PACS photometer pipeline demo

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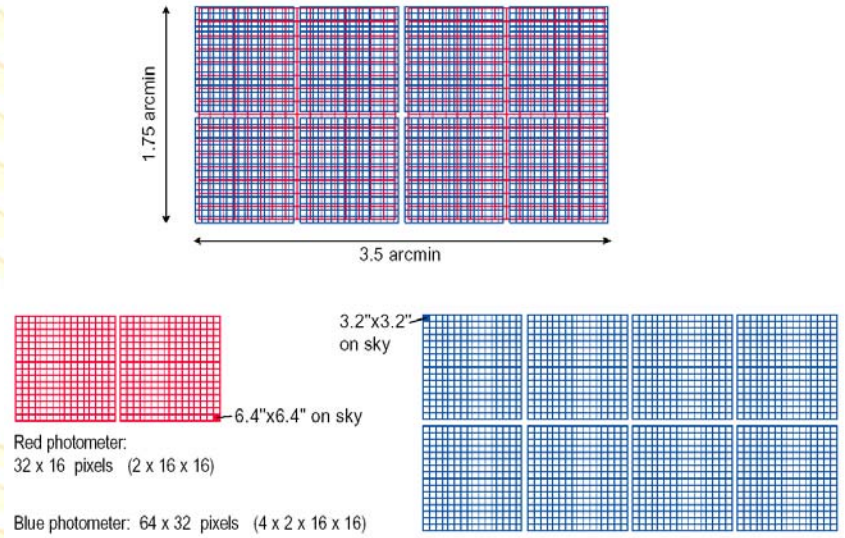
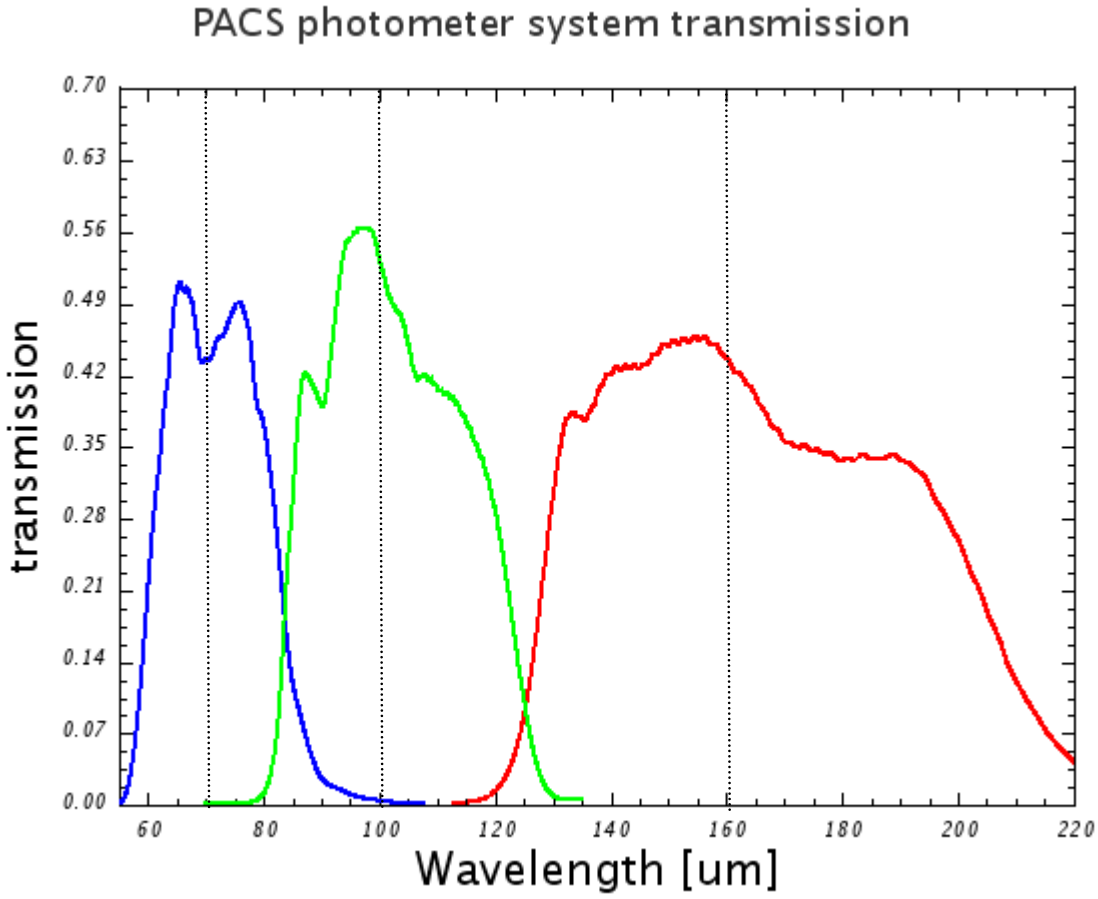
PACS Photometer quick facts (pre-launch)

- Relatively small rectangular 2x1 footprint, FOV = 3.5'x1.75'
- 2 channels simultaneously imaged (dual-band):
  - Blue channel 64x32 array, pixel size = 3.2", **60-85 μm** or **85-130 μm**
  - Red channel 32x16 array, pixel size = 6.4", **130-210 μm**
- Sensitivity (predictions):
  - point source 5σ-1 hour
    - 3.5 mJy at 70 and 100μm
    - 5.0 mJy at 160μm
  - 1sq.deg. to ~10mJy 5σ :
    - ~ 40 hours at 70 and 100μm
    - ~ 80 hours at 160μm
- PSF FWHM: 5.2", 7.7" and 12" in the 3 bands.



