SPIRE

SUBJECT: SPIRE Detector Selection Plan

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CSEC			
GSFC			
JPL			
SAp	•••••••		•••••



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Change Record

ISSUE DATE .01 11th September 1998 Initial Draft



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SPIRE Spectral and Photometric Imaging REceiver





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References

Applicable Documents

Reference Documents



1. INTRODUCTION

2. ARRAY DEVELOPMENT

2.1 CEA

2.1.1 Bolometer Development.

During the period 1997-8 bolometers are being developed using various manufacturing technologies, their properties are being measured and readout electronics tested. A summary of the progress so far is given below:

2.1.1.1 Bolometer Array Manufacture Technology

- (i) heritage of silicon micro sensor machining (CEA-LETI),
- (ii) indium bump hybridisation (ISOCAM LW detector array),
- (iii) and compensated implanted thermometers (CEA-DRFMC, and other groups).

2.1.1.2 Thermometer performances in the 300mK-1K range:

Measured on thick (450 μ m) substrate in 97, and on bolometer (5 μ m) in 1998, compatible with scientific requirements. New developments for thermometers planned for '99.

2.1.1.3 Thermal properties of bolometers at 300 mK:

- (i) **thermal conductance** of micronic silicon beams plus metallic contacts and passivation layer measured for different geometry.
- (ii) **Specific heat** of bolometer components measured to determine the sensor heat capacity.

2.1.1.4 Absorption of sub-millimetre waves:

- (i) **Physical properties** of envisaged metal absorber (TiN & WN) tested in final configuration at low temperature.
- (ii) **3D e-m code** predictions checked for optical structures close to final bolometer arrangement.

2.1.1.5 Read out and MUX scheme:

An original read out scheme for these non-conventional bolometers (very high impedance) is currently checked, the thermal impact has been measured. The main advantage is an easy multiplexing scheme.

All these results are used for the design (started March '98) and manufacture (started June '98) of new arrays (homogeneous pattern on 16 x16 pixels) with read out and MUX included, ready for SPIRE array evaluation process in fall 1999.

These inputs determine some pixel geometric constraint (thermal capacity, thermal conductance, size etc), other parameters like implantation dose or thermometer geometry are controlled by simultaneous manufacture of "splits". Improvements to the technology can occur in late steps of the process: metallization, passivation etc.



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2.1.2 Array Testing and Evaluation.

The main work during 98-99 on bolometer technology will be systematic testing of all the available arrays, differing from the metallic or absorption pattern, thermometer technology: mesa diffused or implanted thermometer, implantation density and geometry etc, to sort out the best specimen for evaluation process.

In parallel we started recently the mechanical and thermal interface design of the detector arrays. This design, made fairly complex by the geometrical constraints of the 300 mK vs. 2K structures and the very low heat load acceptable on the ³He fridge, is strongly dependent of the measurements made on physical thermal models. Most results are consequence of recent measurements. Thermal and mechanical design can now only be developed on the basis of known properties.

Finally, the readout scheme proposed is also highly dependent of the bolometer behaviour: the characteristics of the lock in circuit will be adjusted to actual properties of the arrays.

2.2 JPL

The intention is to fabricate, test and deliver prototype spider bolometer arrays to QMW for evaluation. Two types of bolometers will be provided: a single spider web bolometer with a transition edge superconducting (TES) thermistor, and an array of 141 elements of which 61 are connected to a JFET readout box. The latter array will consist of spider web bolometers with neutron transmutation doped (NTD) germanium thermistors. Provision has been made in the schedule for two fabrication and test cycles for each of these deliveries.

The NTD Ge array will be delivered to QMW in a test dewar with a ³He refrigerator and a BACUS calibrator. Tests will have been performed to demonstrate the performance of the array prior to delivery.

The dewar and array will be accompanied by a person to assist in performing validation testing at QMW prior to detector array selection.

The dewar, refrigerator and calibrator will be part of the same procurement as the units obtained by QMW for validation testing.

A system design of the detector array, readout electronics and warm electronics functionality will also be provided and the instrument PDR will be supported.

