

# SPIRE

**SUBJECT: SPIRE Detector Selection Plan**

**PREPARED BY: K.J. King**

**DOCUMENT No: SPIRE/RAL/D/0028**

**ISSUE: .01**

**Date: 11<sup>th</sup> October 1998**

**CHECKED BY: .....**

**Date: .....**

**APPROVED BY:**

**Date:**

**PI .....**

**.....**

**GSFC .....**

**.....**

**JPL .....**

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**SAP .....**

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**SPIRE**

**Rutherford Appleton Laboratory**

**SPIRE Detector Selection Plan**

**Ref:** SPIRE/RAL/D/0028  
**Issue:** .01 (Draft)  
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**Distribution**

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## Change Record

ISSUE	DATE
.01	11 <sup>th</sup> September 1998 Initial Draft

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## Glossary

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  $\mu\text{m}$ ) substrate in 97, and on bolometer (5  $\mu\text{m}$ ) 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 x 16 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.



### **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  $^3\text{He}$  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  $^3\text{He}$  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.

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

<b>WBS</b>	<b>Title</b>	<b>Responsible</b>
	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

<h1>SPIRE</h1>	<h2>Work Package Description</h2>	<b>WP No:</b> <b>Sheet:</b> 1 of 1																																				
	<b>Title:</b> Pop-Up Detector Array Development  <b>Start Event:</b> <b>End Event:</b> Detector Selection	<b>Issue:</b> .01 (draft) <b>Date:</b> 14 October 1998  <b>Assigned to:</b> GSFC/NIST																																				
<b>Objectives:</b> Fabrication of a 4x8 Pop-Up Detector evaluation array evaluation with its mounting hardware and readout electronics.  Test of the evaluation array prior to delivery to QMW for evaluation.  Support the performance validation at QMW																																						
<b>Task Description:</b> <ol style="list-style-type: none"> <li>1. Fabrication of a 4x8 Pop-Up Detector array</li> <li>2. Design and fabrication of array mounting hardware</li> <li>3. Fabrication of SQUIDS and Interconnects</li> <li>4. Assembly of evaluation array</li> <li>5. Test of evaluation array</li> <li>6. Support Detector performance validation at QMW</li> </ol>																																						
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		<b>Sheet:</b> 1 of 1
<b>Title:</b> Pop-Up Detector Array System Design		<b>Issue:</b> .01 (draft)
		<b>Date:</b> 14 October 1998
<b>Start Event:</b>	<b>Assigned to</b>	
<b>End Event:</b> Preliminary Design review	SAp	
<b>Objectives:</b>		
A system design of the detector array, readout electronics and warm electronics functionality will be provided and the instrument PDR will be supported.		
<b>Task Description:</b>		
1. Develop design and prepare PDR package		
<b>Milestones:</b>		
	<u>Date</u>	<u>Description</u>
M01	18 Jun 99	Delivery of PDR Package
<b>Inputs:</b>		
	<u>Date</u>	<u>Item</u>
		<u>From</u>
<b>Outputs:</b>		
	<u>Date</u>	<u>Item</u>
O01	18 Jun 99	PDR Package
		<u>To</u>
		SPIRE Project

<b>SPIRE</b>	<b>Work Package Description</b>	<b>WP No:</b> <b>Sheet:</b> 1 of 2																																							
<b>Title:</b> Feedhorn Detector Arrays Development  <b>Start Event:</b> <b>End Event:</b> Detector Selection		<b>Issue:</b> .01 (draft) <b>Date:</b> 14 October 1998  <b>Assigned to:</b> JPL																																							
<b>Objectives:</b> 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 $^3\text{He}$ 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.																																									
<b>Task Description:</b> <ol style="list-style-type: none"> <li>Fabricate, test and deliver a single TES spider Bolometer.</li> <li>Fabricate, test and demonstrate a 144-element NTD Ge BOLOCAM instrument operating at 1.3 <math>\mu\text{m}</math>.</li> <li>Fabricate, test and deliver a 144-element NTD Ge prototype SPIRE bolometer array with 61 elements connected to a JFET readout.</li> <li>Support detector performance validation at QMW</li> </ol>																																									
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<b>Title:</b> Feedhorn Detector Arrays Development		<b>Issue:</b> .01 (draft) <b>Date:</b> 14 October 1998
<b>Inputs:</b>		
	<u>Date</u> <u>Item</u>	<u>From</u>
I01	15 Dec 98    Test Dewar	Precision Cryogenics
I02	26 Nov 98 <sup>3</sup> He Refridgerator	QMW
I03	29 Jan 99    Calibration Module	QMW
<b>Outputs:</b>		
	<u>Date</u> <u>Item</u>	<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

