VISTA PUBLIC SURVEY STATUS REPORT
(88th OPC MEETING)

This report has to be returned to the Observing Programmes Office of the European Southern Observatory (opo@eso.org) before April 30, 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 deep multi-band optical (grizY) imaging data will be provided by the Dark Energy Survey (DES). 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 84-86 (including Dry Run observations in Period 84) that have been submitted and executed up to the end of Period 86 on March 30th 2011. A total of 2203 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 1973 Period 85 and 86 OBs, 1522 (77%) are reported by ESO as completed and 451 (23%) are incomplete.

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 OBs submitted in Period 85 were carried over into Period 86 and hence the observing efficiency in each Period cannot be derived from the Table 1.

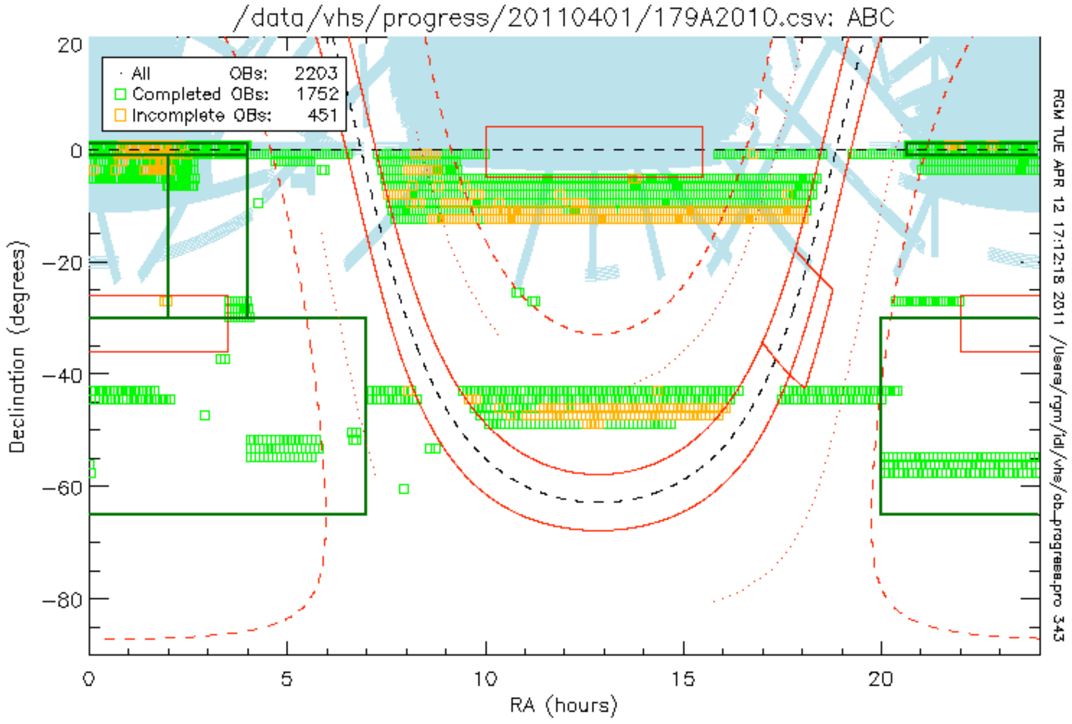

Figure 1: Sky coverage of the VHS survey in equatorial coordinates based on ESO Portal report tables. The green and orange rectangle show complete and incomplete OBs respectively. The light blue shading is the SDSS footprint. The thick green lines show the Dark Energy Survey footprint.

Table 1 VHS OB progress on 2011-04-01

Period	Submitted OBs	Completed OBs	Incomplete OBs
P84 (Dry Run)	230	230	-
P85	1123	1083	40
P86	850	439	411

All data taken in Period 84, 85 and 86 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.

CASU processing of VISTA data has reached a stable state and is released monthly about two 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 last report to the OPC 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 are still under going QC evaluation by CASU and VHS. This QC indentified a problem with the aperture corrections that need to be applied to 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 been transferred to the ESO Phase 3 ftp site.

Observing overhead concerns

We repeat the concerns we raised in our previous report to the OPC about the observing overheads which have increased further since our previous report. In Table 2 we summarise 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
VHS-GPS	360	600	829	1005
VHS-ATLAS	720	1199	1510	1910
VHS-DES	1080	1491	1809	2129

The current charging for observing overheads is 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, based on information provided by ESO and the VISTA project we estimated the total elapsed time including overheads as 600, 1199 and 1491 seconds respectively. The execution time charged within P2PP for Period 85 is 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, 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

No submitted journal 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.

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.

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 being produced for all paw-print and tile bandmerged catalogues. 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. This plots contain repeat OBs and hence although the median value will be robust, poor quality data will be over represented. 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 has improved compared with Period 85.

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 will observe with AO Priority high to determine whether increasing the AO priority will improve the median seeing. This increases observing overheads by ~10% but this would be balanced by better quality data.

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.

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 we used the twilight constraint.

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 amd ~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. 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.

Status and delivery of advanced 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 ready for delivery before Christmas and we expected to formally deliver data products early in 2011. 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 and we expect to close the release before the end of May.

