PUBLIC SURVEY PANEL REVIEW 2011:
VISTA PUBLIC SURVEY STATUS REPORT

This report must be returned to the Observing Programmes Office of the European Southern Observatory (opo@eso.org) before **October 14, 2011**.

PROPOSAL ESO No.: 179.A-2010
TITLE: The VISTA Hemisphere Survey (VHS)
PRINCIPAL INVESTIGATOR: Richard McMahon

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1. Scientific Aims (brief description)

The aim of the Vista Hemisphere Survey (VHS) is to carry out a near Infra-Red survey, which when combined with other VISTA Public Surveys will result in coverage of the whole southern celestial hemisphere (~20,000 deg^2) to a depth 30 times fainter than 2MASS/DENIS in at least two wavebands (J and K_s), with an exposure time of 60 seconds per waveband to produce median 5σ point source (Vega) limits of J = 20.2 and K_S = 18.1. In the South Galactic Cap, ~5000 deg^2 will be imaged deeper with an exposure time of 120 seconds and also including the H band producing median 5σ point limits of: J = 20.6; H = 19.8; K_s = 18.5. In this 5000deg^2 region of sky the Dark Energy Survey (DES) will provide deep multi-band optical (grizY) imaging data. The remainder of the high galactic latitude (|b|>30°) sky will be imaged in YJHK for 60sec per band to be combined with ugriz waveband observations from the VST ATLAS survey.

The medium term scientific goals of VHS include:

- the discovery of the lowest-mass and nearest stars
- deciphering the merger history our own Galaxy via stellar galactic structure
- measurement of large-scale structure of the Universe out to z~1 and measuring the properties of Dark Energy
- discovery of the first quasars with z>7 for studies of the baryons in the intergalactic medium during the epoch of reionization

In addition the VHS survey will provide essential multi-wavelength support for the ESA Cornerstone missions; XMM-Newton, Planck, Herschel and GAIA.

2. Detailed progress report with respect to initial estimate from the Survey Management Plan (including preliminary results, whether published or not).

2.1. Progress report

In Figure 1 we show the RA, Dec distribution of OBs for Period 84-87 (including Dry Run observations in Period 84; runs A-D) that have been submitted and executed up to the end of Period 87 on Sep 30th 2011.

Figure 1 is generated automatically from the csv files available via the ESO Portal. Table 1 reports the OBs execution status for each period. Note incomplete OBs submitted in each observing period except for the Dry Run period are carried over into the next period and hence the observing efficiency in each Period cannot be derived from the Table 1.

A total of 2903 OBs including 230 during the Dry Run period in Period 84 have been submitted. All the 230 DryRun OBs were completed although some may have to be repeated. Of the 2673 Period 85-87 OBs, 2509 (94%) are reported by ESO as completed and 164 (6%) are incomplete. This is a significant improvement on the status reported in our last report at the end of Period 86 where 451 submitted OBs were incomplete.

At least 2 submitted OBs have been cancelled since they were submitted in error. Our progress analysis software counts these as incomplete OBs. The progress software will be modified to take this into account.

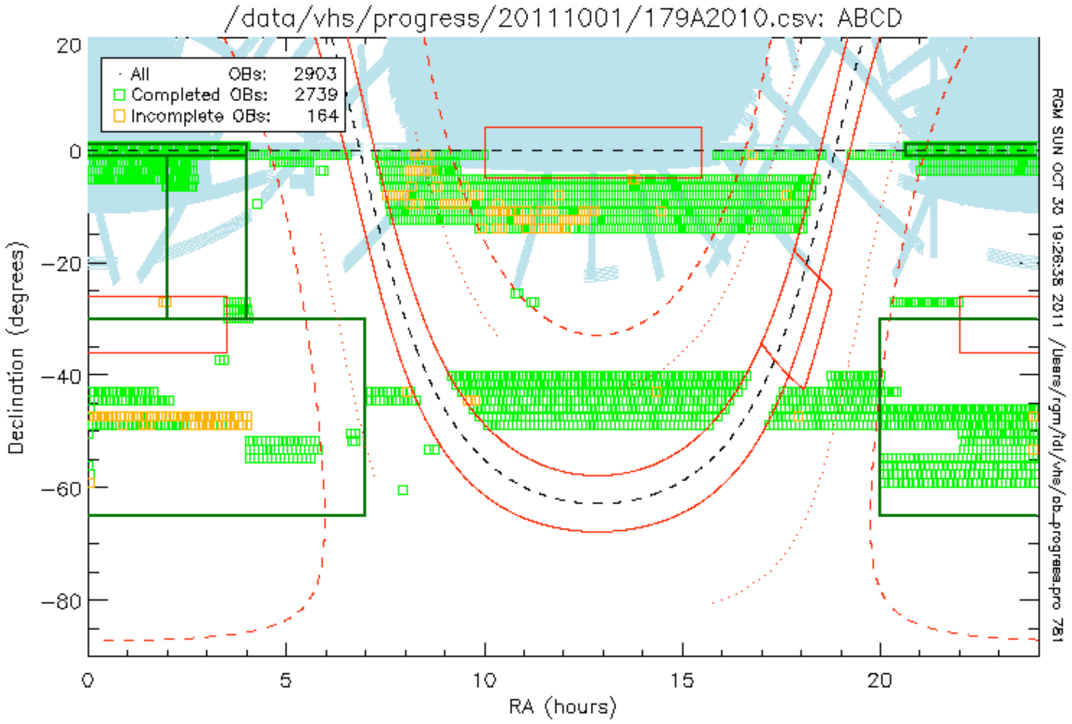

Figure 1: Sky coverage of the VHS survey in equatorial coordinates based on ESO Portal report tables. These are copied each day via a script. The green and orange rectangle symbols show complete and incomplete OBs respectively. The light blue shading is the SDSS footprint. The thick green lines show the Dark Energy Survey footprint. The red solid lines indicate regions that VHS is not covering such as the VIKING and VVV footprints and the inner galactic plane (|b| < 5degrees).

All data taken up to the end of July, 2011 has been processed through the VDFS pipeline at CASU, Cambridge and this data is available to the VHS team for quality control as single band FITS format images and binary table source catalogues. Band merged tables are also available for QC.

Table 1 VHS OB progress on 2011-10-01

Period	Submitted OBs	Completed OBs	Incomplete OBs
P84 (Dry Run)(A)	230	230	-
P85 (B)	1123	1088	35
P86 (C)	850	806	46
P87 (D)	700	615	85
Total	2903	2739	164 (a)

Notes: (a) There is a discrepancy of 2 OBs in the number of incomplete OBs based on the automated analysis of the report tables. This could be due to cancelled OBs and will be investigated by the VHS team.

CASU processing of VISTA data has reached a stable state and is released in month quanta two to three months after the data is acquired by ESO. CASU also provide a very useful FITS format QC table that contains metadata including QC parameters for all their data products. This pipeline product with over 200 columns of metadata has been used to generate many of the QC plots in this report.

In our report to the 87th OPC meeting we reported that the photometric and astrometric calibrated paw-print level image and catalogue products had reached a stable state but that mosaiced tile products were still under going QC evaluation by CASU and VHS. This QC process indentified a problem with the aperture corrections that applied to photometry obtained from mosaics taken in conditions where the seeing varied significantly between pawprints in a tile. Version 1.0 of the Tile catalogues suffered from this problem. This was a known feature of VISTA data and was corrected for in version 1.1 of the Tile catalogues. The version 1.1 products for Period 84 and 85 were released by CASU on 2011 March 1st. These products have all been transferred to the ESO Phase 3 ftp site. The decision to deliver the version 1.1 products for Phase 3 rather than version 1.0 has caused some medium term delays in meeting the Phase 3 schedule. The alternative would have been to deliver version 1.0 products which may have been unsuitable for some science exploitation and would also have been superseded within a few months.

CASU have processed and released Period 87 data up to the end of July 2011. The DQC file used for this report is based on the CASU products covering observations up to the end of June 2011 that were available in early September.

Observing overhead concerns

We repeat the concerns we raised in previous reports to the OPC about the observing overheads which have increased significantly since we submitted our SMP. In Table 2 we summarize the OB execution times compared with the OB time on sky.

Table 2: OB overheads

VHS component	OB time on sky (seconds)	SMP	P85	P87	P88
VHS-ATLAS	720	1199	1510	1910	1910
VHS-DES	1080	1491	1809	2129	2129

VHS-GPS	360	600	829	1005	1005

The current charging for observing overheads is significantly higher than we assumed in the VHS SMP. VHS has three survey components each with slightly different OB structure with the common theme that each OB produces a tile with a full complement of the wavebands that have to be acquired for a tile.

1. VHS-GPS: J and K; 60 seconds per waveband
2. VHS-ATLAS: Y, J, H, and K; 60 seconds per waveband
3. VHS-DES: J, H and K; 120 seconds per waveband

Each VISTA tile requires 6 sparse filled pawprints. Thus the total on-sky time for the 3 components above are 360, 720 and 1080 seconds respectively.

