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*NASA Herschel  
Science Center*



# PACS Photometer AORs

How to Prepare an Observation with HSpot:  
2 Science Use Cases

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## Quick Introduction to HSPOT for PACS Photometry – I: Define a Target and Target List

Target      Target List

1) Enter target (fixed or moving)  
2) Check target visibility  
3) Check background

| Target           | Position                  | Equinox          | Type          |
|------------------|---------------------------|------------------|---------------|
| MS1              | 13h29m52.37s, +47d11m4... | Equatorial J2000 | Fixed Single  |
| Pluto Barycenter | 9                         |                  | Moving Single |
| My_field         | 3h58m00.00s, +60d00m00... | Equatorial J2000 | Fixed Single  |

Target: My\_field Type: Fixed Single

Total Duration (hrs): 0.0

## Quick Introduction to HSPOT for PACS Photometry – II: Define PACS Instrument Settings

Unique AOR Label: PPhoto-GP\_SF

Target information: *Target: Galactic\_field\_59 Type: Fixed Single*  
*Position: 19h45m00.00s,+24d18m00.0s*

Number of visible stars for the target: 25  
Star tracker target: Ra: 116.25 degrees Dec:-24.3 degrees

Instrument Settings

Blue channel filter selection

- 60–85 microns band
- 85–130 microns band

Source flux estimates and gain settings

Source Flux Estimates

Optional: Enter source estimated data for S/N calculation

Warning: Specifying a very bright source will induce a change in gain settings. Please check applicable flux limits in the HSpot User's Guide

| Band (microns) | Point source flux density (mJy) | Extended source surface brightness (MJy/sr) |
|----------------|---------------------------------|---|
| 60–85          | Blue band: 300.0                | Blue band: 20.0                             |
| 130–210        | Red band: 100.0                 | Red band: 40.0                              |

**Warning:** HSpot automatically switches to the low-gain setting if the source estimate exceeds the saturation limits.  
**Low-gain setting reduces sensitivity.**  
**Saturation limits are very conservative**

## Quick Introduction to HSPOT for PACS Photometry – III: Check AOR Performance Estimate

**Instrument performance summary**

| Band (μm) | Point Sour... Flux Density (mJy) | Point Sour... S/N | Averaged... 1-σ noise (mJy) | Central ar... 1-σ noise (mJy) | Extended... Surface Brightness (MJy/sr) | Extended... S/N | Extended... 1-σ noise (MJy/sr) |
|-----------|----------------------------------|-------------------|-----------------------------|-------------------------------|---|-----------------|--------------------------------|
| 60-85     | 500.00                           | 42.18             | 11.85                       | 2.79                          | 20.00                                   | 1.69            | 11.82                          |
| 130-210   | 200.00                           | 7.54              | 26.54                       | 6.25                          | 30.00                                   | 5.74            | 5.23                           |

**Time Estimation Breakdown**

|   |      |
|---|------|
| On-source time (s)                      | 750  |
| Calibration time (s)                    | 59   |
| Instrument and observation overhead (s) | 249  |
| Observatory overhead (s)                | 180  |
| Total time (s)                          | 1179 |

**Confusion noise estimation summary**

| 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) |
|-----------|--|--|--|
| 60-85     | 0.26   | 0.6762   | 0.17   |
| 130-210   | 7.85   | 4.3499   | 4.45   |

**Annotations:**

- Sensitivity estimates: values for extended emission are conservatively underestimated by ~30%
- Details of AOR execution time
- more details here
- Confusion noise estimates

### Scan Map

### 2 AOTs for the PACS photometer

Observing Modes

Observing Mode Settings  
Choose one of the modes below.

Small-source photometry Chopped raster **Scan map**

Observing mode parameters  
Scan Map

PACS Photometry

Unique AOR Label: PPhoto-GP\_SF

Observing Modes

Observing Mode Settings  
Choose one of the modes below.

None selected **Point-source photometry**

Scan Map is the most efficient observing mode !

