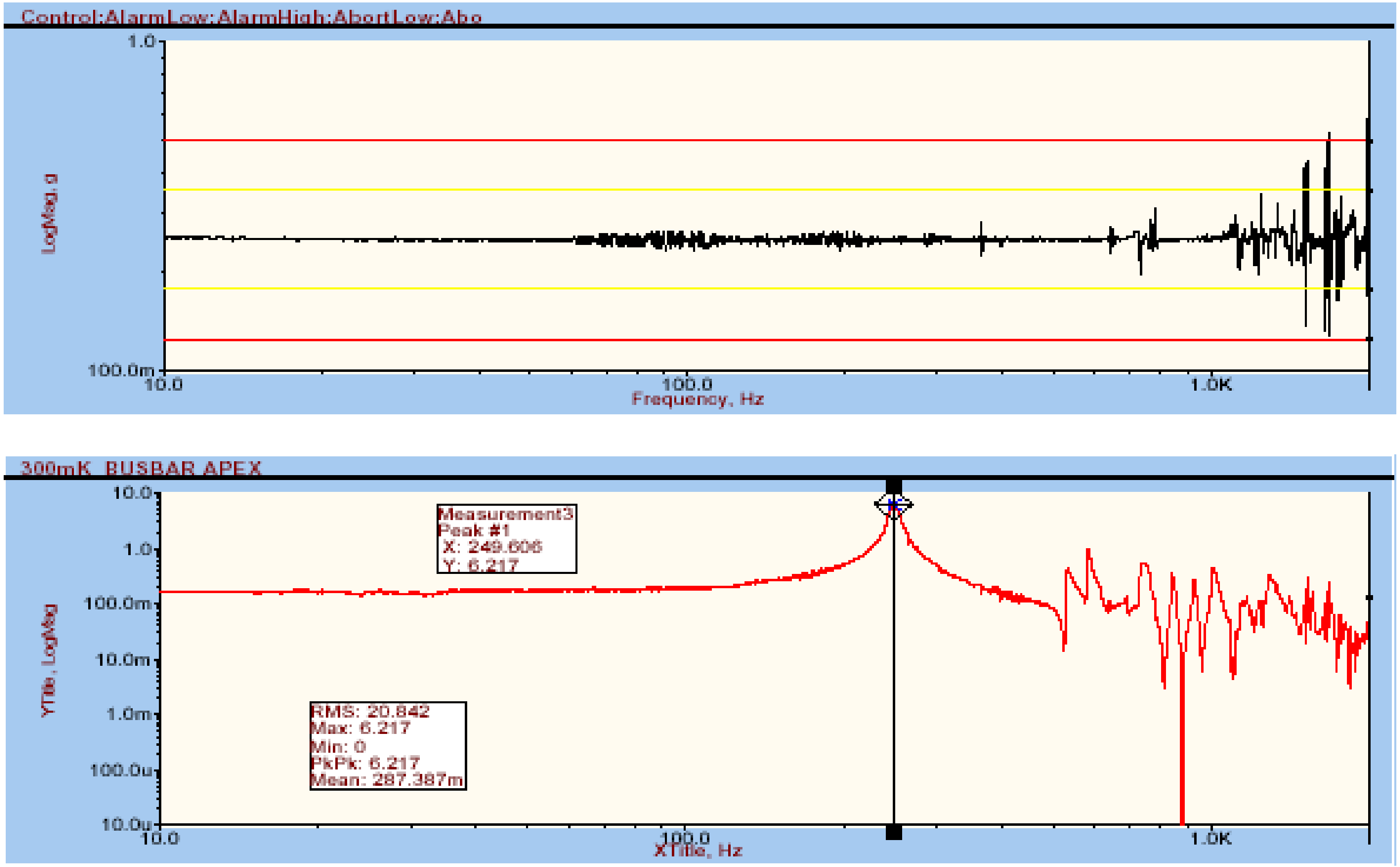
SPIRE CARDIFF COMPONENTS SINE SURVEY 7 Kelvin 5.8E-6mBAR
RUN 00003
N/A AXIS 11:37:40 24/03/2004

