esa FIRST/Planck Project	MINUTES OF MEETING	Date : 11/06/1999 Ref : PT-MM-06892 Page : 1 of 4

SUBJECT: FIRST - AOCS Instrument Interfaces

PLACE: ESTEC room Af205 on 11-06-1999, starting at 09:00 hrs.

Participants	Organ.	Distribution
T. de Graauw	SRON	HIFI, PACS and SPIRE teams via SA-DMS ESTEC: FF; TP; FV; MA; HS; PE; GP; S. Thurey; A. Elfving. ESOC: J. Dodsworth.
O. Bauer	MPE	
A. Poglitsch	MPE	
D. Beintema	SRON	
H. Feuchtgruber	MPE	
M. Griffin (part time)	QMWC	
T. Passvogel	ESTEC	
S. Thuerey	ESTEC	
A. Elfving	ESTEC	
F. Vandenbussche	ESTEC	
G. Pilbratt	ESTEC	
H. Schaap	ESTEC	

AGREEMENTS STATEMENTS	ACTION
Although not complete due to the holiday season, I issue these M.o.M. nevertheless as a draft version, to be amended later.	
1. Introduction/objectives of the meeting.	
- F. Vandenbussche welcomed the participants. The meeting followed the agenda as per PT-06676 (attachment A) It was amended with: - On-target-flag implementation.	
2. FIRST Pointing Capabilities/Modes: **- Performance as given in the System Specification**	
- A. Elfving clarified AOCS terminology and added to the common understanding of it in his presentation (attachment B). What is expected from the meeting is to understand the instrument needs and to obtain further definitions in the areas of accuracy, timing, calibration, peaking-up and the observation strategy. To enable detailed definition, the Instrument Teams are requested to provide additional information on the peak-up mode and typical observation profiles for the different observation modes. In connection with the above ESA will compile the inputs for -00 and -01 to perform analysis on typical S/C timeline and performance, to get a feeling for "real" parameters.	**AI-FI-06892-00** **AI-FI-06892-01**
- The FIRST Pointing Requirements and Goals are based on a	

AGREEMENTS STATEMENTS	ACTION
presently known design implementation, it is expected that the goals will be met. HIFI are not requesting a new design, but use the system as it is known to work now, after the experience gained with ISO. - The HIFI instrument can be used for its own peaking-up i.e. there is no need to involve one of the other instruments. Experience showed that peaking-up on ISO was not absolutely necessary and in fact not used. Should however peaking-up prove to be necessary then required corrections will be passed-on to the AOCS in the form of offset values transmitted via the OBDH bus. - For the tracking of solar systems objects the definition in the IID-A is applicable. The definition as in the Satellite Systems Specification is outdated and will be corrected in the Carrier version which is presently under preparation. The AOCS relevant parts will be updated and sent to the Instrument Teams. The Instrument Teams in turn will provide their comments to the specification. - Raster pointing parameters will be in celestial, not in spacecraft co-ordinates. Also Flight Dynamics will use the celestial co-ordinate system. - Observations will be pre-planned and up-linked in the form of a schedule. Within an observation the use of an On-Target-Flag makes sense to mark when valid data are available. As far as timing is concerned an accuracy of the order of 0.1 sec. seems OK. The OTF will be transmitted to the users as a message on the OBDH bus. - Presently peaking-up is essential. Only if the design goals can be met, it might not be necessary anymore. At the moment it can not be dropped. **3. Planned instrument modes and information requested from the AOCS.** **- Presentation by each of the Instrument Teams** - Presentation HIFI (attachment C) - During observations there are no moving parts inside the instrument other than the chopper. HIFI are chopping to compensate for gain drifts in the first stage amplifiers. - It is presently unclear whether a peak-up procedure applies to a	**AI-FI-06892-02** **AI-FI-06892-03**

AGREEMENTS STATEMENTS	ACTION
single observation only, or whether it should also be applied to the next scheduled observation. It is also unclear whether a daily peak-up would be necessary as part of the calibration. Since Peaking-up can not be done on "weak" sources, a stronger source in the area needs to be selected for the purpose. The question was raised whether a later pointing to the "weak" source is then still correct. - Presentation PACS (attachment D) - PACS do not need the Peaking-up mode. - Presentation SPIRE (attachment E) **4. Implementation Scenarios/Simplifications** **5. Further Actions.** **- On-target-flag implementation**	

esa FIRST/Planck Project	Action Item Initiation Sheet		Date : 11/06/1999 Ref : PT-MM-06892 Page : 4 of 4
	Title: FIRST - AOCS Instrument Interfaces	Place: ESTEC room Af205 on 11-06-1999, starting at 09:00 hrs.	

Ordinal Action Number	Title and Description	Due Date	Originator		Actionee		Completion	
			Firm	Person	Firm	Person	Date	By Document No.
AI-FI-06892-00	Peak-up mode: Instrument Teams to elaborate on the peak-up mode: - Objectives - Sequence for Peak-up (timeline, pointings)	15-09-1999	ESTEC	Vandenbussche	HIFI PACS SPIRE	de Graauw Poglitsch Griffin		
AI-FI-06892-01	Modes of observations: Instrument Teams to provide typical observation profiles for the different observation modes.	15-09-1999	ESTEC	Vandenbussche	HIFI PACS SPIRE	de Graauw Poglitsch Griffin		
AI-FI-06892-02	ESA specification: ESA to provide latest issue of the System Specification (AOCS relevant parts)	30-06-1999	HIFI PACS SPIRE	de Graauw Poglitsch Griffin	ESTEC			
AI-FI-06892-03	Comments to Specification: Instrument Teams to review the specification and provide comments (including pointing modes)	15-09-1999	ESTEC	Vandenbussche	HIFI PACS SPIRE	de Graauw Poglitsch Griffin		

Attachment A

esa

FIRST/Planck Project Telefax

Fax No : (31) 71 565 5244
Tel. No : (31) 71 565 5962

Ref. : **PT-06676** **Date** : 23 April, 1999

From : T. Passvogel/F. Vandenbussche **Page** : 1 of 1

To : Th. de Graauw (SRON/Groningen) **Fax No:** 050 363 4033
A. Poglitsch (MPE/Garching) 49 89 3299 3292
M. Griffin (QMWC/London) 44 181 980 0986

Copy : H. Aarts (SRON/Utrecht) **Fax No:** 030 254 0860
O. Bauer (MPE/Garching) 49 89 3299 3569
K. King (RAL/Oxfordshire) 44 1235 44 6667

Cc : F. Felici, M. Anderegg, P. Estaria, H. Schaap, G. Pilbratt

Subject: FIRST - AOCS to Instrument Interfaces

Dear all,

At the last commonality working group meeting we agreed to have a meeting to identify and discuss the interfaces from the s/c AOCS system to the instruments.

