EQM SIS Test - MOPITT Verification Plan Comparison Matrix

Sec. No. MOPITT Instrument Verification Plan - PLN/MOP/113360/002 (Test Sets)	Sec. No. MOPITT Instrument Verification Plan - PLN/MOP/113360/002	SIS Test Description	Sec. No. EQM EOS-AM Spacecraft Interface Simulator Interface Test Report - TRE/MOP/113360/EQM
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Test Set 2, Instrument Interfaces	5.3.2.2	SIS Isolation/Continuity Checks	5.4.1
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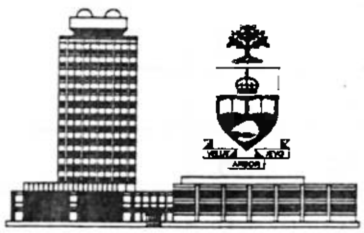

UNIVERSITY OF TORONTO
DEPARTMENT OF PHYSICS

MOPITT TEST PLAN

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NUMBER: MOPITT-TD-0005

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3	1.0	23	1.0	43	1.0	63	1.0		
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5	1.0	25	1.0	45	1.0	65	1.0		
6	1.0	26	1.0	46	1.0	66	1.0		
7	1.0	27	1.0	47	1.0	67	1.0		
8	1.0	28	1.0	48	1.0	68	1.0		
9	1.0	29	1.0	49	1.0	69	1.0		
10	1.0	30	1.0	50	1.0	70	1.0		
11	1.0	31	1.0	51	1.0	71	1.0		
12	1.0	32	1.0	52	1.0	72	1.0		
13	1.0	33	1.0	53	1.0	73	1.0		
14	1.0	34	1.0	54	1.0	74	1.0		
15	1.0	35	1.0	55	1.0	75	1.0		
16	1.0	36	1.0	56	1.0	76	1.0		
17	1.0	37	1.0	57	1.0	77	1.0		
18	1.0	38	1.0	58	1.0	78	1.0		
19	1.0	39	1.0	59	1.0	79	1.0		
20	1.0	40	1.0	60	1.0	80	1.0		

MOPITT TEST PLAN

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1.0 SCOPE

This document describes the tests to be performed on MOPITT by the University of Toronto team at the Instrument Characterisation Facility (ICF) located in the Department of Physics at the University of Toronto.

The document gives a description of the test requirements and objectives as well as a description of the test facility and the necessary equipment.
Test sequencing and scheduling are discussed in the MOPITT Science Test Program Document (MOPITT-TD-0006) and the MOPITT Environmental Test Program Document (MOPITT-TD-0007). Detailed procedures are in the MOPITT Procedure Library (MOPITT-PL-xxxx).

This plan only covers tests at the instrument level that are the responsibility of the UoT test team.

2.0 APPLICABLE DOCUMENTS

University of Toronto Documents

MOPITT-TD-0001	MOPITT Mission Description Document
MOPITT-TD-0002	MOPITT Peer Review Calibration
MOPITT-TD-0006	MOPITT Science Test Program Document
MOPITT-TD-0007	MOPITT Environmental Test Program Document
MOPITT-TD-0010	MOPITT Calibration Blackbody (MCBB)
MOPITT-TD-0011	MOPITT Space Blackbody (MSBB)
MOPITT-TD-0012	MOPITT Solar Reflected Simulator (MSRS)
MOPITT-TD-0013	MOPITT Stray Plate and Baffle (MSPB)
MOPITT-TD-0014	MOPITT Gas Cell (MGS)
MOPITT-TD-0015	MOPITT Collimator System (MCS)
MOPITT-TD-0017	MCBB Calibration to a NIST Standard
MOPITT-TD-0030	MOPITT Collimator Autocollimation
MOPITT-PL-0001	Personal Clean Room Entry Procedure
MOPITT-PL-0002	Equipment Clean Room Entry Procedure
MOPITT-PL-TP0001	Channel Response Test Procedure
MOPITT-PL-TP0002	Channel Offset Measurement Test Procedure

MOPITT-PL-TP0003	Simulated Atmospheric Signal Response Measurement Test Procedure
MOPITT-PL-TP0004	Radiometric Temperature Sensitivity Effects Measurement Test Procedure
MOPITT-PL-TP0005	Integrated Radiometric Strays Measurement Test Procedure
MOPITT-PL-TP0006	Calibrate and Verify On-Board Blackbodies Test Procedure
MOPITT-PL-TP0007	Instantaneous Field of View (IFOV) Measurement Test Procedure
MOPITT-PL-TP008	Polarised Light Response Measurement Test Procedure
MOPITT-PL-TP0009	FOV Temperature Sensitivity Effects Measurement Test Procedure
MOPITT-PL-TP0010	Spectral Response Measurement Test Procedure
MOPITT-PL-TP0011	Spectral Temperature Sensitivity Effects Measurement Test Procedure

Com Dev Documents

MOPITT EQM Instrument Integration and Test Plan

Government Documents

AD1 GSFC 420-03-02	General Instrument Interface Specification (GIIS) for the EOS Observatory
AD2 GSFC 420-05-01	Performance Assurance Requirements (PAR) for EOS (appended by CSA)

3.0 INTRODUCTION

MOPITT will undergo a series of tests, ranging from functional tests, comprehensive performance tests, thermal vacuum/thermal balance tests to calibration and characterisation tests. Table 3.1 gives test responsibility and location and shows that the thermal vacuum and thermal balance tests although conducted at the ICF are Com Dev (CD) tests. These will not be discussed further in this document. The comprehensive performance tests that will interleave vibration and thermal tests will primarily be the responsibility of the UoT test team and are a sub-set of the tests described in this document. They are described in the MOPITT Environmental Test Program Document (MOPITT-TD-0007).

The UoT test team is responsible for the characterisation and calibration of the MOPITT EQM once it has met its specification performance requirements and has been handed over to the test team. Characterisation and calibration tests will fall into three distinct categories, **radiometric tests**, **field of view (FOV) tests** and **spectral tests.**

The radiometric tests are primarily designed to determine the instrument radiance response function by measuring the channel offset, gain and linearity. The instrument noise performance will also be verified in the above tests to ensure MOPITT meets its radiometric performance specification. Further tests will measure the response to a simulated atmospheric signal as well as any integrated radiometric stray effects and temperature sensitivity effects. The on-board targets will also be calibrated to a NIST standard.

The FOV tests will determine the instrument spatial response function. The instantaneous FOV (IFOV) of the four 4 x 1 pixel arrays will be mapped to better than 1/22nd of a pixel. From this data pixel co-alignment within a detector can be verified as can the co-alignment of the four detectors to verify the instrument pointing accuracy. Further FOV tests will measure the response to polarised light and measure any focal shift due to changes in the focal plane array (FPA) temperature.

The spectral tests will determine the instrument spectral response function. The in and out of band response will be characterised as well as any filter spectral shifts due to changes in the FPA temperature. Unknown spectral shifts could falsely be interpreted as a non-linearity in the radiometric response.

TABLE 3.1 MOPITT OVERALL TEST RESPONSIBILITY MATRIX

TEST	RESPONSIBILITY		LOCATION		
	UoT	CD	UoT (ICF)	CD	DFL
Alivness Tests		X		X	
Functional Tests		X	X	X	X
Performance Tests		X	X	X	X
Comprehensive Performance Tests	X	X	X		
Vibration Tests		X			X
EMI/EMC Tests		X			X
Thermal Vacuum Tests		X	X		
Thermal Balance Tests		X	X		
Characterisation & Calibration Tests	X		X		

CD   Com Dev, Cambridge

DFL   David Florida Labs, Ottawa

4.0 TEST EQUIPMENT

4.1 Instrument Characterisation Facility (ICF)

MOPITT will be characterised and calibrated at the ICF located in the Department of Physics at the University of Toronto. The ICF (Fig 4.1) consists of a clean room, preperation room, pump room, general purpose room, control room and a vacuum chamber, located in the clean room.

The clean room is class 10000 (designed and tested) and consists of pre-filters and seven HFM2000 HEPA filters located in a suspended ceiling. The clean room has compressed air lines as well as 200v three phase and 110v electrical outlets. A clean "laminar flow" bench and equipment racks will also be installed.
To minimise contamination all personnal and equipment enter the clean room through a preperation room (one HEPA filter) which consists of a gowning area and a clean table. Personnal and equipment clean room entry procedures are documented in the procedure library (MOPITT-PL-P0001 and MOPITT-PL-P0002 respectively).
The pump room holds the mechanical backing pump and the two cryo-pump compressors. Building water is used to cool the mechanical pump and five 220V three-phase inputs are available (two cuurently dedicated) and one dedicated 600v input. Isolation of this equipment minimises thermal dump, vibration and microphonics into the clean room area. Access into the pump room is through the general purpose/control rooms.
The general purpose room will primarily hold the 500l liquid nitrogen dewars which will feed the direct line into the clean area and provide liquid nitrogen in the vacuum chamber. Work benches are also provided in this area.
All communications and data handling will be conducted through the control room. which also has visual access and a voice link into the clean room. The control room consists of the Sun Sparc station 10 with further PC's and network options. It also holds the vacuum chamber electronics console.

The aluminium vacuum chamber (Fig 4.2), located in the clean room and used for all MOPITT characterisation, is 6m long with a 2.2m id. It has four sections, a fixed base section in which MOPITT will be located and three movable sections that will hold test equipment and which can be brought up to the fixed base section.

The pumping system consists of four cryo-panels located in the end sections of the chamber, two CTI 400 on-board cryo pumps (mounted on the fixed base section) with compressors located in the pump room and a Stokes 2000cfm roots blower backed by a 500cfm rotary pump is used to rough pump the chamber. Furthermore, one oil free Drytel 31 turbo pump is used to regenerate the cryo-pumps. The roughing pump is used to pump down to 10^{-3} torr, at which point the cryo-pumps take over. With the chamber clean and empty a base pressure of 9.8×10^{-8} torr can be routinely achieved.

Instrumentation consists of a pirani gauge, a cold cathode and a Bayert Alpine (BA) gauge all of which are mounted directly onto the chamber. A directly mounted Vascan residual gas analyser (RGA) is also available for leak checking and to monitor contaminants.

The chamber has an automatic, interlocked, pump down and vent control electronics with manual overide options. Figure 4.3 shows the chamber pumping system with associated instrumentation and electronics.

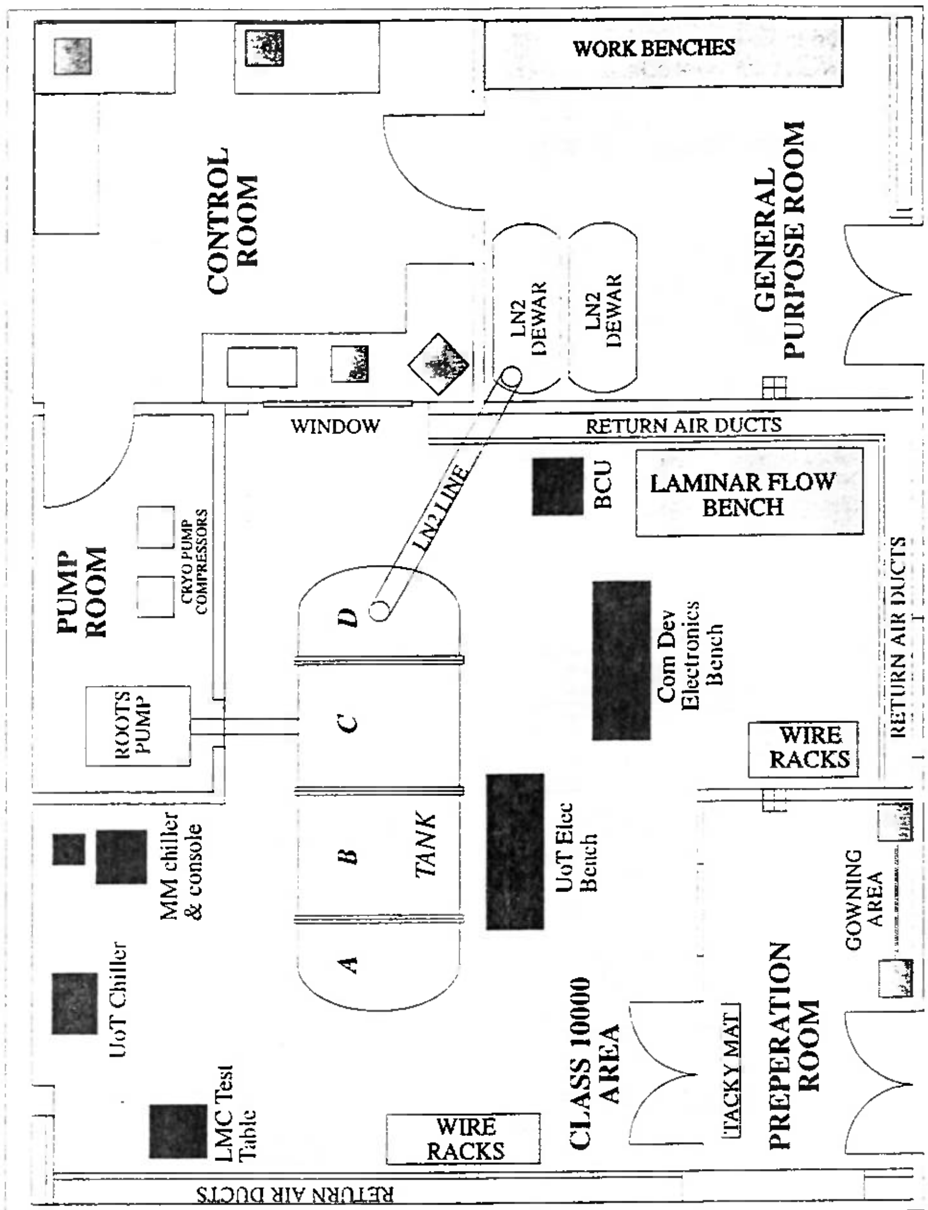


Figure 4.1 MOPITT ICF Layout

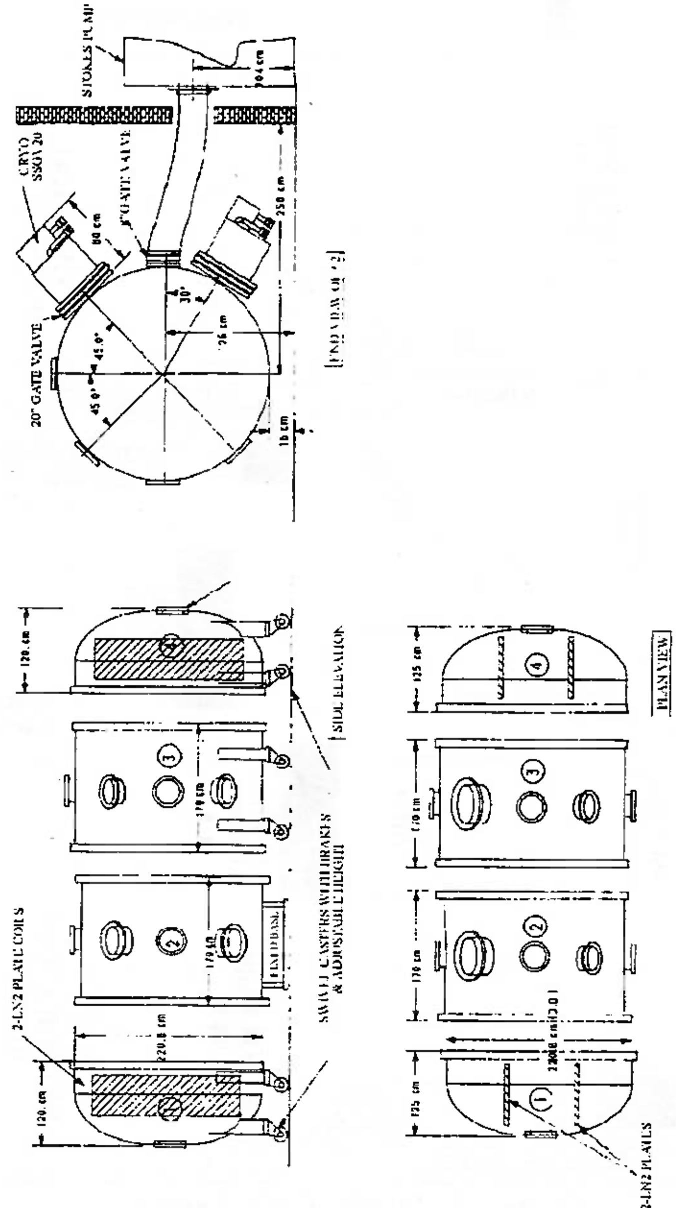


Figure 4.2 Vacuum Chamber General Assembly

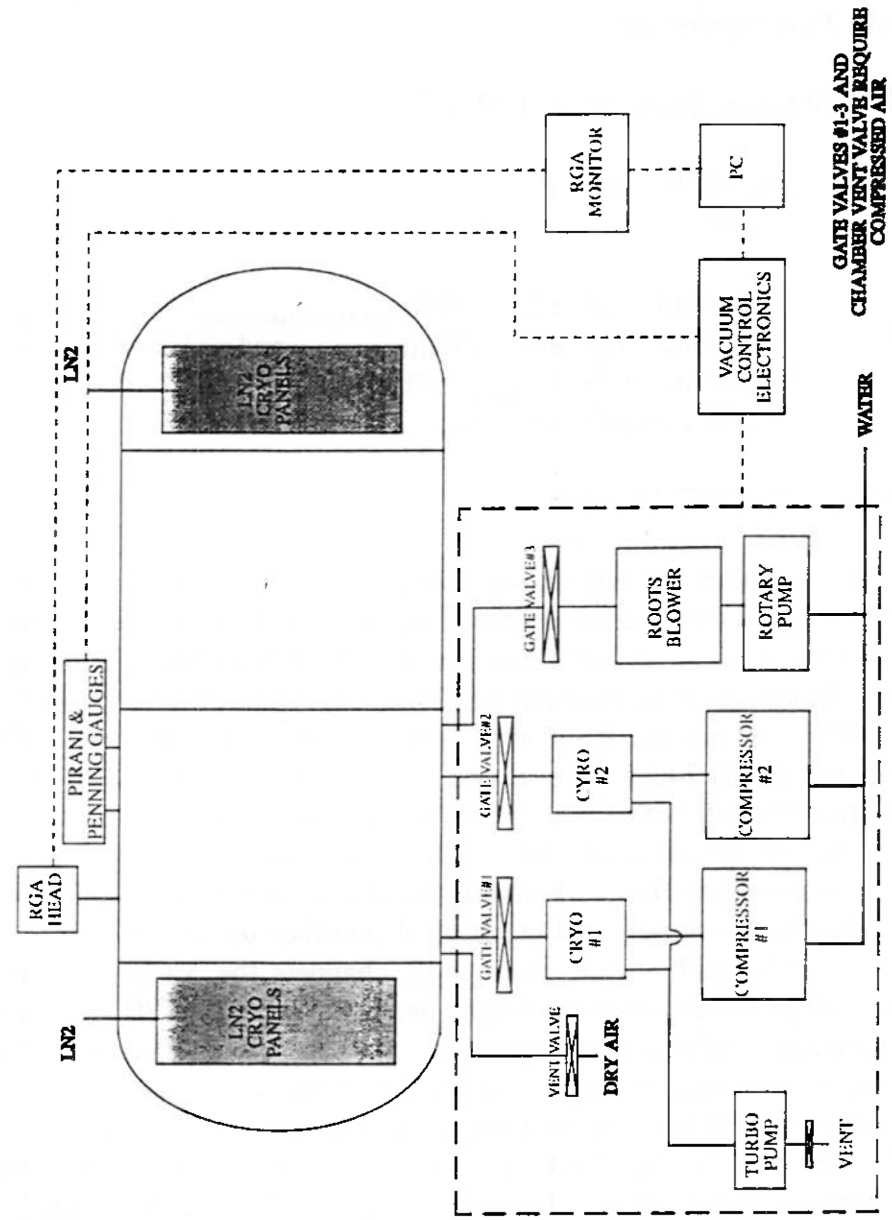


Figure 4.3 MOPITT Vacuum Chamber Pumping System

4.2 Radiometric Test Equipment

4.2.1 MOPITT Calibration Blackbody (MCBB)

Purpose: The MCBB will be the primary target for radiometric calibration of all channels

Requirements: Temperature range 230-350$K_{THERMAL\ CHANNELS}$, 440-520$K_{SOLAR\ CHANNELS}$.
Temperature gradients $\leq\pm$50$mK_{THERMAL}$ and $\leq\pm$100mK_{SOLAR} on baseplate.
Emissivity $\geq$0.999$_{THERMAL}$, >0.97$_{SOLAR}$.
Overall precision $\leq\pm$0.1$K_{THERMAL}$, $\leq\pm$0.25K_{SOLAR}.

