1 Title: VISTA VARIABLES IN THE VIA LACTEA

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1.1 Abstract

We propose a public IR variability survey of the Milky Way bulge and an adjacent section of the mid-plane where star formation activity is high. This would take 1934 hours, covering $\sim 10^9$ point sources within an area of 520 sq deg, including 33 known globular clusters and $\sim$ 350 open clusters. The final products will be a deep IR atlas in 5 passbands and a catalogue of $\sim 10^6$ variable point sources. These will produce a 3-D map of the surveyed region (unlike single-epoch surveys that only give 2-D maps) using well-understood primary distance indicators such as RR Lyrae stars. It will yield important information on the ages of the populations. The observations will be combined with data from MACHO, OGLE, EROS, VST, SPITZER, HST, CHANDRA, INTEGRAL, and ALMA for a complete understanding of the variable sources in the inner Milky Way. Several important implications for the history of the Milky Way, for globular cluster evolution, for the population census of the bulge and center, and for pulsation theory would follow from this survey.

2 Survey Observing Strategy

In the Galactic bulge the survey will use tiles of Δl$\times\Delta$b= 1.0deg$\times$1.5 deg to cover the required 300 square degrees (Δl$\times\Delta$b = 20deg$\times$15 deg) using 200 tiles (20(=20/1.0)$\times$10(=15/1.5)).

In the Plane the survey will use tiles of Δl$\times\Delta$b= 1.5deg$\times$1.0 deg (i.e. rotated by 90 degrees compared to the bulge tiles) to cover the required 220 square degrees (Δl$\times\Delta$b = 55deg$\times$4 deg) with 148 tiles (37(=55/1.5)$\times$4(=4/1.0)).

Figure 1 (created using the development version of the SADT) shows the correct tile orientation in the plane, but in the bulge the tile direction input was rotated through 90 deg from that which we will use resulting in an extra 10 tiles being required. A revised version of the plot will be generated with the released version of SADT.

The grand total to cover the survey area (once) is 348 tiles.

Figure 2 shows the coverage map of the Galactic Centre

2.1 Scheduling Requirements

The total estimated observing time per Period is shown in Table 1 which also shows the requirements on Moon, seeing and transparency conditions.

Table 1: Estimated observing time

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
P81	246	12:00–19:00 h	any	0.8	clear
P83	68	12:00–19:00 h	any	0.8	clear
P85	783	12:00–19:00 h	any	any	thin
P87	576	12:00–19:00 h	any	any	thin
P89	261	12:00–19:00 h	any	0.8	clear

During the **first year (P81 - 2008)** the whole bulge area will be observed once per night in K_s, over 6 consecutive nights to give a first epoch bulge survey. The observing parameters for this year 1 epoch are listed in Fig 3.

The following 6.5 nights will be devoted to complete imaging of each bulge tile through the $ZYJHK_s$ filters in turn (i.e. quasi-simultaneously in the same OB), before moving to the next tile. This will provide reliable

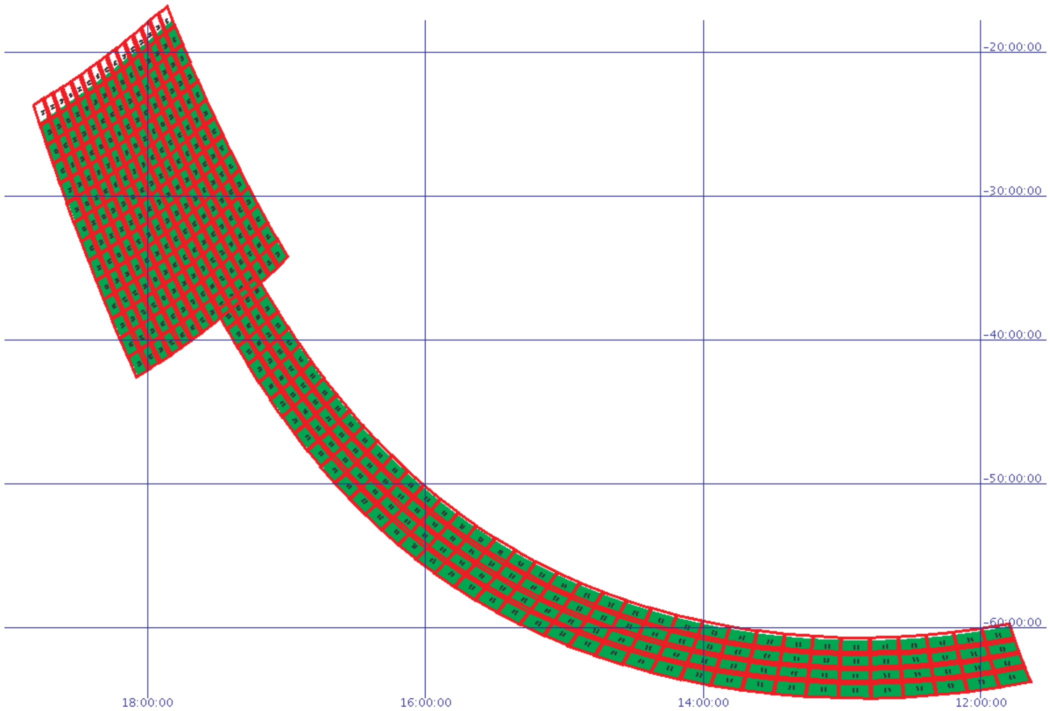

Figure 1: Map of the inner Via Lactea/Milky Way showing the VVV survey area covered by the VISTA tiles: the VVV bulge survey area between $-10° < l < 10°$ and $-10° < b < 5°$, and the VVV plane survey area between $-10° < l < -65°$ and $-2° < b < 2°$.

near-simultaneous fluxes and colours for each tile area. The observing parameters for the quai-simultaneous multi colour bulge survey are given in Fig 4.

The identical strategy will be repeated for the 148 tiles covering the plane area with the observing parameters given in Fig 5 for the single epoch and Fig 6 for the quai-simultaneous multi colour dsik survey.

Note that the individual single epoch OBs in K_s all have the same limiting depth (in the same conditions), whether forming part of the Bulge or Disk components of VVV. Figs 3 for the Bulge and Fig 5 for the Disk differ only in the number and phasing of epochs.

Being fully aware of the confusion and background limits, the observing plan would circle alternatively through fields of varying density for optimal sky subtraction. The filter order in the OBs will be optimized to minimize the overheads.

We estimate that the 6 consecutive epochs in K_s will require 59/43 hours for bulge/disk respectively, while the cycle through the 5 filters will need 64/80 hours respectively. In summary, during the first year we will acquire 5 total epochs in K_s for each field, plus the colors for each source, in a total of 246 hours, or 25 nights.

These times (and those that follow) do not explicitly include time spent on observatory calibrations, or on overheads for changing to a new tile. However they do assume a 9% overall overhead in addition to that given by the ETC and filter changes in an OB. This (which is equivalent to 160 hours) can be vired against the frequent epochs planned in years 3 (a subset of tiles observed 4 or 8 times a night) & 5 (a subset of tiles observed 10-40 times per night) which are not separately accounted for elsewhere. When these overheads are better known (when VISTA is on sky) we will update our time estimates as advised by ESO/VISTA. If the allowance is too generous we can redistribute some time to give better overlap of tiles.

During the **second year (P83 - 2009)** we will acquire another 4 epochs in K_s for the whole bulge (39 hours)

Table 2: 1st-2nd-3rd-4th-5th Yr Variability VVV Fields

Depth, DIT and NDIT etc. will be as in the 1st year. Only K_s tiles will be acquired the following years.					
Year	Region	Elapsed time/tile (s)	Tiles	Epochs	Total (hr)
1st	bulge	162	200	6	59
1st	plane	162	148	6	43
2nd	bulge	162	200	4	39
2nd	plane	162	148	4	29
3nd	bulge	162	200	80	784
4nd	plane	162	148	75	576
5th	bulge	162	200	20	196
5th	plane	162	148	9	65

and for the plane (29 hours), for a period of 7 nights. These extra epochs will improve our ability to detect variable sources (but will not permit finding the phase). These data will also allow the creation of deeper master maps in K_s, in order to fine tune the strategy for the main campaign of the following year.

