



SPIRE - 300mK Spectrometer Filters - PFM

End Item Data Package (EIDP)

SPIRE - 300mK Spectrometer Filters - PFM

SPIRE Ref.: SPIRE-UCF-DOC-002184

Cardiff Ref.: HSO-CDF-EIDP-055 Issue 1.0

10 October 2003

Prepared by: Peter Hargrave

Approved by:

Distribution list

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SECTION 01 - Shipping Documents

| | | |
|---|--|--------------|
| \\Darkstar\Astroworld\Projects\Spire\Cardiff_workpackages\Deliverables\Shipped\Filters\PFM-300mK-filters\PFM-300mK-spec-EIDP\300mK_spec_filt_PFM_HSO-CDF-EIDP-055.doc | SPIRE - 300mK Spectrometer Filters - PFM End Item Data Package (EIDP) | Page 6 of 46 |
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SECTION 02 - Transportation, Packing, Handling & Integration Procedures

**This package contains flight hardware.
To be opened only by authorised SPIRE personnel in clean room conditions.**

Do not touch filter surface.

Handle only by Aluminium frame.

To be integrated to SPIRE CQM PLW BDA according to JPL procedure.

Hand over to JPL Cognisant Engineer – Mark Weilert

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SECTION 03 - Certificate of Conformance

| | | |
|--|--|-------------------------|
| <i>Cardiff University Astronomy Instrumentation Group hereby certifies that the following equipment,</i> | | |
| Spacecraft / Project: | Herschel | |
| Instrument: | SPIRE | |
| Model: | PFM | |
| Subsystem: | 300mK SLW and SSW filter stacks | |
| Serial No: | FILT-PFM-210, FILT-PFM-220 | |
| <i>As described in this End Item Data Package:</i> HSO-CDF-EIDP-055 | | |
| <i>Complies with the requirements set out in:</i> SPIRE-RAL-PRJ-000034 | | |
| | | |
| <i>Responsible Authority</i> | | <i>Signature</i> |
| Cardiff Filter Management | Prof P.A.R.Ade | |
| | Dr C.E.Tucker | |
| Cardiff Product Assurance | Dr I.Walker | |
| Cardiff SPIRE Management | Dr P.Hargrave | |

SECTION 04 - Qualification Status List / Compliance Matrix

| Test | Status | | Test Institute |
|---|--|--|----------------|
| | PFM-SLW FILT-PFM-210 | PFM-SSW FILT-PFM-220 | |
| Spectral behaviour - Near-band transmission | Tested at component level. Compliant. | Tested at component and assembly level. Compliant. | UWC |
| Spectral behaviour - out-of-band blocking, at $\lambda < 15\mu\text{m}$ | Open test. Off-cuts to be tested once facility commissioned | Open test. Off-cuts to be tested once facility commissioned | UWC |
| Dimension and tolerances to specification | Compliant | Compliant | UWC |
| Filter flatness | Compliant | Compliant | UWC |
| Inspection for surface defects | Passed | Passed | UWC |
| Mass | Compliant | Compliant | |
| Thermal cycling (5 cycles 300K-77K-300K) | Passed | Passed | UWC |
| Cold vibration | Not tested | Not tested | RAL |
| Environmental condition - Vacuum $3 \times 10^{-1} \text{mBar}$ | Passed | Passed | UWC |
| Differential pressure (a pumping-out rate of 10mB/sec) | Passed | Passed | UWC |
| Pre-bake out (not exceeding 80°C) | Passed | Passed | UWC |
| Outgassing | Test not performed. All materials used within ESA / NASA specifications | Test not performed. All materials used within ESA / NASA specifications | |
| Cleanliness checks, by visual inspection. | Passed | Passed | UWC |
| Degradation due to high energy radiation. | Not tested | Not tested | |

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

TOP LEVEL DRAWING LIST

| Drawing No. | Title |
|-------------------------|-----------------------|
| FILT-CQM/PFM-200-03.001 | 300mK Filter Assembly |
| | |
| | |
| | |
| | |
| | |
| | |

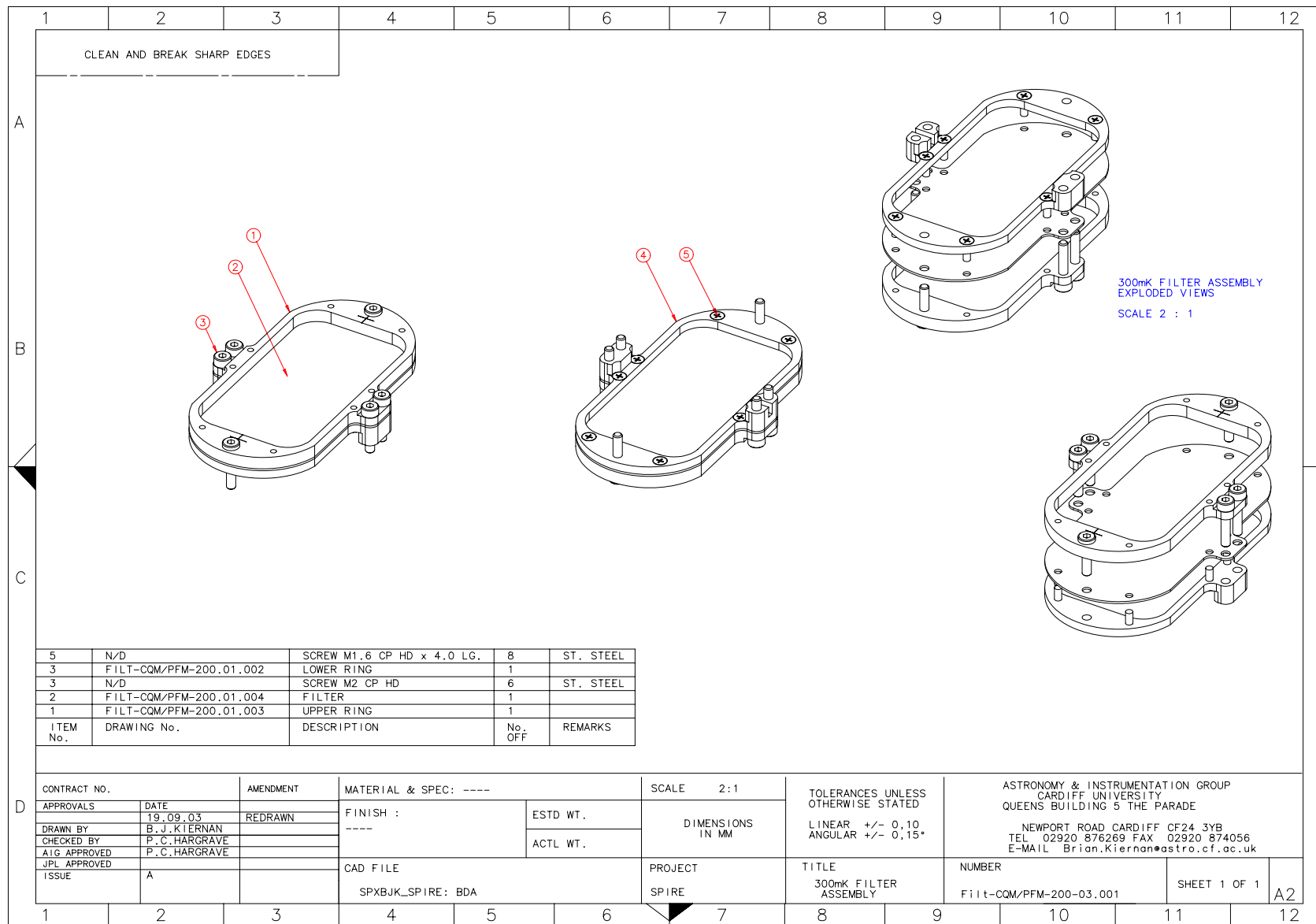


Figure 1 300mK filter stack assembly

SECTION 06 - Interface Drawings

INTERFACE DRAWING LIST

| Drawing No. | Title |
|------------------|------------------|
| FILT-CQM/PFM-200 | 300mK Filter ICD |
| | |
| | |
| | |
| | |
| | |
| | |

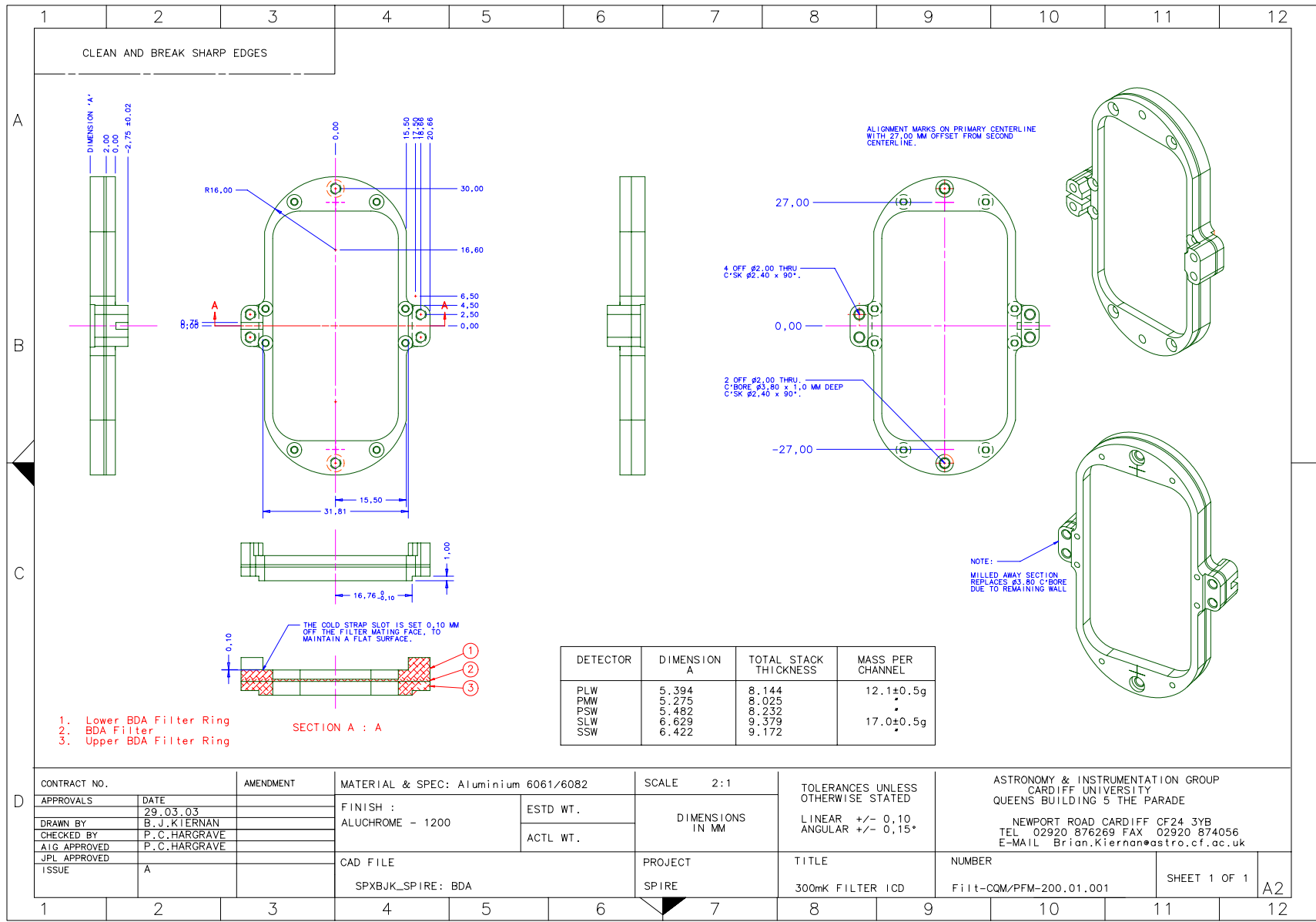


Figure 2 Interface drawing for 300mK filters

SECTION 07 - Functional, Block & Mechanical Drawings

Component drawings are given in this section. Also shown, for illustration purposes, are details of the mounting of the HDPE lens for each filter stack assembly.