In our accepted SMP we used information provided by ESO and the VISTA project to estimate total execution times per OB including overheads of 600, 1199 and 1491 seconds respectively. The execution time charged within P2PP for Period 85 was 829, 1510 and 1809 seconds which is an increase in the observing overheads of 4-5 minutes per OB. We also requested a change to the jitter pattern which should have reduced the overheads but this overhead reduction was not taken into account in P2PP.

In Period 87 and Period 88, the total execution time for the three types OB described above is 1005, 1910 and 2129 seconds respectively. Some of this is due to our decision in Period 87 to use AO Priority high to see if this will improve the median seeing that is delivered. This will hopefully improve our point source sensitivity although at the expense of increased overheads. We hope that the VISTA observing overheads will become lower in future.

Example colour-magnitude and colour-colour diagrams
Figures 2-4 show colour-magnitude and colour-colour diagrams for two typical fully reduced example high galactic latitude tiles. Some examples of problem tiles identified during VHS QC are shown in Figure 2 [see also discussion in section 3]. The blue points are objects classified as stars and the grey points are objects classified in K as non-stellar.

These QC diagrams demonstrate the precision of the photometry and star-galaxy separation. The J-K-v-K stellar locus clearly delineates the distinct disk dwarf and halo giant populations, which show up as two separate populations with J-K<1.0. The non-stellar objects which are mainly external galaxies have J-K>1.0.

2.2. Publications

A publication in a refereed journal associated with the first public data release is planned. This publication was delayed until receipt of the version 1.1 data products.

Much of the planned science program for VHS as described in the proposal requires optical data from VST or the Dark Energy Survey. VST ATLAS observations have only started in the last few months and the Dark Energy Survey is currently expected to start on the CTIO Blanco telescope in September 2012.

We also note that VHS data is being used by the ESO Public Spectroscopic survey project: The Gaia-ESO Survey; PIs: Gerry Gilmore (IoA Cambridge, UK), Sofia Randich (INAF, Obs. Arcetri, Italy) for target selection.

3. Quality Control and Phase3. The Phase3 submission plan should be described here. In addition the PI should comment on Quality Control of the acquired data.

3.1 The PI should comment on the quality control and the science validation of the acquired data.

Robust, objective and quantitative quality control processes for VHS are still under development and we are working closely with the VDFS pipeline team at CASU in Cambridge to develop routine automated machine learning based techniques such as decision tree based QC techniques. A wide range of diagnostic plots are being produced following the plan outlined in the VHS SMP.

Colour-magnitude and colour-colour plots as shown in Figure 2-4 are produced for all paw-print and tile band-merged catalogues. These are made available to the VHS QC team via the WWW. Figure 2 shows examples of version 1.0 VDFS data products that failed our QC. This is the same data presented in Figure 3 of our status report to the 87th OPC meeting. Figure 3 shows the VDFS version 1.1 data products for the same raw data and shows that the version 1.1 products now pass our image classification and photometric QC. Figure 4 shows data from the final VHS OB for Period 85 and Period 86 respectively.

Image quality

Figure 5 shows the distributions of the image quality in all wavebands for all VHS observations obtained in Period 86 and the first few months of Period 87. Figure 5(a) and 5(b) shows the FWHM distributions for the stacked tiles for Period 86 and 87 respectively. Figure 5(c) and 5(d) shows the FWHM distributions for the individual chips in each pawprint that is used for the tiles for Period 86 and 87 respectively. The pawprints have FWHM that are around 0.1” better than the final stacked tiles. It is possible that this is due to the resampling technque that is used for the tiling and will be investigated with CASU to see if the mosaiced Tile image quality can be improved.

Figure 5 shows the measured seeing (FWHM) for stellar objects and Figure 6 shows the image ellipticity distribution. Visual inspection of the images with ellipticity > 0.15 is carried out. Some have double images whereas some may still be useable. In Period 86 the ellipticity distribution improved compared with Period 85.

In period 86, the medians of the seeing distributions show a wavelength dependence increasing from 1.03 arc seconds in K_S to 1.11 arc seconds in J. The ratio of 1.08 is consistent with a Kolmogorov $\lambda^{-1/5}$ wavelength dependence assuming a effective wavelengths of 2.149μm for K_S and 1.254μm for J. The Y band images have median seeing of 1.07 arc seconds. Overall the median measured seeing is similar to the values obtained in Period 85.

The seeing distributions in J has a significant tail to value that exceed out seeing limit of 1.4”. In Period 85, Y band also had a large tail but in period 86 this is reduced. Further analysis is required in order to determine whether a change in observational strategy is required; e.g. increasing the Y and J exposures since the poorer IQ will effect the limiting magnitudes. In Period 87, we observed with AO Priority high to determine whether increasing the AO priority will improve the median seeing. This increases observing overheads by ~10% but could be balanced by better quality data. The data that has been analyzed during period 87 does not show a significant improvement.

Astrometry

Figure 8 shows the distribution of the World Cooordinate System (WCS) rms astrometric errors derived from 2MASS. The J and K bands have a tail to smaller values compared to Y and H, since there are J and K observations in regions of higher stellar density at lower galactic latitude. These distribution meet our science requirements. We plan to carry out independent tests by comparing with SDSS and UKIDSS data to check for systematics by comparing galactic and extragalactic reference frames using known quasars, galaxies and galactic stars.

Sky brightness

Figure 9 shows the measured sky brightness on all VHS tiles for Period 86. Note the tail to bright magnitudes that effects 5% of observations. This is probably due to scattered moonlight when cirrus is present. The median measured values are 16.85, 15.64, 13.67 and 12.91 respectively. The Period 85 measured median values were 16.98, 15.76, 13.86 and 13.10 respectively. i.e. the median measured sky brightness is brighter during Period 86 compared with Period 85 by 0.1 to 0.2 magnitudes.

The values that were assumed based on the VISTA ETC in the VHS SMP were 17.2, 16.0, 14.1 and 13.0. Therefore the median measured sky during Period 86 is +0.3 magnitudes brighter in Y, J and 0.2 magnitudes brighter H and K.

In our last report we noted that the brighter values in Y, J and H may be due to observations taking place too close to evening twilight. During Period 86 and 87 we used the twilight constraint. Table 3 shows how the measured sky brightness has varied in the last three periods compared with the values assumed in the SMP.

Table 3: Median Sky Brightness

VHS component	SMP	P85	P86	P87
Y	17.2	16.98	16.85	16.94
J	16.0	15.76	15.64	15.57
H	14.1	13.86	13.67	13.73
Ks	13.0	13.10	12.91	12.80

Zero-points and atmospheric transparency

Figure 10 shows the measured zero-point on tiles for all Period 86 VHS observations based on photometric calibration using 2MASS. There is a tail to bright magnitudes and ~10% have relative attenuation >0.2 magnitudes which is outside the ESO THIN constraint. Some of this may be due to the known degradation in the VISTA system throughput due to the degradation of the primary mirror reflectivity since the primary mirror was coated in September 2009.

Limiting magnitudes

Figure 11(a,b,c) shows the computed 5sigma point source limiting magnitudes for the 3 VHS survey components for all observations obtained in Period 87. Note the VHS DES component has exposure times of 120 seconds per band compared to 60 seconds for the other two components (GPS and ATLAS). Despite the inclusion of some sub-standard data in these distributions, the K_s limiting magnitudes meet VHS survey goals. However, the Y and J band data has median limits that are ~0.5 brighter than our goals. This is a combination of poorer than expected IQ and brighter sky brightness. We will return to this issue in Section 4.

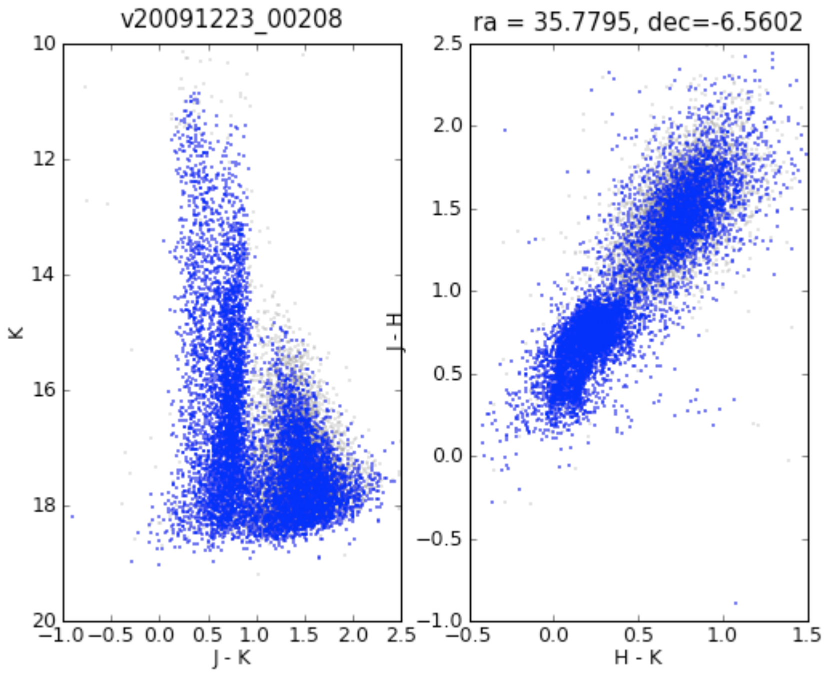

Figure 2(a): Version 1.0 data products showing QC problem with star-galaxy separation. Blue points are starlike objects; Grey points are non-stellar objects