During the **third year (P85 - 2010)** the main bulge variability campaign of 80 epochs is carried out during 78 nights. We ask for consecutive nights during this season, although in practice there will be a few interruptions due to weather and to the unfortunate fact that 2-3 nights per month are unusable because the Moon transits in front of the bulge. We will use the K_s band to map the whole bulge and inner plane for 80 epochs on average (about once per night). A subset of the fields (open clusters, globular clusters, Baade-like windows, Galactic centre, etc.) can be observed more frequently (4 or 8 times per night). This strategy allows to partly remove aliasing and to improve the periods, while being more sensitive to smaller timescale variables and microlensing events.

During the **fourth year (P87 - 2011)** the main Galactic plane variability campaign is carried out over 80 epochs using 58 nights in K_s, following a similar strategy as in the case of the bulge in the previous year.

Finally, during the **fifth year (P89 - 2012)** we will observe for 20/9 epochs 20/7 nights the bulge/plane fields, respectively, but with observations spread over the season. This allows the measurement of longer-timescale variables, and the search for high-proper motion objects. A subset of the fields can be observed much more frequently (10-40 times per night). This strategy allows to find short-period variables and planetary transits.

Figs 3 and 5 show the values in the spreadsheet used in generating the times for years 1-5 for Bulge and Disk respectively.

We also envisage starting the survey with a period of VVV Science Verification during which we will verify the observing strategy, OBs, data reduction, and if necessary refine these to optimize the data and the efficiency of acquiring it. We have not included this time here.

2.2 Observing Requirements

The total times in Table 1 are based on the summary observing parameters given in the Figures 3, 4, 5 an 6, together with Table 2. A copy of the MS Excel spreadsheet from which these Tables were generated was attached to the email of our submission to EST leader.

2.3 Response to PSP Recommendations on observing strategy

- The request for consecutive nights during 3rd and 4th years could probably be relaxed somewhat if the period is overbooked; the program may probably not suffer - or maybe even benefit - from a moderate spread of the data taking. A "hard core" of consecutive nights should be scheduled for short time-scale variability search, and the other nights could probably be spread over a longer period. This possibility should be addressed in the SMP.

We prefer consecutive nights for the 3rd bulge campaign because this will optimize the telescope usage and variable star phasing and it is very important for the short timescale microlensing search. Thus, we reiterate on our request that the VVV survey be the only Survey observed during May-July 2010. For the Galactic Plane Survey the strategy proposed by the PSP is fine (a "hard core" of consecutive nights followed by more flexible nights).

- The main justification for the 5th year seems to be the search for proper motions. For this objective, the later the better. It is worth considering the option of postponing these observations.

We believe that this will naturally happen as the surveys develop, because the weather factor was not taken into account, the 5th year observations would probably be delayed, giving a longer time baseline for the proper motions.

- The seeing constraints may probably be relaxed for the 1st and last year for the least crowded fields that do not need the highest spatial resolution. This possibility should be addressed in the SMP.

We will relax the seeing constraints for the least crowded fields to 1.0 – 1.4 arcsec. (Note that we cannot relax this too much because uncrowded areas should remind uncrowded in order to provide good skies for the rest). This would be better implemented during the last year when we have all the previous data.

- The team should revise the observing strategy considering that VISTA can observe 10 hrs per night on average.

We have updated our calculations assuming 10 hours per night.

3 Survey Data Calibration Needs

3.1 Detector characteristics

Standard sequences of dark/bias frames, twilight and dome flatfields, and also linearity, bad pixel maps, cross-talk and gain calibrations will be needed in order to remove the instrumental signatures. Twilight skyflats will be used in preference to dark-sky flats which can be influenced by thermal emission and fringing (probably at very low levels). The preliminary detailed observatory calibration plan appears to cover the majority of the requirements of this survey.

3.2 Photometry

3.2.1 External photometric calibration

For external photometric calibration, the VVV Survey in principle does not need to be supported by standard field observations outside the survey, except during the ZYJHK_s campaign in year 1 for which standard observatory calibration will be used. According to the VVV observing strategy only one filter (K_s) per single night will be used during the variability campaigns.

During the first period of the survey (P81) we applied for clear time and good seeing. During this period we will make the external calibrations and transformations to the standard system using 2MASS and UKIDSS as described in the draft VISTA Calibration Plan.

In the case of exposures only in one filter during the whole night, the calibration scheme for a single star in every particular filter is:

$$m_{\rm cal} = m_{\rm inst} + ZP - k(X-1) = m_{\rm std} + clr_{\rm std}$$

where $m_{\rm cal}$ is the calibrated magnitude, $m_{\rm inst}$ is the measured instrumental magnitude, ZP is zero point, k is the extinction coefficient, X is the airmass of the object. From the right side of this equation $m_{\rm std}$ and $clr_{\rm std}$ are the corresponding standard magnitude and color. This assumes that the second-order extinction term and color dependency of X are both negligible. An overall zeropoint for a given frame will be obtained by averaging the zeropoints for every standard star.

The photometric calibration and quality control is done using 2MASS stars in the frames themselves, applying color equations to convert 2MASS photometry to the VISTA photometric system. There will be hundreds of unsaturated 2MASS stars in J, H, K_s with photometric errors < 0.1 mag and quality flags of "AAA" in every chip of VISTA. A large fraction of these can be sufficiently isolated even in the crowded fields. One possible source of errors is the difference between transmission curves of J filter in both systems, but the latest results of UKIRT WFCAM shows that the RMS scatter of 600 measurements of 46 standard stars, measured in 19 nights is less than 2%. For the Z, Y filters we recommend that some of the VISTA standard fields overlap with those of UKIRT WFCAM, and we will complement these data with observations at other telescopes if necessary. Synthetic ZP for those filters could also be derived using as standards stars with known spectral type in each tile through the use of stellar atmosphere and Galactic extinction models.

As a bonus, the repeated VVV Survey observations themselves can provide a wealth of faint IR standards spread over a wide range in declination, useful for the other VISTA surveys as well as many other future projects.

3.2.2 Internal photometric accuracy

The internal gain-correction in all detectors applied by the flatfield should place them on a common zeropoint system. After deriving this ZP in each tile, a double check using the overlap regions will be made to estimate the internal photometric accuracy. The median offset of stellar-like objects will be computed for each overlap region and if there is some visible trend all measurements will be put on the same system. Because we can compare the measurements only at the edges of each detector, this probably will overestimate the internal errors of the final photometry. This cross-calibration using overlaps between tiles will be used to improve our photometric solution and bring all survey data onto a common survey-wide flux scale.

3.3 Astrometry

Astrometric calibration will be achieved using the numerous unsaturated 2MASS point sources available in each field. Usually, astrometric calibration incorporates a cubic radial distortion term, but higher order terms can be used if needed, i.e. where the relation between $r_{\rm true}$, the true on-sky angular distance from the optical axis, and r, the distance measured in a VISTA image, takes the form:

$$r_{\rm true} = k_1 r + k_3 r^3 + k_5 r^5 + \ldots .$$

where k_1 is the scale at the center of the field. The solution of this equation together with a linear "plate" constant solution of each chip

$$x' = ax + by + c; \qquad y' = dx + ey + f$$

gives astrometric residuals over the whole field better than 100 mas comparable with the global systematic residual in the 2MASS point source catalog.

The first results of UKIRT Infrared Deep Sky Survey and WFCAM show that the constant k_3 has a small wavelength dependence and that the higher order distortion terms are insignificant, compared to absolute systematic accuracy of 100 mas. For VISTA the wavelength dependence and higher order terms are expected to be negligible.

