SPIRE/PACS Parallel Mode

Herschel Observation Planning Workshop

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Roland Vavrek, Sarah Leeks
Herschel Science Centre
European Space Astronomy Centre
Research and Scientific Support Department of ESA

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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

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 ~1sq 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)

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

PMODE Astronomical Observing Template (AOT)

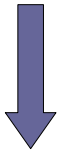
- PMODE AOT is offered with only one observing mode.

  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 is scan mode for large mapping observations.*)

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

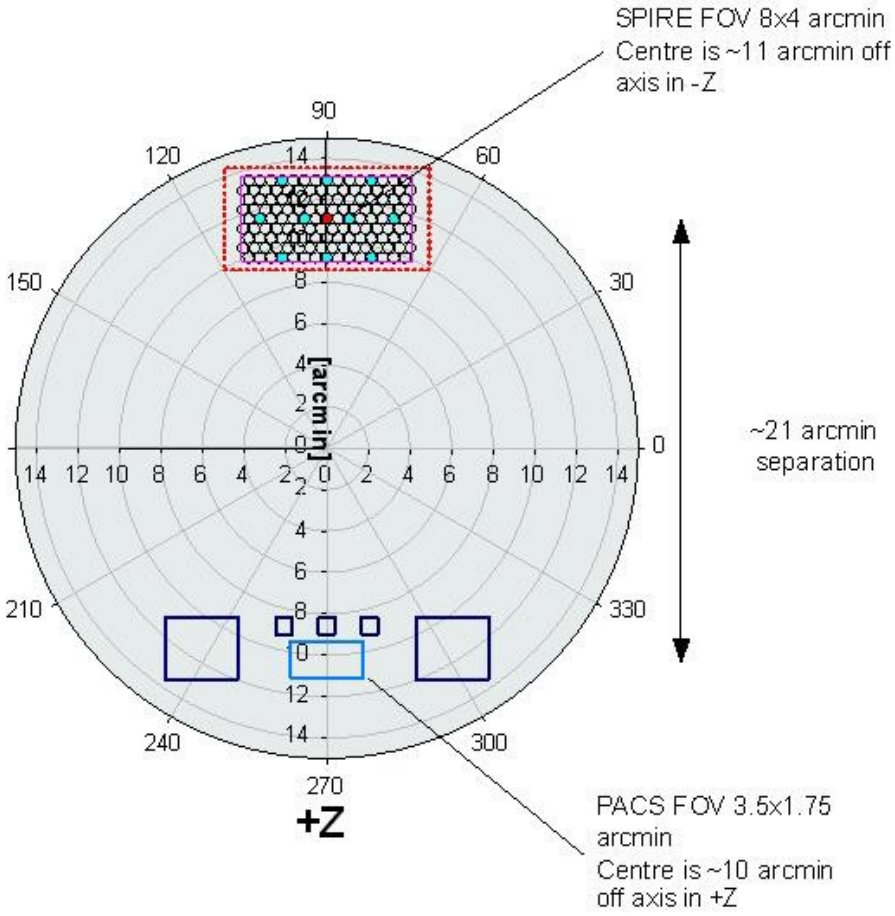
Herschel Focal Plane image

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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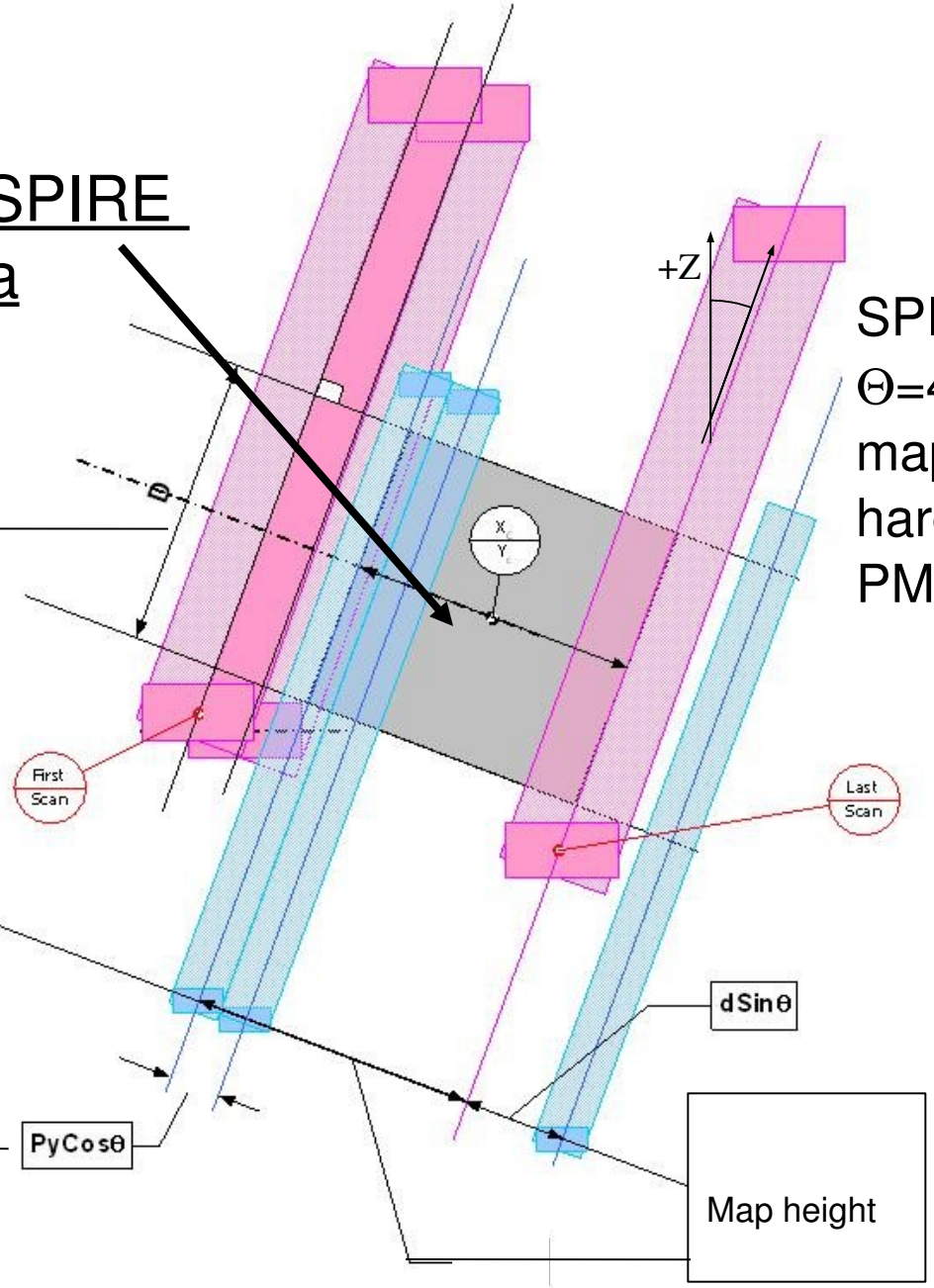
PMODE Geometry

