FIRST/ESA/M/0023-10

FIRST

VIEWGRAPHS FROM IID MEETING HELD AT ESTEC 2/3.09.97

From: hschaap@estec.esa.nl
X-Lotus-Fromdomain: ESA
To: m.j.griffin@qmc.ac.uk, vigroux@sapvxg.saclay.cea.fr, k.j.king@rl.ac.uk, Thijsdg@sron.rug.nl, Nick@sron.rug.nl, puget@ias.fr, puget@feynman.ipac.caltech.edu, charra@iaslab.ias.fr, reno@botes1.tesre.bo.cnr.it, marco@ifctr.mi.cnr.it, alpog@mpe-garching.mpg.de, Ohb@mpe-garching.mpg.de, hunn@hakucho.dsri.dk
Cc: jasteinz@estec.esa.nl, ffelici@estec.esa.nl, mandereg@estec.esa.nl, tpassvog@estec.esa.nl, fvandenb@estec.esa.nl, bguillau@estec.esa.nl, mvhoegen@estec.esa.nl, Goeran_Pilbratt@estec.esa.nl, jtauber@estec.esa.nl
Date: Tue, 12 Aug 1997 14:43:25 +0100
Subject: IID clarification meetings
X-Info: Space Science Department, CCLRC

Dear Reader,

For the purpose of inputs to the industry merger study and to complete the AO documentation we are planning a series of meetings with the participation of Industry Teams, FIRST/PLANCK Instrument Teams and ESA. The meetings are planned to be held at ESTEC on 2, 3 (am) September for FIRST and 3 (pm), 4 September for PLANCK.
The exact schedule is as follows:

2 September:

1	Introduction (FIRST)	09.00 - 09.15
2	FIRST Instrument definitions and interfaces	09.15 - 10.45
2.1	BOL	09.15 - 09.45
2.2	PHOC	09.45 - 10.15
2.3	HET	10.15 - 10.45
3	Detailed review of FIRST IID-B	11.00 - 17.00
3.1	BOL	11.00 - 12.30
3.2	PHOC	14.00 - 15.30
3.3	HET	15.30 - 17.00

3 September:

4	FIRST specific Inputs to IID-A	09.00 - 12.00
5	AOB	
6	Introduction (PLANCK)	14.00 - 14.15
7	PLANCK module baseline	14.15 - 15.00
8	PLANCK Instrument definitions and interfaces	15.00 - 17.00
8.1	HFI	15.00 - 16.00
8.2	LFI	16.00 - 17.00

4 September:

9	Detailed review of PLANCK IID-B	09.00 - 12.00
9.1	HFI	09.00 - 10.30
9.2	LFI	10.30 - 12.00
10	PLANCK specific Inputs to IID A	14.00 - 17.00
11	AOB	

Notes on the items above:

2 Each instrument team should make a small presentation on his/her instrument, thereby concentrating on critical issues such as:
- cryostat optical bench interfaces (cooling, mechanical)
- dissipation in the instrument (heat budget, thermal model)
- cryo-harness requirements

- operating modes (parallel operation to others)
- TM rates

2.1 BOL:
- all cooling interfaces to dilution cooler (is there one?)
- JFET unit definition (size, interfaces, requirements)
- straylight model
- pointing

2.2 PHOC:
- straylight model (update necessary?)

2.3 HET:
- Local osc. unit (new definition of windows)
- Local osc. unit alignment to FPU
- EMC
- cryoharness (coax cables?)

3 IID-B as usual

4 The most imporant items to cover with industry and instrument teams are:
- pointing
- FIRST telescope definition
- straylight
- alignment requirements
- model philosophy
- HET windows
- instrument modes (prime, parallel)

Ground Segment

7 Present PLANCK baseline configuration, including industry feedback on possible improvements to be implemented:
- thermal design
- PLANCK telescope requirements
- straylight
- detailed interfaces i.e. of coolers, harness, waveguides

8 Each instrument team should make a small presentation on his/her instrument, thereby concentrating on critical issues such as:
- PLANCK module design and interfaces (cooling, mechanical)
- instrument dissipation (heat budget, thermal model)
- cryoharness requirements
- TM rates
- EMC

8.1 HFI:
- all cooling interfaces

8.2 LFI:
- all cooling interfaces
- waveguides

9 IID-B as usual

10 Te most important items to cover with industry and instrument teams are:
- PLANCK module
- PLANCK telescope definition
- straylight
- model philosophy related to planned module testing

Please confirm receipt of this message and send me your participation list.

Regards

Harm Schaap

8/9/00 Sept AWS, SPC, meeting in Oxford

2/3 - Sept CRG, MJG, KJK to ESTEC

SUBJECT: IID CLARIFICATION MEETINGS

Below the exact schedule for these meetings:

2 September: (Chairman: J.A. Steinz; Location: Einstein)

			Presentation	Minutes
1	Introduction (FIRST)	09.00 - 09.15	T. Passvogel	G. Pilbratt
2	FIRST Instrument definitions and interf.	09.15 - 10.45		
2.1	BOL	09.15 - 09.45	M. Griffin	G. Pilbratt
2.2	PHOC	09.45 - 10.15	A. Poglitsch	G. Pilbratt
2.3	HET	10.15 - 10.45	N. Whyborn	G. Pilbratt
3	Detailed review of FIRST IID-B	11.00 - 17.00		
3.1	BOL	11.00 - 12.30		M. Anderegg/ H. Schaap
3.2	PHOC	14.00 - 15.30		M. Anderegg/ H. Schaap
3.3	HET	15.30 - 17.00		M. Anderegg/ H. Schaap

3 September: (Chairman: F. Felici; Location: Fresnel)

			Presentation	Minutes
4	FIRST specific Inputs to IID-A	09.00 - 12.00	See Notes #4	F. Vandenbussche
5	AOB			F. Vandenbussche
6	Introduction (PLANCK)	14.00 - 14.15	T. Passvogel	J. Tauber
7	PLANCK module baseline	14.15 - 15.00	T. Passvogel	J. Tauber
8	PLANCK Instrument definitions and interf.	15.00 - 17.00		
8.1	HFI	15.00 - 16.00	J-L. Puget TBC	J. Tauber
8.2	LFI	16.00 - 17.00	R. Mandolesi M. Bersanelli L. Wade	J. Tauber

4 September: (Chairman: M. Anderegg; Location: Einstein)			Presentation	Minutes
9	Detailed review of PLANCK IID-B	09.00 - 12.00		
9.1	HFI	09.00 - 10.30		M. Anderegg/ H. Schaap
9.2	LFI	10.30 - 12.00		M. Anderegg/ H. Schaap
10	PLANCK specific Inputs to IID-A	14.00 - 17.00	See Notes # 10	M. Anderegg
11	AOB			M. Anderegg

Partly in **parallel** to item 9 ESA will have technical clarification meetings with industry as follows:

AS / DSS	08.00 - 10.00
MATRA / DSS	10.00 - 12.00

Notes on the items above:

2 Each instrument team should make a **small** presentation on his/her instrument, thereby concentrating on critical issues such as:
- cryostat optical bench interfaces (cooling, mechanical)
- dissipation in the instrument (heat budget, thermal model)
- cryo-harness requirements
- operating modes (parallel operation to others)
- TM rates

2.1 BOL:
- **all** cooling interfaces to dilution cooler (is there one?)
- JFET unit definition (size, interfaces, requirements)
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2.2 PHOC:
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2.3 HET:
- Local osc. unit (new definition of windows)
- Local osc. unit alignment to FPU
- EMC
- cryoharness (coax cables?)

3 IID-B as usual

4 The most imporant items to cover with industry and instrument teams are:

	Coordination:
- pointing	M. Anderegg
- FIRST telescope definition	T. Passvogel
- straylight	T. Passvogel
- alignment requirements	M. Anderegg
- model philosophy	F. Felici
- HET windows	H. Schaap
- instrument modes (prime, parallel)	H. Schaap

7 Present PLANCK baseline configuration, including industry feedback on possible improvements to be implemented:
- thermal design
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- PLANCK module design and interfaces (cooling, mechanical)
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- TM rates

- EMC

8.1 HFI:
- all cooling interfaces

8.2 LFI:
- all cooling interfaces
- waveguides

9 IID-B as usual

10 The most important items to cover with industry and instrument teams are:

- PLANCK module	Coordination:	T. Pasvogel
- PLANCK telescope definition		T. Passvogel
- straylight		J. Tauber
- model philosophy related to planned module testing		F. Felici

Harm Schaap

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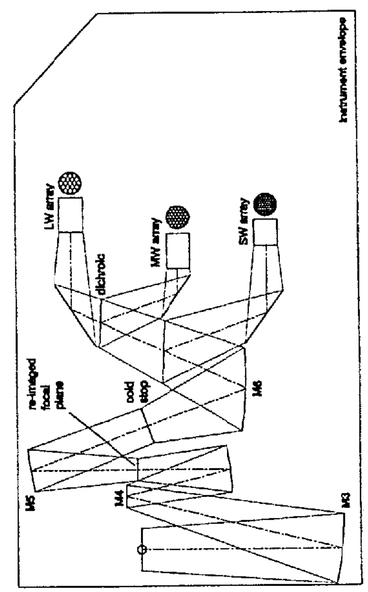
Viewgraphs from '110 Meetg 2-3 Sept 1997

The BOL Instrument

- **Three-band imaging photometer**
  - λ = 250, 350, 500 μm
  - $\lambda/\Delta\lambda \sim 3$
  - Sensitivity limited by telescope thermal emission
  - Three hexagonally close-packed bolometer arrays
  - Simultaneous observation of same ~ 5 arcmin. field of view
  - Total of 117 detectors

