

SPIRE

SUBJECT: SPIRE Calibration Observation Definitions

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Glossary

AOT	Astronomical Observation Template
BSM	Beam Steering Mechanism
CUS	Common Uplink System
ComP	Commissioning Phase
DCU	Detector Control Unit
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
GCO	Gyro Calibration Observation
GCP	Gyro Calibration Position
ICC	Instrument Control Centre
ILT	Instrument Level Test
IST	Instrument System Test
JFET	Junction Field Effect Transistor
LIA	Lock-in Amplifier
MCU	Mechanism Control Unit
MPS	Mission Planning System
NAIF ID	Navigation and Ancillary Information Facility ID
OE	Optical Encoder
OPD	Optical Path Difference
PCAL	Photometer Calibrator (also can be viewed by spectrometer)
PFM	Proto-Flight Model
PHOTSTBY	Photometer Standby Mode (phot. detectors and JFETs on, V _{ss} set to nominal settings, bias amplitude, frequency, and phase are set to their nominal values, offsets are set at current position, but no sampling [i.e. no science data taken], BSM initialised at HOME position)
PHS	Proposal Handling System
PID	Proportional, Integral, Derivative Algorithm (used in PTC and BSM)
POF	Photometer Observatory Function
PTC	Photometer Thermal Control
PTC-VM	Virtual Machine of the Photometer Thermal Control
PV	Performance Verification (Phase)
RC	Resistance-Capacitance (circuit)
REDY	Ready mode (detectors, BSM/SMEC not on, all other electronics [except DCU] are on)
RSRF	Relative Spectral Response Function
SPIRE	Spectral and Photometric Imaging REceiver
SPT	Special Performance Test
V _{ss}	JFET source voltage
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 will be implemented via normal AOTs prepared in HSpot or via special AOTs prepared with expert HSpot . Normal AOTs will be used whenever possible. Unlike for Routine phase they can only be used in very few cases during the PV phase. 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.

Templates for AOT validation/commissioning and optimisation are also included here. The same templates can be used in the Science Verification Phase for the verification of the scientific performance.

2. DOCUMENTS

2.1 Applicable Documents

2.2 Reference Documents

- RD1 SPIRE-RAL-DOC-000000; Draft 0.1, 19 Oct 2007: SPIRE PV Phase Plan
- RD2 SPIRE-UCF-DOC-002890 SPIRE; Issue 4 Draft, 19 Nov. 2007: Analogue Signal Chain and Phot. Det. Data Processing Pipeline
- RD3 SPIRE-BSS-DOC-002966; Version 1.5, 2. Oct. 2007: SPIRE spectrometer pipeline description
- RD4 SPIRE-RAL-DOC-002947: SPIRE Uplink Calibration Data
- RD5 SPIRE-RAL-PRJ-003018; Draft 0.1, 6 Dec. 2007: SPIRE Commissioning Phase Plan
- RD6 SPIRE-RAL-NOT-002881; Issue 1.5, 11.09.2007: SPIRE Spacecraft-Instrument Alignment Matrix (SPIRE SIAM)
- RD7 HERSCHEL-HSC-DOC-1139; Draft 0.3, 19.05.2008: Herschel Pointing Calibration 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.

Timeframe: Provides a general description of when the specific test is executed (e.g. PV phase, routine calibration, etc.)

Operational requirements: – including both instrument and observatory setup. The instrument and any relevant observatory modes (e.g., pointed) will be stated, thermal stability, etc.

Expert Template Required: – is a flag which indicates whether this procedure requires an expert template with expert HSpot or whether it only requires a standard AOT from HSpot. In case the name of the associated top-level CUS script is given here.

Procedure: - This section gives the actual procedure.

Operator Inputs For (expert) HSpot: – indicates all inputs required; for standard AOTs this will be the familiar set of parameters (target name, position, observing mode, etc) in Hspot, ExpertHSpot provides the calibration scientist with a way to enter non-standard observations (i.e. AOTs with different parameters, calibration observations, ...)

Data outputs: – mentions the output data and what to obtain from the measurement in general as well as the science data packets generated (e.g. PHOTF, PHOTOFF, ...) needed to do the analysis. If applicable, this section lists also the name of the calibration table(s) to be populated/updated by this test.

Nominal settings: – indicates a default set of operator inputs

Duration: – indicates duration assuming nominal settings

Comments: Optional section, a holder for any comments, extra explanatory notes, or open issues. The open issues will 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 late in the ComP. However, the exact division between ComP and PV Phase is not yet clear. It will probably be after each of the three instruments had their 'first light' in terms of pointing calibrations (see also RD7). For SPIRE this means we have to wait for the first PACS SIAM update to start our pointing observations.

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. The current ESA policy is to force the lid to come off as early as possible.

There will be about 5 hours ground contact each day, but with very restricted pointing. For PV phase it is currently assumed that no ground contact is needed (see RD1). For commissioning phase it is assumed that some ground contact is needed, but for further details see RD5.

The PV-phase will be divided up between the instruments in blocks. Currently the plan is to have two days on and 4 days off [RD1].

3.3.2 Using These Templates

It is assumed that PHOT and SPEC standby modes (PHOTSTBY, SPECSTBY) have the detectors set at nominal settings (Vss, Bias frequency, bias amplitude and associated phases for each detector array), the BSM initialised at its HOME position, and the offsets (see Section 3.11 of RD2) are set at the current position. Nevertheless after each change in the system (e.g. a move to the target) the offsets need to be set again. This is also done for the science AORs. The nominal detector settings may be modified in-flight during Commissioning and/or PV phase. To allow the operator to easily change input values to be optimised within an expert AOT for a specific test the use of calibration tables for coupled input values is minimised.

It is assumed that there are three conditions defined in which the telescope could be in: *pointing*, *scanning*, or *slewing*. A fourth state would be *tracking* to describe the situation when the telescope is 'tracking' a moving object in the solar system (e.g. a giant planet or their moons and asteroids). It is also possible to track and scan or nod.

Many of the templates defined here can be used with the lid closed (i.e. at the beginning of the Commissioning Phase), so a 'no pointing' option needs to be implemented. This option is also used for other engineering observations such as a *cooler recycle*. Due to the nature of the underlying software (i.e. CUS, PHS, MPS) it is not possible to implement a simple 'no pointing' as an input in the ExpertHSpot GUI. Therefore we have defined a second version of each template, called SpirePhoto_CalEng_Xxxx opposed to SpirePhoto_Cal_Xxxx (for the photometer), for most of the other scripts dealing with the calibration of the instrument, providing a dedicated script with a 'no pointing' only option [TBC].

Many tests require a source of *reasonable* brightness (called *strong source*). 'Reasonable' means here: flux > 200mJy. For the pointing test we require a *pointing source*, point-like and with flux > 50 Jy.

Throughout this document a consistent definition of the bias amplitude is used, which is peak to peak and not rms, however, in some tables both values are given for comparison.

In principle there are observing modes where only one or two of the arrays are used exclusively, however, for this document it is assumed that always all arrays are going to be used.

3.4 Nominal values

Given in the table below are a selection of nominal values to be used in some of the templates described here. Please note, these values can and will be changed in flight and are therefore only specified in this table and not later in the document under each template definition. The current nominal values can be sometimes found in the various Uplink Calibration Tables described in RD4 or in the actual uplink calibration tables currently used.

Photometer			
Bias frequency	fb	130 .2 Hz	18.6 Hz associated ILT sampling rate
Bias amplitude	Vb	31.2 mV	(peak2peak)
Bias phase	φ_b		
Target phase	φ_t	180.7 deg	(Phot Phase up) for all 3 arrays
Scan rate (speed)	$\dot{\theta}$	30, 60 "/s and 20, 60 "/s	SPIRE only and PMODE
Scan rate (nominal)	$\dot{\theta}_{nom}$	30 "/s	For scan map mode
Scan rate (fast)	$\dot{\theta}_{fast}$	60 "/s	For scan map mode
Scan angle	φ	42.4 deg wrt Z axis	For scan map mode (also in PMODE)
Scan leg separation	d2	348 arcsec	For scan map mode with $\varphi=42.4deg$
Scan leg separation P	d2p		only for PMODE
Chop frequency	fchop	2 Hz in Y	range: [0.2-2]Hz
GCP time	gcp_time	15s	Time spend at GCP to recalibrate gyros during a GCO

3.5 Additional calibration (uplink) tables [TB updated]

The Phot Phase Up (6.1.1.) will determine the correct phases for all relevant bias/frequency combinations. This test will be used to populate two additional calibration (uplink) tables. One (e.g. SpireTable_PhotSourceMode.txt) will contain 6 parameters, the bias frequency, amplitude, and phase for the two nominal settings (*normal* and *bright* source). It is still **TBD** if after each AOT using the bright settings the instrument will be set back to nominal, or if many bright AOTs are scheduled together. The second (e.g. SpireTable_PhotMultiLevelNoiseLevels.txt) will contain a list of all possible bias frequencies with a set of bias amplitudes and their associated bias phases. The latter table may be split into separate bias/phase tables for each frequency (maybe about 5) to be tested.

4. QUICK SUMMARY

4.1 Test Summary [TB updated from CUS!]

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	0.09
Phot Multi Level Noise	Noise load curves as done in PFM5 (requires separate phase-up for each setting; priority/feasibility TBC)	1.26
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	0.28
Phot PCAL Load Curve	Single phase load curve with PCAL flash at each level	0.68
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 ILT Flash	Standard ILT flash for Commissioning and PV phase.	0.04
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.	0.39
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 Pickup Mode	POF ** (pickup POF). Should do 7-point before and after.	
Phot Point Source Photometry (POF 2) Optimisation	Optimisation of 7 point jiggle map parameters, in particular, jiggle 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? No, the 4 point is intermediate. sparse is 1 point. [TBC]	
Spec Map	Full 16 point jiggle	

4.2 Expert Templates and Ground Contact [table outdated!]

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 ILT 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

see RD5

5.1.2 Cooler Tests

see RD5

5.1.3 SCAL PID Tuning

see RD5

5.1.4 SMEC PID Tuning

see RD5

5.2 Photometer

This section covers all tests which can be done at Helium-I which require the detector subsystem.

5.2.1 Phot VSS (ComP)

Test Aims:

This test aims to identify the optimum value of V_{ss} to run each JFET at. A set of V_{ss} 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, meaning one has to find a compromise between the lower noise of a higher V_{ss} setting and the higher power dissipation entailed by raising the V_{ss} .

Timeframe:

It is expected that this procedure will only be run once in space, at the beginning of the mission during ComP, while the instrument is still 'warm' (not yet 300mK, @4.2K best time to measure it, see comments below).

