SPIRE Science Verification Review Phase 2

RAL, 26 September 2006

Bolometer Array Performance: Summary

Document Number: SPIRE-UCF-REP-002571

13 September 2006

Matt Griffin

1. Introduction

This note summarises the JPL detector performance data for the PFM arrays and their readout electronics, based on the two documents

SVR-2 12a: *SPIRE Bolometer Array Performance Estimation from JPL EIDP Spreadsheets*
SVR-2 12b: *SPIRE Bolometer Array Noise Performance during PFM1 and PFM2 Test Campaigns*

and on information in other SVR documents and the JFET EIDPs.

Updates with respect to the previous version of this document (produced for the SPIRE SVR-1) are indicated in blue.

2. Summary of bolometer array performance with respect to Instrument-level Requirements

Requirement Name	Description	Verification Method	Models	Test ID	Test Type	Upper Links	Status
IRD-DETP-R01	Detective Quantum Efficiency at 2 Hz at nominal incident power levels	Design analysis Instrument level performance tests	CQM PFMII	ILT_PERF	ILT-PERF-DAL ILT-PERF-DRB ILT-PERF-DRL	IRD-PHOT-R04 IRD-PHOT-R05	JPL unit-level results show arrays are generally compatible with requirements (SVR-2 12a). ILT measurements are essentially compatible with JPL unit-level data during periods when noise is at baseline level (SVR2-12b). No explicit measurements yet at 2 Hz, but available results extrapolate straightforwardly.
IRD-DETP-R02	Time constant	Design analysis Instrument level performance tests	CQM PFM II	ILT_PERF	ILT-PERF-DRB ILT-PERF-DRL	IRD-PHOT-R06	JPL unit-level tests indicate compliance with large margin, except for a very few pixels; only one pixel unusable due to anomalously large tau. (SVR-2 12a). ILT data from PFM 2 are affected by superfluid He leak. To be verified at instrument level in PFM 3. No chopper measurements with variable freq. made during PFM-3. PCal data show no problems.
IRD-DETP-R03	Uniformity	Design analysis Instrument level performance tests	CQM PFMII	ILT_PERF	ILT-PERF-DNA ILT-PERF-DAB ILT-PERF-DAL	IRD-PHOT-R12	JPL unit-level tests indicate array-level compliance with uniformity requirements (SVR-2 12a). Not verified yet at instrument level due to lack of complete electronics set and identified problems with alignment/stray light. To be investigated in PFM 3. PFM-3 results not conclusive due to CBB misalignment. Will be checked in PFM-4.
IRD-DETP-R04	Yield (good pixels)	Design analysis Subsystem acceptance data package	N/A	N/A		IRD-PHOT-R04	Unit level tests indicate 100% yield for JFETs and yield better than spec. for BDAs (SVR-2 12a and JFET EIDPs). List of problem pixels is given in SVR-2 12b. Some pixels with excess noise are attributable to JFET settings and harness problems.
IRD-DETP-R05	Electrical crosstalk for near neighbour pixels.	Design analysis Instrument level cold functional tests Instrument level performance tests	CQM PFMII	ILT_CFT ILT_PERF		IRD-PHOT-R11	Not yet evaluated. Crosstalk tests have been done in PFM 1 and 2 by illuminating individual pixels - data yet to be analysed. Additional relevant data will be acquired in PFM3 testing of the BSM. These tests cannot disentangle electrical and optical crosstalk. In flight, individual cosmic ray hits on pixels will provide a diagnostic. Resistor channel data will be used to inestigate.

Requirement Name	Description	Verification Method	Models	Test ID	Test Type	Upper Links	Status
IRD-DETP-R06	Electrical crosstalk any pair of pixels	Design analysis Instrument level cold functional tests Instrument level performance tests	CQM PFMII	ILT_CFT ILT_PERF		IRD-PHOT-R11	See IRD-DETP-R06 above.
IRD-DETP-R09	Microphonic susceptibility	Design analysis Instrument level performance tests	CQM PFMII	ILT_PERF		IRD-PHOT-R04 IRD-PHOT-R05	Tested in CQM – see SVR17. Tunability of the bias frequency allows microphonic resonances to be avoided. This test needs to be repeated on PFM 3. Not done in PFM-3 – not high enough priority. Will be added to PFM-4 test list.
IRD-DETP-R11	Sensitivity to ionising radiation	Design analysis Subsystem verification programme	N/A	N/A			Behaviour of NTD bolometers in response to ionising radiation is well understood (confined to a spike with exponential decay governed by the detector time constant). No unusual behaviour in this respect is exhibited by the SPIRE arrays.
IRD-DETP-R12	Volume envelope	Design analysis Instrument level integration verification Subsystem acceptance data package	SM CQM	ILT_INTG			Compliant by design and verification in mechanical integration.
IRD-DETP-R14	Mechanical interface	Design analysis Instrument level integration verification Subsystem acceptance data package	SM CQM	ILT_INTG			Compliant by design and verification in mechanical integration.

