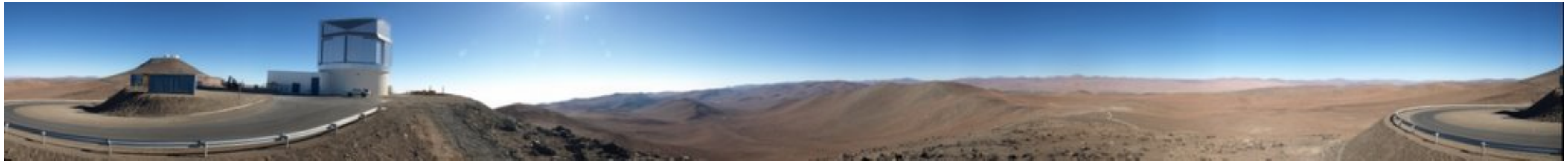


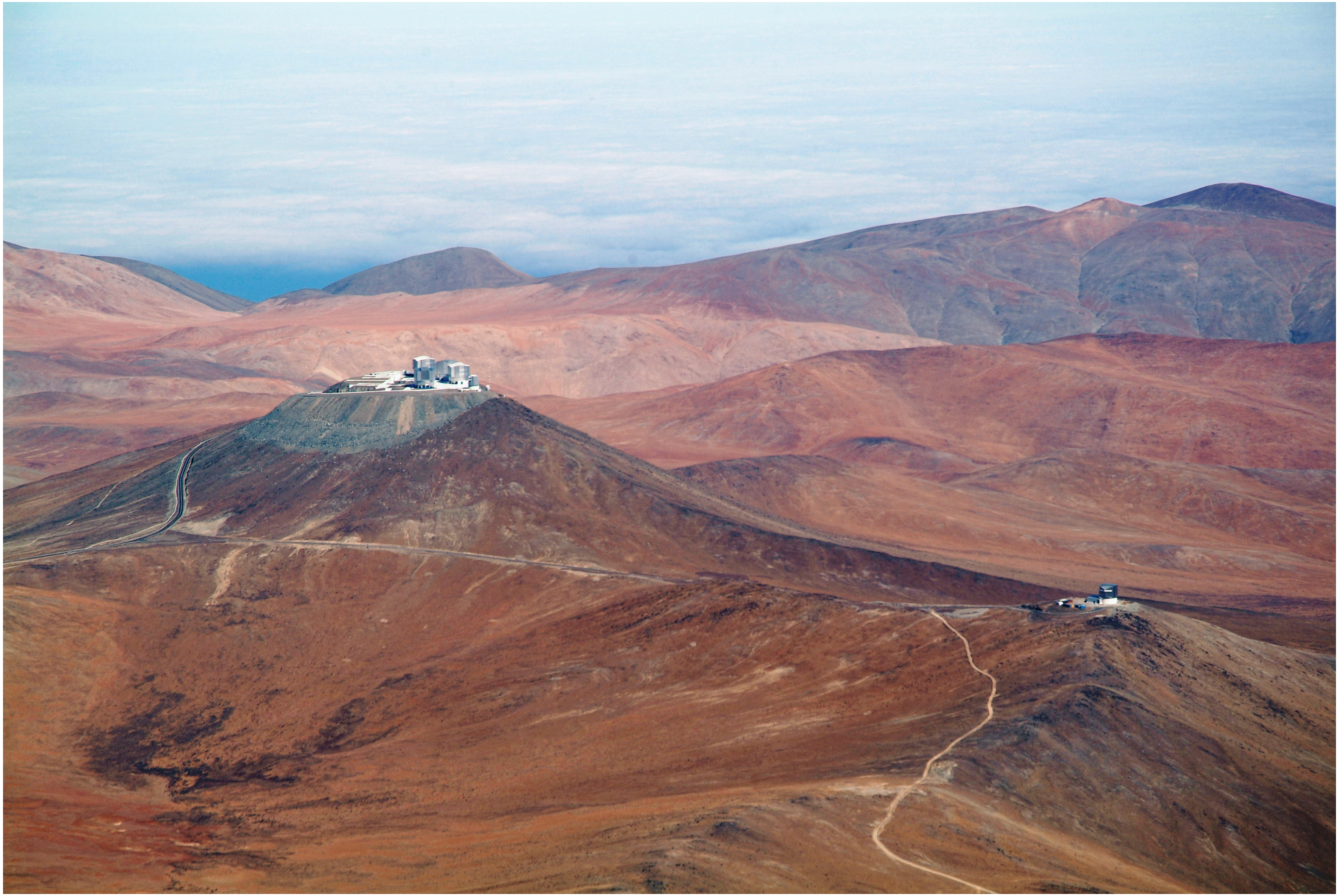
VISTA

An Overview

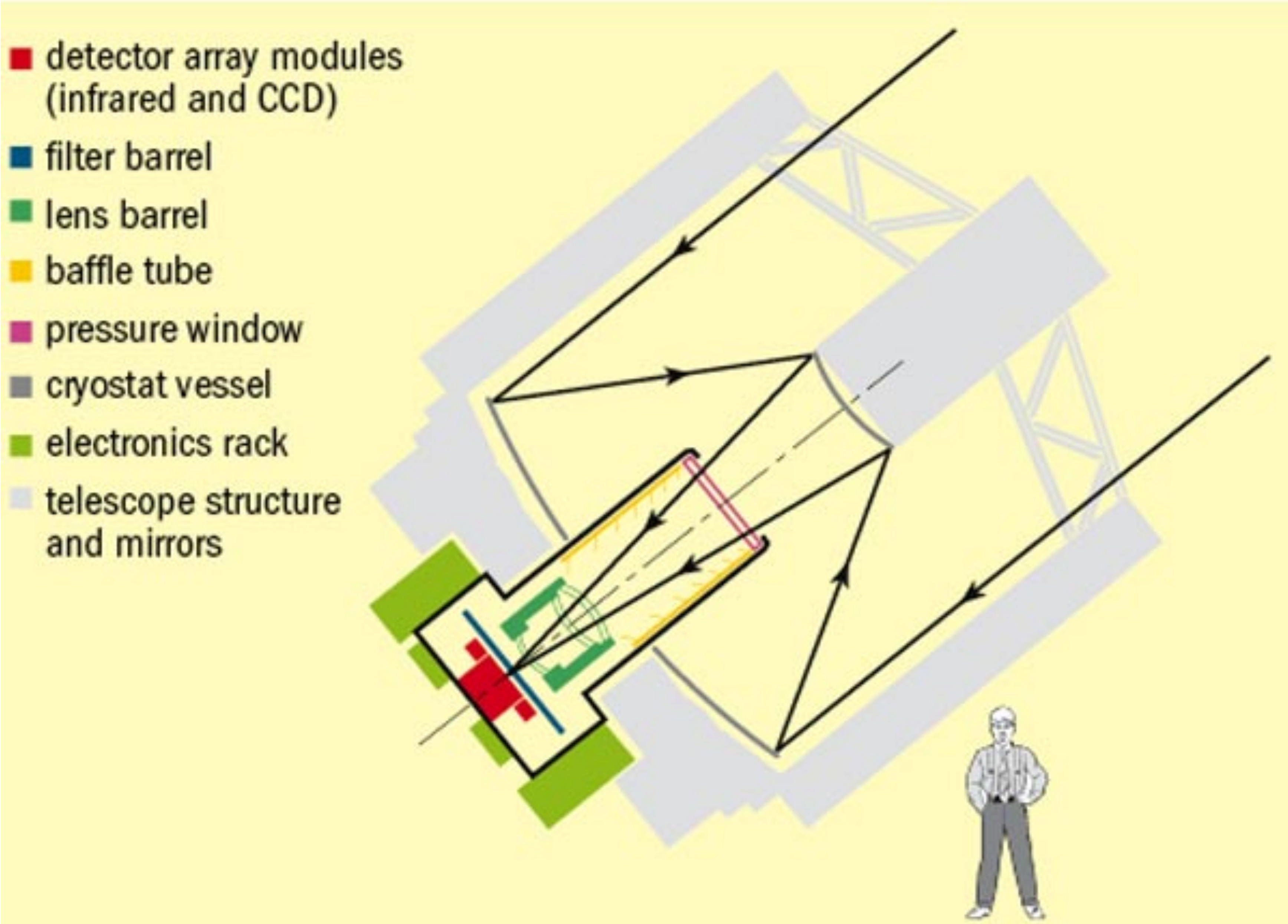
Jim Emerson
Queen Mary, University of London

Overview

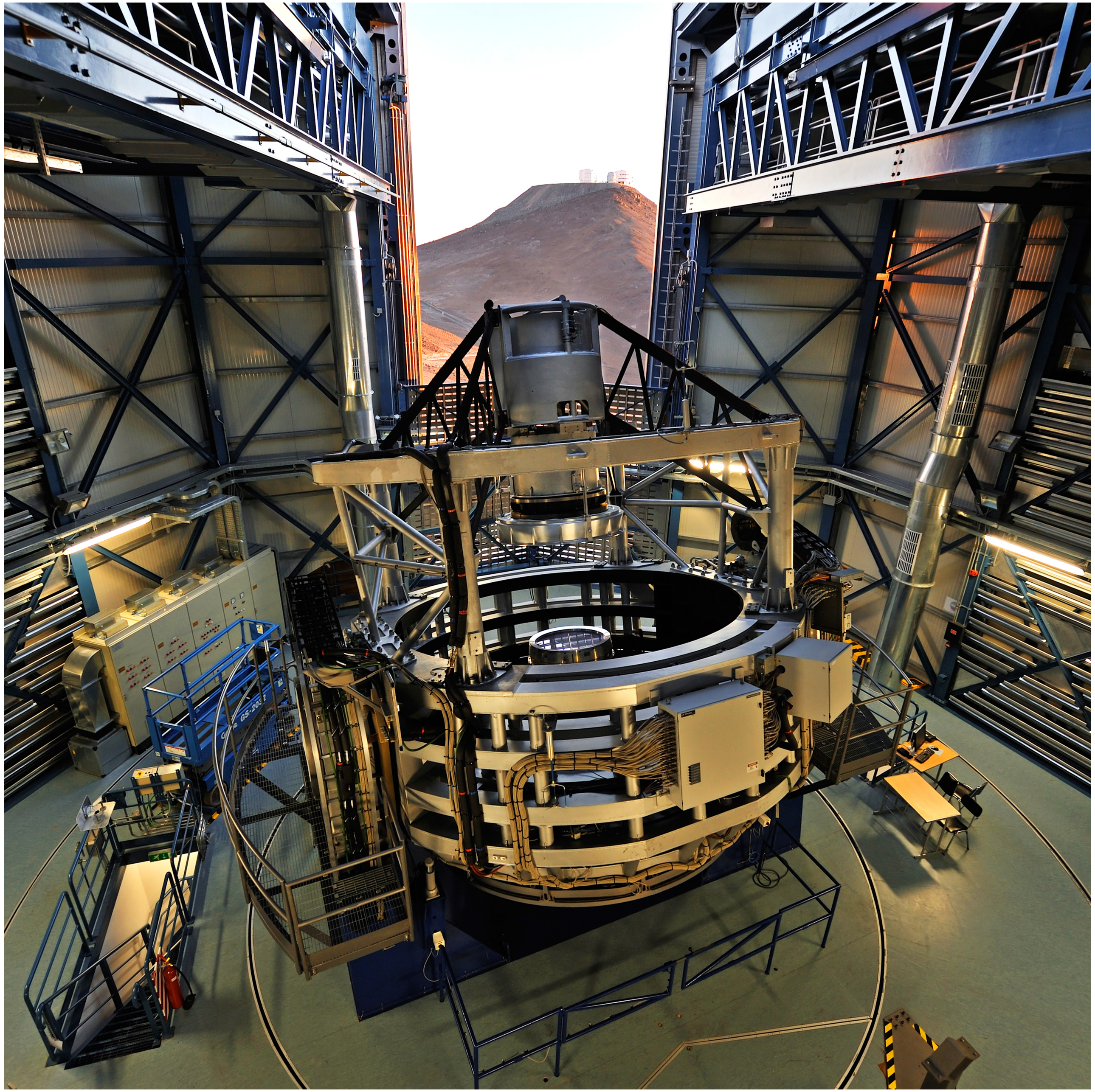
1. Status and impact of VISTA.
2. Using & Interpreting VISTA data
   – Calibration
   – Artifacts near bright stars.



