1 Title: The VISTA near-infrared YJK_s survey of the Magellanic System (LMC, SMC, Bridge & Stream) – VMC.

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1.1 Abstract:(10 lines max)

The Magellanic Cloud system represents the nearest template for the study of stellar populations and galaxy interactions. Its low metallicity and nearby distance are key issues to exploit the unique VMC data. This survey aims to obtain YJK_s-band photometry across the system down to $K_s = 20.3$ at S/N= 10. This sensitivity corresponds to the bottom of the red giant branch field stellar population and allows us to determine the global spatially resolved star formation history with unprecedented quality ($\sim$ 20% errors at a resolution of 0.2 dex in age) and to construct a three-dimensional map of the system. A wide-area (184 deg^2) encompassing the D_{25} as well as major features delineated by the distribution of stars and HI gas, will both trace the structure of the galaxies and signatures of past and present interactions. Contemporary optical and kinematic observations of comparable sensitivity (e.g. VST) will provide the community with a superior database for future studies of the system and will give us an excellent insight as to what has happened elsewhere in the Universe.

2 Description of the survey: (Text: 3 pages, Figures: 2 pages)

2.1 Scientific rationale:

To understand the history of formation and evolution of galaxies we need to study the distribution of age, chemical abundance and kinematics of the stellar as well as the gaseous component. Moreover, we need to obtain a global picture of the star formation history (SFH) that accounts for both the intrinsic evolution and the effects of interactions with neighbouring systems.

Why the Magellanic Clouds?

The Magellanic Clouds (MCs) represent an ideal laboratory for these studies because they span a broad range of stellar populations and are actively forming stars at present. Furthermore, the ongoing interaction between the Clouds themselves and with the Milky Way (MW) is representative of the environmental effects that large galaxies with satellites (low-mass dwarfs) experience anywhere in the Universe. The MCs are close enough to resolve in detail their stellar content, which provides additional sampling of metallicity space compared to the MW as well as a much more extended age range of the massive (up to several $\times 10^5$ $M_\odot$) cluster systems (from newly formed to globular-type ages). The MCs lie in a region of low Galactic extinction and we know their distances quite accurately ($\sim$ 0.1 mag), which is essential for precise photometric studies. The irregular appearance of these galaxies in the sky is dominated by the distribution of young stars, while evolved stars trace a more regular elliptical structure of greater extent. Their thickness along the line of sight is rather small (it is larger for the Small Cloud). Embedded in each galaxy is a bar, which is the result of galaxy evolution and/or interaction. At present it is unclear if the MCs constitute a binary system (Kallivayali et al. astro-ph/0606240), although it is possible that this situation has only existed for $\approx$ 4 Gyr. They are connected by an HI-dominated gaseous Bridge, that like the Stream may result from their interaction with the MW.

Relation to previous studies

Observations of the MCs to disentangle their structure and stellar population have been performed using small telescopes: deep but spatially limited HST observations and wide-area but shallow optical (MCPS, MACHO & OGLE) and near-infrared (2MASS & DENIS) surveys. On the other hand, follow-up observations using large telescopes (i.e. VLT and Keck) have provided detailed chemical abundances of limited samples of stars. Even though these projects had a significant impact on our understanding of the system, a global picture is still lacking. Analysing deep and homogeneous multi-band data obtained from the proposed VMC survey will remedy this issue. Furthermore, combining VMC data with the results of on-going or planned wide-area spectroscopic

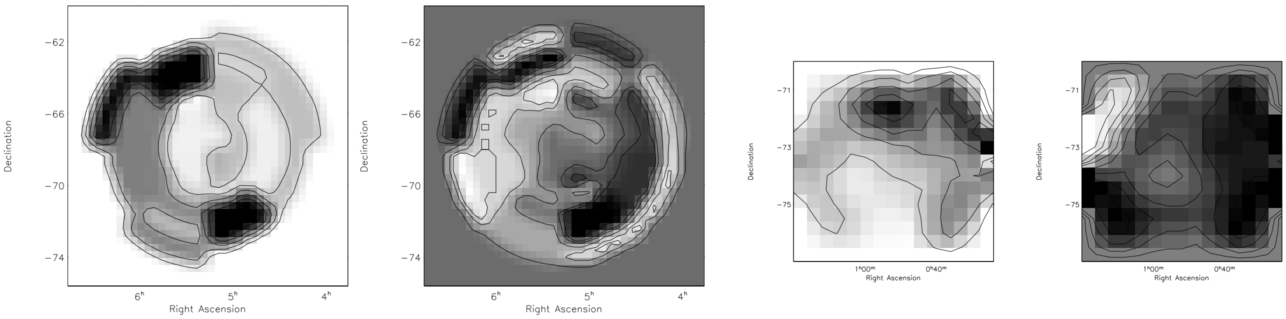


Figure 1: (*from left to right*) Distribution of metallicity (contours: $Z = 0.003 - 0.015$ in steps of 0.003) and of mean age (contours: 2, 3, 5, 7, 8 and 10 Gyr) of the stellar population across the LMC and across the SMC (same contours in metallicity while for age they are from 3 to 10 Gyr with a step of 1 Gyr). Darker regions correspond to higher numbers.

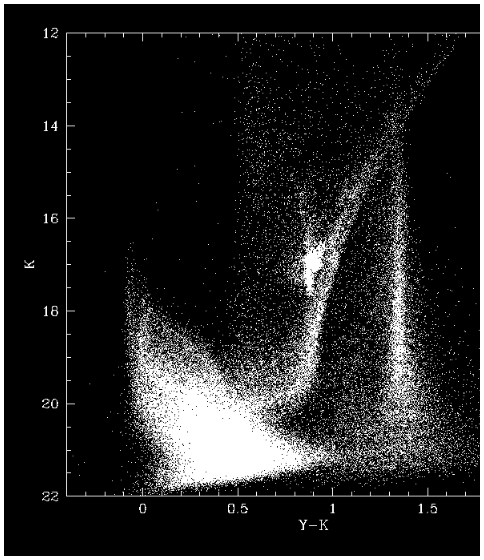
surveys (that allow us to disentangle different generations of stars from their chemistry) and complementary wide-area optical photometric surveys will provide us with the ultimate understanding of the SFH across the system (what triggers star formation? what is the role of the bar? etc.).

Information about the SFH of the Large Magellanic Cloud (LMC) has been derived from the study of many relatively small regions located in the outer and inner disk as well as along the bar. In the Small Magellanic Cloud (SMC), apart from the quite comprehensive study by Harris & Zaritsky (2004, ApJ 127, 1531), which does not probe the outer structure, there have been considerably fewer (and less detailed) observations of the field and cluster stellar populations than in the LMC. Cioni et al. (2006, A&A 448, 1; A&A 452, 195) compared the K_s magnitude distribution of asymptotic giant branch (AGB) stars with theoretical distributions to provide surface maps showing the inhomogeneous distribution of metallicity and mean age within each galaxy (**Fig. 1**). It remains unclear whether this is due to tidal interaction and how long this inhomogeneity can be seen after its formation. Using VMC data the distribution of field stars in different phases of evolution, i.e., upper main-sequence (MS) stars, sub-giant stars, upper and lower red giant branch (RGB) stars, red clump stars, RR Lyrae stars, Cepheids, late-type AGB stars, post-AGB stars and nebulae will be traced out to distances never yet explored. In particular we aim to sample the population of RGB stars because their behaviour is better understood and, because they are likely more metal poor and, they trace the tidally stripped parts of the galaxies and the extended halo component. Densities of different stellar objects are strongly correlated with the SFH. RGB and red clump densities, for instance, are affected by the cumulative SFH between 1 and 12 Gyr. A peak of SFR of equal intensity will generate 10 red clump stars in 1 Gyr and just 1 at 10 Gyr (metallicity is negligible). Therefore, measuring the SFH, via sub-giant stars, is important for the analysis of density maps.