λ_o (μm)	No. of pixels	Beam width (arcsec.)
250	61	18
350	37	25
500	19	36

PHOTOMETER OPTICAL LAYOUT



BOL photometer
f/5 final beam size
dichroic angle - 22.5 degrees

250 μm

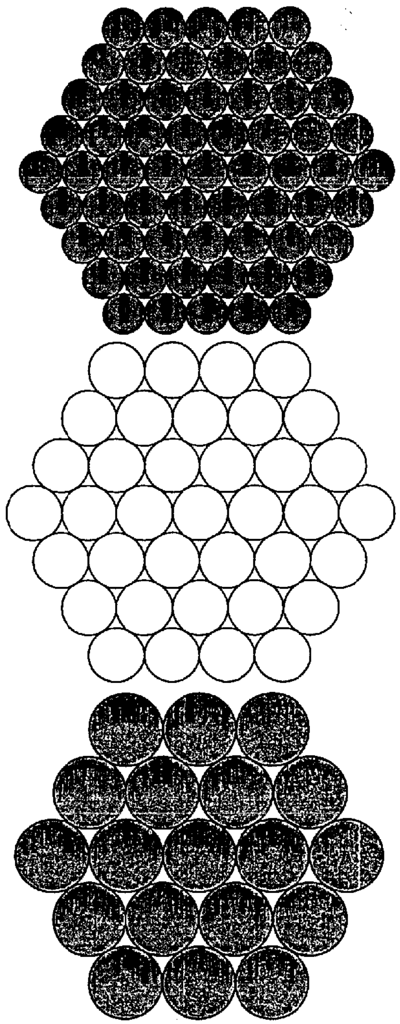
61 detectors

350 μm

37 detectors

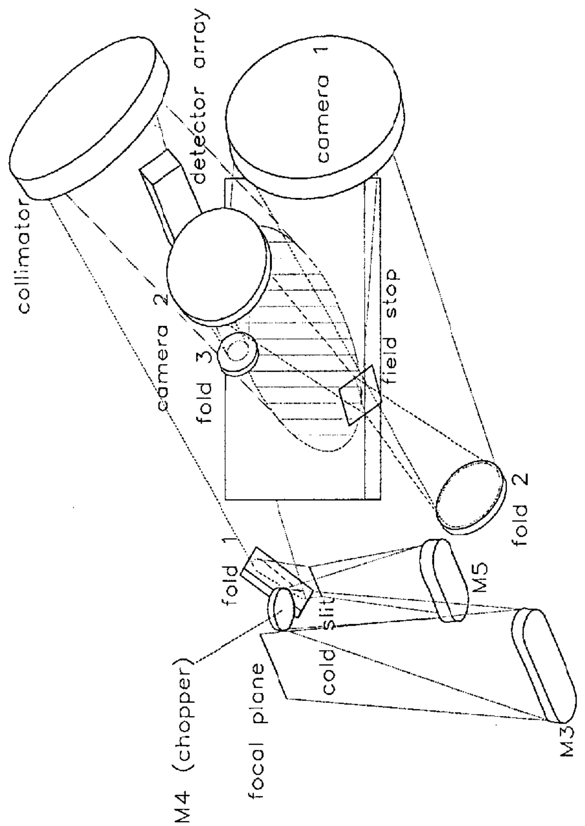
500 μm

19 detectors



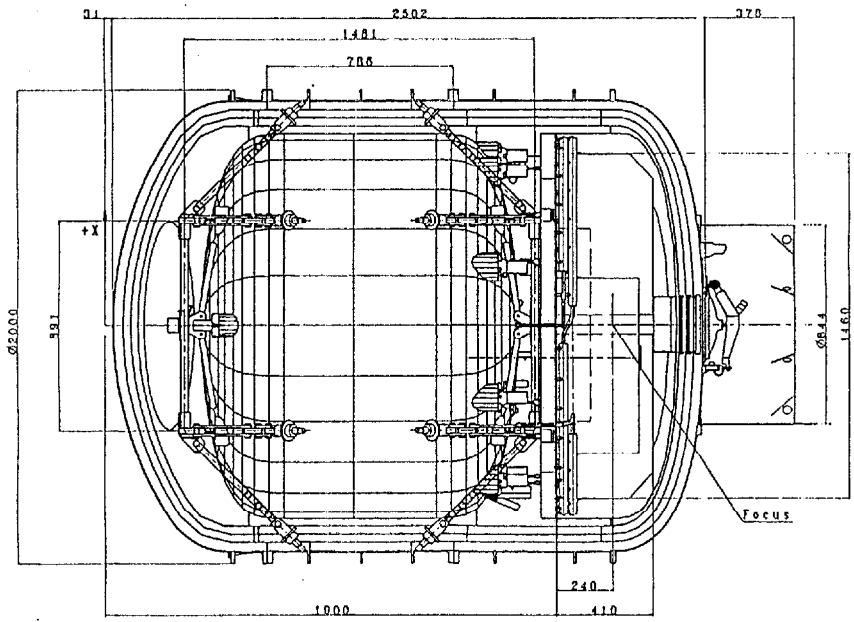
- Spectrometer
  - $\lambda \approx 200 - 400\ \mu m$
  - $\lambda/\Delta\lambda \sim 400$
  - Base-line:
    - Reflection grating
    - Slitless spectrometer (single pixel on the sky)
    - λ-independent beam FWHM ~ 36"
    - 40 detectors:
      - Two rows of 20 (ON - OFF)
      - Chopping between the two rows
  - Option:
    - Fourier Transform Spectrometer (FTS)
    - Would have imaging capability

SPECTROMETER OPTICAL LAYOUT

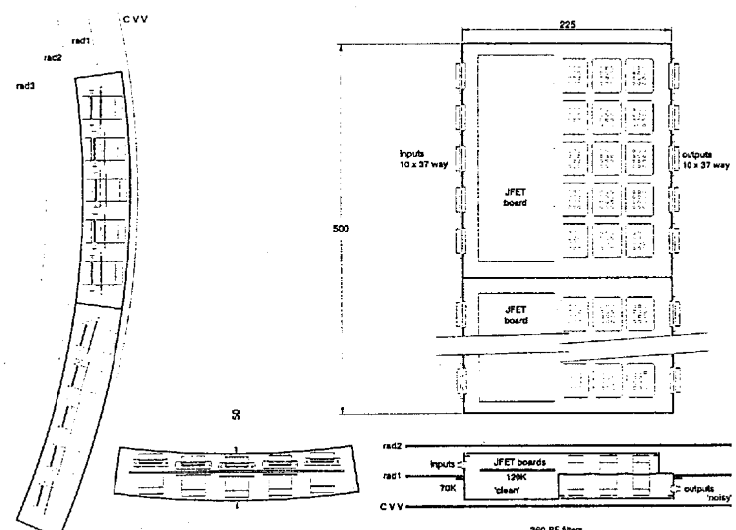


- **BOL detectors**
  - Bolometers cooled to > 200 mK
  - Base-line:
    - Spider-web NTD Ge bolometers
    - Coupled to focal plane by feed-horns
  - Options:
    - Filled arrays (full spatial sampling) being developed using either semiconductor or superconducting bolometers
    - Significant implications for FPU power dissipation, cold + warm electronics, operating modes
  - Proposal will incorporate base-line NTD Ge and describe other options

2.2.2 Overview on cryostat design (cont'd): Longitudinal Section



- **Read-out electronics**
  - Dual JFET source-followers
    - Power dissipation ~ 1 mW per FET
    - Two FETs/detector ⇒ > 300 FETs
    - FET operation at ~ 120 K
  - FET module location: on cryostat radiation shield at ~ 70 K
  - Possibility of FET module on outside of CVV will be considered
- **Internal mechanisms**
  - Chopper (serves both photometer and grating spectrometer)
    - Base-line : Single-axis (based on ISOPHOT)
    - Option : Multiple axis
  - Grating (or FTS) drive mechanism for spectrometer
    - Base-line: ISO LWS grating mechanism

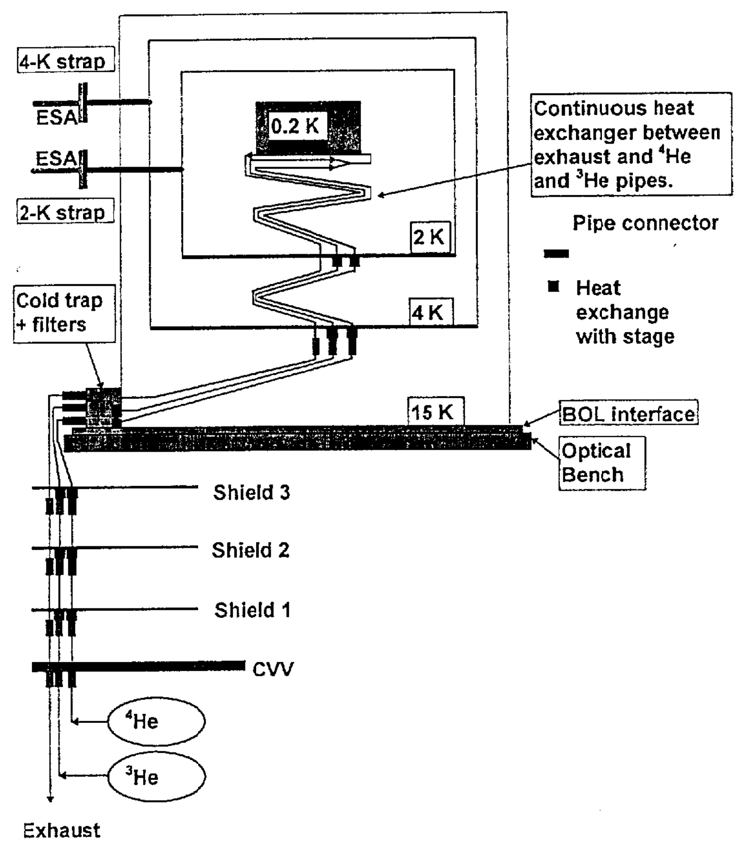


BOL2 schemati view of amplifier / filter module mass ~ 5 kg

- **Internal dissipation**
  - Focal plane : negligible
  - Chopper : 0.4 mW at 15 K
  - Grating drive : 0.6 mW at 4 K
  - FTS drive : TBD
    - May be more than grating drive
    - Current est. ~ 2 mW
  - FET module : Est. 400 mW at 70 K
- **Thermal/mechanical interfaces**
  - 15-K enclosure bolted to optical bench
  - 4-K enclosure interfaces to cryostat 4-K shield via thermal strap
  - 2-K enclosure interfaces to cryostat helium tank via thermal strap
  - FET module located on ~ 70-K radiation shield