Common PACS/SPIRE survey area



Map width

Scan leg separation: 155”

Map height

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

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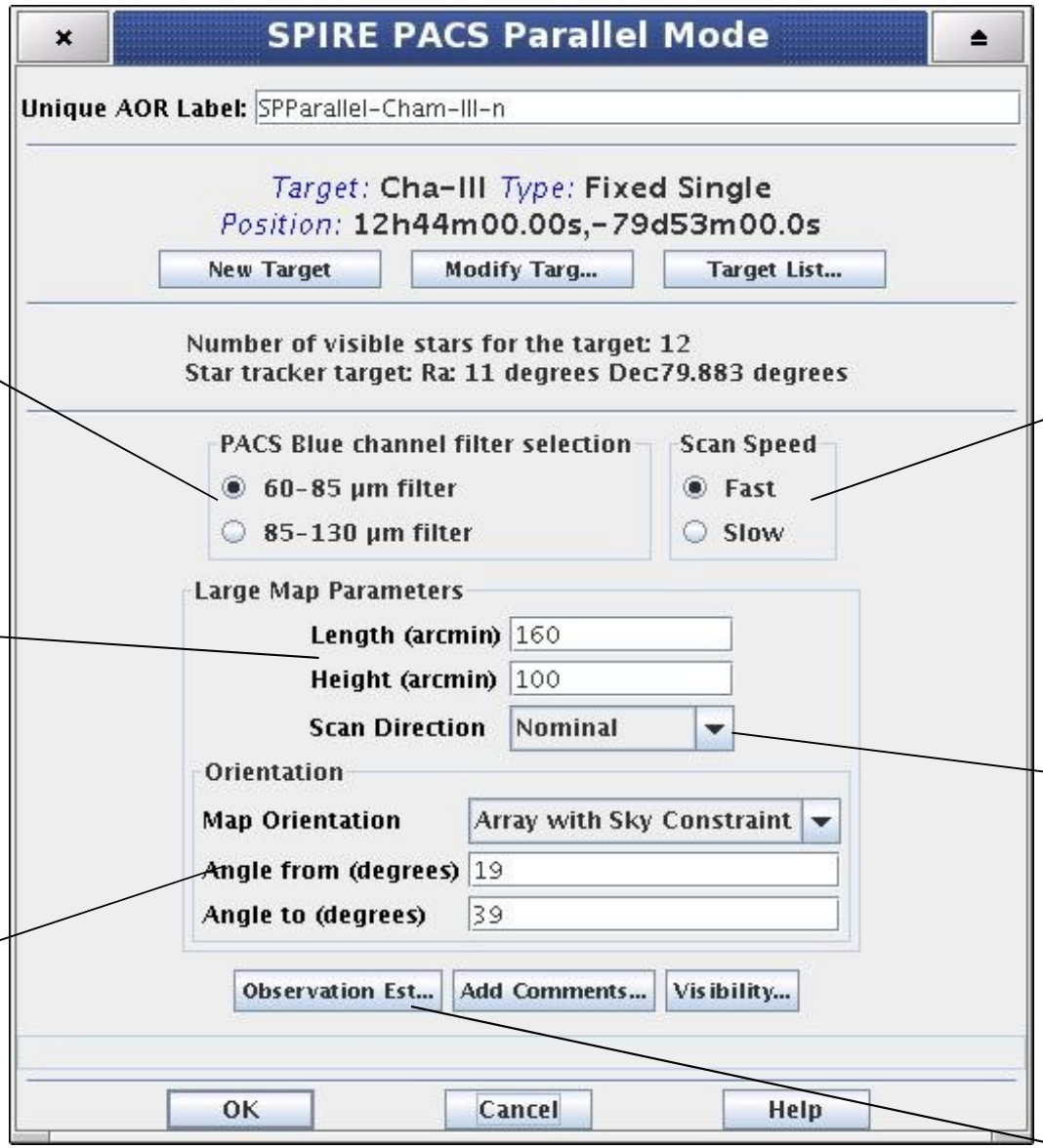
PMODE AOT



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

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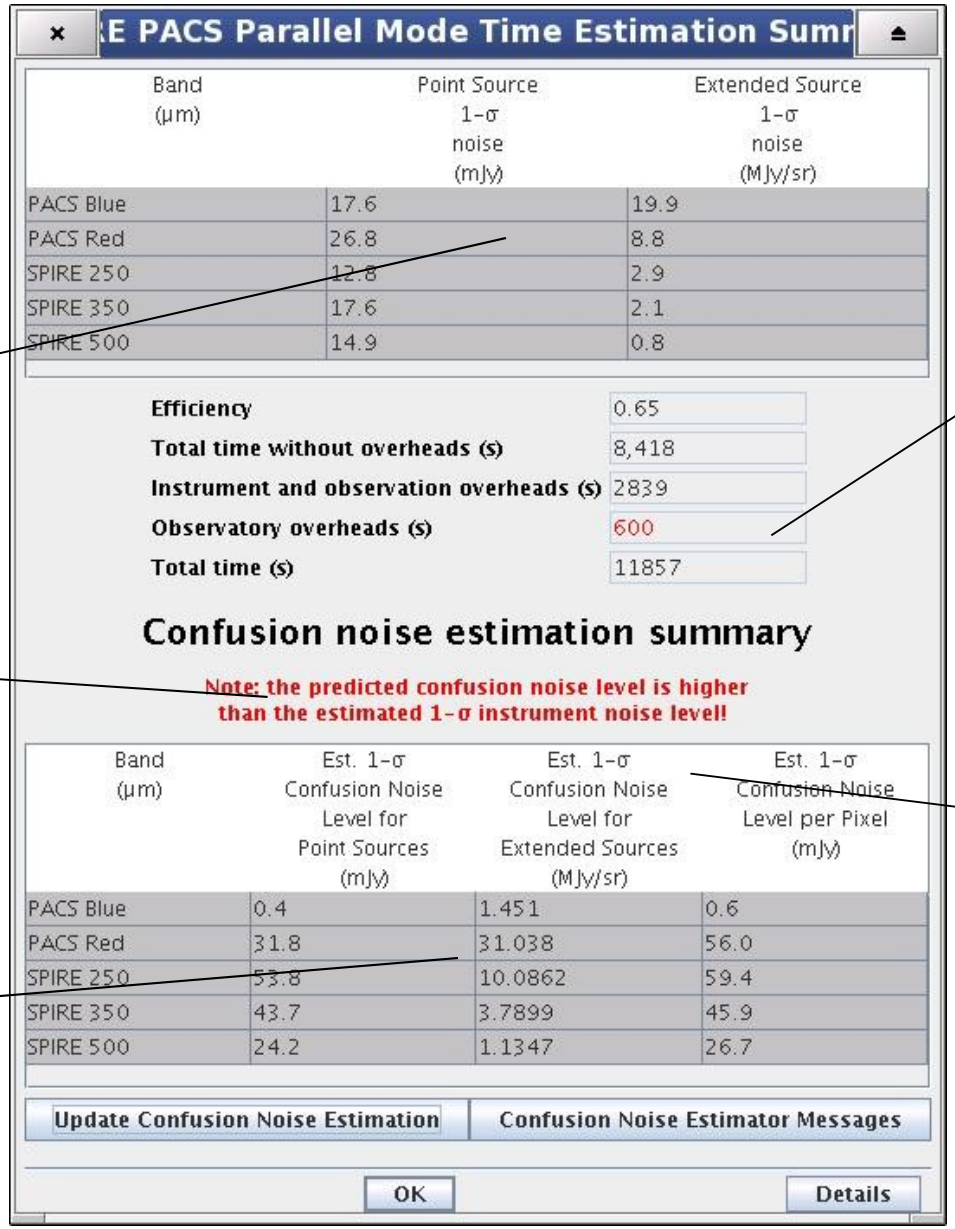
PMODE AOT



