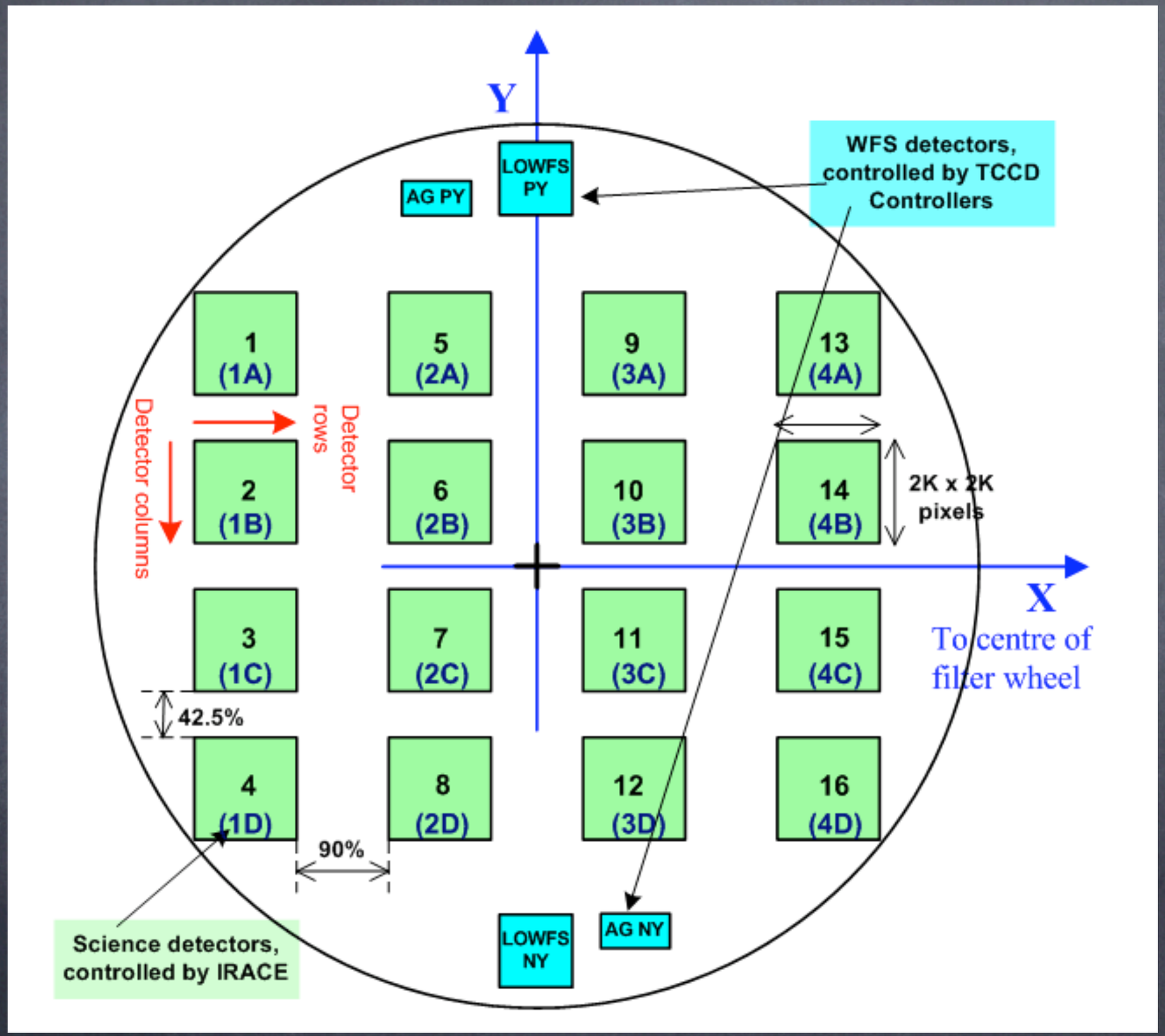
CASU processing for VISTA

Mike Irwin
Jim Lewis
Eduardo Gonzalez-Solares
Simon Hodgkin
Aybuke Yoldas
Marco Riello

- CASU responsible for all NIR processing for WFCAM & VISTA
- + optical mosaic camera processing for projects using MegaCam, Subaru, INT WFC, VIMOS, ESO WFI, VST .....

VISTA focal plane



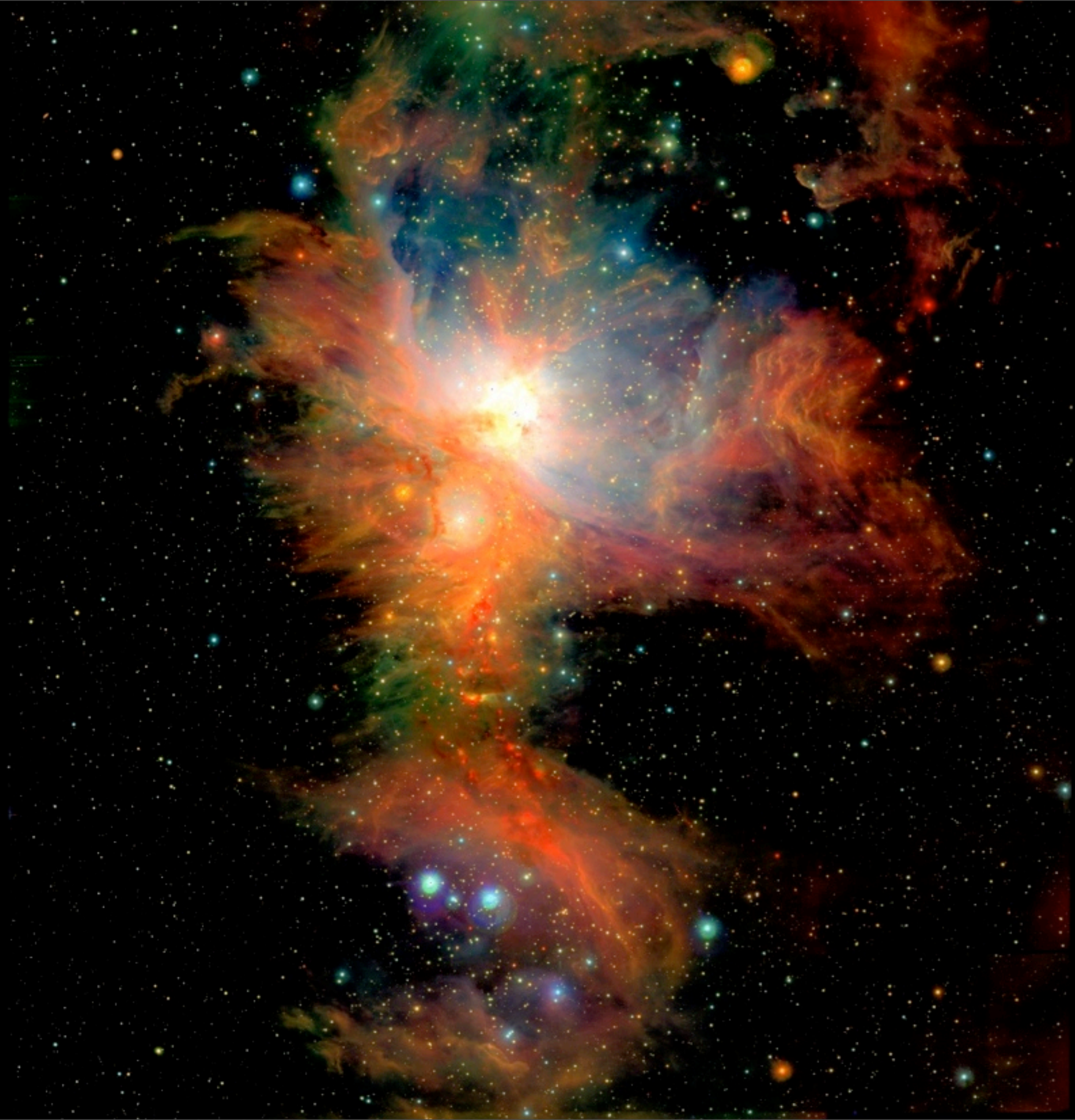
Orion

M42
region

colour
composite
J,H,Ks

16kx13k
pixels/
waveband

mosaic of
96 2kx2k
images/
waveband



VISTA data flow - I

- raw data transfers on USB disk (Rice-compressed MEFs)
- ingest & verification -> raw data archive
- create off-line tape backups
- update calibration files monthly (flats, linearity, masks)
- parallel nightly processing at OB-level (darks updated)
  - stacked pawprint images instrumental signature removed
  - catalogue generation from pawprint images & conf maps
  - astrometric & photometric calibration
- header updates -> pawprint OB-level science products
- check derived QC info & sample of images
- processing web page updates and progress tracking
  - http://casu.ast.cam.ac.uk/surveys-projects/vista

Cambridge Astronomical Survey Unit

VISTA DATA REDUCTION PROGRESS: COMMISSIONING

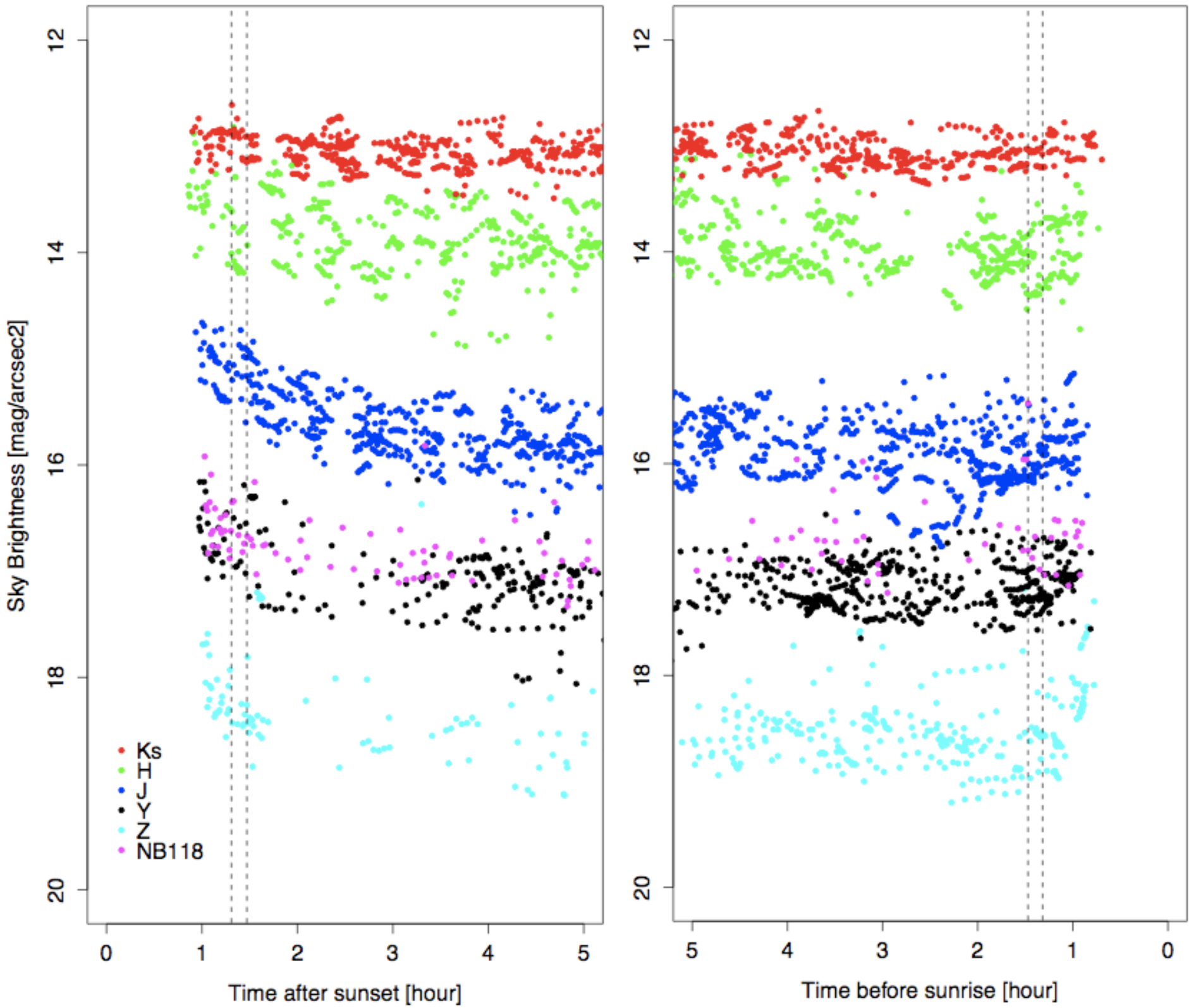
This page displays the reduction progress of VISTA data. Information is automatically updated hourly.

Night	Status	N_{raw}	Version	Summary Plots	Photometry Plots	Summary Info	Observation Log	Paranal ambient conditions	Size raw [Gb]	Size red [Gb]
2009/10/15	REDUCED	363		GIF1 GIF2	GIF	summary	obs_log	nightmon	23.86	43.78
2009/10/16	REDUCED	341		GIF1 GIF2	GIF	summary	obs_log	nightmon	25.53	137.65
2009/10/17	REDUCED	470		GIF1 GIF2	GIF	summary	obs_log	nightmon	33.61	183.47
2009/10/18	REDUCED	398		GIF1 GIF2	GIF	summary	obs_log	nightmon	29.51	154.95
2009/10/19	REDUCED	505		GIF1 GIF2	GIF	summary	obs_log	nightmon	35.24	184.86
2009/10/20	REDUCED	401		GIF1 GIF2	GIF	summary	obs_log	nightmon	29.76	192.84
2009/10/21	Reduction status	448		GIF1 GIF2	GIF	summary	obs_log	nightmon	32.11	179.83
2009/10/22	REDUCED	476		GIF1 GIF2	GIF	summary	obs_log	nightmon	36.66	204.01
2009/10/23	REDUCED	589		GIF1 GIF2	GIF	summary	obs_log	nightmon	42.97	266.31
2009/10/24	REDUCED	434		GIF1 GIF2	GIF	summary	obs_log	nightmon	30.17	131.61
2009/10/25	REDUCED	454		GIF1 GIF2	GIF	summary	obs_log	nightmon	34.09	191.42
2009/10/26	REDUCED	454		GIF1 GIF2	GIF	summary	obs_log	nightmon	33.89	192.52
2009/10/27	REDUCED	492		GIF1 GIF2	GIF	summary	obs_log	nightmon	35.20	198.65
2009/10/28	UNPROCESSED	15					obs_log	nightmon	0.92	
2009/10/29	REDUCED	435		GIF1 GIF2	GIF	summary	obs_log	nightmon	33.04	191.13
2009/10/30	UNPROCESSED	46					obs_log	nightmon	2.64	
2009/10/31	UNPROCESSED	100					obs_log	nightmon	4.91	
2009/11/01	UNPROCESSED	15					obs_log	nightmon	0.85	
2009/11/02	REDUCED	340		GIF1 GIF2	GIF	summary	obs_log	nightmon	25.31	102.82
2009/11/03	REDUCED	599		GIF1 GIF2	GIF	summary	obs_log	nightmon	47.72	249.12
2009/11/04	REDUCED	656		GIF1 GIF2	GIF	summary	obs_log	nightmon	53.90	205.86

Table description :

