Minutes of 3rd SPIRE Bolometer Array Group Meeting NASA Goddard, September 17, 18 1998

Matt Griffin
6 October 1998

Note: 1. These minutes should be read in conjunction with the viewgraph package from the meeting, which contains most of the information.

2. The topics are ordered here as on the original agenda, not as actually presented at the meeting.

3. Actions are tabulated in Section 16.

4. Reports and action lists from three of the four splinter meetings have not yet been produced – they will be circulated when made available (splinter chairmen please note).

1 List of attendees

Peter Ade	QMW
Patrick Agnese	LETI
Bob Baker	GSFC
David Bergman	GSFC
Jamie Bock	JPL
Christophe Cara	CEA
Terry Cafferty	JPL
Colin Cunningham	UKATC
William Duncan	UKATC
Jason Glenn	Caltech.
Bill Gray	JPL
Matt Griffin	QMW
Erich Grossman	NIST
Hien Nguyen	JPL
Peter Hargrave	QMW
Ken King	RAL
Andrew Lange	Caltech
Bruno Maffei	QMW
Phil Mauskopf	Umass.
Harvey Moseley	GSFC
Christopher Paine	JPL
Carl Reintsema	NIST
Louis Rodriguez	CEA
Juan Roman	GSFC
Rick Shafer	GSFC
Bruce Swinyard	RAL
Anthony Turner	JPL
Laurent Vigroux	CEA

For contact details see viewgraph.

2 Review of SPIRE status and aims of meeting

Matt Griffin presented some introductory viewgraphs.

(a) The current status of FIRST

(i) The carrier option is now favoured by ESA, but budget problems remain for both the spacecraft and payload funding.

(ii) Confirmation of the mission implementation and payload approval is planned for early 1999.

(iii) European FIRST and Planck payload funding status was reviewed at a special meeting convened by ESA in July, and another such meeting is planned for October.

(b) The current status of SPIRE

(i) A double-FTS is being considered as an alternative to the classical Martin-Puplett FTS described in the SPIRE proposal. This would recover the 50% of the light lost at the input, but would involve increased mass and complexity. A decision will be made in January.

(ii) The wisdom of the choice of an imaging FTS for SPIRE has not been endorsed by the FIRST Mission Scientists.

(iii) The critical Structure and Systems Engineering work-packages are currently unfunded in the UK. The funding status of SPIRE in the UK will be clarified by the time of the October payload funding meeting.

(iv) The first technical meeting between SPIRE and ESA took place on July 29, and generated many actions on SPIRE, most of which have to be completed by October 10.

(v) The SPIRE project is now formally established, and the lines of communication and reporting must also become more formal.

(c) The main aims of this meeting

(i) Review the schedule and requirements for SPIRE detector array selection and qualification.

(ii) Establish the system design for each option.

(iii) Plan the testing and evaluation programme.

(iv) Review progress on array development since the Saclay meeting in May.

(v) Mid-term assessment of how well the array programme is going: are we being realistic?

The emphasis is very much on making it clear that array selection requires more than proof of detector performance – because of the short time available between selection and CQM manufacture, thorough systems designs and qualification programmes and credible fabrication schedules must be available for all of the options so that the chosen one can be rapidly implemented.

One of our most urgent needs is to produce first drafts of the systems design documents for the various

options. These should include all firm information currently available, and TBDs, TBCs and questions for SPIRE or for ESA as appropriate, so that problems can be identified and sorted out before it is too late. It is the responsibility of the array groups to ensure that they do not de-select themselves by failing to raise critical issues before it becomes too late for us to deal with them internally or in consultation with ESA.

3 Schedule for detector evaluation, SPIRE PDR, CDR and CQM

Ken King presented the current SPIRE schedule, which is driven by the delivery date for the PFM (mid. 2004).

ESA will issue the ITT to potential spacecraft contractors in October 1999 and will require that all major spacecraft interfaces are frozen about six months before then (or if there are options, their spacecraft interfaces must be separately detailed)

Although CQM deliver to ESA has been delayed until early 2003, this makes no difference to us as we have to build and test the CQM before starting PFM manufacture. This results in a very tight schedule for detector array selection and subsequent detailed instrument design. If there is any slip in the schedule in the future (e.g., from a delay in the PFM delivery date) this will not be used to defer detector selection.