PACS/SPIRE sensitivities

Observing time estimation details

Confusion noise estimator warning message

Scan direction

→ Nominal

→ Orthogonal

Confusion noise estimates

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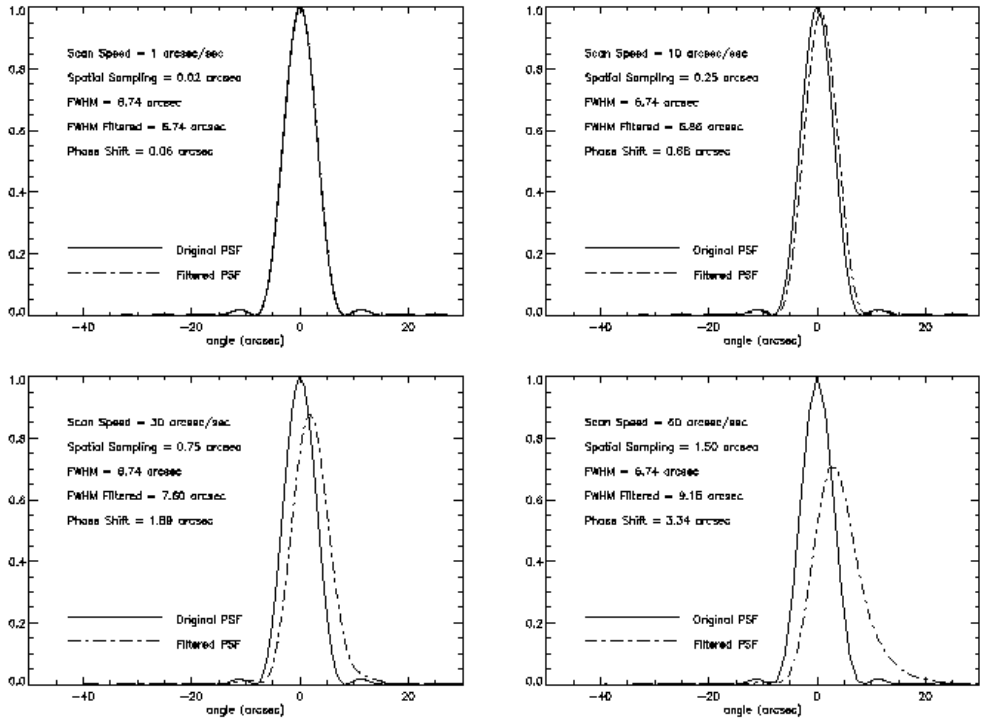
PMODE AOT particularities

- SPIRE's Θ=42.4° 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

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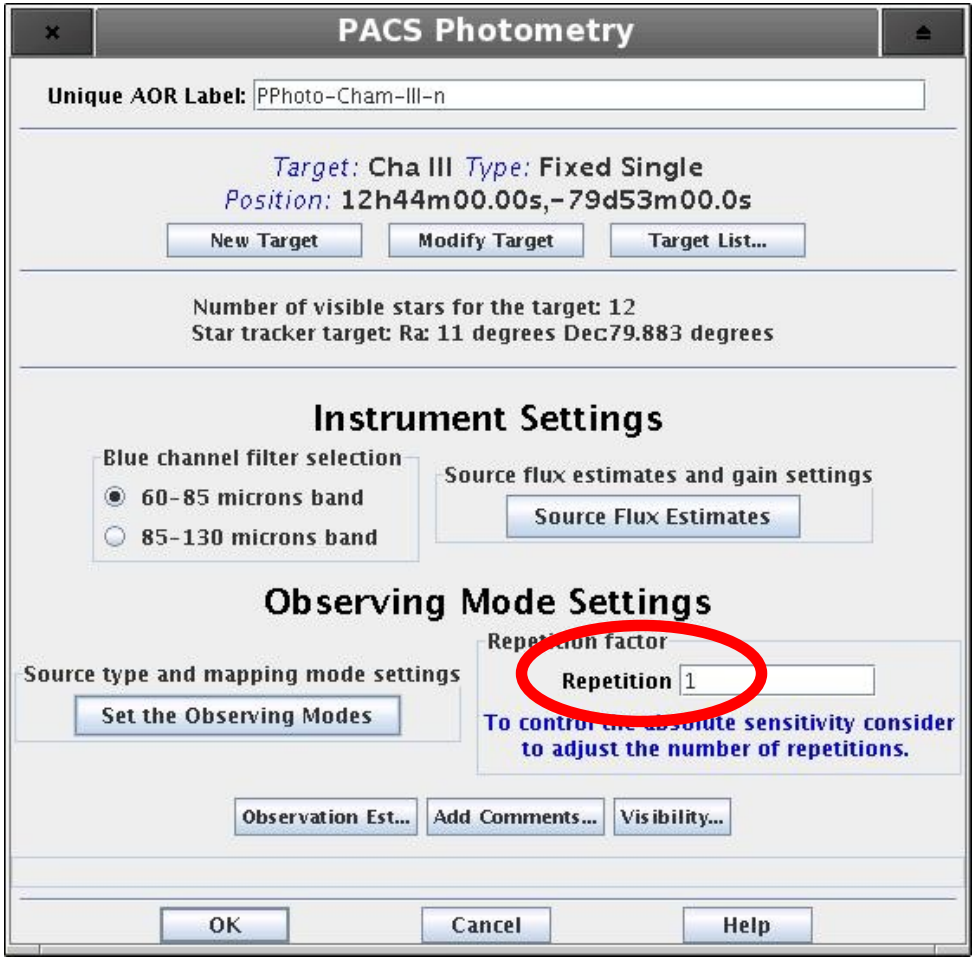
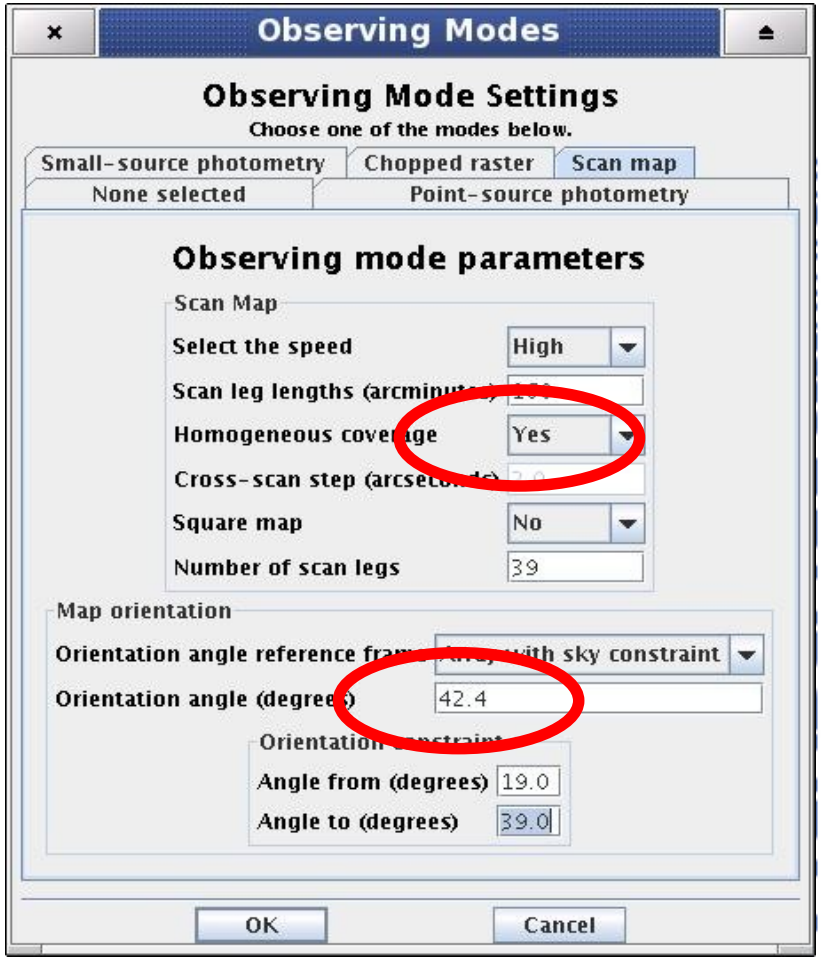
How to create a PACS scan map with PMODE settings?





