HIFI Performance Verification Plan

Version Draft 0.8 of 2009-03-09, by Michael Olberg

Abstract

This document contains the performance verification plan for HIFI. It contains a detailed description of the observations to be carried out with HIFI after successful completion of the commissioning phase and before the science demonstration phase.

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Prepared by:	Michael Olberg	Date: 2008-04-11
Checked by:	Frank Helmich	Date:
Authorised by:		Date:

Distribution

ESA:
T. Passvogel
C. Scharmberg

HIFI Steering Committee:

F. Helmich	SRON

HIFI Project:

H. Aarts	SRON
P. Roelfsema	SRON

Version	Date	Change	Author
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Applicable Documents

Doc. ref		Title
SRON-G/HIFI/SP/2000-01	AD01	Science User Requirements Document
LRM-ENS/HIFI/PL/2000-01	AD02	HIFI calibration plan
HERSCHEL-HSC-DOC-1012	AD03	HERSCHEL Performance Verification Phase Plan & Detailed Timeline
ICC2008-122	AD04	HIFI Commissioning Phase Plan
ICC2008-157	AD05	HIFI AOT Commissioning Plan

Reference Documents

Doc. ref		**Title**
ICC/2001-005	RD01	HIFI Calibration Use Cases
SRON-G/HIFI/RP/2000-001	RD02	Instrument Design Description and Justification
ICC/2002-034	RD03	The intensity calibration for HIFI
L3AB/HIFI/CAL/2003-02	RD04	Frequency calibration framework
SRON-G/HIFI/TR/2008-10	RD05	Spatial response framework
SRON-G/HIFI/RP/2008-022	RD06	HIFI ILT summary report
ICC/2003-008	RD07	HIFI Observing Modes Description Document
ICC/2003-010	RD08	HIFI Observing Modes Calibration Document
Schieder, C., & Kramer, C. A&A 2001, 373, 746	RD09	Optimization of Heterodyne Observations Using Allan Variance Measurements
TN 06/17/2003	RD10	A Unified Allan Variance Computation Scheme
ICC/2007-010?	RD11	HIFI Observing Modes Code Structure
ICC/2005-017?	RD12	HIFI Uplink Parameters for ILT/IST/Flight and AOTs
ICC/2008-131	RD13	HIFI AOT Observing Mode Tests (FM-ILT)
SRON-G/HIFI/TR/2008-001	RD14	HIFI FM radiometry measurements
FPSS-01201	RD15	HIFI ILT Stability
HIFI/TR/2008-027?	RD16	HIFI AOT Observing Mode Tests in IST/SPT
	RD17	DSB Deconvolution Doc
ICC/2008-122	RD18	HIFI Comissioning Phase Plan
HERSCHEL-HSC-DOC-1184	RD19	Herschel HSC-ICC Interactions Document
	RD20	HIFI AOT Work Atlas

Contents

1 Introduction

The complexity of the HIFI instrument is well characterized on the ground during Instrument Level Tests. However, verification of the functioning of HIFI as a scientific instrument is also needed in orbit.
The performance verification plan describes all actions to be undertaken in the Performance Verification Phase as defined in AD06. In doing so, the PV plan is a step-by-step check on instrument capabilities; it provides calibration parameters and it is used to verify the Astronomical Observation Templates (AOTs).

1.1 Assumptions

In the PV plan the following assumptions are made:

- There is an engineering plan provided by the HIFI-AIV group.
- The HIFI instrument functions as such, i.e. it listens to commands, performs the right actions and sends back telemetry and housekeeping.
- The focal plane geometry is known from this plan.
- The AOTs have been defined by the HIFI ICC and the priorities of these for the science have been identified.
- The observing modes I-2 and II-2 (point with DBS and DBS raster map, respectively) as well as mode II-4 (OTF-load chop) will be required early on in the PV phase and will be checked for functionality near the beginning of PV, separately from the other AOTs.
- The HCSS has the required functionality to support the necessary analysis of HIFI data to be carried out during the PV phase. The functionality required at each step is given in the implementation section of this document.
- Band changes introduce periods of time when the system is less stable. This will cause a time penalty when optimally calibrated data are required, but can most likely be accepted when only functionality is tested. It is in fact mandatory to take data during LO stabilisation, in order to calibrate this process itself.

1.2 Structure of this document

This document is structured as follows. In Chapter 2 the strategy is described, as far as needed here. The main sources for the strategy are the Calibration Plan (AD02) and the framework documents (RD03, RD04 and RD05). Each strategy section has a visual overview of the different steps involved. The remaining chapters describe the implementation of the strategy. In particular chapters 4-6 list all the assumptions involved and contain time estimates (detailed time line to be added). The time line will mainly consist of series of use cases with appropriate choices for parameters. Also responsibilities will be assigned to the different observations. These persons will be responsible for uplink preparation, downlink and analysis, including a final report. Note that there is a failure/success criteria for every observation. While use-cases contain their own success criteria, there will also be failure/success criteria (or decision points) within the time-line. These latter are the most crucial for planning, since failure within any use case will have influence on the scheduling of the time-line.

1.3 Glossary

1.3.1 Acronyms

ACMS	Attitude Control and Measurement System
AD	Applicable Document
AOR	Astronomical Observation Request
AOT	Astronomical Observation Template
COP	Commissioning Phase

CUS	Common Uplink System
DP	Data Processing
DTCP	Daily Telecommunication Period
ESA	European Space Agency
FM	Flight Model
GT	Guaranteed Time
HCalSG	Herschel Calibration Steering Group
HCSS	Herschel Common Science System
HIFI	Heterodyne Instrument for the Far-Infrared
HPBW	Half Power Beam Width
HSC	Herschel Science Centre
IA	Interactive Analysis
ICC	Instrument Control Centre
ILT	Instrument Level Test
KP	Key Programme
OD	Operational Day
PACS	Photo-detector Array Camera and Spectrometer
PV	Performance Verification
RD	Reference Document
SAA	Solar Aspect Angle
SPIRE	Spectral and Photometric Imaging REceiver
TC	Telecommand

2 Strategy

We divide the PV actions into a few topics that in total cover all the intended measurements. The following sequence is foreseen, but is subject to change due to planet visibility constraints:

1. general system performance, stability
2. aperture efficiencies and beam properties
3. spectral properties, standing waves
4. evaluate AOT functionality and performance

In using AOTs as much as possible for all types of calibration observations we shall slowly build up confidence in applying the templates. It is assumed that only special cases will need to be treated by dedicated uplink scripts. For most observations we use both polarisations simultaneously, using all four available spectrometers (WSB-H, WSB-V, HRS-H, HRS-V) in order to maximize the amount of data available for subsequent analysis.
As many of our observations are carried out in all HIFI bands and at different frequencies, they will provide a survey of system performance, in terms of e.g. system temperature and occurrence of spurious signals, as a function of frequency.

2.1 General system performance, stability

HIFI internals are any engineering or calibration parameters needed to either setup the instrument, schedule the observation, or analyse and calibrate HIFI data collected in a given instrumental configuration. In fact, some of these parameters should have already been extensively measured during the commissioning phase since they are e.g. needed for any single (correct) use of HIFI in a pumped way. Some others can be collected in the framework of the PV-phase, either as a redundancy and complementary check of the commissioning measurement (e.g. broader picture of sensitivity or stability performances), or because they are mostly required for data (off-line) calibration.

Table 1: description of commissioning program prior to PV phase

Block-ID	Subblock-ID	Description
HIFI-COP-1 Functional and health tests	HIFI-COP-1.1 Chopper integrity	Open loop small steps
		Open loop scans
		Closed loop health check
	HIFI-COP-1.2 S/S functional	WBS functional tests
		FPU functional tests
		HRS functional tests
		Up-converter functional tests
		LO functional tests
HIFI-COP-2 Instrument characterisation	HIFI-COP-2.1 diplexer and harness	Initial diplexer calibration: fast scans
		Functional tests un-pumped: IVC, IF noise
		IF feed-back tests
		IF stability measurements
		Chopper response time test
	HIFI-COP-2.2 diplexer and LO	2^{nd} diplexer calibration: hot-cold scans
		LO power calibration: vector scans
	HIFI-COP-2.3	Chopper scan with IF power: loads
HIFI-COP-3 performance with cryo cover closed		Functional tests pumped: IVC and Tsys
		Standing wave tests: internal loads
		Noise temperature survey
		Stability measurements: internal reference modes
		Dedicated spur analysis: bands 3b and 7b
HIFI-COP-4 performance with cryo cover open		IF feed-back tests
		Chopper scan with IF power over sky path
		Stability measurements: external reference modes
HIFI-COP-5 focal plane geometry		Focal plane geometry: first light – first order assessment
		Focal plane geometry: refinement all bands
		Peak-up test
HIFI-COP-6 AOT pre-validation		basic AOT validation needed for PV activities

Here it becomes essential to properly define where we think the PV phase is taking over from the commissioning phase (COP). The two phases are closely related and PV depends heavily on COP being complete and having delivered the instrument characteristics on which PV is building. To make this very clear, we list in table 1 explicitly the tests to be done during COP.
Note, that this implies that first light with HIFI is obtained during COP. The blocks HIFI-COP-4, HIFI-COP-5 and HIFI-COP-6 are performed with the cryo lid opened, and as such formally would have to be accounted for in the PV phase.
As a result, we assume the following to be true at the end of the commissioning phase:

- We have a good knowledge of the tuning ranges of the LO system and are aware of any problematic frequencies, due to insufficient LO power, strong spurious signals, poor mixer performance, etc.
- Chopper positions towards the internal hot and cold load are well known, as well as towards M3, calibrated against the loads. The chopper position to reach the off-M3 chop limits has been calibrated against the focal plane geometry.
- Diplexer positions for a given input frequency are known.
- Total power stability has been checked in all bands at approximately 7-9 frequencies per band. At a few (2 per band) frequencies also differential stability will have been assessed.

From ground (ILT and TV) we have a knowledge of :

- the mixer (quasi-optical) coupling to the internal loads, it cannot be checked in flight.
- the sideband ratio from gas cell measurements during ILT.

We organise this part of PV as a series of long time integrations on a cold sky position at a number of frequencies in all HIFI bands, using pointed DBS (dual beam switched) observations.

2.2 Aperture efficiencies and beam properties

This block is dedicated to the characterization of the antenna diagram, which comprises the determination of the beam parameters and all efficiencies involved. All equations and concepts are discussed in the Spatial Response document (RD05).
It is planned to first measure the aperture efficiencies, then the beam shape including half power beam widths (HPBW) and main beam efficiencies. Again, these steps are repeated for each of the 14 mixers. In parallel, the pointing will be checked as e.g. the aperture efficiency depends on accurate pointing.
We use small, highly oversampled maps to derive aperture efficiencies, and larger maps to measure the beam shape and determine associated parameters. Both kind of maps make use of DBS raster observations (AOT II-2) of solar system continuum sources. We suggest to use OTF load-chop observations to validate this mode of observation against the raster maps. In the implementation section we describe two scenarios, depending on whether Uranus (our preferred target) is available at the time of PV or not.
The maps will be repeated for two to three frequencies per band and we expect to get a statistically meaningful set of data that will allow:

1. to check beam parameters as a function of frequency and compare with theoretical expectations, and check for clear outliers/deviations. In particular, we derive beam shapes including two orthogonal HPBWs and gaussicity, as well as aperture and main beam efficiencies.
2. to check pointing at successively more demanding frequencies, i.e. in the order of increasing frequency, without the need of peak-up.
3. to validate the two different mapping procedures, DBS raster and OTF load-chop against each other. This is particularly important at the highest frequencies where pointing uncertainties and possible timing jitter will make validation of an OTF map difficult without a corresponding raster map to validate against.

A stepwise approach ensures that the most important parameters characterizing the beam pattern are measured first. Already the first set of observations will show whether the quality of the beam meets the predictions (RD05). Also, step-by-step the suggested observations become more complex and more time demanding. In case of time constraints, it may e.g. be considered to skip deep maps of the beam pattern, especially, when the beam efficiencies and HPBWs meet the expectations

2.3 Spectral properties, standing waves

Standard calibration of the frequency scale will be an integral part of all data analysis. However, the detailed spectral response of a spectrometer channel cannot be measured in orbit due to the lack of sweepable, narrow signals. *limited use of comb data.* Spectral lines from suitable planets or comets will be used to confirm the correctness of the frequency calibration. Results from the measurements of the sideband ratio from gas cell measurements during ILT are tested against inconsistencies.
Pointed observations of the same continuum source as used for the beam parameters in the previous section, will be carried out in order to measure any baseline ripple/standing wave patterns towards an external source and compare with patterns observed towards the internal loads.

2.4 Evaluate AOT functionality and performance

2.4.1 Background

Astronomical observations with HIFI are to be carried out with AOT Observing Modes which have been designed to fulfil the HIFI Science Requirements (RD-01), represented principally in the HIFI Guaranteed

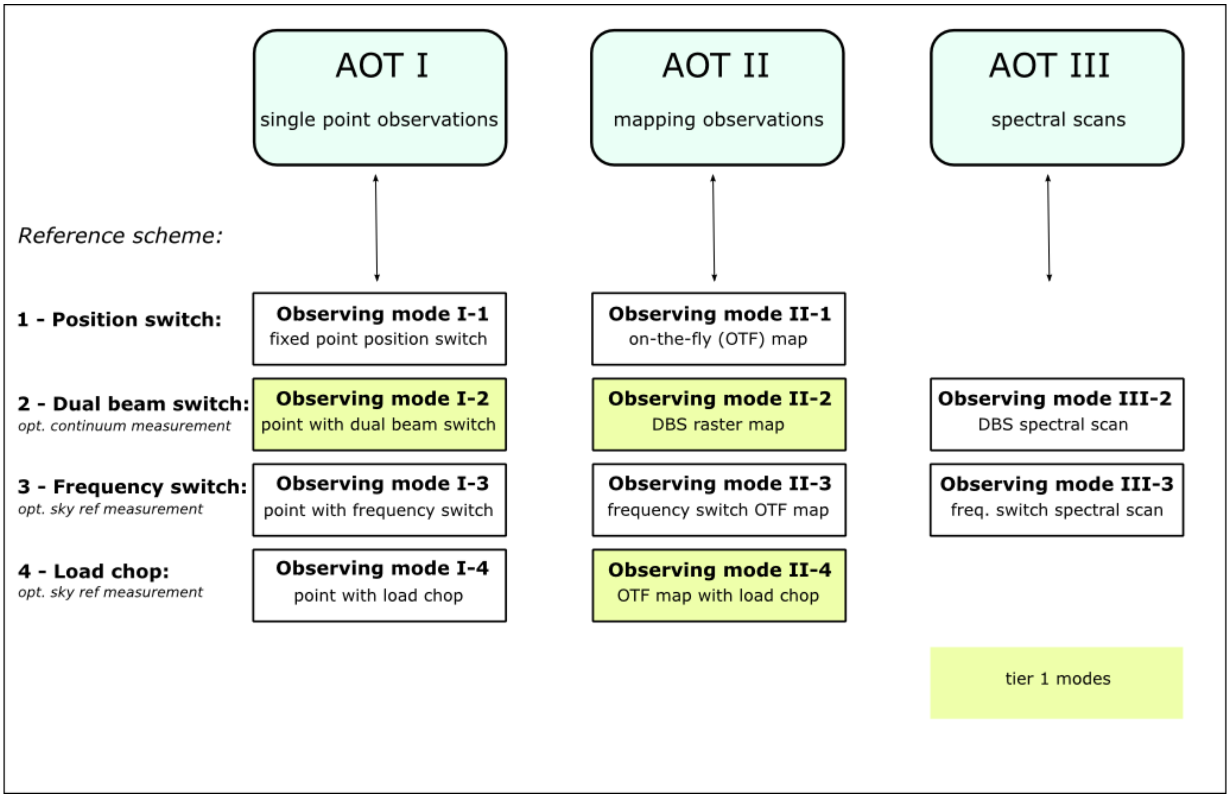

Figure 1: HIFI observing modes

Time Key Programmes. The AOT Modes are conceptually similar to observing schemes available to Astronomers at most ground-based sub-mm telescopes, such as beam switching, but incorporate additional referencing (calibration) functionality designed for space operations of HIFI on the Herschel telescope, that allows Astronomers to meet noise level requirements under specific observing set-ups within permitted ranges of spectrometer backend configurations and LO tunings. The range of configurations follow from the HIFI Instrument Design Requirements (RD-02), while the Position Switch, Dual Beam Switch, internal Load Chopping, and Frequency Switch reference schemes are designed to compensate instrument instabilities with internal plus telescope pointing calibration loops. The calibration loops are timed in a hierarchical scheme depending on system, band-pass stability, and standing wave Allan times as illustrated below, and described in AD01 and AD02.
The observing modes are summarized in the following figure.
The implementation of Observing Mode calibrations combines a timeline of instrument commands with telescope pointing modes. Note that there is no direct interaction between HIFI and the ACMS, there is only a timing of each subsystem's TCs to match instrument and telescope phases via the CUS state machine. Pointing modes as implemented in the CUS are described in RD??.