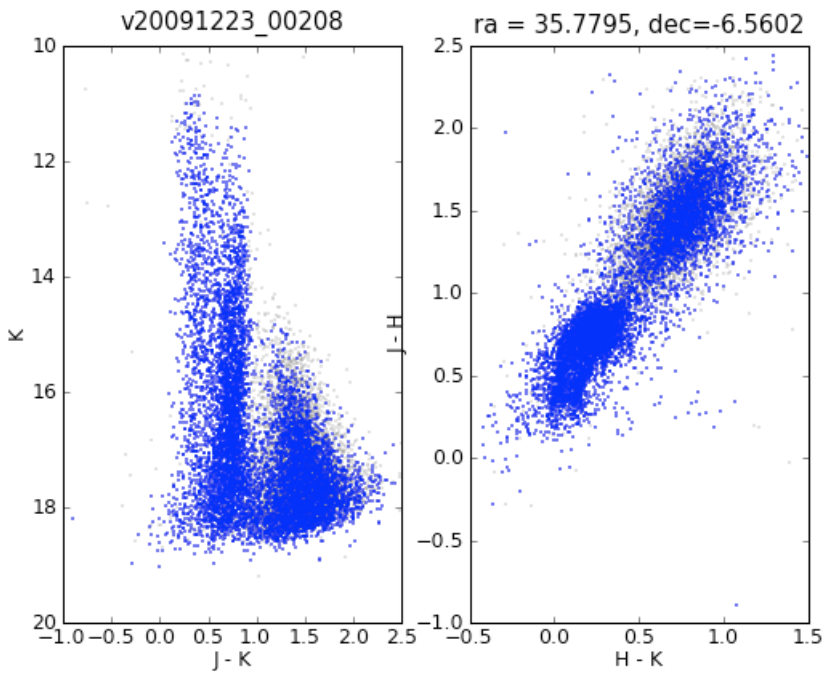

Figure 2(a): Version 1.0 data products showing QC problem with star-galaxy separation. Blue points are starlike objects; Grey points are non-stellar objects

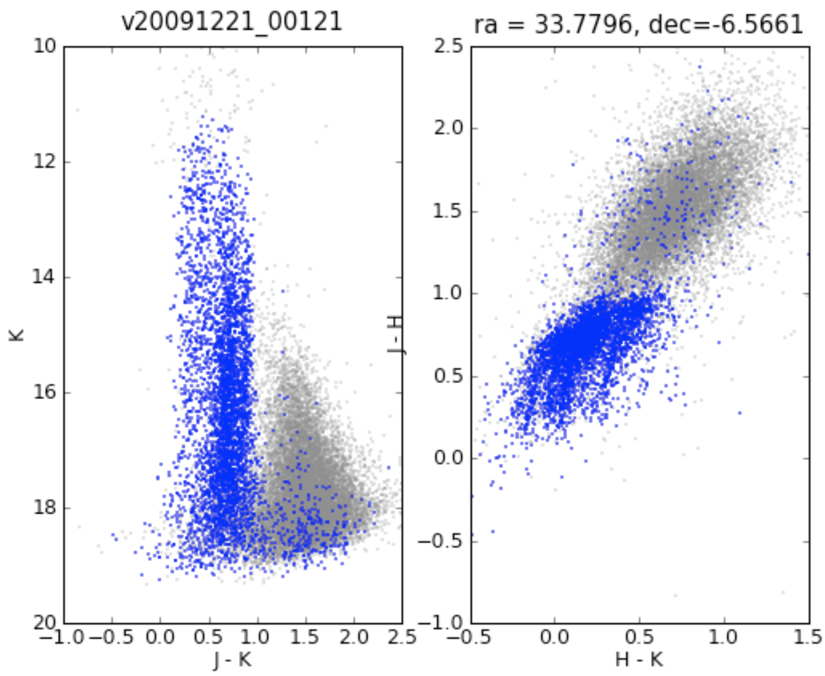

Figure 2(b): Version 1.0 data products showing QC problem with multiple offset stellar loci due to variable seeing causing spatially dependent aperture corrections in different pawprints.

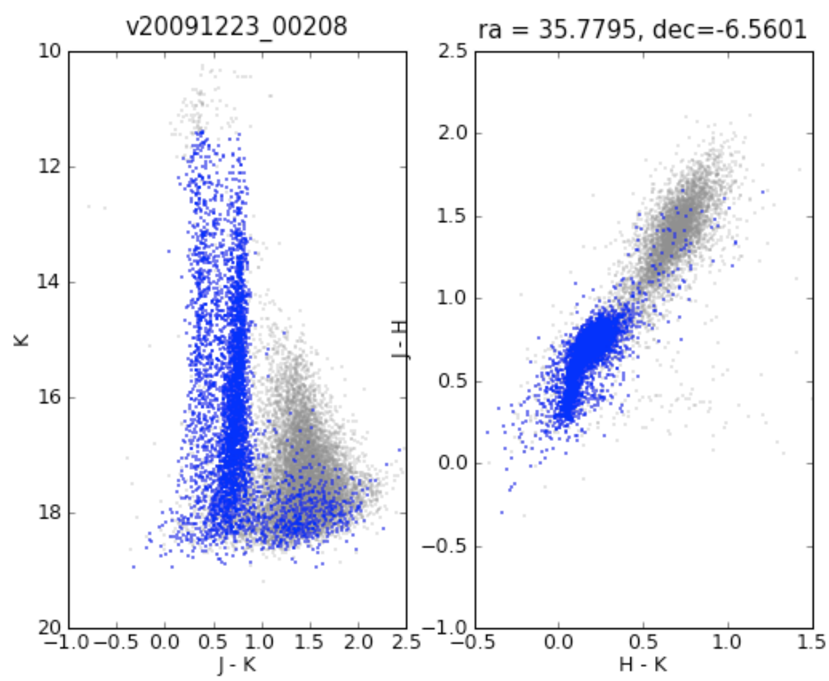

Figure 3(a): Version 1.1 data products for same observations as Figure 2(a) showing the improvement in star-galaxy separation for this OB. Blue points are starlike objects; Grey points are non-stellar objects