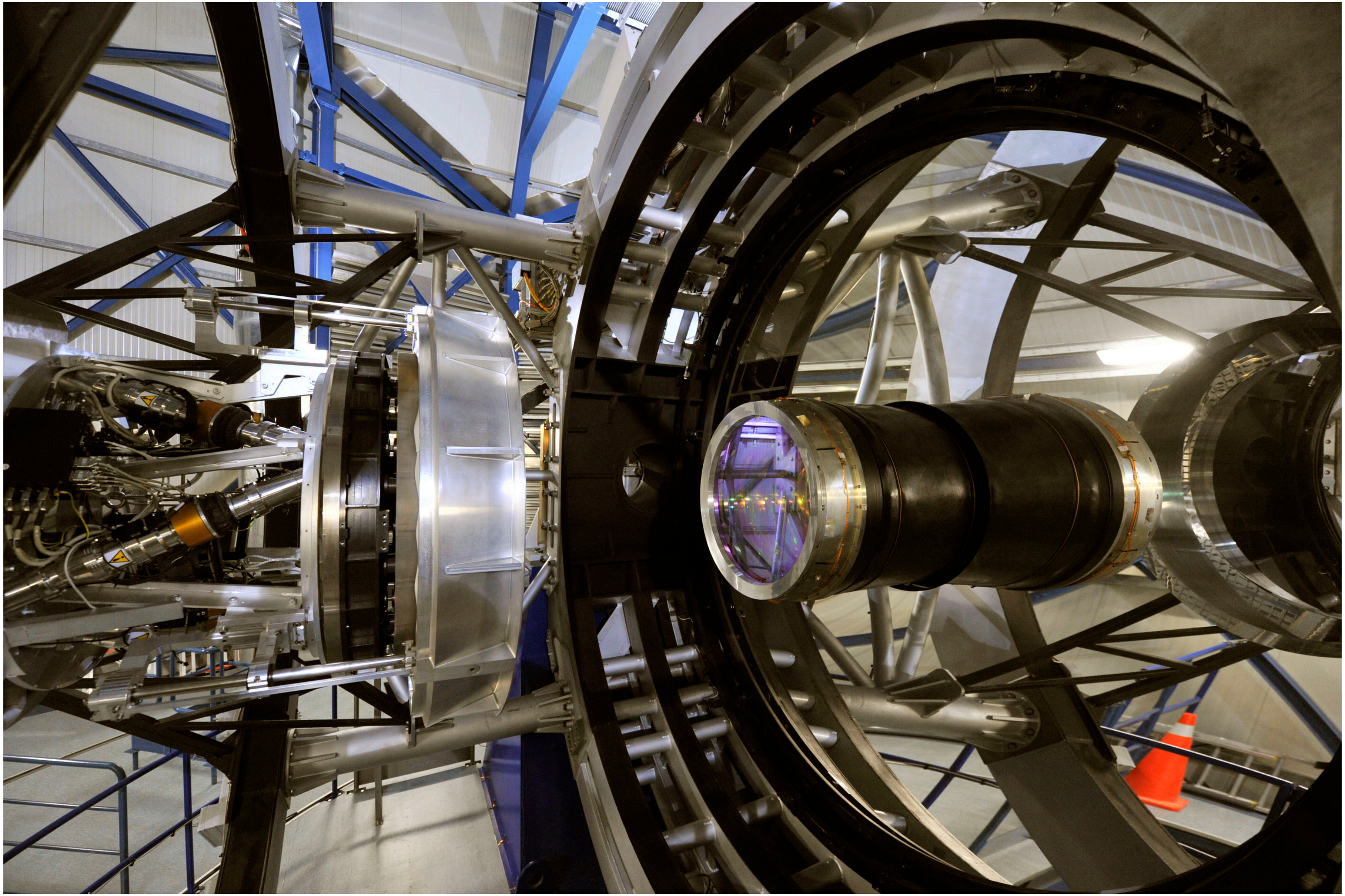
Telescope & Camera Schematic



VISTA at sunset – with VLT beyond



Left: Hexapod & secondary
Right: camera & primary mirror



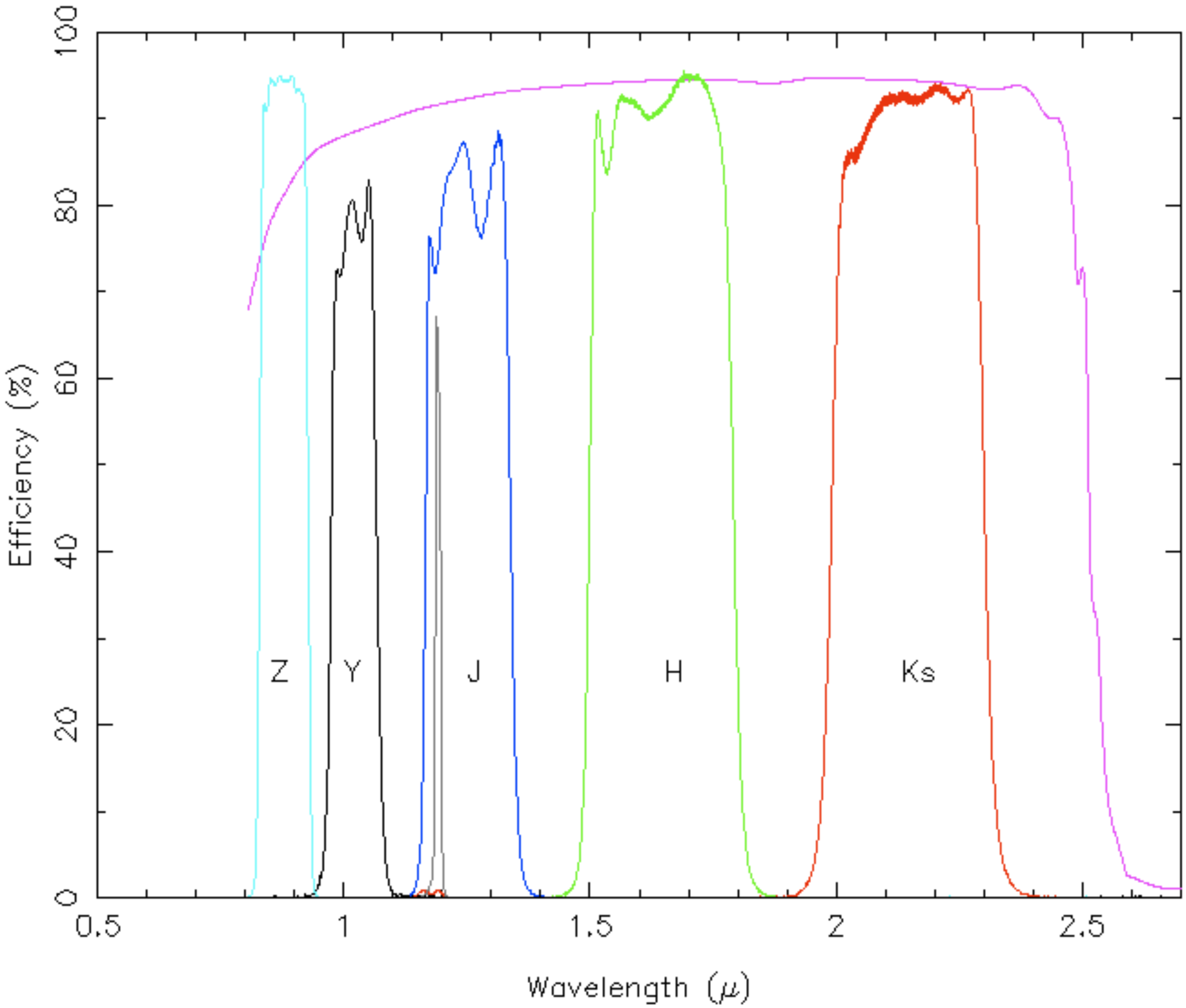
VISTA key facts

- Primary: 4-m
- FOV: 1.65 degree diameter
- Detectors: 0.34” pixels (with some radial variation) sample 0.6 sq deg instantaneous FOV a ‘pawprint’
- Filters: $ZYJHK_s$ (JHK_s like but not same as 2MASS)

	Z	Y	J	H	Ks
Central Wavelength (μm)	0.877	1.020	1.252	1.645	2.147
Width (μm)	0.097	0.093	0.172	0.291	0.309

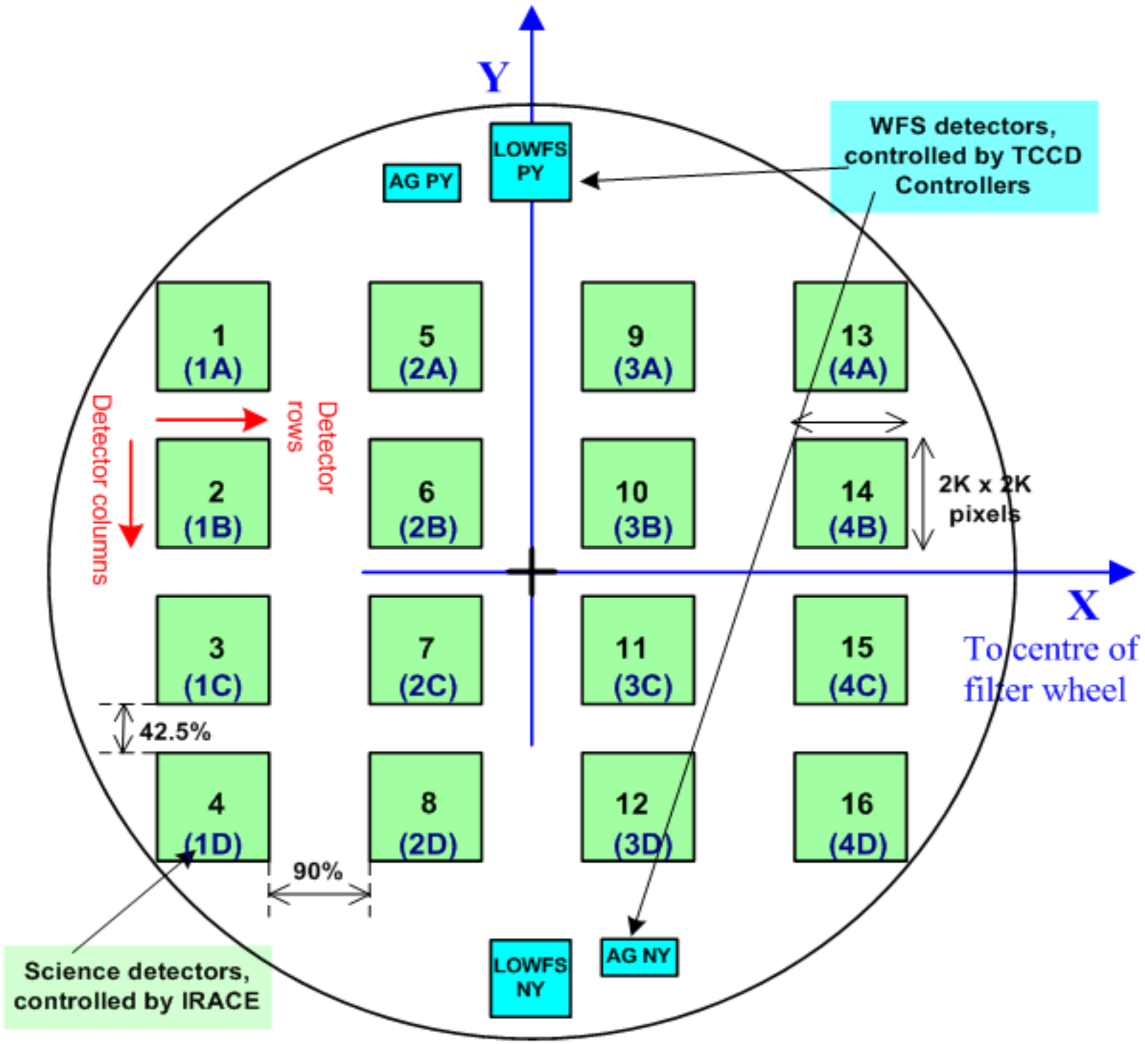
- Images median seeing limited (seeing ~0.7”)
- 6 suitably offset pawprints produce 1.5 sq deg ‘tile’ with each piece of sky covered by at least 2 pixels + 2 edge strips covered once only
- Active optics – f/1 primary

VISTA typical Filter transmission + Detector quantum efficiency curves



Focal Plane

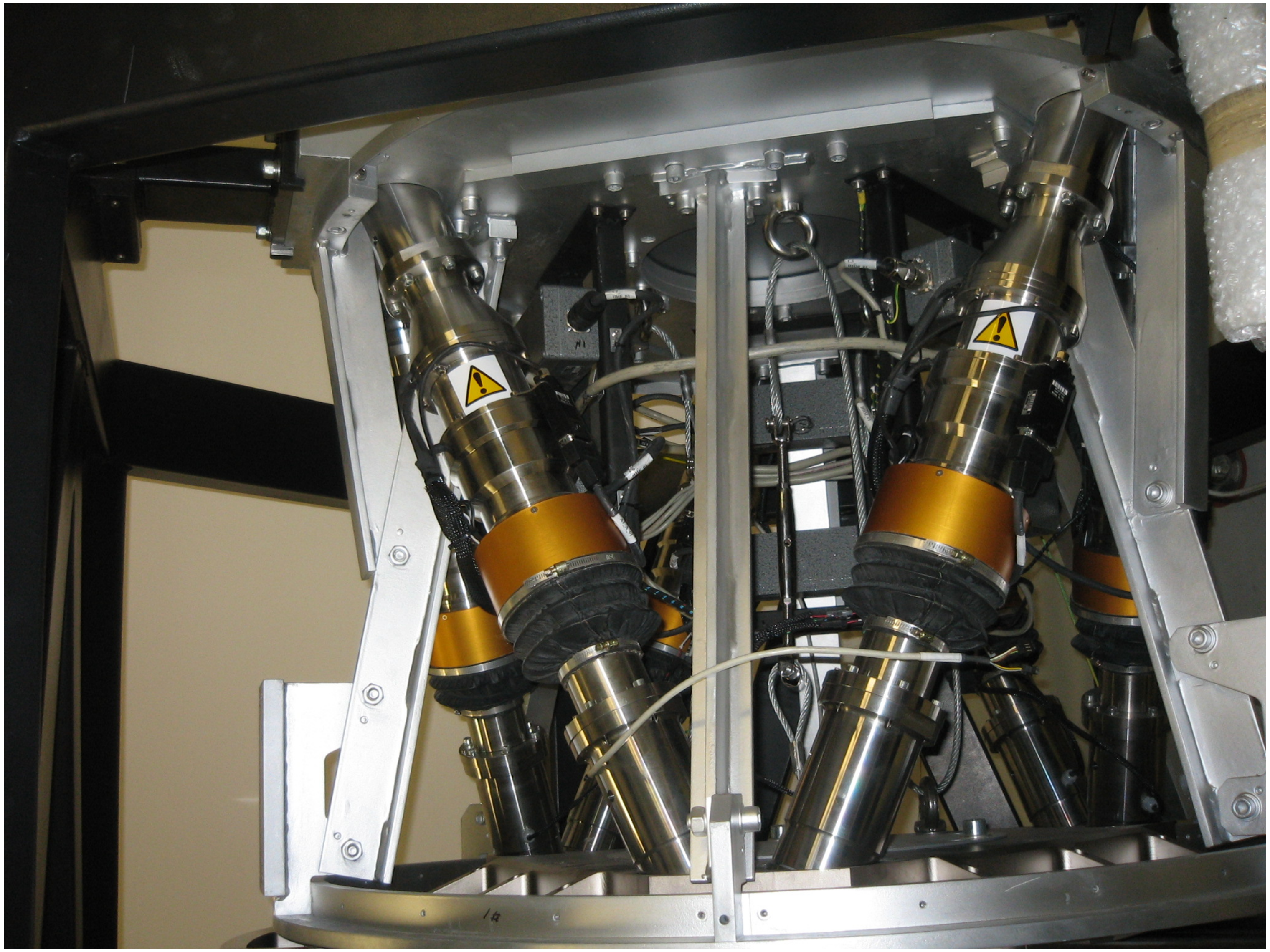
Note different detector separation in X & Y directions