2.3 GSFC

TBW

3. ARRAY EVALUATION FACILITY

TBW

4. MEETINGS

TBW



5. WORK BREAKDOWN

WBS Index

WBS	Title	Responsible
	Pop-Up Detector Array Development	GSFC/NIST
	Pop-Up Detector Array System Design	GSFC
	Feedhorn Detector Arrays Development	JPL
	Feedhorn Detector Arrays System Design	JPL
	CEA Detector Arrays Selection	SAp
	CEA Detector Arrays System Design	SAp
	Array Evaluation	QMW



SPI	RE	Work Package Description	WP No:	
			Sheet:	1 of 1
	Title:	Pop-Up Detector Array Development	Issue:	.01 (draft)
			Date:	14 October 1998
St	art Event:			Assigned to
E	and Event:	Detector Selection		GSFC/NIST
Objectiv	es:			
Fabrication	of a 4x8 Pop-Up	Detector evaluation array evaluation with its mounting hardwar	re and readout of	electronics.
Test of the e	valuation array	prior to delivery to QMW for evaluation.		
Support the	performance va	lidation at QMW		
Task De	escription:			
1. Fabric	ation of a 4x8 P	op-Up Detector array		
3. Fabric	ation of SQUID	S and Interconnects		
4. Assem 5. Test o	f evaluation arra	n array ay		
6. Suppo	rt Detector perf	ormance validation at QMW		
Mileston	es:			
	Date	Description		
M01	26 Nov 98	He-3 refrigerator from QMW		
M02 M02	29 Jan 99 3 Feb 99	Calibration Module delivery form QMW Mounting hardware design ready		
M03	4 May 99	Mounting hardware available		
M04	10 May 99	1x 8 PUDs delivered to GSFC		
M05 M06	18 May 99 31 May 99	Fanouts delivered to GSFC Interconnects delivered to GSEC		
M07	18 Jun 99	Evaluation array assembled		
M08	2 Jun 99	Electrical System ready		
M09	6 Jul 99	Cryogenic Dewar System ready		
M10	1 Sep 99	Delivery of evaluation array to QMW		
Inputs:				
	Date	Item	From	
I01 I02	26 Nov 98 29 Jan 99	He-3 refrigerator Calibration Module	QMW OMW	
Outputs:				
	Date	Item	<u>To</u>	
O01	1 Sep 99	Evaluation Array	QMW	



SPIR	PE	Work Package Description	WP No:	
			Sheet:	1 of 1
	Title:	Pop-Up Detector Array System Design	Issue: Date:	.01 (draft) 14 October 1998
Star	rt Event:			Assigned to
En	d Event:	Preliminary Design review		SAp
Objectives	8:			
A system desig will be suppor	gn of the detected.	ctor array, readout electronics and warm electronics functionality	will be provide	d and the instrument PDR
Task Des	cription:			
1. Develop	design and p	repare PDR package		
Milestone	s:			
	Date	Description		
M01	18 Jun 99	Delivery of PDR Package		
Inputs:				
	Date	Item	<u>From</u>	
Outputs:				
	Date	Item	<u>To</u>	
O01	18 Jun 99	PDR Package	SPIRE Projec	t

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SPIRE	Work Package Description	WP No:				
		Sheet:	1 of 2			
Title•	Feedborn Detector Arrays Development	Issue:	.01 (draft)			
1100		Date:	14 October 1998			
Start Event:			Assigned to			
End Event:	Detector Selection		JPL			
Objectives:						
To fabricate, test and deliver prototype spider bolometer arrays to QMW for evaluation for use in the SPIRE instrument to be flown on the FIRST mission. Two types of bolometers will be provided: a single spider web bolometer with a transition edge superconducting (TES) thermistor, and an array of 141 elements of which 61 are connected to a JFET readout box. The latter array will consist of spider web bolometers with neutron transmutation doped (NTD) germanium thermistors. Provision has been made in the schedule for two fabrication and test cycles for each of these deliveries. The NTD Ge array will be delivered to QMW in a test dewar with a ³ He refrigerator and a BACUS calibrator. Tests will have been performed to demonstrate the performance of the array prior to delivery. The dewar and array will be accompanied by a person to assist in performing validation testing at QMW prior to detector array selection. The dewar, refrigerator and calibrator will be part of the same procurement as the units obtained by QMW for validation testing.						
Task Description:						
1. Fabricate, test and deliver a single TES spider Bolometer.						
2. Fabricate, test and demonstrate a 144-element NTD Ge BOLOCAM instrument operating at 1.3 μm.						