After some e-mail exchange I understand the agreed date of the meeting is the 11.6.1999. Since this was the planned meeting date for the PACS technical meeting I propose to shift this to the 10.6.1999 – PACS please confirm.

I propose the following agenda:

1. Introduction/Objectives of the meeting (ESA)
2. FIRST Pointing capabilities/Modes (ESA)
   – performances as given in the system specification
3. Planned Instrument Modes and Information requested from the AOCS
   – presentation from each instrument team
4. Implementation Scenarios/Simplifications (ALL)
5. Further Actions

In preparation to the meeting I would ask you to provide written comments to the specification (input provided at the last FST).

Please confirm the meeting date and provide list of participants.

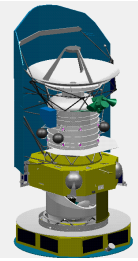
If you have any comments to the agenda or further questions please let us know.

Best regards

T. Passvogel

ESTEC
Postbus 299 - NL 2200 AG Noordwijk - Keplerlaan 1 - NL 2201 AZ Noordwijk ZH
http://sci.esa.int/first -- http://sci.esa.int/planck

Attachment B

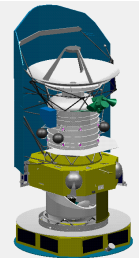


FIRST

AOCS - Instrument Meeting

ESTEC, 11 June 1999

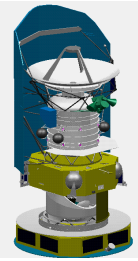
A. Elfving (SCI-PXS)



Presentation Structure

- Pointing Terminology
- Pointing Requirements and Goals on the S/C
- Spacecraft Slew and Scan Requirements
- Observation Modes

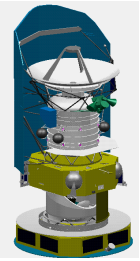
This presentation summarises the pointing requirements on the S/C as presently defined in the System Specification. This specification is under review and will be frozen in due time (prior to FIRST/Planck ITT)



Pointing Terminology

- **Absolute Pointing Error (APE):** is the angular separation between the commanded direction and the instantaneous actual direction

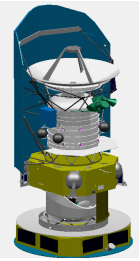
- **Pointing Drift Error (PDE):** is the angular separation between the short time average (barycentre of the actual pointing during some time interval) and a similar average pointing at a later time. The drift is given over 24 hours during the same observation period.



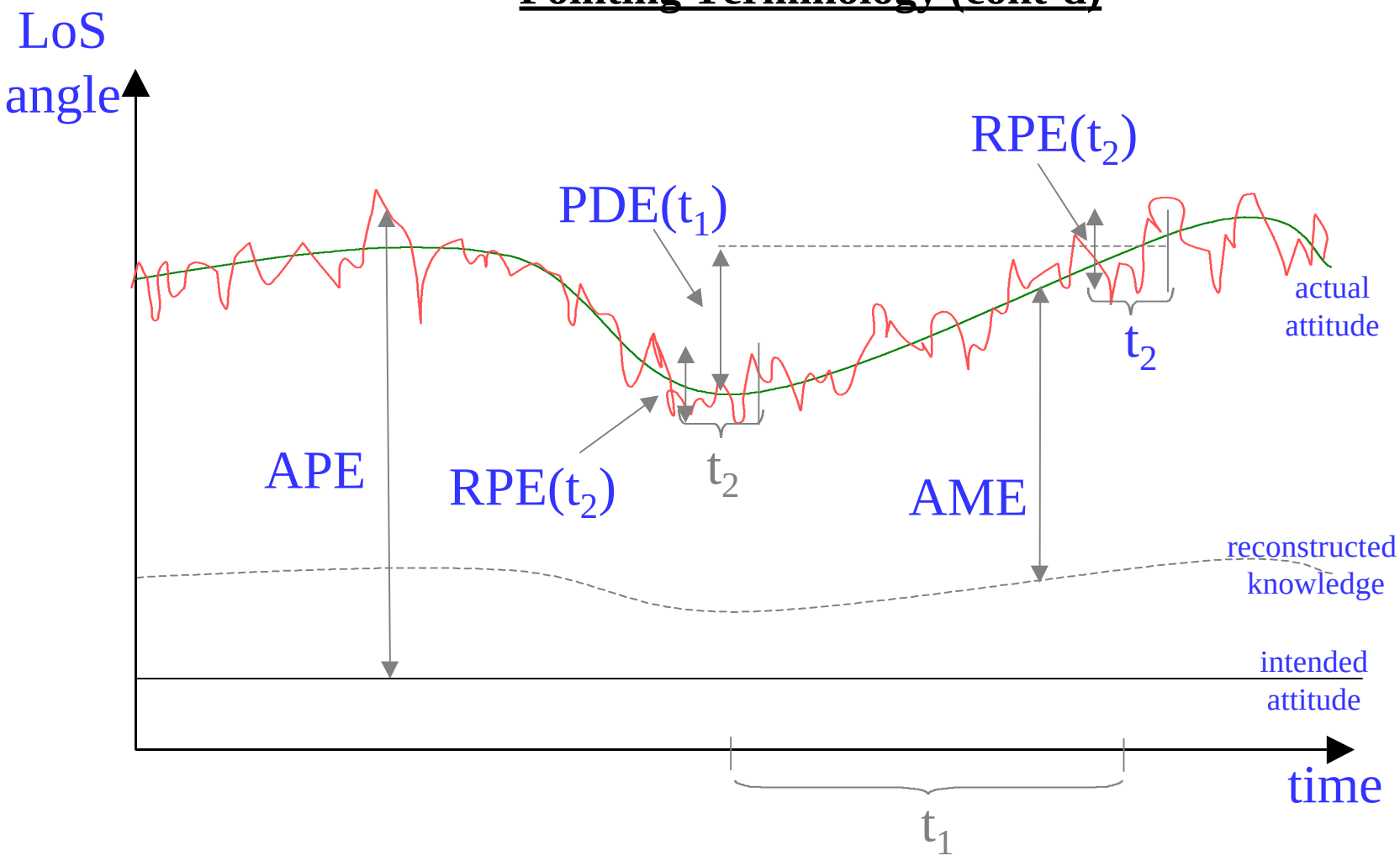
Pointing Terminology (cont'd)

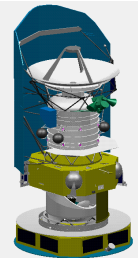
- **Relative Pointing Error (RPE):** is the angular separation between the instantaneous orientation of the satellite fixed axis at some time t and a reference axis (average, barycentre) over a defined period. This is also known as the pointing stability.

