SPIRE

SUBJECT: **SPIRE Calibration Observation Definitions**

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Glossary

AOT	Astronomical Observation Template
SPIRE	Spectral and Photometric Imaging REceiver
ICC	Instrument Control Centre
OE	Optical Encoder
OPD	Optical Path Difference
PCAL	Photometer Calibrator (also can be viewed by spectrometer)
PHOTSTBY	Photometer Standby Mode, phot detectors on but not sampling
PTC	Photmeter Thermal Control
REDY	Ready mode, detectors, BSM and SMEC not on, but electronics are
ZPD	Zero Path Difference

1. Scope

The aim of this document is define a set of SPIRE calibration procedures to be used in-flight. These procedures should be considered as calibration templates which may be implemented via AOTs, via Expert HSpot, or via CUS scripts. AOTs will be used whenever possible. While many procedures are defined here, the approach taken is to keep the number to a minimum allowing a combination of different tests to be done with single template if possible.

This document mainly deals with PV phase i.e. it is assumed that Commissioning phase ends with the lid opening and that PV phase will start at that point. It will not describe the functional tests which will be done during spacecraft commissioning although some of the procedures described here will be used during commissioning phase.

Observations which are the responsibility of the spacecraft such as focal plane geometry and far field straylight are currently considered to be out of the scope of this document but as our input to these activities becomes better defined; they are likely to get included in later versions.

Science verification phase procedures are currently included here but may later be dropped as a science verification plan gets developed.

2. Documents

2.1 Applicable Documents

2.2 Reference Documents

RD1 SPIRE PV Phase Plan

3. INTRODUCTION

3.1 Procedure Layout

Each procedure is broken down into several sections.

Test aims: The tests associated with the use of the template and their purpose.

Operational requirements **-** are a catch all both for instrument setup and observatory setup. The instrument and any relevant observatory modes (e.g., pointed) will be stated, thermal stability, etc.

Expert observing template – is a flag which indicates whether this procedure requires an expert template or whether it requires an AOT.

Procedure **-** The next section gives the actual procedure.

Data outputs – Packet types produced

Operator Inputs For Template – indicates all inputs required, for AOTS this will be the familiar set of parameters, source, estimated flux etc, for expert templates a tailor made set of parameters will be defined

Nominal settings – indicates a default set of operator inputs and the time taken if these defaults are used

Duration – indicates duration assuming nominal settings

Open Issues – optional section, holder for any open issues. These should diminish as this document matures and will be used to pose and address key questions.

3.2 Activities Assumed To Be Covered By Functional Test Description

This section will give a brief outline of commissioning tests and point out areas where activities are already covered.

3.3 Assumptions

3.3.1 Mission Timeline

A detailed summary of assumptions concerning mission operations is given in RD1, only key assumptions are listed here.

The overall mission timeline after launch consists of

1. Launch and Early Orbit Phase (Launch to Launch plus 3 days)
2. Commissioning Phase (Launch plus 3 days to Launch plus 1 month)
    a. Decontamination complete, telescope cooldown starts at launch plus 3 weeks
    b. Cryocover opening at launch plus one month
3. PV Phase (assumed to be 3 months in duration)
4. Science Verification Phase (assumed to be one month in duration)
5. Routine Operations Phase (remainder of the mission)

It is assumed that the activity of establishing the focal plane geometry, which requires the lid to be off, will take place early in PV phase.

The adopted telescope cooldown rate is described in RD1, the predicted temperature at the start of PV phase is 125 K and 90 K is the assumed temperature at the end of PV phase.

Open points:

- How much ground contact will be available in PV phase? Early on we'd like a lot, but it will only be done for tests for which it is essential?
- How is PV phase time divided up between the instruments (e.g., how much time in one block, interval between blocks)?

3.3.2 Using These Templates

It is assumed that PHOT and SPEC standby modes have the detectors set at nominal settings (Vss, Bias frequency, bias amplitude and associated phases). These settings may be modified in-flight during commissioning and/or PV phase.

4. QUICK SUMMARY

4.1 Test Summary

Not at 300 mK		**Nominal duration (hours)**
Engineering		
BSM PID Tuning	Run BSM chopping with input set of PID parameters and chop throw. Note the final tuning can only be done after the position angle calibration and is therefore a PV phase activity as well as a commissioning activity	
Cooler tests TBD	Hold time, manual and automatic recycling	
SCAL PID tuning	In-flight checkout and any tweaking	
SMEC tuning	TBD whether this is done	
Others TBD	TBD	
Photometer		
Phot Vss	Noise at TBD Vss levels	0.33
Spectrometer		
Spec Vss	Noise at TBD Vss levels	0.33
At 300 mK		
Photometer		
Phot Phase Up	Same as ILT phase up procedure	0.17
Phot Multi Level Noise	Noise load curves as done in PFM5 (requires separate phase-up for each setting; priority/feasibility TBC)	1.25
Phot PTC PID Setup	Initial setup, where PTC PID parameters are entered manually.	TBD
Phot Thermal Stability	Noise: Long duration test with PTC off to determine 1/f noise	5.00
Phot Thermal Stability	PTC Optimisation: Long duration tests at various PTC settings to determine optimum settings	5.00
Phot Standard Load Curve	Single phase load curve as done in ILT	0.50
Phot PCAL Load Curve	Single phase load curve with PCAL flash at each level	
Phot Focal Plane Geometry	TBD – so placeholder here	
Phot Time Response and Dynamic Beam Profile	Scan point source at various speeds across array. Must be done for all lines, scanning along the Y or Z directions (not at the magic angles)	
Phot PCAL Standard Flash	Standard ILT flash for commissioning and PV phase.	
Phot PCAL AOT Flash	Standard AOT flash evaluation	
Phot PCAL Level Check	One off measurement of PCAL in flight chopping at 0.25 Hz for each level. Other (low) frequency can be done in IST for step response.	
Phot BSM Angle Calibration	BSM Scans as done in ILT	
Phot Field of View Mapping	Peakup point source on detector – needed for initial FOV mapping (finding geometrical positions of the detectors), use telescope while chopping with BSM – central position used for optical crosstalk check.	0.33 per pixel
Phot Static Beam Profile	Non Scanning Measurement of beam profile – use BSM or telescope or both?. Validates ground comparison. Not clear yet whether best to step telescope or BSM.	
Phot Peakup Mode	POF ** (peakup POF). Should do 7-point before and after.	
Phot Point Source	Optimisation of 7 point jiggle map parameters, in particular, jiggle	