The most powerful tool for quantitatively measuring the SFH in nearby galaxies is the analysis of colour-magnitude diagrams (CMDs) via objective algorithms that search for the composite model that best-fits the observations – thus quantifying the several single-burst populations that make the observed mixed one. A primary target of our survey is to allow the SFH measurement in the MCs with unprecedent accuracy and detail, via this kind of analysis. We have made several experiments to determine the magnitude depth that will provide a definitive improvement in this field. First, we have made simulations like the one shown in **Fig. 4**, for several choices of survey depth. After cleaning for Galactic foreground stars, the SFH was recovered using a slightly adapted version of Harris& Zaritsky StarFISH code (2001, ApJS 136, 25) using both YK and JK CMDs, bins 0.2 dex wide in log(age). **Figure 2** shows a typical result for the LMC assuming our targeted depth of $K = 20.3$ and an input SFH constant over the $0.1 - 12$ Gyr range. The relative error in SFH-recovery is $< 20\%$ for most ages, and becomes significant just at the extremes of the total age interval. **Figure 3** shows how the χ^2 (input minus recovered) varies with survey depth. It is clear that *to attain a good accuracy in the SFH, the survey depth in K should be fainter than* 19.75 *in the LMC (*20.25 *in the SMC)*. Otherwise, the derived SFHs may be severely in error and VMC would not represent a significant progress over present-day surveys.

Outstanding problems

Despite numerous previous studies, it has not yet been established conclusively whether the field has experienced



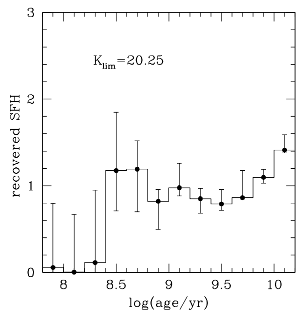


Figure 2: Recovered SFH vs. age for a constant input rate for ages between 0.1 and 12 Gyr. The simulation has $K_{lim} = 20.3$, i.e. the errors are very similar to those expected from the VMC survey.

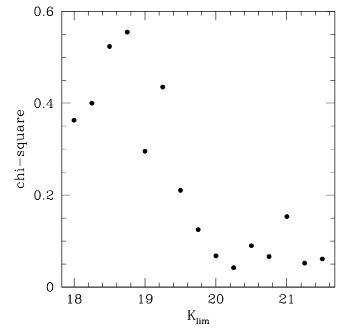


Figure 3: The chi-square error (input minus recovered) for several SFH-recovery tests, as a function of survey depth K_{lim}. Notice that the errors become small and almost constant only for $K_{lim} > 19.75$.

Figure 4: Simulated colour-magnitude diagrams for a 0.6 deg^2 LMC area close to Hodge 10, whose SFH is known from HST data (Holtzman et al. 1999, AJ 118, 2262). The simulation uses UKIDSS filter curves, a uniform extinction of A$_V$ = 0.18 mag, and the photometric errors expected from our targeted S/N. Clearly shown are: the MS with turn-offs between 10^8 to 10^{10} yr, at $-0.1 < (Y-K) < 0.7$ and $16.5 < K < 20.5$; the complete RGB, plus early-AGB and red clump phases; the Galactic foreground stars, mostly comprised in the almost-vertical sequences at $0.5 < (Y-K) < 1.5$.

the same SFH as the cluster stellar population system. By combining integrated properties with resolved stellar population studies, the MC cluster system offers a unique chance to independently check the accuracy of age (and corresponding mass) determinations based on broad-band spectral energy distributions. Anders et al. (2004, MNRAS 347, 196) and de Grijs & Anders (2006, MNRAS 366, 295) developed a method that employs multiple passband observations to obtain simultaneously cluster ages, masses, metallicities and extinction values. Absolute ages were derived with a precision of 35% and relative ages to an order of magnitude better (**Fig. 6**). This is the precision we expect to reach from the analysis of the VMC data set. Moreover, by including near-infrared (IR) passbands we can constrain any metallicity and extinction variations much more precisely than using optical data alone (Ivanov & Borissova 2002, A&A 390, 937; Valenti et al. 2004, MNRAS 354, 815). Wide-field VMC data will produce a complete census of the cluster population that will allow us to draw statistically robust conclusions; we will properly compare spatial differences within the Clouds and possibly – for the first time – strongly constrain the shape of the low-mass cluster mass function (Larsen et al. 2002, AJ 124, 2615). A search for new clusters based on the stellar surface density will work better than in the MW (Ivanov et al. 2002, A&A 394, L1; Borissova et al. 2003, A&A 411, 83) because of the lower confusion along the line of sight.

The Bridge holds important clues about the most recent ($\approx 10^8$ yr ago) interaction between the Clouds, its own formation history and possible origin. What is the age difference between the western and easter parts of the Bridge? If it formed by LMC-SMC collision, and if the SMC is a disk (rotating) system, we should observe AGB, PNe, etc. (not just HI). Our multi-passband survey will answer the question above and will also test the formation scenario predicted by simulations of a Magellanic collision. By comparing the observed amount of old stellar populations with the simulated one, we can constraint the gas/stellar structure of the SMC before interaction. It is a known mystery that only HI gas (not stars) shows rotation in the SMC, thus 3D structures dependent on ages of stellar populations will give us hints about this problem. Galaxy interactions play a major role in controlling the SFH of field stars and clusters but also in transforming galactic morphologies. The SFH of the MCs depends strongly on the interaction history of the triple system (LMC-SMC-MW), thus on the orbits and masses of the MCs. Constraints on these fundamental parameters can be set by comparison with simulations: chemodynamical (Bekki & Chiba 2005, MNRAS 356, 680), hydrodynamical (Mastropietro et al. 2005, MNRAS 363, 509) and pure N-body (Connors, Kawata & Gibson 2006, MNRAS 371, 108) while the self-consistency of the predicted orbits will be assessed using precise proper motion data. Although current

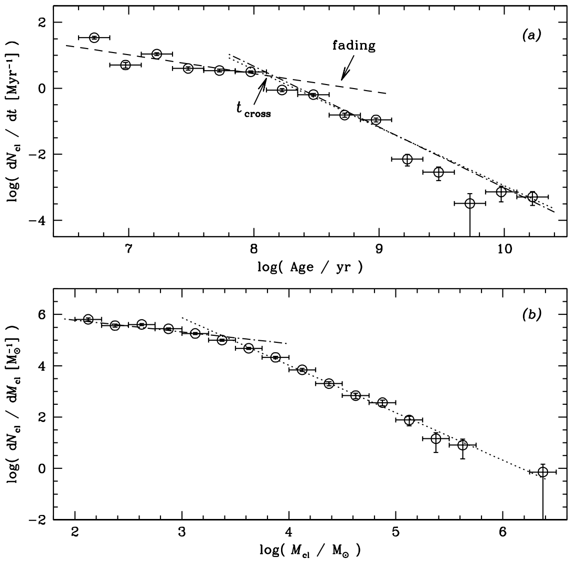


Figure 6: *(a)* – The LMC cluster formation rate as a function of age. The dashed line is the least-squares power-law fit to the fading, non-disrupted clusters, for a constant ongoing cluster formation rate. The other lines are the disruption lines for the most likely age ranges where disruption may dominate evolutionary fading. *(b)* – Mass spectrum of LMC clusters; the dotted line is a power-law fit to the cluster-mass-function that is as yet unaffected by disruption; the slope of the dash-dotted line was determined by the initial slope derived from the dotted line, and stellar population synthesis.

