ESO PS with the VST and VISTA

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A new chapter for European astronomy will soon begin with dedicated survey telescopes in the optical and near-infrared. The intent of this article is to illustrate the ESO policies for managing PS and validating their advanced data products, to introduce the VST and VISTA telescopes along with their wide-field instruments, and to provide a brief summary of the planned public surveys (PS).

ESO policies for PS and their implementation

These large collaborative surveys within Europe target many of the fundamental questions in astrophysics today, ranging from the nature of dark energy to the universality of the stellar initial mass function. In the following, we illustrate briefly the mechanisms that ESO has set in place to manage the survey projects, to ensure their legacy value and their usefulness for the astronomical community at large.

Survey Management Plan: The PIs whose public survey (PS) proposals have been reviewed by the Public Survey Panel (PSP) and recommended by the Observing Programme Committee (OPC) are then asked to submit their Survey Management Plan (SMP). The ESO Guidelines for the preparation of the SMP are available at **http://www.eso.org/observing/observing.html.**

The SMP represents an additional form requested from the PIs and it is an integral part of ESO's appraisal of the proposal. The SMP aims at collecting the necessary information to carry out PS in Service Mode (SM), and allows for an efficient and timely planning of Phase 2 and telescope operations. The SMP must illustrate the observing strategy, the survey data calibration needs, the data reduction process, the manpower and hardware capabilities, the data quality assessment process, and the data product delivery to the Virtual Observatory. During the SMP process, the iterations with the Survey Consortia for the definition of the observing strategy will ensure that at no time there are never more than 2 active PS covering the same RA range or similar observing conditions (dark time, excellent seeing, etc.).

ESO survey team: The ESO survey team (EST) follows the implementation of the ESO policies for PS. The EST members are Magda Arnaboldi (*team leader*), Jörg Dietrich, Wolfgang Hummel, Mark Neeser, Laura Parker, and Piero Rosati. In the framework set by the current policies, the EST has a role which is similar to that of an audit group. We will supports the teams during their observations at the survey instruments and telescopes (VST and VISTA) monitor the progress of the surveys, and referee the data quality of the PS products submitted for ingestion into the ESO archive, based on the quality control parameters and technical reports provided by the Survey Consortia.

Monitoring of the survey progress: The PSP is asked to serve as independent referee of the progress and achievements of the PS. The Chair of the PSP will receive a yearly report by the EST with the information on the basic monitoring of the progress for each PS. The first progress review will be carried out one year after the surveys have started, and then once per year, until the completion of each survey. The EST leader, after consultation with the PSP Chair, will report to the OPC on the status and progress of each PS. Furthermore, any time required for additional survey related observations (e.g. spectroscopic follow-up) at other ESO telescopes must be applied for.

Survey data products: What makes these surveys particularly unique is that while they are facilitated and archived by ESO, the Principal Investigator (PI) of each survey is ultimately responsible for the higher level data products. The surveys are simply too large and diverse to all be carried out by ESO and having PIs with a vested interest in the data, will ensure the best data products for the community at large.

Raw data: In Figure 1 we show a comparison of the total monthly output of the current VLT instruments, and that expected from OmegaCAM and VIRCAM. The values for the survey instruments are based on image sizes and the data rates expected from the PS, and this plot clearly shows the challenge and efforts to carry out PS! The raw data from the PS with OmegaCAM and VIRCAM will be immediately made public worldwide from the ESO archive, with public users being able to download limited volumes.

Advanced data products: Advanced data products from the ESO PS (instrumentally corrected-stacked frames, weight maps and objects catalogues) will be available from the ESO archive. For the VISTA

PS, a copy of the advanced data products will be available also from the Edinburgh archive. The accuracy/uniformity of the advanced data products from the PS must be validated before their acceptance and ingestion into the ESO archive, and the EST has issued guidelines which describe the required reports and tests supplied by the Survey Consortia in order to verify the declared data quality. They also include information on data formats and metadata to be delivered to ESO which will publish them into the Archive in compliance with Virtual Observatory standards. These guidelines are available at http://**www.eso.org/observing/observing.html.** Nonetheless, the ultimate responsibility for the quality of the delivered data products rests on the teams proposing and processing the surveys.