Instrument Settings

Blue channel filter selection

64-85 microns band  
 85-130 microns band

Source flux estimates and  
Source Flux Estimat

Cancel OK

Observing Mode Settings

Repetition factor  
Repetition 1

To control the absolute sensitivity consider adjusting the number of repetitions.

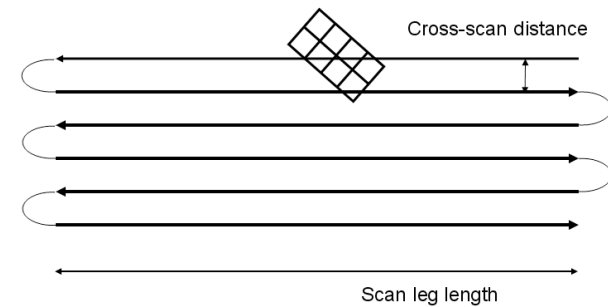
Set the Observing Modes

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

Cancel OK

## Scan-map AOT

Scan maps are performed by slewing at constant speed along parallel lines



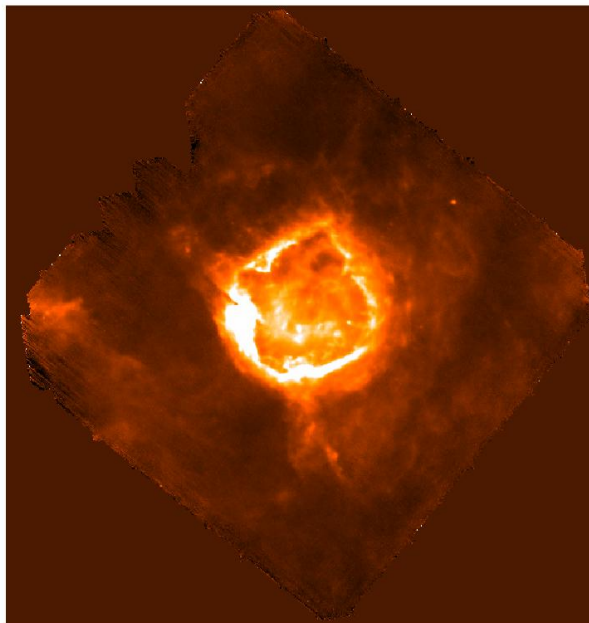
### Special case: Mini-scan map

- Scan along the diagonal of the array, i.e. at 70° and/or 110° in array coordinates
- 20''/s scan speed
- Concatenate X-scan map at 110° or 70°
- Allows various kinds of mapmaking techniques, and provide higher quality photometry and better spatial characterization of the near source vicinity
- NO homogeneous coverage, and NO square map
- 8 - 10 scan legs with cross-scan distance of 4''
- For shallow observations: less legs (but even number to minimize satellite movement) with larger cross-scan distances or skip cross-scan direction
- Scan leg length from 2'' to 4''
- 3'' length: optimal usage of constant scan speed of 20''/s, but during idle-positions the source is outside the array
- 2'' length: Source is always on-array, but acceleration/deceleration of source on array might require more elaborated processing

## Scan Map AOT - We consider 2 science case examples

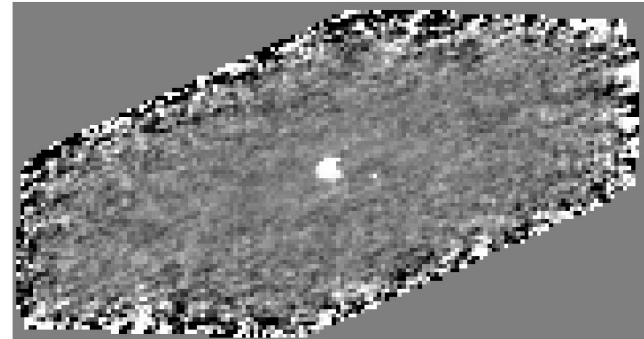
### Galactic star formation region: SH104 (scan map)