- A**ttitude Measurement Error (AME):** is the angular separation between the actual and the measured orientation of the satellite fixed axis defined instantaneously or over a time interval. This performance requirement is referred to as "a posteriori knowledge".



Pointing Terminology (cont'd)

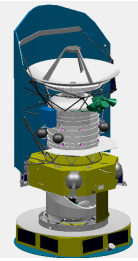




Pointing Requirements and Goals

Pointing requirements: performance to be satisfied under all applicable conditions and margins

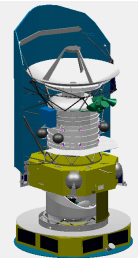
Pointing goals: performance to be satisfied under restricted, but specified, conditions and without margins



Pointing Requirements and Goals (cont'd)

ERROR	*Optical Axis (arcsec)*	*Around Optical Axis (arcmin)*	*Goals (arcsec)*	*Goals around Optical Axis (arcmin)*
APE	*£ 3.7*	*3.0*	*£ 1.5*	*3.0*
PDE(24 hours)	*£ 1.2*	*3.0*	*n.a.*	*n.a.*
RPE (1 min)	*£ 0.3*	*1.5*	*£ 0.3*	*1.5*
AME	*£ 3.1*	*3.0*	*£ 1.2*	*3.0*

Values all 1σ (68% probability)



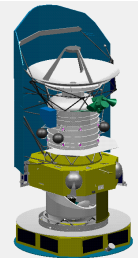
Pointing Requirements and Goals: Calibration

- A calibration mode supports execution of multiple calibrations in order to establish the angles between stellar reference and the instruments lines of sight.

  > telemetry will be used to improve APE and AME

- During the routine operations phase, the spacecraft shall be able to support a check of the validity of the initial calibrations by a single calibration every 24 hours.

  > telemetry will be used to improve AME



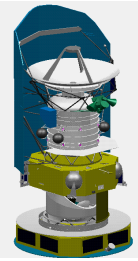
Pointing Requirements and Goals: Calibration

Peaking Up for HIFI (TBC)

- During the observation of bright sources, a way of correcting the blind pointing error when the source is bright enough is envisaged. The spacecraft perform a five-point cross scan (left, right, centre, up, down) and a double gaussian is fitted to the two three point linear scans by the instruments.

- The pointing offsets in the two orthogonal directions are computed by the instrument and the spacecraft pointing is adjusted accordingly before a much longer integration on the now correct position is carried out.

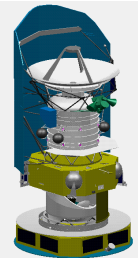
- On-board data exchange between spacecraft and instrument is required.



Spacecraft Slew and Scan Requirements

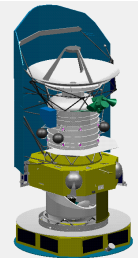
Definitions:

- slew is a manoeuvre of the S/C from one pointing direction to another without specific requirements on the path
- scan is a manoeuvre of the S/C along a specified path with a specified rate along this path



Spacecraft Slew and Scan Requirements

- The maximum slew speed is at least 7°/min when the slew angle is large enough to permit full angular velocity (≈8°)
- The total time to accelerate to and decelerate from the maximum slew speed is 300 s.
- For a slew smaller than 10 arcmin the total time between initiation of the slew and achievement of the pointing requirements on the new target is less than 30 s (tbc).
- The system is dimensioned for operational slews of at least 90 degrees, executed twice per day.
- A scan can be commanded in the range 0.1 arcsec/s to 1 arcmin/s with a resolution of 0.1 arcsec/s.



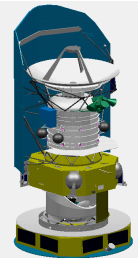
Observation Modes

Fine Pointing Mode

The fine pointing mode is the basic operation mode and consists of observation pointings, followed/preceded by slew(s).

During science observations, the pointing requirements corresponding to the selected observation mode are met.

It is possible to maintain the fine pointing for periods of up to 20 hours, during which momentum unloading and wheel speed reversal will not occur.

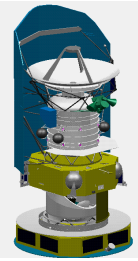


Observation Modes (cont'd)

- Tracking of solar system objects
  The satellite is able to follow, by ground commanded attitude polynomes, objects such as planets, comets, etc. having a maximum speed relative to the tracking star of 10 arcsec/min.
  The pointing requirements whilst tracking solar system objects are met.

- Nodding
  The FIRST Nodding Mode is an observing mode in which the target source is moved from one instrument chop position to the other chop position. In this case the pointing direction will change in the direction of the instrument chopper throw. Integration efficiency shall be at least 80%.

  Specifically, for a throw of 5 arcmin, the total cycle time shall not exceed 3 min; i.e. 72 s integration in either position and two 5 arcmin slews lasting 18 s each (including settling time).



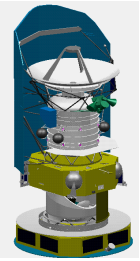
Observation Modes (cont'd)

