Data Flow System

Calibrating VISTA Data

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VISTA

Data Flow System

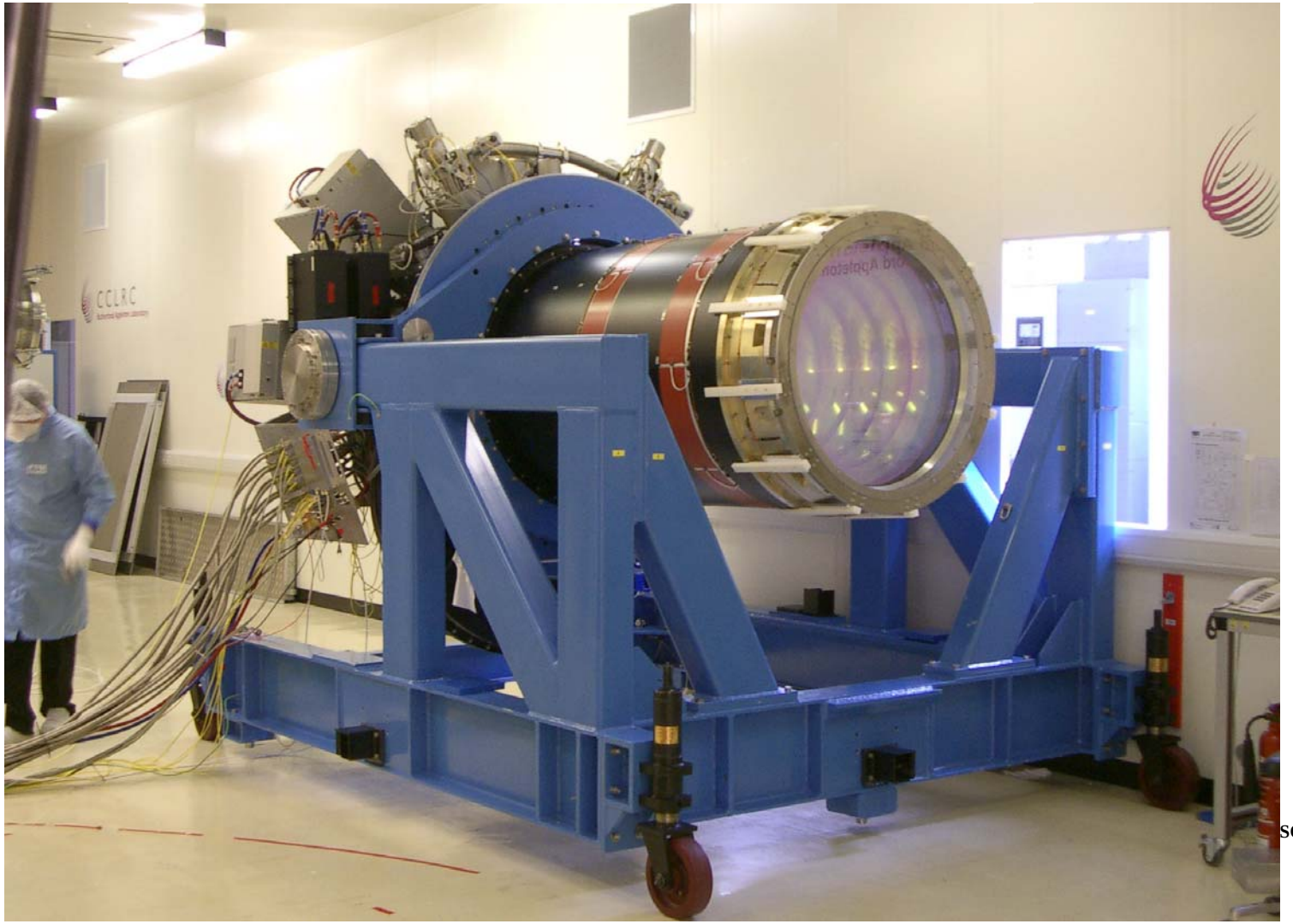
- 4-m Survey Telescope
- 1.65 deg diameter FOV
- Near-IR Camera

