



SPIRE/PACS Parallel Mode

Herschel Observation Planning Workshop

ESAC, 20-21 September 2007

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Definition of Parallel Mode

PMODE is treated as a 4th Herschel instrument

- PACS & SPIRE operates in photometry mode simultaneously, carrying out 5 band large area scanning observations
- **3 SPIRE bands**
 - 250, 350 and 500 μm
- **2 PACS bands**
 - 170 and 70/110 μm

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Parallel Mode operational constraints

- Both SPIRE and PACS cryo coolers have to be recycled, their hold time is ~48 hrs
- PMODE is used during 2x21 hrs observing windows
- No single observation could last longer than 18 hrs
- PACS has to apply a higher science data compression ratio compared to PACS prime operations
 - PACS prime: 4 frames averaged (10 Hz) on-board
 - PMODE: 8 frames averaged (5 Hz) on-board

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Scientific benefits of PMODE

PMODE offers a major mapping efficiency gain or major additional scientific data wrt two separate PACS and SPIRE coverages without significant degradation of instrument performance

BUT CONSIDER TO USE

- Only for programs relaxed in (PACS) sensitivities
- If relative PACS/SPIRE sensitivities fit to the science goal
- If primary science interest requires SPIRE bands
- If mapping area exceeds at least ~ 1 sq degree (typically >10 sq degrees)

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Additional benefits of PMODE



- Operating PACS and SPIRE increases the load on the Helium tank of Herschel by much less than a factor of 2. It is favourable in terms of science per litre of Helium.
- Improved SPIRE/PACS astrometry
- Improved mission planning efficiency (minimize on-target slew times and more efficient instrument cycle)

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Herschel Key Programmes exploring PMODE



- Programmes involving shallow galactic surveys over large area of sky
 - Nearby molecular clouds (e.g. SAG3 GTKPs on star formation)
 - Galactic plane survey (e.g. Hi-Gal OTKP)
- Extragalactic mapping programmes
 - Galaxy evolution probe (HerMES GTKP)
- See poster presentations from ESTEC OTKP workshop

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PMODE Astronomical Observing Template (AOT)



- PMODE AOT is offered with only one observing mode.

Scanning is the most compatible operating mode of PACS and SPIRE. (*Scan maps are the default for PACS to map large areas of the sky. SPIRE always operates in scan mode for large mapping observations.*)

- PMODE is inherited from its PACS/SPIRE 'parent' AOTs

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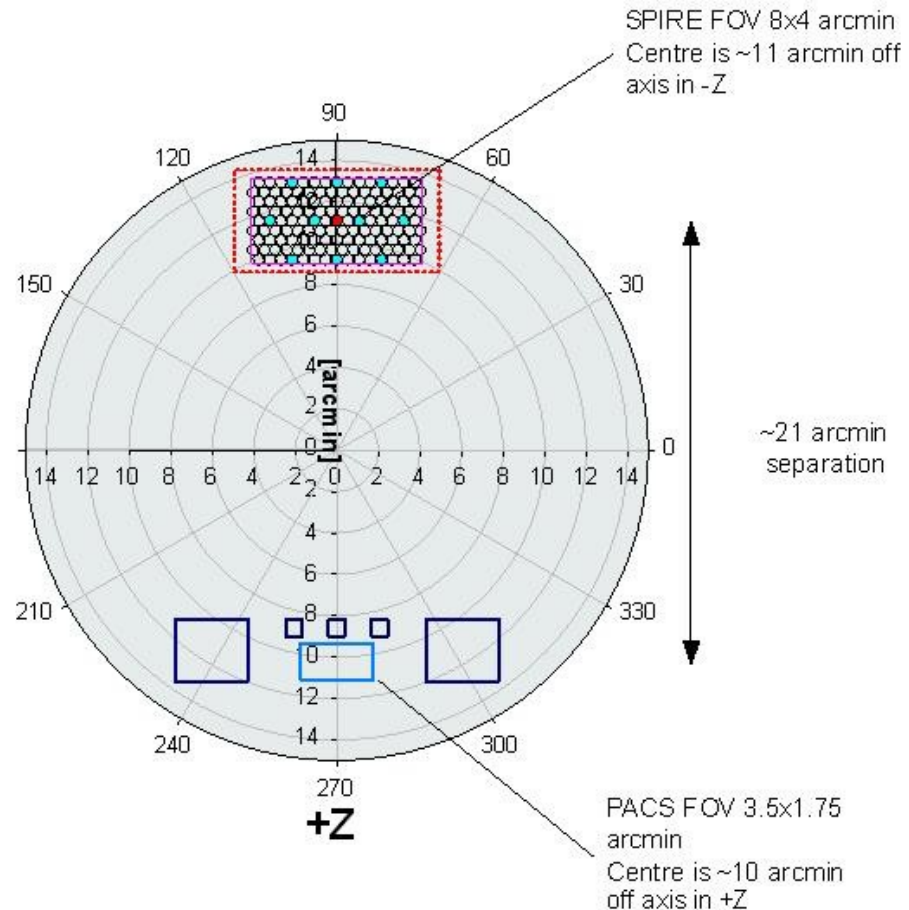
Herschel Focal Plane image