- Raster Pointing

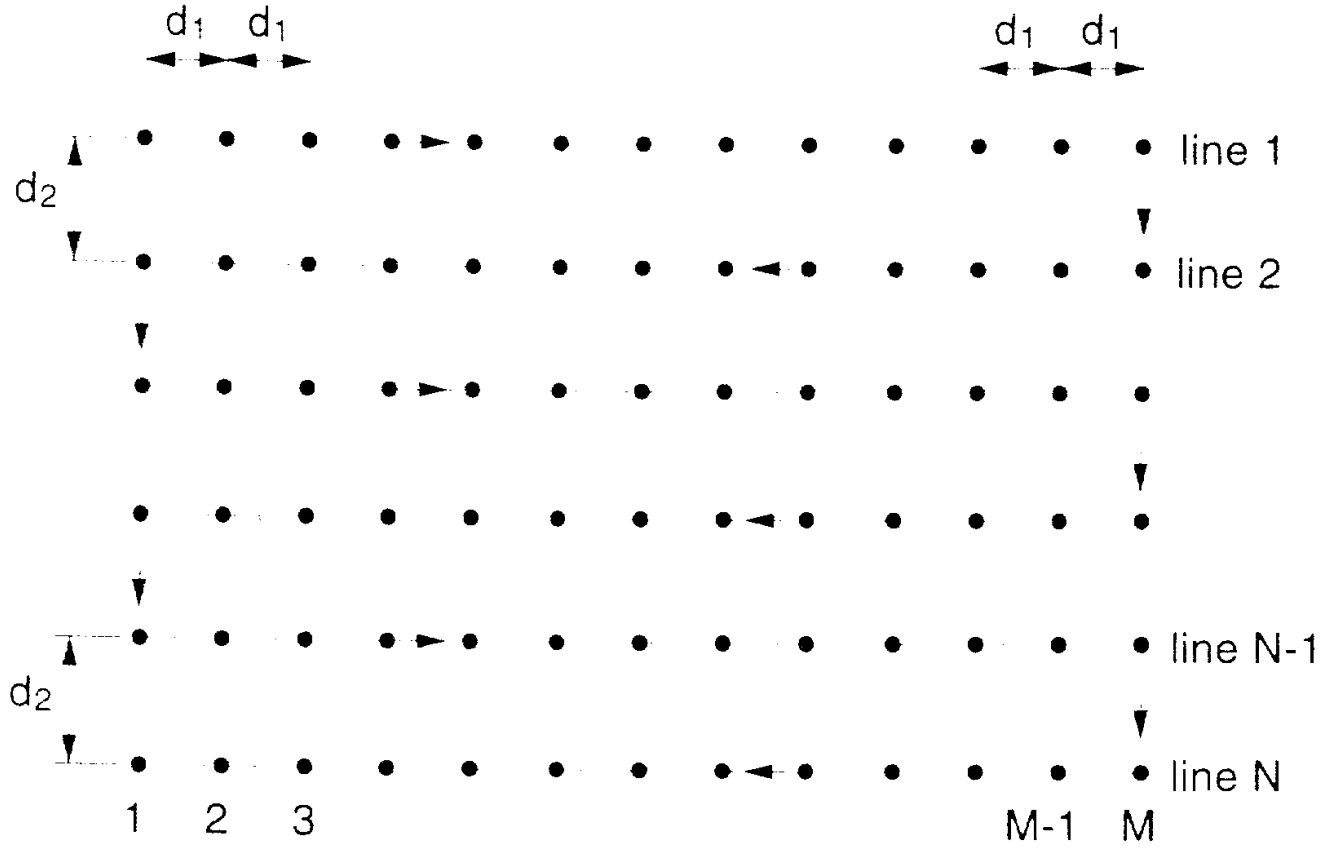
  Raster pointing is a series of fine pointing observations of equal duration (t), separated by slews, in order that the pointing of the telescope axis moves in a raster pattern.

  The raster parameters, M, N, d_1 and d_2 are within the following range and resolution:
  - M: 2 - 32
  - N: 1 - 32
  - d_1: 2 arcsec - 4 arcmin; resolution: 0.5 arcsec
  - d_2: 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec

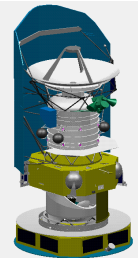
  Note that d_2 being zero, means that it is possible to scan N times the points of a single line.
  The duration of stable pointing at any position, t, will be between 10s and 30 minutes.



Observation Modes (cont'd)



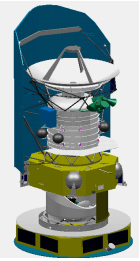
Normal Raster Pointing



Observation Modes (cont'd)

- Raster Pointing with OFF position

Raster pointing with OFF-position is a special form of raster pointing where, after a specified number of raster points (ON positions), the spacecraft slews to a predefined point (the OFF position), after which it resumes its raster pointing where it left the raster before going to the OFF position. The number of raster pointings (K) before going to the OFF position is determined by the timing characteristics of the raster pointing such that the time between each subsequent OFF position is less than some characteristic stability time of the instrument.



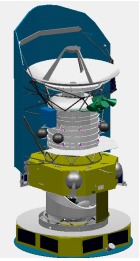
Observation Modes (cont'd)

- Raster Pointing with OFF position (cont'd)

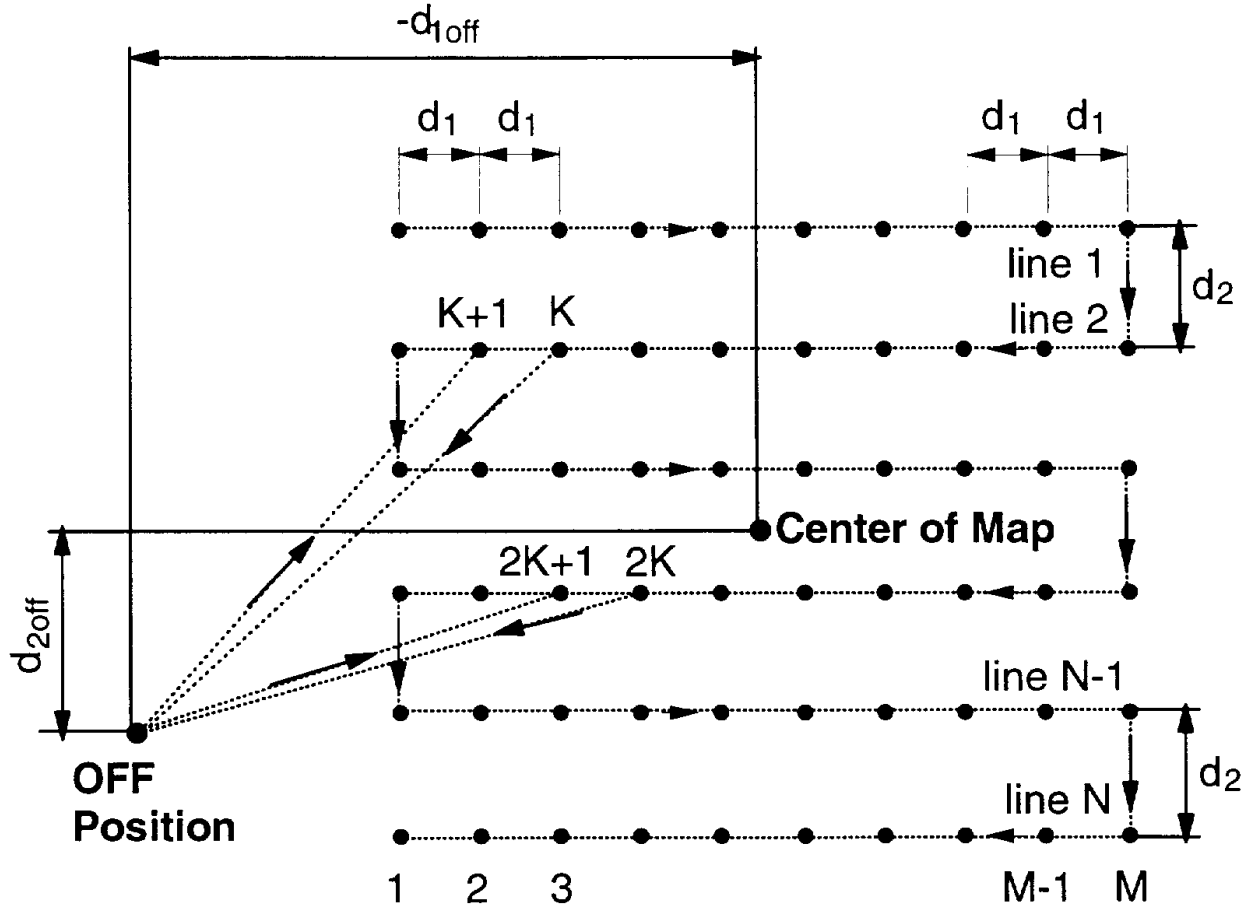
  The raster parameters, M, N, K, d_1 and d_2 are within the following range and resolution:
  - M: 2 - 32
  - N: 1 - 32
  - K: 2 - M H N
  - d_1: 2 arcsec - 1 arcmin; resolution: 0.5 arcsec
  - d_2: 2 arcsec - 1 arcmin or 0; resolution: 0.5 arcsec

  The maximum value of K being equal to the total number of ON positions implies normal raster pointing with only a single OFF position pointing at completion of the raster. The duration of stable pointing at any position, t, will be between 10s and 30 minutes.