The schedule for Systems Design requires that the first draft of the Scientific Requirements Document be produced in the very near future, for which the Project Scientists are responsible. In particular, the decision on the FTS choice in January requires it.

A detector selection plan must be produced and available for ESA endorsement by the time of payload approval in early 1999.

4 Actions from the Saclay meeting

Bruce Swinyard reviewed the status of actions from the Saclay meeting. An up-to-date summary is given in section 16 below, together with a summary of new actions arising from this meeting.

5 Qualification programme

Bruce Swinyard presented the requirements and schedule for qualifying the detector arrays for SPIRE. This is a critical requirement for selection, and the schedule is worryingly optimistic. It is vital to carry out as much of the qualification work as possible before array selection.

See the viewgraphs for more details.

6 Systems design and array interface specifications

6.1 TES-Pop-up option

Mechanical design (Michael Amato):

The detector mechanical assembly and mounting scheme will be based on the design for the SOFIA HAWC instrument. It can be adapted for SPIRE, and it should be possible to accommodate it within the existing envelope (perhaps even a bit smaller).

It was agreed that the structure as presented could be employed for the purposes of array selection tests. A detailed description of the proposed design for SPIRE will have to be made available at the same time. Some characteristics (e.g. volume envelope, mass, connectors) need to be defined much earlier.

It may also be feasible (and would be highly desirable) to use a near-identical structure for the feed-horn option.

Some concerns were raised about the light tightness of the back of the assembly.

Electronics design (Bob Baker and David Bergman):

Important points which will need to be addressed are the readout rate, power dissipation and whether the electronics can be built with approved components. These questions need to be addressed as soon as possible, through provision of a first draft systems design document.

For the purposes of selection, the readout must be representative in that it should faithfully represent the impact, if any, of the readout on overall sensitivity and performance. Whatever is proposed for the flight instrument must at the same time be fully described in the systems design document.

6.2 Feed-horn option (Jamie Bock)

There are good prospects for employing the same basic mechanical configuration for either the TES pop-up or feed-horn options, and this will be investigated further by Goddard and JPL

It may be possible to bend the leadout wires into the perpendicular plane to reduce the area taken up by an array.

The noise specification form the JFETs is not very stringent because the detectors will be strongly photon noise limited (~ 20 nV Hz^{-1} for 5 MΩ operating resistance)
Considerable progress has been made on the FET box design since the last meeting, and a scheme for mounting the FETs on a silicon nitride membrane is being examined, which could provide a large reduction in the heat loads. It may be possible to avoid having any connection to the 30-K shield, which would greatly simplify the interface with ESA. The viability of this concept is still to be demonstrated in practice, so we should not rely on it too much at this stage. An outline design (summary of mechanical an thermal properties) will be prepared for ESA including both options will be provided to ESA for their comments.

It is important to examine the constraints on the number of detectors that can be fitted into the focal plane in the case of the feed-horn option. It may be feasible to enhance mapping speed by using more of the focal plane area. Using dc-stable detectors (little or no 1/f down to ~ 30 mHz) slow scanning modes (either using the telescope or the SPIRE chopper) could be used to modulate the signal.

Data rate and FPU mass should not be a problem – the limit may be set by the number of wires and connectors. This should be included as questions in the first-draft systems design document.

RF filtering is regarded as a potential problem, and an RF filter box (inactive) should be baselined for location at the outside of the CVV feedthrough (mechanically similar to the BAU for the CEA option, but with zero internal dissipation).

The first-cut electronics design incorporates 18-bit resolution, which is not feasible with current standard components. It is desirable that a baseline be identified which is consistent with current ESA requirements. At a later stage, it can be enhanced depending on what we are allowed to fly. The requirements on SPU memory and processing power should also be estimated.

6.3 CEA arrays (Louis Rodriguez)

This presentation included an update on technical progress since the last meeting (item 8). Measurements on absorption efficiency and bolometer characteristics were reported (see viewgraphs for details), Some problems have arisen with the grid structure, the implanted thermistors and power dissipation per array.