The PACS and SPIRE photometer footprints are separated by ~21 arcmin along the spacecraft Z-axis



Consequence for PMODE:

The area the Herschel boresight paints on the sky has to be larger than the common PACS/SPIRE survey area

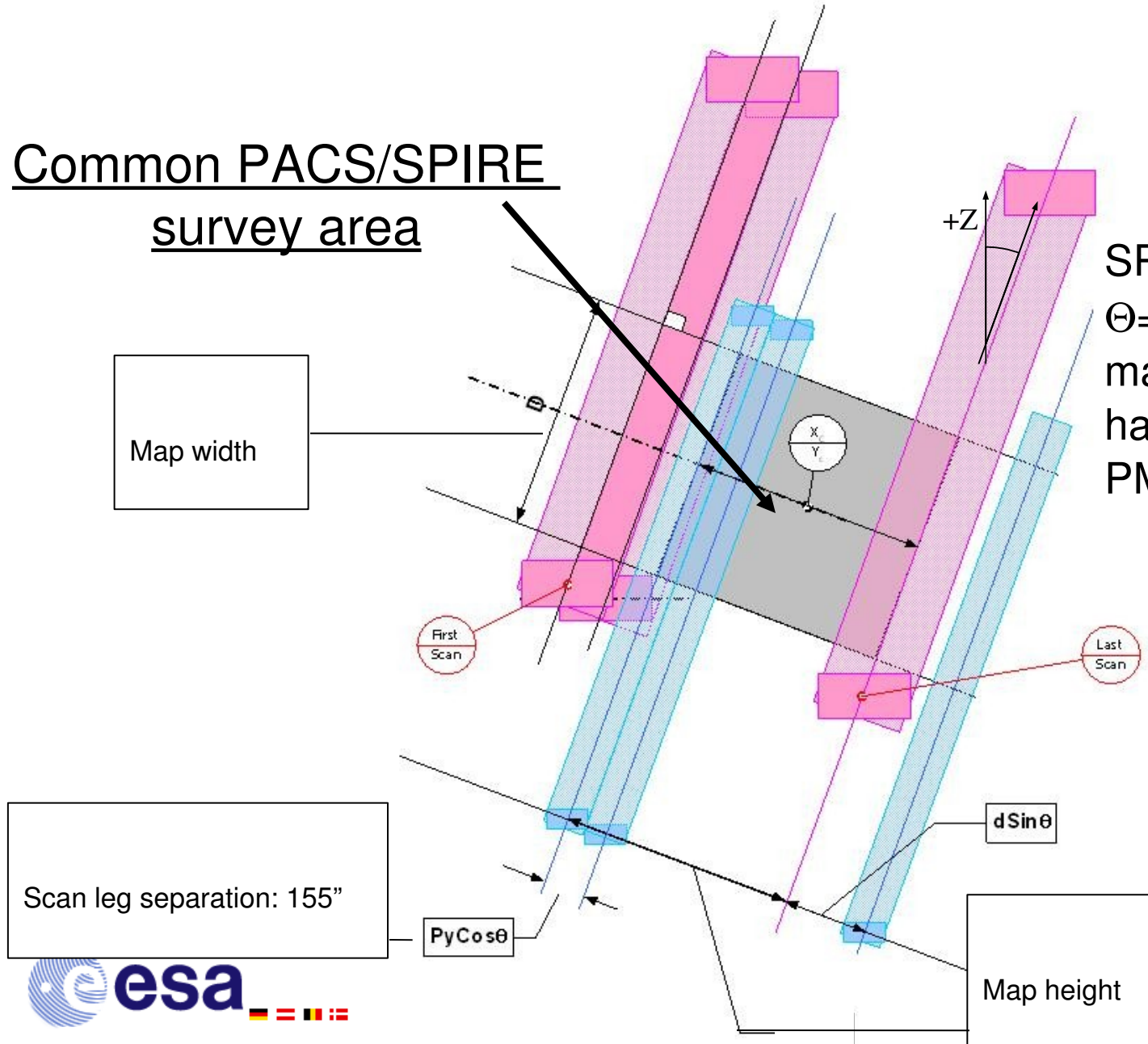


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PMODE Geometry

Common PACS/SPIRE
survey area

SPIRE's magic $\Theta=42.4$ array-to-map angle is hardcoded in the PMODE AOT



Map width

First Scan

Last Scan

Scan leg separation: 155"

$P_y \cos \Theta$

$d \sin \Theta$

Map height

PMODE AOT



SPIRE PACS Parallel Mode

Unique AOR Label:

Target: Cha-III Type: Fixed Single
Position: 12h44m00.00s, -79d53m00.0s

Number of visible stars for the target: 12
Star tracker target: Ra: 11 degrees Dec: 79.883 degrees

PACS Blue channel filter selection

60-85 μm filter
 85-130 μm filter

Scan Speed

Fast
 Slow

Large Map Parameters

Length (arcmin)
Height (arcmin)
Scan Direction

Orientation

Map Orientation
Angle from (degrees)
Angle to (degrees)

