1 Title: The VPHAS+ survey of the southern Galactic Plane

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1.1 Abstract

The primary goal of VPHAS+ is to collect $u/g/r/i$ broad-band, and Hα narrow-band photometry across the southern Galactic Plane within the latitude range $-5^o < b < +5^o$ down to point-source magnitudes of 21–22. With the agreement of the Public Surveys Panel, the survey footprint now also includes the inner Galactic bulge, defined as a 20×20 deg^2 box centred on the Galactic Centre: this increases the survey footprint by 10 percent, and assures optical coverage of the VVV NIR footprint. For all massive OBA stars this survey is deep enough to fully explore all but the most heavily obscured locations of the southern Plane (where the penetration will still be several kpc). These data should multiply the number of known southern emission line objects by $\sim$10, yielding much better statistics on important short-lived types of object. Their superior photometric accuracy will also facilitate large-area stellar population studies, tracing structure within the Plane, that have hitherto been impossible. VPHAS+ will trawl the star-formation history of the Galaxy as written in its stellar remnants. The final point-source catalogue will contain of order 2×10^8 objects. VPHAS+, along with IPHAS/UVEX, its northern counterpart surveys, will provide a hugely attractive database of Hα imagery to be used to publicise astronomy in the community.

This document contains the management plan for the VPHAS+ public survey. Contemporaneous $u/g/r/i/H\alpha$ imaging requires grey time, and we anticipate a detection rate in the region of half a million point sources per hour of observing. The data will be processed by the Cambridge Astronomical Survey Unit (CASU). Within, on average, 6 months of receipt of data, reduced images and band-merged object catalogues, with photometry calibrated against nightly standards will be available (typical broad-band errors of under 0.05 magnitudes). As data-taking approaches completion, it will be appropriate to begin to correct the whole survey to common zero points to yield the final legacy database.

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2 Survey Observing Strategy

The observations required for this survey are matched OmegaCam images obtained with (i) a narrow-band $H\alpha$ filter ($\sim$100 Å FWHM: procured from Barr Associates and received/lab-tested 2009), (ii) a continuum filter in the same part of the spectrum as $H\alpha$ - here r, (iii) three remaining continuum filters spanning the optical ($u/g/i$), yielding the optical colours of stellar sources. The Sloan filter set is the best choice currently available by virtue of their box-like passbands.

Our observing strategy for each VPHAS+ field is to obtain the following exposures: u, 150 sec; g, 30 sec; r, 30 sec; $H\alpha$, 120 sec; i, 30 sec, sequentially for two pointings at each field centre. Obtaining the full set of exposures within a single sequence has several advantages. Chief among these are minimising the impact that point-source time variability might otherwise have on derived colours and spectral energy distributions, whilst minimising survey overheads. This strategy will also maximise the likelihood of equivalent image quality (in terms of PSF and photometric conditions) in each field, facilitating optimal r image subtraction from Hα emission and simplifying the final uniform calibration of the entire survey. The acquisition of images in all five bands makes it necessary to schedule the observations in grey or darker time (as noted in our VPHAS+ proposal submission to the ESO OPC).

2.1 Scheduling requirements

VPHAS+ will require in the region of 18 weeks of VST time (895 hours, excluding time needed for routine calibration observations). Some limited VPHAS+ observations should be gathered early in VST operations (end P87) to verify that the data and data-taking strategy will meet requirements.

Thereafter, we propose a formal start of VPHAS+ using the verified survey strategy at the beginning of 2012, as the Galactic Plane returns to the southern hemisphere. Thereafter a rate of observing such that $\sim$ 6 weeks worth of survey-standard data is gathered each calendar year (nearly all over the months January to June) will see the survey complete by end 2014[1].

The southern Galactic Plane defines our target fields: below the celestial equator they lie in the RA range between 06h50 and 18h50, reaching down to Dec: -68 deg (at RA 12h50). We propose to survey the Plane up to 2.5 degrees above the celestial equator in order to ensure good overlap with the northern surveys, IPHAS and UVEX. Hence the Plane survey area is defined in Galactic co-ordinates as being all longitudes in the range $210^o \leq \ell \leq 35^o$, passing through the Galactic centre, and all latitudes in the band $-5^o \leq b \leq 5^o$. The extra fields associated with the Galactic bulge fall within the latitude range $|b| < 10^o$, and longitude range $|\ell| < 10^o$, adding 10 percent more sky coverage. This has been accounted for in the table below.