Photometry (POF 2) Optimisation	offset angle, based on 7 point jiggle AOT this can also be used to optimise nod throw. Optimum angle depends on telescope pointing which will need to be measured and understood beforehand. In fact this test is a simple check for telescope pointing.	
Phot Point Source Photometry	Non-linearity correction: Run AOT with number of known objects from bright to faint, to establish calibration. For non-linearity calibration we want to stare and operate PCal – so use a sequence of "null" AOTs, with no chop or nod (advantage is that it goes through the pipeline).	
Phot Point Source Photometry	Flux calibration: Use standard AOT on standard calibration sources	
Phot Point Source Photometry	Sensitivity estimation: Use standard AOT on faint sources.	
Phot Scan Map Sensitivity	Run AOT with faint object, run result through pipeline to check get expected sensitivity	
Phot Small Map Sensitivity	Run AOT with faint object, run result through pipeline to check get expected sensitivity	
Phot Raster Map Sensitivity	Run AOT with faint object, run result through pipeline to check get expected sensitivity	
Parallel Mode Map Sensitivity	Run AOT with faint object, run result through pipeline to check get expected sensitivity	
Spectrometer		
Spec Phase Up	Same as ILT phase up procedure	0.17
Spec Multi Level Noise	Noise load curves as done in PFM5 (requires separate phase-up for each setting; priority/feasibility TBC)	1.25
Spec Thermal Stability	Noise: Long duration test with PTC off to determine 1/f noise	5.00
Spec Standard Load Curve	Single phase load curve as done in ILT	0.50
Spec BSM Angle Calibration	BSM Scans as done in ILT	
Spec PCAL Standard Flash	Standard ILT flash for commissioning and PV phase.	
Spec PCAL AOT Flash	Standard AOT flash evaluation	0.03
Spec PCAL Level Check	One off measurement of PCAL in flight chopping at 0.25 Hz for each level. Other (low) frequency can be done in IST for step response.	0.08
Spec Focal Plane Geometry	TBD – so placeholder here	
Spec Field of View Mapping	Peakup point source on detector – needed for initial FOV mapping (finding geometrical positions of the detectors), use telescope while chopping with BSM – central position used for optical crosstalk check.	
Spec Fixed SMEC Beam Profile	Non Scanning Measurement of beam profile – use BSM or telescope or both?. Validates ground comparison. Not clear yet whether best to step telescope or BSM.	
Spec Scanned Beam Profile	Glenn's test	
Spec Point Source Observation	This AOT can be used for almost anything which requires SMEC to be scanned. Scans of line calibrators to validate spectral resolution and wavelength. This will also check fringe contrast. Set of lines across the band to measure instrument profile	
Spec Point Source Observation	Observations of a continuum source to optimise scan speed, and vignetting.	
Spec Point Source Observation	Scans of primary spectral calibrator(s) to obtain RSRF	
Spec Point Source Observation	FTS scans and associated PCAL flashes at regular intervals during telescope cool-down to characterise small-signal responsivity vs.	

	detector voltage	
Spec Sparse Map	4 point jiggle, have I got the name right?	
Spec Map	Full 16 point jiggle	

4.2 Expert Templates and Ground Contact

Test	**Expert template required**	**Ground contact?**
Not at 300 mK		
Engineering		
BSM PID Tuning	Yes	Yes
Cooler tests TBD	TBD	TBD
SCAL PID tuning	Yes	Yes
SMEC tuning	Yes	Yes
Others TBD	TBD	TBD
Photometer		
Phot Vss	Yes	No
Spectrometer		
Spec Vss	Yes	No
At 300 mK		
Photometer		
Phot Phase Up	Yes	No
Phot Multi Level Noise	Yes	No
Phot PTC Setup	Yes	No
Phot Thermal Stability	TBD (maybe adjusted scan map)	No
Phot Standard Load Curve	Yes	No
Phot PCAL Load Curve	Yes	No
Phot Focal Plane Geometry	TBD	Yes
Phot Beam and Time Response	TBD (maybe adjusted scan map)	No
Phot BSM Angle Calibration	Yes	No
Phot PCAL Standard Flash	Yes	No
Phot PCAL AOT Flash	TBD (maybe adjusted scan map)	No
Phot PCAL Level Check	Yes	No
Phot Field of View Mapping	Yes	No
Peakup Mode	No	No
Phot Optical Beam Profile	Yes	No
Phot Point Source Photometry	No (AOT will need extra parameters setting)	No
Phot Scan Map Sensitivity	No	No
Phot Small Map Sensitivity	No	No
Phot Raster Map Sensitivity	No	No
Parallel Mode Map Sensitivity	No	No
Spectrometer		
Spec Phase Up	Yes	No
Spec Multi Level Noise	Yes	No
Spec Thermal Stability	Yes	No
Spec Standard Load Curve	Yes	No
Spec Focal Plane Geometry	TBD	Yes
Spec BSM Angle Calibration	Yes	No
Spec PCAL Standard Flash	Yes	No
Spec PCAL AOT Flash	Yes	No

Spec PCAL Level Check	Yes	No
Spec Field of View Mapping	Yes	No
Spec Fixed SMEC Beam Profile	Yes	No
Spec Scanned Beam Profile	Yes	No
Spec Point Source Observation	No	No
Spec Sparse Map	No	No
Spec Map	No	No

5. Procedures Which Can Be Run without the detectors at 300 mK

5.1 Engineering

This section covers all tests which can be done at Helium-I which don't require either detector subsystem and are not currently covered by functional tests.

5.1.1 BSM PID Tuning

TBW

5.1.2 Cooler Tests

TBD

5.1.3 SCAL PID Tuning

TBD

5.1.4 SMEC PID Tuning

TBD

5.2 Photometer

5.2.1 Phot VSS

Test Aims:
This test aims to identify the optimum value of Vss to run each JFET at. A set Vss values will be commanded in turn and the noise will be measured at each value. The lowest noise value with reasonable power dissipation will be adopted. It expected that this procedure will only be run once, at the beginning of the mission.

Operational requirements:
- The instrument must be in REDY mode (**TBC**)
- Observatory pointing not applicable
- Thermal stability **TBD**

Expert Template Required:
Yes

Procedure:
1. Set the Vss to **TBD** Volts for every photometer JFET
2. Readout the channels for input seconds
3. Repeat steps 1 and 2 for the following JFET values, **TBD** values

Operator Inputs:

- Number of seconds to spend at each Vss value

Data outputs:
- Noise vs. Vss
- Vss setting to be used for nominal operation as given by lowest noise values

Nominal settings
- 10 hardcoded settings are assumed,

Duration
Each setting is assumed to have a nominal duration of 2 minutes giving a nominal time of 20 minutes

Open Issues:
The Vss values used to be defined by JPL and, as written, these are hardcoded. It remains an open issue as to whether these should be hardcoded or defined as an operator input.

5.3 Spectrometer

5.3.1 Spec VSS

This is the same test as Phot Vss but a different set of Vss settings is likely to be defined.

6. PROCEDURES WHICH REQUIRE DETECTORS AT ~300MK

6.1 Photometer

6.1.1 Phot Phase Up

Aim:
This test aims to identify the optimum value of phase for a given detector bias amplitude and frequency setting. It does this by stepping the detectors through a given set of phases while keeping the bias amplitude and frequency setting the same. The maximum value of the output is the phase which should be selected.

Operational requirements:
- At the start of this test the instrument is in PHOTSTBY
- Ideally this test will be run with real time contact with the ground so if the central phase is missed, the test can be re-run within a short timescale.
- The observatory must not be slewing, if the cover is off the observatory must be pointing to a dark patch of sky

Expert Template Required:
Yes

Procedure:
1. Set the Vss to nominal settings as defined by Phot Vss
2. Set the bias amplitude and frequency to the input values
3. Set the three central phases to the input values
4. Set the stepsize and number of steps to the input values
5. Set the detectors to the phase given by the the stepsize, number of steps and central phase
6. Take offsets
7. Readout detectors for specified time

Operator Inputs for HSpot:
1. Bias frequency to be tested
2. Bias amplitude to be tested
3. Central phase to set for all three arrays
4. Number of steps to move away from central phase (for example by entering 3, 7 steps in total will be performed, 3 each side plus the central phase)
5. Stepsize, user enters 1, 2 etc (1=1.4 degrees, 2=2.8 degrees etc)
6. Time to readout the detectors (Typically 5 or 10 seconds)

Data outputs:
- Output voltage level vs phase set
- Phase setting to be used for nominal operation as determined from highest voltage level

Nominal settings and duration
- Bias frequency 130 Hz
- Bias Amplitude 31 mV peak to peak

- Central phase 183 degrees for all three arrays
- Number of steps 5
- Stepsize of 1 (1.4 degrees)
- Time per step 5 seconds

Duration
Total time given by total number of steps (5+1+5=11) times the time per step plus offset time per step (5+35 seconds) = 11x40 = 440 seconds = 8 minutes. Then add 2 minutes for setup and end obs giving 10 minutes in total.

If a full sweep is done (256 steps) the time taken is 40 x 255 = 10200 seconds = 170 minutes = 2.83 hours.