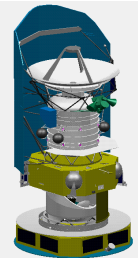
  The coordinates of the OFF position with respect to the centre of the map are within the following range and resolution:
  - d_{1off} : "(0 arcmin - 2 degrees); resolution: 0.5 arcsec
  - d_{2off} : "(0 arcmin - 2 degrees); resolution: 0.5 arcsec



Observation Modes (cont'd)



Raster Pointing with OFF-Position



Observation Modes (cont'd)

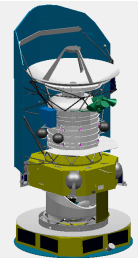
- Line Scanning

  This is a scanning mode along short parallel lines, such that the telescope axis moves. Which pointing requirements are essential, only AME?

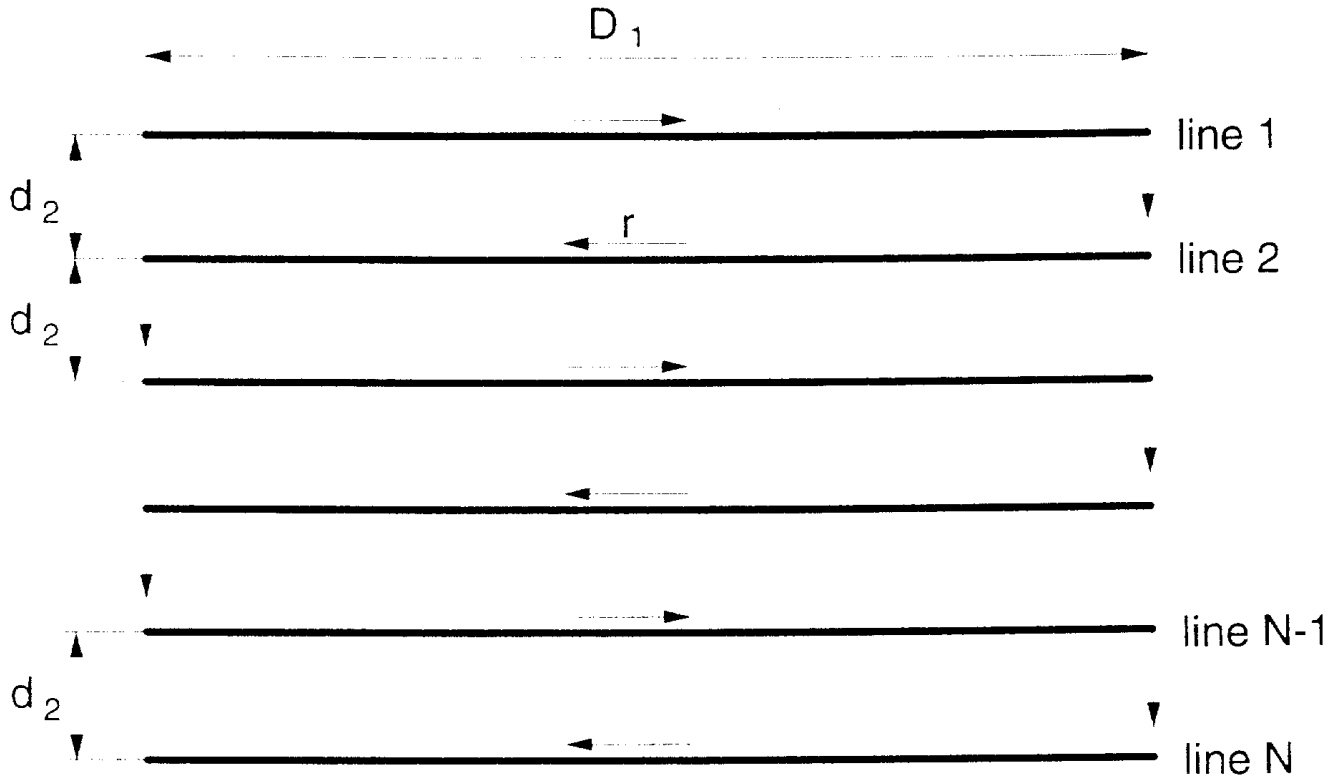
  The scan parameters, N, D_1 and d_2 are within the following range and resolution:

  - N : 1 - 32
  - D_1 : 1 arcmin - 110 deg; resolution: 1 arcmin
  - d_2 : 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec

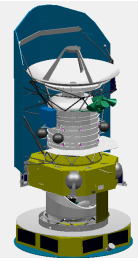
  The scan rate, r, shall be changeable by ground command and will be between 0.1 arcsec/s and 1 arcmin/s with a resolution of 0.1 arcsec/s. Scan acceleration will be fixed to 0.05 arcmin/s2, i.e. 20 s and 10 arcmin to reach 1 arcmin/s



Observation Modes (cont'd)



Normal Line Scanning



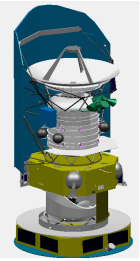
Observation Modes (cont'd)