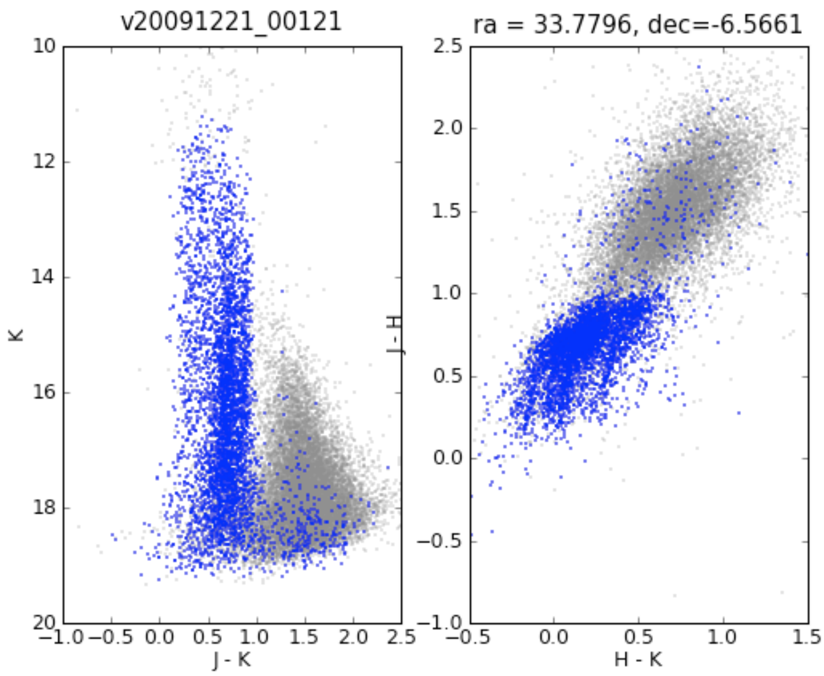

Figure 2(b): Version 1.0 data products showing QC problem with multiple offset stellar loci due to variable seeing causing spatially dependent aperture corrections in different pawprints.

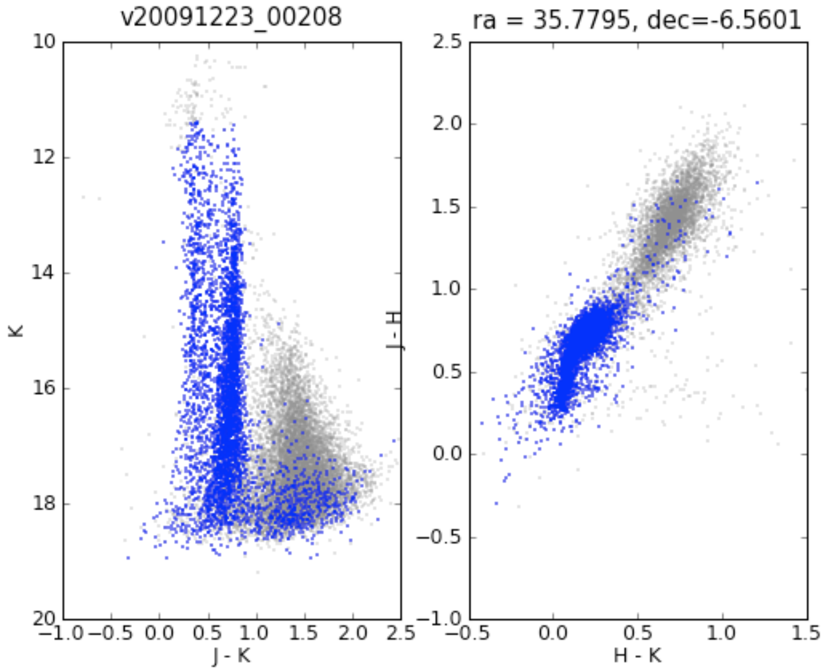

Figure 3(a): Version 1.1 data products for same observations as Figure 2(a) showing the improvement in star-galaxy separation for this OB. Blue points are starlike objects; Grey points are non-stellar objects

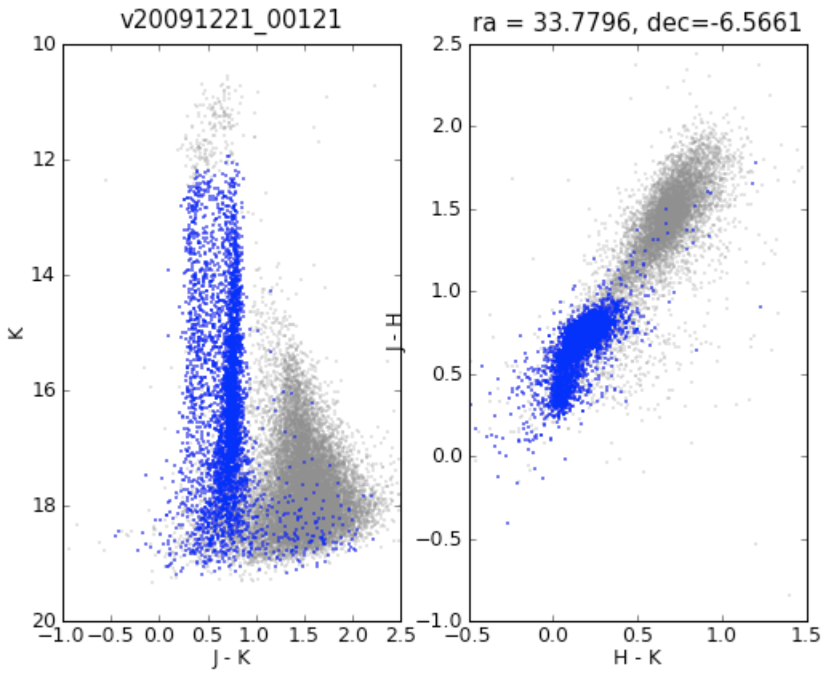

Figure 3(b): Version 1.1 data products for same observations as Figure 2(a) showing the improvement in photometry. Blue points are starlike objects; Grey points are non-stellar objects. The QC problem showing multiple offset stellar loci due to variable seeing causing spatially dependent aperture corrections in different pawprints has been removed. The same raw data has been used in both Figure 2 and 3.

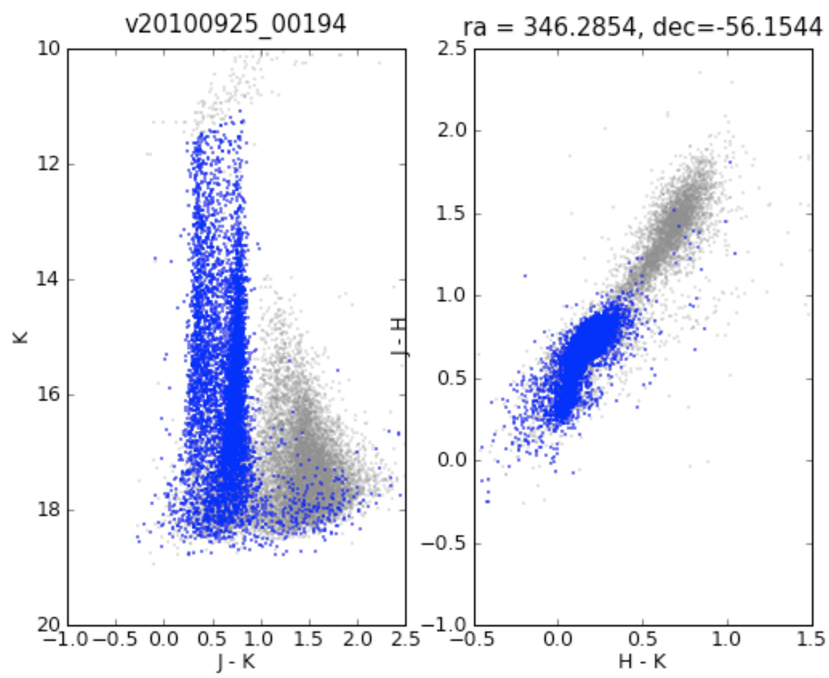

Figure 4(a): Version 1.1 data products for VHS final Period 85 OB acquired on 2010 Sep, 25th. Blue points are starlike objects; Grey points are non-stellar objects