2.4.2 Objectives

The design and execution of all observing modes available with the three HIFI AOTs are to be tested by using the modes to observe different celestial sources in a variety of astronomical settings (point and extended sources, fixed and moving, single and clustered, weak and bright) and scientific utility (spectral, spectrophotometric, etc.), while spanning the fullest range of instrument configurations. These tests will be performed in three phases, in which a brief functional checkout of one or two modes is performed early in PV (Phase A), and then the emphases are placed on the back end spectrometers (Phase B) and front end configurations (Phase C). Phases B and C occur in parallel near the end of PV.

Table 2: description of phases of PV plan

Block-ID	Subblock-ID	Description
HIFI-PV-1	HIFI-PV-1-LICS	stability: long integrations on cold sky
HIFI-PV-2	HIFI-PV-2-AE	aperture efficiencies
	HIFI-PV-2-BP	beam patterns
HIFI-PV-3	HIFI-PV-3-XSW	standing wave pattern towards external continuum source
HIFI-PV-?		*AOT commissioning, described elsewhere*

Full redundancy between AORs using the different modes is not possible or needed. In other words, it is not necessary to exercise every mode using both spectrometers in every allowable configuration, with all HIFI bands, in all front-end configurations, on all target types, etc. Instead, the observing modes can be assessed for readiness with mutually dependent emphases on the back ends and front ends:

1. The back end phase will employ the basic DBS modes I-2 and 2a, using both slow and fast chop, and both the HRS and WBS over a limited range of frequencies to observe different target types, providing spectrometer performance measures as well as certain essential aspects of telescope performance (pointing accuracies, slew times, tracking stability) that figure into final observing efficiencies.
2. The logic for adjusting the front end settings, covering different bands, frequency ranges, tuning methods, etc., will be tested with another mode, such as I-3 or III-2/2a (TBD). It will not be possible to cover all frequency ranges with the different mixer assemblies, considering also the smaller IF bandwidth of Band VI.
3. Remaining modes will be tested for their performance, functionality, and general flexibility in moving through the remaining parameter space of additional settings, which could not be tested in the previous step. These will be specified in detail in the Inputs section. Some redundancy between the modes is planned, and there will be naturally occurring overlap with HK and S/C engineering data.

This 3-step approach leads to the most practical means of analysis planning and OR scheduling. The activity in scheduling terms is desired to occur over 2 periods, once early in PV (Phase A), and near the end of PV (Phases B and C). This will be specified in detail as the AORs are planned.
It is intended that the parameter space, which can be accessed by end users and sequenced into AOT parameters, will be tested as part of commissioning. However, some sequencing parameters, their range of values, and suitability to H-SPOT are expected to depend on the outcome of this activity. Various throws of the internal chopper will be tested, for example, for the purposes of offsetting potential reduction in observing efficiencies by undesirably lengthy slew times, leading to an optimized default throw distance, or to implementation as a changeable (set up) parameter in H-SPOT. Another example is sizing the number of frequency settings between calibration measurements in the spectral scan AOT, which can be investigated in ground FM testing, but can only be validated and optimized under flight optical and thermal conditions.

2.4.3 Assumptions

- This activity occurs over the last week of PV, so that the instrument is close to its nominal operating condition for routine science operations as possible, following successful completion of functional and performance tests and (re)calibration of the instrument's subsystems.

3 Implementation

As noted, the actual implementation is done in calibration use cases. The time line is presented here, with parameters, and outcomes are summarized. At each stage the derived calibration parameters are listed and their place in the frame work documents indicated.

The complete description of all internal parameters is given in the Intensity Framework document (RD03) and the HIFI observing modes calibration document (RD08). The measurement procedures are compiled in the calibration Use Case document (RD01).
Figure 2 shows the visibility of planets and suggested AOT targets for a PV phase based on a April 16, 2009, launch, the date which has is currently being considered to be the actual launch date. The operational days assigned to HIFI are marked. This launch date scenario allows a fair amount of time for planet observations. Mars and important sources like Orion and the Galactic centre only become available towards the end of the PV phase, however.

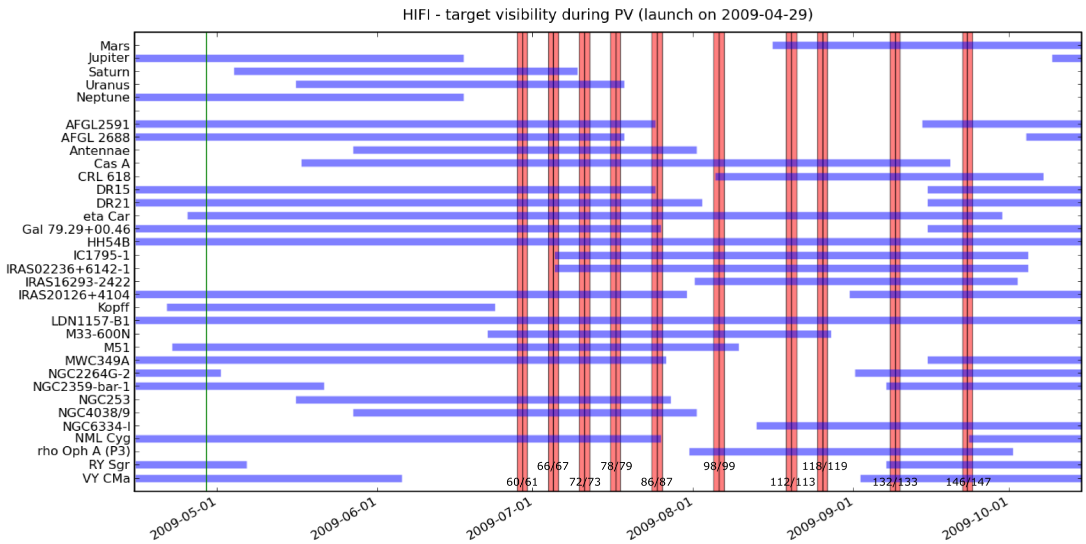

Figure 2: Source visibility for launch on Apr 16, 2008.

4 Stability – HIFI-PV-1

4.1 Long integrations on cold sky – HIFI-PV-1-LICS

4.1.1 Purpose

Perform one to three hours DBS pointed slow-chop observations of a cold sky position.

4.1.2 Pre-conditions

Successful check-out of DBS point mode.

4.1.3 Constraints

4.1.4 Source

We select a cold sky position near the ecliptic pole at α =18:05:00, δ = +66:30:00 (J2000) to avoid any scheduling constraints. The final data set will contain three different (but assumed equivalent) cold sky positions A, B and C, where A plays the role of the source position and B and C are one beam throw away on either side.

Table 3: selected frequency settings for stability analysis

Band	**LO freq.** [GHz]	**Sky freq. [GHz]**	**Molecule**	**Comment**
1a	494	487.2	O_2	
	542	547.676	H_2O-ortho	
1b	564	556.936	H_2O-ortho	ground state transition
	618	624.205	HCO^+	
2a	643	645.834	H_2O-para	
	686	691.66	D_2H^+	
2b	728	734.32	CS	
	758	752.033	H_2O-para	
3a	814	809.342	C	
	837	835.071	CH^+	
3b	887	893.639	HDO	
	928	921.8	CO	
4a	968	974.462	NH	
	995	987.927	H_2O-para	
4b	1091	1097.364	H_2O-ortho	
	1108	1113.343	H_2O-para	ground state transition
5a	1145	1139.515	H_2O^+	
	1177	1207.666		
5b	1202	1207.666	H_2O-para	
	1223	1228.799	H_2O-para	
6a	1457	1461.134	N^+	
	1544	1540.988	^{13}CO	
6b	1653	1655.813	H_2O^+	
	1667	1669.905	H_2O-para	
7a	1720	1716.765	H_2O-ortho	
	1773	1769.876	HCN	
7b	1845	1841.346	CO	
	1897	1900.545	$^{13}C^+$	

4.1.5 Bands and frequencies

4.1.6 Execution Method

Data taking is started immediately. It is mandatory that the LO stabilisation is covered and monitored. Data from all four backends, i.e. both polarisations, are collected simultaneously. This requires a dedicated engineering mode, as the normal AOTs allow the LO to stabilize before data are collected.
The HIFI *proc mode* to be used is `HifiPointProcDBS`. Data dump interval set to 4 seconds, 16 chop cycles and 12 (24, 36) on-off cycles for bands 1–4 (5, 6–7), respectively.

4.1.7 Duration

In the following we assume that up to 20 minutes are needed to stabilize the LO in a given band. We suggest to spend ≈1 hour for each of the proposed observations in bands 1-4, ≈2 hours in band 5 and ≈3 hours in bands 6 and 7, where performance is poorer. In all bands there are two suggested frequencies in each of the LO subbands (a and b). The total amount of time spent is listed in Appendix **??**.

4.1.8 Required analysis

For this step proper intensity calibration is not yet needed and is performed via standard pipeline reduction using ILT results or theoretical best guesses. Standard frequency calibration is to be performed. For each of the resulting data sets:

1. look for spurious signals and add to database.
2. collect calculations of system temperature from pipeline and look for temporal changes (drifts) during the course of an observation at one frequency.
3. characterise and produce plots for LO stabilisation
4. check noise in average spectrum as a function of time, i.e. add more and more data to average. Use only LO stable part of data set if necessary.
5. perform Allan variance analysis on LO stable part of data set.
6. check for asymmetries in results from the two beams. Compare all possible differences of phases: A-B, A-C, B-C
7. check that calibrated, integrated intensities during the LO-stable phase are distributed as random white noise. Note, that absolute intensity calibration is not required, but spectra should be correctly calibrated relative to each other. The width of the noise distribution should be reasonable, given the uncertainties in the intensity calibration. Produce Q-Q-plots (i.e. compare observed quantiles of distribution with theoretical ones) to see derivations from a normal distribution.
8. whenever possible perform these analysis steps both for individual spectrometer subbands and total bandwidth. Inter-compare results from different subbands.
9. compare results from different polarisations.
10. compare results from different spectrometers.
11. check for (serendipitous) real spectral lines in final average spectra.

4.1.9 Success/failure scenario

Success: The times required for LO stabilisation in space are derived. The dependence of noise level on integration time for the various bands is measured. Any asymmetries/imbalances between chop positions/spectrometers/polarisations are known.
Failure: tbw

5 Characterizing the beam - HIFI-PV-2

5.1 Aperture efficiencies HIFI-PV-2-AE

5.1.1 purpose

Determine aperture efficiencies in all bands (UC-1.4.3).

5.1.2 pre-conditions

- Calibrated hot and cold loads, i.e. known effective radiation temperatures
- For theoretical aspects: quasi-optical description of the whole optics.
- Pointing is good enough to find the target within the proposed maps, we assume an APE of 2” . This is absolutely necessary for this measurement as stressed in UC-1.4.3.
- DBS (double-beam switch) mode works well.
- A bright continuum source of well known flux is available (Uranus is preferred candidate).
- Data reduction software allows to work in co-moving coordinates, rather than in RA, Dec; i.e. in a frame where the observed solar system object does not move.

Table 4: Duration and performance at selected frequencies for stability analysis as estimated by HSpot 3.4.7.

Band	**LO freq.** [GHz]	**Duration** [s]	**noise** [K]	T_{sys} [K]
1a	494	3469	0.007	189
	542	3469	0.005	147
1b	563	3469	0.007	182
	618	3469	0.007	198
2a	643	3469	0.012	314
	686	3469	0.011	286
2b	728	3469	0.014	373
	758	3469	0.014	392
3a	814	3469	0.018	489
	837	3469	0.017	469
3b	887	3469	0.017	464
	928	3469	0.018	489
4a	968	3469	0.029	793
	995	3469	0.027	722
4b	1091	3469	0.030	803
	1108	3469	0.034	907
5a	1145	6937	0.044	1679
	1177	6937	0.049	1889
5b	1202	6937	0.054	2065
	1223	6937	0.058	2213
6a	1457	10477	0.074	3230
	1544	10477	0.067	2929
6b	1653	10477	0.063	2917
	1667	10477	0.063	2935
7a	1720	10477	0.065	3007
	1773	10477	0.060	2772
7b	1845	10477	0.072	2844
	1897	10477	0.068	3157

Table 5: Frequency selection for beam efficiency measurements

Band	Frequency [GHz]	T_{sys} [K]	η_A	HPBW [arcsec]	T_A [K] Uranus	Neptune
1a	520	68	0.706	43.48	0.530	0.239
1b	600	108	0.705	37.68	0.651	0.295
2a	680	138	0.704	33.24	0.787	0.353
2b	760	197	0.703	29.74	0.922	0.415
3a	840	242	0.702	26.91	1.064	0.476
3b	920	238	0.700	24.57	1.206	0.540
4a	1000	555	0.698	22.60	1.344	0.603
4b	1080	353	0.697	20.93	1.485	0.666
5a	1160	846	0.695	19.49	1.621	0.730
5b	1240	1132	0.692	18.23	1.761	0.793
6a	1480	1519	0.685	15.27	2.157	0.966
6a	1562	1301	0.683	14.47	2.284	1.023
6b	1642	1378	0.680	13.76	2.406	1.075
7a	1720	1353	0.677	13.14	2.518	1.122
7a	1800	1237	0.674	12.56	2.623	1.167
7b	1880	1481	0.671	12.02	2.719	1.216

5.1.3 constraints

Ideally, the targeted source(s) should be strong and point-like, but source availability constraints may force us to use strong/extended or point-like/weak sources.

5.1.4 source

Most favourable source is Uranus, which has no surface and therefor no coupling needs to be considered. It is smaller than the beam and rotates fast, presenting a compact, uniform object to HIFI. This source is available twice per year for durations of approx. 2.3 months, i.e. it is likely it will be observable during a 3 months PV phase for at least some time.
For the launch scenario of 16 April 2009, Uranus (Neptune) is available until July 18=OD 94 (June 17=OD 63), so we propose to use Uranus, which is the preferred source anyway.