- Line Scanning with OFF Position

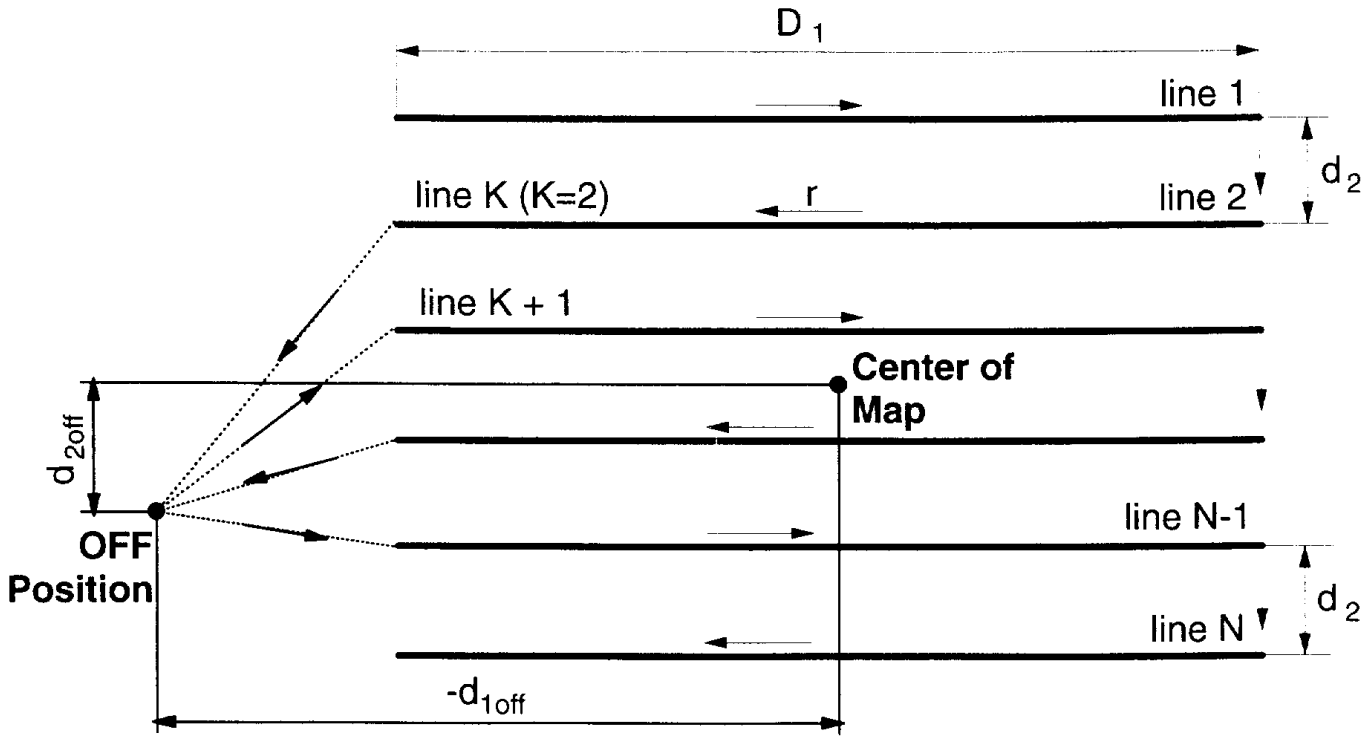
  Line scanning with OFF-position is a special form of line scanning where, after a specified number of lines, the spacecraft slews to a predefined point (the OFF position), after which it resumes its line scanning where it left the pattern before going to the OFF position.

  The scan parameters, N, D_1 and d_2 are command within the following range and resolution:
  - N : 1 - 32
  - K : 1 - N
  - D_1 : 1 arcmin - 2 deg; resolution: 1 arcmin
  - d_2 : 2 arcsec - 4 arcmin or 0; resolution: 0.5 arcsec

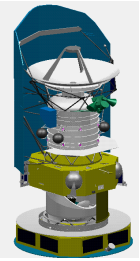
  The scan rate, r, is between 0.1 arcsec/s and 1 arcmin/s with a resolution of 0.1 arcsec/s.
  - d_{1off} : "(0 arcmin - 2 degree); resolution: 0.5 arcsec
  - d_{2off} : "(0 arcmin - 2 degree); resolution: 0.5 arcsec



Observation Modes (cont'd)



Line Scanning with OFF-Position



Need for On-board Data Exchange

AOCS to Instruments: “On-Target Flag”

- can improve time efficiency of individual observations but no overall benefit expected since follow-on observations will be initiated by on-board schedule using absolute time.
- can improve commanding efficiency: no need for explicit P/L commands within an observation.

HIFI to AOCS: Attitude correction data after peaking up

- is this an essential requirement?

Attachment C

HIFI interactions with the FIRST AOCS

1. Which interactions?

Only interaction foreseen: pointing correction request during a peaking up procedure.

No handshake needed if a peaking-up and a normal observation are pre-programmed and time-tagged in a single observing procedure.

Rationale for peaking up: the **specified** FIRST pointing accuracy is insufficient for HIFI observations at the highest frequencies. A peaking-up procedure must be implemented in case the more stringent pointing accuracy **goals** are not met. The assumption here is that peaking up will be done with the HIFI instrument. Using PACS or SPIRE could be an alternative.

2. Proposed scenario for peaking up:

- Spacecraft performs 3 x 3 raster scan, by time-tagged commanding. Step size ~ 4 arcsec
- HIFI integrates on the 9 points of the raster, also through time-tagged commands
- HIFI computes offsets in two dimensions
- Spacecraft ready to accept pointing update
- Interaction: pointing offsets communicated to the spacecraft:
  - Data packet sent to spacecraft. Contents:
    - pointing correction around Y axis
    - pointing correction around Z axis
- .....
- Spacecraft commanded to undo pointing update
  - (normally before the next observation,
  - possibility to carry correction over to next observation should exist, alternatively corrections could be re-sent before the next observation.

DAB, 12 June 1999

3.7.1 Observing Techniques

Three observing techniques are foreseen:

Total power observing where no internal switching is used. This mode may be used in combination with telescope movements such as position switching where the telescope (and satellite) is moved between two or more pointing positions on a time-scale of about 100 s, or on-the-fly mapping where the telescope performs a raster scan across the astronomical source.

Beam switching where the focal plane chopper in the HFPU switches the beam between two positions 3' arcmin apart on the sky at a rate of 1 Hz. This mode will be used for point-like astronomical sources, and optionally for on-the-fly mapping of extended objects.

Frequency switching where the LO frequency is switched between two values spaced by up to a few 100 MHz at a rate of 1 Hz. This may be used to observe sources with narrow spectral features.

Table 4.3-3 Pointing accuracy calculation. Signal losses for various pointing errors and pointing errors for a signal loss of 10%

Frequency (GHz)	Beam width FWHM	Loss from 2" pointing error	Loss from 3" pointing error	Loss from 4" pointing error	Required pointing accuracy (10 % loss)
500	44"	1 %	1 %	2 %	9.0"
1000	23"	2 %	5 %	8 %	4.5"
1500	15"	5 %	10 %	18 %	3.0"
2000	12"	7 %	16 %	27 %	2.3"
2500	9.4"	12 %	25 %	39 %	1.9"

Attachment D

PACS Questions/Comments on FIRST AOCS related issues:

Related to documents:
FIRST Satellite System Specification PT-SP-00211,11-Jun-1997
FIRST Scientific Pointing Modes PT-SP04673, Sep-1997
FST Meeting #2 viewgraphs, 22/23-Mar-1999

- Will the OTF be a hardware line or could it be a command to the instrument ?