- Dilution cooler pipework
  - FPU delivered with internal pipe-work to 15-K interface
  - Break at 15-K optical bench interface
  - Total number of breaks must be minimised
  - Need to solder/weld at break-points ?
  - Breaks at radiation shield interfaces ?
- Electrical interfaces
  - Cryoharness linking focal plane to FET box and FET box to warm electronics
  - Stainless steel wires (but brass needed for some high current lines
  - Could route all wires through this box for simplicity
  - Total no. of wires to FPU = 424

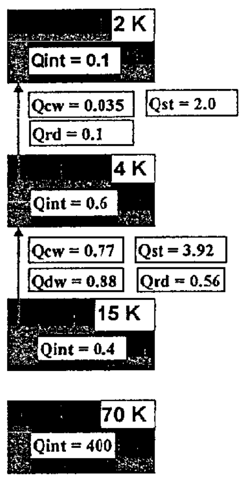
- Dilution system interfaces



- Thermal model
  - Assumptions:
    - Temperatures of 15, 4 and 2-K stages
    - Mechanical design for $f_o > 150$ Hz
    - Conduction by mechanical supports and electrical wires
    - Internal dissipation
    - Radiation

Stage	"15-K" Temp. (K)	Op. (mW)	Non Op. (mW)
2 K		2.2	2.1
4 K	10	3.2	1.7
	15	6.7	5.3
	20	13.1	11.6
15 K *		0.4	0.0
70 K *		400	0.0

* Dissipation only



Qint	Internal dissipation
Qcw	Conduction due to wiring
Qdw	Dissipation due to wiring
Qst	Conduction due to structure
Qrd	Heat load due to radiation

- Telemetry rates
  - BOL prime modes:

- Photometer only	33 kbs
- Spectrometer only	15 kbs
- Photometer + spectrometer	43 kbs

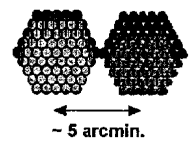
  - Other modes
    - Partner mode with PHOC
    - Serendipity
    - Parallel

      - all these ≡ photometer only 33 kbs

- Photometer operating modes

1. Field mapping

   - Chopper on
   - Chop throw ≡ array size
   - 64-point raster needed for full sampling at all wavelengths
   - Chop direction fixed in spacecraft co-ordinates
   - Raster pointing:



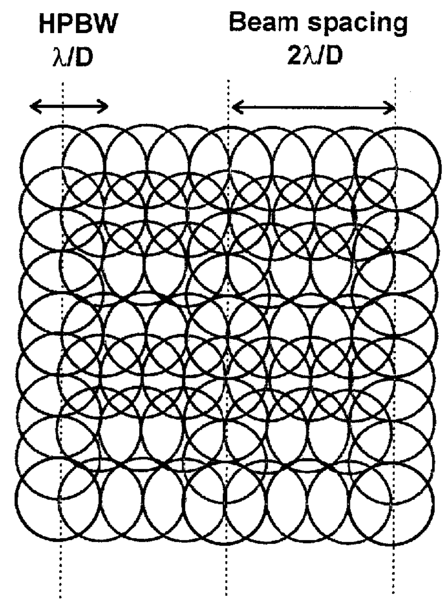
Typ. no. of pointings/line	M	= 8
Typ. no. of lines	N	= 8
Typ. step size	d_1, d_2	= 9”

Note: Reducing min. duration of stable pointing from current 10 s would increase observing efficiency

2. Scan mapping (for large areas)

   - Chopper on
   - Telescope moves continuously
   - Scan direction fixed in spacecraft co-ordinates
   - Normal line scanning

- Typ. no. of lines	$N > 8$
- Typ. length of lines	$D_1 > 5$ arcmin.
- Typ. line-line sep.	d_2 = 8”
- Typ. scan rate	20”/sec.



Minimum of 4 x 4 = 16 array pointings needed for fully sampled map

Step size = $FWHM_{250}/2$ = 9”

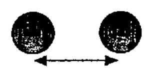
Max beam spacing = $2(FWHM_{500})$ = 72”

⇒ 8 steps needed in each dimension

⇒ for full sampling simultaneously in all 3 bands, 8 x 8 = 64 array pointings are needed

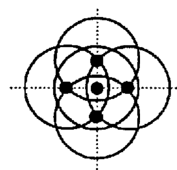
3. Point source photometry

- Chopper on
- Nodding (optional)



- Chop throw typ. 60”
- Nominally only one pixel per array in use

- Pointing accuracy:
  - If APE = 6”
    - ⇒ Max. signal loss ~ 25%
    - ⇒ Need to do small (5-point) map with ~ 6” spacing
    - ⇒ Observation takes much longer



  - If APE = 3”
    - ⇒ Max. signal loss ~ 7.5%
      - Acceptable in some cases

- Need for peak-up mode ?

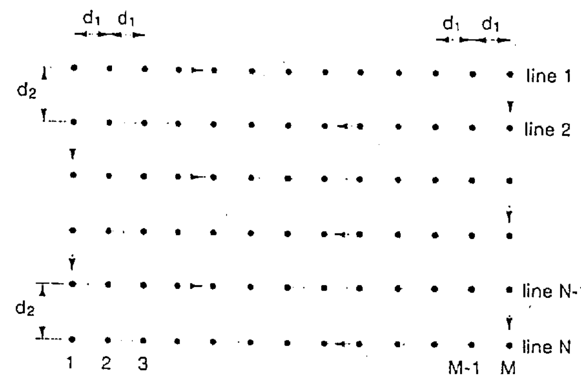


FIGURE 4.3-1 NORMAL RASTER POINTING

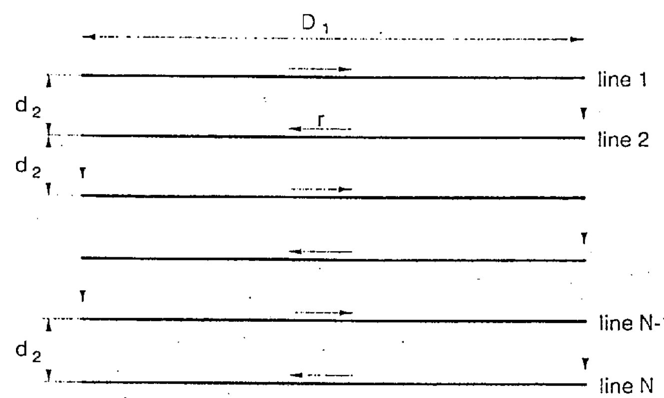
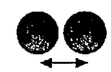


FIGURE 4.3-3 NORMAL LINE SCANNING

- **Spectrometer operating modes**

Full or partial spectral scan

- Chopper on
- Chop throw ~ 40”

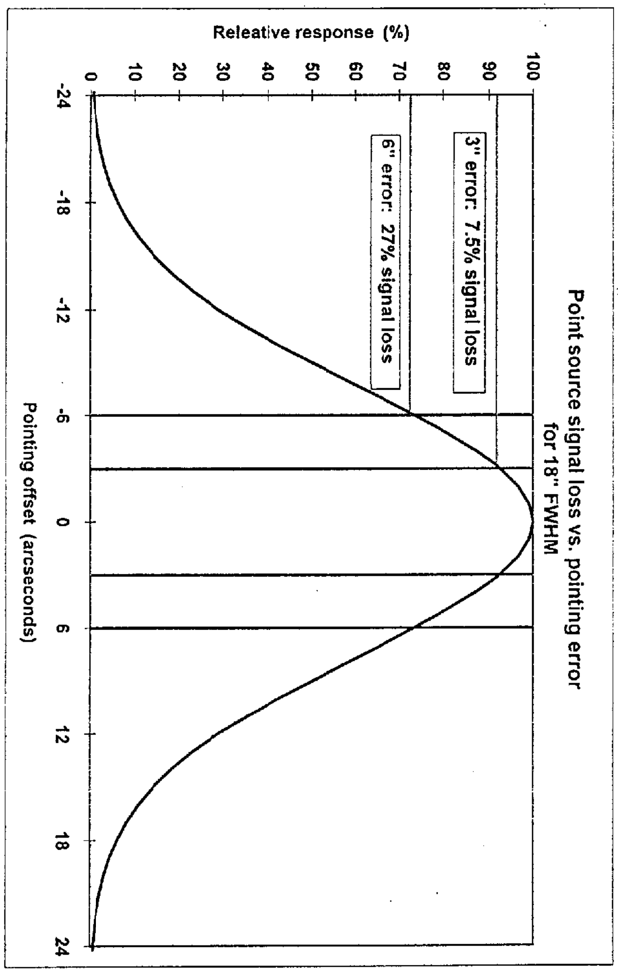


- Nodding (optional)
- Raster mapping (optional)

