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

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1.1 Abstract

The Principal Investigators (PIs) whose Public Survey proposal has been reviewed by the Public Survey Panel (PSP) and recommended by the Observing Programme Committee (OPC) are now asked to submit the Survey management Plan (SMP). Please follow the Guidelines as avaliable at http://www.eso.org/observing/webone.html.

2 Survey Observing Strategy

The observations required for this survey are matched OmegaCam images obtained with (i) a narrow-band $H\alpha$ filter (∼100 Å FWHM), (ii) a continuum filter in the same part of the spectrum as $H\alpha$ - here r', (iii) the 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 minimising the survey overheads. This strategy will also maximise the likelihood of equivalent image quality (in terms of PSF, photometric conditions) in each field, facilitating optimal r' image subtraction from Hα emission and simplifying final flux calibration of the data.

2.1 Scheduling requirements

VPHAS+ will require in the region of 16 weeks of VST time. As it links naturally to the INT WFC northern IPHAS survey (Drew et al. 2005) aimed at substantially completing observations by 12/2006, we propose a relatively compact time line. Ideally some limited VPHAS+ observations should be gathered in the first half of 2007 (as soon as the new Hα filter is available) to verify that the data meet requirements.

Following that, ≈6 clear weeks' grey-time observing in each of 2008, 2009, plus 3 in 2010 could see the survey data-taking finished.

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 survey. Hence the total 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 $-5^o \leq b \leq 5^o$.

Choice of fields to observe on any given night, from among those remaining at the time, need only be governed by air mass (<1.4) and moon distance (>45 degrees) requirements.

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
P79	40	10–18h	grey	<1.2	clear
P80	160	6–14h	grey	<1.2	clear
P81	160	10–18h	grey	<1.2	clear
P82	160	6–14h	grey	<1.2	clear
P83	160	10–18h	grey	<1.2	clear
P84	160	6–14h	grey	<1.2	clear

2.2 Observing requirements

A complete VPHAS+ observation for a given field comprises: target acquistion; guide star aquisition; a sequence of exposures in all 5 filters; an offset of several arcminutes; re-acquiring a guide star; a second sequence of exposure in all 5 filters. This, in effect, defines a single OB. Again, we emphasise the importance of obtaining all these data contemporaneously to minimise data matching problems caused by stellar variability, a common problem on timescales of hours/days/months.

Experience with processing data from the INT Wide Field Camera demonstrates that the target + offset field strategy efficiently deals with cosmic-rays and allows almost complete coverage of the gaps between detectors.

2.2.1 Dependencies

A contemporaneous sequence of exposures is required in all 5 filters at both the target position and at an offset position several arcmin away.

2.2.2 Exposure times and filter choice

At first light the OmegaCam will be equipped with a segmented Hα filter in which only one quadrant is designed to pick up Hα centred at 0 km/s (central wavelengths of the segments will be at 657, 661, 668 and 678nm, each of width 10nm). For our purposes, only the first two segments are usable as our Hα narrow band, (the two most redshifted segments miss rest frame Hα). We discount use of this filter for VPHAS+, in that it could only be used at a 50% efficiency level, whilst introducing unwanted spectral-type dependent calibration problems due to the wavelength shifts between filter segments. In order to meet our needs, we have placed an order with Barr Associates for an additional four-segment Hα filter, each segment centred on 657 nm with a FWHM of 10nm (specification supplied by U. Hopp). We have also placed a request with D. Baade to use a spare OmegaCam blank filter holder. We will aim to have the filter tested and available by early 2007. This would be made available for general use with OmegaCam (subject to ESO approval).

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. We also base our estimates on data from the web page describing VOCET, the VST Omegacam Exposure Time Calculator (http://www.na.astro.it/These must be presumed liable to change once the camera is commissioned, and updates to system efficiency are in place. Our estimates for the throughput of the Hα filter is based on the design specification for the OmegaCam Consortium Hα filter (email communication from U Hopp).

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. In grey time, an Hα exposure time of 120 sec would be expected to deliver a 10σ result for an equivalent AB magnitude of 21.6. To actually match the r' 10σ limit in Hα would take more telescope time than we know it to be worth. In the exploitation of IPHAS data we are finding that a 4:1 Hα:r' exposure time ratio is perfectly workable, for the reason that Hα in-band magnitudes are typically around 0.5 or more brighter than r' magnitudes. This pattern arises from the fact that the great majority of faint stars are significantly reddened and/or intrinsically red.