Open Issues:
- The ILT test allowed separate central phases to be defined for each array. This test assumes this is now restricted to one.
- We need to have a consistent definition of bias amplitude in all templates which require it i.e. all should either be rms or peak to peak

6.1.2 Phot Multi-Level Noise

Test Aims

This test aims to characterise instrument noise performance under a range of conditions, in particular it will characterise noise as a function of bias frequency and amplitude under a range of JFET conditions as defined by the telescope temperature. A final characterisation will take place when the telescope is cold.

This test will be run before the lid comes off and will be repeated after the lid comes off. The source used for this test, once the lid is open, will be dark sky and ideally the same patch of dark sky near an ecliptic pole will be used throughout PV phase. As this test may be repeated periodically in routine phase, other patches of dark sky may need to be selected for pointing reasons. Additionally a bright source may be selected so that the noise can be characterised under loaded conditions.

While it is possible to run this test with the PTC heater on, increasing the detector temperature by ~10 mK, it is not desirable to do so in flight, hence this is not included as an input for this test.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing, if the cover is off the observatory must be pointing to a dark patch of sky

Expert Template Required:

Yes

Procedure:

1. Set the Vss to nominal settings as defined by Phot Vss
2. Set the bias amplitude and frequency to the first input values
3. Set the three phases to the input values
4. Take offsets and leave detectors producing data
5. Wait inputted time
6. Repeat steps 2-5 for each bias amplitude

Operator Inputs for HSpot:

1. Bias frequency to be tested
2. Phases to set for all three arrays for all bias amplitudes tested (TBR, ideally we could upload a table based on phase up results to be used for all subsequent tests)
3. Time to readout the detectors (Typically 5 or 10 minutes)
4. The source RA and Dec

Data outputs:

- Noise vs bias frequency and vs bias amplitude
- Optimum bias frequency and amplitude settings to run the detectors

Nominal settings

- Bias frequency 130 Hz
- Phased up phases for this frequency (around 183 degrees)
- 5 minutes per level

The assumed bias levels, which will be hardcoded, are:

Setting (Hex)	Bias Amplitude (Peak to Peak)	Bias Amplitude (RMS)
02	1.0	0.7
04	2.0	1.4
0A	5.0	3.5
0E	7.0	4.9
14	10.0	7.0
18	12.0	8.4
1E	15.0	10.5
22	17.0	11.9
28	20.0	14.0
3C	30.0	21.0
64	50.0	35.0
8C	70.0	49.0
C8	100.0	70.0
FC	126.0	88.2

The bias amplitude values are: FF= PSW 127.813 mV, PMW 128.625, PLW 129.159

Duration
The duration is given by number of settings (13) times the time at each setting (5 minutes) plus time required to reset offsets for each new bias amplitude (40 seconds) = 13 x 5.67 = 73.71 minutes. With start obs and end obs this totals about 75 minutes.

Open Issues:
- The test is defined as being done at one frequency unlike the ILT equivalent where many frequencies could be entered.
- We need to have a consistent definition of bias amplitude in all templates which require it i.e. all should either be rms or peak to peak
- If this test is run with the lid on the source RA and Dec is not required but it is not clear how the requirement for this can be decoupled from the template

6.1.3 Phot PTC PID Setup

Test aims
Initial setup, where PTC PID parameters are entered manually – Do we need this test?
Needs input from Doug

6.1.4 Phot Thermal Stability

Test aims
The aim of this test is to take long duration noise data to establish the 1/f performance of the photometer. This template will be used with the PTC off to establish baseline performance and also with the PTC on at various settings

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing, if the cover is off the observatory must be pointing to a dark patch of sky
- The background (telescope or lid) must be thermally stable. The required stability is **TBD**

Expert observing template
Yes (**TBC**, a pointed AOT could be used which does not jiggle but this would still have PCAL flashes which are probably undesirable for this test)

Procedure
1. Enter bias amplitude frequency and phase (**TBC**, nominal settings may be a pre-requisite for PHOTSTBY)
2. Run PTC VM at requested setting (**TBD**, see open issues, note ‘PTC off’ is a valid input for this test)
3. Readout detectors for input time
4. Return to PHOTSTBY

Data outputs
- Average noise for each detector as determined from plateau of the Fourier transform
- Frequency of 1/f knee for each detector as determined from the Fourier transform of the detector timeline

Operator Inputs For Template
- PTC settings (**TBD**, see open issues)
- Duration of test
- The source RA and Dec

Nominal settings
- PTC settings (**TBD**, see open issues)

Duration
5 hours

Open Issues

- In ILT the PTC was run controlling off SUBKTEMP, PTC T2 and the thermistors. None of these settings proved satisfactory and more work is required with the flight spare and during IST and SPT to establish nominal operation. Once this is established PID parameters need to be found, which may need to be checked in-flight. Bruce should stop being a glory hunter and support a proper football team. It is not yet clear how the PTC will be operated in flight therefore it remains open what parameters will be needed for this test.

6.1.5 Phot Standard Load Curve

Test aims
This test will be one of the 'work horse' tests of PV phase as it can be used to fulfil a number of objectives i.e.

- It will sample the detector noise and responsivity vs. bias (amplitude and frequency) and JFET conditions. Note this is not as detailed a test as the multi level noise test but it does have the advantage of being a lot quicker and therefore can be done more often and under more test conditions.
- It will be used to establish bias settings to be used for bright sources i.e. we envisage at least one load curve done on a bright sources
- It will be used to establish of an initial set of calibrators and dark fields near the ecliptic poles
- It will be used to monitor the health of the instrument i.e. a standard load curve will be done regularly following cooler recycle

Some of this can be done before the lid comes off, but will be re-done after the telescope has got cold enough.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Point the observatory to the chosen source
2. Set the detectors to the input bias frequency and phase
3. Set the detectors to the initial bias amplitude
4. Set offsets
5. Readout for input time
6. Repeat steps 3-5 for each bias amplitude
7. Return to PHOTSTBY

Data outputs
- TBW

Operator Inputs for Template
- Bias frequency and associated phases at nominal bias amplitude
- Duration of integration at each level
- The source RA and Dec

Note the bias amplitude settings are hardcoded. These are:

Setting (Hex)	PSW Bias Amplitude (peak to peak)	PSW Bias Amplitude (RMS)
00	0.000	0.000
01	0.501	0.354

02	1.002	0.709
03	1.504	1.063
04	2.005	1.418
05	2.506	1.772
06	3.007	2.126
07	3.509	2.481
08	4.010	2.835
09	4.511	3.189
0A	5.012	3.544
0C	6.015	4.253
0E	7.017	4.962
12	9.022	6.379
14	10.025	7.088
16	11.027	7.797
19	12.531	8.861
1E	15.037	10.633
23	17.543	12.405
28	20.049	14.177
2D	22.555	18.070
32	25.061	17.721
3C	30.074	21.266
46	35.086	24.809
50	40.098	28.354
5A	45.110	31.897
64	50.123	35.442
78	60.147	42.530
8C	70.172	49.619
A0	80.196	56.707
B4	90.221	63.796
C8	100.245	70.884
E1	112.776	79.745
FA	125.306	88.605
FF	127.813	90.377

The bias amplitude values are: FF= PSW 127.813 mV, PMW 128.625, PLW 129.159

Nominal settings

- The nominal bias frequency used for ILT was 130 Hz, the associated peak phases were around 183 degrees
- 10 seconds per level

Duration

For 10 seconds per level, the overall duration is about 30 minutes.