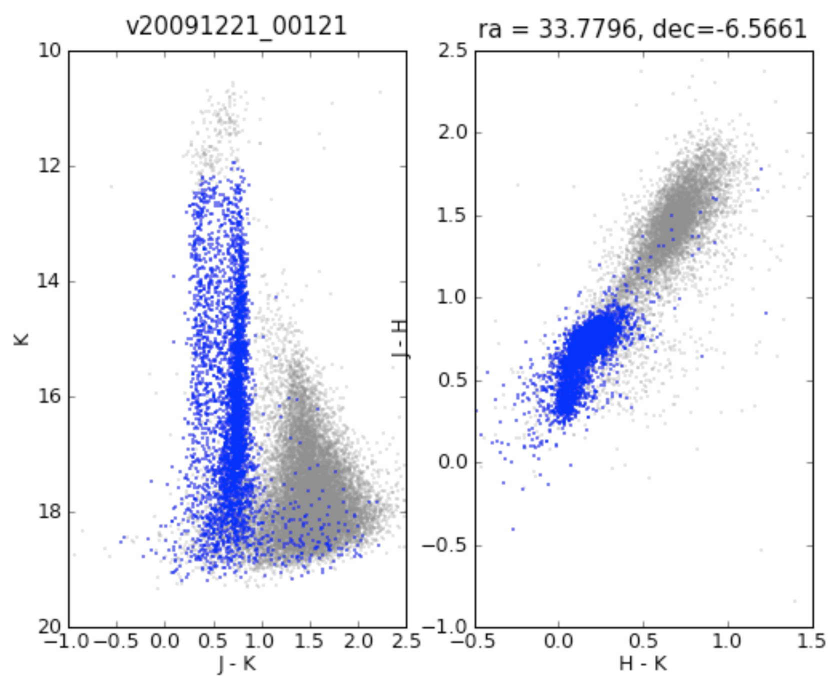

Figure 3(b): QC problem showing multiple offset stellar loci due to variable seeing causing spatially dependent aperture corrections in different pawprints.

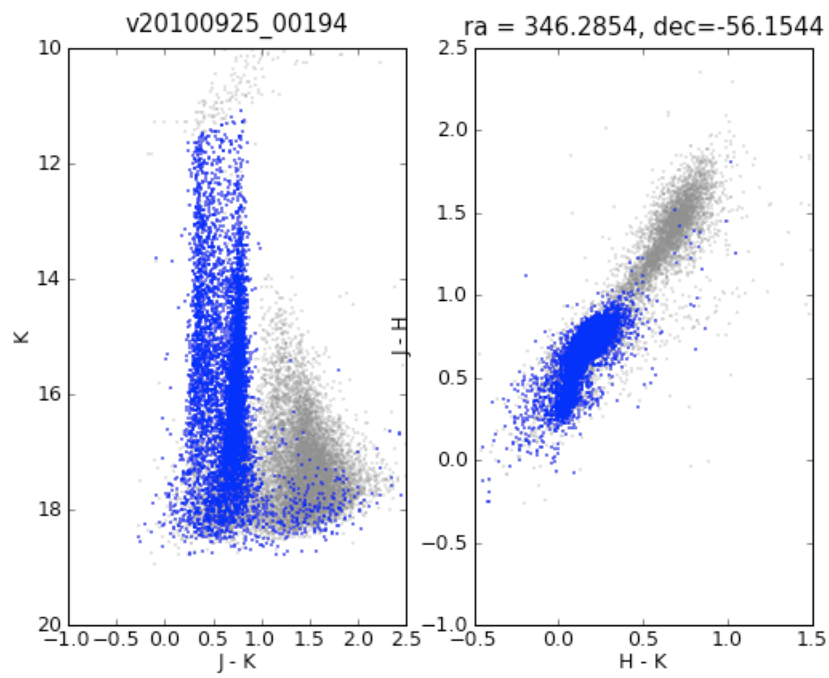

Figure 4(a): Version 1.1 data products for VHS final Period 85 OB acquired on 2010 Sep, 25th. Blue points are starlike objects; Grey points are non-stellar objects