- 3. Fabricate, test and deliver a 144-element NTD Ge prototype SPIRE bolometer array with 61 elements connected to a JFET readout.
- 4. Support detector performance validation at QMW

Milestones:

Date	Description

M01	1 Oct 98	Order JFET
M02	14 Oct 98	Receive JFET dies
M03	16 Oct 98	Order Load Resistor Module
M04	30 Oct 98	Order Feedhorn Array Plates
M05	2 Nov 98	Ship Ti/Nb TES Bolometer #1 to QMW
M06	26 Nov 98	Receive Load Resistor Module
M07	15 Dec 98	Receive Test Dewar and Refridgerator
M08	15 Jan 99	Receive Feed horn Array Plates
M09	15 Jan 99	Receive Calibrator
M10	11 Feb 99	Ship Ti/Nb TES Bolometer #2 to QMW
M11	8 Jun 99	Deliver SPIRE 61-Element Array #1
M12	24 Aug 99	Deliver SPIRE 61-Element Array #2



SPIRE		Work Package Description	WP No:	
			Sheet:	2 01 2
	Title	Feedborn Detector Arrays Development	Issue:	.01 (draft)
	The.	reculoin Detector Arrays Development	Date:	14 October 1998
Inputs:				
	Date	Item	From	
I01	15 Dec 98	Test Dewar	Precision Cry	vogenics
102	26 Nov 98	³ He Refridgerator	QMW	-
103	29 Jan 99	Calibration Module	QMW	
Outputs:				
	Date	Item	<u>To</u>	
O01	11 Nov 98	Ti/Nb TES Bolometer #1 (option)	QMW	
O02	11 Feb 99	Ti/Nb TES Bolometer #2	QMW	
O03	8 Jun 99	NTD Ge Bolometer Array #1	QMW	
O04	24 Sep 99	NTD Ge Bolometer Array #2	QMW	



CDI		Work Poolson Description	WP No:	
SPI1	KE	work rackage Description	Sheet:	1 of 1
	T:4los	Foodhorn Arrays System Design	Issue:	.01 (draft)
	Thie:	reeditorii Arrays System Design	Date:	14 October 1998
Sta	art Event:			Assigned to
Е	nd Event:	Preliminary Design review		JPL
Objective	es:			
A system des will be suppo	sign of the deter orted.	ctor array, readout electronics and warm electronics functionality	will be provide	ed and the instrument PDR
Task De	escription:			
1. Develo	p design and p	repare PDR package		
Mileston	es:			
	Date	Description		
M01 M02 M03 M04 M05	7 Dec 98 1 Jan 99 14 Jan 99 14 Jan 99 18 Jun 99	Provide RF Shielding Requirements to QMW Provide preliminary Warm Electronics Requirements to SAp Provide Focal Plane Support Structure Design to QMW Receive revised RF Shielding requirements Delivery of PDR Package		
Inputs:				
	Date	Item	From	
I01	14 Jan 99	Revised RF Shielding Requirements	ESTEC	
Outputs:				
	Date	Item	<u>To</u>	
O01 O02 O03 O04	7 Dec 98 1 Jan 99 14 Jan 99 18 Jun 99	RF Shielding Requirements preliminary Warm Electronics Requirements Focal Plane Support Structure Design PDR Package	SPIRE Projec SAp QMW SPIRE Projec	ct



SPI	RF	Work Package Description	WP No:
			Sheet: 1 of 1
	Title	CEA Detector Arrays Selection	Issue: .01 (draft)
	T IIIC.	CENT Detector Annays beleation	Date: 14 October 1998
Sta	art Event:		Assigned to
E	nd Event:	Delivery of final evaluation array to QMW	SAp
Objective	es:		
To test the d pattern, then specimen for	etector arrays d mometer techno r further evaluat	elivered by LETI/SLIR by systematic testing of all the available ology (mesa diffused or implanted thermometer), implantation de ion.	arrays with differing metallic or absorption nsity and geometry etc, to sort out the best
To evaluate t bandpass) of cryostat (tod	the static optica f selected detect ay) or BACUS	l properties (response, noise density vs. background: NEP), and o or arrays. The tests will be carried out in the QMW laboratory or early 1999. Support will be provided to QMW during these tests	dynamic aspects (response time and total n dedicated evaluation devices: optical
Eventually o	ne array will be	selected for evaluation as part of the detector selection process	
Task De	escription:		
 Testing Develo Testing Support 	g of arrays opment of Acqu g at QMW and rt to Evaluation	isition interface and system Design of BACUS interface selection of evaluation array of the Arrays at QMW	
Mileston	es:		
	Date	Description	
M01 M02 M03 M04 M05 M06 M07 M08 M09	15 Oct 98 1 Jan 99 1 Mar 99 1 Mar 99 3 May 99 1 Jun 99 1 Jun 99 1 Jul 99 1 Sep 99	Delivery of prototype detector to QMW 1 st Receipt of prototype arrays from LETL/SLIR Ship 1 st evaluation array to QMW Delivery of Manual Switchbox to QMW 2 nd Receipt of prototype arrays from LETI/SLIR Ship 2 nd evaluation array to QMW Delivery of Acquisition System to QMW 3 rd Receipt of prototype arrays from LETI/SLIR Ship 3 rd evaluation array to QMW	
Inputs:			
	Date	Item	From
I01 I02 I03	1 Jan 99 3 May 99 1 Jul 99	1 st prototype arrays 2 nd prototype arrays 3 rd prototype arrays	LETI/SLIR LETI/SLIR LETI/SLIR
Outputs:			
	Date	Item	<u>To</u>
001 002 003 004 005 006	15 Oct 98 1 Mar 99 1 Mar 99 1 Jun 99 1 Jun 99 1 Sep 99	Prototype Detector 1 st Evaluation Array Manual Switchbox 2 nd Evaluation Array Acquisition System 3 rd Evaluation Array	QMW QMW QMW QMW QMW QMW