5.1.5 bands and frequencies

The following table lists the frequencies at which beam properties will be measured, together with expected values for parameters which determine the time line of these observations, using Uranus or Neptune as a target. There are two frequencies per band for bands 1-5, three frequencies for bands 6 and 7, each.
Notes: Half power beam widths are calculated using a scaling relation that reproduces beam widths given in RD05. Values for system temperature are based on ILT results. The last column is the integration time listed in RD05 necessary to reach the -20 dB level of the expected signal, assuming a detection bandwidth of 100 MHz. The same bandwidth was also used to calculate the signal-to-noise ratio (SNR) after 1s of integration listed in the second last column.
Frequencies 1560, 1640 GHz from original proposal in bands 6a, 6b were changed to 1562, 1642 GHz, respectively, in order to avoid poor performance.

5.1.6 execution mode

The aperture efficiency will be measured by small 3 by 3 raster maps using a grid spacing of one fifth of the beam width, which at the highest frequencies corresponds to roughly the expected pointing APE.
Data from all four backends, i.e. both polarisations are to be collected simultaneously.

5.1.7 duration

Using the ExpertHSpot interface (v.3.4.7) the 3×3 aperture efficiency maps can be scheduled using the `HifiMappingProcDBSRaster` procedure, yielding the times listed in Appendix A.

5.1.8 required analysis

1. reduce map results through standard pipeline
2. look for spurious signals; if seen, add to database
3. derive aperture efficiencies from small maps using state-of-the-art model of sub-mm emission (absolute photometry) for target in question (UC-1.4.3).
4. given the HPBW and assuming Gaussian beam shapes, a first estimate of main beam efficiencies can be derived.

5.1.9 success/failure scenario

Success: The aperture efficiencies is derived at the listed frequencies with at least 10% accuracy. The dependence of aperture efficiency on frequency is checked against theoretical expectations.
Failure: tbw

5.2 Beam patterns HIFI-PV-2-BP

5.2.1 purpose

Measure the main beam efficiency (UC-1.4.4). Measure the shape of the beam down to a level of -20dB (UC-1.2.2).
Optional: Map the beam pattern down to -30dB, this is a fall-back option in case the previous observations indicate problems with the beam shape. This would obviously require much more integration time.

5.2.2 pre-conditions

Same as for aperture efficiencies.

5.2.3 constraints

5.2.4 source

On operational days 60 and 61 Jupiter is still available is proposed as the source to measure beam patterns in bands 1–3. The higher bands are proposed to be measured using Saturn, which is available until OD 85. Determination of the main beam efficiency optimally uses a source which fills (or extends beyond) the main beam.

5.2.5 bands and frequencies

Same as for aperture efficiencies. Table 5.2.5 lists predicted antenna temperatures for Jupiter at the given frequencies. The main beam efficiencies were calculated as 1.28*η_A, following RD05.

5.2.6 execution mode

In this step larger, 5x5 maps, out to one beam width on either side of the target are obtained which will allow to determine the half power beam widths in any direction, the possible degree of eccentricity of the beam and the deviations from a Gaussian beam profile. Maps are chosen large enough to allow the observation of the beam patterns down to -20 dB. Use UC-1.2.2 (RD1).
These maps are done in DBS raster mode and will be complemented by OTF load-chopped maps of equal extent. Data from all four backends, i.e. both polarisations are again to be collected simultaneously.

Table 6: Frequency selection for beam pattern measurements.

Band	Frequency [GHz]	η_{mb}	T_A [K]
1a	520	0.904	45.9
1b	600	0.903	52.8
2a	680	0.902	68.8
2b	760	0.900	79.7
3a	840	0.898	88.0
3b	920	0.896	93.8
4a	1000	0.894	96.8
4b	1080	0.892	95.4
5a	1160	0.889	85.0
5a	1240	0.886	89.5
6a	1480	0.877	102.7
6a	1562	0.874	99.9
6b	1642	0.870	95.5
7a	1720	0.867	87.5
7b	1800	0.863	77.6
7b	1880	0.859	86.7

5.2.7 duration

The times spent is listed in Appendix A. Note that a similar amount of time is needed to repeat these maps in OFT-load chop mode.

5.2.8 required analysis

1. reduce map results through standard pipeline
2. look for spurious signals; if seen, add to database
3. analyse beam pattern (UC-1.2.2)
4. determine HPBW along y- and z-axis
5. check for deviations from Gaussian shape
6. check for coma, astigmatism
7. compare with results from PACS and SPIRE, where possible and applicable.
8. derive main beam efficiencies and compare with predictions.

5.2.9 success/failure scenario

Success: a map of the target with the requested signal-to-noise ratio; HPBW, gaussicity and eccentricity of the beam(s) are determined at listed frequencies.
Failure: beams deviate strongly from predicted patterns, widths.

6 Spectral properties, standing waves - HIFI-PV-3

The complete description of the HIFI frequency scale and of its calibration is given in the Frequency Calibration Framework document (RD04).
We do not propose any dedicated observations to specifically address frequency calibration during PV, but rather rely on the fact that whenever a source with spectral features is observed the results of the frequency

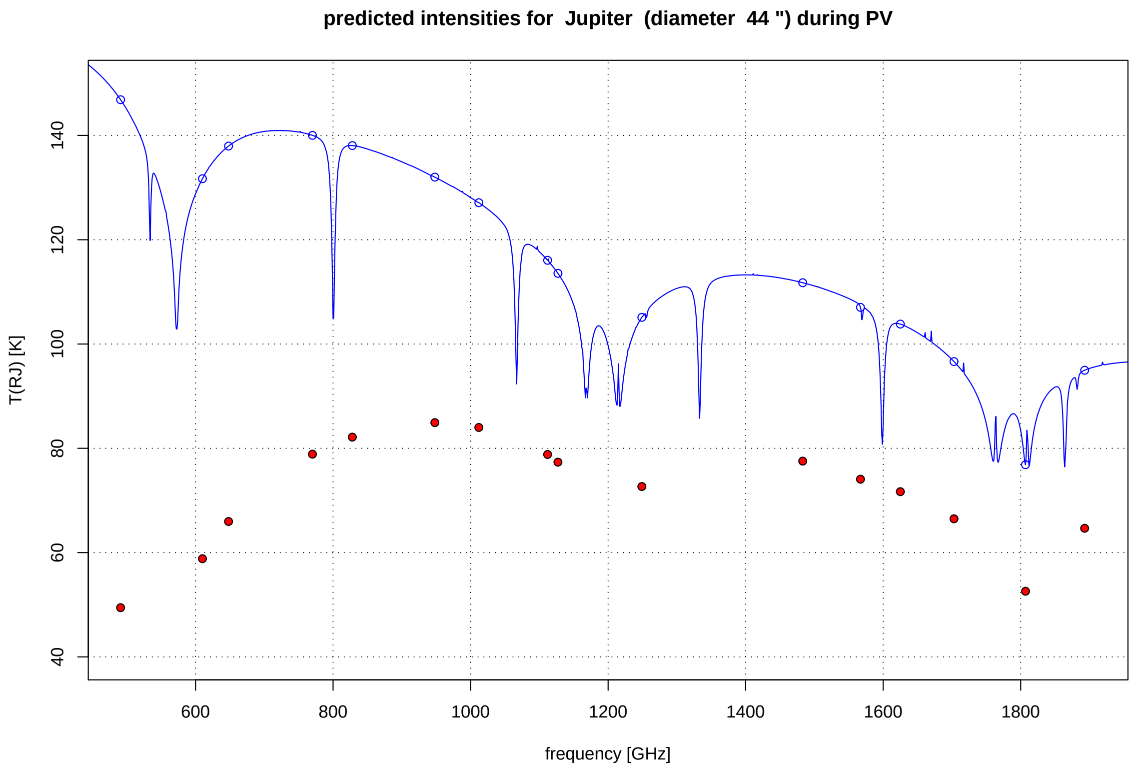

Figure 3: Predicted brightness (empty blue circles) and antenna temperatures (filled red circles) for Jupiter.

calibration from the data reduction pipeline will be checked for correctness. Suitable sources, which are assumed to be covered either by the afore mentioned observations or as part of AOT commissioning include the following:

- narrow absorption/emission features in planetary atmospheres
- narrow emission lines in galactic dark clouds
- narrow absorption features in e.g. water emission profiles
- emission lines from circumstellar envelopes
- multiple emission features from the same molecular species observed as part of a frequency scan

All such observations should be analysed as outlined in UC-1.3.1 to 1.3.3. Frequency scans performed during AOT testing are also used to check the proper functioning of the deconvolution algorithm.
The instrument line profiles are known from ILT. For the WBS it has to be noted that ILT only produced line profiles in an environment of room pressure and temperature, leading to asymmetric, broadened profiles compared to what is expected in space. The lack of very narrow and tunable line sources prevents us from repeating these measurements in space, results will be checked for consistency instead.
The frequency accuracy relies on the stability of the reference oscillators, on the thermal stability of the temperature sensitive spectrometer components and on the accuracy of frequency calculations and frequency tuning. The frequency calibration of HIFI is split into the calibration of HRS and WBS. The resulting signal at intermediate frequencies needs further characterization, which is done by a comb signal for the WBS and reference to the LO signal by the HRS. It has been demonstrated that a failed comb signal

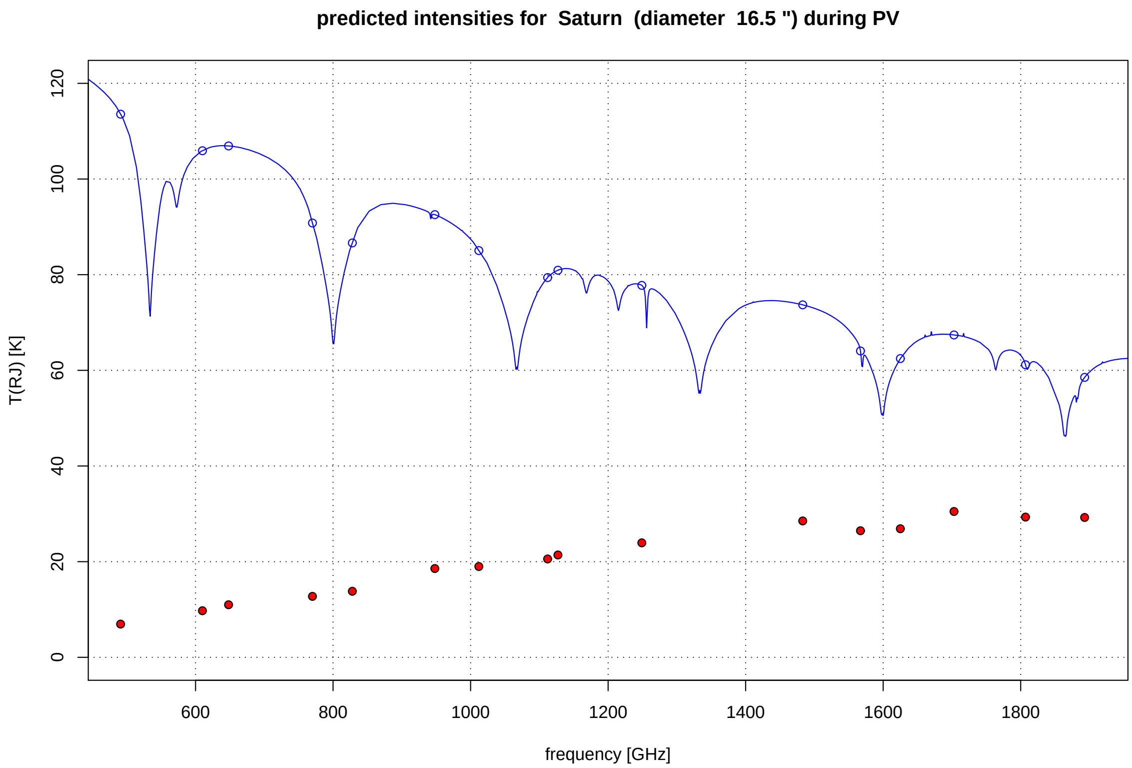

Figure 4: Same as Fig. 3 but for Saturn.

can be compensated for by cross-correlating two spectrometers looking at the same noise (or astronomical) signal, provided that one of them can be frequency calibrated properly.

7 Standing waves towards external source – HIFI-PV-3-XSW

7.0.10 purpose

Measure the standing wave pattern against a strong external continuum source, to be compared with patterns seen towards the internal loads which are already known from ILT.

7.0.11 pre-conditions

7.0.12 constraints

Reliable pointing towards source.

7.0.13 source

Strong continuum source with few spectral features in selected band. Current planning uses Jupiter.

7.0.14 bands and frequencies

At one frequency per mixer band:

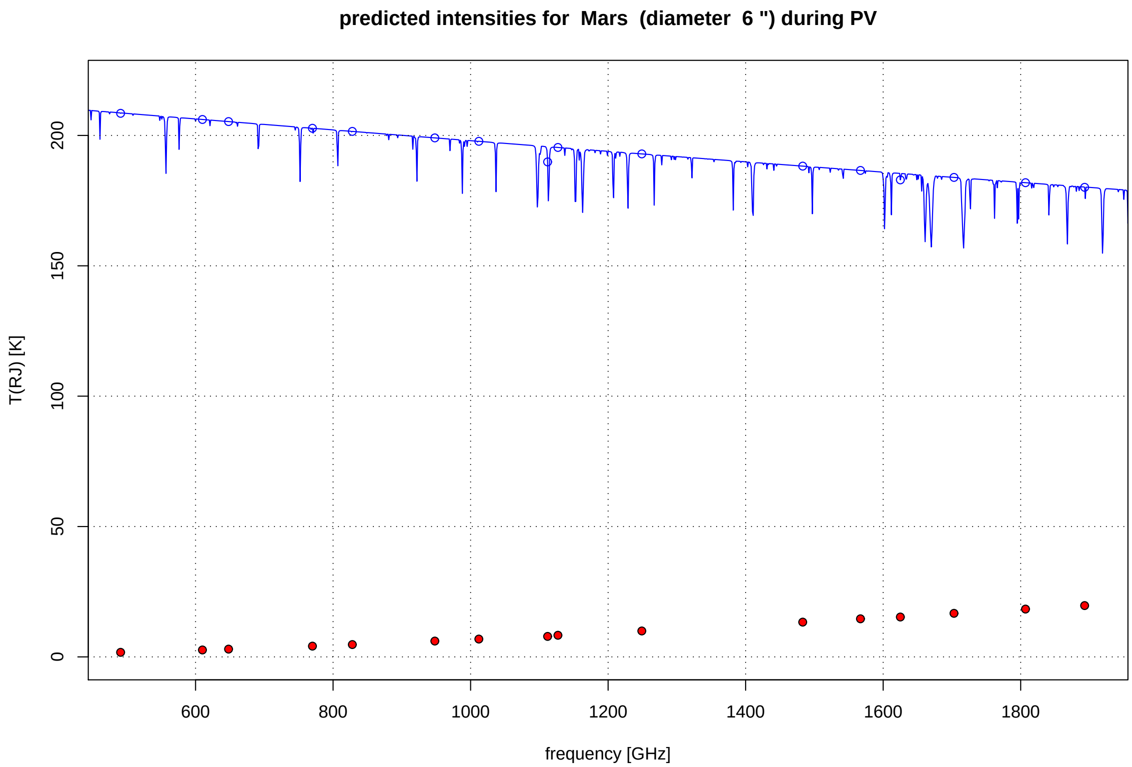

Figure 5: Same as Fig. 3 but for Mars, which becomes available towards the end of PV.

