Report on Structure Detailed Design Review (DDR) at MSSL on 29th November 2001.

1 Introduction
The panel was impressed with the quality and amount of work that had been completed in the period leading up to this review.
A mature design was presented in most areas.
There are a few areas of that need to be addressed and these are described in this report.

2 Aims of the review.
Subsystem DDR aims are:
Freeze the subsystem requirements specification
Freeze the subsystem design and release for manufacture of STM/CQM.

3 Documentation.
The following list of documents were made available in advance of the review.

Document tree
Hardware tree
Declared materials list
Declared processes list
FMECA
MAIV flow chart
PA plan
SPIRE interface drawing
Interface control document (ICD)
Development plan
Schedule
Subsystem specification doc (SSD)
Technote 2, Thermal strap support level 0
Technote 3, detector box support.
Technote 6, Random interfaces forces.

4 Agenda.
The agenda is included in annex A

5 Presentation.
All presentations are included as annex B

6 Minutes of meeting

6.1 Review of the Specification and requirements.
Based on December issue of the instrument requirements spec, which is in process of minor updates.
Spectrometer baffle only covers the beam area, it does not go as far as the lid.
Photometer baffle does divide the unit in two, it is mounted in the clam shell lid.

Block diagram 3.1-3 is incorrect. The thermal strap between the cooler and detector boxes should enter the spectrometer box first.
Isolation of the thermal straps not covered in this review.
Thermal requirements are based on old information. The design cannot be fully verified until the Herschel cryostat model is available.
There may be some scope for changing the conductivity of the mounting feet to improve the thermal isolation. e.g. change to titanium.
The thermal characteristics of the mounts should be reassessed.
More thermal modelling is required in order to determine if a change is required.
A firm decision regarding the supports should be available when the new thermal analysis is complete.

6.2 Overall instrument design.

Random vibration.
Overall damping assumed at 3%, this was questioned by ESA.
FEA modelling shows that the first three modes are the instrument moving on its mounts. Fourth mode and above are all detector modes.
Entrance baffle stop position will need checking during the structure integration.
An alignment document will be written by MSSL, not yet available.

6.3 Main interfaces.

All mirror mounts use two hollow dowels for location.
Aperture alignment plate drawing to go to LAM for construction of the OGSE (alignment plate).
Interface with the SMEC is not finalised, but can be soon.
Position of STM temperature sensors need to be defined by RAL.
Location of blacked areas is not finally confirmed, action RAL.
Cold stop interfaces to be passed to Tony Richards for checking.
Thermal bus bars not part of this review.
Harness routing is not fully defined.
RF filters.
Thermistor locations for STM and FM.
All other subsystems defined.

6.4 FMECA.

To be updated by Dec 15th so it can be incorporated into the system level FMECA in time for the IBDR documentation.
Short to cold strap needs to be assessed, this should be assessed for all instrument.
Fatigue analysis on feet required, for no fail safe items.
New FMECA due on 15/12/01.
Dynamic clearance to be addressed in the FMECA.
There will be a requirement in the IID-A to measure displacement during vibration tests.
Comments by ESTEC are included as annex C

6.5 Document tree

Interface drawings are issued through the interface doc. The latest drawing is in the latest issue of the doc.
Technical notes covering issues like margins of safety should be written, i.e. analysis should be documented.

Interface doc 4.11 has out of date vibration levels and needs updating.

6.6 MAIV plan.
Clamp optical bench to a surface table.
Build up photometer cover.
Fit to MGSE
Build up spectrometer cover.
Never remove both covers at the same time.
Photometer lid and sides can be removed leaving the base and mounts attached to the optical bench.
Lubrication of fixing screws, a solution needs to be identified, the system team to recommend a lubricant.
Procedure for checking flatness of optical bench, e.g. optical method needs to be addressed.
AIV procedure needs to be extended to the internal components.

6.7 MGSE
All based on hob simulator plate.
Used for transport as well.
Assembly onto Herschel starts with the cone fixed to spacecraft and A frames attached to SPIRE.
Transport case from Light Alloys Ltd.

6.8 Planning.
Detailed design now to Jan
STM manufacture Dec 2001 to May 2002
AIT May 2002 to Aug
Margin Aug to September
Delivery mid Sept
A second photometer box could be manufactured if the thermal bus bar becomes a holding item.
ESA would like to see an optimistic schedule based on maximum parallel manufacture.
A detailed list of milestones to be identified for tracking.
Internal review of each instrument and industry is being carried out by ESTEC

6.9 PA.
Heat/cold cycle, is this required. Consider doing at instrument level before mirror int.
Confirmation of design temperature required.

Note.
Shutter harness routing. Put the requirements for the harness in the IID-B.
Check creep of Kevlar.

6.10 Open Items.
Thermal requirements are based on old information. The design cannot be fully verified until the Herschel cryostat model is available.
The thermal characteristics of the mounts should be reassessed.

Dynamic envelope for all instruments.
Overall damping assumed at 3%, this was questioned by ESA. The SPIRE mechanical design relies on this figure.
A figure of 2% is more normal.
MSSL should re-run the analysis using 2% damping and see if this throws up any problems.
Thermal design or the mounting feet, raise as an issue.
ECR for vibration level and notches, check status.

7 Summary of Main points

The thermal characteristics of the mounts should be reassessed.
An alignment document to be written by MSSL.
Overall damping assumed at 3%, this was questioned by ESA.
MSSL should re-run the analysis using 2% damping and see if this throws up any problems.

The following interfaces are not finalised:
SMEC
STM temperature sensors
Location of blacked areas
Harness routing
RF filters.

In the FMECA, a short to cold strap needs to be assessed; this should be assessed for all instruments.
Fatigue analysis on feet required, for non fail-safe items.
Dynamic clearance to be addressed in the FMECA.
There will be a requirement in the IID-A to measure displacement during vibration tests.
Technical notes covering issues like margins of safety should be written, i.e. analysis should be documented.
Interface doc 4.11 has out of date vibration levels and needs updating.
Lubrication of fixing screws, a solution needs to be identified, the system team to recommend a lubricant.
Procedure for checking flatness of optical bench, e.g. optical method needs to be addressed.
AIV procedure needs to be extended to the internal components.
A second photometer box could be manufactured if the thermal bus bar becomes a holding item.
ESA would like to see an optimistic schedule based on maximum parallel manufacture.
A detailed list of milestones to be identified for tracking.
Heat/cold cycle - is this required. Consider doing at instrument level before mirror int.

ANNEX A

SPIRE STRUCTURE
DETAILED DESIGN REVIEW – 29 & 30 NOVEMBER 2001
MULLARD SPACE SCIENCE LABORATORY
Library

AGENDA (Chair – Eric Sawyer)

Thursday 29 November

14:00	Welcome and Aims of the Meeting	ES
14:15	Main Specification - Specification Document - Requirements Downflow	BW
14:45	Overall Instrument Design - Dynamic Performance	BW/JC
15:45	Tea	
16:00	Main Interfaces	BW/JC/PG
18:00	Questions	
18:30	Close	

8 Friday 30 November

08:30	Recap of Previous Day	
08:45	Main Interfaces - continued	BW/JC
09:15	Questions	BW
09:30	MGSE	PB
10:00	AIV Plan	CBB
10:30	Coffee	
10:45	Planning	BW
11:15	PA Planning	TD
11:45	FMECA	CBB
12:15	Lunch	
13:45	Wrap up of Meeting Aims	
14;00	Final Questions	
14:15	Board Sitting (Closed)	
15:00	Tea	
15:15	Feedback from Board	
15:30	Close	

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Herschel/SPIRE structure DDR
Specification & Requirements

Berend Winter

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Contents

- Specification
  - Purpose of the instrument
  - General overview of layout of the instrument
- Overview of requirements and open issues
  - down flow from IID-A and IID-B
  - Overview of the various design implementations with regard to the requirements

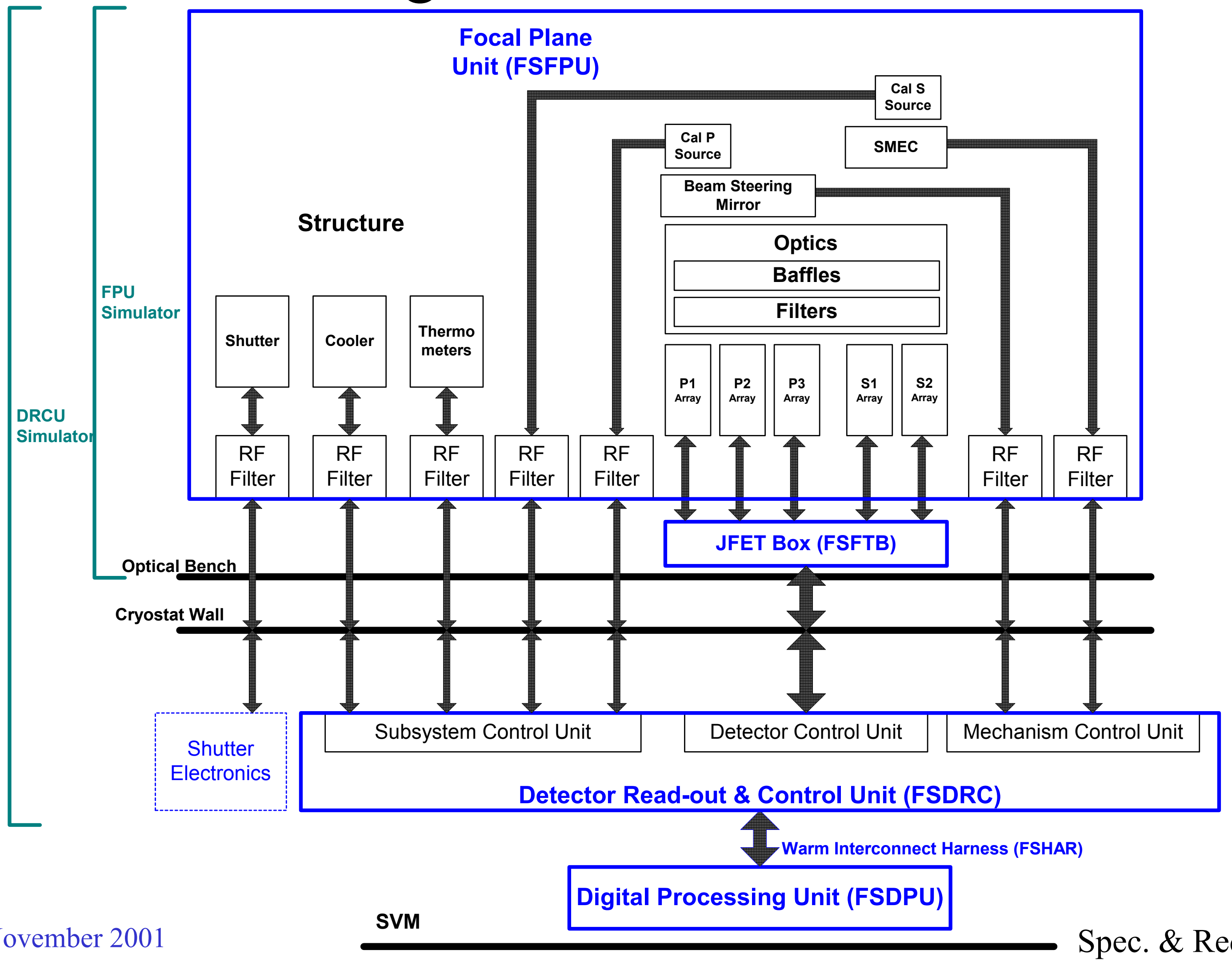
Purpose of the structure of the Instrument-1

- House various parts of the instrument
  - Housing (two covers separated by SPIRE optical bench
  - Photometer
    - Photometer detectorbox
  - Spectrometer
    - Spectrometer detectorbox
  - Optics
  - Straylight baffles
  - Iso-static mounting, thermally insulating and stiff
- Thermal control
  - Cryogenic instrument with different temperature zones
    - Level 0 (about 1.8 K) for detector boxes
    - Level 1 for the rest of the instrument structure (about 5 K)
    - 0.300 K busbar, cooling the detectors using a He^3 refrigarator

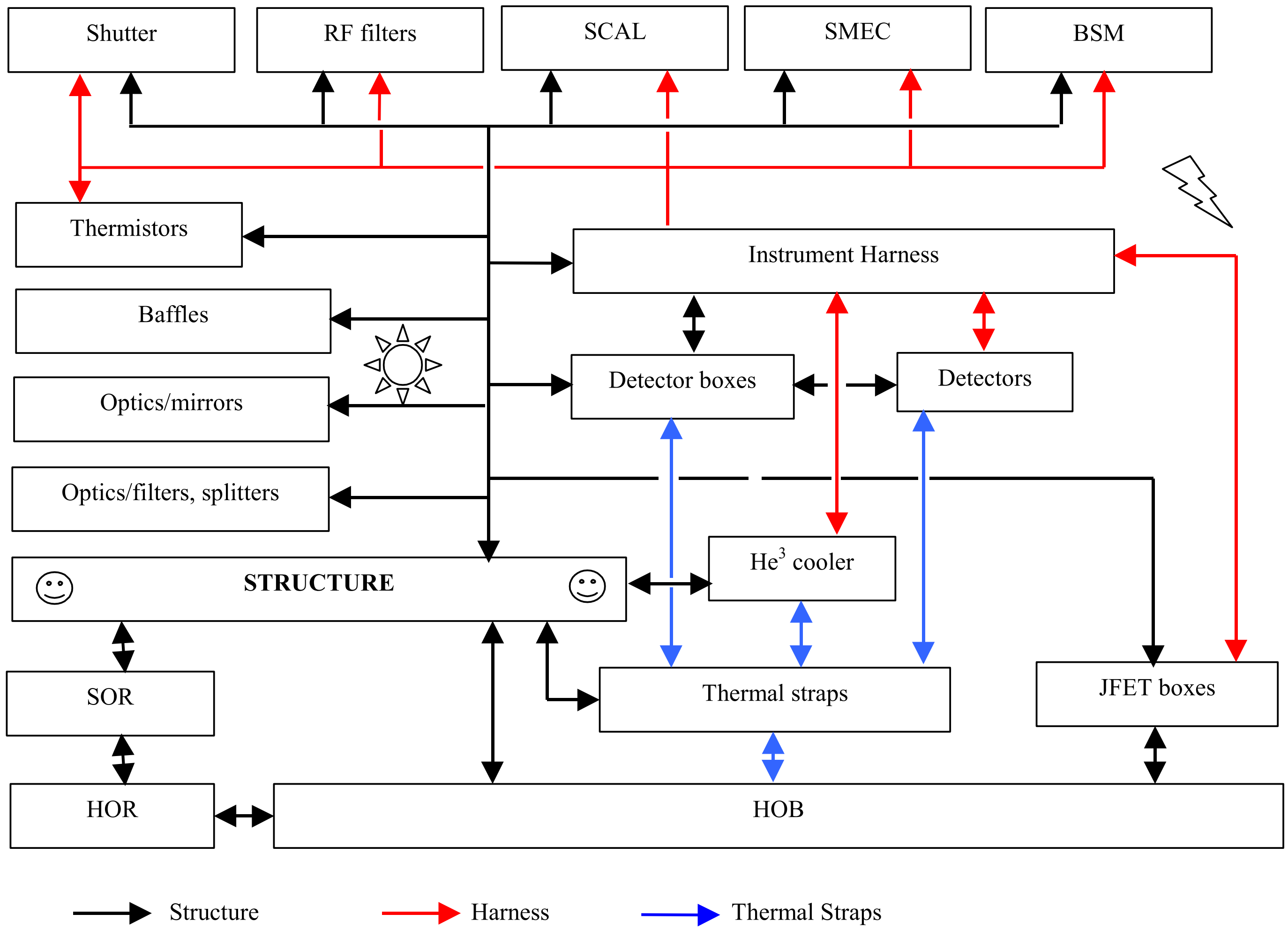
Purpose of the structure of the Instrument-1

- Straylight control
  - Mainly embedded in the optics (see block diagram presented later)
  - Straylight baffles
- RF-control
  - The outer contour of the structure works as an RF-attenuator
  - RF-filter boxes
- Structure
  - Provide for strength
    - strong enough to survive mechanical environment
      - Launch
      - Handling and integration
  - Provide for Stiffness
    - Maintain optical alignment
    - Help to separate main spacecraft dynamical modes from main instrument dynamical modes

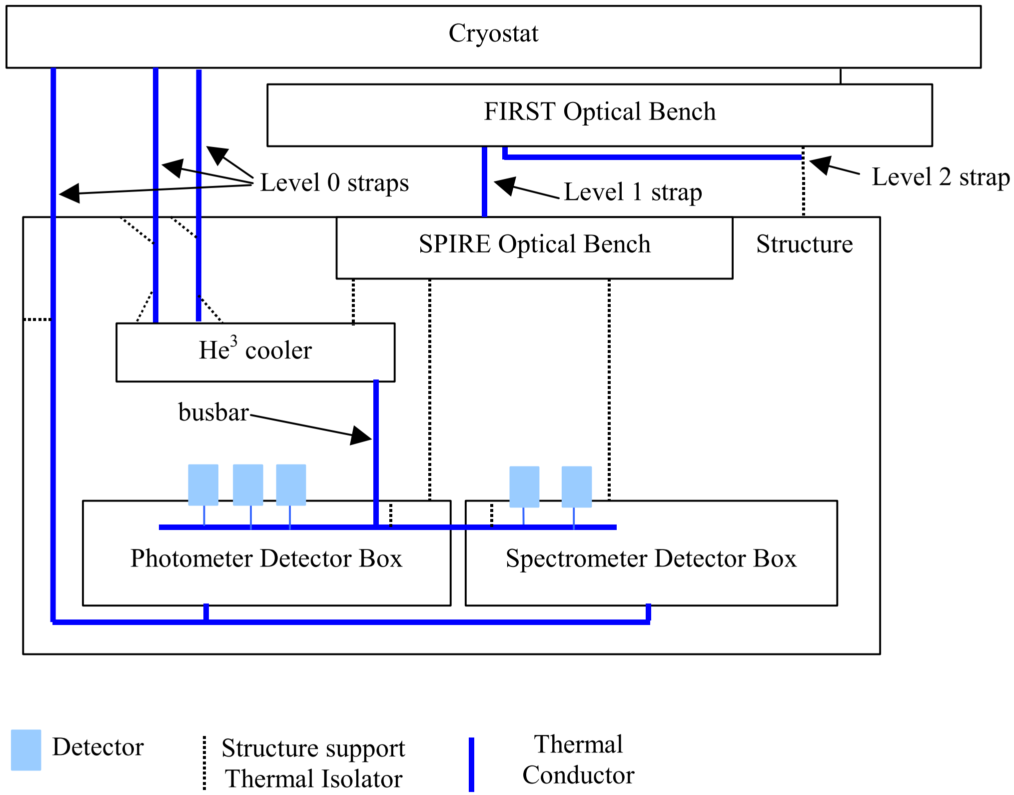
Block Diagram-1 The Whole of SPIRE



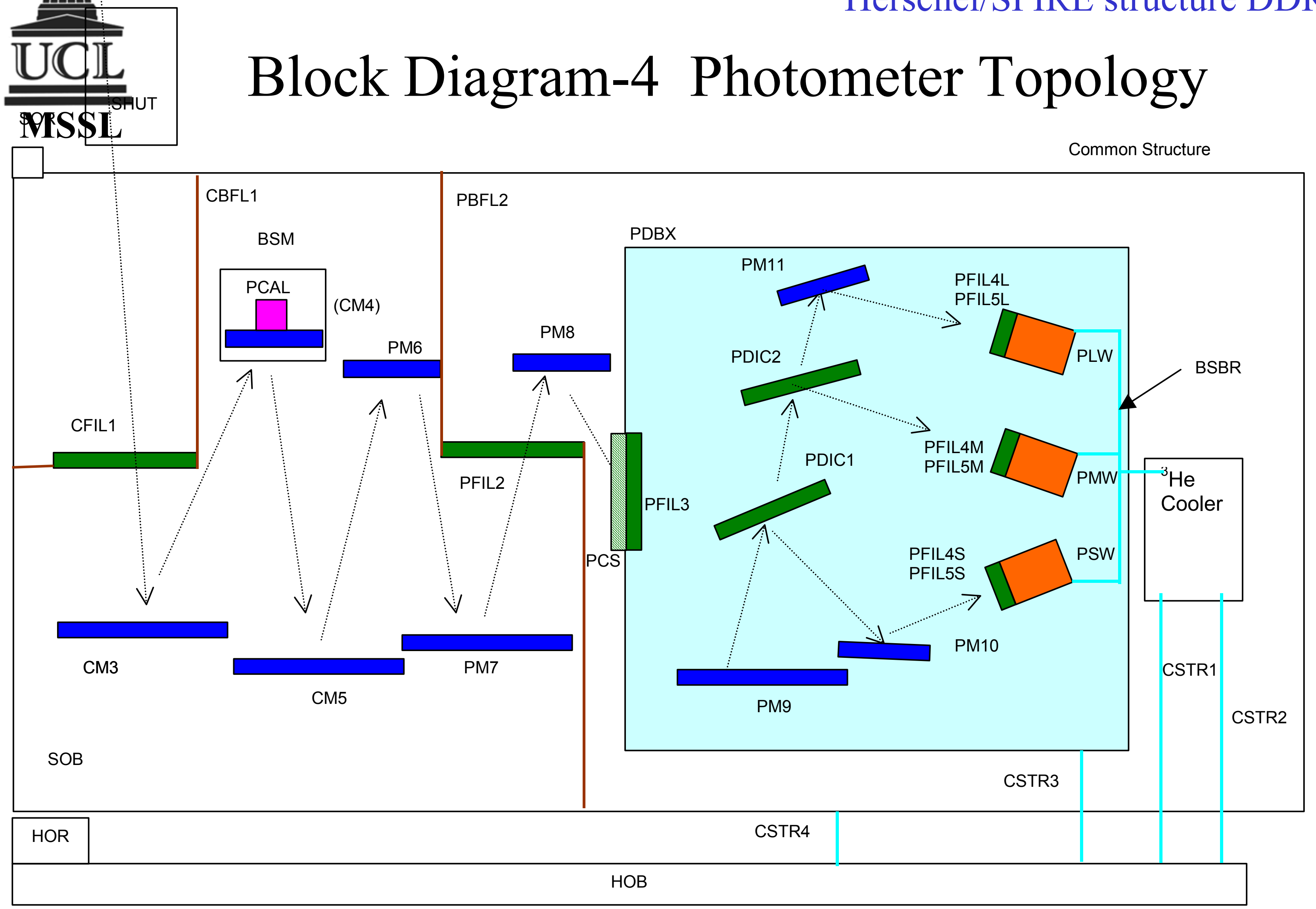
Block Diagram-2 Components Supported



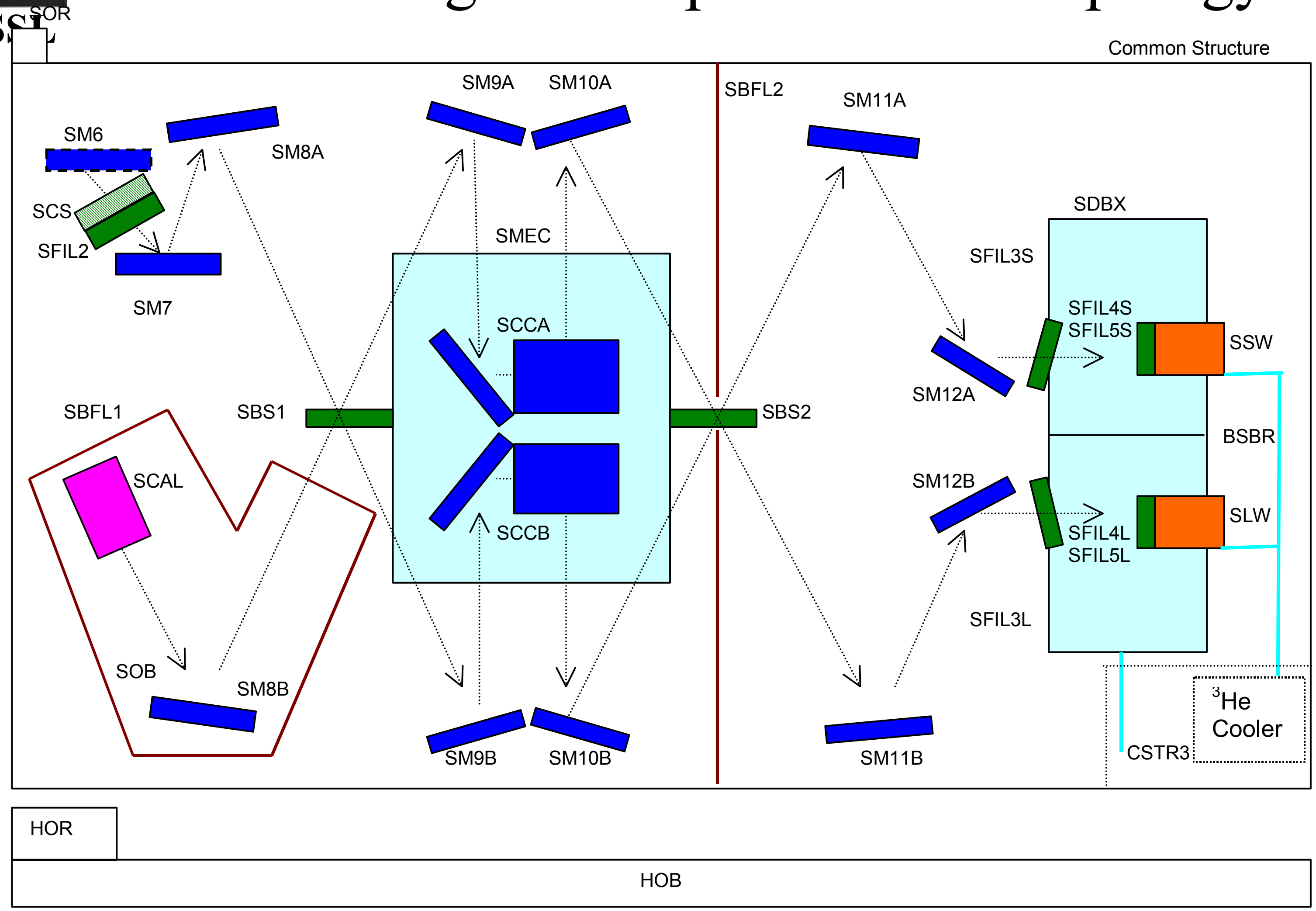
Block Diagram-3 Thermal topology



Block Diagram-4 Photometer Topology



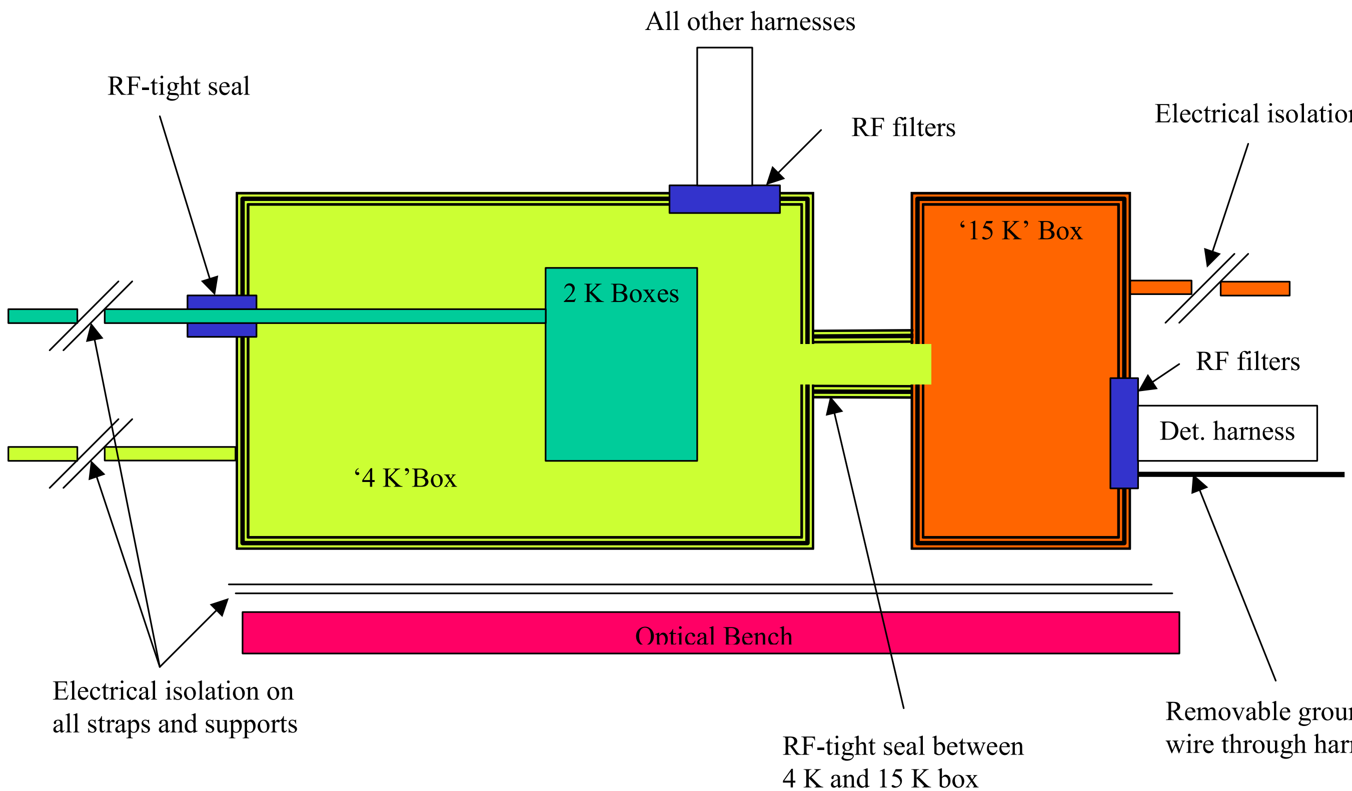
Block Diagram-5 Spectrometer Topology



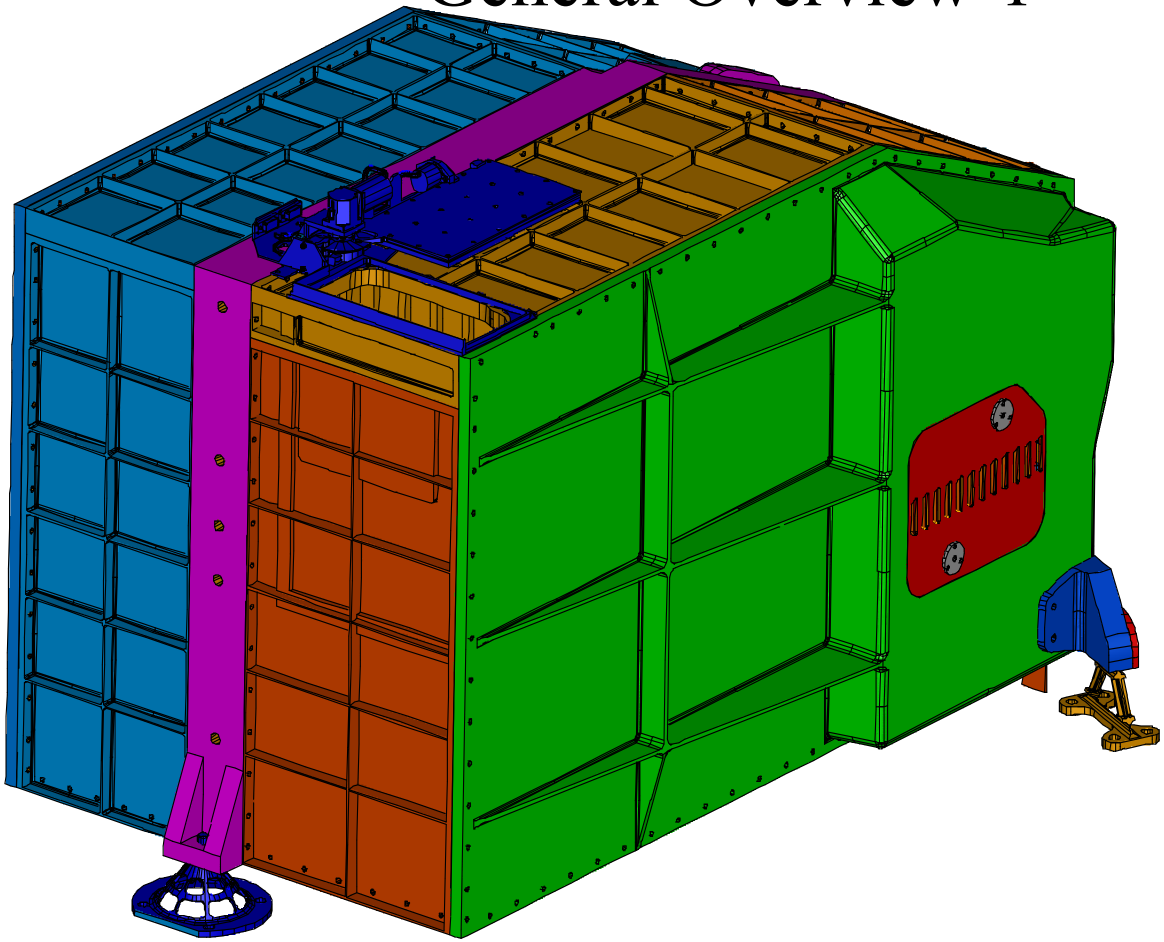
Block Diagram-6 RF Topology

Denotes RF-tight boundary

- RF-box to float electrically from cryostat
- Only electrical connection is through ground wire
- All thermal, optical, and electrical penetrations to
- have RF-filters or seals

