Calibrating VISTA Data

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VISTA

- 4-m Survey Telescope
- 1.65 deg diameter FOV
- Near-IR Camera
Telescope
Camera
Focal Plane

- 16 Raytheon VIRGO 2k x 2k
- 4 x 4 sparse array
- spacings 90% & 42% of detector
- 0.34” pixels
1.65 deg diagonal

0.6 sq deg detector ‘pawprint’
Types of Calibration

calibrations characterize:

2. Transfer function (image in, DN out) of end-to-end system so that instrumental effects can be removed from the data.
   - VISTA has a wide field of view, so particular attention must be paid to variations across the field – illumination, etc etc

3. astrometric distortions of the images

4. photometric zero points and extinction coefficients

5. generate Quality-Control measures (see Riello’s talk).
Calibration Pipeline

- Removes instrumental artefacts
- Combine pawprints component exposures offset by small jitters
- Calibrates each pawprint photometrically and astrometrically
- Provides Quality Control measures

- See Jim Lewis’s talk
VISTA/WFCAM Similarity

VISTA & WFCAM have similar data

<table>
<thead>
<tr>
<th></th>
<th>WFCAM</th>
<th>VISTA</th>
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</thead>
<tbody>
<tr>
<td>Telescope</td>
<td>4-m (UKIRT)</td>
<td>4-m</td>
</tr>
<tr>
<td>2x2k Detectors</td>
<td>4 x Hawaii</td>
<td>16 x VIRGO</td>
</tr>
<tr>
<td>Pixel size</td>
<td>0.4 arcsec</td>
<td>0.34 arcsec</td>
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• How to mitigate risks in properly handling VISTA data (and archive volumes)?

• data flow system (developed in UK) designed to first handle already available WFCAM data

• Have learnt from this experience
Cross-Talk

• WFCAM has Cross talk from saturated images
  => ‘bumps’ symmetrically above and below brightest stars.
• WFCAM mostly (but not perfectly) correctable.
• VISTA???
Persistence

- On a sequence of (monthly) dates choose a fairly empty field with a nearly saturated star.
- Take an exposure and then a sequence of dark frames to measure the characteristic decay time.

WFCAM hard to correct. VISTA???
Dome ‘flat’ screen

- **Not** used for flatfielding

- For Monitoring
  - instrument performance
  - image structure
  - confidence maps

- Linearisation:
  Take series of differently timed dome screen observations under constant illumination.

- with pixel timing => true linear value for each pixel & bad-pixel maps for each detector
Twilight (flat) fields

- Used to remove multiplicative instrumental signatures
  - pixel-to-pixel gain variations
  - instrumental vignetting profile.
  - gain correction between the 16 detectors
  - gain correction between the 16 read out channels of each detector
Illumination Correction

Flat-field should remove all pixel-to-pixel gain differences as well as any large-scale variations due to vignetting within the focal plane.

BUT any scattered light within the camera may lead to large-scale background variations which cannot be modeled due to the ambient flux.

The illumination correction can be measured in three ways.

1. Secondary photometric standard fields (100-200 objects/detector) & look at the variation of zero-point across each detector.
=> map of spatial systematics across each detector

2. "mesostep" sequence of exposures of a sparse field of relatively bright stars on a regular grid of offsets to completely sample across the face of the detectors in medium-sized steps.
=> monitor residual systematics in photometry

3. Stacked zero point differences from 2MASS objects in each pawprint.
radial scale distortion also has an impact on photometric measurements, inducing an error up to 3.5% in the corners of the field, compared to the centre, if uncorrected.
Calibration: Photometric-0

- Goal 2% calibration accuracy
- Two *independent* methods:
  1. from 2MASS all-sky point source catalogue.
  2. from routine observations of standard star fields

- Zeropoints derived for each image
- allows monitoring of effective Zero Points at ~few % level.
- Subsequent inter-detector comparisons enable residual errors in the gain correction to be detected and calibrated.
- Offline analysis => measure of median zeropoint for the night, associated error (and scatter), indicative of photometric quality
Calibration: Photometry-1

- **Photometry-1**: based on 2MASS
- Initial photometric calibration for all filters based on 2MASS photometric system which is globally consistent to ~1% (Nikolaev et al. 2000).

- colour equations to convert 2MASS to VISTA instrumental system (with some colour s/n cuts)
- enables each detector image to be calibrated directly from 2MASS stars that fall within field of view.

- Analysis of WFCAM data wrt UKIRT standards => 2MASS calibration delivers product frame-by-frame photometric zero-points at the +/-2% level (with factored-in extinction tracking).
Calibration: Photometry-2

Photometry-2 based on a network of standard star fields:

- Network of Secondary Standard photometric fields, every 2 hours in RA will be set up with VISTA -2MASS 'Touchstone' fields and/or UKIRT faint standard fields
- ~100 stars/detector J<18, $\kappa < 16$ to avoid long exposures will characterize systematic position dependent photometric effects
- encompass broad spread in colour to derive colour terms robustly
- observe every two hours elapsed time throughout each night
- enables an independent calibration to be made on a nightly basis.

• Touchstone fields provide information on the stability
• used to measure illumination correction.
Extinction monitored

- from zeropoints of the 2MASS stars in each pawprint
- from zeropoints in individual Touchstone fields
- through each (photometric) night assuming a fixed zero point and measuring Touchstone fields over a range of airmass.
WFCAM cf 2MASS
The End