1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	6a	6b	7a	7b
491	620	649	732	839	948	1012	1078	1135	1228	1479	1693	1739	1893

7.0.15 execution mode

Fast DBS single point mode with continuum stabilisation.

7.0.16 duration

HSpot v. 3.4 yields
(257+253+257+281+257+257+257+294+294+326+467+459+345+461)s = 4465s
for a noise level of 0.15 K and a goal resolution of 1 MHz.

7.0.17 required analysis

1. Reduce spectra through standard pipeline
2. Analyse standing wave patterns observed in terms frequency and amplitude. In particular pay attention to periodicities in standing wave patterns corresponding to path lengths of 8.4 m, corresponding to a round trip path between mixer and subreflector.

7.0.18 success/failure scenario

Success:

8 AOT check-out

8.1 Scope

This document provides a detailed description on how the HIFI AOTs will be validated during the Performance Verification Phase, including pre-validation of certain modes at the end of the formal Check-Out Phase.

8.2 Goals

The HIFI Observing Modes, whose scientific drivers are described in RD02 and whose technical design is described in RD07, must be validated at a functional level, and in scientific performance terms.

8.2.1 Functional goals

These encompass operative aspects of commanding, data generation, and CUS- OBS interactions:

- Command execution and acknowledgement verification: command rejections/failures and runtime events identified and classified.
- Executed integration time verification
- Data completeness verification (Dataframes and HK)
- Data rate verification
- Data labelling verification (BBType assignment)
- Spacecraft instrument operations relative timing (ACMS vs HIFI timeline verification).

These functional goals will be applied in their entirety to all executed obsids, and only these have strict pass/fail conditions.

8.2.2 Performance goals

These allow the Observing Modes to be assessed for their intended astronomical applications and efficacy, which essentially verifies the design for different types of observing scenarios by calibration scheme (RD07 and RD08) and performances driven by an assumed noise model for the instrument (RD09 and RD10) and the results of FM-ILT and -IST incorporated into CUS AOT logic and uplink tables. The CUS logic in structural terms is described in RD11. Calibration parameters from ILT/IST used in the AOTs are tabulated in RD12.
Performance metrics include:

- Noise temperatures
- Baseline stability
- Platforming stability
- Gain stability
- Spectral correctness (frequencies and profiles)
- End-to-end radiometric accuracies (intensities)
- Linearity
- Sideband ratio stability/repeatability
- Spurs / spurious signal
- Pointing performance verification
  - tracking on fast targets such as comets and slow outer planets
  - APE, SRPE, PDE, AME, and slew times
- Net observing, noise efficiencies and drift (compared to HSpot estimations)

All of the above metrics are not required to be deduced from every AOR, but deduced interactively from suitably representative AORs.
Telescope Pointing: The implementation of Observing Mode calibrations combines a timeline of instrument commands with telescope pointing modes. Note that there is no direct interaction between HIFI and the ACMS, there is only a timing of each subsystem's TCs to match instrument and telescope phases via the CUS state machine. Figures 6 and 7 summarize pointing modes used for fixed targets and Solar System Objects.

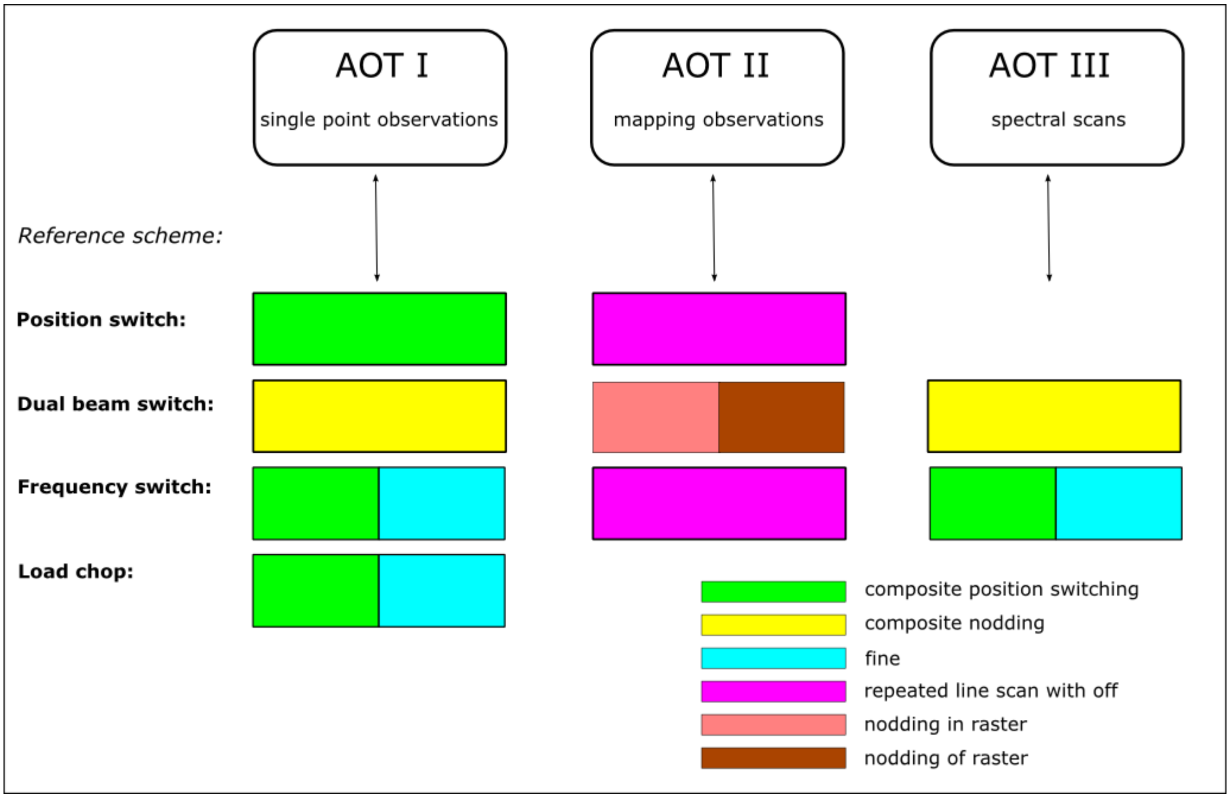

Figure 6: Pointing modes in the AOTs for fixed targets. Not shown are the modes for the OTF Load Chop and SScan Load Chop Observing Modes, which use "Repeated line scan with off" (OTF Load Chop) and either "Composite position switching" (SScan Load Chop with OFF) or "Fine pointing" (SScan Load Chop with no OFF). Note also that the DBS Raster and Point DBS modes may use gyro propagation, depending on timing of the telescope movement to allow for periodic gyro calibrations. At this writing, gyro propagation to be used in either real time attitude control or ground-based pointing reconstruction has not been implemented.

In order to achieve full validation, Observing Mode relative performances and repeatability must also be assessed by running

- Identical AORs on the same celestial source on different ODs
- AORs using different Observing Modes on the same celestial source, same targeted line(s) and noise goals
- Different AOR setups using the same Observing Mode on the same celestial source, targeted line(s) and noise goals.

These Observing Mode relative stability / performance requirements do not be need to be filled out comprehensively (i.e. with all possible variations), but sufficiently centred around utilization by the KPs

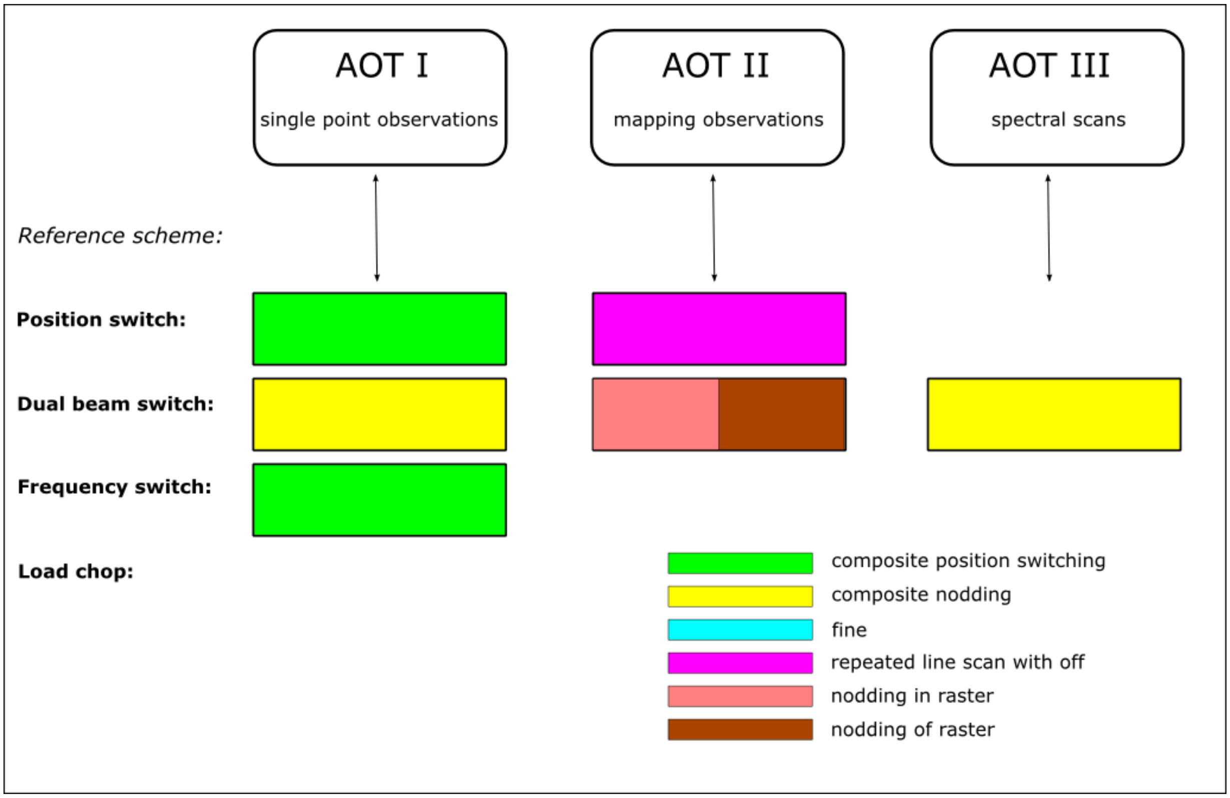

Figure 7: Pointing modes for moving targets.

that recommendations can be made for the performance and observing efficiency trade-offs learned on-orbit from

- FSwitch vs. LoadChop modes on extended sources
- FSwitch and LoadChop with and without sky Position Switching
- DBS with and without continuum optimization.
- SScans at different frequency scan redundancies (for sideband deconvolution)

Furthermore test coverage is required in all LO sub-bands. For SScans this includes full scans in all 14 sub-bands at different redundancies. There should be no LO tunings left for the first time to science observations.

Performances are not considered for strict pass/fail conditions. Rather, there will be an accounting of the above metrics that will be distilled into a matrix of performance versus observing cost, caveated by special circumstances such as the locations of spurs or spurious response effects. If it becomes evident that an assessed performance is so low that the mode or specific setups of a mode should not be used, and that recourse by changes in logic or calibration tables will not have a substantial benefit over cost in effort, then recommendations on its usage in HSpot and alternatives will be proposed as part of the PV AOT validation report.

8.3 Context with FM-ILTs and ISTs

8.3.1 FM-ILTs SRON

Functional validation (Sec. 8.2.1) of Observing Modes executed as CUS testmodes (outside the MPS) on the FM has been undertaken with continuously evolving analysis methods and scripts since the FM3-ILT period of June 2007. Although the tests could be conducted with LOs at nominal operating temperatures (≈ 70 K comparable to the ambient space), HIFI as an instrument was in continuous state of hardware I&T and OBS updates. The test campaigns in which the first generation of Observing Modes could be exercised in opportunistic fashion served to reveal a significant number issues to be solved in OBS–AOT CUS interactions and engineering vs. AOT procedures (e.g. LO tuning). Very few performance verifications resulted from this period. It should also be stressed that most Spectral Scan AOT tests and Frequency Switch modes were especially unsuccessful, in terms of command rejections (timing errors somewhat hidden by EGSE SCOS-related timing jitter) and many runtime events, loss of data (TmIngest failures), OBS incompatibilities, the unsteady state of LO tuning and other ILT procedures adopted into AOT logic, and an overall complex configuration of AOT CUS branches during development and testing. The FM-ILT AOT report is given in RD13.

8.3.2 FM-ISTs: Special Performance Testing

The Observing Modes entering the period of ISTs beginning (for the AOTs) with SPTs in August 2008 encompass changes to AOT logic and CUS calibration tables and the introduction of new Load Chop modes as possible alternatives to Frequency Switching (particularly in the HEB bands). This set of changes incorporates FM-ILT results, especially the Radiometry (Tsys survey; RD14) and Stability tests (RD15). The short set (≈ 3.7 h) of Observing Mode CUS testmodes, executed in SPTs via tcl and with the LOs OFF, have been functionally examined and results summarized in RD16.

8.3.3 Reference Mission Scenario / System Operational Validation Tests (1)

A selection of short-duration testmodes have been executed on the FM as part of RMS and SOVT-1 scenario testing in September 2008. These have been executed in the MTL (i.e. in an I-EGSE SCOS-timing jitter free timeline), with the LOs OFF. A functional verification (Sec. 8.2.1) of the testdata propagated from the HSC has been accomplished, revealing a non-negligible number of missing dataframes in several of the 19 AORs run during SOVT-1. The missing data are not judged to originate with on-board systems, rather in the upstream ground system. Accounting is provided for a test report from the HIFI ICC, in progress, and PointingProducts generated from SOVT-1 are under appraisal. Preceding RMS contents are a sub-set of SOVT-1 (in AOR terms), but no analysis of these data have been undertaken since the version of the merged CUS used in these tests was already obsolete by several weeks, and propagated database corruption issues were not solved.
Note further, that due to constraints on operating the LOU at room temperature at the time of planning than none of the executed AORs represent KP AORs, but were instead planned at "safe" frequencies across HIFIs observing modes (instrument + spacecraft) with varied setups and sequence parameters determining integration times and calibration timing for functional purposes.

8.3.4 Thermal Vacuum / Thermal Balance

36 Observing Mode CUS testmode scripts constituting ≈ 12 h of test time with the LOs at their nominal ambient operating temperatures are planned for be execution in the final block of TV/TB tests. It is planned to run Block 4 containing the AOTs and stability tests via MTL, so that these will be the first and only tests for HIFIs AOTs in an I-EGSE timing-jitter free timeline, and with the full instrument in nominal operation. Spectral Scans and Frequency Switch modes are the primary emphases, as well as the new OTF Load Chop modes, and several short-duration (< 5 min) tests which will also be run during SOVT-2 with the LOs at room temperature. Overall constraints on TV/TB test time prevent any full-band Spectral Scans (instead covering short stretches of mainly 8 GHz at the edges of selected LO bands), and no sources other than the internal loads and cryo-cover reflections will be observed.

8.3.5 System Operational Validation Tests (2)

AORs prepared for PV (the focus of this document) will be run in part during SOVT-2. These include certain representative AORs for the 3 phases of AOT validation in PV, described below. Most testing will

Figure 8: Fractional LO frequency usage in OT and GT KP Point AOTs, from RD16.

Figure 9: Fractional LO frequency usage in OT and GT KP Mapping AOTs, from RD16.

be done with the LOs OFF. In each LO sub-band, a short-duration (< 5 min) test will be run at the safe frequency with the LOU powered ON.