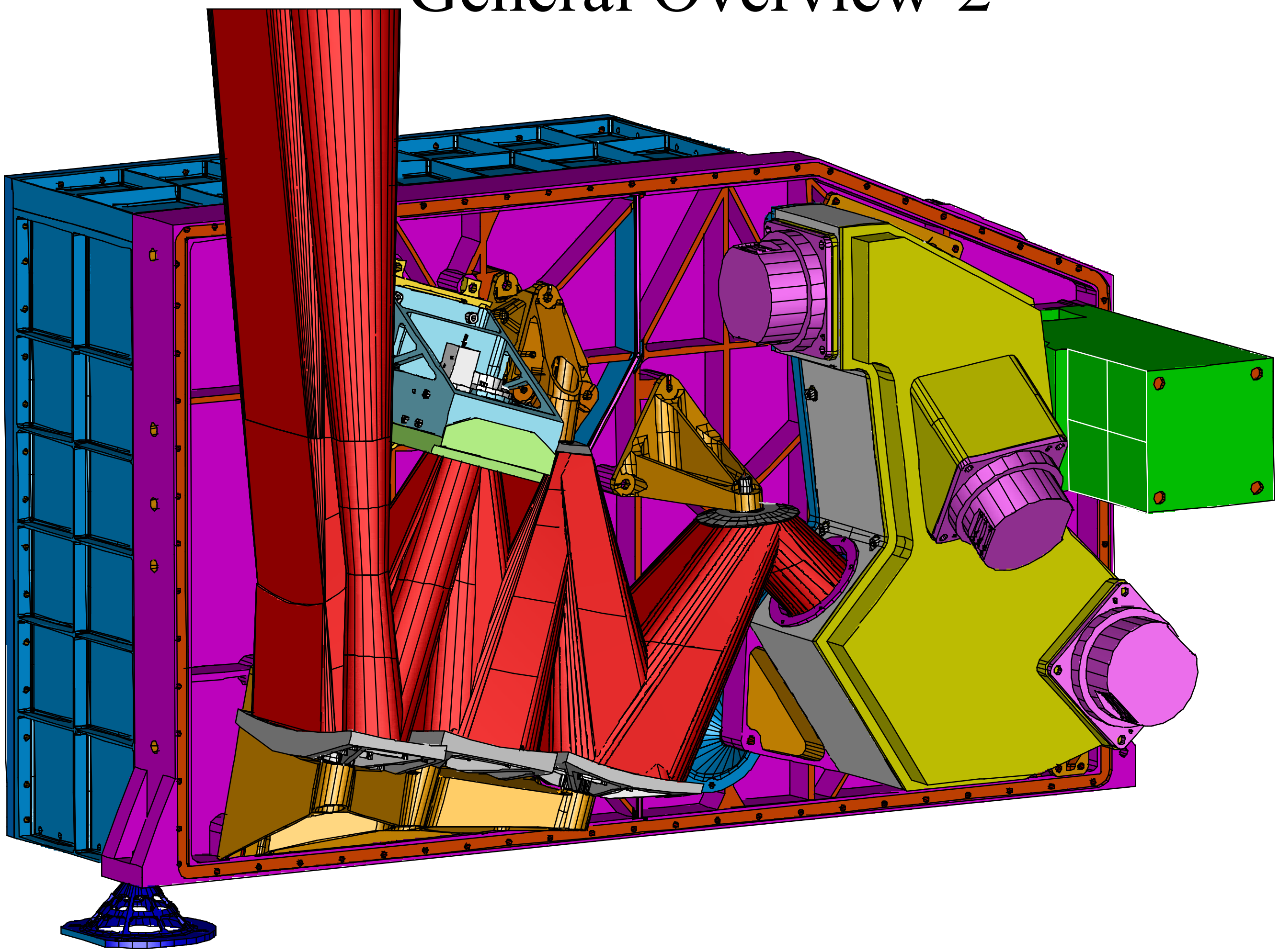


General Overview-1



Outside view of the Instrument

General Overview-2



View of the Photometer part of the instrument

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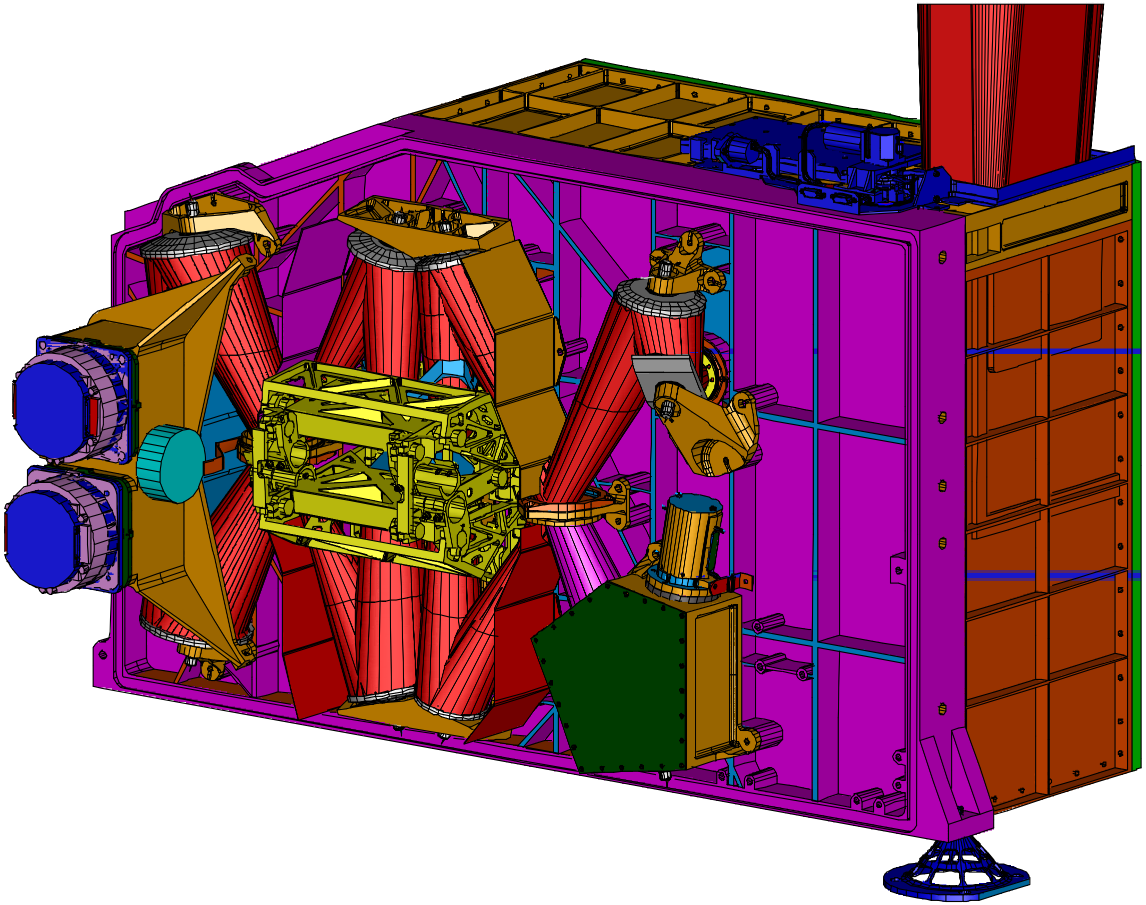
General Overview-3



View of the Spectrometer part of the instrument

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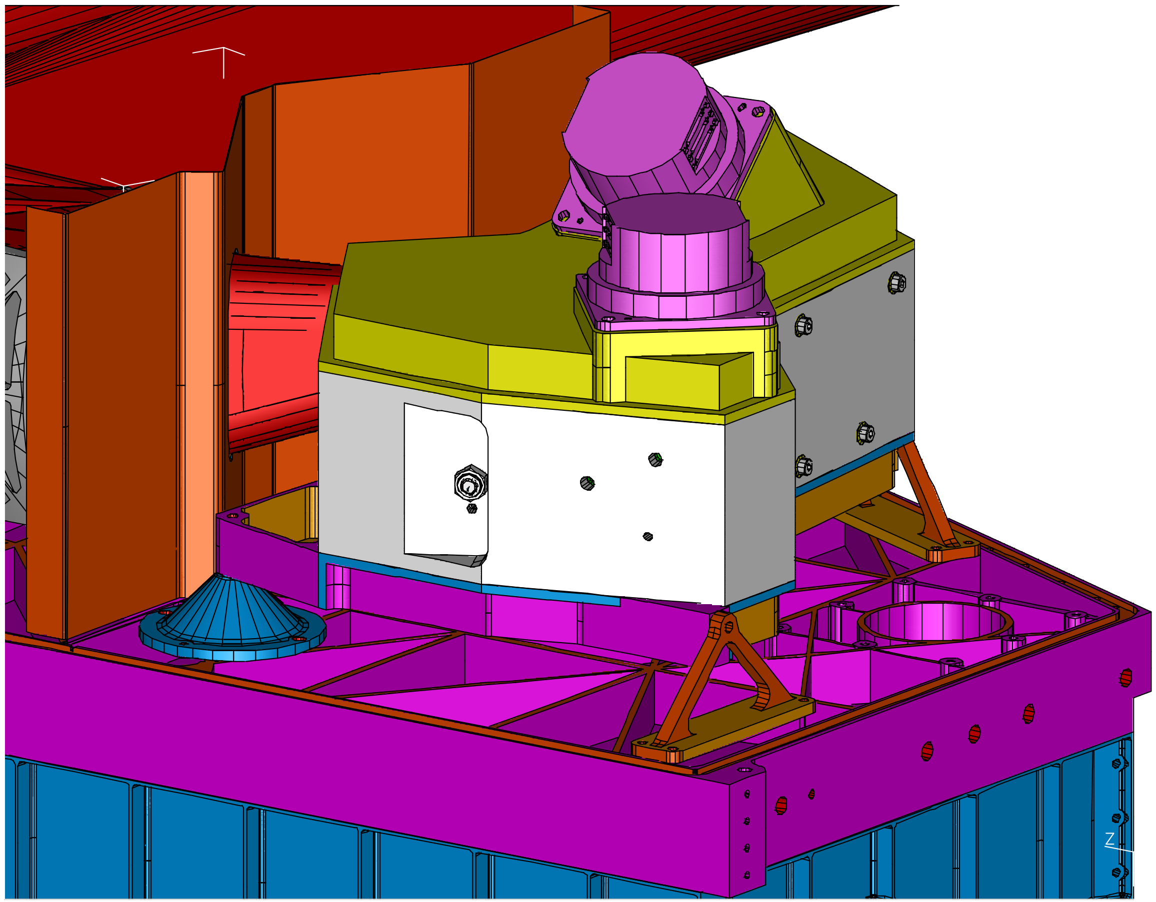
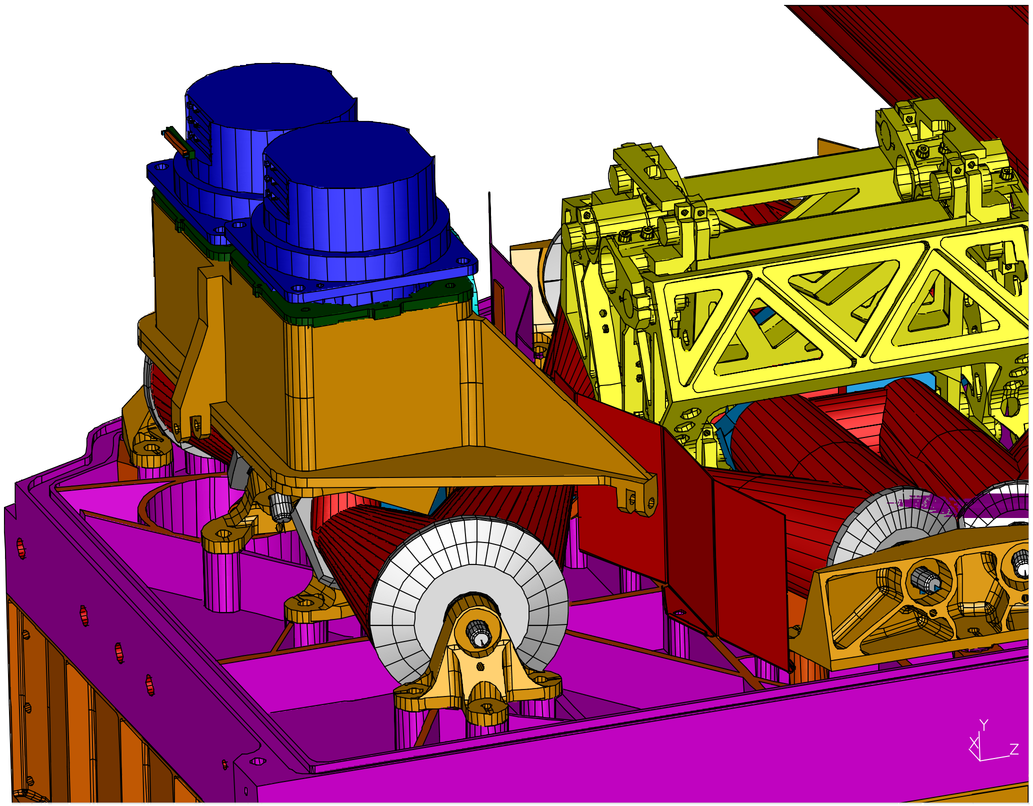
General Overview-4



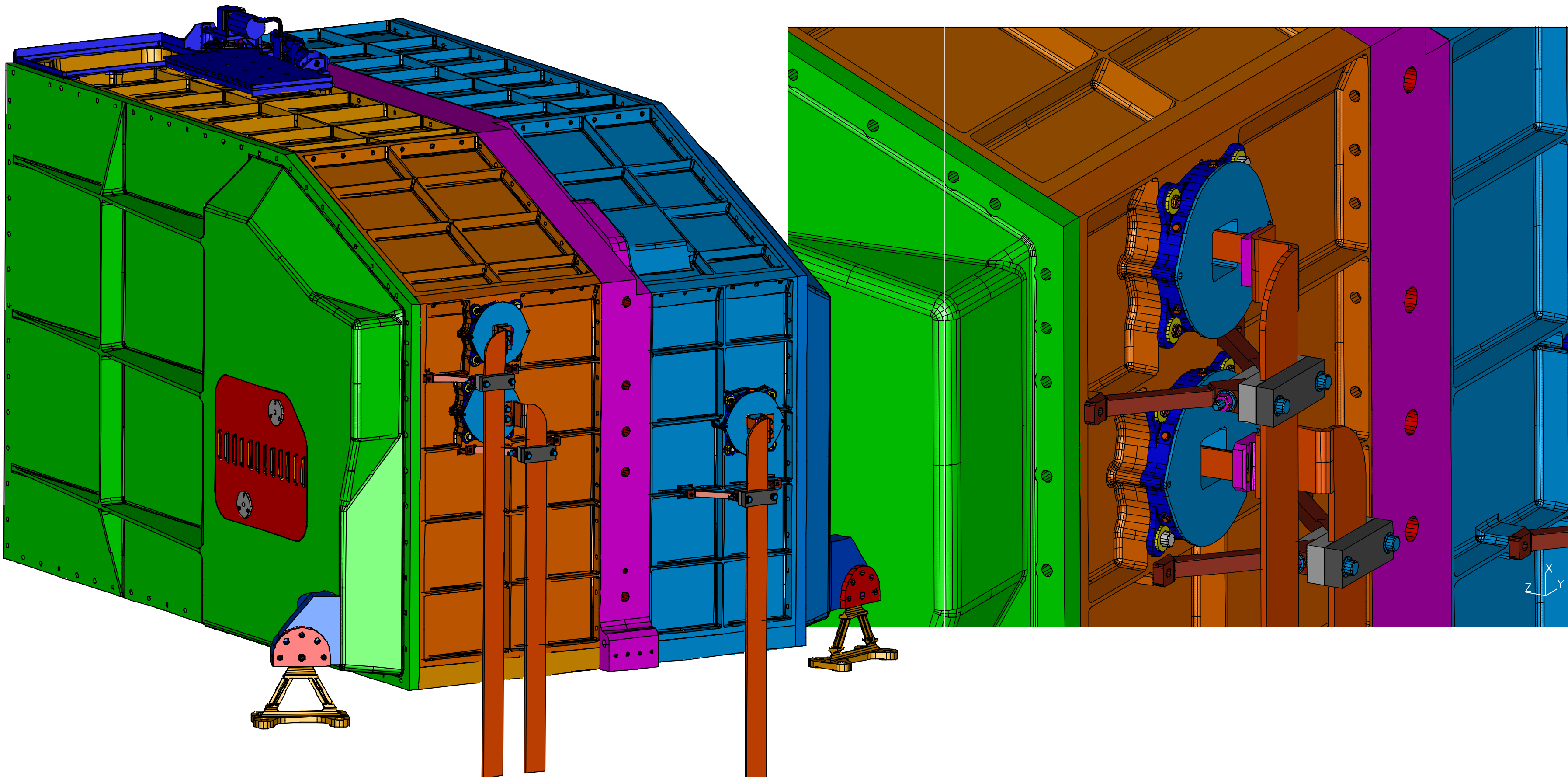
Photometer Detectorbox

General Overview-5



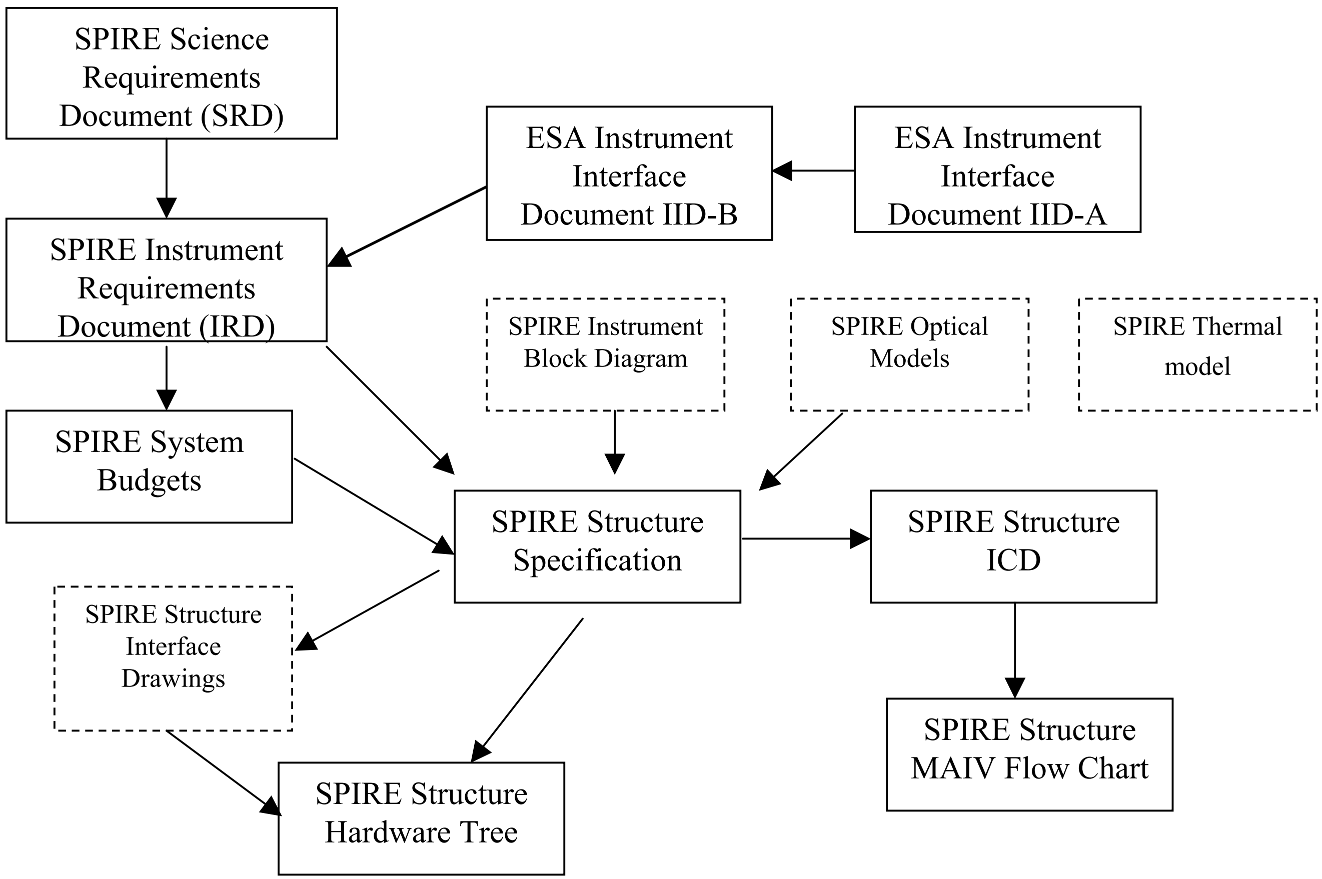
Spectrometer Detector Box

General Overview-5



Thermal Straps outside

Requirements Down Flow-1



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Requirements Key Requirements

The following requirements were taken from the IRD and are the key requirements

- Alignment: The instrument alignment requirements are specified FIRST SPIRE Optical Alignment Plan, compliant (IRD-STRC-R04)
- Temperature:The structure will facilitate the cooling of the active part of the detectors down to 0.3 K. Three temperature zones identified. Level 0 for the dector boxes. Level 1 for the common structure and SOB. Level 2 for the FOB interface. (IRD-STRC-R14, IRD-STRP-R01/R09, IRD-STRS-R01/R09), compliant
- RF: The RF will be sufficiently attenuated, following the specification in the IRD (IRD-STRC-R02), compliant
- Stiffness: The structure will have an eigenfrequency of at least 100 Hz with a goal of at least 120 Hz, compliant (IRD-STRC-R09)
- Mass: The total mass of the structure will not exceed 27.2 kg excluding contingency, compliant. (IRD-SUBS-R03)

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Non-Compliance or Open with IRD issue 1

The following requirements were taken from the IRD and are open or non-compliant

Problems indicated in red

Common Structure

- IRD-STRC-R01 Alignment instrument wrt Herschel, open (TBC/TBD)
- IRD-STRC-R02 RF-attenuation, open, (TBD)
- IRD-STRC-R12 Grounding open (TBD)
- IRD-STRC-R13 Elect. Insulation (TBD)

Photometer

- IRD-STRP all compliant

Spectrometer

- IRD-STRS all compliant

Eigenfrequency Distribution

Mode	Freq.	Normalised effective mass		
Number		X	Y	Z
	f [Hz]	(launch)	(lateral)	(lateral)
1	136	0.00	**0.75**	0.01
2	151	0.05	0.01	**0.79**
3	189	**0.46**	0.00	0.02
4	191	0.06	0.00	0.03
5	207	0.01	0.01	0.00
6	221	0.05	0.00	0.00
7	227	0.16	0.01	0.05
8	238	0.01	0.01	0.00
9	242	0.02	0.00	0.00
10	246	0.00	0.00	0.00
21	299	0.04	0.00	0.00
	total:	0.93	0.83	0.94

The goal is above 120 Hz with uncertainty of 10%
This means in the analysis the first frequency should be above 131 Hz

Mass Budget-1

MSSL mass spreadsheet						
Nominal estimate + contingency						Contingency
Issue 1.4 November 2001						uncertainty
						[%]
	Nett	Contg.	Total			
Photometer cover	5.94	0.30	6.24	[kg]		5.00
Spectrometer cover	5.37	0.27	5.64	[kg]		5.00
Optical bench	8.86	0.89	9.75	[kg]		10.00
Mounting common structure	0.52	0.04	0.56	[kg]		7.01
RF-attenuation	0.00	0.00	0.00	[kg]		0.00
Phot. det. box	4.19	0.42	4.60	[kg]		10.00
Spect. det. box	1.09	0.11	1.19	[kg]		10.00
Structure:	**25.96**	2.02	27.98			6.72

Mass Budget - 2

MSSL mass spreadsheet						
Nominal estimate + contingency						Contingency
Issue 1.4 November 2001						uncertainty
						[%]
Structure:	**25.96**	2.02	27.98			6.72
Mounts, Clamps Phot.	1.28	0.06	1.34	[kg]		5.00
Mounts, Clamps Spect.	0.86	0.04	0.90	[kg]		5.00
Thermal straps	0.52	0.10	0.62	[kg]		20.00
Straylight Baffles	1.39	0.07	1.46	[kg]		5.00
Thermistors	0.35	0.07	0.42	[kg]		20.00
RF-filter boxes	*1.72*	*0.34*	*2.06*	[kg]		20.00
total	32.07	2.71	**34.77**	[kg]		8.44

Thermal Budget

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Herschel/SPIRE structure DDR
Overall Instrument Design

Berend Winter

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Contents

- Static
- Dynamics
  - sine vibration
  - random vibration
- Thermal
  - Level 1 - Level 2
  - Level 0 - Level 1
- Stray Light
- RF-sealing
- Alignment

Sine Vibration

Sine vibration levels	Frequency range	Input at base (QUAL)
X - Axis	5-40 Hz 40-100 Hz	20 g 10 g
Y - Axis	5-100 Hz	14 g
Z - Axis	5-100 Hz	14 g

- Allowed to notch on interface loads
  - Strength is limited by quasi static I/F loads
  - Instrument is designed for 100 g in any direction (static)
- No problem, safety factor is 1.5

Static

Quasi Static levels	Case 1	Case 2	Case 3
x-direction	20 g	-	-
y-direction	-	14 g	-
z-direction	-	-	14 g

- Instrument was designed for static loading
- Lowest margin of safety in Y direction
  - safety factor 1.6 in the A-frame support
- Structure is not a problem