Choice of fields to observe on any given night, from among those remaining at the time, generally need only be governed by air mass (<1.4) and moon distance (>45 degrees) requirements. However, in the first phase we will assign higher priorities to fields that are of interest to the Gaia-ESO Spectroscopic Survey (PIs Gilmore and Randich), due to begin using FLAMES on UT2 from January 2012: 54 clusters to be targeted for spectroscopy fall within the VPHAS+ footprint and are fairly evenly spread in RA.

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
Aug	<4 (tests)	various	various	<1.2	clear
Sept - Dec	0				
P88	140	6–14h	grey/dark	<1.2	clear
P89	145	10–18h	grey/dark	<1.2	clear
P90	150	6–14h	grey/dark	<1.2	clear
P91	150	10–18h	grey/dark	<1.2	clear
P92	155	6–14h	grey/dark	<1.2	clear
P93	155	10–18h	grey/dark	<1.2	clear

We discuss our assumptions, including overhead estimation, that leads to these time requirements in the next section.

2.2 Observing requirements

A complete VPHAS+ observation for a given 'field pair' has two parts: (i) a set of exposures in all 5 filters at a nominal pointing; (ii) a second set of exposures in the same 5 filters, observed at an offset of $\sim$ 13 arcmin in each of RA and Dec. These exposures, executed optimally, should preferably define a single OB. As before, we emphasise the importance of obtaining all these data approximately contemporaneously to minimise data matching problems caused by stellar variability, a common problem on timescales of hours/days/months.

The offset field strategy is aimed at dealing with cosmic-rays; almost complete coverage of the gaps between detectors; better final photometric calibration via the provision of significant field overlap; the already known (i.e. lab-determined) characteristics of the segmented Hα filter, NB-659. For comparison, in the northern hemisphere we have used 5 arcmin offsets in both RA and Dec for a field size a quarter that of VST/OmegaCam.

2.2.1 Exposure times and filter choice

We obtained NB-659 from Barr Associates, who agreed to construct the filter out of 4 segments (final format of report under discussion). Once characterised on sky, and subject to ESO approval, this will be offered for general use with OmegaCam.

[1]For calculation purposes, we assume an average of 7 hours on target fields per night

To arrive at suitable exposure times, we take 1.0 arcsec seeing at airmass 1.2 against a grey sky (7-day old moon) as "typical" conditions. For the timebeing we continue to base our estimates on data from the web page describing VOCET, the VST OmegaCam Exposure Time Calculator (see http://www.na.astro.it/%7Erifatto/vst/). Our estimate for the throughput of the Hα filter is based on its lab measurement, scaled to what we know of the properties of the analogous filters belonging to the Isaac Newton Group.

Our aim for all the broadband filters is 10σ at an AB magnitude of $\sim$22. For the exposure times we have settled on, we estimate that 10σ is achieved for: $u(AB) = 21.8$ (150 sec); $g(AB) = 22.5$ (30 sec); $r(AB) = 22.5$ (30 sec); and $i(AB) = 21.8$ (30 sec). We would expect saturation at these exposure times for AB magnitudes of 14, a bright limit close to the faint limit of older-generation objective prism surveys. An Hα exposure time of 120 sec would be expected to deliver a 10σ result for an equivalent AB magnitude of 21.6. In the exploitation of IPHAS data we have found that a 4:1 Hα:r exposure time ratio delivers satisfactory results in the analysis of the $(r - H\alpha, r - i)$ colour-colour diagram. Final adjustments to these exposure times will be considered when on-sky zeropoints measured in commissioning tests have been received and we have assimilated the preliminary data beginning to become available.

Grey or darker time has become essential for VPHAS+ because of the inclusion of the u- and g-filter observations, alongside the requirement for contemporaneous observation in all bands. For the purposes of mosaicked image construction from Hα and r filter data, the use of grey/dark time also offers the considerable benefit of much less variable sky background.

Estimation of overheads at this stage still remain somewhat assumption-dependent as follows. We note that the short exposure times envisaged for VPHAS+ may remove the need to guide, leaving as the dominant overhead the time to acquire, change filters, offset and read out – present indications are that read out can be performed in parallel with a filter change or a telescope offset. The most costly overhead arises from the filter changes: these can be kept to 65 secs per change if each change is between the two magazines. We assume this will be feasible as the main constraint it imposes is that NB-659 should be in the magazine *not* containing the r filter (r and NB-659 should always be obtained consecutively).