FUNCTIONAL & BLOCK DRAWING LIST

| Drawing No. | Title |
|-------------|-------|
| | |
| | |
| | |
| | |
| | |
| | |
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MECHANICAL COMPONENT DRAWING LIST

| Drawing No. | Title |
|-------------------------|-------------------------|
| FILT-CQM/PFM-200-01-004 | 300mK Filter |
| FILT-CQM/PFM-200-01-003 | 300mK Filter Upper Ring |
| FILT-CQM/PFM-200-01-002 | 300mK Filter Lower Ring |
| FILT-CQM/PFM-200-02-001 | 300mK Spectrometer Lens |
| | |
| | |
| | |

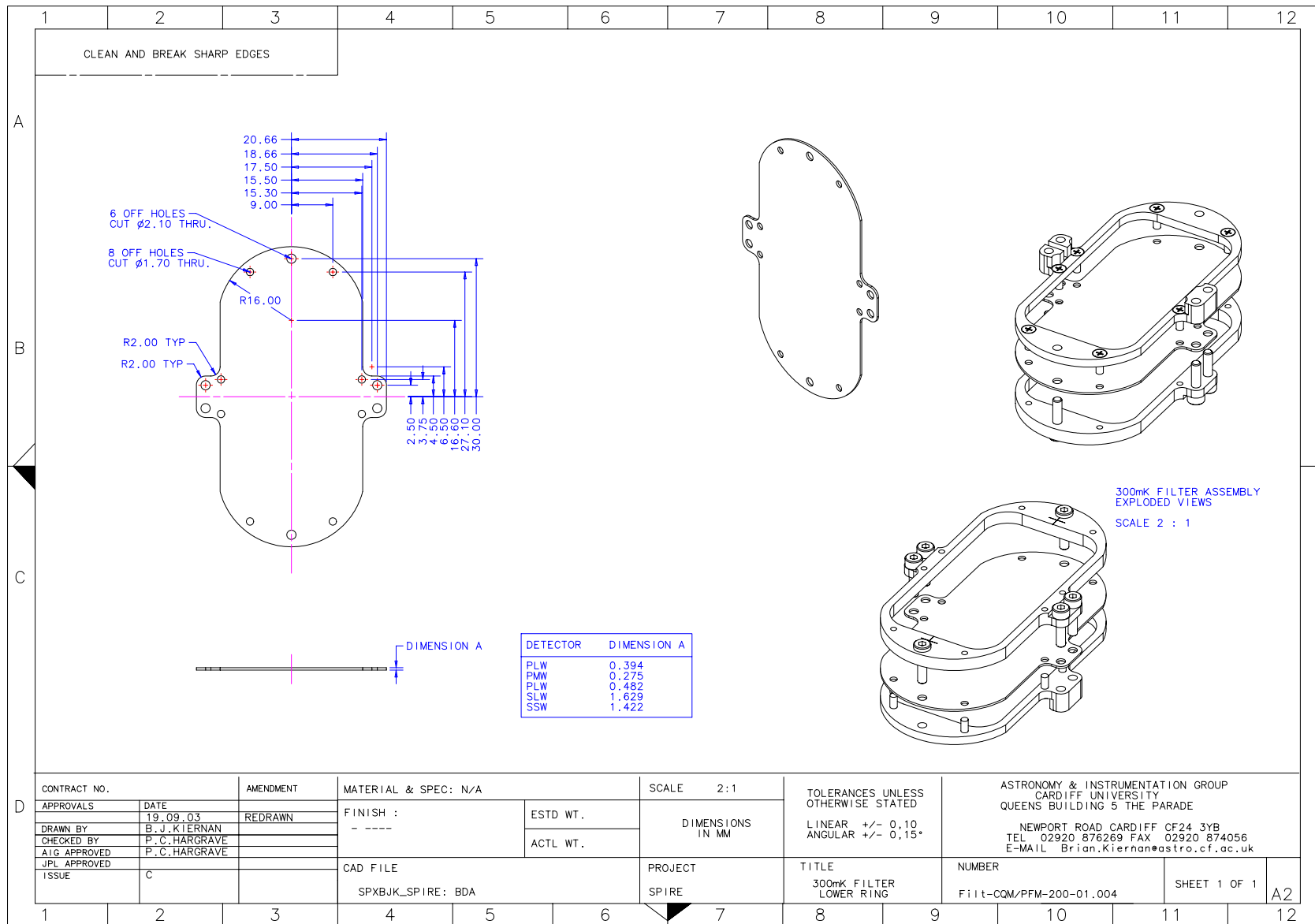


Figure 3 300mK Filter

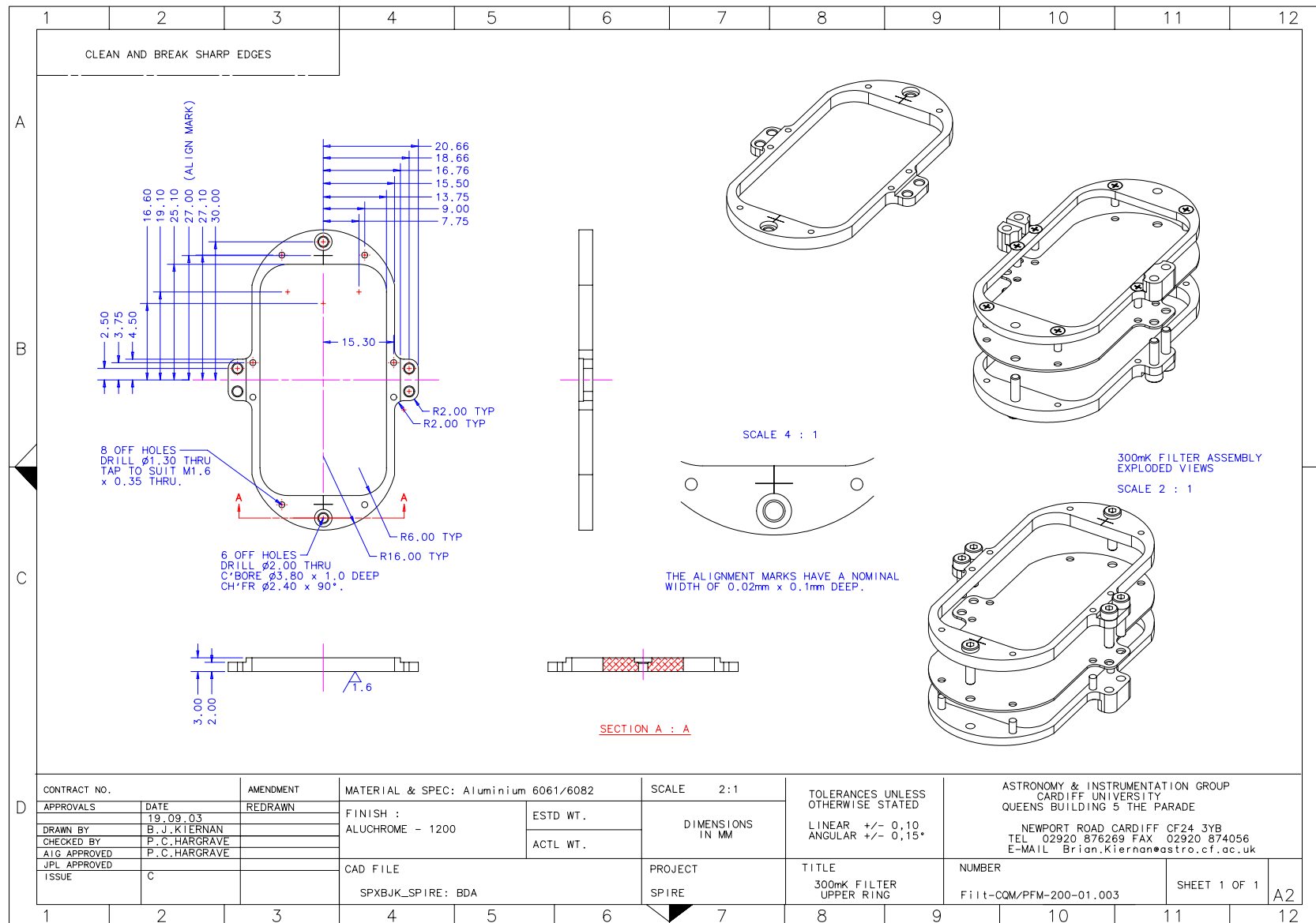


Figure 4 300mK Filter Upper Ring

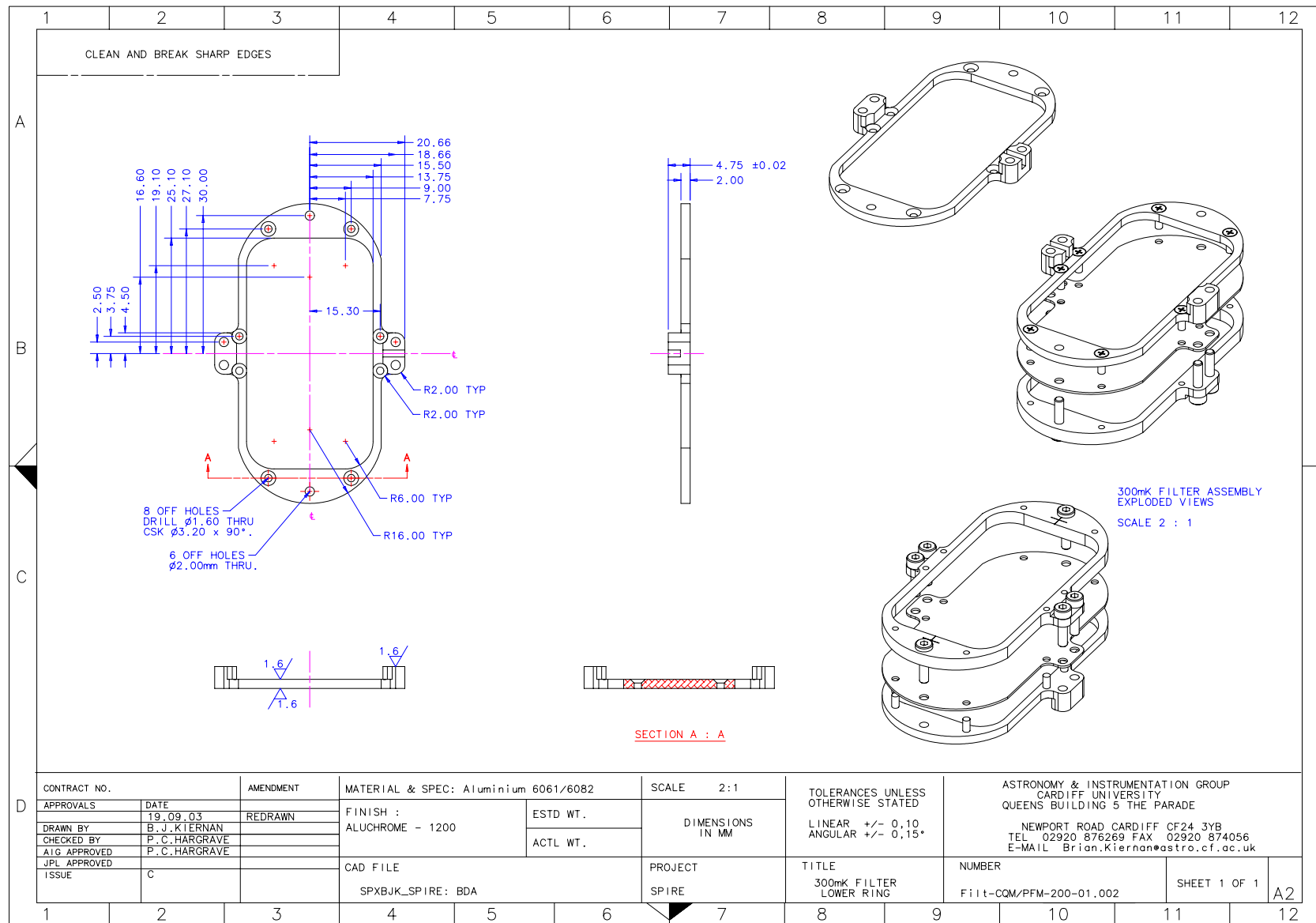


Figure 5 300mK Filter Lower Ring

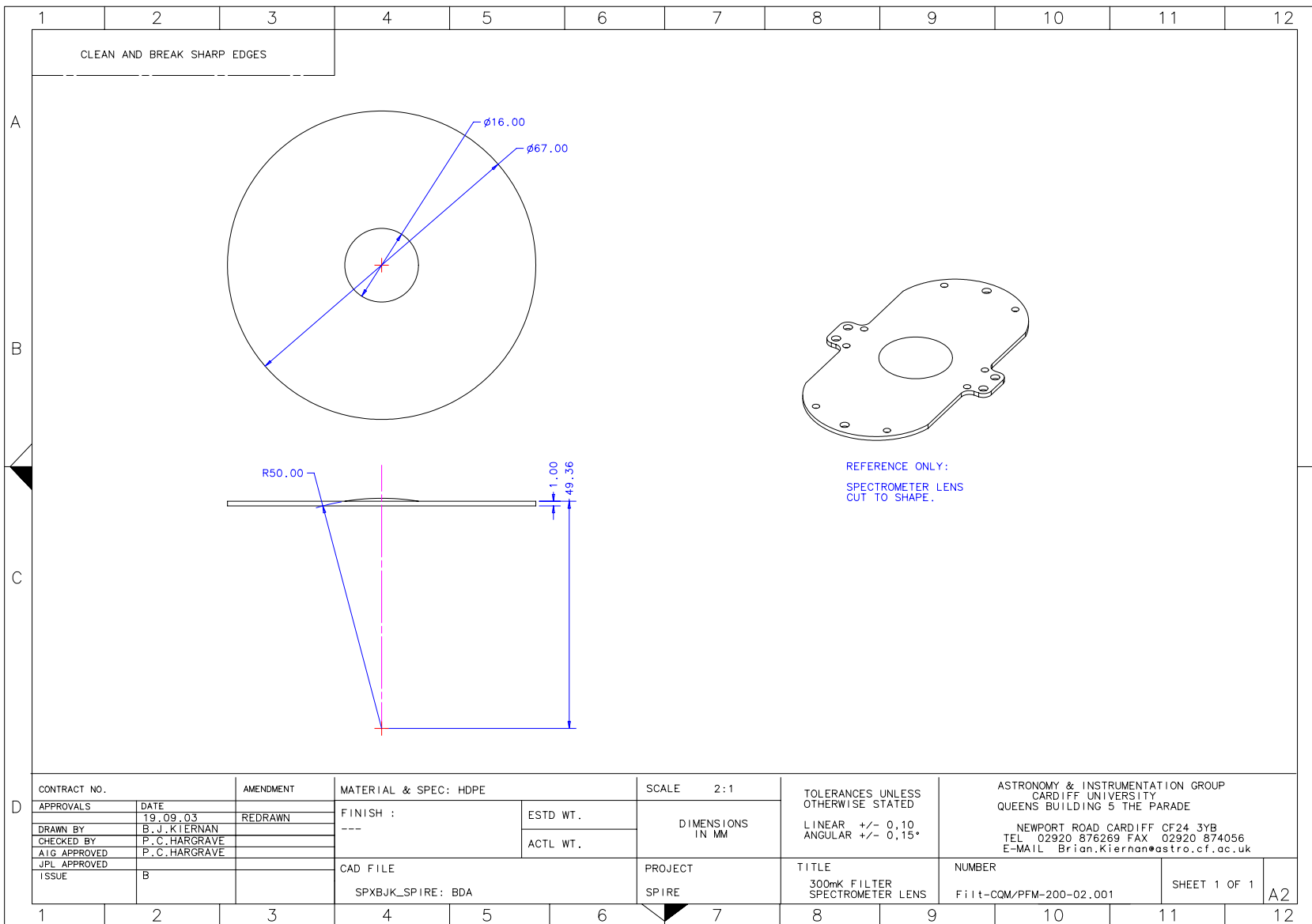


Figure 6 300mK Spectrometer lens

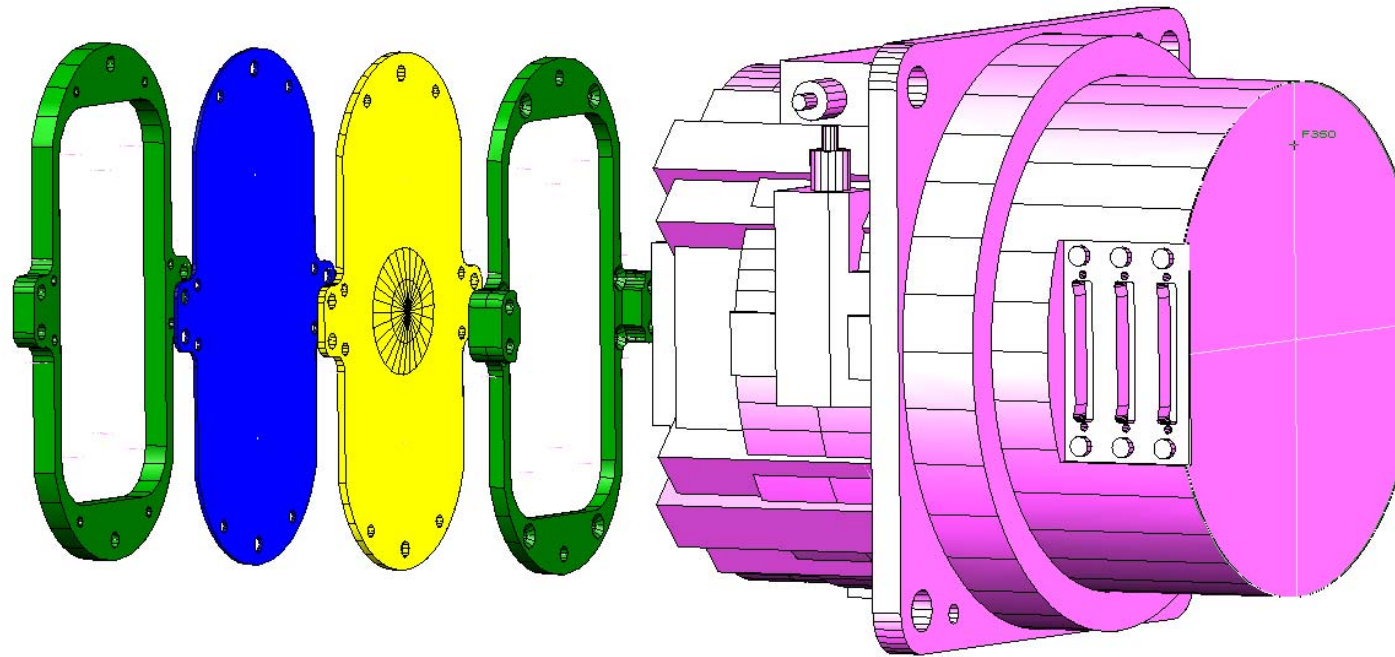


Figure 7 Location of spectrometer lens in 300-mK filter stack.

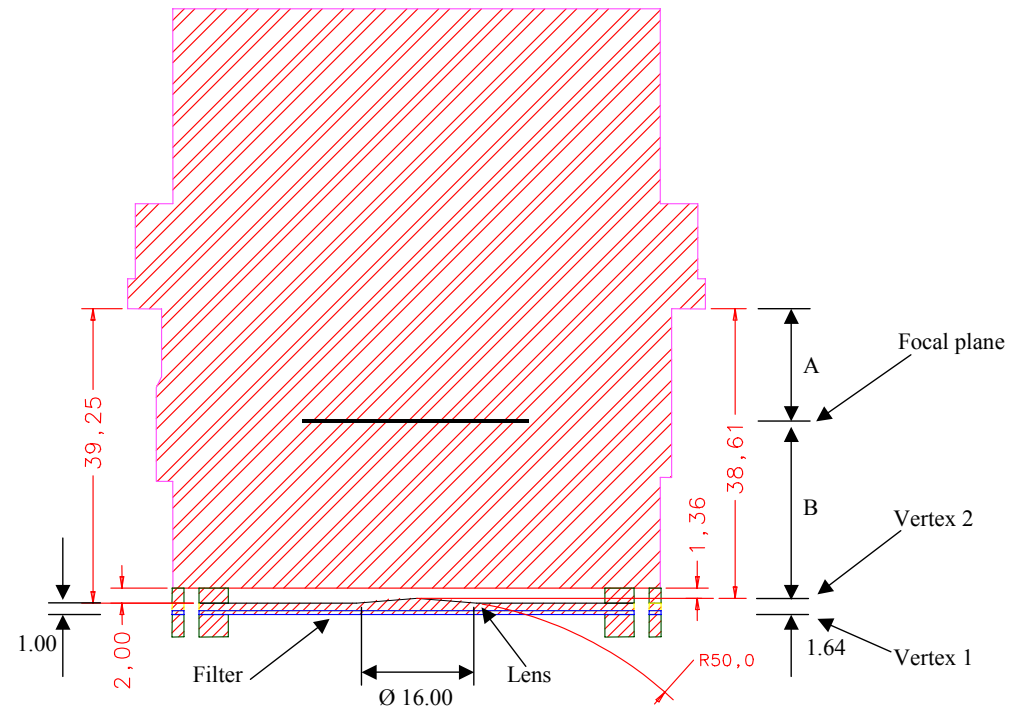


Figure 8 Dimensions of spectrometer lens – filter – detector assembly.