4 Data Reduction Process

We will use an enhanced VISTA Data Flow System (VDFS; Emerson et al. 2004, Proc SPIE, 5493, 401; Irwin et al 2004, Proc SPIE, 5493, 411; Hambly et al 2004, Proc SPIE, 5493, 423). It will meet all basic data processing and management requirements of our survey once extraction of variables from difference images has been implemented:

(i) removing instrumental signature, merging pawprints into tiles and calibrating photometrically and astrometrically;

(ii) extracting source catalogs on a tile by tile basis;

(iii) constructing survey level products - stacked pixel mosaics, difference images and merged catalogs;

(iv) providing the team with both data access and methods for querying and analyzing the data;

(v) producing VO compliant data products for delivery to the ESO archive

Next, we discuss the individual data processing/reduction steps, to the extent to which the properties of VISTA are currently known.

Figure 7 shows a flow chart of the Data Processing.

4.1 Removing the instrument signature, quality control and calibration (Pipeline)

The Cambridge Astronomy Survey Unit (CASU) component of the VDFS will be responsible for the basic pipeline processing and first pass calibration, all done on daily basis. The VISTA pipeline is a modular design allowing straightforward addition or removal of processing stages and has been tested on various datasets. The basic correction includes:

(i) linearity correction: the WFCAM non-linearity is better than 1% and therefore there is no correction for non-linearity. A correction will be implemented for VISTA although our science goals are related to faint targets so the linearity is not critical.

(ii) dark/bias will be taken daily for all exposure times and readout modes

(iii) electronic effects such as odd-even column effect, quasi periodic structures, etc. Their presence will be studied in detail in the future and if necessary, appropriate corrections will be included in the pipeline.

(iv) cross-talk between individual array readout channels is present in almost all infrared instruments. Unfortunately, jittering can not remove the artifacts because they are always separated from the source that produced them by a constant offset. If possible VDFS will remove any cross talk effects (which will be possible if the detector behaviour is sufficiently stable), and in any case these will be flagged using the detector properties.

(v) persistence is a detector "memory" preserving the knowledge that a bright star was present on a certain array location over a few subsequent images. Unfortunately, bright stars are common in our fields. Fortunately, it is possible to predict where persistence may occur from previous images, and any remnant persistence after jitters mimics an extended source while our project is aimed at point sources. Persistence can still affect our photometric accuracy, therefore we will vary the order in which tiles are observed during the variability campaign, where possible. The importance of persistence in VISTA data will not be known until the instrument is on sky, but VDFS has a method to remove persistence, subject to its characteristics being sufficiently reproducible (stable), and can also flag possible persistence events. (WFCAM's persistence is not sufficiently stable that it can be compleltely removed, but it is hoped that the situation with VISTA will be better).

(vi) flat fielding: the WFCAM experience shows that weekly twilight sky flats taken in 9-point jitter sequence are sufficient to provide 1% level correction. Ideally, the sky flats will be taken alternating filters every day as necessary to obtain flats for all bands during each week.

(vii) sky subtraction: perhaps this is the most important of the basic corrections steps because of the large (and variable on time scale of minutes!) sky background, in comparison with the targets. We will use the data itself to create a sky frame and then we will subtract it from the individual frames after rescaling to the sky level of the frame. The WFCAM experience shows that the residual gradients are below 1%. Some of our fields will be very crowded and to improve the sky subtraction will use priorities and/or concatenation to try to ensure that each night also contains some uncrowded fields for creating skies. We hope to avoid having to observe offset skies, but will keep the possibility under review when we see the real data.

(viii) Last but not least, the pipeline produces instrument corrected astrometrically and photometrically calibrated tiles (with calibration information included in the image headers), extracts object catalogues from these, and updates a database which facilitates monitoring of selected quality control parameters (i.e. seeing, ellipticity of stellar images, sky brightness and noise, zero point and extinction trends e.g. http://casu.ast.cam.ac.uk/survey-progress/wfcam). The WFCAM experience shows that the external astrometric accuracy is of order 100 mas, and the internal one is about 50 mas. The typical photometric accuracy is at the 2% level. VISTA should be at least as good.

The pipeline products are: corrected astrometrically and photometrically calibrated tiles in each filter used, confidence maps and homogeneous object catalogs (merged for all filters if observed in same OB (each covering just one tile area). The pipeline records the processing history and calibration information of each file in the FITS header, including calibration files and quality control parameters.

The contact person responsible for the interaction with the pipeline team is V.D. Ivanov (ESO).

4.2 Combination/image subtraction (archive)

The "second" order data processing requires higher access to larger sets of data to produce survey products. It is carried in the Wide Field Astronomy Unit's (WFAU) VISTA Science Archive (VSA) in Edinburgh. The Science Archive contains only calibrated data and catalogs, it does not contain any raw data.

The Science Archive is responsible for:

(i) image stacking to produce stacked and differenced tiles, and source merging: obviously, in the case of the VVV the same field will be observed more then once. This implies a capability to merge both tiles and catalogs derived from different tiles in the same area. Naturally, these procedures can not be implemented by the pipeline which at any time operates only on data from a given night. Therefore both coadding and differencing combination is performed at the Science Archive where the combining tools have access to all multi-epoch data. The VDFS stacking and merging are described in Irwin et al. (2007, in prep) and Hambly et al. (2007, in prep). This "post-processing" allows to facilitate complex requirements such as measuring upper limits for an object detected in some bands for all other bands in which this object was not detected or selection of objects from multi-color criteria, in cases where the imaging in the different filters was carried out at different times.

(ii) Quality Control (QC): assessment of the data quality and filtering of the data that do not meet the established criteria for photometric and astrometric accuracy. The multiple epochs of our VVV Survey naturally allows quality control by internal comparison. External comparisons (e.g. 2MASS) will also be used for quality control and calibration in the appropriate filters.

(iii) Identification of Variables

Very importantly, the Archive can carry out the image subtraction analysis that will allow us to create the catalog of variable sources and to derive their light curves.

The main element required by the goals of our survey is the variability detection via image subtraction. This analysis will be carried out only after a sufficient data is acquired and the timing is described in Sec. 2. The basic principle of the differential image subtraction is simple: given a set of images of the same field, the best seeing image is degraded to the quality of each of the other images and subtracted from them (Alard 2000, A&ASuppl., 144, 363; Alard & Lupton 1998, ApJ, 503, 325). Ideally, all constant sources cancel out and the variable sources appear as quasi-stellar positive or negative images. This method provides excellent results for crowded fields in which the traditional aperture or PSF-fitting photometry fails because of the contamination from the nearby sources. Our survey will benefit tremendously from the differential image analysis, in comparison with the direct source photometry. VDFS already has already implemented the differencing, which is being tested on WFCAM data. Further VDFS development to extract variables from the difference images is underway and should be completed (and tested on WFCAM data) before the VVV survey begins.

Direct point source photometry will also be performed for the first years data in all filters to be used as reference.

Our project will tap into both the VDFS team experience handling the WFCAM/UKIRT and VISTA data, and the experience of the VVV team members who are leading participants in other surveys such as OGLE and in the routine data processing and delivery to ESO.

Our experts on the variability detection are D. Minniti, M. Catelan (Univ. de Catolica, Santiago) J. Borissova (Univ. de Valparaiso) and M. Rejkuba (ESO). They will interact with the Archive unit for the implementation of the procedure.

Note that there will be no real-time alerts for microlensing, these would be detected in the post-processing data.

4.3 Variability and Other Analysis

4.3.1 Variability

The members of the team in Chile will carry out the final analysis: variability studies, including light curves fitting, period determination, source identification/classification. etc.

The steps here are:

(i) Variable selection according to robust criteria.

(ii) Preliminary variable classification (using peak to peak amplitudes, color-magnitude diagrams, color-color diagrams, etc.).

(iii) Period determination for periodic objects (roughly half of the variable objects are expected to be periodic according the experience of the microlensing databases, the rest are not periodic or transients or fluctuations in the data).

(iv) Light curve fitting where appropriate.

4.3.2 Other

Members of the team in Europe will take the lead in cross checking and combining the data with other large datasets. The datasets are UKIDSS GPS (near IR), VST/VPHAS+ (optical) and GLIMPSE and GLIMPSE-II (mid-IR). This will lead to:

(i) improved extinction maps for the survey region.