If an OB is defined as observing the on- and offset-field consecutively through the same filter, and then changing filter – repeating this until data in all 5 filters has been taken – the overhead amounts to:
the original acquisition. This may only be 120 sec if this can also absorb the initial filter change;
4×65 sec for optimised filter changes;
5 read-outs/offsets assumed to take 45 sec;
a final 40 sec read out.
This adds up to 645 sec. Hence, if indeed no guide stars need to be set, the overhead time is 90% of the total exposure time of 720 sec per putative OB. Our calculations in the last revision of the SMP were based on an assumed overhead amounting to 100 percent of the total science exposure time.

We are willing to consider some variation on the definition of an OB in order. For example we could look at working on 2 field pairs at a time, such that filter changes take place after 4 exposures/short telescope movements, typically, instead of after 2. In essence, we are open to continuing discussion/negotiation on this as the operation of VST/OmegaCam becomes better understood.

Whilst the overhead for VPHAS+ is significant compared to the time spent exposing, it is worth remembering that the rate of information gathering is nevertheless exceptionally high: stellar densities in the plane of the Milky Way are at a level that 5-filter optical photometry on over half a million objects will commonly be collected per hour of telescope operation.

We have chosen to set 1.2 arcsec as the maximum acceptable seeing both because it will ensure good point source separation in most survey fields, and because it will protect the overall uniformity of the data products. We note that at Paranal, this is not an onerous constraint since this seeing is bettered 80 percent of the time (see http://www.eso.org/gen-fac/pubs/astclim/paranal/seeing/seewind/). However, as discussed in September 2010 with the Public Surveys Panel, it will be desirable to tighten the requirement to 'better than 0.8 arcsec' for the densest star fields. These are mainly in the Galactic bulge and less commonly in some parts of the inner Plane. We will threshold on stellar densities exceeding 500,000 per square degree, and expect this to affect

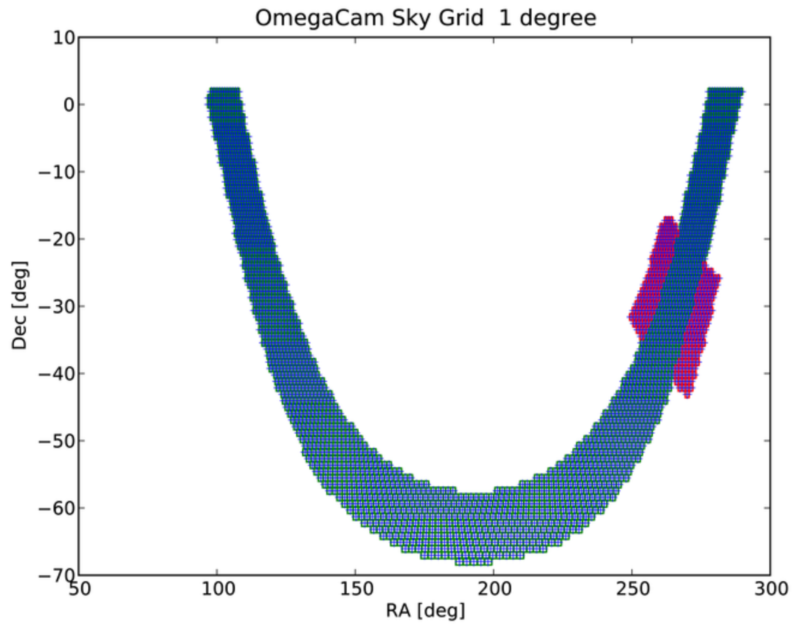

Figure 1: The tiled survey footprint, including Bulge fields.

under 10 percent of pointings.

2.2.2 Survey footprint coverage

We have experimented with different tiling patterns for the 10 degree wide, 180 degree long strip of the southern plane leading to an optimal design using ∼2301 field centres (see figure 1). This takes into account that we will use OmegaCam at PA=0 in all exposures. We have also included the software-standard 5% overlap in the field tiling, the proposed small overlap across the celestial equator with the northern surveys, and the recently added Galactic bulge component.

2.3 Details of requested observations prior to Dec 2011

We require a small number of test observations between now and the end of August 2011, plus access to other more general commissioning data. These data, once properly assimilated, will enable us to start the survey from January 2012, confident we then have the best, most efficient strategy in place.