Operational requirements:

- The instrument must be in PHOTSTBY mode
- Thermal stability: Detector arrays should best be at 4.2K (>> 300 mK)

Expert Template Required:

Yes (SpirePhotoEng_Xxxx.txt)

Procedure:

1. Set the Vss to first value in list for all photometer JFETs for all three arrays
2. Wait for <input> seconds
3. Read out the detectors for <input> seconds
4. Repeat steps 2 and 4 for the following JFET Vss value
5. Return to PHOTSTBY

Operator Inputs for expert Hspot:

- Nominal values for bias amplitude, frequency, phase
- Read out time spend at each Vss value

Data outputs:

- Data output needed: PHOTF
- Noise vs. Vss
--> Vss setting to be used for nominal operation as given by lowest noise values
- Calibration table: SpireTable_PhotPswNominalSettings.txt,
SpireTable_PhotPmwNominalSettings.txt, SpireTable_PhotPlwNominalSettings.txt

Nominal settings:

- 16 hardcoded settings for Vss are given (1.0, 1.1, 1.2, 1.3,, 2.5)
- Nominal bias frequency (f_b), bias amplitude (V_b), and bias phase (phi_b)
- Settling time: 30seconds
- Read out time: 120 seconds

Duration:

Total time is given by the number of steps (16) times the sum of settling times (30s) plus read out time (120s) , so 40 minutes (16*150s) in case all three arrays can be done in parallel.

Comments:

- The Vss steps will be hardcoded, while the read out time will be kept a flexible parameter .
- At 300 mK, the bolometer have a high resistance, and the detector's Johnson noise will be the dominating noise term, making it difficult to separate it from the JFET noise. At 4.2 K, however, the noise that is measured will be dominated by the JFET noise, which should be minimised here.
- This test does not need input from 'Phot Phase Up'. At 4.2 K the correct phase setting is not critical and the values measured on the ground during ILT can be used.
- Note: Each of the total 12 JFETs is connected to several detectors. There are 6 JFETs for the 139 detectors of the PSW, 4 JFETs for 88 detectors of the PMW, and 2 for the 43 detectors of the PLW.
- Note: The associated CUS script uses the 'no pointing' mode.

5.3 Spectrometer

5.3.1 Spec VSS (ComP)

Test Aims:

This test aims to identify the optimum value of Vss to run each JFET at. A set of 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, meaning one has to find a compromise between the lower noise of a higher Vss setting and the higher power dissipation entailed by raising the Vss.

Timeframe:

It is expected that this procedure will only be run once in space, at the beginning of the mission during ComP, while the instrument is still 'warm' (not yet 300mK, @4.2K best time to measure it, see comments below).

Operational requirements:

- The instrument must be in SPECSTBY mode
- Thermal stability: Detector arrays should best be at 4.2K (>> 300 mK)

Expert Template Required:

Yes (SpireSpecEng_Xxxx.txt)

Procedure:

1. Point the observatory to 'no pointing'
2. Set the Vss to first value in list for all photometer JFETs for both arrays
3. Wait for <input> seconds
4. Read out the detectors for <input> seconds
5. Repeat steps 2 and 4 for the following JFET Vss value
6. Return to SPECSTBY

Operator Inputs for expert Hspot:

- Nominal values for bias amplitude, frequency, phase
- Read out time spend at each Vss value

Data outputs:

- Data output needed: SPECf, NHK
- Noise vs. Vss
--> Vss setting to be used for nominal operation as given by lowest noise values

Nominal settings:

- 16 hardcoded settings for Vss are given (1.0, 1.1, 1.2, 1.3,, 2.5)
- Nominal bias frequency (f_b), bias amplitude (V_b), and bias phase (phi_b)
- Settling time: 30seconds
- Read out time: 120 seconds

Duration:

Total time is given by the number of steps (16) times the sum of settling times (30s) plus read out time (120s) , so 40 minutes (16*150s) in case both arrays can be done in parallel.

Comments:

- The Vss steps will be hardcoded, while the read out time will be kept a flexible parameter . At 300 mK, the bolometer have a high resistance, and the detector's Johnson noise will be the dominating noise term, making it difficult to separate it from the JFET noise. At 4.2 K, however, the noise that is measured will be dominated by the JFET noise, which should be minimised here.
- This test does not need input from 'Spec Phase Up'. At 4.2 K the correct phase setting is not critical and the values measured on the ground during ILT can be used.
- Note: The associated CUS script uses the 'no pointing' mode.

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 the phase for each of the three arrays for a given detector bias amplitude and frequency setting, to have the LIA working optimal. It does this, by stepping the detectors through a given set of phases around a target phase determined during ground testing, while keeping the bias amplitude and frequency setting the same. A target phase is necessary due to the relatively long time (40s) the test takes for each phase. Each bias amplitude and frequency setting has its own optimal phase. The best (here maximum) value of the output signal is the phase which should be selected.

Timeframe:

Commissioning and PV phase activity to populate associated calibration tables (Phot_Phase_tab.txt and SpireTable_PhotMultiLevelNoiseLevels.txt) used by PHOTSTBY or in later tests (i.e. the Phot Multi-Level Noise).

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 optimal phase (the maximum in the output signal) is missed, the test can be re-run within a short timescale. (Note: Try to avoid real time contact by having a good set of phase measurements from the ground.)
- 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 (SpirePhoto_Cal_PhaseUp.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set the bias amplitude, frequency, and sampling rate to the <input> values
3. Set the detectors to the phase given by $target\ phase - stepsize * number\ of\ steps$ using the <input> values for stepsize and number of steps, and using the target phase from the list provided below
4. Set detector offsets (see comments)
5. Read out detectors for <input> time
6. Repeat steps 3 to 5 adding each time the stepsize to the phase for the following $2 * number\ of\ steps$ cycles
7. Return to PHOTSTBY

Operator Inputs for expert HSpot:

1. Bias frequency to be tested

2. Requested sampling rate
3. Bias amplitude to be tested
4. Target phase to set for all three arrays (see list below)
5. Number of steps to move away from target phase (for example by entering 3, 7 steps in total will be performed, 3 each side plus the central phase)
6. Stepsize, user enters 1, 2 etc (1=1.4 degrees, 2=2.8 degrees etc)
7. Read out time (Typically 5 or 10 seconds)
8. The source RA and Dec (observable dark patch of sky, if lid open)

Data outputs:

- Data output needed: PHOTF, PHOTOFF, NHK
- Output voltage level vs phase set
--> Phase setting (for each array) to be used for nominal operation as determined from a second order fit to the highest voltage levels
- Calibration table: SpireTable_PhotPswNominalSettings.txt, SpireTable_PhotPmwNominalSettings.txt, SpireTable_PhotPlwNominalSettings.txt

Nominal settings:

- Set of bias frequencies used in ILT [80, 110, 130, 170, 200] Hz
- Nominal sampling rate used in ILT: 18.6 Hz (for nominal bias frequency of 130.2Hz)
- Set of bias amplitudes used in ILT [3, 31, 84] mV
- The target phase is phi_T for all three arrays at nominal f_b and V_b
- Number of steps 5
- Stepsize of 1, eq.~1.4 degrees (8bit = 255 values -> 360deg/255 = 1.4118 deg)
- Time per step 10 seconds

Tanya's list of target phases for a given bias amplitude and frequency setting. These values come from a fit to the few values actually measured in the ILT testing campaign (see Phases.xls).

Duration:

single run of script with default values:	329s
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If a full sweep is done (256 steps) the total time is 7405s == 2.07 hours.

Comments:

- The ILT test allowed different target phases to be defined for each array. This test assumes this is now restricted to one, as only very small differences were measured in ILT for the three photometer arrays (in contrast to the spectrometer ones).
- Note: In ILT 5s per step was used, but should be higher (10) in flight.
- Note: Contrary to ILT testing this test will be run only without the PTC running. The PTC was used in ILT (running at maximum power) to really heat the detectors and create a significantly

different temperature. Under normal PTC working conditions the PTC should not have an influence on the phase.

- Note: The phase difference depends to first order on the RC time constant of the detector-harness system, and on the bias frequency. It depends also on the bias amplitude because that influences the detector resistance. Furthermore it will be dependent on the detector temperature (i.e. the bath temperature), since that too affects the resistance. However, given the relatively narrow range of temperature variations expected in flight, this will be a very small effect. During PFM5 the PTC heater was switched on to mimic bath temperature variations. This changed the spectrometer phases by ~1.5 degrees and the photometer phases by a similar amount or slightly less (so the variations are in the range of only one stepsize). The additional load from any (allowed) astronomical source is small compared to the load from the telescope itself. However, the additional extra load by switching SCAL on changed the spectrometer phase by about 10-15 deg.
- Note: In principle one can set three different bias amplitude values (but only one frequency) for each array, although this is not envisaged.
- Note: Set offsets means offset subtraction which means 'putting detectors in range', see 3.11 of RD2

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 temperatures as defined by the telescope temperature. It does this by stepping the detectors through a given set of bias amplitudes while keeping the bias frequency fixed, but adjusting the phase at each step depending on the given bias amplitude/frequency setting. This procedure/template has to be repeated for all bias frequencies to be tested. While it is possible to run this test with the PTC heater on, increasing the detector temperature by ~10 mK, and so getting the noise measurements at a range of temperatures, it is not desirable to do so in flight (as it 'burns' helium), hence this is not included as an input for this test.

Timeframe:

This test is a ComP and PV phase activity. It 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. A final characterisation will take place when the telescope is cold. As this test may be repeated periodically in routine phase, make sure to choose a dark patch continuously visible throughout the mission. Additionally a strong source may be selected so that the noise can be characterised under loaded conditions.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing (even for closed lid), if the cover is off the observatory must be pointing to a dark patch of sky
- Needs results of multiple Phot Phase Up tests to populate SpireTable_PhotMultiLevelNoiseLevels.txt calibration table.