- On-board readout frequency : 40Hz
- On-board averaging, downloaded frequency : 10Hz, to stay within allocated 130kb/s rate.

Photometer system transmission



70 µm 100 µm 160 µm

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Photometer observing modes

The size of mapped region usually determines which mode is more efficient, originally :

- 1. Point-source mode: unresolved single sources
- 2. Small-source mode: single source <1'-1.5' in size : dropped
- 3. chopped raster: sources >1' and <12' : dropped
- 4. Scan maps: Source > 12'
- 5. Parallel mode : square degrees
  - Offset in sky between PACS and SPIRE = 21'

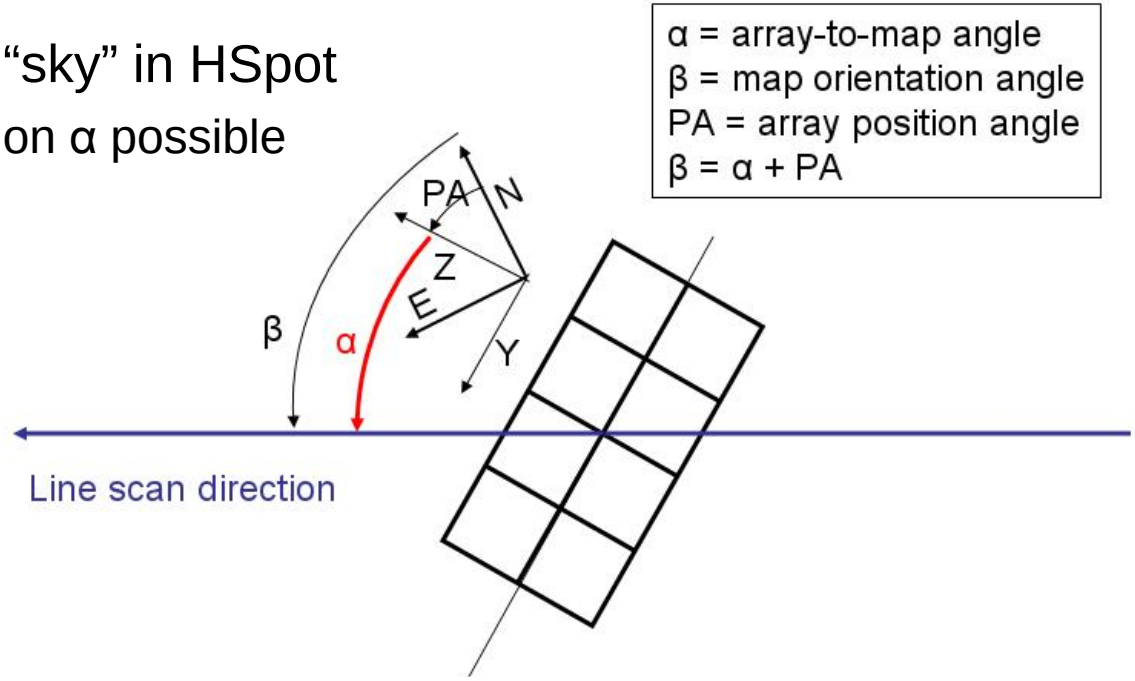
- Alternative of point-source mode: mini-scan maps
  - Scanning at 63 & 117 degrees (wrt Z axis) i.e. along detector diagonal
  - With 4 legs as minimum
  - Advantages:
    - slightly more sensitive than point-source mode since new slew-time predictor (Hspot v4.4 to be deployed)
    - no negative beams
    - Larger FOV
  - Disadvantages :
    - Possibly slightly degraded PSF

- Cross scanning advised in scan mapping
  - Especially in the view of maximum likelihood map reconstruction techniques (MADmap, Sanepic, Romagal)

Scan map orientation

- In reference frame “array” in HSpot
  - α fixed, constraint on β is possible
  - Selection of homogeneous coverage offered in HSpot.

- Oriented in the sky, “sky” in HSpot
  - β fixed, constraint on α possible



- Note: If α=45^{o} then orthogonal coverage has same depth

Scan map pipeline

10 step to apply to PACS photo data cube (frames)

1. Flag bad pixels
2. Flag saturated pixels
3. Convert ADUs to Volts
4. Cross-talk correction
5. Pixel timeline deglitching (multi-median resolution)
6. Flat-field and responsitivity correction: Jy/pixel
7. Get ra/dec for virtual aperture (centre)
8. Assign ra/dec to every pixel (spatial calibration)
9. Run high-pass filter, to filter 1/f noise
   - In two passes to mask out (bright) sources for high-pass
10. Project cube onto a grid to get WCS map