Our 10σ estimates are thus entirely consistent with the experience acquired working with the redder filters used in IPHAS observing with the 2.5-m INT and Wide Field Camera. For the same exposure times, IPHAS observations typically reach 20-21 magnitude because a significant fraction of the allocated time has been bright time. Grey 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 time also offers the considerable benefit of much less variable sky background.

Estimation of overheads at this stage is notional. We note that the short exposure times envisaged for VPHAS+ may remove the need to guide, leaving as the dominant overhead the time to change filters and read out (operations that are routinely performed in parallel for IPHAS observing). Our original guess, based on our IPHAS experience, was that the total overhead is unlikely to be less than ∼100 % (for IPHAS, using the more compact Wide Field Camera, it is around 70 %). Since the total integration time for two pointings per field is 2×6 min, this would suggest a total time per field (per OB) in the region of 24 mins. To expose on all 2100 fields (number of fields justified in the 'Observing Strategy' section) will require a total of 840 hours. If we assume effective 8-hour nights averaged across the January-June observing season, the requirement becomes 105 clear nights, or ∼15 clear weeks.

However, if (i) read-out time is 40 secs, (ii) filter changes take between 30 and 70 secs (we adopt 50 secs as mean), (iii) and these operations must be sequential, then the overhead tots up to 14.2 minutes per field, or an additional 77 hours (+9%) for the whole survey (assuming 10 read-outs, 9 filter changes) – a little more than the 12 minutes given above that we continue to use for our total time calculation. If filter changes and read-out can be performed in parallel, the overhead per field drops to around 8 minutes – a saving of 140 hours (−17%) with respect to our existing etimate of the total time needed for the survey.

We have chosen to set 1.2 arcsec as the maximum acceptable seeing both because it will ensure good point source separation even in the most crowded Galactic Centre 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/).

2.2.3 Survey 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 ∼2000 field centres. An assumption in this is that the CCD array is oriented at a fixed sky position angle (following on from the practice in place for IPHAS). In order to enable cross calibration with the northern survey, we propose a 5% overlap across the celestial equator, and hence request 2100 field centres (with observations to Dec +2.5).

A second set of overlapping pointings is needed, in order (a) to establish a common calibration across the survey, including making allowance for the different sensitivities of the 32 CCDs forming the camera; (b) to negate problems due to chip blemishes, cosmic rays and – most important – to correct for loss of sky coverage due to gaps between the CCDs and filter mount vignetting. This requirement is most efficiently met with an immediate set of repeat exposures obtained at a small offset from each field centre. We propose offsetting 4 arcmin in RA and 7 arcmin in Dec (i.e. 0.5 of a CCD in each direction). For IPHAS in the north, we use this same method, differing only in the offset angles (5 arcmin in both RA and Dec).

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 constructed from deeper (and higher Galactic latitude) observations in the i'-band will also be needed: we foresee no requirement to carry out special observations to construct these as we have confirmed that the required stacked frames will be available from e.g. the KIDS survey programme (K. Kuijken, priv.comm). Illumination corrections are also needed to ensure uniform photometric calibration across the array - these are in addition to flatfiels and 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 standard (e.g. Landolt or Sloan) field observations through all five filters every two to three hours through each night. Regular observations of standards also help determine how photometric a given night is, which is of later help when cross-calibrating contiguous survey observations. At this stage it is not yet clear how far the standard observatory calibration plan will meet these needs. We can supply standard-field OBs as needed.

On photometric nights, when VPHAS+ observations are carried out, we would also like to continue the practice followed for IPHAS that a spectrophotometric standard is also obtained in all five filters. One observation in twilight will suffice.

It is assumed that ESO will provide basic sky quality parameters such as photometric quality and extinction measures at zenith.

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

For the purposes of quality control (eg. sky transparency and system performance) a photometric zeropoint will be determined for each set of observations by direct comparison of the i'-band instrumental magnitudes with appropriately colour-corrected magnitudes of 2MASS stars. A more accurate nightly photometric calibration will be applied retrospectively given the standard star observations.

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 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 κ are both negligible. 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 κ should be constant in each passband. The extinction κ 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 airmass.

Goals for photometric accuracy of individual pointings are <5% in all broad-bands and <10% in H_α (depending on frequency of spectrophotometric calibrator observations).

Later downstream cross-calibration using the overlaps between fields will be used to improve this by about a factor of 2.