PACS blue band

Common PACS/SPIRE survey area

Map orientation constraint

Scan speed

→ 60"/sec

→ 20"/sec

Scan direction

→ Nominal

→ Orthogonal

Observing time, sensitivity and confusion noise estimator

PMODE AOT



THE PACS Parallel Mode Time Estimation Summary

Band (μm)	Point Source 1- σ noise (mJy)	Extended Source 1- σ noise (MJy/sr)
PACS Blue	17.6	19.9
PACS Red	26.8	8.8
SPIRE 250	12.8	2.9
SPIRE 350	17.6	2.1
SPIRE 500	14.9	0.8

Efficiency 0.65
Total time without overheads (s) 8,418
Instrument and observation overheads (s) 2839
Observatory overheads (s) 600
Total time (s) 11857

Confusion noise estimation summary

Note: the predicted confusion noise level is higher than the estimated 1- σ instrument noise level!

Band (μm)	Est. 1- σ Confusion Noise Level for Point Sources (mJy)	Est. 1- σ Confusion Noise Level for Extended Sources (MJy/sr)	Est. 1- σ Confusion Noise Level per Pixel (mJy)
PACS Blue	0.4	1.451	0.6
PACS Red	31.8	31.038	56.0
SPIRE 250	53.8	10.0862	59.4
SPIRE 350	43.7	3.7899	45.9
SPIRE 500	24.2	1.1347	26.7