(ii) determination of most likely spectral type and luminosity class for all stars detected in multiple wavebands.

(iii) identification and classification of Young Stellar Objects.

4.3.3 Response to PSP Recommendations

- This proposal has a rather generic description of the data handling aspects of the program, which is a concern, given the complicated data reduction required in variability studies. This must be addressed in greater detail in the SMP.

We have given more details throughout this Management Plan, specifically in this Section 5.

- VISTA is not set up yet as a real microlensing finding experiment, which requires some kind of dedicated telescope on-line data reduction to trigger alert. How is the survey team going to cope with this?

We are NOT going to trigger microlensing alerts, as this is much more demanding than the pipeline can handle.

We will detect microlensing events after the fact.

- *Using differential imaging technique is an enormous and complicated task that should be considered in balance with the -fully estimated- benefit.*

Difference imaging has already been implemented in the archive by WFAU. It is also planned (by WFAU) to implement source detection in the difference images, in addition to the prior source detection by the CASU pipeline. By experience with the previous microlensing surveys (MACHO, EROS, OGLE), we conclude that DIA is an essential element of the pipeline for these crowded fields. Note that these microlensing experiment started without DIA, but had to implement it later on in the project, leading to significant improvement in the quality of the light curves. Once implemented for the purpose of our Survey, the DIA can be used by other Surveys.

- *Tasks and responsibilities in the team should be clearly identified.*

We have done this throughout this Management plan and in Section 6.

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

5.1 VDFS manpower and hardware

As already described we will use the VISTA Data Flow System (VDFS) for all aspects of data management, including: pipeline processing and management; delivery of agreed data products to the ESO Science Archive by internet transfer.

The VDFS is a collaboration between the UK Wide Field Astronomy Units at Edinburgh (WFAU) and Cambridge (CASU) coordinated by the VISTA PI (QMUL) and funded for VISTA by PPARC. The VDFS team at CASU (pipeline) consists of Irwin, Lewis, Hodgkin, Evans, Bunclark, Gonzales-Solares, Riello, and at WFAU (archive) of Hambly, Bryant, Collins, Cross, Read, Sutorius, Williams, with overall VDFS coordination by Emerson. The VDFS is a working system that is already being successfully employed for the UKIRT WFCAM surveys as a test bed for the VISTA infrared surveys, and which is sufficiently flexible as to be applicable to any imaging survey project requiring an end-to-end (instrument to end-user) data management system. We emphasize the track record over the last decade of both the Cambridge and Edinburgh survey units in processing and delivering large-scale imaging datasets to the community as exemplified by the WFCAM Early Data release (EDR, *http://surveys.roe.ac.uk/wsa/dboverview.html*; Dye et al 2006, MNRAS 372, 1227) and Data Release 1 (DR1 Warren et al 2007 MNRAS 375, 213).

The VDFS pipeline and archive teams each have, by design, appropriate hardware to handle VISTA data and products, as verified by success in handling the (similar type) WFCAM data. The VDFS Science Archive uses a commercial relational database management system for creating imaging and catalog products on-demand via web interface applications that provide access to the database through Structured Query Language (SQL) queries.

The two VDFS Units (CASU & WFAU) are funded by long term 'rolling' grants and were built up specially to handle VISTA data, using WFCAM data as a real test bed.

5.2 Other manpower and hardware

The VVV survey team involves astronomers of Chilean institutions, of the European Southern Observatory, and of many of its member nations, in addition to the UK VDFS. Our Chilean team includes experienced members from the microlensing surveys (OGLE, MACHO, EROS), as well as staff ESO members experienced in all aspects of IR imaging and instrumentation. Since we submitted the VVV Survey proposal to the PSP our Chilean FONDAP project was renewed - FONDAP is a national Chilean project with substantial funding.

The VVV Survey proposal was one of the big components for the next 5 years of funding request. We requested funding for hardware (computers, database, infrastructure), and for manpower (postdocs and students).(**JE-QUESTION ,It would look better said we said how many? Can Ignacio, Valentin or Manuela provide this? -JE)** The funding was approved, and we are announcing the opening of a postdoctoral position at Univ. Catolica to start in Sep 2007, and are planning to expand our 16 processor Beowulf cluster.

Our European team members also have extensive experience of large surveys (IPHAS, UKIDSS, SuperCosmos). At Hertfordshire there is a concentration of VISTA and UKIDSS PIs and co-PIs (VIDEO, VMC, VVV, UKIDSS GPS), so we plan to submit joint proposals to the UK funding body (PPARC) for postdoc funding to assist with quality control as well as science analysis. At Hertfordshire there is already a UKIDSS postdoc (Burningham) who will devote part of his time to VISTA support in future. We have capable people in charge of the data reduction, pipeline, photometry, astrometry, database, light curves, and simulations.

The effort available comes from amongst the members listed in Table 3 and its continuation Table 4. The total excluding the VDFS effort is 9.5 FTE, of which 2.5 FTE is from postdocs.

5.3 Detailed responsibilities of the team:

DM and PL will manage and be involved in all aspects of the project, as will JE for the VDFS. They will hold regular telecons, or meetings, including other key team members as appropriate, to review VVV progress and to negotiate the assignment of tasks to team members as necessary and generally manage the survey in response to actual performance, rate of progress and events.

As described in the next section there will a 5-10 member Quality Control Team from which, at any one time, there will always be (at least) one 'duty' member monitoring the VDFS products and processing. This is in the steady state - naturally early in the survey there will be an even more intense level of effort required from the team.

VI, MZ and MC will help deciding the data taking strategy and scientific priorities. VI and RB will lead the OBs preparations efforts, aided by RG, JB, IS, LM, RK, GC & JE.

All members of the collaboration will be involved in the photometry led by GP and DG (including DIA photometry), and will support MR, AS, MM in making the Monte-Carlo simulations to compute detailed photometric and sampling efficiencies. The astrometry will be carried out by GC, LM and MTR. RM and WG will decide on variability and phasing criteria, along with AA, JJC, BB, FM. LM and EB will take charge of creating the variability catalogue, including LK, GC, CT, AS, CP, GB.

6 Data quality assessment process

The team realizes the importance of the timely quality control process, especially considering how important any long-term trends will be for our variability analysis. Therefore, we will forma QC team, that will include 5-10 VVV team members that will exercise routine QC. The QC duty will be distributed among the QC team on a weekly basis - the "QC duty officer" will:

(i) check master frames used

(ii) check random reduced tiles logging in the VDFS VISTA Science Archive. The exact number of tiles will be determined by the frequency with which problems occur during the first year of the survey and the verification rate will be adjusted during the following years. We select a pipeline reduced tile to be the a basic QC element for our Survey because the raw data contain strong instrument signatures (i.e. gradients and patterns before the flat fielding) that might mask real artifacts. Our examination aims to discover unusable data due to for example to artifacts and strange patterns produced by the detector, moon ghosts, trailed frames, etc. Some

[1] Designated contact overall with VDFS Management
[2] Designated contact with VDFS pipeline (Cambridge)
[3] Designated contact with VDFS archive (Edinburgh)