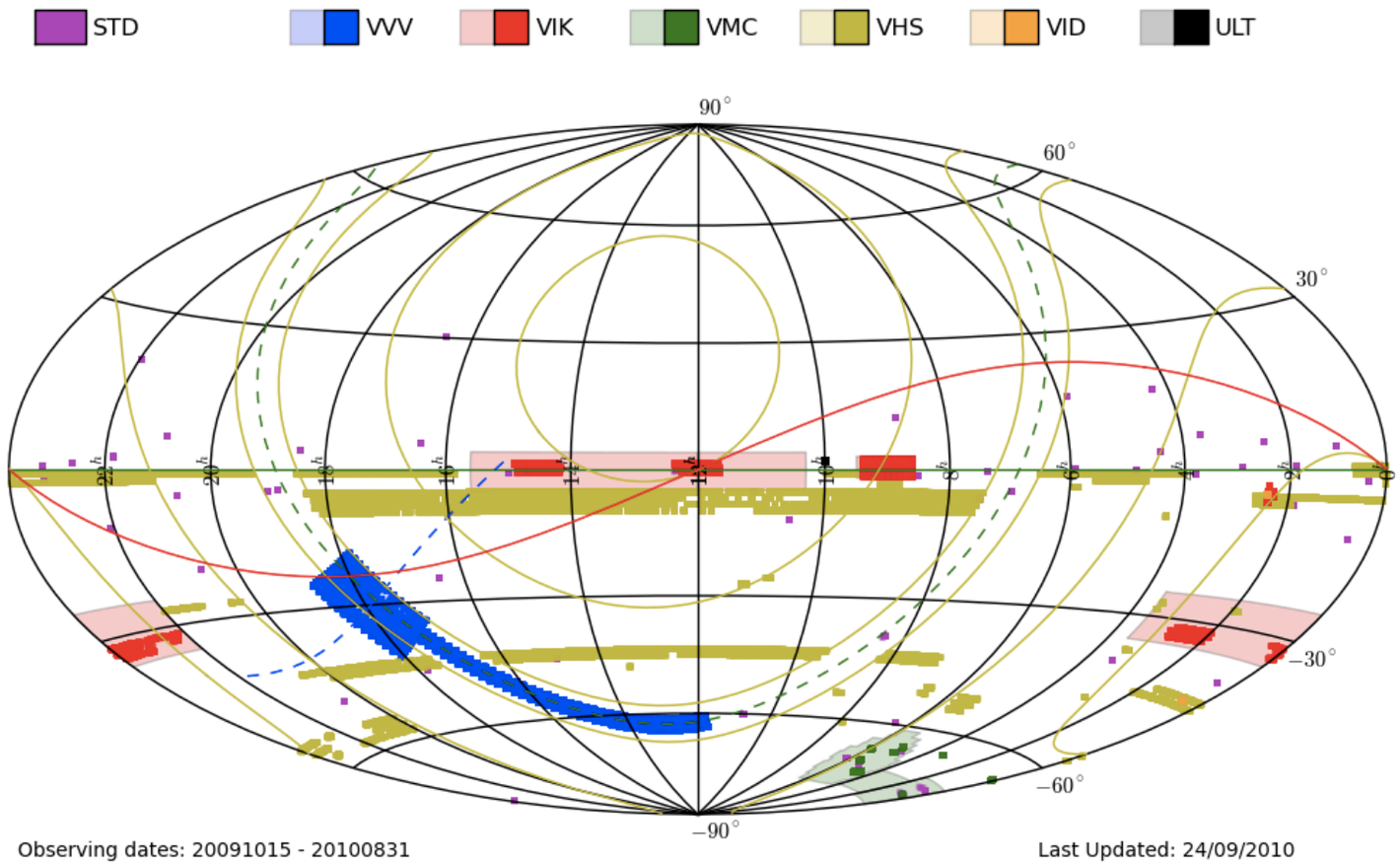
- **N_{raw}**: total number of raw images for the given night (this includes darks, flats, focus runs etc.).

Monitoring sky surface brightness

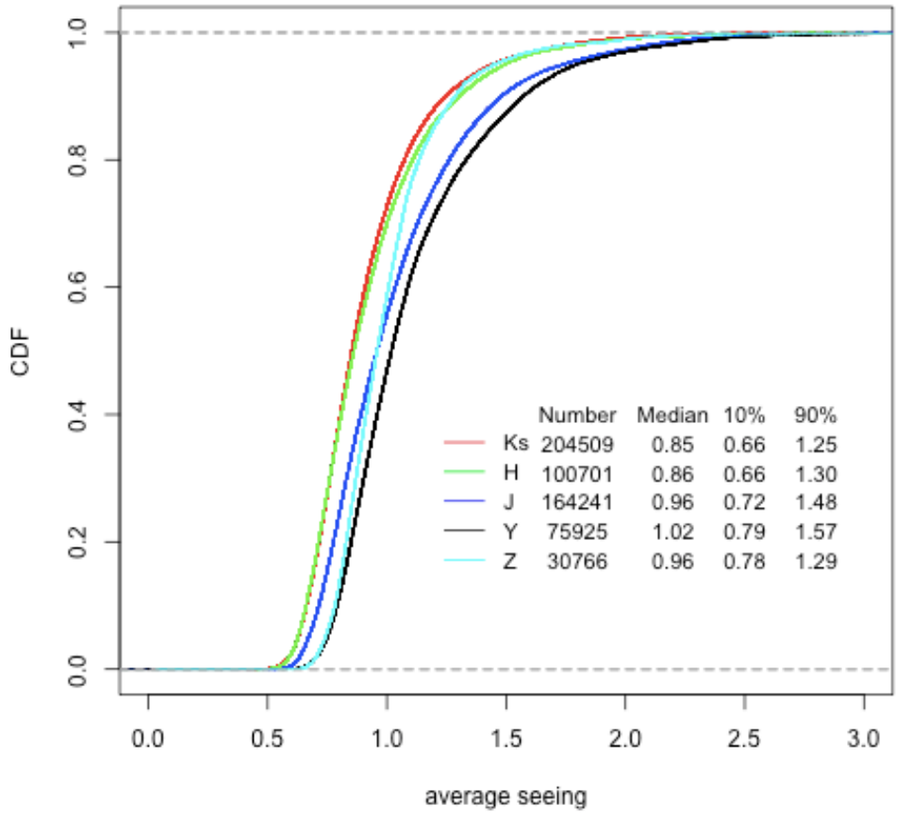


VISTA data flow - II

- detector level monthly photometric zpt updates
  - illumination correction tables
- mosaic OB-level tile image and create confidence map
- tile image cataloguing (Tangent Plane projection)
  - nebulosity filter 6 component pawprints
  - mosaic and correct for sky levels and distortion
  - generate tile catalogue
  - grout tiles to fix PSF and detector zpt variations
- check derived QC info & sample of images (cf. OB grade)
- ingest to post-processing database enables checks:- FITS header contents, file size, provenance and calibration files, exploration of long-term trends, survey progress, data access http://casu.ast.cam.ac.uk/vistasp/imgquery/search

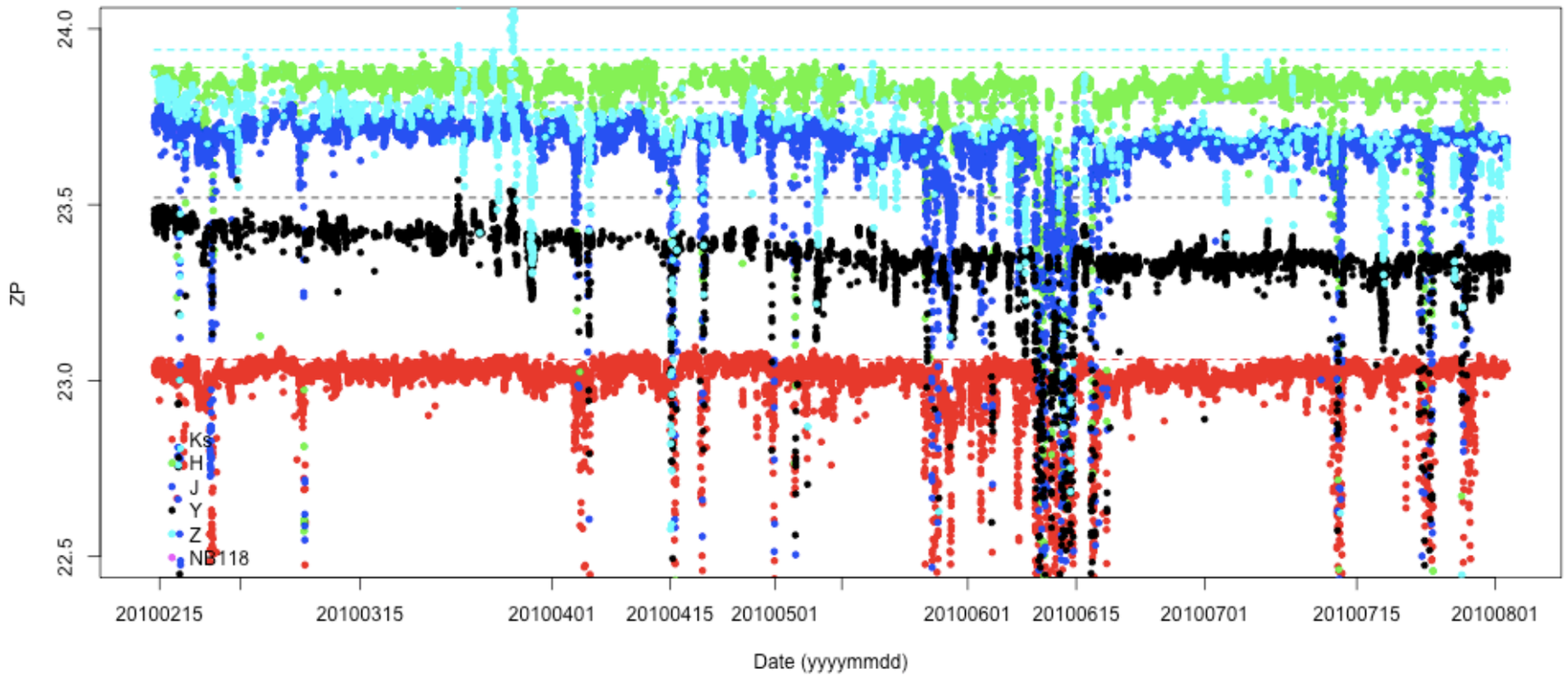


Survey progress overview



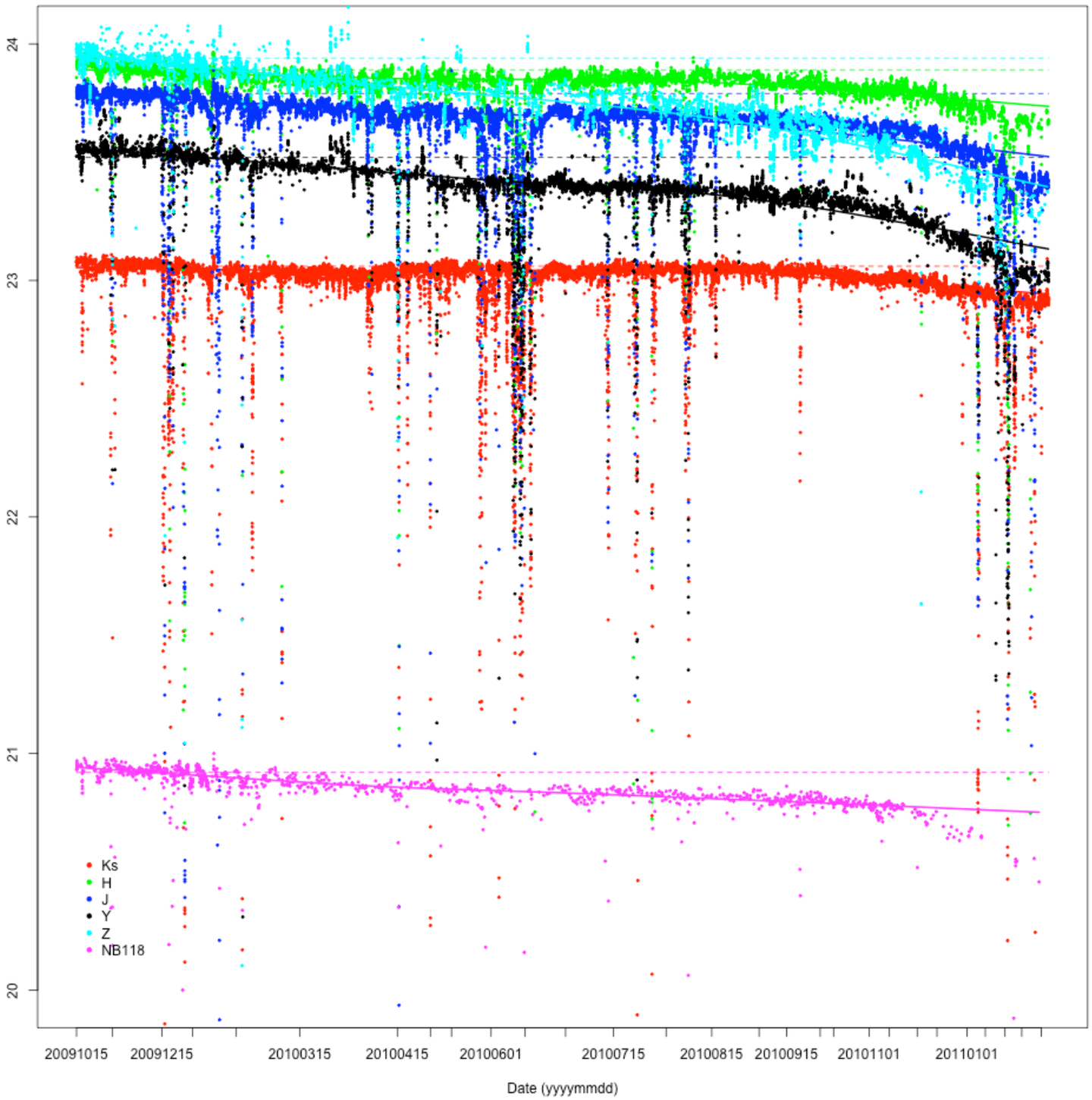
QC plots summarise:

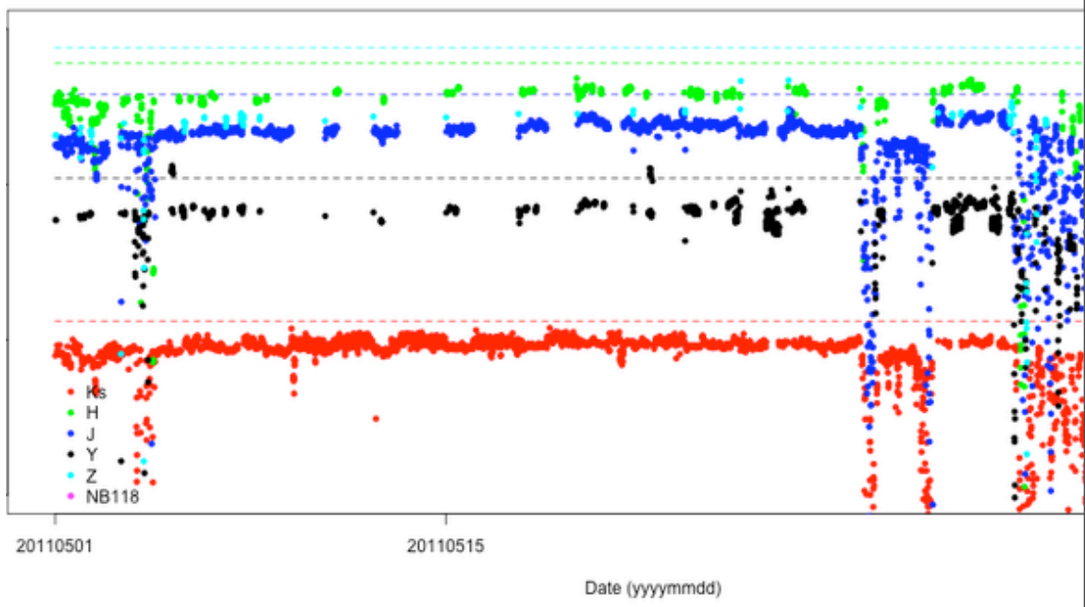
astrometry; seeing; stellar ellipticity; sky brightness; magnitude zero-point trends



Silvered

Aluminised





P87

Photometric ZP variation

SV

P85

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Data Products - recap

- products consist of:
  - calibrated single exposure images
  - shifted "average" stack frames (pawprints) + conf maps
  - calibrated stacked pawprint catalogues
  - filled area tile images + confidence maps
  - calibrated tile object catalogues
  - sky background images, flats, darks, bad pixel mask
- science products are MEF files (images Rice-compressed)
- all QC parameters are stored in MEF headers