Expert Template Required:

Yes (SpirePhoto_Cal_MultiLevelNoise.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set the bias frequency and sampling rate to the <input> value
3. Set the bias amplitude to the first <input> value
4. Set the phase for each of the three arrays separately
5. Set detector offsets (see comments)
6. Read out detectors for <input> time
7. Repeat steps 3-6 for each bias amplitude from hardcoded list
8. Return to PHOTSTBY

Operator Inputs for expert HSpot:

1. Bias frequency to be tested
2. Requested sampling rate
3. Read out time (Typically 5 or 10 minutes)
4. The source RA and Dec (observable dark patch of sky, if lid open)

Data outputs:

- Data output needed: PHOTF, PHOTOFF, NHK
- Noise vs bias frequency and vs bias amplitude
 - Optimum bias frequency and amplitude setting to run the detectors
- Calibration table: SpireTable_PhotPswNominalSettings.txt, SpireTable_PhotPmwNominalSettings.txt, SpireTable_PhotPlwNominalSettings.txt

Nominal settings:

- Read out time: 5 minutes per bias amplitude level
- Sampling rate for ILT was 18.6Hz for a bias frequency of 130.2Hz

Setting (Hex)	PSW Bias Amplitude (peak to peak)	PSW Bias Amplitude (RMS)
[Sunils]	[mV]	[mV]
02	1.002	0.709
04	2.005	1.418
0A	5.012	3.544
0E	7.017	4.962
14	10.025	8.506
18	12.029	7.797
1E	15.037	10.633
22	17.042	12.050
28	20.049	14.177
3C	30.074	21.266
64	50.123	35.442
8C	70.172	49.619
C8	100.245	70.884
FC	126.309	88.605

Duration:

single run of script with default values: 4546s

Comments:

- The test is defined as being done at one frequency unlike the ILT equivalent, where many frequencies could be entered.
- This test will be done at various bias frequencies (including the nominal f_b).
- The required uplink table SpireTable_PhotMultiLevelNoiseLevels.txt for this test can be filled with dummy values before the Phot Phase Up tests are run.
- Note: A byproduct of this test is a 'full' load curve with fewer bias amplitudes than used for the Phot Standard Load Curve (6.1.5) but with the correct phase settings for each amplitude/frequency combination.
- The bias amplitudes are hardcoded in terms of a scaling parameter (BIASConvertPxW.txt) for each array and 256 possible steps (coded in Hex) and do not need to include the exact nominal value. The scaling factors are: 0.506506 (PLW), 0.504412 (PMW), and 0.501227 (PSW). The maximal bias amplitude values are therefore: FF (Hex for 255) = PSW 127.813 mV, PMW

128.625 mV, PLW 129.159 mV ($255 * 0.506506 = 129.159$). The values in the table above are chosen to have a reasonable subset of bias amplitudes with more points on the steeply rising inner part compared to the flat tail in the outer part of a load curve.

- Note: 'Multi' is in contrast to a 'Single'-Level test used during ILT.
- Note: 'Set offsets' means offset subtraction, which means 'putting detectors in range' (see 3.11 of RD2)
- Note: Make sure that this long test is not halted to execute a standard PCAL flash (e.g. it could be that routinely always after x hours a PCAL flash is done).
- Note: Long test! Make sure that the script has a Trest after $t > 3.5h$.

6.1.3 Phot PTC PID Tuning

Test aims:

The aim of this test is to find and optimise the PID parameters (the constants K_p , K_i , and K_d used in the PID algorithm of the PTC control loop) for each PTC setting, i.e. the specific control temperature on which the PTC runs from. The template to verify the general performance of the PTC is described in 6.1.4 (Phot Thermal Stability).

Timeframe:

This is considered either an engineering or a commissioning observation. Once there is a working setup of the PTC, there should be no need to set it up again unless there is a degradation in performance, therefore it will not be done routinely. From current data (ILT) the PTC needs more work during IST, SPT, Commissioning and PV-phase (see comments below). Currently it is envisaged to determine the PID parameters during Commissioning (with the lid on) when there is a reasonable amount of time available where one cannot yet look at the sky.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- Needs the instrument to be setup properly, i.e. *Phot Vss* and *Phot Phase Up* done.
- Test and setup can be performed in pointing mode, no need for the telescope to actually scan.
- Needs constraint on thermal stability (**TBD**): At what point during Commissioning can this test be done? Only during the first ~20 days when telescope is actively keep warm (constant) or also in the cool down phase thereafter?
- Needs approach on how to disentangle effects caused by the algorithm from those caused by changes in the environment.

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set detector offsets (see comments)
3. Read out detectors for <input> time
4. Set <input> PTC PID parameters
5. Switch PTC to run on <input> reference temperature
6. Read out detectors for <input> time
7. Switch PTC off
8. Read out detectors for <input> time
9. Return to PHOTSTBY

Operator Inputs for expert HSpot:

1. The source RA and Dec (observable dark patch of sky, if lid open)
2. Read out time
3. Reference temperature for PTC

Data outputs:

- Data output needed: PHOTF, NHK

- Detector noise vs. PTC setting

Nominal settings:

- Typical read out times per setting should be ≥ 1 h to check for 1/f noise floor and knee
- Reference temperatures to be used could be: SUBKTEMP, PTC T1, PTC T2, PTC T3, thermistors

Duration:

≥ 3 hours per reference temperature

Comments:

- Note: The PTC is a 'heater' running in a closed loop and strapped to the detectors to actively keep the temperature constant by in- or decreasing a minimal amount of continuous heating. This function is only needed for the scan map mode if the temperature drifts are too large, otherwise the chopping and nodding will take care of the temperature fluctuations.
- In ILT the PTC was run controlled by three different reference sources (SUBKTEMP @cooler, T1-T3 @PTC itself, and the thermistors on the individual detector arrays). 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.
- Open issue: Need to specify in detail what are the criteria to decided PTC is working properly.
- Open issue: It needs to be checked if this test could be combined with other activities.
- Open issue: How to disentangle PTC-PID tuning from PTC general performance tests?
- Note: In general, PTC should be used if this test shows a measurable improvement in the 1/f noise with the PTC running (i.e. a running PTC entails no significant negative effects on the system).
- Note: Set offsets means offset subtraction, which means 'putting detectors in range' (see 3.11 of RD2)
- Note: Long test! Make sure that the script has a Trest after $t > 3.5$ h.

6.1.4 Phot Thermal Stability

Test aims:

The aim of this test is to take long duration noise data to establish the noise performance of the photometer on various timescales for pointed observations. This template will be used with the PTC off to establish baseline performance and also with the PTC on at various settings

Timeframe:

Only PV phase activity

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must not be slewing, if the lid is open the observatory must be pointing a dark patch of sky
- Do not schedule PCAL flashes during this test.
- The background (telescope or lid) must be thermally stable. There is an action on Matt to specify the allowed rate of change for this test (**TBD**).

Expert Template Required:

Yes (Needs a pointed AOT which does not jiggle. This is non-standard.)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Switch PTC to run on <input> reference temperature
3. Set detector offsets (see comments)
4. Read out detectors for <input> time
5. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, NHK
- Average noise for each detector as determined from plateau of the Fourier transform
--> Frequency of 1/f knee for each individual detector as determined from the Fourier transform of the detector timeline

Operator Inputs For Template:

1. PTC settings (**TBD**, see Comments)
2. Read out time
3. Reference temperature for PTC
4. The source RA and Dec (observable dark patch of sky, if lid open)

Nominal settings:

- PTC settings (**TBD**, see Comments)
- Read out time: 5 hours

Duration:

5 hours (est., to see thermal variations)

Comments:

- Note: 'PTC off' is a valid input for this test.
- Aside from the jiggling in a standard, pointed AOT, this test does not requires an expert AOT. The PCAL flashes during the observation in a standard AOT can be switched off (in case the instrument teams decides to use the PCAL flashes at all) leaving only a flash at the beginning and end of this AOR).
- Note: Because this test takes so long only the PHOTSTBY detector settings will be used.
- In ILT the PTC was run controlled by three different reference sources (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 and after EM 2008 Matt should probably start to bet on another 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.
- Note: Long test! Make sure that the script has a Trest after $t > 3.5h$.

6.1.5 Phot Standard Load Curve

Test aims:

This test will be used to fulfil a number of objectives at various stages of the mission, from an initial characterisation of the detectors to monitoring the bolometers by means of frequently measuring a standardised Load Curve (measurement of the bolometer resistor voltage versus bias current):

- It will sample the detector noise and responsivity vs. bias (amplitude and frequency) and JFET conditions (i.e. temperatures). Note: This is not as detailed a test as the Phot Multi-Level Noise test but it does have the advantage of being a lot quicker (although sampling a lot more bias settings but with only 5-10 s per level compared to 5-10 min) 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. it is planned to have two working bias settings with all the associated calibrations, one for normal and one for bright sources
- It will be used to measure the background level due to the telescope alone by observing some (always observable) dark fields near the ecliptic poles
- It will be used to monitor the health of the instrument

Timeframe:

This test is a ComP and PV phase activity. It will be one of the 'work horse' tests of PV phase. It will be done before the lid comes off, and re-done after the telescope has got cold enough. A standardised load curve (nominal frequency, specific set of bias amplitudes) may be done following cooler recycle and will so be a regular engineering observation.

Operational requirements:

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

Expert Template Required:

Yes (SpirePhoto_Cal_StdLoadCurve.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set the detectors to the <input> bias frequency and <input> sampling rate
3. Set the detectors to the <input> phase
4. Set the detectors to the initial bias amplitude
5. Set detector offsets (see comments)
6. Read out detectors for <input> time
7. Repeat steps 4-6 for each bias amplitude in hardcoded list
8. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, PHOTOFF, NHK
- Load curve
--> Measure detector noise at each bias amplitude setting, which is a very good indicator of the health of the system

--> Using the slope of the load curve at each measured bias amplitude level, together with the values for the bias amplitude, the measured detector voltage, and the resistance of the load resistor, one can measure the bolometer DC responsivity

--> Determine 'zero level', emission due to the telescope alone

--> Determine if and how much detectors follow ideal bolometer theory

Operator Inputs for expert HSpot:

1. Bias frequency to be used
2. Requested sampling rate
3. Bias phase to be used
4. Duration of read out at each level (Typically 5 or 10 seconds)
5. The source RA and Dec or NAIFID (depending on test aim and if lid open, a observable dark patch of sky, or a strong source)

Nominal settings:

- The nominal bias frequency used for ILT was f_b , the associated peak phases were around ϕ_b
- 10 seconds per bias amplitude level
- Sampling rate for ILT was 18.6Hz for a bias frequency of 130.2Hz

Set of hardcoded bias amplitudes which are going to be used:

Setting (Hex) [Sunils]	PSW Bias Amplitude (peak to peak) [mV]	PSW Bias Amplitude (RMS) [mV]
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

Duration:

single run of script with default values:	1022s
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Comments:

- Note: Set offsets means offset subtraction, which means 'putting detectors in range' (see 3.11 of RD2).
- Note: 'Standard' here means 'benchmark', i.e. having a quick and standardised way of doing a load curve. This implies that only one phase for all bias frequency/amplitude combinations is used, so ignoring the fact that the arrays are then slightly out of phase. Doing it this way however significantly speeds up the procedure of taking a load curve. A 'full' load curve with fewer bias amplitudes but with the correct phase settings will be the byproduct of the Phot Multi-Level Noise (6.1.2) test.
- The bias amplitudes are hardcoded in terms of a scaling parameter (SpireTable_PhotP[x]wMaxbias.txt) for each array (x=[s, m, l]) and 256 possible steps (coded in Hex) and do not need to include the exact nominal value. The scaling factors are: 0.506506 (PLW), 0.504412 (PMW), and 0.501227 (PSW). The maximal bias amplitude values are therefore: FF (Hex for 255) = PSW 127.813 mV, PMW 128.625 mV, PLW 129.159 mV (255* 0.506506 = 129.159). The 35 values in the table above are chosen to have a reasonable subset of bias amplitudes to use covering the full range of possible values with more points on the steeply rising inner part compared to the flat tail in the outer part of the load curve.