3.4 Artefacts

The vast majority of these will be dealt with using the pair of offset pointings obtained for each field. 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 reduction process

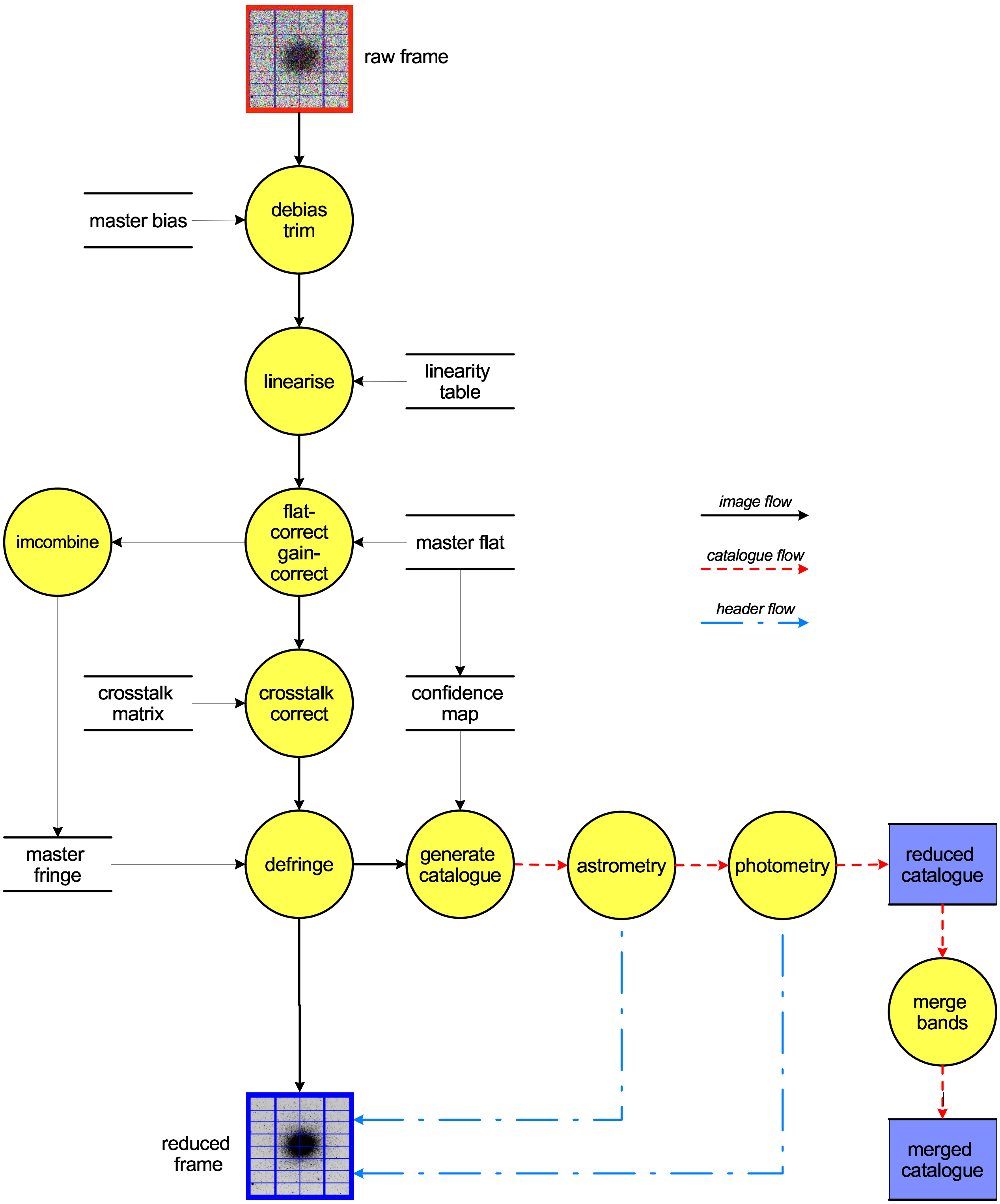
We will use a version of the VISTA Data Flow System (VDFS; Emerson et al. 2004, Irwin et al. 2004) for all aspects of data processing and management. The Cambridge Astronomy Survey Unit (CASU) will be responsible for the VDFS pipeline processing component and first pass calibration. This will be augmented by input from R. Greimel (ING) and a PDRA (TBD) at the PI institute, especially for product definition, product Quality Control and delivery to the ESO Science Archive IVOA-compliant data products.