Random Vibration

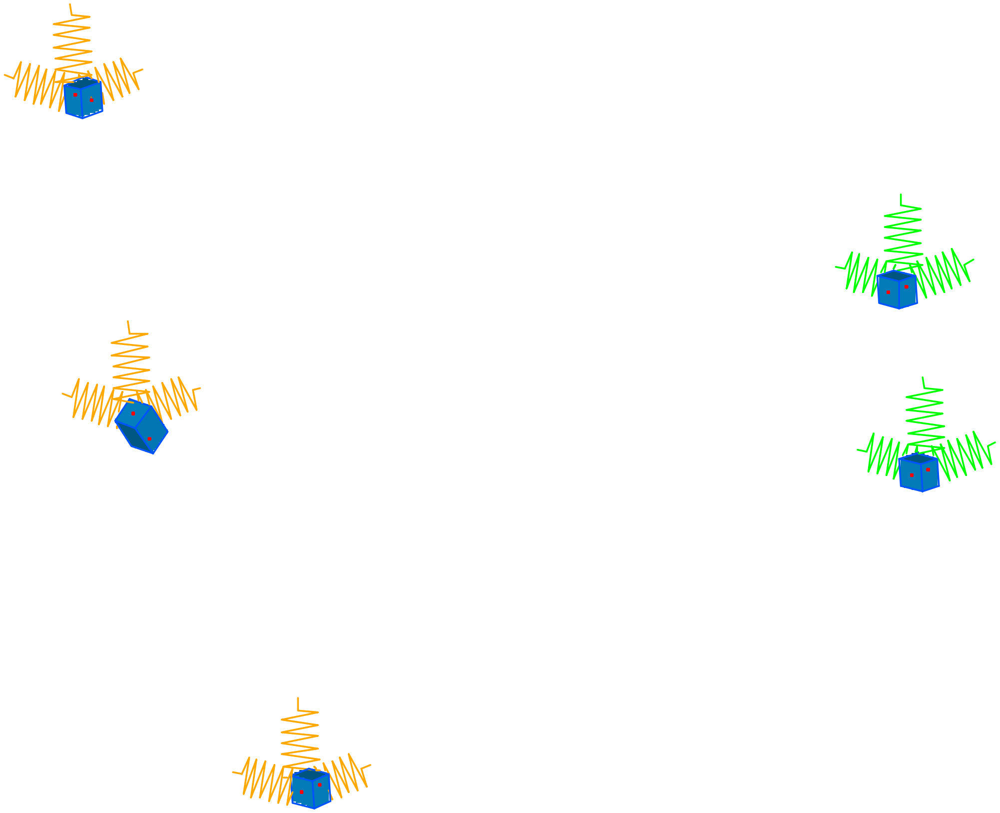
Random vibration levels	Frequency range	Input at base (QUAL.)	RMS
X – Axis	20 – 100 Hz 100 - 300 Hz 300 – 2000 Hz	+6 dB Hz/Oct 0.05 g^2/Hz -6 dB/Oct	5.27g RMS
Y – Axis	20 – 80 Hz 80 - 300 Hz 300 – 2000 Hz	+6 dB Hz/Oct 0.05 g^2/Hz -6 dB/Oct	5.27 g RMS
Z – Axis	20 – 80 Hz 80 - 300 Hz 300 – 2000 Hz	+6 dB Hz/Oct 0.05 g^2/Hz -6 dB/Oct	5.27 g RMS

- Allowed to notch on interface loads
  - Strength is limited by quasi static I/F loads
- No problem, safety factor is 1.6

Random Vibration

- Implemented notch on interface loads and adjusted design of photometer detector box support
  - Strength is limited by quasi static I/F loads
- No problem, safety factor is 1.7
- However....
  - Loads on detectors proved to be a problem, un-notched with previous design detector responses were exceeding 40 g-rms
- Adjusted design of photometer detector introduce increase in parasitic heat loads through support
- Overall damping assumed in random analysis of 3%, and 4% for detector modes
- Detectors modeled using 1-dof mass-spring system in all 3 orthogonal directions for each detector individually

Detector model



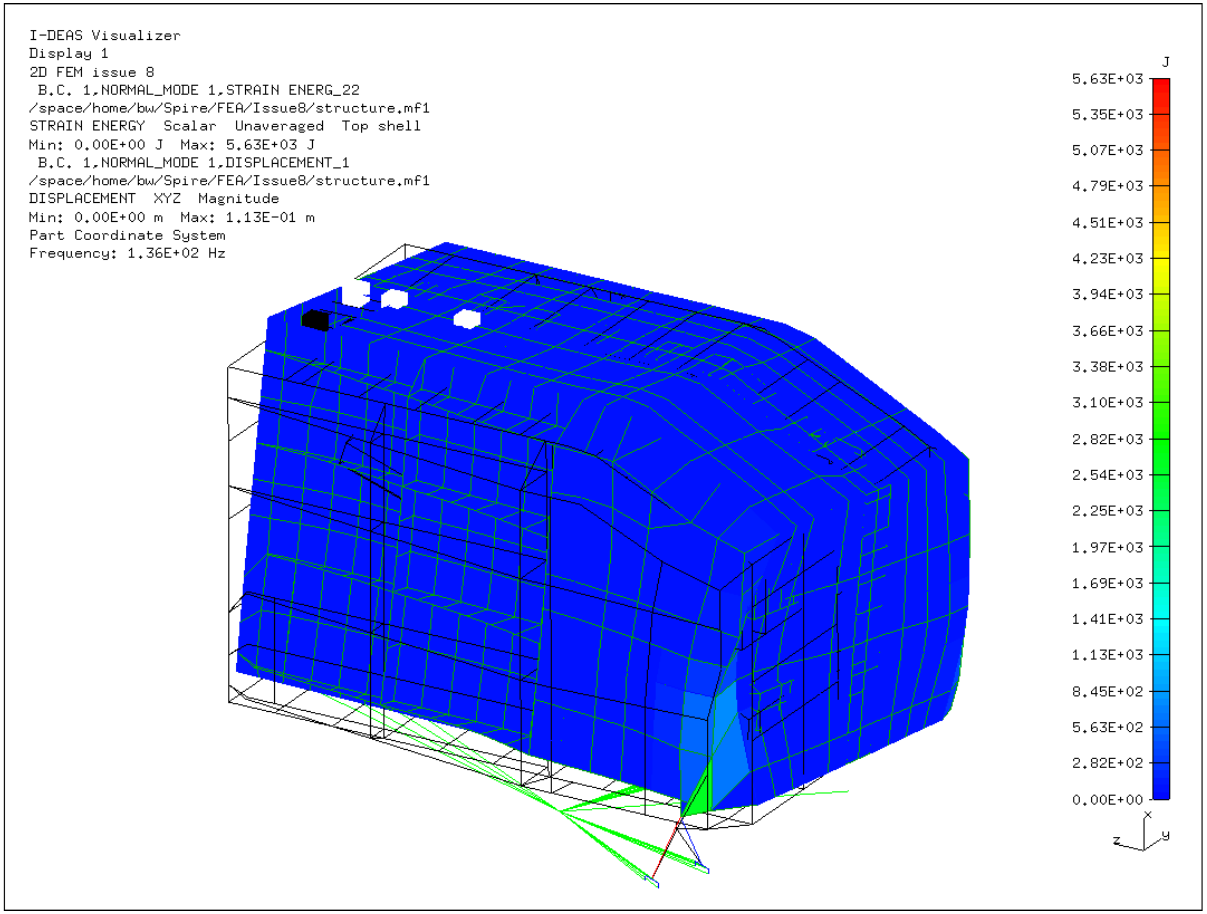
Detectors 1st mode

First mode						
	PLW	PMW	PSW	SLW	SSW	
f-given	221	236	247	265	272	[Hz]
lbs	1.338	1.244	1.126	1.012	0.964	[LBS]
modal %	0.65	0.65	0.65	0.65	0.65	[%]
m1	0.3945	0.3668	0.3320	0.2984	0.2842	[kg]
m2	0.212	0.197	0.179	0.161	0.153	[kg]
m-total kg	0.607	0.564	0.511	0.459	0.437	[kg]
k-effective	7.61E+05	8.06E+05	8.00E+05	8.27E+05	8.30E+05	[N/m]
k-approx	**8.00E+05**	**8.00E+05**	**8.00E+05**	**8.00E+05**	**8.00E+05**	[N/m]
f-approx	**221**	**236**	**247**	**265**	**272**	[Hz]
m1	**0.415**	**0.364**	**0.332**	**0.289**	**0.274**	[kg]
m2	**0.192**	**0.200**	**0.179**	**0.170**	**0.163**	[kg]
difference	0	0	0	0	0	[%]

Detectors 2nd and 3rd mode

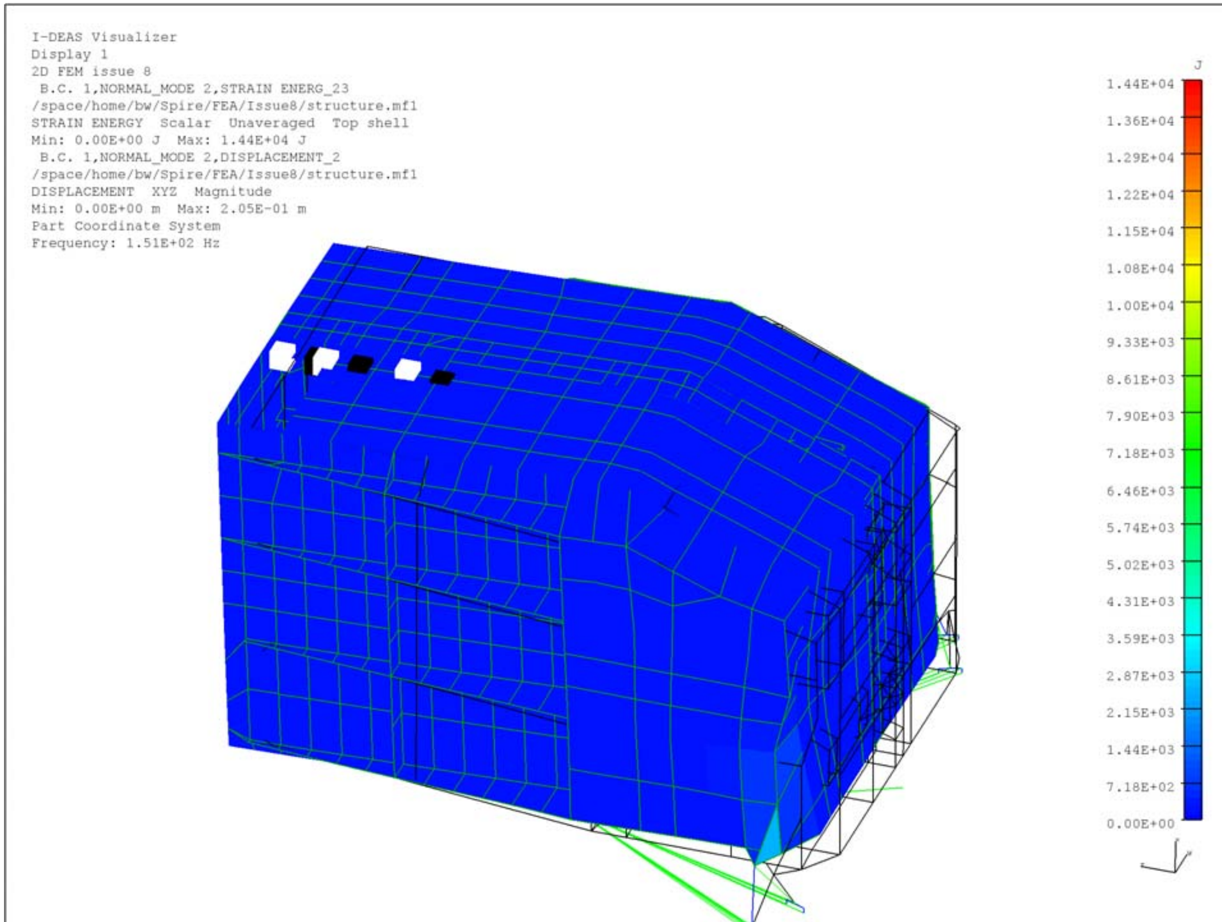
Second mode						
f-given	274	292	304	328	331	[Hz]
k-effective	1.17E+06	1.23E+06	1.21E+06	1.27E+06	1.23E+06	[N/m]
k-approx	**1.20E+06**	**1.20E+06**	**1.20E+06**	**1.20E+06**	**1.20E+06**	[N/m]
f-approx	**270.7**	**289.0**	**302.5**	**324.6**	**333.1**	[Hz]
difference	1.22	1.01	0.49	1.05	-0.64	[%]
Third mode						
f-given	332	345	371	399	410	[Hz]
k-effective	1.72E+06	1.72E+06	1.80E+06	1.88E+06	1.89E+06	[N/m]
k-approx	**1.80E+06**	**1.80E+06**	**1.80E+06**	**1.80E+06**	**1.80E+06**	[N/m]
f-approx	**331.5**	**354.0**	**370.5**	**397.5**	**408.0**	[Hz]
difference	0.2	-2.6	0.1	0.4	0.5	[%]

First Mode 136 Hz



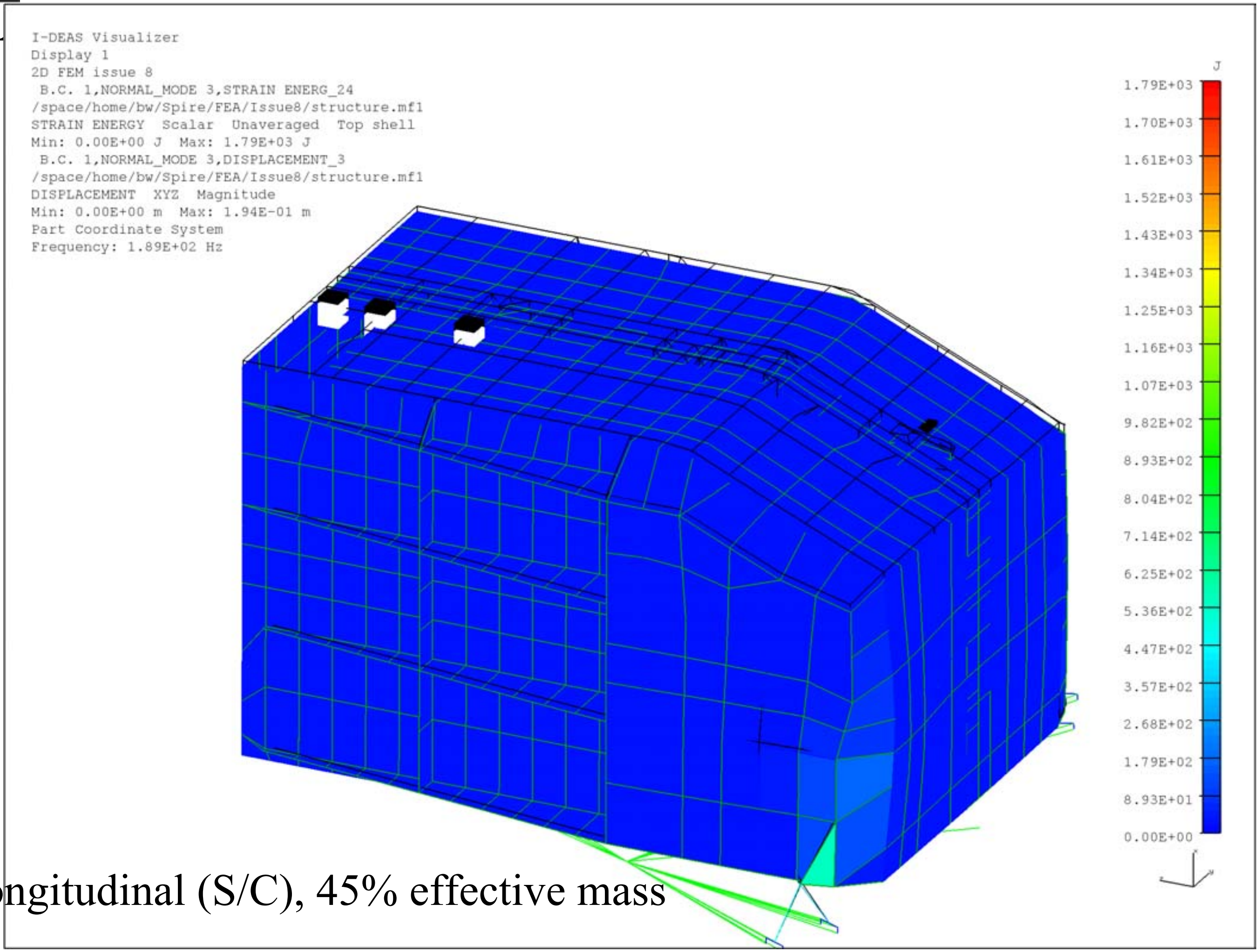
- Lateral mode (S/C), 80% effective mass

Second Mode 151 Hz



- Lateral mode (S/C), 80% effective mass

Third Mode 189 Hz



- Longitudinal (S/C), 45% effective mass

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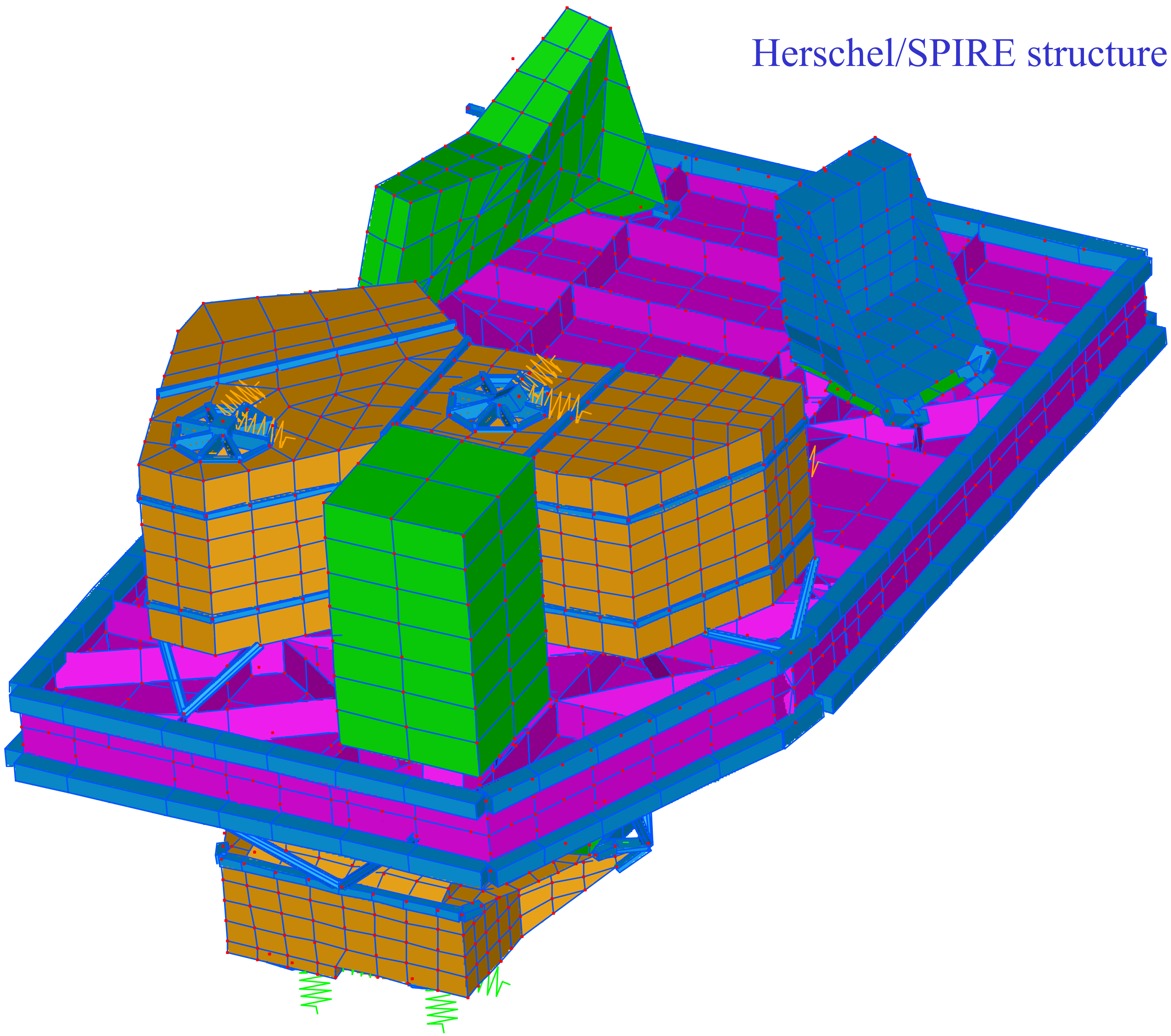
Herschel/SPIRE structure DDR



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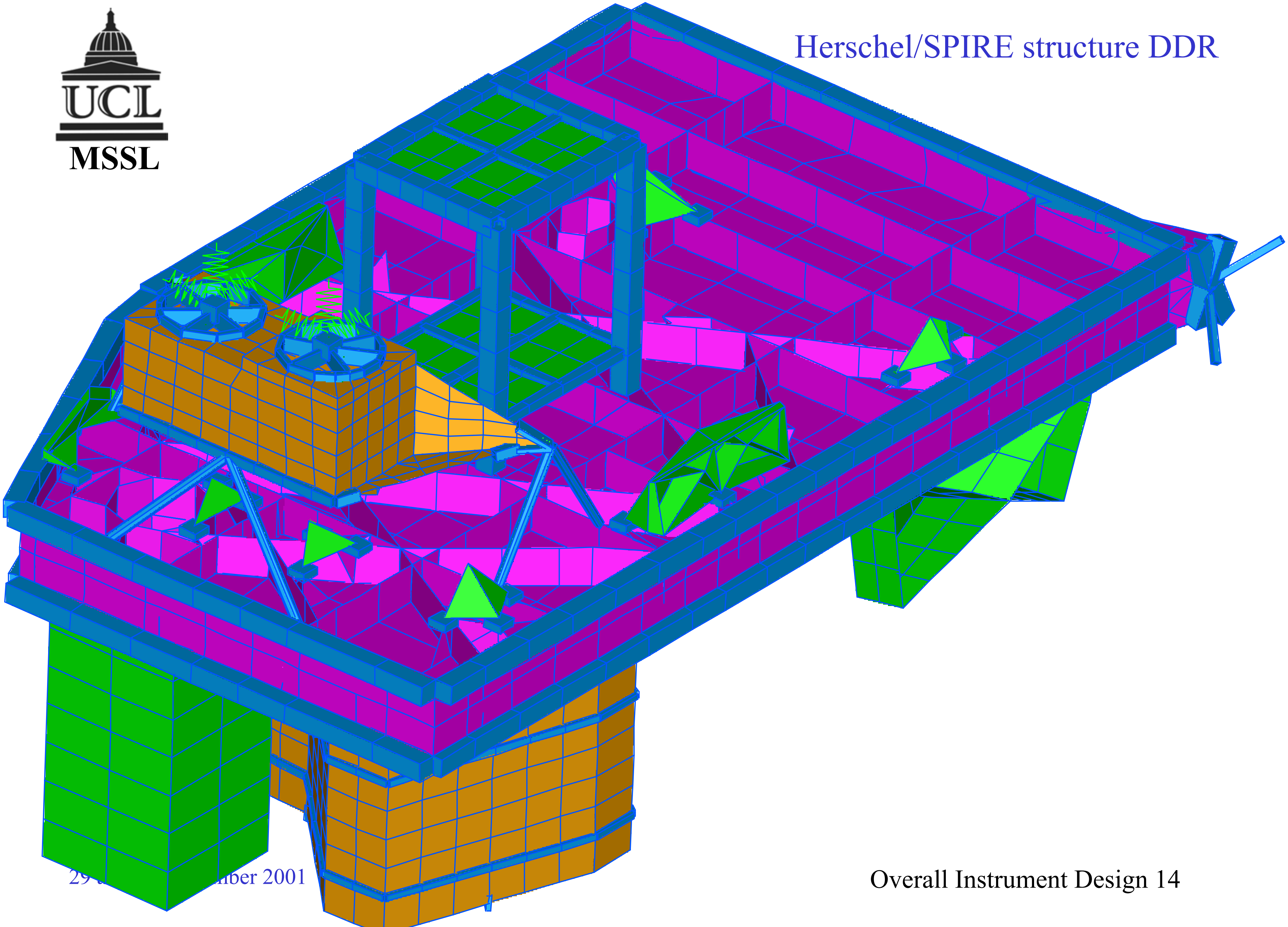
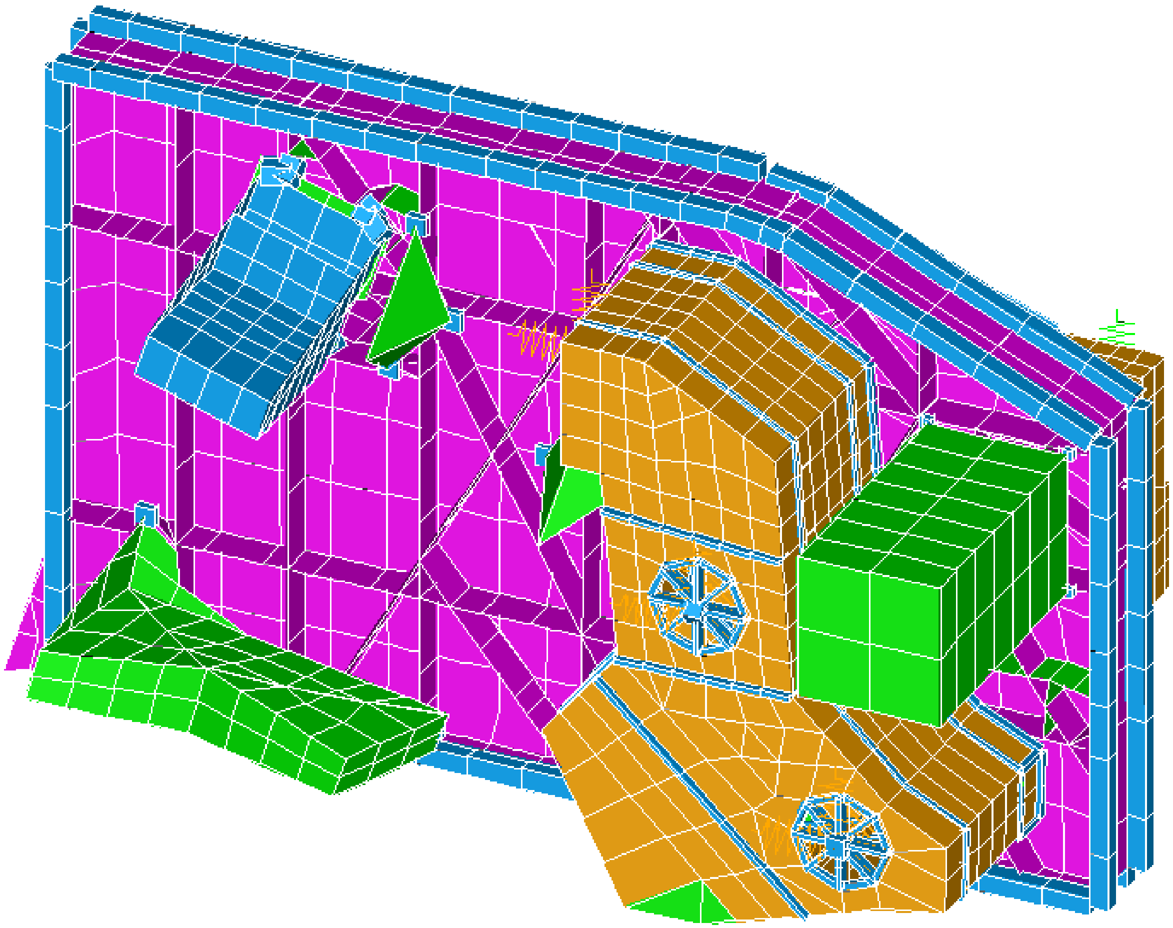
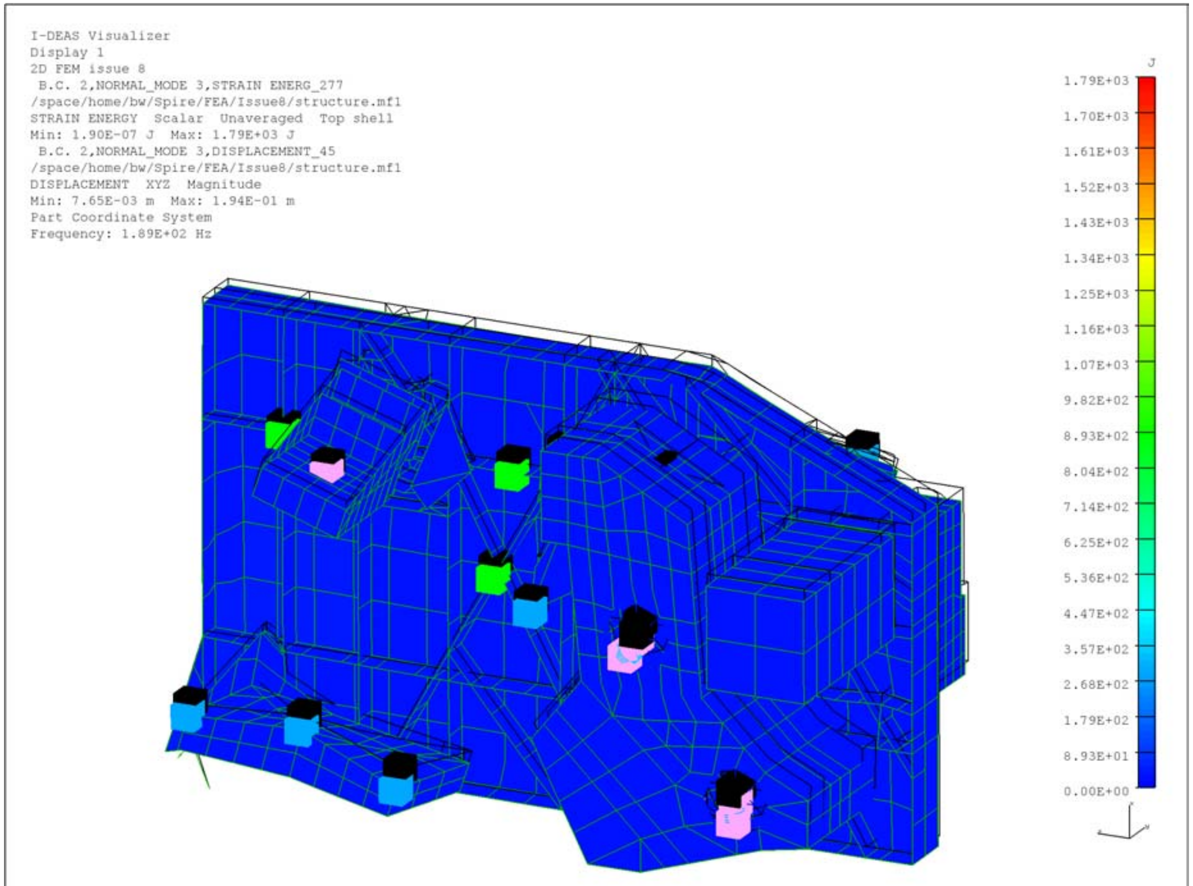
Herschel/SPIRE structure DDR