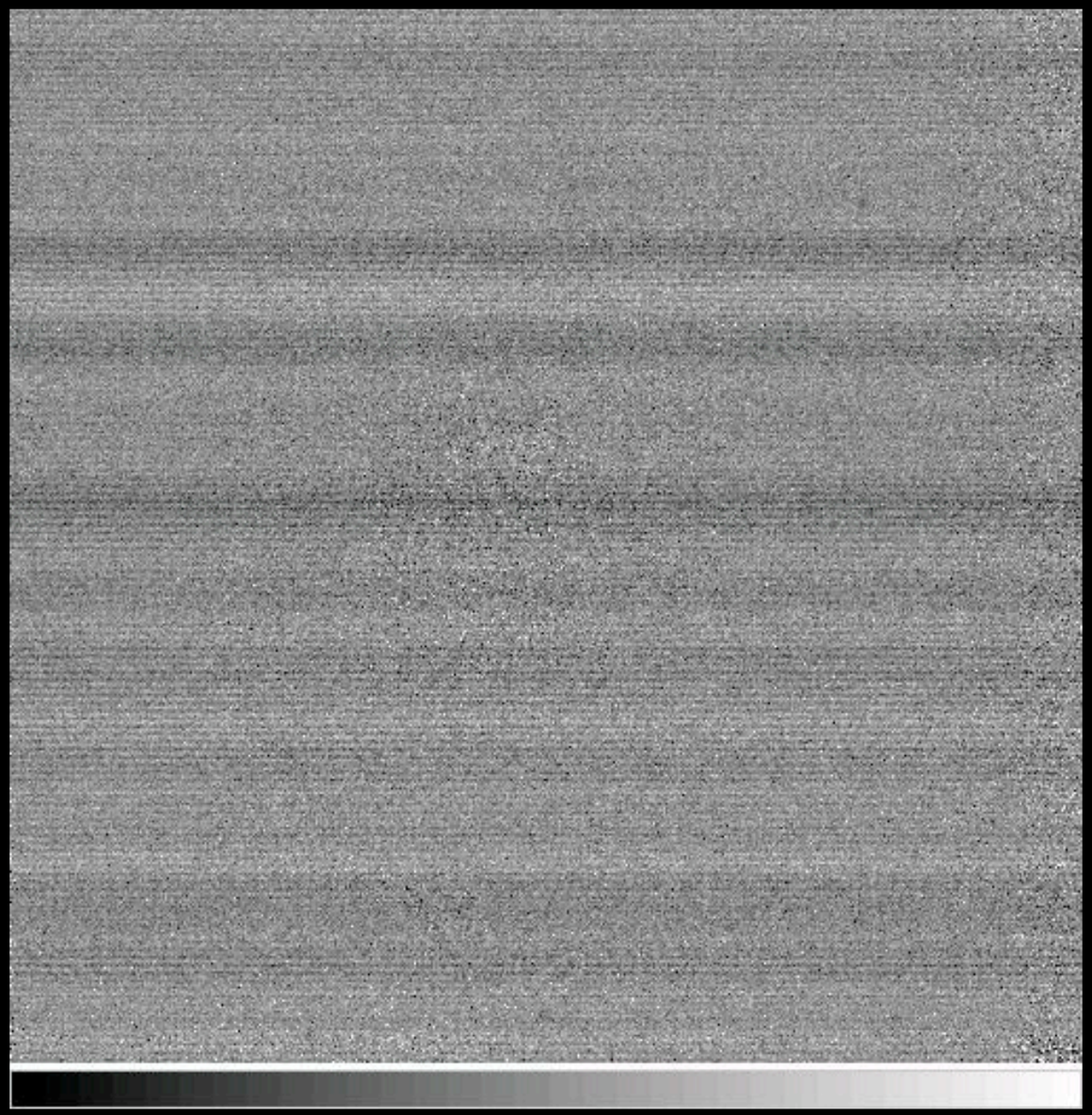
The Naming of Parts

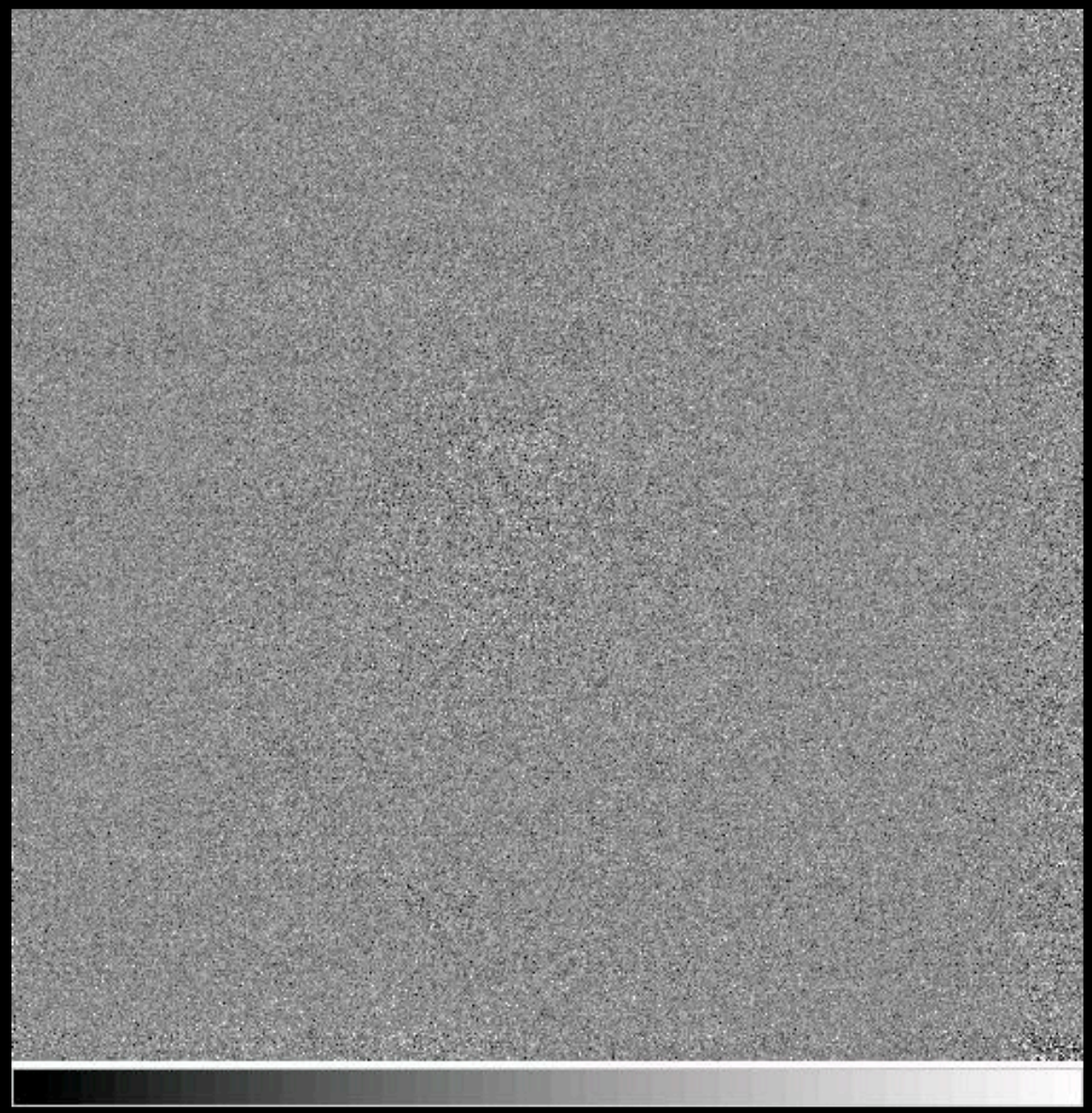
- filenaming conventions
  - v20091102_00123.fit (raw & processed)
  - v20091102_00123_st.fit _st_cat.fits _st_conf.fit
  - v20091102_00123_st_tl.fit .....
  - dark_20091102_5_1.fit
  - J_flat_20091016.fit
  - sky_20091102_00123_J.fit
- ESO arcfile and origfile names in header
- as is the version no. - currently v1.1** and OB grade

Image processing Steps

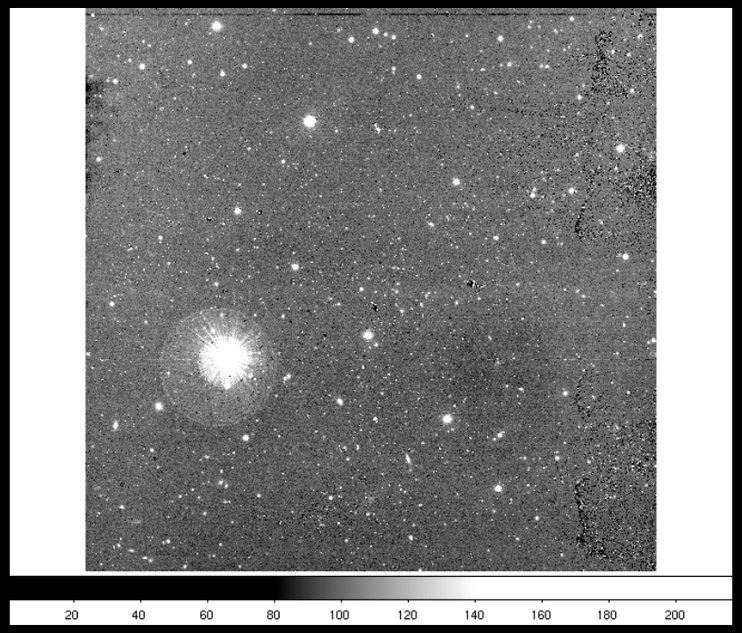
- Reset correction (debias - inline)
- Dark correction
- Linearity correction
- Flat field correction
- Sky background correction *****
- Destripe - controller level pickup
- Crosstalk, persistence and fringing corrections are not necessary