Observations to end August 2011

We propose to collect commissioning data mainly relating to NB-659 between now and the end of August – when the Galactic Plane becomes essentially unreachable in the southern hemisphere. Also in coming months we request access to other commissioning data relating to telescope performance (affecting overheads), and to the performance of the Sloan broad-band filters, u to i.

The total time needed for characterisation of NB-659 is unlikely to be more than 4 hours. We are willing to see the filter used in science verification time, and have already provided first specifcations of data needed for some basic on-sky tests (data now in hand). Below we lay out the further testing needed to complete the picture started by the lab measurements.

Test 1: fine-scale on-sky throughput variations in NB-659 It is expected that band-pass variations across the filter glass will be smoothed to lengths of 1 cm or so, when used in OmegaCam. This suggests a scale of 2–2.5 arcmin for these changes. We wish to obtain what amounts to a moderately dense dithered set of SA110 standard-field exposures that will sample this. A suitable step between exposures is 1 arcmin, whilst a suitable pattern would be a cross made up of a central pointing, plus 3 along each arm. This will complement the data already taken that rotated the camera into its 4 available PAs, comparing the standard-star data between filter segments.

Test 2: NB-659 response to minimally-broadened flux-calibrated nebular line emission These will serve as critical on-sky counterparts to the measurements possible with the monochromator in the lab that traced out positional variation of the blue edge of the band-pass. Ideally, we would obtain an unbroken sequence of 20 exposures that places the planetary nebula, ESO 178-4, in turn in all four corners and the centre of each filter segment. The PN is selected for the following reasons: it has accurate measured Hα and [NII] λ6584 line fluxes (Dopita & Hua 1997, ApJS, 108, 515); a well-determined somewhat negative radial velocity ($v_{hel} = -88.8$ km s^{-1}, Dopita & Hua 1997); and it is not large (4.2×3.1 arcsec^2, Tylenda et al 2003 A&A, 405, 627) or complex in form. At an RA of close to 16 hrs, it will continue to be reachable on sky for a while. There is also the bonus of a second well-calibrated PN (ESO 178-5) about 20 arcmins away that will also fall within the imaged area some of the time, providing some extra data. Via these observations, if obtained in stable reasonably-clear sky conditions, we can obtain both absolute and relative measurements of NB-659 nebular-line throughput to compare with simulation. We estimate the total time needed to acquire these data, together with 'bookend' r, i exposures at the beginning and end will be in the region of $\sim$70 minutes. If this is felt to be too long, it can be split into two sequences - such that two segments are covered in each. Neither guiding nor very good seeing is needed for this test.

Over time, the band-pass may drift a little and most probably to shorter wavelengths. If all/half of the above measurements can be repeated at yearly intervals, we will be able to trace such shifts at the more Galactic-science sensitive blue end of the bandpass.

Test 3: NB-659 response to emission line stars (lower contrast broader Hα line emission) The young open cluster NGC 6530 in the Lagoon Nebula occupies an area of sky roughly 14×14 arcmin^2 and has recently been the subject of a spectroscopic study (Arias et al 2007 MNRAS, 374, 1253) that has revealed a scatter of over 30 pre-main sequence emission-line stars with Hα equivalent widths ranging from a few Angstroms up to over 200. The field is only lightly reddened ($A_V \sim 1$), and the target star V magnitudes range from 14.5 down to 19. This represents an opportunity to carry out a first efficient test of the Hα emission detectability of an object type that will often be extracted from VPHAS+ data – a useful worked example for a filter cookbook. We propose to image the young cluster in each segment of NB-659 in turn, exploiting (as we have done already) the simple device of PA rotation to achieve this. These should be accompanied by an r and i exposure at, say, PA = 0 so that we can roughly type all objects in the field at the analysis stage, as needed. This will not require more than $\sim$15 mins at the telescope.

Test 4: dry run of the probable survey observing pattern in two Sloan fields Here the aim would be to try out the observing sequence, outlined in section 2.2.1 above, on fields for which both Sloan photometry and many stellar spectra (>100 in each, over the magnitude range $16 < g < 20$) already exist. The particular fields chosen each include a compact binary presenting with appreciably wider Hα emission than that associated with more common emission line stars like those in test 3. For both objects, the FWHM of the Hα line is close to 2100 km s^{-1}. This test would consist of data collection in all 5 survey filters including NB-659. As for test 3, these data will be useful input to a filter (and survey) cookbook.

