The VISTA Hemisphere Survey(VHS) Science Goals and Status

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VISTA site choice: Cerro Paranal (ESO) or Cerro Pachon (Gemini)

VISTA SCIENCE COMMITTEE
VSC-00-1

Scientific issues concerning VISTA site choice

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Date: 2000 Feb 4

Abstract: This report aims to summarise and compare in a quantitative manner the *scientific* related issues that affect site choice. We include material that characterises the sites that are currently under consideration. Other issues relating to operational cost and logistics which can indirectly affect scientific output in a major manner are not considered.

Comparing the two sites under consideration, we find that:

- the seeing at the two sites is probably similar
- Paranal has 20% more photometric nights than Pachon
- Paranal is a warmer winter site and hence the K_s sky background may be brighter by ~0.25-0.34mag. If 50% of all time (think of it as bright + some grey time) is spent in K_s this would reduce Paranal's advantage in terms of the number of winter photometric nights by 6-8%, so it would be 12-14%.
- We conclude that either Pachon or Paranal would make an excellent site for VISTA.

VHS Science Goals

- the nearest and lowest mass stars
- Galactic structure; formation and merger history of the Milky Way
- evolution of Large scale structure in the Universe; the nature and evolution of Dark Energy
- physics and baryonic content of the Universe during the Epoch of Reionization using z>7 quasars
- discovery of the most luminous quasars in the southern celestial hemisphere at all
- redshifts as probes of the IGM and the formation of the most massive supermassive black holes in the Universe
- **Your science here since it is a ESO Public Survey**

- Synergy with VST ATLAS, KIDS/VIKING, AKARI(Astro-F), WISE, eROSITA
- Support for ESA Survey Missions:
  - XMM-Newton, Herschel, Planck, GAIA
- Targets for the VLT, ALMA, ELT, JWST

Survey volume compared with other near IR surveys

100 times volume of Universe compared with 2MASS
- increased depth of a factor of 40

10 times the volume of the Universe compared UKIDSS
- increased depth and area

VISTA Large (>20deg^2) Area ESO Public Surveys

Survey	Area (deg^2)	5σ point source depth (AB mag)				
		Z	Y	J	H	K_s
VHS (required depths)	**18, 000**			**21.2**		**19.8**
1. VHS-DES	4500	*24.7*	*23.0*	21.6		20.2
2. VHS ATLAS	5000		20.9	21.2	20.6	19.8
3. VHS-GPS (5°<|b|<30°)	8000			21.2		19.8
VIKING	**1,500**	**23.1**	**22.3**	**22.1**	**21.5**	**21.2**
VVV (Galactic Centre)	520	22.4	21.8	21.1		
VMC (Magellanic Clouds)	184		23.3	21.4		

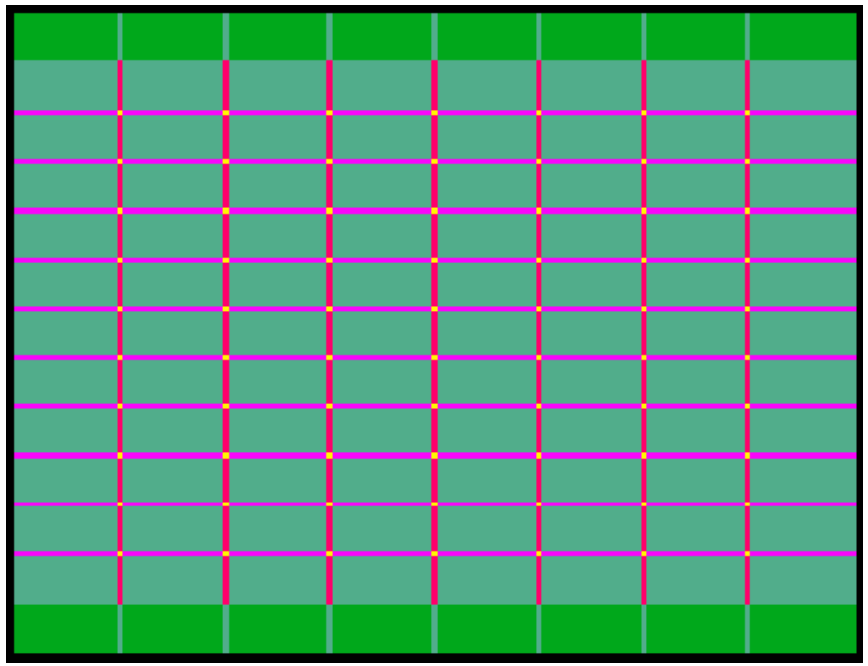
- Dark Energy Survey (5000deg^2) will cover VHS-DES and VIKING-SGC footprints in grizY (Z and Y depths are given above)
- VHS goal is full hemisphere coverage when combine with other ESO surveys

VHS Components

- VHS Galactic Plane (VHS-GP)
  - 5< |b| <30
  - 8200deg^2
  - J(60sec); K(60sec)
- VHS-ATLAS (cf. Optical Survey: VST-ATLAS PI: Shanks)
  - 5000deg^2
  - Y(60sec), J(60sec), H(60sec), K(60sec)
    - Changed April 2012 to Y(120sec), J(60sec), H(0sec), K(60sec)
- VHS-Dark Energy Survey (VHS-DES)
  - 4500deg^2 (excludes 500deg^2 from VIKING footprint)
  - J (120sec), H(120sec), K(120sec)
    - Changed April 2012 to J(240sec), H(0sec), K(120sec)

VISTA Tile

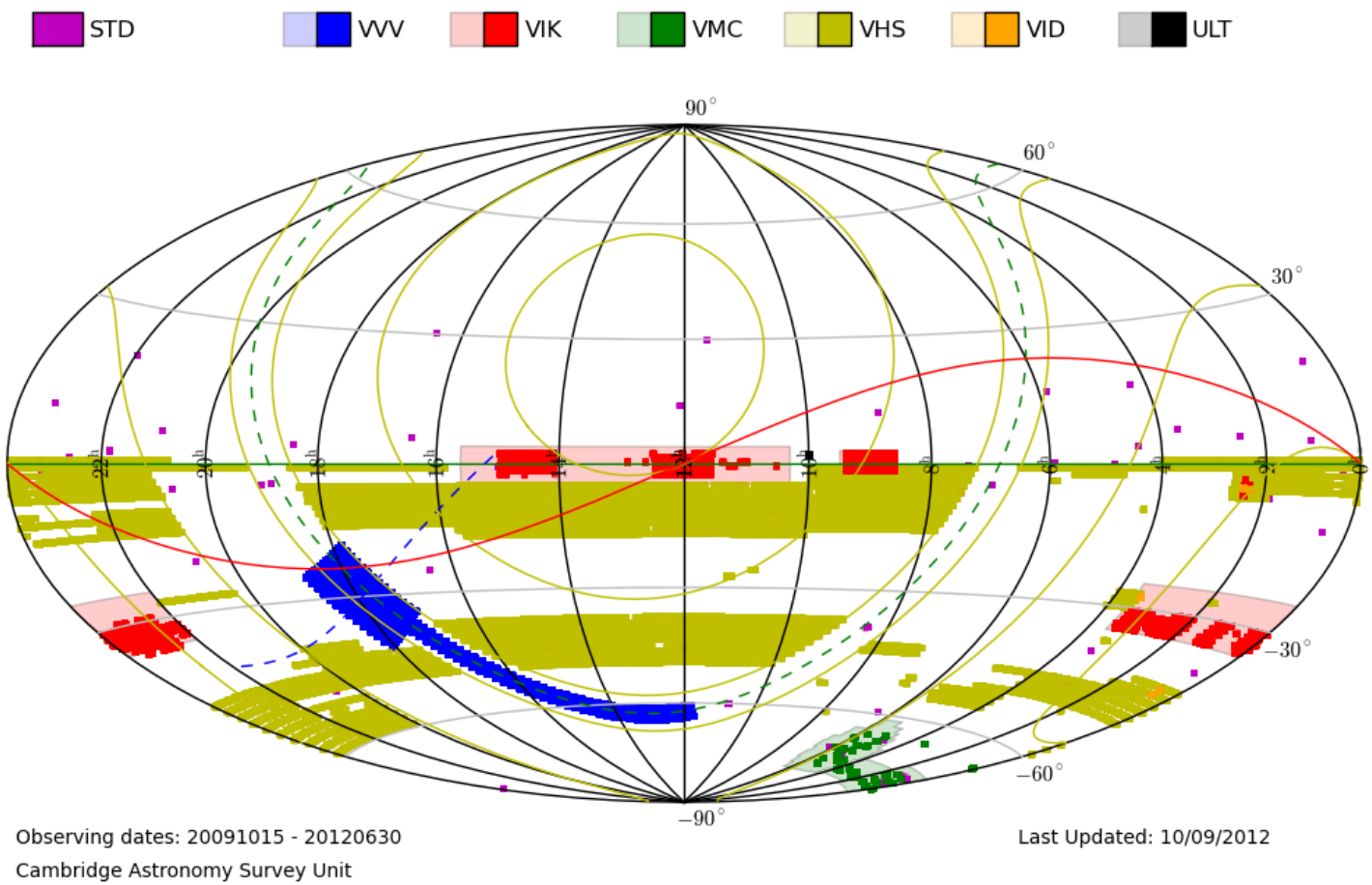
- 6 pointings or paw-prints are required to give a contiguous ‘tile’
- 0.60deg^2 of sky coverage per pointing
- 1.017 deg x 1.475deg = 1.501 deg^2 sky is covered (by a minimum of 2 pixels) as shown in light green in the exposure time map below for a filled tile.



Relative Exposure Time
dark green = 1
light green = 2,
magenta = 3
red = 4
yellow = 6

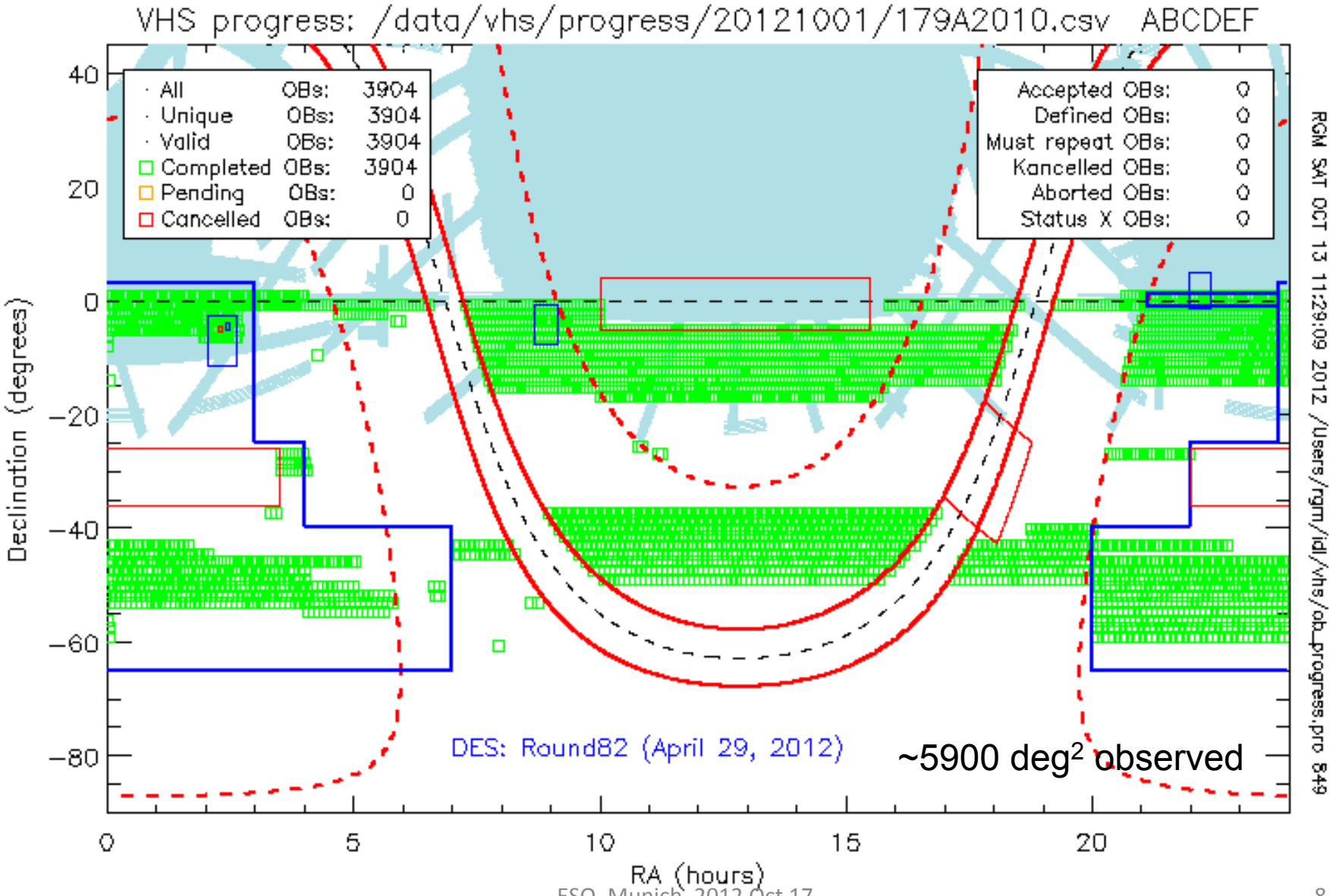
104 different ‘half-chips’ when mosaiced