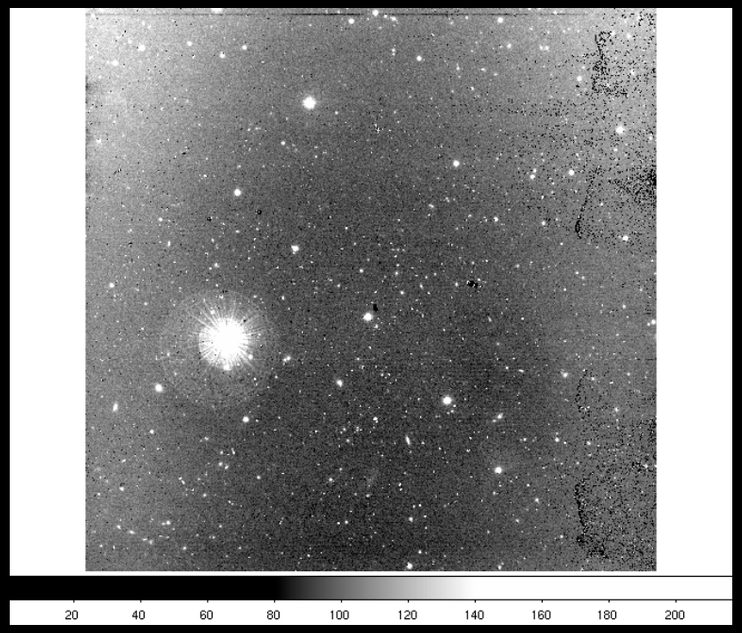
VIRCAM Stripes

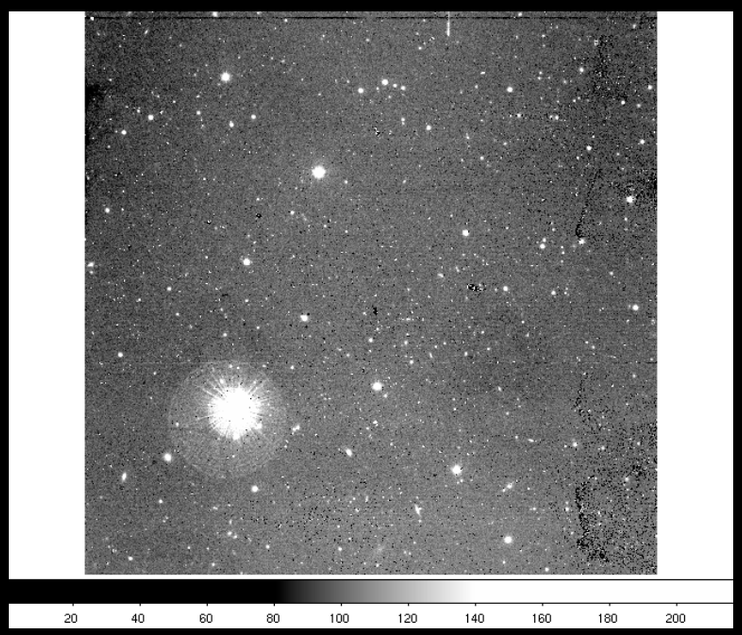


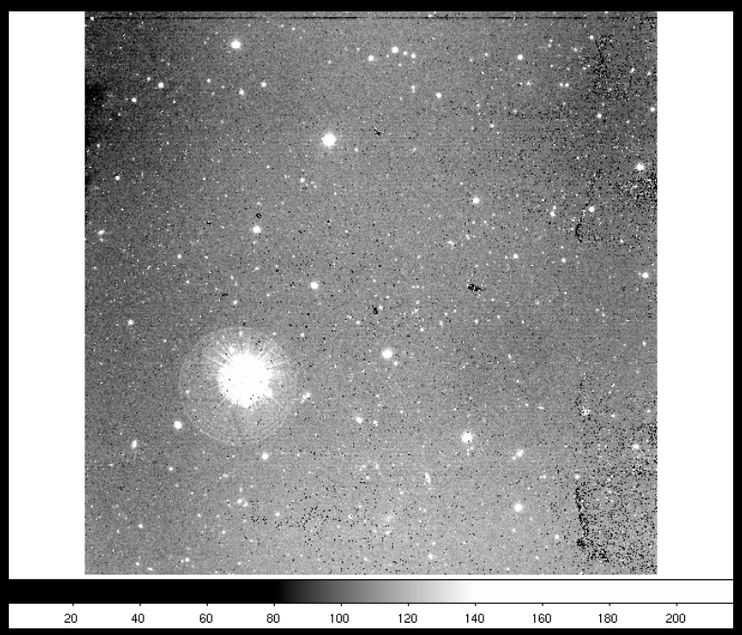


Time Variable Sky





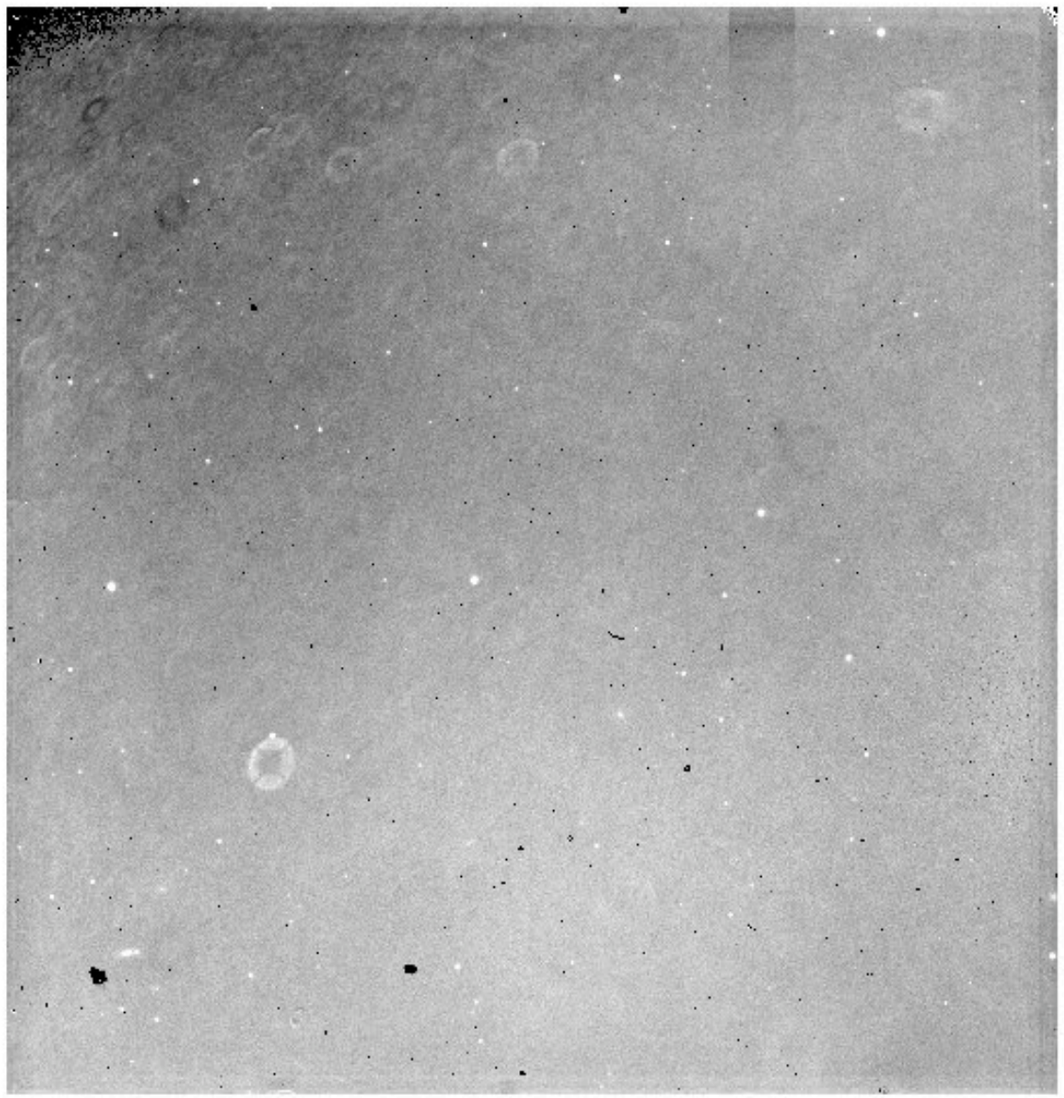


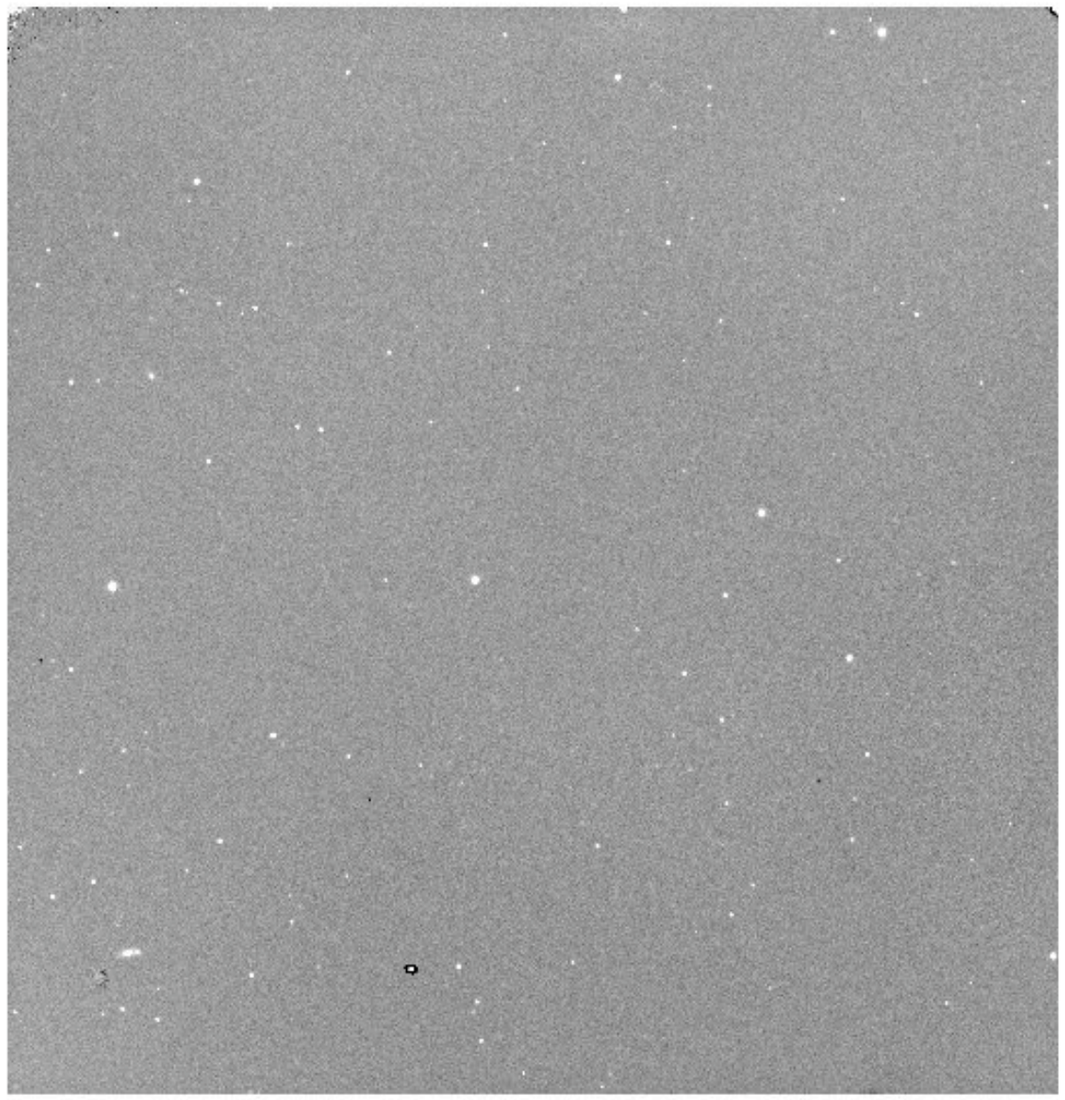


Available Sky Background Subtraction Algorithms

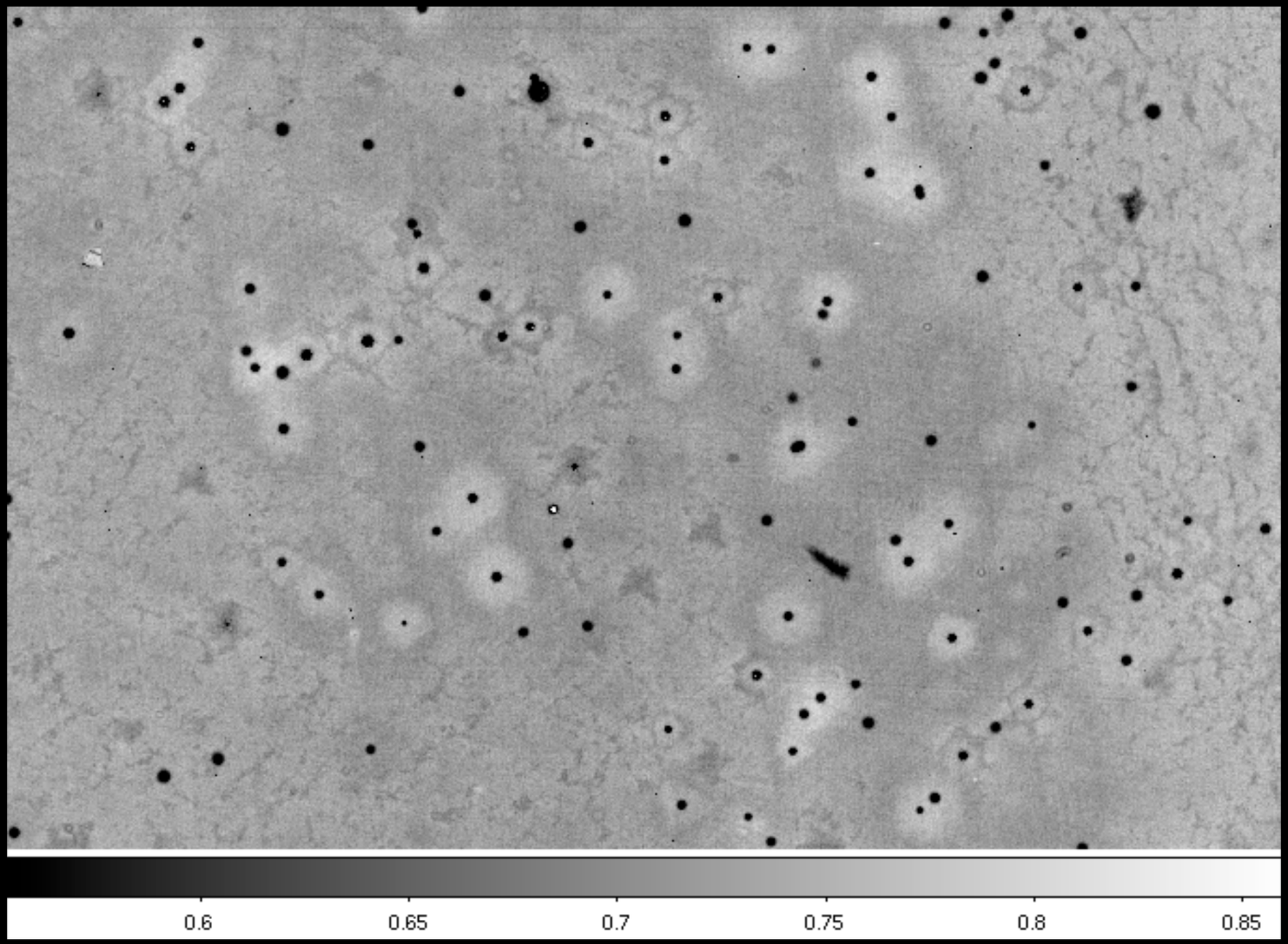
- Tilesky – double pass combination of all observations in tile(s)
- Pawsky – single pass combination of all observations in a pawprint with object masking iterated 'dynamically'
- Pawsky with object mask – as above, but the mask is defined beforehand using e.g. deep stacked tiles
- Offset sky – use a sky taken nearby (spatially & temporally)
- Pawsky and "half" tilesky - minus ****

Before And After Background Correction

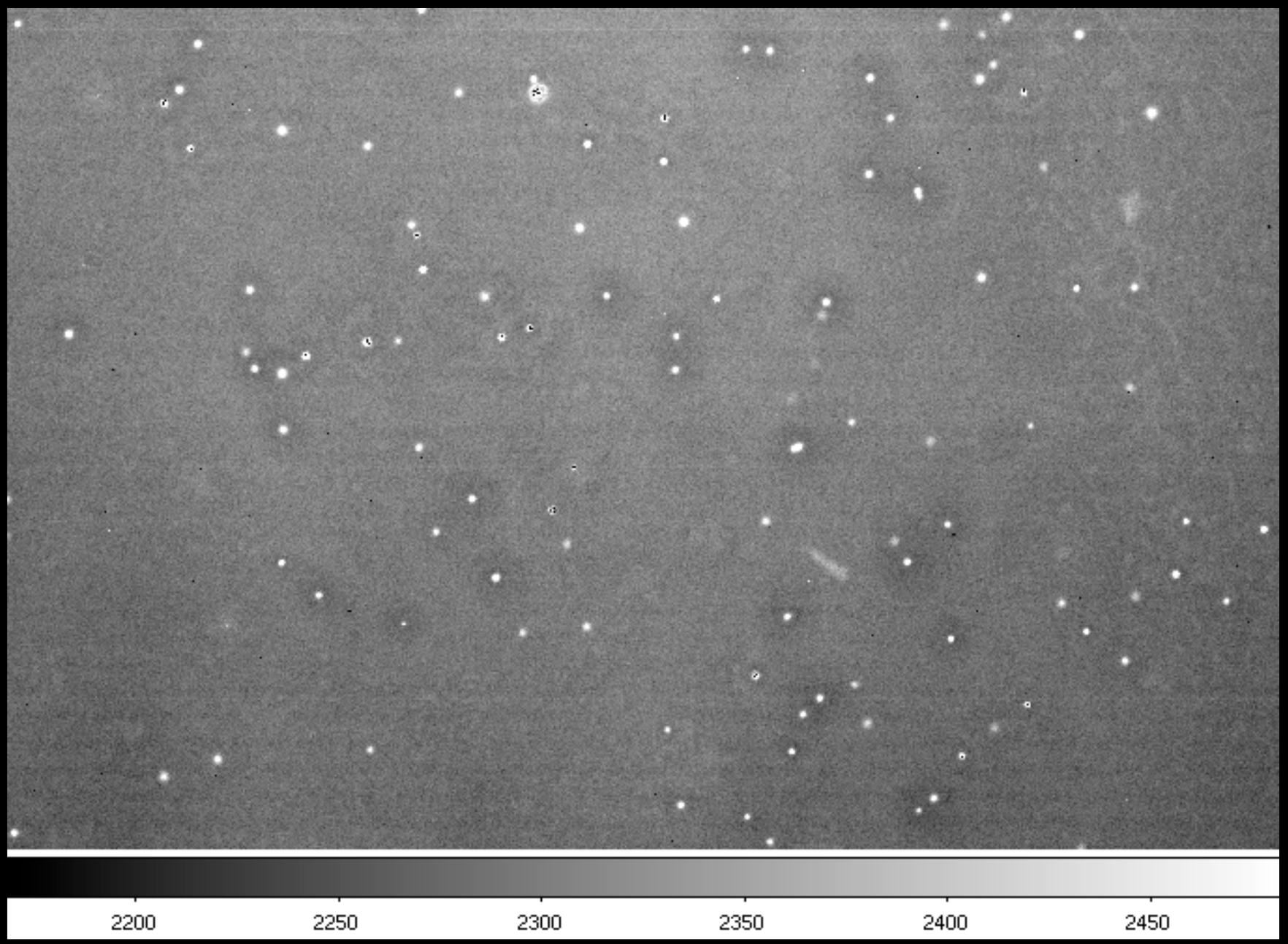




Flat Field Holes



-> Sky frame blobs (not stars)



General Detector Properties

- the VIRCAM detectors are non-linear (2-10%) @10k ADU
- the VIRCAM detectors do not use full 16 bit range
  - saturation levels 24k-37k

Detector	Linearity (%)	Saturation (ADU)
1	2.33	33000
2	3.32	32000
3	3.79	33000
4	3.50	32000
5	1.98	24000
6	2.98	28000
7	1.99	35000
8	3.38	33000
9	3.31	35000
10	4.44	35000
11	4.64	37000
12	2.55	34000
13	9.99	33000
14	2.72	35000
15	1.74	34000
16	3.28	34000