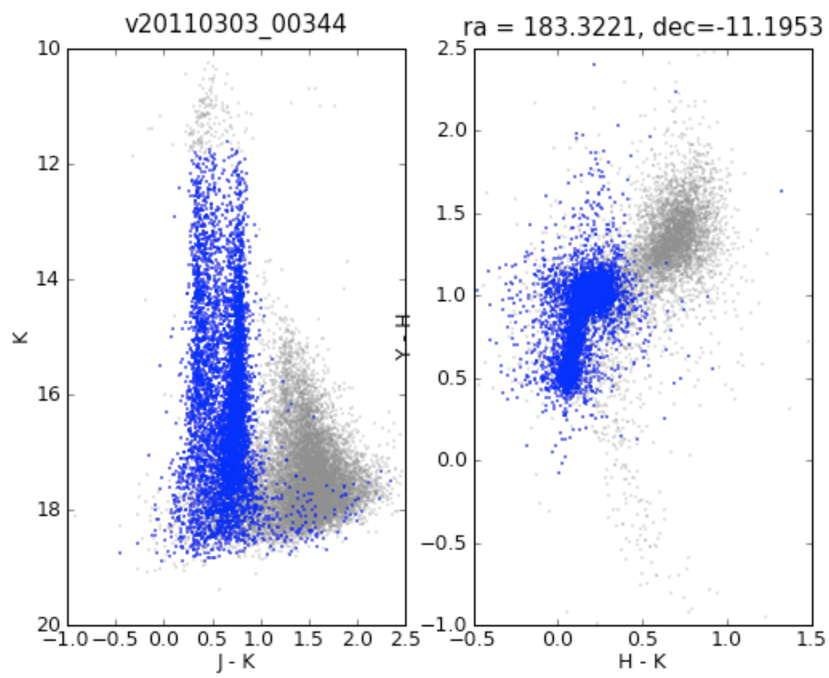

Figure 4(b): Version 1.1 data products for final VHS Period 86 OB acquired on 2011 March, 3rd; Note the right plot is H-K v Y-H whereas in other plots it is H-K v J-H

3.2 The PI should describe the current status of the Phase 3 submission. Any feedback or requested modifications of data products or timeline for survey releases should be described here. PIs should also include any relevant information for the scientific validation of the data products.

The astrometric and photometric calibrated VHS paw-print catalogues and images and ancillary calibration frames for observations obtained up-to the end of period 86 were planned to ready for delivery in December, 2010 based on the CASU version 1.0 pipeline products. The details of the ESO delivery procedures were presented by ESO at a workshop in Garching on Nov 30th, 2010. After this meeting ESO announced a delay in the availability of the Phase 3 system. The system was eventually opened in mid-March.

The version 1.1 products for Period 84 and 85 data were released by CASU to the VHS team on March 1st, 2011. This data has been transferred to the ESO Phase 3 ftp site. The data has been validated by ESO and a number of changes made. Due to the fact that the new CASU version was released quite close to the Phase 3 deadline there were some logistic problems within VHS since QC was well advanced on the version 1.0 products.

The decision to deliver the version 1.1 products for Phase 3 rather than version 1.0 has caused some medium term delays in meeting the Phase 3 schedule. The alternative would have been to deliver version 1.0 products which may have been unsuitable for some science exploitation and would also have been superseded within a few months.

The updated Release Description will be submitted by November 4th and the Phase 3 release closed again. The lessons learnt with the first release should make progess with the next release smoother and the current ESO schedule should be met unless there are unforeseen new issues. Band merged products on a tile by tile basis are being created for all tiles as part of the QC process and these are ready for deliver to ESO.

4. Are any changes proposed with respect to the Survey Management Plan in P89 (e.g., in strategy, field coordinates, exposure time and/or other)

The OPC ranked VHS as the highest ranked VISTA Public survey. We are concerned that our current VHS observations are not meeting our median limiting magnitude goals in the shorter wavelength bands, especially J in VHS-DES and in both Y and J in VHS-ATLAS as described in section 3. This is likely to be combination of poorer median IQ than expected and the brighter median measured sky brightness particularly in Y and J. The use of the new twilight constraint in P2PP in Period 86 does not seem to have improved the sky brightness situation. In fact the median sky brightness increased between P85 and P86. The airmass distribution for the two periods is similar with the largest difference of 0.1 in H.

In Period 87 we observed with the AO priority set to high to see if this improves the delivered IQ in the bluer wavebands although it would increase our overheads by 10%. Based on the data upto the end of June, there is no significant improvement.

Another option that we are considering is redistribute observing time from the redder bands to the bluer wavebands. e.g. in VHS-DES we could change from 120 seconds in J, H and K_S by reducing the K_S from 120 seconds to 60 seconds, leave H unchanged and increase J from 120seconds to 180 seconds so that the relative depths are closer to our goal. We are also considering whether it would be better to move the time spent on H to J. i.e. increase the J exposure time to 240seconds.

The J band is important for photometric redshifts at redshifts less than 1.5 since J is above the rest frame 4000Å break. It is also very important for the L dwarf and high redshift quasar science goals. An exposure time redistribution between the wavebands would not require any additional observing time or increase the overheads.

Another option as outlined in the VHS SMP in section 2.2.3 and 2.2.4 is to follow the UKIDSS survey implementation strategy where the default exposure times are doubled when there are specific combinations of seeing, sky brightness and sky transparency observing conditions which would result in data that does not meet the survey requirements (see section 5.2.1 in Dye et al, MNRAS, 372, 1227, 2006). This would only be needed in Y, J and H. Since some of the overheads remain the same, the increase in the execution time for these OBs would be around 50%.

This 'extra' OB execution time could result in a "zero-sum" game from an operational point of view since it could be cost neutral if more OBs would the pass the VHS magnitude limit threshold. It would require an increase in the observing time allocated to VHS to allow for the use of 'poorer' conditions.

This issue was discussed in the VHS SMP in section 2.2. We are not sure how to implement this strategy in the most efficient manner since ESO policies for Service Mode Observations mean that exposure times cannot be adjusted at the telescope. One approach would be to for VHS to provide extra RA stripes of OBs that have double the nominal YJH exposure times and this would be executed ONLY when the seeing at the start of an OB was between 1.2 arc seconds and 1.4 arc seconds and the sky conditions were not CLEAR. This form of logic is not supported in the current operational model. OB selection logic based on the measured sky brightness could also be useful.

There are a number of different options and we assume ESO is also evaluating these. Even if ESO cannot support UKIDSS type of OB implementation at the moment it would be useful if such a mode was evaluated.

5. Observing Plan.

Please include the specific request for P89 observing time in the table below.

Period	Field name/ mean RA	Filter	Time (h)	Seeing	Moon	Transparency	Comments / strategy (e.g., no. of epochs)
89	12hr	Y,J, H,K	311	<1.4	any	thin	

6. Overall survey completion

Specify the overall survey completion after the first 1.5yr of operations. What has been achieved? Please provide total estimate of the time necessary to complete the survey using the current survey observation overheads. In case this differs from the request in the approved SMP, please provide a short rationale for the difference.

This input will be reviewed by the Public Survey Panel and will be taken together with the section on the survey progress report (Sect. 2) and Phase 3 submission report (Sect. 3) into account to assess your survey together with the other VISTA surveys and to make recommendations regarding the time allocation for Period 89 and beyond.

After 1.5yr of operations, VHS has completed 2739 OBs. See Figure 1 and Section 2 for further details. Each OB represents a single independent tile in all bands. Assuming a field of view per tile of 1.5deg^2 the sky coverage is 4108deg^2 out of the total goal of 17,700deg^2 i.e. 23%.

In Table 4 we summarize the number of completed OBs for each of the VHS survey components. In Table 5 we show the number of OBs needed to complete the survey and the total execution based on the current overheads. The estimated time required to complete the survey is 4092 hours. This is larger than our SMP estimate due to the longer than expected OB execution times. See Section 2 for further details.