The optical pipeline processing component of the VDFS has been scientifically verified by processing wide field mosaic imaging data using a range of existing CCD mosaic cameras e.g. ESO WFI, CFHT 12K and MegaCam, CTIO Mosaic, KPNO Mosaic AAO WFI, INT WFC and WHT PFC.

4.1 Pipeline processing

The VDFS pipeline is a modular design allowing straightforward addition or removal of processing stages and has been tested on a range of input datasets. The standard processing (see figure) assumes availability of the calibration data discussed in section 3. and includes:

- instrumental signature removal – bias, non-linearity, dark, flat, fringe, cross-talk
- consistent internal photometric calibration to put observations on an approximately uniform system
- catalogue generation including astrometric, photometric, and morphological shape descriptors and derived Quality Control(QC) information
- accurate astrometric calibration from the catalogue with an appropriate and World Coordinate System (WCS) in all FITS headers
- nightly photometric calibration from catalogue using suitable pre-selected standard areas covering entire field-of-view to monitor and control systematics
- each frame and catalogue supplied with provisional calibration information and overall morphological classification embedded in FITS files
- propagation of error arrays eg. weight maps, bad pixels, relative exposure via the use of confidence maps
- realistic errors on selected derived parameters
- nightly average extinction measurements in all relevant passbands


raw frame
master bias
debias trim
linearise
linearity table
imcombine
flat-correct gain-correct
master flat
image flow
catalogue flow
header flow
crosstalk matrix
crosstalk correct
confidence map
master fringe
defringe
generate catalogue
astrometry
photometry
reduced catalogue
merge bands
reduced frame
merged catalogue

- merging of bands within each pointing to form muticolour catalogues
- pipeline software version control – version used recorded in FITS header
- processing history including calibration files used recorded in FITS header

We note that some initial quality control processing may be carried out within the context of the ESO DFS group's processing. The required calibration data were identified in section 3.

The intermediate VPHAS+ products will be (i) instrumentally-corrected image frames in all five filters, (ii) homogeneous band-merged object catalogues ($u', g', r', i', H\alpha$ from single pointings).

5 Manpower and hardware capabilities devoted to data reduction and quality assessment

5.1 Team members with functional tasks:

Name	Function	Affiliation	Country	% FTE
J. Drew	PI	Imperial College London	UK	20
M. Irwin	Pipeline development	IoA, Cambridge	UK	20
N. Walton	Pipeline + VO compatibility	IoA, Cambridge	UK	10
E. Gonzalez-Solares	Pipeline processing	IoA, Cambridge	UK	50
D. Evans	Astrometric Calibration	IoA, Cambridge	UK	10
S. Hodgkin	Photometric Calibration	IoA, Cambridge	UK	20
PDRA (TBD)	Data Quality Control	Imperial College London	UK	20
R. Greimel	Quality Assurance Manager	Isaac Newton Group	UK/E/NL	
J. Eislöeffel	Data Release Oversight	Thüringer Landessternwarte	D	
J. Fabregat	Data Release Oversight	Valencia	E	
P. Groot	Data Release Oversight	Nijmegen	NL	
C. Knigge	Data Release Oversight	Southampton	UK	
J. Walsh	Data Release Oversight	STECF, München	D	
B. Gaensicke	Internal website manager	Warwick	UK	
M. Barlow	Public Outreach	University College London	UK	
A. Zijlstra	Public Outreach	Manchester	UK	

Note: The full list of CoIs incorporates a longer list of individuals who have interests in the early exploitation of the survey and who are invited to attend Consortium meetings held at least twice a year. The full list will soon be available from http://www.egaps.org/, with a partial list already available via the IPHAS pages (http://www.iphas.org/).

5.2 Detailed responsibilities of the team:

The PI, Drew, comes to this having led the existing IPHAS consortium since its inception in mid 2003. Most of her research effort is now focused on Galactic Plane surveying and this would naturally continue into the execution of VPHAS+. As with IPHAS, she would liaise closely with the management of the data pipeline, keeping an eye on quality, and she would communicate with the wider team to identify needed manpower and co-ordinate science exploitation. The PI's institution hosts a public website for IPHAS (iphas.org) and will be adding one specifically for VPHAS+ (vphas.org) and also for the combined science consortium EGAPS ('European Galactic Plane Surveys', egaps.org).