Open Issues

None

6.1.6 Phot PCAL Load Curve

Test aims
This test is similar to the standard load curve in that readouts are taken at a set of bias amplitudes at a given bias frequency and phase. The difference is that at each level a PCAL flash is added. This has the advantage that it allows a direct measurement of detector responsivity but has the disadvantage that it takes longer to do. Also not all tests requiring load curves require the PCAL flashes hence both templates are adopted.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Point the observatory to the chosen source
2. Set the detectors to the input bias frequency and phase
3. Set the detectors to the initial bias amplitude
4. Set offsets
5. Readout for input time
6. Run a standard PCAL flash sequence
7. Repeat steps 3-6 for each bias amplitude
8. Return to PHOTSTBY

Data outputs
- **TBW**

Operator Inputs for Template
- Bias frequency and associated phases at nominal bias amplitude
- Duration of integration at each level
- The source RA and Dec

Note the bias amplitude settings are hardcoded and are the same as for the standard load curve.

Nominal settings and duration
- The nominal bias frequency used for ILT was 130 Hz, the associated peak phases were around 183 degrees
- 10 seconds per level

Command Value	Bias Amplitude (Peak to Peak)	Bias Amplitude (RMS)
02	1.0	0.7
04	2.0	1.5

0A	5.0	3.5
0E	7.0	4.9
14	10.0	7.0
18	12.0	8.4
1E	15.0	10.5
22	17.0	11.9
28	20.0	14.0
3C	30.0	21.0
64	50.0	35.0
8C	70.0	49.0
C8	100.0	70.0
FC	126.0	88.2

The bias amplitude values are: FF= PSW 127.813 mV, PMW 128.625, PLW 129.159

Duration
TBD - to be checked with ILT data.

Open Issues

- The PCAL sequence used should be the same as for ILT, the ILT templates need to be checked to establish whether the AOT sequence or the ILT sequence was used.

6.1.7 Phot Focal Plane Geometry

Placeholder here, will likely migrate to commissioning plan

6.1.8 Phot Time Response and Dynamic Beam Profile

Test aims
This test aims to characterise the detector channel time response and also the dynamic beam pattern. These aims are achieved via scanning a point source along the Z and Y axis of the telescope corresponding to the chop and jiggle axes of the photometer arrays at various speeds.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will be slewing during the test

Expert observing template
Yes (**TBC**) – It is desirable, and may be possible, to use the scan mode AOT but instead of scanning at the magic angle we scan along the telescope axes. It is assumed here that this is not possible and therefore an expert template is required.

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Point the observatory to the chosen source
3. Offset the observatory the input angle in the input specified direction
4. Run a standard PCAL flash sequence
5. Start reading out detectors
6. Slew the telescope from offset pointing, through the source to offset pointing in the other direction at the specified slew speed (e.g. from – 4 arcminutes in Y to + 4 arcminutes in Y)
7. If requested to do more than one slew, slew back in the opposite direction (e.g. from +4 arcminutes to – 4 arcminutes)
8. Repeat the requested number of times
9. Run a standard PCAL flash sequence
10. Return to PHOTSTBY

Data outputs
- SPIRE dynamic beam profiles i.e. beam profiles of the instrument at a given slew speed
- Detector time response extracted from dynamic beam profiles

Operator Inputs for Template
- The source information (Name and/or RA and Dec)
- Offset angle
- Axis (Y or Z)
- Scan speed

Nominal settings and duration
- The source – this will need to be a bright point source. It could be done with planets but their movement will need to be factored in to the data analysis so a fixed source would be preferred. The main requirement is that it is point-like and not extended at all.
- Offset angle – **TBD**, a few arc minutes
- Axis (Y or Z) – both will be used
- Scan speed – **TBD**

Duration

TBD

Open Issues

- It is assumed that the nominal detector operating parameters can be entered without user input.
- How fast can we go?
- Can this observation be done with moving targets?
- Should we specify direction?
- We may want to turn the sample rate up to eleven for this one. If sample rate is the driver though 130 Hz would not be the optimum bias frequency as we would want to go faster. We could add an input to this test to run detectors at a specified set of settings and then run this test slewing at the same rate with nominal readout and with super fast high bias frequency readout the model will then have to be used to understand the results with respect to each other.
- If the PTC is to be used, commissioning this (i.e. finding the correct algorithm and tuning it) will be a pre-requisite for this test

6.1.9 Phot Standard PCAL Flash

Test aims
This test executes the same PCAL flash sequence as was done in ILT. It has three main objectives. The first is to compare ILT flashes with in flight flashes and check that PCAL is giving similar output and illumination pattern. The next objective is to a have an independent flash template to be used alongside other tests giving a monitor of detector behaviour. The third objective is to aid the transition from PCAL flashes done as independent tests to those done as part of AOT sequences.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Flash PCAL between 0 and 3.8 mA at a frequency of 0.25 Hz for 16 seconds
3. Flash PCAL between 0 and 4.8 mA at a frequency of 0.25 Hz for 16 seconds
4. Return to PHOTSTBY

Data outputs
- PCAL illumination pattern
- Trend information throughout commissioning and PV phases

Operator Inputs for Template
- No operator inputs are required, the total duration is about 1 minute

Nominal settings
- No operator inputs are required

Duration
About 1 minute

Open Issues
None

6.1.10 Phot PCAL AOT Flash

Test aims
This test executes the same PCAL flash sequence as is done in AOTs. This then allows the flash to be optimised and used before AOTs are fully commissioned.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Flash PCAL between 0 and input current at a input frequency for input number of cycles
3. Return to PHOTSTBY

Data outputs
- Optimised PCAL flash for use with AOTs
- Trend information throughout commissioning and PV phases

Operator Inputs for Template
- PCAL current (0-7mA)
- Flash frequency (**TBR**, may need all parameters for the table)
- Number of cycles

Nominal settings
- The current should be? (need to check current values)
- Frequency = 0.25 Hz
- Number of cycles = 2

Duration
Less than 1 minute

Open Issues
None

6.1.11 Phot PCAL Level Check

Test aims
This test will chop at a set of levels in order to characterise its behaviour in-flight and to compare with the behaviour in ILT.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Flash PCAL between 0 and 1.0 mA at a frequency of 0.25 Hz for 30 seconds
3. Repeat flashes between 0 and the levels 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 mA
4. Return to PHOTSTBY

Data outputs
- Optimum level for PCAL to be flashed at

Operator Inputs for Template
- No operator inputs are required

Nominal settings
- No operator inputs are required

Duration
The total duration is about 5 minutes including overheads

Open Issues
- Do we need to chop at other frequencies in flight?
- It is TBD whether we need to add a source input or whether we will use current pointing.

6.1.12 Phot BSM Angle Calibration

Test aims

This test is used to setup the fundamental BSM angle on sky vs. position senor output calibration. It essentially will be done in the same way as the scanning test from ILT. SPIRE apertures need to be setup as a pre-requisite for this

Operational requirements

- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template

Yes

Procedure

1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on input aperture
3. Move the BSM to one end of its operating range
4. Chop the BSM between this position and an input reference position at the input chop frequency
5. Wait input number seconds while reading out the detectors
6. Move the BSM position 0x180
7. Repeat steps 4 and 5 until the full useable range is covered
8. Return to PHOTSTBY

Data outputs

- Positions of pixels in BSM position units (e.g. CHOPPOSN, CHOPSENSSIG)
- Calibration curve of BSM position vs. angle on the sky

Operator Inputs for Template

- Source (Name and/or RA and Dec)
- SPIRE aperture
- Axis to scan (Y or Z)
- Reference position (supplied CHOPPOSN and JIGGPOSN)
- Chop speed
- Integration time at each position

Nominal settings and duration

- Any bright point source can be used
- At least initially the SPIRE boresight (centre of FOV) will be used
- Both axes will be scanned
- If the chop axis is scanned the reference position will be an offset in jiggle

Duration

TBD, in ILT scans typically took 30-40 minutes

Open Issues

- PHOTSTBY has the BSM powered on in closed loop at its rest position

6.1.13 Phot FOV Mapping

Test aims
This test is used to find the positions of the pixels using the telescope. Note the focal plane geometry test will establish the position of the SPIRE boresight. It is not yet clear if the position of the pre-defined SPIRE apertures will also be established as part of the focal plane geometry but if not this test can be used. Each run of this test will establish the position of a pixel. It is **TBD** whether to use cross rasters on the pixels, as defined here, or to use a larger raster across the whole array. Providing the telescope pointing performance is good, a dedicated cross-raster on a target pixel will give better accuracy.