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		<b>Date:</b> 14 October 1998	
<b>Start Event:</b>	<b>Assigned to</b>		
<b>End Event:</b> Preliminary Design review	JPL		
<b>Objectives:</b>			
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<b>Task Description:</b>			
1. Develop design and prepare PDR package			
<b>Milestones:</b>			
	<u>Date</u>	<u>Description</u>	
M01	7 Dec 98	Provide RF Shielding Requirements to QMW	
M02	1 Jan 99	Provide preliminary Warm Electronics Requirements to SAp	
M03	14 Jan 99	Provide Focal Plane Support Structure Design to QMW	
M04	14 Jan 99	Receive revised RF Shielding requirements	
M05	18 Jun 99	Delivery of PDR Package	
<b>Inputs:</b>			
	<u>Date</u>	<u>Item</u>	<u>From</u>
I01	14 Jan 99	Revised RF Shielding Requirements	ESTEC
<b>Outputs:</b>			
	<u>Date</u>	<u>Item</u>	<u>To</u>
O01	7 Dec 98	RF Shielding Requirements	SPIRE Project
O02	1 Jan 99	preliminary Warm Electronics Requirements	SAp
O03	14 Jan 99	Focal Plane Support Structure Design	QMW
O04	18 Jun 99	PDR Package	SPIRE Project

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	<b>Title:</b> CEA Detector Arrays Selection	<b>Issue:</b> .01 (draft) <b>Date:</b> 14 October 1998																														
	<b>Start Event:</b>	<b>Assigned to</b>																														
	<b>End Event:</b> Delivery of final evaluation array to QMW	SAP																														
<b>Objectives:</b> <p>To test the detector arrays delivered by LETI/SLIR by systematic testing of all the available arrays with differing metallic or absorption pattern, thermometer technology (mesa diffused or implanted thermometer), implantation density and geometry etc, to sort out the best specimen for further evaluation.</p> <p>To evaluate the static optical properties (response, noise density vs. background: NEP), and dynamic aspects (response time and total bandpass) of selected detector arrays. The tests will be carried out in the QMW laboratory on dedicated evaluation devices: optical cryostat (today) or BACUS early 1999. Support will be provided to QMW during these tests</p> <p>Eventually one array will be selected for evaluation as part of the detector selection process</p>																																
<b>Task Description:</b> <ol style="list-style-type: none"> <li>1. Testing of arrays</li> <li>2. Development of Acquisition interface and system Design of BACUS interface</li> <li>3. Testing at QMW and selection of evaluation array</li> <li>4. Support to Evaluation of the Arrays at QMW</li> </ol>																																
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I02	3 May 99	2 <sup>nd</sup> prototype arrays	LETI/SLIR																													
I03	1 Jul 99	3 <sup>rd</sup> prototype arrays	LETI/SLIR																													
<b>Outputs:</b> <table border="1"> <thead> <tr> <th></th> <th><u>Date</u></th> <th><u>Item</u></th> <th><u>To</u></th> </tr> </thead> <tbody> <tr><td>O01</td><td>15 Oct 98</td><td>Prototype Detector</td><td>QMW</td></tr> <tr><td>O02</td><td>1 Mar 99</td><td>1<sup>st</sup> Evaluation Array</td><td>QMW</td></tr> <tr><td>O03</td><td>1 Mar 99</td><td>Manual Switchbox</td><td>QMW</td></tr> <tr><td>O04</td><td>1 Jun 99</td><td>2<sup>nd</sup> Evaluation Array</td><td>QMW</td></tr> <tr><td>O05</td><td>1 Jun 99</td><td>Acquisition System</td><td>QMW</td></tr> <tr><td>O06</td><td>1 Sep 99</td><td>3<sup>rd</sup> Evaluation Array</td><td>QMW</td></tr> </tbody> </table>				<u>Date</u>	<u>Item</u>	<u>To</u>	O01	15 Oct 98	Prototype Detector	QMW	O02	1 Mar 99	1 <sup>st</sup> Evaluation Array	QMW	O03	1 Mar 99	Manual Switchbox	QMW	O04	1 Jun 99	2 <sup>nd</sup> Evaluation Array	QMW	O05	1 Jun 99	Acquisition System	QMW	O06	1 Sep 99	3 <sup>rd</sup> Evaluation Array	QMW		
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O06	1 Sep 99	3 <sup>rd</sup> Evaluation Array	QMW																													