VISTA Surveys Processing Status

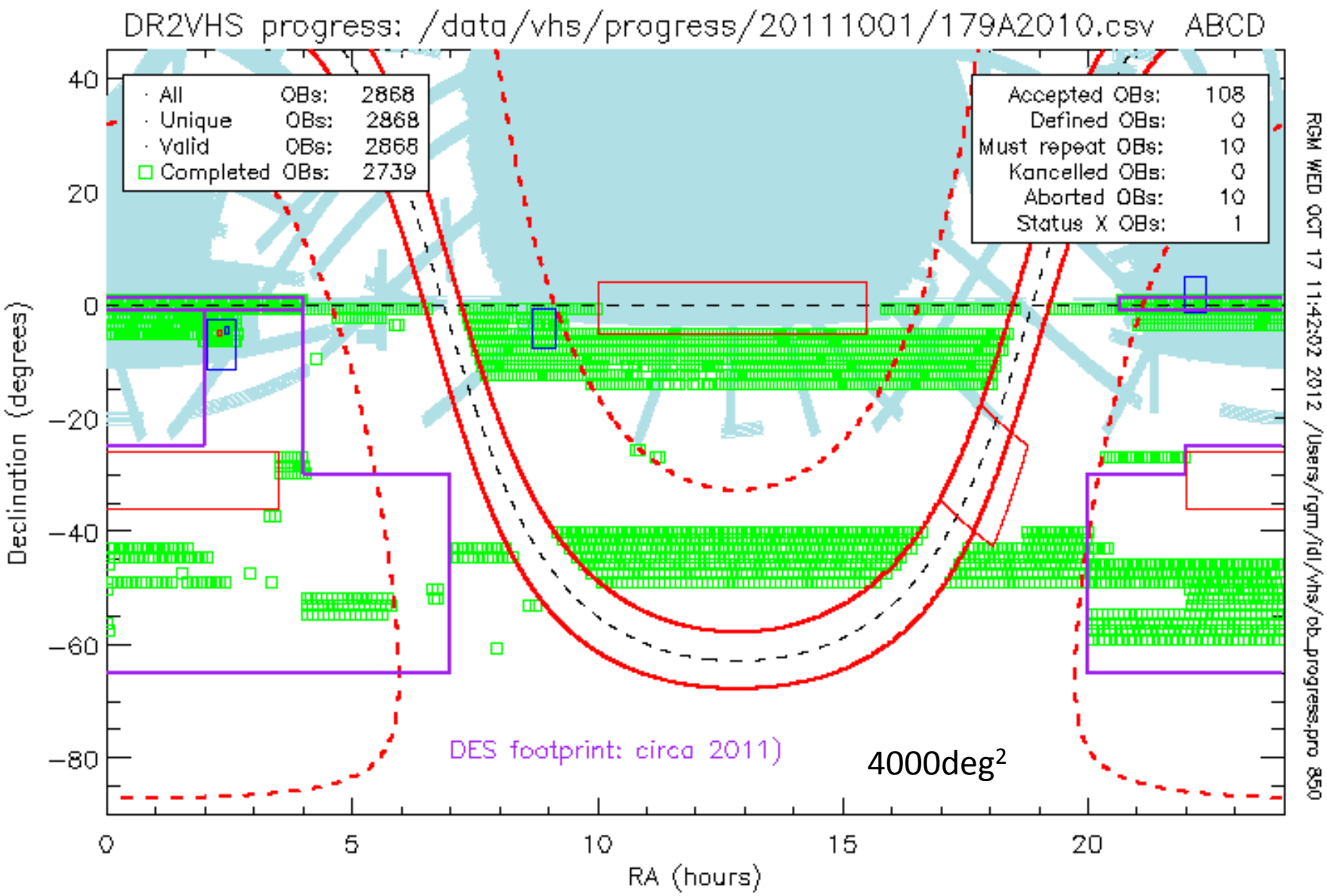


VHS observations status on Oct 1st

Each Observing Block(OB) = 1.5deg^2

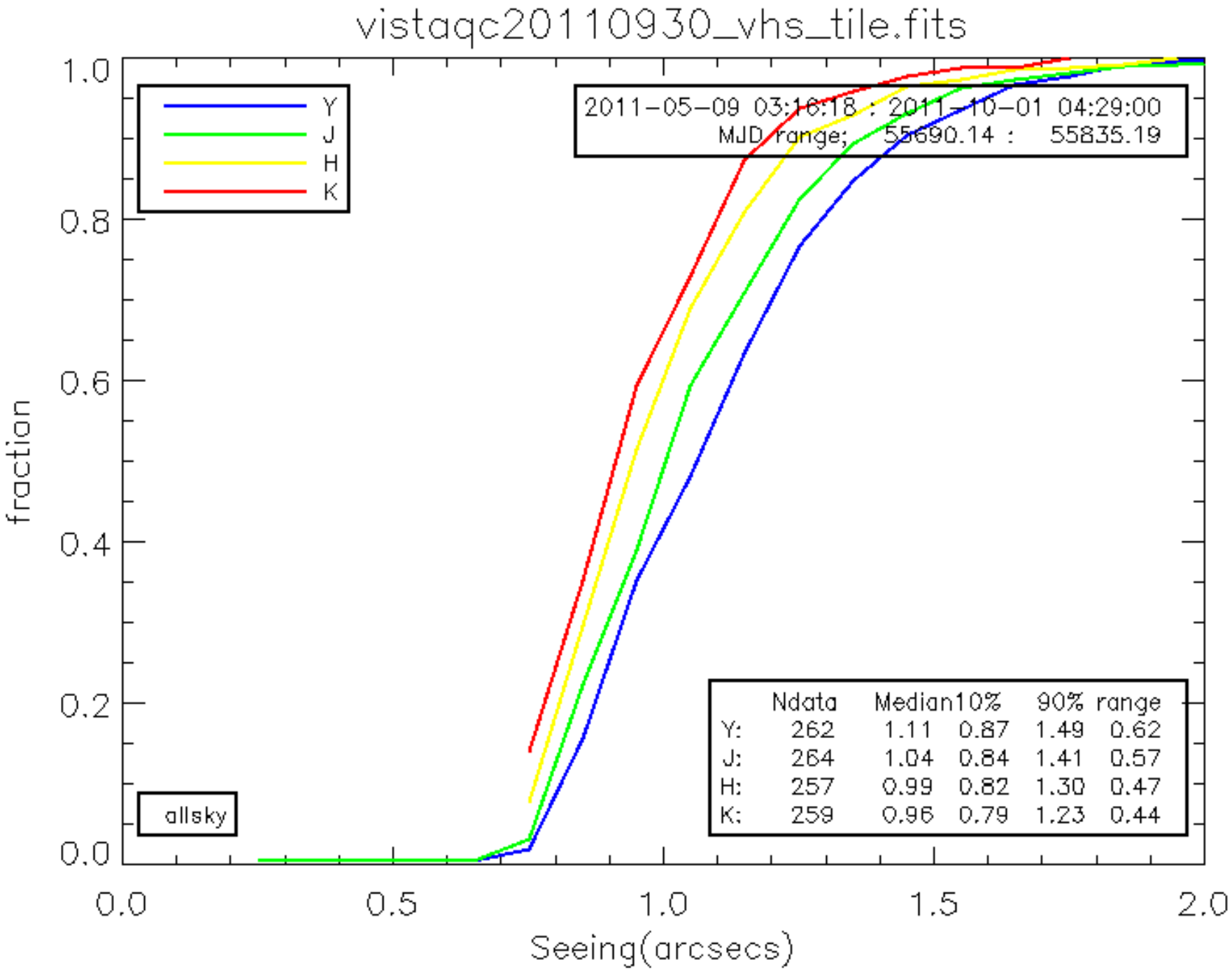


Next Public Release (observation up to 2011 Sep 30)