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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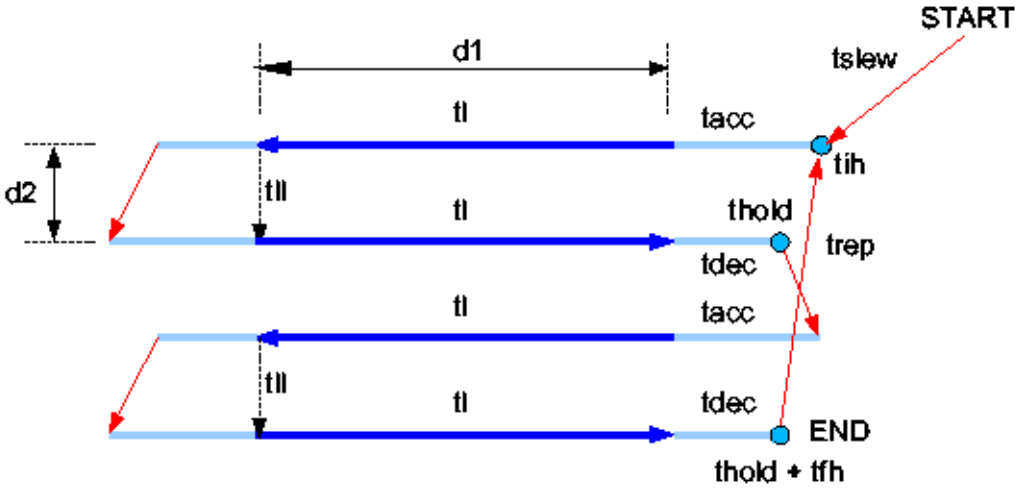
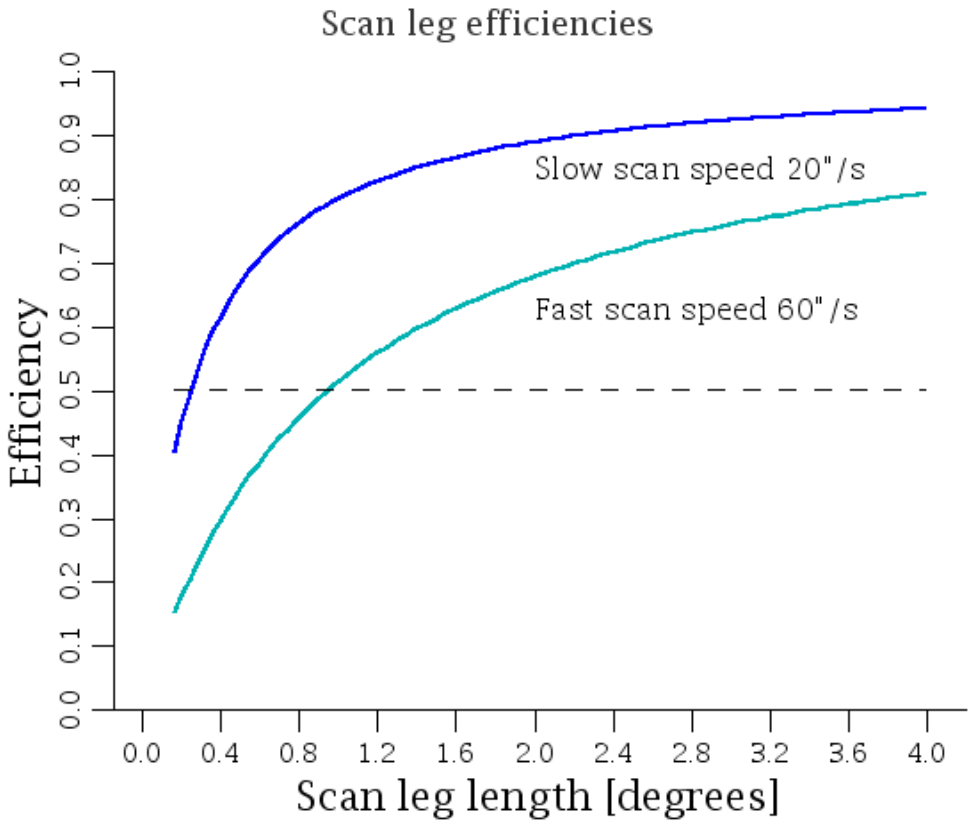
AOT scanning overheads