Design Document: MOPITT-TD-0010

Description: The aluminium MCBB, shown in Fig 4.4, consists of a 25 degree retro-cone base with a two section 4 degree tapered baffle attachment. The blackbody base has a 26cm od and 22cm id with a 75cm long baffle tapering to a 13cm id. The inside of the base and baffle are sprayed with Electrodag 502 black (ε >0.97 @ 4.7µm and 0.965 @ 2.3µm). A rectangular aperture 10.26 x 5.6cm (or 13.41 x 63.74cm if the second baffle section is not used) with a 45 degree knife-edge will define the input. The outside of the aperture will be goldised in order to minimise any thermal loading effects on the aperture.

A rear mounting flange, thermally isolated from the base section, will be used as the main electrical and mechanical interface to the MCBB.

In order to calibrate the thermal IR channels the MCBB coolant ring and coolant jacket arrangement will be used. A Neslab ULT80 sealed reservoir re-circulating chiller unit in conjunction with 70/30% ethylene glycol/water fluid loop will be used to control the MCBB temperature between 220-350K. The same loop will be used for rapid cooldown of the blackbody from 520K.

To heat up the blackbody and operate between 440-520K proportionally controlled Minco polyimide kapton heaters circumferentially employed on the base and baffles shall be employed.

Due to the temperature extremes the MCBB spans with respect to ambient the entire blackbody will be covered with a minimum 10 layers of aluminised kapton multi layer insulation (MLI) to minimise radiative losses (TBC).
The MCBB temperatures will be monitored by six Rosemount four wire 118MK 100Ω PRT's. Four will be located on the base and two along the baffle sections. The PRT's will be monitored with an ASL F250 AC bridge in conjunction with a 16 channel switching box.

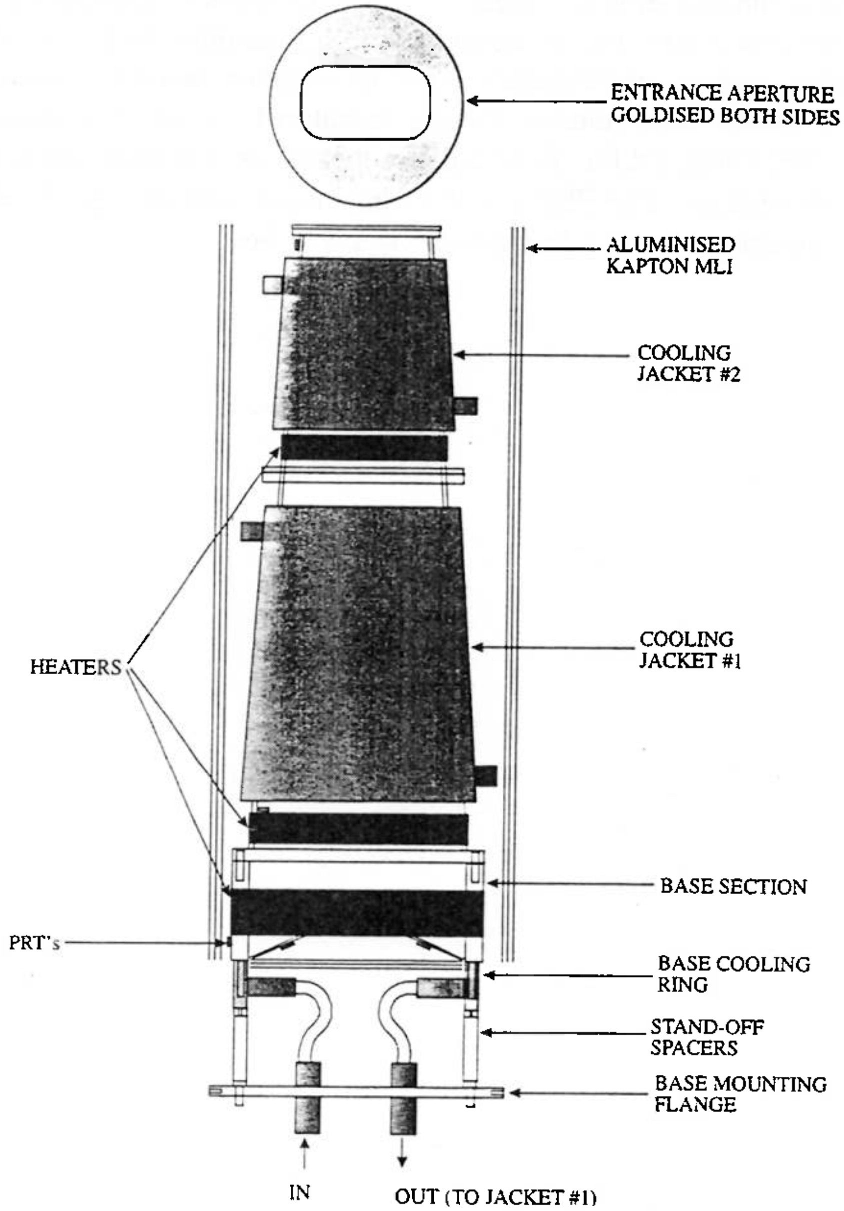


Figure 4.4 MOPITT Calibration Blackbody

4.2.2 MOPITT Space View Blackbody (MSBB)

Purpose: The MSBB will simulate cold space and be used to determine the radiometric zero offset for all channels.

Requirements:
Temperature 77K
Temperature gradients on baseplate $\leq\pm 50$mK
Emissivity >0.99
Overall precision $\leq\pm 100$mK

Design Document: MOPITT-TD-0011

Description: The MSBB, shown in Fig 4.5, consists of a 29 x 34cm rectangular aluminium linear V grooved baseplate with a 35cm long tapered rectangular baffle (the V grooves have a 15 degree half angle, a 2cm pitch and are 3.73cm deep). The V grooved plate and the inside of the baffle are sprayed with Aeroglaze Z306 diffuse black paint (ε = 0.94-0.96 between 2-5μm). The input plate consists of the four apertures, two 13.7 x 6.4cm and two 9 x 5.3cm with 45 degree knife-edges, to cover all four space view fields simultaneously. Both sides of the aperture plate are black. This increases the thermal loading effects on the aperture plate but more importantly minimises the ambient reflected radiance off the aperture into MOPITT. A rear mounting flange, thermally isolated from the base section, will be used as the main electrical interface to the MSBB.

All channels will be calibrated by operating the MSBB at 77K. this will be achieved by flooding the rear cavity and the baffle cooling jacket with liquid nitrogen. Heaters will be mounted on the base for fast warm-up. To minimise radiative losses the entire blackbody will be covered with a minimum 20 layers of aluminised mylar MLI.

The MSBB temperature will be monitored via four Rosemount four wire 118MK 100Ω PRT's. Two will be located on the base, one along the baffle and one on the aperture plate. The PRT's will be monitored with the ASL F250 AC bridge in conjunction with the 16 channel switching box.

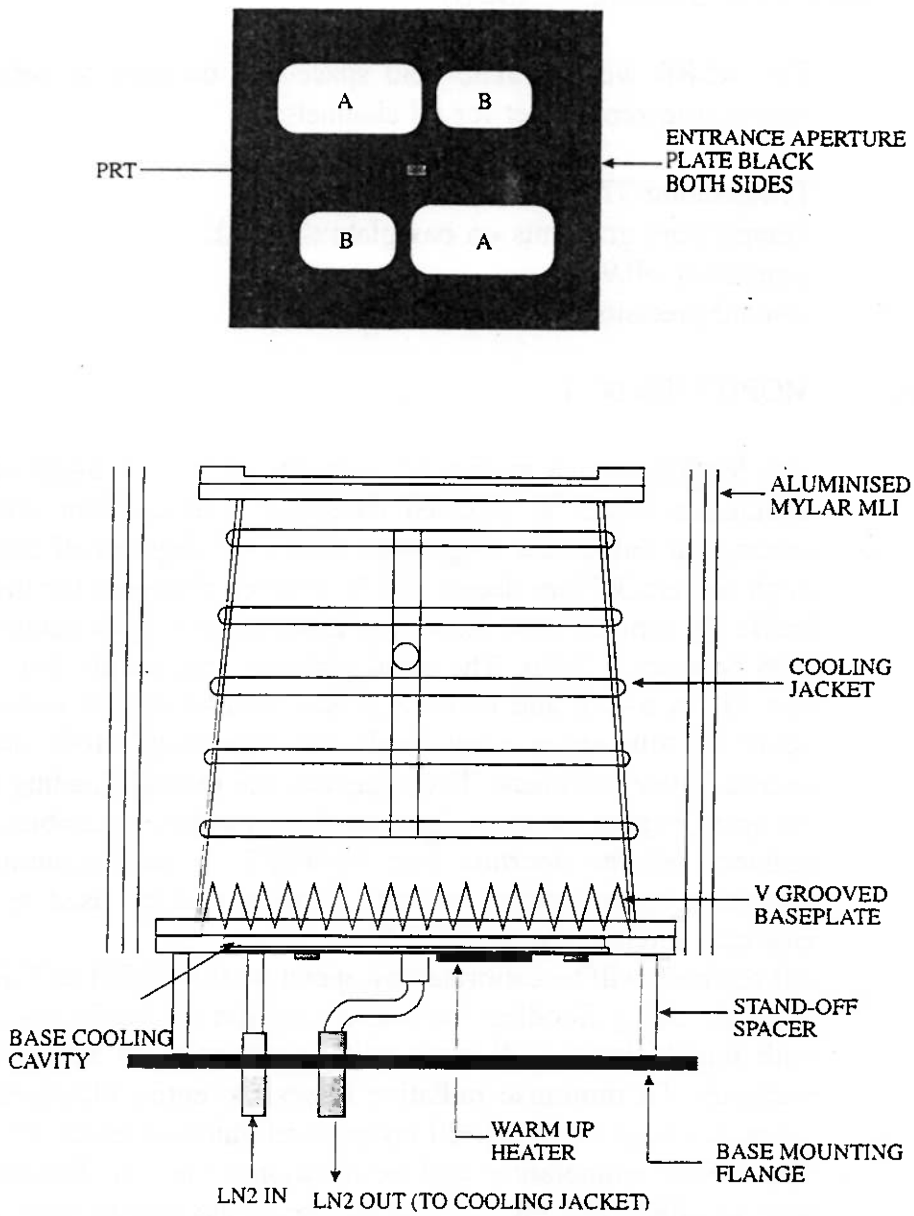


Figure 4.5 MOPITT Space View Blackbody

4.2.3 MOPITT Solar Reflected Simulator (MSRS)

Purpose: The MSRS will provide a nearly correct radiance source for the solar channels to compliment the radiometric calibration for these channels.

Requirements:
Source temperature >2000K
Radiance output variable from 1-100mW/m^2/sr
Radiance non-uniformity ≤1%
Heat removal ≤250W

Design Document: MOPITT-TD-0012

Description: The MSRS, shown in Fig 4.6, is made from stainless steel and has a 42cm od and is 24cm long. It consists of a 21cm diameter Spectralon CSTM-SRM-990 diffuser plate located at one end with a calcium fluoride glass window at the other end. The inside is coated with Aeroglaze Z302 diffuse white paint (TBC). A twenty four lamp ring arrangement consisting of twelve 20W quartz iodine (QI) bulbs and twelve 10W QI bulbs is used as the source (QI bulbs have a filament temperature of approximately 2800K). The ring is connected such that sub-rings can be operated. This arrangement is a method of stepping up and down the radiance whilst maintaining the uniformity. Furthermore, in case of bulb failure a sub-ring may be used to optimise the radiance uniformity and prevent the need to immediately replace the bulb.
The MSRS is sealed and filled with Neon (TBC) to assist in heat transfer to the coolant loop. The coolant loop will use the Neslab ULT80 re-circulating chiller with 70/30% ethylene glycol/water mix.

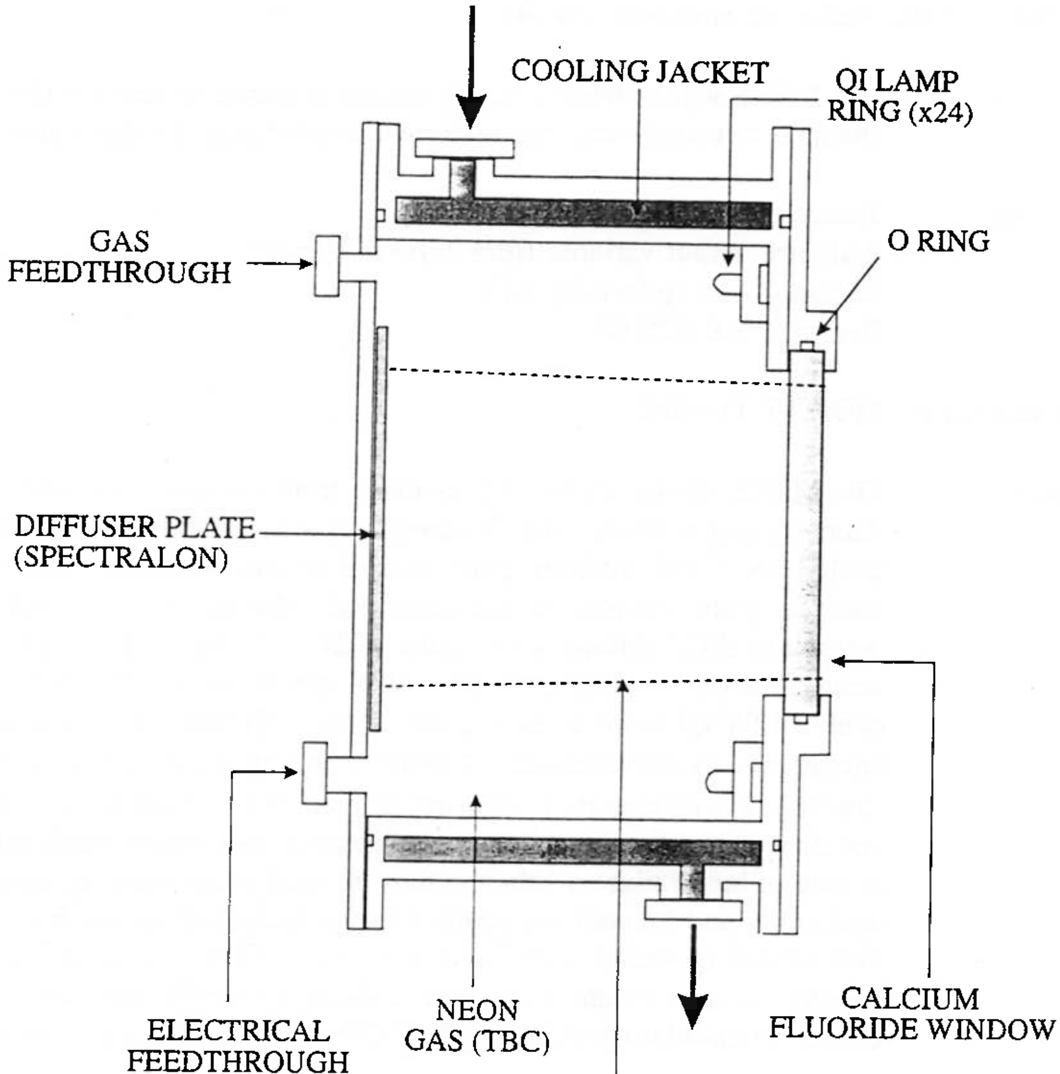


Figure 4.6 MOPITT Solar Reflected Simulator

4.2.4 MOPITT Stray Plate and Baffle (MSPB)

Purpose: The MSPB will be used to check the out-of-field radiometric response of the thermal channels.

Requirements:
Stray plate temperature range 300-500K
Stray plate emissivity ≥0.9
Baffle plate temperature 298-310K
Baffle emissivity ≤0.1

Design Document: MOPITT-TD-0013

Description: The MSPB as the name suggests will consist of a stray plate with stand-off spacers and a baffle plate. Figure 4.7 shows the MSPB.

The aluminium stray plate is a 25cm diameter, 3mm thick disk with a 11.4 x 5.8cm central aperture. The front face of the disk will use the same black coating as the MCBB whilst the rear will be reflective in order to minimise and thermal coupling to the baffle.

The baffle is thermally isolated from the stray plate via eight 10cm long thin walled stainless steel spacers. This plate has the same dimensions as the stray plate but the central aperture will be 12.5 x 6cm. Both surface will be goldised in order to minimise thermal coupling between it and the stray plate and more importantly between it and the front aperture of the MCBB (which will be used to provide a stable in-field response).

The MSPB will have a polyimide kapton heater and a type T copper constantan thermocouple attached to the rear surface of the stray plate.

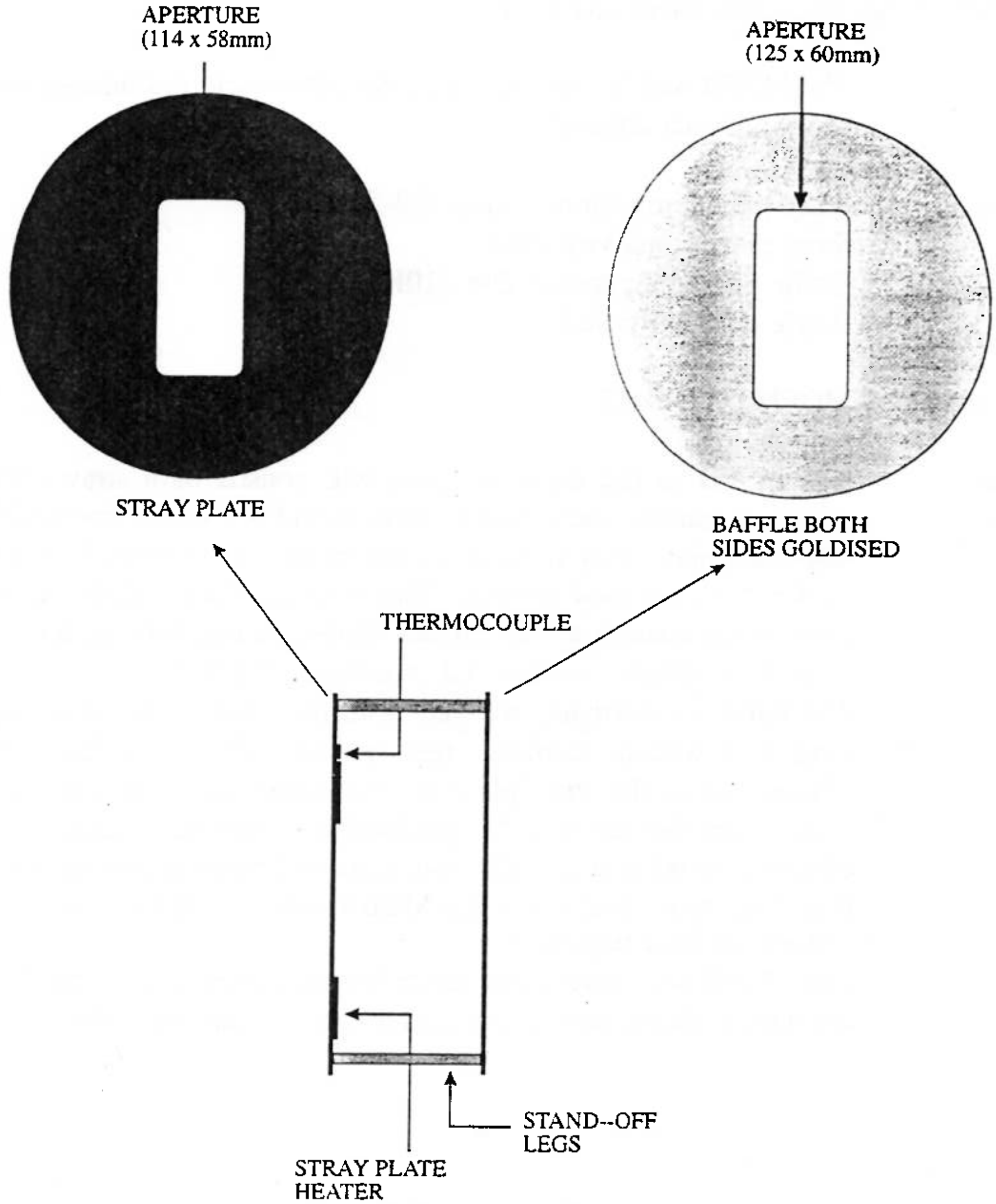


Figure 4.7 MOPITT Stray Plate and Baffle

4.2.5 MOPITT Gas Cell (MGC)

Purpose: To introduce a "simulated atmosphere" between MOPITT and the calibration target.