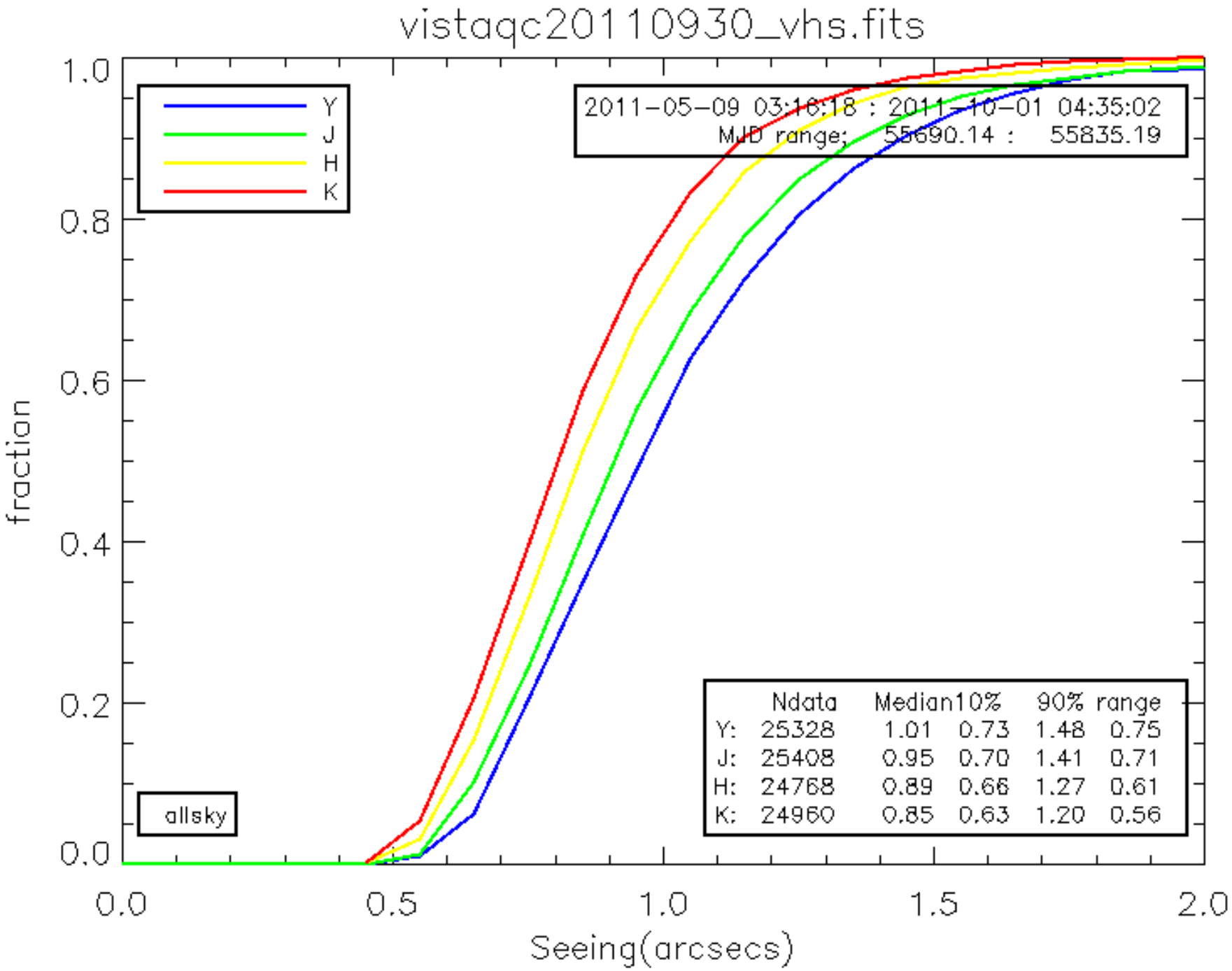


Period 87 QC

April 2011 – Sep 2011



RGM MON JAN 23 00:41:06 2012 /home/rgm/idl/libdqc/dqc_analysis.pro 731



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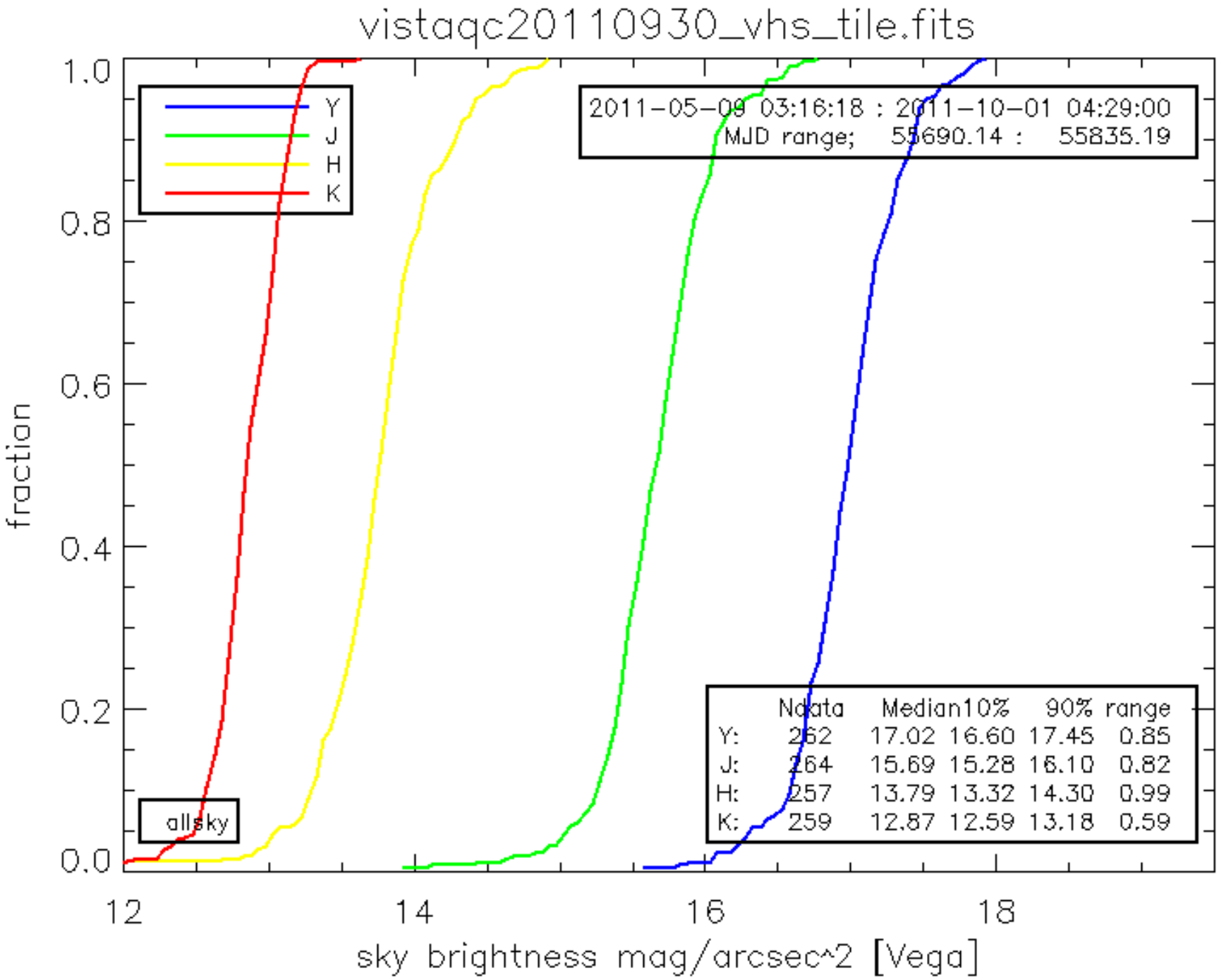

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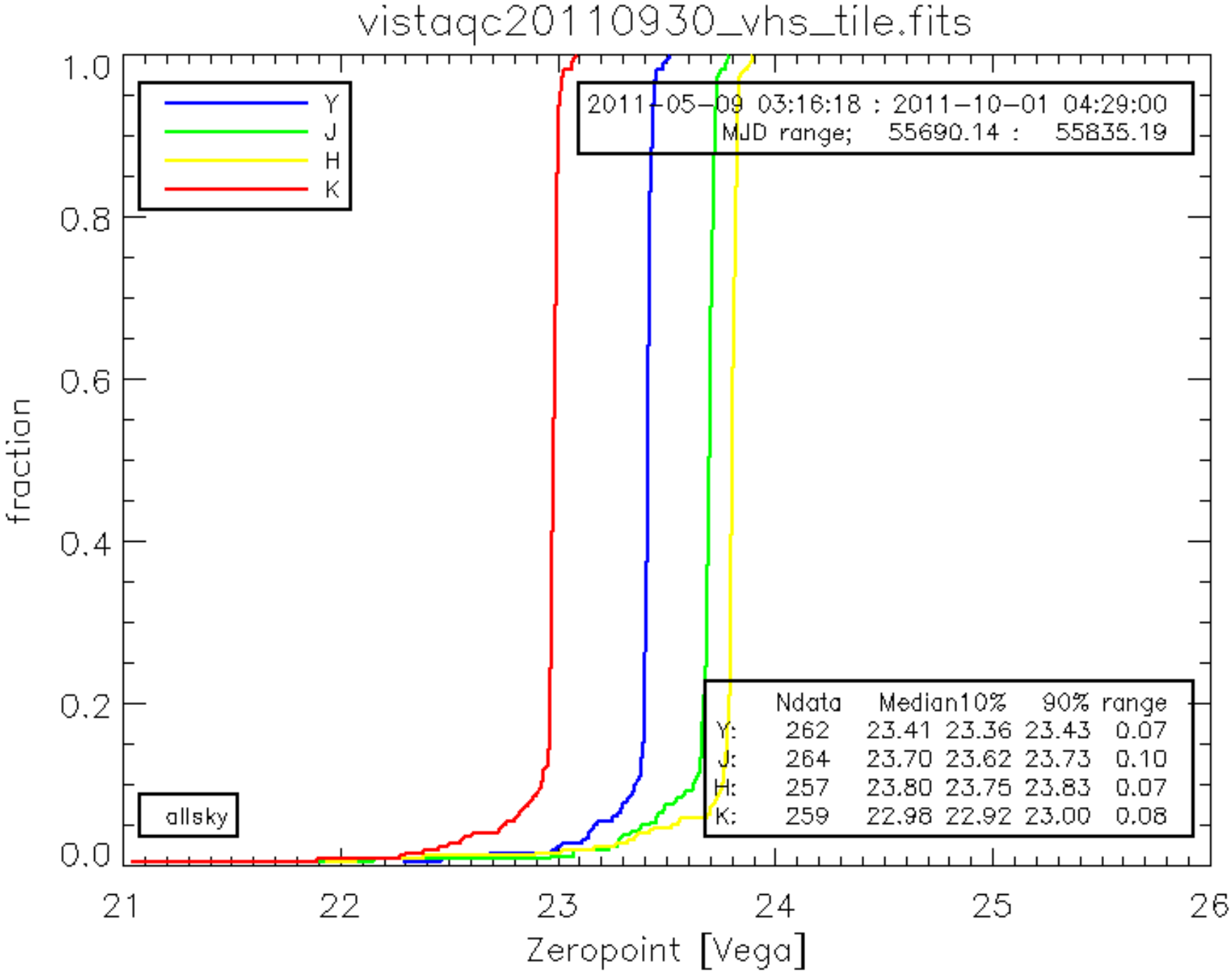
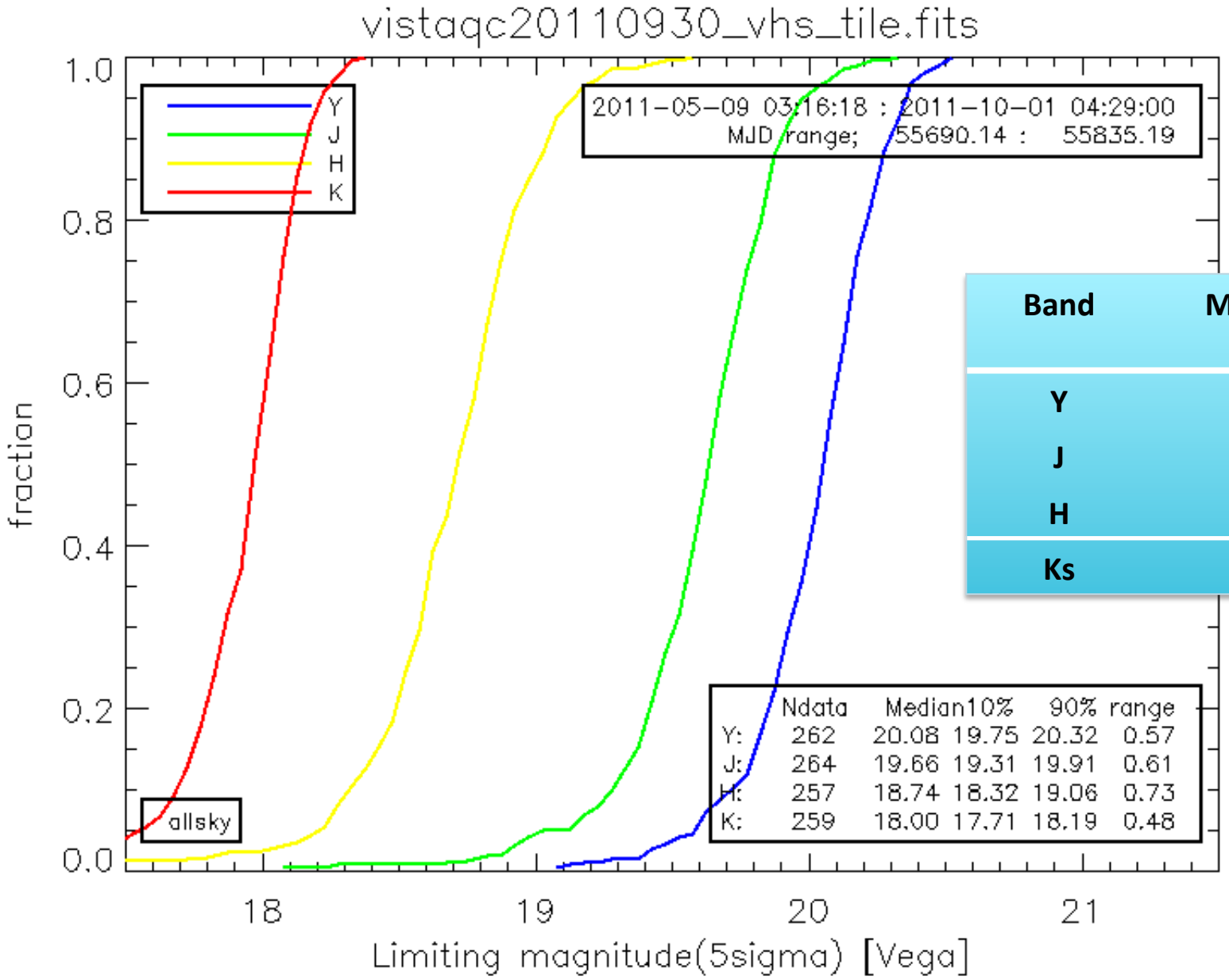


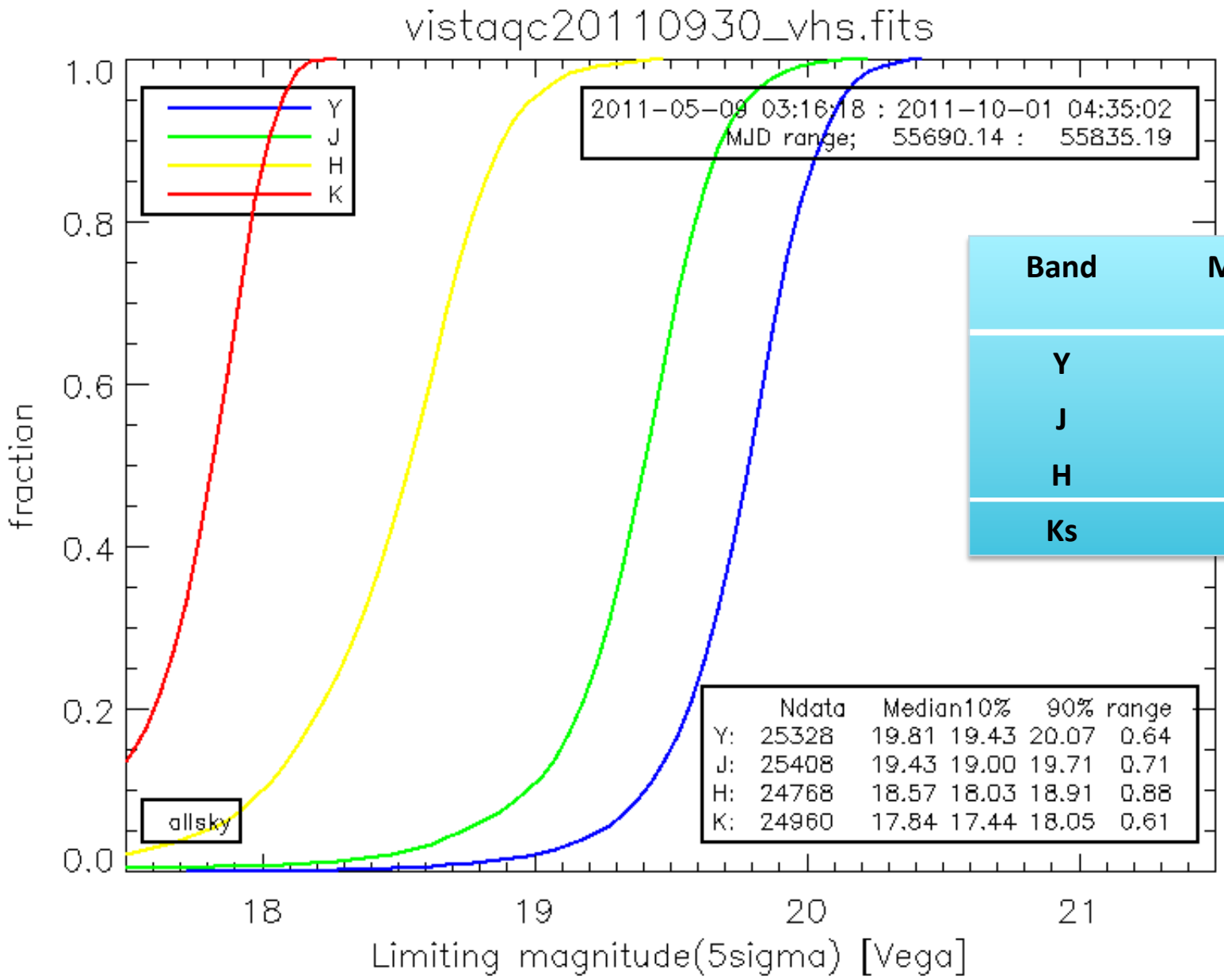
RGM MON JAN 23 00:41:07 2012 /home/rgm/idl/libdqc/dqc_analysis.pro 731