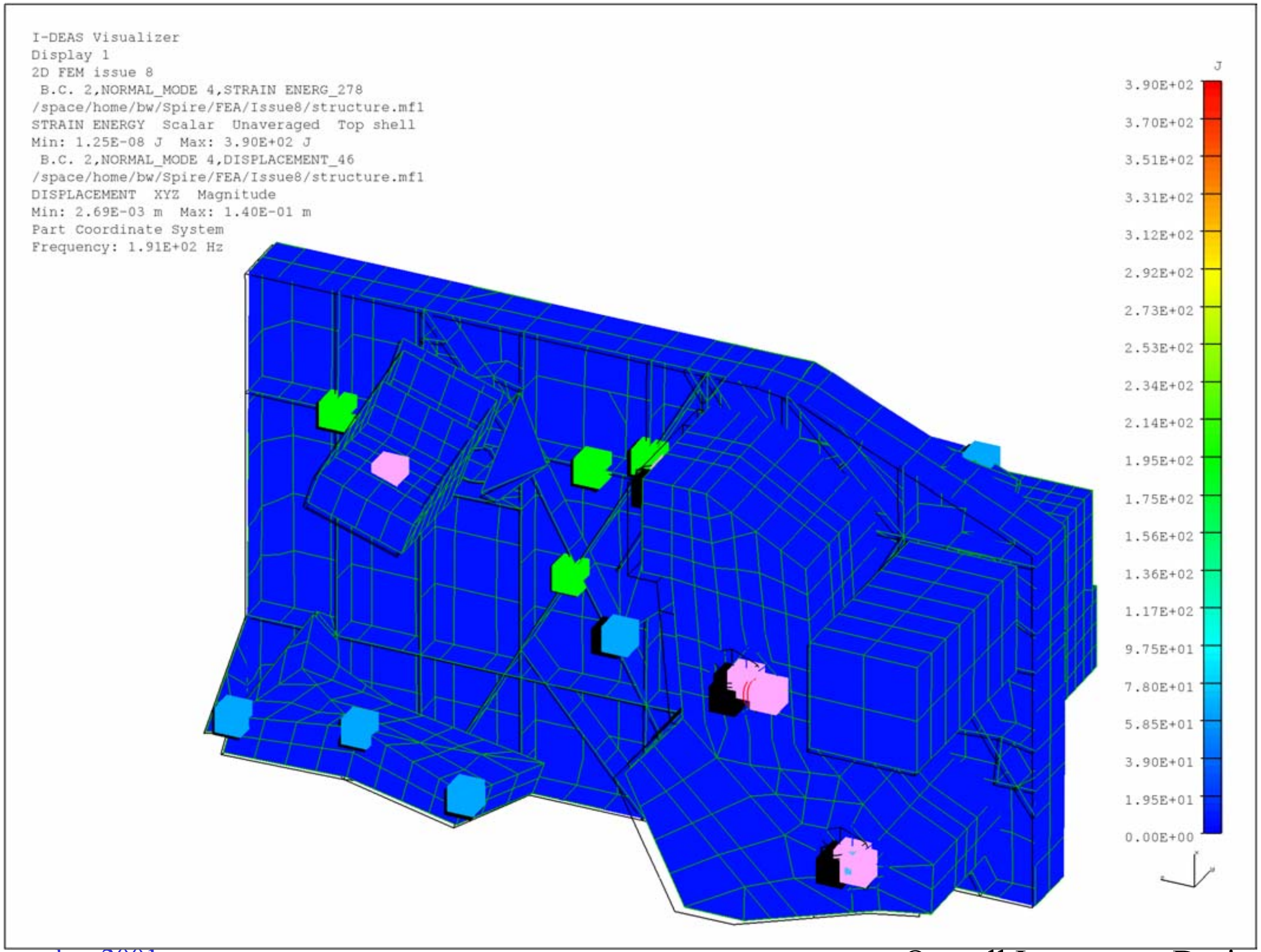
Photometer FEA



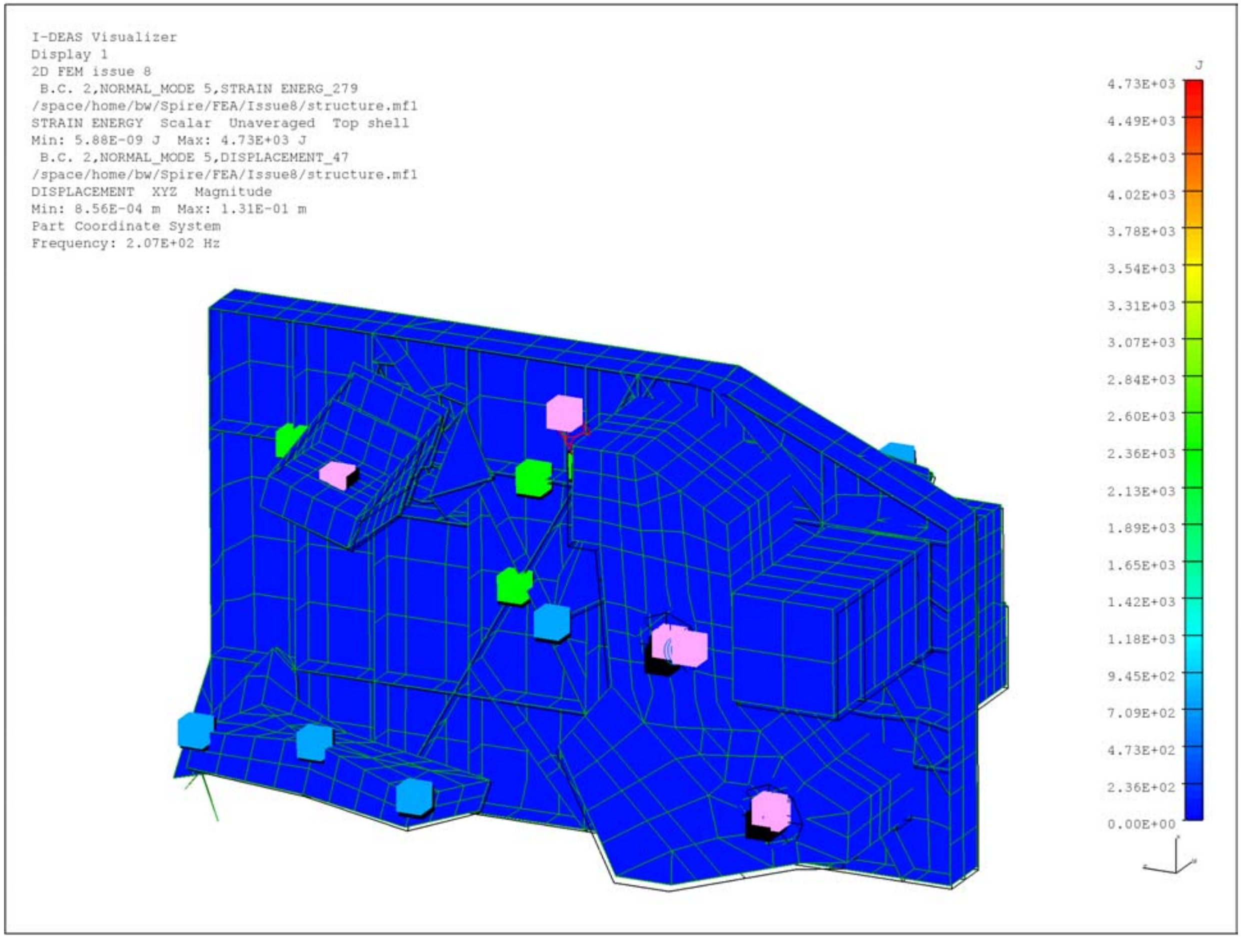
Third Mode, 189 Hz



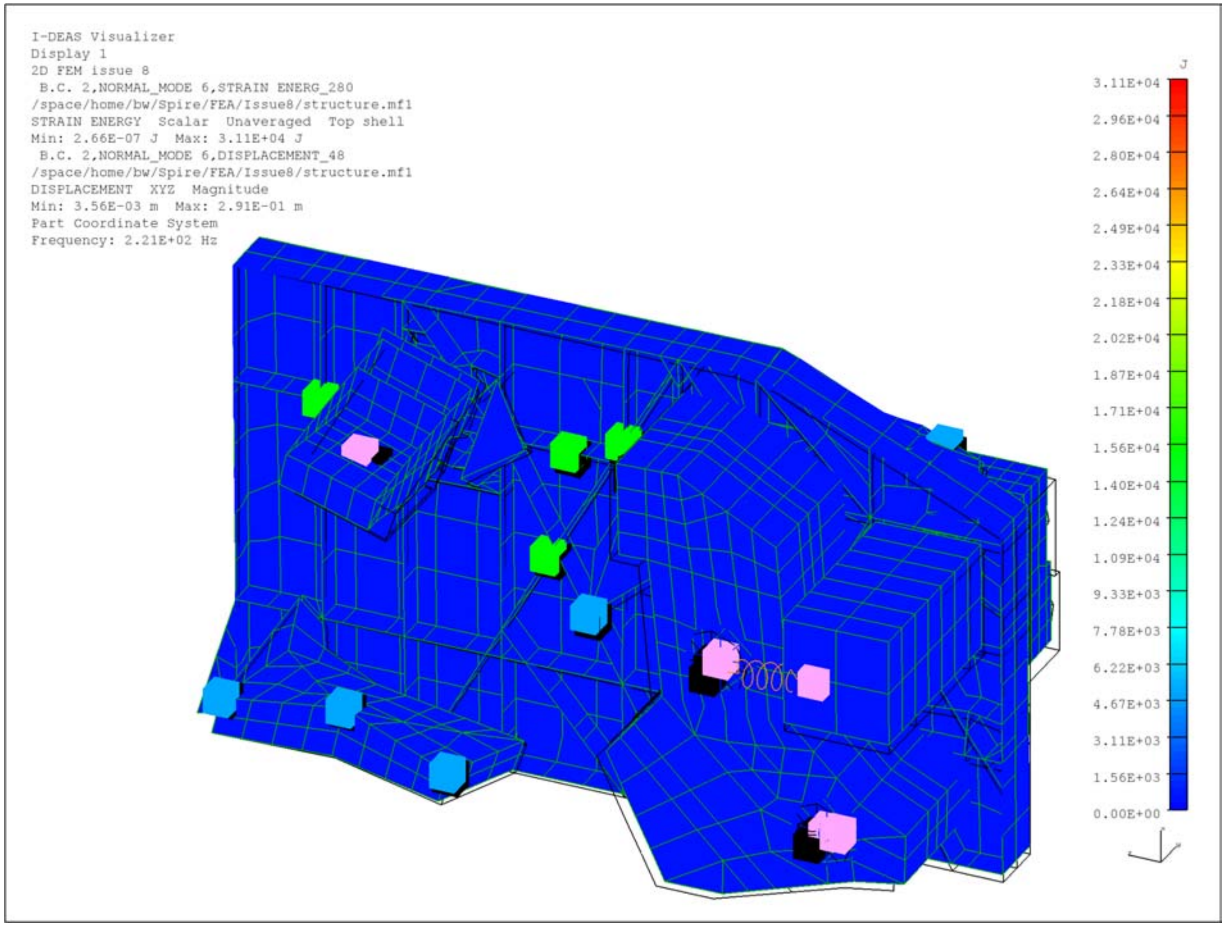
Fourth Mode 191 Hz



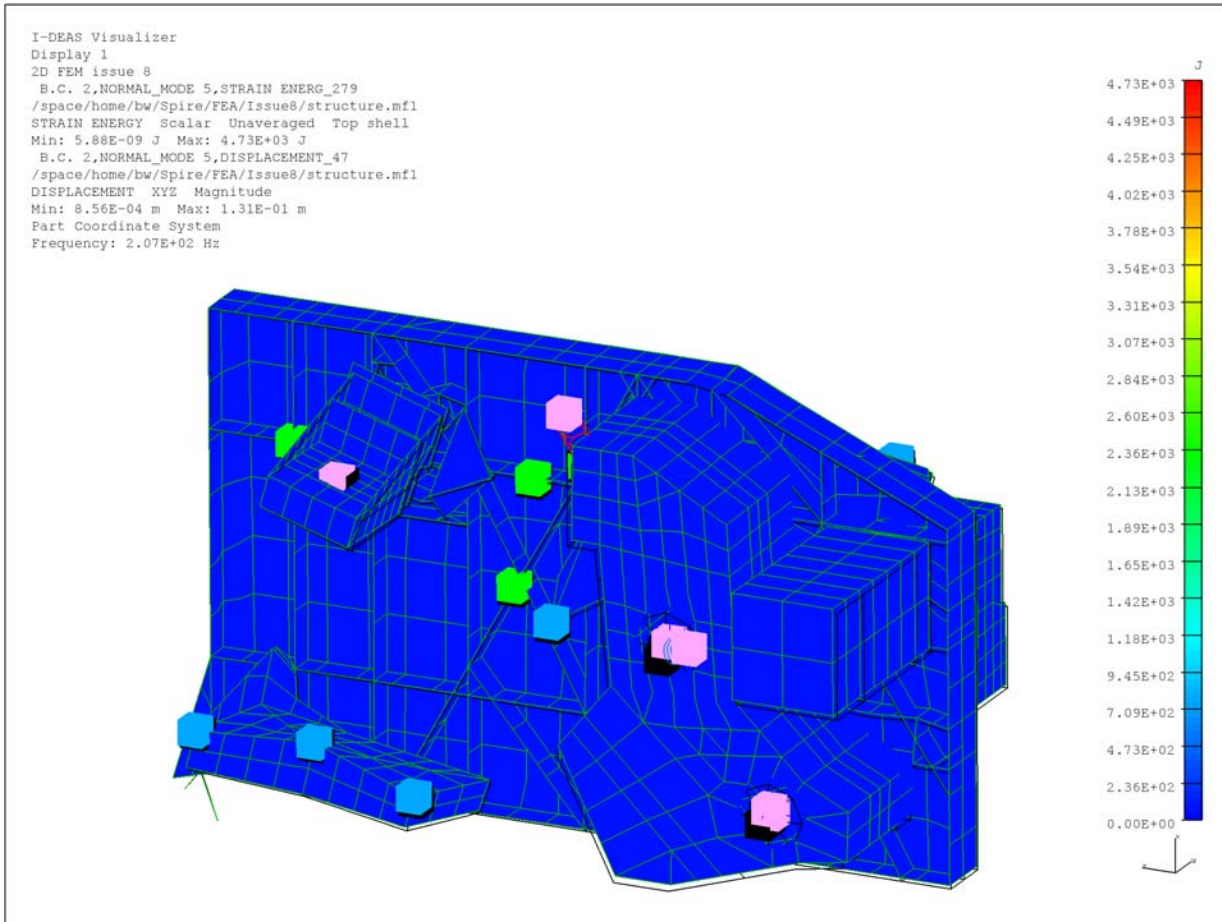
Fifth Mode 207 Hz



Sixth Mode 221 Hz

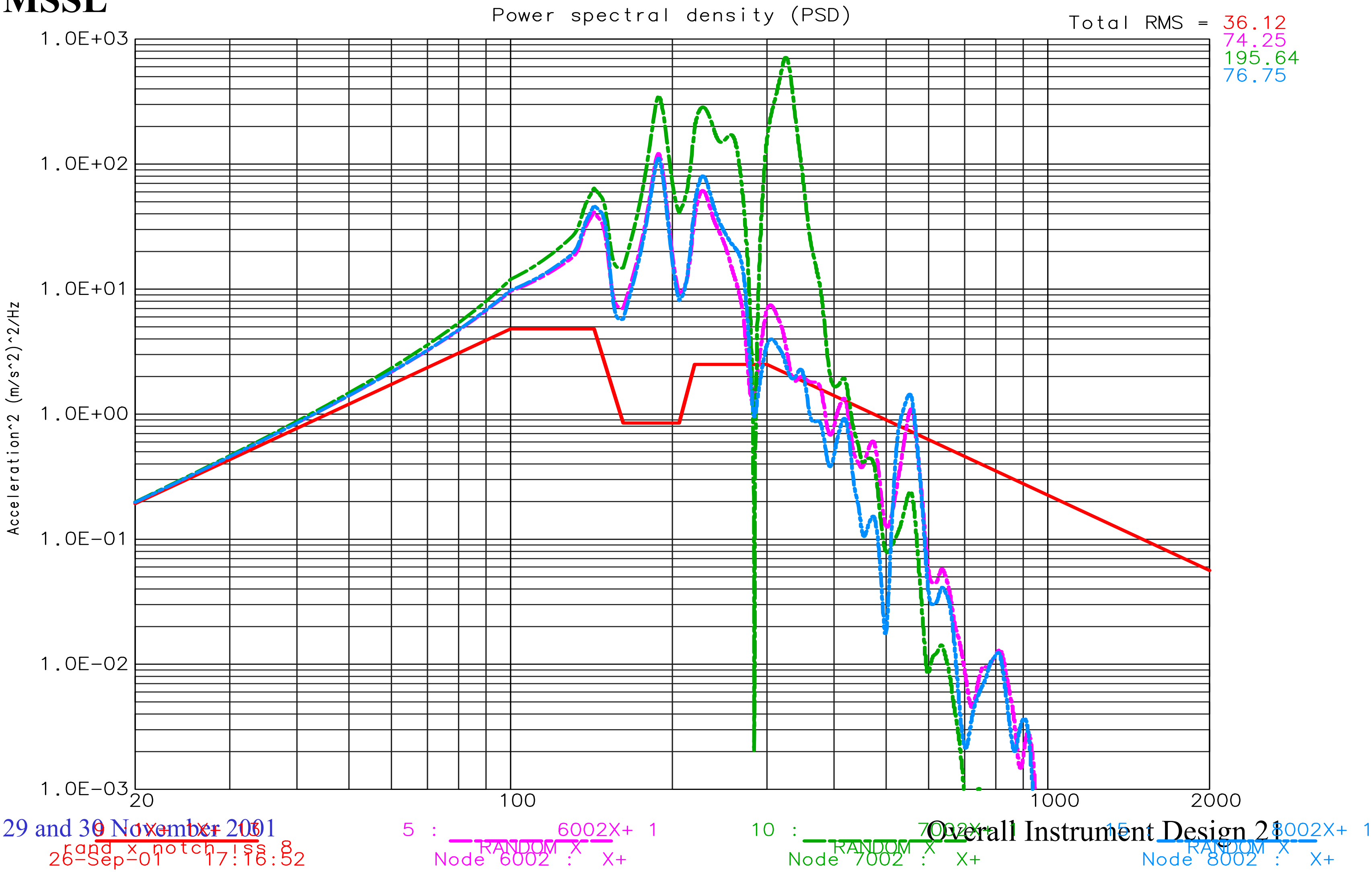


Seventh Mode 227 Hz

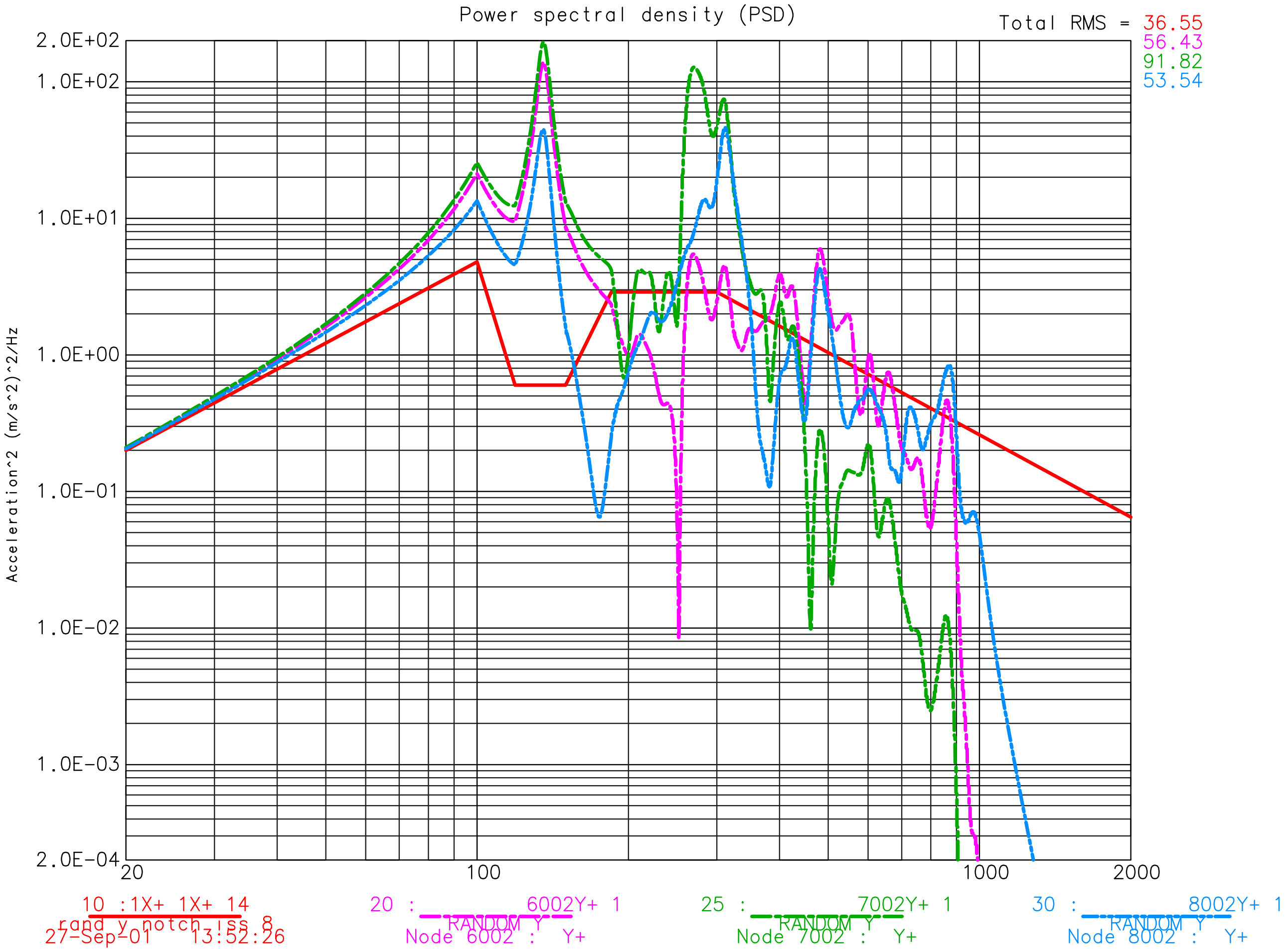


UCL
MSSL

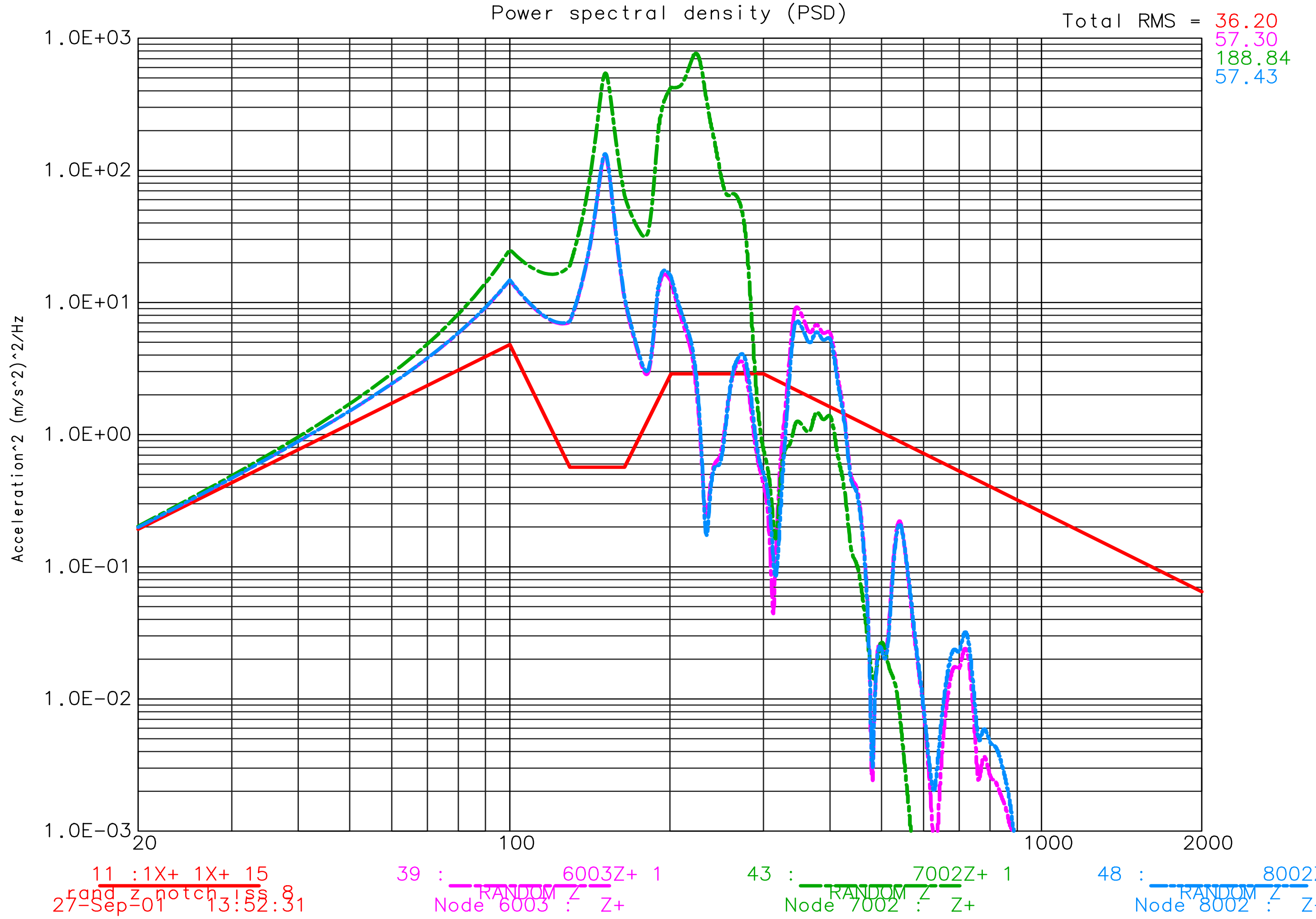
Random -X



Random -Y

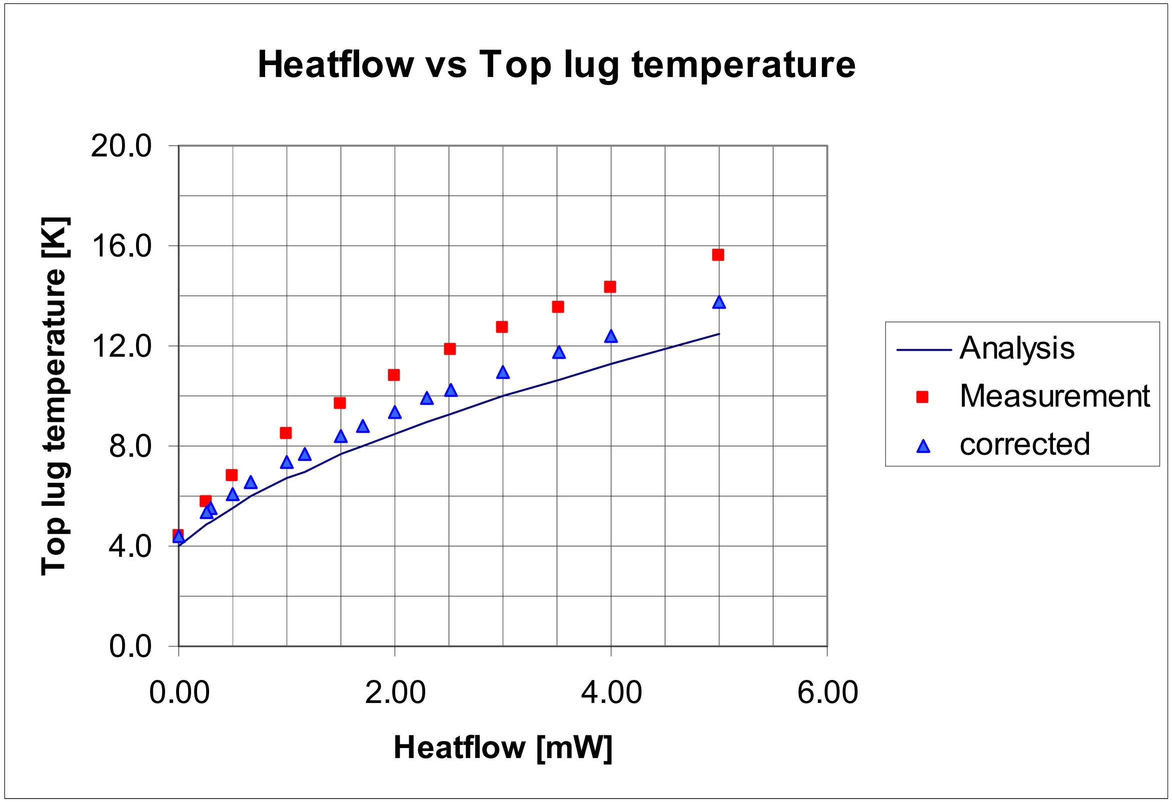

Power spectral density (PSD)
Total RMS = 36.55
56.43
91.82
53.54
2.0E+02
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
1.0E-03
2.0E-04
20
100
1000
2000
Acceleration^2 (m/s^2)^2/Hz
10 :1X+ 1X+ 14
rand y notch iss 8
27-Sep-01 13:52:26
20 : 6002Y+ 1
RANDOM Y
Node 6002 : Y+
25 : 7002Y+ 1
RANDOM Y
Node 7002 : Y+
30 : 8002Y+ 1
RANDOM Y
Node 8002 : Y+