Requirements: The gas mixing/exchange system shall be outside the vacuum chamber. Materials shall not react with either CO or CH_4.

Design Document: MOPITT-TD-0014

Description: The MGC will have a stainless steel body (15cm diameter and 7cm long) and two calcium fluoride windows (19cm diameter and 2cm thick). An external gas/vent line will allow gas exchange and mixing. A pressure and temperature transducer will be incorporated into the cell.

4.3 Field of View (FOV) Test Equipment

4.3.1 MOPITT Collimator System (MCS)

Purpose: The MCS will be used for all field of view and spectral measurements for all channels.

Requirements: Must be able to map a detector array.
The primary mirror cannot be more than 2.7m from MOPITT.
Overall collimator abberations will be ≤100μm (TBC).

Design Document: MOPITT-TD-0015

Description: The MCS (Figure 4.8) consists of a 30 degree off-axis parabolic mirror and a fold mirror to relay the beam. There are additional optics close to the focal point are used in the initial alignment process.
The diamond machined aluminium parabolic mirror has a 6" diameter and a 22.5" focal length (f 3.75). The mirror is gold coated with a 150A rms surface finish and a 1/2 wave figure accuracy at 6328A (equivalent to 1/8 wave accuracy at 2.3μm).
The fold mirror is a 4x3" elliptical aluminium gold coated mirror with a 1/8 wave figure at 6328A.
When used in conjuction with MOPITT the MCS has a linear magnification of x17.28.

In order to map the detector IFOV (4 x 1 pixel array) the collimated light from the MCS will have to input the entrance pupil at elevation angles of ±3.6 degrees and azimuthal angles of ±0.9 degrees. This is achieved by moving the MCS ±3.46 x ±0.865cm about its gimbal point. Collimated light entering the pupil at fixed angles will correspond to a point on the pixel. By changing this angle the IFOV will be mapped.

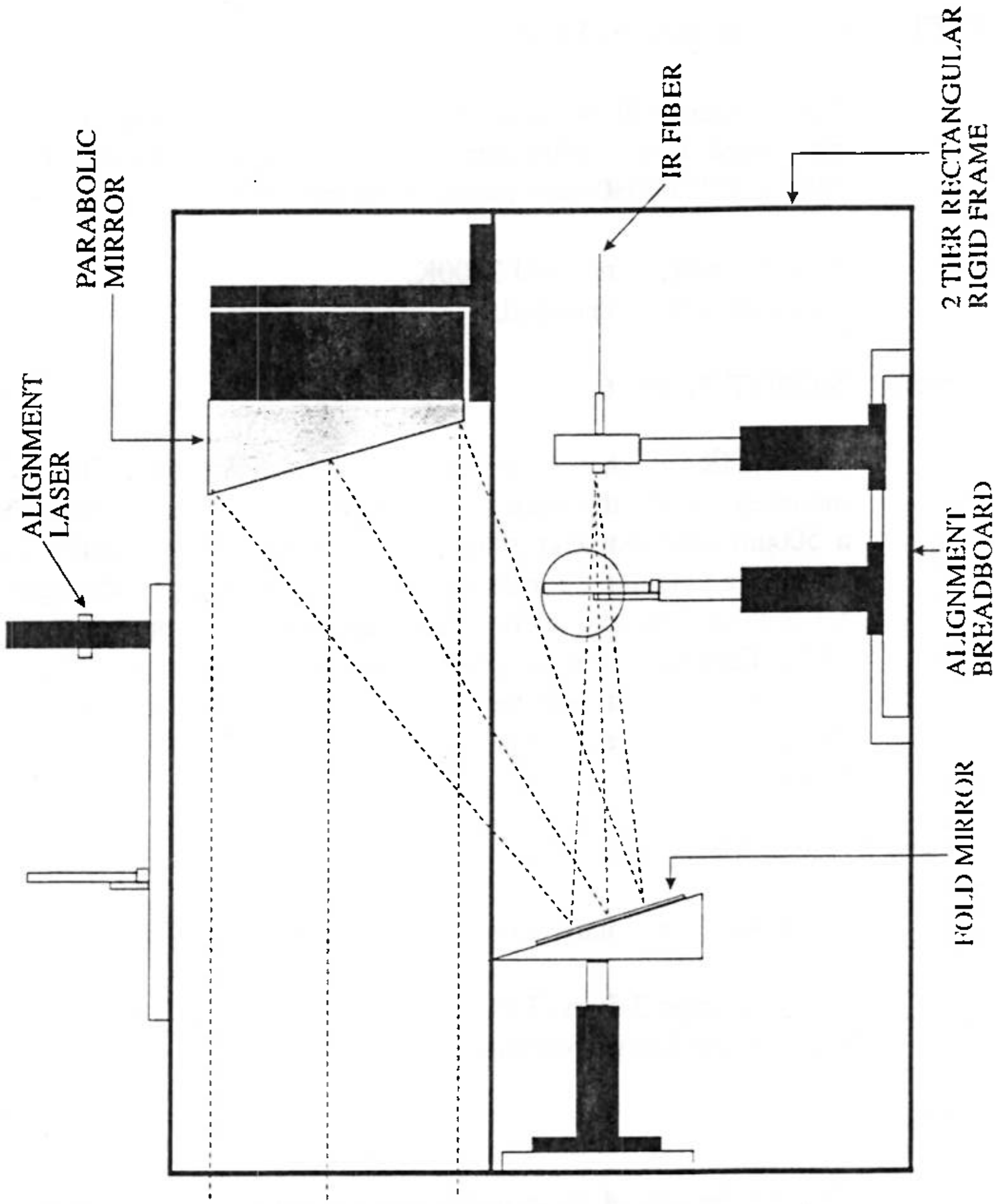


Figure 4.8 MOPITT Collimator System

4.3.2 MOPITT Collimator IR Source (MCIR)

Purpose:	This source will be used for all the FOV measurements. It will positioned at the collimator focus (via an auto-collimation process, MOPITT-TD-0030) and moved with the MCS to map out the FOV.
Requirements:	Source temperature 1000-2800K. Radiance will be chopped.
Design Document:	MOPITT-TD-0016
Description:	The MCIR, as shown in Fig 4.9, will consist of a 50W QI bulb mounted outside the vacuum chamber. The filament is focussed onto a 500μm core diameter fluoride glass fiber, located inside the tank, through a calcium fluoride window. The fiber pipes the light to the MCS focus, the exit of the fiber serves as the input aperture to the MCS. The radiance is chopped with a slow chopper after the external focussing element and before the calcium fluoride window. The fluoride glass fiber losses are 0.07dB/m at 2.3μm and 0.9dB/m at 4.7μm.

4.3.3 Polariser and Rotation Mechanism

Purpose:	To measure any polarisation effects, in particular of the solar channels.
Requirements:	Polariser range 2-5μm (TBC). Rotation mechanism vacuum compatable.
Design Document:	---
Description:	This will be placed close to the focus point of the collimator system. A polariser for the 2-5μm is TBD. The rotation mechanism is a standard optical component that will be sized depending on the polariser.

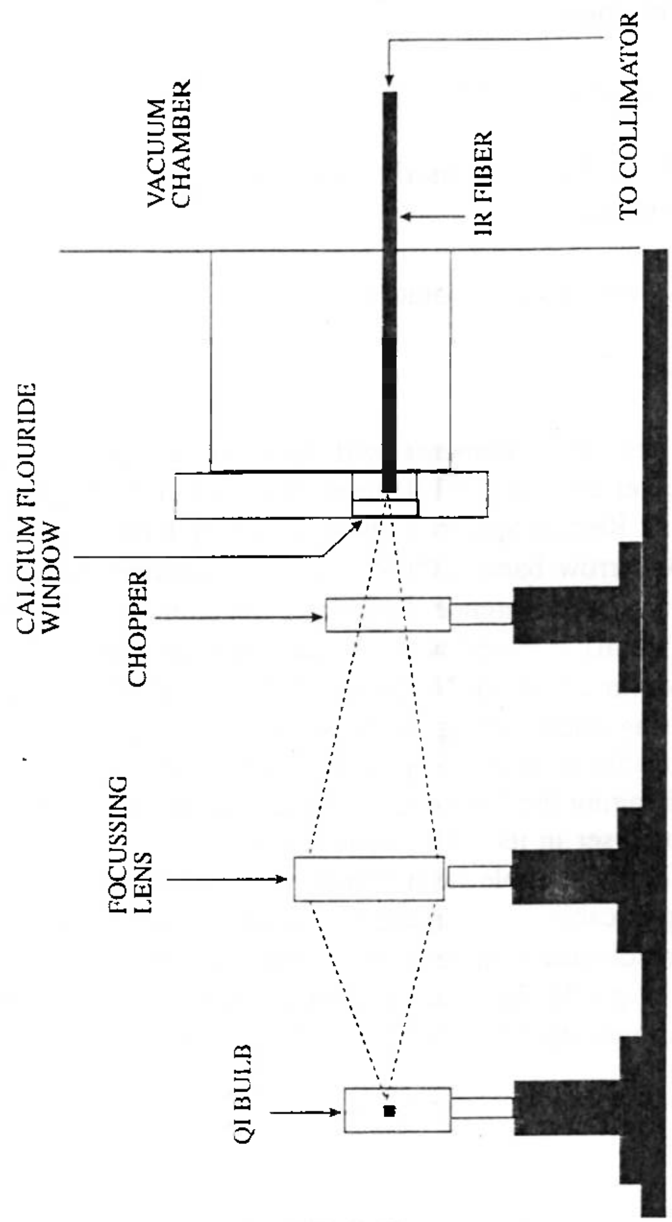


Figure 4.9 MOPITT Collimator IR Source

4.4 Spectral Test Equipment

4.4.1 MOPITT Monochromator (MM)

Purpose: The MM will be used to spectrally calibrate all channels in conjunction with the MCS.

Requirements: 1-5cm^{-1} range resolution.

Design Document: ----

Description: These measurements will be made using the Difference Frequency Laser System (DFLS) routinely used in the High Resolution Infra Red and Raman Spectroscopy Laboratory located next door to the ICF.

A narrow band (10nW, 10^{-4} cm^{-1}) tunable, infrared source is created using a difference frequency spectrometer. An Ar^+ ion laser (6W, 514nm), is mixed with a tunable R6G dye laser, (600mW, 565-610nm), within a Lithium Niobate ($LiIO_3$) crystal. Phase matching is performed using angle tuning of the optic axis. The result is an infrared source tunable from 3.3-5.5μm, this range can be extended to 2μm by either changing the R6G dye in the tunable laser and/or by operating the AR^+ ion laser in its other mode (488nm).

The two visible laser beams will be brought into the ICF using fiber optic cable. The mixing to produce the infrared beam will occur on the breadboard mounted outside the vacuum chamber. The resultant beam will go through the calcium fluouride window, into the IR fiber and through the MCS to MOPITT. The DFLS is shown in Figure 4.10

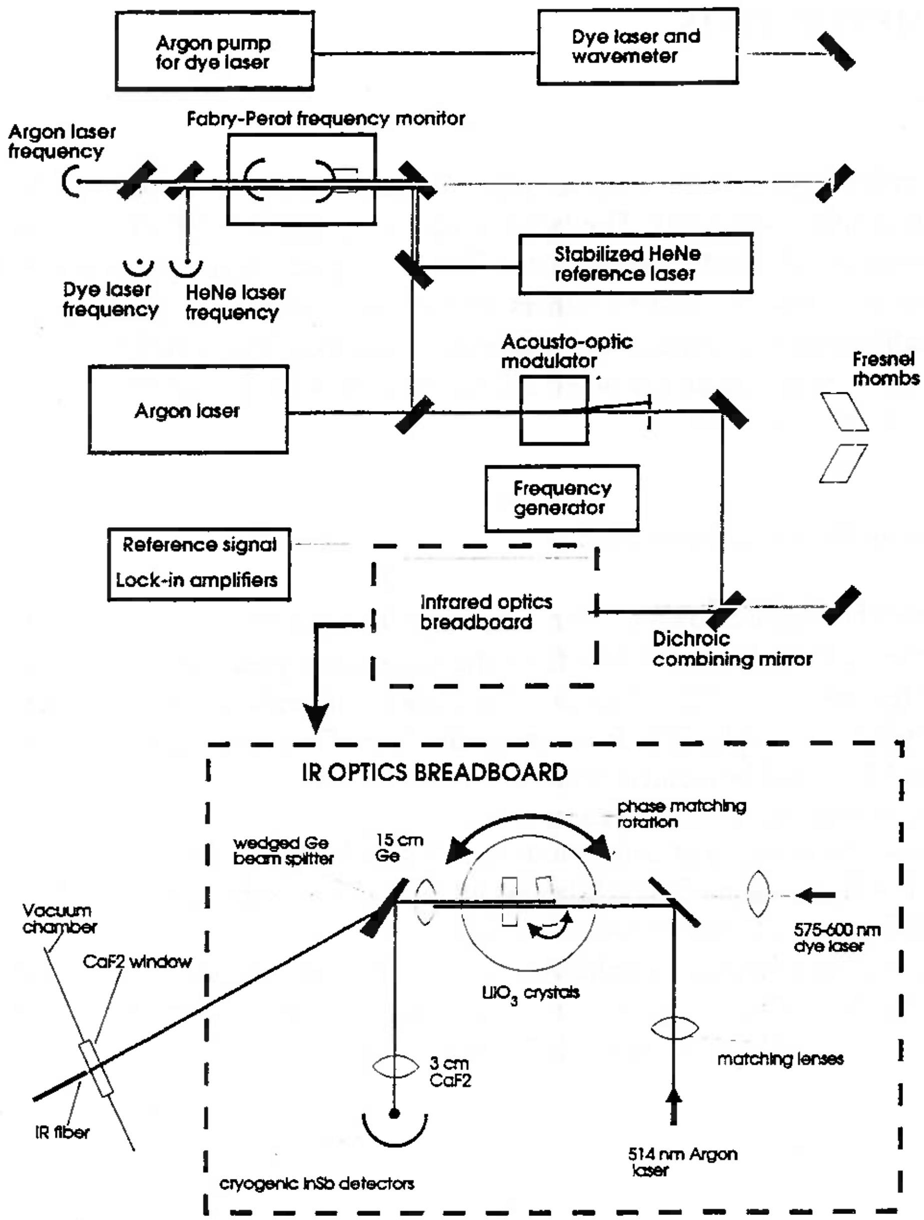


Figure 4.10 The Difference Frequency Laser System

5.0 RADIOMETRIC TESTS

5.1 Purpose

Radiometric calibration is performed in order to determine the instrument performance and to calibrate to absolute standards. The latter is necessary since MOPITT will use other data sets (temperature profiles and humidity data, TBC) during the retrieval process. Furthermore, MOPITT data sets may be used by others within the community. Therefore, an absolute radiometric calibration to International Standards is essential. The MOPITT requirements are an absolute measurement accuracy of ±0.5K for the longwave 4.7μm channels and ±1K for the shortwave 2.2-2.4μm channels.

5.2 Radiometric Test Configuration

The MCBB will be located down the tank axis with its base one meter from MOPITT. The MSBB aperature will be located 10cm from the space view ports (implies space port cover must be open before the MSBB is located. The MSRS will replace the MCBB for some tests and its base will be located 75cm from the nadir face. The other interchangable items the MSPB and the MGC will be located 30cm and 25cm respectively from the nadir face. Figure 5.1 shows the radiometric test configuration.

Figure 5.2 shows the equipment configuration. All data handling and communication to and from MOPITT will be via the Bench Check-Out Unit (BCU, supplied by SED systems) and the Sun SPARCstation 10 system using OASIS.

The coldplate system (defined as coldplate, chiller, PC and printer) is supplied by Martin Marietta for test. All calibration equipment power supplies, heater controllers, stepper motors, thermometry etc, will also be handled throught the Sun SPARCstation.