Astrometric Calibration 2MASS - VISTA

WCS - ZPN projection $\quad r' = r + k_3 r^3 + k_5 r^5 \ldots$

NB. tiles are TAN projection

Linear solution
per detector

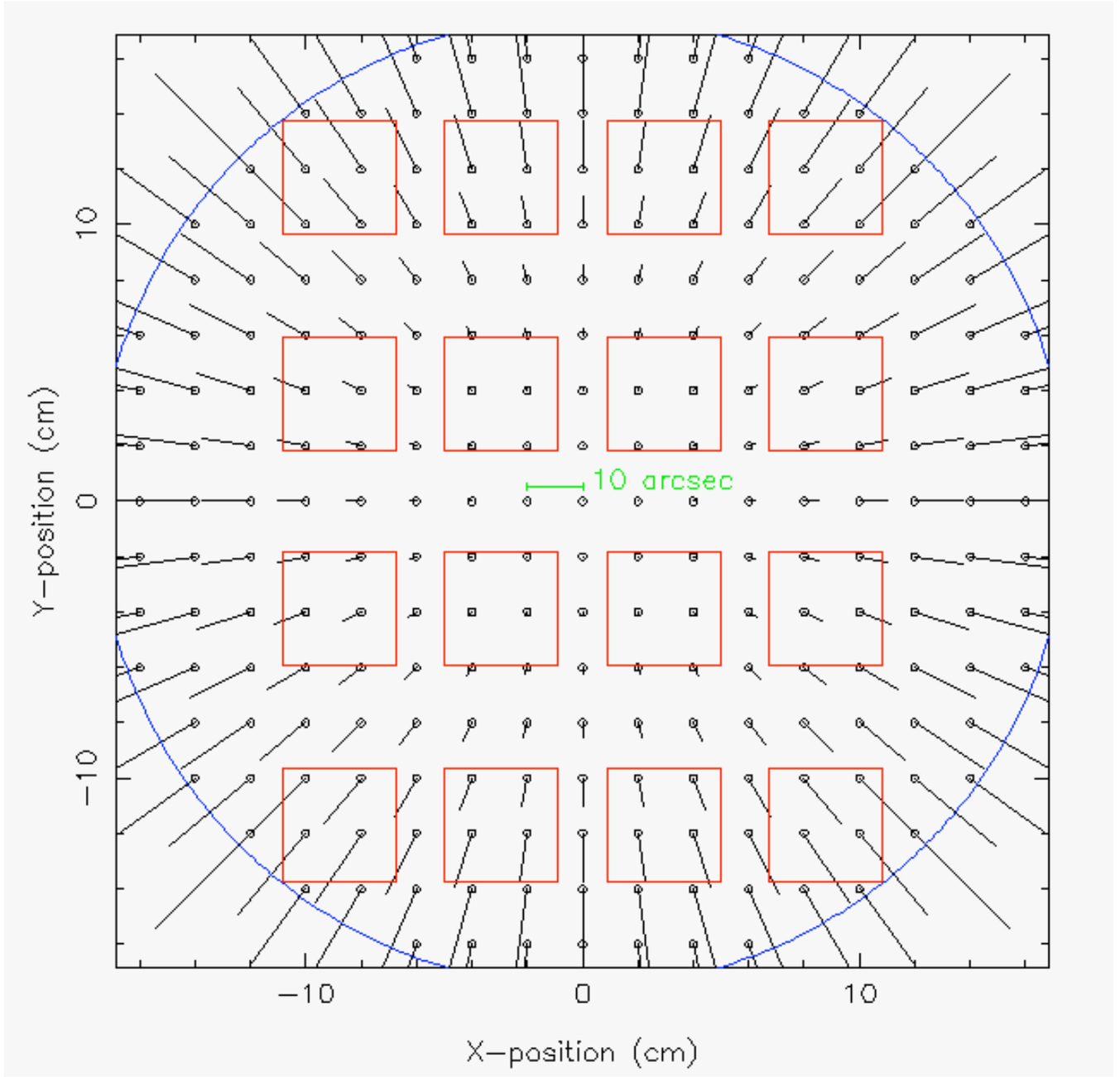
$$\xi' = ax' + by' + c$$

$$\eta' = dx' + ey' + f$$

⟶ rms < 100 mas

Tabulated
systematics
from stacked
residuals

⟶ sys < 25 mas



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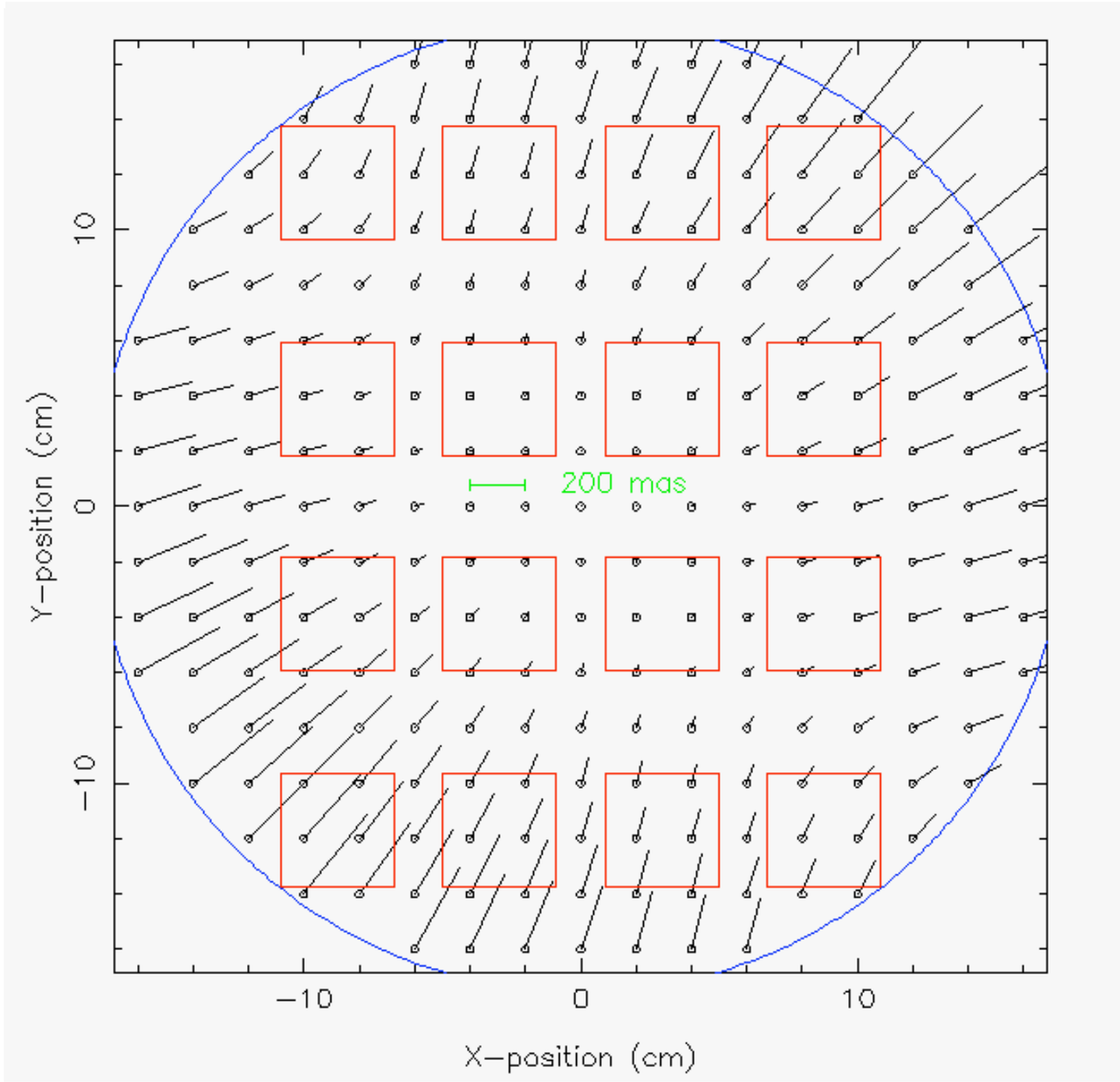
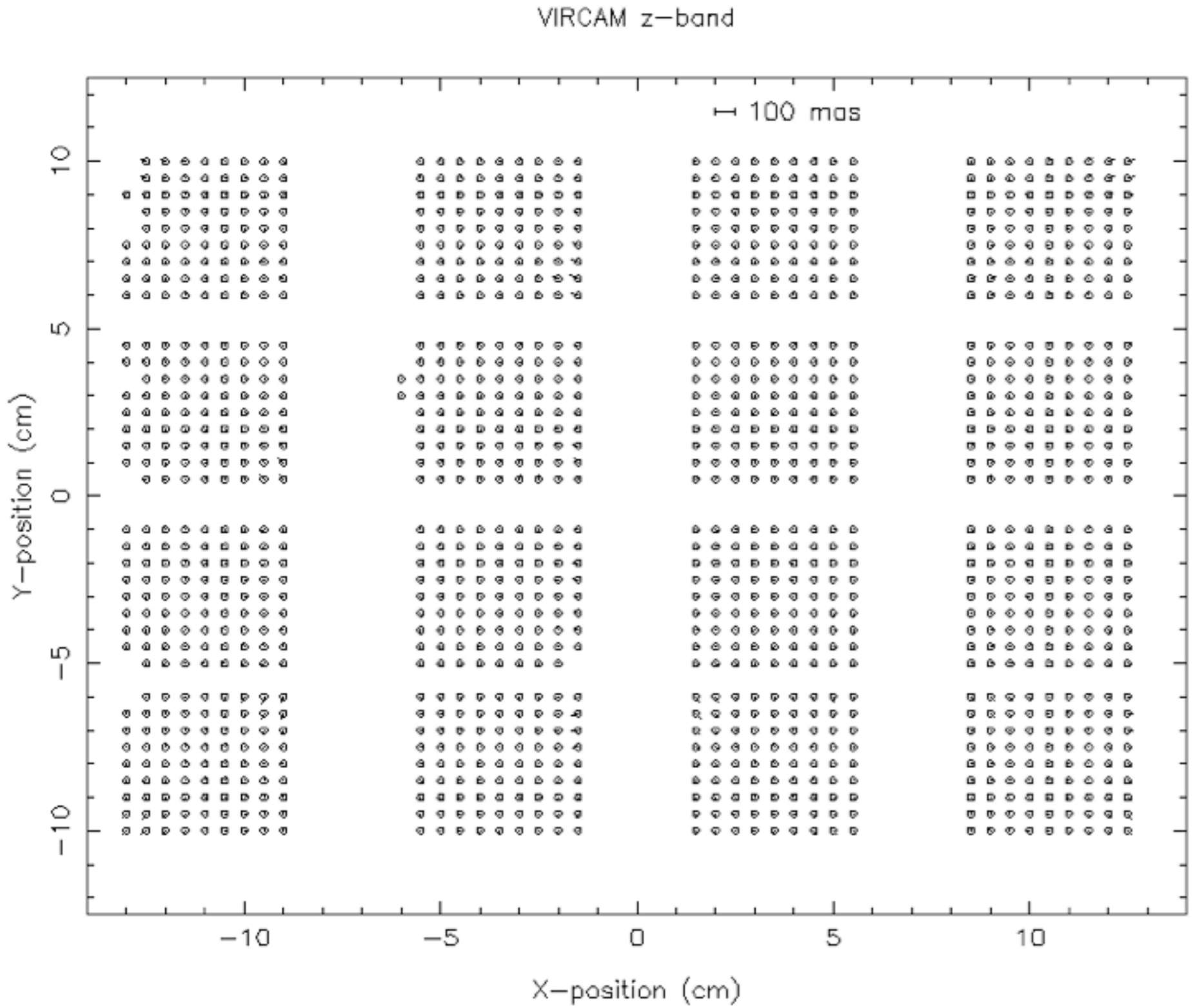
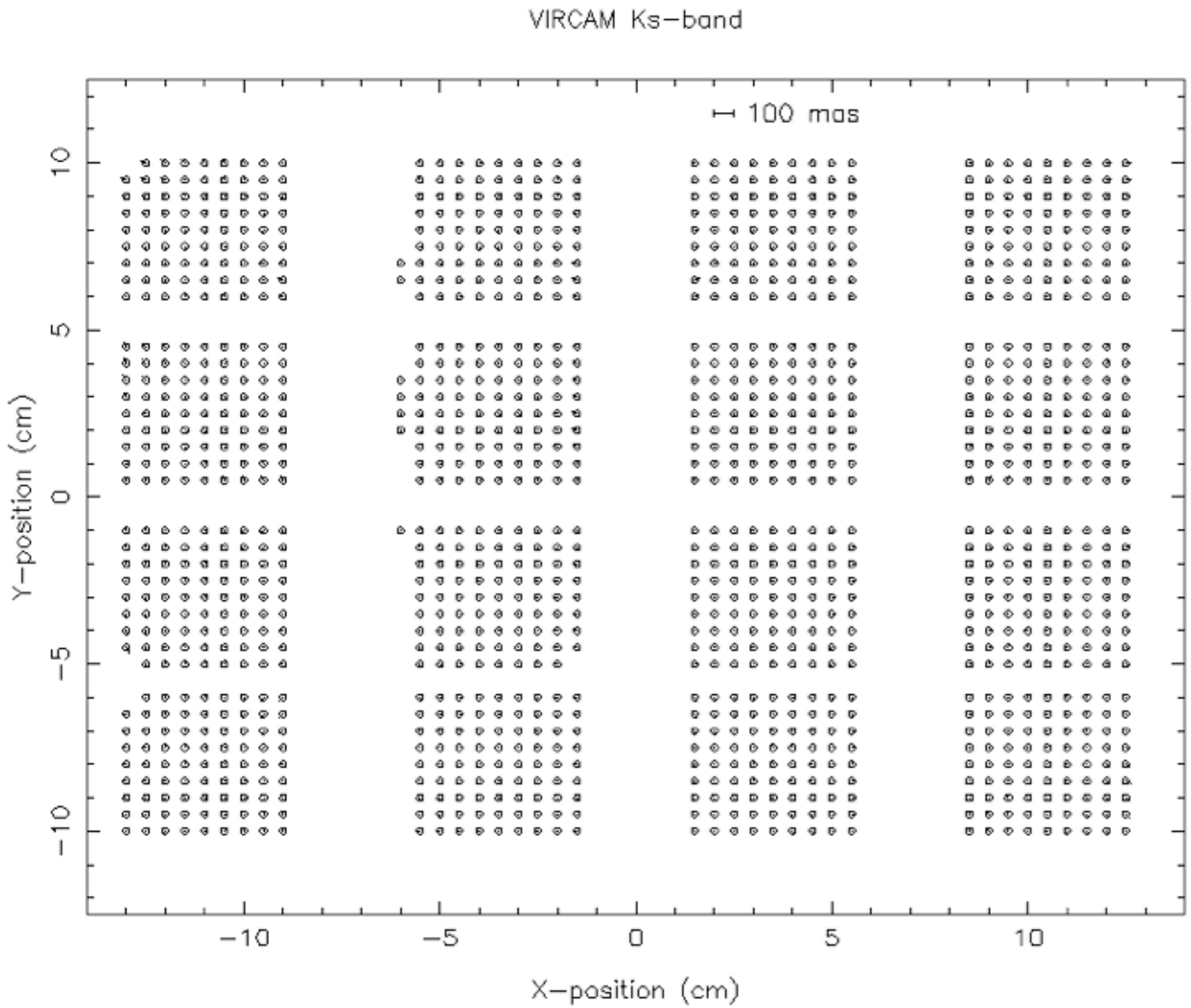


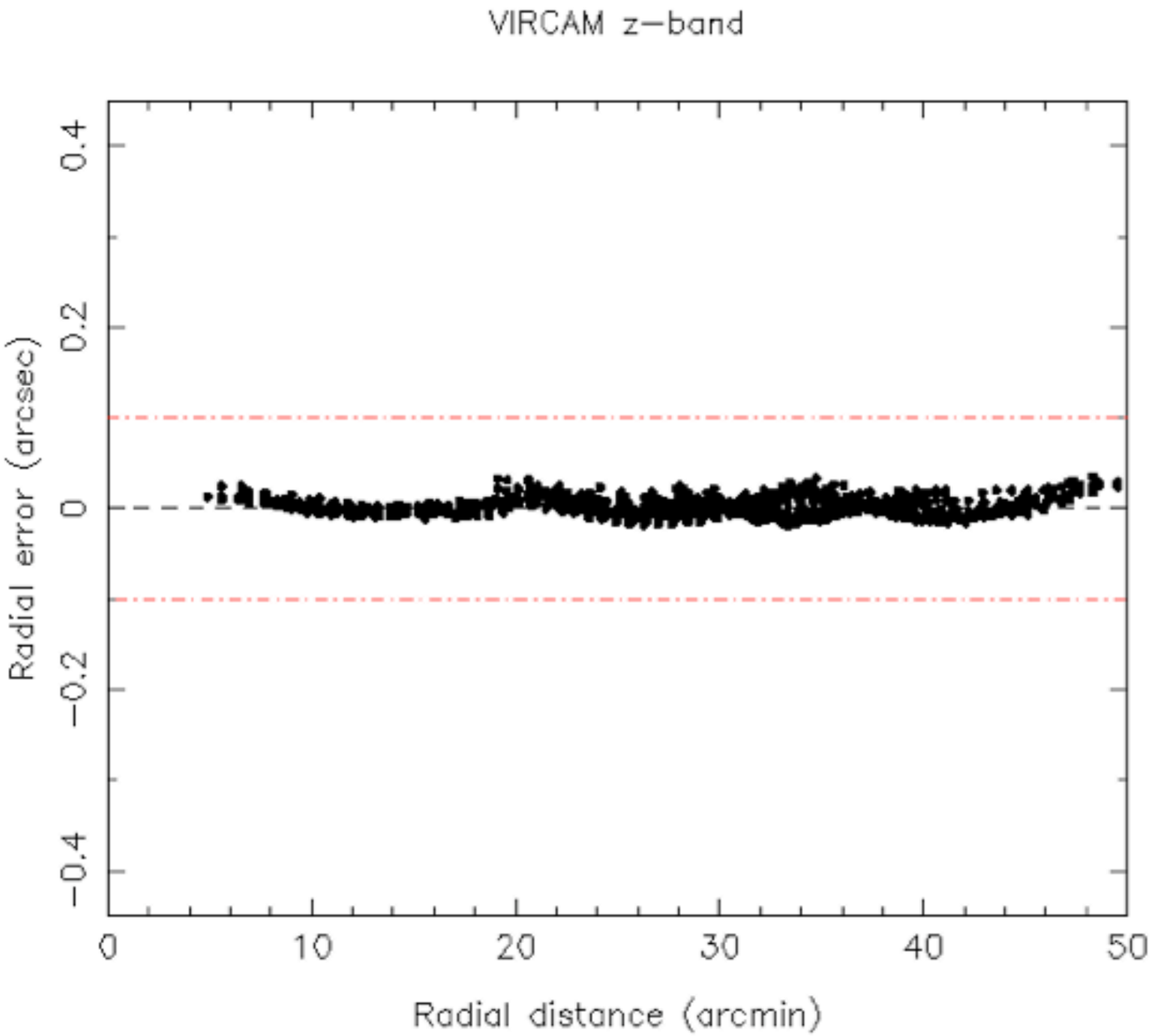
Astrometric Calibration - residual distortion map