PACS/SPIRE sensitivities

Confusion noise estimator warning message

Confusion noise estimates

Observing time estimation details

Scan direction
 → Nominal
 → Orthogonal

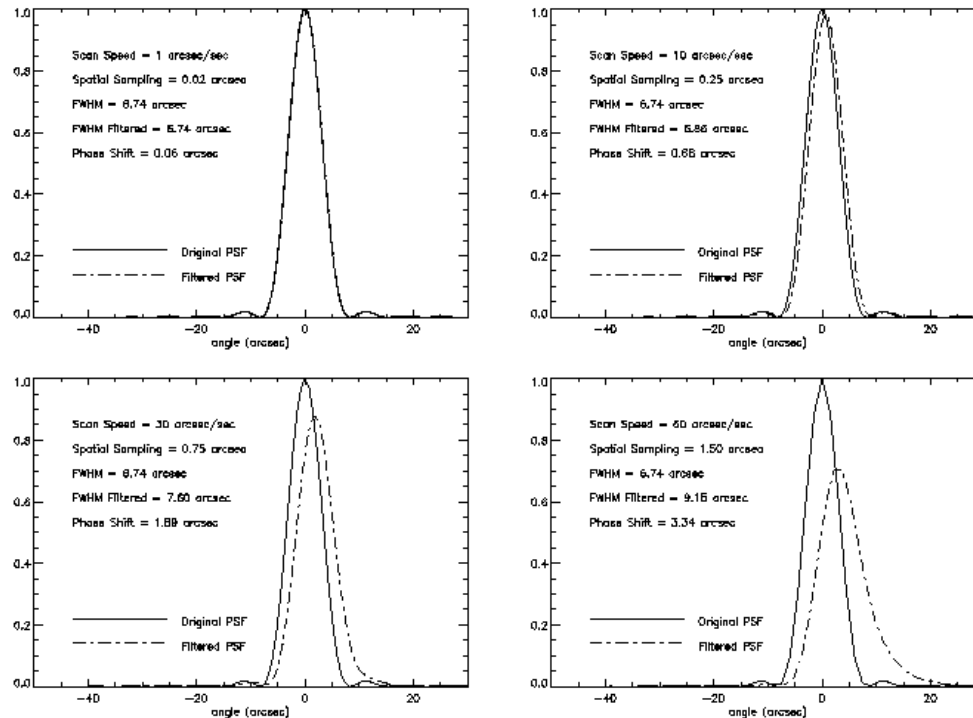
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PMODE AOT particularities

- SPIRE's $\Theta=42.4^\circ$ array-to-map angle is used
- SPIRE's 348" cross-scan step size decreased to 155"
- 5 extra scan legs
- 20 arcmin extra length for scan legs
- Scan speed 60"/sec or 20"/sec (SPIRE 60"/sec or 30"/sec)
- Map repetition not possible within a single AOR
- PACS applies double compression (8 frames averaged)
- PACS PSF degrades at 60"/sec along the scan direction (smearing effect of ~ 60 ms bolometer time constant + on-board data compression)

PACS PSF degradation along the scan direction



Plain line PSF represents the PSF 'on the sky' and the dot-dashed corresponds to the filtered PSF for the optimum NEP bias at 1, 10, 30 and 60 arcsec/sec scan rates

How to create a PACS scan map with PMODE settings?



PACS Photometry

Unique AOR Label: PPhoto-Cham-III-n

Target: Cha III Type: Fixed Single
Position: 12h44m00.00s, -79d53m00.0s

New Target Modify Target Target List...

Number of visible stars for the target: 12
Star tracker target: Ra: 11 degrees Dec: 79.883 degrees

Instrument Settings

Blue channel filter selection

60-85 microns band
 85-130 microns band

Source flux estimates and gain settings
Source Flux Estimates

Observing Mode Settings

Source type and mapping mode settings
Set the Observing Modes

Repetition factor
Repetition 1

To control the absolute sensitivity consider to adjust the number of repetitions.

Observation Est... Add Comments... Visibility...

OK Cancel Help

Observing Modes

Observing Mode Settings

Choose one of the modes below.

Small-source photometry Chopped raster Scan map
None selected Point-source photometry