8.4 General Considerations for Celestial Sources and Spectral Lines

The Observing Modes are designed for observing point-like and extended sources. However, there is no single point-like source or single extended source with which to validate the modes at all frequencies of scientific interest (see below and Sec. 8.5), including fixed and moving (SSO) objects and most desirable ground-based calibration sources for cross-reference, taking also visibility constraints into account.

In practice, sources from the HIFI Key Programmes provide a valuable set from the standpoint of selecting key spectral lines among different object classes with varied (frequency-dependent) source structure. In other words, AOT validation planning is aided by the lines which are planned with specific signal to noise goals set in the Key Programmes. This does not mean strictly adhering to the AOR setups (Sec. 8.5).

The lines which are being targeted in KPs with Point and Mapping AOTs are illustrated below. This is not a comprehensive representation, since it is the LO frequencies stored in the AORs, whereas the information on specific spectral line(s) of interest placed in either sideband are not reliably extracted from the databased AORs. The intended lines by target are linked. From these two figures the importance of the C^+ 1897 GHz line to KP science is obvious.

Note that while "key" frequencies are identified with specific transitions of greatest scientific interest, the tuning of the LOs varies in AORs targeting the same line(s) due to

- Source radial velocity
- Tuning of line placement into one of the upper or lower sideband, according to the Astronomers objectives to observe (or avoid) other lines of interest (or trouble) over the available IF.
- Slight re-tuning, when the observation is scheduled and the S/C radial velocity is taken into account.

Concerning target availability: for an 16 April 2009 launch date, the PV period excludes some of the most scientifically prolific regions such as Orion and the Galactic Center, well-known YSOs such as W33A and the W3, W4, W51 regions, as well as key calibration sources found in CSO, JCMT, KOSMA lists such as IRC+10216, CRL 618, Mars, and Neptune. [1]

It is essential to observe one or more of the standard calibrators at frequencies well observed on the ground, in order to verify overall radiometric and frequency calibrations, as well as the veracity of data processing software (such as sideband deconvolution). T_A^* must be conserved!

For reference, online calibration objects and lines observed from JCMT may be found at: `http://www.jach.hawaii.edu/JCMT/spectral_line/Standards/standards.html`

8.5 Mode usage in GT/OT Key Programmes in relation to AOT checkout

Utilization of the HIFI Observing Modes in GT and OT KPs is broken down in RD16. There the AOTs, modes and their setups, spectrometer utilization (including mixer polarization, and HRS resolution settings), and LO band utilization are statistically summarized. RD16 is an important complement to this document, as it defines the scientific operating parameter space that must be sampled for AOT checkout. Two important aspects in relation to KP utilization of the AOTs are taken into account here:

1. The parameter space covered by the KPs is necessary but not sufficient to sample for AOT validation, from the standpoint of the offered capabilities and alternatives based on performance vs efficiency

[1] Some of these sources may fall at visibility window edges with respect to the beginning and end of PV, but anyway representing difficult observational timing constraints.

tradeoffs which have to be demonstrated. For example, it is necessary to test SScans at all offered redundancies in order to assess both the scientific performances in line-rich objects, and efficacy of sideband deconvolution software, despite the fact that some programs use only the lowest redundancy on either the assumption of very low line confusion on certain targets or as a measure to save observing time. The problem of deconvolving DSB SScan data and the effects of different redundancies on the SSB solution are described in RD17.

Similarly, many of the other setups available to Users are unutilized, or very lightly utilized (e.g. FSwitch with Position Switched sky measurements, likely due to high observing cost), covered by permutations in the bulletized list of Sec. 8.2.2.

In planning terms this means that while many (but not all) of the celestial objects and targeted lines (or bands) are taken from the KPs, the AORs themselves are substantially modified for purposes of AOT validation across the widest operating parameter space that is viable for scientific observations with HIFI. For all validation tests using KP targets and associated lines, no assumptions on duplication issues are made: it is assumed that all observations from AOT validation no matter how the AORs are varied will be proprietary (embargoed), and leave it to the HIFI PI team and the HSC to manage data distribution outside the HIFI ICC.

2. The AOR composition of the KPs consists of Observing Modes available through HSpot 3.1.0 (Phase 2), which have since undergone substantial changes as summarized in Sec. 8.3. One particular key issue is the performance of FSwitch modes in the HEB bands as a consequence of instabilities deduced during FM-ILTs and -ISTs, and under these circumstances the new OTF and SScan Load Chop modes have been introduced as possible alternatives.

8.6 AOT Validation Requirements

1. All Modes must be tested
    - HifiPointModePositionSwitch
    - HifiPointModeFrequencySwitch
    - HifiPointModeFrequencySwitchNoRef
    - HifiPointModeDBS
        - with continuum stabilization
        - without continuum stabilization
    - HifiPointModeFastDBS
        - with continuum stabilization
        - without continuum stabilization
    - HifiMappingModeOTF
    - HifiMappingModeOTFLoadChop
    - HifiMappingModeOTFLoadChopNoRef
    - HifiMappingModeDBSRaster
        - with continuum stabilization
        - without continuum stabilization
    - HifiMappingModeFastDBSRaster
        - with continuum stabilization
        - without continuum stabilization
    - HifiMappingModeDBSCross
        - with continuum stabilization
        - without continuum stabilization
        - 5-point step size options
            - Nyquist
            - Pointing jitter
            - Non-Nyquist
    - HifiMappingModeFastDBSCross
        - with continuum stabilization

        · without continuum stabilization
        · 5-point step size options
            – Nyquist
            – Pointing jitter
            – Non-Nyquist
    ◦ HifiSScanMode
        · Redudancy 2, 3, 4, 6, 8, 12
            – HifiSScanModeDBS
                · with continuum stabilization
                · without continuum stabilization
            – HifiSScanModeFastDBS
                · with continuum stabilization
                · without continuum stabilization
            – HifiSScanModeFSwitch
            – HifiSScanModeFSwitchNoRef
            – HifiSScanModeLoadChop
            – HifiSScanModeLoadChopNoRef

   It is not required to cover all continuum stabilization options in the above DBS and FastDBS modes, or all step size options for every DBSCross and FastDBSCross test; they are listed to ensure that they are sufficiently tested according to target and observing setup.

2. All LO sub-bands must be utilized among the Point and Mapping modes.
3. All LO sub-bands must be utilized in full SScans, at varied redundancies.
4. The backend spectrometers must be utilized in combinations of the WBS and the HRS in High, Nominal, Low, and Wide resolution modes, and hybrid resolution modes of the separate HRS-H and -V sections.
5. Observing Mode setups must sample the regions of instrument sequence parameter space which are most efficient (lowest cost function) to operate the instrument.

   It is not possible to test all combinations of sequence parameters, numbering in the millions. The "efficient" or low cost range of parameter space is much more restricted, and it is possible to take slices of the space containing the Key Programme AORs. It is important to note, however, that this validation activity is not necessarily centred on GT Key Programme space, since the complexion of the Programme AORs is systematically directed towards maximizing observing time on as many sources as possible within the allocated total time, and less towards robust calibrations of the data from individual AORs.
6. The Observing Modes must be exercised on fixed and moving targets. In the solar system, a fast target (comet) and outer planet should be observed to validate tracking performance, but this is not a strict requirement as it depends on source availability.
7. Differential performances of the Observing Modes must be evaluated. See Sec. 8.2.2.
8. Observing mode stability and repeatability must be demonstrated. See Sec. 8.2.2.
9. All observations must pass sanity/integrity checks (see Sec. 8.2.1), and those which do not must be determined to be faulty due to processes downstream from onboard systems (instrument subsystems, AOT logic, and OBS should not be at fault).

If all of the above Requirements are met, then dissemination of performance results and recommendations relevant to best use of the Observing Modes, and/or programme re-planning in HSpot will be provided in the AOT Validation Test Report.
If any one of the Requirements cannot be met, then the provisions for use of the affected Observing Mode(s) and plans for immediate problem resolution will be reported to the HIFI ICC.

8.6.1 Assumptions

1. The AOT commissioning occurs as a final PV activity, so that the instrument is as close to its nominal operating condition for routine science operations as possible.
2. Several early-PV characterization and calibration activities are expected to employ standard observing modes, such as FPG mapping and beam characterization using the DBS and FastDBS Raster modes (FPG will use a special half-chop engineering mode base on FastDBS) on an outer planet. It is therefore necessary to include a pre-commissioning "Tier 1" test period, in which selected modes are exercised at the end of COP, in order to verify an acceptable handling of instrument commands in time series with S/C pointing manoeuvres. The goal is to examine the sequential execution of commands through their telemetry indicators (that need not rely on radiometrically calibrated external source signals or depend on meeting stability requirements for science), relative timings between the ACS and HIFI OBS. The time estimated for Tier 1 AORs is $\approx 10\,\%$ (TBC) of the total time allocated for the AOT commissioning.
3. The ACMS will have been calibrated by the end of the COP, and the Required and Goal performance results will have been disseminated by HSC and/or the Herschel Pointing Working Group, important for assessing impact on pointing-sensitive observations in Bands 5–7.
4. An updated SIAM following completion of FPG-1 and -2 measurements will been implemented in the MPS slew model prior to scheduling the main body of AOT Validation (Tier 2).
5. Peaking up or raster maps for the sole purpose of re-initializing the S/C attitude when using Bands 5–7 will not be performed on an AOR basis.

8.6.2 Prerequisites

To be written.

8.7 Data Analysis

8.7.1 Command and Data Sanity/Integrity

Analysis scripts written for AOT data sanity checking are under Herschel CVS in `HCSS_DIR/lib/Herschel/hifi/scripts/users/share`:

- `GetPackets.py`
- `ErrorTmPackets.py`
- `DataFrameCount.py`
- `IltObsContext.py`
- `IntegrationSequenceCount.py`
- `IntegrationTime.py`
- `SequenceCounter.py`

Inputs, outputs, and pass/fail will be written here.
Other common analysis utilities used during IA are under this area. The above scripts are run at the JIDE command line. Tabledata generated from the scripts are viewed in the DatasetInspector or exported to ASCII.
At this time, additional analysis scripting is in preparation or else needed to accomplish verification of

- Building block numbers (according to sequence parameters)
- Data rates (maximum and average according to the CUS)
- WBS zero and comb switch status during collection of science data
- Frequency grid integration scheme

Table 7: Summary of Observing Mode performance metrics.

AOT Performance Items	
01	Noise Temp
02	Baseline stability
03	Platforming stability
04	Gain stability
05	Spectral correctness
06	E2E radiometric accuracy
07	Linearity
08	SB ratio stability/repeatability
09a	Spurious signal
09b	Spurs (LO)
09c	Spurs (WBS CCD)
10a	Pointing accuracy: APE
10b	Pointing accuracy: SRPE
10c	Pointing accuracy: PDE
10d	Pointing accuracy: AME
10e	Pointing accuracy: slew time
11a	Tracking performance: fast
11b	Tracking performance: slow
12a	Efficiencies: observing
12b	Efficiencies: noise
12c	Drift

- Hot/cold measurements at expected frequencies
- Consistency between the Bb sequence and the chopper position/LO frequency.

Some of these analysis tasks may be accomplishable from pipeline modules, where this is possible has to be confirmed and tested.

8.7.2 Performance Evaluation

Performance metrics introduced in Sec. 8.2.2 are
The main tools which will be used to perform the measurements are the HIFI pipelines, to be run interactively, found in

- `HCSS_DIR/lib/herschel/hifi/pipeline/wbs/WbsPipeline.py`
- `HCSS_DIR/lib/herschel/hifi/pipeline/hrs/HrsPipeline.py`
- `HCSS_DIR/lib/herschel/hifi/pipeline/generic/GenericPipeline.py`

The HIFI Pipeline Users Manual containing descriptions for running the threads and modules with inputs and outputs is at
`http://www.sron.rug.nl/docserver/wiki/doku.php?id=docbook:hifi-um`
Additionally, Level 1–2 packages in the HCSS will be employed to validate or investigate:

- DSB deconvolution (SScans) and Performance Item 8
- Spurs (Performance Item 9), to produce a spur inventory using deconvolution preprocessing
- Standing wave detection/correction (All Observing Modes) and Performance Item 2.
- Spectral correctness (Performance Item 5) employing the spectral toolbox and CASSIS or other scientific analysis level packages.

Table 8: ACMS HK for Pointing Mode Performance monitoring.

Star Tracker	Reaction Wheels	Gyros	Quaternions	Tracking and Slewing
ATDT_FAIL	TACH_WHEEL_SPEED_1	IRU_AUTO_RSS	ACG_PK_UP_Q1	TRACK_RATE_X
ATDT_ACQ_ENA	TACH_WHEEL_SPEED_2	IRU_BODY_X	ACG_PK_UP_Q2	TRACK_RATE_Y
ATDT_COUNT	TACH_WHEEL_SPEED_3	IRU_BODY_Y	ACG_PK_UP_Q3	TRACK_RATE_Z
STA_BODY_Q1	TACH_WHEEL_SPEED_4	IRU_BODY_Z	ACG_PK_UP_Q4	ACG_RATE_X
STA_BODY_Q2	RWA1_SPIN_DIRECTION	IRU_RSS_SEL	ATT_Q1	ACG_RATE_Y
STA_BODY_Q3	RWA2_SPIN_DIRECTION		ATT_Q2	ACG_RATE_Z
STA_BODY_Q4	RWA3_SPIN_DIRECTION		ATT_Q3	ACG_TRAK_MAN
STA_SELECT	RWA4_SPIN_DIRECTION		ATT_Q4	ATDT_REST_X
PHR_STA_ST			ATDT_QEST_1	ATDT_REST_Y
S1_NUM_STARS			ATDT_QEST_2	ATDT_REST_Z
ATDT_STA			ATDT_QEST_3	ACG_MAN_PROG
ATDT_ACQ			ATDT_QEST_4	PRI_MODE
			ATDT_OBSQ_1	PRI_CNTR_SET
			ATDT_OBSQ_2	PRI_OBS_SET
			ATDT_OBSQ_3	PRI_FLAG
			ATDT_OBSQ_4	GV_SLEW_COMP
				GV_POINT_RDY

The methods to perform these measurements will be explained in further detail, as more experience is gained with the pipeline and extended packages and the usecases for them have been finalized.

8.7.3 Pointing Performances

Table 7 contains metrics for evaluating telescope pointing performances. These cannot be measured directly with HIFI science data or HK, but must instead indirectly determine that they are consistent with performance results, over the range of Pointing Modes (Figure 6 and 7) for fixed and tracked observations of targets spanning a range of solar aspect angles, while on STA guidance and GYR guidance (TBD).
To accomplish this, a combination of

- HIFI science data with special emphases on
  - DBS Raster
  - DBS Cross
  - OTF Mapping
- PointingProduct
- Attitude History File (AHF)
- ACMS HK

will be analyzed to assess the consistency with pointing performances as understood when entering the Tier 2 phase of AOT checkout. At this time there are no special tools defined to accomplish this, beyond general methods to query the PointingProduct and ACMS HK data by APID in the HCSS environment. Regarding ACMS HK, specific channel points have been identified as useful for tracking status of the pointing system over the timeline of HIFI observations. The actual APIDs and HK channel numbers are to be updated.