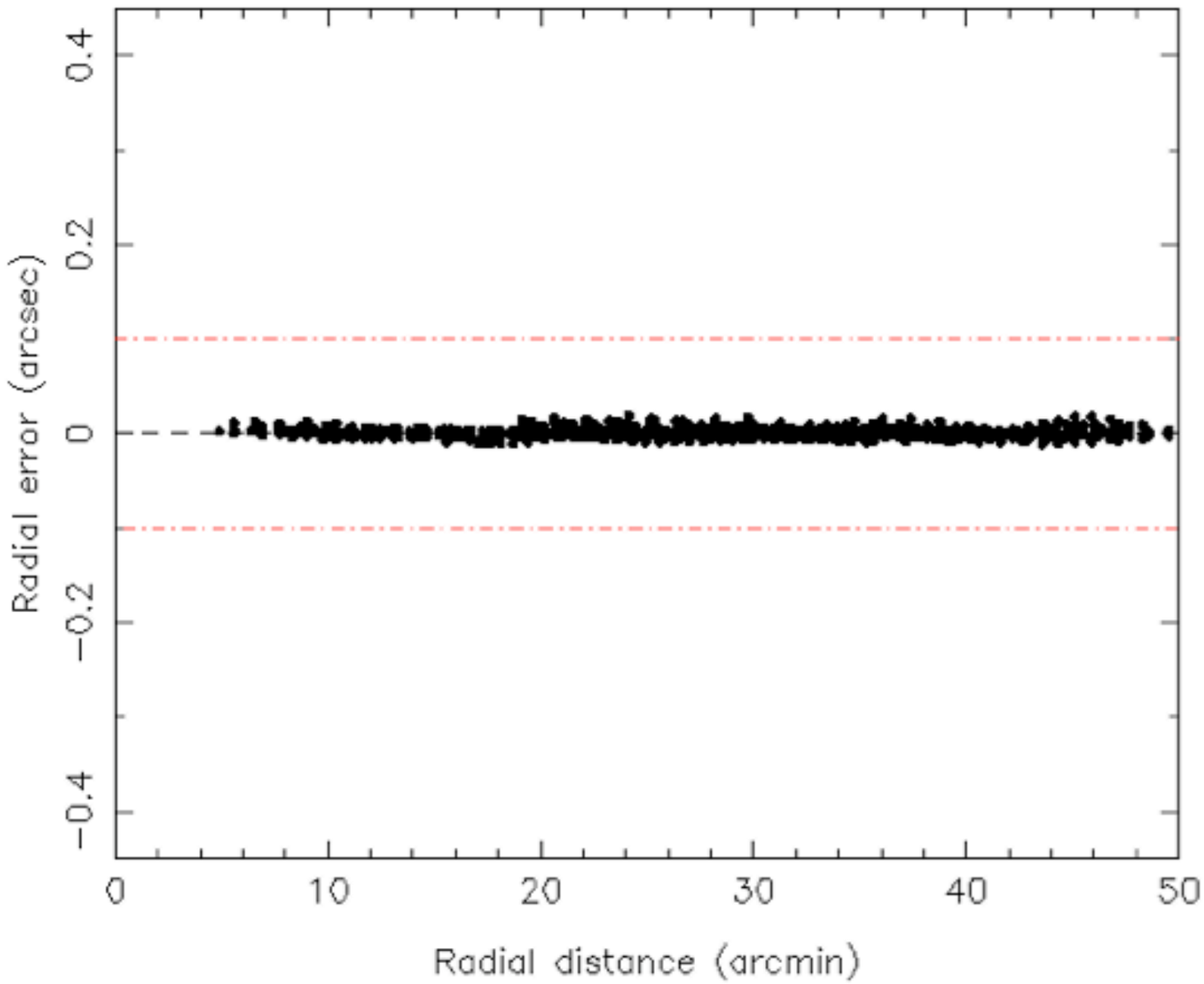
Astrometric Calibration - residual distortion map



Astrometric Calibration - residual distortion map



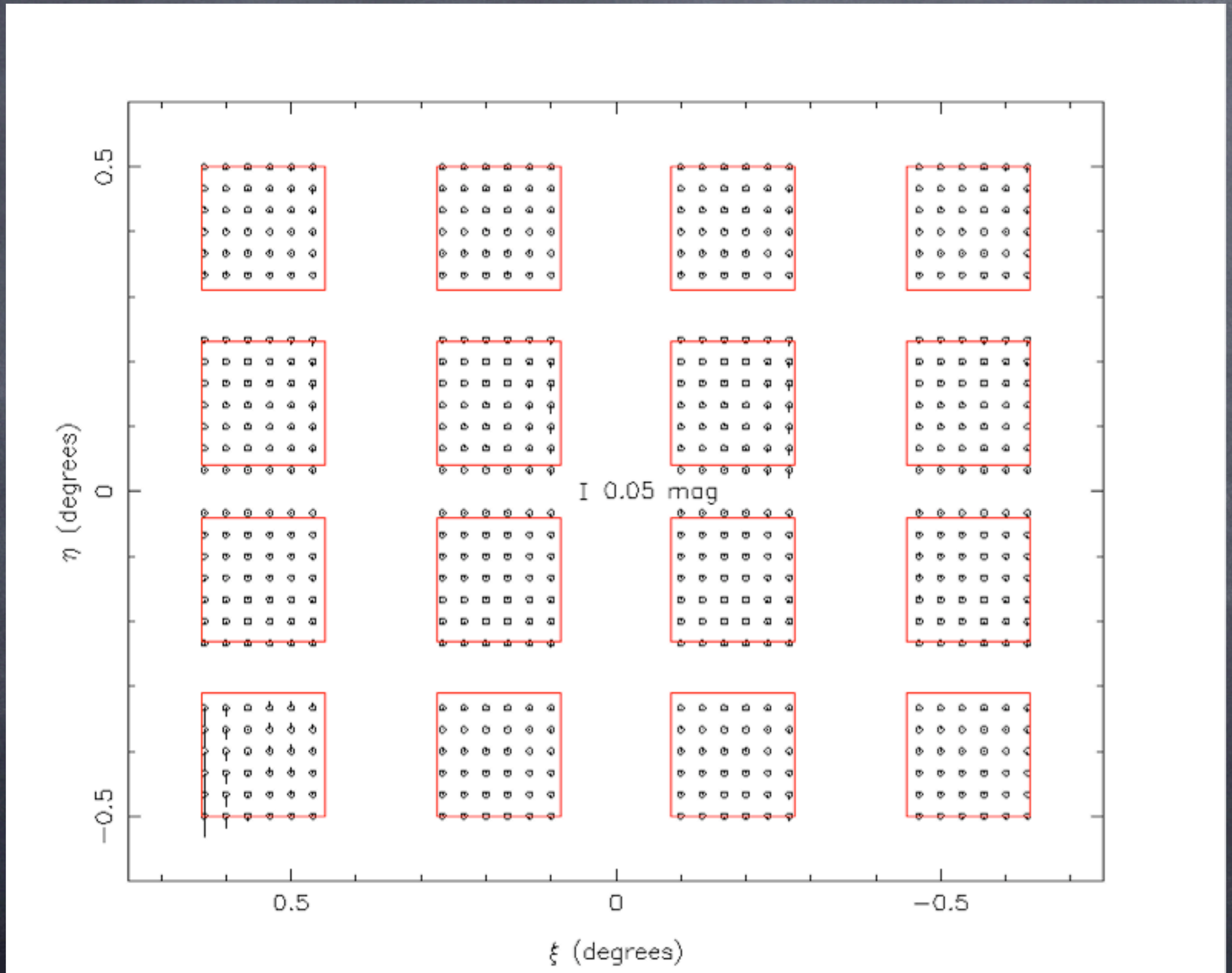
Astrometric Calibration - residual distortion map



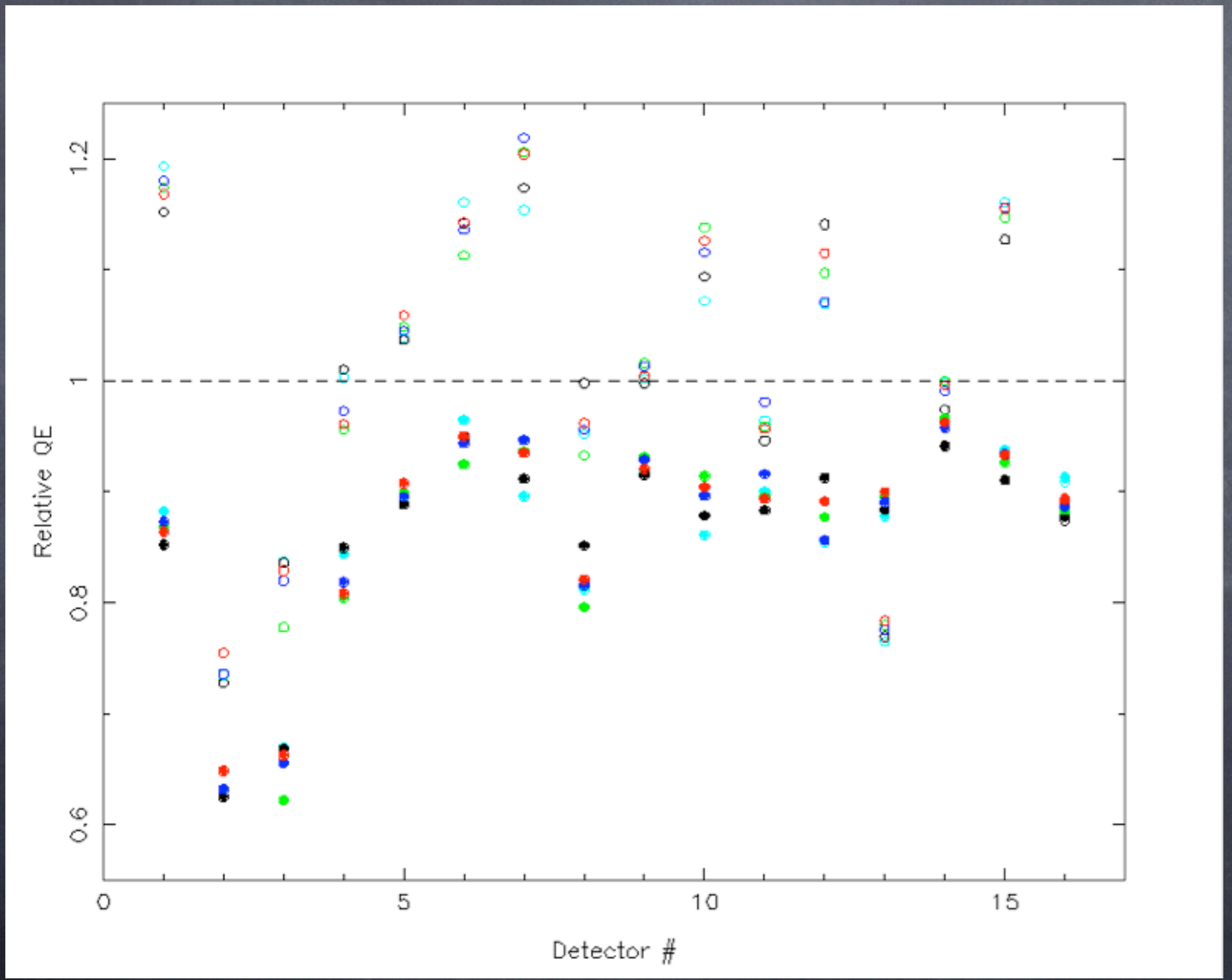
Photometric calibration (2MASS incl. touchstone fields)

- colour equations to convert 2MASS to instrumental system
- 2MASS s:n> 10 in J,H,Ks and
  - 0 < (J-Ks) < 2 & 0 < (J-Ks)_o < 1 (extinction corr)
  - 0 < (J-Ks) & (J-Ks)_o < 1 & (J-Ks) < 0 (update extcorr)
  - no restriction
- NIR ~100-1000 "standards" per pointing
- required to be stellar and unsaturated
- Zpt + error per pointing; can compare with FS fields
- monitor long term Zpt behaviour
  - average monthly detector Zpt offsets
  - illumination corrections