Note: the following table has undergone some redesign, and is intended to be indicative of what is needed for the test data rather than definitive at the present time. Target RA/Dec is given rather than that of e.g. the first demanded telescope pointing. A fully-specified list of pointings will be constructed as/when the priciple of undertaking the tests is agreed.

RA DEC	No. OBs	Filter	T_{exp} (s) ($\times n_{exp}$)	Dither offset	Dither pattern	Seeing (arcsec)	Transp.	Moon
18 42 21.12	1	r	25	none	n/a	<1.3	thin cirrus	any
+00 12 03.0		i	20	none	n/a			
(test 1)		NB-659	100×13	1 arcmin/step	see text			
15 59 58.0	1 or 2	r	25	none	n/a	<1.3	clear	avoid full
-55 55 31		i	20	none	n/a			moon
(test 2)		NB-659	120×20 or	>5 arcmin	see text			
			120×10×2					
		r	25	none	n/a			
		i	20	none	n/a			
18 04 10	1	r	25	none	n/a	<1.3	thin cirrus	any
-24 22 30		i	20	none	n/a			
(test 3)		NB-659	150×4	rotate PA	n/a			
20 48 17.84	1	NB-659	120×2	13'N+13'E	once	<1.3	thin cirrus	grey/dark
-06 10 44.8		r	30×2	return	once			
(test 4-i)		i	30×2	13'N+13'E	once			
		u	150×2	return	once			
		g	30×2	13'N+13'E	once			
21 04 49.9	1	NB-659	120×2	13'N+13'E	once	<1.3	thin cirrus	grey/dark
+01 05 45.8		r	30×2	return	once			
(test 4-ii)		i	30×2	13'N+13'E	once			
		u	150×2	return	once			
		g	30×2	13'N+13'E	once			

3 Survey data calibration needs

3.1 Detector characteristics

Standard sequences of bias frames, darks and twilight (or dome) flatfields will be used to remove the gross instrumental signatures.

Fringe frames will need to be constructed for observations in the i' band. The fringe level is not yet known. However, if it is similar to that encountered on other systems using similar detectors, it will impact at about 2% of sky. As this is an additive correction it requires its own calibration frames for its reduction to an acceptable level. However, since the sky level in our proposed i'-band exposures will typically be of order 100-200 counts per pixel, this implies that the likely fringe pattern (+/- a few counts) will be more of a cosmetic problem than a serious limitation to photometric accuracy.

A strategy that we have found works to sufficient precision for IPHAS data is to make a small series of master fringe frames over a range of observing conditions and simply use the closest match to the current dataset to reduce the effect to a negligible level. In practice we find that this reduces the level of the fringing by a factor of 10 and puts it into the quantisation noise regime where it no longer affects the photometric analysis. This strategy works well mainly because the i' region avoids the strongest and most rapidly varying atmospheric OH-bands which are more sensitive to atmospheric water vapour content and solar activity.

We request access to KIDS frames obtained for this purpose, as the needs of that project are considerably more exacting in this respect and it would seem a pointless duplication for us to also obtain these.

Illumination corrections are also needed to ensure uniform photometric calibration across the array - these are in addition to flatfields and can correct for effects such as scattered light. These can be characterised using dense large area photometric standard fields or from suitable sub-sampling of photometric fields across the array.

3.2 Astrometry

Astrometric calibration will be via the numerous unsaturated 2MASS point sources available in each field. Previous experience for a wide range of telescope systems indicates that a standard ZPN projection with a radially symmetric correction of the form

$$r_{true} = k_1 \times r + k_3 \times r^3 + k_5 \times r^5 + ... \tag{1}$$

where r_{true} is an idealised angular distance from the optical axis, r is the measured distance, and k_1 is the scale at the centre of the field; will provide a good description of the field distortion. Coupled with a linear "plate" constant solution for each detector of the form

$$\xi = a * x + b * y + c \qquad \eta = d * x + e * y + f \tag{2}$$

we find that this gives astrometric residuals over the whole field of better than 100mas. The global systematics in 2MASS (on the ICRS system) are also below the 100mas level.