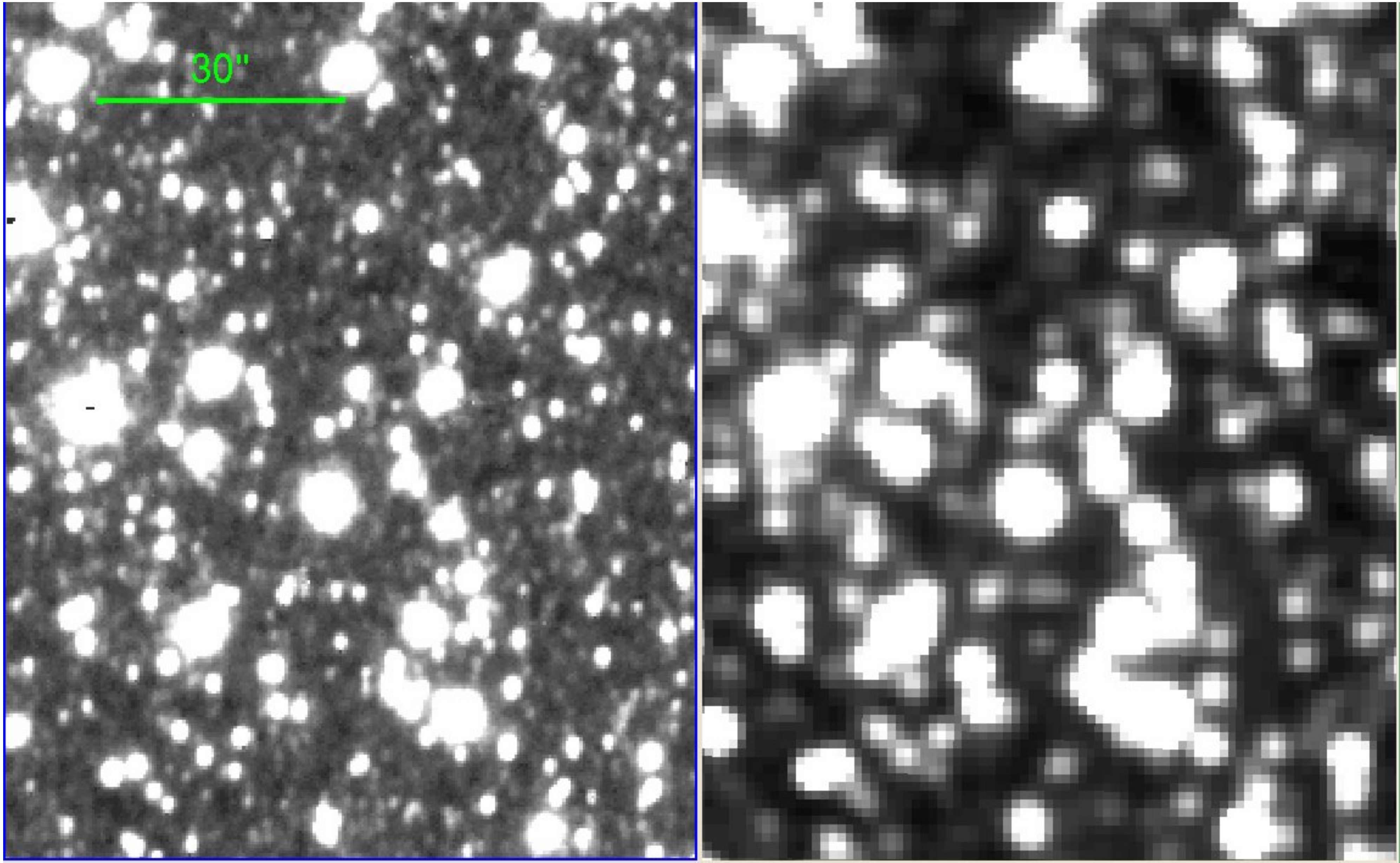
Showing why detctors can't be butted

Notice the electronics at the top of each of the 16 arrays

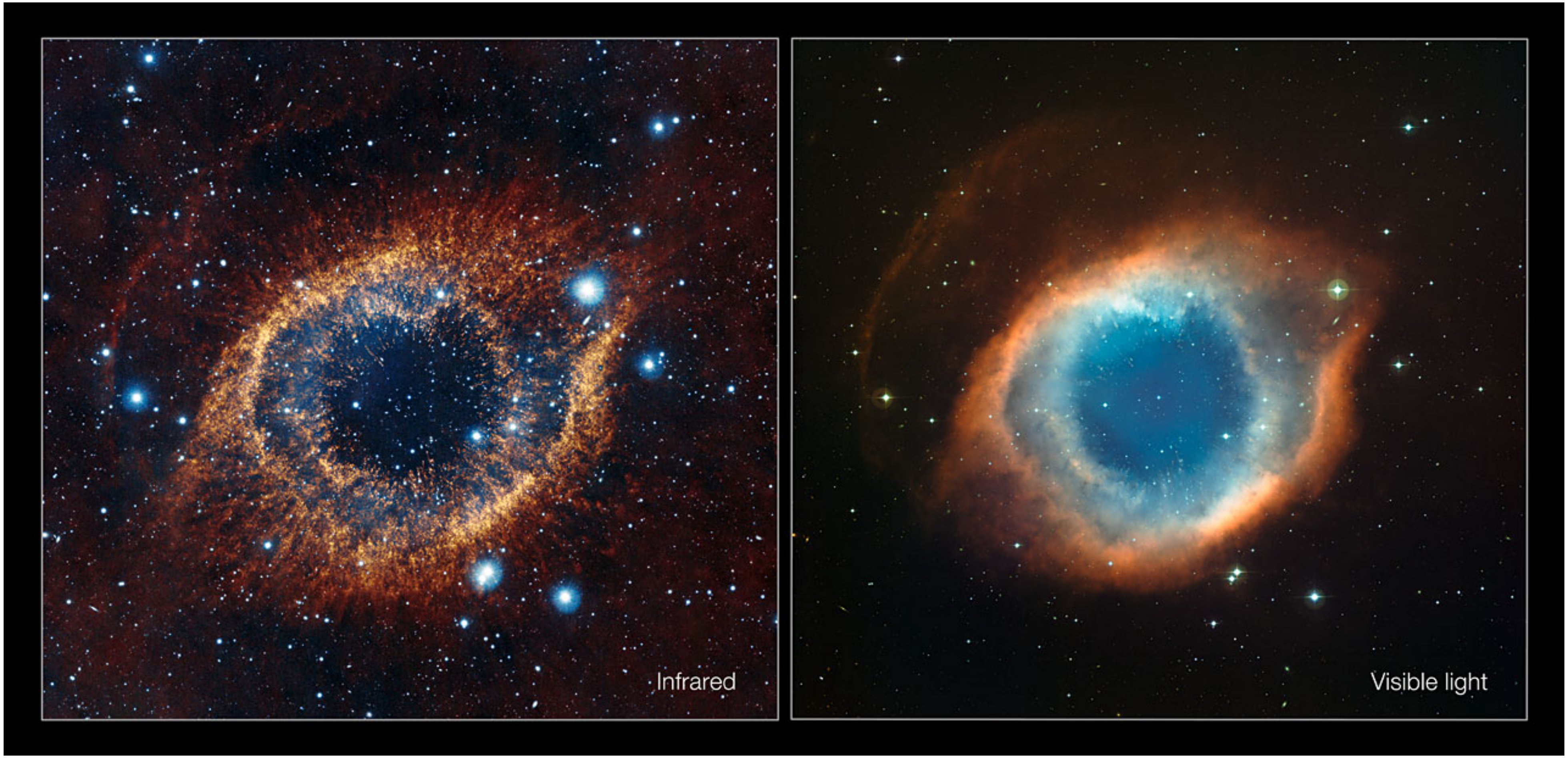
Hexapod to adjust secondary focus, tip & tilt.



VISTA J cf 2MASS J

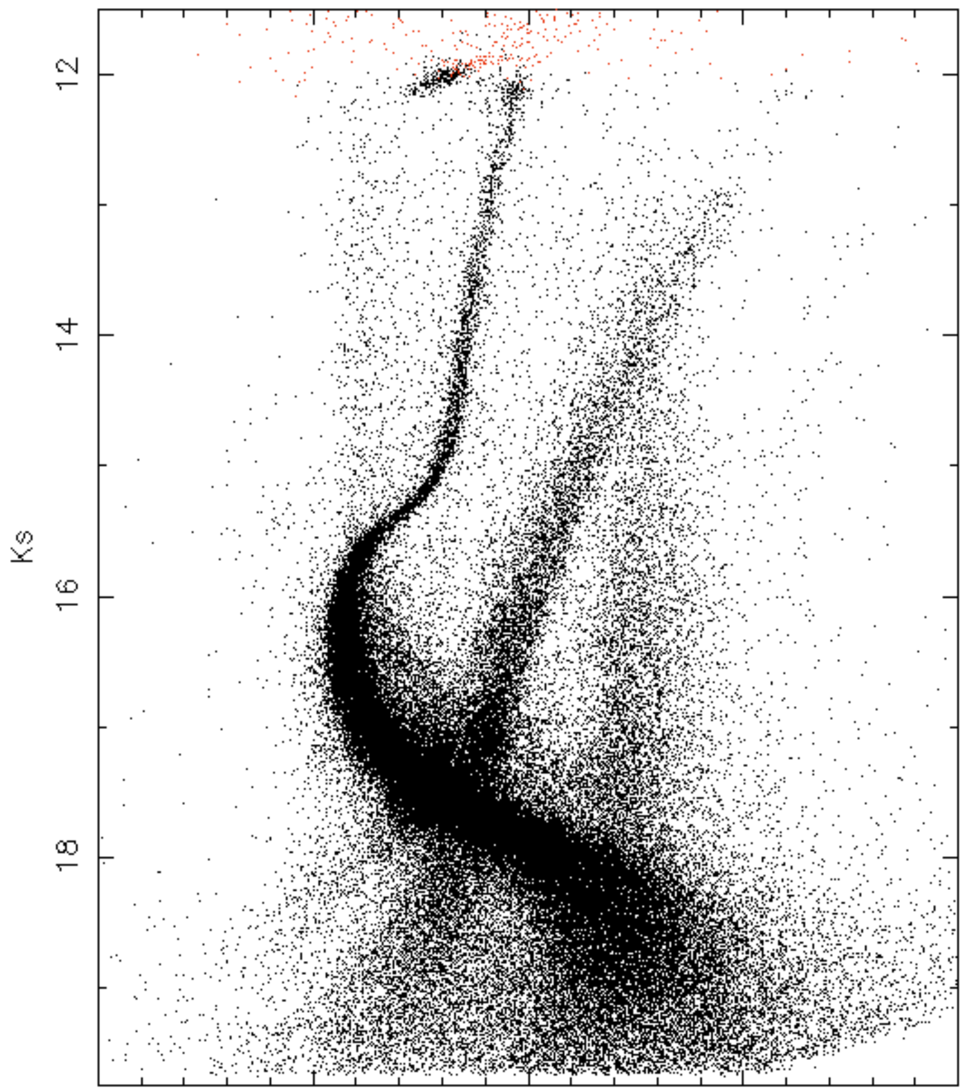


Helix – planetary nebula (eso 1205)



47 Tuc false colour (YJK_s)

47 Tuc K_s Y-K_s CMD



Large Magellanic Cloud (eso1033)