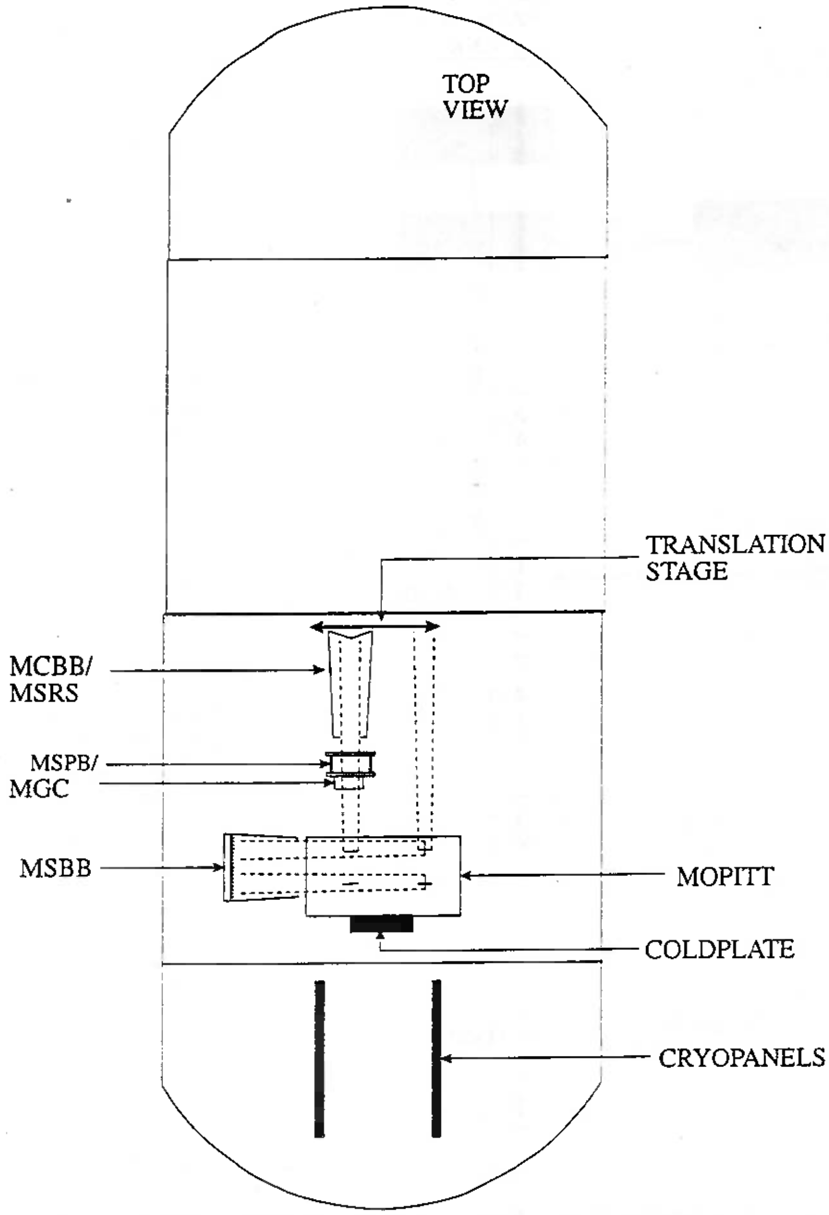


Figure 5.1 MOPITT Radiometric Test Configuration

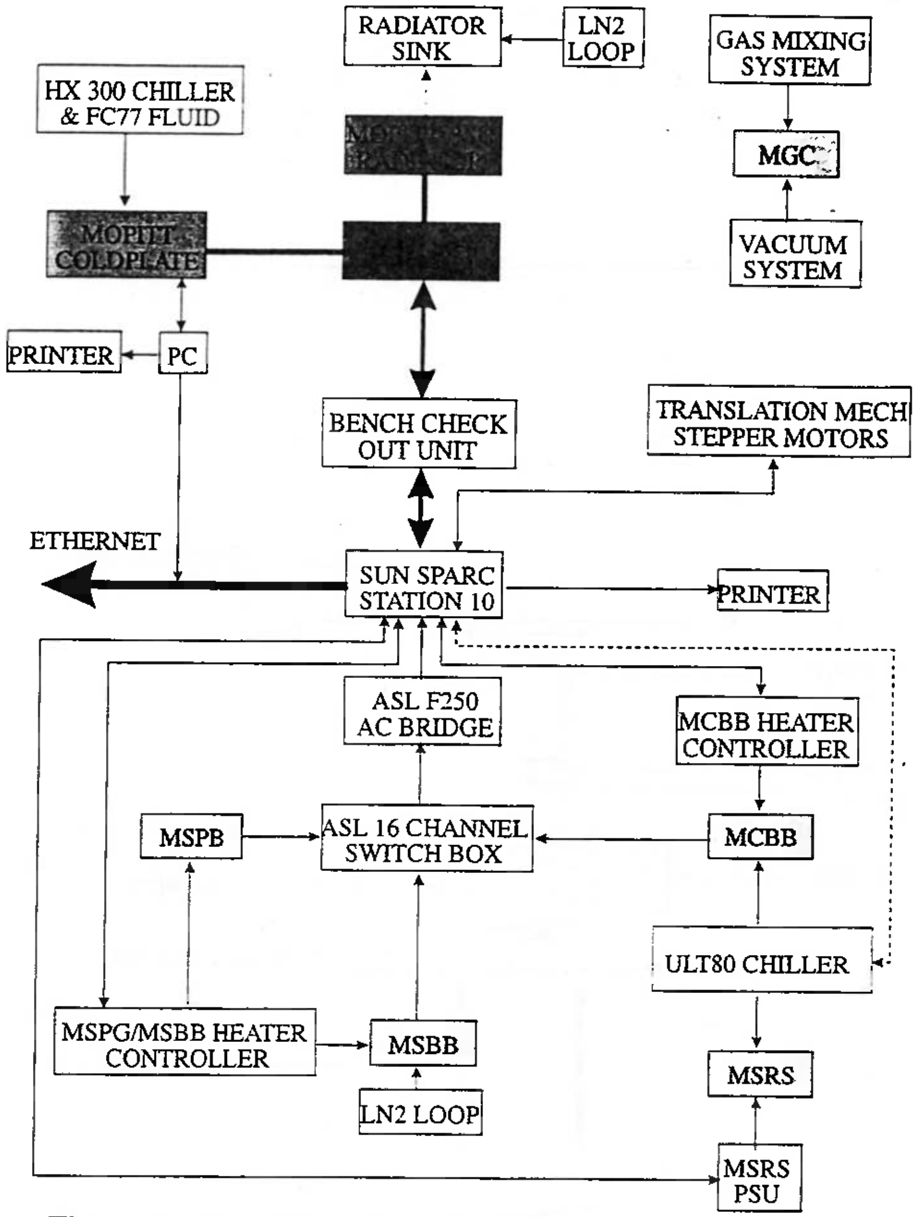


Figure 5.2 MOPITT Radiometric Equipment Configuration

5.3 Tests

5.3.1 Channel Response

Test No.:	1
Objective:	To characterise the response of the Difference (DIFF) and Average (AV) signals of all channels and check the linearity. Furthermore, validate the BOMEM radiometric model.
Equipment:	MOPITT Calibration Blackbody (MCBB).
Method:	For the thermal CO channels (#1,3,5 &7) the MCBB will be operated in the 230-350K range using the re-circulating loop. The channel will be calibrated in 5K increments over this range with an additional measurement at 289.4K. For the solar channels (CO #2&6, CH_4 #4&8) the MCBB will be operated in the 440-510K range using heaters. The channels will be calibrated in 5K increments over this range with an additional measurement at 467K for the CH_4 channels.
Procedure:	MOPITT-PL-TP0001
Results:	The measured DIFF and AV count rate will be averaged for each pixel over 100 scans (TBC) and then averaged over the four pixels in each detector array, resulting in a DIFF and AV signal for each channel. This signal will then be further manipulated.

Since the InSb detectors and digital electronics are highly linear the counts, C, obtained for an input radiance. R, are given by

$$C = (\mathrm{gain}(R_{INPUT} + R_{INSTRUMENT})) + \mathrm{offset}$$

providing $R_{INSTRUMENT}$ is constant it can be incorporated into the offset, such that

$$C = gR_{INPUT} + \delta$$

With the MCBB set to two temperatures T_1 and T_2 (these being the temperature extremes for the thermal and solar channels), producing radiances R_1 and R_2 and hence counts C_1 and C_2 the gain, g and offset, δ, can be calculated

$$g = \frac{C_1 - C_2}{R_1 - R_2} \qquad \delta = C_1 - [C_1 - C_2]\,[\frac{R_1}{R_1 - R_2}]$$

where the DIFF and AV radiance terms are given by

$$R_{DIFF} = \int_{\nu_1}^{\nu_2} [B(T_{MCBB},\nu)\,\varepsilon(T_{MCBB},\nu) + (1 - \varepsilon(T_{MCBB},\nu))\,B(T_{BACK},\nu)]\,\tau_{OPTICS}(T,\nu)\,[\tau(T,\nu,P)_{S1} - \tau(T,\nu,P)_{S2}]\,d\nu$$

$$R_{AV} = \int_{\nu_1}^{\nu_2} [B(T_{MCBB},\nu)\,\varepsilon(T_{MCBB},\nu) + (1 - \varepsilon(T_{MCBB},\nu))\,B(T_{BACK},\nu)]\,\tau_{OPTICS}(T,\nu)\,[\frac{\tau(T,\nu,P)_{S1} + \tau(T,\nu,P)_{S2}}{2}]\,d\nu$$

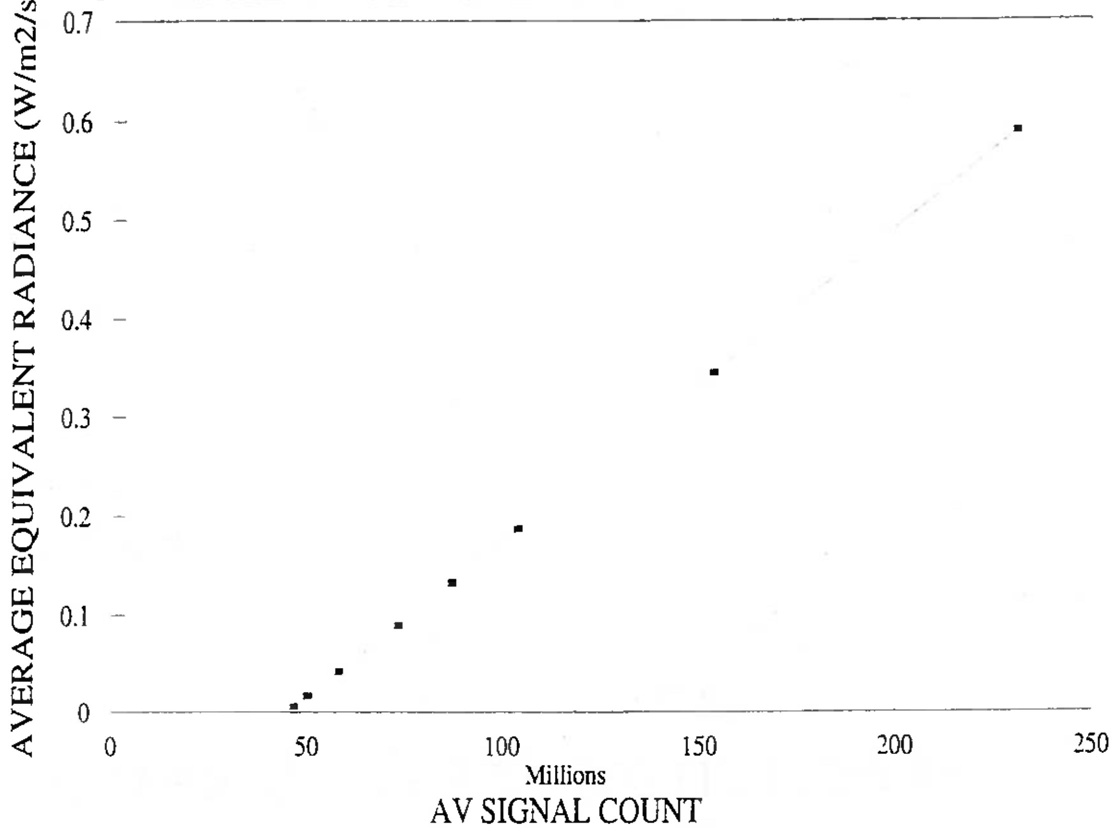
where τ_{OPTICS} is the end to end channel transmission, $B(T,\nu)$ is the Planck function, $\varepsilon(T,\nu)$ is the MCBB emissivity and τ_{S1} and τ_{S2} are the transmission factors of the modulator for two states. The transmission factors can be determined from GENASIS by using the modulator temperature and pressure information.
The gain and offset coefficients can then be used to convert the measured counts into an equivalent AV and DIFF radiance. By doing this over the entire temperature range the channel responsivity can be characterised. Figure 5.3.1a and b show the simulated channel 5 and 6 AV and DIFF signal responses by using the BOMEM model data.
By comparing the AV and DIFF equivalent to the input MCBB radiance the channel linearity can be determined.

Requirement: TBD

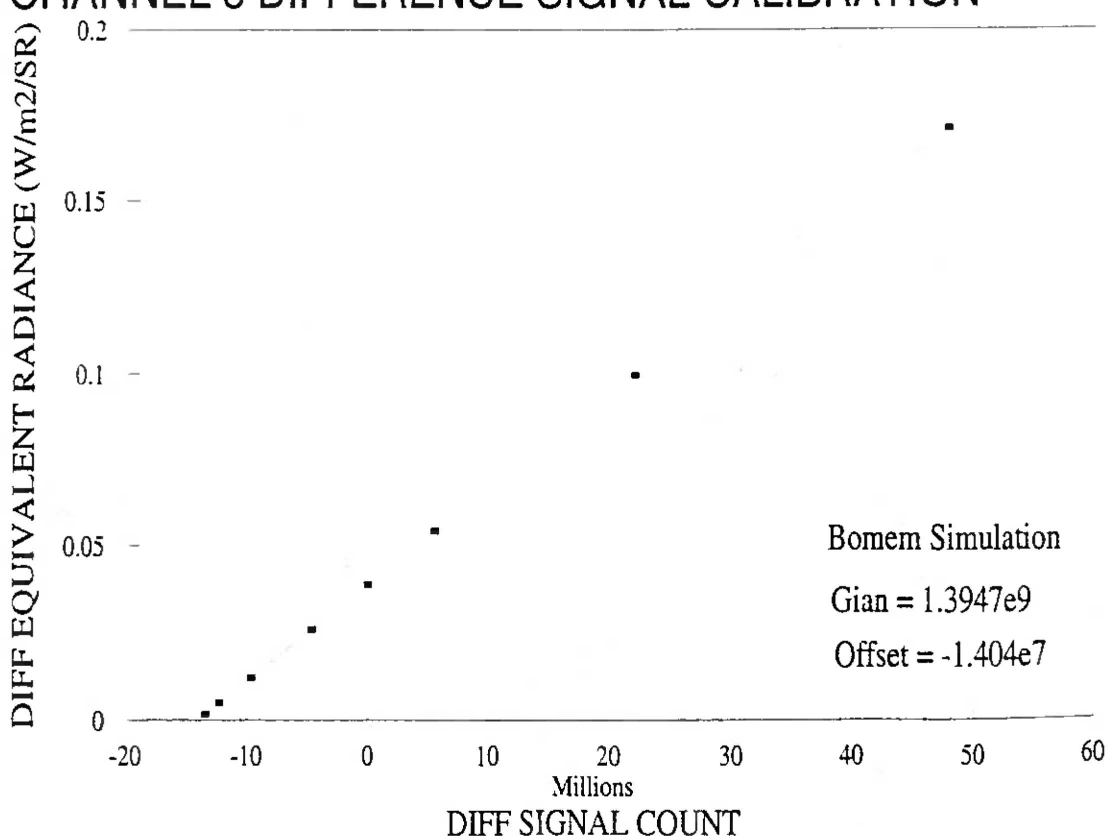
As designed: TBD

Notes: The baseplate and FPA temperatures are held at their nominal operating points of 295K and 95K (TBC) respectively.

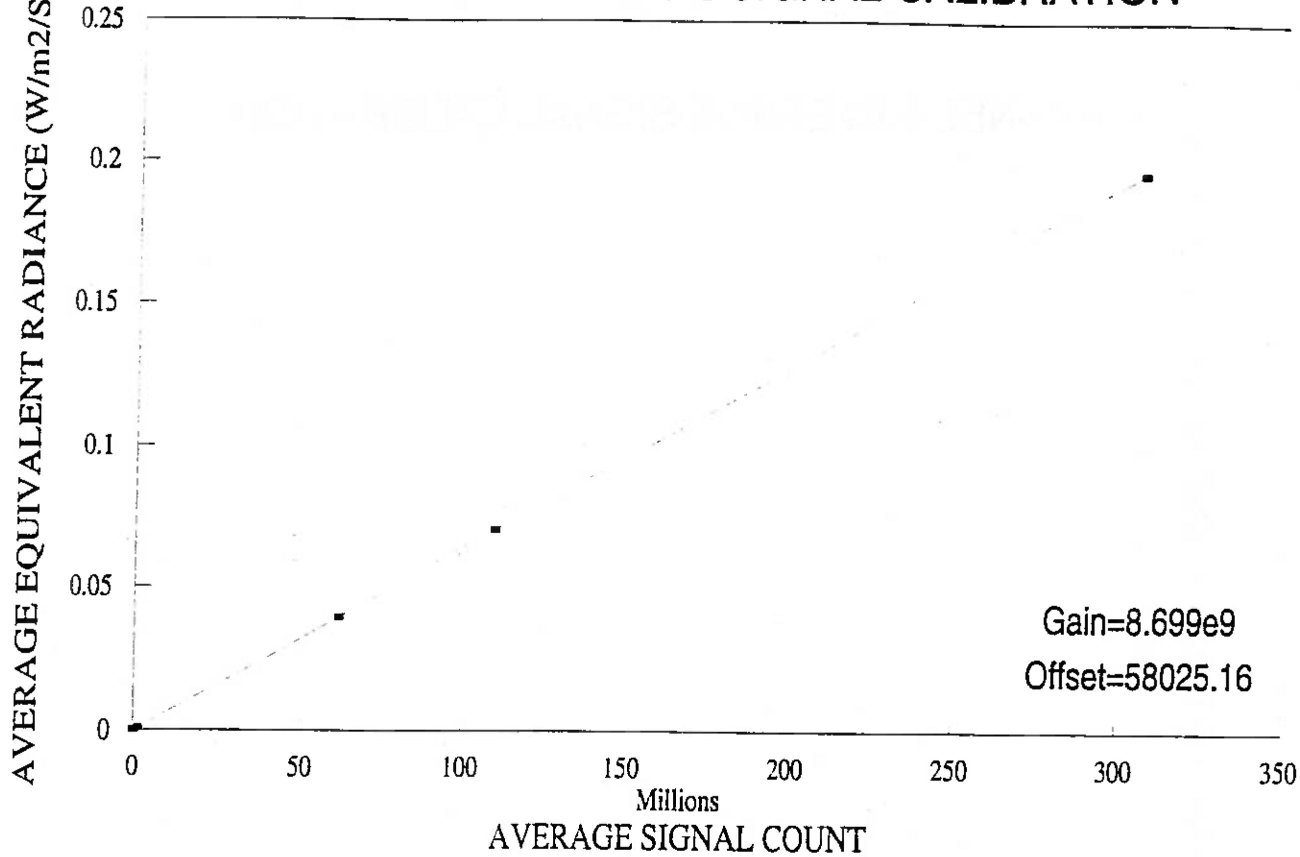
CHANNEL 5 AVERAGE SIGNAL CALIBRATION



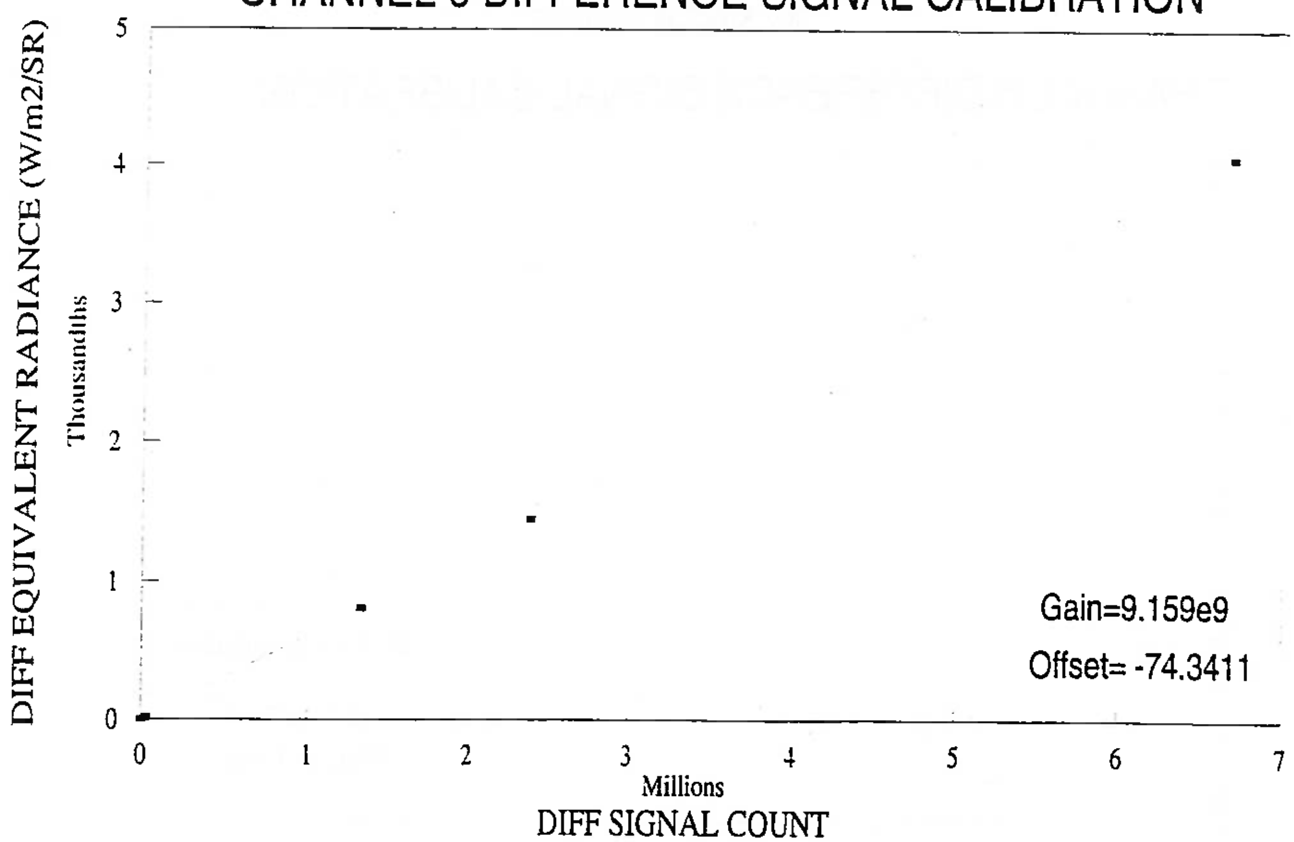
CHANNEL 5 DIFFERENCE SIGNAL CALIBRATION



CHANNEL 6 AVERAGE SIGNAL CALIBRATION



CHANNEL 6 DIFFERENCE SIGNAL CALIBRATION



5.3.2 Channel Offset

Test No.:	2
Objective:	To measure the zero/offset level for the Difference (DIFF) and Average (AV) signals of all channels.
Equipment:	MOPITT Space Blackbody (MSBB)
Method:	The MSBB is cooled to 77K using the liquid nitrogen flood loop.This results in a near zero radiance. The four scan mirrors view the MSBB simultaneously via the space view ports and the cold MSBB can be used to determine the zero level/offset for each channel. The offset will be pre-dominantly due to the scan mirror and fore-optics.
Procedure:	MOPITT-PL-TP0002
Results:	The measured count rate for the DIFF and AV signals for all channels will be equivalent to the background offset level. This value can be compared to the calculated values from Test 1 (the Test 1 values assume zero radiance, that is cold space view, <5K).
Requirement:	TBD
As designed:	TBD
Notes:	Allow sufficient MSBB settling time after the mirrors are rotated to view it. Ensure baseplate is held at its nominal opertaing temperature and carefully monitor the fore-optics/chopper temperatures.