Observing mode parameters

Scan Map

Select the speed High

Scan leg lengths (arcminutes) 300

Homogeneous coverage Yes

Cross-scan step (arcseconds) 1.0

Square map No

Number of scan legs 39

Map orientation

Orientation angle reference frame Any with sky constraint

Orientation angle (degree) 42.4

Orientation constraint

Angle from (degrees) 19.0

Angle to (degrees) 39.0

OK Cancel

PMODE AOT sensitivities



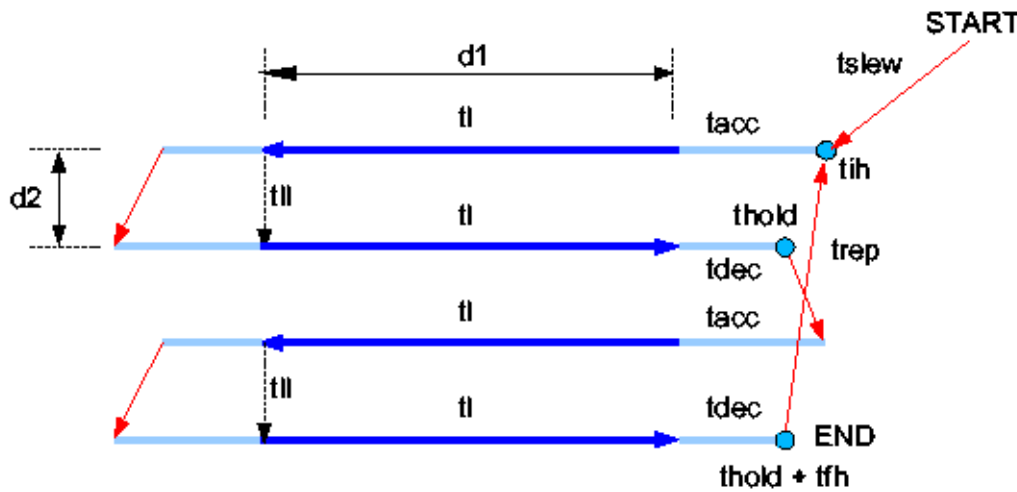
PMODE 1- σ sensitivities for a single coverage (in mJy)

Scan speed	60"/sec	20"/sec
PACS 60-85 μm	17.6	10.2
PACS 85-130 μm	18.9	10.9
PACS 130-210 μm	26.8	15.5
SPIRE 250 μm	12.8	7.4
SPIRE 350 μm	17.6	10.2
SPIRE 500 μm	14.9	8.6

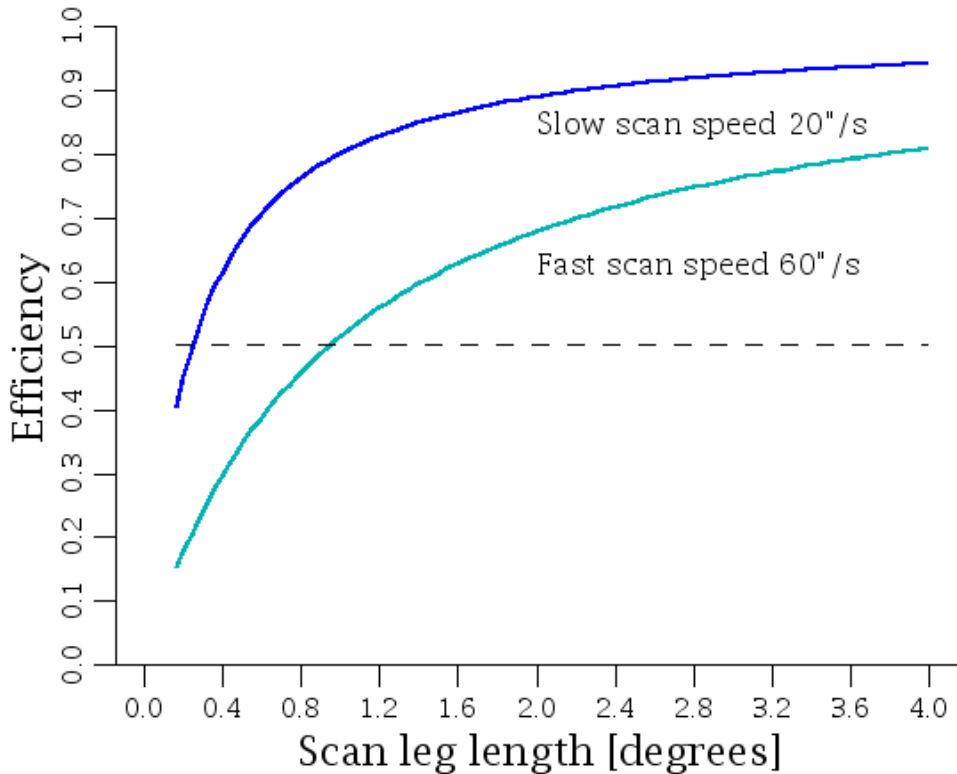
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AOT scanning overheads