SPIRE	٦	Work Package Description	WP No:			
	4		Sheet:	1 of 1		
Т	Title:	CEA Detector Array System Design	Issue: Date:	.01 (draft) 14 October 1998		
Start Ev	vent:			Assigned to		
End Ev	vent:	Preliminary Design review		SAp		
Objectives:						
A system design of t will be supported.	the dete	ctor array, readout electronics and warm electronics functionality	will be provide	ed and the instrument PDR		
Task Descrip	tion:					
1. Develop desig	n and p	repare PDR package				
Milestones:						
	Date	Description				
M01 18 J	lun 99	Delivery of PDR Package				
Inputs:						
	Date	Item	From			
Outputs:						
	Date	Item	<u>To</u>			
O01 18 J	lun 99	PDR Package	SPIRE Projec	ct		



apr			WD No.	
SPI	RE	Work Package Description	WP NO:	
1			Sheet:	1 of 2
	Title	Array Evaluation Facility	Issue:	.01 (draft)
	1 1110.	Array Evaluation Facility	Date:	14 October 1998
Sta	art Event:			Assigned to
Б	nd Evont.	Detector Selection		QMW
E	nu Event:	Detector Selection		
Objective	es:			
QMW will d	lesign and man	ufacture a detector calibration/evaluation facility to validate the	performance cha	aracteristics of the JPL, GSFC
and Sap dete	ctor arrays. The	ese will be compared to the required performance criteria at a De	etector Selection	meeting
Task De	escription:			
1 Design	• of calibration/	evaluation facility		
2. Constr	uction of calibr	ation/evaluation facility		
3. Testing	g of calibration	evaluation facility		
4. Delive	ry of calibration	/evaluation facility "copies" to array providers		
5. Testing	g and evaluation	n of candidate array technologies		
0. F10VISI	ion of test repor	ts to consolitum/array selection team.		
Milaston	06:			
whieston	5.			
	Date	Description		
M01	16 Oct 98	Mirrors to QMW		
M02	30 Oct 98	Calibration module stray light analysis results from RAL		
M03	30 Oct 98	Calibration module electrical interface specifications from QM	IW (document)	
M04	6 Nov 98	Final engineering drawings of calibration module to RAL		
M05	18 Nov 98	Connectors delivered		
M06	26 Nov 98	He-3 tridge tests complete		
M07	26 Nov 98	Delivery of US He-3 fridges & shields to GSFC & JPL		
M08 M00	2/ NOV 98	Filters complete		
M109	10 Dec 98	Uyusiai to Qivi w Illuminator arrays to OMW		
M11	24 Dec 98	Construction of calibration modules		
M12	29 Jan 99	Calibration module tests completed		
M13	29 Jan 99	Delivery of calibrated calibration modules to GSFC & JPL		
M14	1 Sep 99	Delivery of Pop-Up Detector Evaluation Array to OMW		
M15	1 Sep 99	Delivery of Feedhorn Evaluation Array to QMW		
M16	1 Nov 99	Delivery of CEA Evaluation Array to QMW		
M17	31 Dec 99	Evaluation of prototype detector arrays completed		