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 (without relying on the ideal bolometer theory when evaluating standard load curves) 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

Timeframe:

Only PV phase activity plus engineering observation to monitor health

Expert Template Required:

Yes (SpirePhoto_Cal_PcalLoadCurve.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set the detectors to the <input> bias frequency and <input> sampling rate
3. Set the detectors to the initial bias amplitude
4. Set the detectors to the <input> phase
5. Set detector offsets (see comments)
6. Run a standard PCAL flash sequence
7. Read out detectors for <input> time
8. Repeat steps 3-7 for each bias amplitude in hardcoded list
9. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, PHOTOFF, SCUNOMINAL, NHK
- Two load curves (with and without PCAL signal)
--> In the small-signal approximation (given by PCAL levels) the quotient between the difference in measured voltage and the applied difference in signal (with and without PCAL) is equal to the responsivity ($\Delta V/\Delta Q=S$).

Operator Inputs for expert HSpot:

1. Bias frequency to be used
2. Requested sampling rate
3. Bias phase to be used
4. Duration of read out at each level (Typically 5 or 10 seconds)
5. The source RA and Dec or NAIFID (depending on test aim, observable dark patch of sky, or strong source)

Nominal settings:

- The nominal bias frequency used for ILT was f_b , the associated peak phases were around ϕ_{Trees}
 - Sampling rate for ILT was 18.6Hz for a bias frequency of 130.2Hz
 - 10 seconds per level
- Set of hardcoded bias amplitudes which are going to be used:

Setting (Hex) [Sunils]	PSW Bias Amplitude (peak to peak) [mV]	PSW Bias Amplitude (RMS) [mV]
02	1.002	0.709
04	2.005	1.418
0A	5.012	3.544
0E	7.017	4.962
14	10.025	8.506
18	12.029	7.797
1E	15.037	10.633
22	17.042	12.050
28	20.049	14.177
3C	30.074	21.266
64	50.123	35.442
8C	70.172	49.619
C8	100.245	70.884
FC	126.309	88.605

Duration:

single run of script with default values: 2457s

Comments:

- The PCAL sequence used should be the same as for ILT. During ILT PCAL was flashed at two levels (between 0 and 3.8mV and between 0 and 4.8mV) at a frequency of 0.25Hz (i.e. 1 'flash' every 4 seconds) and for 15 cycles.
- Note: Set offsets relates to offset subtraction, which relates to 'putting detectors in range' (see 3.11 of RD2)
- The bias amplitudes are hardcoded in terms of a scaling parameter (SpireTable_PhotP[x]wMaxbias.txt) for each array ($x=[s, m, l]$) and 256 possible steps (coded in Hex) and do not need to include the exact nominal value. The scaling factors are: 0.506506 (PLW), 0.504412 (PMW), and 0.501227 (PSW). The maximal bias amplitude values are therefore: FF (Hex for 255) = PSW 127.813 mV, PMW 128.625 mV, PLW 129.159 mV ($255 * 0.506506 = 129.159$). The 14 values in the table above are chosen to have a reasonable subset of bias amplitudes to use covering the full range of possible values with more points on the steeply rising inner part compared to the flat tail in the outer part of the load curve.
- Note: To save time the PCAL load curve is again done with only a single phase, so ignoring the fact that the arrays are then slightly out of phase.

6.1.7 Phot Focal Plane Geometry (Initial Pointing)

Test aims:

This test has multiple purposes. Firstly, it will find the boresight of the SPIRE array and define the offset between the PACS and SPIRE array by offsetting the telescope from the known PACS (smallest beam on Herschel) boresight. Currently it is envisaged to measure the initial offset by visiting a 25-point raster driven by the telescope (5x5 points with ~4-5arcsec offset) while chopping the BSM (without nodding) on a strong source. Since the spatial relative pointing error (SRPE) is measured to be 2.2 arcsec (and so non-compliant with the requirements of 1.0 arcsec) a mechanism has been devised to perform SRPE-compliant raster pointing by using exclusively the accurate gyro information. However, the originally planned on-board gyro-propagation (a priori gyro mode) will most probably be not available so we have to use the on-ground gyro reconstruction (a posteriori gyro mode) to get an accurate measure of the raster points actually driven by the telescope. This means our 25-point raster will not be perfectly aligned (regular grid) but we will know the deviation afterwards. Following a first 25-point raster on the SPIRE boresight (the central pixel of the PSW array) it is planned to visit 3-4 other 'fiducial' pixels with 25-point rasters in the same measurement, i.e. without losing the accurate gyro information (the exact implementation of this special mode is still under discussion, currently a custom_map including all the rasters is favoured over the concatenation of the individual 25-point rasters). It is planned to use 3-4 of the co-aligned pixels forming at least a triangle to check for optical distortions and the alignment of the array with the telescope axis, which is the second purpose of this test. The third purpose of this test is to get a good measure of the beam shapes for this handful of 'fiducial' pixels. A further goal is to check the photometric calibration by using a photometric standard as the source. The test *Phot FOV Mapping (6.1.8)* will be used to define the remaining pixels on the SPIRE array.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point
- The gyro reconstruction mode is available
- PACS aperture found

Timeframe:

This activity will be performed early in the ComP (under the umbrella of the Herschel Pointing Calibration Plan, see RD7) to establish the first SPIRE pixel. Depending on the availability of Neptune (SPIRE's primary photometric calibrator) during the ComP, this test will be repeated during the PV phase.

Expert Template Required:

Yes

(SpirePhoto_CalGCO_FpgInitialPointing.txt/SpirePhoto_CalGCO_FpgInitialPointingSingleRaster.txt)

Procedure:

1. Point the observatory to <input> source
2. Set MCU(BSM) to <input> framerate
3. Drive a regular 25-point raster on the first <input pixel> using the <input> angular stepsize and chopping the BSM with the <input> frequency between its home and an <input> GCP or off position. Set detector offsets (see comments) at each raster point.

4. Read out detectors for <input> time at each of the 25 raster points
5. Repeat step 2-3 for the remaining <input> pixels

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- A map will be created with the pipeline and the peak fitted to the source
--> Refine SPIRE-SIAM for the measured pixels

Operator Inputs for expert HSpot:

1. The source RA and DEC or NAIFID (see note below)
2. BSM sampling frequency (see note below)
3. Currently the GCP or off position is defined as the first raster position.
4. Fiducial pixels to be used
5. The angular stepsize of the 25-point regular grid
6. The BSM chopping frequency
7. The BSM off position
8. Read out time

Nominal settings:

- Neptune should be used if observable, alternatively any other observable bright asteroid. The source should be point-like and have a flux of > 50 Jy.
- The ILT BSM sampling rate of 125Hz would just about work with the current nominal DCU sampling rate of 18.6Hz.
- The boresight plus 3-4 of the outer co-aligned pixels (see Figure).
- Angular step: 4-5arcsec
- BSM chopping: 2Hz
- The BSM chop 1 position is $y=0, z=0$ (*BSM home*) the chop 2 is $y=\pm 60\text{arcsec}, z=0$ (see note)
- The current nominal read out time is 15s

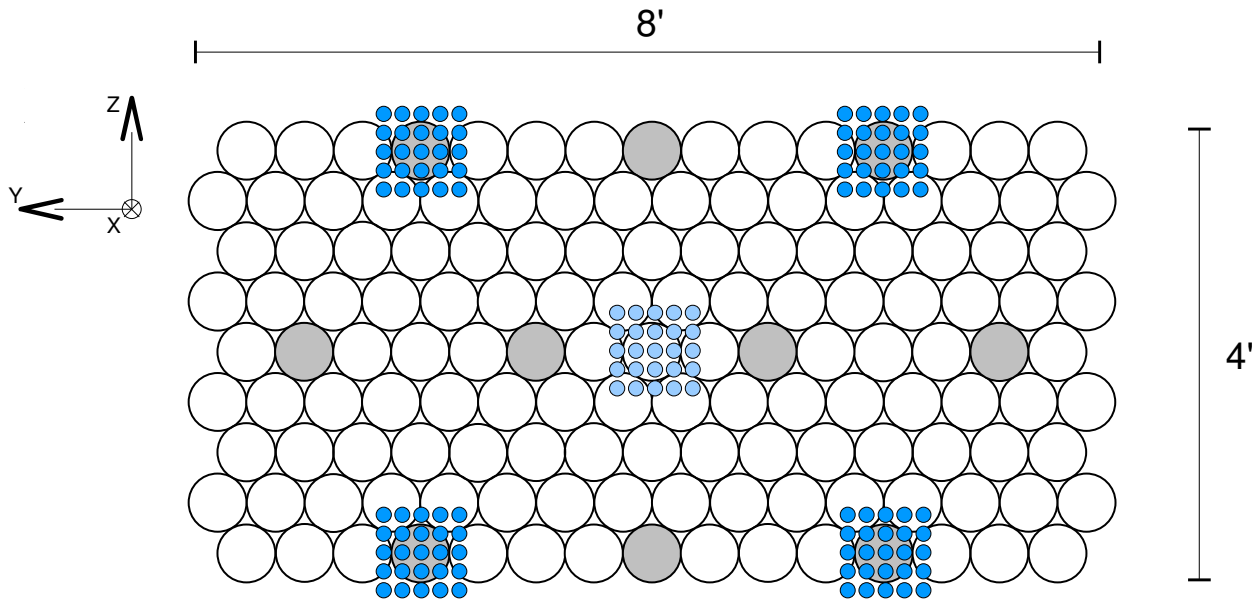
Duration:

TBD – the pure exposure time, without slewing or other overheads, will be (4 or 5) times 25 times 15 sec, so larger than 30 minutes

Comments:

- Note: The selection of the BSM framerate has to be made in connection with the DCU sampling rate in such a way not to exceed the allowed data rate.
- Note: Currently the gyro reconstruction mode does not allow solar system objects. A proposal to change this is under discussion. Treating Neptune as a fixed source for the time of the observation does only work on a very limited number of days during the mission.
- Note: If the current set of fixed pointing targets (with fluxes between 1-5 Jy) turn out to be too faint we may look for alternatives, e.g. Arp 220 which is very bright, but slightly extended.
- Note: At the time of this test the BSM is still uncalibrated, however, the conversion of commanded position in Hex vs. arcsec on the sky determined during ILT (160 Hex == 1 arcsec) can be used to determine the second chop position. The sign of the user input determines the direction of the chop.