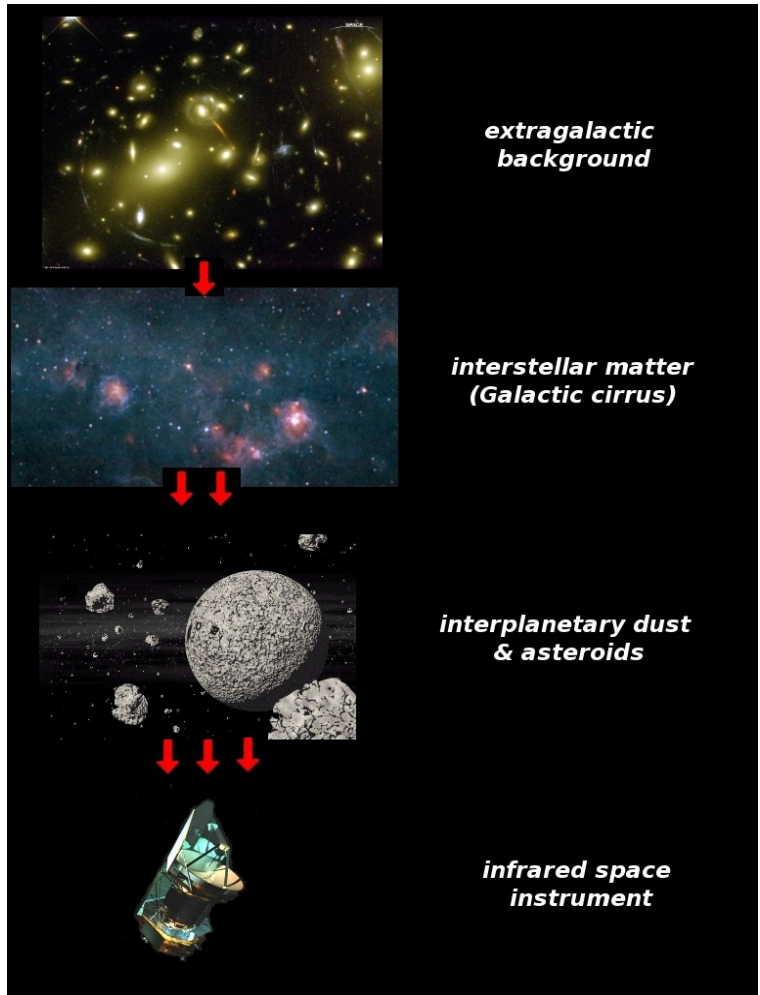
Scan leg efficiencies



Overhead per scan leg

- Slow: 45 sec
- Fast: 57 sec

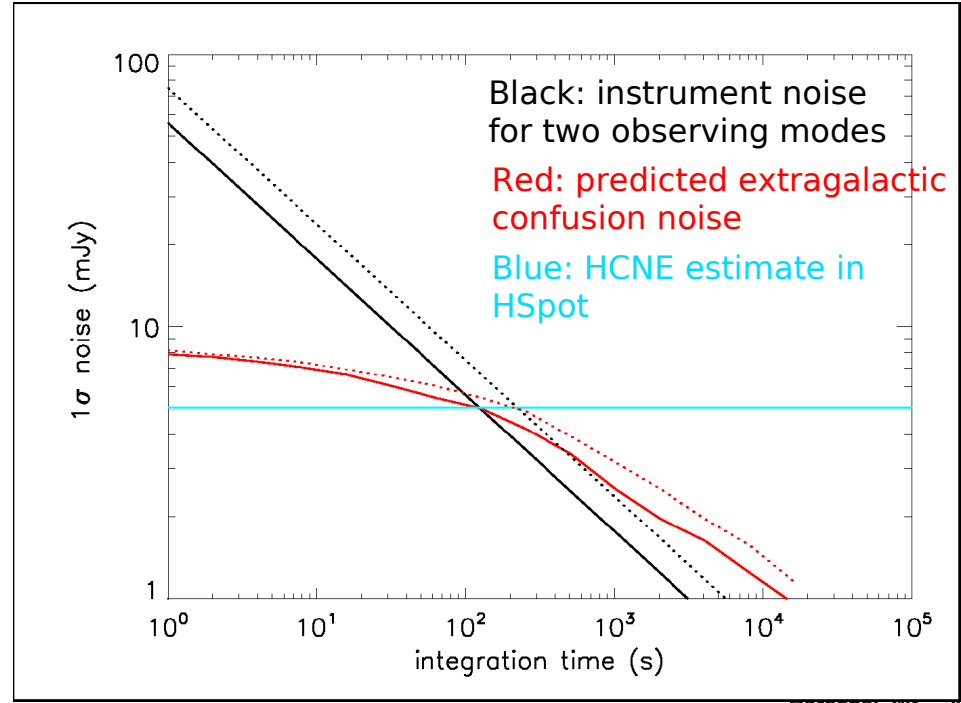
The Herschel Confusion Noise Estimator (HCNE)



Provides estimates for the confusion noise (i.e. uncertainty of flux determination due to the sky background) for the PACS and SPIRE photometric bands.