Level 0 to 1

Level 1 to 2

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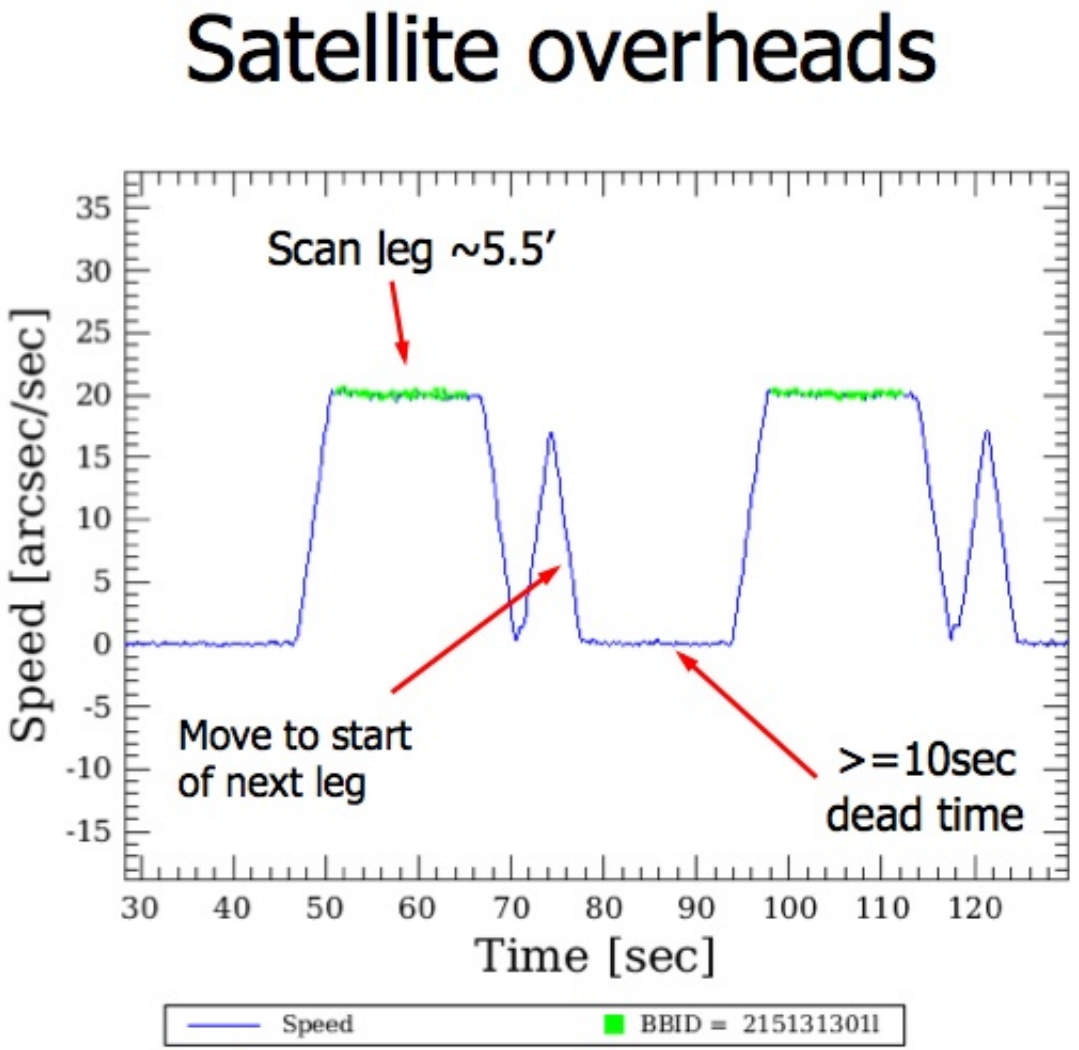
Pipeline tuning

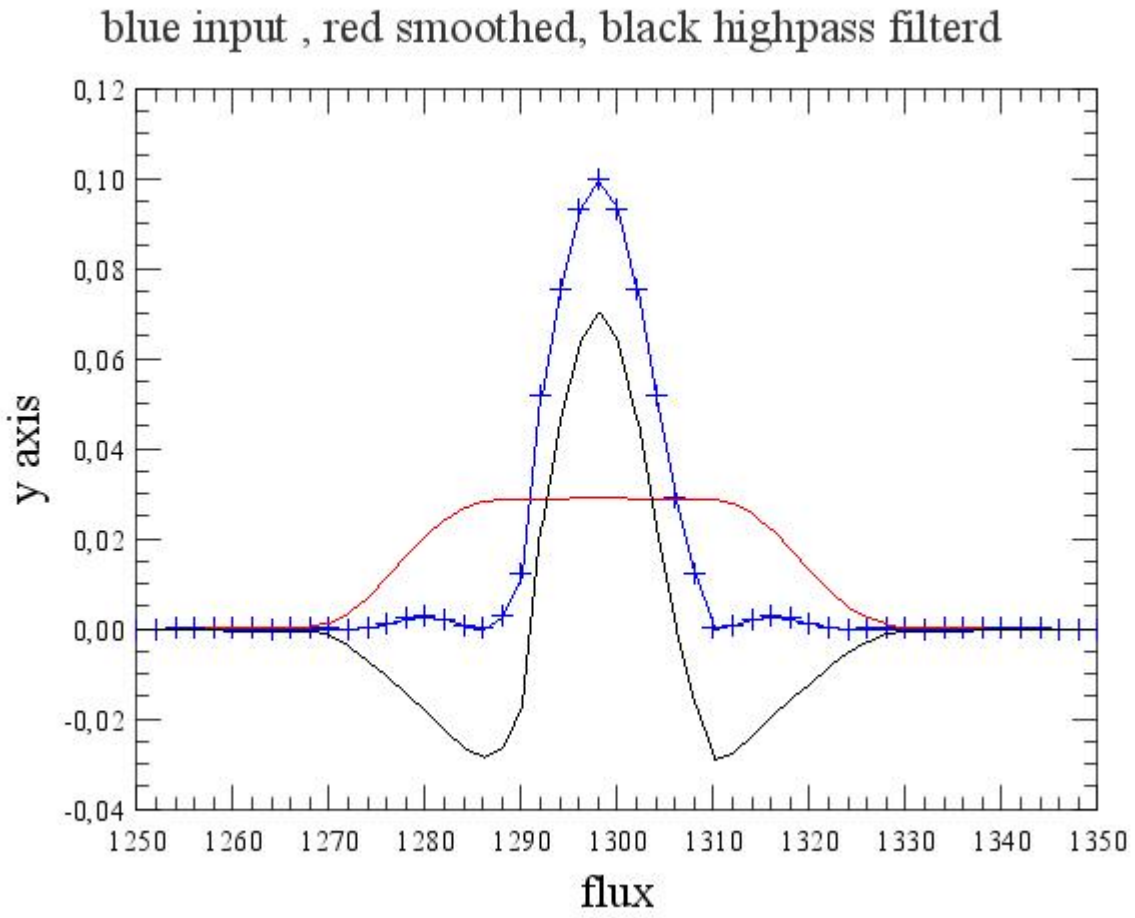
- Bad pixels
- Deglitching
  - Smaller `scales` / higher `nsigma` parameters at high speed or on bright sources (temporal deglitching)
  - 2nd order deglitching experimentary, taking advantage of spatial redundancy
- High-pass filter width:
  - the short the the better the 1/f noise is removed and striping removed
  - But at too short width PSF becomes distorted
  - Common :
    - 15 in the blue (→ 10)
    - 26 in the red (→18)
  - Not suited for large extended emission
- Mask sources for high pass
  - by coordinates/disks
  - by signal above map noise
- Scan leg re-centering
  - To mitigate PSF degradation/smearing due to SRPE/RPE.