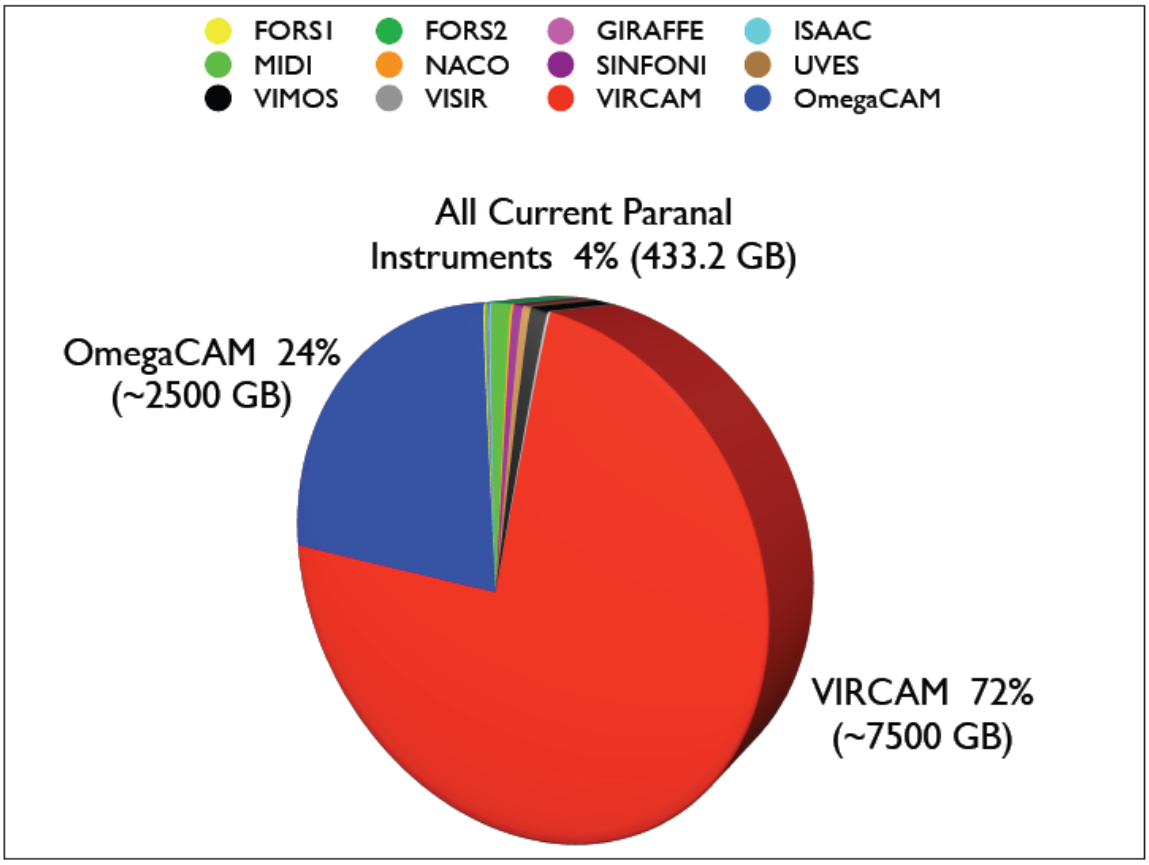

Figure 1: A comparison of the total monthly output (raw calibration and raw science frames) of the VLT instruments, and that expected from OmegaCAM and VIRCAM. The statistics for the current Paranal instruments are based on the monthly average for all 2006, while the values for the survey instruments are based on image sizes and the data rates expected from the PS.

VST

The VLT Survey Telescope (VST) is a 2.6 metre optical telescope that will be fitted with a large camera (OmegaCAM) comprised of 32 separate CCD chips (280 Megapixels). This enormous camera has a field-of-view of 1 square degree with a pixel scale of 0.2 arcseconds: in Figure 2 we show a real image from the OmegaCAM laboratory tests. The large field-of-view is ideally suited for surveying large areas. The camera will be equipped with 5 broadband filters (u', g', r', i', z') as well as an H-α filter, a Strömgren v filter, Johnson B and V filters, and a 4-segmented u'g'r'i' filter for photometric monitoring.