The confusion noise is derived considering the two main astrophysical components in the far-infrared: the Galactic cirrus and the cosmic infrared background.

For a low cirrus position (where the CIB dominates the background) HCNE will provide noise estimates matching the blue limit (**see the last release note!**)

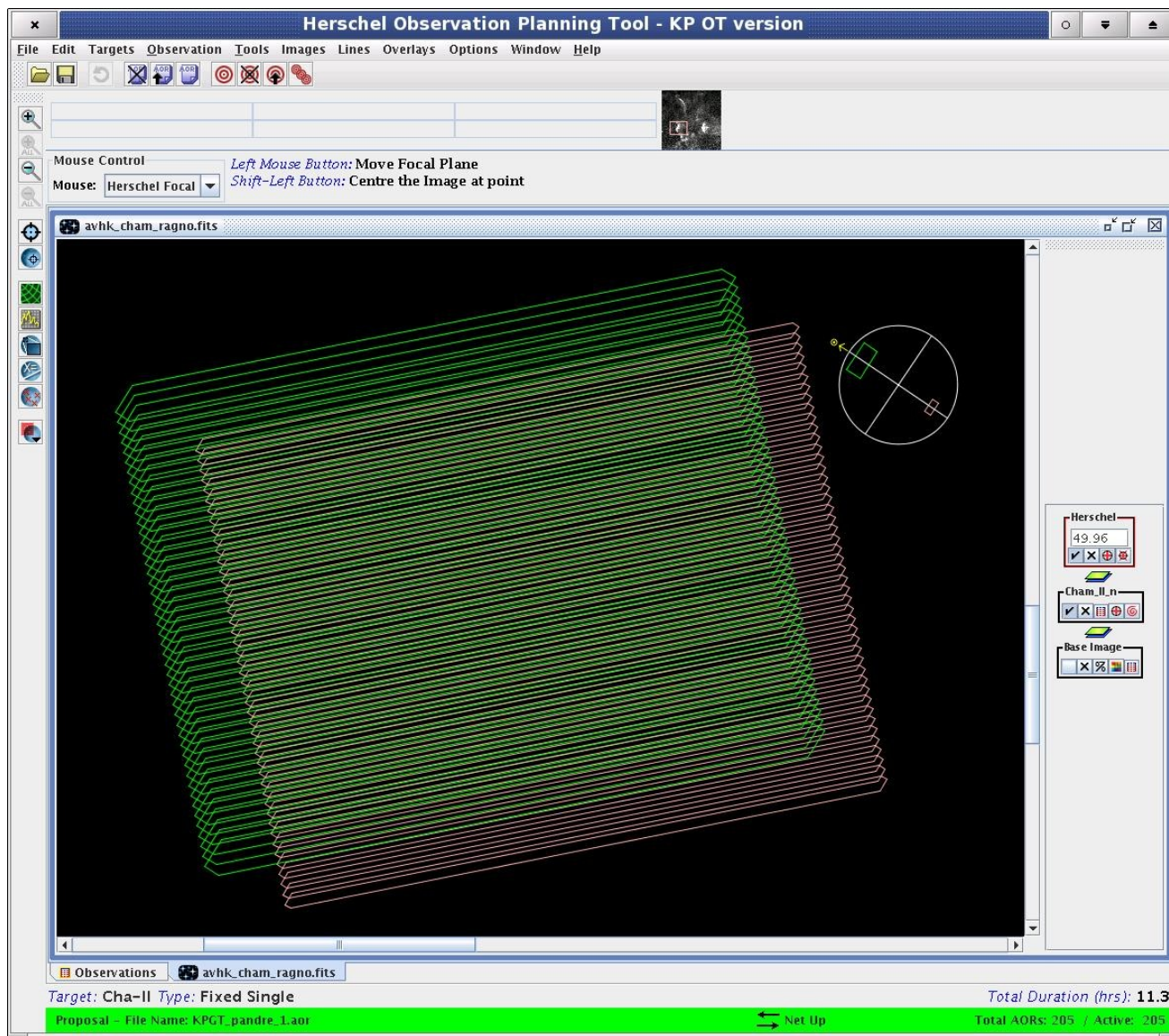


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- HCNE is developed by Csaba Kiss (Konkoly Observatory, Budapest)
- The HCNE server is hosted at IPAC and maintained by NHSC