Table 1 Position of lens vertex and focal plane wrt detector mounting flange

| | SLW | SSW |
|---------------------------|------------|------------|
| A (cf JPL ICD 9 Nov 2001) | 36.9 | 26.7 |
| B = 38.61 - A | 1.71 | 11.91 |

SECTION 09 - As Built Configuration Items Status List

| Item | Reference | Location | Notes |
|--|-----------|--|-------|
| Filter drawings and manufacturing files | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Filters\Drawings\300MK-filter-CQM-PFM.doc | |
| Material certificates of conformance | | Available at Cardiff for inspection | |
| FILT-PFM-210 Spectroscopic test data SLW-PFM assembly | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\FILT-PFM-210_filterstack_August2003.xls | |
| FILT-PFM-214 Spectroscopic test data SLW-PFM SFIL4L | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\B488_43cm-1_SFIL4L_PFM.xls | |
| FILT-PFM-215 Spectroscopic test data SLW-PFM SFIL5L | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\B476_33.3cm-1_SFIL5L_PFM.xls | |
| FILT-PFM-220 Spectroscopic test data SSW-PFM assembly | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\FILT-PFM-220_SSW_assembly_October2003.xls | |
| FILT-PFM-223 Spectroscopic test data SLW-PFM lens material | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\FILT-PFM-223_SSW_HDPE_October2003.xls | |
| FILT-PFM-224 Spectroscopic test data | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\Issued\Data\FILT-PFM-224_SSW_SFIL4S_October2003.xls | |

| | | | |
|--|--|---|--|
| SLW-PFM SFIL4S | | | |
| FILT-PFM-225 Spectroscopic test data SLW-PFM SFIL5S | | \\Darkstar\Astroworld\Projects\SPIRE\Cardiff_workpackages\Configured_documents\ Issued\ Data\FILT-PFM-225_SSW_SFIL5S_October2003.xls | |
| | | | |

| Part number | Description | Details |
|---------------------|--------------------------------|--|
| FILT-PFM-220 | PFM SSW FILTER ASSEMBLY | |
| FILT-PFM-221 | SSW PFM lower filter ring | Aluminium-6082 – Aluchrom 1200 coated |
| FILT-PFM-222 | SSW-PFM upper filter ring | Aluminium-6082 – Aluchrom 1200 coated |
| FILT-PFM-223 | SSW PFM lens | HDPE lens |
| FILT-PFM-224 | SFIL4S – PFM – B679 filter | 60cm ⁻¹ LPE blocking filter |
| FILT-PFM-225 | SFIL5S – PFM – B650 filter | 52.6cm ⁻¹ LPE band defining edge filter |
| FILT-PFM-210 | PFM SLW FILTER ASSEMBLY | |
| FILT-PFM-211 | SLW PFM lower filter ring | Aluminium-6082 – Aluchrom 1200 coated |
| FILT-PFM-212 | SLW-PFM upper filter ring | Aluminium-6082 – Aluchrom 1200 coated |
| FILT-PFM-213 | SLW PFM lens | HDPE lens |
| FILT-PFM-214 | SFIL4L – PFM – B488 filter | 43cm ⁻¹ LPE blocking filter |
| FILT-PFM-215 | SFIL5L – PFM – B476 filter | 33.4cm ⁻¹ LPE band defining edge filter |
| | | |
| | | |

SECTION 11 - List of Waivers

SECTION 12 - Copies of Waivers

SECTION 13 - Operations Manual

SECTION 14 - Historical Record

The following table contains *brief* historical details of the manufacture, assembly and testing of the PFM 300mK spectrometer filter set, including the levels of environmental cleanliness.

A *full* historical record of every stage of manufacture for each individual grid integral to the final mounted filter is traceable at UWC, in both hard copy log-book format and on a Microsoft Access database.

Filter SFIL4L

| Date | Action | UWC Test reference |
|----------|--|--------------------|
| 8/7/02 | Filter B488 manufactured in class 1000 clean room | |
| 11/7/02 | Filter B488 spectroscopically tested in the range 3-40cm ⁻¹ | T0013ra |
| 14/7/02 | Filter B488 spectroscopically tested in the range 20-650cm ⁻¹ | S2569ra |
| 06/08/03 | Filter B488 cut to SFIL4L drawing | Process HC1 |
| 06/08/03 | Filter B488 spectroscopically tested in the range 0-145cm ⁻¹ at two locations over area | T0148r16, T0148R19 |
| 06/08/03 | Filter B488 thermally shocked 5 times between 77K and 350K | |
| 06/08/03 | Filter B488 spectroscopically tested in the range 0-145cm ⁻¹ at two locations over area | T0148R31, T0148R34 |
| 06/08/03 | Filter B488 cleaned & baked for 12 Hrs at 350K | |
| 07/08/03 | Filter B488 mounted in PFM-SLW stack | |
| 07/08/03 | PFM-SLW stack final clean, 12Hr bake-out | |
| 08/08/03 | PFM-SLW shipped to JPL | |

Filter SFIL5L

| Date | Action | UWC Test reference |
|----------|--|--------------------|
| 6/6/02 | Filter B476 manufactured in class 1000 clean room | |
| 19/6/02 | Filter B476 spectroscopically tested in the range 20-650cm ⁻¹ | S2583r4 |
| 26/6/02 | Filter B476 spectroscopically tested in the range 3-40cm ⁻¹ | S2584r7 |
| 16/7/02 | Filter B476 spectroscopically tested for uniformity in the range 4-40cm ⁻¹ | T0015ra |
| 06/08/03 | Filter B476 cut to SFIL5L drawing | Process HC1 |
| 06/08/03 | Filter B476 spectroscopically tested in the range 0-145cm ⁻¹ at two locations over area | T0148R25, T0148R28 |
| 06/08/03 | Filter B476 thermally shocked 5 times between 77K and 350K | |
| 06/08/03 | Filter B476 spectroscopically tested in the range 0-145cm ⁻¹ at two locations over area | T0148R37, T0148R40 |
| 06/08/03 | Filter B476 cleaned & baked for 12 Hrs at 350K | |
| 07/08/03 | Filter B476 mounted in PFM-SLW stack | |

| | | |
|----------|--|--|
| 07/08/03 | PFM-SLW stack final clean, 12Hr bake-out | |
| 08/08/03 | PFM-SLW shipped to JPL | |

SLW-PFM Lens

| Date | Action | UWC Test reference |
|----------|---|---|
| 13/08/02 | HDPE material purchased from Goodfellow Cambridge LTD | Cat.# ET327980, order ref. LS241088/S K |
| 16/10/02 | Lens blanks embossed by Cardiff MEC centre, School of Engineering | Inspection report Q2217 |
| 06/08/03 | Lens cut to size | Process HC1 |
| 06/08/03 | SLW-PFM lens thermally shocked 5 times between 77K and 350K | |
| 06/08/03 | SLW-PFM lens cleaned & baked for 12 Hrs at 350K | |
| 07/08/03 | SLW-PFM lens mounted in PFM-SLW stack | |
| 07/08/03 | PFM-SLW stack final clean, 12Hr bake-out | |
| 08/08/03 | PFM-SLW shipped to JPL | |
| | | |
| | | |

Filter SFIL4S

| Date | Action | UWC Test reference |
|----------|--|------------------------------|
| 4/7/03 | Filter B650 manufactured in class 1000 clean room | |
| 8/7/03 | Filter B650 spectroscopically tested in the range 10-145cm ⁻¹ | S2676r7 |
| 9/7/03 | Filter B650 spectroscopically tested in the range 3-40cm ⁻¹ | T0118r7 |
| 24/7/03 | Filter B650 thermally cycled 2 x [300K-77K-300K) | |
| 9/9/03 | Filter B650 repressed | |
| 10/9/03 | Filter B650 spectroscopically tested in the range 3-40cm ⁻¹ | T0174r12 |
| 11/9/03 | Filter B650 spectroscopically tested in the range 15-140cm ⁻¹ | T0175r7 |
| 13/10/03 | Filter B650 cut to SFIL4S drawing | Process MC1 |
| 14/10/03 | SFIL4S spectroscopically tested for uniformity in the range 10-145cm ⁻¹ – Three locations over area | T0199r13, T0199r28, T0199r31 |
| 14/10/03 | SFIL4S mounted into 300mK SSW-PFM filter assembly | |
| | | |
| | | |

Filter SFIL5S

| Date | Action | UWC Test reference |
|----------|--|---------------------------------|
| 8/8/03 | Filter B679 manufactured in class 1000 clean room | |
| 11/8/03 | Filter B679 spectroscopically tested in the range 10-145cm ⁻¹ | T0150r7 |
| 11/8/03 | Filter B679 thermally cycled 5 x [300K-77K-300K] | Therm0031 |
| 11/8/03 | Filter B679 spectroscopically tested in the range 3-40cm ⁻¹ | T0150r13 |
| 13/10/03 | Filter B679 cut to SFIL5S drawing | |
| 14/10/03 | SFIL5S spectroscopically tested for uniformity in the range 10-145cm ⁻¹ | T0199r16, T0199r19, T0199r22 |
| 14/10/03 | SFIL5S mounted into 300mK SSW-PFM filter assembly | |
| | | |

SSW PFM filter stack assembly

| Date | Action | UWC Test reference |
|-----------|--|----------------------------|
| 14/10/03 | HDPE SSW lens material spectroscopically tested in the range 10-145cm ⁻¹ | T0199r4, T0200r13 |
| 14/10/03 | Filters B650, B679 and lens mounted into SSW-PFM assembly. | |
| 14/10/003 | SSW-PFM filter stack measured on clean room CMM | |
| 14/10/03 | SSW-PFM filter stack thermally shocked 2 times between 77K and 350K while mounted on invar BDA replica | |
| 14/10/003 | SSW-PFM filter stack re-measured on clean room CMM | |
| 15/10/03 | SSW-PFM stack assembly spectroscopically tested for uniformity in the range 10-145cm ⁻¹ | T0200r4, T0200r7, T0200r13 |
| 15/10/03 | Final cleaning, followed by 8Hr bakeout (350K) | |
| 15/10/03 | PFM-SSW assembly shipped to JPL | |
| | | |
| | | |
| | | |

SECTION 15 - Logbook / Diary of Events

Not provided – available from subsystem provider upon request.

SECTION 16 - Operating Time / Cycle Record

SECTION 20 - Calibration Data Record

The recommended total stack transmission for the SLW and SSW channels to be used for calibration purposes is indicated in this section.

Important notes on these data:-

- It was not possible to measure the transmission of the stack assemblies through the central area of the filter stacks, due to the presence of the lenses. The lenses would change the FTS beam and make background measurements impossible.
- For the SLW stack, the data shown in Figure 9 were calculated as follows:-
 - Measure the filter transmissions individually
 - Measure the HDPE lens material transmission through the 1.0mm thick planar areas
 - Combine these data to calculate the total transmission of the stack
- For the SSW stack, the data shown in Figure 10 were calculated as follows:-
 - Measure the filter transmissions individually
 - Measure the HDPE lens material transmission through the 1.0mm thick planar areas
 - Combine these data to calculate the total transmission of the stack (shown in red)
 - Measure the transmission of the stack, either side of the lens to verify the calculated transmission