We have a slight chicken and egg situation between this test and the BSM setup tests. In essence this test must be done to establish pixel positions, which are then used to calibrate the BSM position angle on the sky. This is then used to finalise BSM PID parameters. Therefore for this test the BSM does not, and is not required to, chop exactly between two pixels.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on the appropriate aperture
3. Offset the target to the raster starting point
4. Chop the BSM over the input range
5. Readout detectors for input time
6. Move to the next raster point and readout detectors for input time
7. Repeat until all raster steps are covered
8. Return to PHOTSTBY

Data outputs
- Offset, in angle on the sky, between pixel centres and centre of the array of all measured pixels, this will be two angles given in spacecraft Y and Z directions
- Interpolated positions of the remainder pixels
- Rough static beam maps of measured pixels, the fidelity of these is TBD and will depend on the raster type adopted

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Offset for start of raster (for cross-raster this will be the estimated pixel position)
- Integration time at each raster point
- BSM positions (the BSM will need to be chopped in an unusual way for this test as it's nominal rest (zero current) position will be adopted as one of the chop positions. The other is **TBD**.

Nominal settings

- Any bright fixed position point source can be adopted, a source with no nearby sources to accidentally chop on to is most desirable
- The BSM positions are the zero current position (determined during commissioning phase) and a TBD offset position on the chop axis

Duration

Assuming a cross raster of 18 points and about 1 minute per point this will take 20 minutes per pixel.

Open Issues

- If the SPIRE apertures are not established as a spacecraft test then each one must be included by this test
- The raster used is TBD

6.1.14 Phot Static Beam Profile

Test aims
This test has the aim of characterising the beam profile without needing to consider the detector time response. This test does is deep raster across a single pixel while chopping the BSM.

There are two ways to achieve this, which are to produce a raster pattern with the telescope or to do a 64 point jiggle map. The telescope raster is preferred. The reason for this is that this test is a good candidate test for early in PV phase as it can be executed while the telescope is cooling. The alternative BSM 64 point jiggle map requires a final BSM calibration which sits not only on the FOV mapping having been analysed, but also the BSM angle calibration done and analysed, then the BSM PID finally tuned. The combination of all these in the required order is not likely to have been done in early PV phase.

Scanning across point source is covered by Phot Time Response and Dynamic Beam Profile template.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point, then remain at that point duing the integration

Expert observing template
TBD, if the BSM version is adopted this can be done with a 64 point jiggle map AOT

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on the input pixel
3. Offset the target to the raster starting point
4. Chop the BSM over the input range
5. Readout detectors for input time
6. Move to the next raster point and readout detectors for input time
7. Repeat until all raster steps are covered
8. Return to PHOTSTBY

Data outputs
e.g., flux density vs. BSM position; spacecraft data required for analysis

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Target pixel (Name or pixel offset in angle on the sky in Y and Z coordinates)
- Integration time at each raster point
- Raster pattern (**TBR**, we were able to upload tables in ILT, it is not clear that this is possible for the real telescope)
- BSM positions (the BSM will need to be chopped in an unusual way for this test as it’s nominal rest (zero current) position will be adopted as one of the chop positions. The other is **TBD**.

Nominal settings

- Any bright fixed position point source can be adopted, a source with no nearby sources to accidentally chop on to is most desirable
- The BSM positions are the zero current position (determined during commissioning phase) and a TBD offset position on the chop axis

Duration
Assuming a 11x11 raster of points and about 10 seconds per point (plus 10 seconds of overhead) this will take 40 minutes per pixel.

Open Issues
- Bruce has an action to write a short note proposing and justifying the level down to which we want to measure the beams (based on technical and science considerations)
- The raster pattern and dimensions are **TBD**, the pattern used in ILT cold be adopted but it is not clear what the telescope constraints are.

6.1.15 Phot Peakup Mode

Test aims
This test commissions the peakup observing mode. Need to say what the peakup mode does here.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will do what?

Expert observing template
No

Procedure
1. Input the target
2. Run the AOT

Data outputs
- Target flux

Nominal settings
TBD

Duration
TBD

Open Issues
None

6.1.16 Phot Point Source Observation

Test aims
This test uses the point source AOT for several purposes. The first purpose will be to optimise the AOT itself, to do this the jiggle offset may be varied and the nod offset and period may be varied. The second use will be to commission the AOT, for this the AOT will be checked with a number of sources. In particular, faint sources will be used to verify the sensitivity achievable using this AOT. A set of standard calibration sources i.e. planets through asteroids to stars, will be observed with this AOT to verify the instrument photometric model and confirm the correct processing of data.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point, then remain at that point during the integration

Expert observing template
No

Procedure
3. Input the target
4. Input the nod offset, nod period and number of nod cycles
5. Input the jiggle offset
6. Run the AOT

Data outputs
- Target flux
- Optimal parameters to use i.e. optimal jiggle offset, nod offset, nod period

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Jiggle offset (currently supplied as a table listing BSM positions for all 7 positions)
- Jiggle period (no of chops or total time per jiggle position)
- Nod offset (and direction?) – What co-ordinates?
- Nod period (number of jiggles per nod?)
- Number of nod cycles

Nominal settings
- Jiggle offset 6 arcseconds
- Jiggle period 2 seconds
- Nod offset TBD
- Nod period – 1 jiggle per nod
- Number of nod cycles = 2 (ABBA)

Duration
TBD – will base it on nominal AOT values from CUS

Open Issues

- It is not clear how, in practice, the inputs are made. Nominal use of HSpot would not allow us to vary all the parameters we would want to. Updating tables with deliveries would also not be ideal as we may want to vary jiggle offsets throughout a series of runs in the same day.

6.1.17 Phot Scan Map Observation

Test aims
This test uses the scan map AOT for several purposes. The first purpose will be to optimise the AOT i.e. by checking different scan speeds. The second use will be to commission the AOT, for this the AOT will be checked with a number of sources. In particular, faint sources will be used to verify the sensitivity achievable using this AOT. A set of standard calibration sources, will be observed with this AOT to verify the instrument photometric model and confirm the correct processing of data.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will be slewing for most of this test
- Good **TBD** thermal stability is required for this AOT

Expert observing template
No

Procedure
1. Input the map
2. Input the slew speed
3. Run the AOT

Data outputs
- Target flux
- Optimal scan speed to use

Operator Inputs for Template
- Map (using HSpot?)
- Scan speed

Nominal settings
TBD

Duration
TBD

Open Issues
- If we decide to use the PTC then there is a pre-requisite that the PTC needs to be commissioned and setup for the conditions where this AOT is run. This may require some PTC commissioning once the lid is removed and possibly at various stages during telescope cooldown. Alternatively, we can use the telescope stability operational requirement and make sure commissioning of the PTC is done once the telescope is cold and stable.