5.3.3 Channel Noise Performance

Test No.: 3

Objective: To measure the noise equivalent radiance (NER) of the DIFF and AV signals for all channels.
Furthermore, the NER calculations within the BOMEM model can be validated.

Method: Obtain the NER data from the Test 1 data set for each incremental point at which the thermal and solar channel has been calibrated. For the thermal channels (1,3,5&7) the DIFF NER has been specified at a MCBB temperature of 289.4K, for the CO solar channel (2&6) it is defined for a MCBB temperature of 467K and for the CH_4 solar channels (4&8) the NER is defined for a MCBB temperature of 450K.

Procedure: MOPITT-PL-TP0001

Results: The DIFF and AV signal noise, ΔC_n, per pixel is calculated as the standard deviation for the 100 scans (TBC) at each temperature setting.

$$[\Delta C_{PIXEL}]_{DIFF/AV} = [\sigma_{PIXEL}]_{DIFF/AV} = \sqrt{\frac{\sum_{S=1}^{N=100} (C_S - \overline{C}_{PIXEL})^2}{N - 1}}$$

The noise per channel is then calculated using

$$[\Delta C_{CHANNEL}]_{DIFF/AV} = \frac{1}{2}\sqrt{\sum_{P=1}^{4} \Delta C^2{}_P}$$

This can then be converted into a NER figure by using the corresponding gain coefficient for the DIFF and AV case for each channel

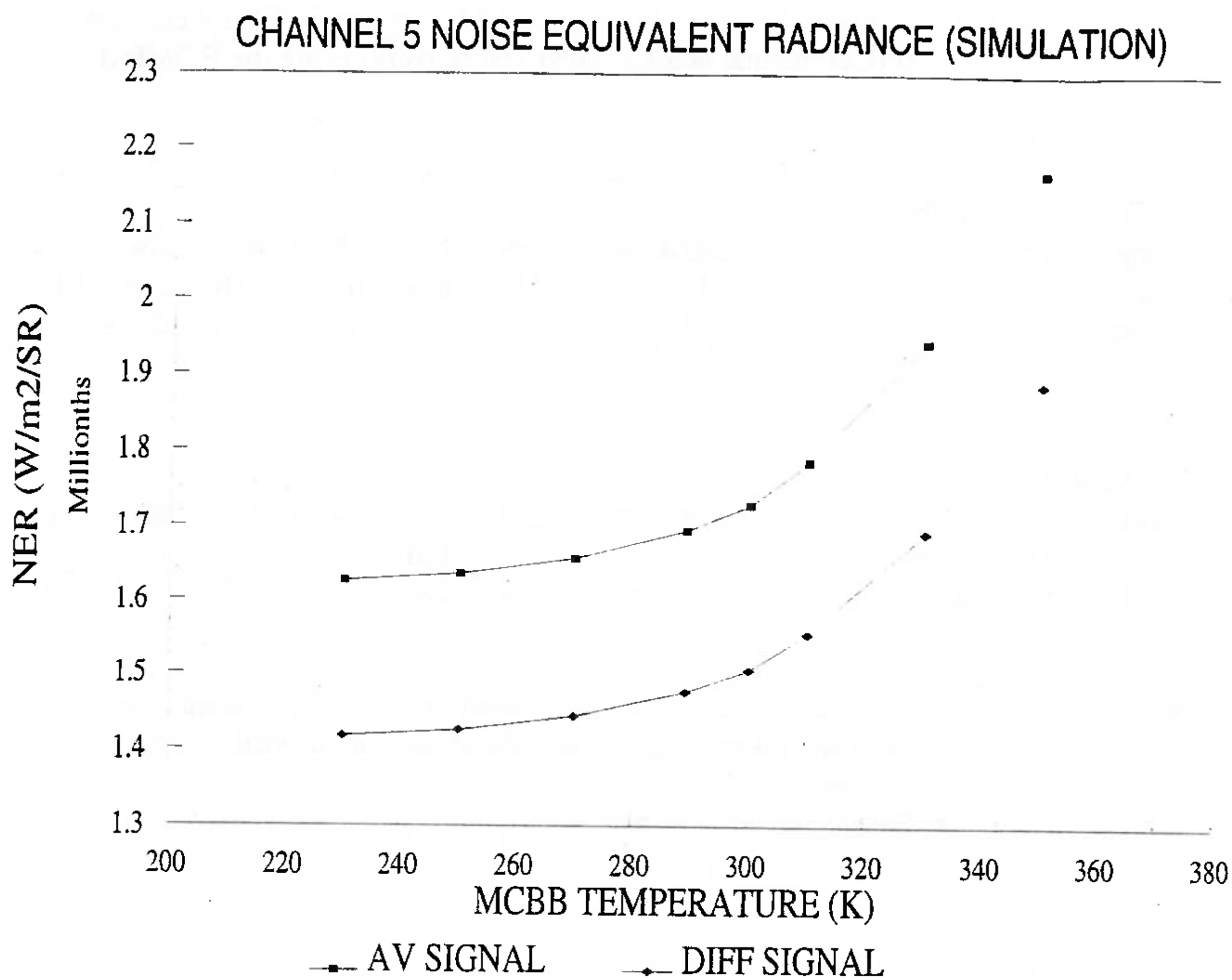
$$NER_{DIFF} = \Delta C_{DIFF}/g_{DIFF} \quad \text{and} \quad NER_{AV} = \Delta C_{AV}/g_{AV}$$

Figure 5.3.2 shows the expected AV and DIFF NER for channels 5 and 6 (CO thermal and CO solar respectively) using the BOMEM model.

	#1	#2	#3	#4	#5	#6	#7	#8
DIFF NER ($\mu W/m^2/sr$)								
Temperature:	289.4	467	289.4	450	289.4	467	289.4	450
Requirement:	84	2.69	55	10.6	68	3.48	23.4	10.6
As designed:	<84	<2.69	<55	<10.6	<68	<3.48	<23.4	<10.6

AV NER ($\mu W/m^2/sr$)								
Temperature:	289.4	467	289.4	450	289.4	467	289.4	450
Requirement:				TBD				
As designed (TBC):	257	570	346	295	39.5	175	318	295

Notes: The NER test data can be extracted from test 1 providing adequate care has been taken in test 1 and the specification NER points have been covered.
Baseplate and FPA held at their normal operting temperatures.


CHANNEL 5 NOISE EQUIVALENT RADIANCE (SIMULATION)
NER (W/m2/SR)
Millionths
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
200
220
240
260
280
300
320
340
360
380
MCBB TEMPERATURE (K)
AV SIGNAL
DIFF SIGNAL

5.3.4 Simulated Atmospheric Signal

Test No.: 4

Objective: To measure the response of the DIFF and AV signals of all channels to a gas mixture simulating the atmosphere (the results can be compared to GENASIS calculations).

Equipment: MOPITT Calibration Blackbody (MCBB) or MOPITT Solar Reflected Simulator (MSRS) and MOPITT Gas Cell (MGC).

Method: For the thermal CO channels (1,3,5&7) the MCBB will be maintained at 350K using the re-circulating loop. The MGC (inserted between MOPITT and the MCBB) will have a N_2/CO mixture. The channel response to changing the CO partial pressure between 0->2.1kPa and the cell total pressure between 0-100kPa will be measured.
For the solar channels the MCBB is replaced by the MSRS. For the CO solar channels (2&6) the CO partial pressure range is 0->4.2kPa and the cell total pressure range is 0-100kPa. The solar CH_4 channels will use a CH_4/N2 mixture with a partial pressure range of 0->70kPa and a cell total pressure range of 0-100kPa.

Procedure: MOPITT-PL-TP0003

Results: TBD (GENASIS calculations).

Requirement: TBD

As designed: TBD

Notes: The test may be repeated with CO_2 and N_2O fill mixtures replacing the CO and CH_4 gas. This will determine the effect of contaminant gases from the DIFF signal.

5.3.5 Optical Balance Measurement

Test No.: 5

Objective: To measure the optical balance of channels containing LMC's (1,2,4,5,6&8).

Method: The optical balance measurement can be extracted from test 4 data. A two point calibration can be obtained by using the evacuated MGC data and the data set for when the MGC is filled with either CO or CH_4 only (TBC).

Procedure: MOPITT-PL-TP0003

Results: TBD

	#1	#2	#4	#5	#6	#8
DIFF ($\mu W/m^2/sr$) Requirement:	33.6	1.07	5.30	6.80	1.57	5.30

As designed: TBD

Notes:

5.3.6 Focal Plane Temperature (FPA) Sensitivity Effects

Test No.: 6

Objective: To measure any effects of FPA temperature changes on the channel responsivity and noise of the DIFF and AV signals.

Equipment: MOPITT Calibration Blackbody (MCBB).

Method: For the thermal channels (1,3,5&7) the MCBB is incremented in 30K steps between 220-340K. At each temperature the FPA temperature is increased from 95 to 110K (TBC), by reducing the Stirling Cycle Cooler (SCC) compressor amplitude.
For the solar channels (2,4,6&8) the MCBB is incremented between 440 and 500K in 30K increments. At each MCBB temperature the FPA temperature is changed as described above.

Procedure: MOPITT-PL-TP0004

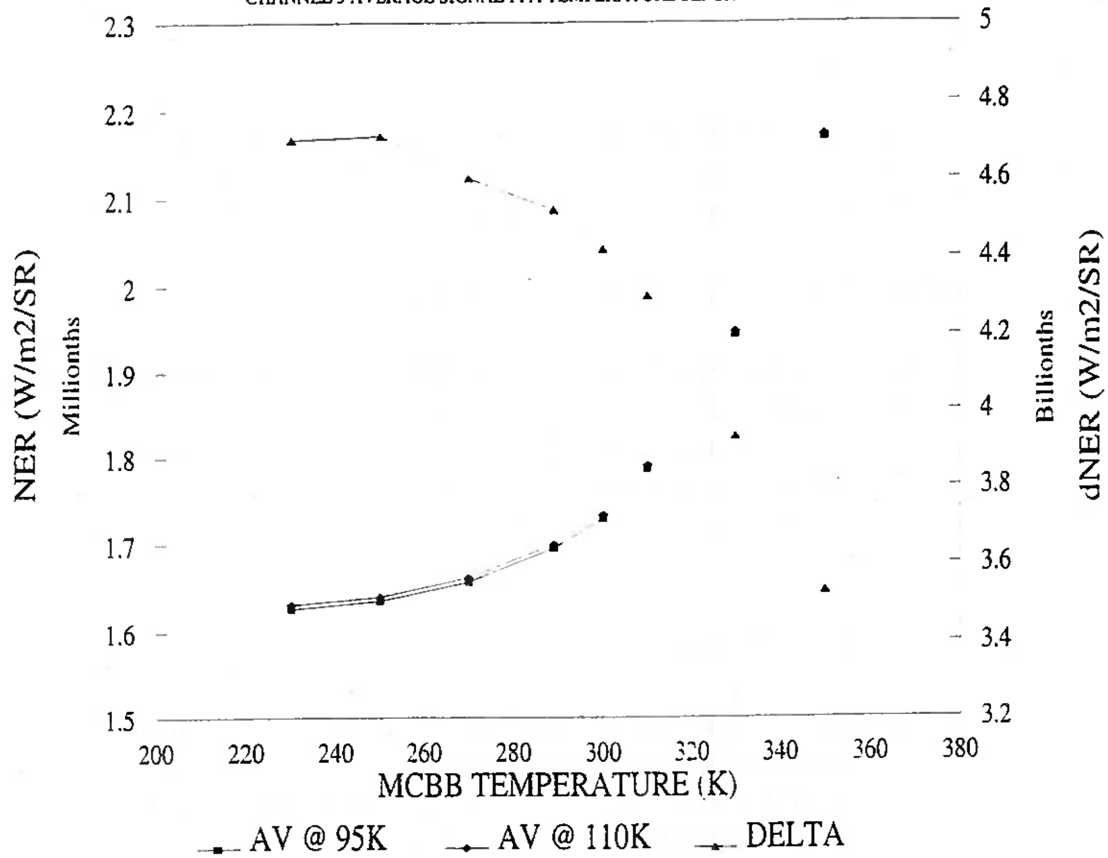
Results: The channel responsivity and noise are determined as described in Tests 1 and 3 respectively by taking the average and standard deviation of the count rate and converting it to a radiance using the gain and offset factors.
Providing the instrument is at its nominal operating temperature the offset should be the same as that determined in Test 1. Any change in the gain factor (and hence response/linearity) as compared to Test 1 can be attributed to filter shift effects (TBC). The noise equivalent radiance will increase with the FPA temperature. Figure 5.3.3 shows how the NER will vary for channel 5 using the BOMEM simulation (the dNER is the change in the FPA NER).

	#1	#2	#3	#4	#5	#6	#7	#8
Detector NER_{DIFF}($\mu W/m^2/sr$)								
Requirement:					TBD			
As designed:					TBD			

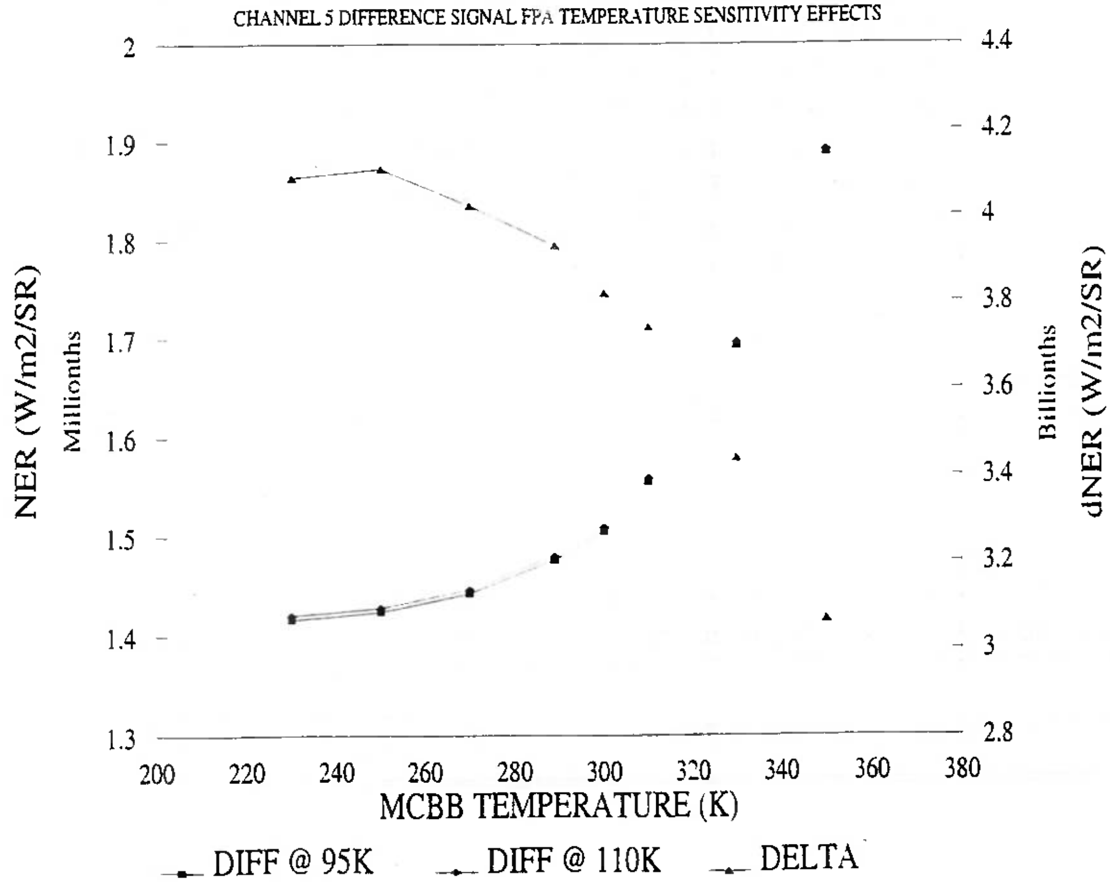
Detector NER_{AV}($\mu W/m^2/sr$)
Requirement: TBD
As designed: TBD

Notes: This test could be complimented with Test 1.

CHANNEL 5 AVERAGE SIGNAL FPA TEMPERATURE SENSITIVITY EFFECTS



CHANNEL 5 DIFFERENCE SIGNAL FPA TEMPERATURE SENSITIVITY EFFECTS



5.3.7 Baseplate Temperature Sensitivity Effects

Test No.: 7

Objectives: To measure the effects of instrument temperature (in particular the chopper and fore-optics) on the channel responsivity and noise of the DIFF and AV signals of the thermal channels (1,3,5&7).

Equipment: MOPITT Calibration Blackbody (MCBB)

Method: With the instrument temperature at 293K the MCBB temperature is varied between 220-340K in 30K increments (by using the re-circulating loop) the instrument baseplate temperature is slewed to 298K (TBC) by changing the coldplate temperature and the MCBB temperature changed from 340-220K in 30K steps.

Procedure: MOPITT-PL-TP0004

Results: The channel responsivity and noise are determined as described in Tests 1 and 3 respectively by taking the average and standard deviation of the count rate and converting it to a radiance using the gain and offset factors calculated for the above baseplate setting.
It is expected that the gain coefficient shall remain constant but the offset will change reflecting the temperature change of the instrument especially the fore-optics and chopper section.
Figure 5.3.4 shows the effects of fore-optics and chopper temperature changes on the channel 5 AV and DIFF signals using the BOMEM simulation (the DIFF and AV error radiance clearly show the need for accurate knowledge of these temperatures and for re-calibration if the fore-optics and chopper temperature change).

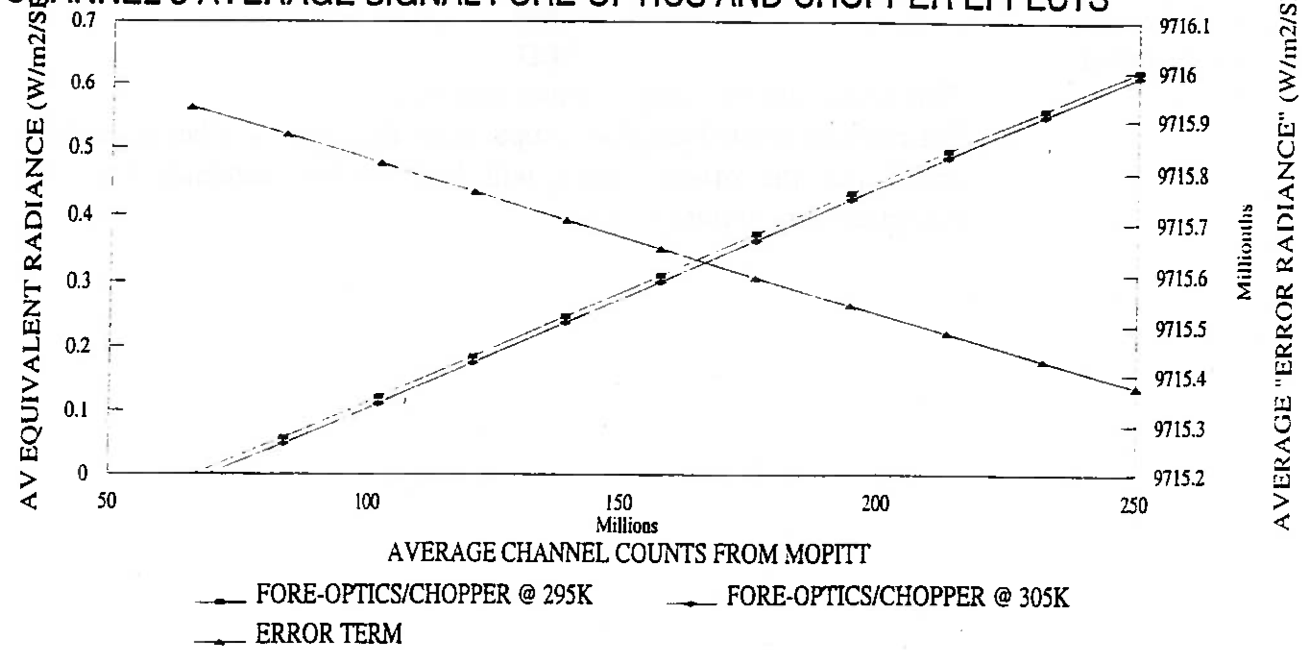
Diff Gain change
⇒ Gas temp inc.