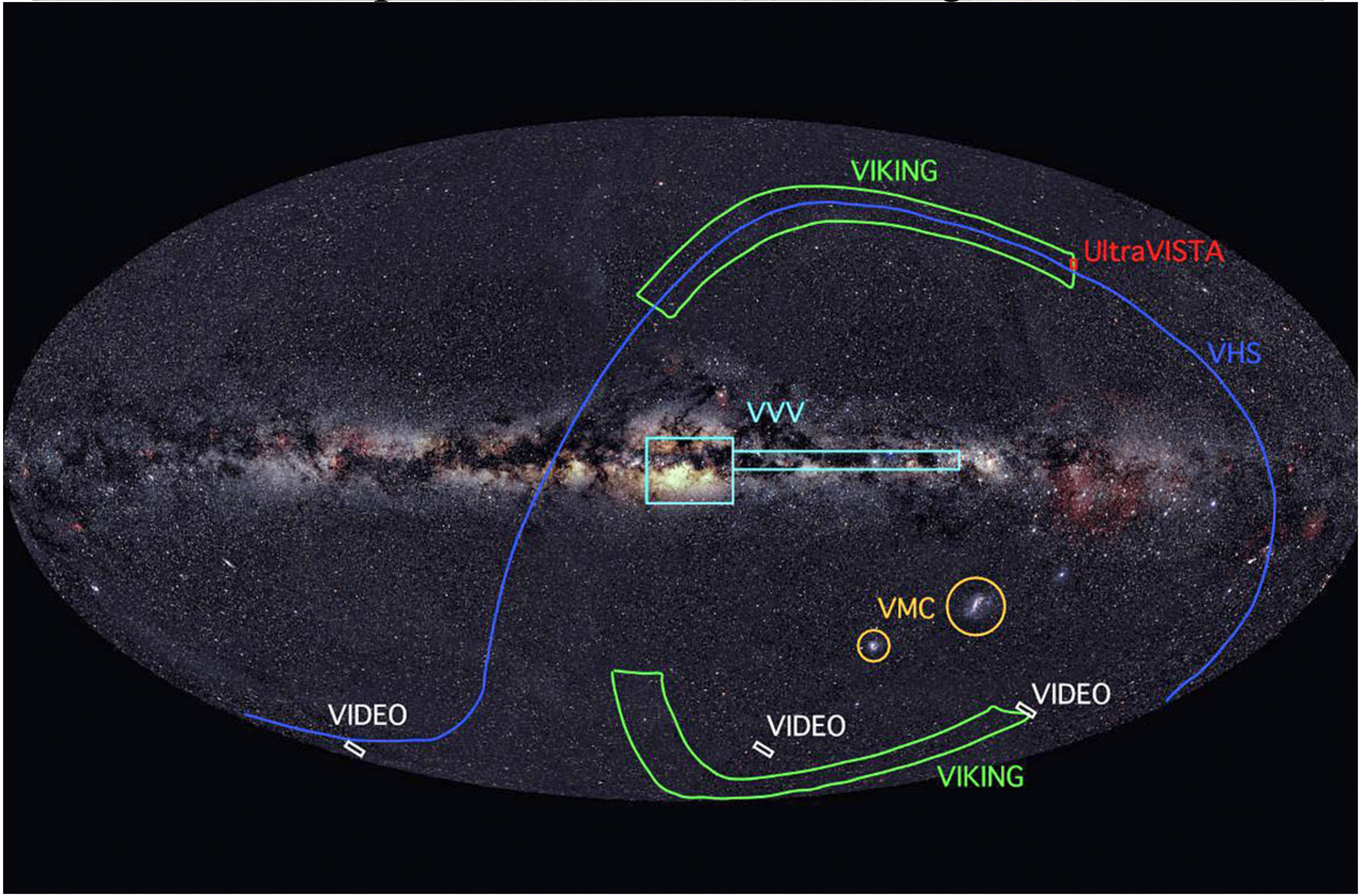
G305 in galactic plane (from VVV)

Deep field cutouts (from UltraVISTA)

Six Public Surveys: 1 Hemisphere, 2 Galactic, 3 Extragalactic

- Ultra-VISTA: Ultra-deep extragalactic survey
  - 1 field = COSMOS. Y,J,H,Ks + narrowband 1.18 μm.
  - 0.75 deg^2 gets ¾ of time (~ 200 hrs / filter).
- VIDEO: VISTA Deep Extragalactic Observations
  - 12 deg^2, 3 SWIRE+SERVS+HERMES fields. "SDSS at z ~ 1 - 2".
- VIKING: VISTA Kilo-degree Infrared Galaxy survey
  - 1500 deg^2, extragalactic, ~ 2dFGRS stripes. ~ 400 sec / filter.
- VHS: VISTA Hemisphere Survey
  - ~ 18,000 deg^2 , ~ 60 – 120 sec/filter .
- VMC: Magellanic Clouds + bridge:
  - 180 deg^2 , ~ 40 min – 2 hr per filter.
- VVV : VISTA Variables in Via Lactea.
  - 520 deg^2 , Bulge + plane, multi-epoch for variables.
- Smaller non-public survey PI progams (<25% of time)

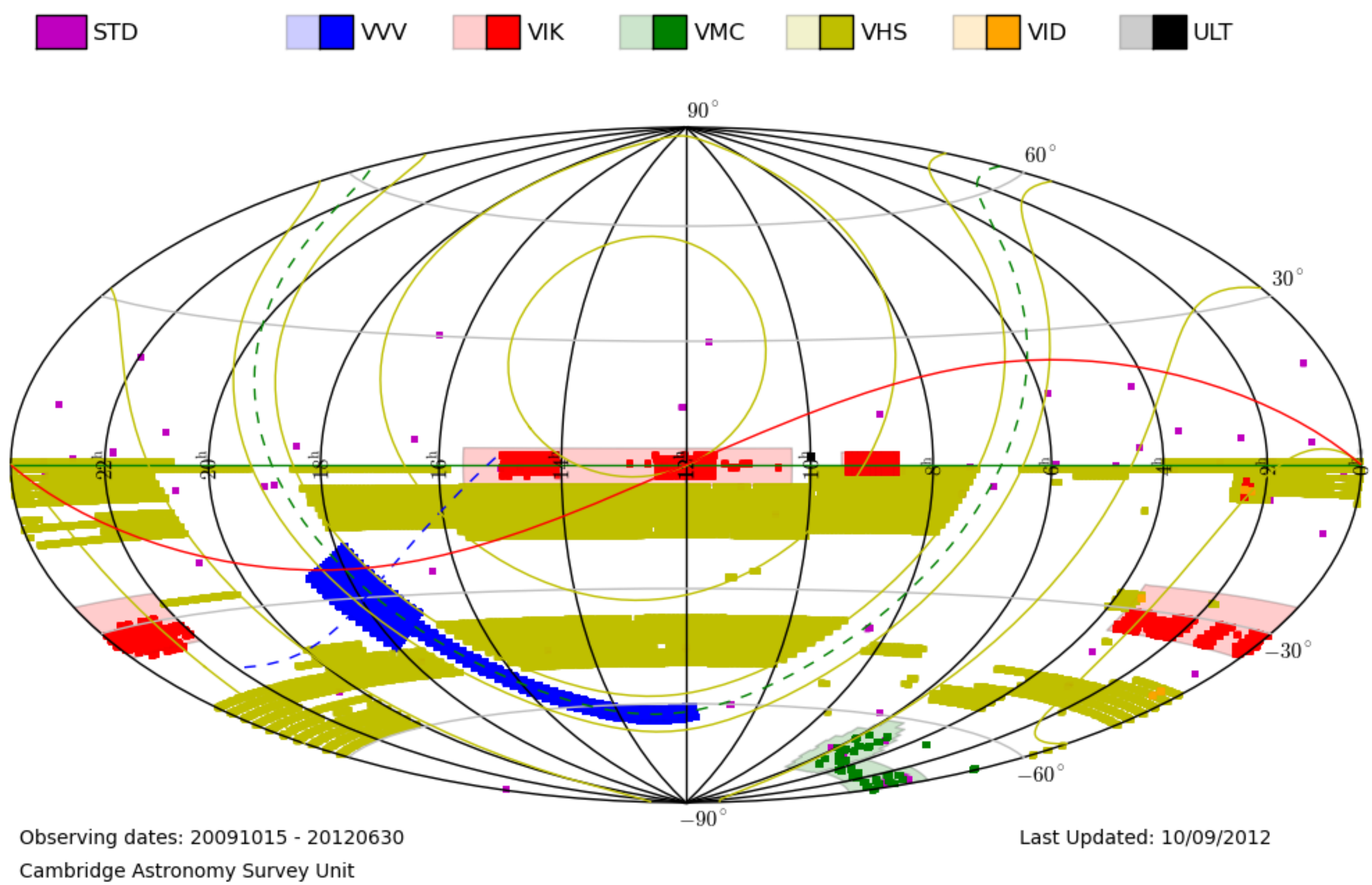
Six Public Surveys:
1 Hemisphere, 2 Galactic, 3 Extragalactic



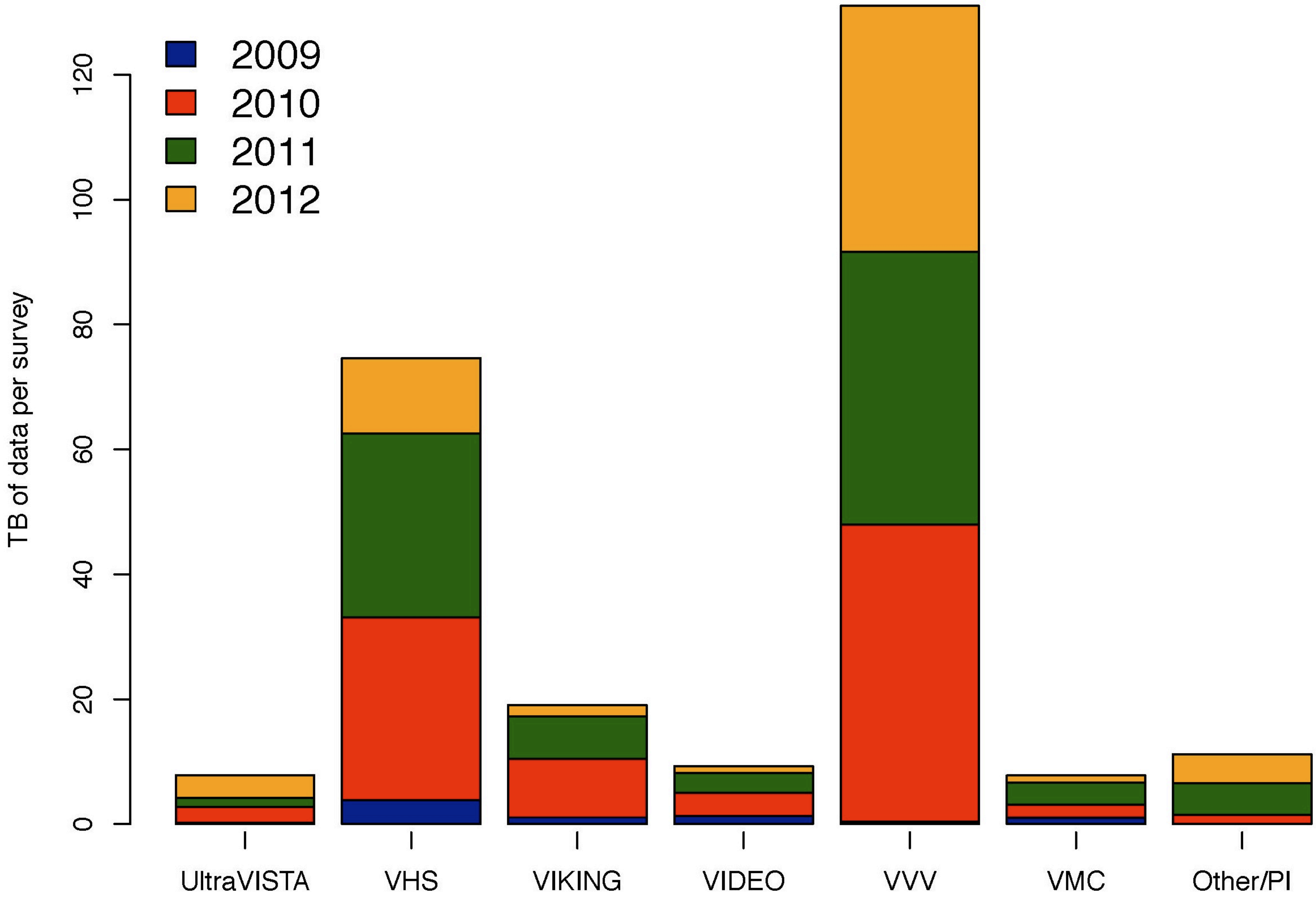
Processing

- Quality control pipelines at Paranal & Garching (to monitor telescope/instrument health)
- Science calibration pipeline (part of VISTA Data Flow System VDFS in UK) at Cambridge Astronomical Survey Unit.
  - Calibrates data on nightly basis taking into account VISTA properties, produce catalogues & images.
- Catalogues & images ingested into VDFS' VISTA Science Archive (at Wide Field Astronomy Unit Edinburgh)
  - multi night products (e.g stacks) are generated.