More information on the VST telescope (http://twg.na.astro.it/vst/vst_homepage_twg.html) and the OmegaCAM camera (http://www.astro.rug.nl/~omegacam/) can be found at the relevant web sites.

There are three VST PS in the process of final approval by the ESO Director General, and they are described below. In Figure 3 we show the sky coverage of the three VST PS, overlaid on a 2MASS image of the southern hemisphere. It is anticipated that the surveys will take approximately 5 years to carry out and they are scheduled to begin data acquisition in 2008. The VST survey details are

summarized in Table 1. The VST and OmegaCAM have been discussed in previous ESO Messenger articles (Capaccioli et al 2005; Cappellaro 2005).

(1) KIDS – The Kilo-Degree Survey
PI Konrad Kuijken (Leiden)

This survey aims to image 1500 square degrees in 4 bands (to be complemented in the near-infrared with data from the VISTA VIKING survey). The survey aims to cover this large area to a depth 2.5 magnitudes deeper than the Sloan Digital Sky Survey (SDSS), with considerably better image quality. The primary science driver for the design of this project has been weak gravitational lensing. The science goals of the KIDS project are numerous, including studying dark matter halos and dark energy with weak lensing, investigating galaxy evolution, searching for galaxy clusters, and looking for high redshift quasars. The KIDS project fills an important niche in lensing surveys between smaller, slightly deeper surveys, such as the CFHT Legacy Survey, and larger, shallower surveys like the SDSS.

(2) The VST ATLAS
PI Tom Shanks (Durham)

This survey is targeting 4500 square degrees of the Southern Sky in 5 filters to depths comparable to the SDSS. This survey will also be complemented with near-infrared data from the VHS VISTA survey. The primary science driver is to determine the dark energy equation of state by examining the 'baryon wiggles' in the matter power spectrum, via surveys of luminous red galaxies using both photometric and spectroscopic redshifts. This survey will also provide the imaging base for many other future spectroscopic surveys, both at the VLT and also via wide-field fibre spectrographs such as the new AAOmega instrument at the Anglo-Australian Observatory. For example, the VST ATLAS will be valuable in the hunt for high redshift galaxies and quasars.

(3) VPHAS+ –The VST Photometric H-α Survey of the Southern Galactic Plan
PI Janet Drew (Imperial)

This survey will combine Hα and broadband u'g'r'i' imaging over an area of 1800 square degrees capturing the whole of the Southern Galactic Plane within the latitude range |b| < 5 degrees. VPHAS+ will facilitate detailed extinction mapping of the Galactic Plane, and can be used to map the structure of the Galactic disk and its star formation history. The survey will yield a catalogue of around 500 million objects, which will include greatly enhanced samples of rare evolved massive stars, Be stars, Herbig and T Tau stars, post-AGB stars, compact nebulae, white dwarfs and interacting binaries. This survey is complementary to IPHAS, a survey of the Northern Galactic Plane nearing completion, but VPHAS+ will include more filters and will achieve better image quality.

Table 1 – Summary of the VST PS based on their SMPs.

Survey	Area Deg^2	Filter	Magnitude limits	Depth Measure
KIDS	1500	u’ g’ r’ i’	24.1 24.6 24.4 23.4	10σ (AB)
ATLAS	4500	u’ g’ r’ i’ z’	22.0 22.2 22.2 21,3 20.5	10σ (AB)
VPHAS+	1800	u’ g’ H-α r’ i’	21.8 22.5 21.6 22.5 21.8	10σ (AB)

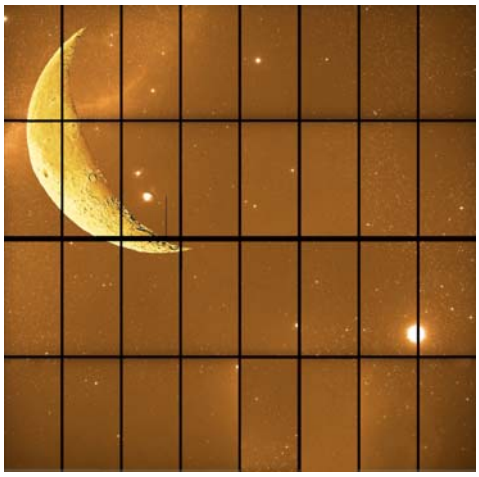

Figure 2 – A real image from the OmegaCAM laboratory tests. The field-of-view is demonstrated by superimposing an image of the moon.