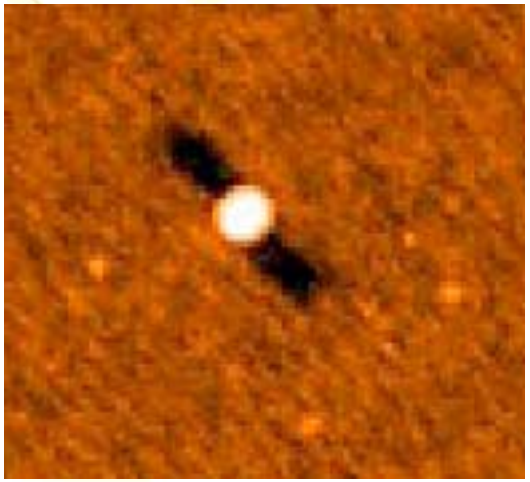
Turnover loops optimization

- "dead time" decreased from 17s to 5s starting OD221 onwards



Artefact of high-pass filter on bright sources





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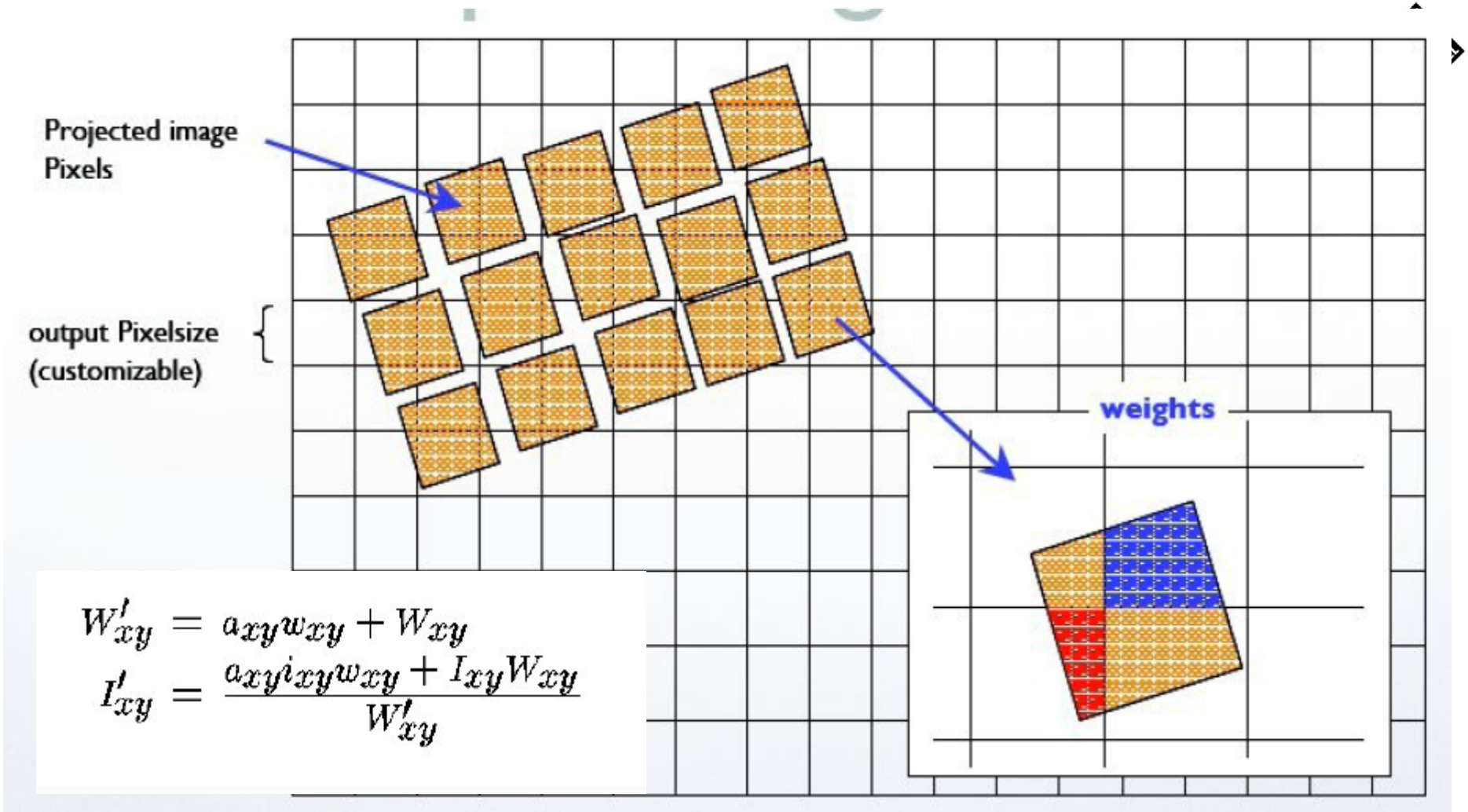
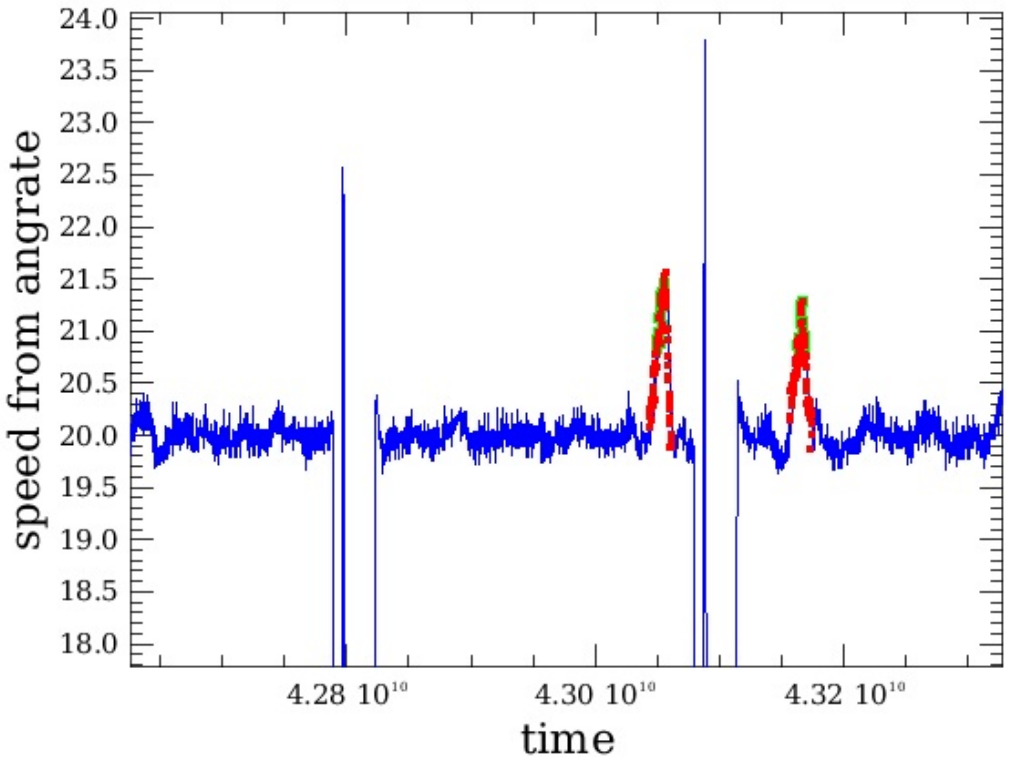


$$W'_{xy} = a_{xy} w_{xy} + W_{xy}$$
$$I'_{xy} = \frac{a_{xy} i_{xy} w_{xy} + I_{xy} W_{xy}}{W'_{xy}}$$

- only geometrical weights in the current version
- exposure maps to estimate weigths

Speed bumps

- Scan speed experiences 10s-20s bumps
  - during bumps attitude unreliable by several arcsec up to tens of arcsec
  - Tentatively attributed to some bad/rogue Star Tracker pixels
  - on-going investigation to mitigate effects
    - suppress: frame filtering
    - Correct: local gyro propagation