VHS-ATLAS Tiles: Limiting magnitude 5sigma (stars)



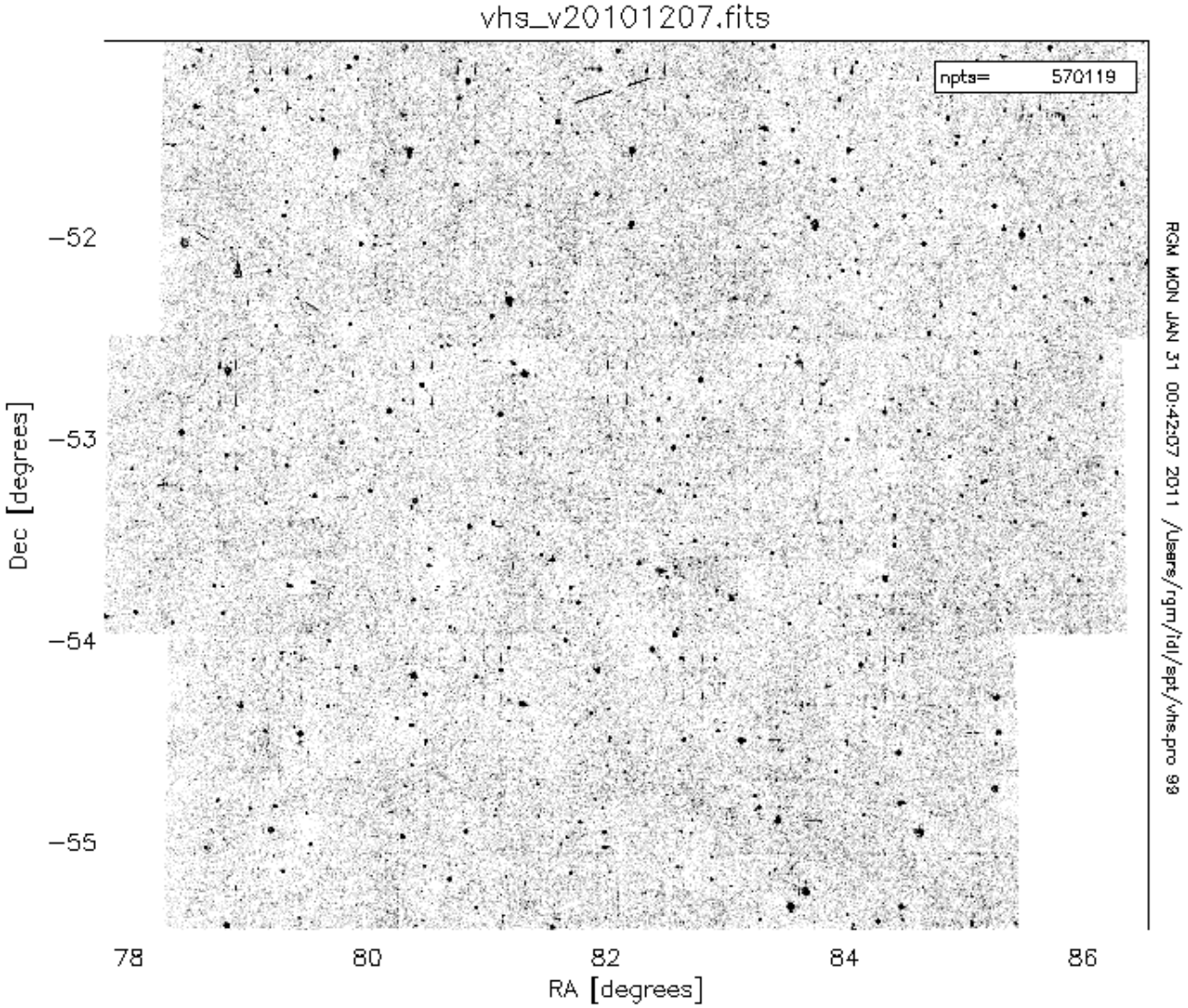
Band	Measured (Vega)
Y	20.08
J	19.66
H	18.74
Ks	18.00

VHS-ATLAS Pawprints: Limiting magnitude 5sigma (stars)

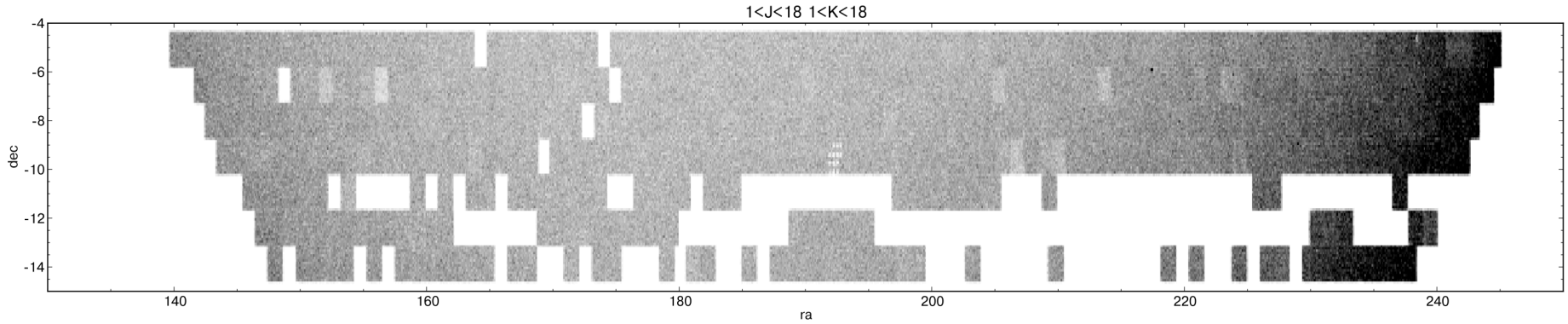


Band	Measured (Vega)
Y	19.81
J	19.43
H	18.57
Ks	17.84

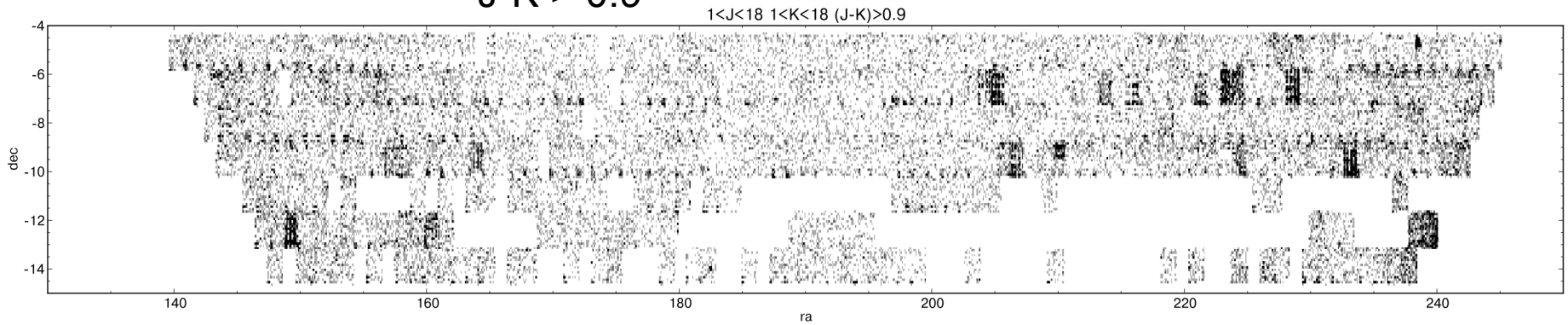
5 deg x 5 deg patch:



VHS-ATLAS NGP
Stellar density distribution



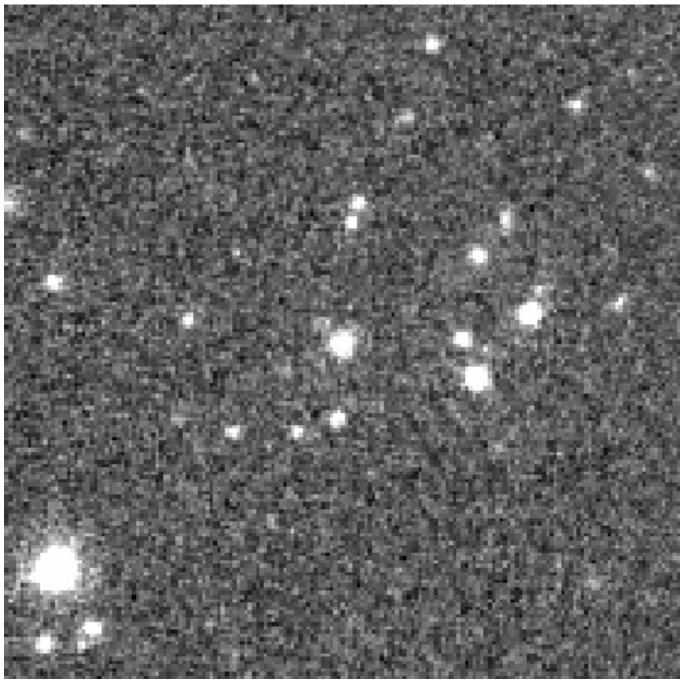
J-K > 0.9



Sergey Koposov, Eduardo Gonzalez

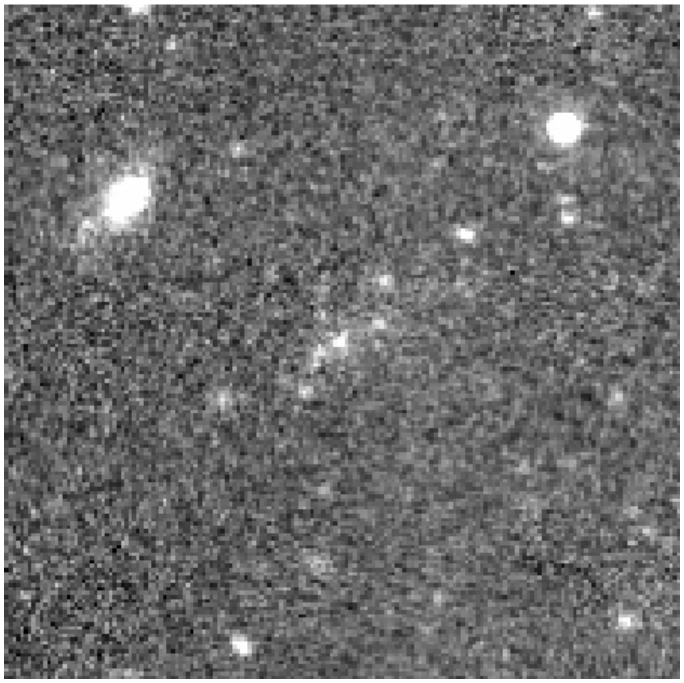
South Pole Telescope S-Z clusters

SPT-CLJ0528
(z=0.76)



Ks~18.9 (10σ AB)

SPT-CLJ0546
(z=1.06)