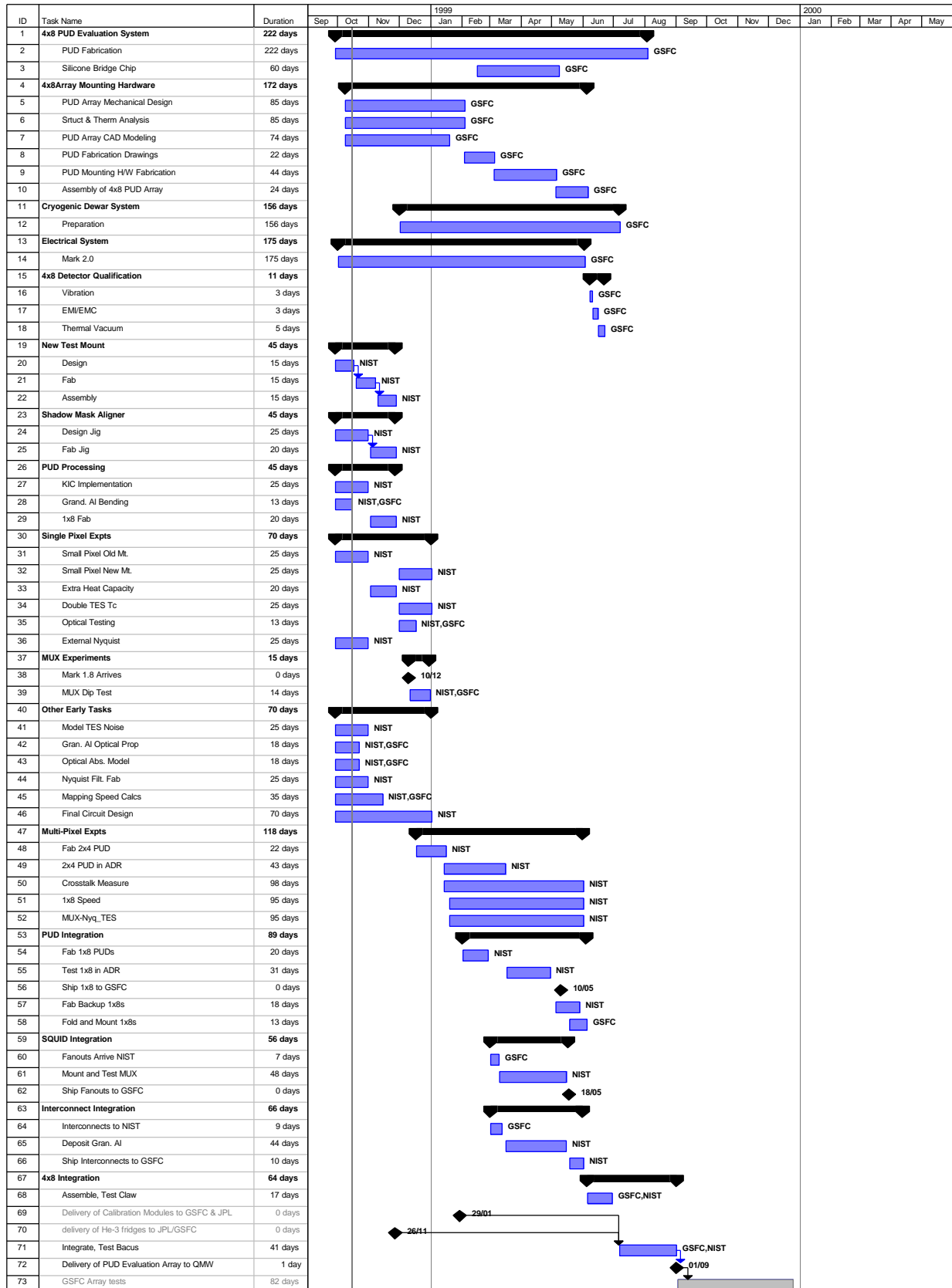
<h1>SPIRE</h1>	<b>Work Package Description</b>	<b>WP No:</b>
		<b>Sheet:</b> 1 of 1
<b>Title:</b> CEA Detector Array System Design		<b>Issue:</b> .01 (draft)
		<b>Date:</b> 14 October 1998
<b>Start Event:</b>	<b>Assigned to</b>	
<b>End Event:</b> Preliminary Design review	SAp	
<b>Objectives:</b>		
A system design of the detector array, readout electronics and warm electronics functionality will be provided and the instrument PDR will be supported.		
<b>Task Description:</b>		
1. Develop design and prepare PDR package		
<b>Milestones:</b>		
	<u>Date</u>	<u>Description</u>
M01	18 Jun 99	Delivery of PDR Package
<b>Inputs:</b>		
	<u>Date</u>	<u>Item</u>
		<u>From</u>
<b>Outputs:</b>		
	<u>Date</u>	<u>Item</u>
O01	18 Jun 99	PDR Package
		<u>To</u>
		SPIRE Project