The combination of $R > 10^{10}\ \Omega$ and $C \sim 3$ pF results in a time constant of > 30 ms (< 5.3 Hz). Assuming that this time constant dominates the speed of response requirement (switching transients in multiplexing may also need to be considered), this is consistent with the photometer specification but may require the FTS drive to be slowed down. It was agreed that the combination of bolometer resistance, preamplifier noise and input capacitance needs to be carefully optimised for the CEA option.

While the thermal load does not need to be in spec. for the array evaluation tests, the proposed flight system must be demonstrated in a separate experiment to meet the allowed load.

The internal time constant of the absorber might influence the limiting speed of response, and should be calculated in a manner similar to what Jamie Bock has done for the spider-webs.

6.4 Summary of progress on systems designs and interface specifications (Bruce Swinyard)

See viewgraphs.

7 Evaluation criteria and plan for future meeting schedule (Matt Griffin)

A brief summary of the evaluation criteria was presented, based on the draft note circulated before the meeting (and attached to these minutes).

In discussion, it was agreed that the required array performance should be assessed by a complete analysis of the scientific performance of the arrays in the SPIRE instrument, with observing/mapping speed for faint point-like objects being the main figure of merit. Placing requirements on the detector parameters will not be enough. The response of the whole system must be modelled through simulations of SPIRE observations, adopting an approach similar to the one used in the note by Aussel, Vigroux and André on *Confusion noise in SPIRE surveys* (attached to these minutes). The splinter group on sensitivity (Splinter Meeting 2) would make a start on this.

Future meeting schedule (viewgraph is now out of date):

January 1999	QMW	Dates: Jan. 21, 22
May 1999	Caltech	
September 1999	Saclay	
January 2000	RAL (formal selection meeting: full documentation to be provided by mid-Dec. 99)	

The main aims of the January meeting will be:

(i) review and planning of the array testing programme;

(ii) review of the array selection criteria based on simulations of SPIRE observations for the various options;

(iii) review of the systems design documents for the various options and identification of further work needed before PDR. (Comment: it is assumed that these documents will be in a fairly mature state by January. An option for which this is not the case cannot be regarded as a serious candidate for selection.)

8 Array development progress reports

8.1 TES pop-up arrays (Harvey Moseley)

This report covered

- Detector electronics
- Test cryostat
- Mechanical design
- Squid multiplexer
- Detector tests
- Schedule for October - December

See viewgraphs for full details

8.2 Feed-horn arrays (Jamie Bock)

This report covered

- Problems encountered with Al/Ag film (degradation due to heating above 100 ^{o}C during sensor manufacture
- Results of measurements on TES sensors with Ti films
- Array design and development for feed-horn + NTD Ge option
- Related development of BOLOCAM
- Procurement and plans for the SPIRE test dewar

See viewgraphs for full details

8.3 CEA arrays (Louis Rodriguez)

See item 6.3.

9 BACUS status and array test plan (Peter Hargrave)

This report covered

- Design of BACUS module
- Cryogenics
- Optics
- Illuminators
- Connectors
- Summary of BACUS capabilities
- BACUS schedule

- Array test schedule

See viewgraphs for full details.

Note: The schedule and array test plan and schedule were discussed in the splinter meeting on the following day - see report below.

10 Presentations on technical issues

10.1 TES detector optimisation for SPIRE (Matt Griffin)

This presentation was a summary of the note *Specifications for TES-ETF bolometers for SPIRE* (SPIRE/QMW/NOTE/0043.20) by Matt Griffin and Peter Hargrave. The main conclusion, that for TES bolometers the thermal noise NEP should be designed to be around half of the photon noise limited NEP, was in agreement with the assessment of the Goddard/NIST team.

The need for having a cold shutter ($\leq$ 4 K) in SPIRE was also discussed. It was concluded that this would be highly desirable and possibly essential for ground testing at spacecraft level, given that the background level in the cryostat would be far higher than in orbit.

10.2 Simulations of SPIRE observations (Laurent Vigroux)

This presentation summarised the methods and initial results of the Saclay group study of simulated SPIRE deep survey observations and the relative performance of the different array options in terms of faint point source detection in a crowded field (Aussel *et al*., attached).

It was agreed that this approach was the correct one for evaluating array performance. Various technicalities about the assumptions and methods should be discussed and agreed.