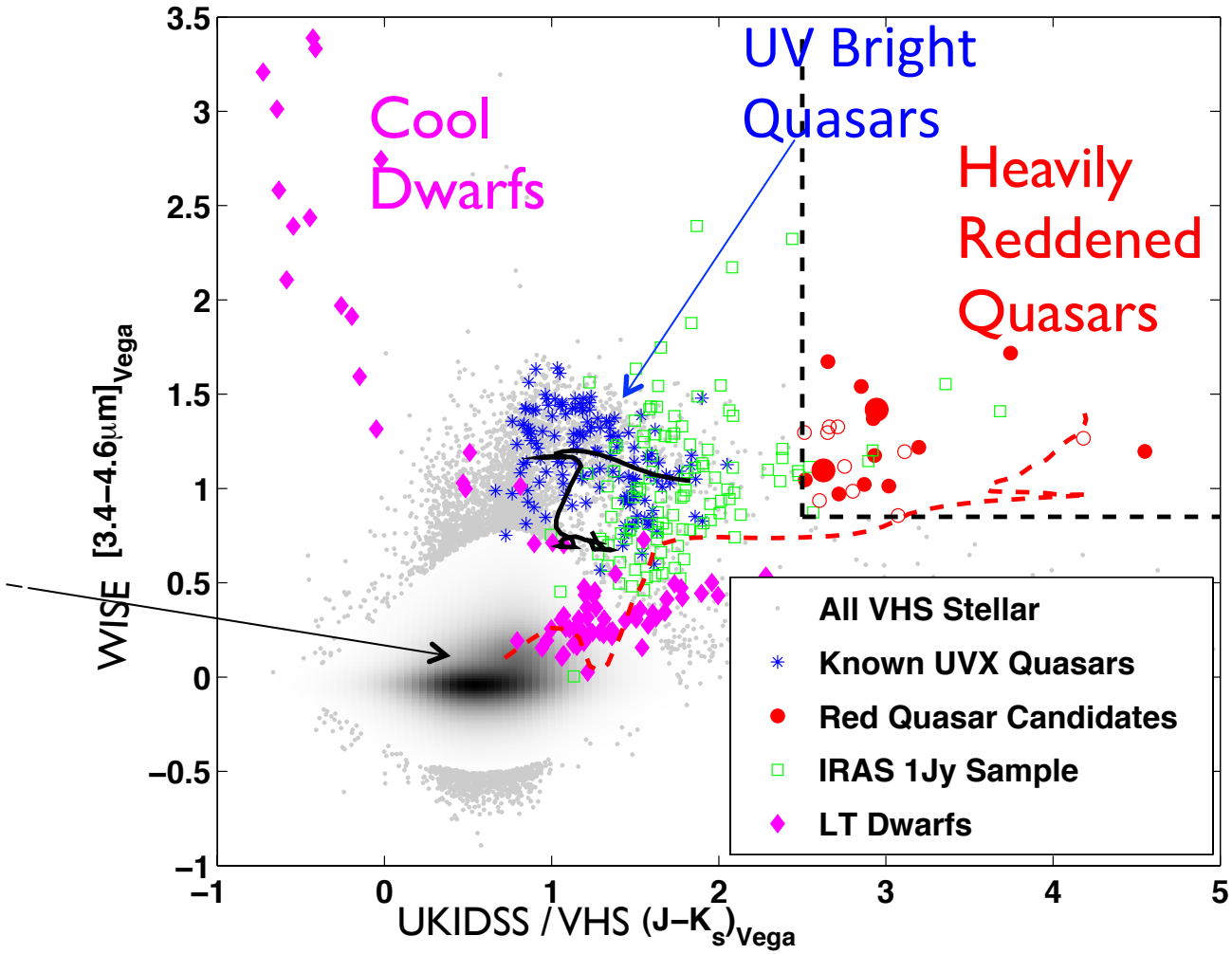


Ks~18.5 (10σ AB)

Banerji, Stroe, McMahon, Mohr et al.)

Dust Reddened Broad Line Quasars at Redshift 2:

Starbursts Transitioning to UV-Luminous AGN?



Banerji, McMahon et al. 2012b

K_{vega}<17.0
A_v > 5
undetected in optical to i=22.5

not Type 2 AGN

Mon. Not. R. Astron. Soc. **000**, 000–000 (0000) Printed 13 August 2012 (MN LATEX style file v2.2)

A new L-dwarf member of the moderately metal-poor triple system HD 221356

B. Gauza[1,2] ⋆, V. J. S. Béjar[1,2], R. Rebolo[1,2], K. Peña Ramírez[1,2], M. R. Zapatero Osorio[3], A, Pérez-Garrido[4], N. Lodieu[1,2], D. J. Pinfield[5], R. G. McMahon[6,7], E. González-Solares[6], J. P. Emerson[8], S. Boudreault[1,2], M. Banerji[6]

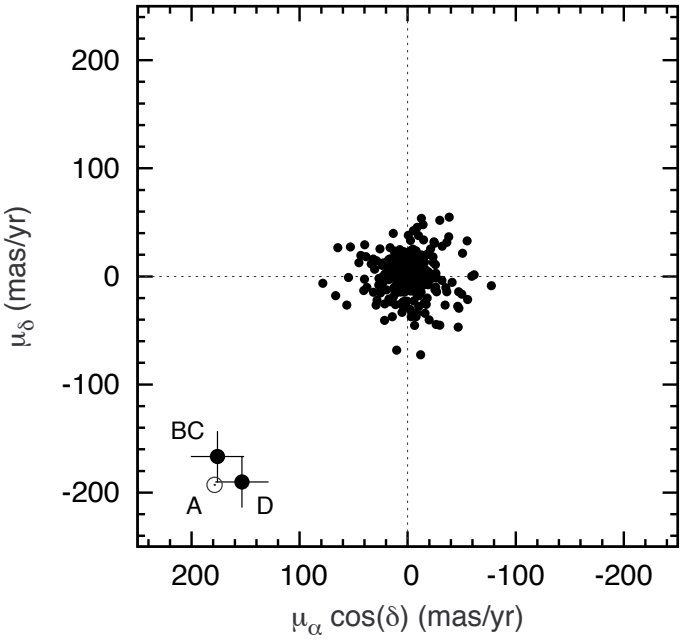


Figure 1. Proper motion vector-point diagram for the HD 221356 system. All correlated objects within 15 arcmin from the primary are plotted as black dots, with HD 221356 components labelled as A, BC and D. The primary is saturated in both surveys, its proper motion value was taken from the literature. Time baseline between the 2MASS and VHS epochs is 12.18 years.

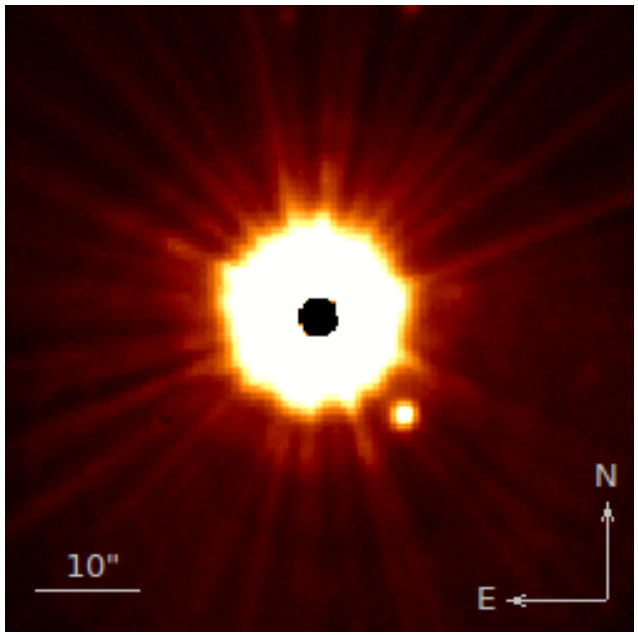


Figure 2. False colour VISTA *J*-band image of HD 221356AD. Angular separation is 12.13 ± 0.18 arcsec and the position angle of the identified companion is 221.8 ± 1.7 degrees. Saturation in the centre of the primary is visible. Field-of-view is 1×1 arcmin, with North up and East to the left.

Future

- Image quality on processed Tiles 0.1” worse than Pawprints and will be effecting depth
  - Could be due to sampling or astrometric WCS
  - Need to run further mosaicing and stacking tests

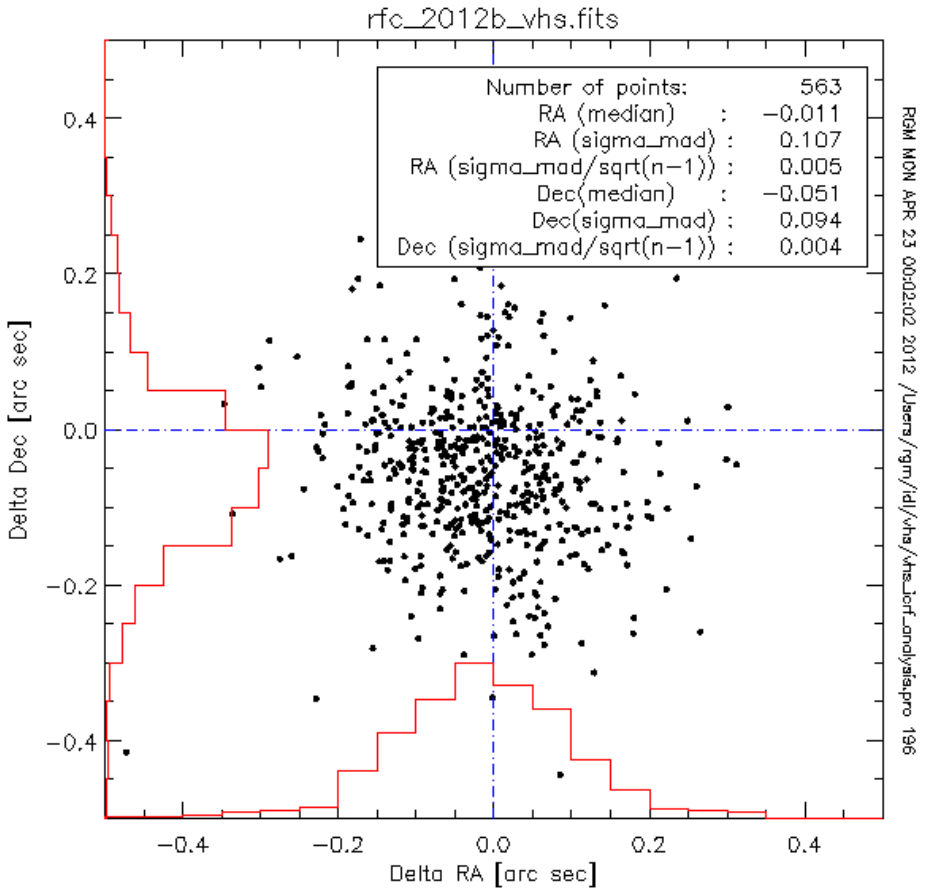
Astrometry Quality Assurance

- Early independent tests on Pawprint data at the IAC showed that VHS Astrometry reliable to 0.1”; both random and systamatics errors

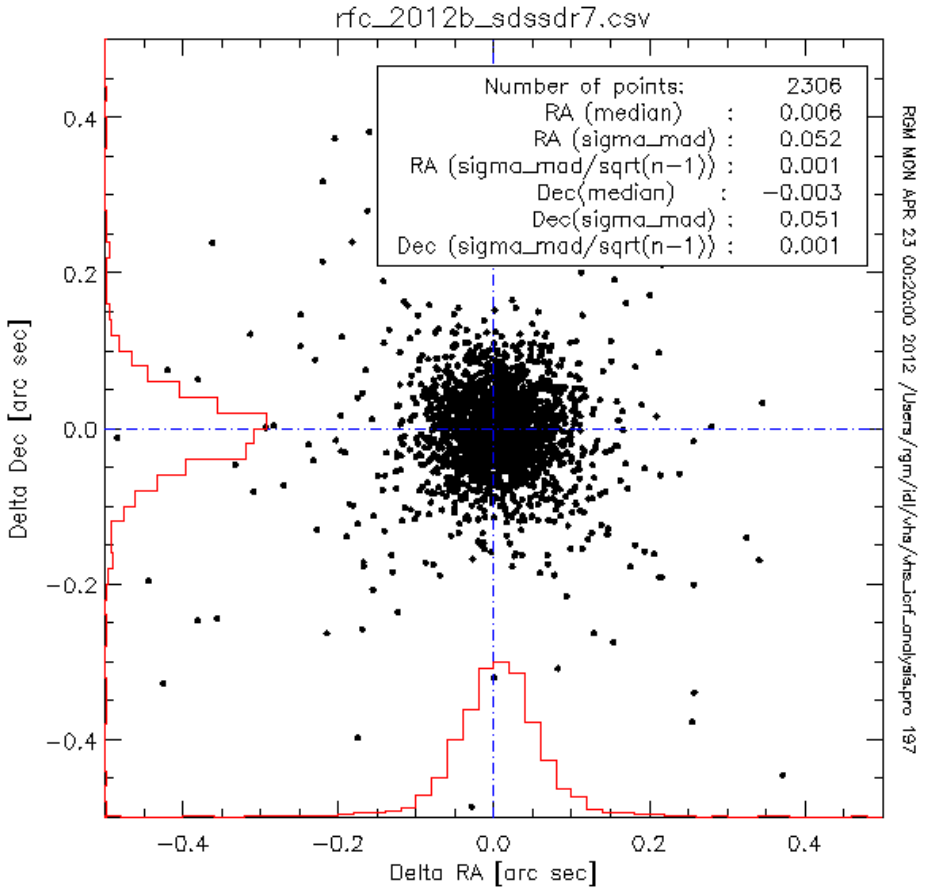
- Recently has been revisited by McMahon, Koposov and Gonzalez looking at Tles. Found that Tile astrometry is reliable at the 0.1” level BUT below 0.1” there are two systematic effects
  - as a function of position on sky due to reference stars proper motions
  - as a function in the focal plan due to WCS transformation