PFM-SLW FILT-PFM-210 Stack Transmission

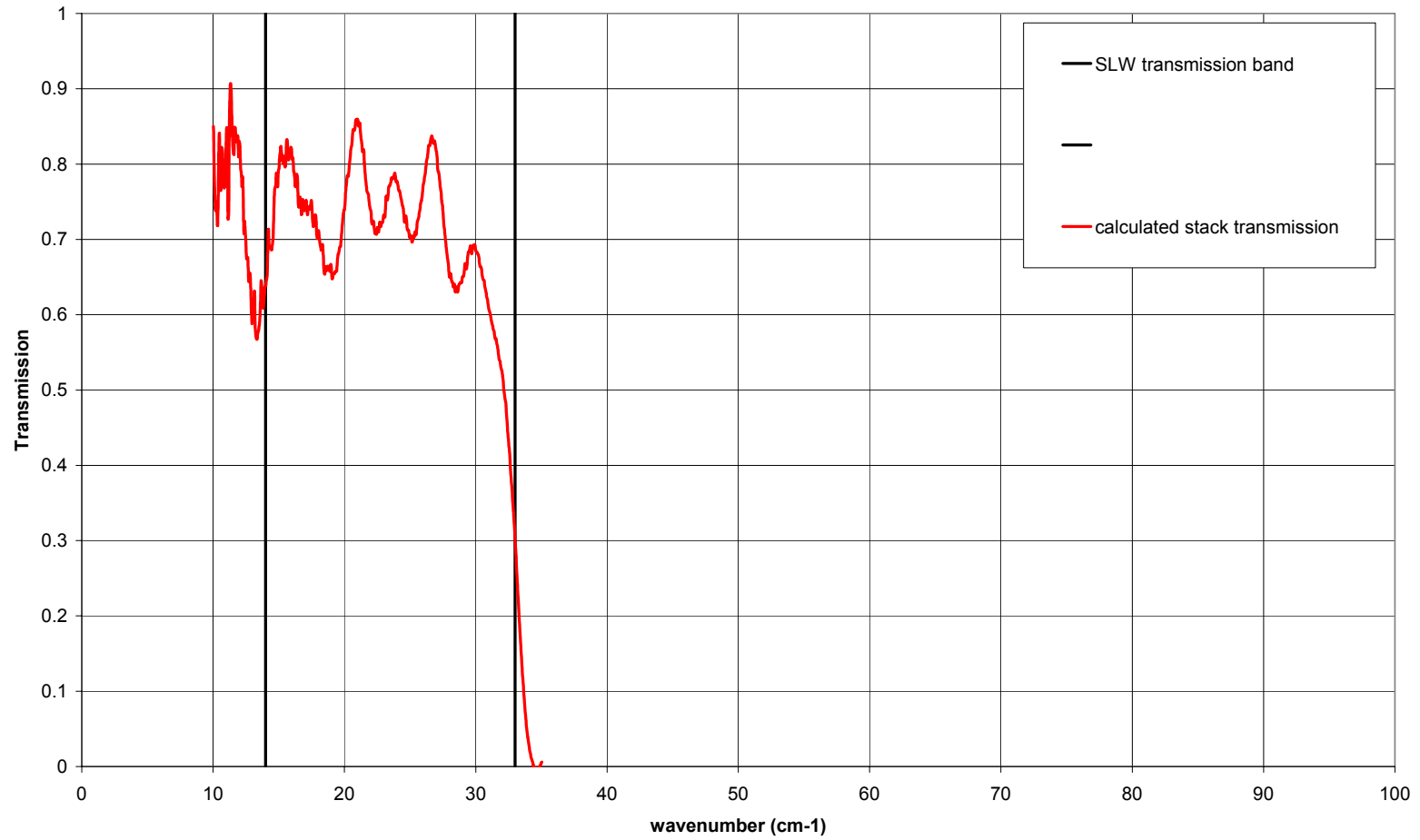


Figure 9 Spectroscopic data for PFM-SLW stack

PFM-SSW FILT-PFM-220 Stack Transmission

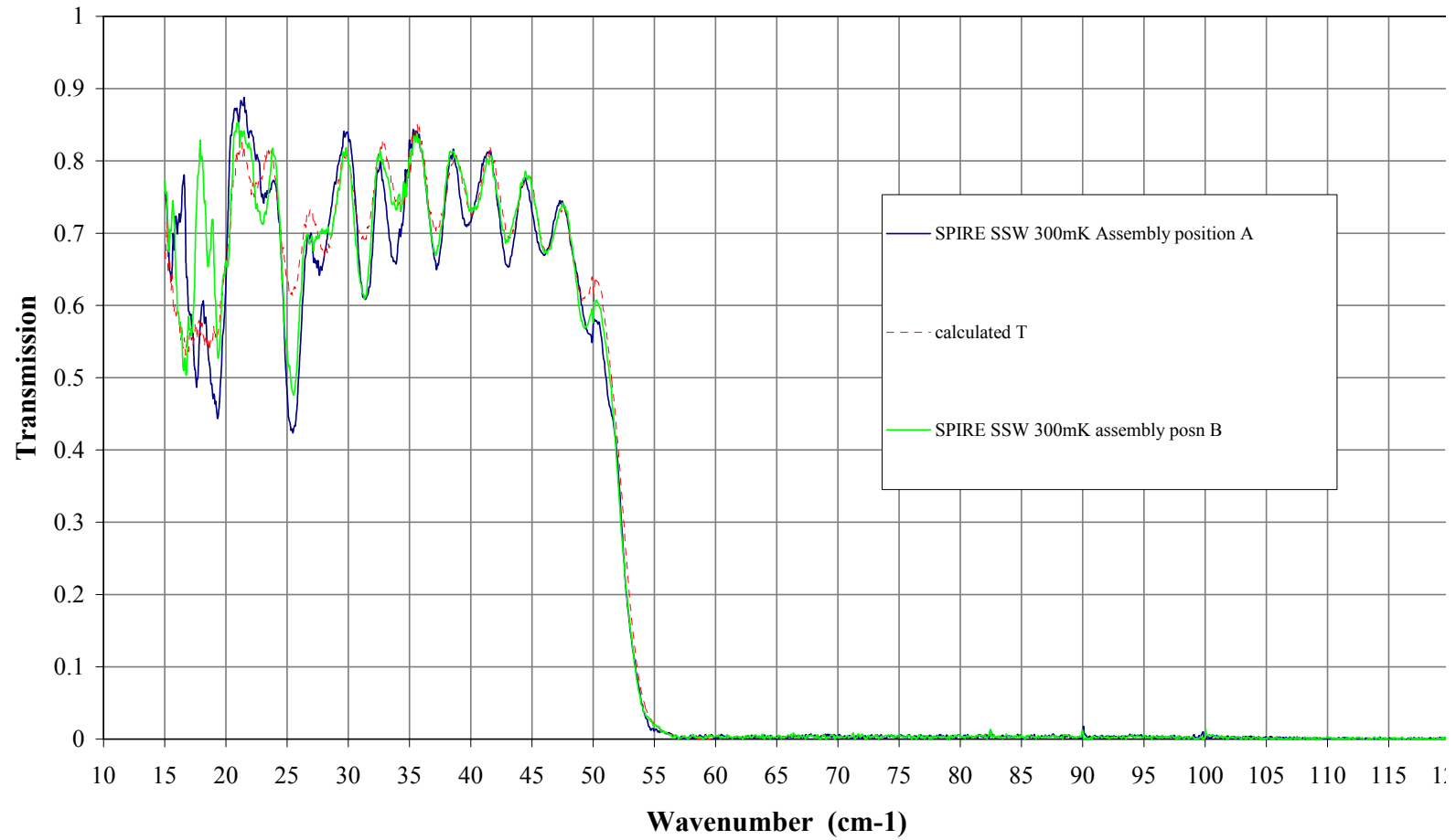


Figure 10 Spectroscopic data for PFM-SSW stack

SECTION 21 - Temporary Installation Record

e.g. in cryostats etc – refer to hist record – include fit checks

SECTION 22 - Open Work / Deferred Work / Open Tests

SECTION 23 - List of Non-Conformance Reports

SECTION 24 - Copies of Non-Conformance Reports

SECTION 25 - Test Reports

Each filter module (SLW and SSW assemblies) underwent the following series of qualification tests:-

- a) Post-manufacture spectroscopic measurements
- b) Thermal shocks of the filter material. This consists of between two and five cycles of:-
 - Plunge filter material at room temperature into bath of liquid nitrogen and leave for 2 minutes
 - Remove filter material from LN₂ and place in oven at 353K for 10 minutes
- c) Visual inspection
- d) Post-shock spectroscopic measurements
- e) Cutting to size
- f) Visual inspection
- g) Spectroscopic measurements of filter material at three points over the filter area
- h) Second thermal shock cycle – repeat of step (b)
- i) Visual inspection under microscope
- j) Spectroscopic measurements of filter material at three points over the filter area
- k) Mounting filter material in clamp assembly
- l) Spectroscopic measurements of mounted assembly
- m) Thermal shocks of filter assembly – repeat step (b)
- n) Final spectroscopic measurements of filter assembly – 3 points over filter area

Spectroscopic tests – index

Spectroscopic tests were carried out according to standard UWC FTS procedures. Refer to historical record for index.

Spectroscopic test details

- Uniformity checks:-
 - Filter components were checked for uniformity at three points along the filters long axis - at the centre of the filter, and at two points along the long axis, 16mm either side of the central point.
 - The FTS geometric beam footprint was approximately 7mm diameter.
 - The SSW stack transmission was measured at the two 16mm off-set points, but not through the centre point, for reasons discussed earlier (section 20)