Telescope

Camera

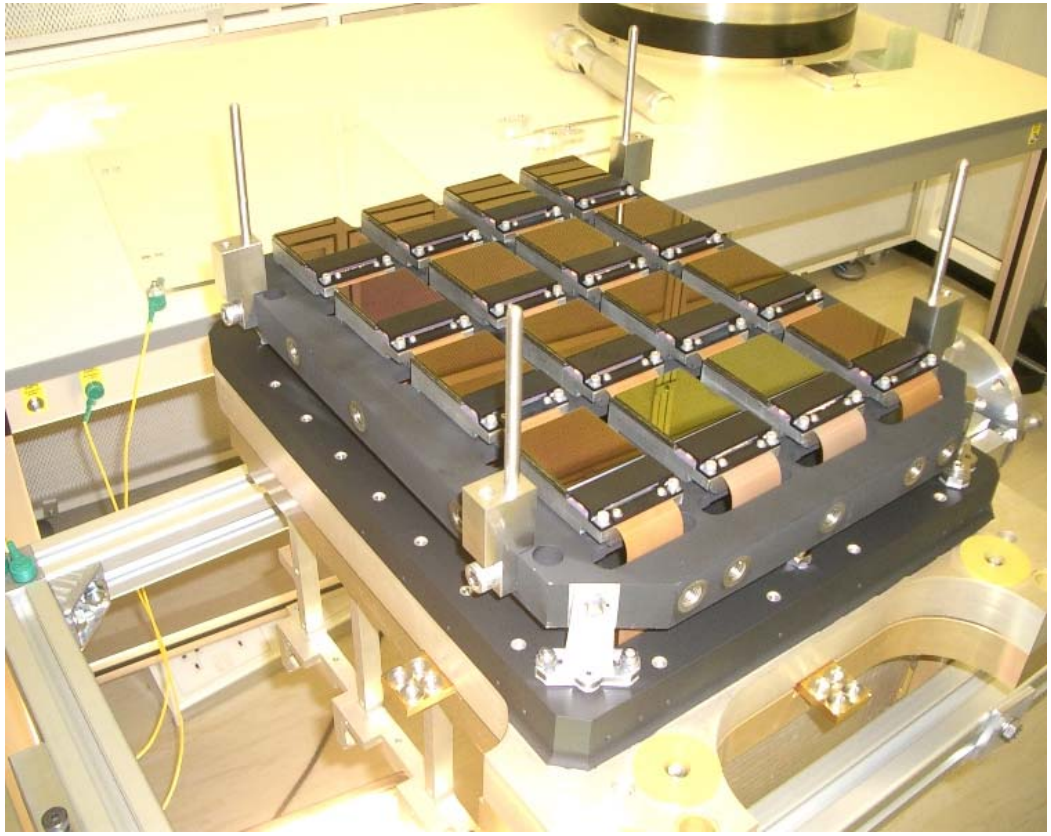
only one moving part, the filter wheel

Z,Y,J,H,Ks (0.9-2.5micron)