- How will the OTF work for rasters (and Line scans etc.) ? Will it be OFF during slews (which thresholds) ?

- Raster and Line scanning modes should not be limited to 32 positions, we propose at least 128 instead.

- Smallest raster and Line scan step sizes are limited currently to 2 arcsec, we propose 0.5 arcsec instead. Smallest steps for SSO tracking should be also of this size.

- How will a raster look in time, will the slew duration be constant per raster point (see also questions on OTF) ?

- Transverse pointing accuracy for long Line scans seems mainly limited by the 3 arcmin APE *around* optical axis ?

- Is this the same for pointing accuracy of OFF positions with large d_{1off} and/or d_{2off} ?

PACS Observing Modes

2-Band Photometry

Essentially all pointing modes are required, however some restrictions might apply for Partner-Mode operations (ex.: OFF-positions are different for the two instruments etc.)

- Fine, Raster, Raster+OFF, Line, Line+OFF, all SSO Tracking and Raster modes, Nodding, Position switching

Single-Band Photometry and Line Spectroscopy Mode

Same pointing requirements as for 2-band photometry

Serendipity Mode

- The gyro based pointing information of FIRST, at *sufficient time resolution* during the slews, should be made available to PACS.

Test Modes and Calibration Modes

Some of these modes will be dedicated to investigate which pointing strategy is best for the main observing modes and specific target characteristics, therefore again all pointing modes will be required.

Peaking Up

- While for all observing modes we currently do not expect a need of online spacecraft pointing information, pending the question on slew durations during rasters, nodding etc., bi-directional online exchange of position pointing between spacecraft and PACS instrument will be required. The details of this mode are still TBD.

Off-line Spacecraft Pointing Information

- All pointing related spacecraft information has to be made available to PACS via the nominal daily downlink (RA(t), DEC(t), FIRST velocity towards target, Roll angle etc.)
- In order to correct for possible signal modulations in PACS data caused by the RPE, the time resolution of RA(t) and DEC(t) has to be sufficient for correlation work.

Attachment E

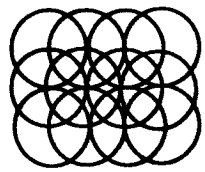
SPIRE Photometer

- Field size = 4 x 8 arcmin. (goal)
  4 x 4 arcmin. (requirement)

- Either 0.5Fλ square pixels or 2Fλ feedhorns

- Square pixels (filled array):

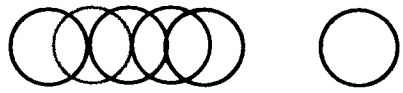
  - **Beams on the sky overlap at HWHM**



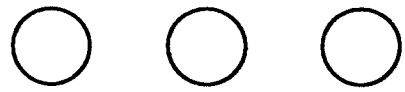
  - **Instantaneous full sky sampling**

  - **Microstepping (motions of field by fraction of a beam) is still useful**

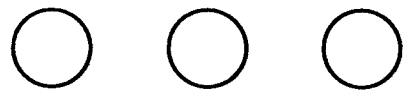
- **Feedhorns:**

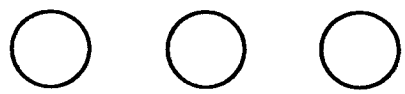


  - **Beam separation on the sky = 2 x FWHM**



  - **"Jiggle" pattern or scanning needed for proper sky sampling**





SPIRE Beam Steering Mirror

- Chopping mode

  - Chopping in Y-direction about any defined position
  - Amplitude up to 4 arcmin
  - Minimum step = 1.7 arcsec.

- Jiggling/microstepping mode

  - Mirror stepped in small increments in Y and Z axes
  - Max step in Z direction = 30 arcsec.
  - Min step in either axis = 1.7 arcsec.

- Fine pointing (peak-up) mode:

  - Not needed for filled arrays
  - May be useful for feedhorn option for point source observation

- Requirement: BSM should not be a single point failure $\Rightarrow$ alternative observing modes using telescope for spatial modulation

Mapping of an area < 4 arcmin in size

- BSM performing chopping
- Chop throw ≤ 4 arcmin
- Chop direction fixed in spacecraft coords
- Feedhorns: 64-point jiggle using BSM
- Filled arrays: No jiggle needed, but microstepping optional

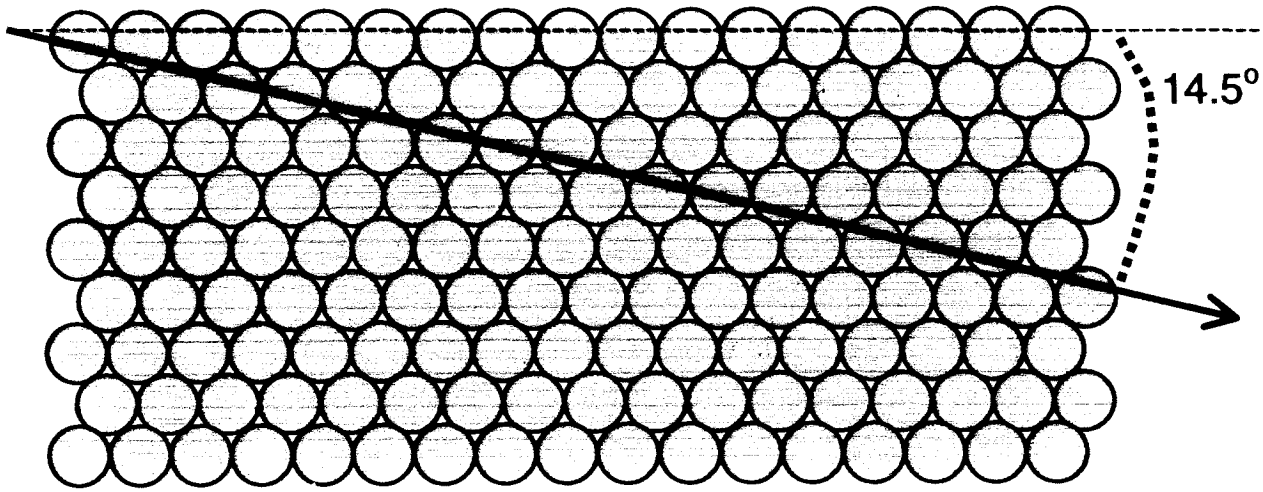
Mapping of an area > 4 arcmin in size

- Telescope operated in Raster Pointing mode
- Repetition of above with telescope re-pointed in between fields
- Questions:
  - Effective settling time when repointing is given as 10 sec.
  - What determines this number?
  - Can it be reduced?