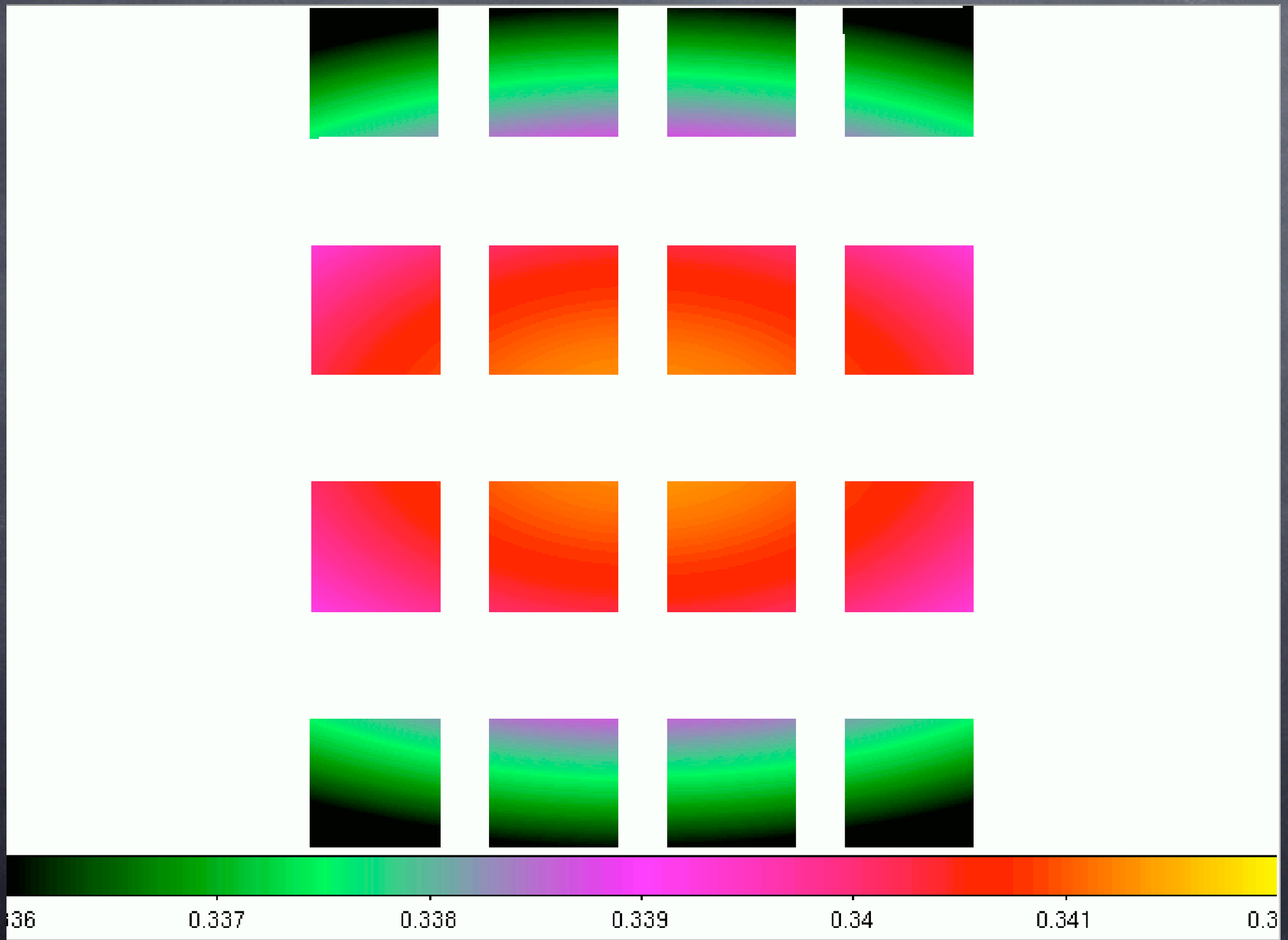
Illumination correction J-band



Relative QE for VISTA detectors



Variation of x,y pixel scales



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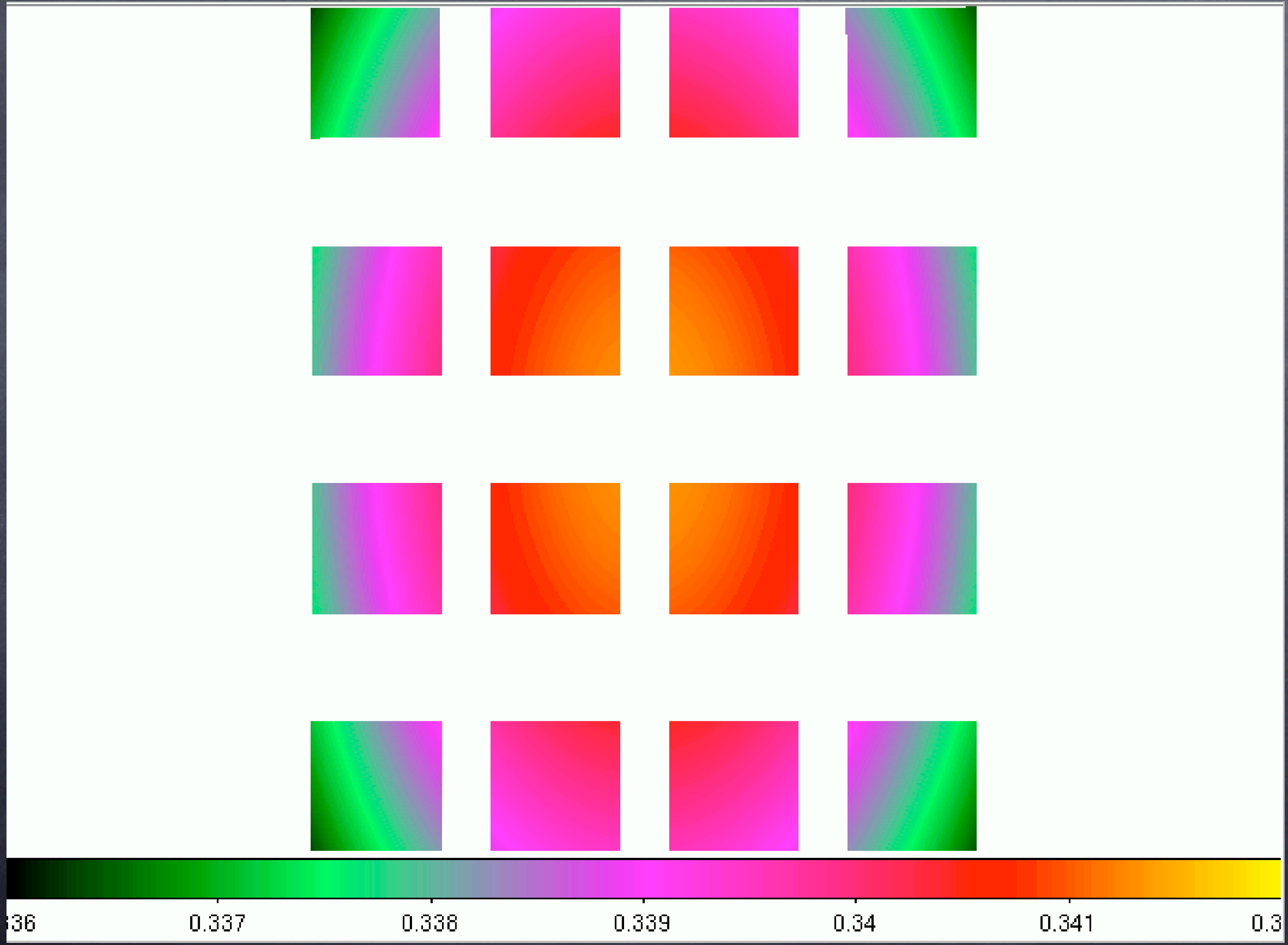
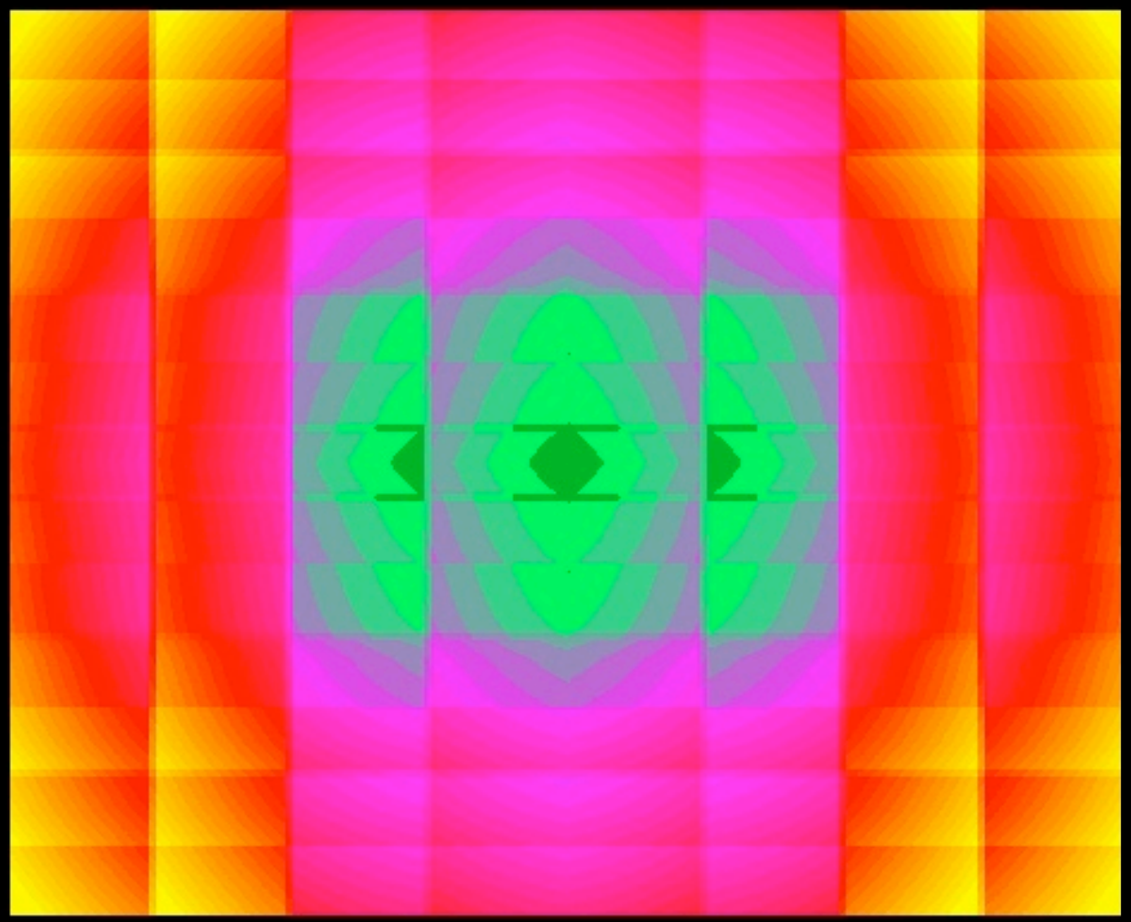
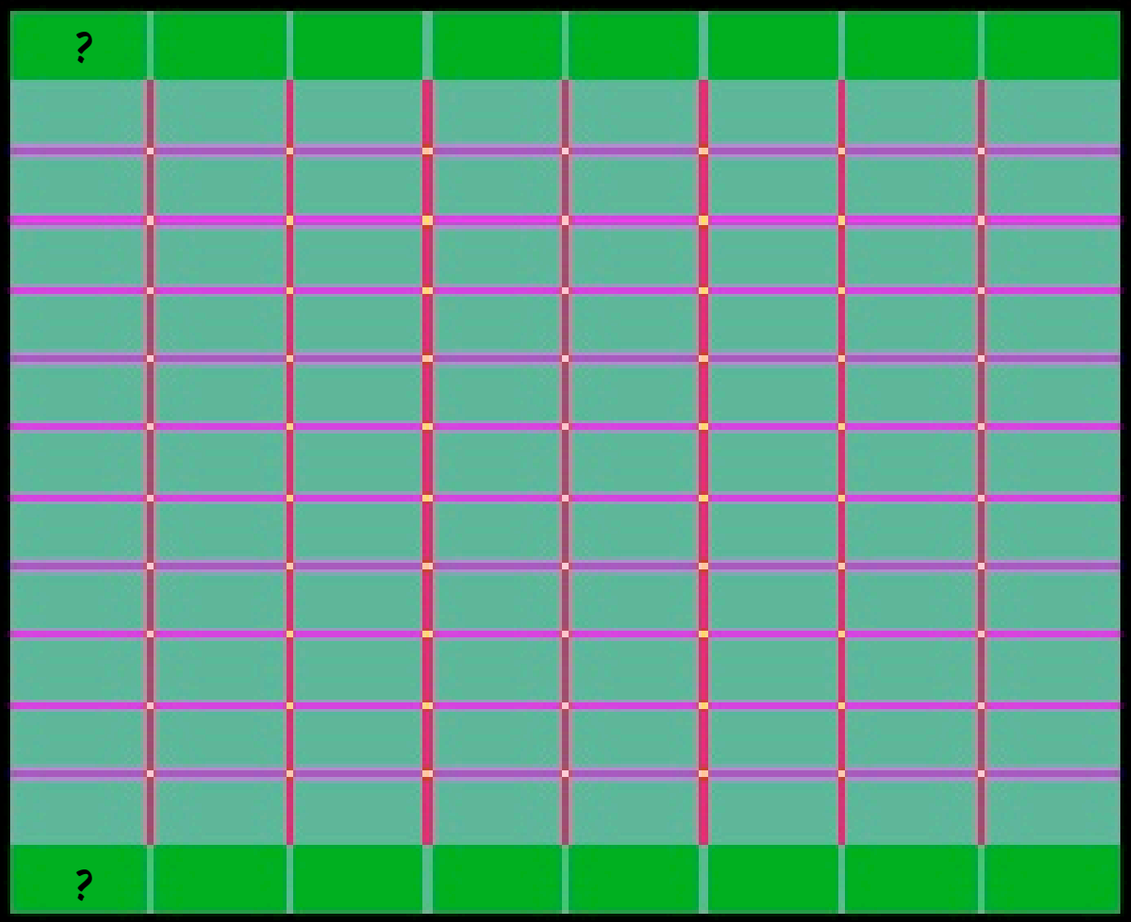


VISTA photometric distortion

Inherent illumination correction



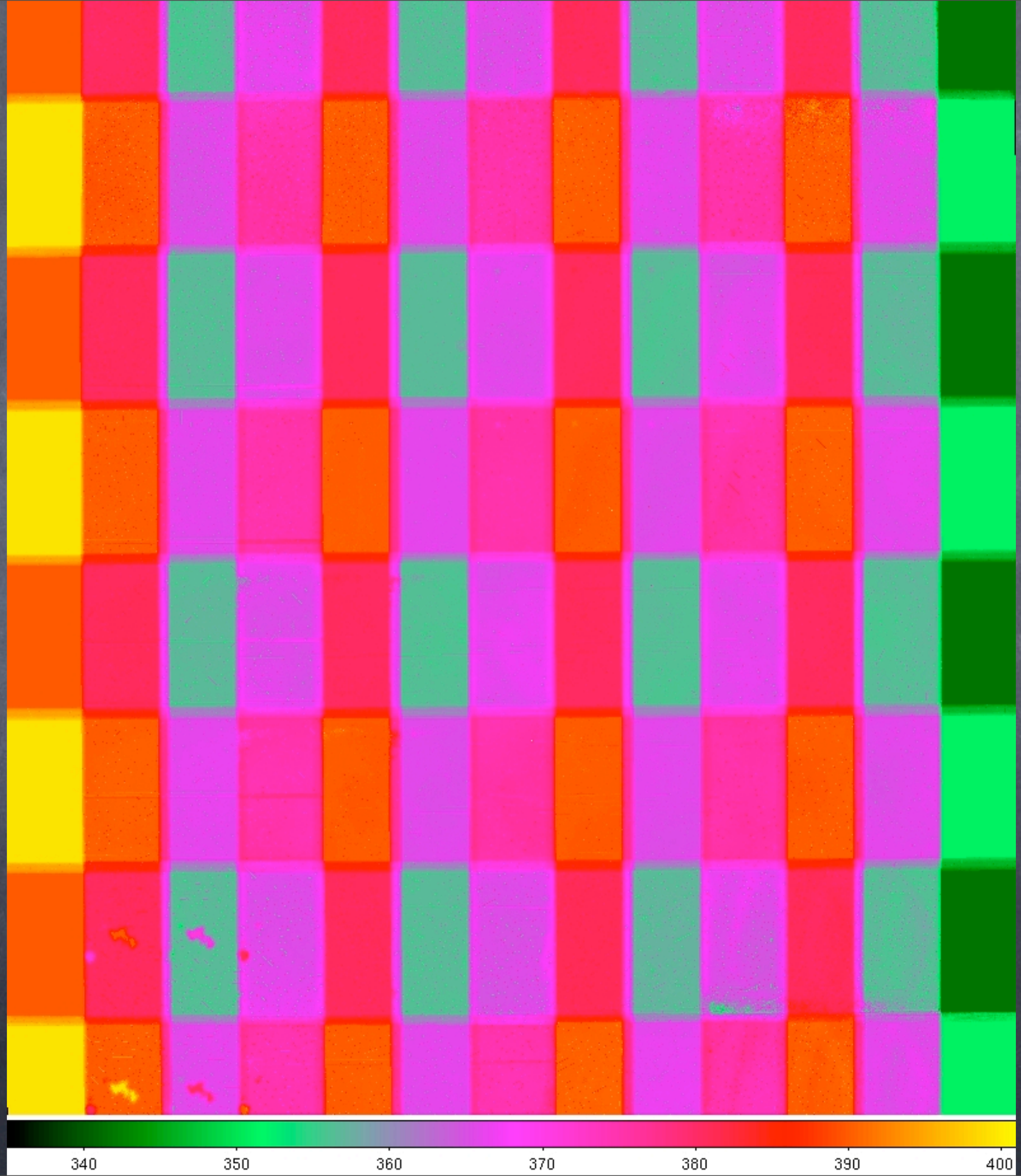
Tile exposure map



Issues with tiles

- imperfect sky subtraction pawprint matching
  - low level discontinuous artefacts
- variable PSF across single pawprints
  - each detector has different PSF
- variable seeing conditions
  - each pawprint has different PSFs
- variable saturation levels
  - each detector has different levels
- variable extinction during tile observation
  - variation of Zpt over tile
- astrometric distortion = need for
  - photometric distortion correction (sky -v- objects)
- interpolation options (NN, drizzle, cubics)
  - varying correlated noise patterns
- "interesting" MJD pattern