Focal Plane

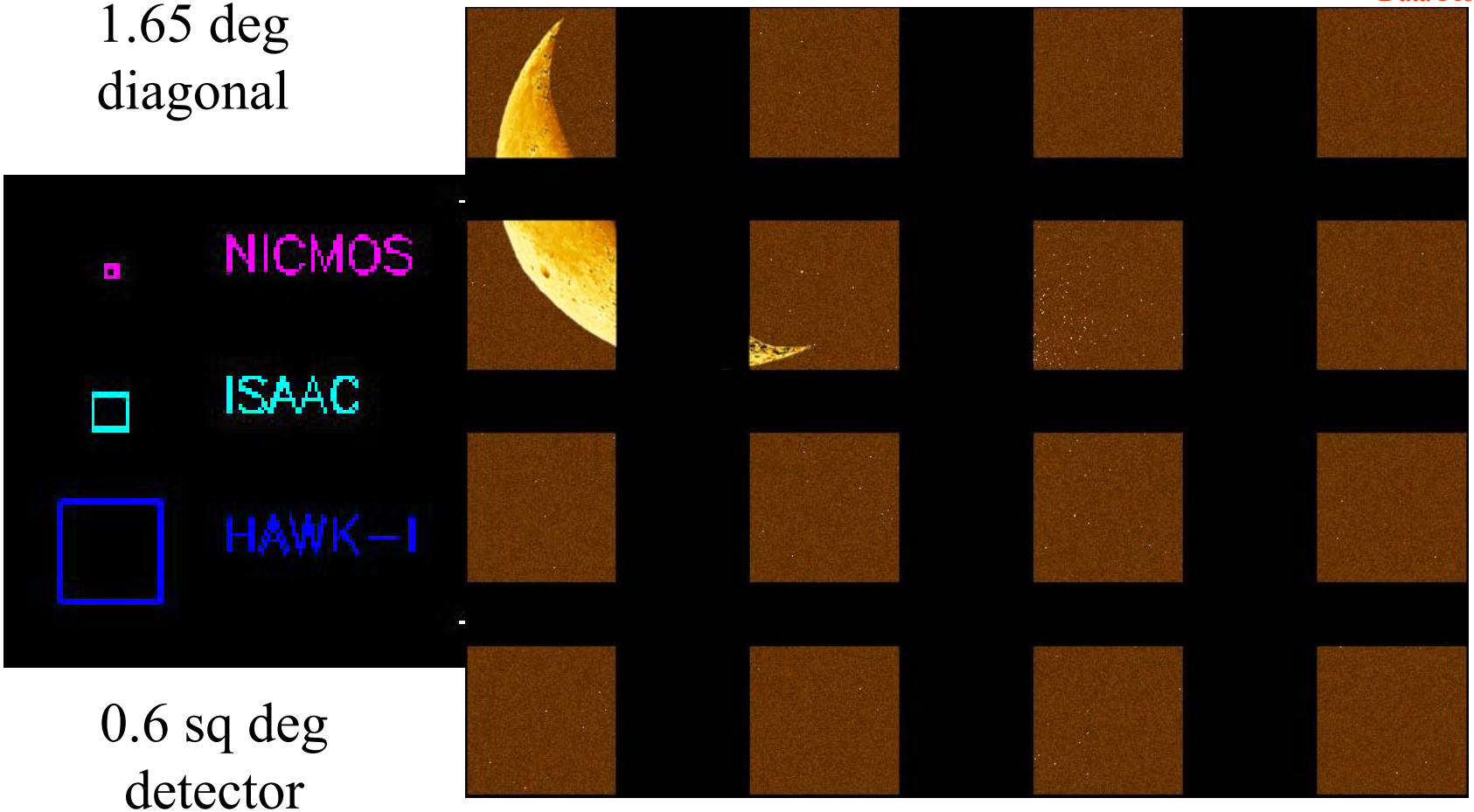
Data Flow System



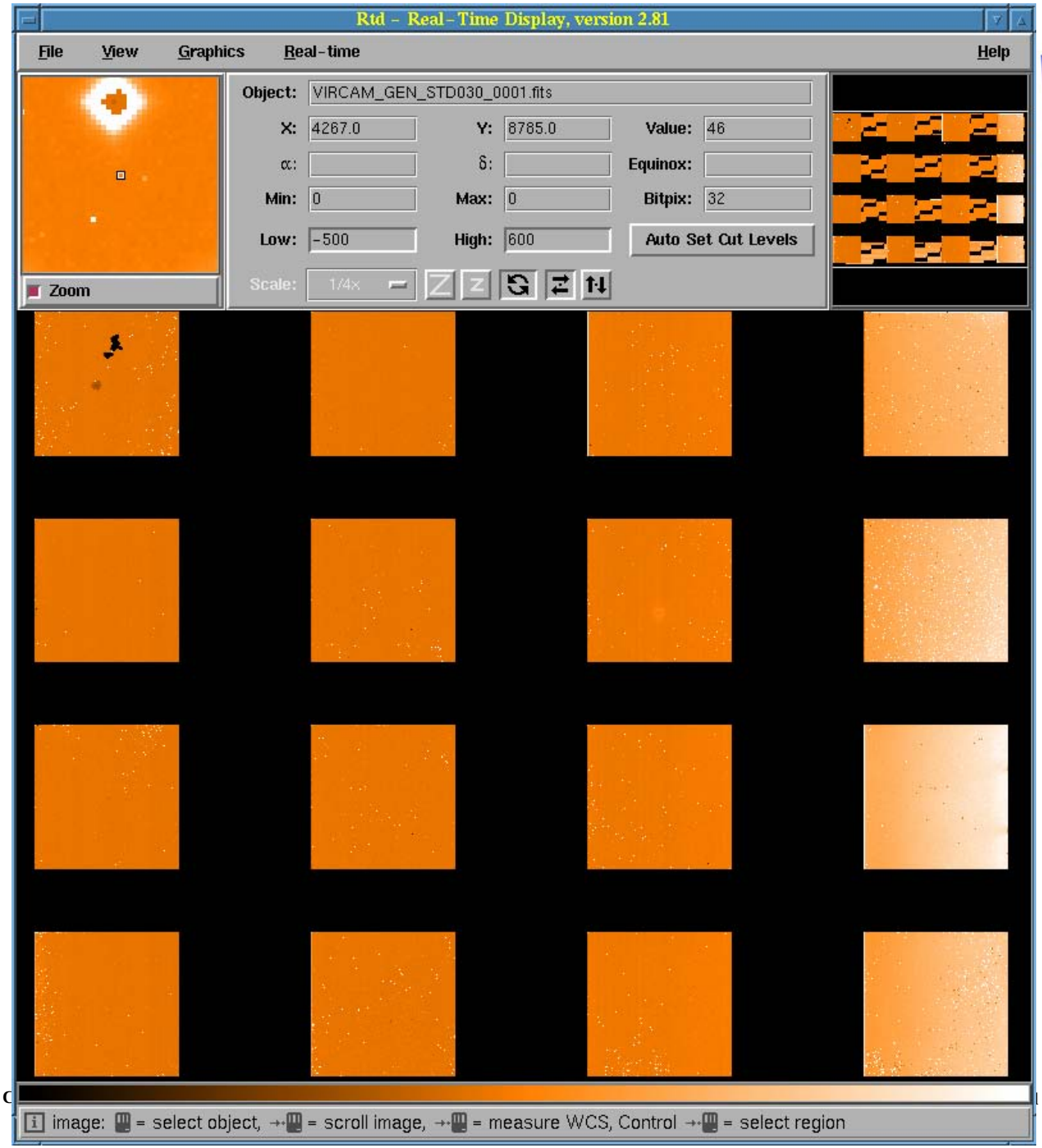
- 16 Raytheon VIRGO 2k x 2k
- 4 x 4 sparse array
- spacings 90% & 42% of detector
- 0.34”pixels

Focal Plane

1.65 deg diagonal



0.6 sq deg detector 'pawprint'



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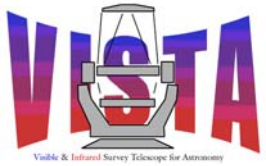
Types of Calibration



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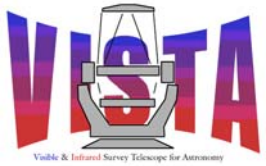
calibrations characterize:

1. 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
2. astrometric distortions of the images
3. photometric zero points and extinction coefficients
4. generate Quality-Control measures (see Riello's talk).