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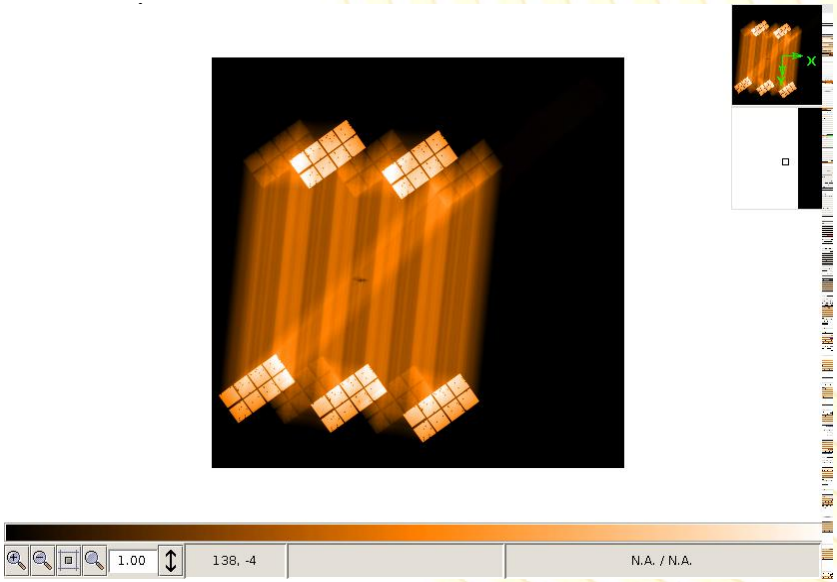
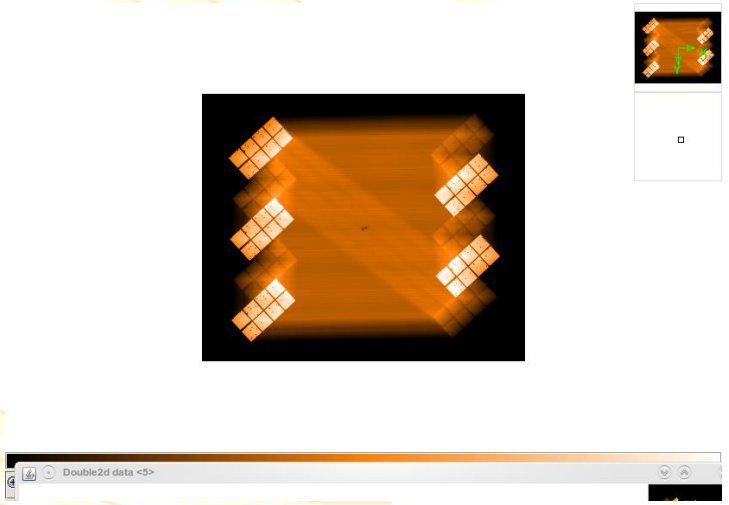
Homogeneous coverage

- PACS scan map were somewhat inhomogeneous, when in 'homogeneous coverage'
  - inhomogeneous at 45 degrees (~25% level)
  - but very homogeneous at 135 degrees !
  - Due to the combined effect of larger footprint size and tilt angle of 2.5



45 degrees

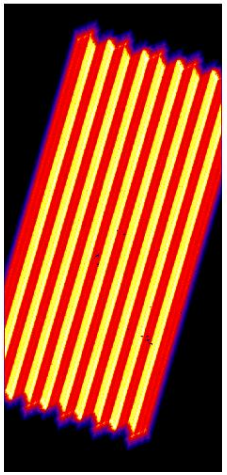


135 degrees

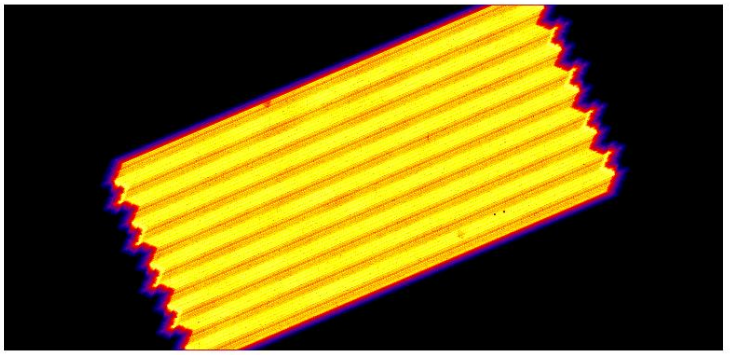
- Corrected starting OD221
  - adjusting the cross-scan step size and detector tilt

Parallel mode

- Calibration blocks interleaved every hour
  - In parallel to PCAL flashes
  - Nuisance because of transients effects
  - suppressed starting in OD228
- Homogeneity
  - Not solved/implemented yet



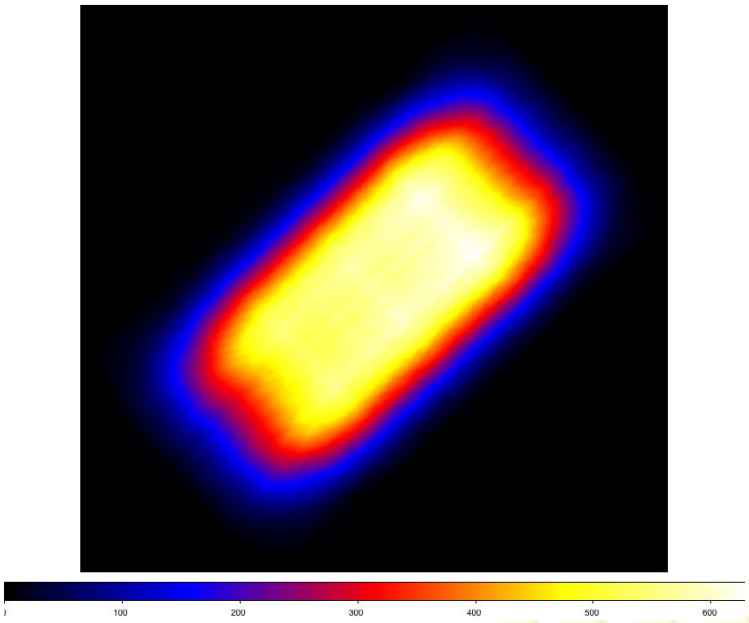
42.4 degrees (magic angle)