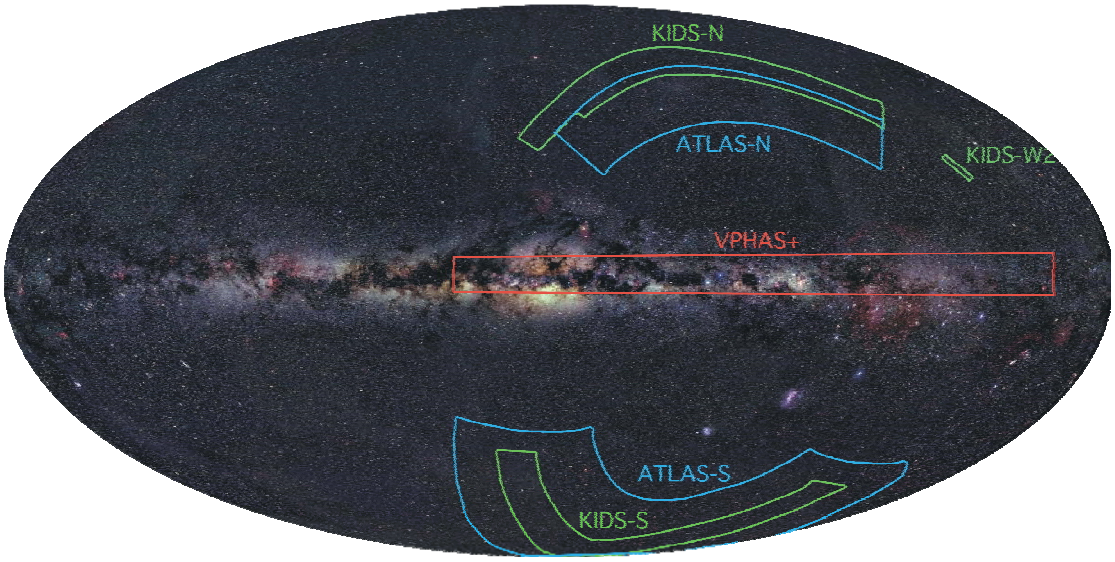

Figure 3 - The sky coverage of the three VST PS, overlaid on a 2MASS image of the southern hemisphere

VISTA

The Visible and Infrared Survey Telescope for Astronomy (VISTA) is a 4 meter near-infrared optimized telescope that will be equipped with a large array of 16 infrared detectors that will fill a 1.5 square degree field (after stepping to fill in the gaps between the detectors). In Figure 4 we shown the VIRCAM field-of-view, with the moon superimposed for scale. The VISTA filter set includes Z,Y,J,H,K_s and a narrow band filter at 1.18 microns. Each exposure will contain 67 Megapixels, and a typical observing night will see the collection of 300 GB of data. This enormous data volume will require very efficient processing and considerable resources.

At present there are six VISTA PS that have been recommended by the VISTA Public Survey Panel and endorsed by the OPC. They are currently in the process of submission of their SMP, and their final approval awaits acceptance of the SMPs (planned for early 2007). They are listed below according to the priority for their implementation given by the VISTA Public Survey Panel, and in Figure 5 we show their sky coverage. The VISTA PS are scheduled to begin data acquisition sometime in late 2007 and carry on for 5 years. The basic VISTA survey properties are summarized in Table 2. The VISTA project was recently reviewed in the ESO Messenger (Emerson et al. 2006), and more information is available from the VISTA web page (http://www.vista.ac.uk).