<h1>SPIRE</h1>	<b>Work Package Description</b>	<b>WP No:</b>
		<b>Sheet:</b> 1 of 2
<b>Title:</b> Array Evaluation Facility		<b>Issue:</b> .01 (draft)
		<b>Date:</b> 14 October 1998
<b>Start Event:</b>	<b>Assigned to</b>	
<b>End Event:</b> Detector Selection	QMW	
<b>Objectives:</b>		
QMW will design and manufacture a detector calibration/evaluation facility to validate the performance characteristics of the JPL, GSFC and Sap detector arrays. These will be compared to the required performance criteria at a Detector Selection meeting		
<b>Task Description:</b>		
<ol style="list-style-type: none"> <li>1. Design of calibration/evaluation facility</li> <li>2. Construction of calibration/evaluation facility</li> <li>3. Testing of calibration/evaluation facility</li> <li>4. Delivery of calibration/evaluation facility "copies" to array providers</li> <li>5. Testing and evaluation of candidate array technologies</li> <li>6. Provision of test reports to consortium/array selection team.</li> </ol>		
<b>Milestones:</b>		
	<u>Date</u>	<u>Description</u>
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 QMW (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 fridge tests complete
M07	26 Nov 98	Delivery of US He-3 fridges & shields to GSFC & JPL
M08	27 Nov 98	Filters complete
M09	18 Dec 98	Cryostat to QMW
M10	24 Dec 98	Illuminator arrays to QMW
M11	31 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 QMW
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