Table 3: VVV Team members

Name	Function	Affiliation	Country
Dante Minniti[1]	PI, photometry, light curves, bulge	Univ Catolica	RCH
Phil Lucas	Co-PI, photometry, plane	Univ Hertfordshire	UK
Manuela Zoccali	Photometry, analysis, bulge	Univ Catolica	RCH
Marcio Catelan[2]	Theory, light curves, bulge	Univ Catolica	RCH
Lorenzo Morelli	Astrometry, light curves, bulge	Univ Catolica	RCH
Claus Tappert	Photometry, light curves, bulge	Univ Catolica	RCH
Giuliano Pignata	Pipeline, astrometry, bulge	Univ Catolica	RCH
Ignacio Toledo	Pipeline, astrometry, bulge	Univ Catolica	RCH
Maria Teresa Ruiz	Astrometry, photometry, bulge	Univ Chile	RCH
Giovanni Carraro	Astrometry, photometry, bulge	Univ Chile	RCH
Simon Casassus	Astrometry, photometry, bulge	Univ Chile	RCH
Leonardo Bronfman	Astrometry, photometry, bulge	Univ Chile	RCH
Rodolfo Barba	Reductions, Pipeline, bulge	Univ La Serena	RCH
Roberto Gamen	Reductions, Pipeline, bulge	Univ La Serena	RCH
Wolfgang Gieren	Photometry, light curves, bulge	Univ Concepcion	RCH
Douglas Geisler	Photometry, analysis, bulge	Univ of Concepcion	RCH
Grzegorz Pietrzynski	Photometry, astrometry, light curves	Univ Concepcion	RCH
Ronald Mennickent	Photometry, astrometry, light curves	Univ Concepcion	RCH
Radostin Kurtev	Reductions, pipeline, bulge	Univ Valparaiso	RCH
Jordanka Borissova	OB Prep, photometry, light curves	Univ Valparaiso	RCH
Valentin Ivanov[3]	OB Prep, Data Quality Control III	ESO	ESO
Felix Mirabel	Photometry, analysis, bulge	ESO	ESO
Ivo Saviane	OB Prep, Pipeline, bulge	ESO	ESO
Leonardo Vanzi	OB Prep, Pipeline, bulge	ESO	ESO
Lorenzo Monaco	OB Prep, Reductions, bulge	ESO	ESO
Marina Rejkuba	Simulations, light curves, bulge	ESO	ESO
Maria Messineo	Simulations, light curves, bulge	ESO	ESO
Luigi Bedin	Astrometry, simulations, bulge	ESO	ESO
Andrew Stephens	Simulations, photometry, bulge	Hawaii	USA
Beatriz Barbuy	Photometry, analysis, bulge	Univ Sao Paulo	Other
Eduardo Bica	Photometry, analysis, bulge	Univ Porto Alegre	Other
Juan Jose Claria	Photometry, analysis, bulge	Univ Cordoba	Other
Andrea Ahumada	Pipeline, photometry, bulge	Univ Cordoba	Other
CASU (VDFS) team	Pipeline Processing	Cambridge Univ	UK
CASU (VDFS) team	Data Quality Control I	Cambridge Univ	UK
WFAU (VDFS) team	Science archive	Edinburgh Univ	UK
WFAU (VDFS) team	Data Quality Control II	Edinburgh Univ	UK
Jim Emerson	OB prep, VDFS Coordinator Bulge & Plane	Queen Mary Univ London	UK
Janet Drew	VPHAS/VVV joint analysis	Imperial College London	UK
Martin Lopez-Correidora	Galactic structure analysis	IAC	Spain
Eduardo Martin	Variability analysis, plane	IAC	Spain
Bertrand Goldman	Cluster analysis, plane	MPIA Heidelberg	Germany
Teresa Giannini	Cluster analysis, plane	Rome Observatory	Italy
Jochem Eisloeffel	VPHAS/VVV joint analysis	Thueringer Landessternwarte	Germany
Paul Groot	VPHAS/VVV joint analysis	Nijmegen Univ	Netherlands
Juan Fabregat	VPHAS/VVV joint analysis	Univ de Valencia	Spain

Table 4: VVV Team members (continued

Name	Function	Affiliation	Country
Ben Burningham	QC and star formation science	Univ Hertfordshire	UK
Andy Longmore	VVV/UKIDSS GPS overlap	Royal Observatory Edinburgh	UK
Nic Walton	VPHAS/VVV combination	Cambridge Univ	UK
Richard de Grijs	Cluster analysis	IoA Cambridge	UK
Melvin Hoare	VVV/mid-IR/radio analysis	Leeds Univ	UK
Anja Schroeder	Galactic structure	Leicester Univ	UK
Tim Naylor	stellar populations	Exeter Univ	UK
Mike Barlow	Evolved stars	Univ College London	UK
Albert Zijlstra	Evolved stars	Manchester Univ	UK
Glenn White	planetary science	Open Univ	UK
Andrew Gosling	VVV/X-ray analysis	Oxford Univ	UK
Katherine McGowan	VVV/γ ray analysis	Southampton Univ	UK
Andy Adamson	VVV/UKIDSS GPS overlap	Joint Astronomy Center	USA
Reba Bendyopadhyay	VVV/X-ray analysis	Univ Florida	USA
Mark Thompson	Galactic structure	Univ Hertfordshire	UK
Mark Cropper	Galactic structure	Mullard Space Science Lab.	UK
John Lucey	Local group structure	Durham Univ	UK
Eammon Kerins	Microlensing science	Liverpool John Moores Univ	UK
Simon Hodgkin	Planetary transits	IoA Cambridge	UK
David Pinfield	Planetary transits	Univ Hertfordshire	UK

of these have highly irregular pattern and are hard to be detected by the automated tools. Some calibration frames will be also checked. The raw data will be inspected only to trace problems.

(iii) check the behavior of the pipeline and archive calculated QC parameters by generating and inspecting the QC plots from each night. We will pull from the database a number of critical QC parameters such as:

- Our defined constraints on a tile by tile basis - seeing and transparency. For the period P81, P83 and P89 we require on detector seeing < 0.8 and clear conditions, while the P85 and P87 the seeing is not specified.
- Quality of the pipeline reduction - to detect for example frames where the sky subtraction is not satisfactory, frames suffering from extreme bias offsets, etc.
- The ellipticity for all stellar objects will be calculated as a quality control parameter in the pipeline. The measured values should be around or less than 0.1. It is possible to have elongated images, especially at high airmass, these will be removed.
- The limiting magnitude or the depth of the tiles. The expected single epoch limiting magnitude and σ in the Ks band are the same for Bulge and Disk (Fig 3 & 5). We will not apply any specific depth cuts to the observations, since all frames can contribute the depth in the stack images. But, we are expecting to eliminate a number of frames that are taken in conditions of very bright sky (usually a few percent) in order to keep the quality.
- Photometric zero point. Since we are asking for “clear” and “thin” conditions we will use the computed zero point for each frame, relative to the mean value for the corresponding filter as an indicator of how much cloud extinction is there. Since the goal is to search for variable stars using the image-subtraction method the variation of the photometric zero point should lie within 0.2 mag of the mean value.
- and others as appropriate and necessary

(iv) Report regularly to the rest of the QC team and to the Management team.

7 Data products and VO compliance

The standardised VO compliant data products produced by the VDFS science archive for VVV in Edinburgh will be delivered to ESO by internet transfer, with a copy remaining at the Science Archive in Edinburgh. These are the calibrated tiles and with their associated source catalogues and the higher level merged science products detailed below.

8 Timeline for delivery of data products to the ESO archive

The VVV survey will operate for five years and will finally cover 520 square degree of Milky Way giving new and interesting data to the community.

All the final objectives of the project will be obtained by merging or differencing different modular blocks of observations achieved during each years of the survey. For this reason the schedule of the data products release is mainly defined by the survey observing strategy.

The VDFS team will release the data to the PIs within two months of the raw data arriving in UK. After further work by the survey team, including QC checking, the annual public releases of VVV data products to the ESO Science Archive are expected to occur six months after the end of the VVV observing season.

In detail data products are expected to appear in the ESO science archive with a yearly release as follow:

- **Year 1 + 6 months** - Release of complete tiles of the whole 300 sq deg in the bulge and 220 sq deg in the plane in $ZYJHJK_s$ bands at first survey epoch together with associated merged and unmerged catalogues.
- **Year 2 + 6 months** - Release of complete tiles of the whole 300 sq deg in the bulge and 220 in the plane in K_s band (five epochs - 1 in year 1 and 4 in year 2) together with associated catalogues.
- **Year 3 + 6 months** - Release of the data products of the year 3 variability campaign in the whole 300 sq deg in the bulge. This will comprise K_s band tiles, a merged catalogue with fluxes from all epochs and a list of likely variables.
- **Year 4 + 6 months** - Release of the data products of the P87 variability campaign in the whole 220 sq deg in the main plane. This will comprise K_s band tiles, a merged catalogue with fluxes from all epochs and a list of likely variables.
- **Year 5 + 6 months** - Release of the data products for long timescale (months) and very short (hours) variability. Release of proper motion catalogue, and an updated merged catalogue of fluxes. Release of stacked K_s tiles using the multiple epochs over 5 years, and single band source catalogues.
- **Year 5 + 18 months** - Release of final variability catalogue with idnetification of periodic variables and phasing.