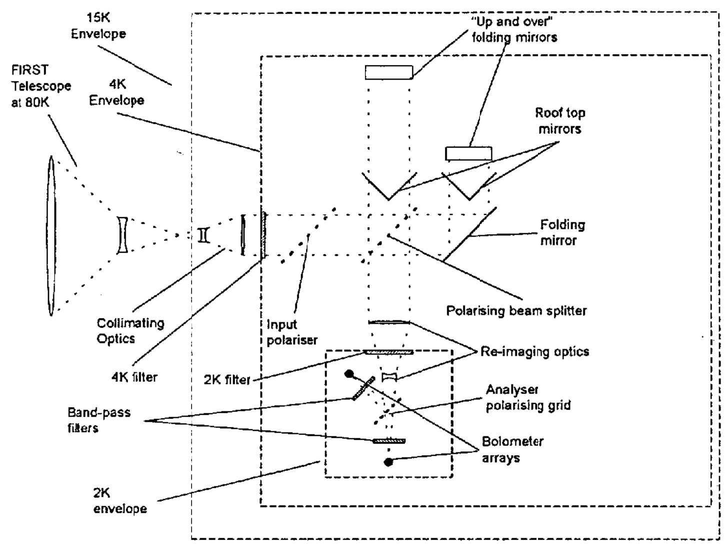
- **Operation simultaneously with other instruments**

1. “Partner mode” with PHOC needs to be studied
   - Desirable for simultaneous deep mapping of large areas
   - Implications for internal design of instruments
   - May not be practical with current BOL base-line
2. Serendipity mode (during slews)
   - Photometer operating with chopper on
3. Other modes TBC

ESTEC Sept. 2 1997



- **BOL FTS option**

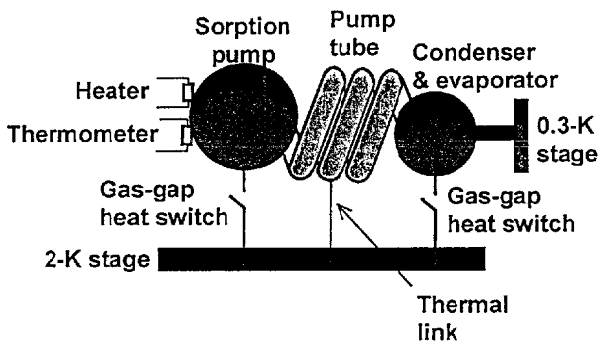


- **FTS option: System implications**

- Mass	~ Same or less
- Volume	~ Same or less
- No. of detectors	~ Same
- Dissipation	Higher First-cut (guess) 2 mW at 4 K in operation (compare 0.6 mW for grating)
- Telemetry rate:	TBC (higher than for grating)

- Operating modes:
  - Continuous back and forth scanning
  - No chopping or nodding
  - Scan time = 15 sec max.; 2 sec. min
  - Pointing fixed for a given scan
  - At least three scans per spatial point
  - If fully sampled spatial map needed, may need to do raster-map as for photometer

- ^{3}He cooler: System implications



- Mass, volume ~ Same or less
- No. of detectors ~ Same
- Cooling power 20 μW
- Fill pressure 70 bar at 300 K
- Dissipation at 2 K (all figures TBC):
  - Peak load on 2-K stage 20 mW
  - Avg. during BOL operation 3 mW
  - Cycle time ≈ 2 hrs
  - Hold time ≈ 24 hrs
- Interfaces to spacecraft:

  Outside FPU: Electrical connector (no piping going into FPU)

  Inside FPU: Thermal interface to 2-K

FIRST/PLANCK

MODEL PHILOSOPHY

ESTEC, 03-04 SEPT. 97

F. FELICI
Fabricio

FIRST PLANCK Model Philosophy

Introduction

- This presentation outlines concepts and ideas being discussed in the FIRST-PLANCK Project for a model philosophy at system level.
- Units/experiments/assemblies model philosophy would have to include, but not be limited to deliverable models outlined in a plan of this type.
- These concepts differ substantially from past, even recent, ESA projects and therefore will have to be discussed more broadly within ESA and with potential Prime Contractors.
- This higher risk approach to AIV is tailored on the ongoing merged FIRST-PLANCK mission and on the ISO heritage of FIRST.
- The driver to this reduced AIT program is keeping cost as low as possible.

Mission Development Criticalities

FIRST Telescope	**Accuracy** **Stiffness** **Mass**	**Focus for resolution** DM-FM units
Planck PLM	**Cryo coolers** **Straylight** **Thermal**	QM payload model
AOCS "double mode"		EM system model
Phased array antenna		QM unit
FIRST PLM Compatibility		QM's + ISO cryostat

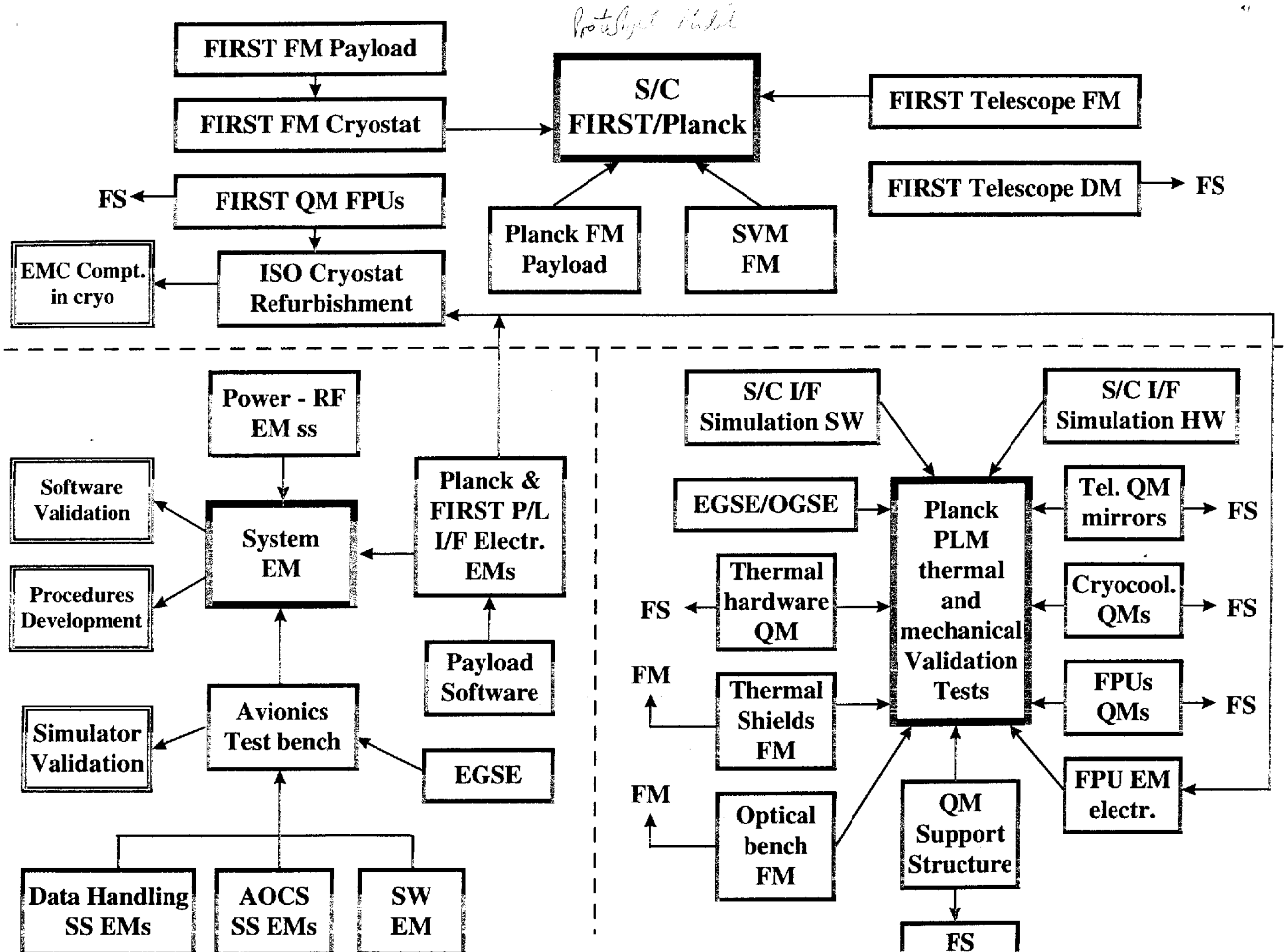
FIRST-PLANCK Model Philosophy :

MAIN CONCEPTS AT SYSTEM LEVEL

- No dedicated Structural or Thermal Models at system level
- An Electrical Model to :
  - Progressively increase confidence on the end-to-end functionality of the system
  - Check early the AOCS modes and transitions
  - Create a system level test-bench for units, AIV & OPS procedures
  - Possibly be part of an Independent Software Verification Facility or of an end-to-end simulator

FIRST-PLANCK Model Philosophy

- A Planck Payload Module Functional Test at QM/FS level in thermal vacuum to verify thermal models and EMC behaviour of the whole Module
- A First Focal Plane Instruments functional test at cryogenic conditions (QM/FS level)
- A Protoflight Model to perform :
  - System Functional Tests
  - Acoustic and Vibration Tests
  - EMC conducted and radiated Tests
  - Solar Simulation, Thermal Vacuum Tests



PRELIMINARY

FIRST-PLANCK Model Philosophy

Electrical Model Definition

- Form, fit and function like FM. (“integration spare”)
- Redundant channel can be waived
- Non hi-rel components
- Compatible with TV test
- Able to run flight software (except redundancies)

FIRST-PLANCK Model Philosophy

Spare Philosophy

- All electronic units will only supply spare kits of flight quality
- All new developments (First telescope, First FPU's, Planck payload, will supply refurbished QM's as flight spare
- NO Spare of Cryostat
- No spare of structure, solar array/shields

FIRST-PLANCK Model Philosophy

	Development	EM	FM	FS
- FIRST FPUs	TBD	Sims	yes	QMs
- FIRST FPUs Electronics	TBD	yes	yes	kits
- FIRST Telescope	TBD	-	yes	DM
- Planck Mirrors	TBD	-	yes	QMs
- Planck LFI FPUs	TBD	Sims	yes	QMs
- Planck LFI coolers	TBD	-	yes	QMs
- Planck LFI interface electronics	TBD	yes	yes	kits

FIRST-PLANCK Model Philosophy

- SW Simulators still to be discussed at system level
- Contribution of PI to these simulators is TBD.
- Further hardware, SW/EGSE necessary to set up a coherent experiment program at unit and experiment assembly level is TBD and depends, inter alia, on the experiment criticality and characteristics.