Overhead per scan leg

- Slow: 45 sec
- Fast: 57 sec

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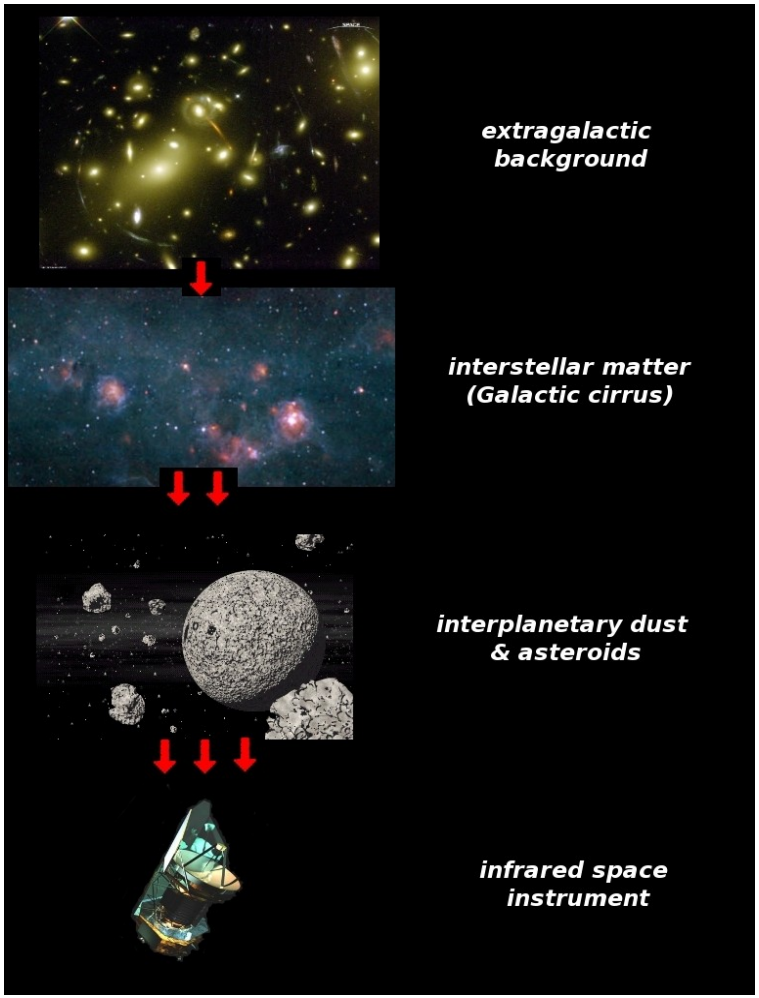
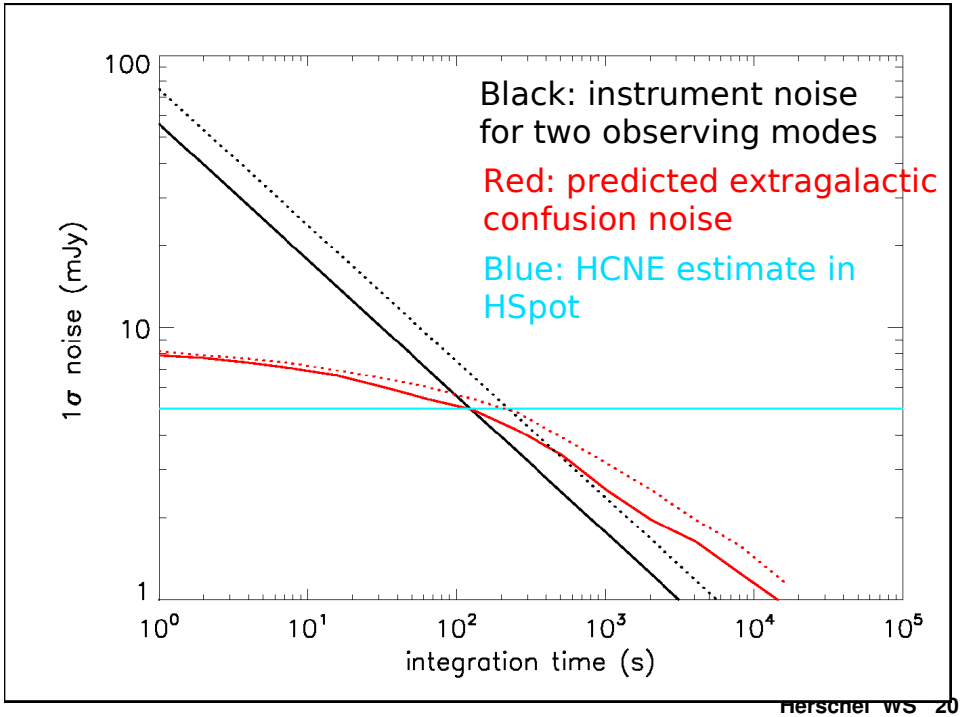
The Herschel Confusion Noise Estimator (HCNE)



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 astrophyiscal 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!**)



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

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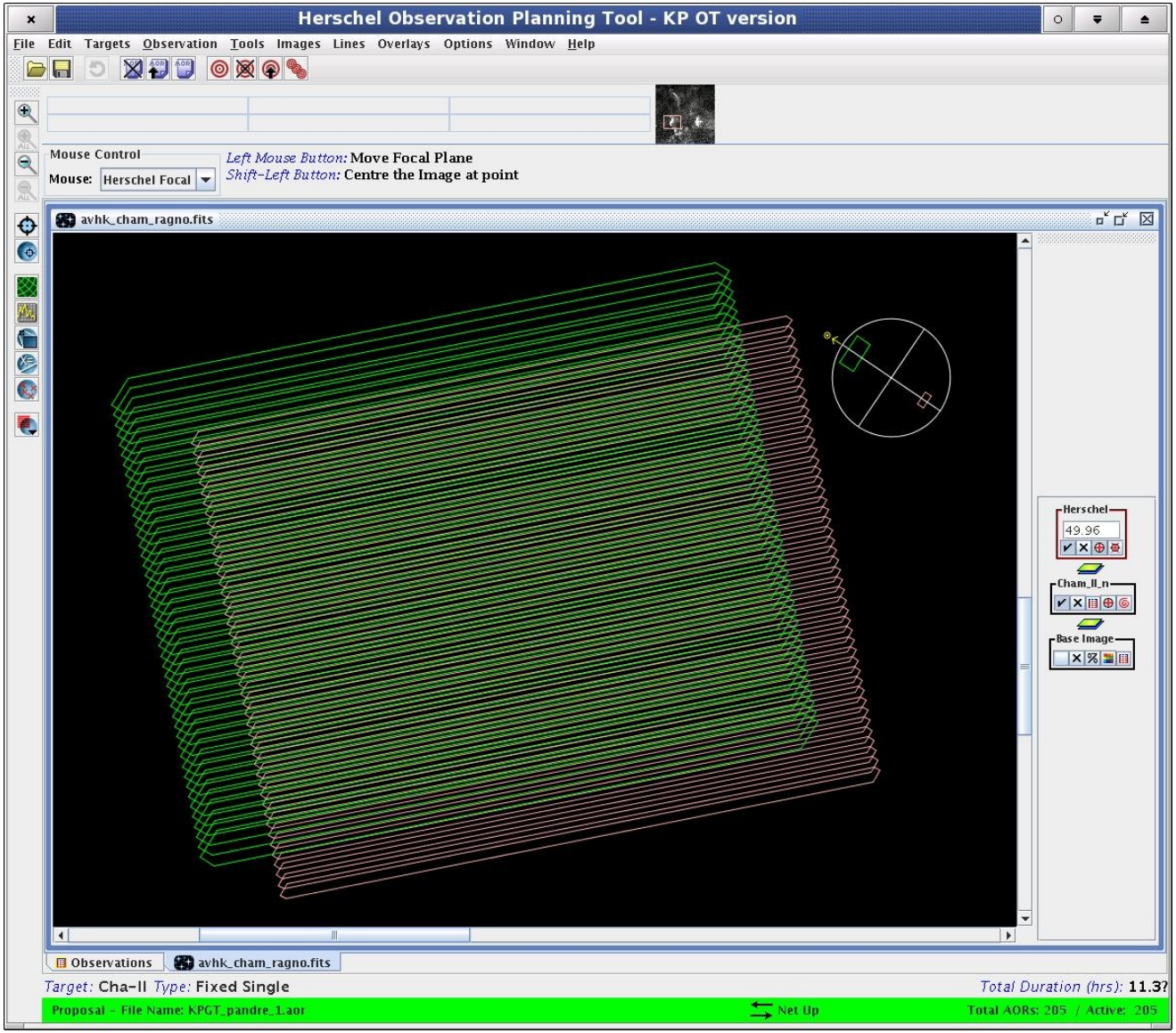
PMODE footprint on the sky