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			Sheet: 2 of 2
	Title:	Array Evaluation Facility	Issue: .01 (draft)
Start Event:			Assigned to
End Event:		Detector Selection	QMW
Inputs:			
L I	Date	Item	From
I01	10 Oct 98	Bolometer for characterisation of calibration module stray light environment	JPL
102	16 Oct 98	Mirrors	Symons Mirror Technology
I03	30 Oct 98	Verification of stray light analysis for calibration module	RAL
I04	2 Nov 98	He-3 fridge	Chase Research
I05	18 Nov 98	Hermetic Connectors	Ultratech
I06	26 Nov 98	He-3 fridge test results	QMW
I07	27 Nov 98	Filters	QMW
108	18 Dec 98	Cryostat	Precision Cryogenics
I09	24 Dec 98	Illuminator arrays	GSFC
I10	1 Sep 99	Feedhorn Evaluation Array	JPL
I11	1 Sep 99	Pop-Up Detector Evaluation Array	GSFC
I12	1 Nov 99	CEA Detector Evaluation Array	SAp
Outputs:			
	Date	Item	<u>To</u>
O01	30 Oct 98	Calibration module electrical interface specifications	GSFC, JPL
002	6 Nov 98	Final engineering drawings of calibration module	RAL
O03	26 Nov 98	He-3 refrigerators	GSFC, JPL
O04	29 Jan 99	Calibration Module Performance Report	GSFC, JPL
O05	29 Jan 99	Calibrated Calibration Modules	GSFC, JPL
O06	31 Dec 99	Array Evaluation Report	SPIRE
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6. SCHEDULE

6.1 Detector Selection Schedule





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6.2 PUD Array Development Schedule

ID	Task Name	Duration
1	4x8 PUD Evaluation System	222 days
2	PUD Fabrication	222 days
3	Silicone Bridge Chip	60 days
4	4x8Array Mounting Hardware	172 days
5	PUD Array Mechanical Design	85 days
6	Srtuct & Therm Analysis	85 days
7	PUD Array CAD Modeling	74 days
8	PUD Fabrication Drawings	22 days
9	PUD Mounting H/W Fabrication	44 days
10	Assembly of 4x8 PUD Array	24 days
11	Cryogenic Dewar System	156 days
12	Preparation	156 days
13	Electrical System	175 days
14	Mark 2.0	175 days
15	4x8 Detector Qualification	11 days
10	Vibration	3 days
17	ENV/ENC	3 days
10	New Test Mount	5 days
19		45 days
20	Design	15 days
21	Fab Accombly	15 days
22	Assembly	15 days
2.5	Design lig	25 days
24	Eab lia	20 days
25	PIID Processing	45 days
20	KIC Implementation	25 days
28	Grand Al Bending	13 days
29	1x8 Fab	20 days
30	Single Pixel Expts	70 davs
31	Small Pixel Old Mt	25 days
32	Small Pixel New Mt.	25 days
33	Extra Heat Capacity	20 davs
34	Double TES Tc	25 days
35	Optical Testing	13 days
36	External Nyouist	25 davs
37	MUX Experiments	15 days
38	Mark 1.8 Arrives	0 days
39	MUX Dip Test	14 days
40	Other Early Tasks	70 days
41	Model TES Noise	25 days
42	Gran. Al Optical Prop	18 days
43	Optical Abs. Model	18 days
44	Nyquist Filt. Fab	25 days
45	Mapping Speed Calcs	35 days
46	Final Circuit Design	70 days
47	Multi-Pixel Expts	118 days
48	Fab 2x4 PUD	22 days
49	2x4 PUD in ADR	43 days
50	Crosstalk Measure	98 days
51	1x8 Speed	95 days
52	MUX-Nyq_TES	95 days
53	PUD Integration	89 days
54	Fab 1x8 PUDs	20 days
55	Test 1x8 in ADR	31 days
56	Ship 1x8 to GSFC	0 days
57	Fab Backup 1x8s	18 days
58	Fold and Mount 1x8s	13 days
59	SQUID Integration	56 days
60	Fanouts Arrive NIST	7 days
61	Mount and Test MUX	48 days
62	Ship Fanouts to GSFC	0 days
63	Interconnect Integration	66 days
64	Interconnects to NIST	9 days
65	Deposit Gran. Al	44 days
66	Ship Interconnects to GSFC	10 days
67	4x8 Integration	64 days
68	Assemble, Test Claw	17 days
69	Delivery of Calibration Modules to GSFC & JPL	0 days
70	delivery of He-3 fridges to JPL/GSFC	0 days
71	Integrate, Test Bacus	41 days
72	Delivery of PUD Evaluation Array to QMW	1 day
73	GSFC Array tests	82 days





6.3 Feedhorn Array Development Schedule





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6.4 CEA Detector Development Schedule





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6.5 Evaluation Facility Schedule





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6.6 Array Evaluation Schedule





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7. MILESTONES