



EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

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APPLICATION FOR OBSERVING TIME

LARGE PROGRAMME

PERIOD: **77A**

To be submitted only to: proposal@eso.org

Important Notice:

By submitting this proposal, the PI takes full responsibility for the content of the proposal, in particular with regard to the names of COIs and the agreement to act according to the ESO policy and regulations, should observing time be granted

1. Title Category: **D-10**

The VST photometric $H\alpha$ and broad-band survey of the southern Galactic Plane (VPHAS+)

2. Abstract / Total Time Requested

Total Amount of Time:

Total Number of Semesters:

The primary goal of VPHAS+ will be to collect $u'g'r'i'$ broad-band, and $H\alpha$ narrow-band photometry across the entire southern Galactic Plane within the latitude range $-5^\circ < b < +5^\circ$ down to point-source magnitudes of 21–22. 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 ~ 10 , yielding much better statistics on important short-lived types of object. Their superior photometric accuracy will also facilitate large-area stellar population studies 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 catalogue will contain in excess of 200 million objects. VPHAS+, along with its northern $r'i'H\alpha$ sister survey already more than half complete, will provide a hugely attractive database of $H\alpha$ imagery to be used to publicise the science of astronomy as a whole.

3. Run	Period	Instrument	Time	Month	Moon	Seeing	Sky Trans.	Obs.Mode
A	78	OMEGACAM	120h	feb	g	$\leq 1.2''$	CLR	s
B	79	OMEGACAM	120h	may	g	$\leq 1.2''$	CLR	s
C	80	OMEGACAM	150h	feb	g	$\leq 1.2''$	CLR	s
D	81	OMEGACAM	150h	may	g	$\leq 1.2''$	CLR	s
E	82	OMEGACAM	150h	feb	g	$\leq 1.2''$	CLR	s
F	83	OMEGACAM	150h	may	g	$\leq 1.2''$	CLR	s

4. Principal Investigator: **J. Drew** (Imperial College London, UK, j.drew@imperial.ac.uk)

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5. Description of the proposed programme

A) Scientific Rationale:

The full description and scientific case for this survey is given in the accompanying submission to ESO/VISAS.

We use this space to provide direct answers to the questions put by the Public Surveys Panel (PSP). The PSP recommended that the original submission for the VST Photometric $H\alpha$ Survey of the Southern Galactic Plane (VPHAS) be awarded core status. But they also asked us to consider adding the $u'g'$ filters (originally proposed for UVEX, PI Groot) to the original proposed set ($r'i'H\alpha$) in order to broaden the survey's utility in underpinning studies of stars and stellar populations in the Galactic Plane. This we have done. We have named the expanded 5-filter survey, VPHAS+. We were also asked to address 3 questions, as follows:-

1. Please indicate explicitly the scientific goals that require spectroscopic follow-up observations, and which telescopes?
2. Complementary to this information, should the spectroscopic follow-up not be possible, what fraction of the scientific goals can be achieved only with the photometric data?
3. How would the scientific goals of the survey be compromised if a substantial fraction of the survey was conducted in bright time?

Answers to these questions are embedded within the accompanying full description and science case: qns 1 and 2 are addressed in section 7, while qn 3 is answered within section 5.1. But we also provide answers here.

Answer to questions 1 and 2: We may crudely divide up the science goals of VPHAS+ into three, a division that is paralleled by the way the existing consortium running the northern Galactic Plane survey (IPHAS) is divided into interest groups. These areas are: (i) evolved intermediate mass stars and their nebulae; (ii) populations of young and massive stars; (iii) compact objects – particularly those in interacting binaries. In each case a driver for surveying the Galactic Plane is to obtain better demographics to apply to understanding relatively short-lived phases of stellar evolution.