BOL2 (FET module) specification

- Si JFET pairs used to read out detector signals
- Two FETs per detector ⇒ 314 FETs
- FETS operate optimally at 100 - 150 K (nominally 120 K)
- Power dissipation per FET ≈ 1 mW
- High-impedance connections from detectors to FETs
  ⇒ sensitive to EMC and microphonics
  ⇒ cables should be as short as possible

Box contents
FETs for signal readout
RF filters on low-impedance side of all lines for EMI rejection
Heaters, thermometers for FET circuit boards
Option: For simplicity, could route all BOL wiring through this module

Location:
Base-line: On first radiation shield (i.e., the one next to the cryostat outer can)
Option: On outside of CVV
- Advantage: Ease of integration and access
- Disadvantages: Longer cable length to FPU
  Worse for EMC ?
  FETs at 300 K for ground testing

Size
500 x 225 x 50 mm (curved shape to fit between radiation shields)

Temperature
External: 70 or 80 K in orbit
150-200 K (?) on ground
Internal: Nominally 120 K (FETs will function but may be out on ground. of spec.)

Mass
5 kg

Cable length
BOL1 - BOL 2: as short as possible, preferably < 0.5 m

Power
400 mW (1 mW per FET pair + some heater power)

Connectors
10 37-way connectors in and same number out

Grounding
Metal box bolted to metal radiation shield
FET circuits inside will be isolated from the box

Heater control
Open loop with internal FET module heaters and thermometers

Open issues:

1. Will there be MLI on the radiation shield on which the box is to be mounted?
2. Pros and cons of putting it on the outer shield.
3. Specification for RF filters.
4. Availability of small, space-qualified/qualifiable RF filters capable of operating at 70 K.
5. Availability of connectors with integral RF filters.
6. Feasibility of incorporating RF filters into the cryo-harness or the CVV vacuum feed-through.

IIDWIR03.XLS

BOL Instrument Cryoharness

29 Aug. 1997

Harness:			
	Len4_15	0.3	m
	Len15_50	0.3	m
	R_SS	80	Ω/m
	R_BR	7.5	Ω/m

NBOLS	157	Ifet (mA)	0.50
NCOM	8		

4 K to 15 K

ID	Signal definition	Name	No. of Cond.	No. of shields	Est. Res. (Ω)	Current (A)	Duty Cycle (t*T)	Max. Line Volt (V)	Remarks	Avg. Harness Dissip. (mW)
1	NBOLS Det. signals	Bols	314	19	24	1.00E-09	1		SST AWG38	0.00
2	Bolometer biases/gnds	Biases	38	8	24	1.00E-09	1		SST AWG38	0.00
3	4 thermoms (0.1 K; 2 K)	Therms_1	16	4	24	1.00E-05	1		SST AWG38	0.00
4	4 thermoms (4 K)	Therms_2	16	4	24	1.00E-05	1		SST AWG38	0.00
5	Grating temp sensors	G_Temp	4	0	24	1.00E-05	0.01		SST AWG38	0.00
6	Grating posn sensors	G_Posn	4	2	24	1.00E-04	1		SST AWG38	0.00
7	Grating drive coils	G_Drive	8	0	2.25	8.00E-03	0.5		Brass AWG38	0.58
8	Dilution cooler control	Dilution	8	2	24	1.00E-05	1		SST AWG38	0.00
	Total		408	39			Tot. dissipation (mW)			0.58

15 K to 50 K

ID	Signal definition	Name	No. of Cond.	No. of shields	Est. Res. (Ω)	Current (A)	Duty Cycle (t*T)	Max. Line Volt (V)	Remarks	Avg. Harness Dissip. (mW)
1	NBOLS Det. signals	Bols	314	19	24	1.00E-09	1		SST AWG38	0.00
2	Bolometer biases/gnds	Biases	38	8	24	1.00E-09	1		SST AWG38	0.00
3	4 thermoms (0.1 K; 2 K)	Therms_1	16	4	24	1.00E-05	1		SST AWG38	0.00
4	4 thermoms (4 K)	Therms_2	16	4	24	1.00E-05	1		SST AWG38	0.00
5	Grating temp sensors	G_Temp	4	0	24	1.00E-05	0.01		SST AWG38	0.00
6	Grating posn sensors	G_Posn	4	2	24	1.00E-04	1		SST AWG38	0.00
7	Grating drive coils	G_Drive	8	0	2.25	8.00E-03	0.5		Brass AWG38	0.58
8	Dilution cooler control	Dilution	8	2	24	1.00E-05	1		SST AWG38	0.00
9	Chopper drive coils	Ch_Dr	4	2	2.25	2.00E-03	1		Brass AWG38	0.04
10	Chopper pick-up coils	Ch_Pu	4	2	2.25	1.00E-03	1		Brass AWG38	0.01
11	2 thermometers (15 K)	15K_Temp	8	2	24	1.00E-05	0.01		SST AWG38	0.00
	Total		424	45			Tot. dissipation (mW)			0.62

50 to 300 K

ID	Signal definition	Name	No. of Cond.	No. of shields	Max. Res. (Ω)	Current (A)	Duty Cycle (t*T)	Max. Line Volt (V)	Remarks	Max. Harness Dissip. (mW)
1	NBOLS JFET signals	Bols	314	19	1000	1.00E-09	1		SST AWG38	0.00
2	Bolometer biases/gnds	Biases	38	8	1000	1.00E-09	1		SST AWG38	0.00
3	4 thermoms (0.1 K; 2 K)	Therms_1	16	4	1000	1.00E-05	1		SST AWG38	0.00
4	4 thermoms (4 K)	Therms_2	16	4	1000	1.00E-05	1		SST AWG38	0.00
5	Grating temp sensors	G_Temp	4	0	1000	1.00E-05	0.01		SST AWG38	0.00
6	Grating posn sensors	G_Posn	4	2	1000	1.00E-04	1		SST AWG38	0.04
7	Grating drive coils	G_Drive	8	0	30	8.00E-03	0.5		Brass AWG38	7.68
8	Dilution cooler control	Dilution	8	2	1000	1.00E-05	1		SST AWG38	0.00
9	Chopper drive coils	Ch_Dr	4	2	30	2.00E-03	1		Brass AWG38	0.48
10	Chopper pick-up coils	Ch_Pu	4	2	30	1.00E-03	1		Brass AWG38	0.12
11	2 thermometers (15 K)	15K_Temp	8	2	1000	1.00E-05	0.01		SST AWG38	0.00
12	JFET module power	FET_Pow	16	16	30	9.81E-03	1		Brass AWG38	46.22
13	JFET thermometers	FET_Temp	4	2	1000	1.00E-05	1		SST AWG38	0.00
14	JFET heaters	FET_Htr	4	0	30	5.00E-03	1		SST AWG38	3.00
	Total to instrument		448	63						
						Tot. harness dissipation (mW)				57.54

BOL Thermal Loads

29 Aug. 1997

Stage	"15-K" Temp.	Int. Diss.	Cond. by structure	Cond. by wires	Dissip. by wires	FET box	Rad.	Total (Op.)	Total (Non Op.)
2-K		0.10	2.00	0.035	0.00		0.10	2.24	2.14
4-K	15	0.60	3.92	0.77	0.88		0.56	6.73	5.25
	10	0.60	1.30	0.31	0.88		0.11	3.20	1.72
	20	0.60	8.40	1.43	0.88		1.77	13.08	11.60
15-K	15	0.40		9.39	0.92			10.71	9.39
	10	0.40		9.89	0.92			11.21	9.89
	20	0.40		8.68	0.92			9.99	8.68

These are the thermal loads on three out of the four cold stages (2 K, 4 K and 15 K) of the BOL focal plane instrument. These numbers have been worked out using some assumptions.

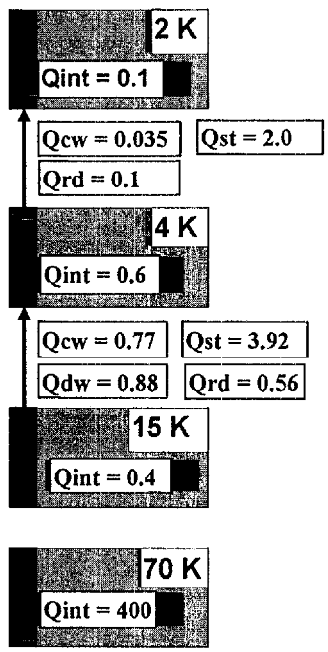
1. The grating of the spectrometer is at 4 K and the scanning range is between +/- 5 deg.
2. The chopper mirror is on the 15K stage and will dissipate around 0.4 mW.
3. All the wiring is in stainless steel except the wires for the grating and chopper which are made of brass.
4. The dissipation in the harness between two temperature stages is assumed, as a worst case, to fall entirely on the lower temperature stage.
5. The support structures for 2 K and 4 K are in Kevlar
6. The heat load on the 15-K stage shown here is due to the wires and to the chopper. The heat load coming from the structural mounting to the next stage is not taken into account. For the wiring conduction, it is assumed that the next stage is at 50 K.