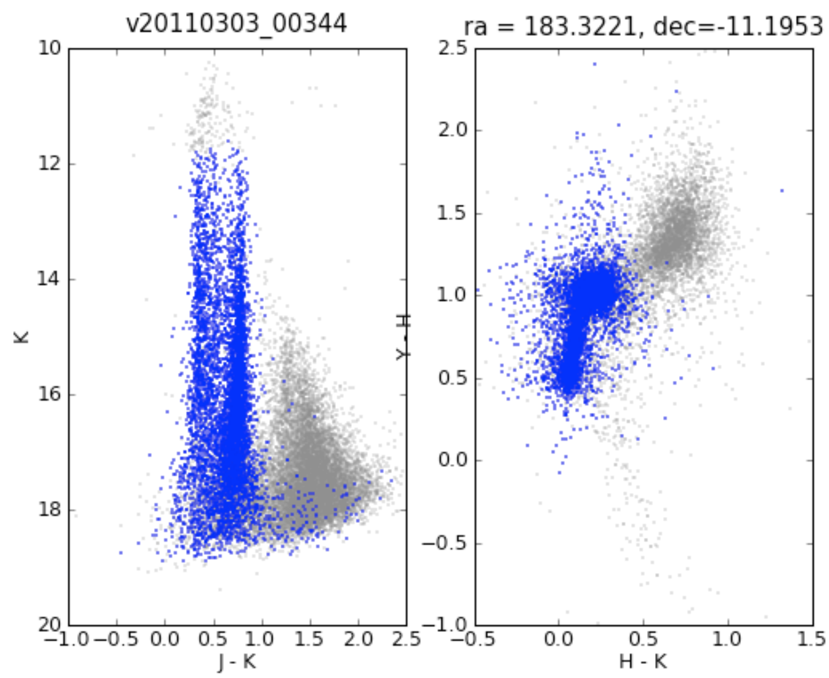

Figure 4(b): Version 1.1 data products for final VHS Period 86 OB acquired on 2011 March, 3rd; Note the right plot is H-K v Y-H whereas in other plots it is H-K v J-H

Are any changes proposed with respect to the Survey Management Plan in P88 (e.g., in strategy, field coordinates, exposure time and/or other settings)? If yes, please provide a clear and detailed justification.

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 improved the sky brightness situation. In fact the median sky brightness increased. The airmass distribution for the two periods is similar with the largest difference of 0.1 in H.

In Period 87 we will 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%.

Another option that we are considereing 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 the measured sky brightness would 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 models was evaluated.

4. Observing Plan for Period 88.

Specify which part of the Survey Management Plan (SMP) the survey will focus on in P88 in the 1st column and provide the corresponding details in the table below. In particular please highlight any changes with respect to the SMP for P88, and provide a full justification for these changes in Section 4 above.

SMP Period	Field name/ mean RA	Filter	Time (h)	Seeing	Moon	Transparency	Comments / strategy (e.g., no. of epochs)
P88	6hr	Y,J, H,K	311	<1.4	any	thin	

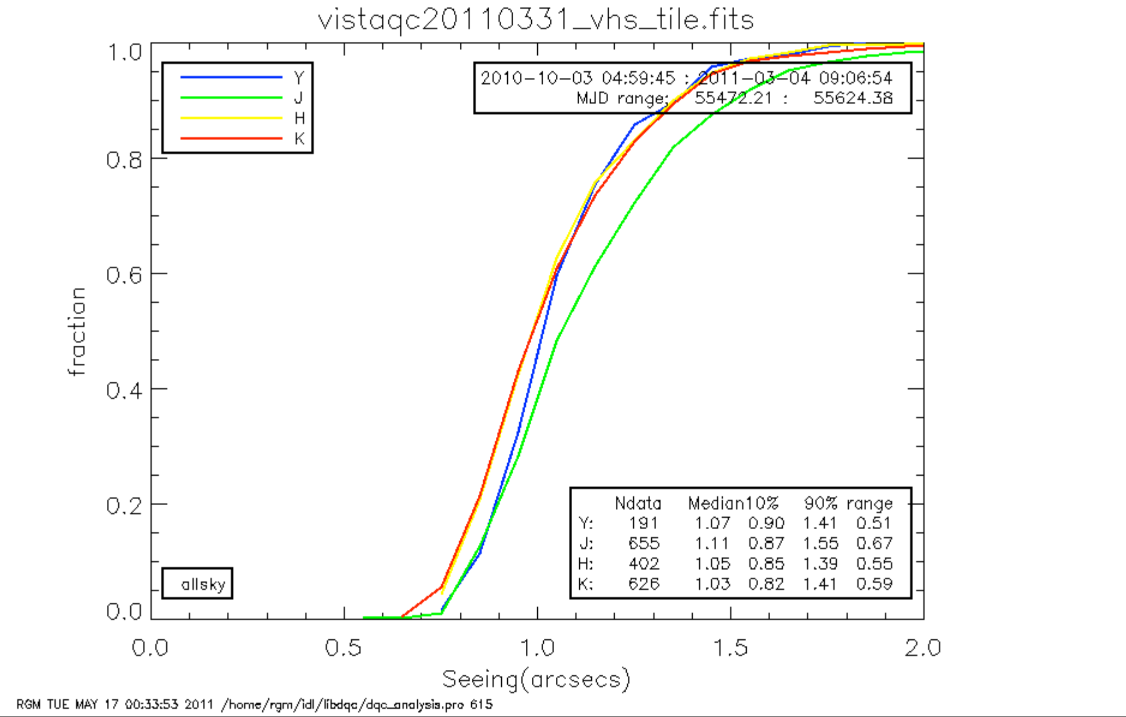

Figure 5: Measured image seeing (stellar FWHM) on tiles for all Period 86 VHS observations including rejected and repeated OBs.