The completeness of the coverage in the whole planned observing area is key for meeting the finals aim of the variability survey. If after the planned five years survey the coverage is incomplete due to scheduling or weather we would propose to extend the survey for an additional year in order to complete the observations and meet all the proposed objectives.

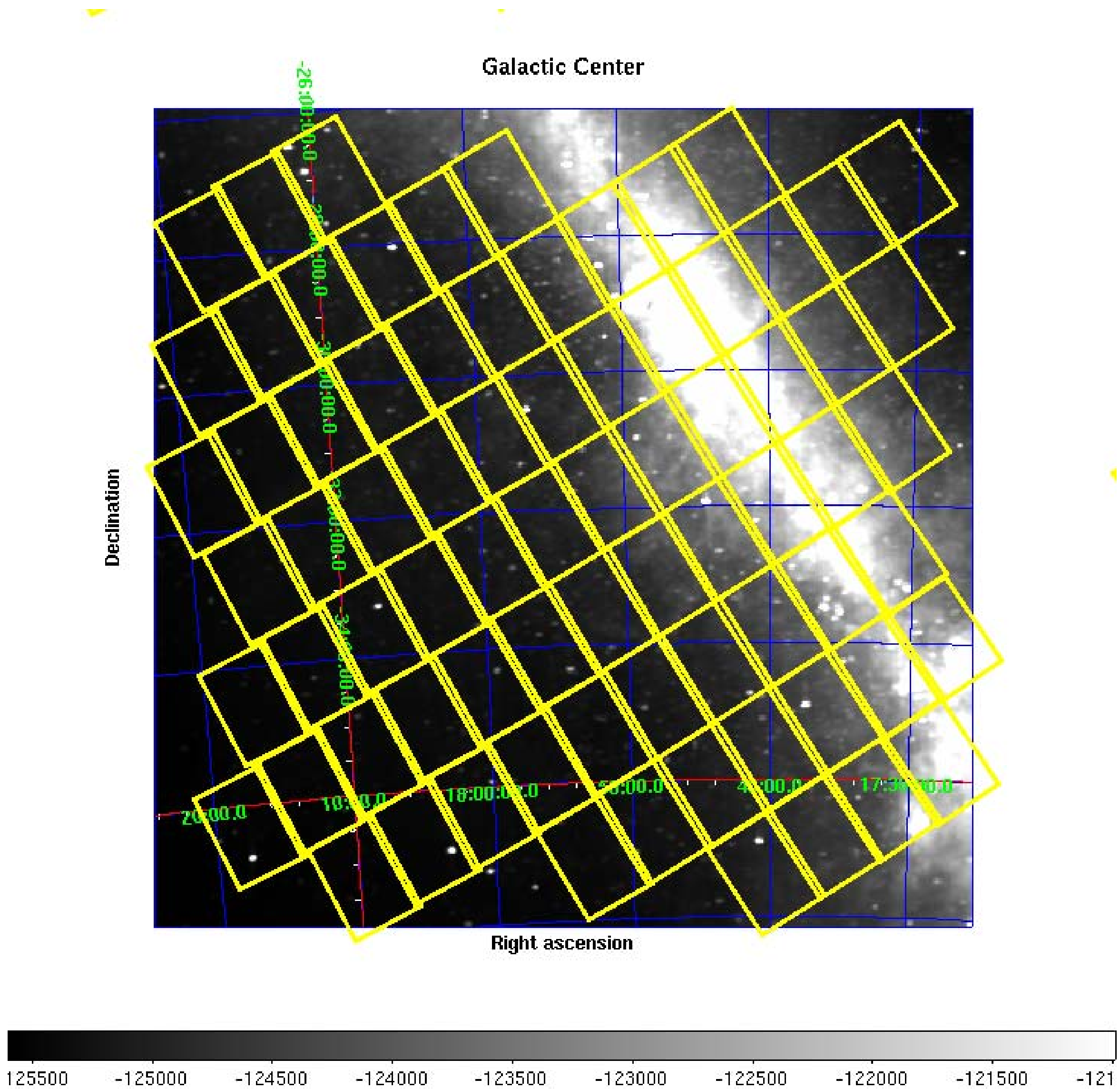

Figure 2: Coverage of the Galactic center region overlayed on the mid-IR all-sky map.

R	VVV-Bulge	Ks	Ks	Ks	Ks	Ks	value from
	Time & depth on sky in coadded Tiles	**yr1**	**yr2**	**yr3**	**yr4**	**yr5**	
	Vega or AB mags?	Vega	Vega	Vega	Vega	Vega	PI
	Depth (mag) required	18.0	18.0	18.0	18.0	18.0	Science
	Sigma required	3.0	3.0	3.0	3.0	3.0	Science
	Assumptions						
	SED assumed in using ETC	BB5000K	BB5000K	BB5000K	BB5000K	BB5000K	PI
	Aperture assumed in ETC - arcsec	2.4	2.4	2.4	2.4	2.4	PI
	In band sky brightness assumed - Vega mag/arcsec	13.0	13.0	13.0	13.0	13.0	PI
	Airmass assumed in ETC	1.2	1.2	1.2	1.2	1.2	PI
	In band on-chip image size assumed in ETC - arcsec	0.8	0.8	0.8	0.8	0.8	PI
	Extra extinction assumed in ETC	0.08	0.08	0.08	0.08	0.08	PI
3	Detector Integration Time (DIT) sec used in ETC	4	4	4	4	4	PI
	N.B. the DIT assumed will affect the number of seconds to reach a specified depth, because it affects the amount of read noise.						
1	Time (sec) required per object assuming above values	16	16	16	16	16	PI using ETC
	Area required sq. deg	300	300	300	300	300	Science
2	Tiles required to cover area(s)	200	200	200	200	200	PI, or PI using SADT
	effective useful sq deg/tile	1.50	1.50	1.50	1.50	1.50	R17/R18
	Assign priorities to different areas?	None	None	None	None	None	PI
	Single Tile Strategy						
	Parameters set						
3	DIT already assumed above	4	4	4	4	4	PI
4	Ndit - # of Exposure coadds	1	1	1	1	1	PI
5	Nexp # of Exposure loops	1	1	1	1	1	PI
6	Nmicro- # of microstep positions (steps <3 arcsec)	1	1	1	1	1	PI
7	Njitter - # of Jitter positions (steps odd # of 0.5 pixels < 30 arcsec)	2	2	2	2	2	PI
8	Npaw - # of Pawprints in tile	6	6	6	6	6	PI
	Observe tile in same OB how many times?	5	5	5	5	5	PI
	Number of filters in same OB? If >1 which other?	5	5	5	5	5	PI
	Number of tile positions in same OB?	1	1	1	1	1	PI
	Resulting values						
9	Total Exposure sec/tile	48	48	48	48	48	R3*R4*R5*R6*R7*R8
10	Total Elapsed sec/tile	161.7	161.7	161.7	161.7	161.7	PI using ETC
	Total Elapsed mins/tile	2.7	2.7	2.7	2.7	2.7	R10/60
	Observing efficiency %/tile	29.7	29.7	29.7	29.7	29.7	R9*100/R10
11	Time per object for s-to-n -single OB	16	16	16	16	16	R9/3
	Signal to noise (at depth required in row 3) - single OB	2.9	2.9	2.9	2.9	2.9	PI using ETC
	Depth (to sigma in row 4) - single OB	18.0	18.0	18.0	18.0	18.0	PI
	Multiple Tile Strategy						
12	# of Tiles per filter for S/N	1	1	1	1	1	R1/R11
	Time links between OBs in same filter on a Tile?						PI
	Priorities between OBs in same filter on a Tile?						PI
	Time links between OBs on a Tile in different filters?						PI
	Priorities between OBs on a Tile in different filters?						PI
	Time links between Tiles by position?						PI
	Priorities between Tiles by position?						PI
	Total Elapsed Hours per filter	9.0	9.0	9.0	9.0	9.0	R2*R10*R12/3600
	Epochs	6	4	80	0	20	
	Total time for epochs	53.90	35.93	718.67	0.00	179.67	=G54*(G52+G53)