Proposal = SDP\_fmotte\_3  
Ra = 304.4159 deg  
Dec = 36.7789 deg



### Point source: calibration star delta Dra (Mini-scan map)

Proposal = Calibration\_rppacs\_5  
Ra = 288.1277 deg  
Dec = 67.6631



## How do we choose the settings in these 2 cases ?

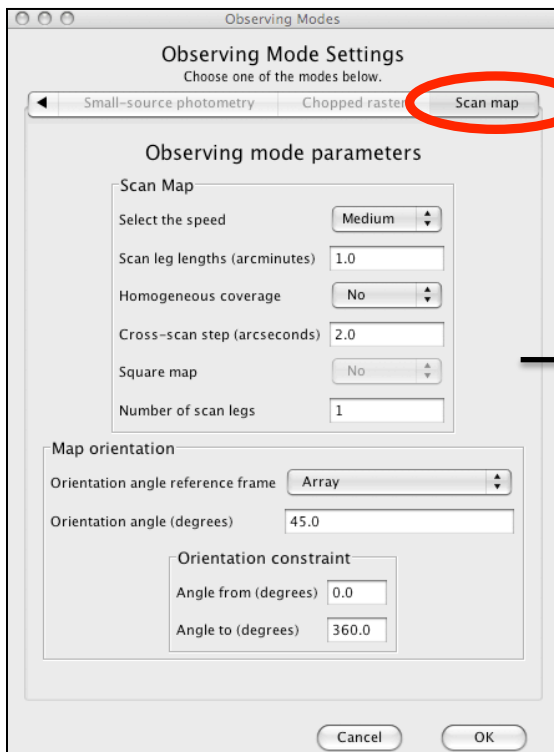
Observing mode



Settings



Values ?



- Filter
- Scan Speed
- Scan Leg Length
- Cross-scan Distance
- Number of Scan Legs
- Square Map
- Homogeneous Coverage
- Orientation Reference Frame
- Orientation Angle
- Orientation Constraint
- Repetition Factor

What are the  
best choices of  
parameter  
values  
???





## Scan Map AOT Setting: Scan Speed

### Options:

- Medium (20"/s) for optimal modulation of the signal from the telescope motion (celestial signal between the 1/f knee and the post-detection low-pass frequency)
- Fast (60"/s), **for large maps only**, at the expense of degraded PSFs (**10% - 60%** elongation in scan direction, for the **red** and **blue** channel, respectively) and longer overheads due to longer turnover time

### Galactic Star Formation Region: SH104

- Scan speed: 20"/s

(Note: it could have been 60"/s if PSF quality was not critical and region to map was larger than 20')

### Calibration star: Delta Dra

- Scan speed: 20"/s



## Scan Map AOT Setting: Map Size Parameters

(1) Scan Leg Length, 2) Cross-scan distance, 3) Number of scan legs, 4) Square map, 5) Homogeneous coverage)

### Options:

- Scan leg length: sets dimension of one map side, has to be  $< 20^\circ$
- Cross-scan distance  $< 105''$  ensures overlapping between scan legs for all array-to-map angles (in sky coordinates). Note: cross-scan distance of  $51''$  (~sub-array size) gives relatively flat exposure maps in Sky coordinates, whatever the array-to-map angle
- Square Map makes observation scheduling easier (number of scan legs is set automatically)
- Recommended use of Homogeneous Coverage (cross-scan distance is set automatically)

### Galactic Star Formation Region: SH104

- Scan length: 20 arcmin
- Cross-scan distance:  $2''$  (set automatically)
- Square map: 1 scan leg (set automatically)
- Homogeneous coverage
- Cross-scans (extended emission)

### Calibration star: Delta Dra

- Scan length:  $4'$
- Cross-scan distance:  $4''$
- NO square map: 8 scan legs (Note: it could be less for shallow observations)
- NO homogeneous coverage



## Scan Map AOT Setting: Map Orientation Parameters

### Options:

- All scan directions are possible in array or sky reference frame, with optional constraints
- Orientation constraints translates into scheduling constraints, hence in observing time penalties
- Avoid scanning at array angles of 0° and 90° because of empty inter-module gap
- If scan maps in Sky coordinates without array constraints, the map coverage depends on the exact observation date, and there is a risk that the array-to-map angle is 0° or 90°. Check the AOR overlay on image at given visibility windows