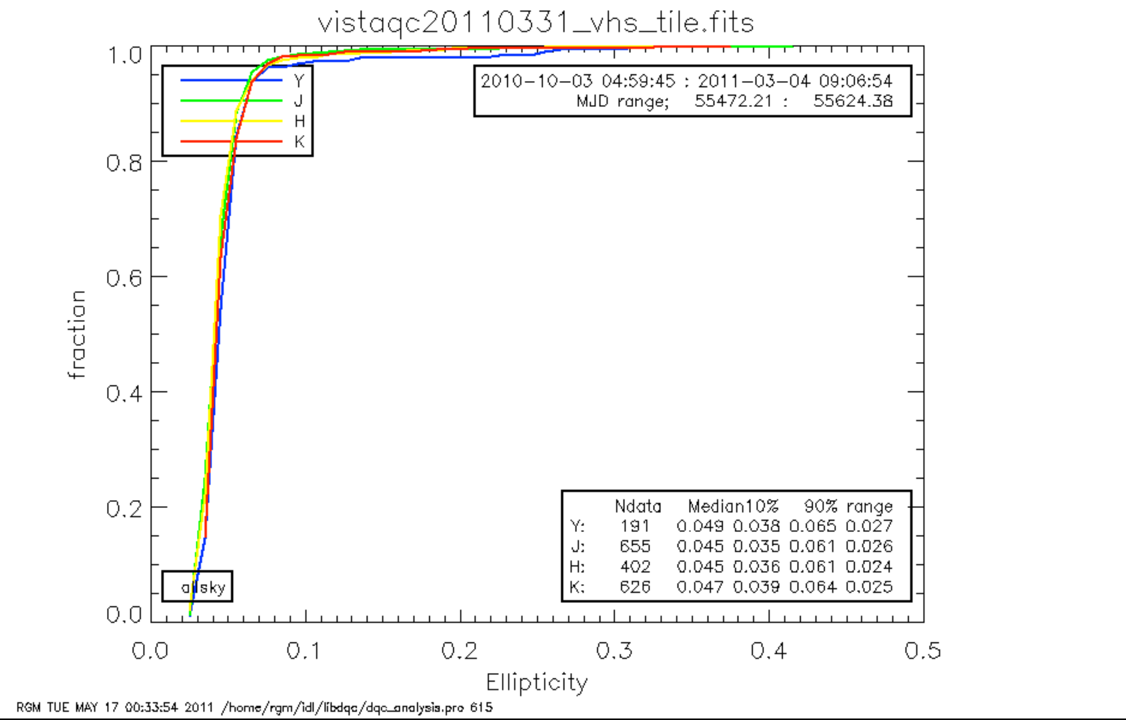

Figure 6: Measured image ellipticity on all tiles for Period 86 VHS observations including rejected and repeated OBs

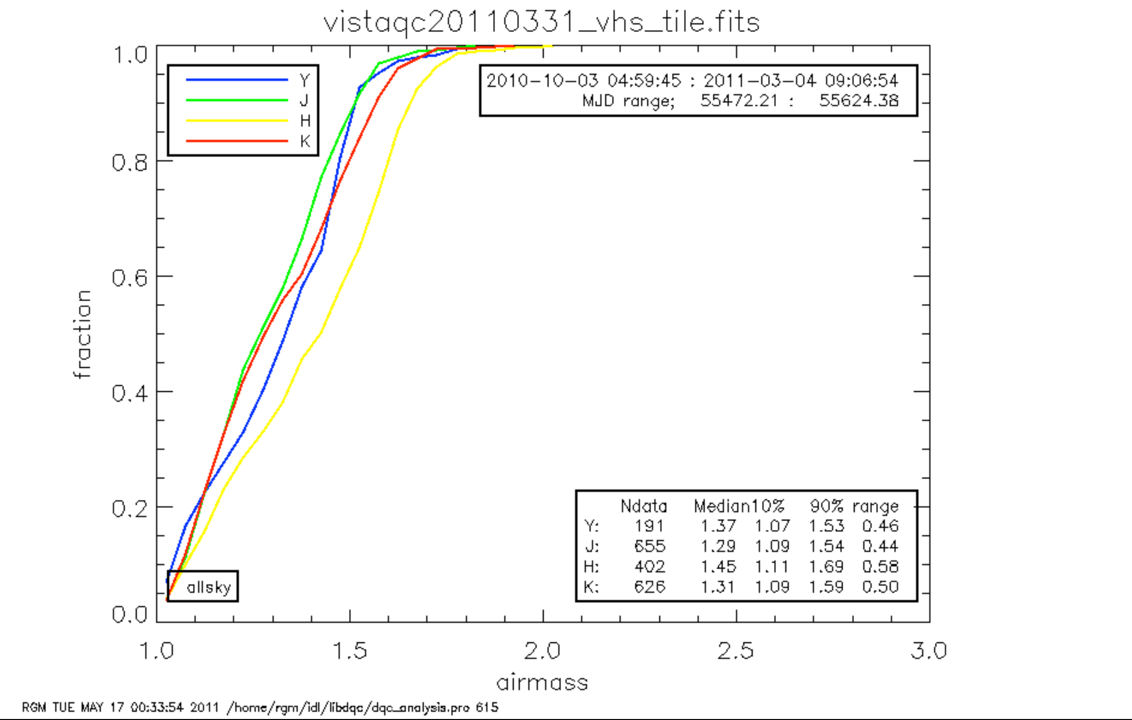

Figure 7: Airmass distribution for all Period 86 VHS observations i.e. includes rejected and repeated OBs.