(1) UltraVISTA
PIs Jim Dunlop (Edinburgh); Marijn Franx (Leiden); Johan Fynbo (Copenhagen); Olivier LeFèvre (Marseilles)

Ultra-VISTA aims to image one patch of the sky (the COSMOS field) over and over again to unprecedented depths. The survey will use the Y, J, H, and K_s broadband filters along with one narrow-band filter specifically designed to study Lyman-α emitters at redshift 8.8, of which ~30 are expected to be found with this survey. The science goals of Ultra-VISTA include studying the first galaxies, the stellar mass build-up during the peak epoch of star formation activity, and dust obscured star formation.

(2) VHS – VISTA Hemisphere Survey
PI Richard McMahon (Cambridge)

The VHS will image the entire Southern Sky, with the exception of the areas already covered by the VIKING and VVV surveys, in J and K_s. The resulting data will be about 4 magnitudes deeper than 2MASS and DENIS. The 5000 square degrees covered by the Dark Energy Survey (DES), another imaging survey scheduled to begin in 2010 at the CTIO 4 meter Blanco telescope, will also be observed in H-band. The area around both of the Galactic Caps will be observed in Y- and H- band as well to be combined with the data from the VST ATLAS survey. The main science drivers of the VHS include examining low mass and nearby stars, studying the merger history of the Galaxy, measuring the properties of Dark Energy through the examination of large-scale structure to a redshift of ~1, and searches for high redshift quasars.

(3) VIDEO – VISTA Deep Extragalactic Observations Survey
PI Matt Jarvis (Hertfordshire)

VIDEO is a 15 square degree survey, Z, Y, J, H, Ks survey of AGN, galaxy cluster evolution, and very massive galaxies to study galaxy evolution as a function of epoch and environment to a redshift of ~4. There fields of the original four described in the proposal have been recommended by the VISTA PSP: the Chandra Deep Field South, 4.5 square degrees of the XMM-Newton Large-Scale Structure Survey, and a field of the European Large-Area ISO Survey. The width and area of VIDEO are intermediate between the wide but relatively shallow VIKING survey and the small, but very deep, Ultra-VISTA.

(4) VVV – VISTA Variables in the Via Lactea
PI Dante Minniti (Universidad Catolica)

The VVV survey will target the galactic bulge and a region of the adjacent plane in Z, Y, J, H, and K_s. The total area of this survey is 520 square degrees and contains 355 open and 33 globular clusters. The VVV is multi-epoch in nature in order to detect a large number of variable objects and will provide > 100 carefully spaced observations for each tile. A catalog with ~10^9 point sources including 10^6 variable objects is expected. These will be used to create a 3-dimensional map of the Bulge using well-understood distance indicators such as RR Lyrae stars. High-proper motion objects will be detected and other science drivers include the ages of stellar populations, globular cluster evolution, as well as the stellar initial mass function.

(5) VIKING – VISTA Kilo-Degree Infrared Galaxy Survey
PI Will Sutherland (Cambridge)

The VIKING survey provides an important complement to the optical KIDS project. The VISTA PSP has recommended that VIKING shall cover the KIDS 1500 square degrees of the sky in Z, and few hundreds square degrees in Y, J, H, and K_s at a limiting magnitude 2 to 2.4 mag deeper than the northern hemisphere UKIDSS Large Area Survey. The near-infrared data will be used in the determination of very accurate photometric redshifts, especially at z > 1, and is crucial for the weak lensing analysis and the observation of baryon acoustic oscillations. Other science drivers include the hunt for high redshift quasars, galaxy clusters, and the study of galaxy stellar masses.

(6) VMC – VISTA Magellanic Survey
PI Maria-Rosa Cioni (Edinburgh)

This survey will image 184 square degrees of the Magellanic System, i.e., the Large Magellanic Cloud, the Small Magellanic Cloud, the Bridge, and the Magellanic Stream in the Y, J, and Ks wavebands. Multi-epoch observations will constrain the mean magnitude of short-period variables. The survey will be used to study resolved stellar populations, the star formation history of the system as well as to trace its three-dimensional structure.