8.8 Manpower

A detailed allocation of persons and tasks in a timeline will be determined by the scheduling of HIFI ODs during the period between the end of COP (Tier 1 AORs) and end of PV (Tier 2 and possibly Tier 3

merged).
The main resource pool and areas of responsibility (with plenty of overlap in real work) are:

- Volker Ossenkopf – AOT testing oversight, CUS logic and tables
- Pat Morris – AOT testing oversight, test program management, pipeline data analyses
- Kevin Edwards – AOT sanity/integrity and systems support
- Michael Olberg – uplink product generation, calibration liaison (intra- HIFI calibrations)
- Raphael Moreno – Moving target AOT performances
- Willem Jellema (TBC) – Pointing performances

Additionally, personnel from specific areas of data processing efforts will be allocated selected AORs for analysis support responsibilities:

- Steve Lord, Colin Borys – DSB deconvolution
- Adwin Boogert – Pipeline analyses and standing waves
- Colin Borys, John Pearson (TBC) – Spur detection and inventory, spurious response
- CHUG – TBD

An allocation of specific AORs to individuals will be placed in Sec. 8.9 when the Test Program is set and delivered to HSC.

8.9 Data Analysis Timeline

To be written at the point that the Test Program is finalized (all AORs are defined) and the approximate scheduling across HIFI ODs is known.
Here the timeline will be constrained by conditions to return AOT modifications (logic and table updates) into the system for replan (see also Sec. 8.10).

8.10 HIFI ICC – HSC Interactions

The procedures for interactions between the ICCs and HSC for uplink systems are contained RD19.
To be resolved are detailed procedures for returning and retesting AOT modifications into the system, as a result of Tier 1 testing (prior to execution of the FPG survey and PV calibration activities), and Tier 2 testing (prior to Science Demonstration Phase and opening of the Mission Database for Routine Operations).
Reporting procedures are to be defined further. Namely, the specific interactions between the HIFI AOT group with the SciOpsWG and the Herschel Pointing WG and on AOT validation progress and issues will be described here as they become clarified.

8.11 Open Points

The normal work of development and testing activities are tracked in RD20. Open points pertaining specifically to PV are:

- Procedure for returning and retesting AOT modifications following Tier 1 and Tier 2 testing to be defined in detail.
- AOT test program to be updated for 16 April 2009 Launch.
- AOT test program to updated for CUS Observing and relevant Engineering Mode changes following TV/TB and SOVT-2.
- HIFI Data Analysis scripts development to be completed and validated.
- ACMS data analysis tools defined, developed, and validated.
- Uplink product QA procedures to be defined.

Table 9: Summary of test programme observing times in hours (estimates have HSpot rounding uncertainties of ±0.1 h).

HifiTestProgramme_PV_ALL_071031.aor HSpot 3.2.0, time estimator 0.65					
HifiPointMode		HifiMappingMode		HifiSScanMode	
10.0		20.9		141.9	
PosSwitch	0.8	OTF	9.3		
FSwitch	2.9	FSwitchOTF	1.0	FSwitch	18.7
FSwitchNoRef	2.2	FSwitchOTFNoRef	2.2	FSwitchNoRef	19.9
LoadChop	0.1	DBSRaster	4.6		
LoadChopNoRef	0.1	FastDBSRaster	0.5		
DBS	1.8	DBSCross	0.6	DBS	42.9
FastDBS	2.2	FastDBSCross	2.7	FastDBS	60.3
Total: 172.8					

- Reporting procedures to be defined.
- Coordination with the CHUG in data analyses to be defined.

[PM 22-Oct-2008]: This Section must be updated for the new launch date = 12 Apr 2009. The draft program is left for description.

9 AOT Test Programme Description

The AOT Test Programme is contained in `HifiTestProgramme_PV_ALL_YYMMDD.aor`, and summarized in a spreadsheet form. Both files are available on the HIFI AOT test team wiki page at SRON.
The latest version and observing time broken down by Observing Mode are:
Note that observing time spent on the various Observing Modes are driven primarily by objectives to sample HIFIs operating parameter space in the AOT context, and do not scale directly with times spent in the KPs but do nonetheless reflect a weighting towards KP utilization (Sec. 8.5).

9.1 Test Tiers

Each AOR in the AOT test programme is assigned to a Test Tier of 1, 2, or 3.

Tier 1 is identified with Observing Modes which are expected to be employed for calibration activities, in late COP phase (RD18). These are selected DBS Raster AORs, which should be executed ahead of AORs marked for Tiers 2 and 3. Selected DBS Cross mode AORs with the HEB bands are also considered in Tier 1, since they can be exploited to independently check pointing accuracy on line-emitting point sources with accurate sky coordinates. See Sec. 8.7 for peak up and pointing performance evaluation description.

Tier 2 identifies the bulk of the test programme, and is composed of Observing Modes and setups utilized in the KPs, plus additional setups to cover the scientifically serviceable instrument operating parameter space.

Tier 3 AORs are not used in the KPs, or necessary for COP/PV activities, and can therefore be given lower weighting in scheduling and/or data analysis. This tier is may be unnecessary by the start of PV depending on KP AOR updates beyond the current (Phase 2) set.

Figure 10: Summary of HifiPointMode AOR setups; additional details are contained in the Programme AOR spreadsheet. Highlighted AORs are grouped for relative performance evaluation (see Sec. 9.2.5).

9.2 Fixed Point AOT

9.2.1 PositionSwitch

ID	Label	Target	Line	Duration	Comments

9.2.2 FSwitch and FSwitchNoref

ID	Label	Target	Line	Duration	Comments

9.2.3 DBS and FastDBS

ID	Label	Target	Line	Duration	Comments

9.2.4 LoadChop and LoadChopNoRef

ID	Label	Target	Line	Duration	Comments

9.2.5 Grouped Tests

In order to assess relative performance of the Modes, several cases using different modes of the HifiPointMode on the same celestial target, spectrometer utilization and LO tuning have been devised. This is generally done by selecting a comparable Mode, and requiring that the resulting SSB noise estimate from the first AOR is the goal of the second AOR at its goal resolution. This is restricted to cases that do not end up costing several times more in observing time.
Four sets of HifiPointMode AORs are grouped together, identified in Table 2, for comparison of Observing Mode performance on the same target and at the same LO tuning and SSB noise goals, but enabling/disabling one of the calibration options.
Grouped observations include DBS with and without continuum stabilization, and FSwitch and LoadChop with and without OFF measurement for baseline (standing wave) calibration. In the case of FSwitch, a point and extended source are included.

9.2.6 Scheduling Constraints

TBD by visibilities and HIFI OD schedule.

9.3 Mapping Modes

9.3.1 OTFMap

ID	Label	Target	Line	Duration	Comments

Figure 11: Summary of HifiSScanMode AOR setups; additional details are contained in the Programme AOR spreadsheet. Highlighted AORs are grouped for relative performance evaluation (see Sec. 9.4.4).

9.3.2 DBSRaster and FastDBSRaster

ID	Label	Target	Line	Duration	Comments

9.3.3 DBSCross and FastDBSCross

ID	Label	Target	Line	Duration	Comments

9.3.4 OTFLoadChop and OTFLoadChopNoRef

ID	Label	Target	Line	Duration	Comments

9.3.5 Scheduling constraints

TBD by target visibility and HIFI OD schedule.

9.4 Spectral Scans

The HifiSScanMode AORs are largely based on HIFI GT KP AOR targets and band selection, with adjustments to the following setup parameters:

- Redundancies: The accuracy of sideband deconvolution at the generally lower redundancies requested in the KPs can be simulated at the data processing level from high redundancy PV observations. However, the range of redundancies must be tested, since the logic is different for the number of frequency steps before going to either the second DBS pointing phase (HifiSScanModeDBS and HifiSScanModeFastDBS) or second frequency pointing phase (HifiSScanModeFSwitch and HifiSScanModeFSwitchNoRef), i.e., `n_freq_point`= 1 and `n_freq_point` > 1. Retuning is not performed at high redundancies for small steps, which are not present at low redundancies. Furthermore, drift effects on SScans at different diplexer scan rates are not known. Therefore the range of allowed redundancies (2–12) is planned in one SIS band (3b) and one HEB band (7a). The HEB case is in Tier 3 but subject to revision.
- Frequency Throws: KPs employing the FSwitch mode use only +120 MHz (AD-07); none use −120 or ±240 MHz; this may be related to SPR-3639. The +120 and +240 MHz throws are currently selected for PV testing purposes. It is likely that at least one of ±240 MHz will be selected in some OT-KPs or future small programmes. The −120 MHz throw is included with HifiFixedPosition cases. The selection of throws to be tested in PV will be modified if their availability is changed in HSpot.
- Fast Chop DBS: None of the KPs employ FastDBS, and none request continuum stabilization, even though this is recommended especially for the HEB bands. Both PV cases set in HEB bands will use FastDBS with continuum measurement. There are also 3 cases set in the SIS bands which use fast chop, one of which without continuum stability measurement.
- Offset reference measurements: KPs employing FSwitch only use FSwitchNoRef. Measurement on an offset sky position for best calibration of the baseline is likely to be employed in GT-KP updates, OT-KPs and smaller programmes, and can in principle be verified as part of characterizing the internals if FSwitch AOT modes are employed. This is already the goal for characterizing differential

frequency stability concentrating on total power and spectroscopic Allan times. Nonetheless, two cases of FSwitch with offset measurement are included with the formal AOT checkout: one SScan in a SIS band, and one FixedPosition in an HEB band. The latter is planned as an early pre-validation case.

9.4.1 SScanDBS and SScanFastDBS

ID	Label	Target	Line	Duration	Comments

9.4.2 SScanFSwitch and SScanFSwitchNoRef

ID	Label	Target	Line	Duration	Comments

9.4.3 SScanLoadChop and SScanLoadChopNoRef

ID	Label	Target	Line	Duration	Comments

9.4.4 Grouped Tests

In order to assess relative performance of the Modes, several cases using different modes of the HifiSScanMode at different redundancies on the same celestial target and LO band have been devised. This is done by deriving a SSB noise temperature from the time estimation at highest redundancy (12), and using this result as a goal for AORs set to redundancies of 2, 3, 4, 6, and 8.
Two sets of HifiSScanMode AORs are grouped together, identified in Table 3, for comparison of Observing Mode performance at the different redundancies.
Grouped observations include normal DBS without continuum stabilization in band 3b (Tier 2), and FastDBS with continuum measurement in band 7a (Tier 3). Within each group, the option of continuum measurement has been switch on (off) in band 3b (7a) at a redundancy of 4 for further performance assessment.

9.4.5 Scheduling Constraints

TBD by visibility and HIFI OD scheduling.

A Scheduled observations during PV

OD	**title**					duration
	source	RA	Dec	band	starts on	
60	**FPG2_FastDBSRaster_1a_491**					01:22:43
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 12:03:53	
60	**FPG2_FastDBSRaster_1a_491**					01:22:43
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 12:03:53	
60	**FPG2_PeakUp_1a_491**					00:03:56
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 13:27:44	
60	**FPG2_PU-Verify_1a_491**					00:03:21
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 13:33:06	

Continued on next page

OD	title / source	RA	Dec	band	starts on	duration
60	**FPG2_HalfThrowDBSRaster_1a_491**					01:22:28
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 13:37:53	
60	**Beam-1a-491GHz**					01:34:57
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 15:01:47	
60	**OTF-1a-491GHz**					01:34:39
	Jupiter	21h59m00s	-13d19m00s	1a	2009-06-14 16:38:10	
60	**Stability-1a-494GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	1a	2009-06-14 18:28:01	
60	**Stability-1a-542GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	1a	2009-06-14 19:29:27	
60	**Stability-1b-618GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	1b	2009-06-14 20:46:31	
60	**Stability-1b-564GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	1b	2009-06-14 21:47:57	
60	**Beam-1b-610GHz**					01:34:57
	Jupiter	21h59m00s	-13d19m00s	1b	2009-06-14 23:03:10	
60	**OTF-1b-610GHz**					01:29:03
	Jupiter	21h59m00s	-13d19m00s	1b	2009-06-15 00:39:34	
60	**Beam-2a-648GHz**					01:34:09
	Jupiter	21h59m00s	-13d19m00s	2a	2009-06-15 02:25:40	
60	**OTF-2a-648GHz**					01:29:03
	Jupiter	21h59m00s	-13d19m00s	2a	2009-06-15 04:01:14	
60	**Stability-2a-643GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	2a	2009-06-15 05:45:29	
60	**Stability-2a-686GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	2a	2009-06-15 06:46:56	
61	**FPG2_FastDBSRaster_2b_770**					01:21:54
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 12:00:52	
61	**FPG2_PeakUp_2b_770**					00:03:48
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 13:23:56	
61	**FPG2_PU-Verify_2b_770**					00:03:21
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 13:29:12	
61	**FPG2_HalfThrowDBSRaster_2b_770**					01:21:34
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 13:34:01	
61	**Beam-2b-770GHz**					01:34:09
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 14:57:03	
61	**OTF-2b-770GHz**					01:27:11
	Jupiter	21h59m00s	-13d19m00s	2b	2009-06-15 16:32:40	

Continued on next page

OD	title					duration
	source	RA	Dec	band	starts on	
61	**Stability-2b-728GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	2b	2009-06-15 18:15:05	
61	**Stability-2b-758GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	2b	2009-06-15 19:16:32	
61	**Stability-3a-814GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	3a	2009-06-15 20:33:39	
61	**FPG2_FastDBSRaster_3a_828**					01:21:54
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-15 22:04:32	
61	**FPG2_PeakUp_3a_828**					00:03:48
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-15 23:27:35	
61	**FPG2_PU-Verify_3a_828**					00:03:21
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-15 23:32:50	
61	**FPG2_HalfThrowDBSRaster_3a_828**					01:21:34
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-15 23:37:38	
61	**Beam-3a-828GHz**					01:34:09
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-16 01:00:39	
61	**OTF-3a-828GHz**					01:21:35
	Jupiter	21h59m00s	-13d19m00s	3a	2009-06-16 02:36:15	
61	**Beam-3b-948GHz**					01:33:21
	Jupiter	21h59m00s	-13d19m00s	3b	2009-06-16 04:14:56	
61	**OTF-3b-948GHz**					01:25:19
	Jupiter	21h59m00s	-13d19m00s	3b	2009-06-16 05:49:45	
61	**Aot2_P_DBS_3b_13CO8-7_NGC253central**					00:04:10
	NGC253	0h47m33.12s	-25d17m17.6s	3b	2009-06-16 07:23:06	
61	**Aot2_P_DBSNoC_3b_13CO8-7_NGC253central**					00:06:10
	NGC253	0h47m33.12s	-25d17m17.6s	3b	2009-06-16 07:25:40	
66	**Stability-3a-837GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	3a	2009-06-20 11:34:03	
66	**Stability-3b-887GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	3b	2009-06-20 12:51:08	
66	**Stability-3b-928GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	3b	2009-06-20 13:52:34	
66	**Stability-4a-968GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	4a	2009-06-20 15:09:43	
66	**Stability-4a-995GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	4a	2009-06-20 16:11:10	
66	**Beam-4a-1012GHz**					01:33:21
	Saturn	11h10m00s	+07d35m00s	4a	2009-06-20 17:25:48	
66	**OTF-4a-1012GHz**					01:24:23
	Saturn	11h10m00s	+07d35m00s	4a	2009-06-20 19:00:36	
66	**FPG2_FastDBSRaster_4b_1112**					01:21:10
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-20 20:42:06	
66	**FPG2_PeakUp_4b_1112**					00:03:40
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-20 22:04:23	
66	**FPG2_PU-Verify_4b_1112**					00:03:21
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-20 22:09:28	