VHS and Absolute Astrometry

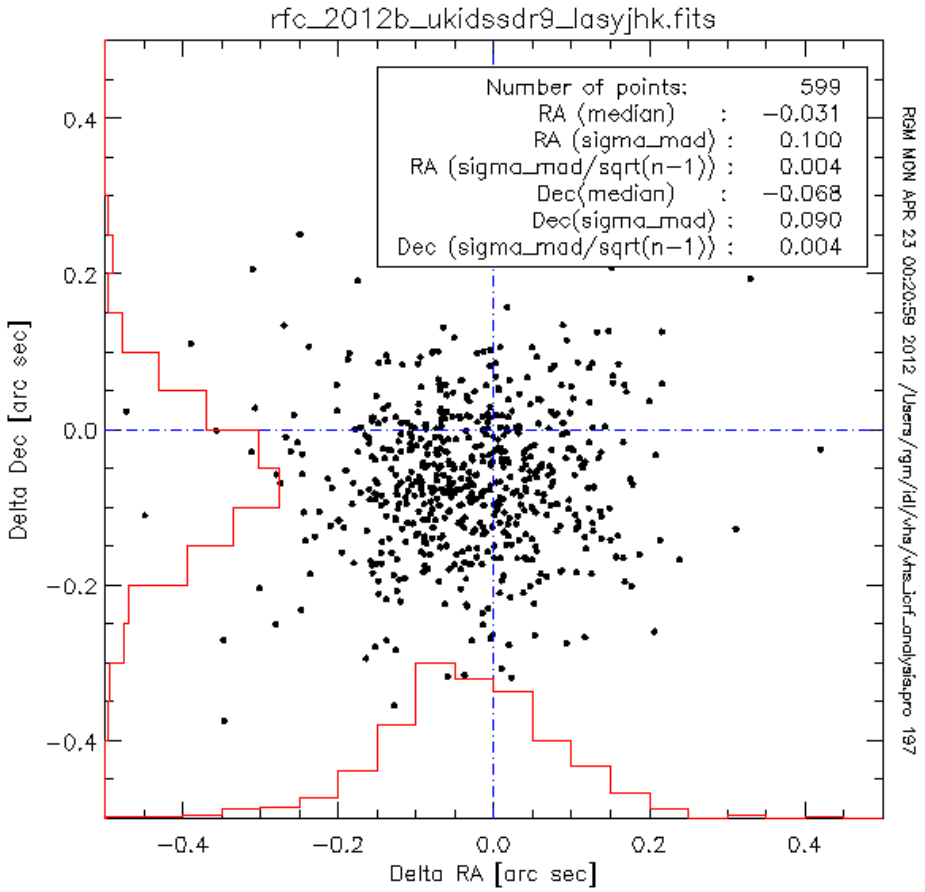
Comparison with ICRS Radio Reference Frame



Comparison of SDSS with ICRS



Comparison of UKIDSS LAS with ICRS



Absolute Astrometry Uncertainties

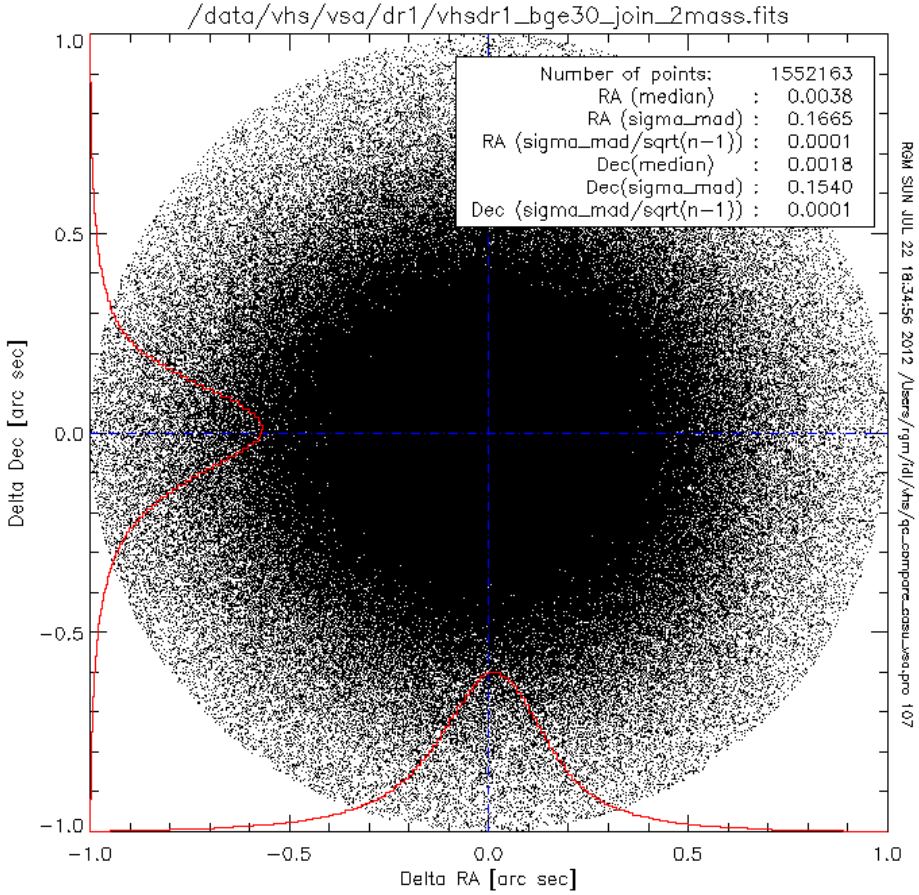
Survey (n)	sigma (Statistical)		Systematic uncertainty	
	RA	Dec	RA	Dec
VHS (563)	0.11	0.09	-0.011±0.005”	-0.051±0.004”
SDSS (2308)	0.05”	0.05”	0.006±0.001”	-0.003±0.001”
UKIDSS (599)	0.10”	0.09”	-0.031±0.004”	-0.068±0.004”

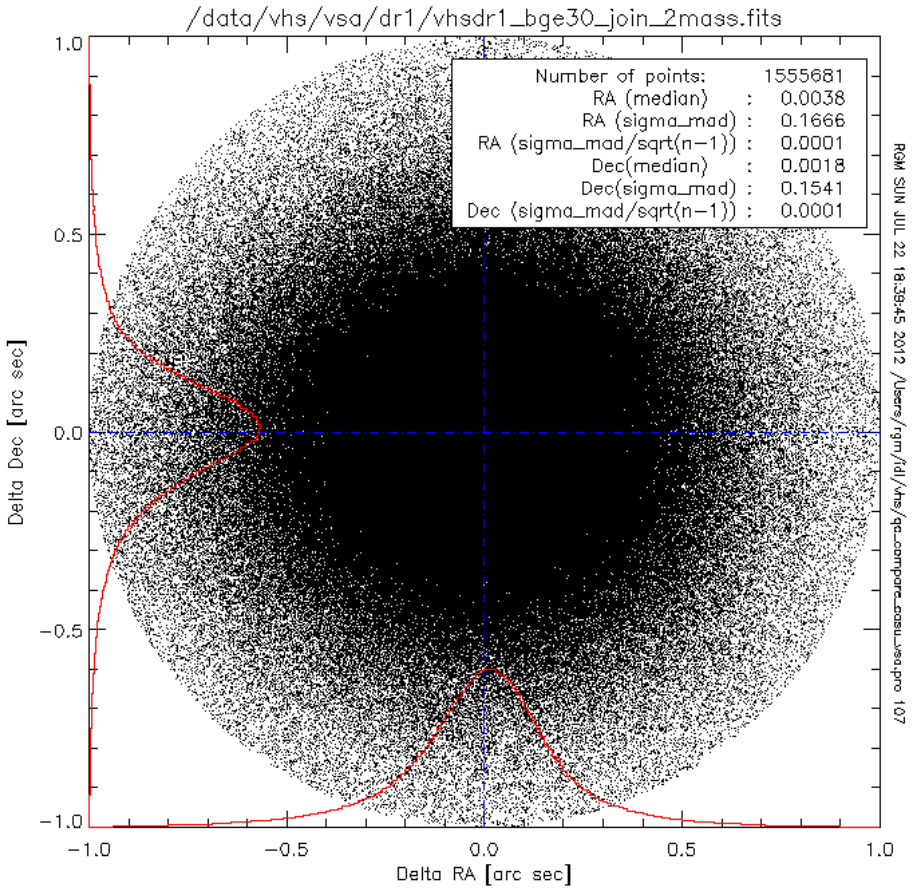
- Note random error will depend on the signal to noise of the object
  - sigma = FWHM/ (S/N)

- Systematic is consistent with expected proper motions of 2MASS stars due to the 10 year difference in epoch between 2MASS and VHS. Note this systematic error varies depending on direction in sky due to Solar motion with respect to average 2MASS reference star
- Proper motions will be included in a future CASU processing based on UCAC4 or PPMXL

VHS versus 2MASS Astrometry

VDFS end to end self-consistency check: CASU-WFAU



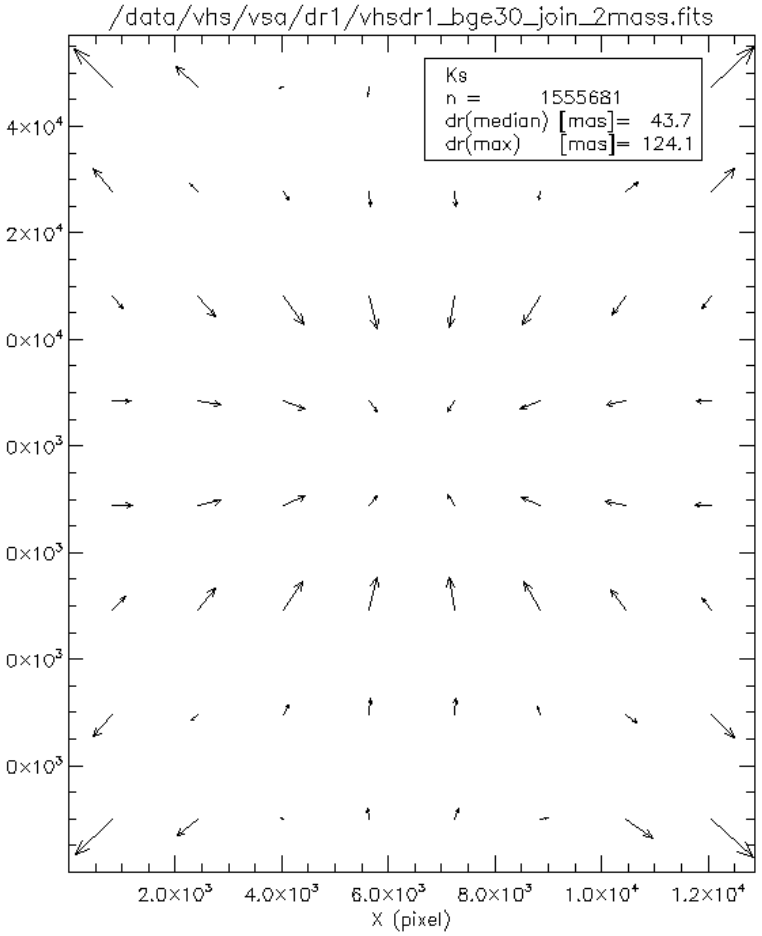


J: rms=0.17, 0.15: median=0.004, 0.002

Ks: rms=0.17, 0.15: median=0.004, 0.002

VHS versus 2MASS Astrometry

VDFS end to end self-consistency check: CASU-WFAU



- Spatial systematic across the focal plane
- Median: 0.044”
- Due to FITS World Coordinate System (WCS) numerical issue in mosaicking of tiles.
- Now fixed for future Tile data
- Does not effect pawprint data
- Existing Tile data might be fixed later

The missing V for Visible in VISTA

- As part of the ESO negotiations the IR field of view of VISTA was increased from 9 IR detectors to 16 detectors.
- The optical camera was deemed of secondary importance since IR capability was the highest priority and increased the unique value of VISTA to the ESO community which includes the UK.
- Thus the IR survey power of VISTA increased by a factor of 3 from larger detector focal plane coverage 100% of time would be IR.
- VST is part of the V; the other part of the Dark Energy Survey on the CTIO Blanco 3.9m telescope

VISTA was designed for the optical and 4MOST will benefit from this.