See the report on the Splinter Meeting 2.

11 Discussion following day 1
12 Summary of day 1

Due to pressure of time, these were conducted over drinks and dinner. Many wise and insightful things were said but nobody was taking notes.

13 Agenda review
14 Splinter meeting organisation

The four splinter meetings identified on the original agenda were retained.

15 Reports from splinter meetings

15.1 Array test programme (Peter Hargrave)

- 3 x BACUS scenario agreed (QMW/GSFC/JPL)
  - QMW to supply drawings & filters
  - RAL may supply some engineering effort

- Schedule: See revised schedule below
  - CEA prototype to QMW Oct. '98 for optical tests - retain 1 He-3 fridge (GSFC or JPL) until Jan. '99 for this purpose.
  - CEA iterative tests through '99.
  - NTD pixel to QMW early Dec. to characterise BACUS stray light environment.
  - Jan. - Feb. BACUS testing (QMW)
  - US BACUS modules to QMW Feb. '99 for verification.
  - Single pixel TES from JPL/CALTECH end '98
  - Expecting final arrays from all providers at QMW between Aug. '99 and Nov. '99
    - Phased delivery of US dewars in Sept. '99 and Oct. '99 - GSFC and JPL/CALTECH to decide between themselves who will have which delivery date.
    - Array groups to supply additional staff effort during QMW tests

- Interfaces/Tests: to be defined via template document between QMW and array providers within 1 month of Goddard meeting

List of actions arising from array test programme splinter:

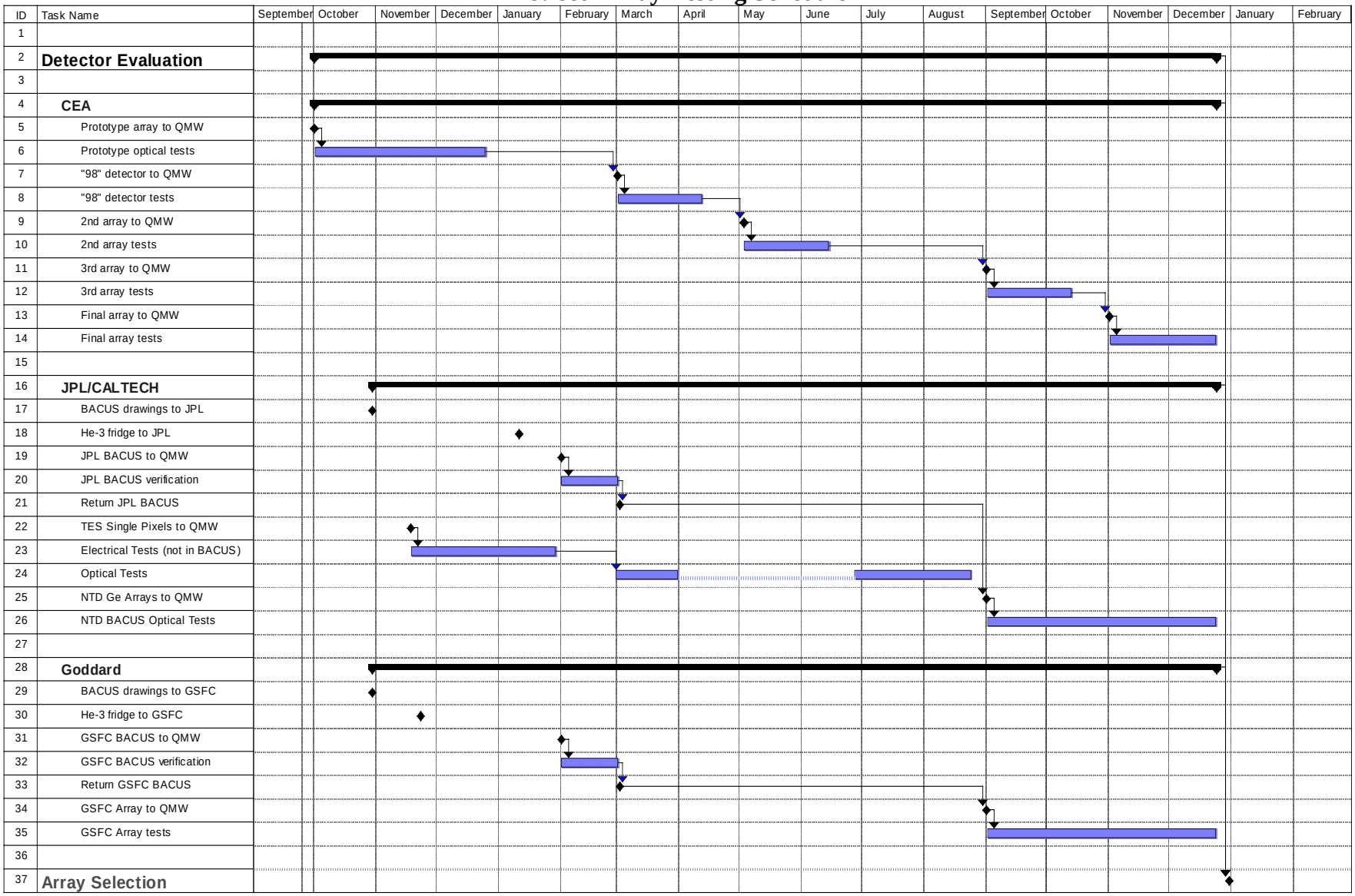
- QMW
  - supply BACUS drawings to GSFC and JPL/CALTECH (Oct. 23)
  - distribute interface/test document (Oct. 23)
  - QMW/RAL to perform stray light/baffling analysis on BACUS module
  - complete FIR illuminator tests (Oct. 23)

