Date: Mon, 12 Feb 1996 18:38:37 +0000 (GMT)
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Subject: Report on Feb. 2nd meeting and request for action
X-Info: Space Science Department, CCLRC

To: Len Culhane
Walter Gear - please pass on to Peter Hastings
Ian Furniss
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Roger Emery
Ken King
Peter Ade
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Gary Davis

From: Matt Griffin

Below is a draft summary (still to be agreed with Jean-Michel) of the Feb. 2nd meeting.

It is being proposed that a Payload Working Group meeting (perhaps augmented by one or two extra people per instrument if appropriate) be held at ESTEC around March 11th to report on the refinement of the instrument concept and the initil results of the various studies planned at the Feb. 2nd meeting, which will hopefully have produced some initial results or conclusions by then.

The main emphasis should be on identifying any significant problems or essential design modifications that would have an impact on the current industrial studies:

e.g.:
* F-P and filter combination optimisation for the required spectral performance and throughput.
* Support of the 4-K box; requirement for launch-lock devices; credible thermally conducted heat-load from 23 K to 4 K.
* Engineering of wheel mechanisms for low mass, low power.

The more progress we can make on such issues the better at this stage.

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SUMMARY OF FIRST BOLOMETER INSTRUMENT MEETING AT ESTEC
FRIDAY FEB. 2nd 1996

Matt Griffin, 11th Jan. 1996

INTRODUCTION

The purpose of this informal meeting was to introduce the current model payload instrument to a wider community of European instrumentalists, to invite comments and criticism, to identify key issues which are in need of more detailed design effort or experimental development, and to commence such work in order to refine the current design. In the current circumstances, it was recognised that the most urgent technical issues to be addressed were those which might have an impact at system level.

The meeting was attended by 26 people (see attached list). Short presentations and discussions were held on some of the key topics, and specialist splinter meetings were held to discuss some specific issues and formulate plans for future work.

SUMMARY OF MEETING FORMAT

In the morning there were short presentations on several topics followed by discussions:

Introduction	(Griffin, Lamarre)
Bolometers:	
LETI bolometer array development programme	(Vigroux)
Spider-web bolometers	(Bock - pres. by Lamarre)
SCUBA experience	(Gear)

Cooling:

Dilution refrigerator	(Benoit)
Adiabatic Demagnetisation	(Hepburn)
Adsorption Coolers	(Ravex)
High-resolution thermometry	(Duncan)

In the afternoon, parallel splinter meetings were held on the following topics:

- Fabry Perot systems
- Mechanisms and thermal/structural issues
- Bolometers and cryogenics

In addition, a presentation was made by H Schaap and P Estaria on the question of accurate definition of the operations and interface requirements for the purposes of the spacecraft studies.

SUMMARIES OF PRESENTATIONS

Note: These are condensed summaries, intended just to record some of the main points made in these informal presentations and in the ensuing discussions. They are not necessarily complete or fully accurate.

1. LETI/CEA bolometer array development (Vigroux)

* The aim of this programme is to fabricate bolometer arrays using established Si micro-machining technology which will meet the FIRST sensitivity requirements, and be compatible with operation as ••"CC-type"arrays without an individual feed element for each pixel, over-sampling the Airy disk.

* Cold readout electronics are an integral part of the system.

* Extensive simulation and modelling of the optical performance has been done, showing that good absorption efficiency can be achieved over a broad range of wavelengths.

* Important milestones to be achieved are the development of a low-noise thermometer and demonstration of the optical performance over the FIRST wavelength range. It is hoped to build a prototype array within two years.

2. Spider-web bolometers (Lamarre)

Lamarre presented a set of viewgraphs sent by Jamie Bock of JPL, who was unfortunately unable to attend. These summarised the current achievements in this state-of-the-art technology, which, with some foreseeable development, should be able to meet the most important FIRST performance requirements (NEP, speed of response, operating temperature, etc.)

* It is possible that the FIRST sensitivity requirement could be met at a temperature considerable higher than 100 mK.

* The structure is inherently insensitive to vibration and cosmic ray impacts.

* 1/f noise is negligible.

* The devices are highly reproducible.