Calibration Pipeline

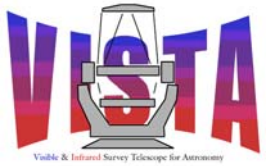


Data Flow System

- 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



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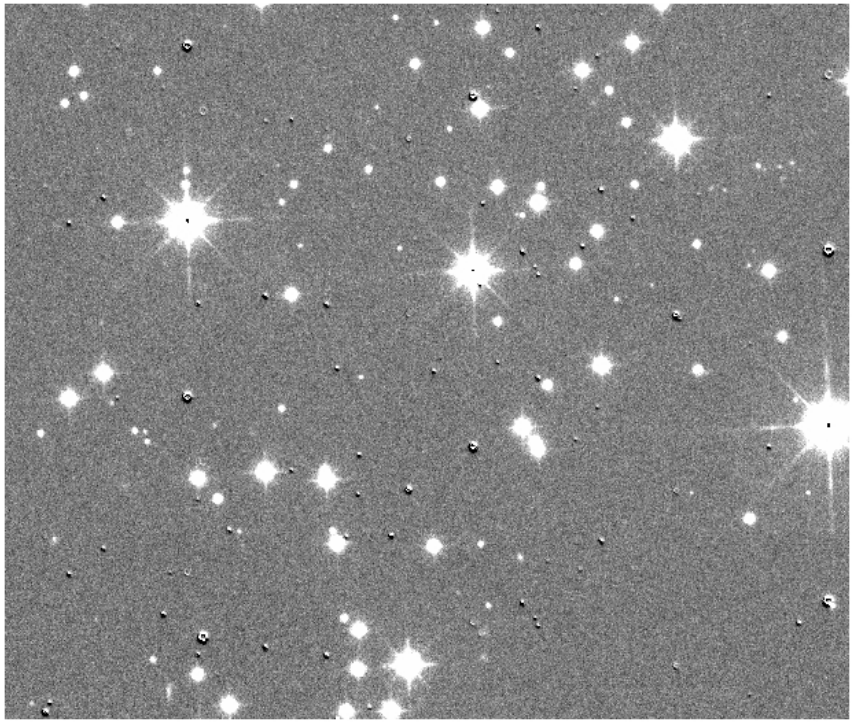
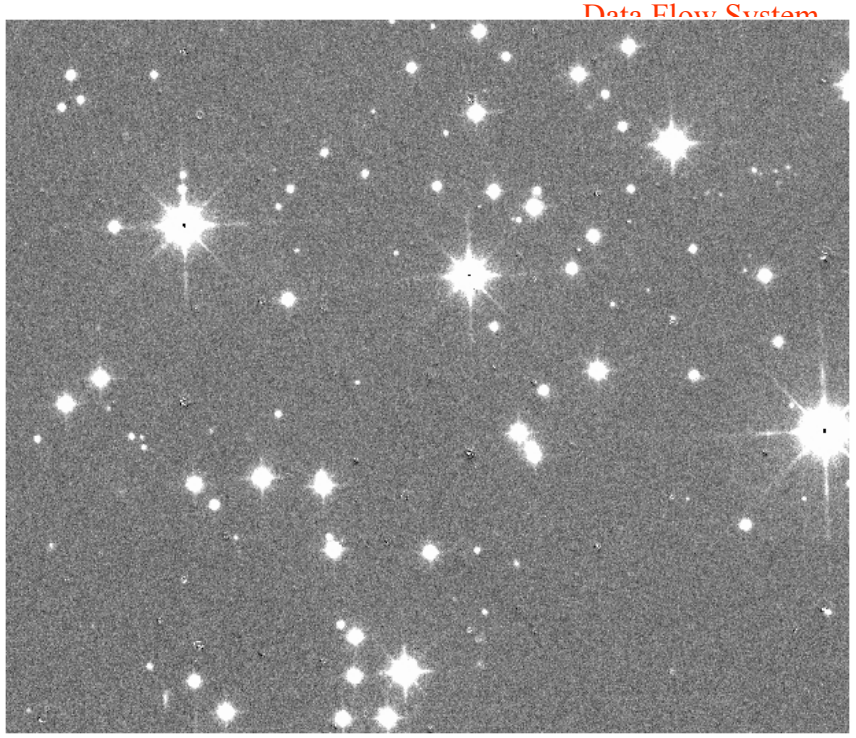
VISTA & WFCAM have similar data

	WFCAM	VISTA
Telescope	4-m (UKIRT)	4-m
2x2k Detectors	4 *x* Hawaii	16 *x* VIRGO
Pixel size	0.4 arcsec	0.34 arcsec

- 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





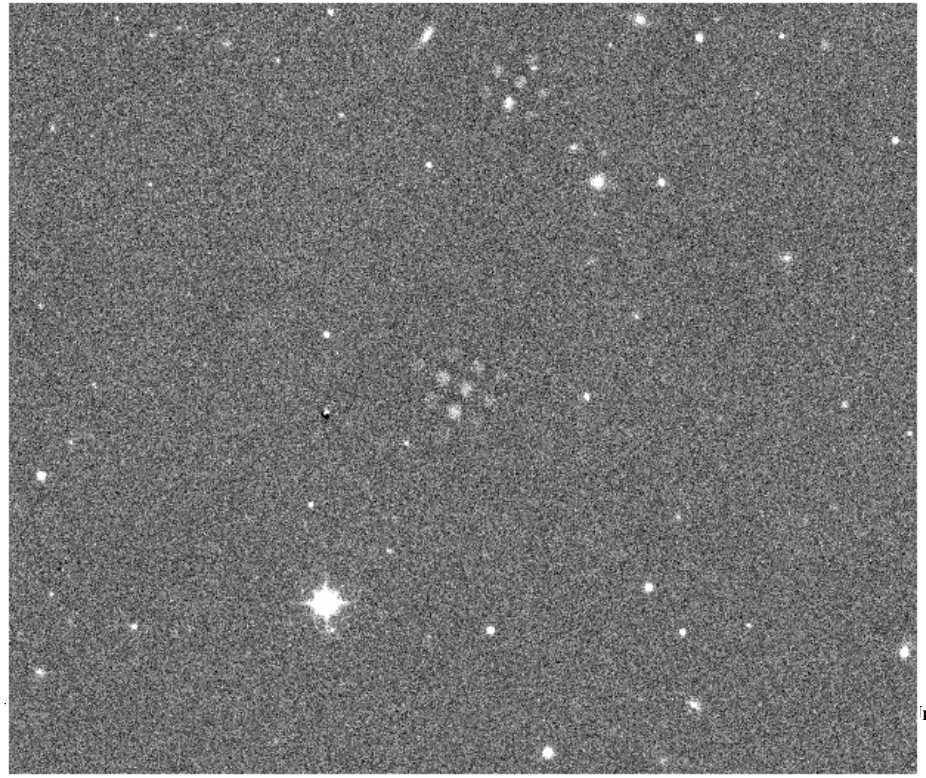
•WFCAM has Cross talk from saturated images
=>‘bumps’ symmetrically above and below brightest stars.

• WFCAM mostly (but not perfectly) correctable.

• VISTA???