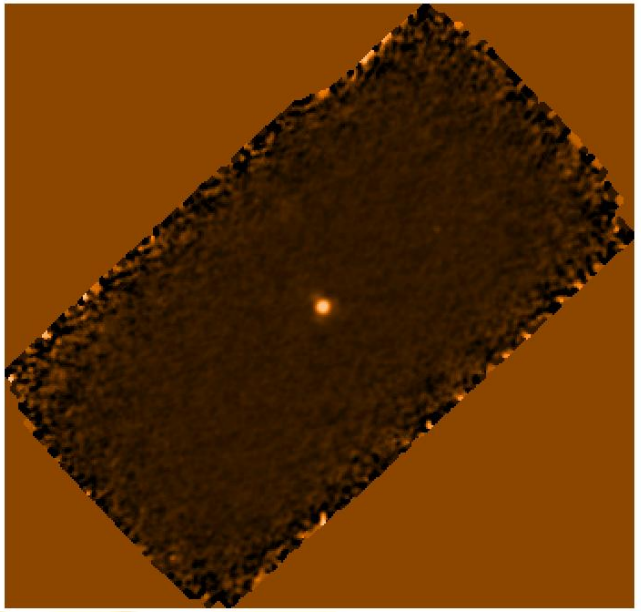


-42.4 degrees

Mini Scan map

- Two scan maps at 63 & 117 degrees
- Rectangular exposure map for combined scans
- (Hspot) tool need to compute sensitivity.





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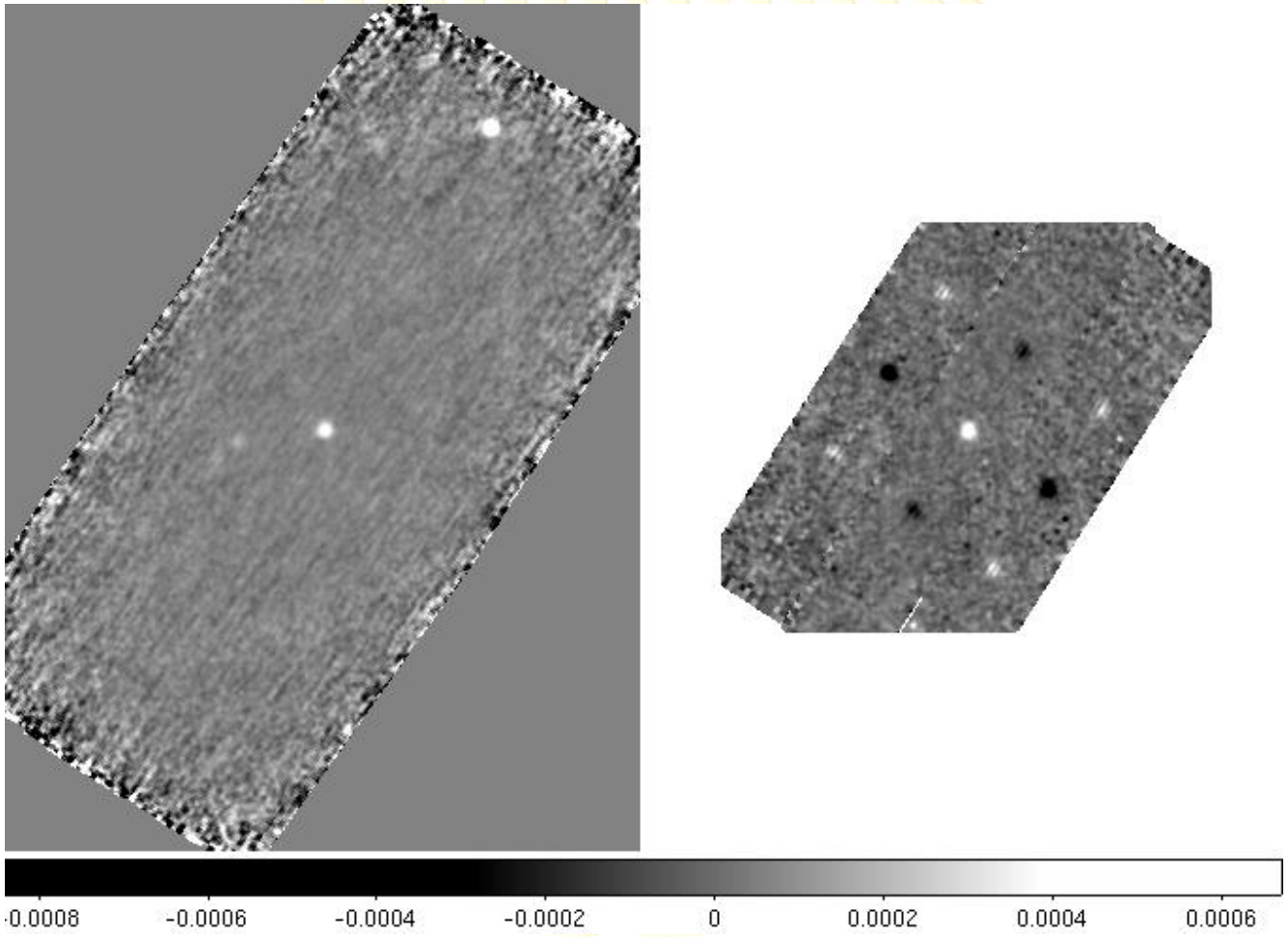
PS versus scanning