3. SCUBA experience (Gear)

Gear outlined the most important lessons learnt during development and manufacture of the SCUBA instrument for the JCMT:

* Large-format bolometer arrays (> 100 detectors) can be made with good yield and uniformity with NTD Ge bolometers.

* In operation, active temperature control is not required (at least when the cooling power is as great as it is in the case of SCUBA).

* In practice, it is found that the bolometer operating temperature is greater than the nominal base temperature. If this is a general phenomenon, it means that one must "over-design" by allowing for more cooling than is theoretically required.

* Microphonic noise is a potentially big problem, and is mainly due to the

"capacitative microphone" efft.

* Electromagnetic interference can be beaten by "brute-force" - heavy RF filtering of all lines going into and out of the cryostat.

* Data acquisition and reduction and instrument operating modes are inter-related and can be complex in practice. Such issues need careful thought at an early stage.

* Careful design of the front-end electronics and wiring scheme is needed to minimise inter-pixel crosstalk.

4. Dilution refrigeration (Benoit)

* The dilution system has been successfully operated on ground-based telescopes as apart of the continuing DIABOLO programme.

* The cooling power can be substantially higher than 100 nW if the operating temperature is greater than 100 mK.

* Careful precautions against blockages due to hydrogen outgassing from the capillaries will be needed in a space environment.

* In flight, it would be possible to schedule the bolometer in such a way that it is switched off for long periods. The gas flow rate can be reduced to 10% of the normal value for long periods during which the instrument will be effectively dormant (with minimal consumption of the consumable gases). This could be useful in extending the active lifetime of the instrument.

* At present, the storage tanks are not qualified for operation at the outside temperature of the cryostat CVV (about 100 K). The technical and cost implications of this must be studied.

5. Adiabatic demagnetisation (Hepburn)

An ESA funded project is underway to at MSSL to develop an ADR system with the following features:

* 2-microwatt cooling power at 100 mK
* 50 mK - 1 K operating range, operating from 4.3 K
* 1-Tesla magnetic field
* Zero-field at the detector position
* Mass 5-6 kg at 4.3 K
* 2-3 mW dissipation at 4.3 K

A laboratory version will be made by the end of 1996.

6. Adsorption coolers

Re-cyclable He-3 adsorption cooler systems are capable of achieving 300 mK with a single-stage system or less than 250 mK with a two-stage system. Such a system might be an option for FIRST if the required operating temperature for the detectors is increased. The impact on the cryocooler heat-lift capacity or the cryostat lifetime can be quantified.

7. High-resolution thermometry (Duncan)

Highly sensitive SQUID-based paramagnetic susceptibility sensors with will be used for the DYNAMX experiment to be flown on the Space Shuttle. This technology is speculative when it comes to applications in submillimetre photometry, but offers the possibility of operation at a much more convenient temperature (around 2 K). There are plans to investigate the applicability of the technique to astronomical bolometry. Any performance demonstration giving results compatible with the FIRST requirements would be potentially very interesting.

SUMMARY REPORTS FROM THE SPLINTER GROUPS

1. Fabry-Perots

The current F-P design was seen to be sound in principle. To study in detail the feasibility of the current model payload design, and optimise it for the scientific and technical requirements, the following issues will be studied:

* Assessment of order-sorting and transmission efficiency requirements with realistic F-P performance figures

* Feasibility of larger clear aperture (> 60 mm)
* Improved mesh design for reduced absorption and easier mounting
* Digital F-P servo
* An internal spectral source for F-P alignment
* Improved electrical contacts from fixed to moving elements
* Use of new materials for magnets
* Improved mesh mounting and flatness
* Assessment of stray-light problems with 3-element F-P/filter combination
* Reliability analysis to identify critical areas

A preliminary design study will be carried out by UCL (Furniss), MSSL (Culhane), IAS (Pajot), RAL (Emery) and the University of Saskatchewan (Davis)

2. Mechanisms and Structure

The bolometer instrument mechanisms must be optimised for low mass and power dissipation and high reliability. Important considerations are:

Mechanisms:

* Minimisation of number and complexity of mechanisms
* Use of superconducting motor coils to minimise dissipation
* Reduction of motor speed to minimise instantaneous power dissipation
* Mechanical step-scanning of the F-P