Summary:

Stage	15-K Temp. (K)	Op. (mW)	Non Op. (mW)
2-K	Any	2.2	2.1
4-K	15	6.7	5.3
	10	3.2	1.7
	20	13.1	11.6
15-K	15	10.7	9.4
	10	11.2	9.9
	20	10.0	8.7

BOL Thermal Model
Version 01
Sept. 2 1997

All figures in mW



Qint	Internal dissipation
Qcw	Conduction due to wiring
Qdw	Dissipation due to wiring
Qst	Conduction due to structure
Qrd	Heat load due to radiation

4. INSTRUCTION DESCRIPTION

Revised IID Chaps. 4 and 5 for IID meeting Sept. 2/3

4.1 INTRODUCTION

For low background direct detection at wavelengths longer than around 200 microns, the most sensitive detectors are cryogenic bolometers operating at temperatures in the 0.1 - 0.3 K range.

The FIRST BOLometer instrument (BOL) comprises a three-band imaging photometer covering the 200-500 micron range and a grating spectrometer with a resolution of order 1000 covering wavelengths between 200 and 350 microns. The detectors are bolometers cooled to 300 mK or less. The photometer is optimised for deep photometric surveys, and can observe simultaneously the same field of view in all three bands. The grating spectrometer is optimised for spectral rather than spatial multiplexing, the aim being to measure the complete spectrum as sensitively as possible.

4.2 SCIENTIFIC RATIONALE

The wavelength range 200 - 500 microns is largely unexplored. The thermal emission from many astrophysical sources peaks in this part of the spectrum, including comets, planets, star-forming molecular cloud cores, and starburst galaxies. The short submillimetre region is also rich in atomic and molecular transitions which can be used to probe the chemistry and physical conditions in these sources.

Wavelengths between 200 and 350 microns are not observable from the ground and will not be observed by ISO. Low transparency submillimetre windows allow some observations to be made with difficulty from the ground, but with far lower sensitivity than can be achieved from space.

One of the most important scientific projects for the FIRST mission is to investigate the statistics and physics of galaxy formation at high red shift. This requires the ability to carry out deep photometric imaging at far-infrared and submillimetre wavelengths (100-500 microns) to discover objects, and the ability to follow up the survey observations with spectroscopy of selected sources. The FIRST bolometer instrument is essential for this programme, and is being designed so as to be optimised for these extragalactic imaging and spectral surveys. Another key scientific project for the BOL is a sensitive unbiased search for proto stellar objects within our own galaxy.

4.3 OVERALL CAPABILITIES

The BOL instrument contains a three-band imaging photometer and a grating spectrometer.

4.3.1 Photometer

The imaging photometer operates at nominal wavelengths of 250, 350 and 500 microns with a spectral resolution of around 3. Three hexagonally close-packed detector arrays observe the same *approx. 5-arcminute field of view simultaneously*, with dichroic beam dividers separating the bands. The 250, 350 and 500 micron arrays have 61, 37 and 19 detectors, respectively. This array design is similar to that of ground-based bolometer array receivers such as the SCUBA instrument on the JCMT and the bolometer array on IRAM, using diffraction-limited feedhorns of a size comparable to the diffraction spot size. This involves spatial undersampling of the sky and the need to make a number of separate array pointings in order to acquire a fully sampled image. The focal plane arrays incorporate spider-web bolometers coupled by feed-horns. Signal readout is via cold JFETs located on a cryostat radiation shield (around 70 K) as close as is feasible to the instrument enclosure, but heated to a temperature of around 120 K.

Further work on refining the instrument design continues, and it is likely that the current design will change before it must be frozen (around 2000 according to the current schedule). There are three particular areas in which changes may *be* made:

(i) Operation of the detectors at 0.3 K using a helium-3 refrigerator instead of at 0.2 K or below, which requires the more complex dilution refrigerator.This would simplify the thermal and mechanical engineering of the instrument and its interface with the cryostat.

(ii) Use of a polarising Michelson interferometer (Fourier Transform Spectrometer (FTS) as an alternative to a grating spectrometer. A detailed comparison of the scientific and technical merits of the two spectrometer types is currently underway.

(iii) Incorporation of large-format planar bolometer arrays designed to sample fully the telescope diffraction disc (these are currently under development). This offers the prospect of improved sensitivity through having more detectors, and simpler operating modes.

It is hoped that (i) and (ii) will be decided by the time of proposal submission (early 1998). The decision on the use of planar detector technology must wait for evaluation of the various options now being developed, and is not likely to happen until 1999 or 2000 - i.e., well after instrument selection. The AO response will adopt proven technology (spider-web bolometers and feedhorns) as the baseline and propose an instrument design which is capable of incorporating planar bolometer arrays if they are proven in time and are compatible with spacecraft resource budgets.

4.3.2 Spectrometer

The grating spectrometer covers the range 200 - 350 m with a resolution of around 400. It is designed for maximum spectral multiplexing, with a minimal capability for imaging. *Two arrays of 20 bolometric detectors are used to sample the spectrum produced by a diffraction grating operating in reflection (one array is used to measure the spectrum of the target source and the other measures the spectrum of an adjacent "off" position.* The complete spectrum is sampled by scanning the grating.

4.4 HARDWARE DESCRIPTION

The BOL consists of:

1. A cold Focal Plane Unit (FPU) which interfaces to the 15-K, 4-K and 2-K temperature stages provided by the cryostat. Within the unit, further cooling of the detector arrays to a temperature of around *200 mK (TBC)* is provided by a dilution refrigerator which is part of the instrument.

2. *A JFET module for detector signal readout, located on one of the cryostat radiation shields at around 70 K (but as close to the focal plane unit as possible to minimise susceptibility to EMI).*

3. A continuous flow dilution refrigerator system comprising helium-3 and helium-4 gas storage tanks mounted on the outside of the payload module, and piping at temperatures down to *200 mK (TBC).*

4. Warm electronics boxes located in the service module (SVM) at 300 K for:
   (I) analogue signal readout;
   (ii) instrument mechanism control;
   (iii) digital data processing, instrument control and telemetry interface to the spacecraft;
   (iv) control of the dilution refrigerator.

5. Interconnecting harnesses between the FPU and the JFET module and between the warm electronics units.

4.5 SOFTWARE DESCRIPTION

TBD

4.6 OPERATING MODES

4.6.1 Primary operating modes

4.6.1.1 Point source observation (photometer)

This mode produces a photometric measurement of a single position on the sky.

- *Chopper on*
- *Nodding (optional)*
- *Chop throw typ. 60"*
- *Nominally only one pixel per array in use*

The details of this operating mode depend critically on the absolute pointing error. The BOL photometer beam shape will be roughly Gaussinan, with a FWHM of about 18 arcseconds at the shortest wavelength band. The beams on the sky do not overlap, so that observing a point source means placing a designated pixel at its position with high accuracy. If the pointing error is up to 6", then the loss of signal from a point source could be up to 25%, which constitutes an unacceptable calibration uncertainty. To reduce this uncertainty, it will be necessary to perform a five-point cross map when observing point sources, to make sure that the peak signal can be recovered. This will take much longer than a single pointing. If the APE is a factor of two smaller, then the maximum signal loss would be only 7.5%, which would be acceptable in many cases, eliminating the need to do five-points.

4.6.1.2 Mapping of one field (photometer):

This mode produces a fully sampled (less than half-beam spacing) map of an area equal to the BOL field of view. Because the detector beams do not overlap on the sky, a number of array pointings must be made to acquire a fully-sampled (half-beam-spacing) map. To do this for all three bands simultaneously requires 8 x 8 = 64 array pointings per field.

- *Chopper on*
- *Chop throw = array size (approx. 5 arcmin)*
- *Raster pointing with typically 64 positions*
- *Grid separation typically 9"*
- *Chop direction fixed in spacecraft co-ordinates*
- *Raster pointing:*

Typ. no. of pointings/line	$M = 8$
Typ. no. of lines	$N = 8$
Typ. step size	$d_1, d_2 = 9''$

Note: Reducing min. duration of stable pointing from current 10 s would increase observing efficiency.

4.6.1.3 Scan mapping (photometer)

This mode produces a map of an area typically much larger than the BOL field of view. It will be the prime mode for deep survey observations. It has the advantage over single-field mapping that there are no overheads due to telescope settling at each point in a raster.

- *Chopper on*
- *Telescope moves continuously*
- *Scan direction fixed in spacecraft co-ordinates*
- *Normal line scanning:*

Typ. no. of lines	$N > 8$
Typ. length of lines	$D_1 > 5$ arcmin.
Typ. line-line sep.	d_2 = ~~8'~~ 4-5 arcmin
Typ. scan rate	20"/sec.

4.6.1.4 Spectrometer operation

This mode produces a full or partial spectral scan of a single position or a grid of positions on the sky.

- *Chopper on*
- *Chop throw ~ 40"*
- *Raster mapping (optional)*
- *Nodding not required (TBC)*

4.6.2 Serendipitous/parallel and other non-prime modes

4.6.2.1 Serendipitous mode: BOL operation while telescope is slewing

The BOL photometer can take data during telescope slews, producing strip maps at three wavelengths.