NER_{DIFF}($\mu W/m^2/sr$)	#1	#3	#5	#7
Requirement:	63.00	46.75	57.80	18.72
As designed:			TBD	

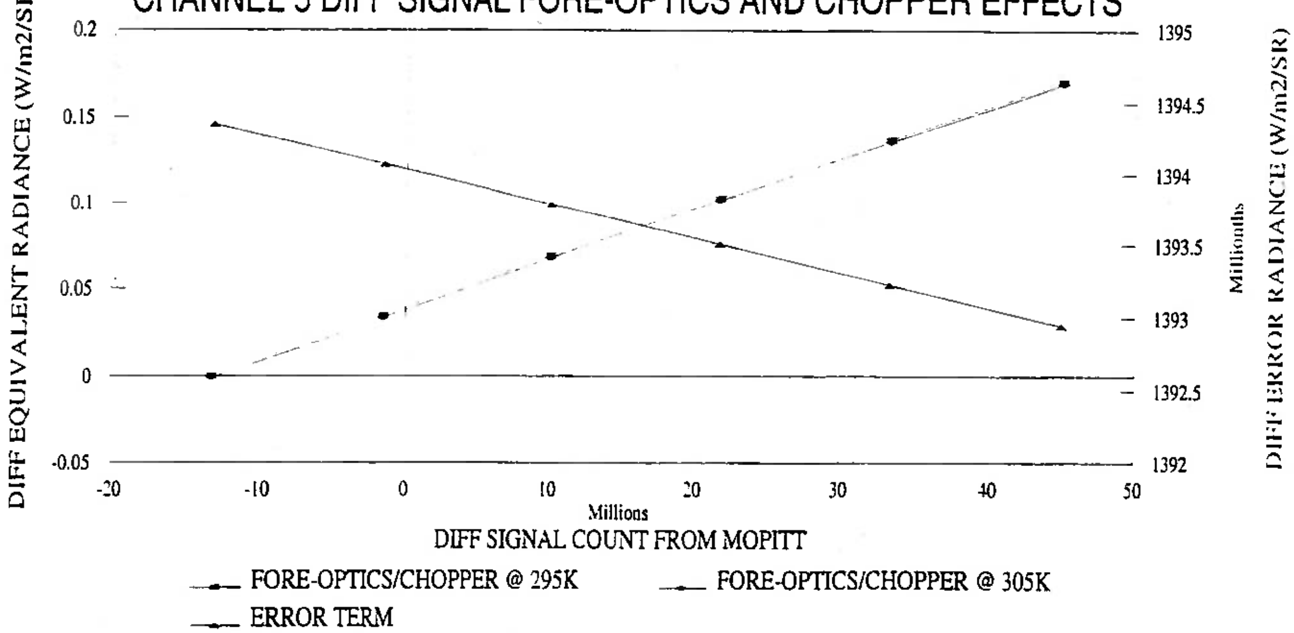
NER_{AV}($\mu W/m^2/sr$)

Requirement:	TBD
As designed:	TBD
Notes:	This test could be complimented with test 6. For changes in the baseplate temperature, $R_{INSTRUMENT}$ is being changed and hence the offset factors will have to be calculated for each baseplate temperature setting.

CHANNEL 5 AVERAGE SIGNAL FORE-OPTICS AND CHOPPER EFFECTS



CHANNEL 5 DIFF SIGNAL FORE-OPTICS AND CHOPPER EFFECTS



5.3.8 Integrated Radiometric Strays

Test No.: 8

Objectives: To determine and measure any radiometric leaks.

Equipment: MOPITT Calibration Blackbody (MCBB) and MOPITT Stray Plate and Baffle (MSPB)

Method: With the MCBB set at 300K (TBC) and measuring the in field response the MSPB is heated from 300 to 500K and the out of field response is measured for the thermal channels (1,3,5&7).

Procedure: MOPITT-PL-TP0005

Results: The out of field signal is determined by subtracting the base signal (when both the MCBB and MSB are at 300K) from the gross signal. This is then converted into a radiance using the calculated gain and offset coefficients.

	#1	#3	#5	#7
NER_{DIFF}($\mu W/m^2/sr$)				
Requirement:	8.40	5.50	6.80	2.34
As designed:			TBD	
NER_{AV}($\mu W/m^2/sr$)				
Requirement:			TBD	
As designed:			TBD	

Notes: FPA and baseplate held at nominal operating temperatures.

5.3.9 Calibrate and Verify On-Board Blackbodies

Test No. 9

Objectives: To calibrate and verify the on-board MOPITT flight blackbodies (MFBB) to the MCBB and to a NIST standard (TBD).

Equipment: MOPITT Calibration Blackbodies (MCBB).

Method: With the MCBB calibrated to a NIST standard (see MOPITT-TD-0017) the MFBB's are calibrated using the MCBB. This is done by initially setting the two blackbodies to the same nominal temperature and chopping between the two using the input scan mirror. The MOPITT detectors are used to transfer the standard.
For the thermal channels (1,3,5&7) the MFBB's are calibrated in the 295-350K range in 5K increments and for the solar channels (2,4,6&8) in the 440-500K range in 5K increments.

Procedure: MOPITT-PL-TP0006

Results: Plot tempertaure versus counts for the MCBB and the MFBB and determine the gain and offset parameters for each.

Requirement: TBD

As designed: TBD

Notes:

6.0 FIELD OF VIEW (FOV) TESTS

6.1 Purpose

The FOV tests will determine the instrument spatial response. The detector uniformity and response have to be mapped on a pixel by pixel basis (MOPITT has eight channels each of which has a 4x1 pixel array) in order to compliment the radiometric calibration. Furthermore, the instrument pointing requirements can also be verifed.

6.2 FOV Test Configuration

For these tests all tank sections are used. The MCS is located down the tank axis such that the front of the collimator is 35cm from the MOPITT front face (the rear end of MCS is 90cm from MOPITT). The collimator will be translated in the X and Y axis (see Figure 6.1) in order to map out the FOV. The MCIR source will be outside the vacuum chamber and brought to the collimator focus using the IR fiber. This fiber and the MCS will move as a fixed unit to map out the IFOV.

The equipment configuration is shown in Figure 6.2, once again everything is handled through the Sun SPARCstation.

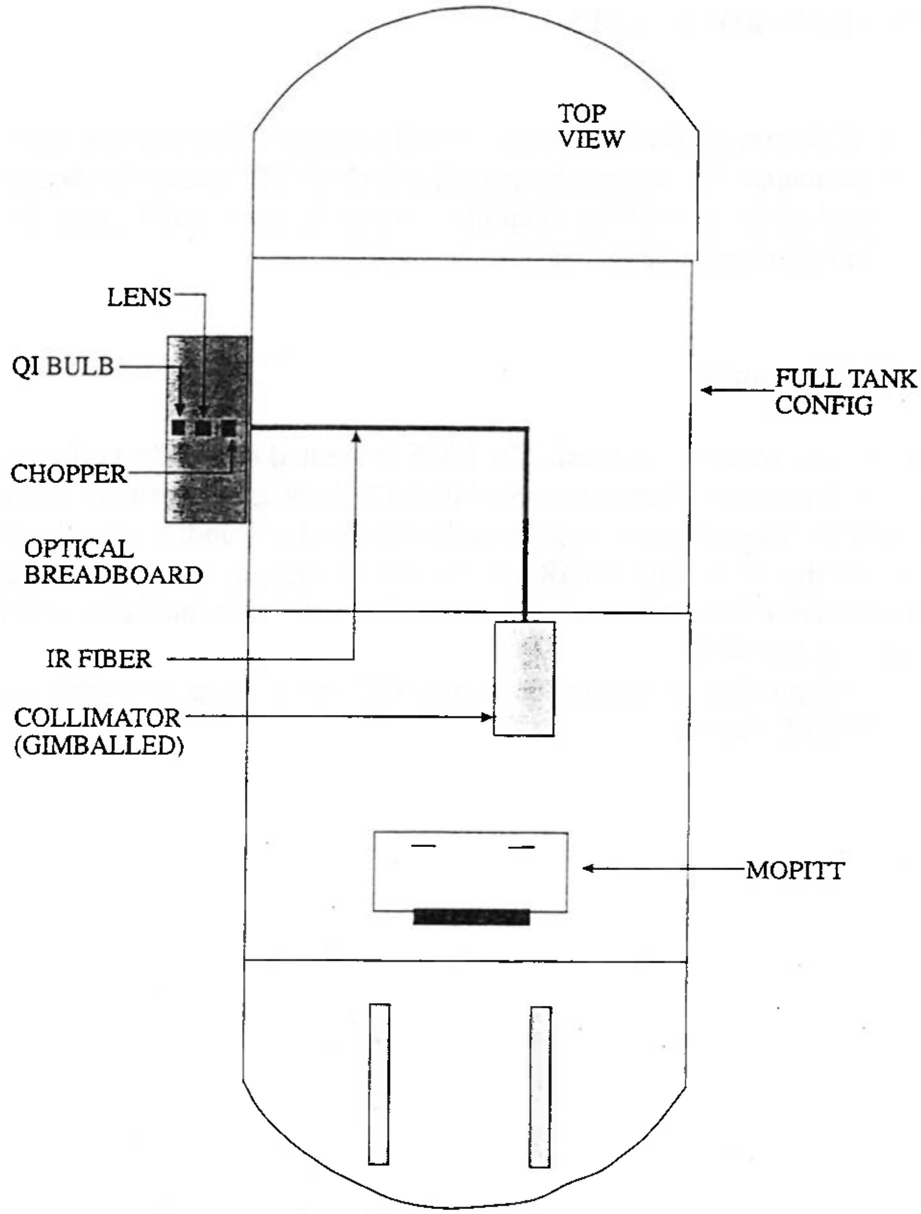


Figure 6.1 MOPITT FOV Test Configuration

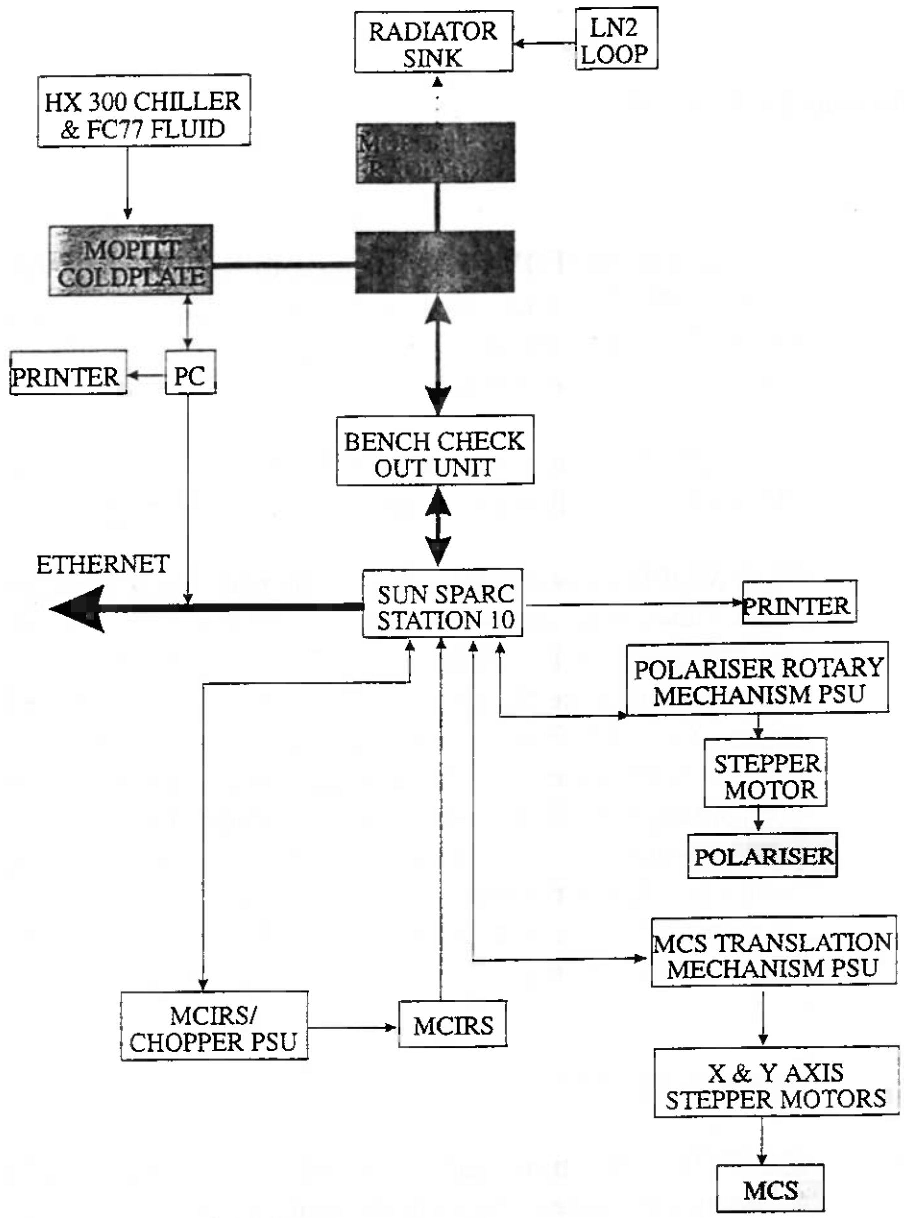


Figure 6.2 MOPITT FOV Equipment Configuration

6.3 Tests

6.3.1 Instantaneous FOV (IFOV)

Test No.: 10

Objective: To measure the IFOV of all channels to better than 1/30th of a pixel, with MOPITT in nadir view and at the extreme scan angles.
From this data set the pixel co-alignment and the detector co-registration can be determined.

Equipment: MOPITT Collimator System (MCS), MOPITT Collimator IR Source (MCIRS) and Collimator Azimuthal and Elevation.

Method: With MOPITT positioned such that the nadir view or the extreme scan angle views point down the tank axis the collimator system (including the MCIRS) can be scanned to simultaneously map one pixel in all channels and hence the whole array. In order to cover the ±3.6 and ±0.9 degree MOPITT FOV acceptance angle the rear end of the collimator system will have to translate ±3.46cm vertically and ±0.77cm horizontally in 0.42mm steps. This corresponds to scanning a 28μm spot over the entire 3.6 x 0.9mm detector array in 50μm steps (approx 2000 points per detector array).
A calibration scan, at a set location will be made before and after each pixel has been imaged to correct for any source temperature drift effects.

Procedure: MOPITT-PL-0007

IFOV Results: The IFOV data is time stamped according to the time and date at which the scan was started. This information can be used to correct for any source temperature drift effects by calculating a scaling factor for each scan line by linear interpolation, in time, between initial and final calibration scans. A second scaling factor is then calculated to normalise each scan line relative to the initial calibration scan.

The IFOV plot is then normalised to a peak value of 1.0 (Figure 6.3.1a shows the expected IFOV response characteristics). This can then be used to determine the pixel spatial response uniformity.

Requirement: The peak to peak non-uniformity of any pixel should be ≤5% (TBC).

As designed: TBD

Pixel Co-Alignment

Results: Using the above data set the IFOV plots are referenced to the MCS position. Hence the position of each pixel within the detector array can be compared with each other by comparing the positions of the 50% response points, as is shown in Figure 6.3.1b.

Requirements: Pixels within a detector array should align to 1/25th of a pixel (35μm at the pixel and is equivalent to 0.294mm wrt MCS).

As designed:

Detector Co-Reg

Results: Using the referenced data set created during the pixel co-alignment checks the registration of each detector array can be compared with the other detectors, as is shown in Figure 6.3.1b. This will verify the instrument pointing requirements.

Requirements: Detectors co-register to 1/22nd of a pixel (41μm at the pixel, which is equivalent to 1km on the Earth surface and to 0.344mm wrt MCS).

As designed: TBD

Notes:

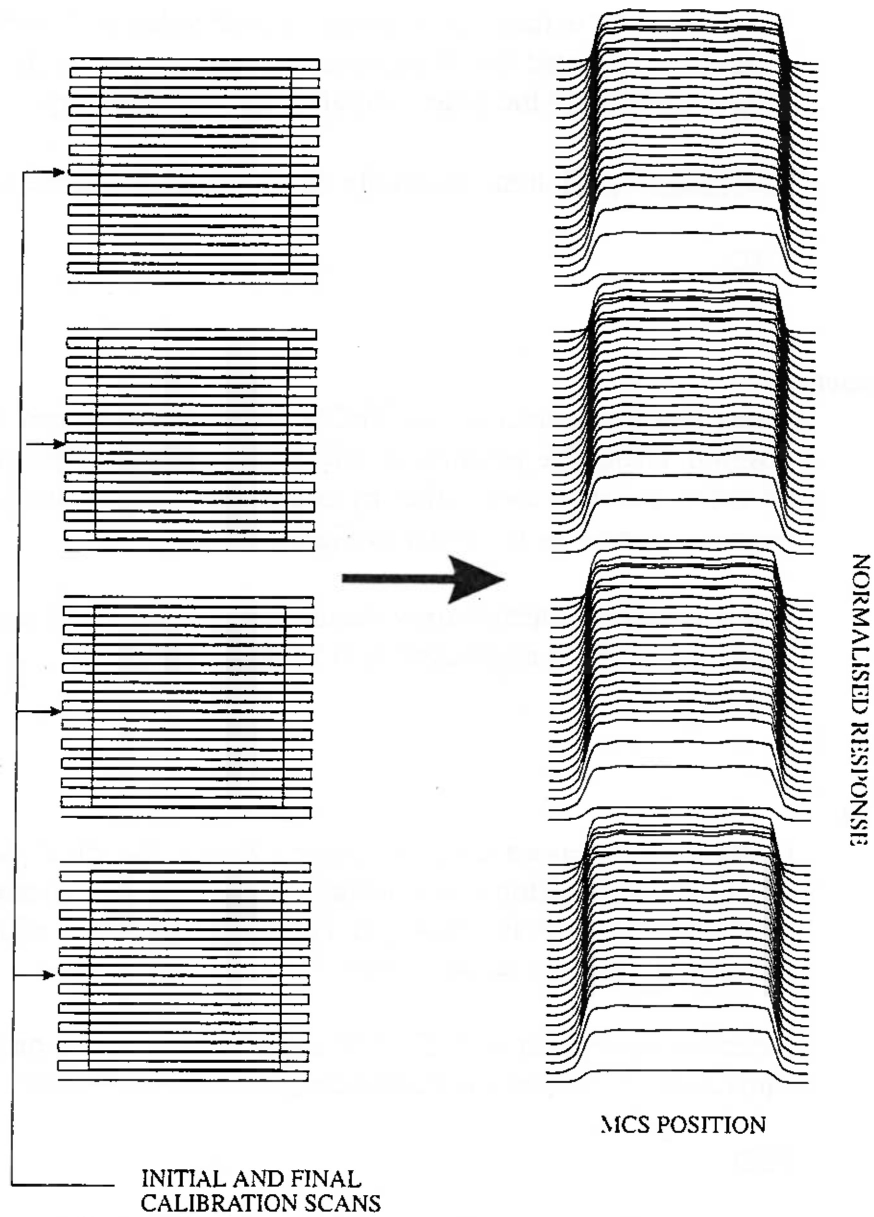


Figure 6.3.1a Scan Pattern and Pixel IFOV Response Plot

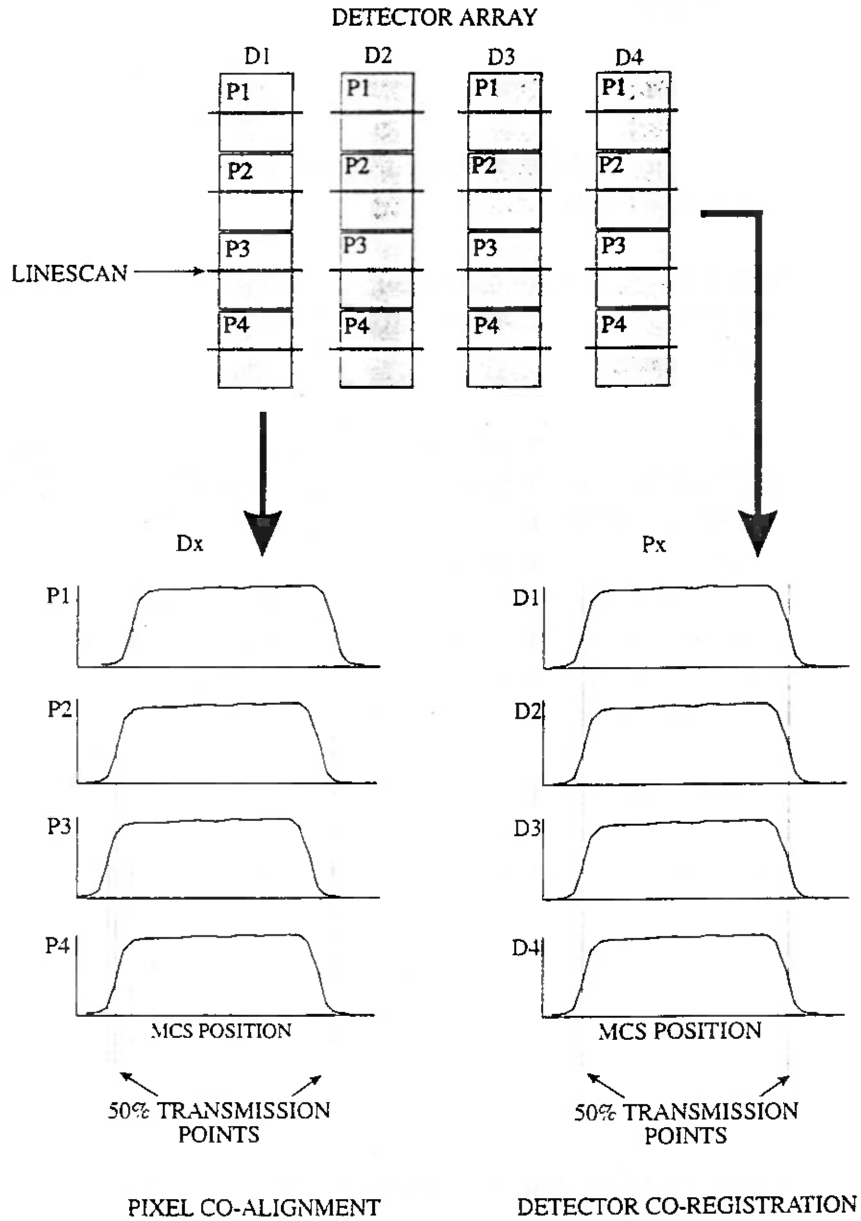


Figure 6.3.1b Pixel Alignment and Detector Co-Registration

6.3.2 Polarised Light Response

Test No.: 11

Objectives: To measure and characterise the response of the AV and DIFF signals to polarised light.

Equipment: MOPITT Collimator System (MCS), MOPITT Collimator IR Source (MCIRS), Polariser with Rotation Mechanism and Collimator Azimuthal and Elevation.

Method: Using the referenced information from test 10 the collimator system can be positioned with respect to the pixel. Initially the MCIRS is operated at two temperatures (2000K and 2800K TBC) at the pixel centre location for the minimum polarisation position.
The test is then conducted, at fixed source temperature, for a five point cross in x and y (Figure 6.3.2). For each point rotate the polariser 360 degrees in 45 degree steps (TBC). Repeat this for the other three pixels in the array to map out the effect for all pixels.

Procedure: MOPITT-PL-TP0008

Results: Using the initial two temperature calibration the gain can be determined

$$g = \frac{C_1 - C_2}{R_1 - R_2}$$

where the DIFF and AV radiance terms are given by

$$R_{DIFF} = \int_{\nu_1}^{\nu_2} [r^2 B_{MCIRS}(T,\nu)\varepsilon_{MCIRS}(T,\nu)\frac{\Omega_{MOPITT}}{\Omega_{PINHOLE}} + B_{BACK}(T,\nu)\frac{(\Omega_{MOPITT} - r^2\Omega_{PINHOLE})}{\Omega_{MOPITT}}]\tau(T,\nu)[\tau(T,\nu)_{SI} - \tau(T,\nu)_S$$

$$R_{DIFF}=\int_{\nu_1}^{\nu_2}[r^2B_{MCIRS}(T,\nu)\varepsilon_{MCIRS}(T,\nu)\frac{\Omega_{MOPITT}}{\Omega_{PINHOLE}}+B_{BACK}(T,\nu)\frac{(\Omega_{MOPITT}-r^2\Omega_{PINHOLE})}{\Omega_{MOPITT}}]\tau(T,\nu)\frac{[\tau(T,\nu)_{S1}+\tau(T,\nu)_{S}}{2}$$

where Ω_{MOPITT} and $\Omega_{PINHOLE}$ are the solid angles subtended by MOPITT and the pinhole respectively, r is the MCS mirror reflectivity, ε is the emissivity, B (T,ν) is the Planck function, τ is the MOPITT optics transmission and τ_{S1} and τ_{S2} are the modulator transmission factors for its two states.

Once the gain, g, has been calculated the count difference, ΔC at each position due to polariser rotation can be converted into a radiance.

$$NER_{DIFF} = \Delta C_{DIFF}/g_{DIFF} \quad \text{and} \quad NER_{AV} = \Delta C_{AV}/g_{AV}$$

	#1	#2	#3	#4	#5	#6	#7	#8
DIFF ($\mu W/m^2/sr$)								
Requirement:	4.2	0.13	2.75	0.53	3.4	0.17	1.17	0.53
As designed:				TBD				
AV ($\mu W/m^2/sr$)								
Requirement:				TBD				
As designed:				TBD				

Notes:

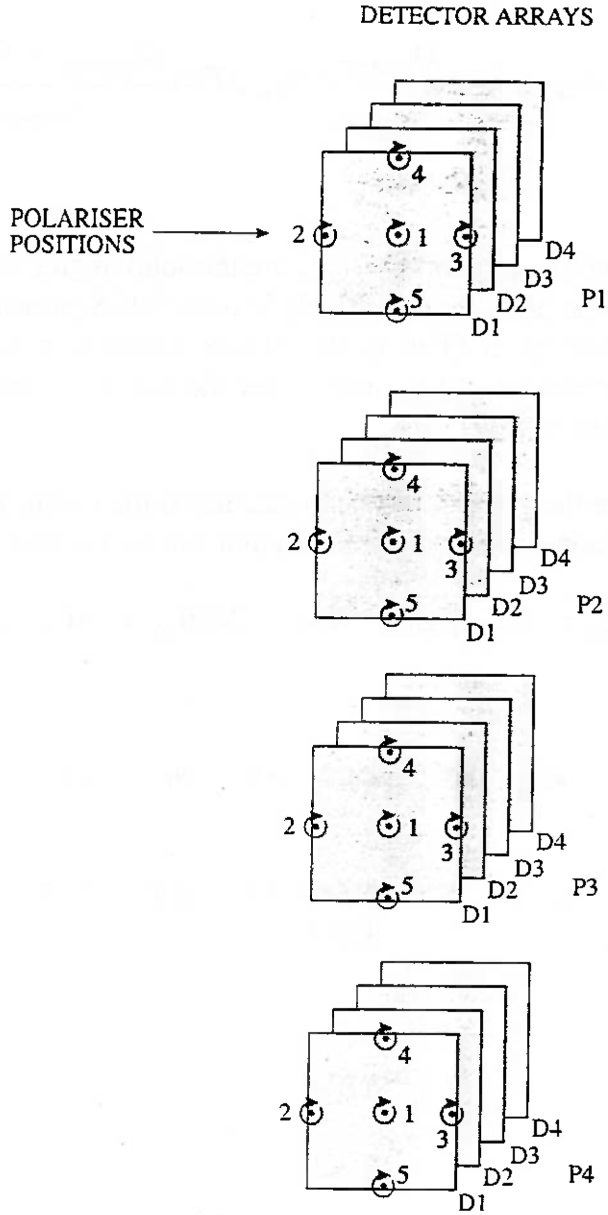


Figure 6.3.2 Polariser Test Positions

6.3.3 FPA Temperature Sensitivity Effects

Test No.:	12
Equipment:	MCS, MCIRS, Collimator Azimuthal and Elevation.
Objective:	Measure the effects on IFOV focus/defocus due to beam focal shifts.
Method:	Increase the FPA temperature from 95K to 110K and run a linescan over a pixel edge at a known location.
Procedure:	MOPITT-PL-TP0009
Results:	This can be compared to results from test 10 over the same pixel edge, any focus/de-focus effects will show up as a change in the response curve. The effect can be quantified by doing a 10%/90% measurement of the response curve and referencing this to the pixel size (Figure 6.3.3).
Requirement:	80% Encircled Energy nominal diameter >70μm and <110μm.
As designed:	TBD
Notes:	

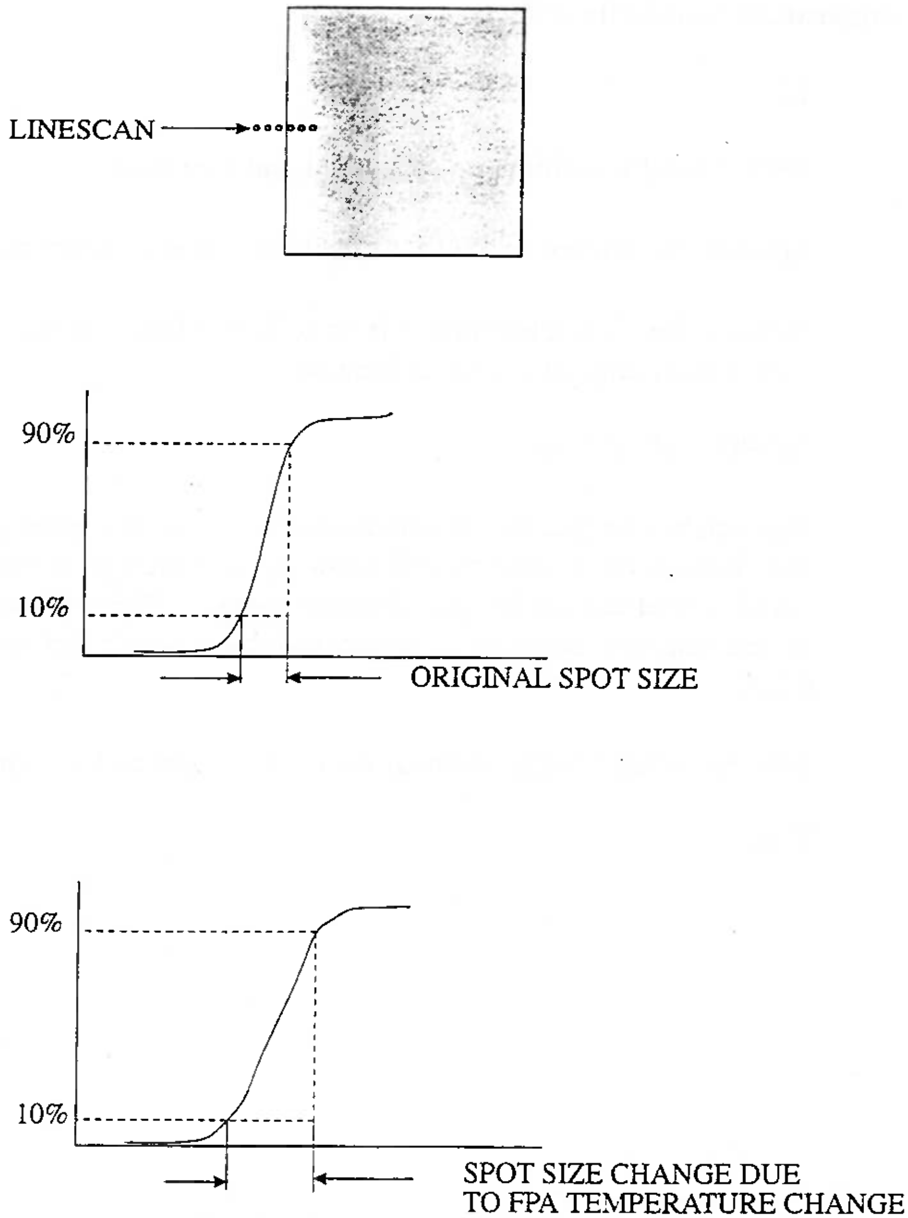


Figure 6.3.3 Measurement of Spot Size

7.0 Spectral Tests

7.1 Purpose

The instrument spectral response is limited by cold (≤110K) narrow band optical filters in each channel. Although the spectral response will have been characterised at component level, spectral changes may occur during build and test. Spectral shifts may occur because of filter location, they are located in a near collimated region (at component level a collimated beam is used) , furthermore, shifts may occur due to changes in the FPA temperature (the filters are characteised at 77K at component level but are used at 95-100K, TBC). Unknown filter shifts could, falsely, be interpreted as a non-linearity in the radiometric channel response.
It is therefore, important to characterise the end to end spectral response of all channels.

7.2 Spectral Test Configuration (TBC)

The test configuration, given in Figure 7.1, shows the two visible laser beams are brought into the ICF (from the High Resolution IR and Raman Spectroscopy Labs) using fiber optic cable. The mixing to produce the IR beam occurs on the optical breadboard mounted outside the vacuum chamber. The resultant beam will go through the calcium fluouride window, into the IR fiber, through the MCS to MOPITT.
The equipment configuration is shown in Figure 7.2. It is similar to the FOV configuration except in this case the MCS will not move. All control of the DFLS, that is spectral sweep rate, spectral range and window etc, will be done through the High Resolution IR and Raman Spectroscopy Labs.

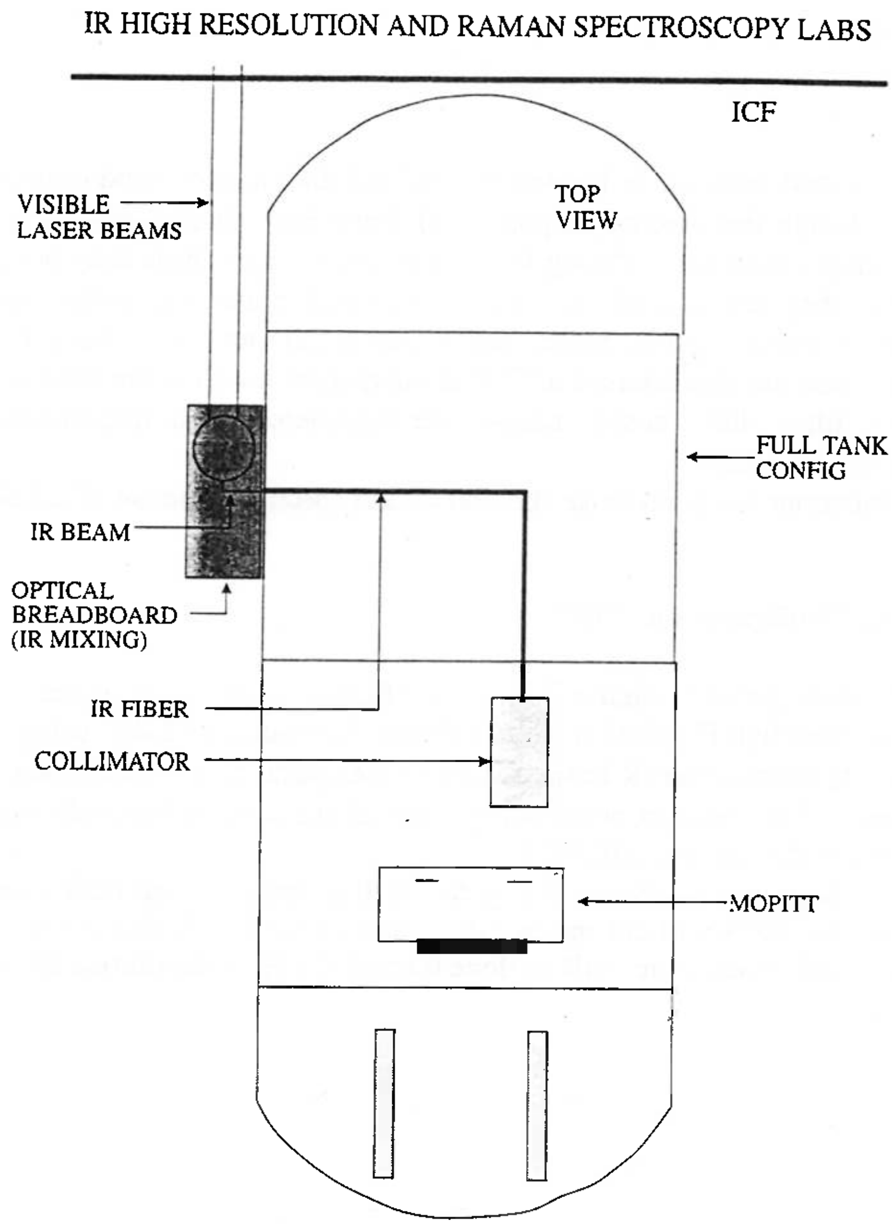


Figure 7.2 MOPITT Spectral Test Configuration

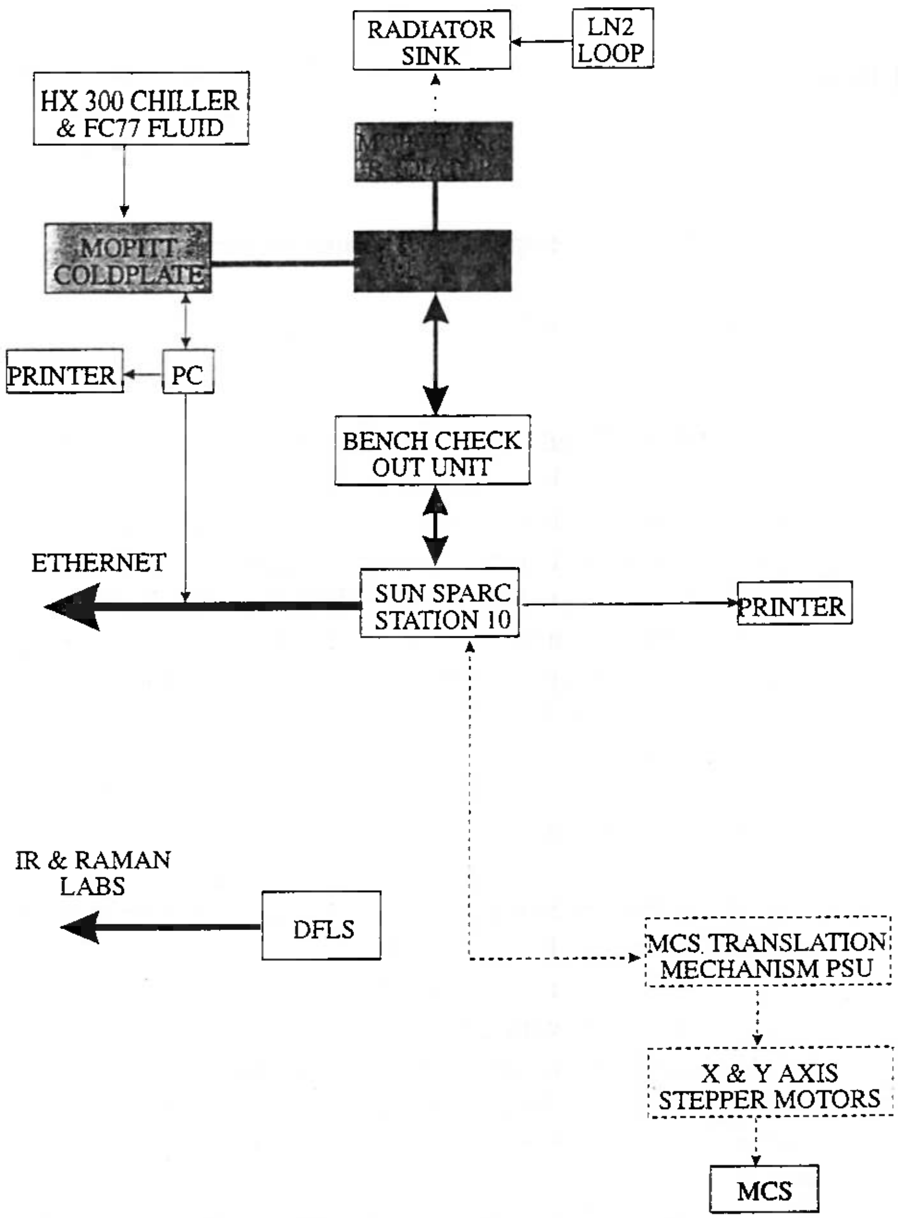


Figure 7.2 MOPITT Spectral Equipment Configuration

7.3 TESTS

7.3.1 In-Band Response

Test No.: 13

Objective: To characterise the spectral response of each channel.