Figure 3: Years 1-5 Bulge single epochs

R	1st year Bulge ZYJHKs	Z	Y	J	H	Ks	value from
	Time & depth on sky in coadded Tiles						
	Vega or AB mags?	Vega	Vega	Vega	Vega	Vega	PI
	Depth (mag) required	21.6	20.9	20.6	19.0	18.0	Science
	Sigma required	3.0	3.0	3.0	3.0	3.0	Science
	Assumptions						
	SED assumed in using ETC	BB5000K	BB5000K	BB5000K	BB5000K	BB5000K	PI
	Aperture assumed in ETC - arcsec	2.4	2.4	2.4	2.4	2.4	PI
	In band sky brightness assumed - Vega mag/arcsec	18.2	17.2	16.0	14.1	13.0	PI
	Airmass assumed in ETC	1.2	1.2	1.2	1.2	1.2	PI
	In band on-chip image size assumed in ETC - arcsec	0.8	0.8	0.8	0.8	0.8	PI
	Extra extinction assumed in ETC	0.00	0.00	0.00	0.00	0.08	PI
3	Detector Integration Time (DIT) sec used in ETC	10	10	6	4	4	PI
	N.B. the DIT assumed will affect the number of seconds to reach a specified depth, because it affects the amount of read noise.						
1	Time (sec) required per object assuming above values	40	40	48	16	16	PI using ETC
	Area required sq. deg	300	300	300	300	300	Science
2	Tiles required to cover area(s)	200	200	200	200	200	PI, or PI using SADT
	effective useful sq deg/tile	1.50	1.50	1.50	1.50	1.50	R17/R18
	Assign priorities to different areas?	None	None	None	None	None	PI
	Single Tile Strategy						
	Parameters set						
3	DIT already assumed above	10	10	6	4	4	PI
4	Ndit - # of Exposure coadds	1	1	2	1	1	PI
5	Nexp # of Exposure loops	1	1	1	1	1	PI
6	Nmicro- # of microstep positions (steps <3 arcsec)	1	1	1	1	1	PI
7	Njitter - # of Jitter positions (steps odd # of 0.5 pixels < 30 arcsec)	2	2	2	2	2	PI
8	Npaw - # of Pawprints in tile	6	6	6	6	6	PI
	Observe tile in same OB how many times?	5	5	5	5	5	PI
	Number of filters in same OB? If >1 which other?	5	5	5	5	5	PI
	Number of tile positions in same OB?	1	1	1	1	1	PI
	Resulting values						
9	Total Exposure sec/tile	120	120	144	48	48	R3*R4*R5*R6*R7*R8
10	Total Elapsed sec/tile	233.7	233.7	269.7	161.7	161.7	PI using ETC
	Total Elapsed mins/tile	3.9	3.9	4.5	2.7	2.7	R10/60
	Observing efficiency %/tile	51.3	51.3	53.4	29.7	29.7	R9*100/R10
11	Time per object for s-to-n -single OB	40	40	48	16	16	R9/3
	Signal to noise (at depth required in row 3) - single OB	3.0	2.9	2.9	3.0	2.9	PI using ETC
	Depth (to sigma in row 4) - single OB	21.6	20.9	20.6	19.0	18.0	PI
	Multiple Tile Strategy						
12	# of Tiles per filter for S/N	1	1	1	1	1	R1/R11
	Time links between OBs in same filter on a Tile?						PI
	Priorities between OBs in same filter on a Tile?						PI
	Time links between OBs on a Tile in different filters?						PI
	Priorities between OBs on a Tile in different filters?						PI
	Time links between Tiles by position?						PI
	Priorities between Tiles by position?						PI
	Total Elapsed Hours per filter	13.0	13.0	15.0	9.0	9.0	R2*R10*R12/3600
	Total time	58.9					
	Epochs	1					
	Total time for 1 epochs	58.92	=c55*c54			0	

Figure 4: Year 1 Bulge multicolour

R	VVV-Plane	Ks	Ks	Ks	Ks	Ks	value from
	Time & depth on sky in coadded Tiles	**yr1**	**yr2**	**yr3**	**yr4**	**yr5**	
	Vega or AB mags?	Vega	Vega	Vega	Vega	Vega	PI
	Depth (mag) required	18.0	18.0	18.0	18.0	18.0	Science
	Sigma required	3.0	3.0	3.0	3.0	3.0	Science
	Assumptions						
	SED assumed in using ETC	BB5000K	BB5000K	BB5000K	BB5000K	BB5000K	PI
	Aperture assumed in ETC - arcsec	2.4	2.4	2.4	2.4	2.4	PI
	In band sky brightness assumed - Vega mag/arcsec	13.0	13.0	13.0	13.0	13.0	PI
	Airmass assumed in ETC	1.2	1.2	1.2	1.2	1.2	PI
	In band on-chip image size assumed in ETC - arcsec	0.8	0.8	0.8	0.8	0.8	PI
	Extra extinction assumed in ETC	0.08	0.08	0.08	0.08	0.08	PI
3	Detector Integration Time (DIT) sec used in ETC	4	4	4	4	4	PI
	N.B. the DIT assumed will affect the number of seconds to reach a specified depth, because it affects the amount of read noise.						
1	Time (sec) required per object assuming above values	16	16	16	16	16	PI using ETC
	Area required sq. deg	220	220	220	220	220	Science
2	Tiles required to cover area(s)	147	147	147	147	147	PI, or PI using SADT
	effective useful sq deg/tile	1.50	1.50	1.50	1.50	1.50	R17/R18
	Assign priorities to different areas?	None	None	None	None	None	PI
	Single Tile Strategy						
	Parameters set						
3	DIT already assumed above	4	4	4	4	4	PI
4	Ndit - # of Exposure coadds	1	1	1	1	1	PI
5	Nexp # of Exposure loops	1	1	1	1	1	PI
6	Nmicro- # of microstep positions (steps <3 arcsec)	1	1	1	1	1	PI
7	Njitter - # of Jitter positions (steps odd # of 0.5 pixels < 30 arcsec)	2	2	2	2	2	PI
8	Npaw - # of Pawprints in tile	6	6	6	6	6	PI
	Observe tile in same OB how many times?	5	5	5	5	5	PI
	Number of filters in same OB? If >1 which other?	5	5	5	5	5	PI
	Number of tile positions in same OB?	1	1	1	1	1	PI
	Resulting values						
9	Total Exposure sec/tile	48	48	48	48	48	R3*R4*R5*R6*R7*R8
10	Total Elapsed sec/tile	161.7	161.7	161.7	161.7	161.7	PI using ETC
	Total Elapsed mins/tile	2.7	2.7	2.7	2.7	2.7	R10/60
	Observing efficiency %/tile	29.7	29.7	29.7	29.7	29.7	R9*100/R10
11	Time per object for s-to-n -single OB	16	16	16	16	16	R9/3
	Signal to noise (at depth required in row 3) - single OB	2.9	2.9	2.9	2.9	2.9	PI using ETC
	Depth (to sigma in row 4) - single OB	18.0	18.0	18.0	18.0	18.0	PI
	Multiple Tile Strategy						
12	# of Tiles per filter for S/N	1	1	1	1	1	R1/R11
	Time links between OBs in same filter on a Tile?						PI
	Priorities between OBs in same filter on a Tile?						PI
	Time links between OBs on a Tile in different filters?						PI
	Priorities between OBs on a Tile in different filters?						PI
	Time links between Tiles by position?						PI
	Priorities between Tiles by position?						PI
	Total Elapsed Hours per filter	6.6	6.6	6.6	6.6	6.6	R2*R10*R12/3600
	Epochs	6	4	0	80	9	
	Total time for epochs	39.62	26.41	0	528.22	59.42	=G54*(G52+G53)