- Note: Define a positional reference point and revisit it in due course, to allow for the gyro reconstruction to work (every >~600s, see RD7).
- Figure to visualise procedure:



6.1.8 Phot FOV Mapping Line Scan (FPG scan)

Test aims:

By scanning a point source along each line (Y-axis and 'orthogonal' axis) of the SPIRE photometer array (see Figure) this test addresses four goals. The output series of beam profile cuts, with peaks separated by a time interval corresponding to the pixel separation along the scan axis, will primarily be used to measure the relative position along the scan direction of all pixels on the array with respect to the 'fiducial' pixels measured in *Phot Focal Plane Geometry (Initial Pointing) (6.1.7)*. Pixels along the lines containing the fiducial pixels will be related to them directly, pixels not on these lines, indirectly. For this test the signal modulation will come from the scanning, leaving the BSM at rest at its home position (no chopping). In addition, this measurement will give 1D beam profiles for all pixels, will provide an estimate of the 'flatfield' and in case a photometric standard is used will provide information for the photometric calibration.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory scans a source across the array multiple times
- The gyro reconstruction mode is available
- Known scan accuracy: relative pointing shift should be small ($< 0.5''$), scan axis and the line of detectors are required to be accurately aligned, scan direction is also required to be uniform (straight, i.e. no "wobbling", and with constant speed) along the scan

Timeframe:

This activity will be performed early in the ComP (under the umbrella of the Herschel Pointing Calibration Plan, see RD7) to establish all pixels of the SPIRE arrays. Depending on the availability of Neptune (SPIRE's primary photometric calibrator) during the ComP, this test will be repeated during the PV phase.

Expert Template Required:

Yes (SpirePhoto_CalGCO_FovMappingFpgScan.txt)

Procedure:

1. Point the observatory to <input> source
2. Provide <input> GCP/OFF position for gyro recalibration
3. Go to start of scan and set detector offsets (see comments)
4. Scan the observatory at <input> scan rate along each of the 9 lines in the Y-direction starting in the <input> direction while taking data
5. Repeat step 3 in the <input> orthogonal direction

Data outputs:

- Data output needed: PHOTF, NHK
- A map will be created with the pipeline and the peak of the source at each pixel will be fitted --> Refine SPIRE-SIAM for the measured pixels
- **TBD**

Operator Inputs for expert HSpot:

1. The source RA and DEC or NAIFID(see note below)
2. Relative offset of GCP/OFF position to source

3. The scan speed
4. The direction of the first scan (+Y or -Y)
5. The 'orthogonal' (to the Y-axis) direction

Nominal settings:

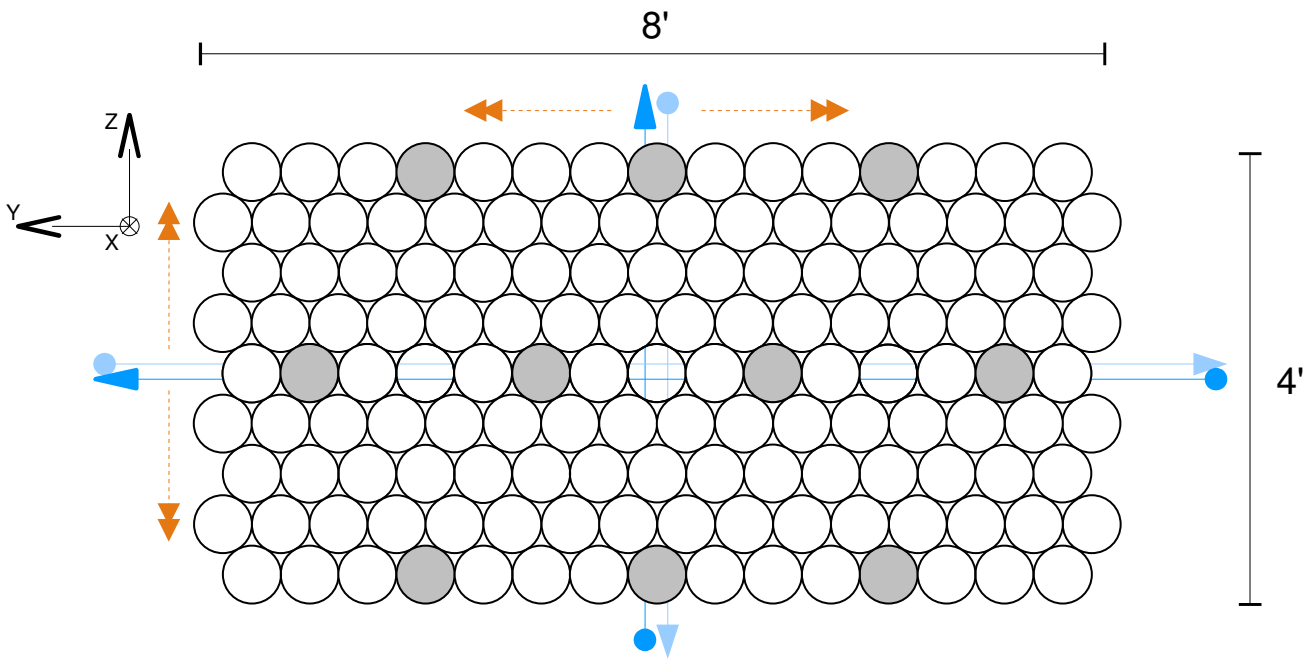
- Neptune should be used if observable, alternatively any other observable bright asteroid. The source should be point-like, have a flux > 50 Jy.
- Scan speed: 30arcsec/s
- Relative offset from input source for GCP/OFF position: (0, 0) arcsec
- The 'orthogonal' axis could be the truly perpendicular axis (Z-axis) which requires 31 scan lines to cover all pixels or a scan line along the 'full' pixels lines, i.e. inclined by 60 deg, which will result in 19 scan lines to cover all pixels. The number of scans in the Y-axis is dictated by the PSW array to be 9.

Duration:

TBD – the pure scanning time, without overheads for accelerating and decelerating, will be 2 times 9 times 16 sec and 2 times 31 times 8 sec, so > 13 min (the 8arcmin in Y are scanned in 16 sec at a speed of 30arcsec/s, the 4 arcmin in Z are scanned in 8 sec).

Comments:

- Note: The method is insensitive to a pointing error perpendicular to the scan axis
- More time consuming raster method (*Phot FOV Mapping Large Raster (FPG raster) (6.1.9)*) is the alternative, if this scan method does not work.
- Note: Define a positional reference point and revisit it in due course, to allow for the gyro reconstruction to work (every >~600s, see RD7). If there is no relative offset from the input source for GCP/OFF position specified, data could be taken during gcp_time reassuring the correct return to the GCP position.
- Note: Currently the gyro reconstruction mode does not allow solar system objects. A proposal to change this is under discussion. Treating Neptune as a fixed source for the time of the observation does only work on a very limited number of days during the mission.
- Note: If the current set of fixed pointing targets (with fluxes between 1-5 Jy) turn out to be too faint we may look for alternatives, e.g. Arp 220 which is very bright, but slightly extended.
- Note: It should be confirmed beforehand if the array is indeed fully aligned to the spacecraft (see test *Phot Focal Plane Geometry (6.1.7)*), otherwise the offset angle has to be an input for this test to make sure we scan exactly along the axes.
- Figure to visualise procedure:



6.1.9 Phot FOV Mapping Large Raster (FPG raster)

Test aims:

This test is the alternative to the *Phot FOV Mapping Line Scan (FPG scan) (6.1.8)*. The positions of the photometer pixels is here measured by moving the telescope along each line (Y-axis and 'orthogonal' axis) in a raster method. Providing the telescope pointing performance is good, a dedicated cross-raster on a single target pixel, as described in *Phot FOV Mapping Cross Raster (6.1.10)*, will give better accuracy.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point
- The gyro reconstruction mode is available

Timeframe:

Commissioning activity

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source on the <input> line/'orthogonal' axis
2. Offset the target to the raster starting point
3. Set detector offsets (see comments)
4. Chop the BSM over the <input> range
5. Read out detectors for <input> time
6. Move telescope to the next raster point
7. Chop the BSM over the <input> range and read out detectors for <input> time
8. Repeat until all raster steps are covered
9. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- Offset, in angle on the sky, between pixel centres and centre of the array of all measured pixels
- Interpolated positions of the remainder pixels
- Rough static 1D beam profiles of measured pixels

Operator Inputs for Template:

1. The source RA and DEC or NAIFID(see note below)
2. The line or 'orthogonal' direction to be measured
3. Number of raster points and offset between them
4. Read out time at each raster point
5. 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

