CASU processing for VISTA

- 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
16k x 13k pixels/
waveband
mosaic of 96 2k x 2k 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](http://casu.ast.cam.ac.uk/surveys-projects/vista)
## VISTA DATA REDUCTION PROGRESS: COMMISSIONING

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

<table>
<thead>
<tr>
<th>Night</th>
<th>Status</th>
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**Table description:**

- $N_{\text{raw}}$: total number of raw images for the given night (this includes darks, flats, focus runs etc.)
Monitoring sky surface brightness

![Sky Brightness vs. Time Graph](image)

- **Sky Brightness [mag/arcsec^2]**
- **Time after sunset [hour]**
- **Time before sunrise [hour]**

Legend:
- KS
- L
- Y
- N
- NB118
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
  - [Link](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
After the mirror coating intervention to the zero points are:

Same plot showing only the trend for more clarity:

Photometric ZP variation

Silvered
Aluminised

SV
P85
P86
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 arcfiile 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)
The VIRCAM detectors are non-linear (2-10%) at 10k ADU.

The VIRCAM detectors do not use full 16 bit range, with saturation levels ranging from 24k to 37k.
Astrometric Calibration 2MASS - VISTA

WCS - ZPN projection

\[ r' = r + k_3 r^3 + k_5 r^5 \ldots \]

Linear solution per detector

\[ \xi' = ax' + by' + c \]
\[ \eta' = dx' + ey' + f \]

\[ \text{rms} < 100 \text{ mas} \]

Tabulated systematics from stacked residuals

\[ \text{sys} < 25 \text{ mas} \]

NB. tiles are TAN projection
Astrometric Calibration 2MASS - VISTA

WCS - ZPN projection

\[ r' = r + k_3 r^3 + k_5 r^5 \ldots \]

\[ \xi' = a x' + b y' + c \]

\[ \eta' = d x' + e y' + f \]

\[ \text{rms} < 100 \text{ mas} \]

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NB. tiles are TAN projection

Linear solution per detector

Tabulated systematics from stacked residuals
Astrometric Calibration - residual distortion map

VIRCAM z-band

X-position (cm)  Y-position (cm)

-100 mas
Astrometric Calibration - residual distortion map

VIRCAM Ks-band

Y-position (cm)

X-position (cm)

\(\sim 100\) mas
Astrometric Calibration – residual distortion map
Astrometric Calibration - residual distortion map

![Graph showing residual distortion map](image)
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
Variation of $x,y$ pixel scales
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