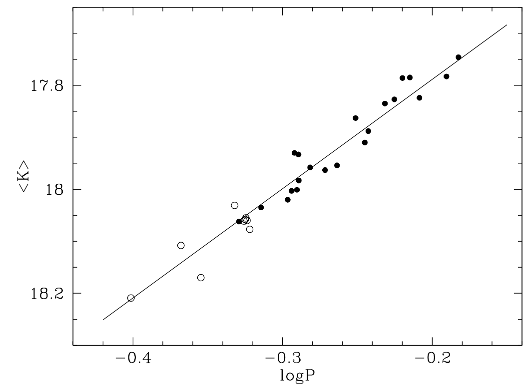


Figure 5: Log$P- < K >$ relation for Reticulum RR Lyrae stars. Open symbols are RRc stars after their periods have been fundamentalized by adding 0.127 to log$P$. Filled symbols are RRab stars. The line is the theoretical prediction for the derived distance.

models explain reasonably well the formation of the bar, the disk and the halo of the LMC as well as the gap in the age distribution of clusters, there are still significant uncertainties. For example, because the formation histories of field stars and globular clusters as well as the structural and kinematic properties in the LMC are different from those in the SMC, it is not yet clear whether these two galaxies were born as a pair. Moreover, did the stellar halo form via a different mechanism for Magellanic-type dwarf galaxies than for large spirals like the MW? (I.e. by tidal galaxy interaction rather than by merging/accretion of subgalactic clumps?)

One of the key points of this survey is to provide a 3D picture of the Magellanic system. For this we plan to use different density and distance indicators: (i) the red clump's apparent magnitude, (ii) the period-luminosity (PL) relations for RR Lyrae stars, and (iii) Cepheids, (iv) standard candles in clusters. None of them is free of *problems*, however, their combination will ultimately constrain the structure of the system. In particular clusters are single stellar populations often without internal extinction, thus they are easier to interpret compared to previous indicators but offer a statistically limited sample. The red clump's magnitude related to any other quantity depends on the SFH (Girardi & Salaris 2001, MNRAS 323, 109). Recovering the SFH with a resolution of 0.2 dex in the age will provide us with an accuracy of 0.05 mag on the determination of distance moduli. RR Lyrae stars trace the old ($t > 10$ Gyr) stellar component and follow a PL only in the K band (Longmore et al. 1986, MNRAS 220, 279). Although it is weakly affected by evolutionary effects, spreads in stellar mass inside the instability strip, and uncertainties in the reddening correction, it does depend on metallicity. Dall'Ora et al. (2004, ApJ 610, 269) show the application of this relation to refine the distance to the Reticulum cluster in the LMC (**Fig. 5**). The theoretical calibration of this relation relies strongly on the $(V-K)$ colour. RR Lyrae stars in the MCs have $K_s \approx 18.0-19.0$ mag and optical data of comparable sensitivity covering most of the LMC and the SMC from which to derive the period of the variation, are or will be available from microlensing surveys while similar data covering the Bridge will be obtained from STEP (Sect. 3). Thus, it is of prime importance to measure the mean K_s-band magnitude of RR Lyrae stars with the VMC survey. Cepheids are young or intermediate-age stars (100 Myr) which follow a much narrower PL in the K_s band than the corresponding optical relations and less affected by systematic uncertainties related to our knowledge of the reddening and metal content (Caputo, Marconi, Musella 2000, A&A, 354, 610); the intrinsic accuracy of the PL-metallicity relation is ≈ 0.05 mag (Dall'Ora et al. 2004, ApJ 610, 269). *Due to the reduced dependence on the intrinsic width of the instability strip these relations can be used to constrain the MC geometry much better than using*

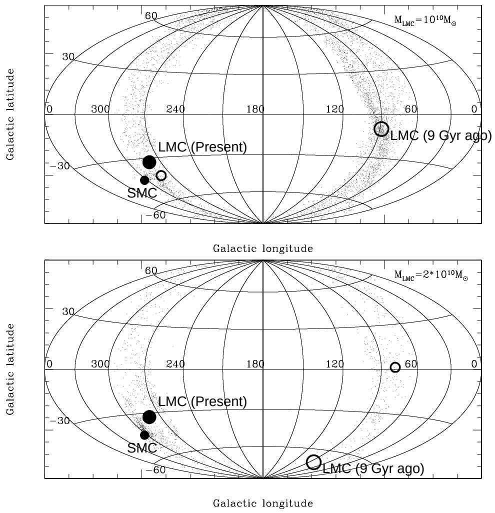


Figure 7: Distribution of old stars stripped from the LMC disc for two models with a different LMC total mass. The location of the MCs at present and ≈ 9 Gyr ago are indicated with filled and open circles, respectively.

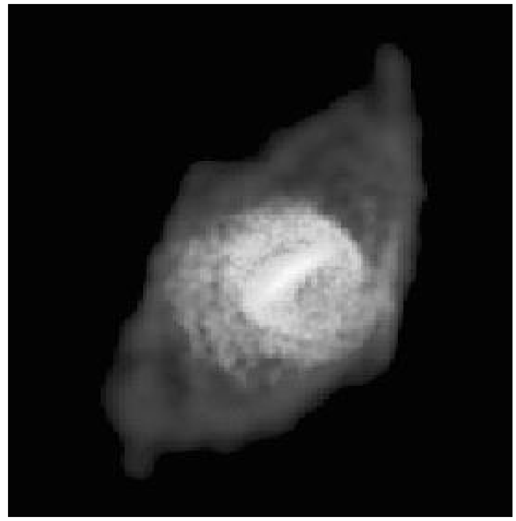


Figure 8: Simulated LMC stellar surface density (face-on projection). Greyscale is a logarithmic scale, where white corresponds to a density of 10^2 $M_\odot$ pc^{-2} and dark grey to 10^{-2} $M_\odot$ pc^{-2}. The bar and the strong warp are visible.

optical data alone. The observed properties of RR Lyrae and Cepheid stars will be compared with updated theoretical work based on nonlinear convective models of pulsating stars (Marconi et al. 2003, ApJ 596, 299). For Cepheids, the application of theoretical PL and PL-colour relations to both near-IR and optical data will allow us to evaluate self consistently distances, reddenings and metal abundances (Caputo et al. 1999, ApJ 525, 784; 2001, A&A 372, 544). Moreover, information on the SFH could be inferred from the application of theoretical period-age and period-age-colour relations (Marconi et al. 2005; MemSait 77, 67).