The BOL spectrometer can take spectral data (with the grating in a fixed position) producing n sparsely sampled spectral data points where n is the number of detectors (around 100)

4.6.2.2 BOL operation in parallel with PHOC

A "partner mode" in which the PHOC and the BOL operate simultaneously in imaging mode for deep mapping of large areas of sky would lead to increased observing efficiency for FIRST surveys. This would have implications for the internal design of the instruments. WIth the present BOL design, in which the field of view on the sky is not fully sampled by the detector arrays, it may not be feasible to devise an observing mode in which both instruments can function optimally. If the BOL is equipped with detector arrays which do fully sample the image, then it may be easier.

4.6.2.3 BOL operation in parallel with HET

TBD

This mode may not prove practical for EMC reasons - undisturbed operation of the BOL may not be feasible while the HET local oscillators are switched on.

4.6.3 Stand-by mode

- *FPU powered*
- *FET module powered*
- *Grating in rest position*
- *Chopper throw set to zero*

4.6.4 Off mode

- *FPU not powered*
- *FET box not powered*

4.6.5 FPU operations at ambient temperature

- Chopper and grating can be operated and checked
- FETs can be switched on and checked for functionality
- Detectors can be powered but do not function

4.7 INSTRUMENT SCIENTIFIC PERFORMANCE

This part is to be considered as containing information which needs to be verified by test, analysis or a combination of the two and shall serve the purpose of demonstrating that the instrument will operate as intended for the particular mission.
Para 9.5 "Scientific Performance Verification" of the IIDs provides more information on this subject.

4.7.1 Optical parameters

TBD

4.7.2 Spectral resolution

Photometer: R = 3
Spectrometer: R = 400 at 250 microns wavelength

~~**4.7.3 Modes of operation**~~

TBD

4.7.4 Sensitivity

TBD

5. INTERFACE WITH SATELLITE

5.1 IDENTIFICATION AND LABELLING

Each individual instrument unit is allocated two unique identification codes:

- a project code which is the normal reference used for routine identification in correspondence and technical descriptive material.

- a spacecraft code allocated by the spacecraft contractor in accordance with the computerised configuration control system to be implemented, and used in particular for connector and harness identification purposes. The project code is part of the spacecraft code. (See IID-A item 5.1)

The project codes allocated to this instrument are:

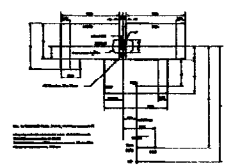
Project code	Instrument unit
BOL1	Cold Focal Plane Unit (Including Dilution Cooler)
BOL2	JFET Module
BOL3	Mechanism Drive *warm electronics*
BOL4	Detector Read Out *warm electronics*
BOL5	Digital Electronics
BOL6	Dilution Cooler Control *warm electronics*
BOL7A, 7B	^{3}He Tanks
BOL8A, 8B	^{4}He Tanks
BOL9	Valves, Piping, etc
BOL10	"Warm" Interconnect Harnesses

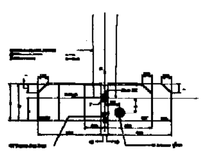
5.2 COORDINATE SYSTEM

Compliant with requirements in IID-A. Unit specific definition shown in the External Configuration Drawings.

5.3 LOCATION AND ALIGNMENT

Figures 1 and 2 show the concept of the location of the BOL Focal Plane Unit (FPU) on the Optical Bench (OB)





5.3.1 Instrument Location

5.3.1.1 Inside cryostat

BOL2, the JFET module, will be located on the first cryostat radiation shield. The unit will be operating at an external temperature of TBD. For reasons of interference/microphony the length of this harness and therefore the distance between the units shall not exceed 50 cm (TBC).

5.3.1.2 Outside cryostat

NA

5.3.1.3 On SVM

There are no location requirements for units on the SVM.

5.3.1.4 On PLANCK module

NA

5.3.2 Instrument Alignment

There are no alignment and/or alignment stability requirements except for the focal plane unit BOL1.

Initl. reqmnts. covrd by Tolerances – optical bench values in the Alignment Plan – see Part A

5.3.2.1 Absolute Requirements

The absolute alignment requirements to the Optical Bench at operating conditions are as follows:

Unit	Δ x	Δ y	Δ z	θ x	θ yz (combined)
BOL1	±1 mm	±1 mm	±1 mm	±5′	±3

5.3.2.2 Stability Requirements

The alignment stability requirements at operating conditions are as follows:

Unit	Δ x	Δ y	Δ z	θ x	θ yz (combined)
BOL1	±0.1 mm/hr	±0.1 mm/hr	±0.1 mm/hr	±3 ′/hr	±1 ′/hr

5.4 EXTERNAL CONFIGURATION DRAWINGS

TBD

5.5 SIZES AND MASS PROPERTIES

The table below shows for each unit its size, mass (one unit) and the number of units:

Project code	Instrument unit	# of	Dimensions (mm)	Mass (kg)
BOL1	Cold Focal Plane Unit (Including Dilution Cooler)	1	690 x410 x410 Irregular shape	29.3
BOL2	JFET Module	1	*500 x 225 x 50 (shape matched to curvature of rad. shield)*	*5.0*
BOL3	Mechanism Drive	1	200 x200 x100	3
BOL4	Detector Read Out	1	200 x200 x100	3
BOL5	Digital Electronics	1	200 x200 x100	4
BOL6	Dilution Cooler Control	1	200 x200 x160	4
BOL7A, B	^{3}He Tanks incl. gas	2	Diameter 352	2 x 5
BOL8A, B	^{4}He Tanks incl. gas	2	Diameter 432	2 x 9
BOL9	Valves, Piping, etc	1		6
BOL10	"Warm" interconnect harness	1		1
TOTAL				69.3 83.3

Note that dimensions and mass do not include margins. The S/C shall apply a margin of TBD %.

5.6 MECHANICAL INTERFACES

5.6.1 Inside cryostat

The Focal Plane Unit will have 4 (TBC) holes for fixation by bolts to the Optical Bench. One of these holes is the reference hole, as marked in the External Configuration Drawing. The interface is such as to allow unit alignment and alignment-stability requirements to be fulfilled.

5.6.2 Outside cryostat

NA

5.6.3 On SVM

Units mounted on the SVM will have attachment points for fixation to the equipment platform. Units with a mass <1.5 Kg will not have more than 4 of these points. For units with a mass >1.5 Kg and units with a specific structural, dynamic or thermal requirement for more than 4 attachment points, the number will have to be approved by the Project.

5.6.4 On PLANCK module

NA

5.6.5 Cooler valves and piping

TBD

5.7 THERMAL INTERFACES

5.7.1 Inside cryostat

The various instrument stages require 3 different temperatures. This will be achieved by strapping the stages to various "cold" parts of the cryostat. These cryostat parts are:

- The He II tank for temperatures at the 2K level
- A wheel-shaped heat-exchanger cooled by the He-flow from the tank for the 4K level
- A connection to the He-ventline for the 15K level

The table below shows the required temperatures at the interface of the instrument unit with the cryostat or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. K	Max. K	^{0}C	^{0}C	Min. ^{0}C	Max. ^{0}C
BOL1	4	20	NA	NA	NA	+ 60 * ~~TBD**~~ 85°C
BOL2	50	150	NA	NA	NA	+ 60 * ~~TBD**~~ 85°C

* Continuous temperature limit.

** Short-duration temperature limit for bake-out during a maximum of TBD hours.

5.7.2 Outside cryostat

NA

5.7.3 On SVM

The table below shows the required temperatures at the interface of the instrument unit with the mounting platform or parts thereof:

Project code	Operating		Start-up	Switch-off	Non-operating	
	Min. ^{0}C	Max. ^{0}C	^{0}C	^{0}C	Min. ^{0}C	Max. ^{0}C
BOL3	- 15	+ 45	- 30	+ 50	- 30	+ 60
BOL4	- 15	+ 45	- 30	+ 50	- 30	+ 60
BOL5	- 15	+ 45	- 30	+ 50	- 30	+ 60
BOL6	- 15	+ 45	- 30	+ 50	- 30	+ 60
BOL7A, B	>90 K					
BOL8A, B	>90 K					
BOL9	>90 K					
BOL10						

5.7.4 On PLANCK module
NA

5.8 OPTICAL INTERFACES

~~5.8.1 Focus location~~

~~TBD~~

5.8.1 Straylight

Instrument straylight model TBD.

5.9 POWER

5.9.1 Inside cryostat

The tables and models below show the heat dissipation of the units mounted inside the cryostat:

Project code	Instrument unit	Power Dissipation (W)
BOL1	Cold Focal Plane Unit (Including Dilution Cooler)	See:Thermal Table and Thermal Model
BOL2	JFET Module	See:Thermal Table and Thermal Model

5.9.1.1 Thermal model BOL1

TBD

5.9.1.2 Thermal table BOL1

Temp. level K	"15 K" level K	Non-operating mW	Operating mW	Serendipity mW
2	Any	2.1	2.2	TBD
4	10	*1.7*	3.2	TBD
4	15	*5.3*	*6.7*	TBD
4	20	*11.6*	*13.1*	TBD
15	10	0	0.4	TBD
15	15	0	0.4	TBD
15	20	0	0.4	TBD

Please note that 4 K heatloads depend on 15 K level.