PMODE footprint on the sky



125'x100'
common survey
area

~2.8 hrs in fast
(60"/s) scan
speed

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Typical example: star forming complex Cha I-II-II & Musca (GTKP)



Herschel Planning Tool

File Edit Targets Observation Tools Images Lines Overlays Options Window Help

Mouse Control
Mouse: Any Shift-Left Button: Centre the Image at point

avhk_cham_ragno.fits

Base Image

Observations avhk_cham_ragno.fits

Total Duration (hrs): 22.6
Proposal - File Name: chamaeleon.aor
Net Up
Total AORs: 7 / Active: 7

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20 Sep 2007

VG #19

l.esac.esa.int/

Typical example: star forming complex Cha I-II-II & Musca (GTKP)



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Herschel Planning Tool

File Edit Targets Observation Tools Images Lines Overlays Options Window Help

Mouse Control
Mouse: Any Shift-Left Button: Centre the Image at point

avhk_cham_ragno.fits

SPParallel-000
SPParallel-000
Base Image

Observations avhk_cham_ragno.fits

Target: Cha III Type: Fixed Single Total Duration (hrs): 22.6

Proposal - File Name: chamaeleon.aor Net Up Total AORs: 7 / Active: 7



20 Sep 2007

VG #21

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Typical example: star forming complex Cha I-II-II & Musca (GTKP)



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Herschel Planning Tool

File Edit Targets Observation Tools Images Lines Overlays Options Window Help

Mouse Control
Mouse: Any Shift-Left Button: Centre the image at point

avhk_cham_ragno.fits

SPParallel-000
SPParallel-000
SPParallel-000
Base Image

Observations avhk_cham_ragno.fits

Target: Cha II - Ortho Type: Fixed Single

Proposal - File Name: chamaeleon.aor

Total Duration (hrs): 22.6

Total AORs: 7 / Active: 7

Net Up



20 Sep 2007

VG #22

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Typical example: star forming complex Cha I-II-II & Musca (GTKP)



The screenshot displays the Herschel Planning Tool interface. The main window shows a grayscale astronomical image of the Cha I-II-II & Musca star-forming complex. Three observation swaths are overlaid on the image, each consisting of multiple parallel scan lines. The swaths are color-coded: the top one is green, the bottom-left one is red, and the bottom-right one is blue. The interface includes a menu bar (File, Edit, Targets, Observation, Tools, Images, Lines, Overlays, Options, Window, Help), a toolbar with various icons, and a 'Mouse Control' section with a dropdown menu set to 'Any' and a note 'Shift-Left Button: Centre the Image at point'. A status bar at the bottom provides details: 'Observations' tab, 'Target: Musca Type: Fixed Single', 'Proposal - File Name: chamaeleon.aor', 'Total Duration (hrs): 22.6', and 'Total AORS: 7 / Active: 7'. A 'Net Up' button is also visible.

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VG #23

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PMODE known bugs in HSpot v3.0.7



In the Time Estimation Details the times sometimes do not agree with those in the Time Estimation Summary (minor inconvenience category).

The confusion noise estimation summary tables in HSpot contain swapped values for the "Confusion level for point sources" and "Confusion level per pixel" columns, i.e. the values displayed in the first and third columns are exchanged.

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Most important points to note for PMODE



- SPIRE has to be considered as the primary instrument
- PACS data quality is somewhat degraded due to enhanced compression and high scan speed
- For programmes relaxed in (PACS) sensitivity
- Optimize map dimensions for slewing overheads
- Combine nominal+orthogonal coverages for de-stripping (1/f noise) and a better preservation of spatial resolution

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[SPIRE PACS Parallel Mode Observers' Manual:](http://herschel.esac.esa.int/Docs/PMODE/html/parallel_om.html)

http://herschel.esac.esa.int/Docs/PMODE/html/parallel_om.html