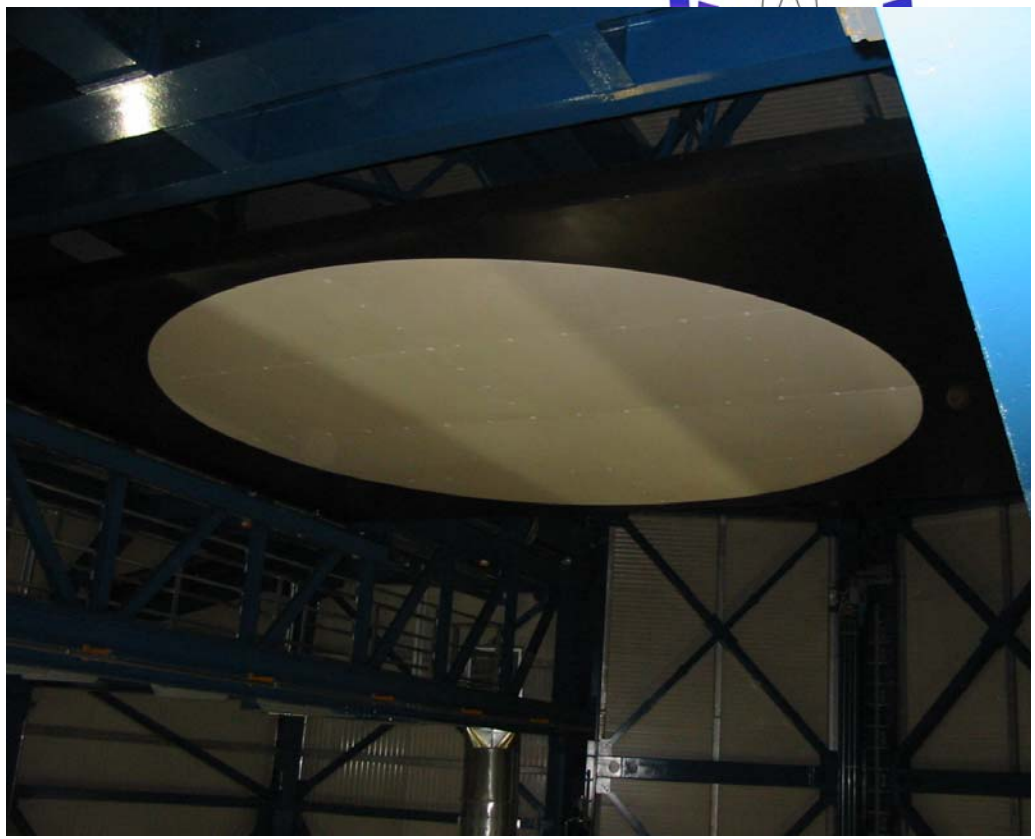
Persistence

- 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.



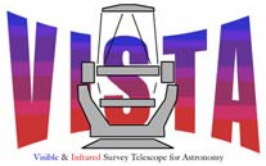
WFCAM hard to correct.
VISTA???

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



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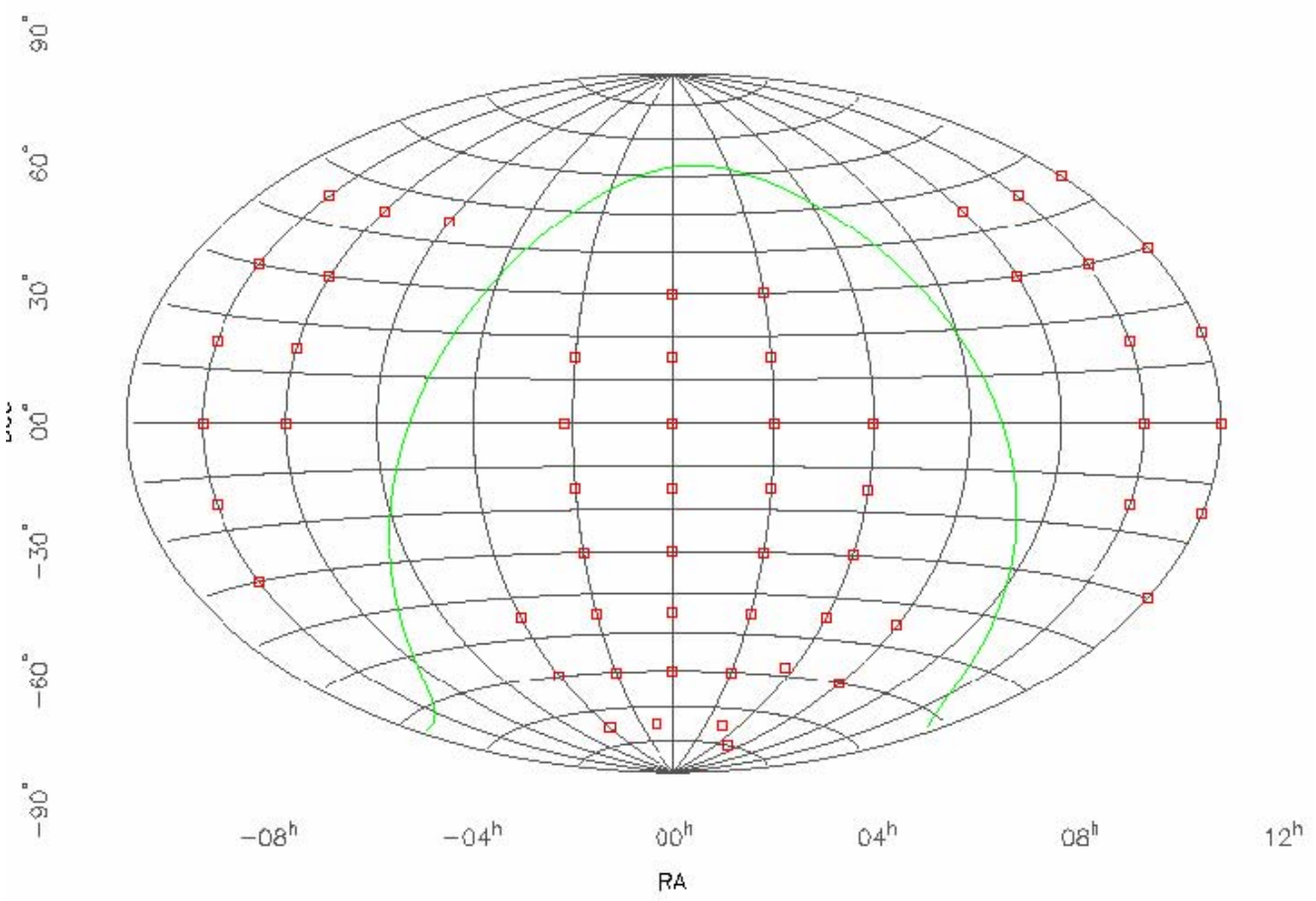
- Used to remove multiplicative instrumental signatures
  - pixel-to-pixel gain variations
  - instrumental vignetting profile.
  - gain correction between the 16 detectors
  - gain correction between the 16 read out channels of each detector