Ancillary science

The distance modulus of the LMC, a key corner stone of the extragalactic distance ladder, estimated by several independent methods and indicators (including red clump and RR Lyrae stars once supporting the "short" distance) is at present 18.5 mag with a residual uncertainty of ~ 0.1 mag. Although shorter moduli around 18.3 mag still appear in the literature, the 18.5 mag seems now a rather well established value (Clementini et al. 2003, Cioni et al. 2000, A&A 359, 601; etc.). In any case, the homogeneous VMC dataset will allow us to cut down by a factor of two the present uncertainty since many independent indicators (RR Lyrae stars, Cepheids, Miras, clump stars, tip of the RGB, etc.) which appear more powerful and reliable in the near-IR will be used.

Previous shallow near-IR surveys have been unable to reach the K_s magnitudes required to reveal large numbers of obscured, reddened stars, late-type and post AGB stars as well as faint (old) PNe. With the benefit of K_s-band VMC observations we will no doubt discover a wealth of embedded and obscured massive stars in their nascent clouds, which will reveal whether our view of present-day star-formation in the MCs is representative of the true situation, i.e. are we 'missing' large numbers of the most massive stars that are still in obscured clusters? On the other hand, $K_s = 20.3$ corresponds to an unreddened ~ 1.5 $M_\odot$ pre-main sequence stars (depending on the evolutionary model), thus, VMC data will allow us to construct initial mass functions down to $\sim$ solar-mass stars, depending on reddening effects etc. Wide-area VMC observations will show systematically where low-mass populations exist – up to now only specific locations were targeted – opening the doors to detailed follow-up studies as well as to a robust comparison with MW stars for the study of environmental influence.

The MACHO, OGLE and EROS monitoring observations have revealed beautifully detailed light curves for optically visible AGB stars in the MCs (Wood et al. 1999, IAU 191, 151; Ita et al. 2004, MNRAS 347, 720; Soszyński et al. 2004, Acta Astr. 54, 129; Fraser et al. 2005, AJ 129, 768). These AGB stars, that mostly have a 2MASS counterpart, are in the early stages of the mass loss process. However, those (fainter) AGB stars returning most of their mass to the interstellar medium are in the very late stages of evolution or the transition to the PN phase. Their surrounding dust shells are thick and the stars are not detected in optical surveys but instead were detected by the MSX and ISO satellites and more recently, in large numbers (1200 across the LMC), by the SAGE survey with the Spitzer Space Telescope. A full understanding of this very brief but important evolutionary stage requires a knowledge of pulsation periods (from which the current stellar mass can be estimated), as well as evidence for secular variations in early post-AGB stars. The 5-year monitoring to be provided by the VMC survey should yield these quantities for a unique and complete sample of stars.

According to the evolution scenario, the number of presently known PNe (< 5 deg^{-2}) corresponds to just $\sim 15\%$ of the predicted number. Thus, we are missing the majority of the population which is fainter and distributed over the "halo". VMC data combined with broad-band optical data and in particular with Hα and [OIII] images (Jacoby et al. 2002, AJ 123, 269; Reid & Parker 2006, MNRAS 365, 401) will allow us to design a method to uncover many of the missing PNe in the MCs. PNe will be bright in K_s because of Brackett Gamma emission and much fainter, if detected, in Y and J (continuum) compared to other emission-line objects, unless they belong to a binary system. Follow-up spectroscopy will provide abundances of those elements that constrain temperature and density (i.e. age and metallicity; Leisy & Dennefeld 2006, A&A 456, 451). The study of PNe and HII regions will complement the information from the oldest (RGB and horizontal branch stars) and youngest (O-B and supergiants) stellar population, respectively. These data will allow us to constrain the evolutionary scenarios as well as an age-dependent 3D structure.

A highly accurate astrometry across the Magellanic system will be provided by GAIA. However, VMC data alone could pre-empt the determination of the proper motion of the MCs with a stable as well as accurate astrometric solution. The VMC survey will contain a sufficient number of stars of different types and locations to disentangle streaming motions from the bulk proper motion. According to King (1983, PASP 95, 163) $\sigma_x/a = 1/(\mathrm{S}/N)$ where σ_x is the accuracy of a star centroid and a is the FWHM. Thus, for $0.8''$ seeing, S/N$=10$ and 12 epochs across 5 years we obtain 5 mas/yr (0.05 mas/yr for 10^4 stars) assuming that projected distances to reference objects (quasars, distant galaxies or foreground stars of known motion) and their centroids can be determined equally accurately. A combination with 2MASS will give us a time baseline of ~ 15 years that could further improve the proper motion determination providing stability is conserved. For comparison HST measured 0.05 and 0.18 mas/yr (Kallivayalil et al. 2006, ApJ 638, 772; astro-ph/0606240) for the LMC and SMC, respectively.

2.2 Immediate objective:

The main goal of the VMC Public survey is to obtain deep and homogeneous YJK_s-band photometry across the LMC, SMC, Bridge and Stream to a sensitivity limit corresponding to $K_s = 20.3$ at $S/N = 10$. This survey reaches sources 6 magnitudes fainter than those detected by 2MASS ($S/N = 10$ at $K_s = 14.3$) across a wide-area, yet never explored at this sensitivity, and with a spatial resolution which, considering the average seeing ($0.8''$), is a factor of 2 better than that of 2MASS. These specifics translate into a tremendous improvement in the study of the overall stellar population: all RGB stars, late and post-AGB stars, red clump stars, RR Lyrae stars, Cepheids, turn-off and upper main-sequence stars will be detected and used to infer the properties (structure and history) of the system. Moreover, observations in the near-IR domain provide a higher source-to-celestial background contrast than in the optical domain. The seeing is better and the interstellar absorption is lower, making images sharper and thus overcoming crowding effects within the galaxies. According to the analytical model developed by Olsen et al. (2003, AJ 126, 452) for the average observing conditions of the VMC survey in the most crowded field we will detect turn-off stars of a 10 Gyr old population with a 10% accuracy.

From the systematic analysis of these data we aim to derive the global and spatially resolved SFH, using both field stars and star clusters, that accounts for both the intrinsic evolution within each galaxy and the dynamical evolution of the interaction between the LMC and the SMC and between the MCs and the MW. By tracing in detail the extent of different kinds of stars and deriving, using up-to-date stellar evolutionary models, age and metallicity, we will constrain the epoch of formation of each galactic component. These studies require observations in three bandwidths: the combination between K_s and Y data provides a longer baseline to interpret sub-giant stars although Y is less sensitive than J in crowded fields where colours are usually more accurate than magnitudes. On the basis of these new data, simulations of this fascinating three-body system will be tested and improved to account for the effect of each stellar component and for the inhomogeneous distribution of age and metallicity across the system.

The observing strategy designed to reach the required sensitivity allows us also to obtain the mean K_s mag of RR Lyrae and Cepheid stars, as well as the periodicity of evolved giant stars, by combining 12 independent observations. The amplitude of the near-IR lightcurve variation of these variables is low (about $0.2 - 0.4$ mag). Thus, only a limited number of points is necessary to calculate their mean magnitude. This information, which in some cases might be enough also to measure the period of variation, will be combined with accurate measures of periodicity obtained from optical surveys to constrain the slope of the zero-point of the PL relations as well as improving the current empirical constraints on the metallicity dependence. PL relations will be used to derive the 3D structure of the MCs which will also be constrained independently by the luminosity of red clump stars.