125'x100' common survey area

~2.8 hrs in fast (60”/s) scan speed

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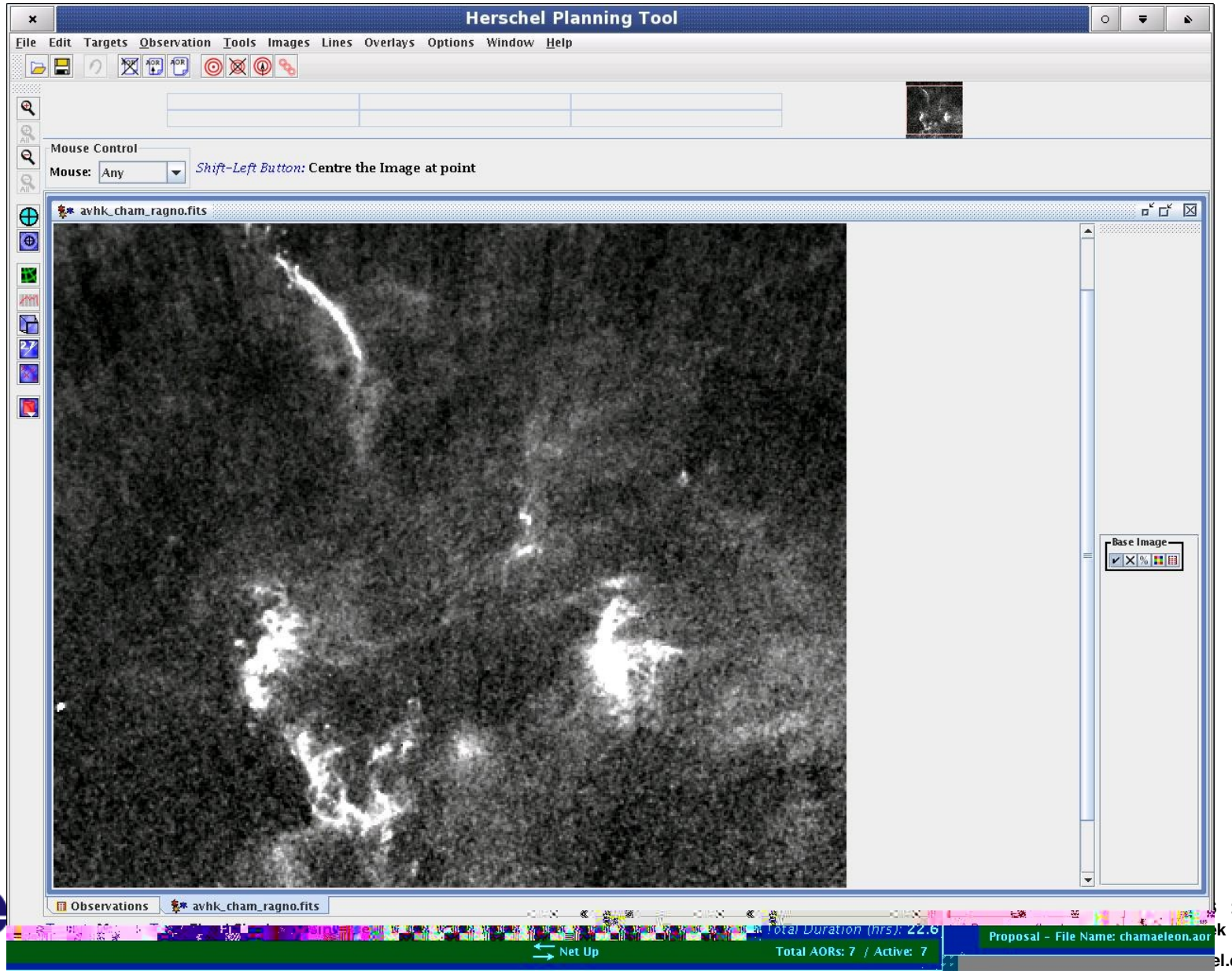
Typical example: star forming complex Cha I-II-II & Musca (GTKP)