- CEA
  - supply prototype to QMW for optical tests Oct. '98
  - '98 detector to QMW March '99
  - next array to QMW May '99
  - next array to QMW Sept '99
  - final array ready for QMW tests Nov. '99

- GSFC
  - build GSFC BACUS and deliver to QMW for verification by Feb. '99
  - deliver final array in test dewar to QMW Sept./Oct. '99
  - supply illuminator modules for all three BACUS modules by Jan. '99

- JPL/CALTECH
  - TES single pixel to QMW mid November '98
  - NTD pixel to QMW early Dec. '98 for BACUS testing
  - build JPL BACUS and deliver to QMW for verification by Feb. '99
  - deliver final array in test dewar to QMW Sept./Oct. '99

Revised Array Testing Schedule



15.2 Array sensitivity and operating modes (Laurent Vigroux)

To follow.

15.3 Feedhorn option (Jamie Bock)

To follow.

15.4 Front-end electronics for US options (Louis Rodriguez)

To follow.

16 Summary of actions

The tables below show the status of actions from the previous meeting at Saclay and from this meeting. Actions which are closed or have been superseded are in the lighter typeface.

Summary of actions from Saclay meeting May 28, 29 1998				
No.	**Action**	**Responsible**	**Deadline**	**Status**
1	Provide template document describing common 2-K interface and circulate to the array groups for completion.	Swinyard	June 30	Closed (issued Aug. 28)
2	Provide detailed description of cryoharness for SQUID/TES options (detail required as in the IID-B).	Moseley, Bock	June 30	Superseded by Action TBD.
3	Co-ordinate further study of capabilities of filled and feed-horn arrays, especially for point source extraction (report to be presented at next meeting).	Gear	Sept. 17	Superseded by establishment of SPIRE Observations Sensitivity Group chaired by Laurent Vigroux
4	Define power and mass budgets for warm electronics and produce base-line functional description.	Rodriguez, Moseley, Bock	June 30	Superseded by Action TBD.
5	Define all the mechanical, electrical and thermal interfaces for BACUS	Maffei, Hargrave, array groups	July	Closed
6	Define detailed test plan for technology evaluation.	Maffei, Hargrave, array groups	Sept. 17	Superseded by Action TBD on Ken King to produce test plan
7	Send to Kent Irwin the details of the temperatures of the SPIRE interfaces with the FIRST cryostat	Griffin	July	Closed: as reported at meeting with ESTEC on July 29, Collaudin and Passvogel paper has latest available information from ESA (but these are not definitive numbers).
8	Specify ^{3}He cold stage temperature requirements for SPIRE and BACUS.	Rodriguez, Moseley, Bock	July	Open. Revised deadline October 7.
9	Specify which FPGA is being considered for the Goddard array control and readout electronics.	Moseley	June 30	Superseded by Action TBD.
10	Define how and by whom the back-up option will be developed in the US (using BOLOCAM and Planck design concepts where possible).	Moseley, Lange	Sept. 17	Superseded by actions from Feedhorn Option splinter meeting.
11	Define a draft schedule for future Array Group meetings, including formal selection meeting.	Griffin	Sept. 17	Closed.
12	Define the quantitative performance requirements and the make-up of the array selection team.	Griffin	Sept. 17	Superseded by action 24
13	Provide monthly reports on progress on the development programme to Matt Griffin, copied to Ken King	Rodriguez, Moseley, Bock, Hargrave	End of each month	Continuing. Future reports should include technical and schedule information separately.