We plan to homogeneously sample a continuous area of sky using a mosaic of 110 VISTA tiles (2 of which are located in the Stream – high stellar density and low contamination from SMC stars) reconstructed using a default of 6 pawprints. This technique is an ideal compromise between the integration time and surface area needed to meet the goals of the survey as well as strengthening its legacy value, facilitating follow-up observations, data-mining and combination with other surveys.

3 Are there ongoing or planned similar surveys? How will the proposed survey differ from those? (1 page max)

The VMC survey proposed here is strongly linked and complementary to other spectroscopic and "photometric visual surveys" of the Magellanic system, which will strongly benefit from each other, providing a new, complete and absolutely unique view of this system. A list of these contemporary surveys is given below.

- STEP is a Guaranteed Time Observation (GTO) program to survey the SMC and the Bridge proposed by some members of our team (PI: Ripepi, co-I's include Cioni), using OmegaCAM on the VST, with the aim of addressing various issues concerning the SFH, the structure and the stellar components of the SMC. These data will provide the period of the light variation of RR Lyrae stars and Cepheids that, combined with the mean K_s-band mag from VMC, constitute powerful distance indicators.
- EROS-II is a micro-lensing project which repeatedly observed the MCs in two optical broad-band filters. In particular, these observations cover all of the LMC area proposed to be observed with VISTA in contrast to similar completed or on-going programs (MACHO & OGLE) that concentrate on the main bodies of the galaxies. We plan to use these data, available on a collaborative basis, to measure the periodicity of VMC RR Lyrae and Cepheid variables across the LMC.
- AAOmegallan is a large spectroscopic survey program that will use AAOmega on the AAT (PI: van Loon, co-I's include Cioni) to observe a large number of stars sampling all structural, kinematical, chronological and chemical stellar populations encompassing both the MCs and the Bridge. This survey will reach red clump stars at about $K_s = 17$. Pilot study observations were successfully obtained in February 2006.
- The SIRIUS camera on the 1.4-m telescope in South Africa has monitored about 3 deg^2 along the LMC bar since 2000 and about 1 deg^2 centred on the SMC since 2001. Both monitoring projects were completed in 2005. This Japanese-led survey has a S/N$\approx$ 20 at $K_s = 16.0$ (about half a magnitude fainter than 2MASS), the use of data products is subject to a collaborative agreement. Major questions related to the evolution of Long Period Variables and Cepheids will be answered by this program.
- There are two Spitzer Space Telescope survey programs to map the LMC (SAGE; Meixner et al. 2006, astro-ph/0606356; Blum et al. 2006, astro-ph/0608189) and the SMC (S3MC; Bolatto et al. 2006, astro-ph/0608561), with the production of a mid-IR point source catalogue as a key goal. The scientific issues focused on by the survey teams (including van Loon for S3MC) are all related to the interstellar medium. However, many mid-IR point sources are late-type giants, and so by combining these mid-IR data with VMC data, we will be able to relate the dust production sites to age and metallicity, on statistical grounds. The first out of two epochs of data from SAGE are already publicly available.

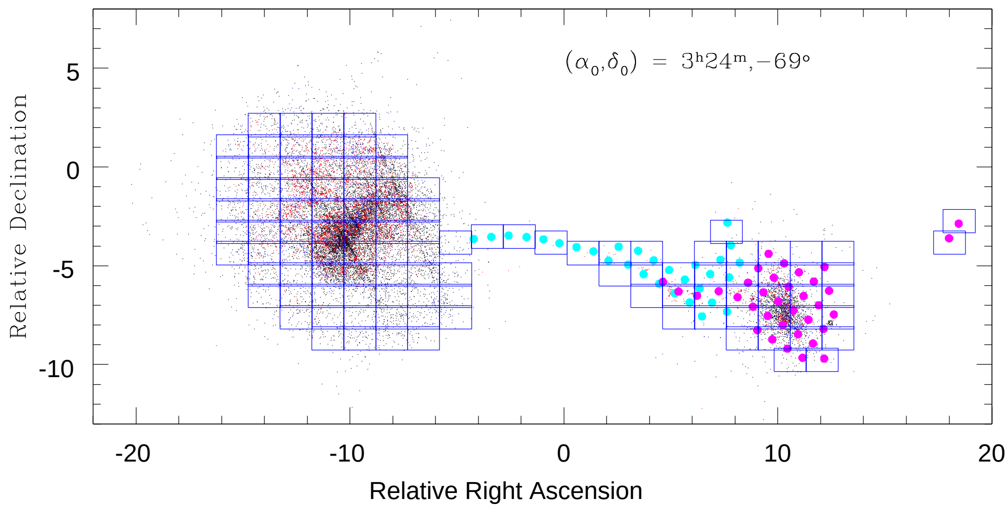


Figure 9: Distribution of VISTA tiles across the Magellanic System. Underlying small dots indicate the distribution of C stars (black), clusters (blue) and associations (red) while thick dots (light blue) show the location of VST pointings.

- The Akari satellite is carrying out a shallow 7-band all sky survey plus targeting about 2 deg^2 of the LMC in the mid-IR and far-IR domain. These observations will take place during Sept. 2006–June 2007 and a catalogue of sources should be released after about 1 year (proprietary period). Although the pixel size is rather large, these data will allow us to study dusty sources with respect to age and metallicity.
- MOSAIC observations from the Blanco 4m-telescope at NOAO of the outer regions of the MCs ($7^\circ - 20^\circ$ away from the galaxy centres) were granted to a team lead by A. Saha. The aim of this deep (about 2 mag below the faintest turn-off) Washington broad-band ($CRIM$ filters) and narrow-band survey is to probe the extent and properties of the halo of the MCs. Both RGB stars, disentangled from nearby dwarf stars, and MS stars will be used for this purpose. The spatial overlap with the VMC survey is minimum, but the scientific outcome of both data sets will be highly complementary to understand the system.
- Additional 2MASS observations covering the MCs, but not the Bridge, have been performed throughout the nominal survey time. These deep data ($6 \times t$) which will be released at the end of 2006 should reach about 1 mag fainter sources ($K_s \approx 15$ at S/N= 10). Although including the red giant bump they will not reach red clump stars. They will provide an up-to-date bright complement to VMC data.

4 Observing strategy: (1 page max)

This proposal aims to put serious constraints on the SFH and 3D structure of the Magellanic system (LMC, SMC, Bridge & Stream). The necessary spatial resolution across the entire system is only possible using deep wide-field data such as those that will be obtained using VISTA. We propose to cover an area that includes the classical D_{25} (Bothun & Thompson 1988, AJ 96, 877) limit for both galaxies as well as major features traced by the distribution of stars (Irwin 1991, IAU 148, 453, Bica et al. 1995, ApJS 101, 41 & 1999, AJ 117, 238) and HI gas (Staveley-Smith et al. 2003, MNRAS 339, 87, Hatzidimitriou et al. 2005, MNRAS 360, 117, Muller et al. 2003, MNRAS 339, 105). Therefore, we need 184 deg^2 distributed as follows: 116 deg^2 in the LMC, 45 deg^2 in the SMC, 20 deg^2 in the Bridge and 3 deg^2 in the Stream. **Figure 9** shows the distribution of VISTA tiles covering these regions as well as the distribution of carbon stars, clusters, associations and VST pointings.