Equipment: MOPITT Collimator System (MCS), Difference Frequency Laser System (DFLS)

Method: The DFLS, used in conjunction with the MCS, will be operated in its high resolution mode (10^{-4}-10^{-2} cm^{-1} TBC) and the in-band response, defined as the 5% transmission points, characterised by scanning the monochromator over this range. In fact the measurements will be extended to the 0.1-1% (TBC) transmission points.
For the thermal channels (1,3,5&7) the in-band response range is 2136-2199 cm^{-1}. This range is 4254-4316cm^{-1} for the CO solar channels (2&6) and the 5% cut-off points are 4344cm^{-1} and 4519cm^{-1} for the CH_4 channels (4&8).

Procedure: MOPITT-PL-TP0010

Results: The DFLS response function has to be divided from the total response in order to obtain the total MOPITT optics response. This is done by dividing the total signal count, $C_{TOTAL}(v)$, by the DFLS output count, $C_{DFLS}(v)$ at each wavenumber. The resulting count $C_{MOPITT}(v)$ is divided by its maximum value in order to obtain the normalised spectral response function. The DFLS response is monitored by an Indium Antiminide detector mounted on the optical mixing breadboard (Figure 4.10)

Requirements:	#1,3,5&7	#2&6	#4&8
Centre Wavelength (μm)	4.617	2.334	2.258
FWHM (μm)	0.110	0.022	0.071
5% Points (μm)	4.548, 4.687	2.317, 2.351	2.213, 2.302

As designed:	#1,3,5&7	#2&6	#4&8
Centre Wavelength (μm)	±0.022	±0.005	±0.015
FWHM (μm)	±0.011	±0.003	±0.007

Notes:

7.3.2 Out of Band Response

Test No.:	14
Objective:	To characterise the out of band response and check for any gross spectral leaks.
Equipment:	MOPITT Collimator System (MCS), Difference Frequency Laser System (DFLS)
Method:	The DFLS is operated over a wider passband at degraded resolution (TBC) in order to maximise throughput. For each channel the scan range shall extend out to the $5x10^{-4}\%$ transmission level (TBC).
Procedure:	MOPITT-PL-TP0010
Results:	The normalised optics spectral response function is obtained as described above (Test 13 results).
Requirement:	Spectral leaks < $5x10^{-4}\%$
As designed:	TBD
Notes:	

7.3.3 FPA Temperature Sensitivity Effects

Test No.: 15

Objective: To measure any spectral shifts due to FPA temperature changes.

Equipment: MOPITT Collimator System (MCS), Difference Frequency Laser System (DFLS)

Method: Increase the FPA temperature from 95K to 110K repeat test 13, that is, measure the in-band response at high resolution for all channels.

Procedure: MOPITT-PL-TP0010

Results: The normalised response can be obtained as described in Test 13. The results can be compared at the 5% and 50% transmission points with Test 13 to see any shift effects.

Requirements:	#1,3,5&7	#2&6	#4&8
Spectral Shift (μm)	0.036	0.036	0.036
As designed:	#1,3,5&7	#2&6	#4&8
Spectral Shift (μm)		TBD	

Notes:

8.0 TEST PLAN MANAGEMENT

8.1 Key Personnal

The UoT test team key personal and their roles are shown in Figure 8.1. Table 8.1 provides contact information for these personal. The contact address for everyone is

University of Toronto
Department of Physics
60 St. George Street
Toronto, Ontario M5S 1A7
CANADA

8.2 Test Readiness Review

A test readiness review will be held prior to the start of the EQM Test Program. The following items will be reviewed: the Test Plan (this document); the EQM Test Program (MOPITT-TD-0006); the status of test procedures ;the status of the test equipment and the status of the instrument.

8.3 Test Procedures (Generation and Implementation)

All testing of the instrument will follow approved test procedures which will be kept under strict configuration control. These procedures will be developed by the UoT test team and kept in the MOPITT Procedure Library (MOPITT-PL). Test procedures for each of the above tests will have the following assignment MOPITT-PL-**TP**xxxx (non-test procedures will be assigned MOPITT-PL-xxxx). Figure 8.2 shows the MOPITT ICF library structure.

8.4 Logbook

The UoT test team will maintain a computerised logbook during instrument calibration and characterisation (an example is shown in Figure 8.3). It will be strictly chronological with the following items routinely logged

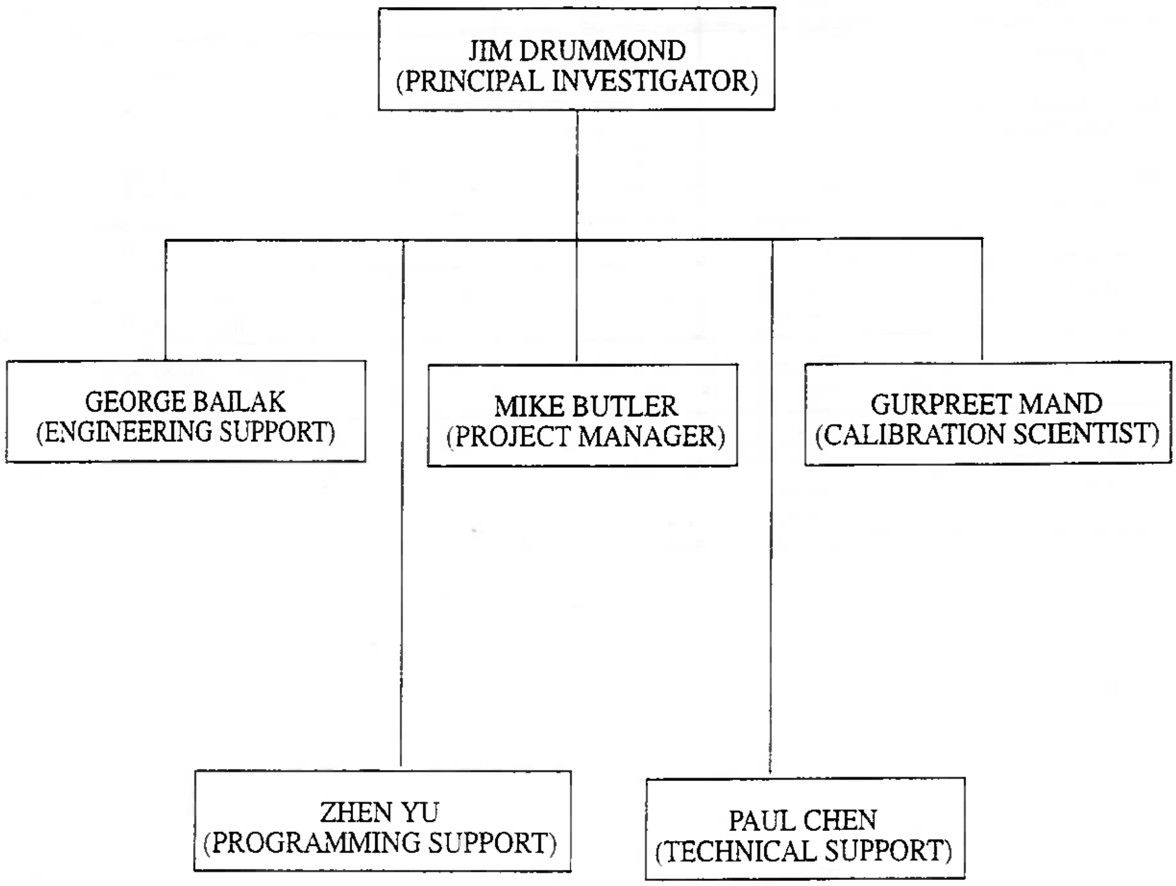


Figure 8.1 University of Toronto Team (Key Personal)

TABLE 8.1 UoT PERSONAL CONTACT INFORMATION

NAME	ROLE	PHONE	FAX	E-MAIL
Jim Drummond	Principal Investigator	(416) 978-4723	(416) 978-8905	JIM@ATMOSP.PHYSICS. UTORONTO.CA
Mike Butler	Project Manager	(416) 978-1297 *6 (519) 746-0904	(416) 978-8905 (519) 746-2591	MBUTLER@NIC. HOOKUP.NET
Gurpreet Mand	Calibration Scientist	(416) 978-1297 *6	(416) 978-8905	GURPREET@ATMOSP. PHYSICS.UTORONTO.CA
George Bailak	Engineering Support	(416) 978-1297 *6	(416) 978-8905	GEORGE@ATMOSP. PHYSICS.UTORONTO.CA
Zhen Yu	Programming Support	(416) 978-1297 *4	(416) 978-8905	ZHEN@ATMOSP.PHYSICS. UTORONTO.CA
Paul Chen	Technical Support	(416) 978-4609	(416) 978-8905	------
Anna Sousa	Secretary (J. Drummond)	(416) 978-2933	(416)-978-8905	------

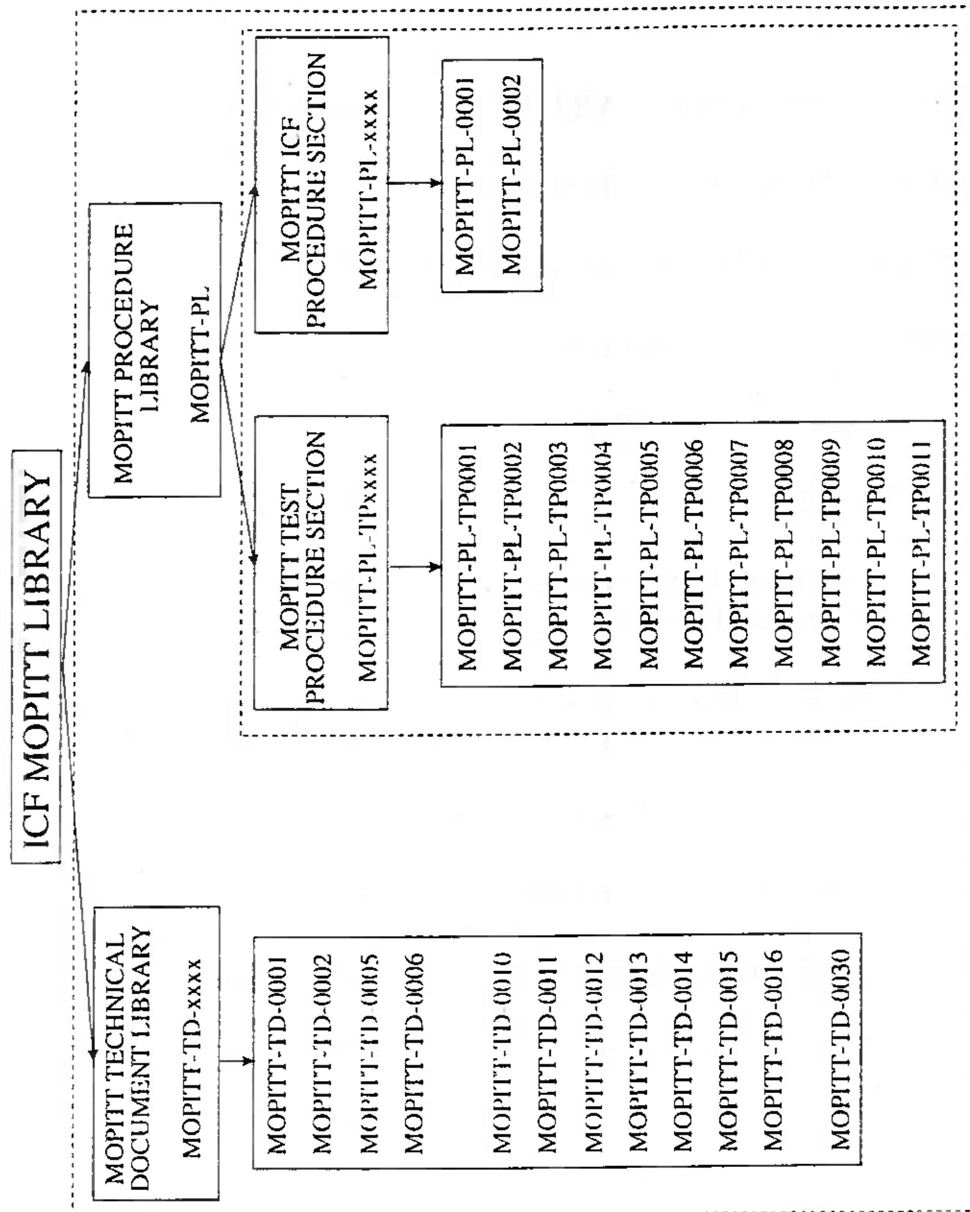


Figure 8.2 MOPITT ICF Library Structure

DATE: Fri 21/7/94 **SHIFT START TIME:** 9.00am **SHIFT No.:** 15

SHIFT PERSONNAL: GSM, GVB, JRD

OBSERVERS: Dave Frampton & Adrian Garner(CDAC)

VISITORS: Paul Davis (Rosemount Aerospace).

SHIFT ACTIVITIES:

9.10am	Handover from previous shift, continuing test sequence 16, Procedure PL-0002.
10.35am	MCBB cannot achieve 500K, 490K is max, last two calibration points not done **(flag problem at progress meeting)**
11.00am	Test sequence 17, procedure PL-0016.
3.00pm	Test sequence 18, procedure PL-0014.
3.35pm	GSM entered clean room to retrieve item (5mins).
5.00pm	Shift end, hand over.

Figure 8.3 MOPITT EQM Log Book

8.4.1 Test Activities

This will be maintained by the shift test personnel. It should contain notes of the test sequence and exact procedures followed and significant test related events. It will also include any problems encountered and deviations from the test procedure. Furthermore, any real time results should also be logged.
There should be enough information in order to reconstruct each shifts activities.

8.4.2 Connector Mate/Demate

A record of mating and demating of all MOPITT connectors will be kept. It will contain the connector reference number.

8.4.3 Problems and Anomolies

Any problems/anomolies however insignificant should be reported and logged. They should also be brought up at the daily progress meetings.

8.4.4 Clean Room Entry

Personal in clean room will be identified and recorded.

8.5 Problem Handling Procedure

Flagged problems will be addressed at daily progress meetings. They will either be resolved (and logged as such) or a formal Non-Conformance Report (NCR) will be raised, an example is shown in Figure 8.4.

8.6 Daily Progress Meetings

These will be limited to ≤1/2hr per day. They will review the progress made in the previous day and outline the work to be done. Any other issues (problems, schedule/test sequence changes) will be reviewed at this time.

REPORTED BY: GSM **DATE:** 21/7/94

NON-CONFORMANCE No.: 6 **CATEGORY:** Medium

Description of Non-conformance (or reference to Report):

MCBB did not could not be heated to 500K during test sequence 13 procedure PL-TP0002. Maximum temeperature obtained 490K.

Remarks:

Decision made to conclude test at 490K.

Disposition (or reference to close out report):

Check MCBB PSU immediately and check MCBB heaters at next opportuinity.

Initials: JRD **Date:** 22/7/94

Figure 8.4 MOPITT Non-Conformance Report (NCR)

8.7 Data Analysis

Data analysis will be performed in sufficient depth to ascertain test success. Real time analysis is performed prior to continuing with other tests or changing the test configuration. Software for test analysis will be kept under configuration control.

8.8 Reports

8.8.1 Weekly Progress Report

These will be prepared from the logbook and be in summary format. Interested parties (Com Dev and CSA) will be updated on the test program in this manner.

8.8.2 Final Comprehensive Test Report

On completion of the test program a comprehensive test report shall be written. This will use the above and the resulting analysed data.

8.9 Test Plan Review and Update

At the end of the EQM test program the test plan shall be reviewed and updated according to the lessons learned in readiness for the FM test program.

8.10 Miscellaneous

8.10.1 Visitors

Visitors are defined as interested parties who have no direct bearing on the MOPITT program. They should provide a minimum 3 days notice prior to their visit. The day and time will be confirmed by UoT personal depending on the test program status. Visitors will not be allowed into the clean room area and may not be allowed into the control room at test critical times (TBC).
Any expected visitors should be mentioned at the daily progress meetings and be posted on the "Expected Visitors and Observers" chart in the ICF control room. Furthermore, visitors to the ICF should be logged in the logbook.

8.10.2 Observers

Observers are defined as people who have a direct bearing on the MOPITT program. They will mainly consist of CSA, Com Dev, BOMEM, Hughes-Leitz and SED MOPITT related personal. They shall provide a minimum 2 days notice prior to their visit. Observers will be allowed into the control room at all times (TBC) and into the clean room if necessary.
Any expected observers should be mentioned at the daily progress meetings and be posted on the "Expected Visitors and Observers" chart in the ICF control room. Furthermore, observers to the ICF should be logged in the logbook.

9.0 ACRONYMS

AV	Average
BCU	Bench Checkout Unit
CDA	Com Dev Atlantic
CH_4	Methane
CO	Carbon Monoxide
DFLS	Difference Frequency Laser System
DIFF	Difference
EQM	Engineering Qualification Model
FOV	Field of View
FPA	Focal Plane Array
HEPA	High Efficiency Particulate
ICF	Instrument Characterisation Facility
IFOV	Instantaneous Field of View
MCBB	MOPITT Calibration Blackbody
MCIRS	MOPITT Collimator IR Source
MCS	MOPITT Collimator System
MFBB	MOPITT Flight Blackbody
MGC	MOPITT Gas Cell
MLI	Multi Layer Insulation
MM	MOPITT Monochromator
MMIRS	MOPITT Monochromator IR Source
MOPITT	Measurement Of Pollution In The Troposphere
MSBB	MOPITT Space View Blackbody
MSPB	MOPITT Stray Plate and Baffle
MSRS	MOPITT Solar Reflected Simulator
N_2	Nitrogen
NCR	Non Conformance Report
NER	Noise Equivalent Radiance
NIST	National Institute of Standards Technology
PRT	Platinium Resistor Thermometers
QI	Quartz Iodine
RGA	Residual Gas Analyser
SCC	Stirling Cycle Cooler
TBC	To Be Confirmed
TBD	To be Deteremined

Fig 5.3.1a Channel 5 (CO Thermal) Response

Figure 5.3.1b Channel 6 (CO Solar) Response

Figure 5.3.2 Channel 5 and 6 AV/DIFF NER

Figure 5.3.3 Channel 5 FPA Temp NER

Figure 5.3.4 Channel 5 Baseplate
Temperature Sensitivity Effects