Fig 2



SPIRE CARDIFF COMPONENTS RANDOM 7 KELVIN @ 5.6e-6mBAR
RUN 00001
N/A AXIS 11:46:44 24/03/2004

Fig 3



SPIRE CARDIFF COMPONENTS POST RANDOM SINE SURVEY 7 Kelvin 5.8E-6mBAR
RUN 00005
N/A AXIS 11:55:48 24/03/2004

Fig 4

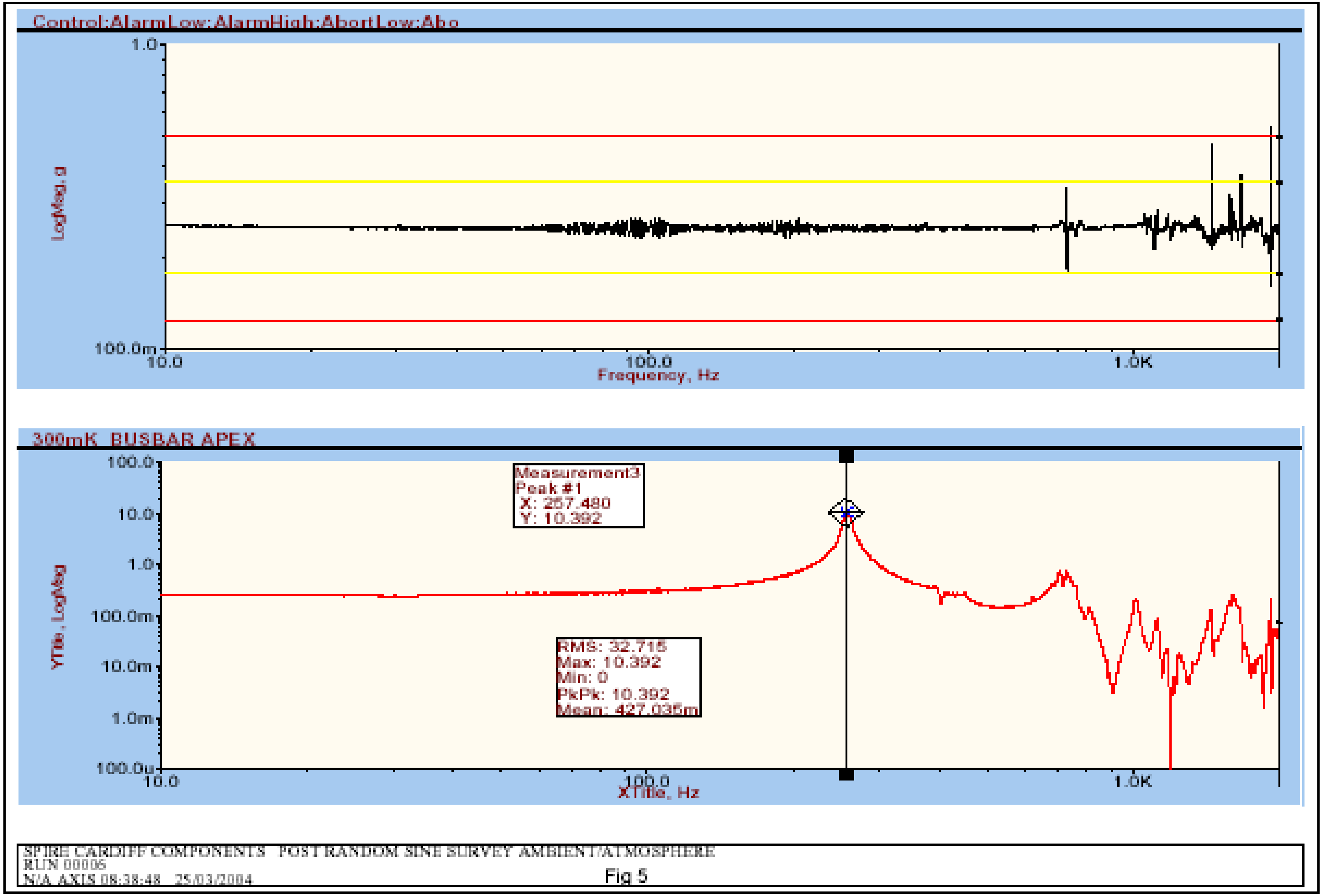
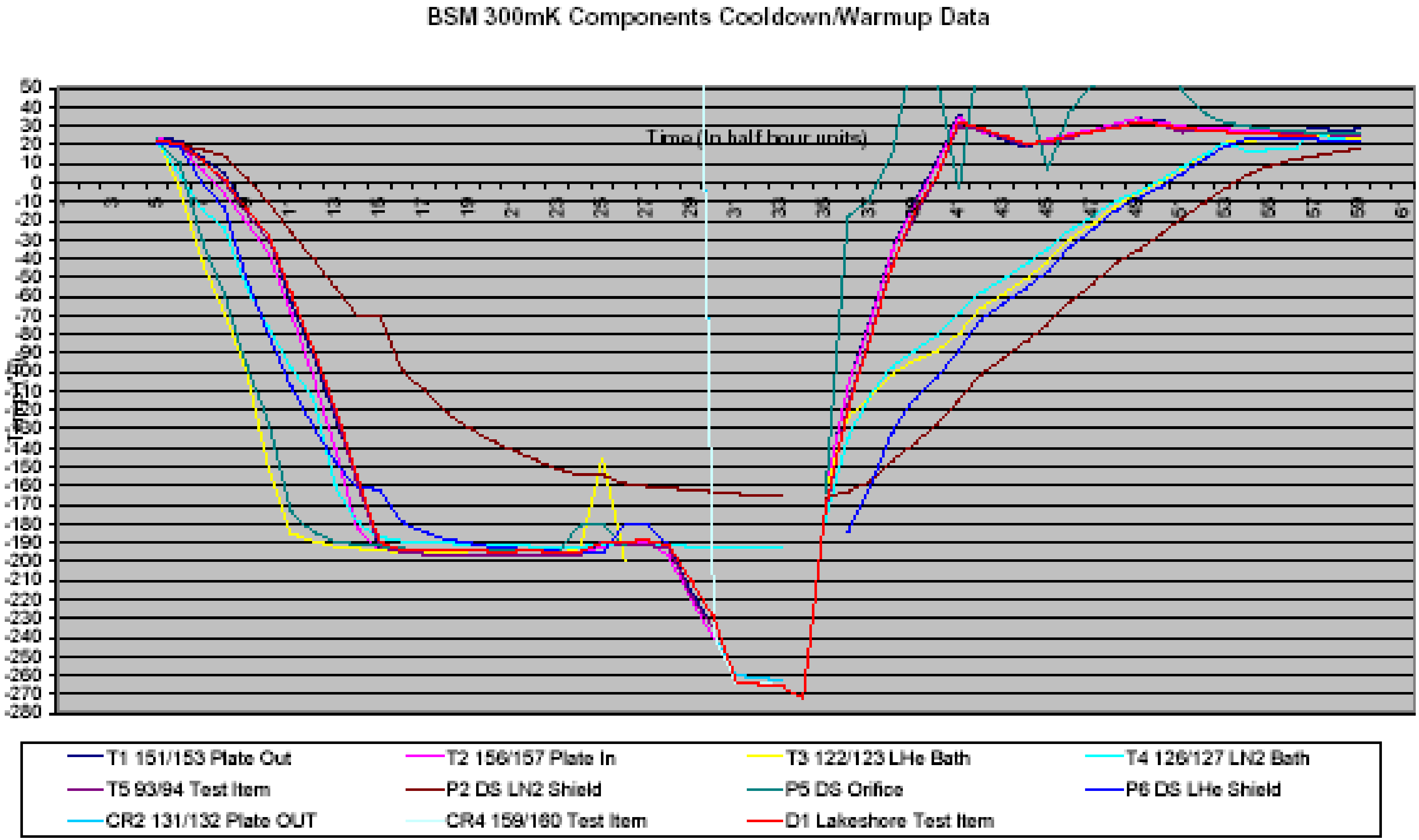

Control:AlarmLow:AlarmHigh:AbortLow:Abo
1.0
100.0m
10.0
100.0
1.0K
Frequency, Hz
LogMag, g
300mK BUSBAR APEX
Measurement3
Peak #1
X: 257.480
Y: 10.392
RMS: 32.715
Max: 10.392
Min: 0
PkPk: 10.392
Mean: 427.035m
100.0
10.0
1.0
100.0m
10.0m
1.0m
100.0u
XTitle, Hz
YTitle, LogMag
SPIRE CARDIFF COMPONENTS POST RANDOM SINE SURVEY AMBIENT/ATMOSPHERE
RUN 00006
N/A AXIS 08:38:48 25/03/2004

Fig 5


BSM 300mK Components Cooldown/Warmup Data
Time (In half hour units)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
-230
-240
-250
-260
-270
-280
T1 151/153 Plate Out
T2 156/157 Plate In
T3 122/123 LHe Bath
T4 126/127 LN2 Bath
T5 93/94 Test Item
P2 DS LN2 Shield
P5 DS Orifice
P6 DS LHe Shield
CR2 131/132 Plate OUT
CR4 159/160 Test Item
D1 Lakeshore Test Item

End of document