Such a homogeneous wide-area survey will allow us to relate, for the first time, spatial variations in the SFH to the interaction between the LMC and the SMC and between the MCs and the MW. We will fully sample stars along the entire RGB with a sufficient S/N that will allow us to use theoretical models to constrain both age and metallicity to an unprecedented accuracy across the whole system (Olsen et al. 2003, AJ 126, 452).

Regions of high source density like the centre of the bar of the LMC may be problematic. To estimate the confusion limit we extracted 2MASS sources in the centre of the LMC and extrapolated the cumulative distribution (i.e. luminosity function). A source density of 1 per 50 detection elements represents this limit (IRAS explanatory supplement, vol. 1, VIII-2). In the best seeing conditions, a detection element ($\sim \sigma^2$) is limited by the instrumental PSF ($\sigma = 0.51''$) and otherwise is given by the seeing itself ($\sigma = 0.8''$). In bluer bands confusion is approached at brighter magnitudes than in redder bandwidths. Confusion limit is not a problem during the best seeing conditions, however if the seeing is $0.8''$ Z-band observations down to 23.5 will be confusion-limited, while Y-band observations will be just about 1 mag brighter than the limit. Therefore, we prefer Y-band over Z-band observations. Because of the airmass observability of the MCs the seeing will be worse (Sect. 5) and the most crowded regions will already approach confusion at $Y = 20.0$ and $J = 21.5$ (DIMM seeing $= 0.8''$), thus it is necessary to observe these regions (about a dozen tiles) during the best possible sky conditions. K_s-band observations will not be limited by confusion for a seeing $\leq 0.9''$. Note that these calculations are rather conservative (Hogg 2001, AJ 121, 1207) and are consistent with a large dataset that is also constrained by the processing time. For example, accurate PSF photometry, to disentangle faint stars in crowded fields, requires several iterations which are currently not part of the data reduction software (Sect. 6.3).

The strategy is to complete the observation of three observing blocks (OBs), one per filter, on a given tile as close as possible in time (same night). This procedure minimises variability effects on colours, which are more important for brighter objects, and at the same time guarantees more or less homogeneous observing conditions among different bands for a given epoch. On the other hand, to obtain average K_s magnitudes for RR Lyrae and Cepheid stars with the required accuracy we need to observe 3 individual K_s-band OBs in consecutive nights and at least 2 additional epochs spread within the following two months, respectively. The remaining K_s-band OBs will ideally be spread throughout the proposed length of the survey (to constrain the periodicity of stars in the late stages of AGB evolution).

The mid-survey goal (P79-P82) consists of (i) covering the whole Magellanic system by observing three OBs per tile (one per band); this requires about 295^h including overheads. This global coverage is essential to provide targets for follow-up observations, especially in the halo of each galaxy because of the limitations of previous surveys. Then (ii), $4 - 5$ additional K_s-band epochs will be obtained for SMC+Bridge tiles (timely with VST observations) to determine the average magnitude of short-period variables. By the end of P82 (iii), a few homogeneously distributed K_s-band epochs will also be obtained for each LMC tile. Afterwards, we suggest to spend again 295^h during P83-84 and P87-88 to obtain almost simultaneous 3-band photometry across the system. Then, LMC tiles can be observed as in (ii) during P84 while, the remaining K_s-band OBs across the system will be spread from P83 to P88.

For the purpose of photometrically calibrating the survey data, we plan to link them to the 2MASS data (one-to-one for JK_s and using colours for Y-band observations), therefore we do not require a special calibration procedure other than the one provided by ESO and we do not need to observe in photometric conditions.

5 Estimated observing time:

Period	Time (h)	Mean RA	Moon	Seeing	Transparency
P79	27	$0^h - 3^h$	bright	$\leq 1.0''$	thin
P80	300	$0^h - 7^h$	bright	$0.6'' - 1.0''$	thin
P81	72	$0^h - 3^h$	bright	$\leq 1.0''$	thin
P82	300	$0^h - 7^h$	bright	$0.6'' - 1.0''$	thin
P83	72	$0^h - 3^h$	bright	$\leq 1.0''$	thin
P84	300	$0^h - 7^h$	bright	$0.6'' - 1.0''$	thin
P85	72	$0^h - 3^h$	bright	$\leq 1.0''$	thin
P86	300	$0^h - 7^h$	bright	$0.6'' - 1.0''$	thin
P87	72	$0^h - 3^h$	bright	$\leq 1.0''$	thin
P88	300	$0^h - 7^h$	bright	$0.6'' - 1.0''$	thin

Observing Strategy	Z	Y	J	H	K_s
Time (s) & depth (mag)					
Time per object	-	3000	2400	-	10800
Depth (10σ) Vega	-	21.9	21.4	-	20.3
Time per object/tile	-	1000	800	-	900
Depth (10σ) Vega/tile	-	21.3	20.8	-	18.9
Saturation & linearity	-	12.9	12.7	-	11.4
Tiling strategy					
Detector Integration Time (DIT s)	-	20	10	-	6
Exposure co-adds (Ndit)	-	5	8	-	15
Exposure loops (Nexp)	-	1	1	-	1
Microsteps (Nmicro)	-	1	1	-	1
Jitters (Njitter)	-	5	5	-	5
Pawprints in tile (Npaw)	-	6	6	-	6
Tile Efficiency/tile					
Total Exposure sec/tile	-	3000	2400	-	2700
Total Elapsed sec/tile	-	3378	2868	-	3378
Observing efficiency /tile	-	88.8	83.7	-	79.9
Time for 184 sq deg = 110 tiles					
Number of OBs per filter for S/N	-	3	3	-	12
Total Elapsed Hours per filter	-	330	275	-	1210

5.1 Time justification: (1 page max)

The estimated exposure time needed to complete the VMC survey has been calculated using the VISTA ETCv1.2 assuming a blackbody (T= 5000 K) flux distribution, an aperture diameter of 1.6″ and 0.8″ seeing at airmass 1.5 in K_s-band (0.9″ in J and 1.0″ in Y) which corresponds to a DIMM seeing of also 0.8″ (this occurs about 45% of the time at Paranal). We have chosen this to be the average seeing for our survey to guarantee homogeneity of the data sensitivity and good point-source separation. In the most crowded regions (e.g. the centre of the LMC bar) in these conditions we will approach the confusion limit (Sec. 4). Observations with thin cirrus add an extra extinction of about 0.08 mag in K_s (much lower in J and Y) which decreases by 10% the S/N of the data, although remaining of acceptable quality to achieve the scientific results of the survey. A similar extinction is caused by observing down to airmass 2 or with a DIMM seeing of 0.9″, however, this is acceptable only in the outer (un-crowded) regions or for K_s-band observations which are not limited by confusion. The moon brightness is never a problem because it is always at least 80° away from the MCs.