Irwin and Walton will lead the management and delivery of the initial reduced data products from the survey. The VST/OmegaCam data will be processed using a version of the VISTA Data Flow System (VDFS), which although being further developed (see http://www.ast.cam.ac.uk/vdfs/) is a proven working system. The Cambridge Astronomy Survey Unit (CASU) will lead the Pipeline Processing activity. Funding and personnel for processing of UK-led VST public surveys are now in place and the hardware infrastructure for this has been designed as a modest extension of the existing VDFS pipeline processing setup. The pipeline processing components have been scientifically verified by processing wide field mosaic imaging data for a range of existing optical CCD mosaic cameras (e.g. Suprime-CAM, ESO WFI, CFHT 12K and MegaCam, CTIO Mosaic, KPNO Mosaic, AAO WFI, INT WFC and WHT PFC). It has also been used to process data from the NIR mosaic camera WFCAM on UKIRT at a rate of up to 250GB/night. CASU already houses the IPHAS pipeline, which has been routinely reducing, and providing reduced image and catalogue products since 2003.

Note 1: The Vista pipeline is being developed through the VEGA programme, PI Gilmore in Cambridge. Emerson (QMUL) is responsible for the Vista elements of that programme, with Irwin being the lead co-I with responsibility for the processing pipeline elements in Cambridge.

Note 2: Walton is project Scientist of the AstroGrid Virtual Observatory project in the UK, and now additionally Project Scientist of the Euro-VO's VO Technology Centre (http://www.eurovotech.org). This centre is defining many of the VO standards that the ESO SAF will conform to and in turn demand compliance with. Walton works closely with staff in ESO, and in particular with Padovani, Head of the ESO VOSystems Group responsible for the SAF. He is thus well placed to ensure the smooth ingression of VPHAS+ survey products into the ESO SAF.

Irwin and Walton, together with Drew, will have responsibility to ensure that the required level of survey products are provided to the ESO Science Archive Facility (SAF), conforming to the agreed ESO SAF and Virtual Observatory standards. Greimel will provide important support in this, extending his central IPHAS role (he has been solely responsible for the INT observing scripts, data quality and progress checking, and initial construction of follow-up catalogues).

In addition, the PI, with a sub-panel of CoIs (identified above), will oversee the science requirements for the cataloguing and base-level exploitation of VPHAS+ data products. The IPHAS team is already going down this path in that a panel of 5 team members is now identifying the styles and organisation of data to go into an early release of photometric catalogues scheduled for mid-2006 (when IPHAS observations will be $\sim$70 % complete). Irwin, Walton and Greimel will be included in the VPHAS+ panel, ex officio. Groot will bring to the panel his prominent interest in the u'g'r' aspects of the survey and linkage to the northern survey in these bands, now underway (UVEX), that he leads. Beyond this, the sub-panel team members' own science interests span most of the broad range of Galactic astrophysics served by VPHAS+. This panel would remain in place until a final calibration of VPHAS+ data is achieved. It will be most active, meeting by telecon in between consortium meetings, during the first couple of years of the survey's execution.

Like IPHAS, VPHAS+ will be generating Hα imagery of eye-catching beauty – the UCL and Manchester groups (led by Barlow and Zijlstra) have taken the initiative in generating these, to date. For example, two IPHAS images have already appeared as 'Astronomy Picture of the Day', and a PPARC Frontiers article has appeared. We anticipate this activity becoming more important as VPHAS+ gets underway as well.

The wider membership of the VPHAS+ consortium will act as a conference of interested scientists making prompt use of VPHAS+ data and instituting early follow-up programmes across a wide range of telescope facilities. Consortium meetings will continue the IPHAS pattern of meeting in person, twice a year at least.

5.3 Hardware

Our VPHAS+ team will accept raw SM data as delivered by ESO. There are no specific time requirements on when we would require the data after acquisition at the telescope (e.g. we are not wishing to detect SN, GRBs etc in near real time). Therefore we would anticipate that ESO would provide the data via ftp download from their raw data repository in Munich. Alternatively we could accept data shipped on NGAS disks or on LTO tapes.

In terms of data volumes, VPHAS+ will generate $\sim$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 $\approx$25–30 Tbytes of raw data per year.

Once the data has been accepted in Cambridge, it will be fed into the VDFS data flow system pipeline running at CASU. The process is described elsewhere in this document (see also Irwin et al, 2004).

Spare disk capacity will be made available by the VPHAS+ team in Cambridge to provide staging storage for the reduced data products as they are produced from the pipeline. It is anticipated that of order 8 TB of disk will be acquired initally for this purpose.