3.3 Photometry

For external photometric calibration, VPHAS+ pointings need to be supplemented by Landolt/Stetson standard field observations through all four broad-band filters every two to three hours within each night. The preferred practise in IPHAS/UVEX has been the acquisition of two standards at each halt of science data-taking. Collected at this rate, standard-field observations are able to validate the photometric quality of the nights on which they are obtained – this is critical post-survey when identifying photometric anchor fields within the survey footprint, to a sufficient density that assures the successful propogation of the global photometric solution via contiguous survey fields.

We also need occasional NB-659 standard field frames (e.g. once or twice per night). The frequency of these need not be as high as for the broad bands, since the narrow-band Hα (NB-659) falls entirely within the r broad band and experience has shown that tying the Hα zeropoint to r works well except in poor observing conditions.

Once a year, a revisit of test 2, described in section 2.3, will provide monitoring of the more science-sensitive blue edge of NB-659's bandpass. Over time the bandpass is more likely to shift to slightly shorter wavelengths – if it does, this should be apparent particularly from PN line flux data obtained in the filter corners measured to have the longest band-pass central wavelength presently.

It is assumed that ESO will provide basic sky quality parameters such as photometric quality and the nightly extinction measure, k, at zenith. We also assume that twilight sky flats will be collected as part of standard procedure.

Internal calibration of observations uses the flatfield and dark sky characteristics of the detectors to place them all on a common gain system.

The internal gain-correction, applied at the flatfielding stage, should place all the detectors on a common zeropoint system (to ≈1-2%): hence given a stable instrumental setup, the apparent variation of zeropoint then directly measures the change in "extinction" without the need to rely solely on extensive standard field coverage over a range in airmass.

Therefore for any given observation of a standard star in a particular passband,

$$m^{cal} = m^{inst} + ZP - k(\kappa - 1) = m^{std} + ce^{std} + \epsilon \tag{3}$$

where ZP is the zeropoint in that passband, κ is the airmass of the observation, ce^{std} is the colour term to convert to the instrumental system and ϵ is an error term. This assumes that the second-order extinction term and colour-dependency of k can both be neglected. By robustly averaging the zeropoints for all the matching stars on the frame an overall zeropoint for the observation can be obtained.

On photometric nights the extinction coefficient k should be constant with respect to each passband. It can be monitored through each night either by assuming the true instrumental zeropoint only varies slowly as a function of time or by making measurements over a range of airmasses.

Goals for photometric accuracy of individual pointings during the initial processing are <5% in all broad bands and <10% in H_α. Finally, on survey completion, cross-calibration using the overlaps between fields will be used to improve this by about a factor of 2 and bring all survey data onto a common survey-wide flux scale.

3.4 Artefacts

The vast majority of these will be dealt with via the field plus offset strategy. For example, temporally variable artefacts such as satellite trails or cosmic-ray hits, can be accommodated using the dual coverage of each region in the survey. Saturated stars are automatically flagged in the processing system and most scattered light or ghosts are dealt with automatically by the catalogue background tracking software.

4 Data products and VO compliance:

VPHAS+ data will be calibrated to ESO agreed standards for the survey, thus the data will be photometrically and astrometrically calibrated by the CASU pipeline to better than 0.05 magnitudes and to 0.1 arcsec rms precision, respectively. The goal for photometric calibration in the finally-released catalogue will be to ±0.02 – 0.03 magnitudes (as we are now approaching for IPHAS, in the northern hemisphere: Miszalski et al, in late stages of preparation). Full object catalogues will be generated for each image. These will be similar to the catalogues that we routinely generate for IPHAS, and conform to the standards developed for the VDFS. It is anticipated that these catalogues will be hosted eventually at the ESO SAF, and additionally in Cambridge. Full global access will be available by ensuring that all products conform to VO standards - as an example see the WFS SIAP service which is callable via a standard API enabling access via tools such as TopCat and CDS Aladin.

In terms of data volumes, VPHAS+ will generate ∼11TB of raw science and calibration data (each exposure of the 32 CCD camera produces 0.5Gbyte). As this will be obtained over several semesters, it will not lead to significant extra data volume pressure on our processing system, which currently deals with ≈25–30 Tbytes of raw data per year. We are, however, purchasing an additional dedicated multi core processing server coupled with additional disk capacity to deal specifically with the VPHAS+ data.