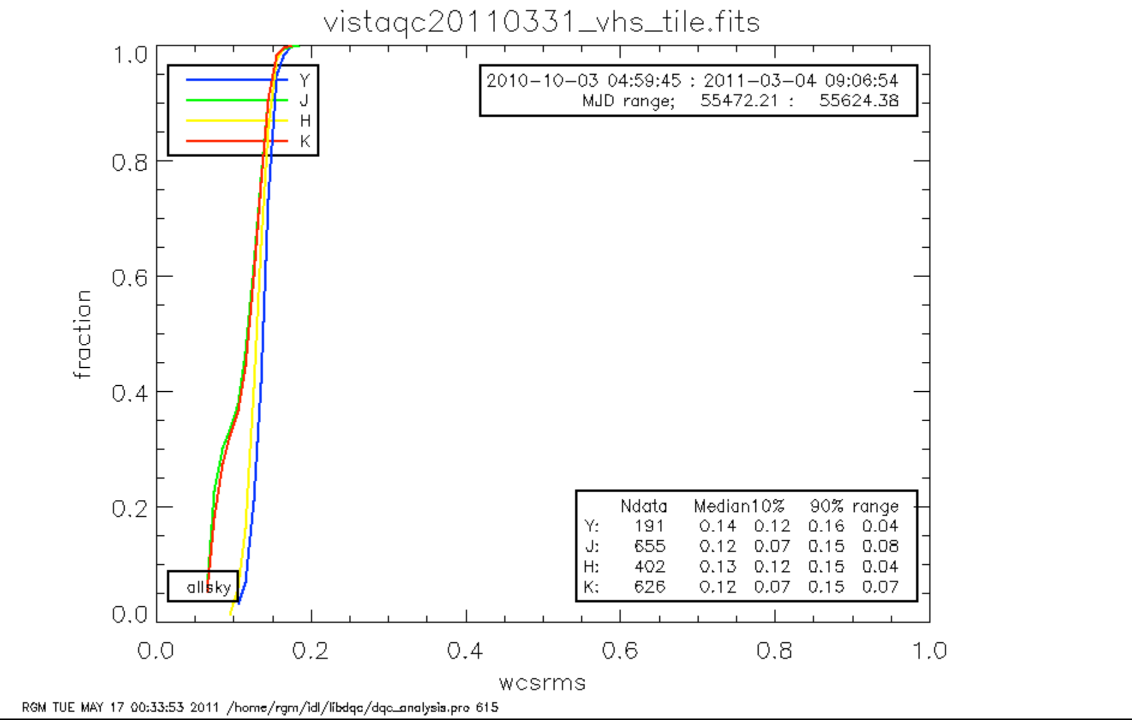

Figure 8: Distribution of the World Cooordinate System(WCS) rms astrometric errors for tiles. The J and K bands have a tail to smaller values compared to Y and H due to larger fraction of fields at low galactic latitude and hence more WCS 2MASS astrometric calibration stars.

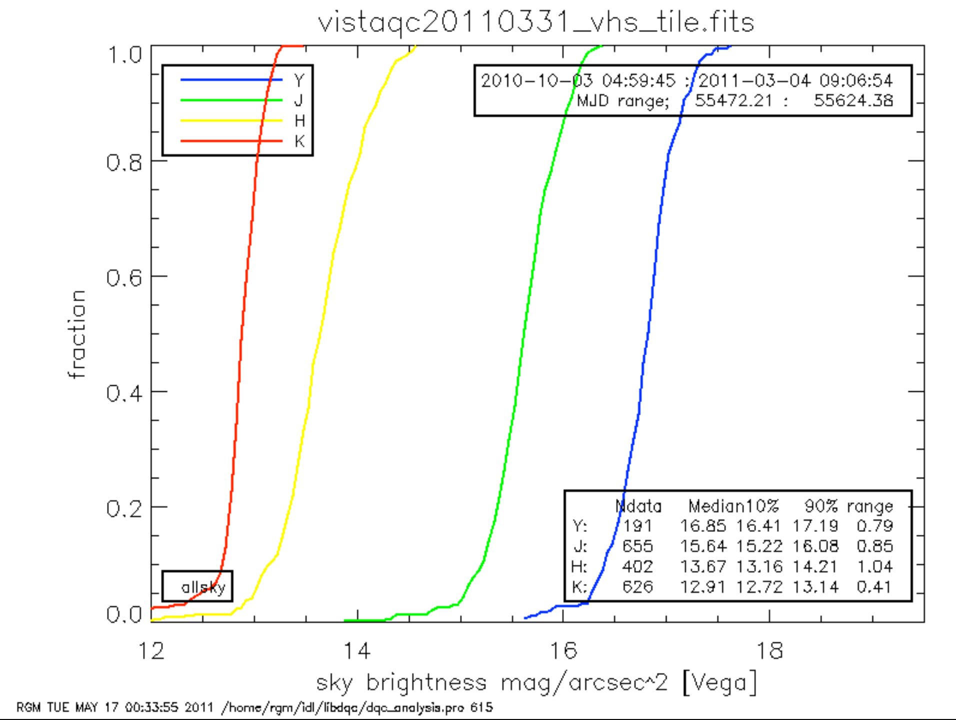

Figure 9: Measured sky brightness seeing on all VHS tiles for Period 86 observations. Note the tail to bright magnitudes that effects ~5% of observations.