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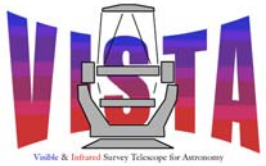
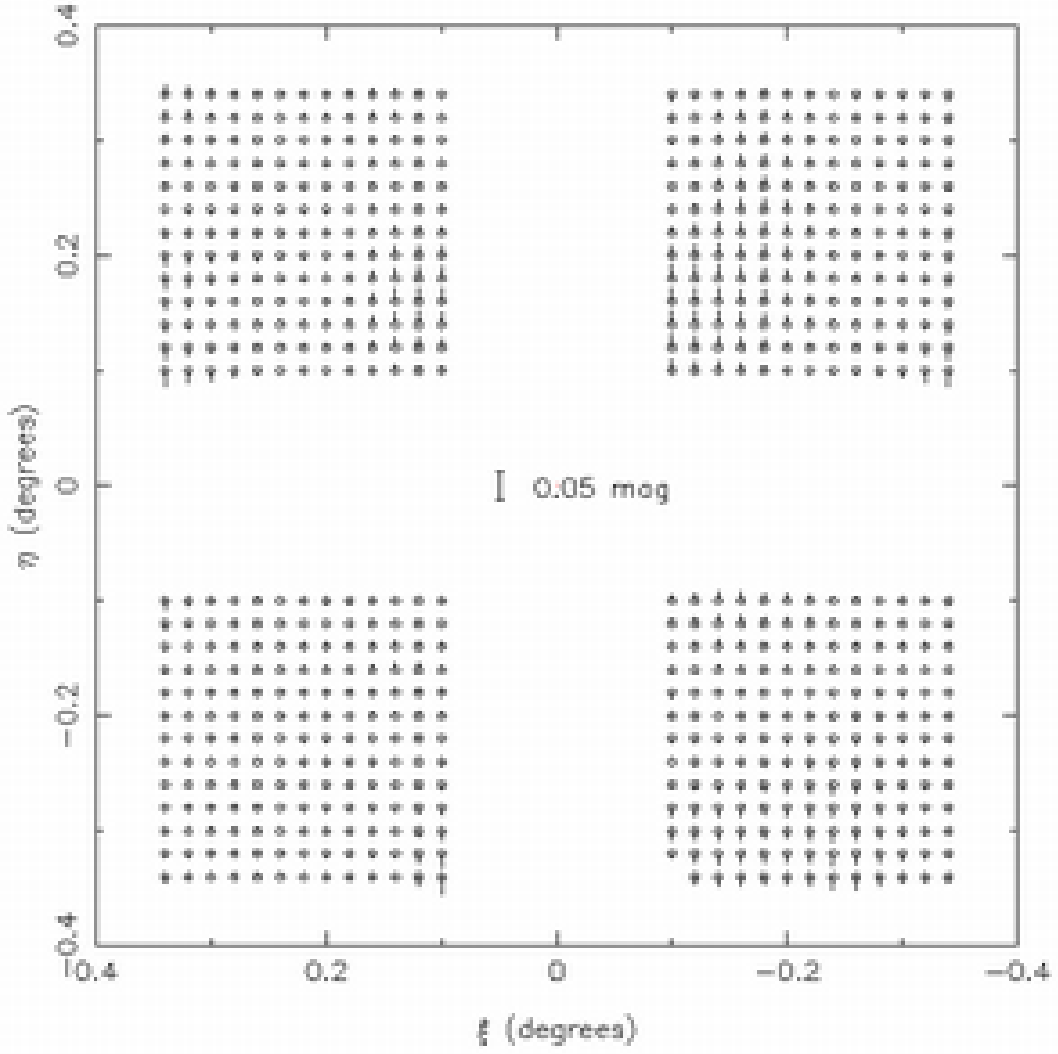
Illumination Correction