6.1.18 Phot Small Map Observation

Test aims
This test uses the small map AOT for several purposes. The first purpose will be to commission the AOT, for this the AOT will be checked with a number of sources. If dead pixels are discovered, different strategies may be tried to recover the area that would have been covered by the dead pixel. Faint sources will be used to verify the sensitivity achievable using this AOT. A set of standard extended calibration sources, will be observed with this AOT to verify the instrument photometric model and confirm the correct processing of data.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point, then remain at that point during the integration

Expert observing template
No

Procedure
1. Input the target
2. Input the nod offset, nod period and number of nod cycles
3. Run the AOT

Data outputs
- Target flux
- Optimal parameters to use i.e. optimal jiggle offset, nod offset, nod period

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Jiggle period (no of chops or total time per jiggle position)
- Nod offset (and direction?) – What co-ordinates?
- Nod period (number of jiggles per nod?)
- Number of nod cycles

Nominal settings
- Jiggle offset 6 arcseconds
- Jiggle period 2 seconds
- Nod offset TBD
- Nod period – 1 jiggle per nod
- Number of nod cycles = 2 (ABBA)

Duration
TBD – will base it on nominal AOT values from CUS

Open Issues

6.1.19 Phot Raster Map Observation

Does this mode exist?

6.1.20 Parallel Mode Observation

Test aims
The aim of this test will be to commission parallel mode and to verify the predicted sensitivity. It is likely, although not a pre-requisite for PACS, that the two instrument teams will agree on a target and that this target will be mapped with both instrument's main mapping modes before using parallel mode. For SPIRE this will be scan map.

Operational requirements
- At the start of this test the instrument is in what mode?
- The observatory is commissioned to the point where it can slew with **TBD** slew accuracy

Expert observing template
No

Procedure
1. Input the map
2. Input the slew speed
3. Run the AOT

Data outputs
- SPIRE and PACS maps of the specified area
- Verification of SPIRE sensitivity using this mode
- Verification of the cross-calibration between SPIRE scan and SPIRE parallel mode maps
- Verification of the cross-calibration between PACS and SPIRE

Operator Inputs for Template
- Map
- Any others?

Nominal settings
TBD

Duration
TBD

Open Issues
None

6.2 Spectrometer

6.2.1 Spec Phase Up

Test aims
This test aims to identify the optimum value of phase for a given detector bias amplitude and frequency setting. It does this by stepping the detectors through a given set of phases while keeping the bias amplitude and frequency setting the same. The maximum value of the output is the phase which should be selected.

Operational requirements:
- At the start of this test the instrument is in SPECSTBY
- Ideally this test will be run with real time contact with the ground so if the central phase is missed, the test can be re-run within a short timescale.
- The observatory must not be slewing, if the cover is off the observatory must be pointing to a dark patch of sky

Expert Template Required:
Yes

Procedure:
1. Set the Vss to nominal settings as defined by Spec Vss
2. Set the bias amplitude and frequency to the input values
3. Set the three central phases to the input values
4. Set the stepsize and number of steps to the input values
5. Set the detectors to the phase given by the the stepsize, number of steps and central phase
6. Take offsets
7. Readout detectors for specified time

Operator Inputs for HSpot:
7. Bias frequency to be tested
8. Bias amplitude to be tested
9. Central phase to set for all three arrays
10. Number of steps to move away from central phase (for example by entering 3, 7 steps in total will be performed, 3 each side plus the central phase)
11. Stepsize, user enters 1, 2 etc (1=1.4 degrees, 2=2.8 degrees etc)
12. Time to readout the detectors (Typically 5 or 10 seconds)

Data outputs:
- Output voltage level vs phase set
- Phase setting to be used for nominal operation as determined from highest voltage level

Nominal settings and duration
- Bias frequency 130 Hz
- Bias Amplitude 31 mV peak to peak
- Central phase 183 degrees for all three arrays
- Number of steps 5
- Stepsize of 1 (1.4 degrees)

- Time per step 5 seconds

Total time given by total number of steps (5+1+5=11) times the time per step plus offset time per step (5+35 seconds) = 11x40 = 440 seconds = 8 minutes. Then add 2 minutes for setup and end obs giving 10 minutes in total.

If a full sweep is done (256 steps) the time taken is 40 x 255 = 10200 seconds = 170 minutes = 2.83 hours.

Open Issues:

- The ILT test allowed separate central phases to be defined for each array. This test assumes this is now restricted to one.
- We need to have a consistent definition of bias amplitude in all templates which require it i.e. all should either be rms or peak to peak

6.2.2 Spec Multi Level Noise

Test Aims

This test aims to characterise instrument noise performance under a range of conditions, in particular it will characterise noise as a function of bias frequency and amplitude under a range of JFET conditions as defined by the telescope temperature. A final characterisation will take place when the telescope is cold.

This test will be run before the lid comes off and will be repeated after the lid comes off. The source used for this test, once the lid is open, will be dark sky and ideally the same patch of dark sky near an ecliptic pole will be used throughout PV phase. As this test may be repeated periodically in routine phase, other patches of dark sky may need to be selected for pointing reasons. Additionally a bright source may be selected so that the noise can be characterised under loaded conditions.

While it is possible to run this test with the PTC heater on, increasing the detector temperature by ~10 mK, it is not desirable to do so in flight, hence this is not included as an input for this test.

Operational requirements

- At the start of this test the instrument is in SPECSTBY
- The observatory must not be slewing, if the cover is off the observatory must be pointing to a dark patch of sky

Expert Template Required:

Yes

Procedure:

7. Set the Vss to nominal settings as defined by Spec Vss
8. Set the bias amplitude and frequency to the first input values
9. Set the three phases to the input values
10. Take offsets and leave detectors producing data
11. Wait inputted time
12. Repeat steps 2-5 for each bias amplitude

Operator Inputs for HSpot:

1. Bias frequency to be tested
2. Phases to set for all three arrays for all bias amplitudes tested (TBR, ideally we could upload a table based on phase up results to be used for all subsequent tests)
3. Time to readout the detectors (Typically 5 or 10 minutes)
4. The source RA and Dec

Data outputs:

- Noise vs bias frequency and vs bias amplitude
- Optimum bias frequency and amplitude settings to run the detectors

Nominal settings

- Bias frequency 160 Hz
- Phased up phases for this frequency
- 5 minutes per level

Command Value	Bias Amplitude	Bias Amplitude

	(Peak to Peak)	(RMS)
02	1.5	1.0
04	3.0	2.1
0B	7.5	5.3
0F	10.5	7.4
16	15.0	10.5
1A	18.0	12.6
21	22.5	15.8
25	25.5	17.9
32	35.0	24.5
41	45.0	31.5
6C	75.0	52.5
91	100.5	70.4
D8	150.0	105.0
FF	177.0	123.9

Duration
The duration is given by number of settings (13) times the time at each setting (5 minutes) plus time required to reset offsets for each new bias amplitude (40 seconds) = 13 x 5.67 = 73.71 minutes. With start obs and end obs this totals about 75 minutes.

Open Issues:

- The test is defined as being done at one frequency unlike the ILT equivalent where many frequencies could be entered.
- We need to have a consistent definition of bias amplitude in all templates which require it i.e. all should either be rms or peak to peak
- If this test is run with the lid on the source RA and Dec is not required but it is not clear how the requirement for this can be decoupled from the template

6.2.3 Spec Standard Load Curve

Test aims

This test will be one of the 'work horse' tests of PV phase as it can be used to fulfil a number of objectives i.e.

- It will sample the detector noise and responsivity vs. bias (amplitude and frequency) and JFET conditions. Note this is not as detailed a test as the multi level noise test but it does have the advantage of being a lot quicker and therefore can be done more often and under more test conditions.
- It will be used to establish bias settings to be used for bright sources i.e. we envisage at least one load curve done on a bright sources
- It will be used to establish of an initial set of calibrators and dark fields near the ecliptic poles
- It will be used to monitor the health of the instrument i.e. a standard load curve will be done regularly following cooler recycle

Some of this can be done before the lid comes off, but will be re-done after the telescope has got cold enough.