Table 4: Summary of survey progress

Survey Component	ATLAS	DES	GPS

Area of sky (deg^2)	5000	4500	8200
Number of OBs required from SMP	3484	3136	5714
Number completed	788	777	1174
% completed	22.6%	24.8%	20.5%

Table 5: Time required to complete survey based on current overheads

Survey Component	ATLAS	DES	GPS	All
Area of sky (deg^2)	5000	4500	8200	17,700
Number of OBs required from SMP	3484	3136	5714	12334
Number completed	788	777	1174	2739
Number of OBs needed to complete	2696	2359	4540	9595
SMP Execution time per OB in seconds (see Table 2)	1199	1491	600	
Current execution time per OB in seconds (see Table 2)	1910	2129	1005	
Hours required to complete survey	1430	1395	1267	4092

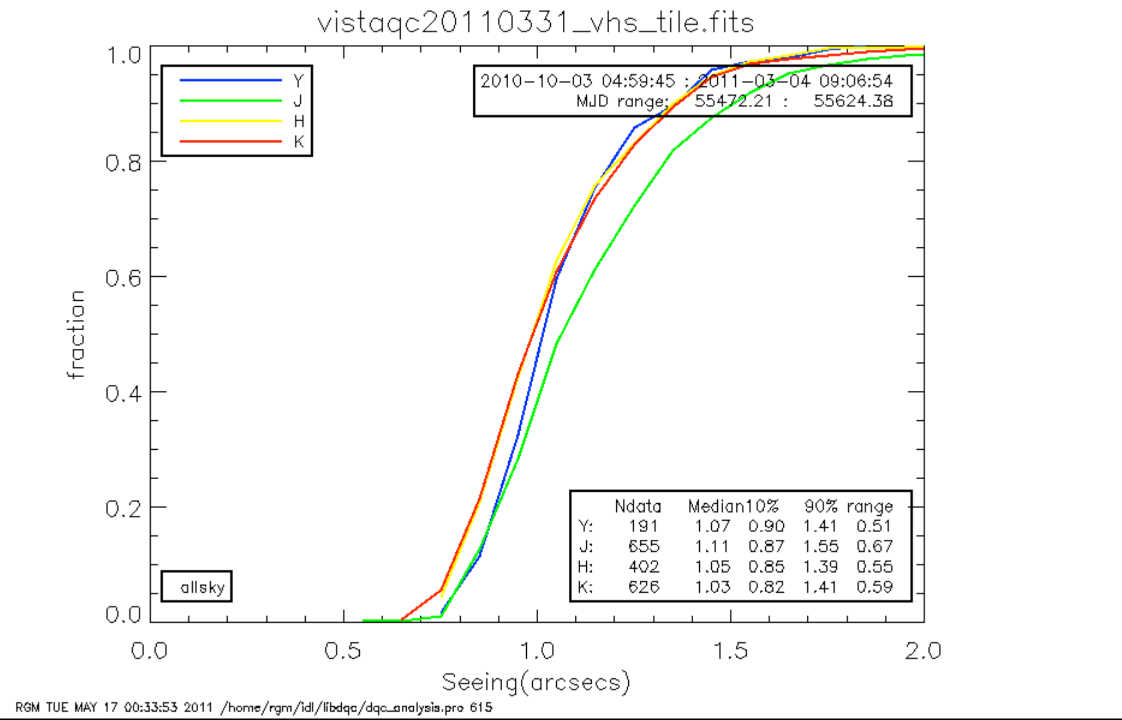

Figure 5 (a): Measured image seeing (stellar FWHM) on tiles for all Period 86 VHS observations including rejected and repeated OBs.

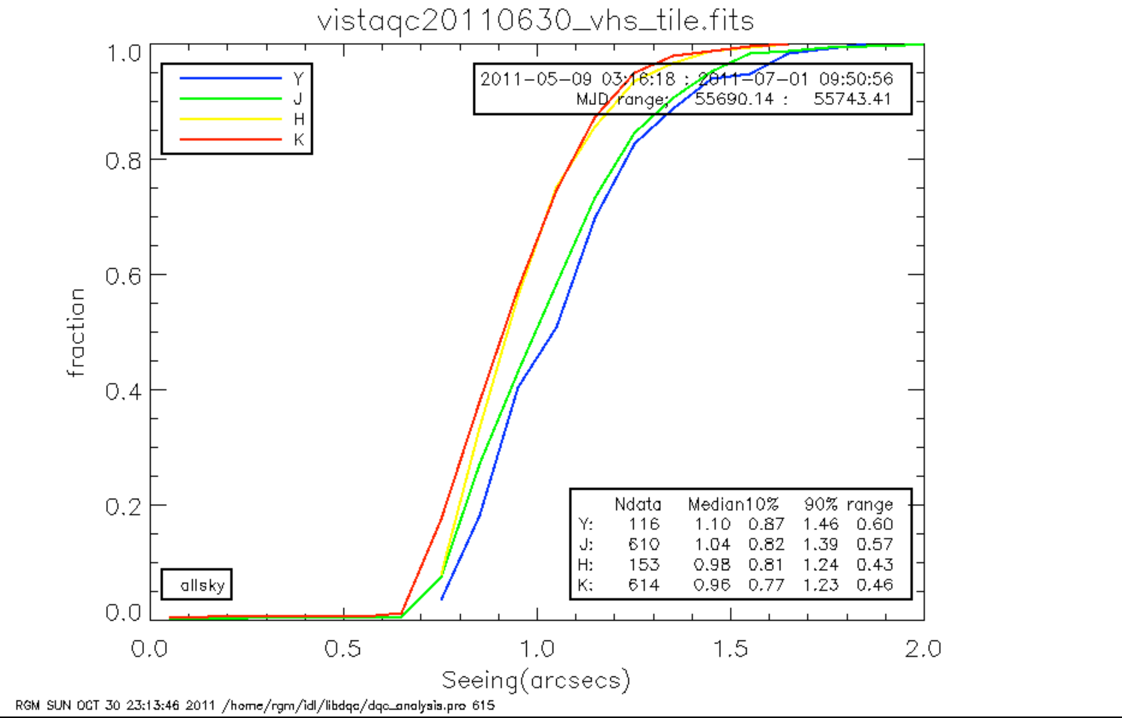

Figure 5 (b): Measured image seeing (stellar FWHM) on tiles for Period 87 VHS observations including rejected and repeated OBs.

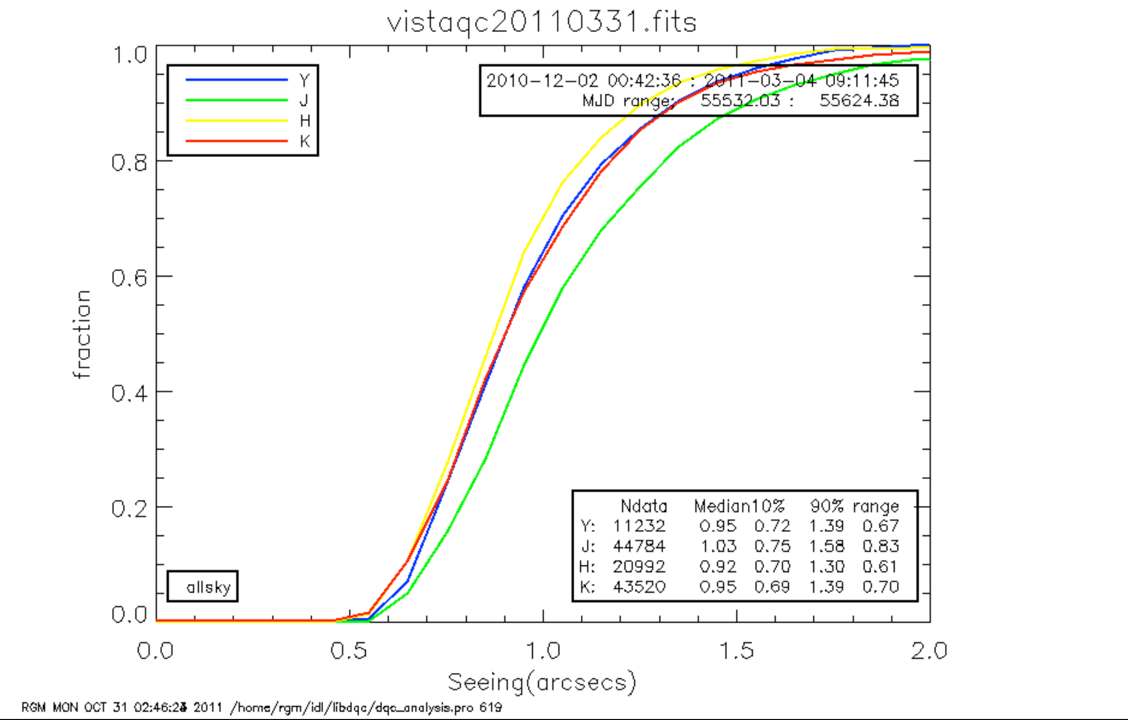

Figure 5 (c): Measured image seeing (stellar FWHM) on pawprints for Period 86 VHS observations including rejected and repeated OBs.