The following data products will be available:

- Astrometrically and photometrically calibrated science images and calibration frames along with header descriptors propagated from the instrument and processing steps.
- Propagation of error arrays eg. weight maps, bad pixels, relative exposure via the use of confidence maps. This will deal with any vignetting effects and/or throughput variations, including those mapped across the segmented NB-659 filter.
- Derived object catalogues based on a standard VDFS set of object descriptors including astrometric and photometric measures, and morphological classification.
- Catalogues from background-subtracted images in areas of high nebulosity to improve detection, astrometry and photometry of point sources.
- Nightly photometric calibration using suitable pre-selected standard areas covering the entire field-of-view to monitor and control systematics.

- Nightly average extinction measurements in the survey passbands.
- Data Quality Control database including measurements of seeing, average stellar shape, aperture corrections, sky background and noise levels, limiting magnitudes.
- Homogeneous band-merged catalogues ($u, g, r, i, H\alpha$ from single pointings). These will retain information on light-centre differences between different bands obtained via the independent astrometric solutions.
- Federation with the 2MASS point source catalogue.

We note that some initial quality control processing may be carried out within the context of the ESO DFS group's processing.

The final photometric products will be based on uniform overlap calibration across each contiguous survey region.

We note that these data products are similar in content and format to the Phase 3 VISTA ESO deliverables.

Although the responsibility to provide a global calibration lies with the VPHAS+ survey PI (based on the experience now accruing from IPHAS), CASU will provide metadata as follows to ensure that catalogues from different pointings can be merged:

- Pipeline software version control – version used recorded in FITS header
- Processing history including calibration files used recorded in FITS header
- All catalogue products come with full preservation of FITS header information and full astrometric calibration in the form of a WCS. The header information in conjunction with the WCS can be used to drive merging of information across different bands. One option for doing this, which CASU uses already, is to ingest the header information into a database and use the database, with various cuts on QC information, to drive the band-merging.

4.1 Expected data products:

According to the signed contract, we are required to supply pipelined data, both as processed images and extracted multi-band catalogues, to the ESO archive at 6 months after the data have been received. In view of our likely observing pattern, focused on the first half of the calendar year, this could approximate to an annual delivery of data towards the end of each year of survey operation (assuming an effective start at the beginning of 2012). These data will be calibrated against the nightly standard-field observations. To go further than provide nightly calibrations requires large contiguous areas of sky coverage, a situation that may not be realised until towards the end of the second season of observing. We propose therefore to expect to begin addressing a global calibration at about this time.

The final release is likely to be timed at survey start plus 3–4 years. This will, finally, incorporate narrow-band Hα, u, g, r and i photometry on all unique catalogued point sources (likely to number $\sim$200 million).

In addition to the formal VPHAS+ public data release with the global photometric and astrometric calibration which will be made one year after completion of the survey - the VPHAS+ consortium will also - on a best efforts basis endeavour to provide a range of additional high level value added science products to the ESO SAF. These will include a range of specialist catalogues focussed on specific object classes studied and identified during the survey. Thus for instance catalogues of late type stars, of nebulae, of variable objects. These catalogues will benefit not only from the VPHAS+ derived parameters but also additional information obtained from follow up observations, often spectroscopic.

5 Important notes from the team on any changes wrt the approved SMP

Since VPHAS+ was initially approved for execution by the Public Survey Panel, there has been the appearance on the world stage of the Australian Skymapper project. The main focus of this new facility will be upon a broad-band survey of the southern sky. At the present time, there remain unresolved commissioning problems and so surveying has not yet started.

In recent years, since it became known that a plan existed to supplement the survey with some narrow-band Hα work, the VPHAS+ consortium has communicated regularly with the Skymapper team. These exchanges have clarified the complementarity between the two: VPHAS+ will reach deeper by 3-4 magnitudes in the narrowband, and benefit from the greatly superior seeing at Paranal in the crowded fields of the Galactic Plane; Skymapper has the capability to quickly cover the rest of the southern sky, if more superficially, better bridging the gap with older-generation surveys. As time goes on we anticipate a valuable opportunity for cross-calibration, both broad-band and narrow-band, if the Skymapper Hα filter procurement is finally successful.

For completeness, we note also the following additions/changes since the last SMP was reviewed: (i) the addition of the Galactic Bulge fields, adding 10 percent to the survey footprint; (ii) the tighter < 0.8 arcsec seeing constraint to be applied to the densest star fields around the Galactic Centre. Both were approved via the PSP October 2010.