### Galactic Star Formation Region: SH104

- Array reference frame
- Array-map angle : 45°
- Cross-scan angle : 135° (spare 2 minutes slew time)

### Calibration star: Delta Dra

- Array reference frame
- Array-map angle : 117°
- Cross-scan angle : 63° (provides better characterization of source proximity)



## Scan Map AOT Setting: Repetition Factor

### Options:

- Sets the sensitivity of the observation once the other parameters are set
- If repetition factor  $>1$ , it is recommended to use an even number of scan legs to minimize satellite slew overheads

### Galactic Star Formation Region: SH104

- Repetition Factor : 1

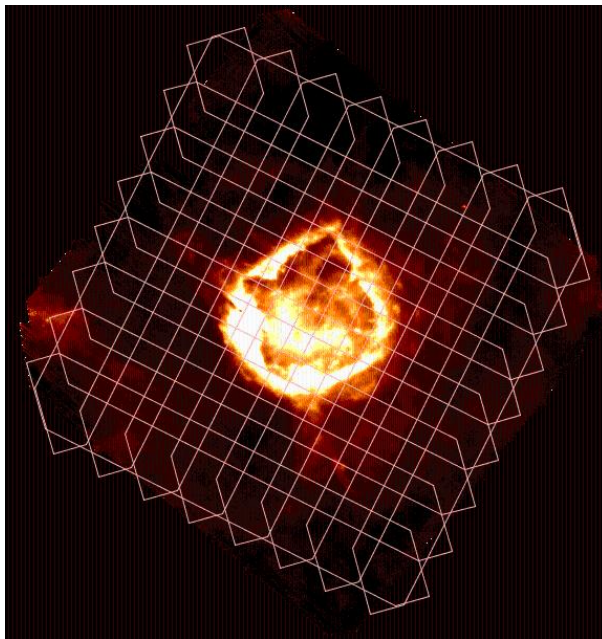
(Note: if RepFactor  $> 1$  and scan at  $60''/s$ , be aware of much longer execution time due to longer turnover intervals between scan legs)

### Calibration star: Delta Dra

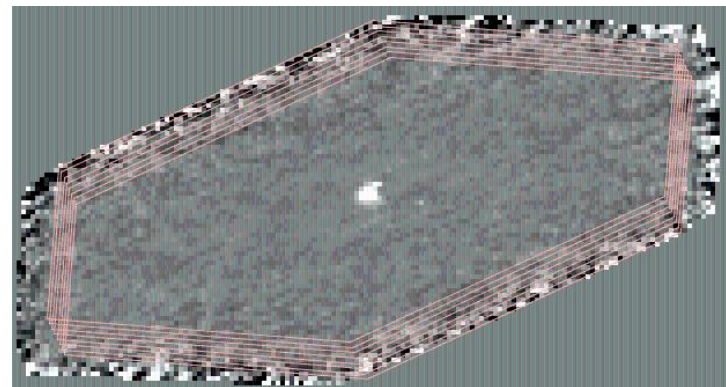
- Repetition Factor : 1

... and this is how your AORs would look like

**Galactic star formation region: SH104  
(scan map)**



**Point source: calibration star delta Dra  
(Mini-scan map)**





## Tips and Tricks

### For deep scan maps and best PSF reconstruction:

- Instead of multiple repeats at the same location, one should dither the entire map by shifting slightly the center and by concatenating pairs of scan/X-scan AORs
- Add follow-on constraints to pairs of scan/X-scan AORs, i.e. repeat scan/X-scan at different epochs to allow the scan direction to rotate, assuming the array reference frame (but it costs 600s extra overheads)

### Scenarios that give same sensitivity in final map:

- 1 Scan at 20'' /s versus 3 Scans at 60'' /s :

AOR execution time is significantly higher in case of fast scan due to longer turnover times between scan legs. It is prohibitive for small maps