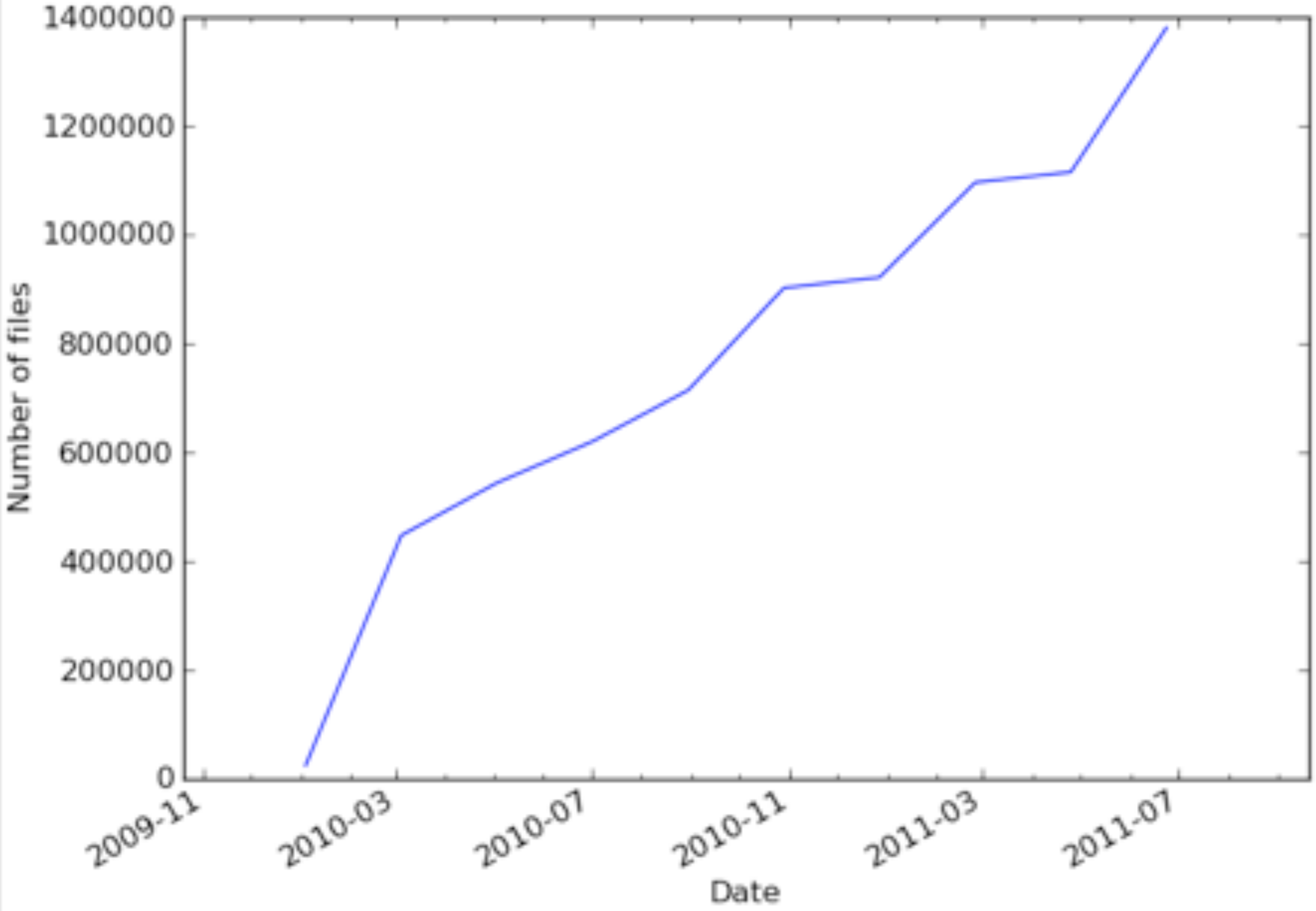
Progress of surveys (from pipeline)



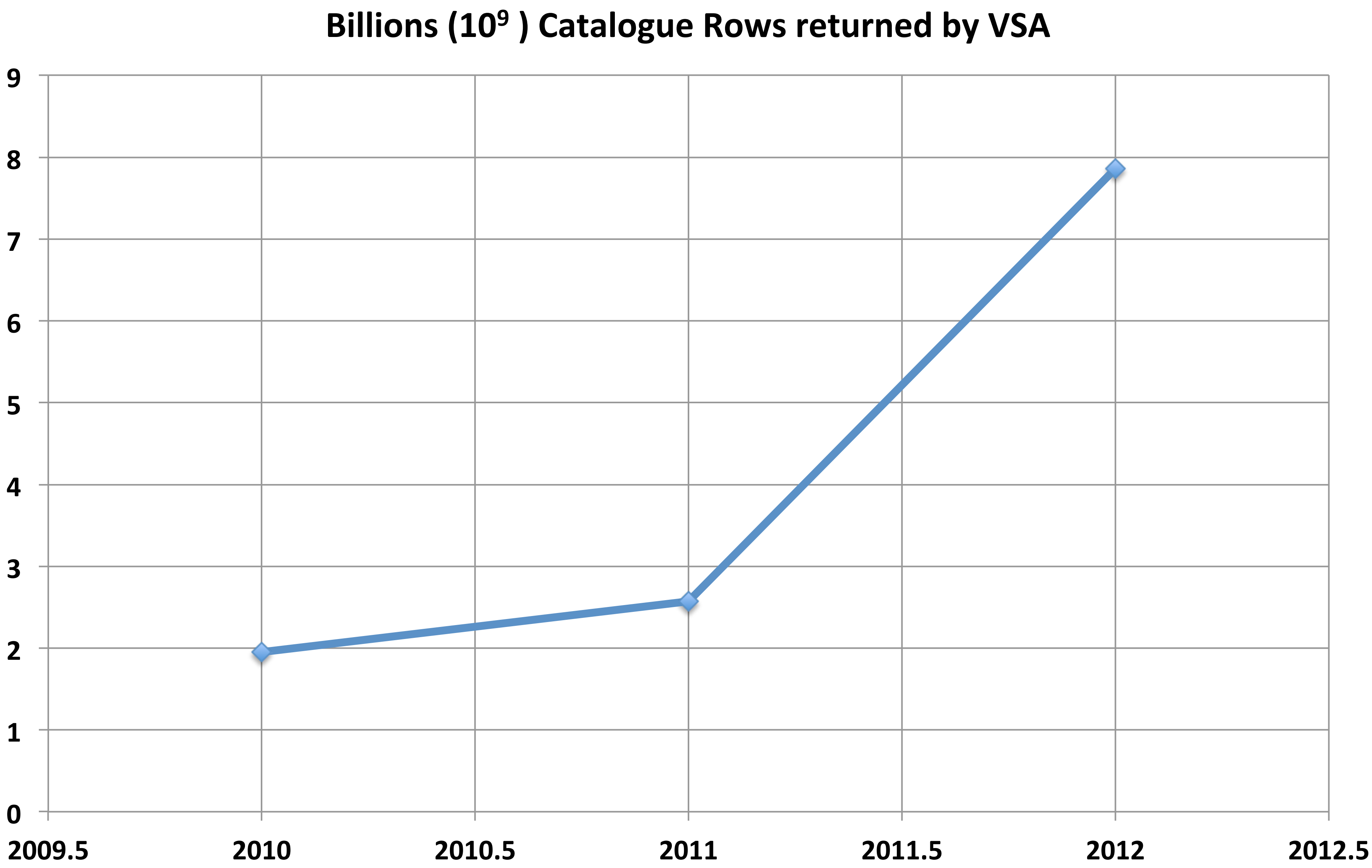
Data Volumes produced by CASU



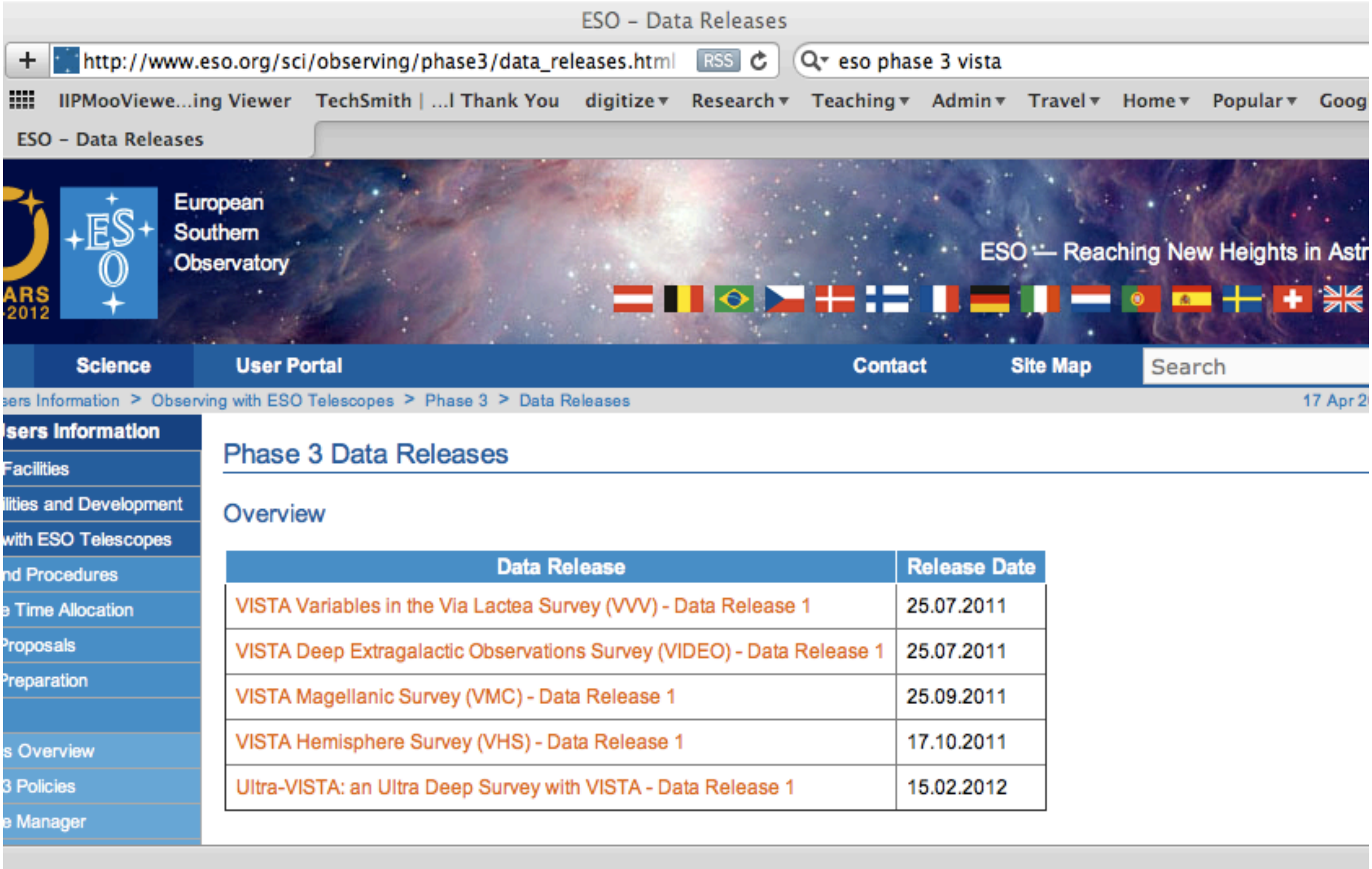
Early number/volume of files out (CASU)



Catalogue objects returned at VSA



Public data releases so far

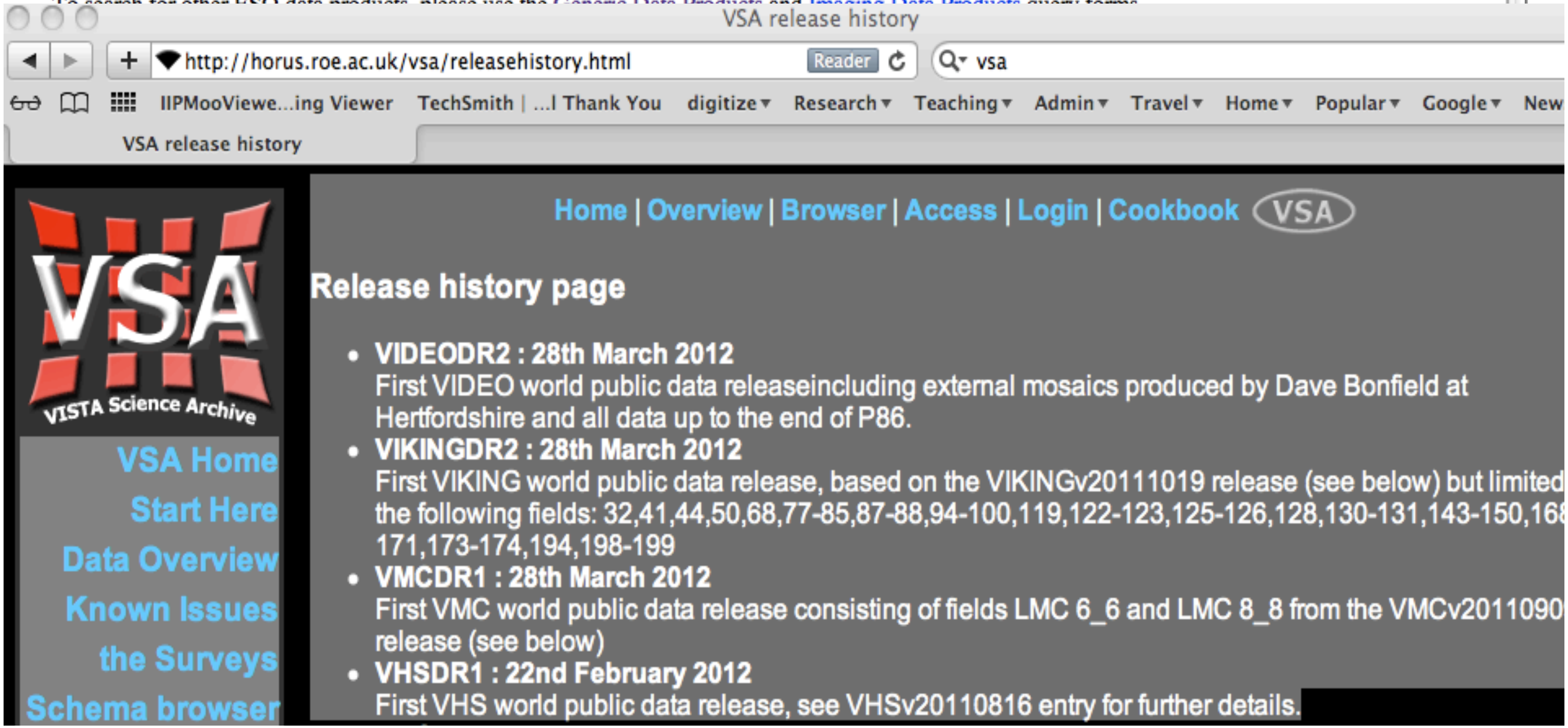


Phase 3 Data Releases

Overview

Data Release	Release Date
VISTA Variables in the Via Lactea Survey (VVV) - Data Release 1	25.07.2011
VISTA Deep Extragalactic Observations Survey (VIDEO) - Data Release 1	25.07.2011
VISTA Magellanic Survey (VMC) - Data Release 1	25.09.2011
VISTA Hemisphere Survey (VHS) - Data Release 1	17.10.2011
Ultra-VISTA: an Ultra Deep Survey with VISTA - Data Release 1	15.02.2012