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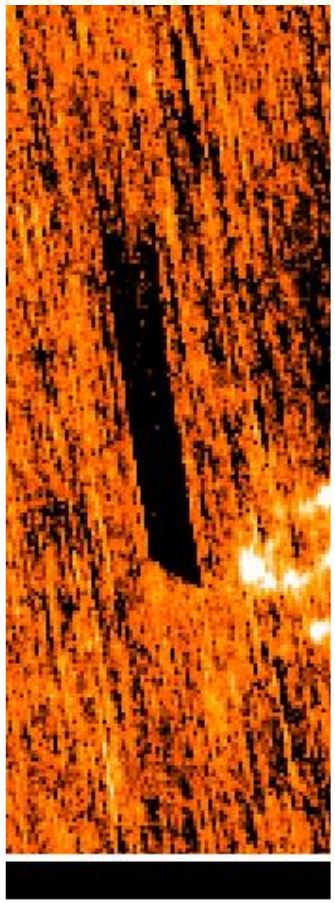
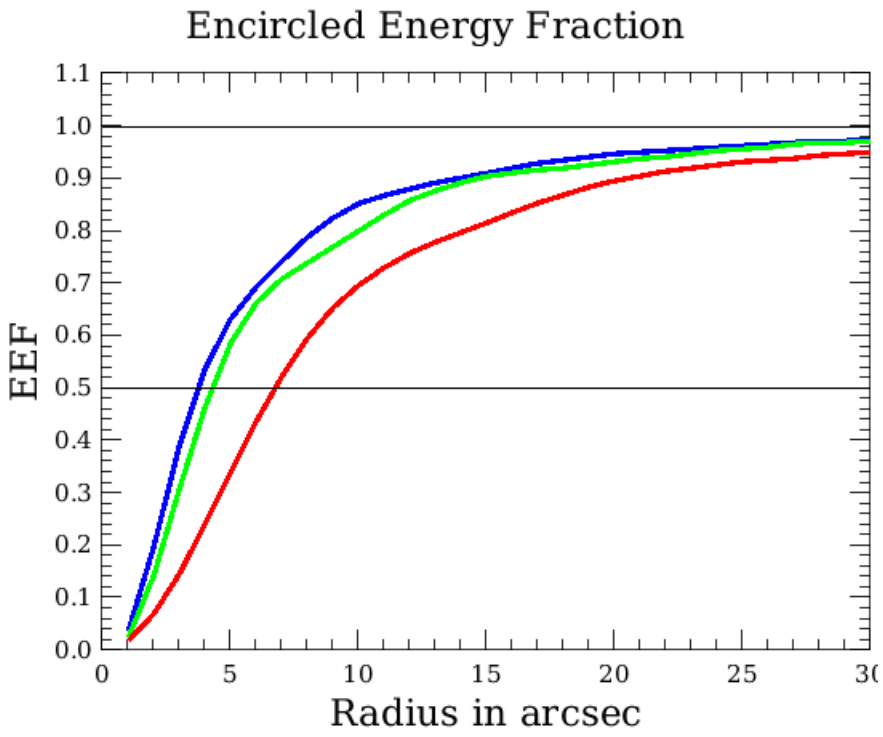
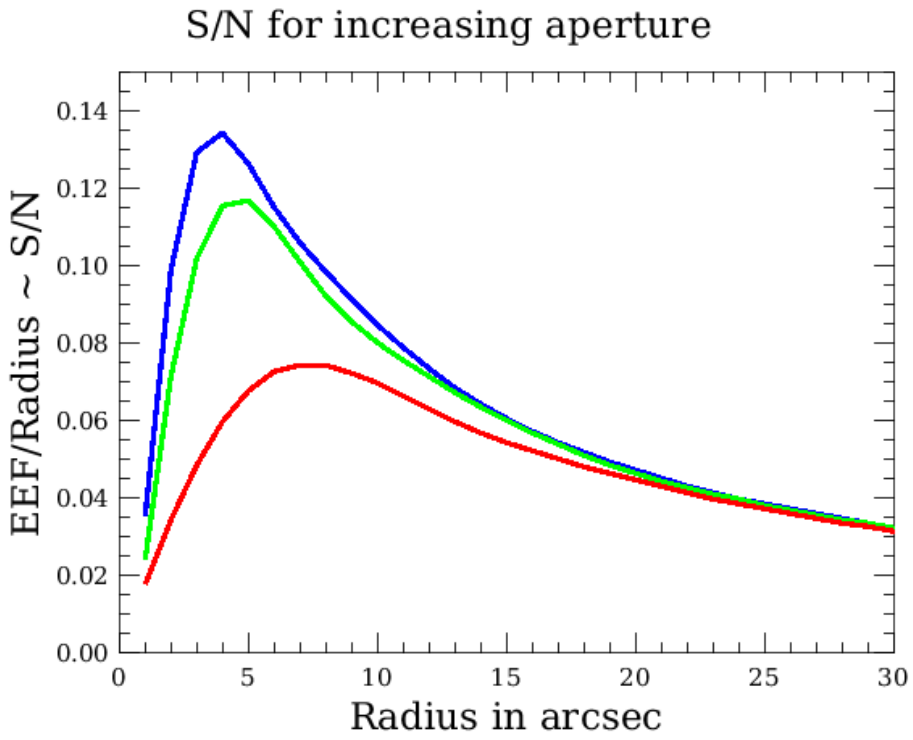
Line DC level offsets



Aperture photometry





Astrometry

- Still a residual time shift between PACS frames and attitude data
  - Delta ~ 50ms
  - ➔ shift of about 1 arcsec in odd and even scan legs in opposite directions at medium speed (20"s), PACS frames are leading
  - Shift of 3 arcsec at high speed (parallel mode)

Test Data

- Target : HIP148387 (η Dra) selected from IGBPP (ISO Ground Based Preparatory Programme)
  - Predicted flux : 480mJy@70μm and 89mJy @160μm
- Two mini scan maps
  - 70 / 110 degrees
  - Medium speed
  - But only 1.5 arcmin scan leg