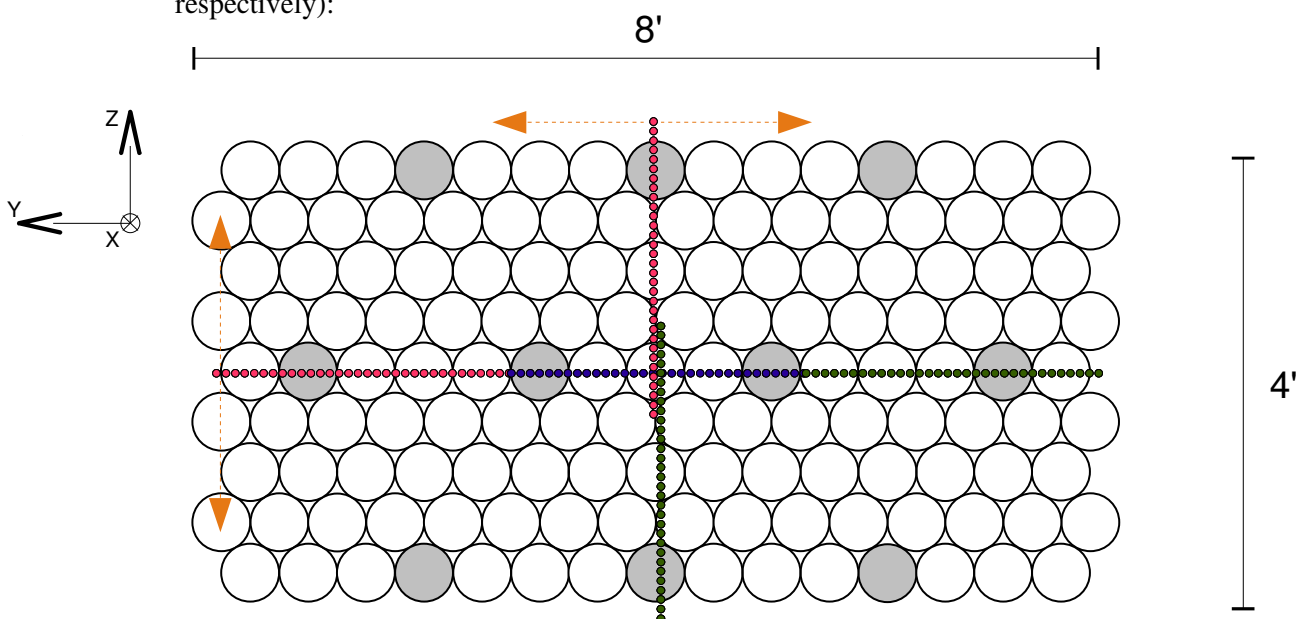
- The BSM positions are the zero current position (determined during Commissioning Phase) and a TBD offset position on the chop axis

Duration:

TBD

Comments:

- If the 17 SPIRE PSW apertures, defined in the SPIRE SIAM (RD6), are not established as a spacecraft test (i.e. by test 6.1.7) then each one must be included by this test.
- Note: The raster is will be done along both axes if this test and not the *FPG Scan (6.1.8)* will be the prime way of determining the FGP.
- Note: Define a positional reference point and revisit it in due course, to allow for the gyro reconstruction to work (every >~600s, see RD7).
- Note: The BSM is operated in a close loop where the current chop/jiggle position of the mirror (magneto-resistive sensor readout) is read by the MCU software. This then computes the error between the original commanded position and the actual position and adjusts the current on the motor coil accordingly.
- Note: It should be confirmed beforehand if the array is indeed fully aligned to the spacecraft (see test *Phot Focal Plane Geometry (6.1.7)*), otherwise the offset angle has to be an input for this test to make sure we scan exactly along the axes.
- Note: Currently the gyro reconstruction mode does not allow solar system objects. A proposal to change this is under discussion. Treating Neptune as a fixed source for the time of the observation does only work on a very limited number of days during the mission.
- Note: If the current set of fixed pointing targets (with fluxes between 1-5 Jy) turn out to be too faint we may look for alternatives, e.g. Arp 220 which is very bright, but slightly extended.
- Figure to visualise procedure (here assumed to be implemented in the basic raster mode, the only one capable of on-board gyro improvement, which is limited to 32 raster points, alternatively one could use the raster_pointing and probably the custom_map pointing mode, which are eligible to on-ground gyro reconstruction, giving 100x100, or 3000x3000 points respectively):



6.1.10 Phot FOV Mapping Cross Raster

Test aims:

This test is used to find the positions of a photometer pixels by moving the telescope (using the accurate gyro mode). Each run of this test will establish the position of one pixel/aperture. It is **TBD** whether to use a cross rasters, as defined here, or to use a larger raster across the whole array done by moving the telescope along several points on the Y axis as described in the template *Phot FOV Mapping Large Raster (FPG raster)* (6.1.9) or a true scan along the pixels as described in *Phot FOV Mapping Line Scan (FPG scan)* (6.1.8). Providing the telescope pointing performance is good, a dedicated cross-raster on a single 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 (see 5.1.1). Therefore for this test the BSM does not, and is not required to, chop exactly between two pixels. It will be chopped between its zero position and an arbitrary position on the sky as given by an uncalibrated BSM, to obtain a modulated signal equivalent to source minus sky and telescope.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory will need to slew to each raster point
- The gyro reconstruction mode is available

Timeframe:

Commissioning activity

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source on the <input> aperture
2. Offset the target to the raster starting point
3. Set detector offsets (see comments)
4. Chop the BSM over the <input> range
5. Read out detectors for <input> time
6. Move telescope to the next raster point
7. Chop the BSM over the <input> range and read out detectors for <input> time
8. Repeat until all raster steps are covered
9. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- 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 [TBD, cross or large] adopted

Operator Inputs for Template:

1. Target (Name and/or RA and Dec)
2. The SPIRE pixel/aperture to be measured
3. Offset for start of raster (for cross-raster this will be the estimated pixel position)
4. Number of raster points and offset between them
5. Read out time at each raster point
6. 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.

Comments:

- If the 17 SPIRE PSW apertures, defined in the SPIRE SIAM (RD6), are not established as a spacecraft test (i.e. by test 6.1.8) then each one must be included by this test.
- Note: The BSM is operated in a close loop where the current chop/jiggle position of the mirror (magneto-resistive sensor readout) is read by the MCU software. This then computes the error between the original commanded position and the actual position and adjusts the current on the motor coil accordingly.

6.1.11 Phot BSM Angle Calibration

Test aims:

This test is used to setup the fundamental BSM calibration: angle (distance) on sky (in arcsec) vs. position sensor output. It is done by chopping the BSM between a fixed reference point and a set of incremental positions along one of the main axis (Y or Z, i.e. chopping or jiggling, respectively).

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must be pointing without nodding
- SPIRE apertures need to be setup as a pre-requisite for this (i.e. the telescope must be able to place the source to a specific pixel on the array, for example the boresight, from where this test will be started)
- The on-sky position of all pixels covered by the BSM movement must be known before this test (e.g. obtained via the *Phot FOV Mapping Cross Raster* test).

Timeframe:

Only PV phase activity

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source and place target on <input> aperture
2. Set MCU(BSM) to <input> framerate
3. Move the BSM to one end of its operating range in the <input> axis to scan
4. Chop the BSM between this position and an <input> reference position at the <input> chop frequency
5. Set detector offsets (see comments)
6. Read out detectors for <input> time
7. Move the BSM position by <input> units along the <input> axis to scan
8. Repeat steps 3 and 5 until the full useable range of BSM positions is covered
9. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- Positions of pixels in BSM position units (e.g. CHOPPOSN, CHOPSENSSIG) by source detection in specific detector timeline
--> Calibration curve of BSM position vs. angle (distance) on the sky

Operator Inputs for Template:

1. Source (Name and/or RA and Dec)
2. SPIRE aperture to be used
3. Axis to scan (Y or Z)
4. The ILT BSM sampling rate of 125Hz would just about work with the current nominal DCU sampling rate of 18.6Hz.
5. Reference position (supplied CHOPPOSN and JIGGPOSN)

6. Increments along scan axis
7. Chop frequency
8. Read out time at each position

Nominal settings:

- Any bright point source can be used
- At least initially the SPIRE boresight (centre of FOV) will be used (Note: it does not really matter where the source starts exactly initially, the incremental movements will be used to find the centre of each pixel later)
- Nominal increments along scan axis are 0×180 (384) units which corresponds to ~ 1 arcsec and is therefore much finer than the typical raster points driven with the telescope for the FOV mapping. (Note: the absolute displacement is different for both axis for a single increment)
- Both axes will be scanned (the chop axis first)
- If the chop axis is scanned the reference position will be an offset in jiggle
- Nominal chop speed in Y is f_{chop}
- Nominal read out time is about 15s

Duration:

TBD in ILT scans typically took 30-40 minutes

This depends on the number of increments used and the read out time at each position.

Comments:

- Note: The selection of the BSM framerate has to be made in connection with the DCU sampling rate in such a way not to exceed the allowed data rate.
- Note: CHOPPOSN is the commanded BSM position along the chop (Y) axis and CHOPSENSSIG the position returned by the sensor; dito for JIGGPOSN along the jiggle (Z) axis
- Note: PHOTSTBY has the BSM powered on in closed loop and it is initialised at its rest (HOME/Zero) position
- Note: Calibrating the jiggle axis is more demanding. While the on-sky rotation range of the chop stage allows a good coverage of the BSM movement along the Y-axis with detectors (~ 14 for the PSW, separated by $31.4''$), the small range of the jiggle stage provides only a coverage of 5 rows giving 2-3 detectors. To increase the number of data points for the fit of the jiggle axis calibration it is planned to let the telescope (not the BSM) move the source from the central pixel along the chop axis by a full beam and then use the two detectors in the row above and below. This gives 5 data points for the jiggle movement.
- Note: The actual range of the BSM movement, measured on the ground, turned out to be larger in both direction compared to the requirement of ± 2 arcmin for the chop and ± 30 arcsec for the jiggle stage.
- Note: From PFM4 data it was measured that 160Hex units in chop and 380Hex units in jiggle correspond to 1 arcsec on the sky.

6.1.12 Phot Transient Response and Dynamic Beam Profile

Test aims:

This test aims to characterise the detector channel transient response (dominated by the lowpass filter with time constant of ~30ms, causing a delay between the astrometric pointing timeline and the detector data timeline) and also the dynamic beam profile (as described in Section 4 of RD2). 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 scanning during the test

Timeframe:

Only PV phase activity plus engineering observation to monitor health

Expert Template Required:

Yes

Procedure:

1. Point the observatory to the <input> source
2. Set <input> bias amplitude mode
3. Set <input> bias frequency and <input> sampling rate
4. Offset the observatory the <input> angle (distance) on sky in the <input> specified direction
5. Run a standard PCAL flash sequence (at start of scan)
6. Set detector offsets (see comments)
7. Start integrating detectors
8. Scan the telescope from offset position, through the source to offset position in the other direction at the specified slew speed (e.g. from - 4 arcminutes in Y to + 4 arcminutes in Y)
9. If requested to do more than one slew, slew back in the opposite direction (e.g. from +4 arcminutes to - 4 arcminutes)
10. Repeat the requested number of times
11. Run a standard PCAL flash sequence (at end of scan)
12. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- SPIRE dynamic beam profiles i.e. beam profiles of the instrument at a given slew speed
- Detector time response extracted from dynamic beam profiles
--> Correction for scan speed to be applied (see Section 5.6 in RD2)

Operator Inputs for Template

1. The source information (Name and/or RA and Dec)
2. Bias amplitude setting (*nominal* or *bright*)
3. Bias frequency to be used
4. Requested sampling rate
5. Offset angle (distance) on sky

6. Axis (Y or Z)
7. Scan speed

Nominal settings:

- The source – this will need to be a bright point source. It could be done with planets (ideally Neptune, as this is our prime photometric calibrator), but their movement will need to be factored in to the data analysis, if the spacecraft will not be able to accurately scan a moving source, so a fixed, or very slow moving, source would be preferred. The main requirement is that it is point-like and not extended at all. There are about 12 quasars with fluxes of $> 1Jy$ available, but the fluxes are not so well known compared to Neptune.
- Sample rate (maximal 1/3 of bias frequency; see Comments below)
- Offset distance – **TBD**, a few arc minutes
- Axis (Y or Z) – both will be used
- Scan speed – **TBD** (at least including the three nominal values of teta_dot)

*Duration:***TBD***Comments*

- Note: *Dynamic Beam Profile* is in contrast to *Static Beam Profile*
- Note: Expert template is required since instead of scanning at the magic angle we scan along the telescope axes and use different speeds. The could be dealt with as a simple user input, but the former requires a change of a calibration table parameter.
- Note: Depending on the availability of multiple (bright) sources within the FOV one could think about scanning this system at an appropriate angle.
- Note: The time constant of the transient response depends on the bias amplitude, therefore this test has to be run at the two baseline bias amplitudes (nominal and bright).
- Note: Scanning along the Z and Y axis prevents having to use the mapmaking algorithm for analysing the data of this test (i.e. only individual bolometer output needed).
- Note: Allowed scan rates/speeds range between $0.1''/s$ to $60''/s$
- Note: To make life easier do not use a moving targets.
- Should we specify direction? The baseline should be to do always both directions, e.g. starting on the negative side. This will be hardcoded in template.
- Note: It should be confirmed beforehand if the array is indeed fully aligned to the spacecraft (see test *Phot Focal Plane Geometry (6.1.7)*), otherwise the offset angle has to be an input for this test to make sure we scan exactly along the axes.
- Note: The sampling rate is coupled to the bias frequency and selected via a Hex number (2,3,...9,A,11,...13) resulting in a sample rate of 'bias frequency divided by 3, 4, 5,14' respectively (e.g. bias frequency=130.21Hz, sampling rate setting=6, then sampling rate=18.6Hz==53.8ms).
- Note: The sample rate (maximal 1/3 of bias frequency, not limited by telemetry) should be maximal for this test. However, using the 'full photometer array' (i.e. all three arrays) the sampling rate is limited to 20Hz in order not to exceed the limit on the number of data packages the spacecraft is able to handle. It is envisaged to include data rate determinations in the cus scripts. If the sample rate is the driver though, nominal f_b would not be the optimum bias frequency as we would want to go faster. However, the higher bias frequency will have an effect on the transient response, i.e. changing the actual parameter to be measured. The

bolometer model will then have to be used to relate the results of this super-fast-high-bias-frequency readout to the nominal readout. The example of TBD showed that it is better to use the standard sample rate for this test.

- 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. Temperature is critical for this test as it may change the transient response.

6.1.13 Phot Static Beam Profile

Test aims:

This test has the aim of characterising the beam profile without needing to consider the detector time response (i.e. in non-scanning mode). The test does this by taking a small map (64 point jiggle map) of a strong source.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory will be nodding
- Requires results from following tests: *BSM PID tuning*, *Phot FOV mapping*, and *Phot BSM angle calibration*
- Requires standard AOT is setup with *Phot Small Map Observation*

Timeframe:

Only early in PV while the telescope is in cooling phase

Expert Template Required:

No

Procedure:

1. Point the observatory to <input> source
2. Set detector offsets (see comments)
3. Set repetition factor to <input>
4. Run AOT
5. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- flux density vs. BSM position (TBC)

Operator Inputs for Template:

1. Target (Name and/or RA and Dec)
2. Repetition factor

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
- Typical repetition factor is 3

Duration:

TBD

Comments:

- 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)
- Note: Scanning across point source is covered by the *Phot Time Response* and *Dynamic Beam Profile* template.

- Note: There are two ways to measure the beam profile, which are to produce a raster pattern with the telescope or to do a 64 point jiggle map. The latter is preferred here, which assumes the BSM will be better calibrated compared to the telescope pointing. Nevertheless, the 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.
- We may wish to do this with a square array, however, this will require a special BSM uplink table (**TBD**).

6.1.14 Phot ILT PCAL Flash

Test aims:

This test executes exactly the same PCAL flash sequence (PCAL amplitude level, frequency, and number of cycles) as was done in ILT in contrast to the *Phot PCAL AOT Flash*. 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 have an independent (from the normal AOTs) 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 in terms of their application as calibration sources.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must be pointing

Timeframe:

Commissioning and PV phase activity plus engineering observation to continuously monitor health, needed to transfer calibration obtained on ground to flight

Expert Template Required:

Yes (SpirePhoto_Cal_IltPcalFlash.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set detector offsets (see comments)
3. Flash PCAL between 0 and 3.8 mA at a frequency of 0.25 Hz for 15 cycles
4. Flash PCAL between 0 and 4.8 mA at a frequency of 0.25 Hz for 15 cycles
5. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- PCAL illumination pattern
- Trend information throughout Commissioning and PV phases

Operator Inputs for Template:

1. The source RA and Dec or NAIFID (observable dark patch of sky, if lid open, or source)

Nominal settings:

- the level, frequency, and number of cycles of the two flash sequences are hardcoded

Duration:

single run of script with default values:	158s
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Comments:

- Note: 0.25 Hz means one flash every 4 seconds with 2seconds off and 2 seconds on (e.g. between 0 and 3.8mA)
- Note: The duration of one flash sequence is given by the number of flash cycles times one over the frequency (e.g. $15 * 1/0.25 = 60s$)
- Note: Currently it is not clear if standard AOTs have PCAL flashes included. This will be decided later by the instrument team. Currently they are in, one at start and one at end, and more in between if AOR takes longer than 45min, but some analysis (maybe by ESA) needs to be performed to see if it saves much time by having the PCALs outside of the observations.

6.1.15 Phot PCAL Level Check

Test aims:

This test will flash PCAL at a set of levels in order to characterise its behaviour in-flight and to compare with the behaviour in ILT. In addition, this test will be used to define the parameters used for the *Phot PCAL AOT Flash* template.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory must be pointing

Timeframe:

Only PV phase activity plus engineering observation to monitor health

Expert Template Required:

Yes (SpirePhoto_Cal_PcalLevelCheck.txt)

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set detector offsets (see comments)
3. Flash PCAL between 0 and 1.0 mA at a frequency of 0.25 Hz for 15 cycles
4. Repeat flashes between 0 and the levels 0.7, 1.05, 1.4, 1.75, 2.1, 2.45, 2.8, 3.15, 3.5, 3.85, 4.2, 4.55, 4.9, 5.25, 5.6, 5.95, 6.3, 6.65, and 7.0 mA
5. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- Signal-to-Noise (S/N) and thermal effects vs. applied PCAL level
--> Optimum level for PCAL to be flashed at. This will be a compromise between a high S/N (which increase with increased PCAL level) and no significant thermal effect (i.e. the increasing drift of the output due to the heating from PCAL).

Operator Inputs for Template:

1. The source RA and Dec (observable dark patch of sky, if lid open)

Nominal settings:

- the frequency and number of cycles for the flash sequences at various PCAL levels are hardcoded

Duration:

single run of script with default values:	1399s
---	-------

Comments:

- Note: 0.25 Hz means one flash every 4 seconds with 2 seconds off and 2 seconds on (e.g. between 0 and 3.8mA)
- Note: The duration of one flash sequence is given by the number of flash cycles times one over the frequency (e.g. $4 \times 1/0.25 = 16s$)

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- Do we need to flash at other frequencies and number of cycles in flight? Currently there are no indication why we have to change them.

6.1.16 Phot PCAL AOT Flash

Test aims:

This test executes a PCAL flash sequence as is done in AOTs, but independent/outside of any AOT. This then allows the final AOT 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

Timeframe:

PV phase activity plus engineering observation to monitor health

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source (or use SpirePhotoEng script if lid closed)
2. Set detector offsets (see comments)
3. Flash PCAL between 0 and <input> current at a <input> frequency for <input> number of cycles
4. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- Optimised PCAL flash for use with AOTs
- Trend information throughout PV phase

Operator Inputs for Template:

1. PCAL current (0-7mA)
2. Flash frequency
3. Number of cycles
4. The source RA and Dec (observable dark patch of sky, if lid open)

Nominal settings:

- The current nominal value is 4.5mA
- Frequency = 0.20 Hz
- Number of cycles = 16

Duration:

80 seconds (depending on frequency and number of cycles)

Comments:

- Note: 0.25 Hz means one flash every 4 seconds with 2seconds on and 2 seconds off (e.g. between 0 and 3.8mA) . 0.20 Hz means one flash every 5 seconds with 2.5 seconds on and 2.5 seconds off.

- Note: The duration of one flash sequence is given by the number of flash cycles times one over the frequency (e.g. $16 * 1/0.20 = 80s$)
- Note: Currently it is not clear if standard AOTs have PCAL flashes included. This will be decided later by the instrument team. Currently they are in, but some analysis (maybe by ESA) needs to be performed to see if it saves much time by having the PCALs outside of the observations.

6.1.17 Phot Pickup Mode

Test aims:

This test commissions the pickup observing mode (originally POF7, which was a 5x5-point cross observation). This mode is designed to allow SPIRE to peak up the pointing on a sufficiently strong point-like source. By moving the BSM, it will take data at positions corresponding to a cross, in the Chop and Jiggle directions, centred on the position corresponding to the central pixel lying on the nominal source position. The offset of the source with respect to the commanded pointing is computed by the DPU and the offsets are either implemented by the BSM or transmitted to the spacecraft.

Operational requirements:

- At the start of this test the instrument is in PHOTSTBY
- The observatory will be nodding

Timeframe:

Only PV phase activity

Expert Template Required:

Yes

Procedure:

1. Input the target
2. TBD
3. Run the expert AOT
4. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- Target flux vs. BSM position

Nominal settings:

TBD

Duration:

TBD

Comments:

- Note: This mode is probably no longer necessary as the standard pointed observation (*Point Source Observation*) is now a 7-point jiggle, allowing for the eventual inaccuracies of the pointing, so it is only low priority.
- Note: In case, we would need here an optimisation of the increment to be chosen for the 9 points in the Chop and Jiggle axis, plus a functional test. The latter can be done by simply measuring an increased flux after executing the peak up, or more refined, by deliberately offsetting the telescope and compare the offset to the correction calculated by the peak-up.
- Note: We have to define what 'sufficiently strong' means in the band observed.
- Note: Does this mode only work on the PSW array (smallest pixel on sky)?