Operational requirements

- At the start of this test the instrument is in SPECSTBY
- The observatory must not be slewing

Expert observing template

Yes

Procedure

1. Point the observatory to the chosen source
2. Set the detectors to the input bias frequency and phase
3. Set the detectors to the initial bias amplitude
4. Set offsets
5. Readout for input time
6. Repeat steps 3-5 for each bias amplitude
7. Return to SPECSTBY

Data outputs

- TBW

Operator Inputs for Template

- Bias frequency and associated phases at nominal bias amplitude
- Duration of integration at each level
- The source RA and Dec

Note the bias amplitude settings are hardcoded. These are:

Setting (Hex)	SLW Bias Amplitude (peak to peak)	SLW Bias Amplitude (RMS)
00	0.000	0.000

01	0.692	0.489
02	1.384	0.979
03	2.075	1.467
04	2.767	1.957
05	3.459	2.446
06	4.160	2.942
07	4.843	4.425
08	5.535	3.914
09	6.226	4.402
0A	6.918	4.891
0C	8.302	5.870
0E	9.686	6.849
12	12.453	8.806
14	13.837	9.784
16	15.220	10.762
19	17.296	12.230
1E	20.755	14.676
23	24.214	17.122
28	27.673	19.568
2D	31.132	22.014
32	34.592	24.460
3C	41.510	29.352
46	48.428	34.244
50	55.346	39.136
5A	62.264	44.027
64	69.183	48.920
78	83.020	58.704
8C	96.856	68.488
A0	110.693	78.272
B4	124.529	88.055
C8	138.366	97.839
E1	155.662	110.070
FA	172.957	122.299
FF	176.417	124.745

Bias Amplitudes full range FF: SLW = 176.417, SSW = 176.385

Nominal settings and duration

- The nominal bias frequency used for ILT was 130 Hz, the associated peak phases were around 183 degrees
- 10 seconds per level

For 10 seconds per level, the overall duration is about 30 minutes.

Open Issues

None

6.2.4 Spec Focal Plane Geometry

Placeholder as this will likely move to the commissioning plan

6.2.5 Spec BSM Angle Calibration

Test aims
This test is used to setup the fundamental BSM angle on sky vs. position senor output calibration. It essentially will be done in the same way as the scanning test from ILT. SPIRE apertures need to be setup as a pre-requisite for this

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on input aperture
3. Move the BSM to one end of its operating range
4. Chop the BSM between this position and an input reference position at the input chop frequency
5. Wait input number seconds while reading out the detectors
6. Move the BSM position 0x180
7. Repeat steps 4 and 5 until the full useable range is covered
8. Return to SPECSTBY

Data outputs
- Positions of pixels in BSM position units (e.g. CHOPPOSN, CHOPSENSSIG)
- Calibration curve of BSM position vs. angle on the sky

Operator Inputs for Template
- Source (Name and/or RA and Dec)
- SPIRE aperture
- Axis to scan (Y or Z)
- Reference position (supplied CHOPPOSN and JIGGPOSN)
- Chop speed
- Integration time at each position

Nominal settings and duration
- Any bright point source can be used
- At least initially the SPIRE boresight (centre of FOV) will be used
- Both axes will be scanned
- If the chop axis is scanned the reference position will be an offset in jiggle

Open Issues
- SPECSTBY is assumed to have the BSM powered on in closed loop at its rest position

6.2.6 Spec PCAL Standard Flash

Test aims
This test executes the same PCAL flash sequence as was done in ILT. It has three main objectives. The first is to compare ILT flashes with in flight flashes and check that PCAL is giving similar output and illumination pattern. The next objective is to a have an independent flash template to be used alongside other tests giving a monitor of detector behaviour. The third objective is to aid the transition from PCAL flashes done as independent tests to those done as part of AOT sequences.

Operational requirements

- At the start of this test the instrument is in SPECSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure

1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Flash PCAL between 0 and 3.8 mA at a frequency of 0.25 Hz for 16 seconds
3. Flash PCAL between 0 and 6.0 mA at a frequency of 0.25 Hz for 16 seconds
4. Return to SPECSTBY

Data outputs

- PCAL illumination pattern
- Trend information throughout commissioning and PV phases

Operator Inputs for Template

- No operator inputs are required

Nominal settings and duration

- No operator inputs are required, the total duration is about 1 minute

Open Issues
None

6.2.7 Spec PCAL AOT Flash

Test aims
This test executes the same PCAL flash sequence as is done in AOTs. This then allows the flash to be optimised and used before AOTs are fully commissioned.

Operational requirements
- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
4. Set the detectors to the nominal bias frequency, amplitude and phase
5. Flash PCAL between 0 and input current at a input frequency for input number of cycles
6. Return to PHOTSTBY

Data outputs
- Optimised PCAL flash for use with AOTs
- Trend information throughout commissioning and PV phases

Operator Inputs for Template
- PCAL current (0-7mA)
- Flash frequency (**TBR**, may need all parameters for the table)
- Number of cycles

Nominal settings
- The current should be? (need to check current values)
- Frequency = 0.25 Hz
- Number of cycles = 2

Duration
Less than 1 minute

Open Issues
None

6.2.8 Spec PCAL Level Check

Test aims
This test is similar to the standard load curve in that readouts are taken at a set of bias amplitudes at a given bias frequency and phase. The difference is that at each level a PCAL flash is added. This has the advantage that it allows a direct measurement of detector responsivity but has the disadvantage that it takes longer to do. Also not all tests requiring load curves require the PCAL flashes hence both templates are adopted.

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory must not be slewing

Expert observing template
Yes

Procedure
1. Point the observatory to the chosen source
2. Set the detectors to the input bias frequency and phase
3. Set the detectors to the initial bias amplitude
4. Set offsets
5. Readout for input time
6. Run a standard PCAL flash sequence
7. Repeat steps 3-6 for each bias amplitude
8. Return to SPECSTBY

Data outputs
- TBW

Operator Inputs for Template
- Bias frequency and associated phases at nominal bias amplitude
- Duration of integration at each level
- The source RA and Dec

Note the bias amplitude settings are hardcoded and are the same as for the standard load curve.

Nominal settings
The nominal bias frequency used for ILT was 160 Hz, the associated peak phases were around 168 degrees
- 10 seconds per level

Duration
Duration to be checked with ILT data.

Open Issues

- The PCAL sequence used should be the same as for ILT, the ILT templates need to be checked to establish whether the AOT sequence or the ILT sequence was used.

6.2.9 Spec Field of View Mapping

Test aims
This test is used to find the positions of the pixels using the telescope. Note the focal plane geometry test will establish the position of the SPIRE boresight. It is not yet clear if the position of the pre-defined SPIRE apertures will also be established as part of the focal plane geometry but if not this test can be used. Each run of this test will establish the position of a pixel. It is **TBD** whether to use cross rasters on the pixels, as defined here, or to use a larger raster across the whole array. Providing the telescope pointing performance is good, a dedicated cross-raster on a target pixel will give better accuracy.

We have a slight chicken and egg situation between this test and the BSM setup tests. In essence this test must be done to establish pixel positions, which are then used to calibrate the BSM position angle on the sky. This is then used to finalise BSM PID parameters. Therefore for this test the BSM does not, and is not required to, chop exactly between two pixels.

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will need to slew to each raster point

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on the appropriate aperture
3. Offset the target to the raster starting point
4. Chop the BSM over the input range
5. Readout detectors for input time
6. Move to the next raster point and readout detectors for input time
7. Repeat until all raster steps are covered
8. Return to SPECSTBY

Data outputs
- Offset, in angle on the sky, between pixel centres and centre of the array of all measured pixels, this will be two angles given in spacecraft Y and Z directions
- Interpolated positions of the remainder pixels
- Rough static beam maps of measured pixels, the fidelity of these is TBD and will depend on the raster type adopted

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Offset for start of raster (for cross-raster this will be the estimated pixel position)
- Integration time at each raster point
- BSM positions (the BSM will need to be chopped in an unusual way for this test as it's nominal rest (zero current) position will be adopted as one of the chop positions. The other is **TBD**.