Random -Z



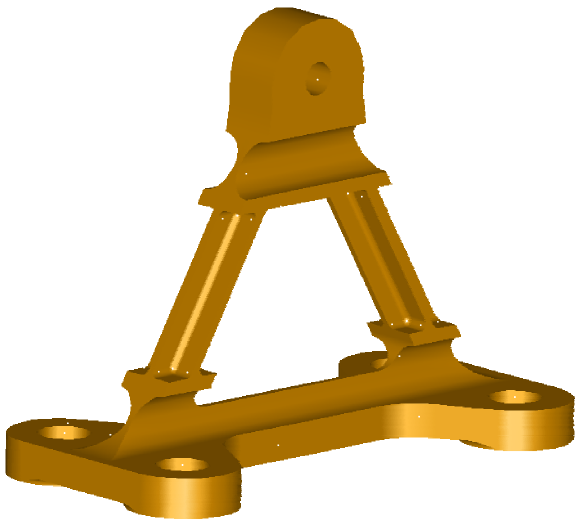
Power spectral density (PSD)
Total RMS = 36.20
57.30
188.84
57.43
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
1.0E-03
Acceleration^2 (m/s^2)^2/Hz
20
100
1000
2000
11 :1X+ 1X+ 15
rand z notch iss 8
27-Sep-01 13:52:31
39 : 6003Z+ 1
RANDOM Z
Node 6003 : Z+
43 : 7002Z+ 1
RANDOM Z
Node 7002 : Z+
48 : 8002Z+ 1
RANDOM Z
Node 8002 : Z+

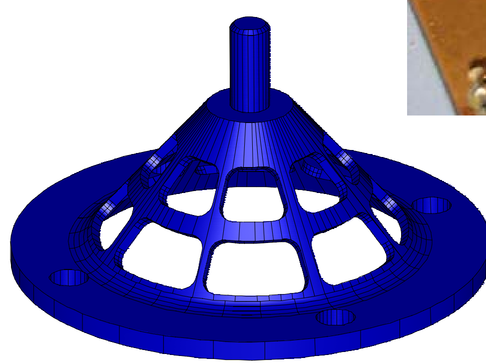
Parasitic Heat Load level 1 - 2

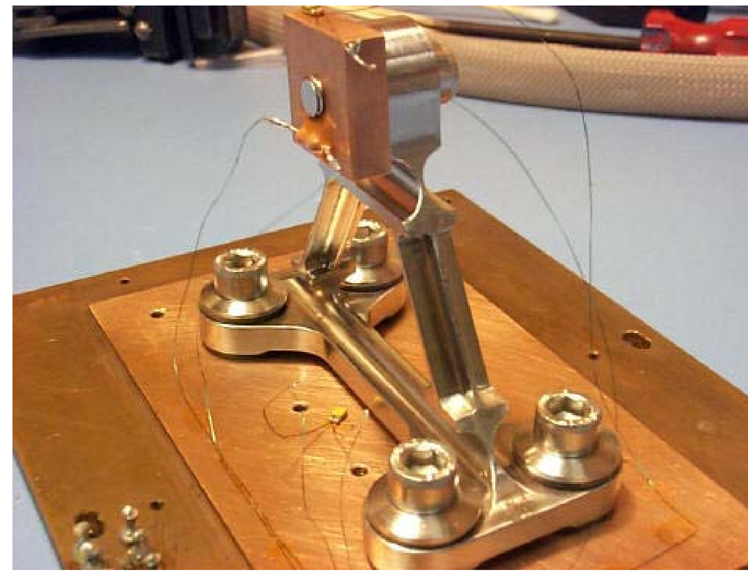


- Heat-flux through A-frame support

A-frame and Cone Support







Parasitic Heat Load level 1 - 2 cont.

- Heat-flux through A-frame support
  - 4.2 - 9 K boundary measured 2 mW
- Cone support
  - 4.2 - 9 K boundary analysed 2 mW (based upon A-frame measurements)
- Total parasitic heat load
  - 6 mW

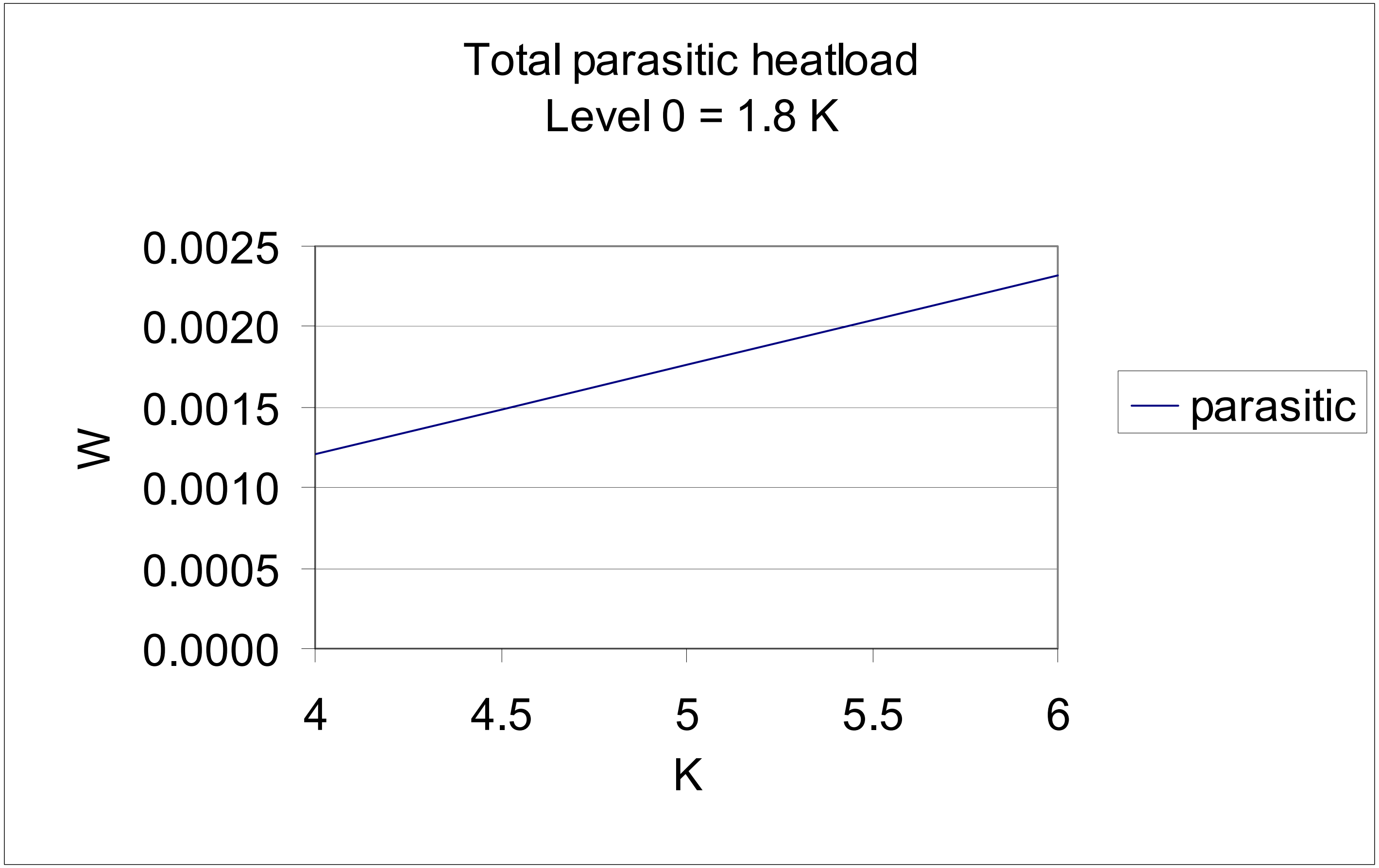
Parasitic Heat Load level 0 - 1

- Two A-frames for photometer box support
- One cone for photometer box support
- Total A/L = 2.0E-3 m

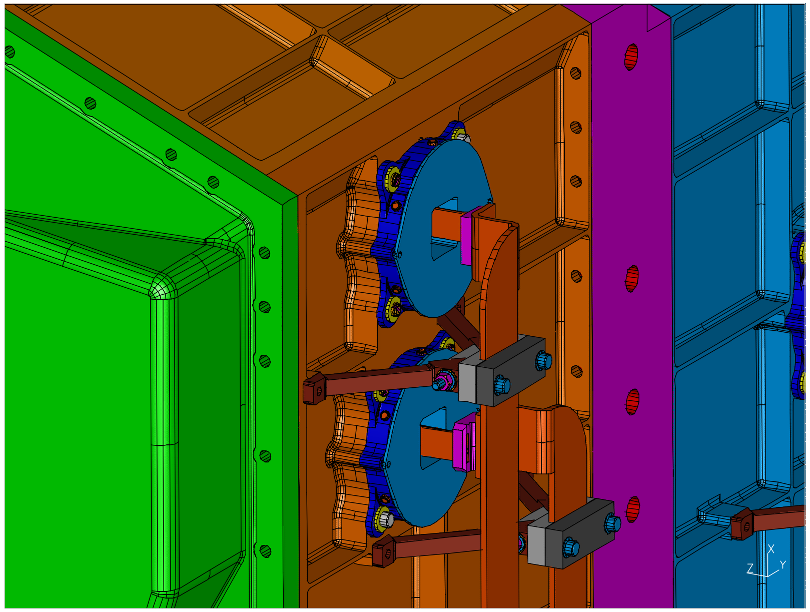
- 3 bi-pots for detector box support
- Total A/L = 0.9E-3 m

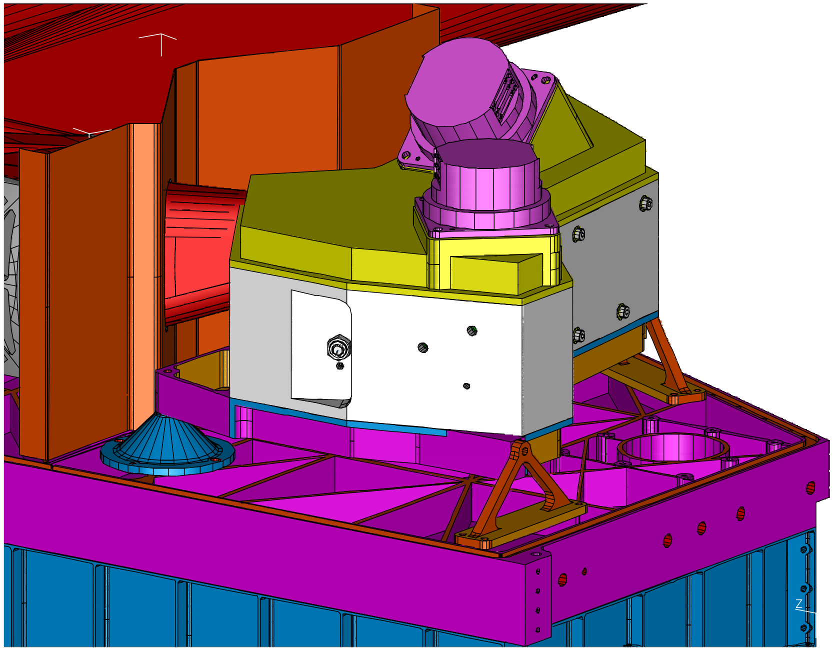
- Temperature law: K = 0.1T-0.1 (based upon measurements)

Parasitic Heat Load level 0 - 1 cont.

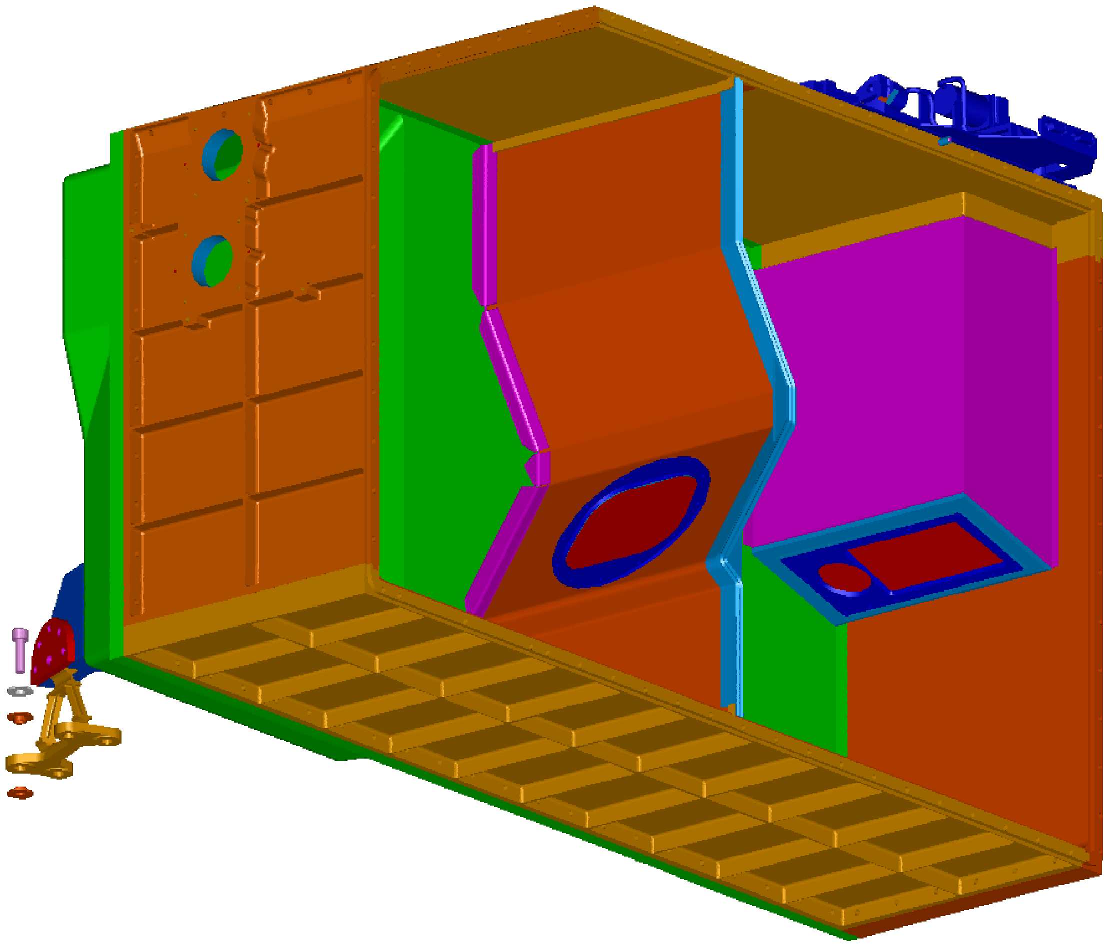


Stray Light

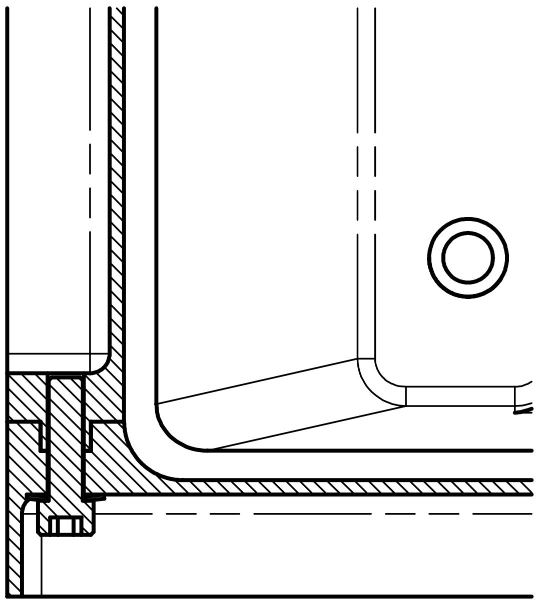


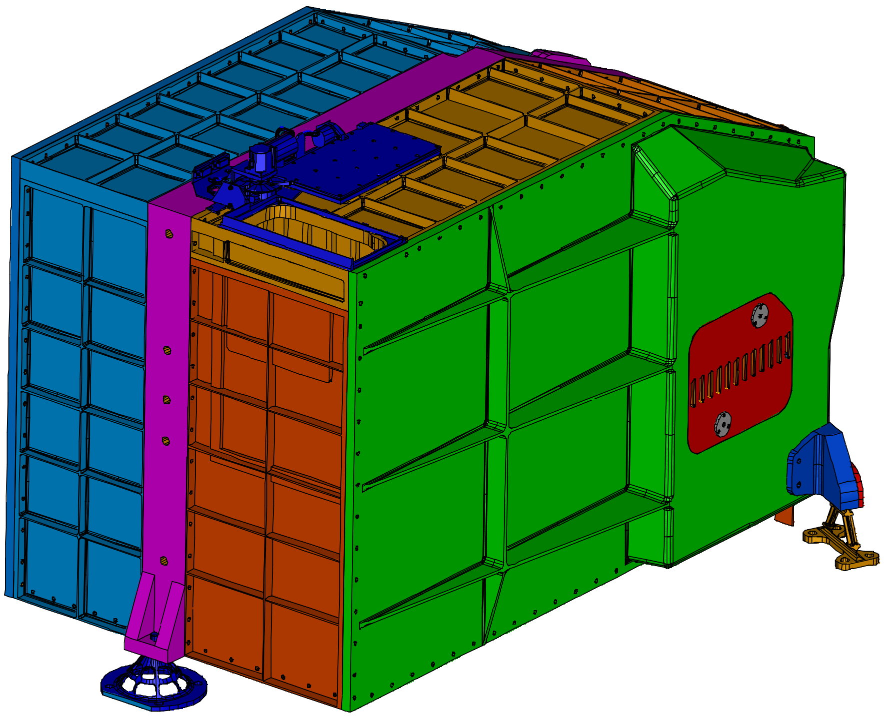


Stray Light cont.



RF-attenuation

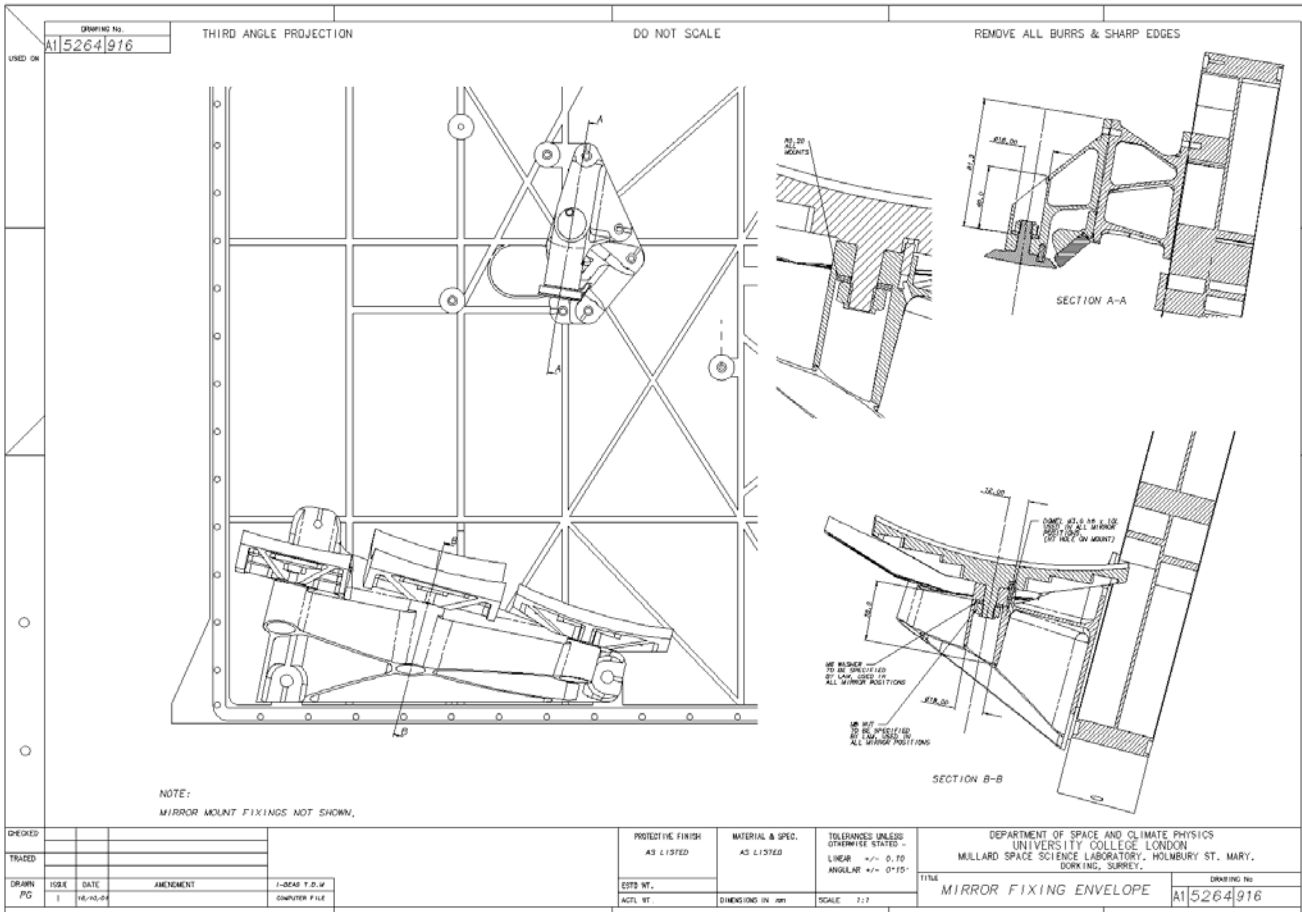




Alignment

- Not reported as such (sorry)
  - all optical parts will be mounted with a nominal tolerance of better than 0.05 mm
  - RSS value for allowable 0.1 mm mirror off-set allows 4 ‘jumps’
  - Reference for alignment is optical bench
  - To almost all mirrors the relative number of ‘jumps’ is 1-2
  - For the detector boxes the number of ‘jumps’ 4
  - Maximum overall angular error per mirror is 1 arcmin
  - The secondary optical bench, holding CM3, CM5 and PM7 are the most critical ones wrt to alignment. Due to construction relative misalignment is very minimal
  - Included combined mirror support for PM6 and SM6, allowing mis-alignment correction

Alignment



A1 5264 916
THIRD ANGLE PROJECTION
DO NOT SCALE
REMOVE ALL BURRS & SHARP EDGES
SECTION A-A
SECTION B-B
NOTE:
MIRROR MOUNT FIXINGS NOT SHOWN.
CHECKED
TRACED
DRAWN
PG
ISSUE
DATE
AMENDMENT
PROTECTIVE FINISH
AS LISTED
MATERIAL & SPEC.
AS LISTED
TOLERANCES UNLESS OTHERWISE STATED -
LINEAR +/- 0.10
ANGULAR +/- 0°15'
DEPARTMENT OF SPACE AND CLIMATE PHYSICS
UNIVERSITY COLLEGE LONDON
MULLARD SPACE SCIENCE LABORATORY, HOLMBURY ST. MARY,
DORKING, SURREY.
TITLE
MIRROR FIXING ENVELOPE
DRAWING No
A1 5264 916
DIMENSIONS IN mm
SCALE 1:1

MSSL

Herschel/SPIRE structure DDR
Main Interfaces

John Coker
Paul Gocher
Berend Winter

Mullard Space Science Laboratory
University College London

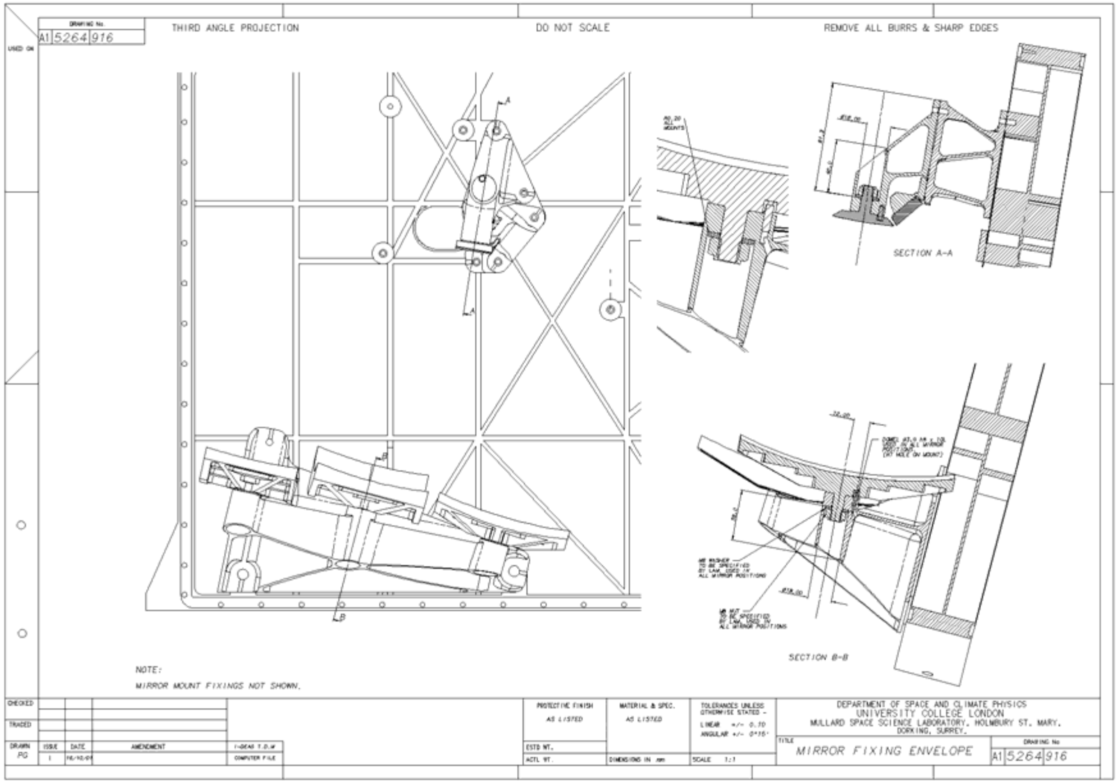
UCL MSSL

Main Interfaces

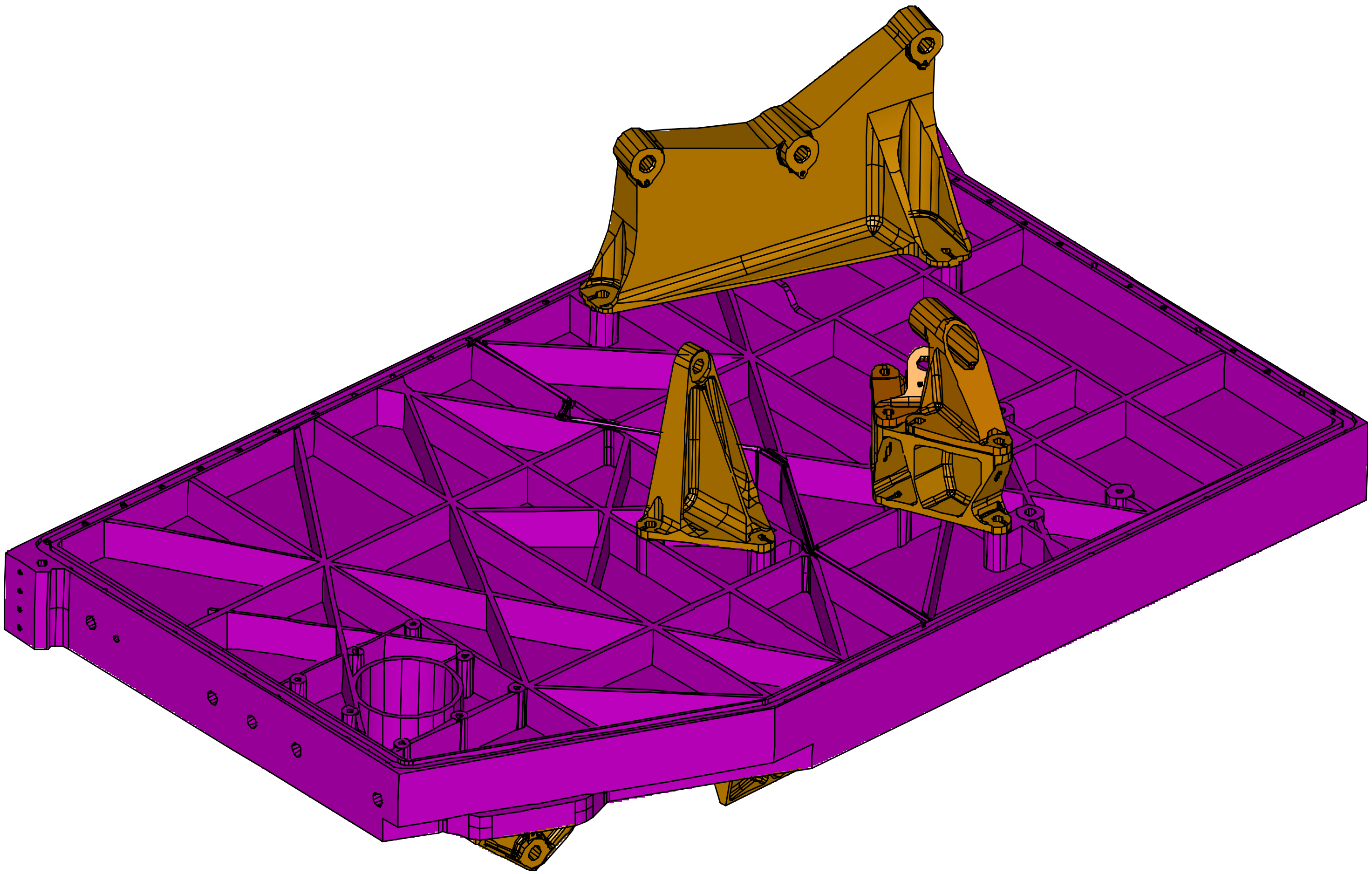
- Mirrors – LAM
- Filters – Cardiff
- Beam Splitters - Cardiff
- Dichroics – Cardiff
- Cooler – CEA
- Detectors – JPL
- BSM – ATC
- SMEC – LAM
- RF Filters – JPL
- Shutter – UofS
- Scal – Cardiff
- JFETS - RAL
- Thermistors – RAL
- Straylight Baffles
- Cardiff Black – Cardiff
- Cold Stops - MSSL