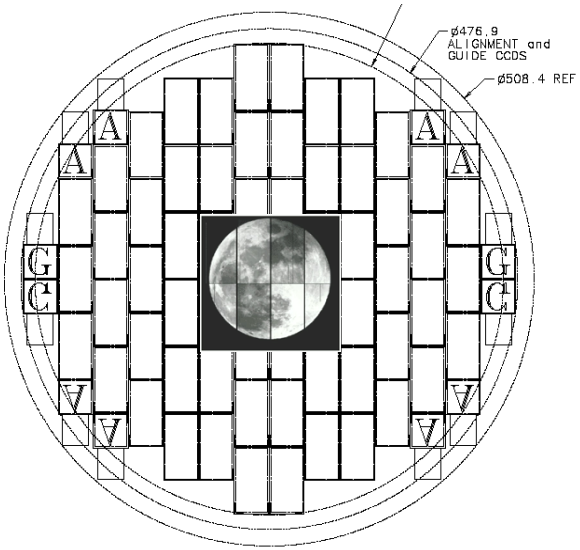
The Dark Energy Survey

(US, UK, Spain, Brasil, Germany, Switzerland collaboration)

DARK ENERGY SURVEY

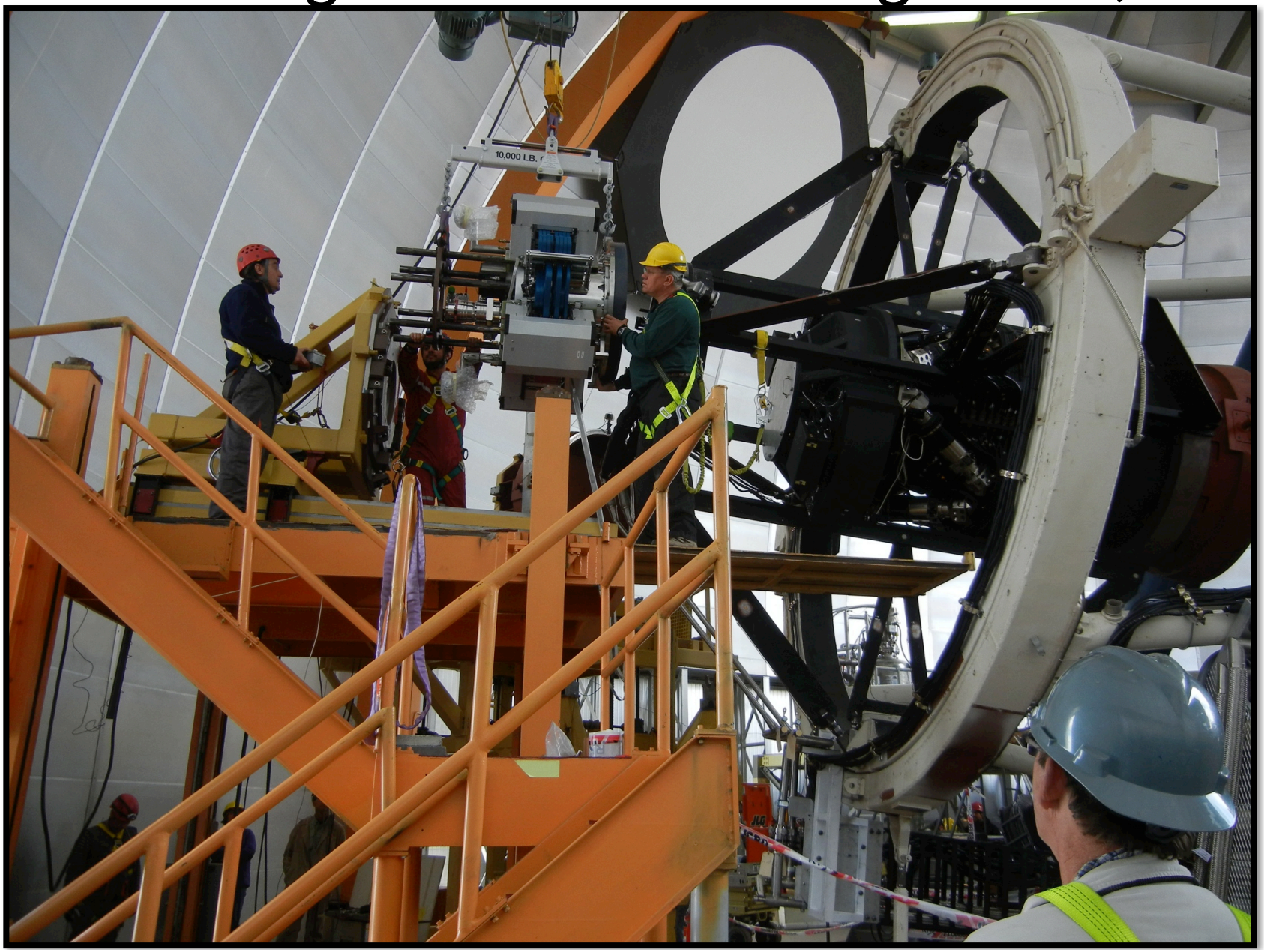
- Telescope; upgraded CTIO 3.9m
- 525 nights over 5 years
- Starting late 2012
- First light occured for in Sep, 2012
- Science Verification on schedule for Nov, 2012; Survey to start in Dec, 2012
- Multiple pass survey so coverage of 5000deg^2 in first full observing season
- Field of view
  - 2.3deg diameter; 3.0deg^2
- Very red sensitive CCDs
  - QE; 90% at 900nm; 50% at 1μm
- g, r, i, z, Y wavebands

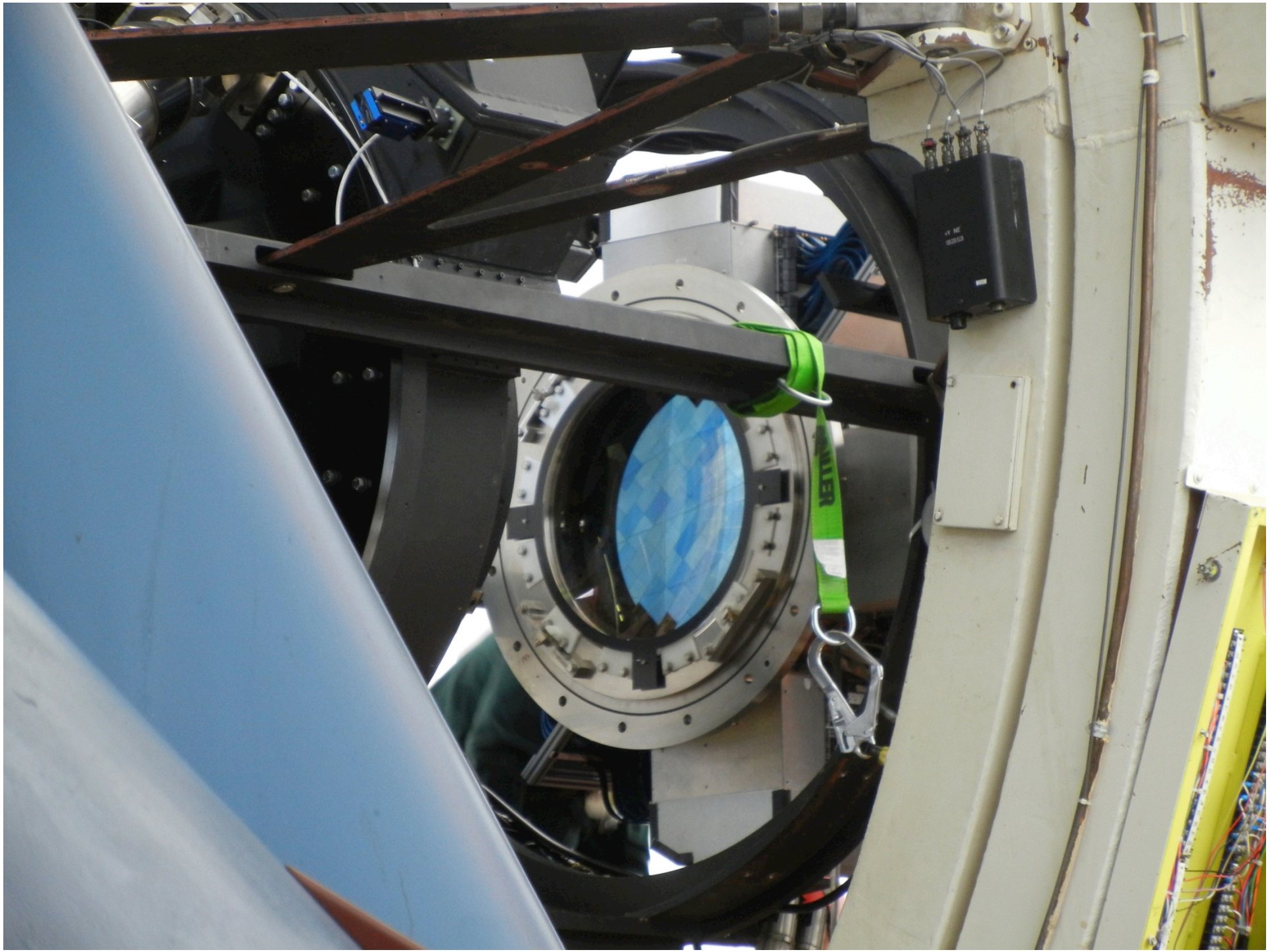
DECam Focal Plane



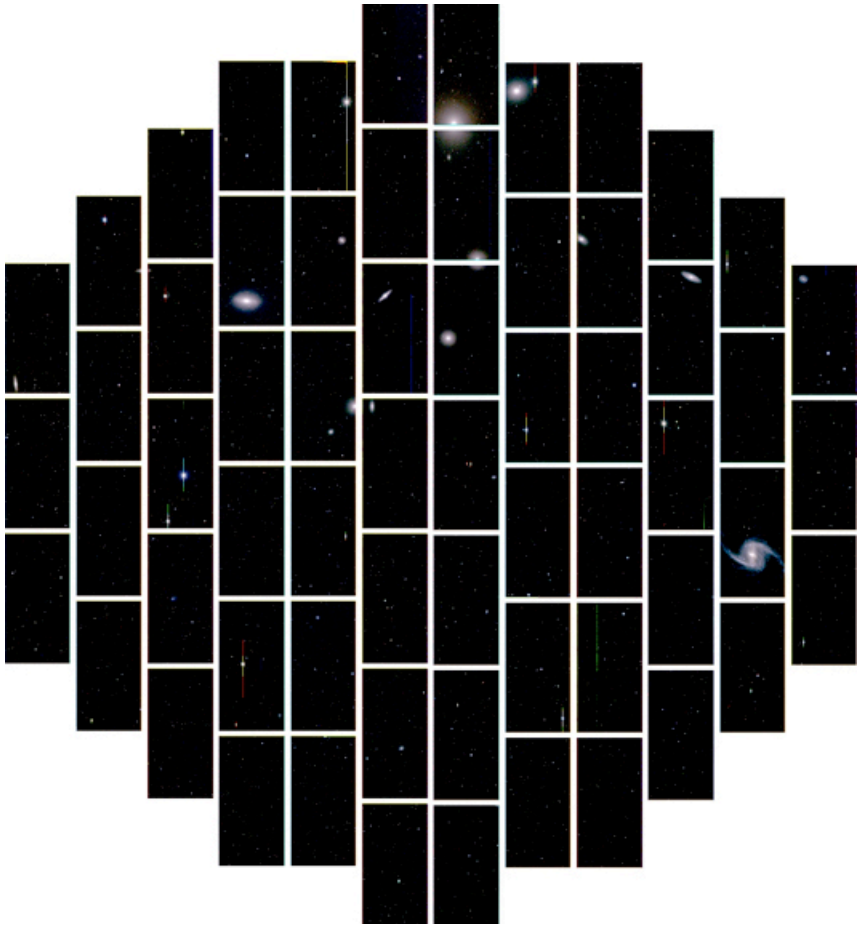
62 2kx4k Image CCDs: 520 MPix
8 2kx2k focus, alignment CCDs
4 2kx2k guide CCDs
0.27" per pixel

