Detector array selection criteria for SPIRE

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1. Array selection requirements

1.1 Consortium requirements

R1 The consortium must have complete confidence that the chosen option can be successfully implemented in SPIRE to specification and within the schedule.

R2 The CEA option will be chosen if it meets the specification, is equivalent or nearly equivalent in mapping speed to the best of the others, and if there are no fundamental problems with its implementation.

R3 The feedhorn option, being the only one based on proven technology, should be selectable (i.e., be developed to have a design consistent with the instrument and spacecraft requirements) by the time of selection. This does not convey any favoured status on this option, but merely states that at least one viable option must be available at the time of selection.

R4 A US option, if chosen, shall be fully funded by NASA.

R5 The warm analogue electronics will be built by CEA for whatever option is chosen (the exact division of responsibilities and work breakdown structure will need to be clarified).

R6 In the event of none of the options having been shown to meet the requirements at the time of selection, a way forward shall be defined by the selection panel based on the goal of meeting R1 above.

1.2 Performance evaluation requirements

R7 Array prototypes or equivalent devices shall undergo testing in the laboratory prior to selection to determine performance parameters. The arrays and associated system and sub-system design should meet the requirements given in the *SPIRE Instrument Requirements Document*. These performance requirements refer to the operating background power and bath temperature for SPIRE. Actual measurements shall be made under conditions as similar as possible similar to those given below, but not necessarily identical, provided that extrapolation of the results to the nominal conditions is straightforward and uncontroversial.

Nominal operating conditions		
Bath temperature (mK)	300	
Central wavelength (μm)	350	
$\lambda/\Delta\lambda$	3	
Incident background power (pW) (a)	0.5Fλ filled array: 2Fλ feedhorn:	1.3 6.7
Ideal photon noise NEP for (W $Hz^{-1/2}$) (b)	Filled array: 2Fλfeedhorn:	3.9×10^{-17} 8.7×10^{-17}

Requirements on measured performance to meet the SPIRE specification		
Detective Quantum Efficiency at 5 Hz (c)	Feedhorn arrays:	> 0.6
	Filled arrays:	> 0.6/α (d) (α = 3 TBC)
3-dB freq. of responsivity roll-off (e)	≥ 20 Hz	
Yield (good pixels) (f)	> 50% (for demonstration arrays only)	

Notes: (a) Background power is calculated assuming a throughput of λ^2 for 2.0Fλ feedhorns and $0.2\lambda^2$ for 0.5Fλ square pixels.

(b) This is the NEP for a noiseless detector of unit quantum efficiency.

(c) Detective Quantum Efficiency is defined as: $\mathrm{DQE} = \left[\frac{\text{Ideal NEP}}{\text{Measured NEP}}\right]^2$.

Mapping speed scales with DQE.

(d) The SPIRE sensitivity specification is based on the feedhorn option. The factor α represents the ideal improvement in mapping speed expected through more efficient use of the focal plane area with filled arrays rather than feedhorn arrays. The nominal values of α are 2.4 at 250 μm and 2.9 at 500 μm (*Comparison of sensitivities of 0.5F l, 1.0F l and 2.0F l arrays for the BOL* by Matt Griffin, Jamie Bock and Walter Gear; BOL/QMW/N/ 0026 .10, Dec. 1997). A value for 350 μm has not been calculated, but will be intermediate, so a nominal value of 2.7 should be assumed. These values of α are TBC and will be refined through more detailed calculations and incorporation of detailed pixel filling factors.

(e) This is set by the FTS mirror scan speed.

(f) A pixel yield of 90% or more is required for the flight arrays, and a reliable means of achieving this shall be identified at the time of selection.

R8 Other important array parameters which shall be taken into account for selection include:

(i) uniformity across the array (NEP, responsivity, time constant, optimum bias, etc.);
(ii) pixel angular response (which determines vulnerability to stray radiation);
(iii) susceptibility to microphonic noise, electromagnetic interference and electrostatic discharge;
(iv) ionising radiation cross section and transient response to ionising events;
(v) electrical crosstalk (especially between non-adjacent detectors);
(vi) ageing effects;
(vii) ability to withstand multiple thermal cycling.

R9 The selection shall be based on measurements to be made at QMW on arrays optimised for the SPIRE 350 μm band and, if necessary, reliable and convincing extrapolations of the test results to other SPIRE wavelengths. Measurements made at the array groups' laboratories shall also be taken into account, but it is expected that critical performance parameters (especially NEP and speed of response) shall be demonstrated in tests at QMW.

R10 All other available relevant information will also be taken into account. Such information shall include:

(i) simulations of the performance of filled array and feed-horn array detectors in the SPIRE instrument for confusion-limited deep imaging surveys;
(ii) stray light modelling of the SPIRE instrument.

1.3 Schedule and qualification programme requirements

R11 A full system design document shall be available, compliant with spacecraft resources and IID-A requirements, and the option shall have successfully undergone the Preliminary Design Review in September 1999.

R12 An array fabrication, test and delivery schedule shall be provided which is consistent with the SPIRE project schedule, and which is realistic given the necessary technical activities and the resources available to perform them. This shall extend at least to the end of CQM manufacture, and shall include the warm readout electronics.

R13 A credible space qualification programme and schedule for qualification shall be provided which is consistent with the ESA requirements and with the SPIRE schedule.

2. Major meeting schedule

Detector array group meeting	September 29/30	1999	Saclay
Warm Electronics Review	December 6, 7	1999	Rome
Formal selection meeting	Jan. 31/Feb. 1	2000	RAL

Full documentation for the array selection meeting is to be provided by mid-January 2000 (with minor updates at the meeting as necesssary).

3. Formal selection team

Participants:	All appropriate members of array providing and testing teams	
Team members:	Matt Griffin	PI
	Laurent Vigroux	Co-PI
	Ken King	Project Manager
	Bruce Swinyard	Instrument Scientist
	Jamie Bock	Caltech
	Harvey Moseley	Goddard
	Walter Gear	Project Scientist
	Jean-Paul Baluteau	Project Scientist
Possible invited advisers:	Göran Pilbratt	ESA Project Scientist
	Paul Harvey	Independent expert; FIRST Mission Scientist
	Eric Young	Independent expert
	Jean-Michel Lamarre	Independent expert; Planck HFI Instrument Scientist