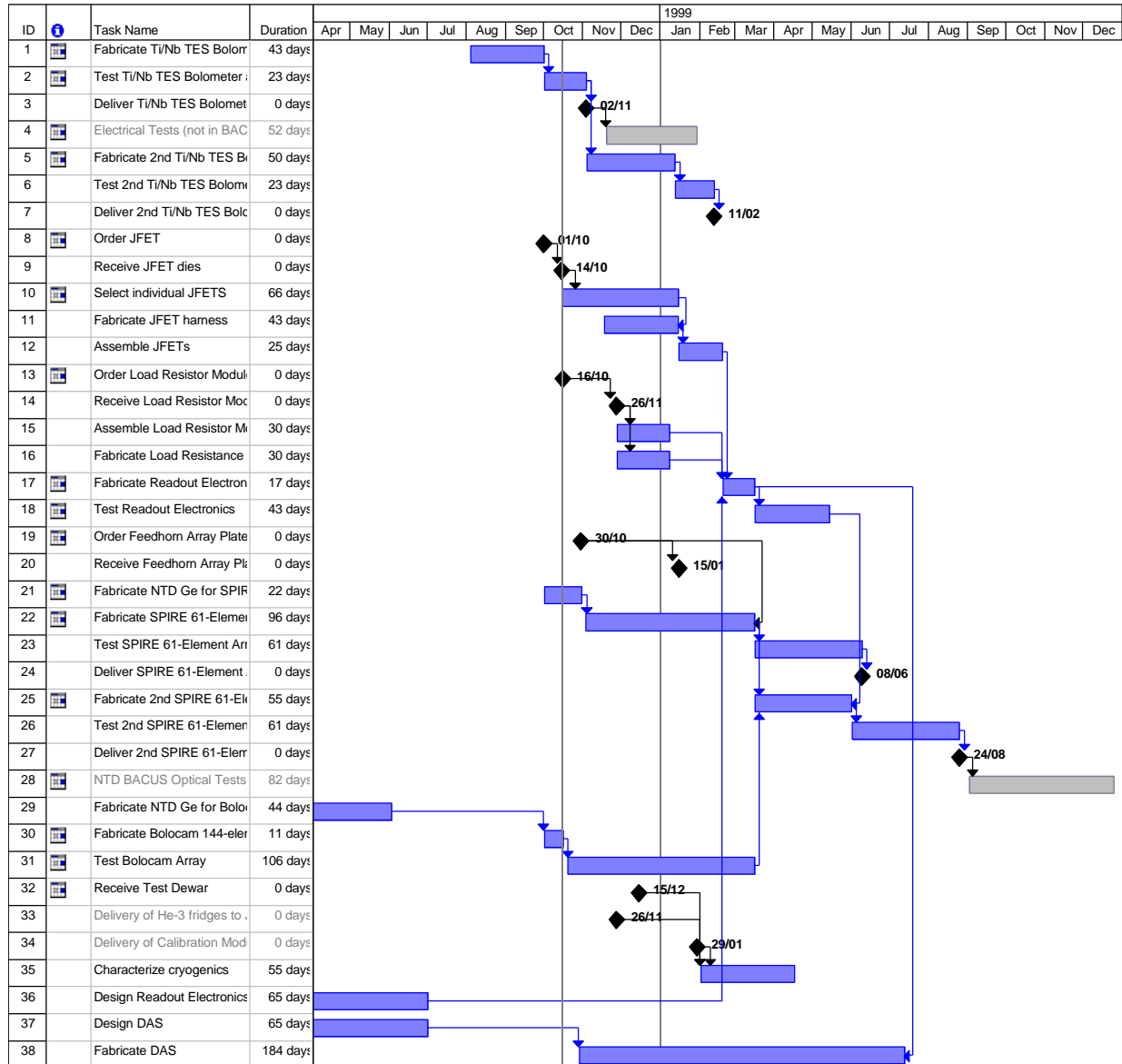
<h1>SPIRE</h1>	<b>Work Package Description</b>	<b>WP No:</b>
		<b>Sheet:</b> 2 of 2
<b>Title:</b> Array Evaluation Facility		<b>Issue:</b> .01 (draft)
<b>Start Event:</b>		<b>Assigned to</b>
<b>End Event:</b> Detector Selection		QMW
<b>Inputs:</b>		
	<u>Date</u> <u>Item</u>	<u>From</u>
I01	10 Oct 98 Bolometer for characterisation of calibration module stray light environment	JPL
I02	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
I08	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
<b>Outputs:</b>		
	<u>Date</u> <u>Item</u>	<u>To</u>
O01	30 Oct 98 Calibration module electrical interface specifications	GSFC, JPL
O02	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