PFM-SFIL4L

B488 Pre-Thermal Shocks

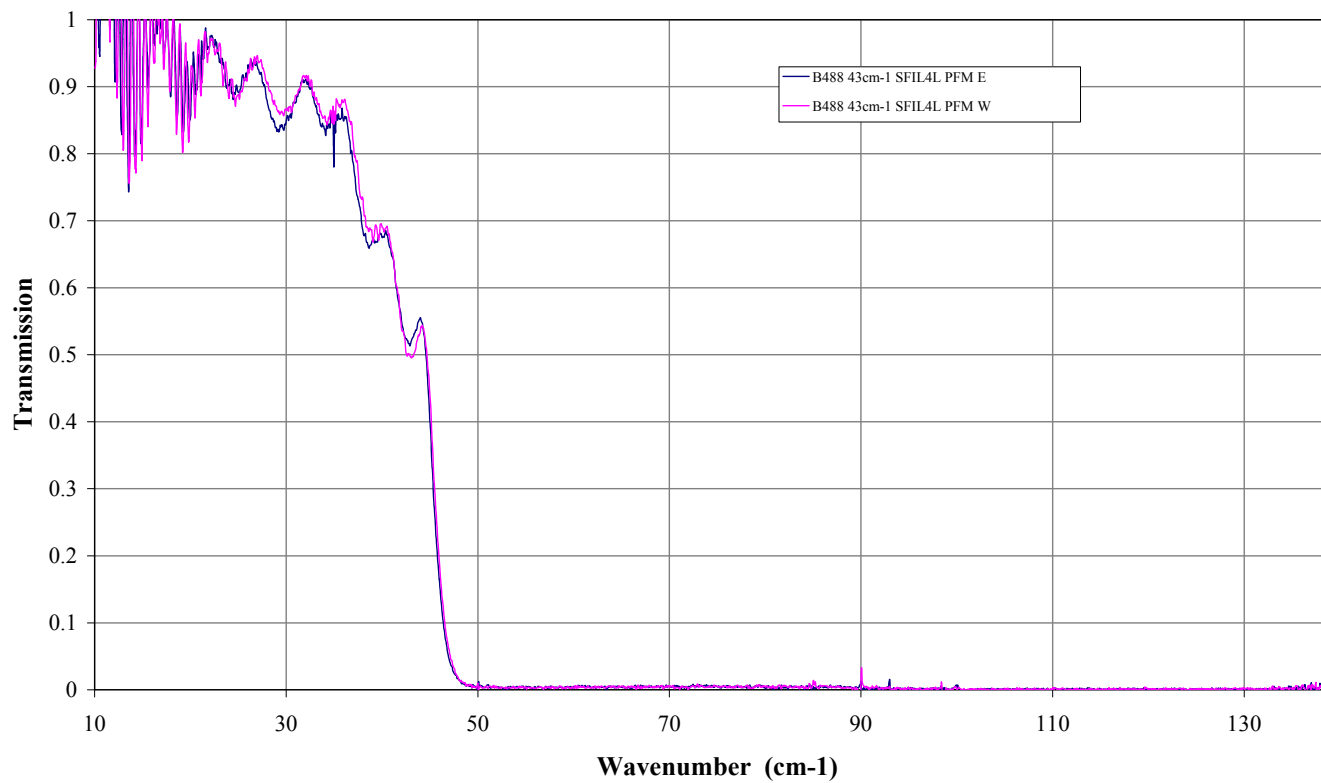


Figure 11 B488 SFIL4L FILT-PFM-214 pre-thermal shocking

B488 Post-Thermal Shocks

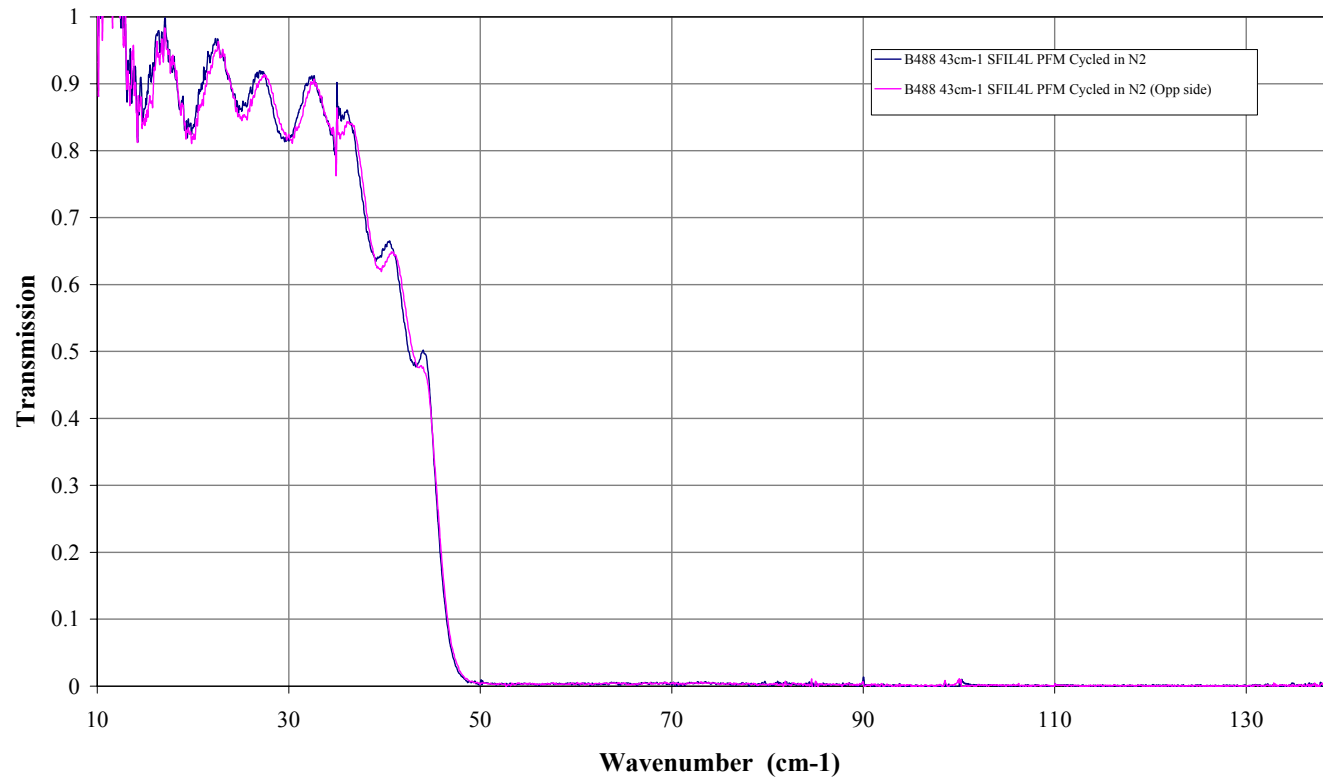


Figure 12 B488 SFIL4L FILT-PFM-214 post-thermal shocking

PFM-SFIL5L

B476 Pre-Thermal Shocks

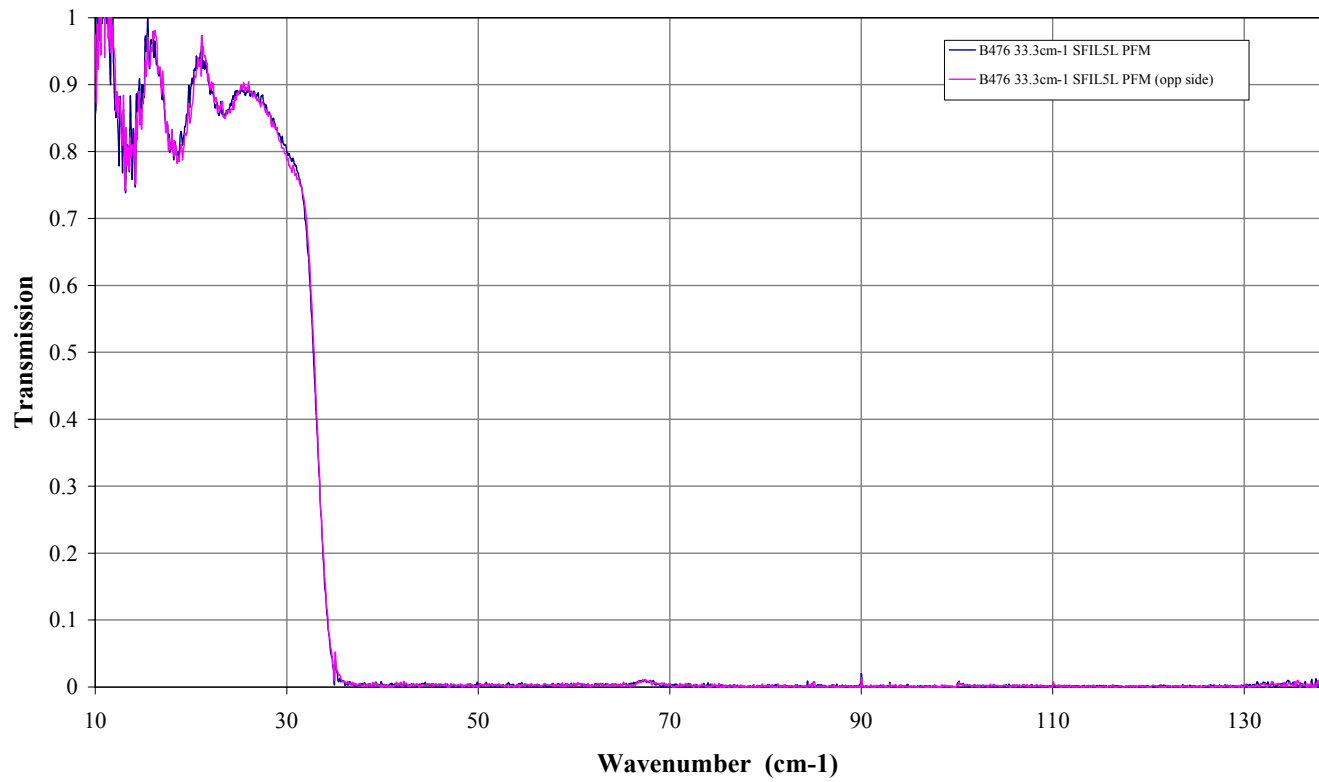


Figure 13 B476 SFIL5L FILT-PFM-215 pre-thermal shocking

B476 Post-Thermal Shocks

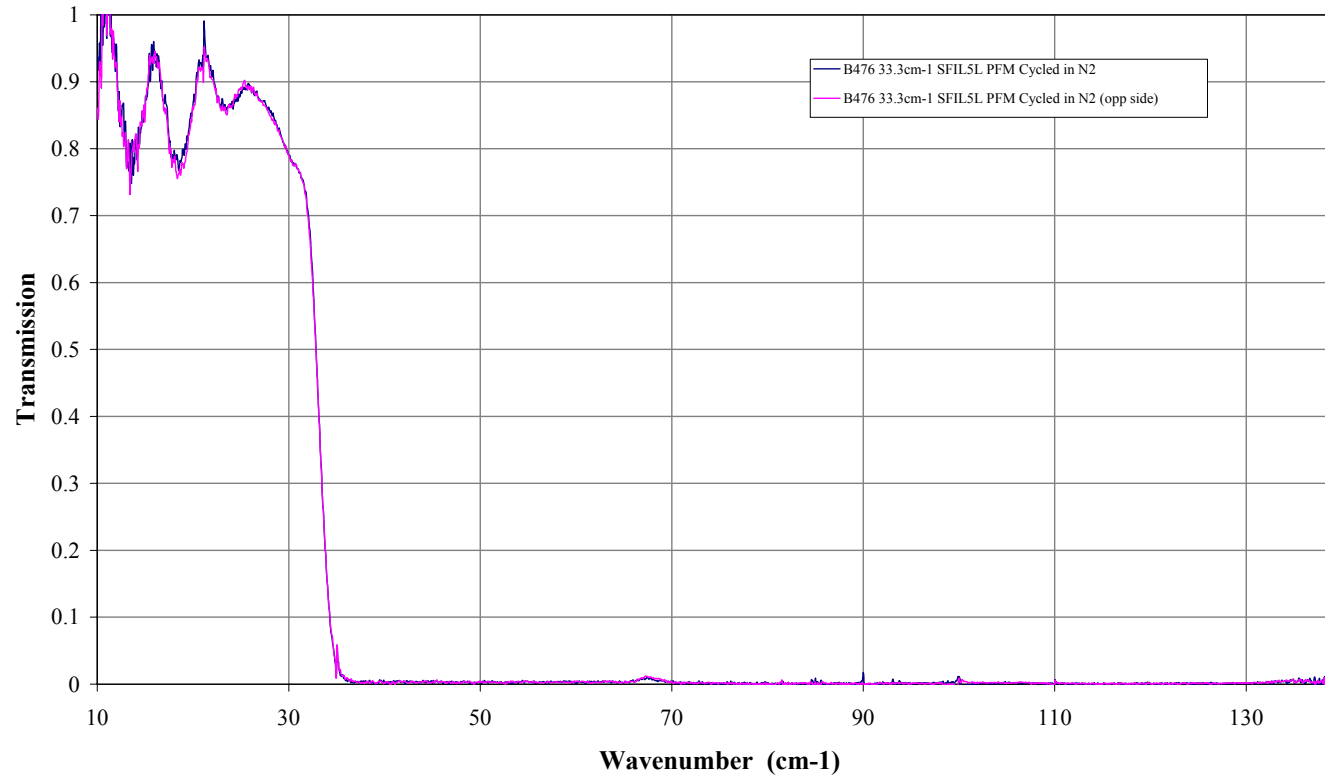


Figure 14 B476 SFIL5L FILT-PFM-215 post-thermal shocking

PFM-SLW Lens

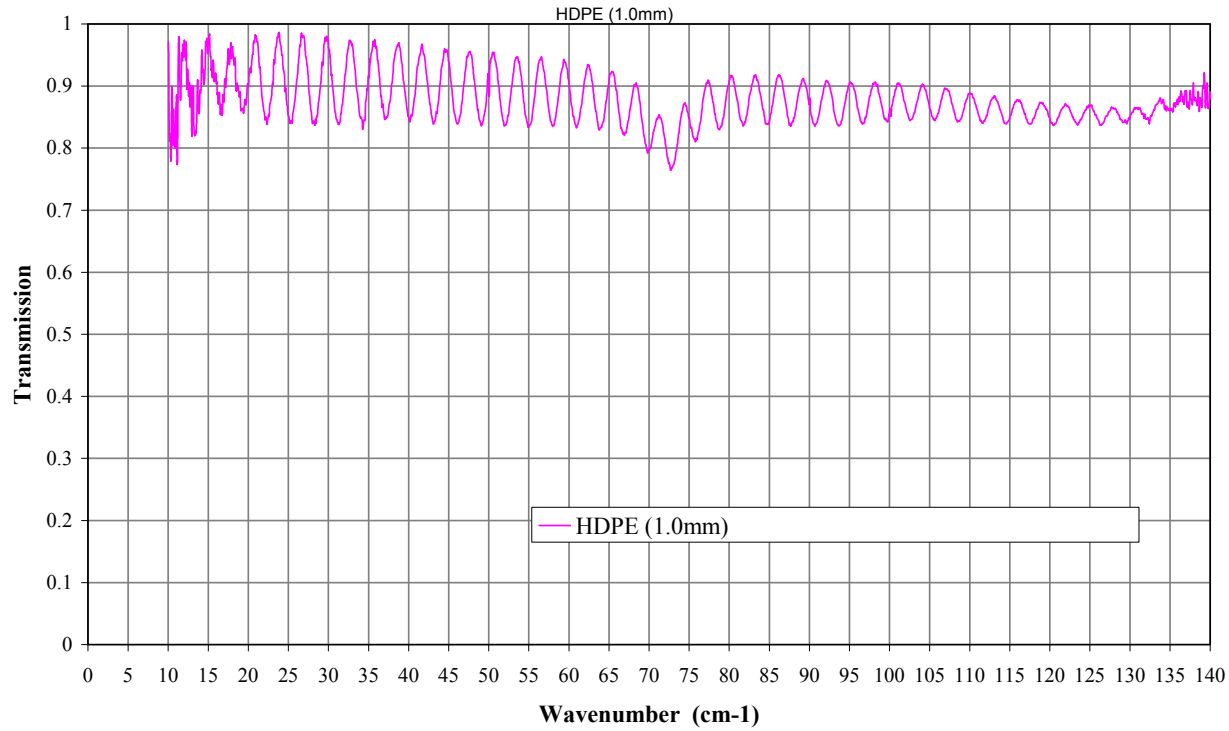


Figure 15 Transmission of 1.0mm thick planar section of PFM-SLW lens

PFM-SFIL4S

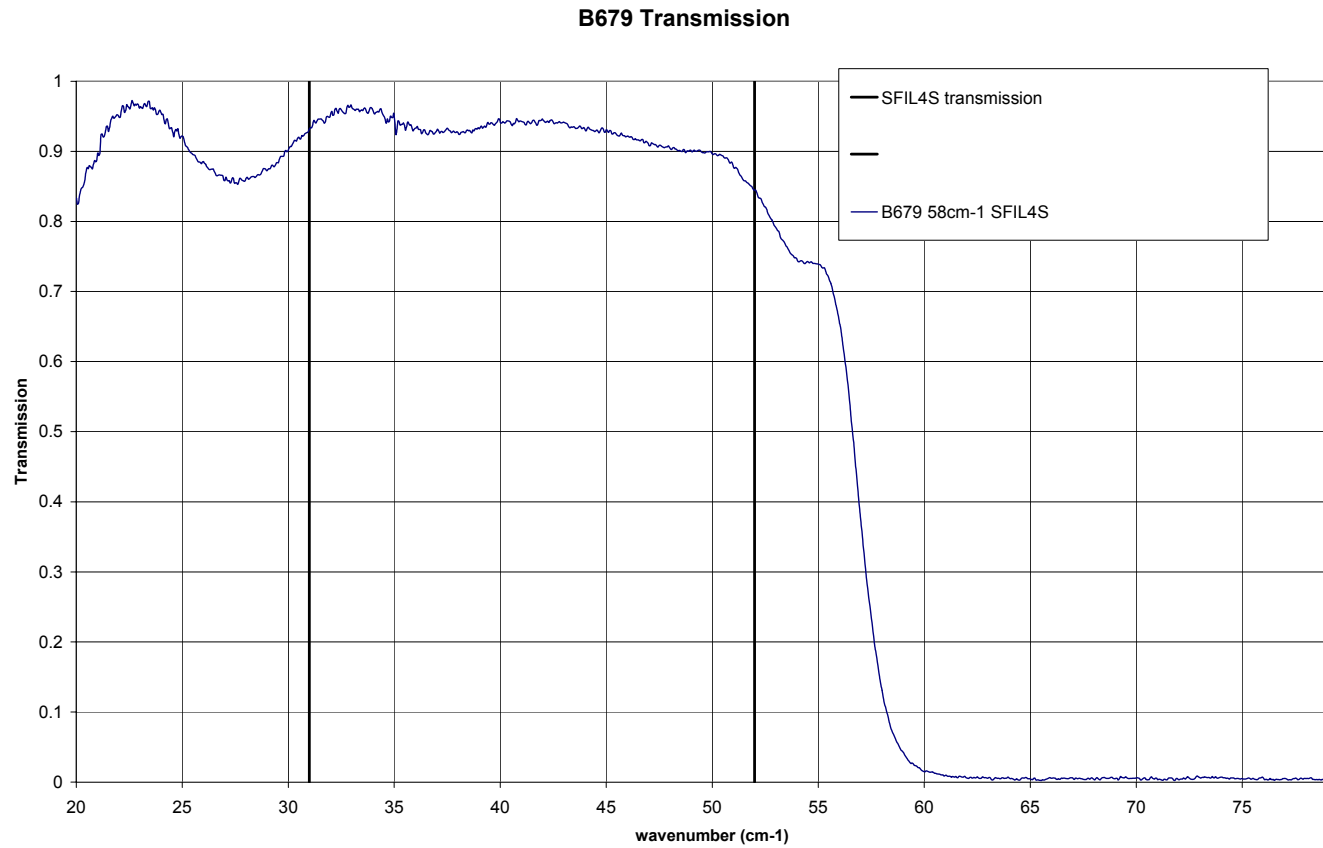


Figure 16 B679 SFIL4S FILT-PFM-224 pre-thermal shocking

B679 Post-Thermal Shocking

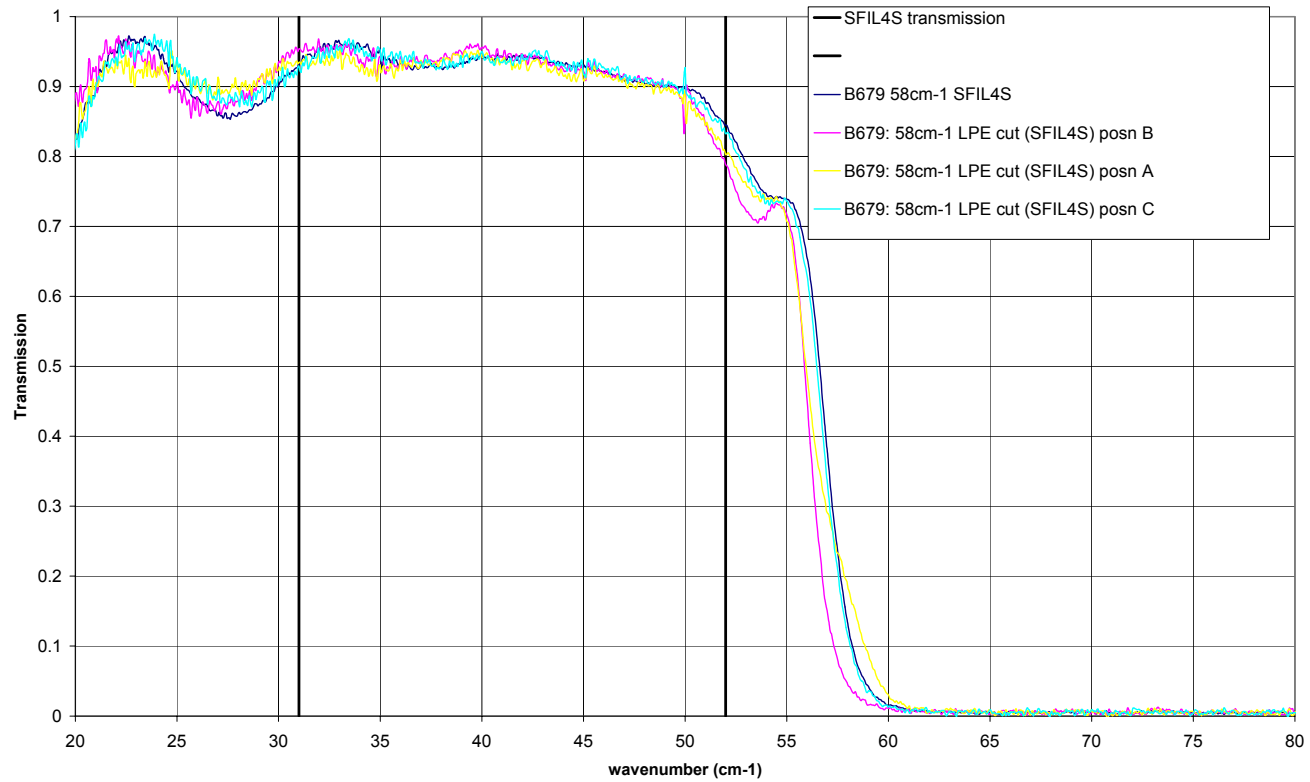


Figure 17 B679 SFIL4S FILT-PFM-224 post-thermal shocking, and uniformity data

PFM-SFIL5S

B650 Pre- & Post-Thermal Shocking