To reach S/N= 10 at Vega magnitudes of $K_s = 20.3$, $J = 21.4$ and $Y = 21.9$, we need to spend on-source 3^h, 40^m and 50^m in each band respectively. These integration times will also allow us to reach 1 magnitude deeper sources at S/N= 4 which is well below the turn-off of the oldest stellar population in the LMC. Details of the observing strategy are given in the table above. Upper magnitude limits have been estimated assuming linearity until about 10^5 e^- which corresponds to a DIT time factor to peak saturation of about 1.5. The total area covered by the survey (184 deg^2; **Fig. 9**) has been calculated taking the 1.5 deg^2 covered by the inner part of each tile and adding the declination overlap (0.135 deg^2) between adjacent tiles. Tiles shown in **Fig. 9** are 1.5×1.18 deg^2 in size and they overlap by 0.1° in DEC and 0.016° in RA. The latter is the same as between adjacent paw-prints re-constructing a tile.

The gross time (including overheads) necessary to observe a tile once in 3 bands is 2^h41^m, including 50^s to move twice to adjacent filters. Our strategy is to observe 3 OBs (one block) per tile (one per band) before changing pointing. Each of the three blocks needed for the same tile will be observed during different nights. The remaining 9 K_s-band OBs per tile to reach the requested sensitivity will be obtained as explanined in Sect. 4. No other overheads are needed if OBs in the same filter precede or follow these VMC OBs. Thus, the total survey time is 1815^h and corresponds to $\sim 17\%$ of the total time available for VISTA Public Surveys.

The observing time has been distributed throughout each season to account for the observability of the MCs above airmass 1.6 for about 3^h of consecutive time but also for the observing time of the VST-GTO program. Finally, note that the Magellanic system's declination means it will probably be observable in periods of mild wind since, judging from Paranal statistics, the wind is preferentially from the North, while its right ascension makes it a primary Chilean summer target.

6 Data management plan: (3 pages max)

6.1 Team members:

Name	Function	Affiliation	Country
M.-R.L. Cioni	**PI**; Data Quality Control-III	University of Edinburgh	UK
K. Bekki	Exploitation (B)	University of New South Wales	AUS
G. Clementini	Exploitation (D,B)	INAF, Bologna Observatory	I
W.J.G. de Blok	Exploitation (A,B)	Mount Stromlo Observatory	AUS
C.J. Evans	Exploitation (C,F)	ATC, Edinburgh	UK
R. de Grijs	Exploitation (A,C)	University of Sheffield	UK
B.K. Gibson	Exploitation (A,B)	University of Central Lancshire	UK
L. Girardi	Exploitation (A)	INAF, Padova Observatory	I
M.A.T. Groenewegen	Exploitation (E)	University of Leuven	B
V.D. Ivanov	Exploitation (C,F)	ESO, Santiago	ESO
P. Leisy	Exploitation (E)	ING, La Palma	E
M. Marconi	Exploitation (D,B)	INAF, Naples Observatory	I
C. Mastropietro	Exploitation (B)	University of Munich	D
B. Moore	Exploitation (B)	University of Zürich	CH
T. Naylor	Exploitation (B)	University of Exeter	UK
J.M. Oliveira	Exploitation (F)	Univerisity of Keele	UK
V. Ripepi	Exploitation (D,B)	INAF, Naples Observatory	I
J.Th. van Loon	Exploitation (B,E)	Univerisity of Keele	UK
M.I. Wilkinson	Exploitation (B,C)	University of Cambridge	UK
P.R. Wood	Exploitation (C,E)	Mount Stromlo Observatory	AUS
J. Emerson	VDFS Coordinator	Queen Mary University of London	UK
CASU (VDFS) team	Pipeline processing & Data Quality Control-I	University of Cambridge	UK
WFAU (VDFS) team	Science Archive & Data Quality Control-II	University of Edinburgh	UK

Note 1: Areas of scientific activity are coded as follows: A - SFH; B - galaxy structure; C - clusters; D - RR Lyrae & Cepheid stars; E - AGB & post-AGB stars, PN; F: star formation, obscured massive stars.

Note 2: The CASU (VDFS) team consists of Irwin, Lewis, Hodgkin, Evans, Bunclark, Gonzales-Solares, Riello. The WFAU (VDFS) team consists of Hambly, Bryant, Collins, Cross, Read, Sutorius, Williams.

6.2 Detailed responsibilities of the team:

We will use the VISTA Data Flow System (VDFS; Emerson et al. 2004, SPIE 5493, 401; Irwin et al. 2004, SPIE 5493, 411; Hambly et al. 2004, SPIE 5493, 423) for all aspects of data management, including: pipeline processing and management; delivery of agreed data products to the ESO Science Archive; production of a purpose-built IVOA compliant science archive with advanced datamining services; enhanced data products including federation of VISTA survey products with SDSS survey products. Standardised agreed data products produced by VDFS will be delivered to ESO, with copies remaining at the point of origin. 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 is a working systems-engineered system that is already being successfully employed for the UKIRT WFCAM surveys as a test bed for the VISTA IR 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 emphasise 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 First Data release.

The VMC science survey team includes 20 members (see Table above) who will be among the first scientists to exploit the survey data. Our expertise covers a broad range of astrophysical topics from stellar astronomy to galactic dynamics and each member has a well-established position in his/her field of research. The team will be in place until about a year after the completion of the survey and it is likely to expand seeking postdocs and/or students to work in association with the VMC survey.

The PI, Cioni, comes to this having compiled and exploited the DENIS catalogue towards the MCs to study in particular the evolved stellar population and its relation to the spatially resolved chemical and formation history of both Clouds. She will supervise the data analysis and work on the product definition and quality assessment of the data products as well as coordinating the science exploitation on behalf of the team and contributing to various aspects of it. The OBs will be prepared by Cioni, van Loon, Ripepi and de Grijs.

Different scientific topics will be tackled by sub-groups within the team: – De Grijs and Ivanov will focus on the cluster properties and the system's interaction history; – Girardi will analyse the field population, first subtracting the Galactic foreground component and then deriving the spatially resolved SFH, with the aid of synthetic data and available SFH-recovery algorithms; – artificial star tests will be performed, using the VDFS code or standard routines, by Girardi and Ivanov; – Clementini, Marconi and Ripepi will coordinate the light curve analysis of the RR Lyrae and Cepheid star population addressing issues related to the structure of the Magellanic System (3D map) using variable stars as population tracers as well as combining these observations with those from optical studies; – Oliveira and Evans will concentrate on the process of star formation and on young stars while Groenewegen, van Loon and Wood will concentrate on evolved stars (both these studies will combine VMC data with mid-IR data from Spitzer, that will be publically available and eventually from Akari, depending on data availability); – Leisy will analyze the data (both images and catalogues) to identify extended sources as well as complementing the VMC data with high-resolution Hα and [OIII] observations which will allow him to develop a method to increase the census of PNe within the system; – Gibson and Wilkinson, as well as other members of the AAOmegallan collaboration, will trace the distribution of different populations of stars combined with the kinematic and abundance data obtained from AAOmega or other facilities (in particular van Loon & Evans will use red-clump stars to constrain the 3D structure of the system); – Naylor has been developing data mining techniques based on his τ^2 fitting work (2005, *Protostars and Planets*, Proc. p8502) which can be applied to search colour-magnitude-position spaces for structures that have the colour-magnitude dependencies expected of stellar groups; – Bekki, Mastropietro, Moore and Gibson will use the data to constrain models of the evolutionary interaction between the MCs and the MW as well as between the LMC and the SMC; – de Blok will relate the SFH and any feature traced by stars with the structures (holes and arms) seen in the HI, to check if consistent conditions/rules for star formation can be derived. Public outreach initiatives within the VMC survey comprise setting-up a dedicated web page, that will also be used by team members to post results of their investigations, producing posters and teaching packs. Several team members are already involved in similar activities.