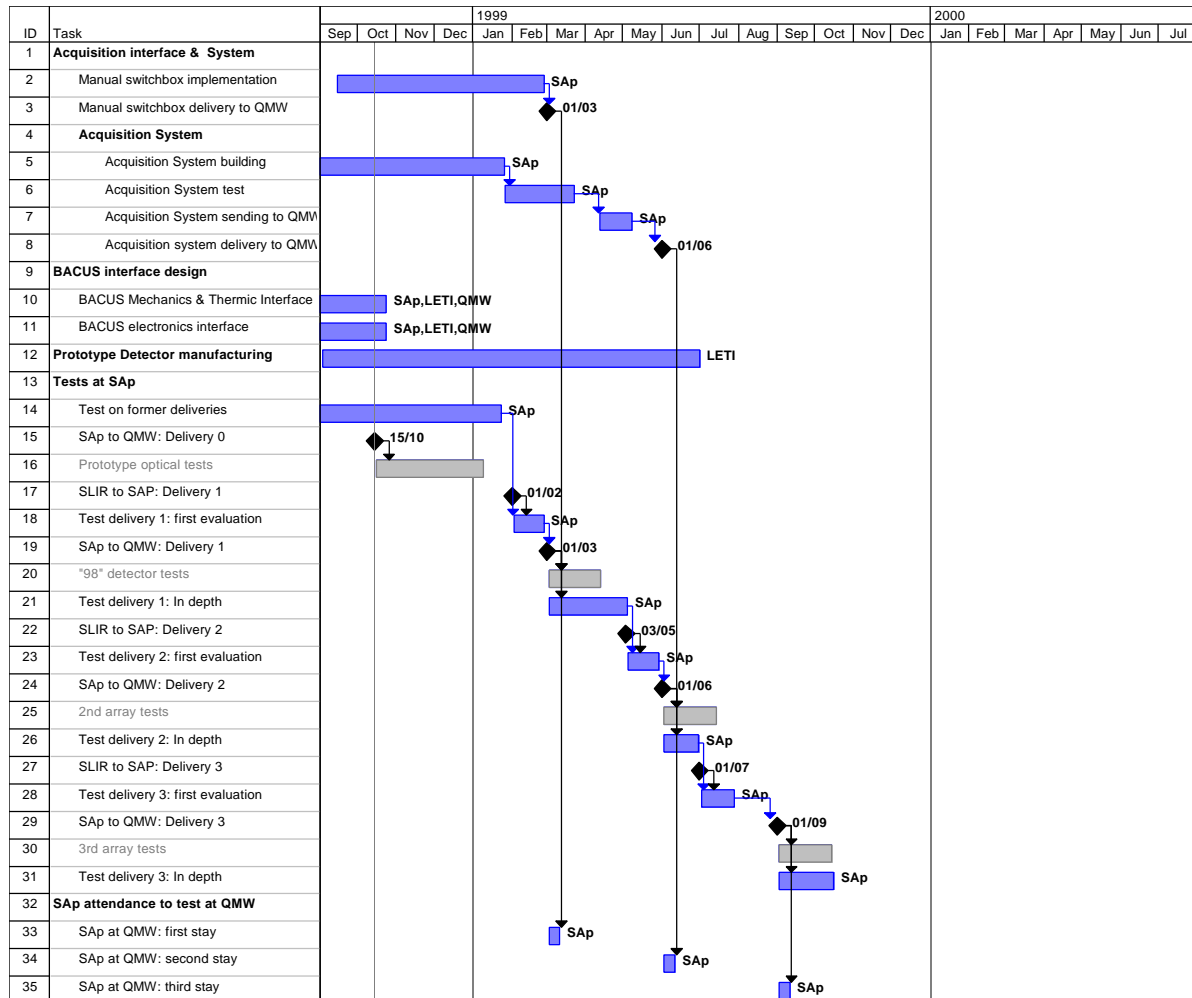
## 6.2 PUD Array Development Schedule



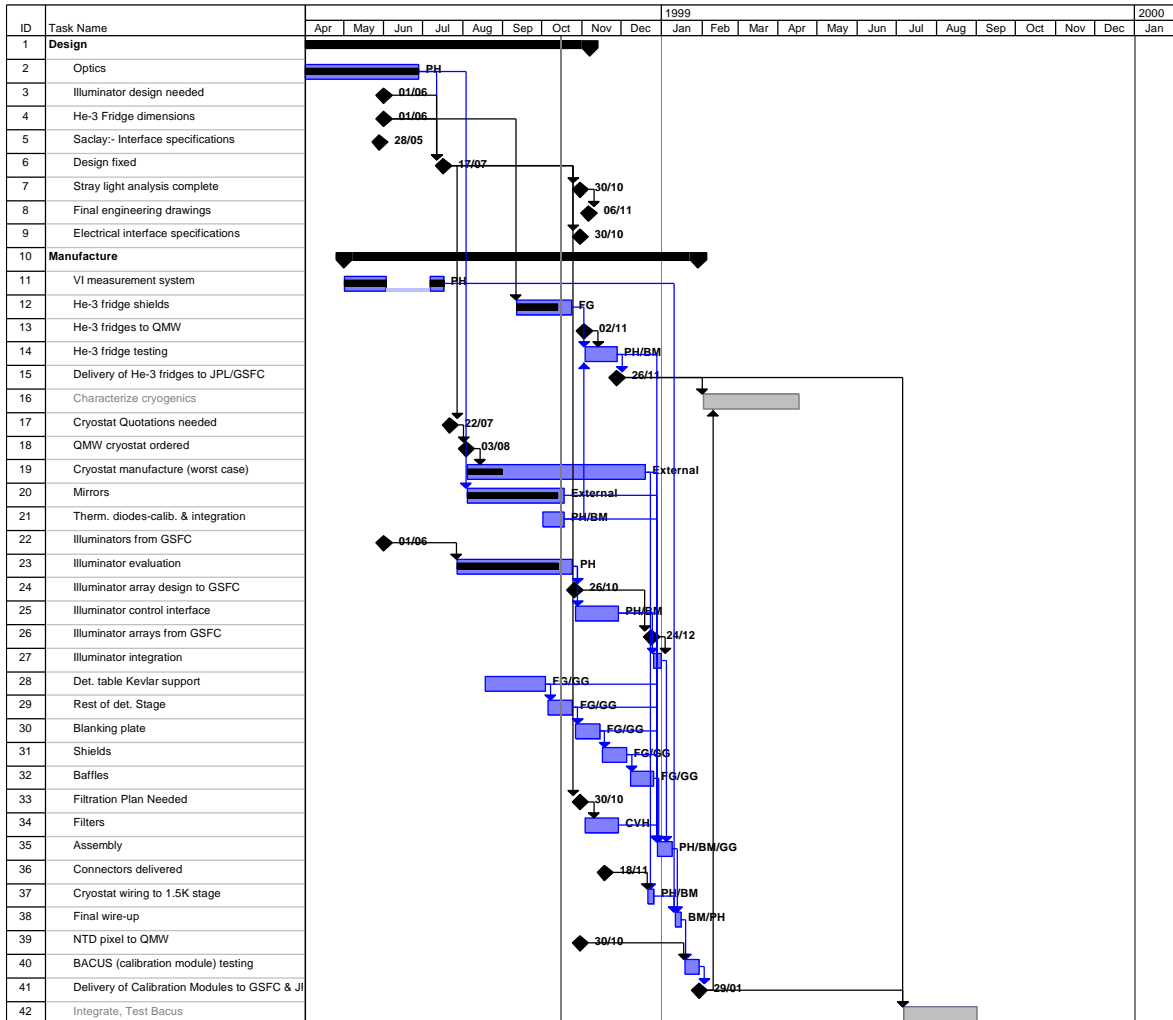
### 6.3 Feedhorn Array Development Schedule