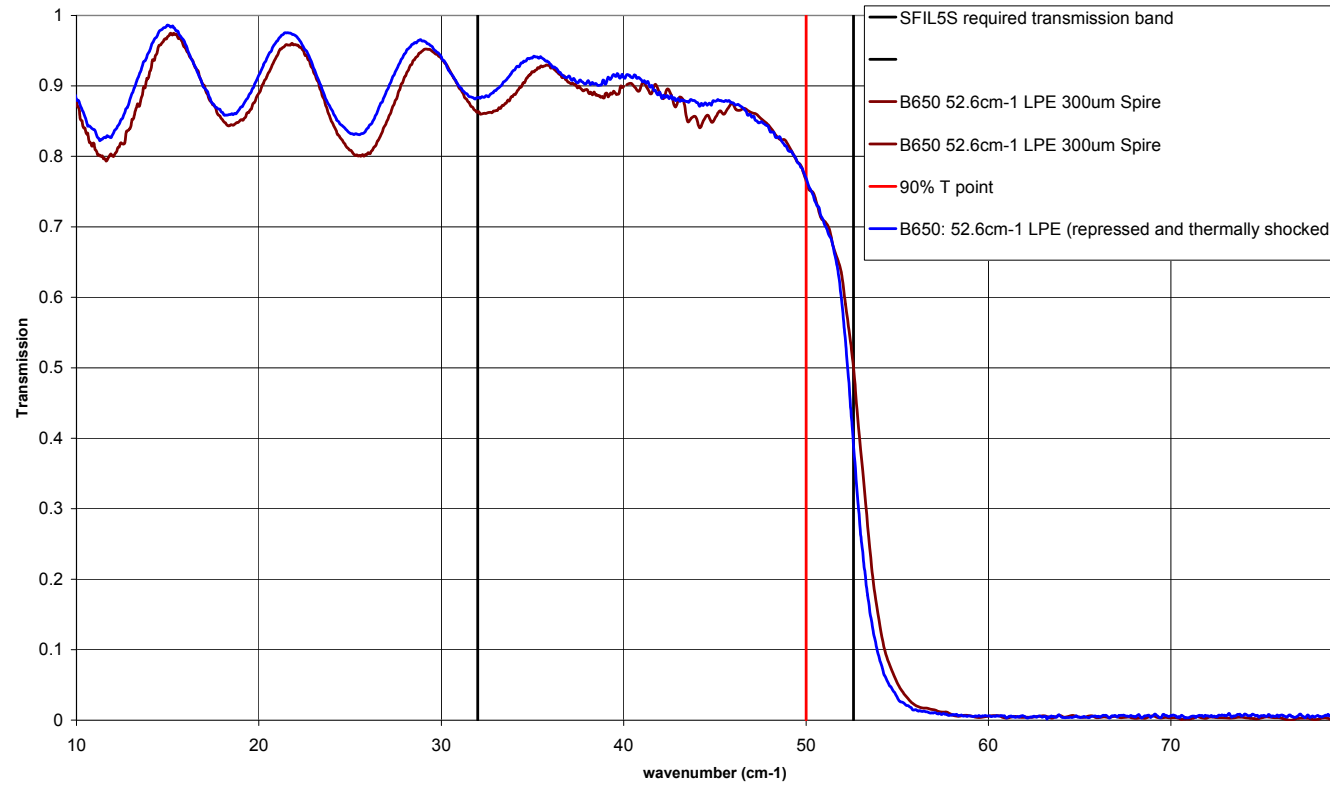


Figure 18 B650 SFIL5S FILT-PFM-225 pre- and post-thermal shocking data

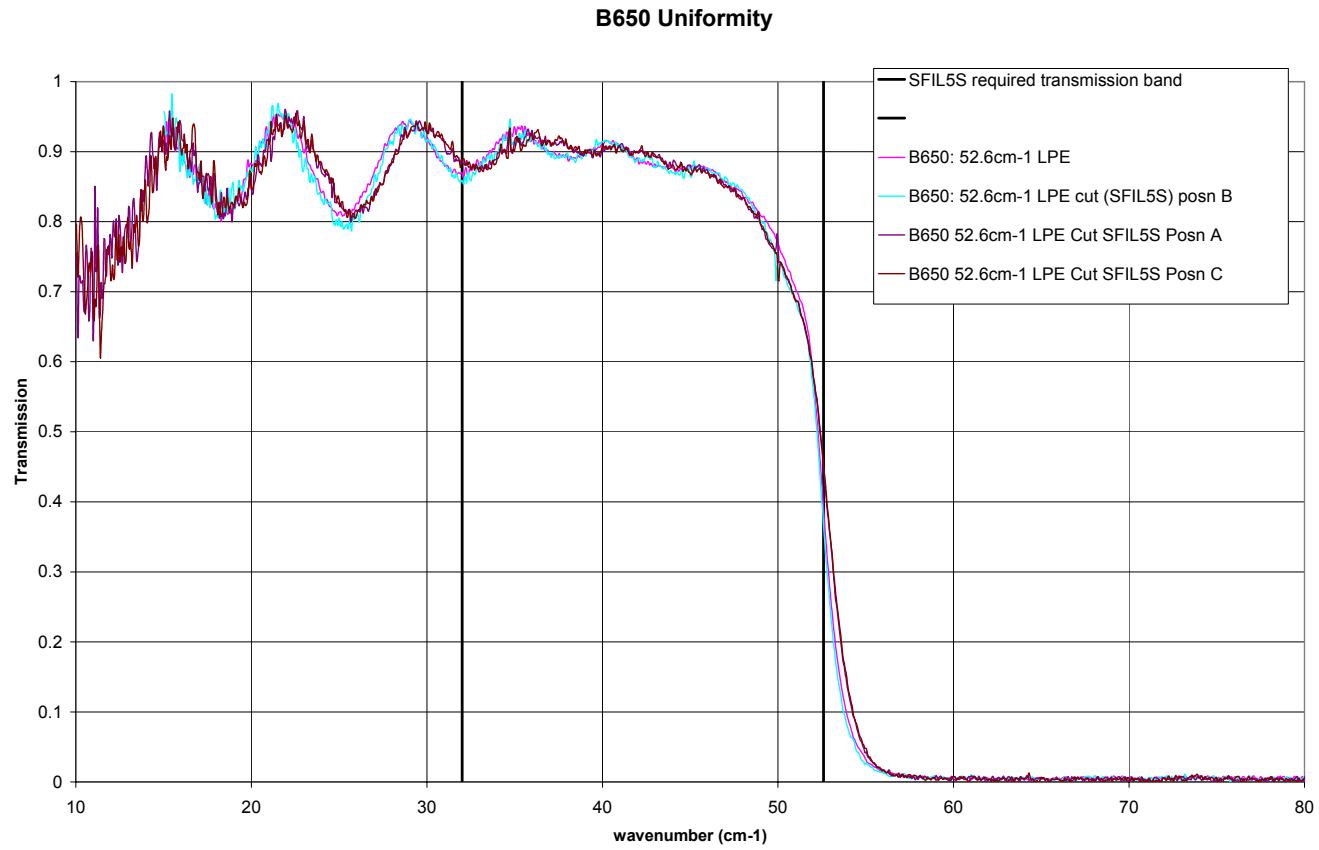


Figure 19 B650 SFIL5S FILT-PFM-225 uniformity data

PFM-SSW Lens

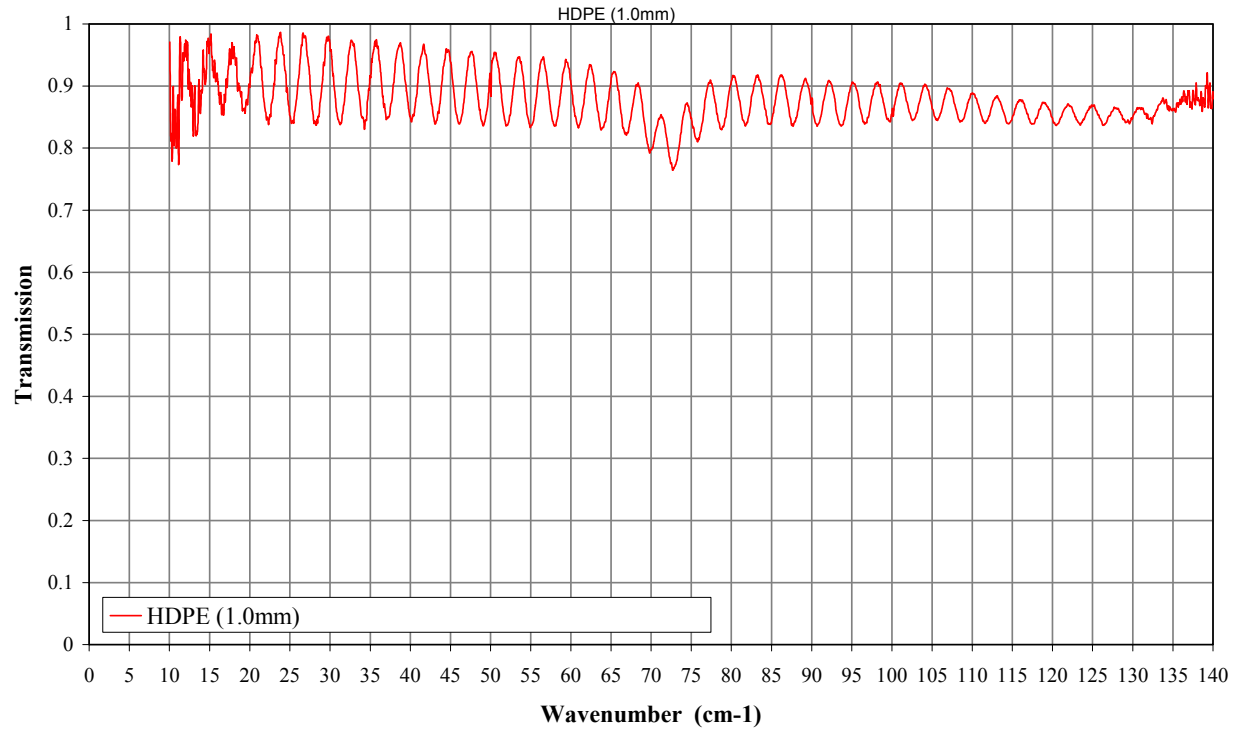


Figure 20 Transmission of 1.0mm thick planar section of PFM-SSW lens

PFM-SSW Filter Stack Assembly

FILT-PFM-220 PFM SSW Stack transmission

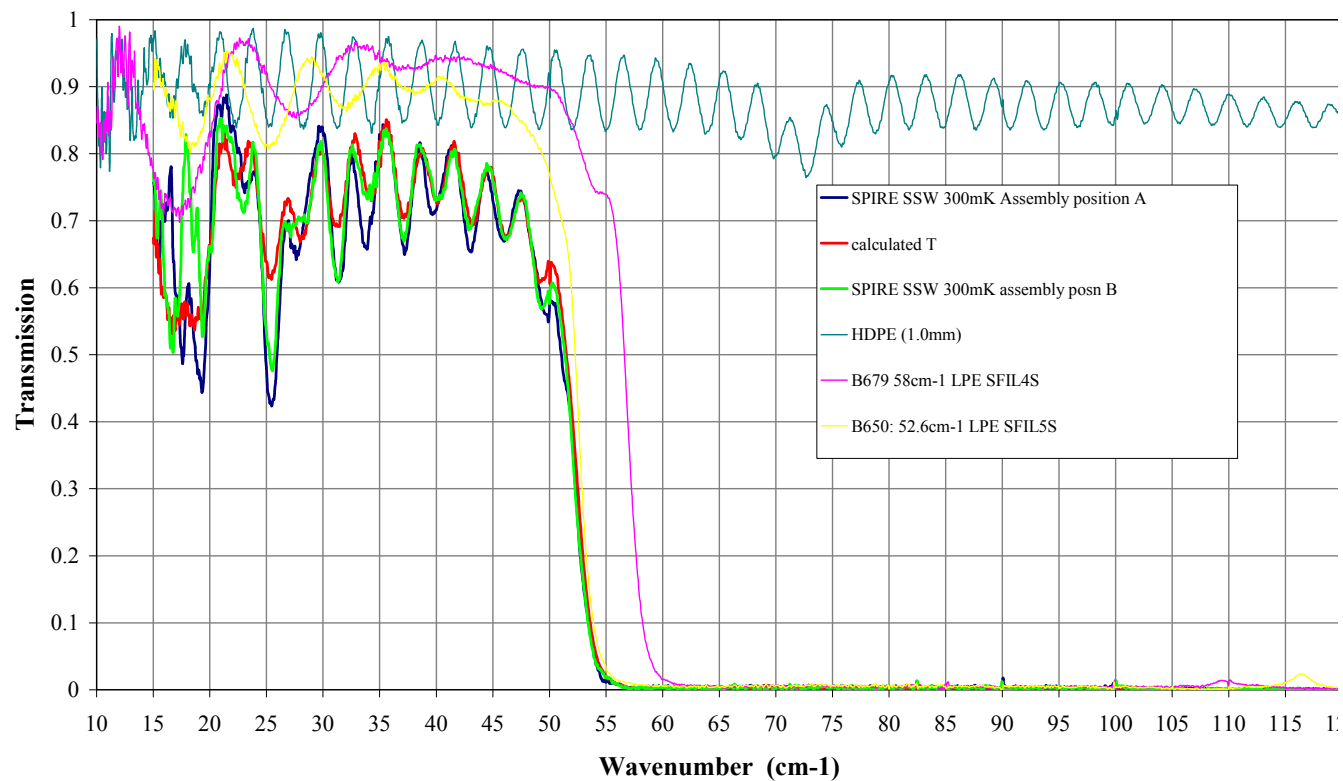


Figure 21 Transmission of assembled SSW filter stack, including lens. Trace in red shows transmission calculated from individual component spectra, green and dark-blue are the actual measured data.

PFM-SSW Metrology Report

To follow

SECTION 27 - Reference List of EIDP's

Associated

| <u>Title</u> (Listed in alphabetical order) | <u>ID</u> (Serial No.) | <u>Acronym</u> | <u>Document No.</u> | <u>Issue</u> | <u>Date</u> |
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| PLW BDA CQM EIDP | | | | | |
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Lower Level

| <u>Title</u> (Listed in alphabetical order) | <u>ID</u> (Serial No.) | <u>Acronym</u> | <u>Document No.</u> | <u>Issue</u> | <u>Date</u> |
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SECTION 28 - Mass Records

| Assembly | Final measured mass |
|---------------------------------|---------------------|
| FILT-PFM-210 – PFM SLW assembly | 11.310 ± 0.002 g |
| FILT-PFM-220 – PFM SSW assembly | 11.000 ± 0.002 g |

SECTION 29 - Cleanliness Statement

SECTION 30 - Other Useful Information

SECTION 31 - DPL/DML etc

SECTION 32 – List of Appendices/Attachments

| <u>Appendix #</u> | <u>Title</u> (Listed in alphabetical order) | <u>Document No.</u> | <u>Issue</u> | <u>Date</u> | <u>Notes</u> |
|-------------------|--|---------------------|--------------|-------------|--------------|
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