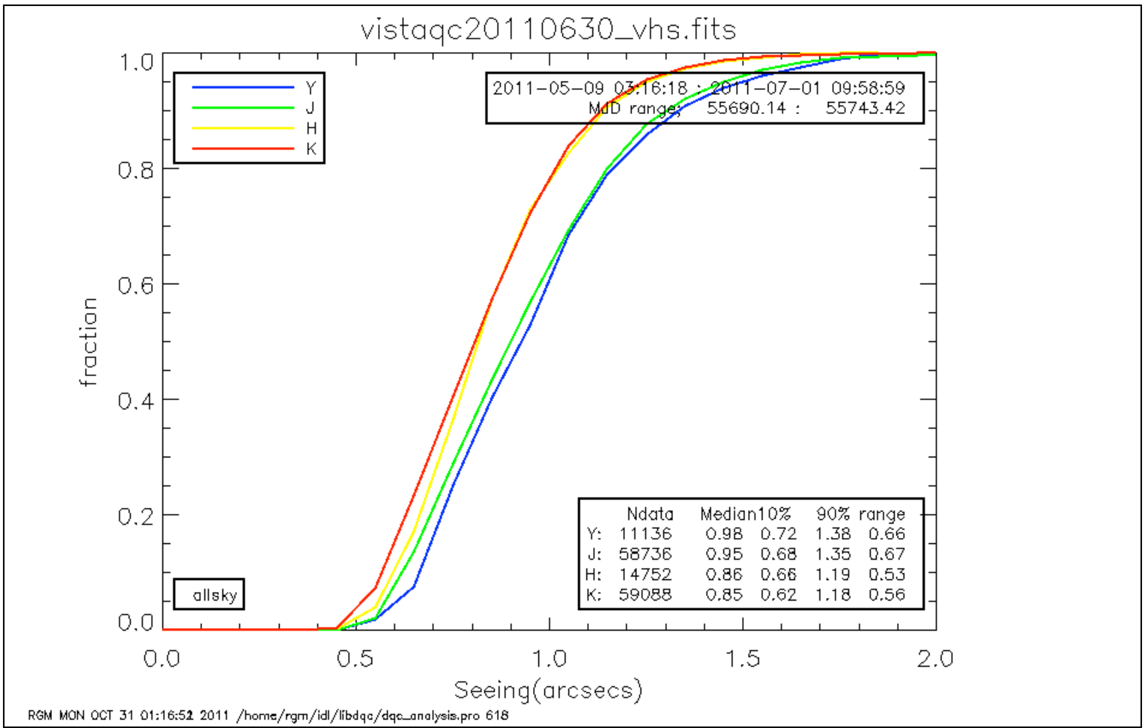

Figure 5 (d): Measured image seeing (stellar FWHM) on pawprints for Period 87 VHS observations upto the end of June, 2011 including rejected and repeated OBs.

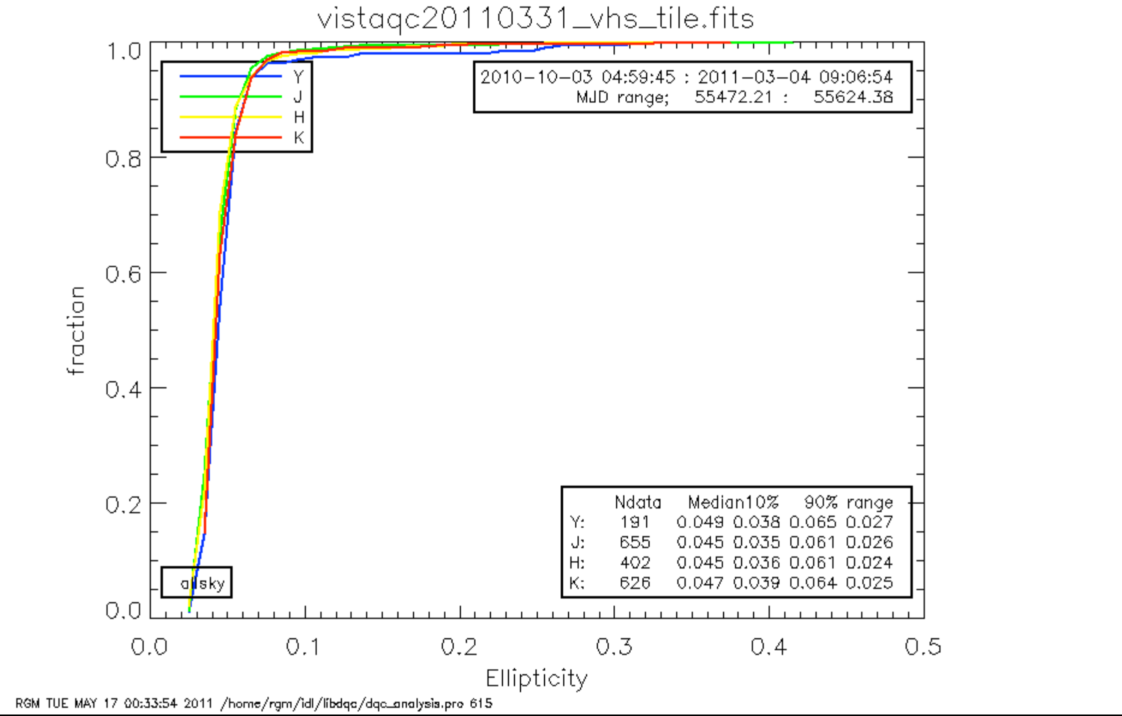

Figure 6 (a): Measured image ellipticity on all tiles for Period 86 VHS observations including rejected and repeated OBs

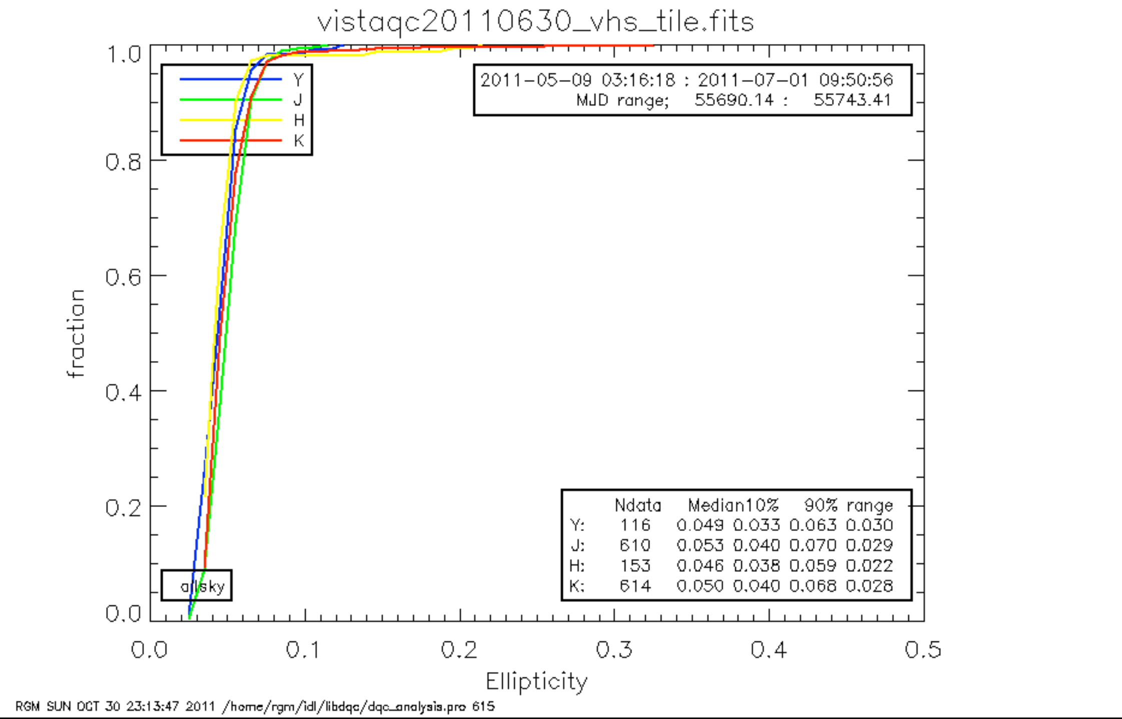

Figure 6 (b): Measured image ellipticity on all tiles for Period 87 VHS observations up to the end of June, 2011 including rejected and repeated OBs.

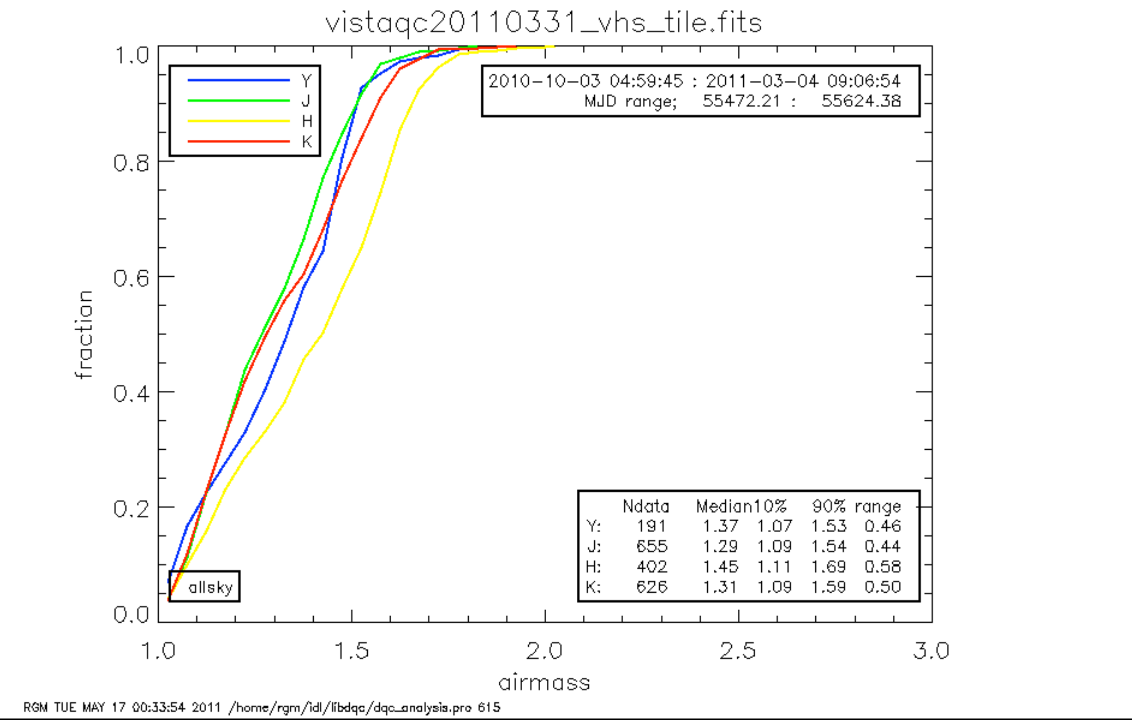

Figure 7: Airmass distribution for all Period 86 VHS observations i.e. includes rejected and repeated OBs.