## 6.4 CEA Detector Development Schedule

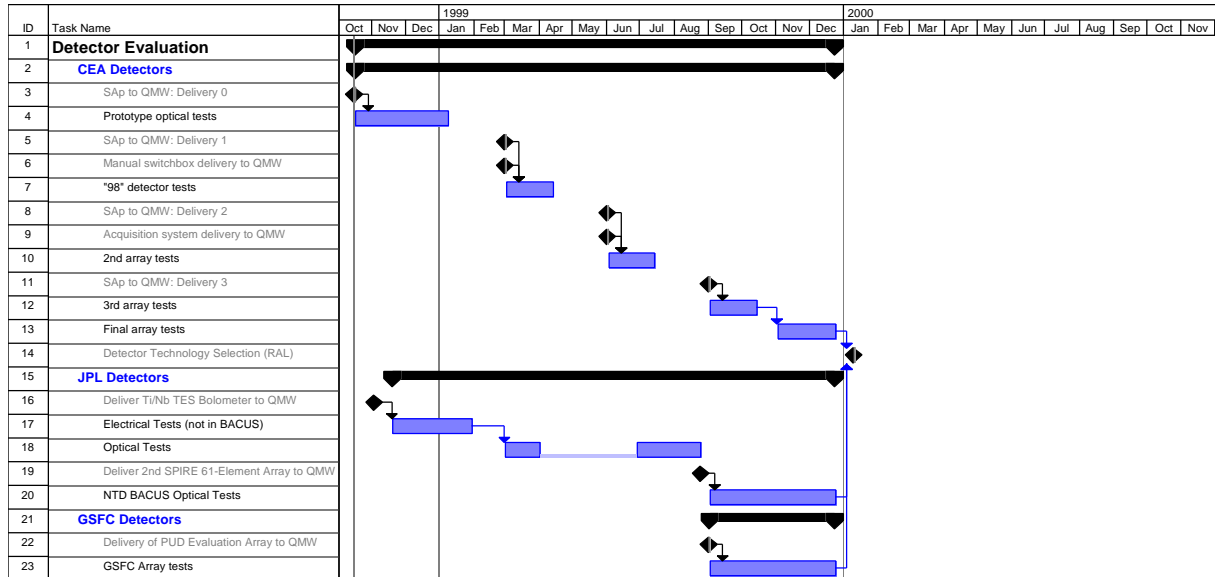


## 6.5 Evaluation Facility Schedule





## 6.6 Array Evaluation Schedule





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## 7. MILESTONES