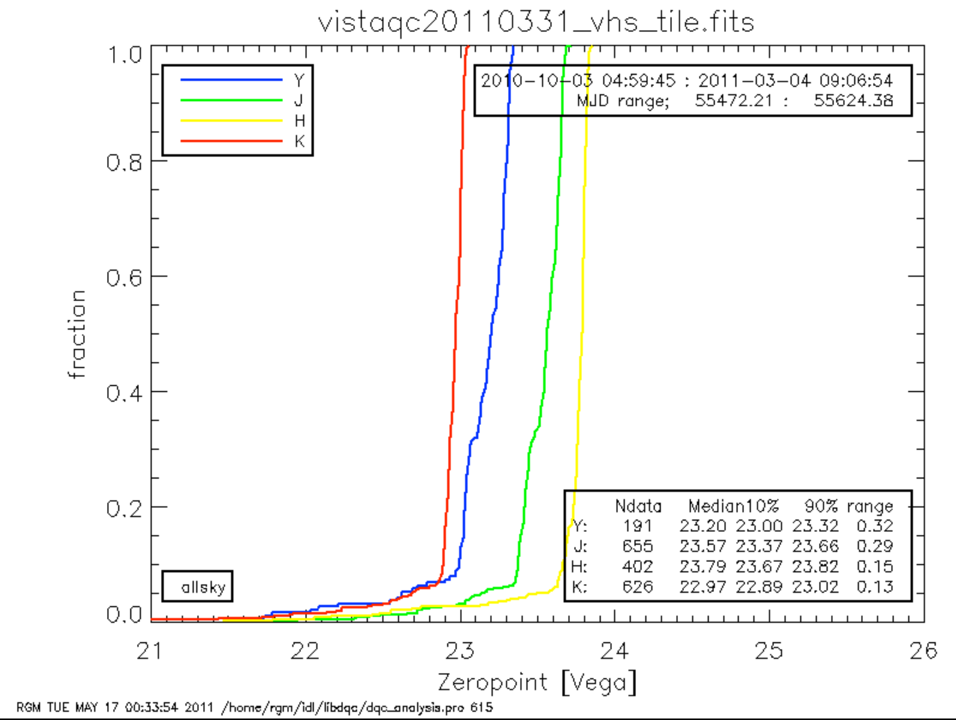

Figure 10: Measured zeropoint on tiles for all Period 86 VHS observations. Note the tail to bright magnitude. 5-10% have attenuation >0.2magnitudes.