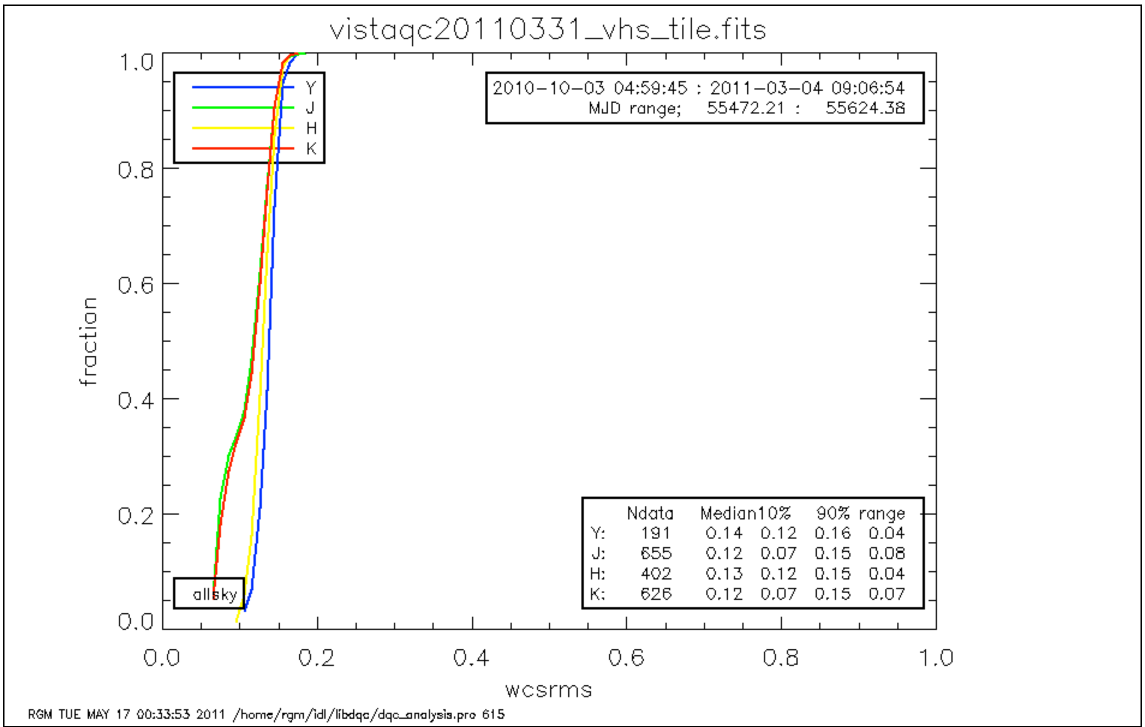

Figure 8: Distribution of the World Cooordinate System(WCS) rms astrometric errors for tiles. The J and K bands have a tail to smaller values compared to Y and H due to larger fraction of fields at low galactic latitude and hence more WCS 2MASS astrometric calibration stars.

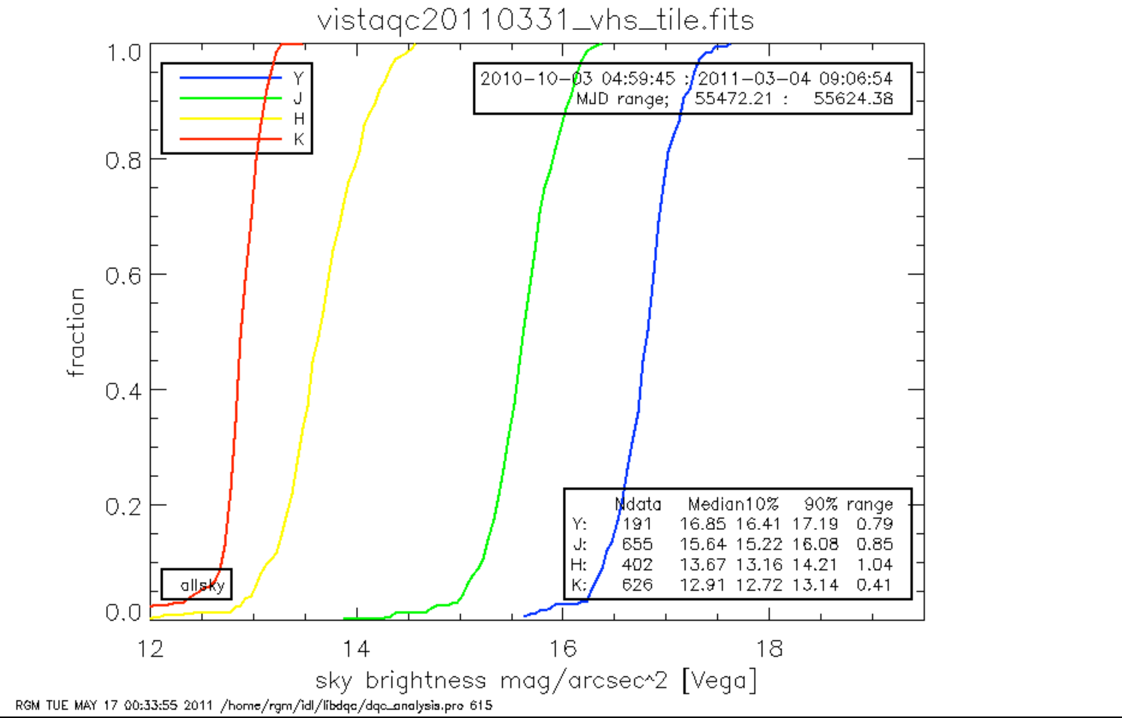

Figure 9: Measured sky brightness seeing on all VHS tiles for Period 86 observations. Note the tail to bright magnitudes that effects ~5% of observations.

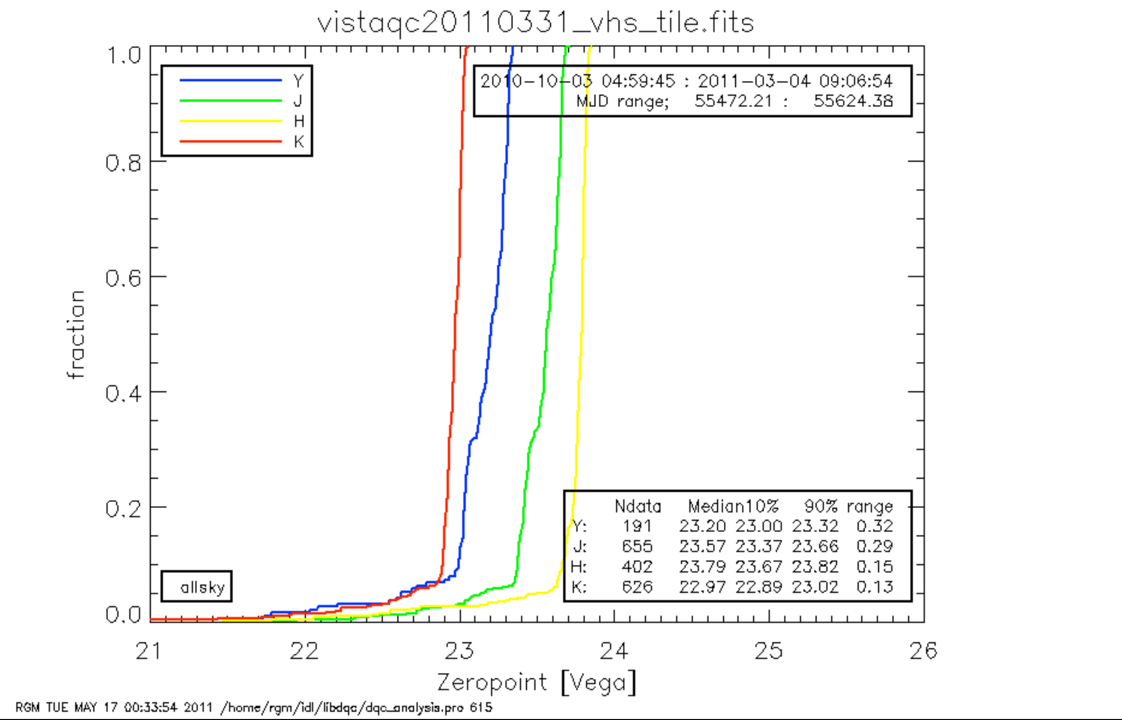

Figure 10: Measured zeropoint on tiles for all Period 86 VHS observations. Note the tail to bright magnitude. 5-10% have attenuation >0.2magnitudes.