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6.1.18 Phot Point Source Observation

Test aims:

This test uses the Point Source AOT (7 point jiggle in hexagonal pattern; POF2) 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 be nodding

Timeframe:

Expert AOT version is only used in PV phase, but optimised AOTs are then routinely used

Expert Template Required:

Yes

Procedure:

1. Point the observatory to <input> source
2. Set <input> chop frequency, <input> chop direction, <input> chop throw
3. Set <input> jiggle pattern offset
4. Set <input> number of chop cycles per jiggle position
5. Set <input> number of jiggle points per nod position
6. Set nod throw and nod direction to same as chop throw and chop direction
7. Set <input> dwell time on each nod position (nod period) and <input> total number of nod cycles
8. Set detector offsets during 'initial hold' (see comments)
9. Run the expert AOT
10. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- Target flux
--> Optimal parameters to use i.e. optimal jiggle offset, nod offset, nod period

Operator Inputs for Template:

1. Target (Name and/or RA and Dec)
2. Chop frequency, chop direction, and chop throw
3. Jiggle offset (of each of the six neighbour positions from centre) (see note below)
4. Number of chop cycles per jiggle position
5. Number of jiggle points per nod position
6. Dwell time on each no position
7. Number of nod cycles

Nominal settings:

- The envisaged nominal settings for this mode are:
 - Chop frequency: 2Hz
 - Chop direction: Parallel to Y axis
 - Chop throw: 126 arcsec (+- 63arcsec) on sky
 - Jiggle offset: 6 arcsec
 - Number of chop cycles per jiggle position: 16
 - Number of jiggle points per nod position: 1
 - Dwell time on each no position: 64 sec
 - Number of nod cycles: 2 (ABBA)

Duration:

Depends heavily on the settings used.

Comments:

- Note: Eight positions are observed (centre + hexagon + centre)
- Note: The jiggle positions have to be changed in the appropriate uplink VM table.
- Do we need to care about the order in which jiggle positions are visited (TBD) ? The order is hardcoded in a BSM uplink calibration file.

6.1.19 Phot Small Map Observation

Test aims:

This test uses the small map AOT (64 point jiggle; POF3) 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 point and 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 be nodding

Timeframe:

Expert AOT version is only used in PV phase, but optimised AOTs are then routinely used

Expert Template Required:

Yes or No (see note below)

Procedure:

1. Point the observatory to <input> source
2. Set <input> chop frequency, <input> chop direction, <input> chop throw
3. Set <input> jiggle pattern
4. Set <input> number of chop cycles per jiggle position
5. Set <input> number of jiggle points per nod position
6. Set nod throw and nod direction to same as chop throw and chop direction
7. Set <input> dwell time on each nod position (nod period) and <input> total number of nod cycles
8. Set detector offsets during 'initial hold' (see comments)
9. Run the expert AOT
10. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, BSMNOMINAL, NHK
- Target flux
--> Optimal parameters to use i.e. optimal jiggle offset, nod offset, nod period, ...

Operator Inputs for expert HSpot:

1. Target (Name and/or RA and Dec)
2. Chop frequency, chop direction, and chop throw
3. Jiggle pattern (64 points with positions (delta_phi_Y, delta_phi_Z) with respect to the pointed position)
4. Number of chop cycles per jiggle position
5. Number of jiggle points per nod position
6. Dwell time on each no position
7. Number of nod cycles

Nominal settings:

- The envisaged nominal settings for this mode are:
 - Chop frequency: 2Hz
 - Chop direction: Parallel to Y axis
 - Chop throw: 126 arcsec (+- 63arcsec) on sky
 - Jiggle pattern: 64 points
 - Number of chop cycles per jiggle position: 4 [Min=2, Max=i*2]
 - Number of jiggle points per nod position: 16
 - Dwell time on each no position: 32 sec
 - Number of nod cycles: 4 (ABBA ABBA) for 64 jiggle points

Duration:

Depends heavily on the settings used.

Comments:

- Note: Currently it is envisaged to perform this test by modifying the calibration table of the original AOT.

6.1.20 Phot Scan Map Observation

Test aims:

This test uses the scan map AOT (POF5) 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 point and 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 be scanning
- Good **TBD** thermal stability is required for this AOT
- Needs a running pipeline (e.g. map making) for the data reduction

Timeframe:

Expert AOT version is only used in PV phase, but optimised AOTs are then routinely used

Expert Template Required:

Yes or No (see note below)

Procedure:

1. Point the observatory to <input> source
2. Set detector offsets during 'initial hold' (see comments)
3. Set <input> length of each line (gives length of map in arcsec)
4. Set <input> angular line separation (distance between successive lines)
5. Set <input> number of lines (to ensure desired height of map in arcsec)
6. Set <input> scan speed/rate
7. Set <input> angle for scan direction (in SpirePhotoLargeScanGen only done via setting <input> scan direction)
8. Set <input> map centre offset (in Y and Z)
9. Set <input> repetition factor
10. Run a standard PCAL flash sequence (see note below)
11. Run the expert AOT
12. Run a standard PCAL flash sequence
13. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- Map and target flux
 - > Optimal scan speed/rate to use
 - > Check uniformity of map with optimal scan angle and line separation
 - > Confirm size of linear overhead introduced to account for the acceleration and deceleration phase at the beginning/end of each line to ensure a uniform scan speed across the user requested map area.

- > Check influence of bad pixel on final map quality
--> Check improvement of final map by cross linking

Operator Inputs for Template:

1. Source (Name and/or RA and Dec)
2. Length of each line in arcsec
3. Angular line separation (distance between successive lines) in arcsec
4. Number of lines (to ensure desired height of map in arcsec)
5. Scan speed/rate
6. Angle for scan direction
7. Map centre offset (in Y and Z)
8. Repetition factor

Nominal settings:

- The envisaged nominal values to be used in normal AOTs are:
 - two scan rates [one nominal (teta_dot_nom) one fast (teta_dot_fast)]
 - the 'magic' scan angle (phi) providing a diagonal scan axis
 - the associated scan leg separation (d_phi)

- Scan rates/speeds range between 0.1"/s to 60"/s
- Angular length of each line between 4 arcmin to 20deg
- Number of lines between 1 and 32
- Map centre offset (in Y and Z) should be 0; Repetition factor should be 1

*Duration:***TBD***Comments:*

- 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 expert AOT is run.
- Note: Currently it is envisaged to perform this test by modifying the calibration table of the original AOT.
- Note: If separate script is needed PCAL flashes should be implemented in the same way as for the original AOT.

6.1.21 Phot Raster Map Observation

Comments:

- This mode is not available for the general user and not envisaged to be used but still kept here as a header in case it will be reactivated during flight.

6.1.22 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 SPIRE is in PHOTSTBY and the satellite in PMODE (i.e. switched to a different sampling rate and having also PACS on)
- The observatory is commissioned to the point where it can scan with **TBD** scan accuracy
- Needs fully commissioned SPIRE scan mode (*Phot Scan Map Observation*).
- Needs fully commissioned PACS scan mode
- Needs a running SPIRE (and PACS) pipeline (e.g. map making) for the data reduction

Timeframe:

Expert AOT version is only used in PV phase, but optimised AOTs are then routinely used

Expert Template Required:

Yes or No (see note below)

Procedure:

1. Point the observatory to <input> source
2. Set PACS blue channel filter selection to <input>
3. Set <input> length of map (in arcmin)
4. Set <input> height of map (in arcmin)
5. Set <input> scan speed
6. Set <input> scan direction
7. Run the AOT
5. Return to PHOTSTBY

Data outputs:

- Data output needed: PHOTF, SCUNOMINAL, NHK
- SPIRE and PACS maps of the specified area
 - > Verification of SPIRE sensitivity using this mode (with/without cross-linking)
 - > 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:

1. PACS blue channel filter selection
2. Length of map (in arcmin)
3. Height of map (in arcmin)
4. Scan speed (in arcsec/s)
5. Scan direction

Nominal settings:

- 60-85 mu filter (TBD)

Duration:

TBD (depends on what exactly we want to do here)

Comments:

- Do we need to optimise the scan speed? Then an expert AOT is needed.
- Note: Currently it is envisaged to perform this test by modifying the calibration table of the original AOT.

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 bias amplitude and frequency to the input values
2. Set the three central phases to the input values
3. Set the stepsize and number of steps to the input values
4. Set the detectors to the phase given by the the stepsize, number of steps and central phase
5. Take offsets
6. Readout detectors for specified time

Operator Inputs for HSpot:

9. Bias frequency to be tested
10. Bias amplitude to be tested
11. Central phase to set for all three arrays
12. 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)
13. Stepsize, user enters 1, 2 etc (1=1.4 degrees, 2=2.8 degrees etc)
14. 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:

- Bias frequency f_b
- Bias Amplitude V_b peak to peak
- Central phase ϕ_{Trees} 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) = $11 \times 40 = 440$ 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 $40 \times 256 = 10240$ seconds = 170 minutes = 2.83 hours.

Comments:

- 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 strong 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:

9. Set the Vss to nominal settings as defined by Spec Vss
10. Set the bias amplitude and frequency to the first input values
11. Set the three phases to the input values
12. Take offsets and leave detectors producing data
13. Wait inputted time
14. 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 (Peak to Peak)	Bias Amplitude (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) = $13 \times 5.67 = 73.71$ minutes. With *start obs* (60s) and *end obs* (60s) this totals about 75 minutes.

Comments:

- 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 Template Required:

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 read out at each level
- The source RA and Dec

Nominal settings:

- The nominal bias frequency used for ILT was f_b , the associated peak phases were around ϕ_{Trees}
- 10 seconds per level

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

Duration:

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

Comments:

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 sensor 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 Template Required:

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
- Read out time at each position

Nominal settings:

- 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

Comments

- 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 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 Template Required:

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:

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

Comments:

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 Template Required:

Yes

Procedure:

5. Set the detectors to the nominal bias frequency, amplitude and phase
6. Flash PCAL between 0 and input current at a input frequency for input number of cycles
7. 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

Comments:

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 Template Required:

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 read out 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.

Comments:

SPIRE

Project Document

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- 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 Template Required:

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)
- Read out 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.

Comments:

- 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 read out

Expert Template Required:

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)
- Read out 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.

Comments:

- 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 could 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 its 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 read out

Expert Template Required:

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 $121 \times 10 = 1210$ minutes = 20.16 hours per pixel.

Comments:

- 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 could 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 Template Required:

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

Comments:

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 Template Required:

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

Comments:

- 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 Template Required:

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

Comments:

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