Mirror Mounts

- Interface frozen

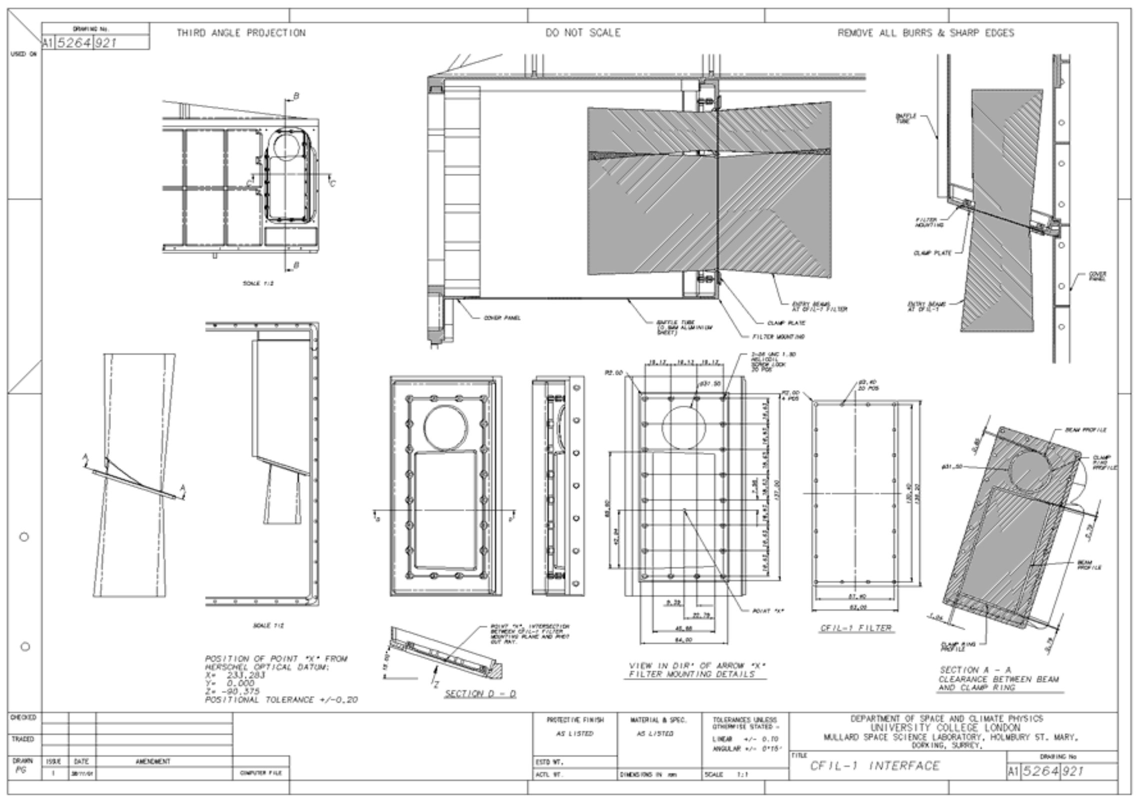


Mirror mounts cont.



Filters

- Interface frozen



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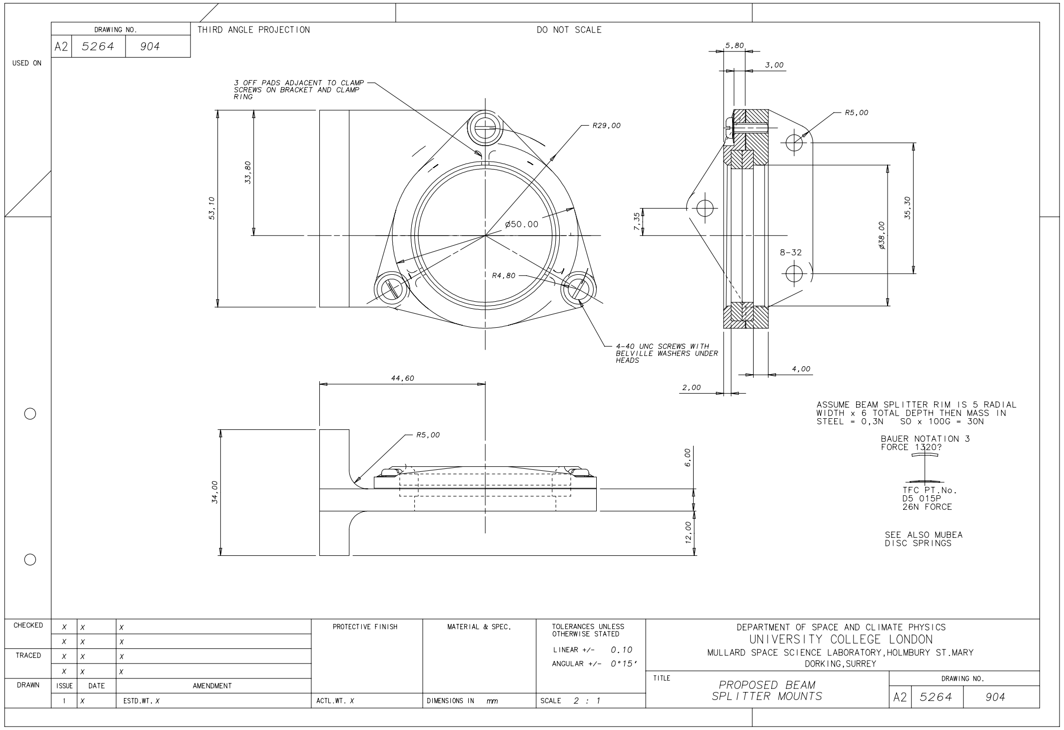
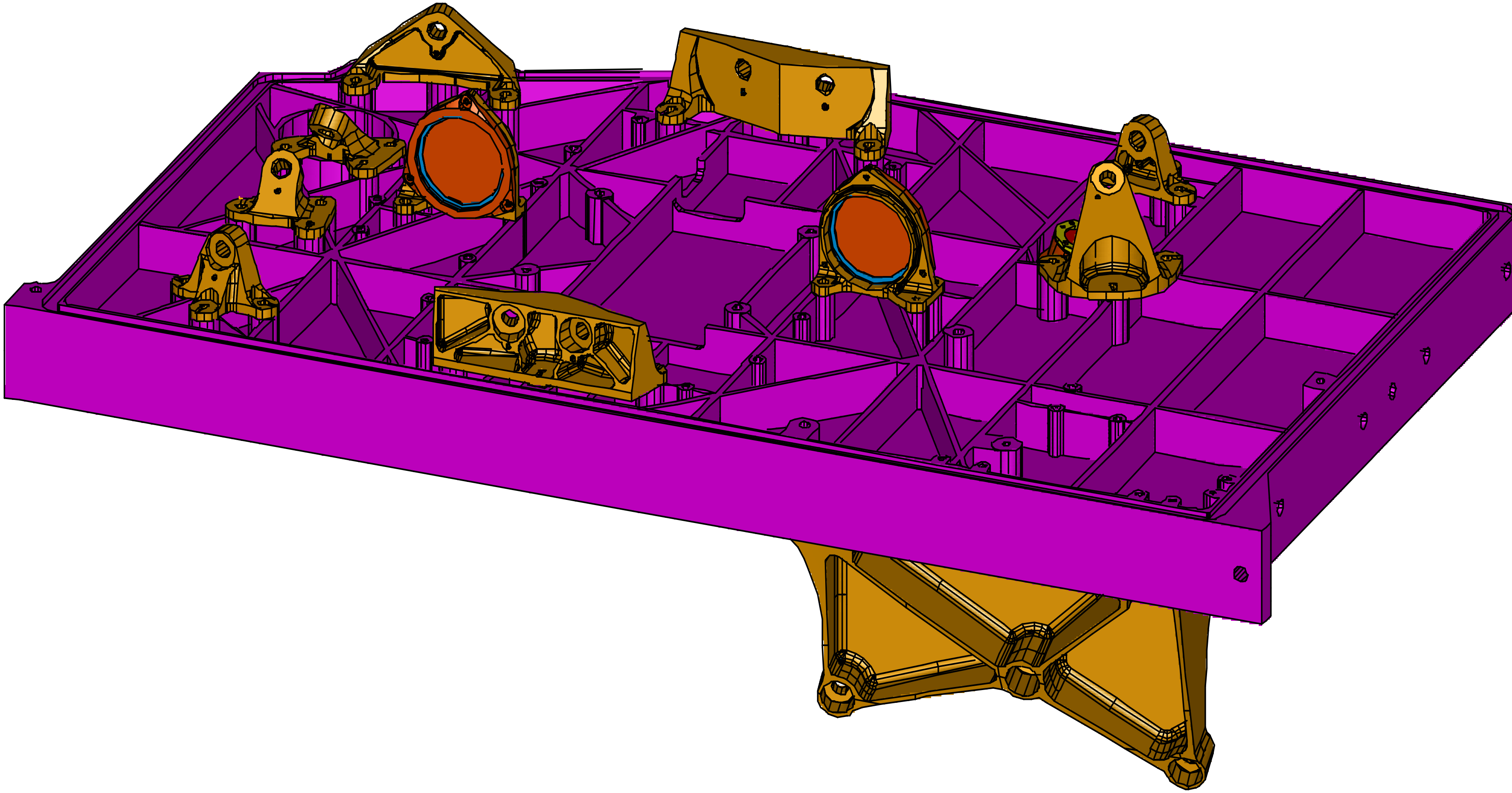
Beam Splitters

- Interface frozen
- Need overall thickness with the rims on

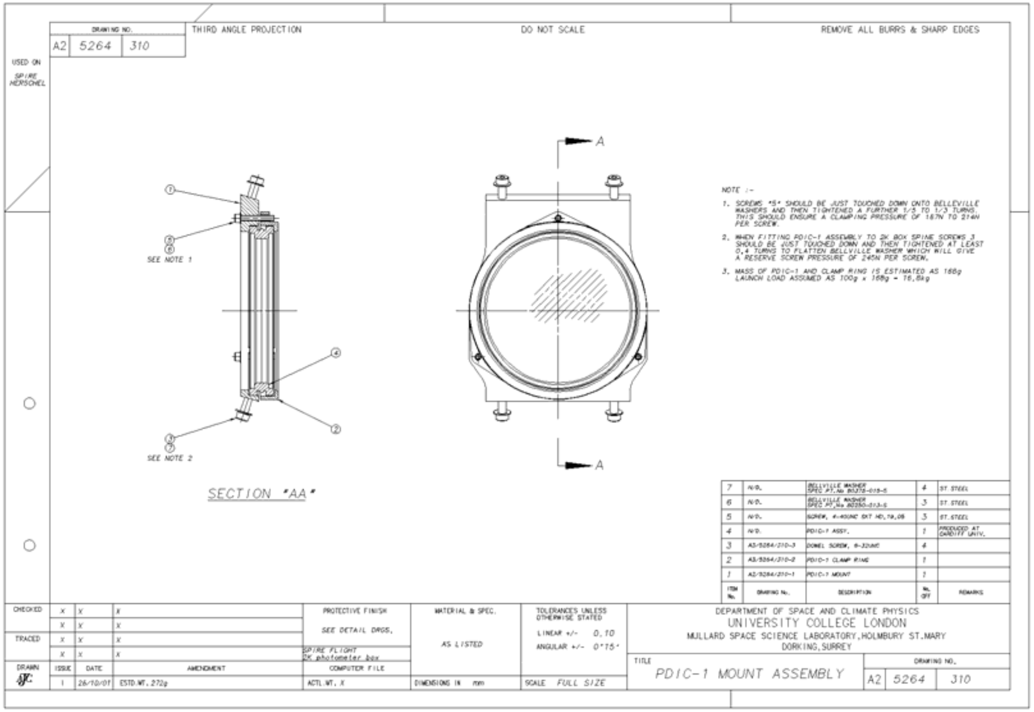


Beam Splitters cont.



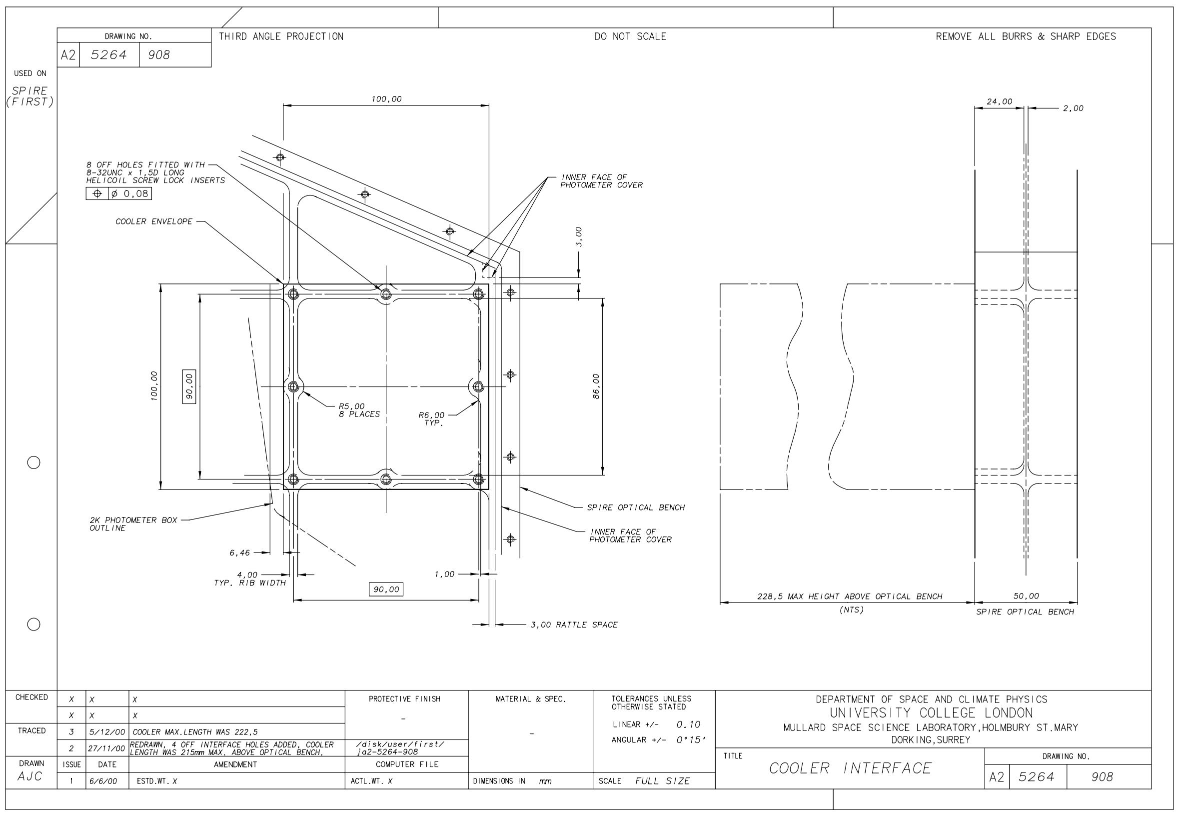
Dichroics

- Interface frozen

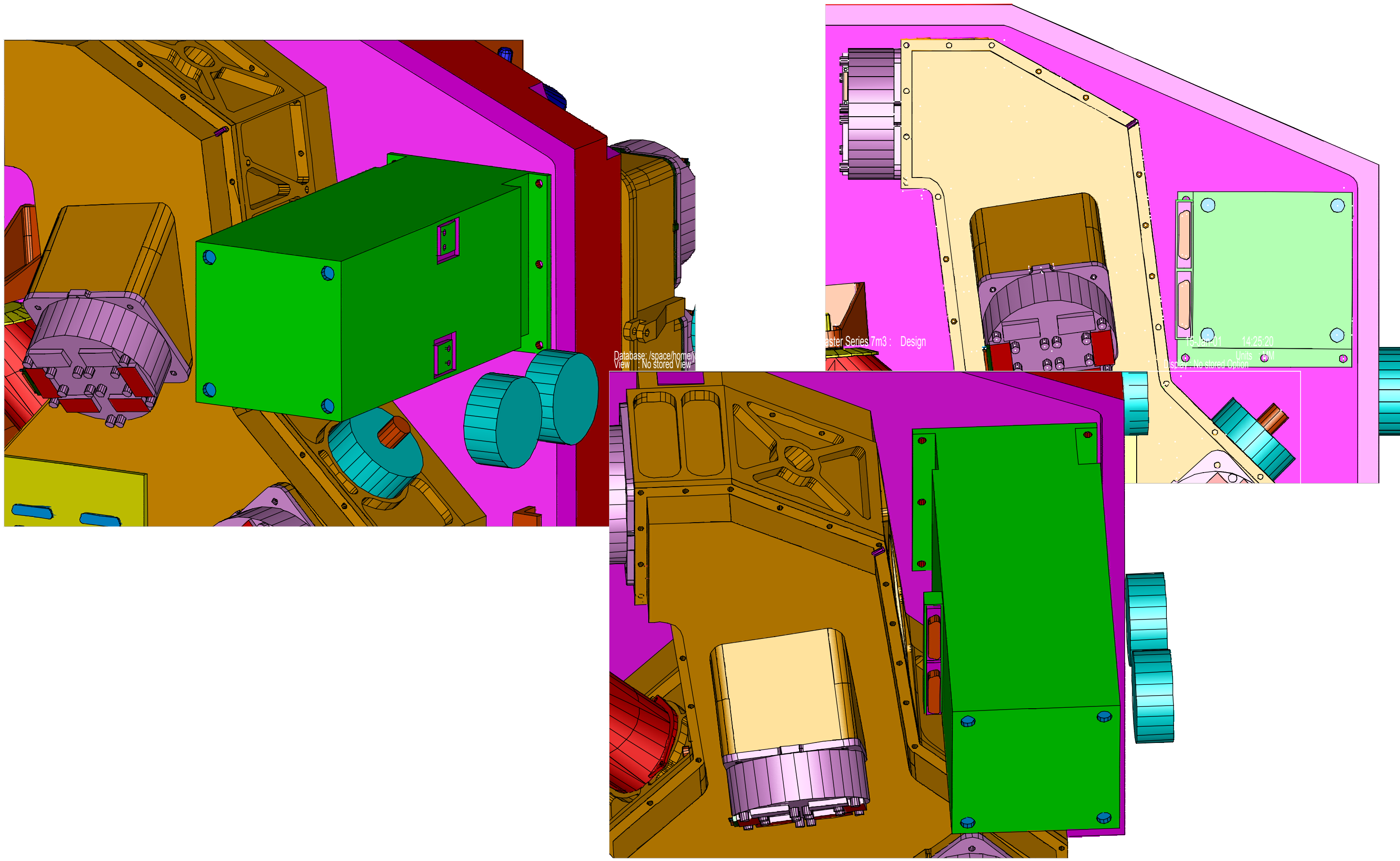


Cooler

- Interface frozen

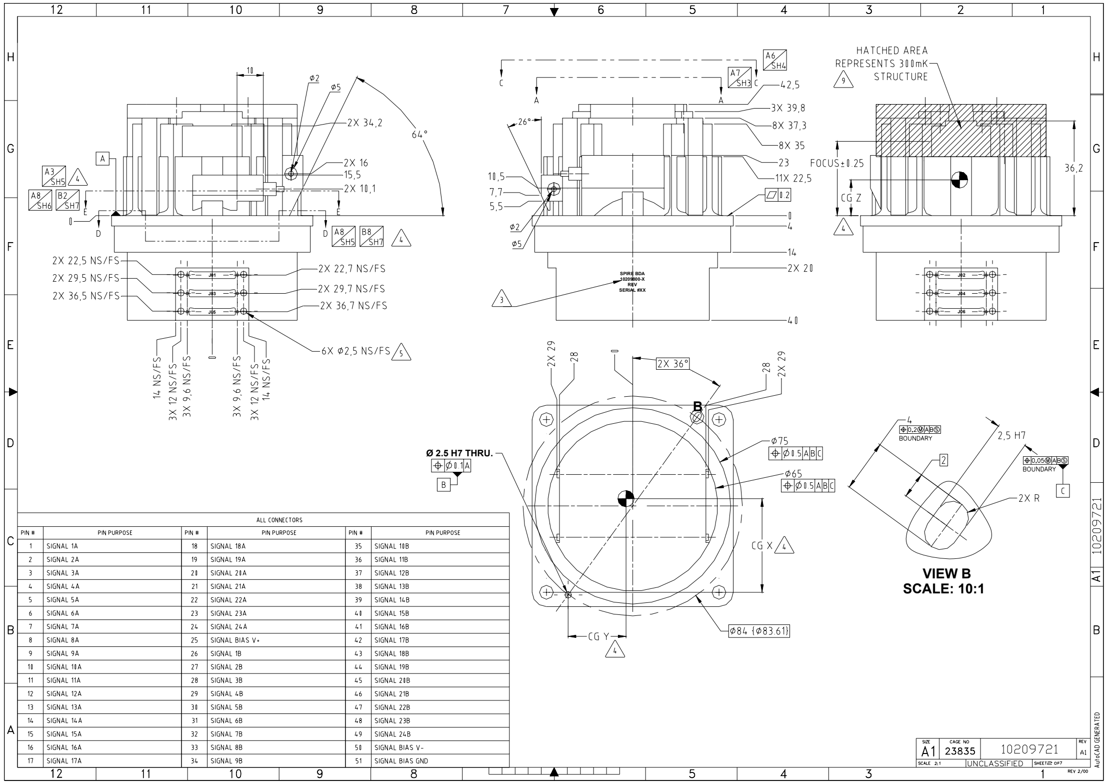


Cooler



Detectors

- Interface frozen

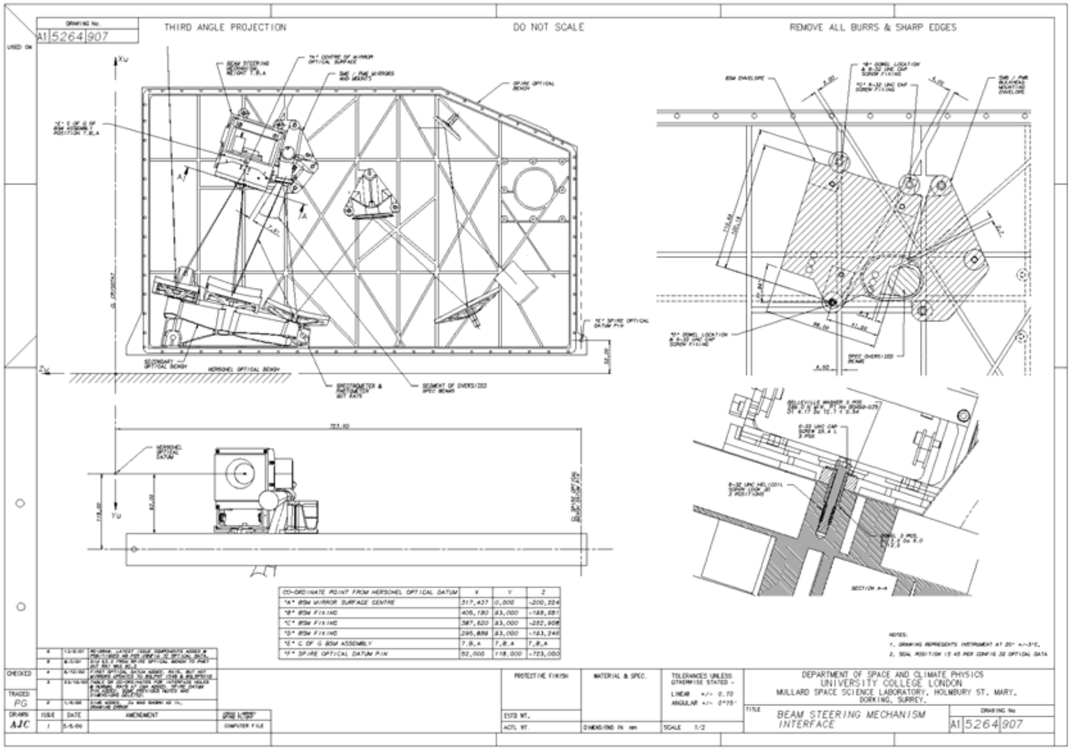


PIN #	PIN PURPOSE	PIN #	PIN PURPOSE	PIN #	PIN PURPOSE
1	SIGNAL 1A	18	SIGNAL 18A	35	SIGNAL 10B
2	SIGNAL 2A	19	SIGNAL 19A	36	SIGNAL 11B
3	SIGNAL 3A	20	SIGNAL 20A	37	SIGNAL 12B
4	SIGNAL 4A	21	SIGNAL 21A	38	SIGNAL 13B
5	SIGNAL 5A	22	SIGNAL 22A	39	SIGNAL 14B
6	SIGNAL 6A	23	SIGNAL 23A	40	SIGNAL 15B
7	SIGNAL 7A	24	SIGNAL 24A	41	SIGNAL 16B
8	SIGNAL 8A	25	SIGNAL BIAS V+	42	SIGNAL 17B
9	SIGNAL 9A	26	SIGNAL 1B	43	SIGNAL 18B
10	SIGNAL 10A	27	SIGNAL 2B	44	SIGNAL 19B
11	SIGNAL 11A	28	SIGNAL 3B	45	SIGNAL 20B
12	SIGNAL 12A	29	SIGNAL 4B	46	SIGNAL 21B
13	SIGNAL 13A	30	SIGNAL 5B	47	SIGNAL 22B
14	SIGNAL 14A	31	SIGNAL 6B	48	SIGNAL 23B
15	SIGNAL 15A	32	SIGNAL 7B	49	SIGNAL 24B
16	SIGNAL 16A	33	SIGNAL 8B	50	SIGNAL BIAS V-
17	SIGNAL 17A	34	SIGNAL 9B	51	SIGNAL BIAS GND