The distribution on the sky of objects relevant to (i) and (iii), both old classes of object, is sparse. This shapes the expected follow-up. On the one hand, e.g. nebulae can be directly identified from VPHAS+ data via their spatial extension, and hot/warm single white dwarfs can be picked out via their $u' - g'$ colour. Where identifications are straightforward statistical studies across the whole survey area can be carried out without additional observations. On the other hand, classification into less photometrically-distinct groups and astrophysical studies e.g. of abundances and kinematics, will require long-slit spectroscopy. The view of the consortium is that VPHAS+ data will stimulate proposals on a wide range of telescopes, extending beyond those operated by ESO. Within the ESO suite of telescopes, NTT/EMMI is likely to be as much a target as the VLT (e.g. with UVES).

For studies of (ii) young and massive populations the situation is a little different, in that their clustering lends them more to photometrically based research programmes. Determinations of cluster ages, reddenings, distances... do not require spectroscopy, although checks on e.g. cluster membership via kinematics can be desirable. Where spectroscopic follow-up is needed, it is more likely to be the case that multi-object spectroscopy can be exploited, allowing efficient data collection. Young and massive populations also tend to be more heavily reddened, and so there will be more linking up with NIR photometry (e.g. UKIDSS/GPS) and/or spectroscopic follow-up.

The VPHAS+ consortium is diverse, and used to accessing a wide range of facilities (Gemini-S, telescopes in South Africa, Magellan, AAO). An attractive option under discussion, that could be pursued as and when VPHAS+ data products begin to emerge, is a long-term programme of wide-field spectroscopy using AAOmega on the Anglo-Australian Telescope.

In summary we intend VPHAS+ to be a major legacy programme, producing data that will remain in use for decades: it is, in roughly equal measures, self-contained and liable to stimulate a rich, varied mix of observational follow-up programmes across the southern hemisphere.

Answer to question 3: It would only be possible to make any use of bright time if the aim of contemporaneous observations in all survey filters is abandoned. We regard this aim as critical for VPHAS+ because noticeable light variations on timescales ranging from hours to months and years are common among many of the most interesting object groups. Indeed one of the hindrances to the exploitation of the UK Schmidt $H\alpha$ survey is the lack of guaranteed contemporaneity.

If VPHAS+ observations were to be broken up e.g. into sequences of $H\alpha, r', i'$ exposures taken in brighter time and u', g' , in darker time, it would be necessary to add r' exposures to the latter to have any chance of tying the blue and red filter data together. This immediately adds to the required telescope time, and also allows light variations to prevent the acquisition of e.g. viable $g' - i'$ colours for many stars. In addition the $H\alpha$ imagery would suffer through a much wider range of sky backgrounds within the VPHAS+ database – many northern

5. Description of the proposed programme (continued)

hemisphere IPHAS observations have been performed in bright conditions, and this has thrown difficulties in the way of mosaicking across large areas. Scientifically this makes it difficult to establish convincing evidence of diffuse background gradients. Finally, shallower bright-time r' , i' , $H\alpha$ data, even if only by a magnitude, would lose large numbers of interesting fainter point sources (most notably, field brown dwarfs).

To ensure VPHAS+ is a definitive comprehensive optical Galactic Plane survey, built to last, the appropriate strategy is to gather data on grey or darker nights.

B) Immediate Objective:

The primary goal of VPHAS+ as a Public Survey will be the gathering of contemporaneous narrow-band $H\alpha$, and broad-band $u'g'r'i'$ photometry across the southern Galactic Plane within the latitude range $-5^\circ < b < +5^\circ$ down to a point-source AB magnitude of 21–22. For a typical seeing of 1 arcsec, this translates to a nebular surface brightness magnitude at $H\alpha$ of ~ 20.8 per arcsec². To assure the data quality and correct for incomplete sky coverage due to vignetting and gaps between CCDs, the southern Plane will be observed in double-pass: every field pointing is to be followed immediately by an offset pointing. For massive OBA stars, VPHAS+ is deep enough to fully explore all but the most heavily obscured parts of the southern Galactic Plane. Even in the highly obscured regions, concentrated down into the mid-plane near the Galactic Centre the VPHAS+ view will extend at least a few kpc. These data will increase the known southern emission line objects by an order of magnitude, leading to much better statistical characterisation of a range of rare object types. The inclusion of u' in the filter set will be critical for distinguishing a rich variety of compact stellar remnants. The superior photometric accuracy of VPHAS+ will facilitate large-scale multi-colour stellar population studies across the Plane that have hitherto not been possible.