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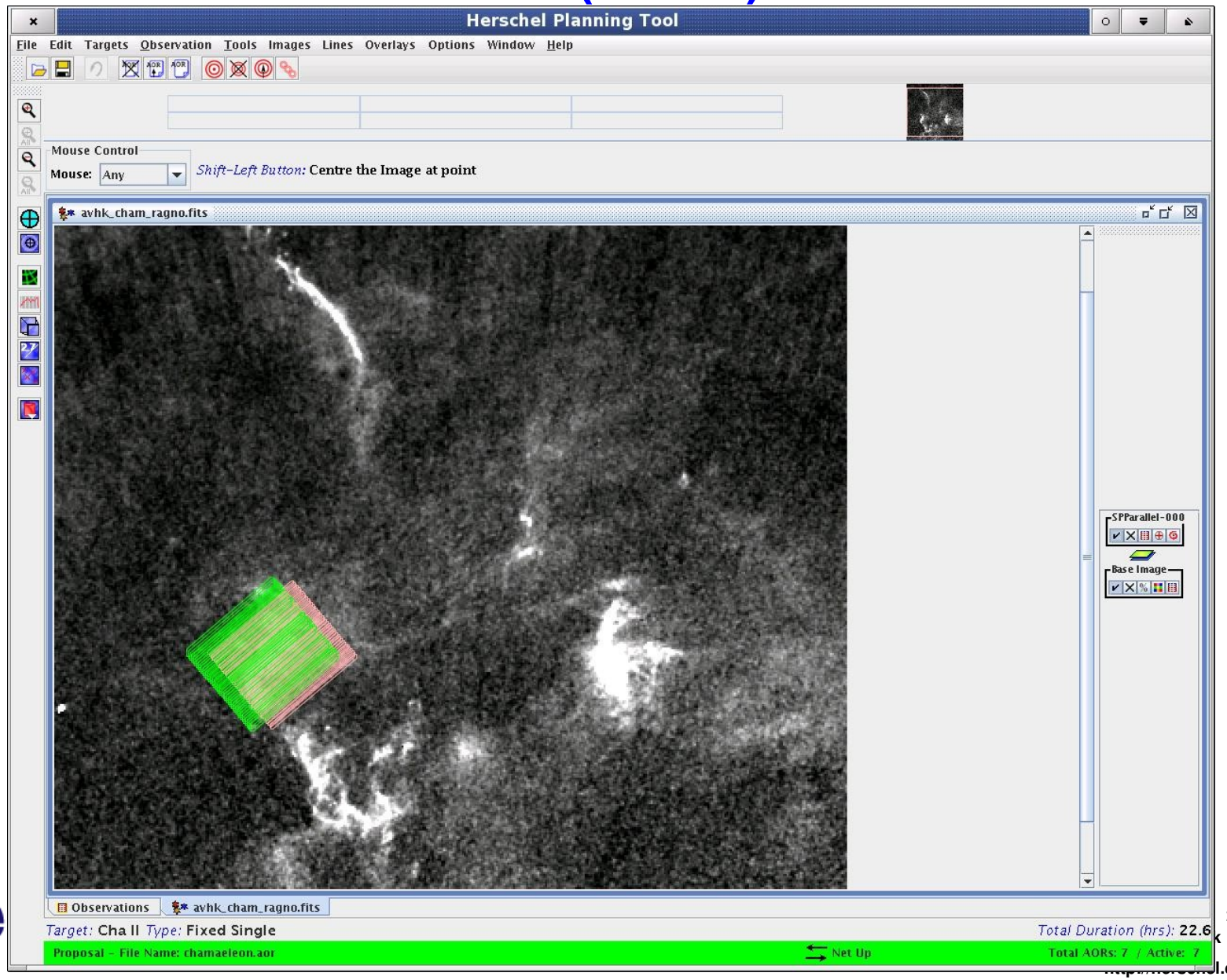

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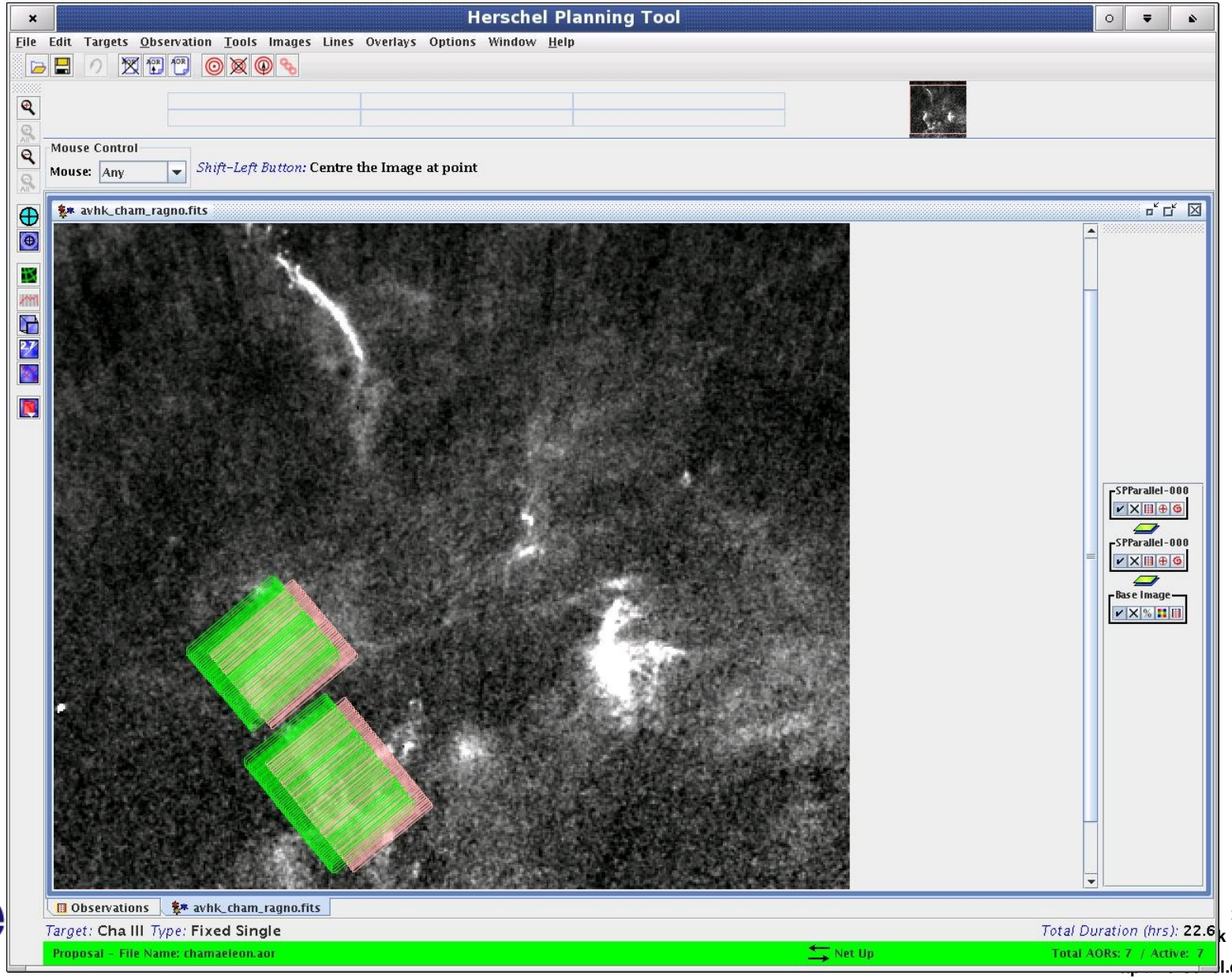