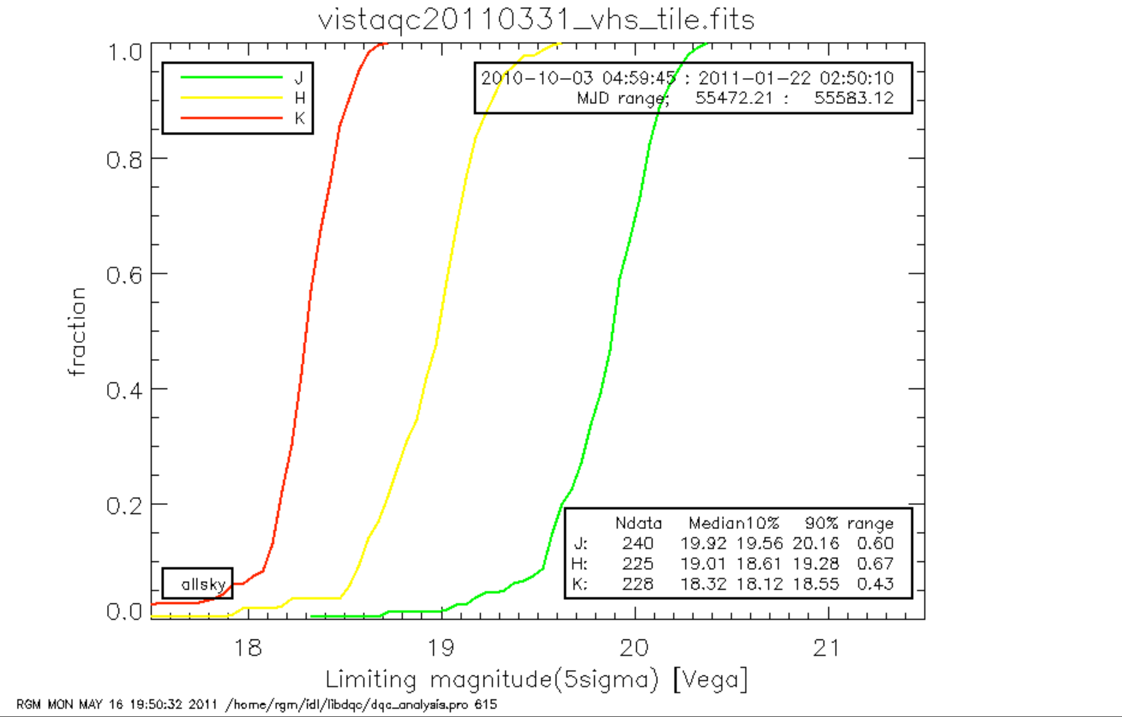

Figure 11(a): Limiting magnitudes for VHS DES component

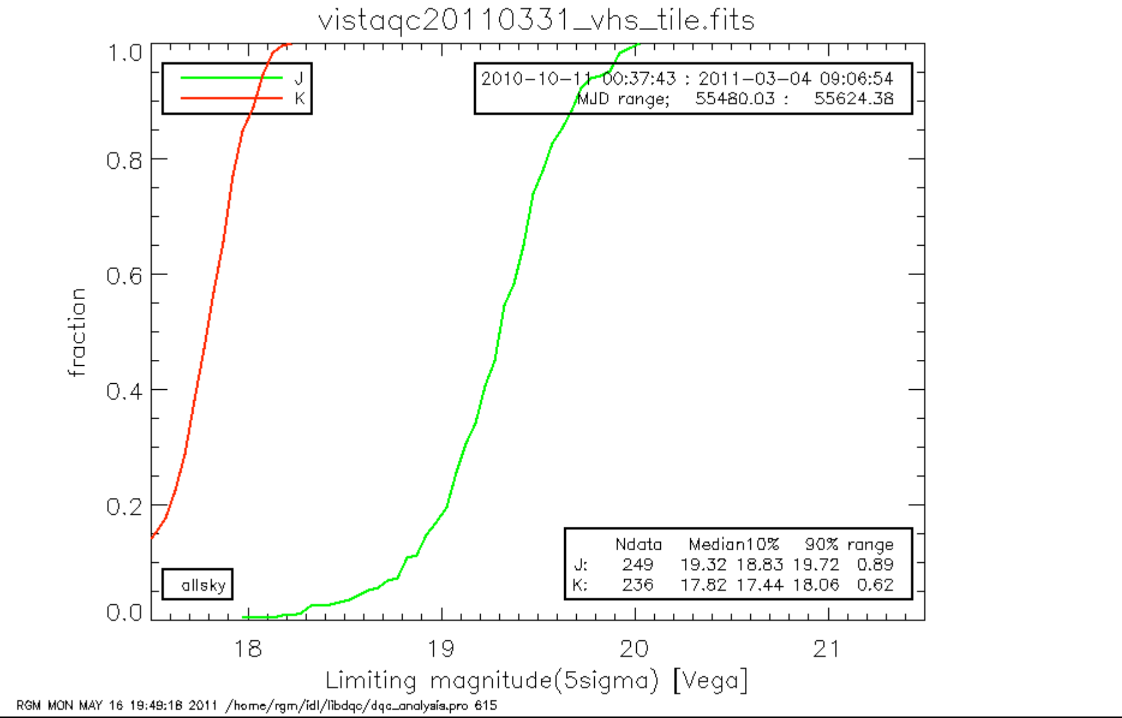

Figure 11(b): Limiting magnitude for VHS GPS component

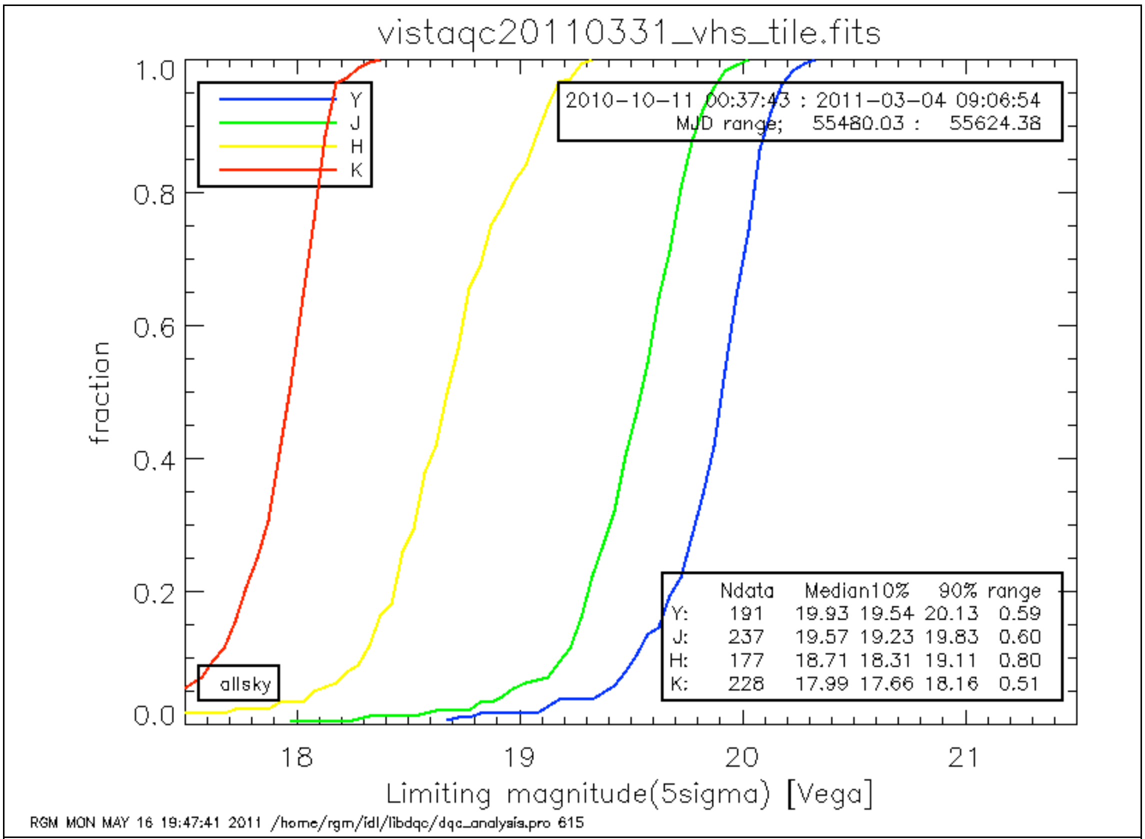

Figure 11(c): Limiting magnitude for VHS ATLAS component

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