Structure:

* Use of launch-lock devices to enable design for about 5g rather than several tens of g
* Achievable thermal loads (especially on the 4-K and 20-K levels)
* In-orbit resonant frequencies
* Optimum support materials
* Use of mono-filament or multiple-filament fibres
* Trade-offs and compromises involving thermal loads, supported mass and tolerable vibration levels and frequencies

These questions will be investigated by ROE (Hastings) and MSSL (Sheather, Hepburn)

3. Bolometers and cryogenics

Bolometer technology:

* Currently, the best available detectors are NTD "spider-webbolometers made by the Caltech/JPL group. With some development, these should be able to meet the FIRST performance goals, with the possibility of operation at somewhat higher temperature than the nominal 100 mK. This technology should be adopted as the base-line for FIRST.

* However, other possibilities, such as the planar bolometer arrays and cold readout electronics being developed by LETI, and the hybrid arrays developed by the Kreysa group have potential advantages, and should be developed in parallel. QMW will provide LETI (Vigroux) with typical parameters for a conventional bolometer to assist in analysis of whether the LETI cold electronics readout development programme could be applied to conventional bolometers.

* Since bolometer technology is a rapidly evolving field, the issue should be kept open, so that advantage can be taken of the most up-to-date developments. At this stage, the design of the BOL instrument should be made as flexible as possible to take advantage of the best bolometer technology available.

* If larger bolometer arrays can be developed, then there may be some system impact in that more electrical connections to the cold FPU may be needed

* The current design involves splitting the short-wavelength array into two parts, one for spectroscopy and one for photometry, because the large difference in thermal background (a factor of about 1000) between the two modes means that it is difficult or impossible to operate the same detector in either mode. While it is not considered likely, the possibility of doing both with one set of detectors will be investigated. QMW (Ade, Griffin) will look at theoretical feasibility of using one bolometer circuit to carry out observations in both spectroscopic and photometric modes.

Bolometer cooling:

* The Benoit dilution refrigerator should remain as the base-line cryogenic system to provide 100-mK cooling. However, the parallel development of other technologies such as ADR and adsorption refrigerators is to be encouraged, and their system implications (mass, power dissipation, integration, re-cycle time, reliability, safety, etc.) should be studied.

* 0.1 K should remain the base-line as this is required for spectroscopy. It may transpire that the scientific goals can be met with a higher operating temperature. This will make the instrument design and operation easier as the available cooling power from the dilution system will be greater.

Array feed optics:

* The instrument optical design will be driven by diffraction and its control

* Single-mode optics are favoured over multi-mode (although not unanimously) as the baseline, but more experimental data are needed to understand the pros and cons. The Bonn group are currently carrying out tests which may be relevant to this issue.

* The possibility of operating planar bolometer arrays with elements small enough to over-sample the diffraction disk should be considered. This will require the development of bolometer arrays which meet the basic sensitivity requirements, and demonstration that they can be operated in a representative optical system without being swamped by excessive background power. MPIfR (Gemund) to provide information on the results of single-mode optics testing currently being carried out by the Kreysa group.

ATTENDANCE

P Ade	QMW, London
Ph. Andre	SAp, Saclay
J-P Baluteau	LAS, Marseille
A Benoit	CRTBT, Grenoble
E Caux	CER, Toulouse
J-L Culhane	MSSL-UCL, London
R Duncan	Univ. New Mexico
R Emery RAl, Oxfordshire	
I Furniss	UCL, London
W Gear ROE, Edinburgh	
M Griffin	QMW, London
M Gemund	MPIfR, Bonn
P Hastings	ROE, Edinburgh
I Hepburn	MSSl-UCL, London
C Jewell	ESTEC
K King	RAL, Oxfordshire
J-M Lamarre	IAS, Orsay
M Mauron	CNRS, Montpellier
A Murray	QMW, London
F Pajot	IAS, Orsay
J-L Puget	IAS, Orsay
M Saisse	LAS, Marseille
P Sheather	MSSL-UCL, London
L Rodriguez	SAp, Saclay
G Ventura	Univ. Firenze
L Vigroux	SAp, Saclay