Data Flow System

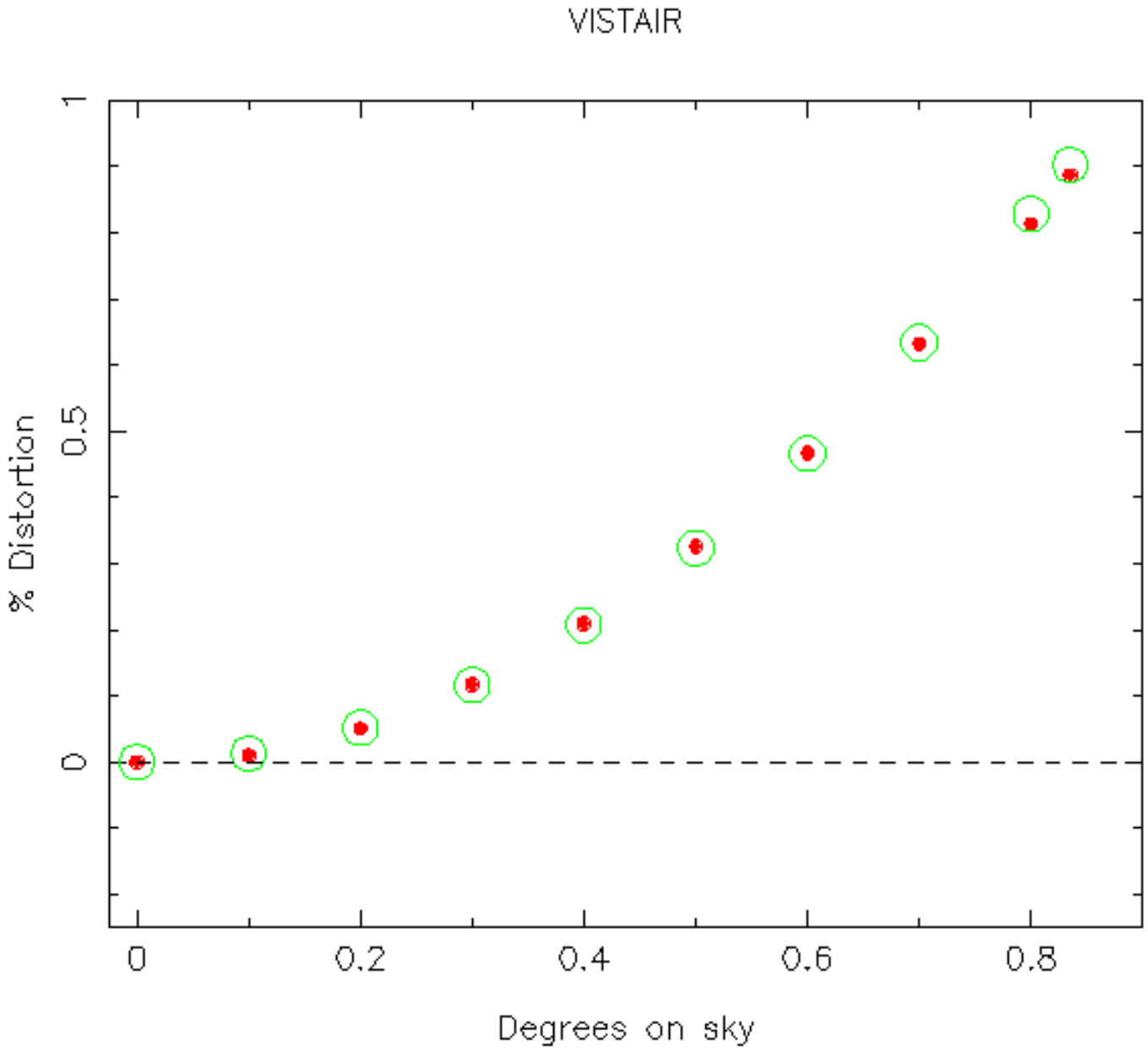
- Flat-field should remove all pixel-to-pixel gain differences as well as any large-scale variations due (generally) to vignetting within the focal plane.
- BUT any scattered light within the camera may lead to large scale background variations which cannot easily be modeled and removed, as level depends critically on 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

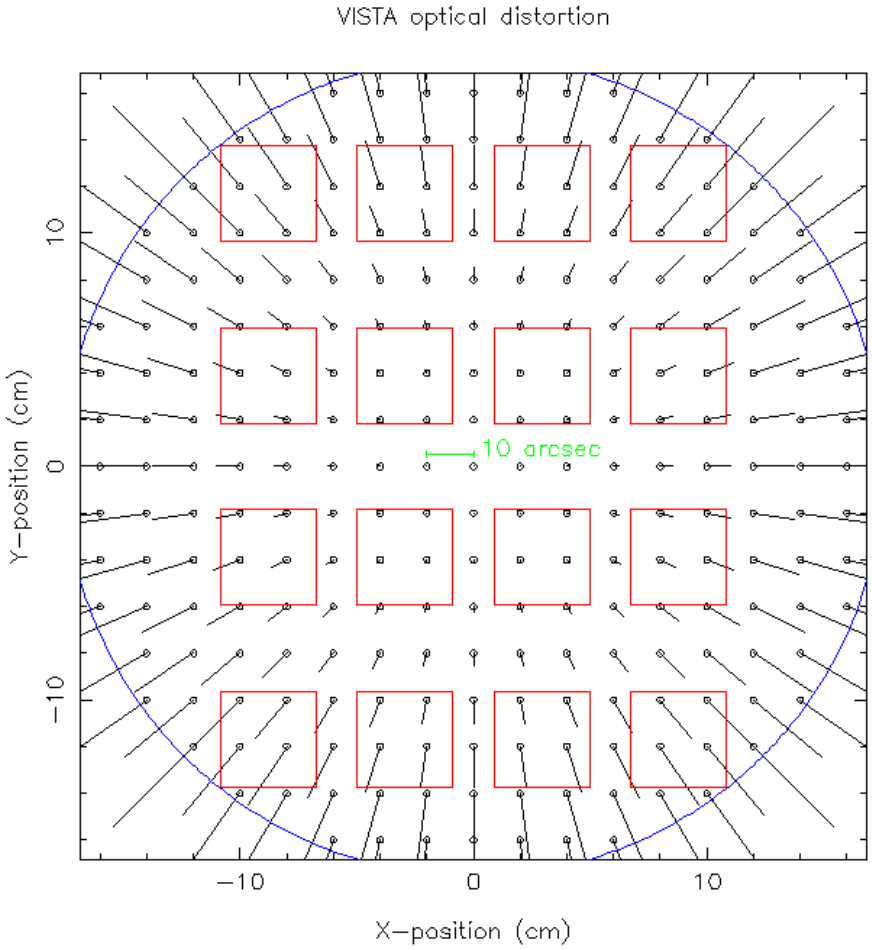

0.4
0.2
0
−0.2
−0.4
η (degrees)
0.05 mag
0.4
0.2
0
−0.2
−0.4
ξ (degrees)