As noted in section 8 below, processed data will be released to ESO on a set timescale. Transfer will be to the ESO SAF, preferably via 'ftp' of the image and catalogue files. It is anticipated that ALL UK processed VST public survey data will be transferred to ESO in an identical fashion, in order to minimse the number of interfaces (to external data product providers) to be managed by ESO.

6 Data quality assessment process

After pipeline processing, the data will be tagged with seeing measurements and other DQC information (see below). Imperial College-based PDRA support staff (to be in place from late 2007), aided by Greimel (ING), will check seeing, limiting magnitudes and sky background level for consistency with survey data quality requirements. OBs failing these checks at a significant level will be reinserted into the observing programme, and noted for report in the 6-monthly progress reviews.

The quantitative criteria applied are liable to be revised in the light of experience with this new facility. In advance of data-taking we would anticipate the following limits:

Seeing: Reported mean seeing across all exposures in an OB required to be $\leq$1.2 arcsec, no single exposure within an OB should be $>$1.5 arcsec.

Magnitude Limit: The software currently reports 5σ limiting magnitudes. Within an OB we would require limiting magnitudes in r' to both be $\geq$21.7, and in u', $\geq$21.

Sky background: This measure is of most significance to mosaicking and/or continuum subtraction of Hα frames to trace diffuse nebular emission. We would look at establishing an acceptable maximum level in r' and Hα frames, that is within a factor of two of the median level achieved in nominal grey sky conditions.

Additional quality flags: A number of secondary quality indicators will be tracked. These will include the estimate of ellipticity of unresolved images. High ellipticity would indicate problems with the optics or the observing system. Sky noise and aperture correction factors will also be measured, logged and examined as flags of potential problems.

An overview of the status of the processing of the VPHAS data will be maintained - giving access to the quality control data, and recording data of arrival of the raw data and date of transfer to the ESO SAF. This overview will be modelled on that currently routinely running for the WFCAM data pipeline - see e.g. http://apm15.ast.cam.ac.uk/wfcam/report_night_reduction_status?semester=05B&SUBMIT=Submit+Query

7 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 to better than 0.05 magnitudes and to 0.1 arcsec rms precision, respectively.

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 (http://esavo.esa.int/registry/result.jsp?searchMethod=GetResource&identifier=ivo://org.astrogrid/INT-WFS.SIAP) which is callable through AstroGrid and the emerging Euro-VO portals.

The following data products will be available:

- instrumentally corrected frames along with header descriptors propagated from the instrument and processing steps (science frames and calibration frames)
- stacked and/or mosaiced data for dithered observations of single targets
- statistical confidence maps for all image products
- derived object catalogues based on a standard VDFS set of object descriptors including astrometric and photometric measures, and morphological classification
- 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).
- federation with the 2MASS point source catalogue

8 Timeline delivery of data products

Our team anticipate two main product releases resulting from the survey, timed at survey start plus 2yr and survey start plus 3–4 years. These will be the DR1 and DR2 catalogue releases and will, finally, incorporate narrow-band Hα, u', g', r' and i' photometry on all catalogued point sources (of $\sim$200 million stars). DR1 would only be flux-calibrated at the individual pointing level, whereas the aim for DR2 would be to place the entire survey on a uniform photometric scale. To this end, funding is being sort for an additional PDRA to work close to full-time on achieving a uniform calibration.

In addition to the DR1 and DR2 catalogue release indicated above, the VPHAS+ team will ensure delivery of the following core data products to the ESO SAF:

- astrometrically and photometrically calibrated, re-gridded images, along with their respective weight maps, in all of the project-relevant filters will be provided on a per pointing basis.
- source catalogues based on individual bands. Associated source catalogues linking the parameters of individual objects across all of the observed filter bands will be provided on a pointing by pointing basis
- these survey products will be supported and characterized by additional 'meta' information providing a full description sufficient for their full scientific exploitation.

These 'core' products will be delivered within 2 months of receipt of the raw data from ESO.

As mentioned above, full status of all data processing and products, together with quality control info - will be provided by the VPHAS+ project. Thus the VPHAS+ will be providing sufficient information to ESO to enable it to carry out its regular six-monthly reviews.

9 References

Drew J. E. et al., 2005, "The INT Photometric Hα Survey of the Northern Galactic Plane (IPHAS)", MNRAS, 362, 753

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