5.9.1.3 Thermal model BOL2

TBD

5.9.1.4 Thermal table BOL2

Temp. level K	Non-operating mW	Operating mW	Serendipity mW
70	*0*	*400*	*400*

5.9.2 Outside cryostat

NA

5.9.3 On SVM

The table below shows the heat dissipation of the units mounted on the SVM:

Project code	Instrument unit	Power Dissipation (W)
BOL3	Mechanism Drive	10
BOL4	Detector Read Out	10
BOL5	Digital Electronics	10
BOL6	Dilution Cooler Control	10
BOL7A, B	^{3}He Tanks incl. gas	
BOL8A, B	^{4}He Tanks incl. gas	
BOL9	Valves, Piping, etc	
BOL10	"Warm" Interconnect Harness	
TOTAL		40

To CVV table

5.9.4 On PLANCK module

NA

5.9.5 Load on main-bus

The power load on the 28V. main-bus for this instrument is as follows:

Operating mode	Average BOL (W)	Average EOL (W)	Peak (W)
Primary mode	TBD	40	TBD
Parallel/Serendipity mode	TBD	TBD	NA
Stand-by mode	TBD	TBD	NA

5.9.6 Keep Alive Line (KAL)

TBD

5.9.7 Interface circuits

TBD

5.10 CONNECTOR, HARNESS, GROUNDING, BONDING

5.10.1 Connectors

TBD

5.10.2 Harness

5.10.2.1 S/C Harness

The S/C harness provides the interconnection between the instrument and two other subsystems i.e. the Power subsystem and the Datahandling subsystem. The harness is supplied through the S/C Contractor.
On the instrument side, pin functions are specified in Annex A to this document.

5.10.2.2 Instrument Harness

The "warm" harness i.e the interconnect harness between the various "warm" instrument units will be delivered by the instrument teams, manufactured to agreed requirements as specified in the IID-A under item 5.10.2.2.
Pin functions and wiring characteristics are specified in Annex A to this document. The Contractor will specify length and routing as soon as an SVM lay-out is available. A Configuration Drawing will be included under item 5.4

5.10.2.3 Cryo Harness

The cryo harness, interconnecting the 15 to 300 K instrument parts, will be delivered through the S/C Contractor, manufactured to agreed requirements. The cryo harness interconnecting the 4 to 15 K instrument parts is considered part of the instrument and therefore to be manufactured by the instrument teams. Pin functions are specified in Annex A to this document.

The blockdiagram and the tables below show the cryo harness composition both for the 4 to 15 K and the 15 to 300 K interfaces.

Figure 3: BOL block diagram

TBD

BOL cryo-harness list for 4 to 15 K interface level

	Instrument:BOL		Date	07/Jul/97				
	4 to 15 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(Amp)	(t * T)	volt. (V)	
1	*157* Bolometers	*314*	*19*	24.00	1.00e-09	1.00		SST AWG38
2	Bolometer biases/grounds	*38*	*8*	24.00	1.00e-09	1.00		SST AWG38
3	4 Thermometers (0.1; 2.0K)	16	4	24.00	1.00e-05	1.00		SST AWG38
4	4 Thermometers (4K)	16	4	24.00	1.00e-05	1.00		SST AWG38
5	Grating temperature sensors	4	0	24.00	1.00e-05	0.01		SST AWG38
6	Grating position sensors	4	2	24.00	1.00e-04	1.00		SST AWG38
7	Grating drive coils	8	0	2.25	8.00e-03	0.50		Brass AWG38
8	Dilution cooler control	8	2	24.00	*1.00e-05*	1.00		SST AWG38
	Total to instrument	*408*	*39*					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t= part of T in which signal is active.

BOL cryo-harness list for 15 to 50 K interface level

	Instrument:BOL		Date	07/Jul/97				
	15 to 50 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(Amp)	(t * T)	volt. (V)	
1	*157* Bolometers	*314*	*19*	24.00	1.00e-09	1.00		SST AWG38
2	Bolometer biases/grounds	*38*	*8*	24.00	1.00e-09	1.00		SST AWG38
3	4 Thermometers (0.1; 2.0K)	16	4	24.00	1.00e-05	1.00		SST AWG38
4	4 Thermometers (4K)	16	4	24.00	1.00e-05	1.00		SST AWG38
5	Grating temperature sensors	4	0	24.00	1.00e-05	0.01		SST AWG38
6	Grating position sensors	4	2	24.00	1.00e-04	1.00		SST AWG38
7	Grating drive coils	8	0	2.25	8.00e-03	0.50		Brass AWG38
8	Dilution cooler control	8	2	24.00	*1.00e-05*	1.00		SST AWG38
9	Chopper drive coils	4	2	2.25	2.00e-03	1		Brass AWG38
10	Chopper pick up coils	4	2	2.25	1.00e-03	1		Brass AWG38
11	2 Thermometers (15 K)	8	2	24	1.00e-05	0.01		SST AWG38
	Total to instrument	*424*	*45*					

Notes: Allowed resistance values are at "operational temperatures"
in column Duty cycle t= part of T in which signal is active.

BOL cryo-harness list for 50 to 300 K interface level

	Instrument:BOL		Date	07/Jul/97				
	50 to 300 K interface	Type of cable		Allowed resist.	Current	Duty cycle	Max. line	Remarks
ID	Signal definition	# cond	# shields	(Ohm)	(Amp)	(t * T)	volt. (V)	
1	217 JFET signals	*314*	*19*	1000	1.00e-09	1.00		SST AWG38
2	Bolometer biases/grounds	*38*	*8*	1000	1.00e-09	1.00		SST AWG38
3	4 Thermometers (0.1; 2.0K)	16	4	1000	1.00e-05	1.00		SST AWG38
4	4 Thermometers (4K)	16	4	1000	1.00e-05	1.00		SST AWG38
5	Grating temperature sensors	4	0	1000	1.00e-05	0.01		SST AWG38
6	Grating position sensors	4	2	1000	1.00e-04	1.00		SST AWG38
7	Grating drive coils	8	0	30	8.00e-03	0.50		Brass AWG38
8	Dilution cooler control	8	2	1000	TBD	1.00		SST AWG38
9	Chopper drive coils	4	2	30	2.00e-03	1.00		Brass AWG38
10	Chopper pick-up coils	4	2	30	1.00e-03	1.00		Brass AWG38
11	2 Thermometers (15K)	8	2	1000	1.00e-05	0.01		SST AWG38
12	JFET module power	*16*	*16*	30	*9.81e-03*	1.00		Brass AWG38
13	JFET thermometers	4	2	1000	1.00e-05	1.00		SST AWG38
14	JFET heaters	4	0	30	5.00e-03	1.00		Brass AWG38
	Total to instrument	*448*	*63*					

Notes: Allowed resistance values are at "operational temperatures"
In column Duty cycle t= part of T in which signal is active.

5.10.3 Grounding

5.10.4 Bonding

5.11 DATA HANDLING

5.11.1 Telemetry

Housekeeping data rate	2 Kbps
Science data rate	41 Kbps *

* Please note that data rate is exclusive of possible compression by a factor of 2.

5.11.2 Timing and synchronisation signals

TBD

5.11.3 Telecommand

TBD

– I/F to AOCS – pointing info from BOL → AOCS
pointing info from AOCS → BOL

5.11.4 Interface circuits

I/F to PSU – to switch ourselves off

TBD

5.12 ATTITUDE AND ORBIT CONTROL/POINTING, ON-TARGET-FLAG

5.12.1 Attitude and orbit control

TBD *******Mapping requirements will be specified. Due date 9 July.*****

5.12.2 Pointing

TBD

5.12.3 On-target-flag (OTF)

TBD *******More input expected on actual position in sky related to OTF. Due date 9 July.***************

5.13 ON-BOARD HARDWARE/SOFTWARE AND AUTONOMY FUNCTIONS

5.13.1 On-board hardware

TBD

5.13.2 On-board software

TBD

5.13.3 Autonomy functions

TBD

5.14 EMC

5.14.1 Conducted Emission/Susceptibility

TBD

5.14.2 Radiated Emission/Susceptibility

TBD

5.14.3 Frequency Plan

TBD

5.15 DELIVERABLE ITEMS

5.15.1 Instrument Models

5.15.2 Electrical Ground Support Equipment (EGSE)

5.15.3 Mechanical Ground Support Equipment (MGSE)

5.15.4 System Test Software

5.15.5 Hardware for the Observatory Ground Segment

5.15.6 Software for the Observatory Ground Segment

5.15.7 Instrument Software Simulator

5.15.8 Test Reference Data

5.15.9 Instrument Characterisation Data

5.15.10 Technical Documentation

5.15.11 Transport and Handling Provisions

********The info below has to be merged in chapter 5.15.11*************

5.15.1 Transport container

5.15.1.1 Focal Plane Unit/JFET Module

For the EQM, FM and FS units, special transport containers will be provided. The containers are made of TBD material and have dimensions of TDB. The mass of the containers is TBD kg.

5.15.1.2 Electronic units and interconnecting harness

For the EQM, FM and FS units, special transport containers will be provided. The containers are made of TBD material and have dimensions of TDB. The mass of the containers is TBD kg.

5.15.2 Cleanliness

5.15.2.1 Focal Plane Unit/JFET Module

The Focal Plane Unit/JFET Module container must only be opened in a cleanroom environment of class 100 with a relative humidity of 50 %.

5.15.2.2 Electronic units and interconnecting harness

The Warm Electronics container must only be opened in a cleanroom environment of class 100 000 with a relative humidity of 50 %.

5.15.3 Physical handling

5.15.3.1 Focal Plane Unit/JFET Module

Condensation shall be avoided at all times.

Connection and disconnection of the instrument units during integration will be allowed under the following conditions:

- Take usual precautions against electrostatic discharge by grounding the operator.
- Before connecting, eliminate the electrostatic charges by a short-circuit device, to be provided with the instrument.

- Before connection or disconnection, be sure of the continuity between electrical and mechanical grounds.

Maximum rates of FPU warm-up and cool-down shall not exceed those specified in TBD.

5.15.3.2 Electronic units and interconnecting harness

Standard handling precautions shall be observed.

5.15.4 Purging

TBD

5.15.5 Mechanism positions

For reasons of possible damage caused by vibration during transport, environmental testing and launch mechanisms shall be placed in the TBD position. This position is shown in table TBD.