Figure 5: Years 1-5 Disk single epochs

R	1st VVV-Plane ZYJHKs	Z	Y	J	H	Ks	value from
	Time & depth on sky in coadded Tiles						
	Vega or AB mags?	Vega	Vega	Vega	Vega	Vega	PI
	Depth (mag) required	21.5	20.7	20.2	19.3	18.3	Science
	Sigma required	5.0	5.0	5.0	5.0	5.0	Science
	Assumptions						
	SED assumed in using ETC	BB5000K	BB5000K	BB5000K	BB5000K	BB5000K	PI
	Aperture assumed in ETC - arcsec	2.4	2.4	2.4	2.4	2.4	PI
	In band sky brightness assumed - Vega mag/arcsec	18.2	17.2	16.0	14.1	13.0	PI
	Airmass assumed in ETC	1.2	1.2	1.2	1.2	1.2	PI
	In band on-chip image size assumed in ETC - arcsec	0.8	0.8	0.8	0.8	0.8	PI
	Extra extinction assumed in ETC	0.00	0.00	0.00	0.00	0.08	PI
3	Detector Integration Time (DIT) sec used in ETC	20	20	10	10	10	PI
	N.B. the DIT assumed will affect the number of seconds to reach a specified depth, because it affects the amount of read noise.						
1	Time (sec) required per object assuming above values	80	80	80	80	80	PI using ETC
	Area required sq. deg	220	220	220	220	220	Science
2	Tiles required to cover area(s)	147	147	147	147	147	PI, or PI using SADT
	effective useful sq deg/tile	1.50	1.50	1.50	1.50	1.50	R17/R18
	Assign priorities to different areas?	None	None	None	None	None	PI
	Single Tile Strategy						
	Parameters set						
3	DIT already assumed above	20	20	10	10	10	PI
4	Ndit - # of Exposure coadds	1	1	2	2	2	PI
5	Nexp # of Exposure loops	1	1	1	1	1	PI
6	Nmicro- # of microstep positions (steps <3 arcsec)	1	1	1	1	1	PI
7	Njitter - # of Jitter positions (steps odd # of 0.5 pixels < 30 arcsec)	2	2	2	2	2	PI
8	Npaw - # of Pawprints in tile	6	6	6	6	6	PI
	Observe tile in same OB how many times?	5	5	5	5	5	PI
	Number of filters in same OB? If >1 which other?	5	5	5	5	5	PI
	Number of tile positions in same OB?	1	1	1	1	1	PI
	Resulting values						
9	Total Exposure sec/tile	240	240	240	240	240	R3*R4*R5*R6*R7*R8
10	Total Elapsed sec/tile	353.7	353.1	365.7	365.7	365.7	PI using ETC
	Total Elapsed mins/tile	5.9	5.9	6.1	6.1	6.1	R10/60
	Observing efficiency %/tile	67.9	68.0	65.6	65.6	65.6	R9*100/R10
11	Time per object for s-to-n -single OB	80	80	80	80	80	R9/3
	Signal to noise (at depth required in row 3) - single OB	4.9	5.1	5.5	5.2	5.0	PI using ETC
	Depth (to sigma in row 4) - single OB	21.5	20.7	20.2	19.3	18.3	PI
	Multiple Tile Strategy						
12	# of Tiles per filter for S/N	1	1	1	1	1	R1/R11
	Time links between OBs in same filter on a Tile?						PI
	Priorities between OBs in same filter on a Tile?						PI
	Time links between OBs on a Tile in different filters?						PI
	Priorities between OBs on a Tile in different filters?						PI
	Time links between Tiles by position?						PI
	Priorities between Tiles by position?						PI
	Total Elapsed Hours per filter	14.4	14.4	14.9	14.9	14.9	R2*R10*R12/3600
	Total time	73.66					
	Epochs	1					
	Total time for 1 epochs	73.66	=c55*c54				

Figure 6: Year 1 Disk multicolour

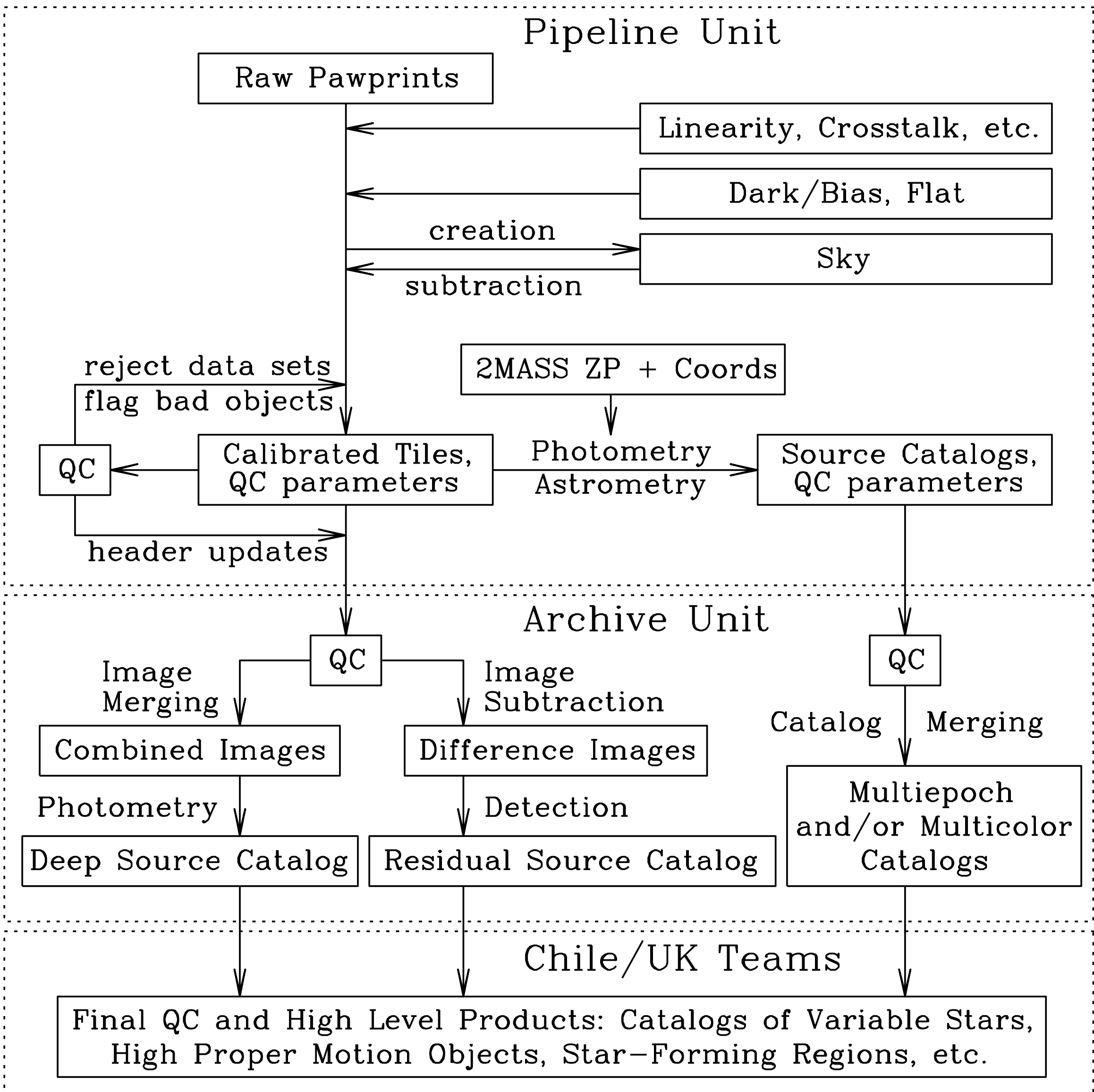

Figure 7: Data processing chart.