C) Telescope Justification:

VST/OmegaCam offers the possibility to survey the entire plane of the southern Milky Way with great efficiency. The consortium supporting VPHAS+ is centred on a number of European countries. This survey is a natural, if more ambitious, counterpart to the northern IPHAS survey already in progress on the 2.5-metre Isaac Newton Telescope.

D) Observing Mode Justification (visitor or service):

VST public survey observations are, we understand, likely to be carried out by local staff. (We note that for IPHAS in the north, the supporting consortium has supplied observers.)

6. Experience of the applicants with telescopes, instruments and data reduction

See accompanying submission to ESO/VISAS.

The VPHAS+ survey concept is modelled on the $H\alpha, r', i$ northern Galactic Plane survey, IPHAS (Drew et al 2005 MNRAS 362 753), that has been underway since 2003. The core of the VPHAS+ consortium is the IPHAS team.

7. Resources available to the team, such as: computing facilities, research assistants, etc.

See accompanying submission to ESO/VISAS.

The VPHAS+ pipeline will be located at the Cambridge Astronomical Survey Unit (CASU), following on from the successful pipelining there of IPHAS northern Galactic Plane data.

8. Special remarks:

None

9. Justification of requested observing time and lunar phase

Lunar Phase Justification: Grey time is requested.

This is needed in order to achieve roughly uniform limiting magnitudes in all filters, without requiring prohibitively long u' , and longer g' exposures. Eventual exploitation of $H\alpha$ imagery will also be aided by lower differences in sky backgrounds.

Time Justification: (including seeing overhead)

See accompanying submission to ESO/VISAS for time calculation.

Calibration Request: Standard Calibration

Convert to a normal programme? No

10. Report on the use of ESO facilities during the last 2 years

PI has no ESO observations to report on.

11. Applicant's publications related to the subject of this application during the last 2 years

Drew J. E., et al., 2005, MNRAS, 362, 753: The INT Photometric $H\alpha$ Survey of the Northern Galactic Plane (IPHAS)

Parker Q. A., et al., 2005, MNRAS, 362, 689: The AAO/UKST SuperCOSMOS $H\alpha$ survey

12. List of targets proposed in this programme

Run	Target/Field	α (J2000)	δ (J2000)	ToT	Mag.	Diam.	Additional info	Reference star
A	Galactic Plane	08 30 00	-39 00 00	120h	14-22	10x189	deg2	
B	Galactic Plane	17 15 00	-39 00 00	120h	14-22	10x189	deg2	
C	Galactic Plane	08 30 00	-39 00 00	150h	14-22	10x189	deg2	
D	Galactic Plane	17 15 00	-39 00 00	150h	14-22	10x189	deg2	
E	Galactic Plane	08 30 00	-39 00 00	150h	14-22	10x189	deg2	
F	Galactic Plane	17 15 00	-39 00 00	150h	14-22	10x189	deg2	

12b. ESO Archive - Are the data requested by this proposal in the ESO Archive (<http://archive.eso.org>)? If yes, explain why the need for new data.

No.

13. Scheduling requirements

14. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
78	OMEGACAM	A	IMG	$u', g', r', i', H\alpha$
79	OMEGACAM	B	IMG	$u', g', r', i', H\alpha$
80	OMEGACAM	C	IMG	$u', g', r', i', H\alpha$
81	OMEGACAM	D	IMG	$u', g', r', i', H\alpha$
82	OMEGACAM	E	IMG	$u', g', r', i', H\alpha$
83	OMEGACAM	F	IMG	$u', g', r', i', H\alpha$