Summary of actions from Goddard meeting, Sept. 17, 18 1998				
No.	**Action**	**Responsible**	**Deadline**	**Status**
14	Remind Project Scientists of urgent need for scientific specifications document	King	Sept. 25	Closed (E-mail of Sept. 23)
15	Produce draft array selection plan	King	Oct. 10	Open
16	Define ^{3}He fridge stability requirements for BACUS	Hargrave		Open
17	Attach the list of test that ESA will carry out on the various instrument models to minutes of this meeting	Griffin	Sept. 28	Closed (see viewgraph package)
18	Provide summary of FET box options to Thomas Passvogel based on input from Jamie Bock	Cunningham	Sept. 28	Open (deferred to Oct. 9)
19	Circulate expanded Interface Specification document template to include warm electronics, and re-name Systems Design Document	Swinyard	Sept. 25	Closed (E-mail of 24 Sept.)
20	Provide first-draft of Systems Design Document	Bock, Moseley, Rodriguez	Oct. 7	Open
21	Provide recommended volume envelope for detector arrays	Swinyard	Sept. 29	Open
22	Provide document describing proposed Spanish SPU capabilities to Caltech and Goddard	Swinyard	Sept. 25	Closed (E-mail of Sept. 24)
23	Provide written comments on existing draft of array selection criteria document to Matt Griffin	All	Oct. 30	Open
24	Revise array selection criteria document	Griffin	Nov. 13	Open
25	Ask Lionel Duband to provide cooling power vs. temperature curve for baseline ^{3}He fridge	Swinyard		Open
26	Copy ESA's Rosetta Parts List to array groups	King	Oct. 7	Closed
27	Define limiting resource dictating maximum permitted number of detectors in the focal plane for feedhorn option	Systems team	Nov. 13	Open
28	Investigate creation of new SPIRE workpackage for a cold shutter	Griffin	Oct. 9	Open
29	Array splinter meeting actions	QMW, CEA, GSFC, Caltech/JPL	Various	To be monitored through monthly progress reports and reviewed at January meeting

17 Summary of the meeting (Griffin)

Below are some comments (written after the meeting) assessing the outcome of the meeting with respect to the aims.

(i) Review the schedule and requirements for SPIRE detector array selection and qualification.

Success: all groups should now have a good understanding of what work needs to be done to meet the schedule.

(ii) Establish the system design for each option.

Very limited success: first draft system design documents have yet to be produced and are urgently needed and must be turned into comprehensive and detailed designs in the coming months.

(iii) Plan the testing and evaluation programme.

Limited success: The programme has been specified in more detail but there are still many uncertainties and potential problems with the success-orientated schedule particularly the fact that the evaluation tests for all of the options are scheduled so late in the programme.

(iv) Review progress on array development since the Saclay meeting in May.

Success: Progress has been reviewed.

(v) Mid-term assessment of how well the array programme is going: are we being realistic?

Success: it is now clear that an enormous amount of work needs to be done to fulfil the aims of this array programme. At present it is barely realistic, and any serious delays from now on will make it infeasible.

- Array development: good progress is being made in the lab., but not always as quickly as one would like.
- Systems designs: progress has been much too slow up to now and this must be rectified well before the time of the next meeting.
- Array test and evaluation schedule: this is very tight, and there are worries that the options will not have been properly developed and tested by the time of selection. In these circumstances, the only realistic choice will be to select the most conservative option.