Continued on next page

OD	title source	RA	Dec	band	starts on	duration
66	**FPG2_HalfThrowDBSRaster_4b_1112**					01:20:45
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-20 22:14:14	
66	**Beam-4b-1112GHz**					01:33:21
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-20 23:36:24	
66	**OTF-4b-1112GHz**					01:16:55
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-21 01:11:10	
66	**Stability-4b-1091GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	4b	2009-06-21 02:42:42	
66	**Stability-4b-1108GHz**					01:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	4b	2009-06-21 03:44:09	
66	**Aot2_M_OTF_1a_H2O110-101_SSO_Kopff**					00:45:23
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 05:14:44	
66	**Aot2_M_FastDBSXNoC_1a_H2O110-101_SSO_Kopff**					00:28:58
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 06:00:07	
66	**Aot2_M_OTF_1a_H2O110-101_SSO_Kopff_XLeg**					00:07:41
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 06:29:03	
66	**Aot2_P_FSw_1a_H2O110-101_SSO_Kopff**					00:18:49
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 06:37:30	
66	**Aot2_P_PSw_1a_H2O110-101_SSO_Kopff**					00:06:09
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 06:55:33	
66	**Aot2_P_FSwNoRef_1a_H2O110-101_SSO_Kopff**					00:18:49
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 07:00:54	
66	**Aot2_M_OTF_1a_H2O110-101_SSO_Kopff_YLeg**					00:07:41
	Kopff	22h15m00s	-10d04m00s	1a	2009-06-21 07:18:57	
67	**FPG2_FastDBSRaster_5a_1127**					01:21:10
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 11:21:37	
67	**FPG2_PeakUp_5a_1127**					00:03:40
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 12:44:20	
67	**FPG2_PU-Verify_5a_1127**					00:03:21
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 12:49:51	
67	**FPG2_HalfThrowDBSRaster_5a_1127**					01:20:45
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 12:55:03	
67	**Beam-5a-1127GHz**					01:33:21
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 14:17:39	
67	**OTF-5a-1127GHz**					01:16:55
	Saturn	11h10m00s	+07d35m00s	5a	2009-06-21 15:52:51	
67	**FPG3_M_FastDBSX_5a_CO10-9_AFGL2688**					00:15:25
	AFGL 2688	21h02m18.78s	+36d41m41.2s	5a	2009-06-21 17:29:34	
67	**FPG3_M_FastDBSX_5a_CO10-9_NMLCyg**					00:15:25
	NML Cyg	20h46m25.46s	+40d06m59.6s	5a	2009-06-21 17:44:47	
67	**Beam-5b-1243GHz**					01:32:33
	Saturn	11h10m00s	+07d35m00s	5b	2009-06-21 18:32:05	
67	**OTF-5b-1243GHz**					01:22:31
	Saturn	11h10m00s	+07d35m00s	5b	2009-06-21 20:06:30	
67	**Aot2_P_PSw_1a_HCN6-5_SSO_Titan_2**					00:09:05
	Titan	11h10m00s	+07d35m00s	1a	2009-06-21 21:46:05	

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OD	title / source	RA	Dec	band	starts on	duration
67	**Aot2_P_PSw_1a_HCN6-5_SSO_Titan**					00:17:38
	Titan	11h10m00s	+07d35m00s	1a	2009-06-21 21:55:10	
67	**Aot2_P_PSw_1a_HCN65_SSO_Titan_VShInt**					00:47:38
	Titan	11h10m00s	+07d35m00s	1a	2009-06-21 22:04:15	
67	**Aot2_S_FSw_2a_full_R4_MWC349A**					06:01:22
	MWC349A	20h32m45.53s	+40d39m36.6s	2a	2009-06-21 23:16:23	
67	**Aot2_S_DBSNoC_2a_full_R4_MWC349A**					02:22:43
	MWC349A	20h32m45.53s	+40d39m36.6s	2a	2009-06-22 05:16:41	
72	**Aot2_S_DBSNoC_1a_488-500_O2_R8_AFGL2591**					02:01:45
	AFGL 2591	20h29m24.70s	+40d11m19.0s	1a	2009-06-26 11:23:04	
72	**Aot2_S_DBSNoC_1a_493-494_O2_R8_AFGL**					02:23:25
	AFGL 2591	20h29m24.70s	+40d11m19.0s	1a	2009-06-26 13:22:55	
72	**Aot2_M_OTFFSw_1a_CH0536_DR21**					00:08:43
	DR21	20h39m01.10s	+42d19m43.0s	1a	2009-06-26 15:45:41	
72	**Aot2_M_OTF_1a_CH0536_DR21**					00:06:16
	DR21	20h39m01.10s	+42d19m43.0s	1a	2009-06-26 15:52:49	
72	**Aot2_S_DBS_1a_full_R8_IRAS20126**					04:35:20
	IRAS20126+4104	20h14m25.97s	+41d13m32.6s	1a	2009-06-26 15:58:50	
72	**Aot2_P_DBSNoC_1a_CI1-0_Antennae**					00:05:42
	Antennae	12h01m52.48s	-18d52m02.9s	1a	2009-06-26 20:51:44	
72	**Aot2_P_DBS_1a_CI1-0_Antennae**					00:17:29
	NGC4038/9	12h01m51.80s	-18d52m10.0s	1a	2009-06-26 20:55:50	
72	**Aot2_P_FastDBSNoC_1a_H2O110-101_SSO_Saturn_ShortInt**					00:08:13
	Saturn	11h10m00s	+07d35m00s	1a	2009-06-26 21:16:35	
72	**Aot2_P_FastDBSNoC_1a_H2O110-101_SSO_Saturn_VShInt**					00:06:41
	Saturn	11h10m00s	+07d35m00s	1a	2009-06-26 21:23:16	
72	**Aot2_P_FastDBSNoC_1a_H2O110-101_SSO_Saturn_LongInt**					00:45:18
	Saturn	11h10m00s	+07d35m00s	1a	2009-06-26 21:29:57	
72	**Aot2_P_FastDBSNoC_1a_H2O110-101_SSO_Saturn_LongInt**					00:46:50
	Saturn	11h10m00s	+07d35m00s	1a	2009-06-26 22:15:15	
72	**Aot2_P_PSw_1a_H2O110-101_SSO_Uranus**					00:08:13
	Uranus	23h49m00s	-02d00m00s	1a	2009-06-26 23:26:07	
72	**Aot2_P_FastDBS_1a_H2O110-101_SSO_Uranus**					00:49:06
	Uranus	23h49m00s	-02d00m00s	1a	2009-06-26 23:32:48	
72	**Aot2_S_DBS_2b_full_R4_NGC253**					02:14:25
	NGC253	0h47m33.13000s	-25d17m17.8000s	2b	2009-06-27 00:40:34	
72	**Aot2_P_DBS_4b_H2O312-303_SSO_Saturn_LongInt**					00:45:59
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-27 03:31:26	
72	**Aot2_P_FastDBSNoC_4b_H2O312-303_SSO_Saturn_LongInt**					00:46:56
	Saturn	11h10m00s	+07d35m00s	4b	2009-06-27 04:17:27	
72	**Aot2_P_FastDBS_6b_H2O212-101_SSO_Saturn_LongInt**					00:47:51
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 05:18:57	
72	**Aot2_P_FastDBSNoC_6b_H2O212-101_SSO_Saturn_LongInt**					00:49:20
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 06:06:48	
72	**Aot2_P_PSw_6b_H2O212-101_SSO_Saturn_1**					00:06:40
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 06:54:43	

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OD	title					duration
	source	RA	Dec	band	starts on	
72	**Aot2_P_PSw_6b_H2O212-101_SSO_Saturn_2**					00:06:40
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 07:01:23	
72	**Aot2_P_FastDBSNoC_7b_CH4_1882Trip_SSO_Saturn**					00:08:08
	Saturn	11h10m00s	+07d35m00s	7b	2009-06-27 07:24:00	
73	**FPG2_FastDBSRaster_6b_1625**					05:22:35
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 11:05:49	
73	**FPG2_PeakUp_6b_1625**					00:03:24
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 16:29:32	
73	**FPG2_PU-Verify_6b_1625**					00:13:00
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 16:34:26	
73	**FPG2_HalfThrowDBSRaster_6b_1625**					05:22:35
	Saturn	11h10m00s	+07d35m00s	6b	2009-06-27 16:48:56	
73	**FPG2_FastDBSRaster_7b_1893**					05:19:39
	Saturn	11h10m00s	+07d35m00s	7b	2009-06-27 22:29:04	
73	**FPG2_PeakUp_7b_1893**					00:03:16
	Saturn	11h10m00s	+07d35m00s	7b	2009-06-28 03:49:52	
73	**FPG2_PU-Verify_7b_1893**					00:13:00
	Saturn	11h10m00s	+07d35m00s	7b	2009-06-28 03:54:39	
73	**Aot2_P_LChopNoRef_5b_NH3_DR15**					00:13:12
	DR15	20h31m53.04s	+40d13m12.0s	5b	2009-06-28 04:42:13	
73	**Aot2_P_FSwNoRef_5b_NH3_DR15**					00:08:08
	DR15	20h31m53.04s	+40d13m12.0s	5b	2009-06-28 04:55:01	
73	**ApertureEff-1a-491GHz**					00:22:48
	Uranus	23h49m00s	-02d00m00s	1a	2009-06-28 05:26:50	
73	**ApertureEff-1b-610GHz**					00:22:40
	Uranus	23h49m00s	-02d00m00s	1b	2009-06-28 06:06:41	
78	**Ripple-1a-490.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	1a	2009-07-02 10:55:34	
78	**Beam-6a-1483GHz**					03:11:50
	Saturn	11h10m00s	+07d35m00s	6a	2009-07-02 11:20:45	
78	**OTF-6a-1483GHz**					01:17:35
	Saturn	11h10m00s	+07d35m00s	6a	2009-07-02 14:34:05	
78	**Beam-6a-1560GHz**					03:11:02
	Saturn	11h10m00s	+07d35m00s	6a	2009-07-02 15:53:10	
78	**OTF-6a-1560GHz**					01:21:59
	Saturn	11h10m00s	+07d35m00s	6a	2009-07-02 19:05:42	
78	**Beam-6b-1625GHz**					02:05:09
	Saturn	11h10m00s	+07d35m00s	6b	2009-07-02 20:45:14	
78	**OTF-6b-1625GHz**					01:15:43
	Saturn	11h10m00s	+07d35m00s	6b	2009-07-02 22:51:53	
78	**Beam-7a-1703GHz**					03:12:06
	Saturn	11h10m00s	+07d35m00s	7a	2009-07-03 00:25:25	
78	**OTF-7a-1703GHz**					01:22:07
	Saturn	11h10m00s	+07d35m00s	7a	2009-07-03 03:39:17	
78	**ApertureEff-2a-648GHz**					00:22:32
	Uranus	23h49m00s	-02d00m00s	2a	2009-07-03 05:44:03	

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OD	title					duration
	source	RA	Dec	band	starts on	
78	**ApertureEff-2b-770GHz**					00:34:17
	Uranus	23h49m00s	-02d00m00s	2b	2009-07-03 06:23:41	
79	**FPG2_HalfThrowDBSRaster_7b_1893**					05:19:39
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-03 10:54:34	
79	**Beam-7b-1807GHz**					03:10:14
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-03 16:15:43	
79	**OTF-7b-1893GHz**					01:17:37
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-03 19:27:28	
79	**Beam-7b-1893GHz**					03:10:14
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-03 20:46:36	
79	**OTF-7b-1807GHz**					01:17:37
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-03 23:58:20	
79	**Ripple-7b-1892.8GHz**					00:23:11
	Saturn	11h10m00s	+07d35m00s	7b	2009-07-04 01:17:28	
79	**Ripple-7a-1738.8GHz**					00:23:11
	Saturn	11h10m00s	+07d35m00s	7a	2009-07-04 01:58:12	
79	**Ripple-6b-1692.8GHz**					00:23:11
	Saturn	11h10m00s	+07d35m00s	6b	2009-07-04 02:38:57	
79	**Ripple-6a-1478.8GHz**					00:23:11
	Saturn	11h10m00s	+07d35m00s	6a	2009-07-04 03:19:40	
79	**Ripple-5b-1243.0GHz**					00:15:16
	Saturn	11h10m00s	+07d35m00s	5b	2009-07-04 04:00:26	
79	**Ripple-5a-1135.2GHz**					00:15:16
	Saturn	11h10m00s	+07d35m00s	5a	2009-07-04 04:33:17	
79	**Ripple-4b-1077.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	4b	2009-07-04 05:05:40	
79	**Ripple-4a-1011.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	4a	2009-07-04 05:30:27	
79	**Ripple-3b-947.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	3b	2009-07-04 05:55:11	
79	**Ripple-3a-838.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	3a	2009-07-04 06:19:55	
79	**Ripple-2b-731.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	2b	2009-07-04 06:44:36	
79	**Ripple-2a-648.8GHz**					00:07:38
	Saturn	11h10m00s	+07d35m00s	2a	2009-07-04 07:09:17	
84	**Aot2_S_FastDBS_7b_full_R2_AFGL2591**					04:13:15
	AFGL 2591	20h29m24.90s	+40d11m21.0s	7b	2009-07-08 11:07:11	
84	**Aot2_S_FastDBSNoC_7b_1799-1880_R12_AFGL2591**					10:31:48
	AFGL 2591	20h29m24.90s	+40d11m21.0s	7b	2009-07-08 15:18:45	
84	**Aot2_M_OTF_7b_CII_DR21**					03:44:53
	DR21	20h39m01.10s	+42d19m43.0s	7b	2009-07-09 01:49:54	
85	**Aot2_M_OTFLChop_7b_Cplus_M51**					04:55:36
	M51	13h29m52.37s	+47d11m40.8s	7b	2009-07-09 10:57:46	
85	**Aot2_S_DBSNoC_7b_full_R2_AFGL2591**					02:10:45
	AFGL 2591	20h29m24.90s	+40d11m21.0s	7b	2009-07-09 16:02:23	