Calibration: Astrometric

Data Flow System

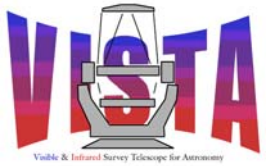
- based on 2MASS point source catalog
  - globally to ~100mas
  - internally to <~50mas.
- 2MASS tied to TYCHO 2 and in ICRS system.
- 2MASS errors systematic <100 mas, RMS <~100 mas for S/N >10 point sources
- distortion terms from on-sky observations.
- strongest term in optical-distortion model is cubic radial term.


VISTAIR
% Distortion
0
0.5
1
0
0.2
0.4
0.6
0.8
Degrees on sky



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

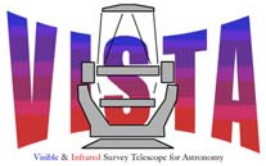


Data Flow System

- Goal 2% calibration accuracy
- Two *independent* methods:
  i. from 2MASS all-sky point source catalogue.
  ii. 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



Data Flow System

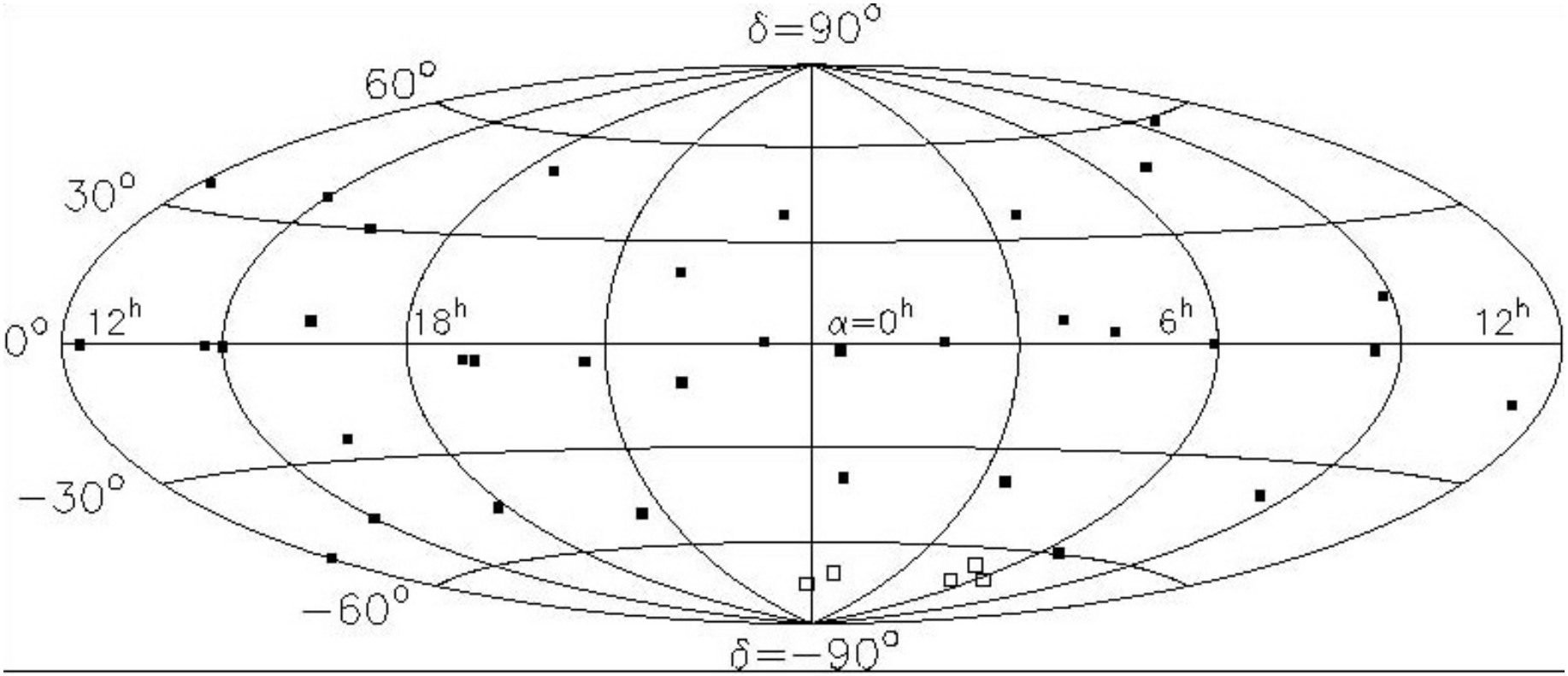
- **Photometry-1**: based on 2MASS
- Initial photometric calibration for all filters based on 2MASS photometric system which is globally consistent to ~1% (Nikolaev et al. 2000).
- colour equations to convert 2MASS to VISTA instrumental system (with some colour s/n cuts)
- enables each detector image 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).

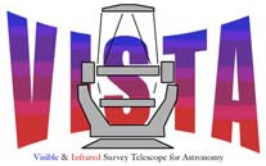
Calibration: Photometry-2

Data Flow System

- **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, $K_{s<}$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.


δ=90°
60°
30°
0°
−30°
−60°
δ=−90°
12h
18h
α=0h
6h
12h

Extinction



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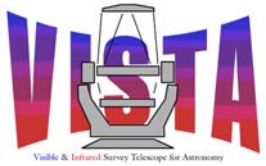
Extinction monitored

- 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.

The end



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