Requirement Name	Description	Verification Method	Models	Test ID	Test Type	Upper Links	Status
IRD-DETS-R01	Detective Quantum Efficiency at 20 Hz at nominal incident power levels	Design analysis Instrument level performance tests	CQM PFMI	ILT_PERF	ILT-PERF-DAL ILT-PERF-DRB ILT-PERF-DRL	IRD-SPEC-R06 IRD-SPEC-R07	JPL unit-level results show arrays are generally compatible with requirements (SVR-2 12a). Instrument level some analysis of relevant PFM 1 data is in p[progress. Full evaluation with flight electronics will be done in PFM 3 testing. To be updated based on PFM-3 results. Still under scrutiny. Spectra show no phase effects – indicates that system response is flat. So answer depends on achieving nominal noise.
IRD-DETS-R02	Time constant	Design analysis Instrument level performance tests	CQM PFMI	ILT_PERF	ILT-PERF-DRB ILT-PERF-DRL	IRD-SPEC-R06 IRD-SPEC-R07 IRD-SPEC-R17	JPL unit-level tests indicate compliance with large margin for all pixels. Not yet measured explicitly in ILT. Analysis of PFM 1 FTS spectral data shows no serious problem with phase errors (which would result if the detectors were anomalously slow). To be verified at instrument level in PFM 3. Not done explicitly – can it be done in PFM-4?
IRD-DETS-R03	Uniformity	Design analysis Instrument level performance tests	CQM PFMI	ILT_PERF	ILT-PERF-DNA ILT-PERF-DAB ILT-PERF-DAL		JPL unit-level tests indicate array-level compliance with uniformity requirements. Instrument level: see SVR 9 – consistent with JPL measurements; vignetting is as expected.
IRD-DETS-R04	Yield (good pixels)	Design analysis Subsystem acceptance data package	N/A	N/A		IRD-SPEC-R06	Unit level tests indicate 100% yield for JFETs and yield better than spec. for BDAs (SVR12a and JFET EIDPs) . To be verified at instrument level as some pixels were left uncharacterised in the JPL test set-up. Overall yield at instrument level also must include electronics and harness. To be updated based on definitive list of problem pixels. This list to be included in doc. Instrument_Level_Det_Array_Performance.doc Check non-operational pixels at array level.
IRD-DETS-R05	Electrical crosstalk for near neighbour pixels.	Design analysis Instrument level cold functional tests Instrument level performance tests	CQM PFMI	ILT_CFT ILT_PERF			See IRD-DETP-R05 above. The electrical passband is wider than for photometer, so crosstalk is a potentially bigger problem. Will be tested with in PFM 3 through illumination of individual pixels with spectral lines. Any results from PFM-3?

Requirement Name	Description	Verification Method	Models	Test ID	Test Type	Upper Links	Status
IRD-DETS-R06	Electrical crosstalk any pair of pixels	Design analysis Instrument level cold functional tests Instrument level performance tests	CQM PFMI	ILT_CFT ILT_PERF			See IRD-DETS-R05 above.
IRD-DETS-R09	Sampling frequency	Design analysis Instrument level warm functional tests Instrument level performance tests	CQM PFMI	ILT_WFT ILT_PERF		IRD-SPEC-R17	Compliant by design. 80-Hz sampling has been used as standard in PFM 1.
IRD-DETS-R10	Microphonic susceptibility	Design analysis Instrument level performance tests	CQM PFMI	ILT_PERF	ILT-PERF-DMA	IRD-SPEC-R17	Not an explicit requirement – more a design guideline. PFM 1 measurements show no major issues with microphonics (see SVR 11). Explicit test of FTS performance in the presence of controlled microphonic disturbance should be done in PFM 3. Not done in PFM-3 – not high enough priority. Defer to PFM-4.
IRD-DETS-R12	Sensitivity to ionising radiation	Design analysis Subsystem verification programme	N/A	N/A			Behaviour of NTD bolometers in response to ionising radiation is well understood (confined to a spike with exponential decay governed by the detector time constant). No unusual behaviour in this respect is exhibited by the SPIRE arrays.
IRD-DETS-R13	Volume envelope	Design analysis Instrument level integration verification Subsystem acceptance data package	SM CQM	ILT_INTG			Compliant by design and verification in mechanical integration.
IRD-DETS-R15	Mechanical interface	Design analysis Instrument level integration verification Subsystem acceptance data package	SM CQM	ILT_INTG			Compliant by design and verification in mechanical integration.

Requirement Name	Description	Verification Method	Models	Test ID	Test Type	Upper Links	Status
IRD-FTB-R01	Amplifier noise	Design analysis Instrument level cold functional test Instrument level performance test	CQM PFMI PFMII	ILT_CFT ILT_PERF	ILT-FUNC-DCU07	IRD-PHOT-R04 IRD-PHOT-R05 IRD-SPEC-R06 IRD-SPEC-R07	Specification met, but with power dissipation higher than spec. (50 mW vs. 42). This is the subject of an RFW. Thermal impact expected to be minor.
IRD-FTB-R04	Envelope	Design analysis Instrument level integration verification Subsystem acceptance data package	CQM PFMI	ILT_INTG			Compliant by design and verification in mechanical integration.
IRD-FTB-R06	Operating temperature range	Design analysis Instrument level performance tests	CQM PFMI PFMII	ILT_PERF			JFETs can be operated at room temperature, and with instrument at 100 K, 4 K (no specific test).
IRD-FTB-R07	Mechanical Interface	Design analysis	N/A	N/A		IID-A-SECT5.6.1.2	Compliant by design and verification in mechanical integration.
IRD-FTB-R08	Nominal operating temperature	Design analysis Instrument level cold functional test	CQM PFMI PFMII	ILT_CFT			Verified at 11 K during ILT (standard operating conditions). Not yet verified over whole 4 – 20 K range, but no problems expected.
IRD-FTB-R10	Thermometers	Design analysis	N/A	N/A			Requirement to be deleted: spacecraft thermometers will provide the necessary functionality.