MSSL

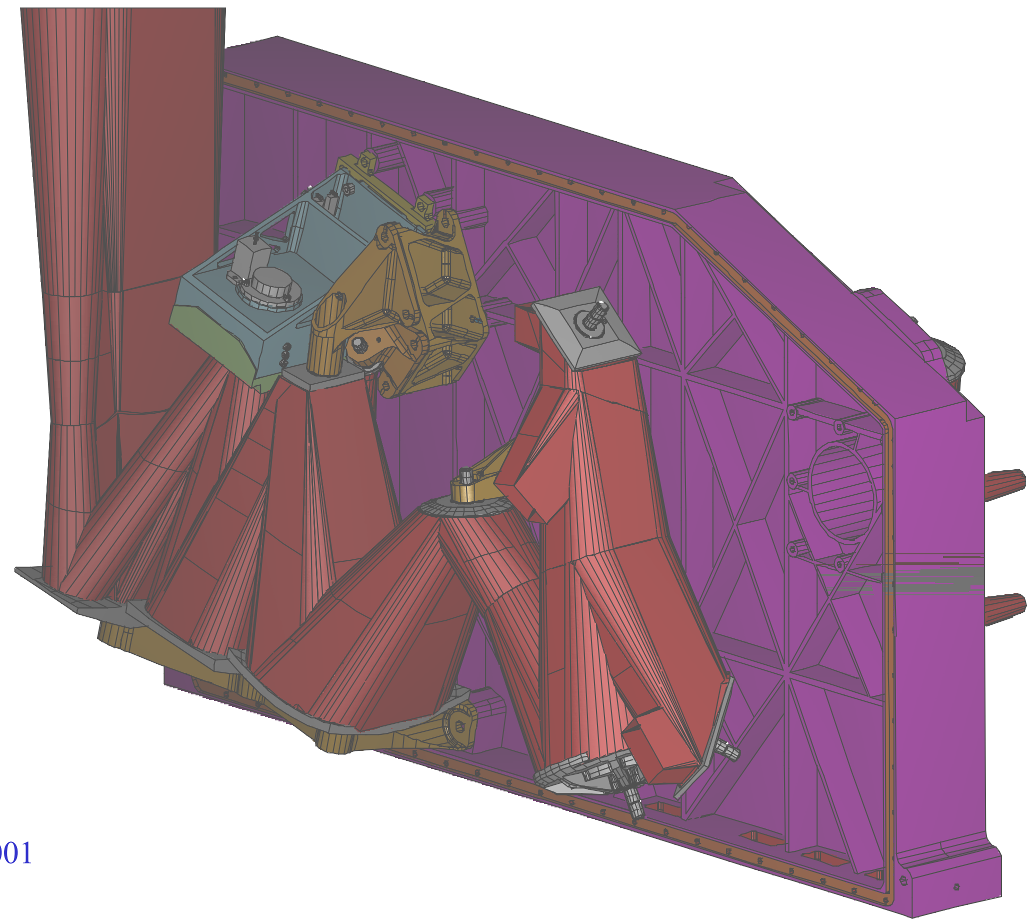
BSM

- Interface frozen



BSM

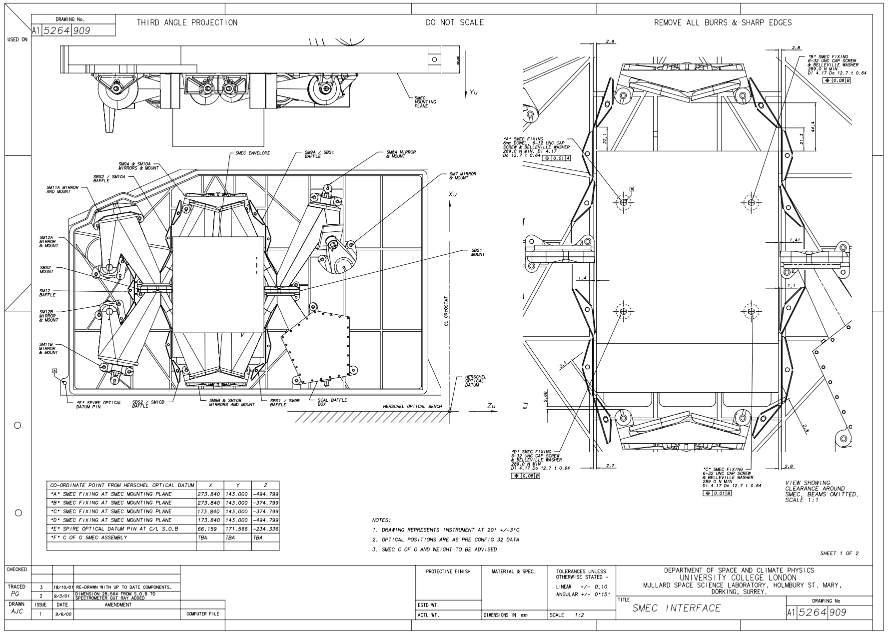
- Interface frozen



UCL MSSL

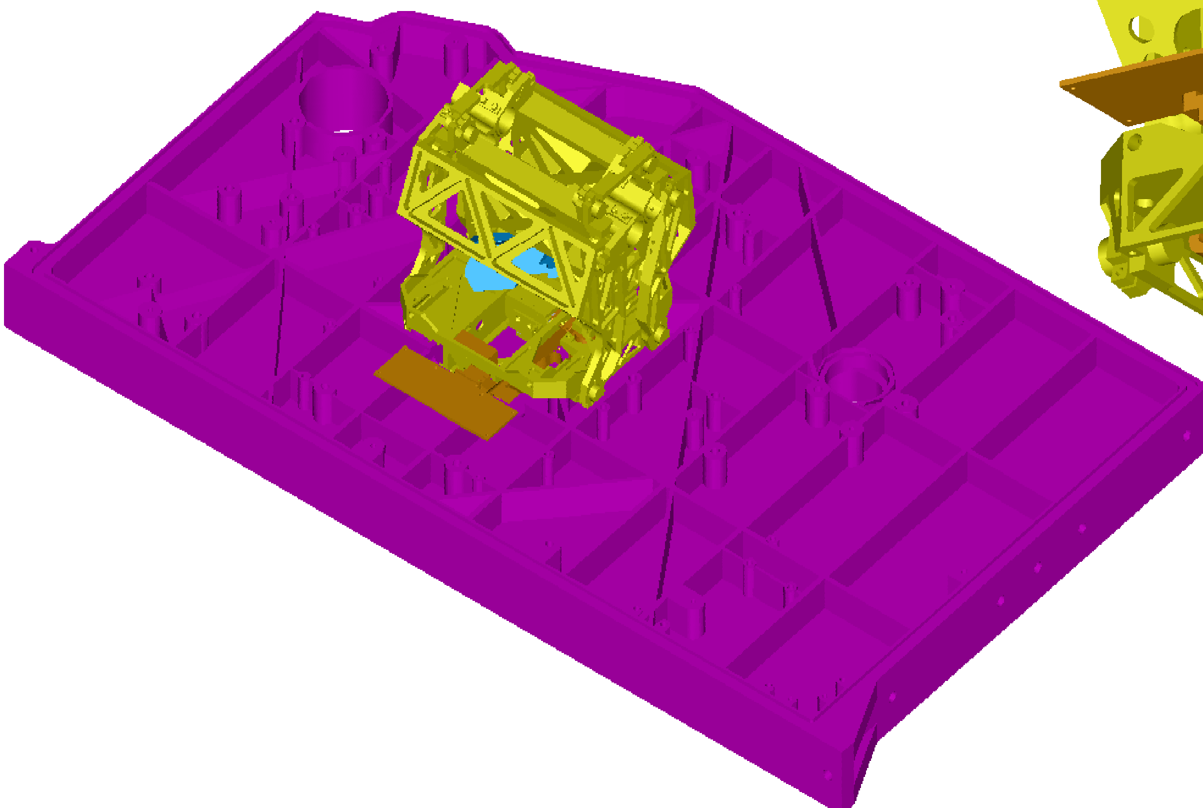
SMec

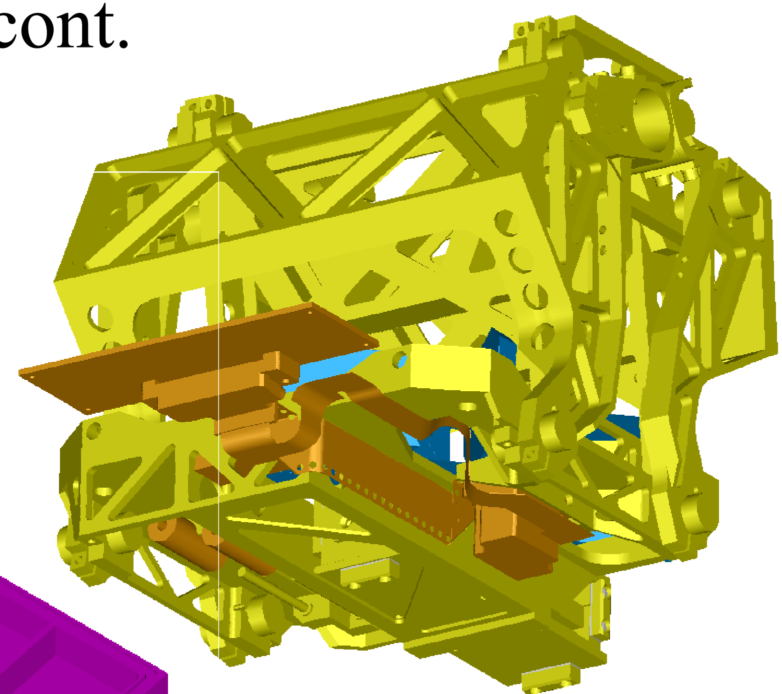
- Interface open, last minor clashes to be sorted after DDR
  - effectively the SMec has a complicated interface with the optical bench
  - LAM, responsible for the SMec design specifies local design of the optical bench



CO-ORDINATE POINT FROM HERSCHEL OPTICAL DATUM	X	Y	Z
"A" SMEC FIXING AT SMEC MOUNTING PLANE	273.840	143.000	-494.799
"B" SMEC FIXING AT SMEC MOUNTING PLANE	273.840	143.000	-374.799
"C" SMEC FIXING AT SMEC MOUNTING PLANE	173.840	143.000	-374.799
"D" SMEC FIXING AT SMEC MOUNTING PLANE	173.840	143.000	-494.799
"E" SPIRE OPTICAL DATUM PIN AT C/L S.O.B	66.159	171.566	-234.336
"F" C OF G SMEC ASSEMBLY	TBA	TBA	TBA

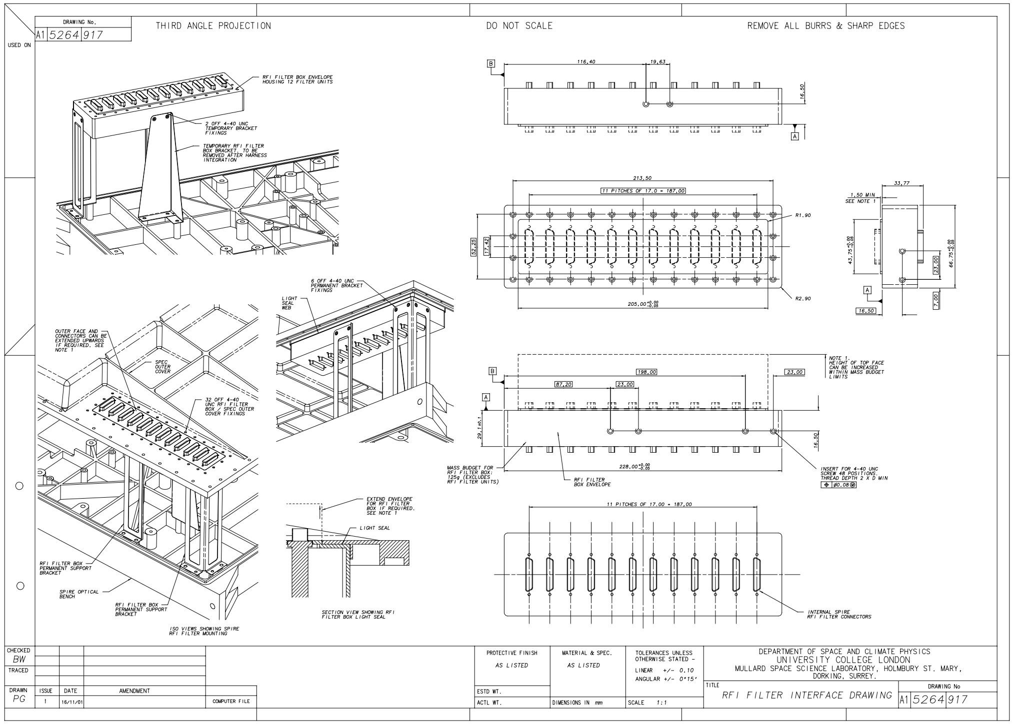
SMec cont.



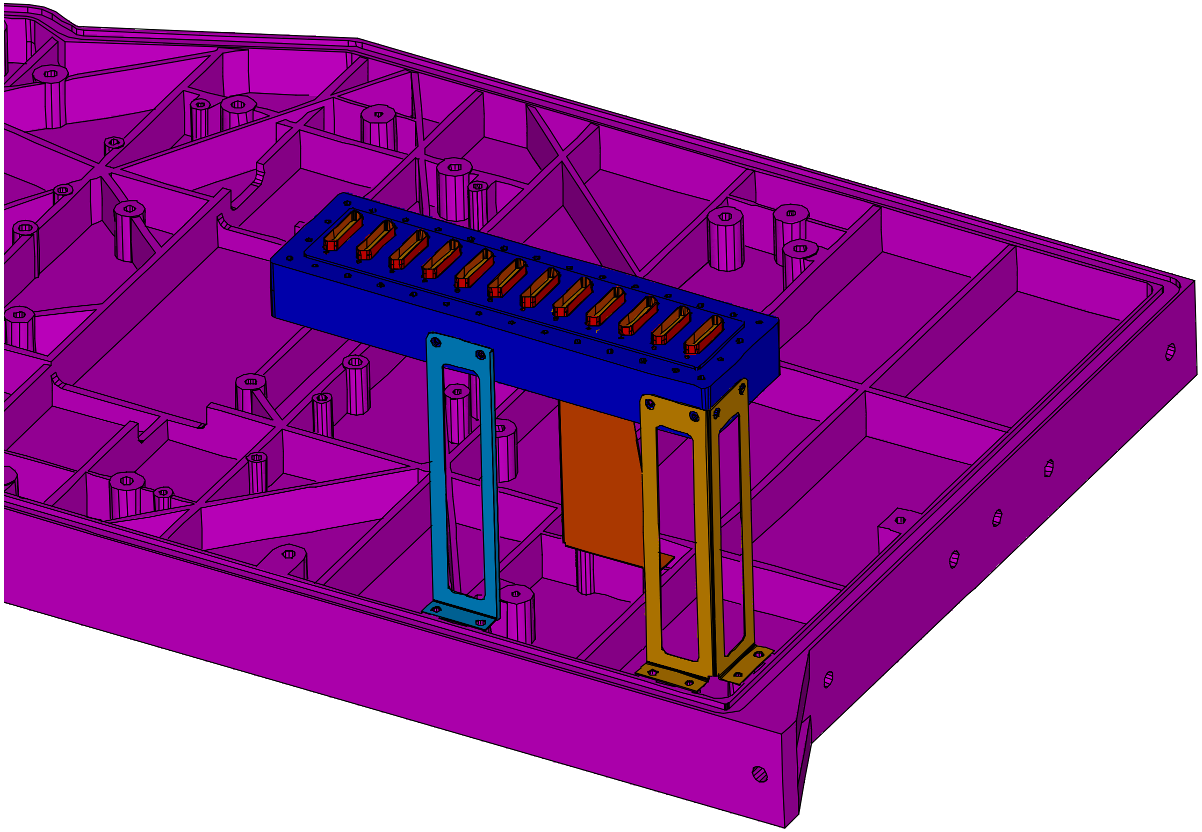


RF Filters

- Specified interface to JPL
- Awaiting to close interface

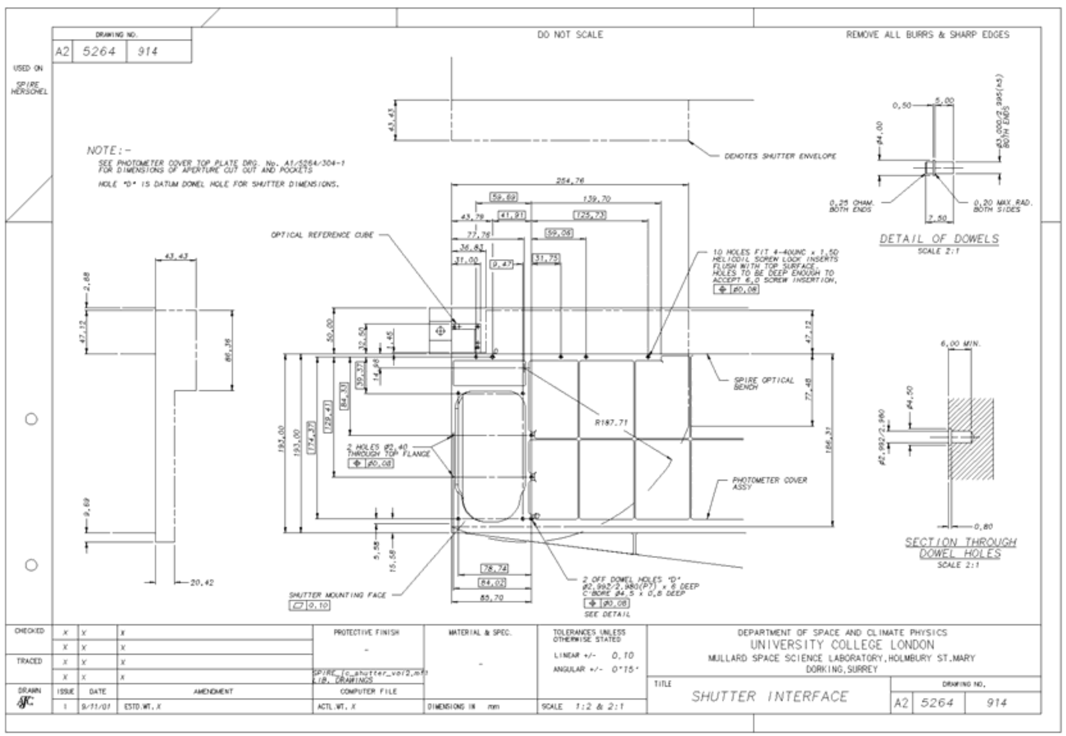


RF-filters Cont.



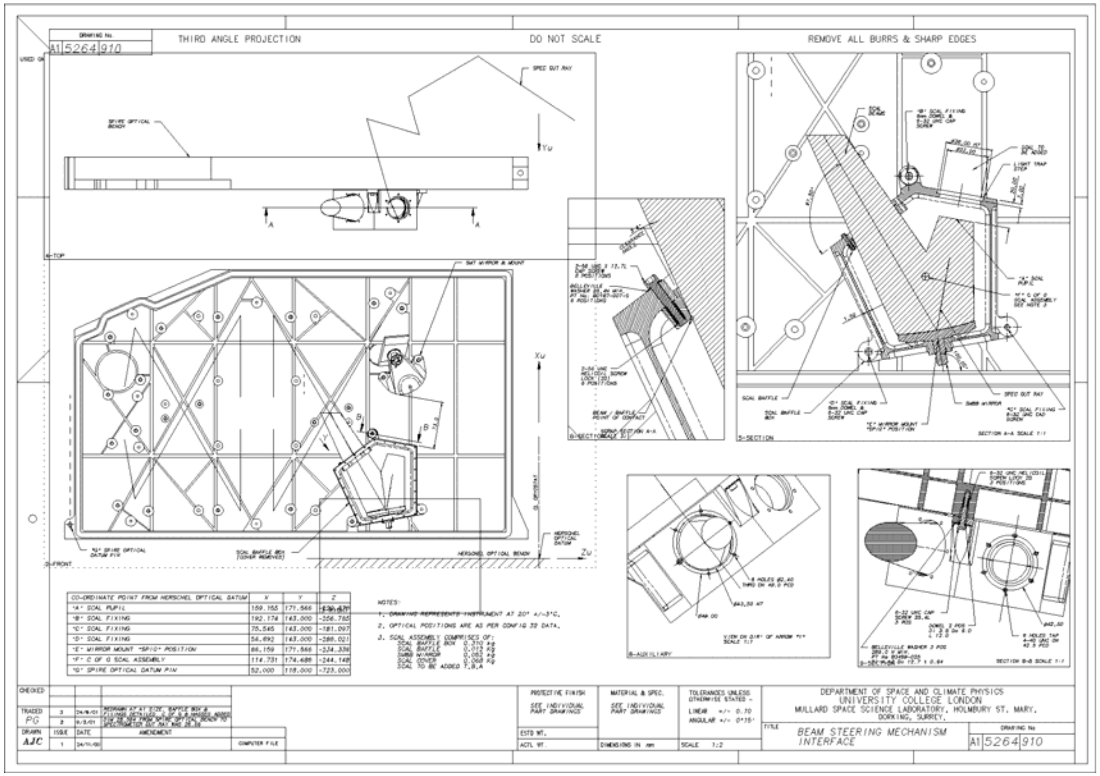
Shutter

- Interface frozen



SCal

- Interface frozen



JFETS

- Interface Closed
  - now RAL responsibility

Thermistors

- Interface open
- Mounting location to be defined
  - minor

Baffles

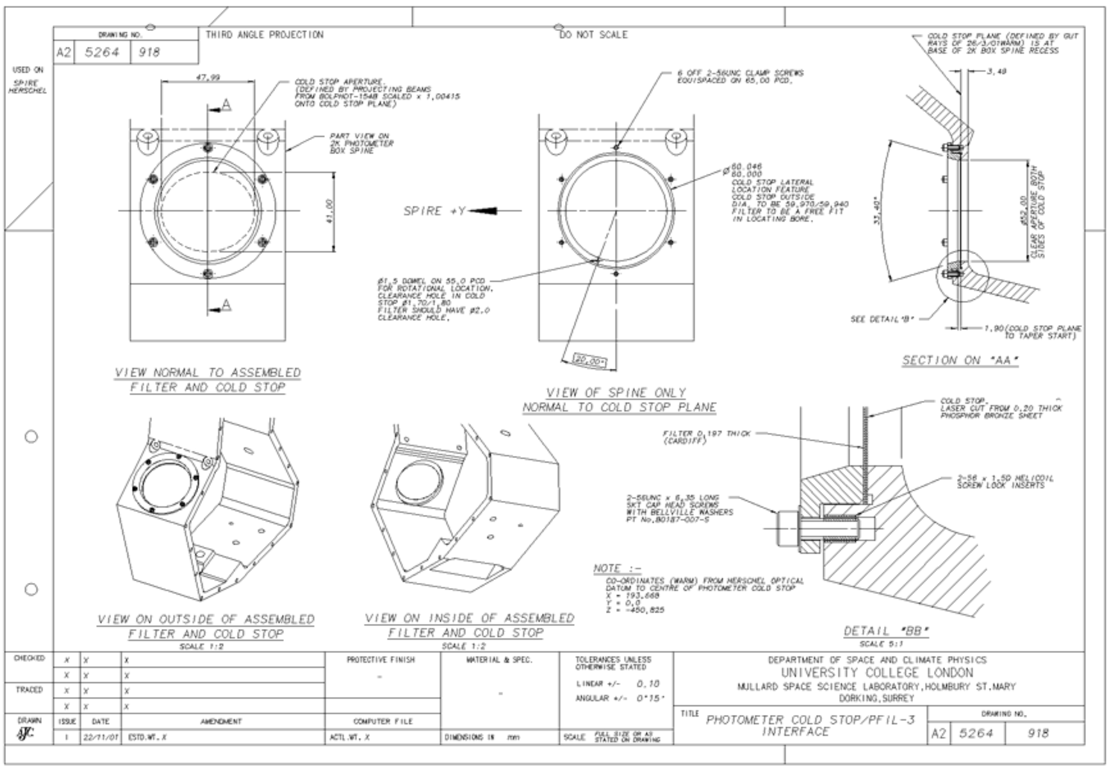
- Closed

Cardiff Black

- Interface Closed
  - locations identified
  - patches at critical locations
  - needs to be formalised in interface drawing, information is available

Cold Stops

- Interface frozen



Thermal Busbar

- Design not part of this design review
  - Separate design and development team
  - Breadboard testing of engineering models is underway now
  - TO BE REWOKED

Harness

- Routing in Progress
- Need details of type of cables and proposed bundling

UCL
MSSL

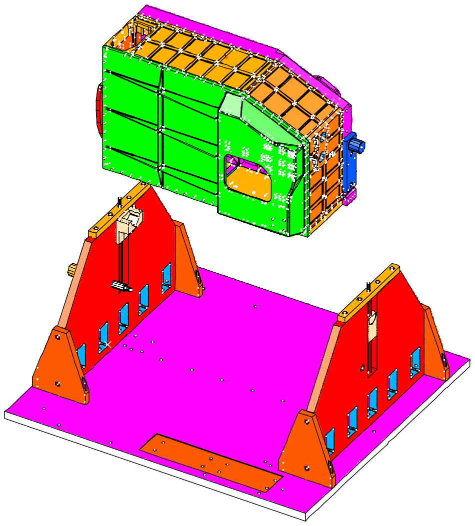
Herschel/SPIRE structure DDR
MGSE

John Coker
Peter Bonhomme

Mullard Space Science Laboratory

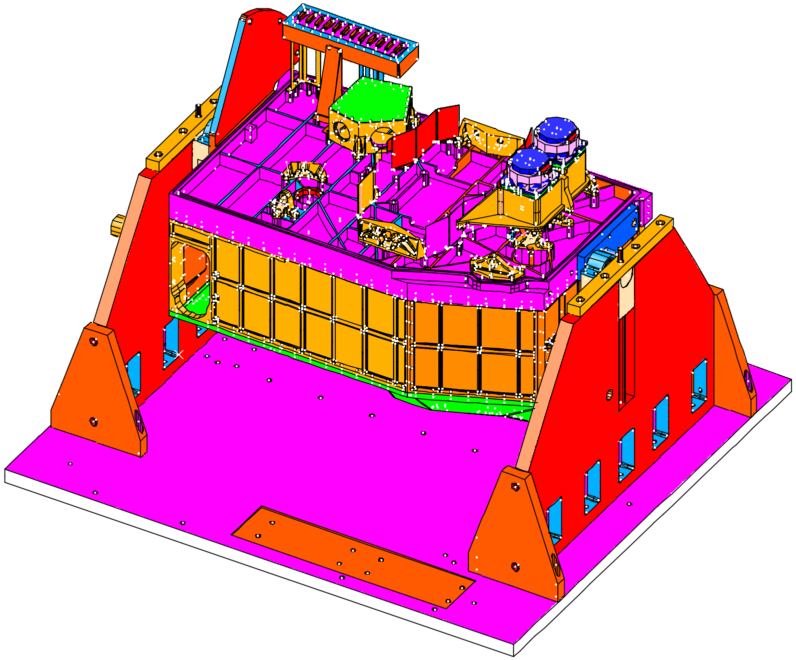
Functions of Assembly Jig

- MSSL Assembly Jig built on RAL Herschel Optical Bench Simulator (HOBS)
- Jig enables SPIRE FPU to be rotated through 360º and locked at 90 º intervals
- HOBS forms transport base for SPIRE FPU
- HOBS used for Vibration test base for SPIRE FPU
- Jig has jacking for controlled mating of FPU to HOBS



Use of Assembly Jig

- Rotation Journals fitted to SOB/Photometer cover sub assembly
- Above assy. fitted to jig which has been installed on HOBS
- Assembly Of all FPU parts
- Optical Alignment



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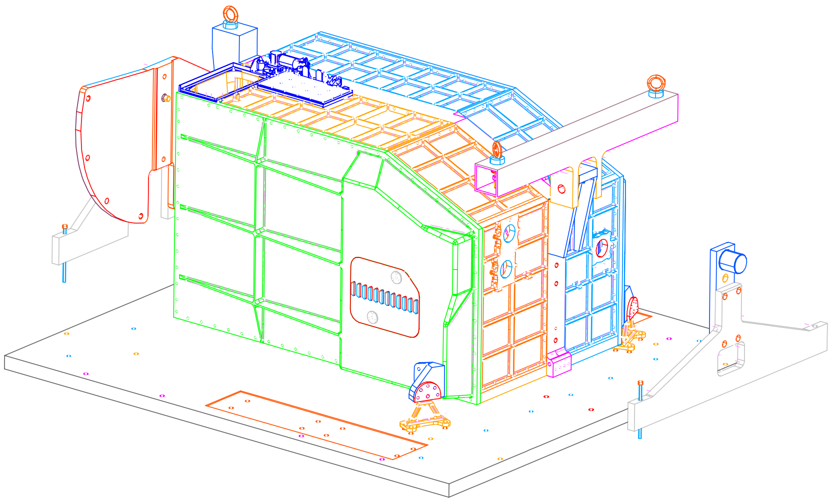
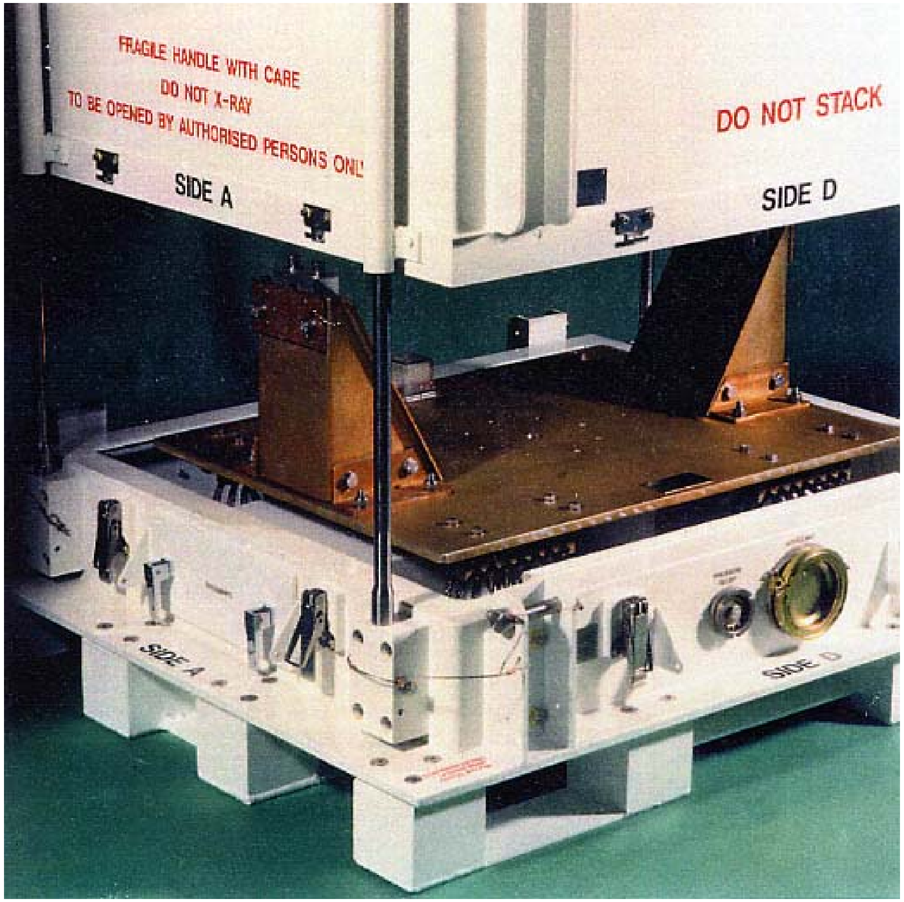
Removal of SPIRE FPU From Assembly Jig