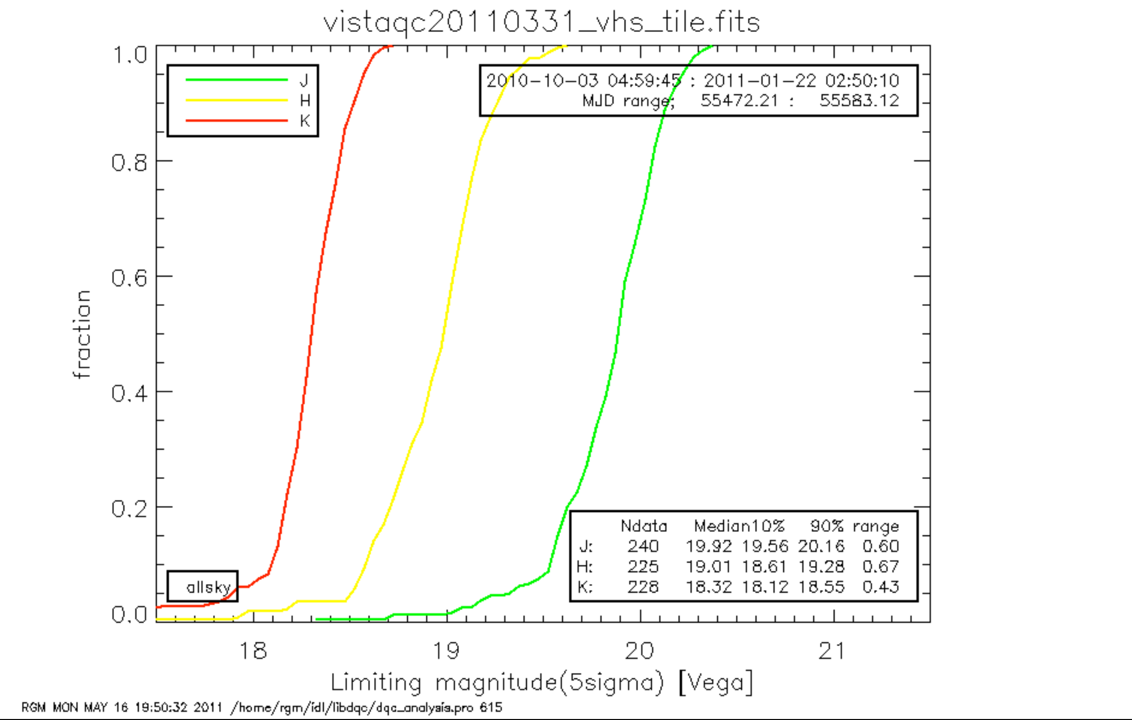

Figure 11(a): Limiting magnitudes for VHS DES component P86 observations

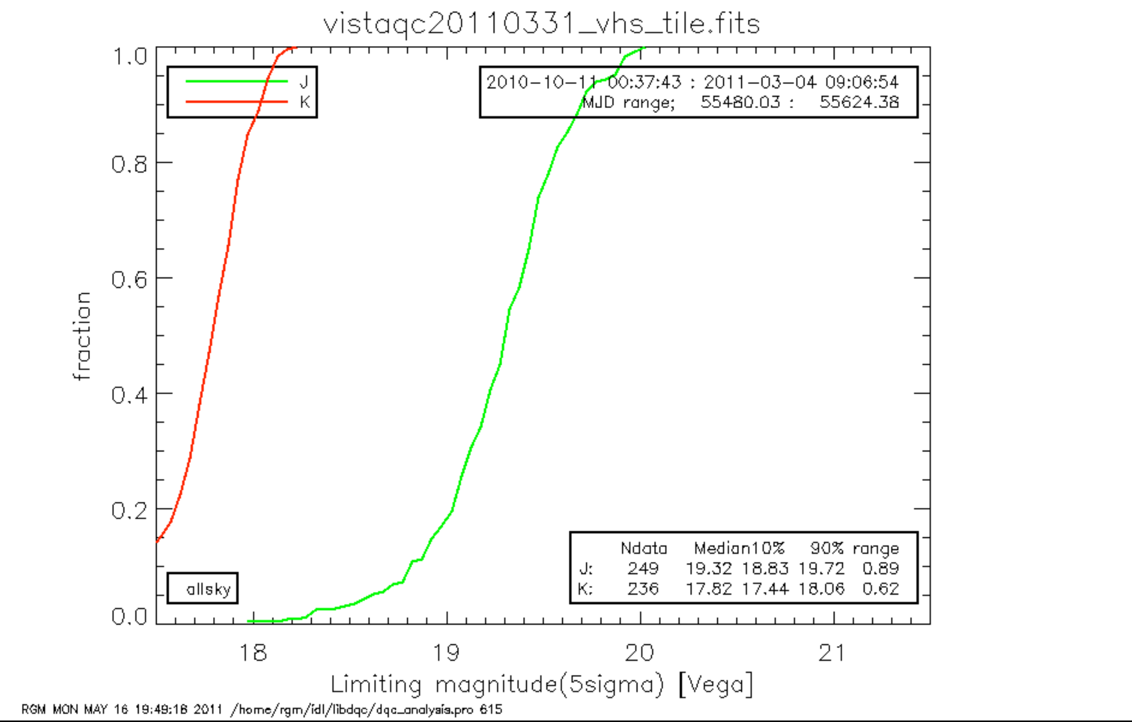

Figure 11(b): Limiting magnitude for VHS GPS component P86 observations

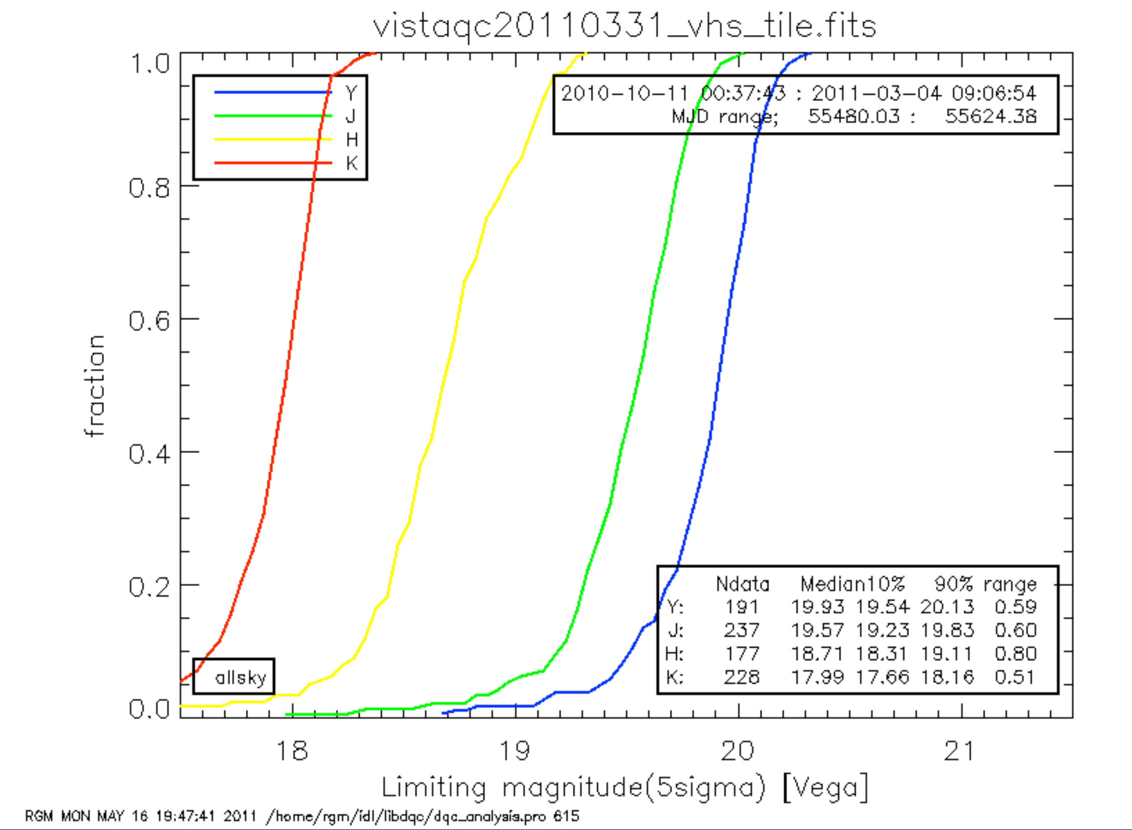

Figure 11(c): Limiting magnitude for VHS ATLAS component P86 observations