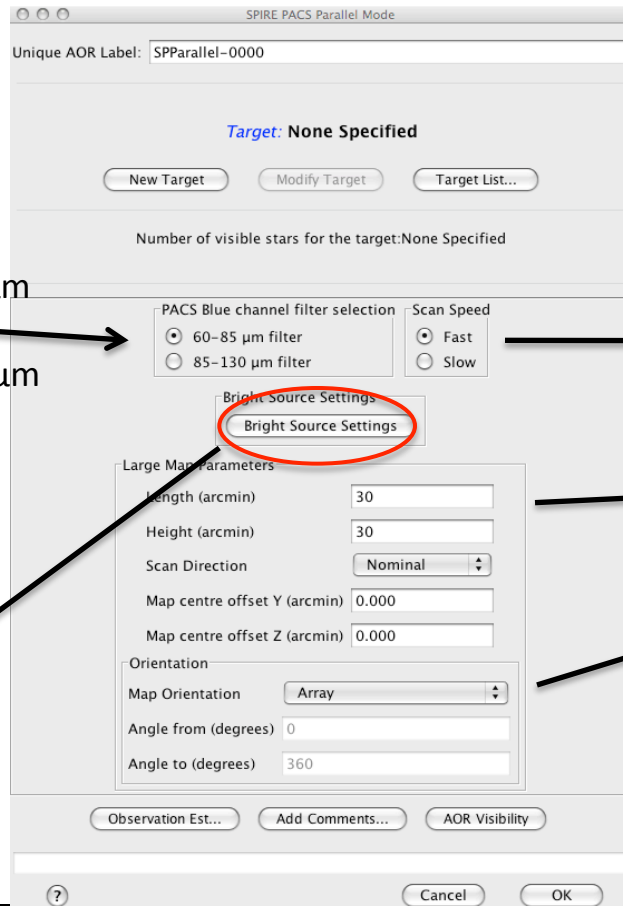
$\text{overhead}_{60''/s} \gg \text{overhead}_{20''/s}$

- 1 fine Scan (short cross-scan distance) versus 3 loose Scans (larger cross-scan distance) while covering the same area (it requires to un-tick homogeneous coverage):

AOR execution time is similar, but fine scanning gives more homogeneous coverage

## PACS/SPIRE Parallel Mode

Hspot Menu → Observations → PACS SPIRE Parallel Mode



70 and 160 μm  
OR  
100 and 160 μm

This is a special observing mode that is intended for **large area photometric mapping** using both PACS and SPIRE simultaneously

Scan speed

“Length” and “Height” set size of the area to map

Direction of scan legs (“Array” or “Sky”)

Set gain (“low” or “high” – default is high)



## Pros and Cons of PACS/SPIRE Parallel Mode

### Pros

- Simultaneous observations in five bands are made possible without significant degradation in instrument performance
- Very efficient for mapping large areas (> 1 deg)
- No evident degradation of SPIRE performance between Parallel Mode and SPIRE-only observations
- More accurate relative PACS/SPIRE astrometry
- Very favorable in terms of science per amount of helium

### Cons

- Due to the large offset of the fields of views of SPIRE and PACS (21 arcmin), this mode is very inefficient for small maps : 45 minutes \*minimum\* execution time for 1 repetition!
- Given that PACS and SPIRE integration times are identical, sensitivities across the bands and between the instruments are different
- if scanning at 60"/s, PACS additional data averaging in blue band (8 by 8 frames instead of 4 by 4) causes PSF elongation
- If scanning at 60"/s, sources in SPIRE bands can appear as glitches, and be mistakenly be corrected for by deglitching algorithms





## Documentation:

- Hspot User's Guide:  
<http://herschel.esac.esa.int/Docs/HSPOT/html/hspot-help.html>
- PACS Observer's Manual:  
[http://herschel.esac.esa.int/Docs/PACS/html/pacs\\_om.html](http://herschel.esac.esa.int/Docs/PACS/html/pacs_om.html)
- Herschel's Observer's Manual:  
<http://herschel.esac.esa.int/Docs/Herschel/html/observatory.html>
- AOT Release Note:  
<http://herschel.esac.esa.int/AOTsReleaseStatus.shtml>
- Herschel Reserved Observation Search Tool:  
<http://herschel.esac.esa.int/Tools.shtml#HROST>