- FPU lowered onto HOBS and jig end plates removed for transport and vibration testing
- FPU/HOBS assembly lifted via eyes in HOBS in this configuration
- FPU fitted with lifting frame for removal from assembly jig or HOBS and fitting to spacecraft
- Cone fitted to spacecraft
- FPU lowered to engage cone spigot and rear frame positions



Transport Case (Light Alloy Limited)

- Previous experience in flight equipment transport cases
- Shock resistant mounting and recording
- Humidity sensing
- Slight overpressure of case with dry nitrogen
- Lifting slings and paperwork storage etc



Herschel/SPIRE structure DDR
MAIV Plan

Chris Brockley-Blatt

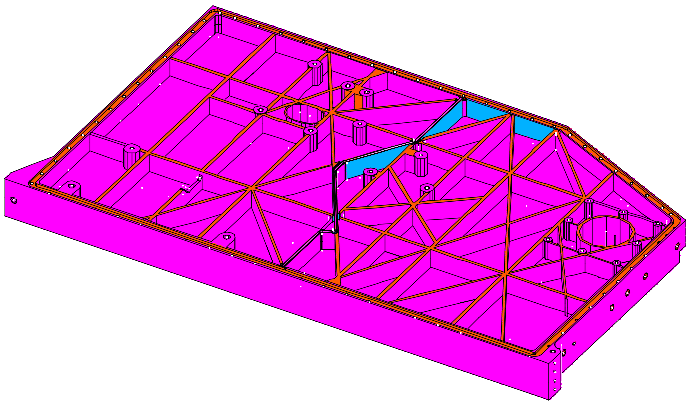
Mullard Space Science Laboratory
University College London

Structure AIV Plan

- HOB Simulator delivered to MSSL from RAL
- Assembly jig installed on HOB
- Photometer side cover panels assembled
- Install structure onto assembly jig
- Build up spectrometer side cover panels
- Install mirror mounts
- Install detector boxes and thermal straps
- Re-assembly covers
- Move to transport container
- Delivery to RAL

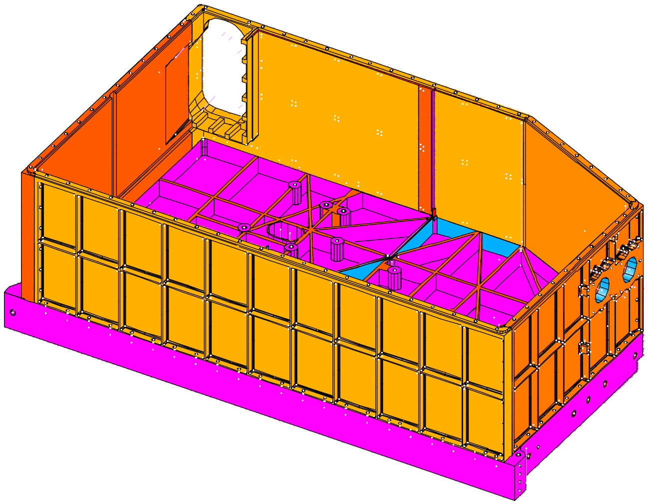
Assembly – Optical bench

- Optical bench clamped to smooth flat surface



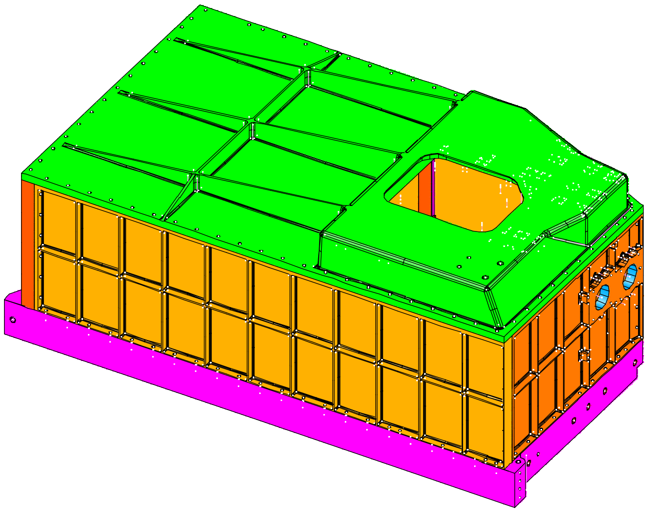
Assembly – Photometer Side Panels

- Photometer side cover panels bolted on
- Straylight baffles are integrated at same time



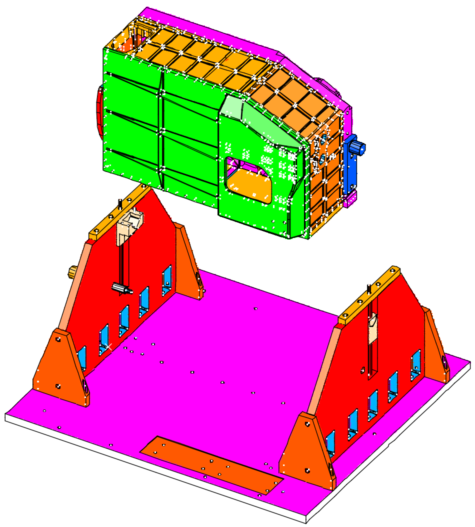
Assembly – Photometer Cover

- Photometer cover is bolted on
- Now structure is a torsionally stiff box



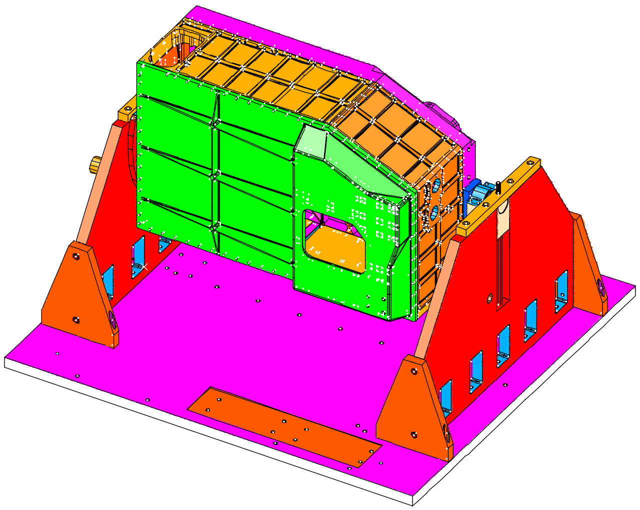
Assembly – Assembly Jig

• Structure removed from smooth surface



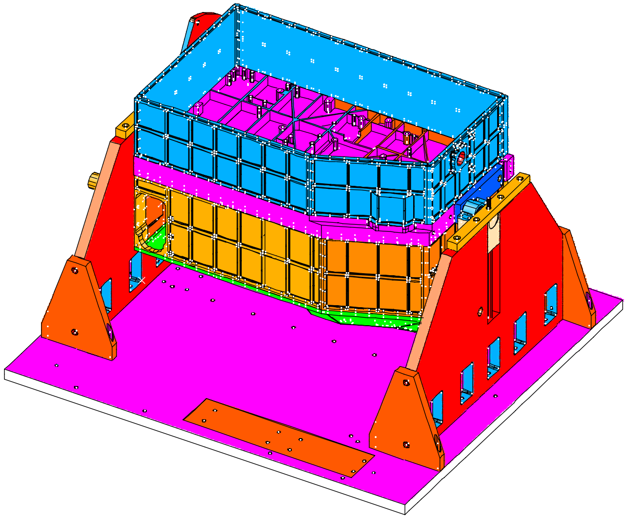
Assembly – Installation onto Jig

- Structure is installed in the assembly jig



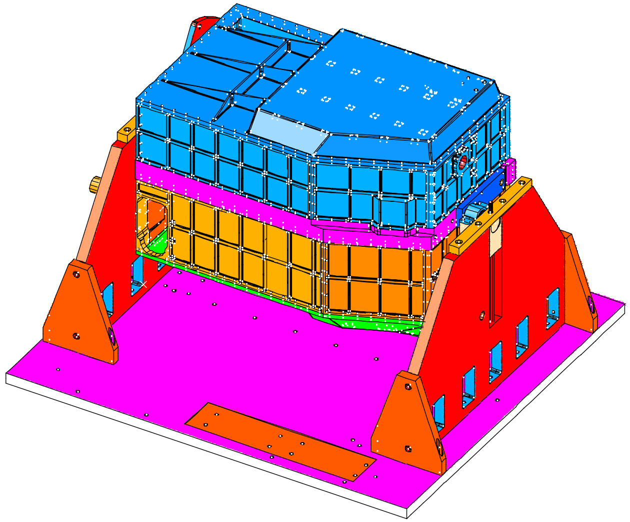
Assembly – Spectrometer Side Panels

- Spectrometer side cover panels bolted on
- Straylight baffles are integrated at same time



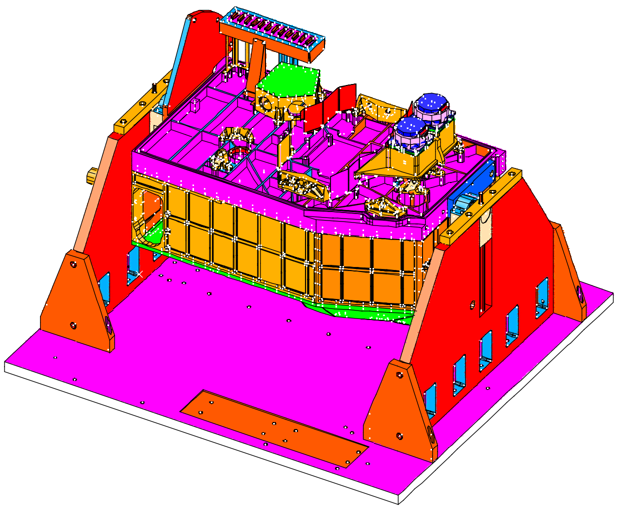
Assembly – Spectrometer Cover

- Spectrometer Cover bolted on



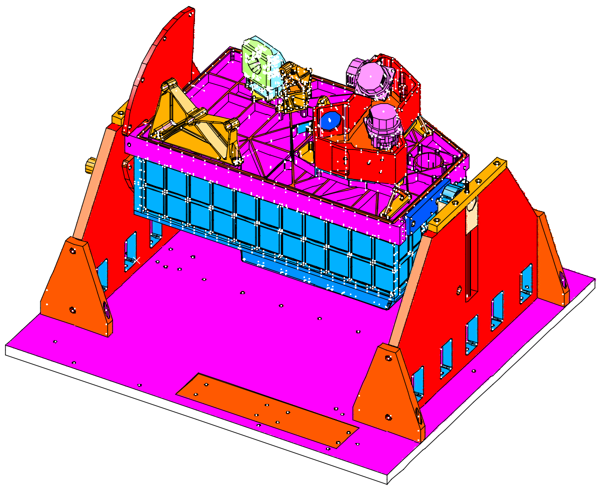
Integration – Spectrometer Side

- Spectrometer cover removed
- Photometer cover left on to ensure rigidity
- Mirror mounts and detector box integrated
- 2-D Alignment check proformed
- RF Filter box is mounted



Integration – Photometer Side

- Photometer cover removed
- Spectrometer cover left on to ensure rigidity
- Mirror mounts and detector box integrated
- 2-D Alignment check proformed
- 300mK Busbar is mounted

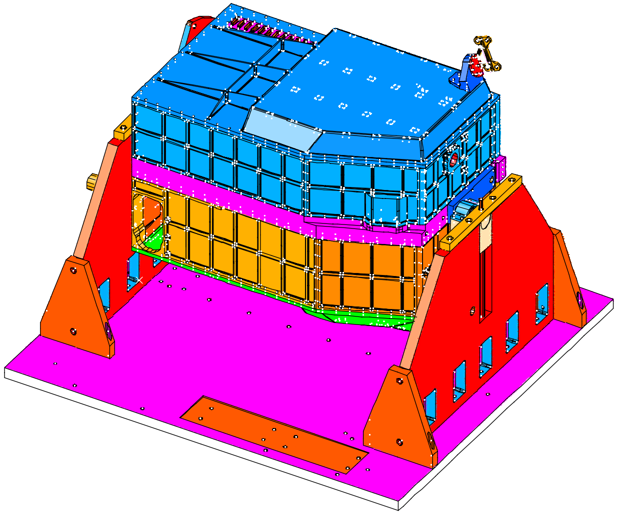


Integration –Installation of Feet

• Spire Structure rotated to upright position

•Feet bolted onto HOB simulator

•Structure lowered on to feet



Made by people at MSSL

PA Plan

Model Philosophy

Selected Components/Materials

Defined Processes

Reliability

Safety

Calibrated Instrumentation

Design Reviews

Cleanliness

Storage/Transportation

Configuration Control

Documentation

Delay Before Proof of Satisfaction

Made by people at MSSL

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Delay Before Proof of Satisfaction

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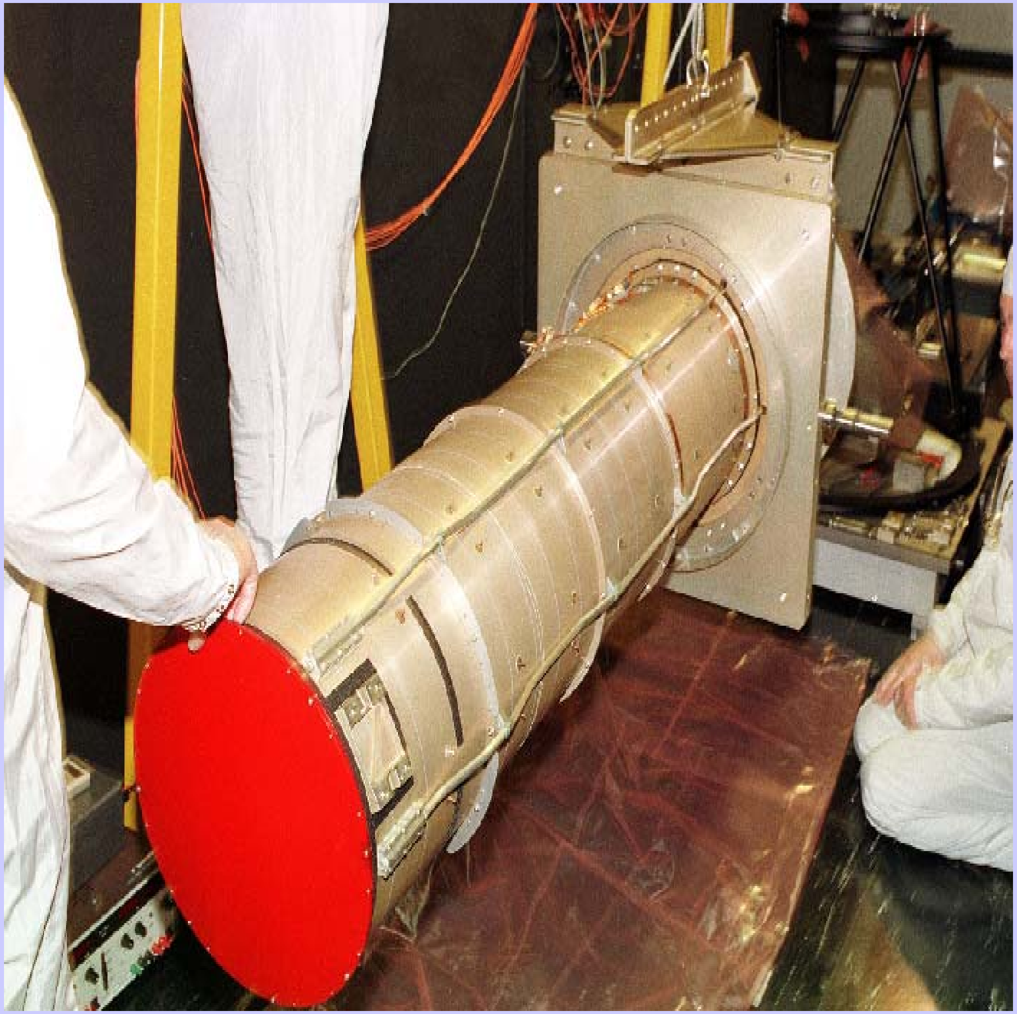


Herschel/SPIRE structure DDR
Structure FMECA

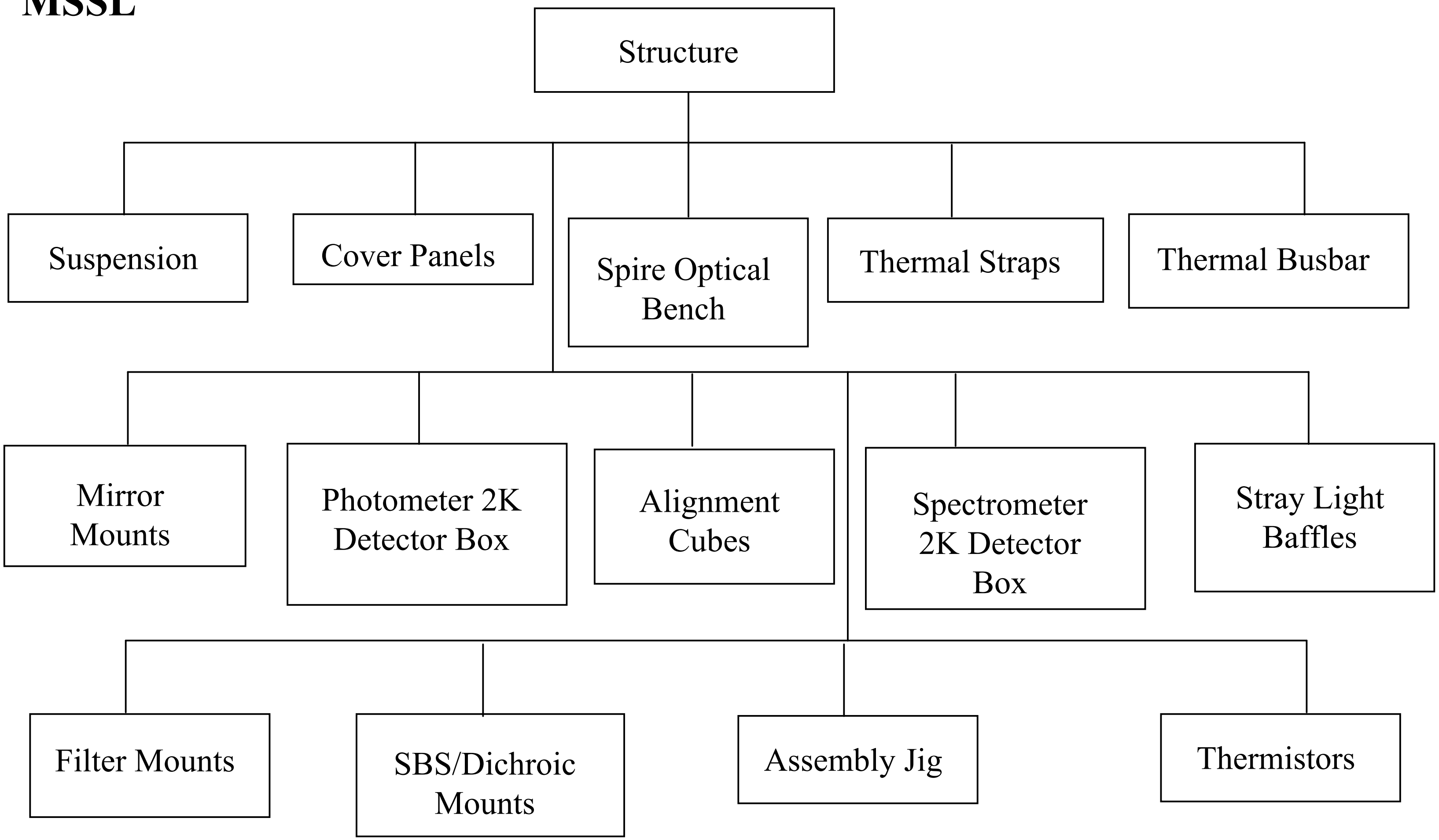
Chris Brockley-Blatt

Mullard Space Science Laboratory
University College London

Structure FMECA

- **Strategy**
  - Categories
    - 1
    - 2
    - 3
  - Criticality Criterion
    - Total
    - Intermittent
    - Partial
    - Degradation

Breakdown of Structure



Results and Comments

- Severity
  - Majority are rated 1 and SFP
  - No Structure, no instrument!
  - Not a concern because….
- Detection
  - Alignment verification
  - Qualification testing
  - Visual health check
  - Running the instrument
- Provisions
  - Testing (prove strength, show margin)
  - Sufficient margin in design
  - Visual Checks in sequence at strategic locations

Most critical ones

- Mounting feet - design margin, we tested them as parts and will do in assy, visual inspection) not serious item
- Structure - design margin, tested in assy, visual inspection, not a serious item
- Thermal Straps – design margin, CQM testing, not a serious item
- Detector boxes – design margin, qualification testing, care taken when mounting
- Mirror Mounts – design margin, alignment checks, easily detectable
- Thermal Busbar - have to be careful with this item. Structure testing, CQM testing

Herschel/SPIRE structure DDR
Planning

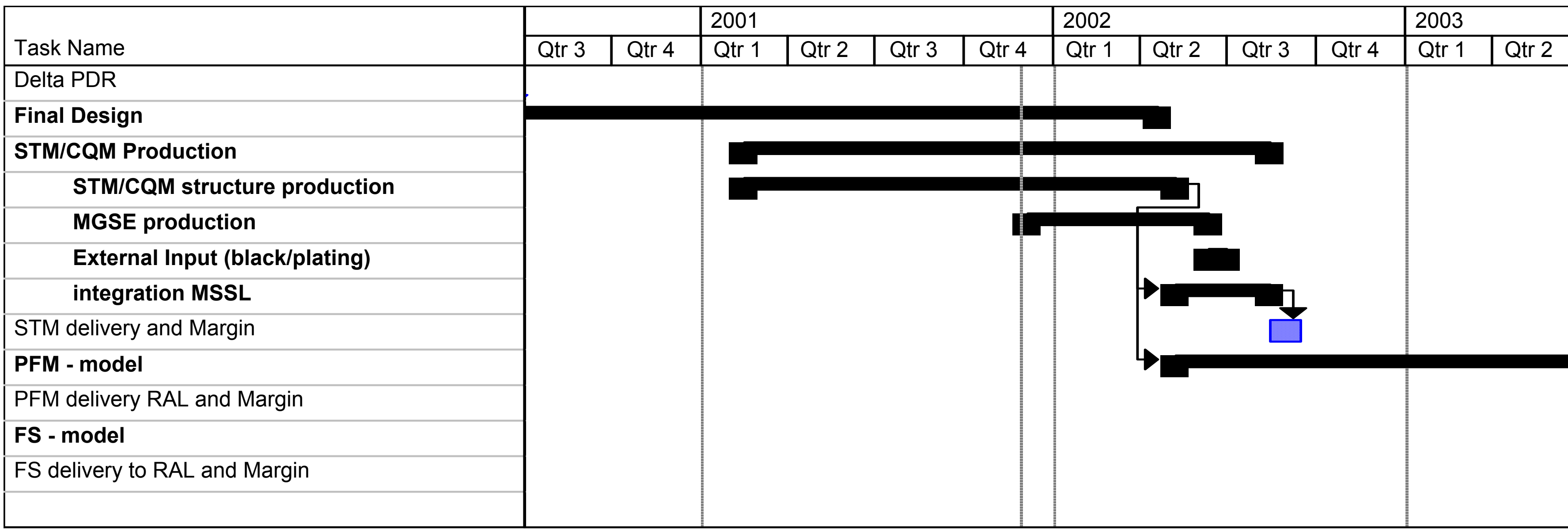
Berend Winter

Mullard Space Science Laboratory
University College London

Development Calendar

• Detailed design	December 2000 – Jan. 2002
• STM Manufacture	December 2001 – May 2002
• STM Integration alignment at MSSL	May - August 2002
• CQM / STM Delivery RAL	Mid September 2002

Schedule


Task Name
2001
2002
2003
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Qtr 1
Qtr 2
Delta PDR
Final Design
STM/CQM Production
STM/CQM structure production
MGSE production
External Input (black/plating)
integration MSSL
STM delivery and Margin
PFM - model
PFM delivery RAL and Margin
FS - model
FS delivery to RAL and Margin

Points to Note

- Four Full time designers
  - Working from now until March 2002
  - Producing manufacturing drawings
- Major lead time items
  - Photometer detector box 7 Man Weeks
  - Spectrometer detector box 7 Man Weeks
  - Optical Bench 7.5 Man Weeks
  - Side Cover Panels 19 Man Weeks
    - Need to be manufactured by same manufacturer to ensure fit

MSSL

An Example

- Optical Bench
  - Start Detailing 17 January 2002
  - Finishing Detailing 18 February 2002
  - Start Manufacture 18 February 2002
  - Finish Manufacture 16 April 2002
  - Plating
  - Integration 13 May 2002
  - Finish integration 13 August 2002

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Critical Items

- Photometer Detector Box
  - Needs to start Manufacture 18 February 2002
  - Design needs to be finished 11 February 2002
  - Design time unknown due to Thermal Busbar Development
  - Same time as Spectrometer Detector box and Optical Bench
- Side Cover Panels
  - Finding a single manufacturer for all of them to ensure fit
  - Manufacture start 7 January 2002
  - Manufacture finish 10 April 2002
- Detector Box Supports
  - One of last things to be manufactured due to design time

Manufacturers

- MSSL
  - Dichroic mounts
  - Filter Mounts
  - Spectrometer Detector Box
- Startrite
  - CAD/CAM ability
  - Secondary Optical Bench (received quote)
  - Mirror mounts
  - Optical Bench
  - Side panels
- Electro Mech
  - Received Quote
- Thrust
  - Awaiting Quote
- Edwards Brothers

ANNEX C

Comments on SPIRE – FMECA MSSL/SPIRE/PA005.1 29.11.2001

The title is misleading since it is not the FMECA for the whole instrument but for the structure.

The functional diagram or drawing is missing in this analysis. A unique reference number for each failure mode and cause is also missing in the analysis sheet. Each failure mode and cause shall have its own unique id number so that it is possible to refer to each row in the analysis sheets. The traceability between the failure modes in the analysis sheets and the drawings is required in the analysis and it shall be unambiguous.

§ 3 Category 2: Loss or degradation. Loss and degradation should be separated into different severity categories, according to ECSS-Q-30-02A. Thus there would be 4 severity categories.

§ 3. Failure modes considered. The failure modes listed are not corresponding to the failure modes in the analysis sheet. The listed failure modes are basically applicable to electronics and mechanics and not to structure. To be corrected.

A description of the columns in the analysis sheets is missing.

The critical items (severity category 1 and 2) shall be summarised and followed up in the report. There is no visibility on how the critical items are treated and what design provisions are taken to remove the criticality or how to control it. The ECSS-Q-30-02A describes how this shall be done, and the standard is available for download at the ECSS homepage http://www.estec.esa.nl/ecss/. Critical items shall be entered into the critical items list and analysed appropriately, if necessary through a process FMECA.

Analysis sheets

In this analysis some failures will occur during ground operations and some during flight. It should be clearly visible for each failure mode/cause if it is analysed during ground tests or during flight. The objective is to identify failures that can occur during flight and how to correct or control these. When other phases are included in the analysis it shall be clearly visible. An additional column shall be added with "Mission phase/Operational mode" stating in which phase or mode a failure occurs.

The "provisions" column. Compensation provisions are design provisions or operator actions, which circumvent or mitigate the effect of a failure. This means provisions that are to be taken when a failure occurs in flight. Design provisions are for instance: redundant items or alternative modes of operation that allow continued and safe operation, and safety or relief devices that allow effective operation or limit the failure effects. For most of the items here there are no provisions if a failure occurs in flight and in the column it should then be stated "None". The provisions described in this column now (such as sufficient design margin, visual inspection, etc.) are ways to control a critical item and minimise the risk of it occurring and should be entered into the corrective actions column or a remarks column.

The corrective actions are actions that are taken to render a critical item non-critical, or if that cannot be done how to control the criticality. This shall be followed up in the critical items list, and traceability shall be kept between the FMECA and the CI list.

The sheets refer in several cases to sufficient design margin. What is a sufficient margin and has a stress analysis been performed to obtain this margin? If an analysis has been performed it shall be referred to and the values of the margin shall be given.

Actions such as “training”, “qualification tests”, “engineering tests” are referred to. Are the plans and procedures available, and are such provisions as “sufficient design margin” known?

Page 7. Why are the three first failure modes SPFs but not the three following? A single point failure is according to ECSS-Q-30-02A: failure of an item, which results in the unrecoverable failure of the analysed product. The three last failures fall under these criteria too. This comment is also valid for the other failure of severity 1.

Id 9a refers to provision as “careful handling”. Are the handling procedures available or will they be written?

Id 13 refers to “sound engineering practice”, which is something that is expected in any case and not a corrective action. Please refer to correct mounting or handling procedures, stress analysis etc. (Quote relevant document number)

There should also be a column in the analysis sheet for remarks or clarifications.