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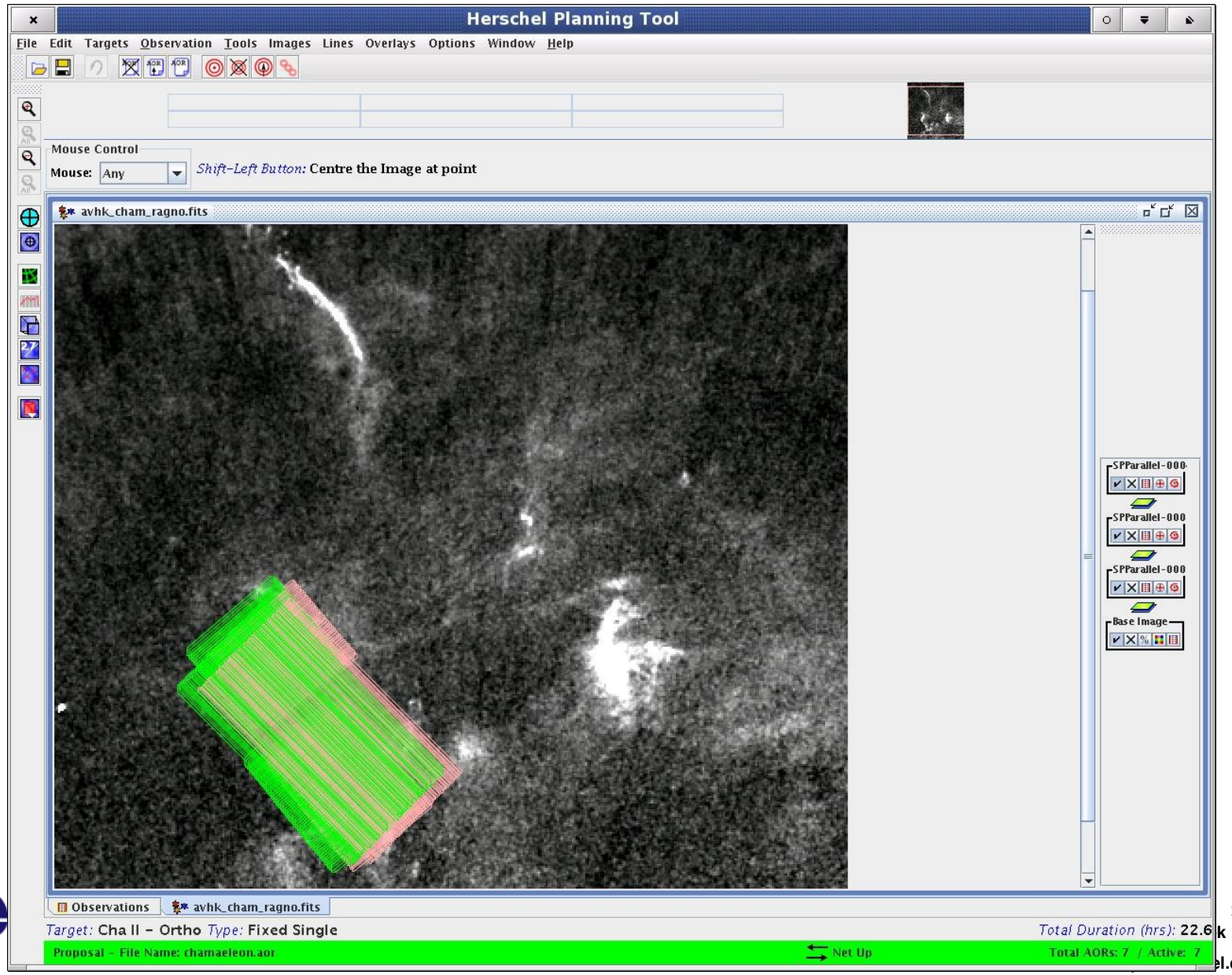

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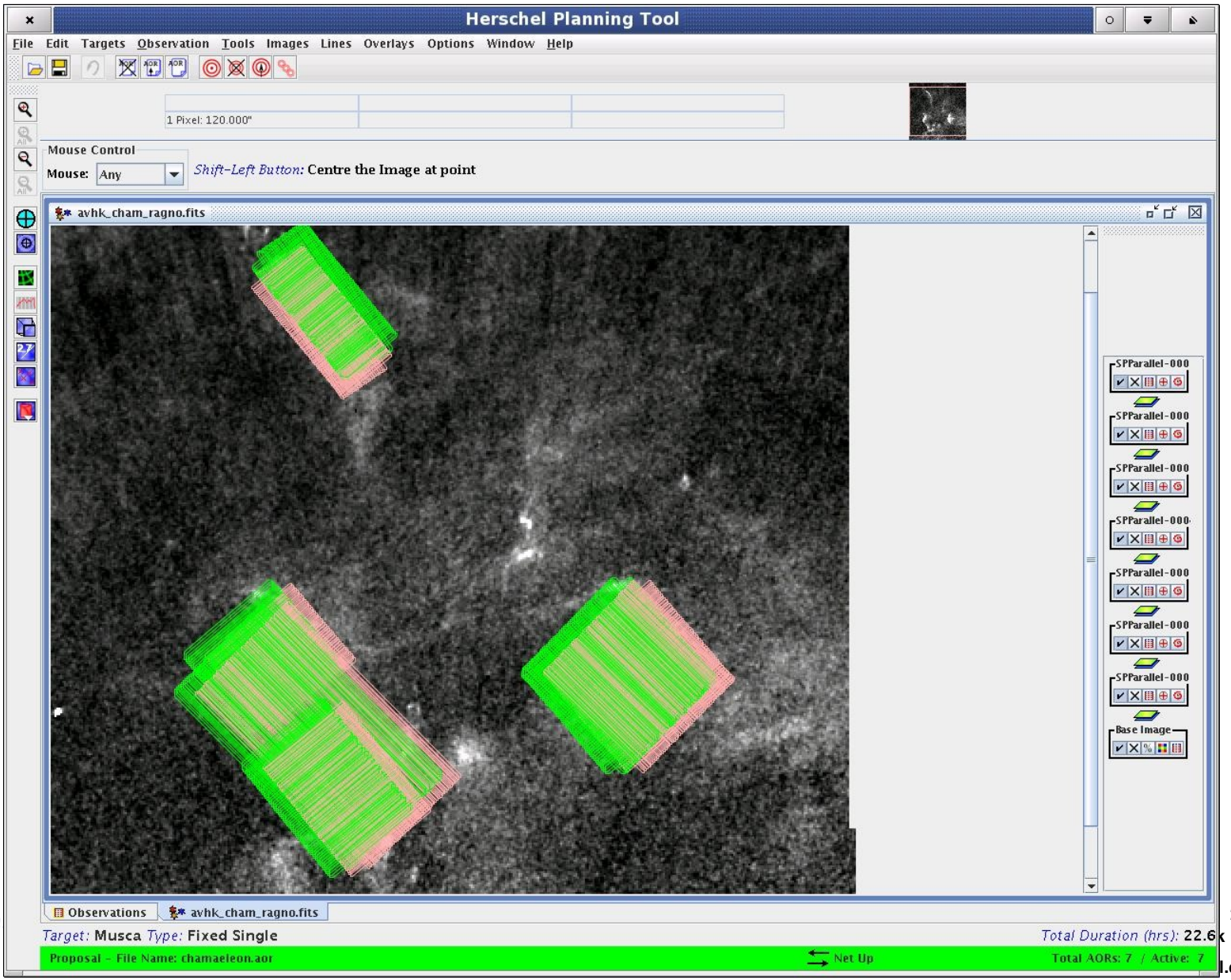

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PMODE known bugs in HSpot v3.0.7

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.

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-striping (1/f noise) and a better preservation of spatial resolution

SPIRE PACS Parallel Mode Observers' Manual:

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