Public data Release 1

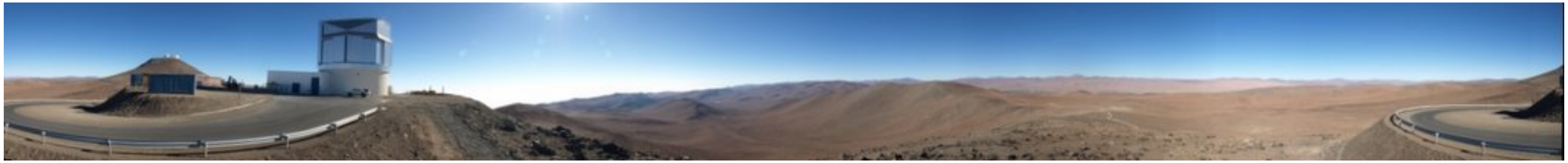


VISTA publications to 11/10/2012

VISTA	Refereed Publications using or referring to VISTA in text
In Text	128
In Abstract	60

Survey	Refereed publications for Survey seen (by JPE) so far
VVV	18 (see Minitti talk for update on number)
VMC	7 (see Cioni talk for update on number)
Other 4	2 each (see PI talks for update on number)

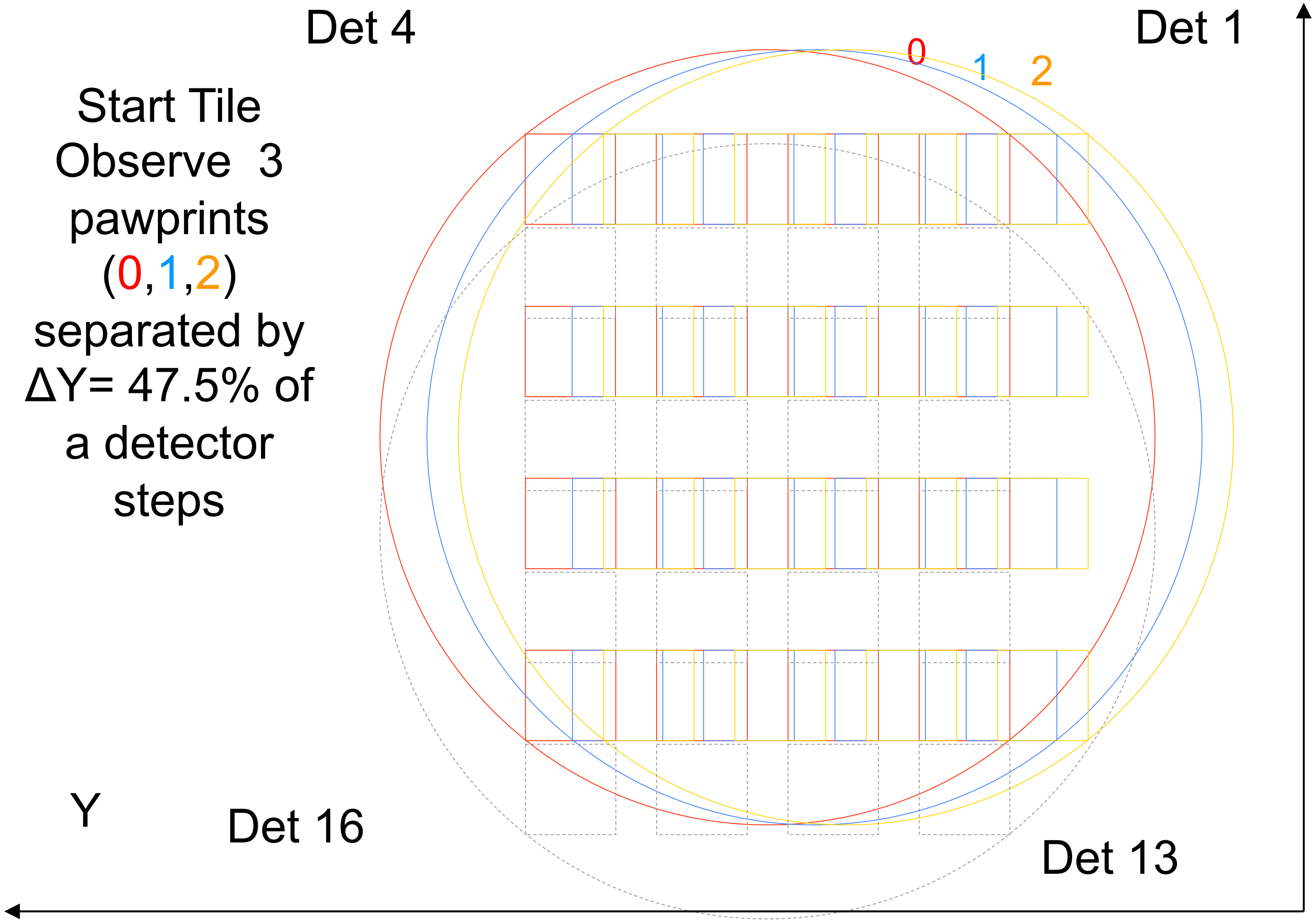
- The different numbers largely reflect the type of science goal of each survey and its observing strategy.
- See later talks and posters for the science results



Part 2: Using & Interpreting VISTA data

Tiles - combining the Pawprints

Start Tile
Observe 3 pawprints (0,1,2) separated by ΔY= 47.5% of a detector steps

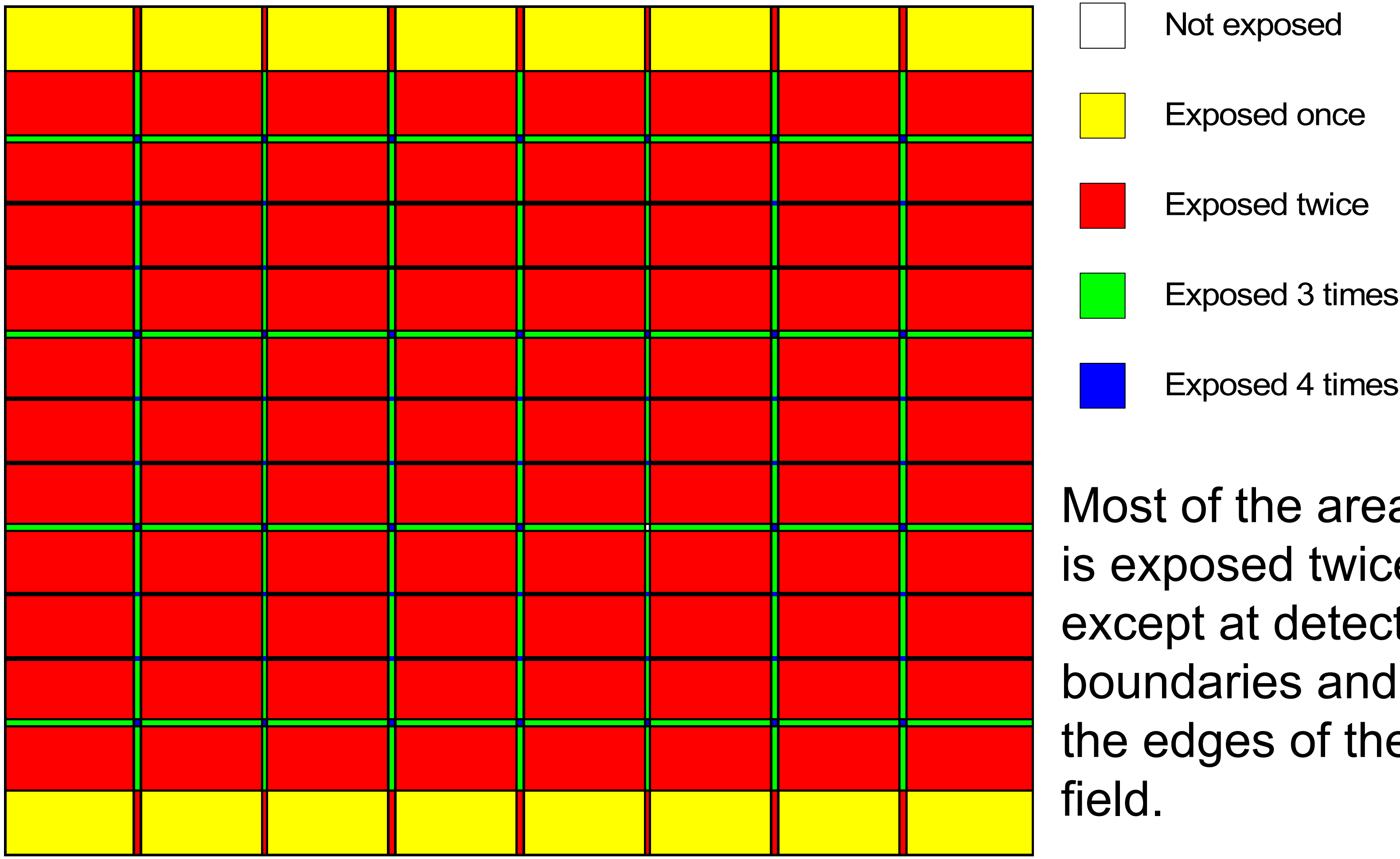


X (to centre of filter wheel)

Move down by ΔX=95% and observe 3 pawprints with ΔY=47.5% again

After 3x2=6 steps sky is (almost) uniformly tiled (by 2 pixels) except at edges

Exposure map within one "Tile"



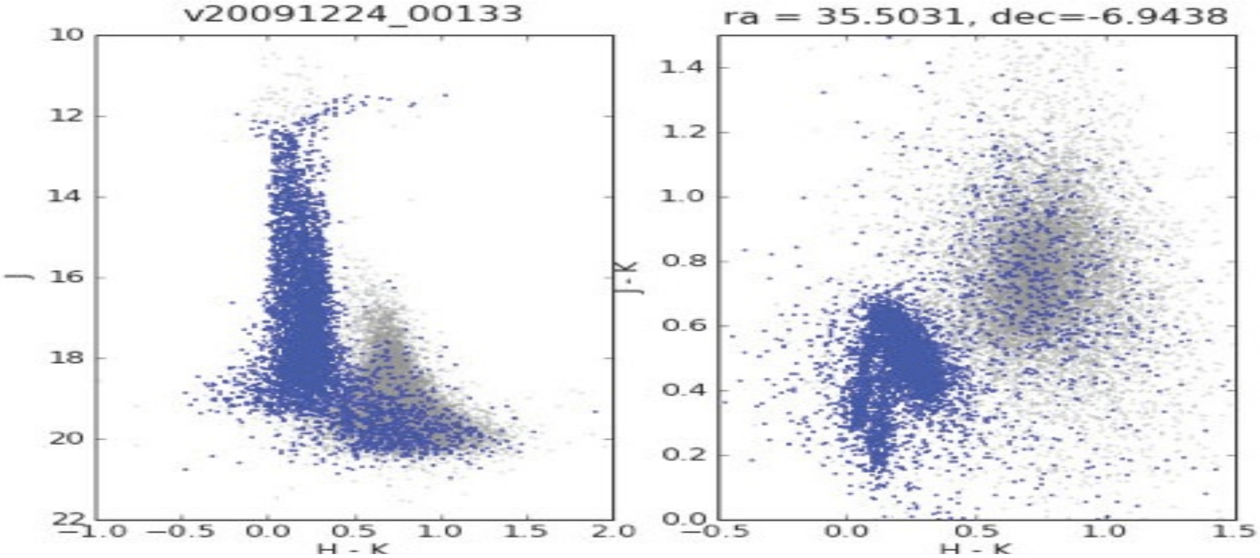
Most of the area is exposed twice, except at detector boundaries and the edges of the field.