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OD	title / source	RA	Dec	band	starts on	duration
85	**Aot2_M_OTFLChop_7b_CII_DR21**					05:28:28
	DR21	20h39m01.10s	+42d19m43.0s	7b	2009-07-09 18:13:02	
85	**Aot2_S_FSw_4b_full_R4_DR21**					06:32:22
	DR21	20h39m01.10s	+42d19m43.0s	4b	2009-07-09 23:55:36	
86	**ApertureEff-3b-948GHz**					00:58:09
	Uranus	23h49m00s	-02d00m00s	3b	2009-07-10 11:13:05	
86	**ApertureEff-4a-1012GHz**					01:47:21
	Uranus	23h49m00s	-02d00m00s	4a	2009-07-10 12:28:23	
86	**ApertureEff-4b-1112GHz**					00:58:01
	Uranus	23h49m00s	-02d00m00s	4b	2009-07-10 14:32:51	
86	**ApertureEff-5a-1127GHz**					01:47:13
	Uranus	23h49m00s	-02d00m00s	5a	2009-07-10 15:48:26	
86	**ApertureEff-5b-1243GHz**					01:47:13
	Uranus	23h49m00s	-02d00m00s	5b	2009-07-10 17:53:14	
86	**ApertureEff-6a-1560GHz**					01:48:22
	Uranus	23h49m00s	-02d00m00s	6a	2009-07-10 19:58:00	
86	**ApertureEff-6a-1483GHz**					01:48:22
	Uranus	23h49m00s	-02d00m00s	6a	2009-07-10 21:47:52	
86	**ApertureEff-6b-1625GHz**					01:48:22
	Uranus	23h49m00s	-02d00m00s	6b	2009-07-10 23:53:47	
86	**ApertureEff-7a-1703GHz**					01:49:42
	Uranus	23h49m00s	-02d00m00s	7a	2009-07-11 01:59:58	
86	**ApertureEff-7b-1807GHz**					01:48:22
	Uranus	23h49m00s	-02d00m00s	7b	2009-07-11 04:07:12	
87	**Aot2_M_OTFFSw_1b_C17ONH3_G79_2**					00:29:41
	Gal 79.29+00.46	20h31m42.10s	+40d22m01.0s	1b	2009-07-11 11:06:15	
87	**Aot2_M_OTF_1b_C17ONH3_G79**					01:15:25
	Gal 79.29+00.46	20h31m42.10s	+40d22m01.0s	1b	2009-07-11 11:34:19	
87	**Aot2_M_OTFFSw_1b_C17ONH3_G79**					00:29:41
	Gal 79.29+00.46	20h31m42.10s	+40d22m01.0s	1b	2009-07-11 12:48:38	
87	**Aot2_S_DBS_1b_full_R4_LDN1157B1**					02:19:30
	LDN1157-B1	20h39m10.2s	+68d01m10.5s	1b	2009-07-11 13:21:32	
87	**Aot2_S_DBSNoC_1b_full_R4_LDN1157B1**					01:55:30
	LDN1157-B1	20h39m10.2s	+68d01m10.5s	1b	2009-07-11 15:39:01	
87	**Aot2_S_DBSNoC_1b_full_R6_etaCar**					01:51:19
	eta Car	10h45m03.59s	-59d41m04.3s	1b	2009-07-11 17:56:32	
87	**Aot2_S_FastDBSNoC_1b_563-585_R2_etaCar**					01:56:18
	eta Car	10h45m03.59s	-59d41m04.3s	1b	2009-07-11 19:46:00	
87	**Aot2_S_FastDBSNoC_3b_full_R6_etaCar**					04:39:02
	eta Car	10h45m03.59s	-59d41m04.3s	3b	2009-07-11 21:56:04	
87	**Aot2_S_DBSNoC_2b_full_R2_NGC253**					01:03:00
	NGC253	0h47m33.13000s	-25d17m17.8000s	2b	2009-07-12 03:02:52	
87	**FPG3_M_FastDBSXNoC_7a_CO15-14_AFGL2688**					00:36:56
	AFGL 2688	21h02m18.78s	+36d41m41.2s	7a	2009-07-12 04:33:32	
87	**Aot2_P_FSwNoRef_3a_CH+_DR21**					00:03:56
	DR21	20h39m01.10s	+42d19m43.0s	3a	2009-07-12 05:26:26	

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OD	title / source	RA	Dec	band	starts on	duration
87	**Aot2_P_LChopNoRef_3a_CH+_DR21**					00:04:40
	DR21	20h39m01.10s	+42d19m43.0s	3a	2009-07-12 05:28:53	
87	**Aot2_P_FSw_2a_H2Omaser658_MWC349A**					00:06:57
	MWC349A	20h32m45.53s	+40d39m36.6s	2a	2009-07-12 05:48:24	
87	**Aot2_P_PSw_2a_H2Omaser658_MWC349A**					00:04:44
	MWC349A	20h32m45.53s	+40d39m36.6s	2a	2009-07-12 05:53:46	
87	**Aot2_P_LChop_2a_H2Omaser658_MWC349A**					00:09:24
	MWC349A	20h32m45.53s	+40d39m36.6s	2a	2009-07-12 05:57:27	
87	**Aot2_P_FastDBSNoC_6b_CH+_H2O_DR15**					00:17:16
	DR15	20h31m53.04s	+40d13m12.0s	6b	2009-07-12 06:21:25	
87	**Aot2_P_DBSNoC_6b_CH+_H2O_DR15**					00:17:04
	DR15	20h31m53.04s	+40d13m12.0s	6b	2009-07-12 06:37:08	
98	**Aot2_P_LChop_6a_NII_DR21**					00:07:25
	DR21	20h39m01.10s	+42d19m43.0s	6a	2009-07-22 11:21:29	
98	**Aot2_P_FSw_6a_NII_DR21**					00:06:11
	DR21	20h39m01.10s	+42d19m43.0s	6a	2009-07-22 11:28:14	
98	**Aot2_M_OTFFSw_7b_Cplus_M33NGC91**					05:58:26
	M33-600N	1h34m08.80s	+30d48m51.0s	7b	2009-07-22 11:57:58	
98	**Aot2_M_DBSRastNoC_5a_H20312-221_HH54B**					11:06:09
	HH54B	12h55m50.30s	-76d56m22.9s	5a	2009-07-22 18:30:08	
98	**Aot2_M_OTFFLChopNoRef_7b_Cplus_M51**					02:53:51
	M51	13h29m52.37s	+47d11m40.8s	7b	2009-07-23 04:01:21	
99	**Aot2_S_LChop_4a_full_R4_W3IC1795**					08:39:02
	IC1795-1	2h25m43.51s	+62d06m13.0s	4a	2009-07-23 11:26:49	
99	**Aot2_S_LChop_4a_full_R12_W3IC1795**					07:31:50
	IC1795-1	2h25m43.51s	+62d06m13.0s	4a	2009-07-23 20:03:52	
99	**Aot2_S_LChopNoRef_4a_full_R4_W3IC1795**					03:14:06
	IC1795-1	2h25m43.51s	+62d06m13.0s	4a	2009-07-24 03:49:55	
112	**Stability-6a-1544GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	6a	2009-08-05 12:38:28	
112	**Stability-6a-1457GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	6a	2009-08-05 15:41:51	
112	**Stability-6b-1653GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	6b	2009-08-05 19:01:18	
112	**Stability-6b-1667GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	6b	2009-08-05 22:04:42	
112	**Aot2_S_FSwNoRef_3b_full_R6_Iras16293**					03:49:23
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	3b	2009-08-06 01:37:47	
112	**Aot2_M_OTFFSwNoRef_7b_Cplus_M51**					01:37:08
	M51	13h29m52.37s	+47d11m40.8s	7b	2009-08-06 05:53:55	
113	**Aot2_S_LChopNoRef_3b_full_R6_Iras16293**					03:05:03
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	3b	2009-08-06 12:35:07	
113	**Aot2_P_FastDBSNoC_3b_H19_etaCar**					00:04:17
	eta Car	10h45m03.59s	-59d41m04.3s	3b	2009-08-06 15:48:50	
113	**Aot2_P_FastDBS_3b_H19_etaCar**					00:11:06
	eta Car	10h45m03.59s	-59d41m04.3s	3b	2009-08-06 15:51:32	

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OD	title					duration
	source	RA	Dec	band	starts on	
113	**Aot2_P_PSw_4b_N2H+12-11_etaCar**					00:07:43
	eta Car	10h45m03.59s	-59d41m04.3s	4b	2009-08-06 16:17:16	
113	**Aot2_P_DBSNoC_4b_13CO10-9_CRL618**					00:55:30
	CRL 618	4h42m53.64s	+36d06m53.4s	4b	2009-08-06 16:42:51	
113	**FPG3_M_FastDBSXjitterNoC_6a_CO13-12_CRL618**					00:50:56
	CRL 618	4h42m53.64s	+36d06m53.4s	6a	2009-08-06 17:53:10	
113	**FPG3_M_FastDBSXNoC_6a_CO13-12_CRL618**					00:50:56
	CRL 618	4h42m53.64s	+36d06m53.4s	6a	2009-08-06 18:42:52	
113	**Aot2_P_DBS_5a_CO10-9_CRL618_HrsWide**					00:44:56
	CRL 618	4h42m53.64s	+36d06m53.4s	5a	2009-08-06 19:48:21	
113	**Aot2_P_DBS_5a_CO10-9_CRL618**					00:18:26
	CRL 618	4h42m53.64s	+36d06m53.4s	5a	2009-08-06 20:32:13	
113	**Aot2_S_FSwNoRef_5a_full_R4_rhoOph**					02:52:44
	rho Oph A (P3)	16h26m27.20s	-24d23m34.0s	5a	2009-08-06 21:13:17	
113	**Aot2_M_OTFFSw_7b_Cplus_M51**					05:53:20
	M51	13h29m52.37s	+47d11m40.8s	7b	2009-08-07 00:32:40	
118	**FPG3_M_FastDBSXjitterNoC_7a_CO15-14_CRL618**					00:36:56
	CRL 618	4h42m53.64s	+36d06m53.4s	7a	2009-08-11 13:21:39	
118	**FPG3_M_FastDBSXNoC_7a_CO15-14_CRL618**					00:36:56
	CRL 618	4h42m53.64s	+36d06m53.4s	7a	2009-08-11 13:57:21	
118	**Stability-7a-1720GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	7a	2009-08-11 14:44:20	
118	**Stability-7a-1773GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	7a	2009-08-11 17:47:43	
118	**Stability-7b-1897GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	7b	2009-08-11 21:07:09	
118	**Stability-7b-1845GHz**					03:01:53
	blank sky	18h05m00.00s	+66d30m00.0s	7b	2009-08-12 00:10:32	
118	**Aot2_M_OTFLChop_7b_Cplus_M33NGC91**					05:04:08
	M33-600N	1h34m08.80s	+30d48m51.0s	7b	2009-08-12 03:24:28	
119	**Aot2_M_OTF_7b_CII_CasA**					05:51:55
	Cas A	23h23m24.00s	+58d48m54.0s	7b	2009-08-12 13:34:42	
119	**Aot2_M_OTFLChop_1a_H2O110-101_Iras02236+6142**					01:44:56
	IRAS02236+6142-1	2h27m25.39s	+61d55m30.0s	1a	2009-08-12 19:44:44	
119	**Aot2_P_FastDBS_2a_CO6-5_CRL618**					00:11:42
	CRL 618	4h42m53.64s	+36d06m53.4s	2a	2009-08-12 21:49:16	
119	**Aot2_M_FastDBSX_2a_CO6-5_CRL618**					00:17:13
	CRL 618	4h42m53.64s	+36d06m53.4s	2a	2009-08-12 21:59:23	
119	**Aot2_P_DBS_2a_13CO6-5_CRL618**					00:10:46
	CRL 618	4h42m53.64s	+36d06m53.4s	2a	2009-08-12 22:15:05	
119	**Aot2_M_FastDBSX_2b_HCN9-8_CRL618**					00:33:28
	CRL 618	4h42m53.64s	+36d06m53.4s	2b	2009-08-12 22:39:57	
119	**FPG3_M_DBSRastNoC_5a_CO10-9_CRL618**					01:30:58
	CRL 618	4h42m53.64s	+36d06m53.4s	5a	2009-08-12 23:27:58	
119	**FPG3_M_FastDBSXjitter_5a_CO10-9_CRL618**					00:14:46
	CRL 618	4h42m53.64s	+36d06m53.4s	5a	2009-08-13 00:57:48	

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OD	title					duration
	source	RA	Dec	band	starts on	
119	**FPG3_M_FastDBSX_5a_CO10-9_CRL618**					00:15:25
	CRL 618	4h42m53.64s	+36d06m53.4s	5a	2009-08-13 01:11:26	
119	**Stability-5a-1145GHz**					02:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	5a	2009-08-13 01:36:53	
119	**Stability-5a-1177GHz**					02:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	5a	2009-08-13 03:38:45	
119	**Stability-5b-1242GHz**					02:00:01
	blank sky	18h05m00.00s	+66d30m00.0s	5b	2009-08-13 05:56:21	
132	**Aot2_S_DBSNoC_1a_full_R2_SSO_Mars**					00:56:40
	Mars			1a	2009-08-25 14:47:40	
132	**Aot2_S_DBSNoC_1a_495-540_R4_SSO_Mars**					01:18:58
	Mars			1a	2009-08-25 15:42:25	
132	**Aot2_P_DBSNoC_1b_CO**					00:08:29
	Mars			1b	2009-08-25 17:15:25	
132	**Aot2_P_DBSNoC_1b_CO**					00:43:05
	Mars			1b	2009-08-25 17:22:24	
132	**Aot2_S_DBSNoC_3a_full_R3_SSO_Mars**					01:17:50
	Mars			3a	2009-08-25 18:20:39	
132	**Aot2_P_DBSNoC_7b_HClmult_SSO_Mars**					00:05:05
	Mars			7b	2009-08-25 19:52:57	
132	**Aot2_S_DBSNoC_6a_full_R2_NGC6334I**					05:50:04
	NGC6334-I	17h20m53.44s	-35d47m02.2s	6a	2009-08-25 20:36:37	
132	**Aot2_S_DBSNoC_3a_full_R12_SSO_Mars**					01:30:24
	Mars			3a	2009-08-26 03:04:53	
132	**Aot2_S_FastDBSNoC_3a_full_R12_SSO_Mars**					01:52:24
	Mars			3a	2009-08-26 04:33:26	
133	**Aot2_P_FastDBS_4b_13CO10-9_CRL618**					00:58:21
	CRL 618	4h42m53.64s	+36d06m53.4s	4b	2009-08-26 14:54:46	
133	**Aot2_S_FastDBSNoC_6a_full_R2_NGC6334I**					07:51:40
	NGC6334-I	17h20m53.44s	-35d47m02.2s	6a	2009-08-26 16:33:17	
133	**Aot2_S_LChop_7a_full_R4_DR15**					09:33:32
	DR15	20h31m53.04s	+40d13m12.0s	7a	2009-08-27 00:54:34	
146	**Aot2_M_OTF_1b_C17ONH3_N2359S**					01:15:25
	NGC2359-bar-1	7h18m33.95s	-13d15m46.0s	1b	2009-09-08 15:48:25	
146	**Aot2_S_FastDBS_6a1440-1525_R3_NGC6334I**					07:00:19
	NGC6334-I	17h20m53.44s	-35d47m02.2s	6a	2009-09-08 17:36:52	
146	**Aot2_S_FSwNoRef_6b_full_R2_Iras16293**					04:35:56
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	6b	2009-09-09 00:54:36	
146	**Aot2_S_FSw_6b1590-1660_R3_Iras16293**					04:16:50
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	6b	2009-09-09 05:29:29	
146	**Aot2_M_DBSRast_5a_H2O_321-312_NGC2264G**					01:33:58
	NGC2264G-2	6h41m18.90s	+9d55m59.2s	5a	2009-09-09 10:23:47	
147	**Aot2_S_LChop_7a_1750-1785_R8_etaCar**					02:34:14
	eta Car	10h45m03.59s	-59d41m04.3s	7a	2009-09-09 16:01:11	
147	**Aot2_S_FastDBSNoC_7a_1730-1806_R4_etaCar**					02:33:42
	eta Car	10h45m03.59s	-59d41m04.3s	7a	2009-09-09 18:34:21	

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OD	title					duration
	source	RA	Dec	band	starts on	
147	**Aot2_S_LChopNoRef_7a_full_R2_etaCar**					02:16:32
	eta Car	10h45m03.59s	-59d41m04.3s	7a	2009-09-09 21:06:19	
147	**Aot2_S_FSwNoRef_7b_full_R2_Iras16293**					02:39:16
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	7b	2009-09-09 23:47:54	
147	**Aot2_S_FSw_7b_1850-1907_R4_Iras16293**					07:27:38
	IRAS16293-2422	16h32m22.80s	-24d28m33.0s	7b	2009-09-10 02:26:07	
147	**FPG3_M_FastDBSRast_5a_CO10-9_VYCMa**					00:15:25
	VY CMa	7h22m58.33s	-25d46m03.2s	5a	2009-09-10 10:25:41	
147	**FPG3_M_FastDBSXNoC_6a_CO13-12_VYCMa**					00:50:56
	VY CMa	7h22m58.33s	-25d46m03.2s	6a	2009-09-10 10:55:55	