Mapping an area much bigger than the field (e.g. deep surveys)

- Telescope moves continuously in Normal Line Scan mode
- Scan rate determined by 1/f noise of system and spacecraft capabilities
- Scan direction fixed in spacecraft coords (Y or Z)
- BSM can be on or off
  - Off is much preferred for deep surveys to avoid increased confusion noise
  - On may be necessary if scan rate is such that 1/f nose is a problem
- Duration of one line scan must be long compared to "turn-around" time of the telescope
- Lower extreme: Feedhorn option
  - Longest desired beam crossing time ~ 10 sec
  - Largest beam = 36 arcsec at 500 μm
  - Slowest rate = 3.6 arcsec/sec
  - Min rate = 0.1 arcsec/sec. - OK

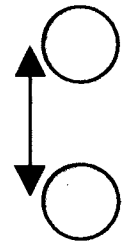
- Upper extreme: Filled arrays
  - Max rate = 60 arcsec/sec.
  - Largest beam = 36 arcsec at 500 μm
  - Beam crossing time ≈ 0.5 sec.
  - This is slower than we would like: could pose problems with 1/f noise
- Scan angle:
  - Filled array: Scanning in Y or Z directions
  - Feedhorn array: Scanning at a certain angle wrt the array provides full spatial sampling:



- Questions:
  - What limits the maximum scan rate?
  - What will be consequences of going faster?
  - Is the RPE maintained while scanning?
  - Can the angle of the scan be chosen wrt spacecraft coordinates?

Point source photometry without microstepping

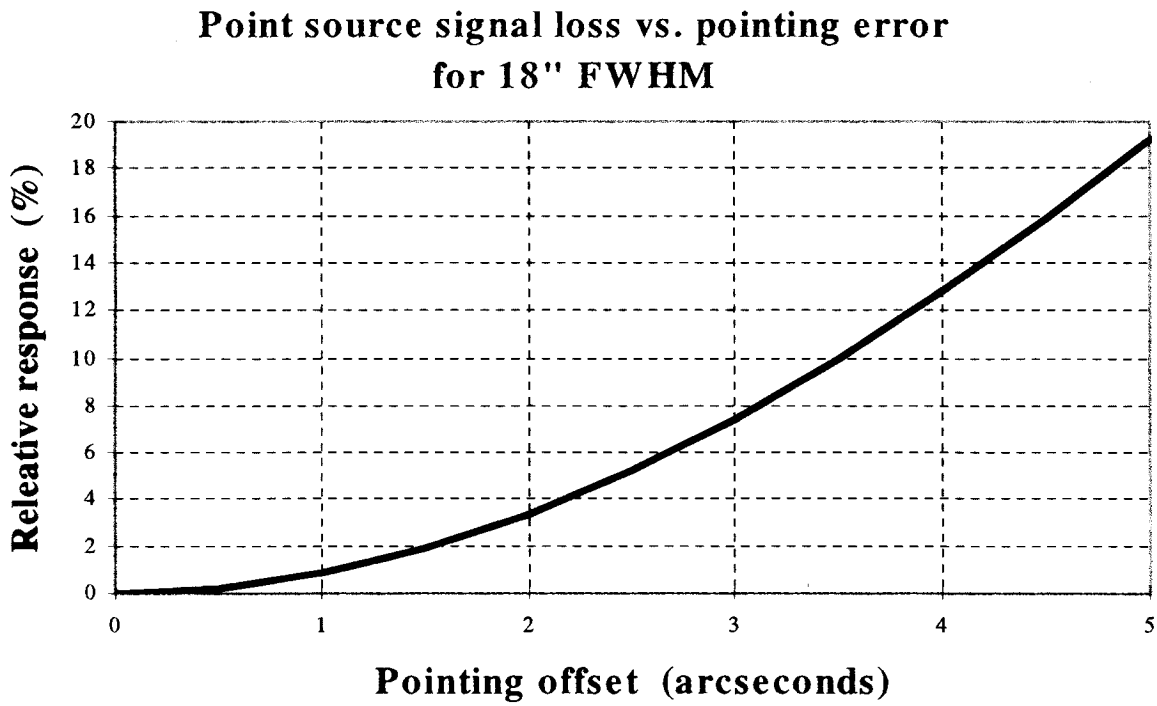
- BSM performing chopping between two array pixels in Y- direction



- Chop throw typically 1 arcminute
- Nodding (optional) may be needed depending on the telescope temperature stability
- Nodding may also be needed for other modes described below
- Question:
  - Settling time between nod positions for 5 arcminutes is given as 18 sec. Is it less for a smaller nod?
- Feedhorn option: Nominally only ~~one~~ 2 pixels per array in use
- Filled array option: PSF covered by several neighbouring pixels

Pointing accuracy

Offset (arcsec.)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
Loss(%)	0	0.2	0.9	1.9	3.4	5.2	7.4	10.0	12.8	15.9	19.3



Required: APE = 3.7" (1 σ) ≡ 11 % signal loss

Goal: APE = 1.5" (1 σ) ≡ 2% signal loss

For the feedhorn option, 11% is not acceptable

Point source photometry with microstepping

A. Use BSM to do small map (5 or 7 point) map with ~ 6" spacing

- S/N for given total integration time is lower by ~ 0.7 at 250 μm, ~ 0.9 at 500 μm
- Feasible regardless of source strength.
- Could be implemented by telescope motions (much more slowly)

B. Use BSM in fine pointing mode prior to observation:

1. SPIRE executes 5-point observation with integration time dependent on expected source brightness.
2. SPIRE on-board S/W computes required pointing correction
3. Offsets (ΔY and ΔZ) sent to AOCS
4. Correction implemented
5. Observations carried out

- Not needed for very bright objects (small map is quick compared to overheads from slewing etc.)
- Not practical for very faint objects (too slow; poor S/N may lead to inaccurate offset calculation)
- Therefore only likely to be useful for a particular band of source strengths (exact limits TBD)

Spectrometer operating modes

- Telescope pointing fixed while FTS is scanning
- BSM is not operating
- Filled array
  - Fully sampled image acquired
  - No telescope motions needed
- Feedhorn array

- Point source:
  - Point sources observed with the FTS will be readily detected with the photometer in much smaller integration times).
  - Peak up on the source itself with the photometer using option B above
  - Alternatively, carry out small map (5 or 7 point) using telescope Normal Raster Pointing as described below (less efficient)

- Extended source:
  - Telescope operates in Normal Raster Pointing mode to achieve fully sampled map

Operation simultaneously with other instruments

1. "Partner mode" with PACS needs to be studied
   - Desirable for simultaneous deep mapping of large areas
   - Implications for internal design of instruments
   - May not be practical with optimum PACS and SPIRE observing strategies

2. Serendipity mode (during slews)
   - Photometer operating (with BSM on or off)

3. Other modes TBC