Real coverage maps also include the effect of Jitters, not included above

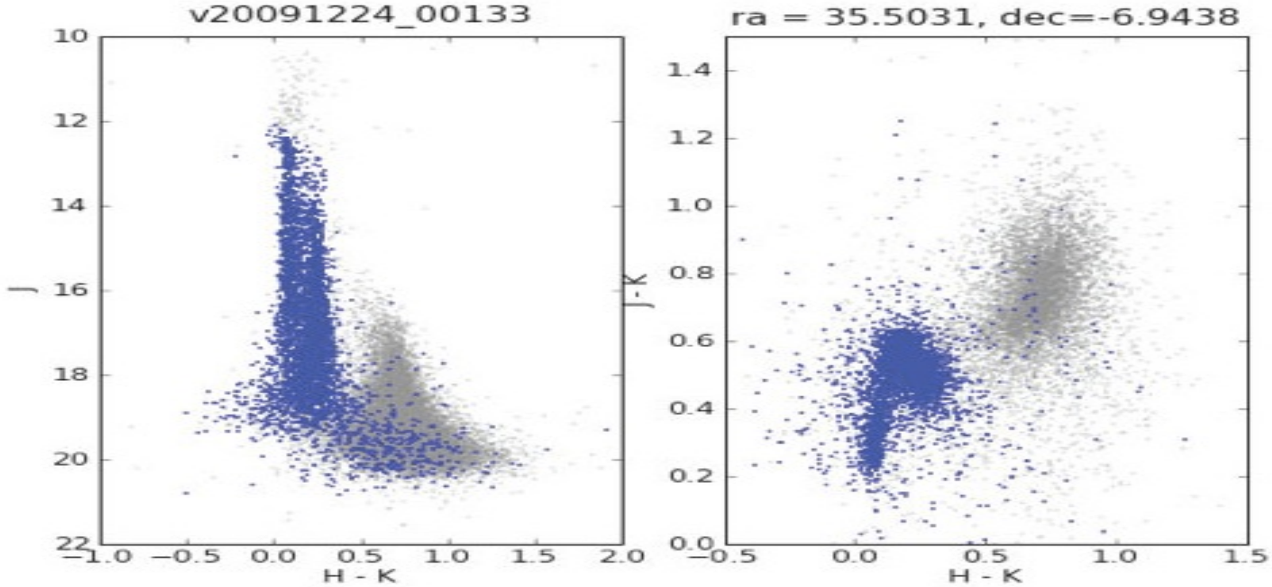
Tiles and pawprints

- Caveats on VISTA tiles
- Tiles are made of 6 offset pawprints each with a radially variation in psf and potentially a different seeing
- Over most of a Tile the exposure is 2x an individual pawprint (from 1-6 x)
- Tiles are composed of 96 different regions (16*6) which may/will in general each have different PSF.
- => Tiles can be trickier to handle than pawprints

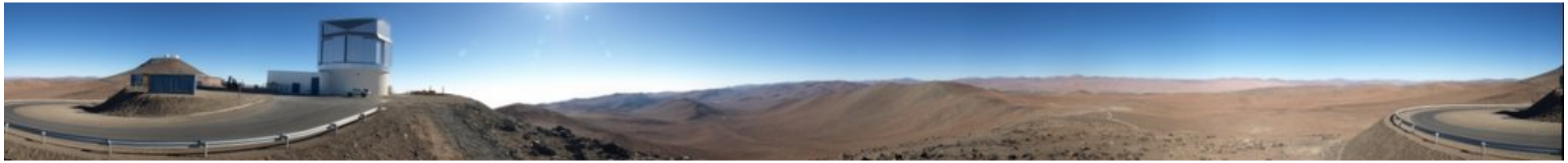
Tile Photometry: grouting



CMD of a tile with no correction made for the 96 different psf regions contributing to it



CMD of the same tile after photometry has been fixed up ('grouted') for these differences. This is implemented in the CASU catalogue pipeline for VISTA tiles.



Calibration: VISTA magnitude system

VISTA photometric system

- VISTA is calibrated onto its natural photometric system (Vega = 0.0)

It is important that users appreciate that VISTA uses 2MASS JHK_s magnitudes

- not to calibrate VISTA to the 2MASS system
- but to set the VISTA zero points to the Vega scale

VISTA Calibration – ideal steps

1. Raw VISTA data is internally calibrated onto a linear scale (without any need to know about 2MASS).✔
2. Need to set the VISTA scale (zero point)
   - – done by reference to 2MASS.
3. IF each detector had flat response and the FOV of each VISTA detector contained >=1 unreddened, high S/N, A0V star then we could use 2MASS magnitude of the A0V star to set the zero point of that detector. Transformation equation would be $J_{vista}=J_{2mass}$ etc
4. Zero points would be well determined. ✔
5. *Because net VISTA and 2MASS system transmission curves differ one should not ✖ expect to use this equation to find exact 2MASS magnitudes of other objects unless they happened to have the same colours as A0V stars.*

VISTA Calibration – realer steps

1. In reality we need a number of 2MASS stars over each detector and not all will be A0V and will / may be reddened so to set zero point of that detector we need to estimate their magnitudes on the VISTA system using some transformation (TBD) for each object.
2. If we knew intrinsic spectrum + reddening of each 2MASS object used we could compute the transformation (different) for each 2MASS object average Zero point would be very well determined & VISTA well calibrated. ✔
3. *One could not ✖ expect to use these (several) transformations to get correct 2MASS magnitudes of any other objects unless they happened to have the same colours as the (several) 2MASS stars. (cf 5 on previous slide)*

VISTA Calibration – realest steps

1. Take all 2MASS stars on detector, cut out extreme colours (limits TBD), use same empirical transformation (TBD) for all remaining 2MASS stars (non-ideal) + an estimate of Av => average (robust) Zero point of that detector well determined & VISTA well calibrated. ✔
2. One could not ✖ expect to use this (single) transformation to get correct 2MASS magnitudes of any other object unless it happened to have a particular set of colours (like the average of the (many) 2MASS stars used) (cf 3 and 5 of previous 2 slides).

Details

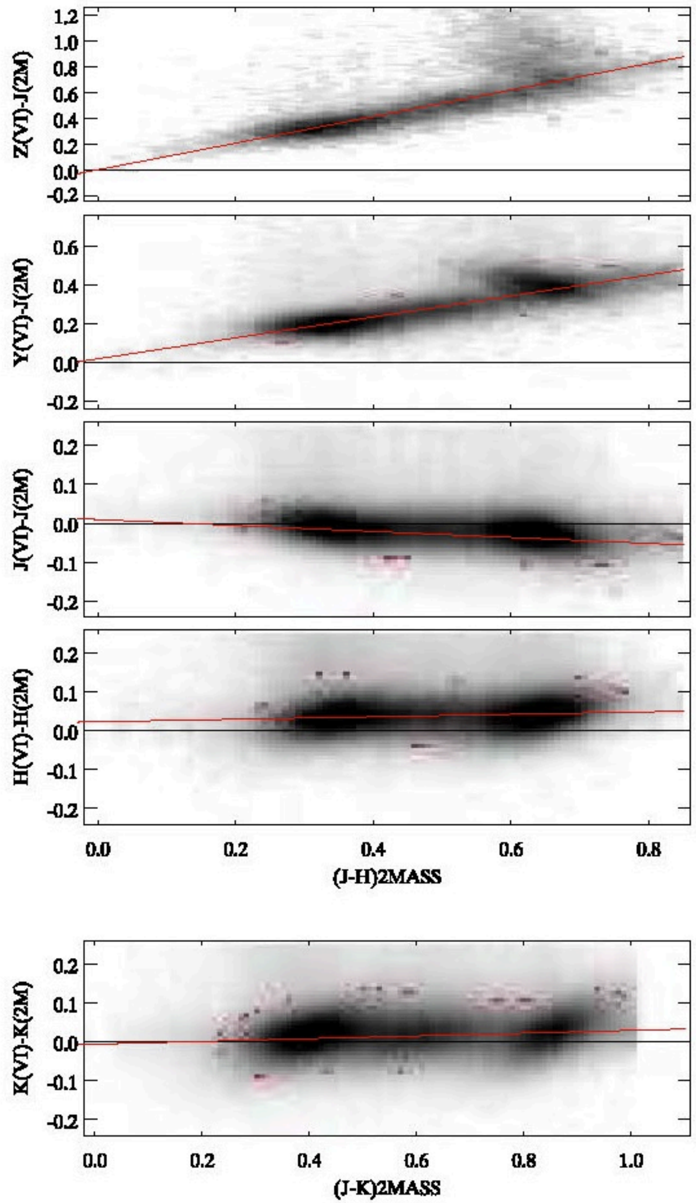
- Details and results are in a paper describing the transformations (and what the TBD values turn out to be) used for VISTA (Hodgkin et al 2012 in preparation)
- or see
- http://casu.ast.cam.ac.uk/surveys-projects/vista/technical
- The approach taken is similar to that used for WFCAM calibration(Hodgkin et al MNRAS 394,675,2009

Calibration Colour Equations

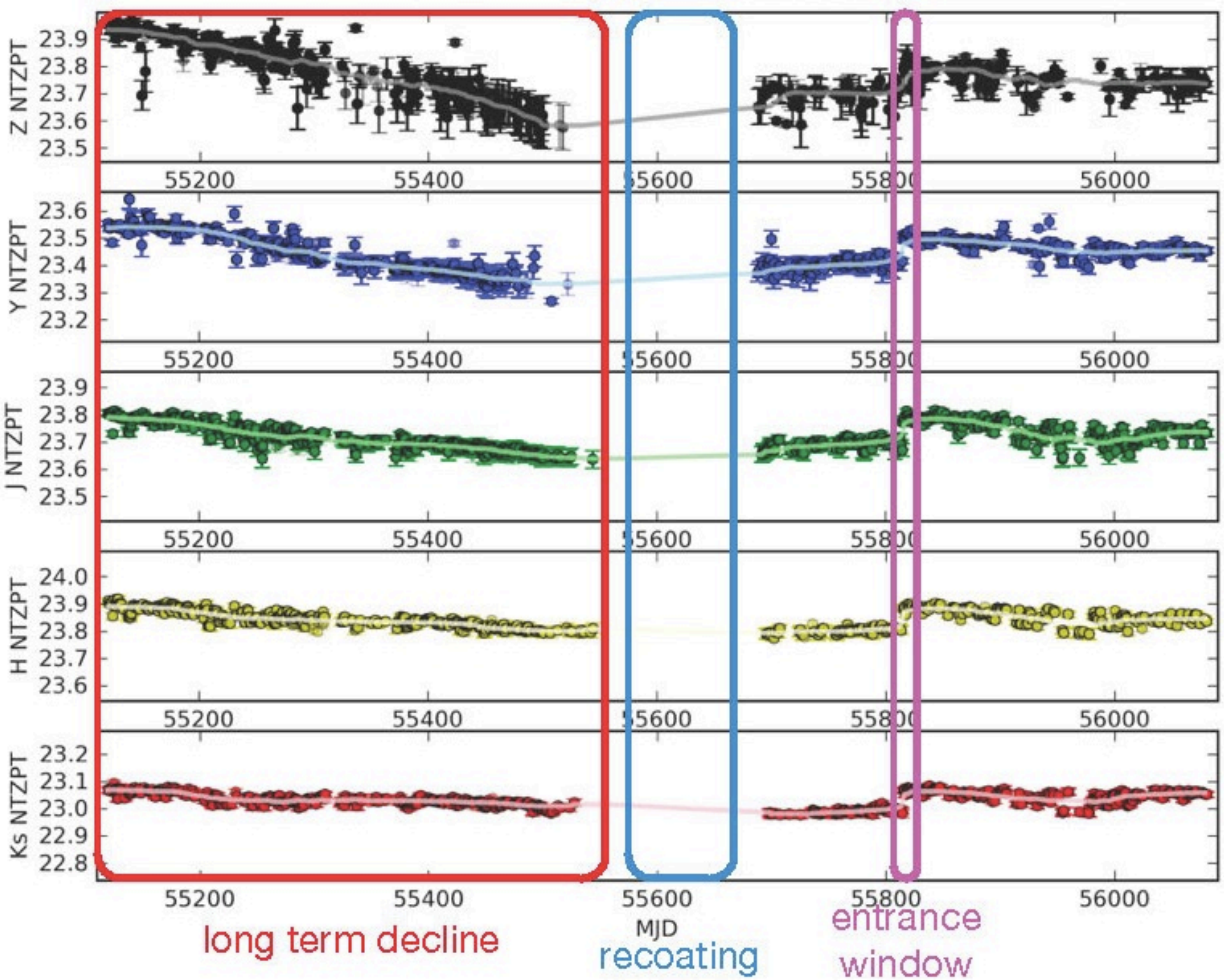
- Colour equations (2MASS to VISTA) used for setting the VISTA zero points of the calibration from 2MASS stars are derived from a compilation of data measured on good (photometric) nights, with good seeing, and for fields with E(B-V)<0.2, and $(J-K)_{2MASS} \leq 2.0$, and adjusted to give robust fits to the data - see next slide