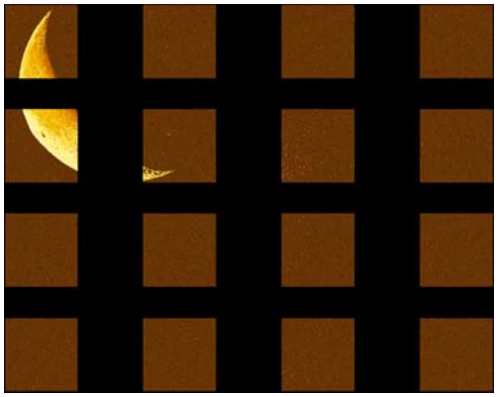

Figure 4 - The VIRCAM detector plane, with the moon superimposed for scale.

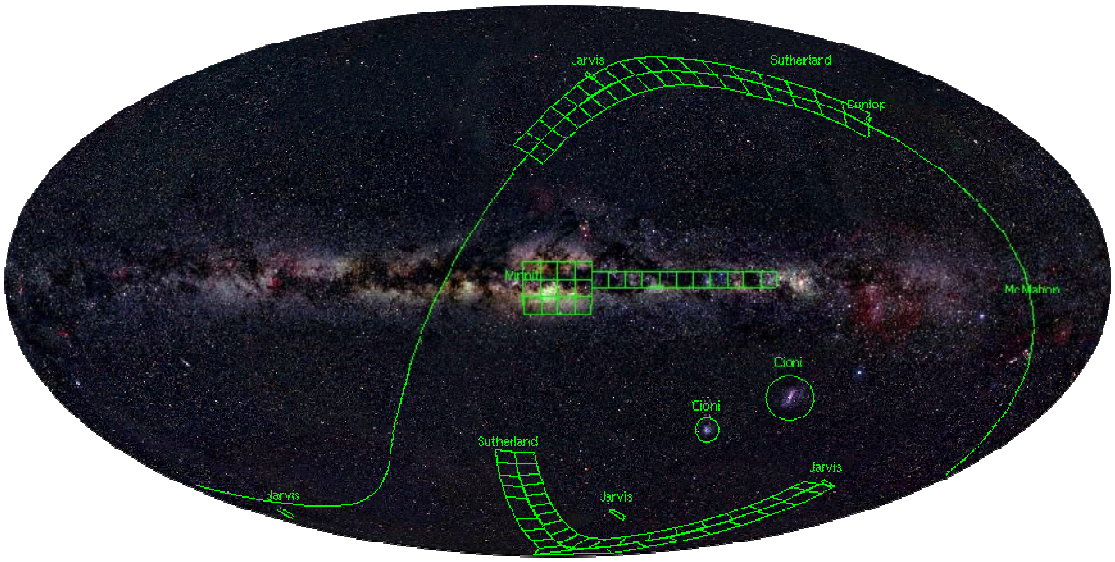

Figure 5 - Sky Coverage of VISTA surveys, overlaid on a 2MASS image of the southern hemisphere.

Table 2 - Summary of VISTA PS as described in the submitted proposals

Survey	Area deg^2	Filter	Magnitude limit	Limit Measure
Ultra-VISTA	0.73 (ultra-deep)	Y	26.7	5σ (AB)
		J	26.6	
		H	26.1	
		K_s	25.6	
		NB	24.1	
VHS	20000	Y	21.2	5σ (AB)
		J	21.1	
		H	20.6	
		K_s	20.0	

VIDEO	15	Z	25.7	5σ (AB)
		Y	24.6	
		J	24.5	
		H	24.0	
		K_s	23.5	
VVV	520	Z	21.9	5σ (Vega)
		Y	21.2	
		J	20.2	
		H	18.2	
		K_s	18.1	
VIKING	1500	Z	23.1	5σ (AB)
		Y	22.3	
		J	22.1	
		H	21.5	
		K_s	21.2	
VMC	184			10σ (Vega)
		Y	21.9	
		J	21.4	
		K_s	20.3	

References

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Emerson, J., McPherson, A., Sutherland, W. 2006, ESO Messenger, 126, 41