DES Imager Installation August 30, 2012



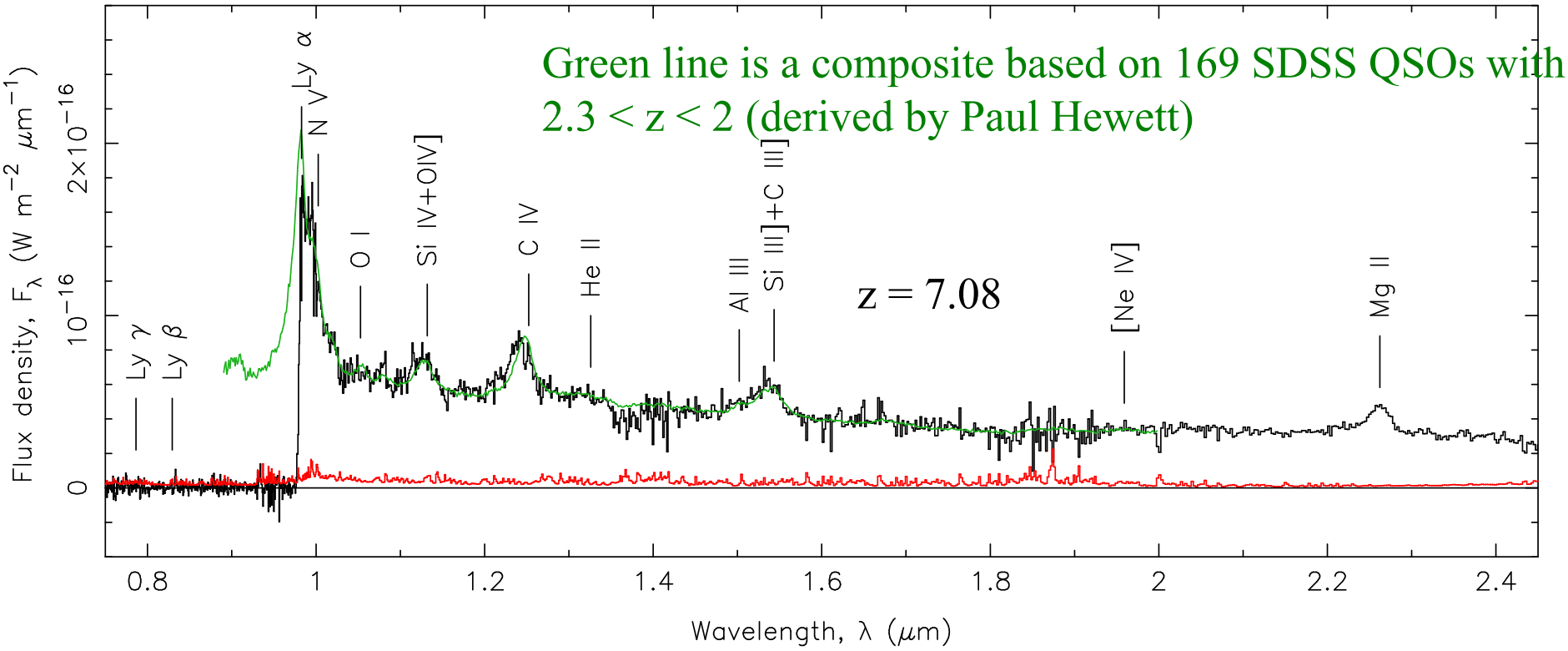


First light images from 12th Sep, 2012
Fornax cluster and NGC 1365



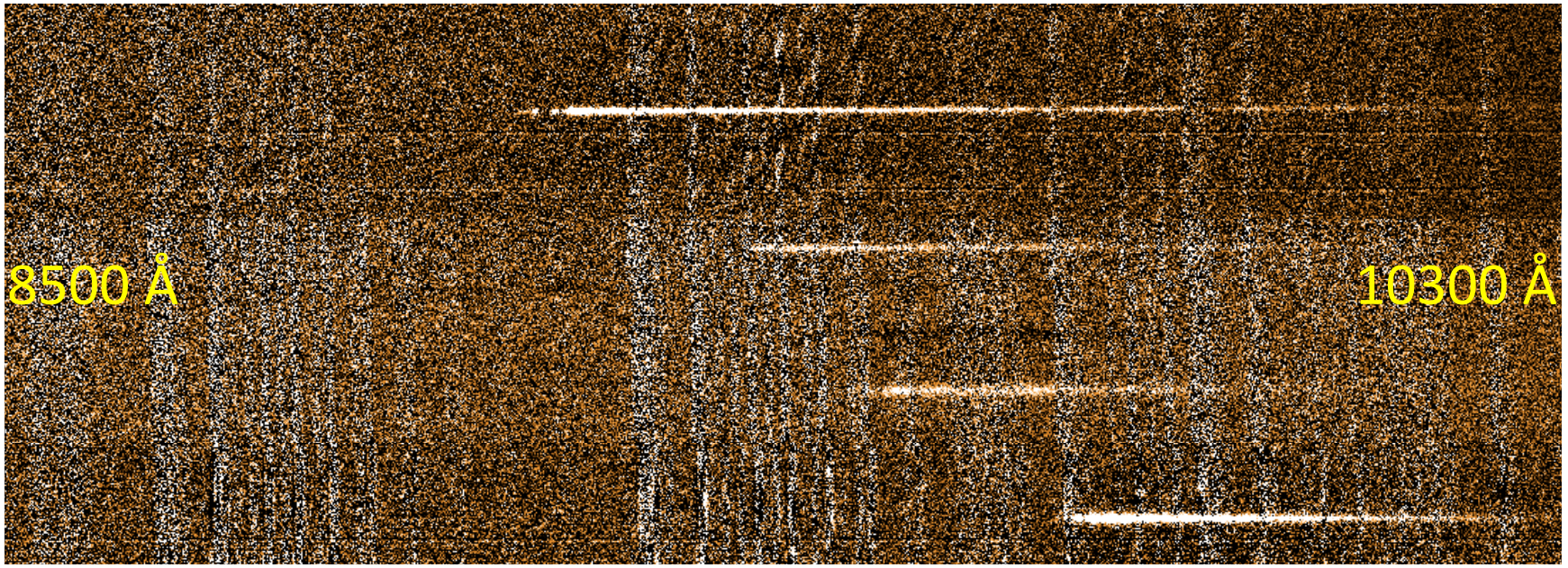
THE END

EXTRA SLIDES



From Mortlock et al, Nature accepted; to appear June, 2011

2D spectroscopic data for four z>6.5 quasars found in last 18 months



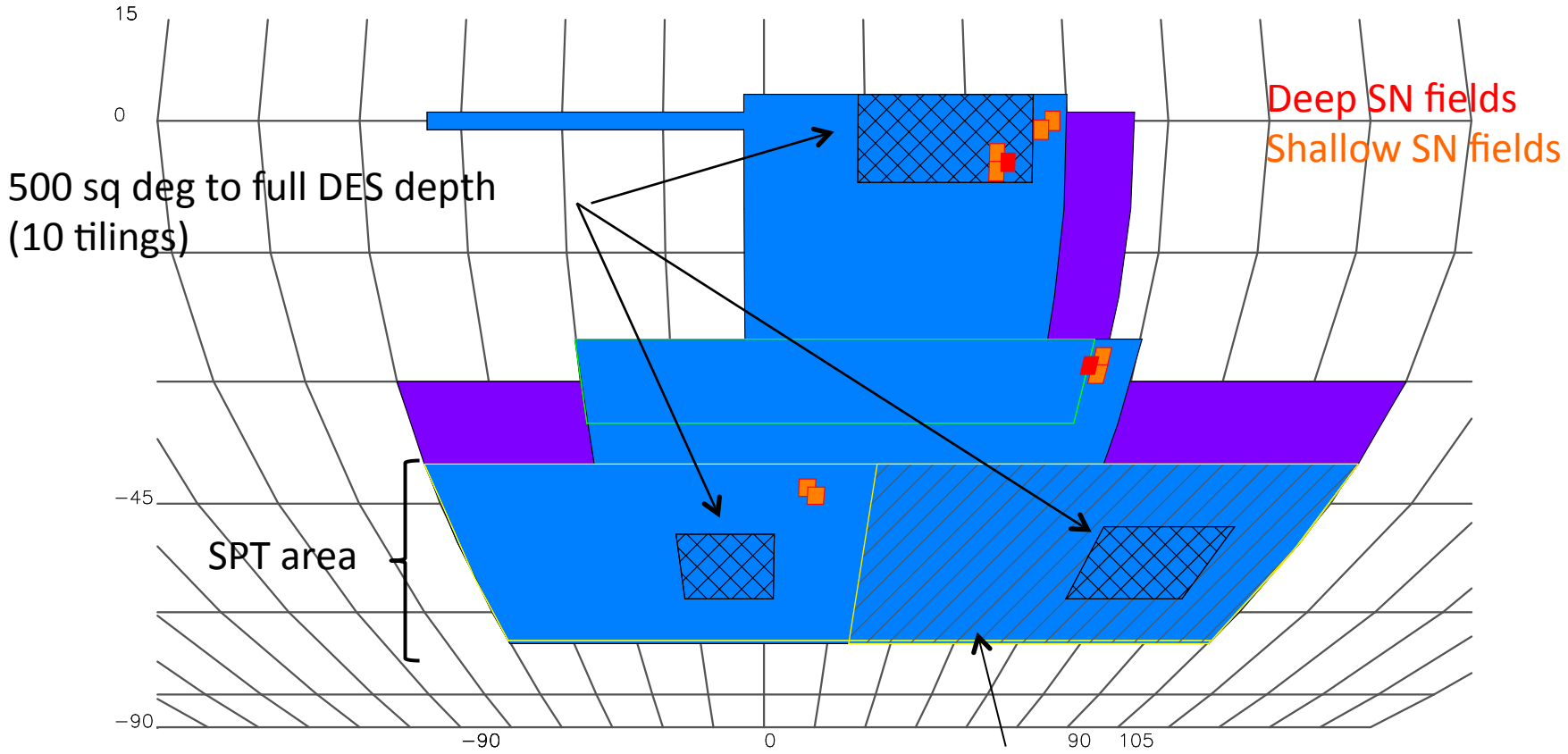
Y[AB]= 21.0; 21.3; 21.1; 20.3

THE NEXT SLIDES CANNOT BE MADE PUBLIC

‘Current’ DES SciVer and Year 1 Footprint

Current Footprint

Revised footprint (will be recommended for adoption next few days)



DES expected depths: AB magnitudes

Table 2. Expected Cumulative Wide-Area Survey Depths and Median Delivered PSF

filter	exp (sec)	mean-PSF 5σ m_{lim}	mean-galaxy 10σ m_{lim}	90%-tile bright m_{lim}	95%-tile bright m_{lim}	median PSF(arcsec)
g	800	26.5	25.2 ± 0.12	25.03	24.99	0.83 ± 0.05
r	800	26.0	24.8 ± 0.11	24.61	24.58	0.79 ± 0.05
i	1000	25.3	24.0 ± 0.10	23.90	23.86	0.79 ± 0.05
z	1000	24.7	23.4 ± 0.08	23.34	23.30	0.78 ± 0.04
y	500	23.0	21.7 ± 0.08	21.61	21.56	0.77 ± 0.04

$n_{eff} = 11.2/\square'$ for weak lensing; survey area = 4944 deg^2; $N_{gals} = 200 \times 10^6$.
PSF $\equiv$ 1.0$*$FWHM aperture mag; galaxy mag $\equiv$ 1.6$*$FWHM aperture mag
4th & 7th column errors denote variations across the survey area

Table 2 from submitted NOAO proposal

10σ PSF mags	
g	25.8
r	25.2
i	24.4
z	24.0
y	22.3

DES Year 1 survey y band limits

DES Science Verification Plan (Docdb-6255) [April 2012]

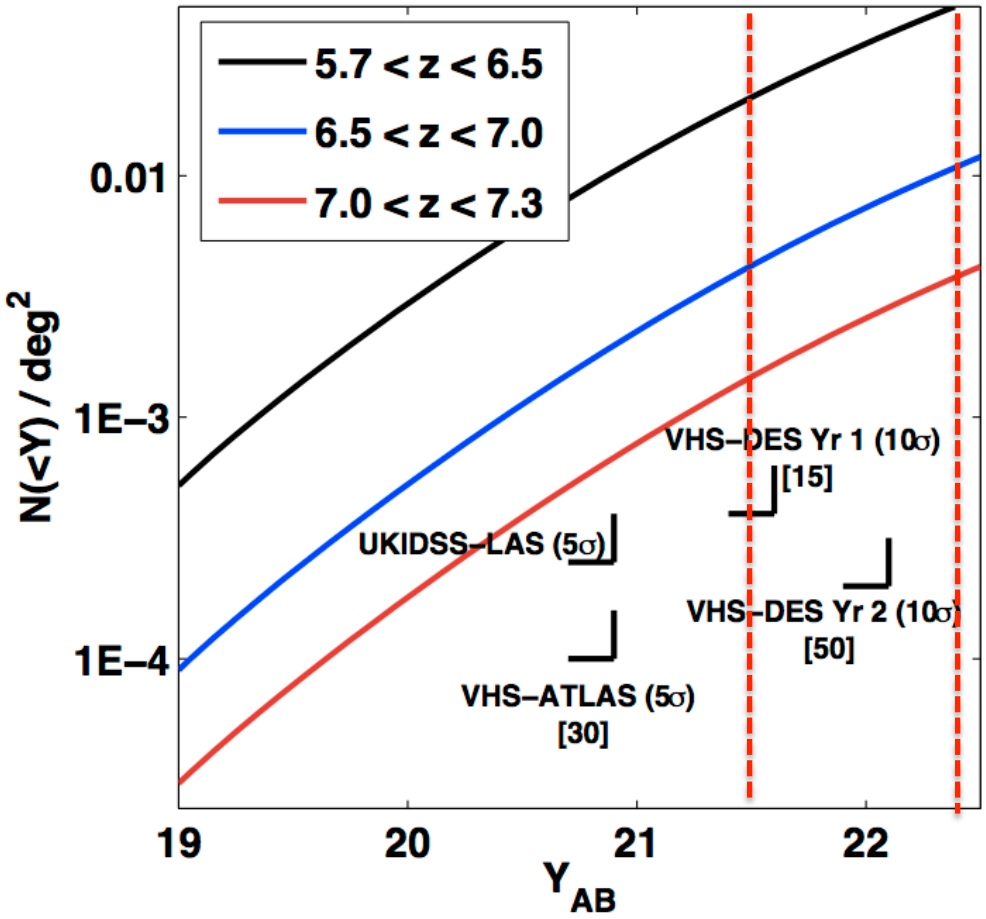
Full depth (10 passes)

- 507 deg^2 (100+258+149)
- y (AB=22.3)

Shallow survey (2 passes; 0.9 mag shallower than)

- 1344 deg^2
- y (AB=21.4)

DES Year 1 Expectations (10σ PSF limits)



Deep (500 deg^2)

z > 6.5: 1 per 100 deg^2 (5)

z > 7.0: 1 per 250 deg^2 (2)

Wide (1300 deg$^{2)}$

z > 6.5: 1 per 200 deg^2 (6.5)

z > 7.0: 1 per 750 deg^2 (1.5)

Wide objects are easier to follow up; could use wide limits for deep i.e. 1800deg^2 to wide depth

VISTA Hemisphere DES Coverage