Calibration Colour Equations

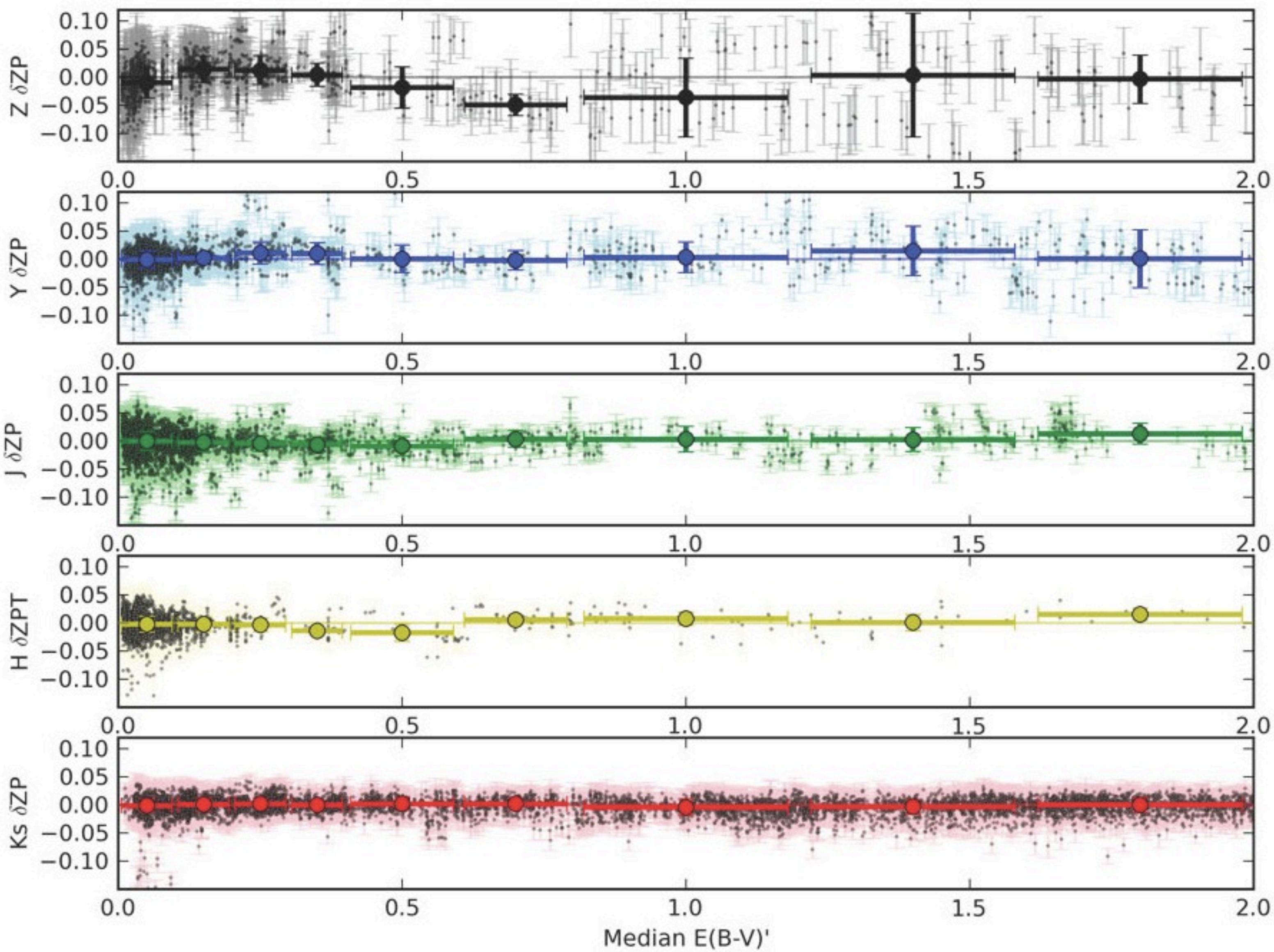
- $Z_{VISTA} = J_{2MASS} + 1.025*(J\text{-}H)_{2MASS}$
  $Y_{VISTA} = J_{2MASS} + 0.610*(J\text{-}H)_{2MASS}$
  $J_{VISTA} = J_{2MASS} - 0.077*(J\text{-}H)_{2MASS}$
  $H_{VISTA} = H_{2MASS} + 0.032*(J\text{-}H)_{2MASS}$
  $Ks_{VISTA} = Ks_{2MASS} + 0.010*(J\text{-}Ks)_{2MASS}$
- But check http://casu.ast.cam.ac.uk/surveys-projects/vista/technical/photometric-properties/sky-brightness-variation/view and Hodgkin et al 2012 for updates!
- *One should not* ✖ *expect to use these transformations to get correct 2MASS magnitudes of any other object unless it happened to have a particular set of colours (like the average of the (many) selected 2MASS stars used to get Zero point).*



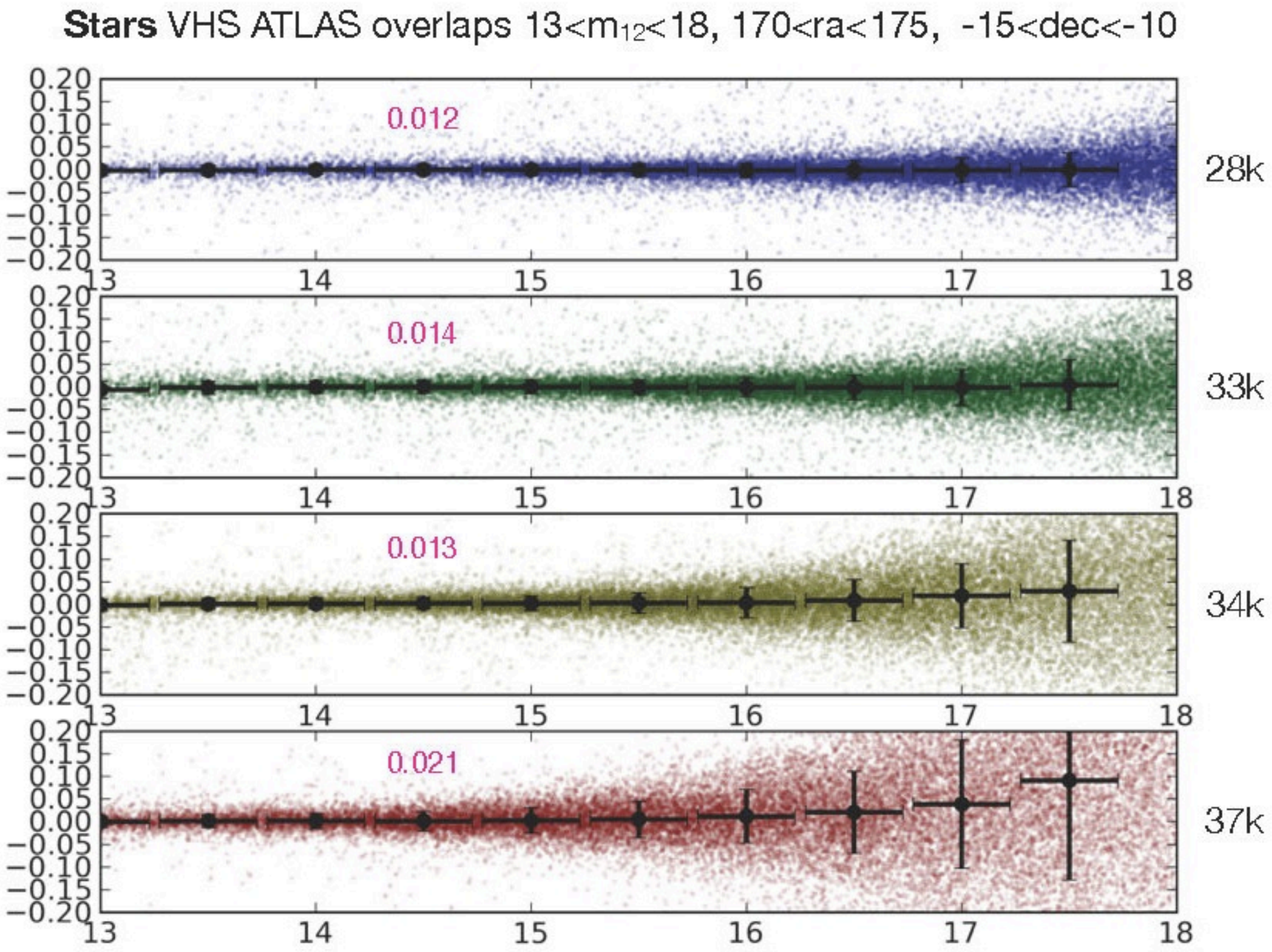
How well does it work - Zero points



How good? Extinction dependence

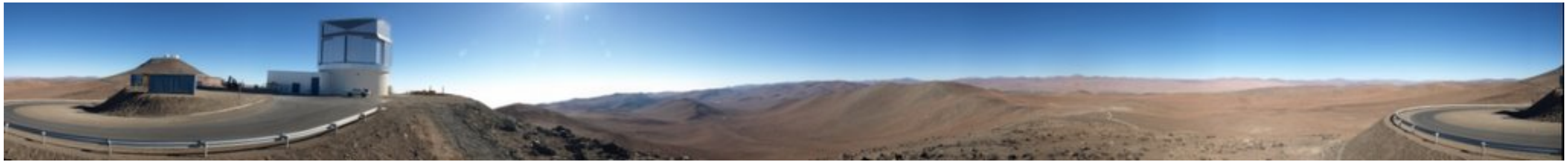


How good? Tile to Tile overlaps



Recommendations

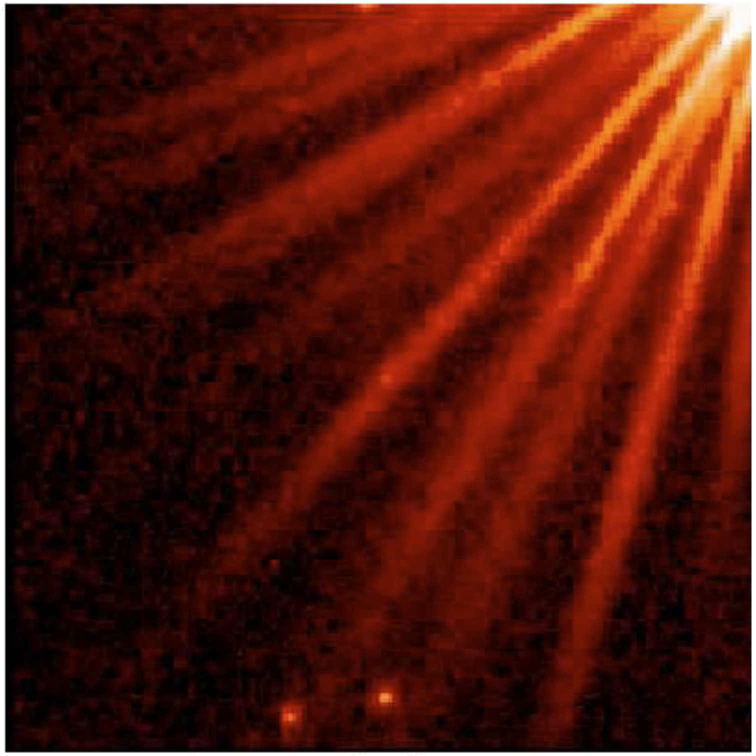
1. Work with VISTA data in the natural VISTA system (see Hodgkin et al & Hewett et al in preparation). VISTA is NOT on the 2MASS system (yes - even at JHK_s) .
2. Use VISTA transmission to put theoretical models onto the VISTA system (e.g. Hewett et al in preparation cf. version for WFCAM MNRAS 367, 454, 2006)
3. If necessary put (the fewer) 2MASS objects onto the (more objects) VISTA system and work in VISTA system – the transformed 2MASS magnitudes will have some imperfections BUT now many fewer objects are thus affected than if one imposed the imperfections on all the (many more) VISTA magnitudes.
4. In any case quantify and state the systematic effects and uncertainties of any other methods. (cf Hodgkin et al 2012 in preparation)



Artefacts - Rotating Ghosts & Spikes

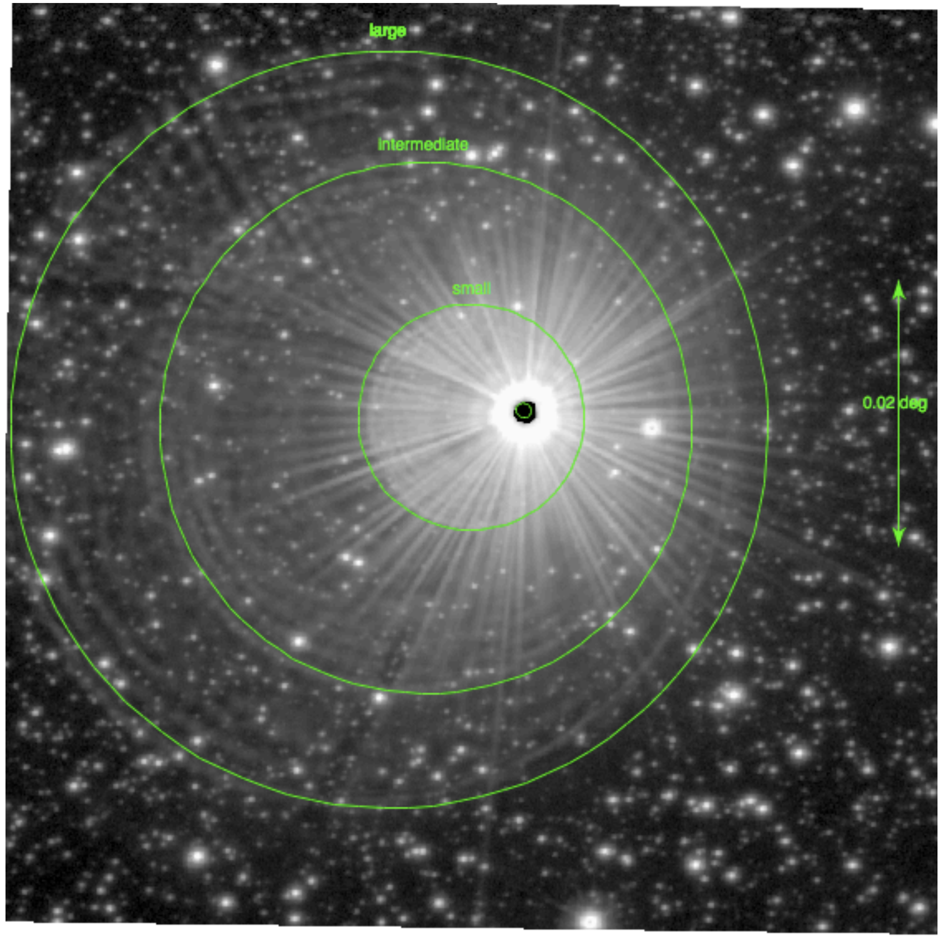
Diffraction spikes (example in J)

- Bright stars show diffraction spikes which can affect photometry of objects lying in their vicinity.
- Spikes rotate as the rotator moves to keep the objects fixed on the detector.
- So sometimes one or other of the two stars at bottom centre will be ‘lit up’ by a spike.
- Can appear as a false variable!



Bright star (J=3.1) on detector 15

- Star (saturated - black)
- Diffraction spikes round *
- 3 ghosts (green circles)
  - Different radii
  - Different brightnesses
  - Offset from *
  - Offset position dependent
  - Line joining the star & 3 ghost centres points to pawprint centre.
- ‘Nebulising’ in CASU cataloguing removes most effect of ghosts but not of spikes.



- For VIKING J (DIT*NDIT=25*2) Ghosts appears until J_{2MASS} <= 6 (Large), 7 (Intermediate), 9 (Small)

Conclusion

- VISTA is working well
- Completing existing public Surveys to their original plans will take longer than 5 years
- Regular data releases to public
- Tens of science papers published
- VISTA is making a significant impact
- Listen to the many VISTA talks to come