Nominal settings

- Any bright fixed position point source can be adopted, a source with no nearby sources to accidentally chop on to is most desirable
- The BSM positions are the zero current position (determined during commissioning phase) and a TBD offset position on the chop axis

Duration

Assuming a cross raster of 18 points and about 1 minute per point this will take 20 minutes per pixel.

Open Issues

- If the SPIRE apertures are not established as a spacecraft test then each one must be included by this test
- The raster used is TBD

6.2.10 Spec Fixed SMEC Beam Profile

Test aims
This test has the aim of characterising the beam profile without needing to consider the detector time response. This is a broadband test, i.e. the SMEC remains at a fixed position throughout the test and as such will not give the wavelength dependency of the beam. It will be used to make follow up checks for pixels which have not had the full beam vs wavelength test done.

There are two ways to create the raster, which are to produce a raster pattern with the telescope or to do a jiggle map. The telescope raster is preferred. The reason for this is that this test is a good candidate test for early in PV phase as it can be executed while the telescope is cooling. The alternative BSM jiggle map requires a final BSM calibration which sits not only on the FOV mapping having been analysed, but also the BSM angle calibration done and analysed, then the BSM PID finally tuned. The combination of all these in the required order is not likely to have been done in early PV phase.

Scanning across point source is covered by Spec Time Response and Dynamic Beam Profile template.

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will need to slew to each raster point, then remain at that point during the integration

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on the input pixel
3. Offset the target to the raster starting point
4. Chop the BSM over the input range
5. Readout detectors for input time
6. Move to the next raster point and readout detectors for input time
7. Repeat until all raster steps are covered
8. Return to SPECSTBY

Data outputs
e.g., flux density vs. BSM position; spacecraft data required for analysis

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Target pixel (Name or pixel offset in angle on the sky in Y and Z coordinates)
- Integration time at each raster point
- Raster pattern (**TBR**, we were able to upload tables in ILT, it is not clear that this is possible for the real telescope)
- BSM positions (the BSM will need to be chopped in an unusual way for this test as it's nominal rest (zero current) position will be adopted as one of the chop positions. The other is **TBD**.

Nominal settings

- Any bright fixed position point source can be adopted, a source with no nearby sources to accidentally chop on to is most desirable
- The BSM positions are the zero current position (determined during commissioning phase) and a TBD offset position on the chop axis

Duration

Assuming a 11x11 raster of points and about 10 seconds per point (plus 10 seconds of overhead) this will take 40 minutes per pixel.

Open Issues

- Bruce has an action to write a short note proposing and justifying the level down to which we want to measure the beams (based on technical and science considerations)
- The raster pattern and dimensions are TBD, the pattern used in ILT cold be adopted but it is not clear what the telescope constraints are.
- We don’t have a 64 point pattern for the spectrometer

6.2.11 Spec Scanned Beam Profile

Test aims
This test has the aim of characterising the beam profile without needing to consider the detector time response. Unlike the previous test where the SMEC remains at a fixed position throughout the test, this test will scan the SMEC at each raster position giving not only the beam profile but also it's wavelength dependence. Naturally this adds a significant amount of time, therefore will probably only be executed on one pixel.

There are two ways to create the raster, which are to produce a raster pattern with the telescope or to do a jiggle map. The telescope raster is preferred. The reason for this is that this test is a good candidate test for early in PV phase as it can be executed while the telescope is cooling. The alternative BSM jiggle map requires a final BSM calibration which sits not only on the FOV mapping having been analysed, but also the BSM angle calibration done and analysed, then the BSM PID finally tuned. The combination of all these in the required order is not likely to have been done in early PV phase.

Scanning across point source is covered by Spec Time Response and Dynamic Beam Profile template.

We could change to doing this with a 16 point jiggle (or 64 if needed) and doing low resolution scans only. FOV mapping with telescope not needed if doing on central pixel.

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will need to slew to each raster point, then remain at that point during the integration

Expert observing template
Yes

Procedure
1. Set the detectors to the nominal bias frequency, amplitude and phase
2. Slew to target and place target on the input pixel
3. Offset the target to the raster starting point
4. Scan the SMEC the input number of scans at the input spectral resolution
5. Move to the next raster point and repeat until all raster steps are covered
6. Return to SPECSTBY

Data outputs
- Spectra per position point in the beam
- Wavelength dependent beam maps
- Relative throughput vs wavelength

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Target pixel (Name or pixel offset in angle on the sky in Y and Z coordinates)
- Number of scans at each raster point
- Scan resolution (low medium or high)
- Raster pattern (**TBR**, we were able to upload tables in ILT, it is not clear that this is possible for the real telescope)

Nominal settings

- Any bright fixed position point source can be adopted
- At least 4 scans per position are required, 8 are assumed here
- High scan resolution is assumed although a version of this test may be executed using medium or low scan resolution

Duration

Time per raster point = 8 scans x 70 seconds = 9.33 minutes, 10 minutes with overheads
Assuming a 11x11 raster of points the test will take 121 x 10 = 1210 minutes = 20.16 hours per pixel.

Open Issues

- Bruce has an action to write a short note proposing and justifying the level down to which we want to measure the beams (based on technical and science considerations)
- The raster pattern and dimensions are TBD, the pattern used in ILT cold be adopted but it is not clear what the telescope constraints are.
- We don’t have a 64 point pattern for the spectrometer

6.2.12 Spec Point Source Observation

Test aims
This test will use the point source AOT for many purposes and as such will be one of the most commonly executed spectrometer tests in PV phase. The aims are:

Using sky background
- Characterise the telescope port via a series of scans as the telescope is cooling

Using flux calibration sources
- Establish the RSRF
- Characterise vignetting

Using lines of known frequency
- Optimise scan speed
- Validate the spectral resolution
- Validate the wavelength scale
- Characterise fringe contrast

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will be in pointing mode

Expert observing template
No

Procedure
1. Input the target
2. Input the scan speed
3. Input the number of scans
4. Input the spectral resolution
5. Run the AOT

Data outputs
- Optimal parameters to use i.e. scan speed
- Throughput of telescope port vs wavelength
- RSRF
- Vignetting cal file
- Fringe contrast
- Confirmation of spectral resolution

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Scan speed (mm/s)
- Number of scans (minimum 4)
- Spectral resolution (low, medium or high)

Nominal settings

- Scan speed 0.5 mm/s
- 8 scans
- high resolution

Duration
About 10 minutes

Open Issues
None

6.2.13 Spec Sparse Map

Test aims
Commission the sparse map AOT (4 point jiggle).

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will be in pointing mode

Expert observing template
No

Procedure
1. Input the target
2. Input the number of scans
3. Input the spectral resolution
4. Run the AOT

Data outputs
- Validation that the AOT does what is expected
- Validation of achievable sensitivity using this mode

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Number of scans (minimum 4)
- Spectral resolution (low, medium or high)

Nominal settings
- 8 scans
- high resolution

Duration
About 40 minutes

Open Issues
- Knowledge of the beam profile is not a pre-requisite but is essential for data analysis.

6.2.14 Spec Map

Test aims
Full 16 point jiggle

Operational requirements
- At the start of this test the instrument is in SPECSTBY
- The observatory will be in pointing mode

Expert observing template
No

Procedure
1. Input the target
2. Input the number of scans
3. Input the spectral resolution
4. Run the AOT

Data outputs
- Validation that the AOT does what is expected
- Validation of achievable sensitivity using this mode

Operator Inputs for Template
- Target (Name and/or RA and Dec)
- Number of scans (minimum 4)
- Spectral resolution (low, medium or high)

Nominal settings
- 4 scans
- high resolution

Duration
About 80 minutes

Open Issues
- Knowledge of the beam profile is not a pre-requisite but is essential for data analysis.