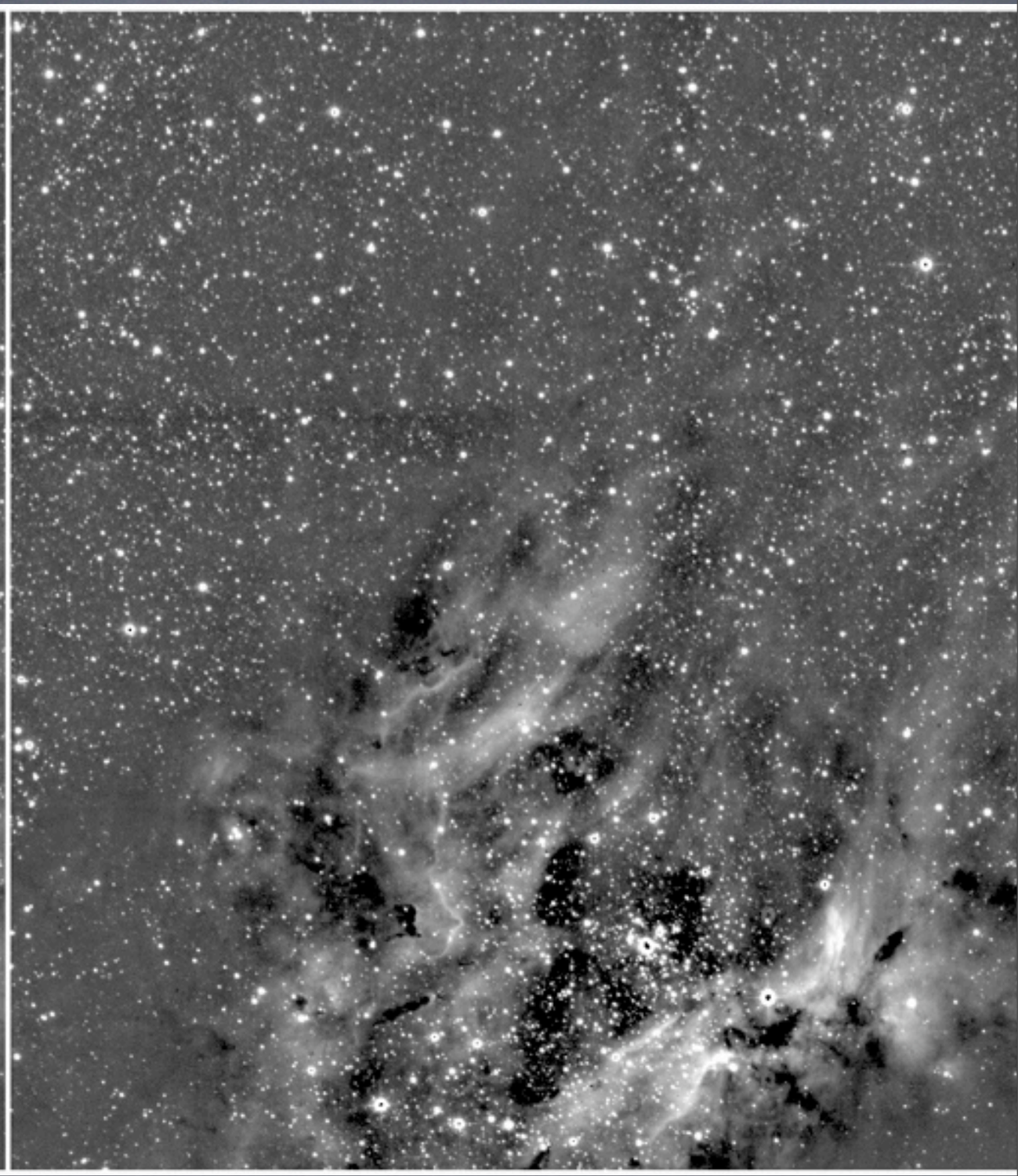
MJD variation across tiles



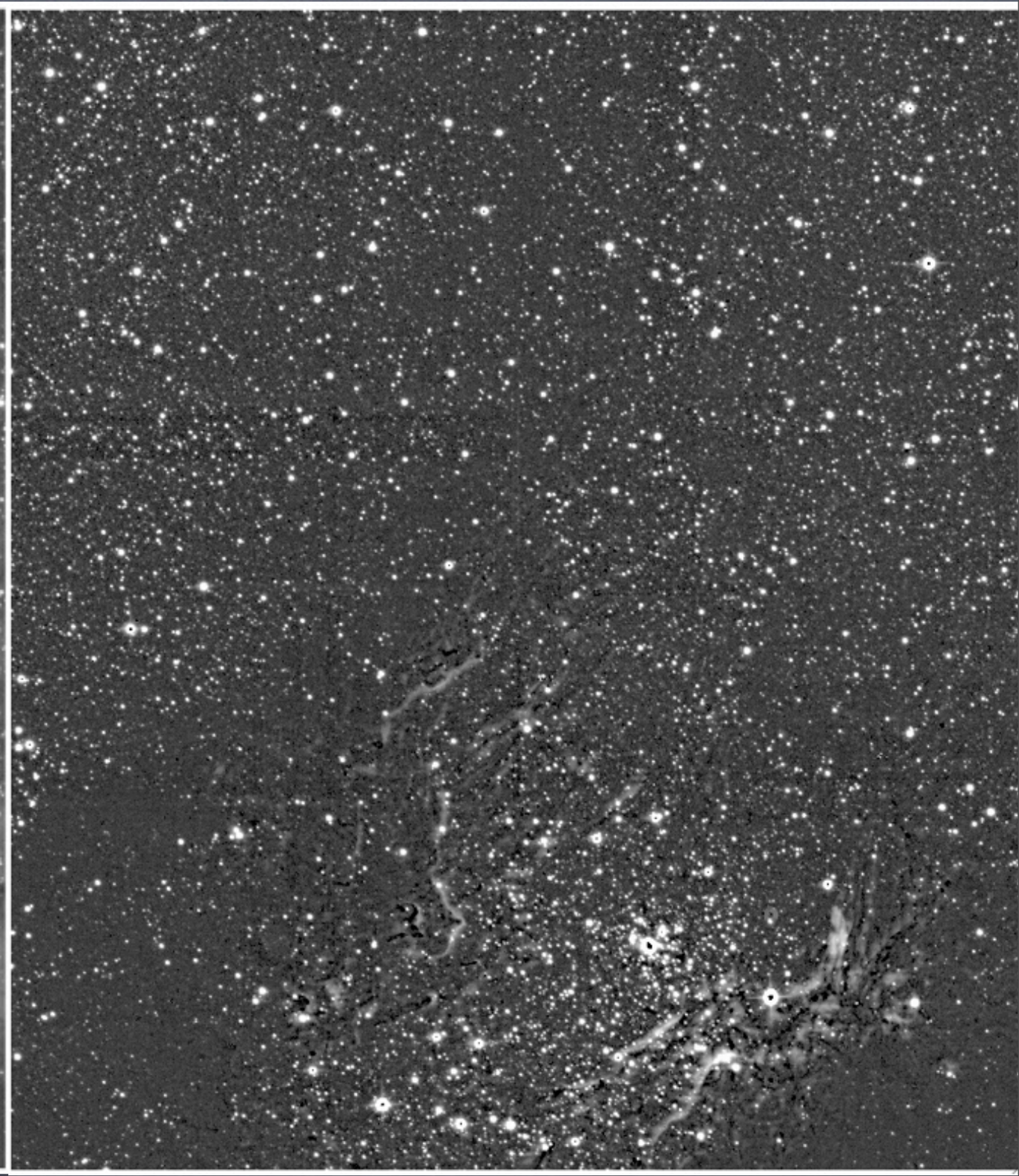
Innovative software solutions

- nebuliser
  - removes complex background variations
  - enhanced object detection & parameterisation
- mosaicer
  - CASU tiling software developed for VISTA
- grouter
  - applied to tile catalogues to remove the effect of PSF variations and photometric throughput (+ MJD column)
- psf'ers
  - automatically generates detector-level PSFs
  - and performs PSF photometry

Nebuliser -> M17 K-band WFCAM

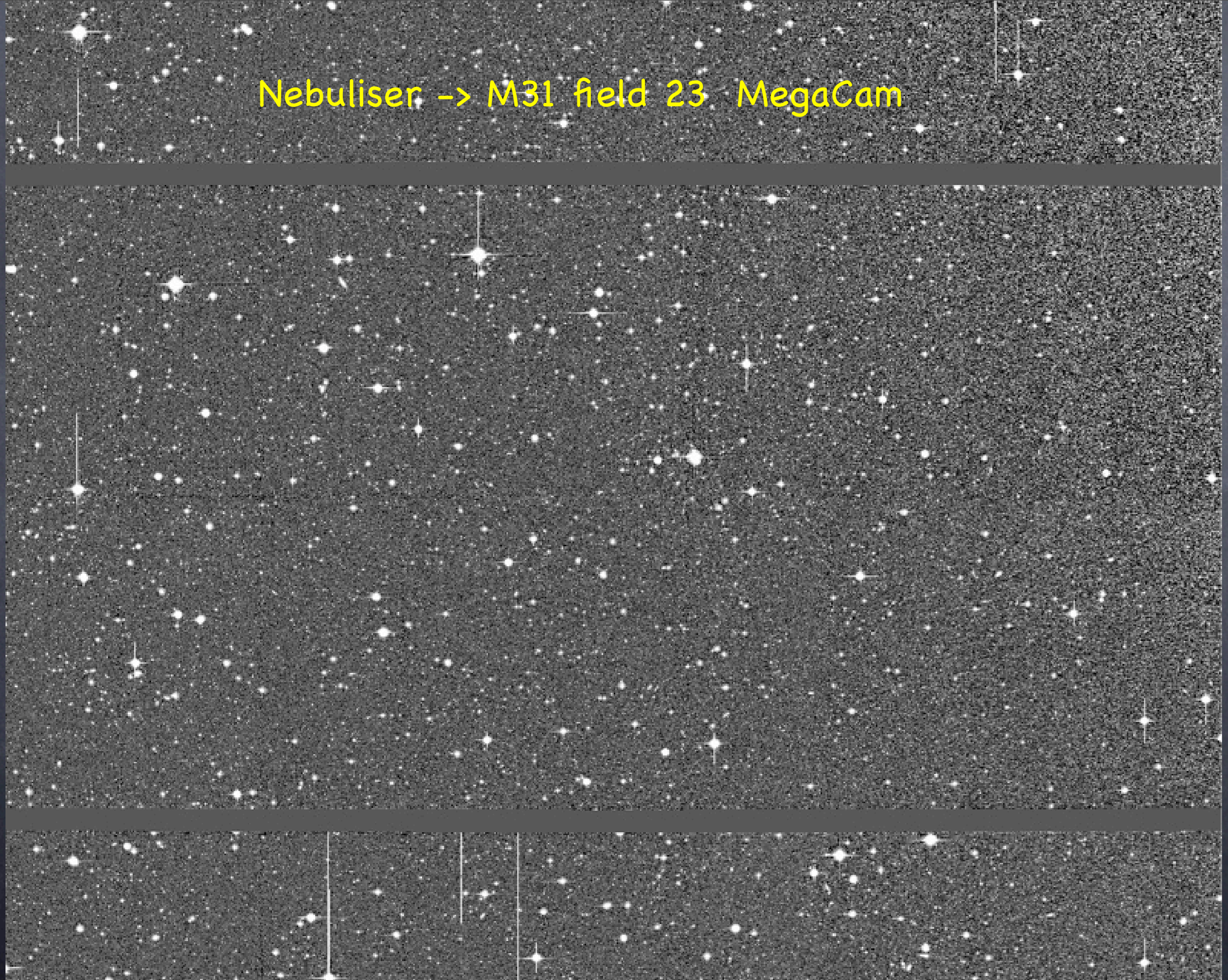


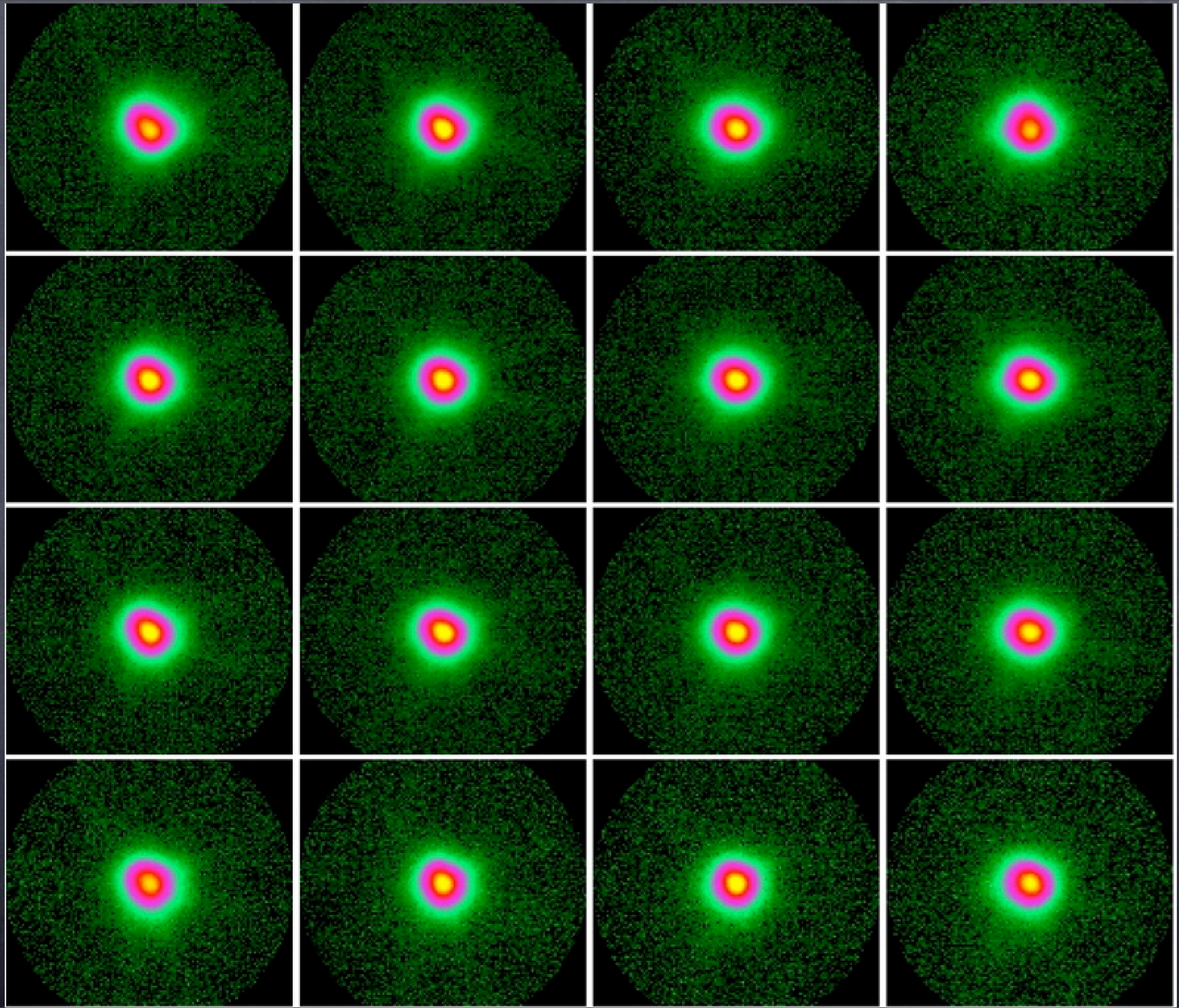
Nebuliser -> M17 K-band WFCAM

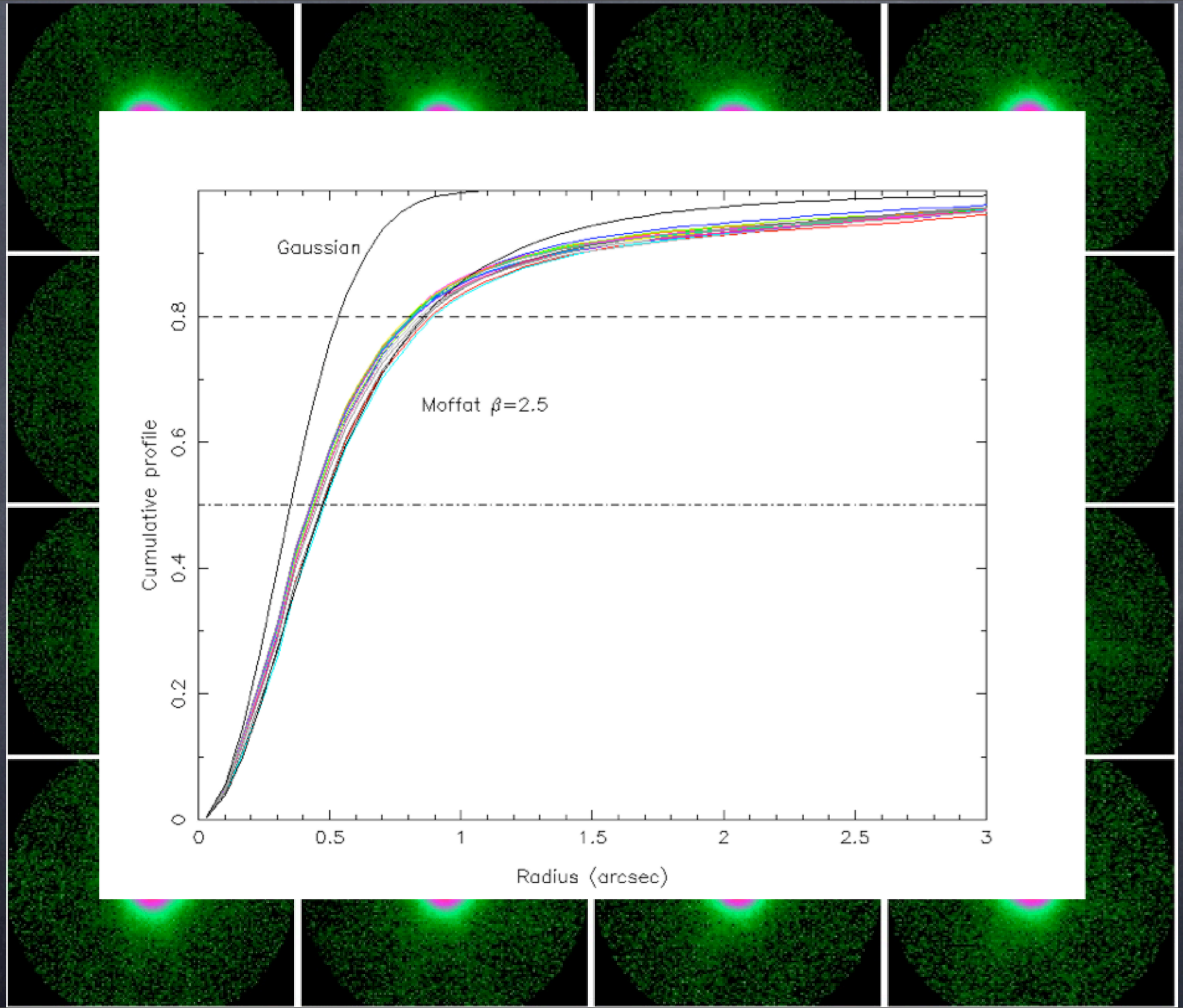


Nebuliser -> M31 field 23 MegaCam

Nebuliser -> M31 field 23 MegaCam






Gaussian
Moffat β=2.5
Cumulative profile
0
0.2
0.4
0.6
0.8
0
0.5
1
1.5
2
2.5
3
Radius (arcsec)