6.3 Data reduction plan:

The data reduction will be using the VDFS, operated by the VDFS team, and augmented by individuals from VMC science team, especially for product definition and product Quality Control. We divide the plan into two distinct but intimately related parts: pipeline processing and science archiving. CASU is responsible for the VDFS pipeline processing component which has been designed for VISTA. It has been scientifically verified by processing wide-field mosaic imaging data from WFCAM@UKIRT and is now routinely used to process up to 250GB/night of data. The pipeline is a modular design allowing straightforward addition or removal of processing stages and will have been tested on a range of input VISTA datasets. The standard processing includes: – non-linearity, dark, flat, fringe and cross-talk correction; – sky subtraction (tracking and homogenisation during image stacking and mosaicing); – combination of dithered images; – point source extraction; – astrometric and photometric calibration (the latter put in an internally uniform system as well as in an optimized system obtained by monitoring suitable pre-selected standard areas covering the specific VMC survey area); – shape and data quality information. The processing history including calibration files is recorded directly in FITS headers.

The Science Archive (SA) ingests the products of the pipeline processing into a database and then curates them to produce enhanced database-driven products. This process includes: – individual passband frame association and source association to provide multi-colour, multi-epoch source lists; – global photometric calibration; – cross-association with external catalogues and generation of new image products (e.g. stacks, mosaics and difference images); – quality control procedures, as required by the public survey consortium, and supported by the archive team members. These features are available in the context of a continually updating survey dataset from which periodic releases (as required by the community) can be made. A point-and-click web form as well as full access to Structure Query Language constitute the dual (simple and sophisticated) end-user interfaces for the data. A generalised relational model for survey catalogue data has been developed in the VDFS. The key features to note are the normalised design with multi-waveband catalogue data that allow the user to track right back to the individual source images and merged-source tables that present the user with a generally applicable science-ready dataset. The SA has a high-speed query interface, links to analysis tools such as TopCat, and advanced new VO services such as MySpace. Data products are being successfully ingested into the WFCAM-SA in Edinburgh, with the first data release in July 2006.

VMC is intrinsically a multi-wavelength project and most science will come from the linking of VISTA data with VST and other survey data; the SA is designed to enable such links.

6.4 Expected data products:

The data products will be made available a few months after the observation of a given tile is performed. The main data products of the VMC survey are: – instrumentally calibrated single-band images of tiles along with header descriptors propagated from the instrument and processing steps (science and calibration frames) and provenance (pawprints re-constructing a tile); – statistical confidence map for each tile; – derived single-band single-epoch tile-object catalogue based on a standard VDFS set of object descriptors including astrometric and photometric (both aperture and PSF) measures, morphological classification, and source extraction flags; – multi-waveband and multi-epoch catalogues per tile obtained as a result of linking individual single-band single-epoch catalogues; – homogeneous epoch-merged and band-merged master catalogues per tile. Such a catalogue will be created at each major survey data release (e.g. mid-survey) from stacked images obtained up to a given date and only at the end of the survey will reach the proposed sensitivity in all three wavebands. While most of these specifics are being implemented in VDFS, source extraction flags and mosaicing of tiles prior to the extraction of point sources, in order to cover the declination tile-overlap down to the same sensitivity as that in the centre of each tile, are under review.

Further data products will be released within about a year after the completion of the survey. A partial release will be made about a year after the mid-survey goal. These include: (i) cross-correlation with VST observations – subject to GTO policy release; (ii) cross-correlation with kinematic and abundance data from the AAOmegallan or other programs – subject to acceptance, scheduling and policy release; (iii) catalogues of known variables (i.e. RR Lyrae stars, Cepheids and late-type giants) containing multi-epoch and mean magnitudes.

6.5 General schedule of the project:

If this proposal is awarded time observations will begin in September 2007. By then commissioning data will allow us to evaluate the efficiency of our observing technique as well as to revise the observing time requested accounting for the instrument efficiency and real overheads.

Before observations begin we will hold a team meeting to define the strategy of the project and the workload, in order to meet our mid-term goal after the first two years of observations (2007 – 2009). As an immediate consequence team members will apply for funding to employ postdocs and students who will promptly contribute to the quality accessment as well as the exploitation of the data.

The time-scale for availability of survey products depends on ESO for the release of raw images and on VDFS for the release of individual point-source catalogues (per tile, per band and per epoch). The ESO policy in this respect is generally to have data products delivered to the ESO archive within the semester following the one in which the raw data was sent out. By default, it is likely that the same will apply for VISTA.

Project mid-term approximately corresponds to the expected completion of the STEP observations. Therefore it is essential that we maximize the scientific output from these surveys. During the following years much will be learned from their unique combination. As soon as the first data (images and catalogues) will be available sub-groups, as defined in the previous section, will begin testing and upgrading analysis routines (i.e. cross-correlation algorithms, artificial star tests, light-curve analysis, cluster analysis, nebulae characterisation, etc...) to perform efficiently and up to expectations with the VMC data.

The observation of the Magellanic System as proposed in this survey (defined as airmass above 1.6 for less then 3 consecutive hours to execute once an OB in each filter; see Sect. 5) will be mostly obtained from August to January, inclusive, of each year. Therefore, before the next 6-months observing season begins we will have analyzed the data of the previous observing season. These will be discussed in a yearly meeting where we will access the progress of the survey as well as define the writing and publication of early-survey results.

Note that a IAU Symposium on the Magellanic Clouds has been proposed in Keele (UK) for the European summer of 2008; this will be an ideal place to present early science results from VMC.

7 Envisaged follow-up: (1 page max)

The global, wide and homogeneous coverage of the Magellanic System in YJK_s bands down to a sensitivity that directly matches recently or newly obtained optical observations is going to provide a unique database for a variety of astrophysical topics, from the investigation of the properties of individual/rare stars to the parametrisation of the galaxies as a whole and their dynamical history.

We expect that a number of follow-up studies will originate from the public release of the VMC survey data (many targets will already be available before its completion). These will span the range from stellar via galactic to extra-galactic topics. For example, such a deep survey in the outer regions of the MCs will provide information on the distant Universe. The sensitivity of the VMC survey ($Ks = 21.5$ and $J = 23.5$ at S/N=4) corresponds to the current UKIDSS Deep Extra-galactic Survey limit which aims to detect obscured objects (starburst galaxies and obscured AGN) as well as normal galaxies defined in the rest-frame optical spectral energy distribution at $z > 1$. These newly detected objects will be suitable targets for multi-object spectroscopic studies to confirm their redshift as well as observations at mm, far-IR and X-rays wavelengths to characterize their properties.

Although the VISTA data combined with STEP data and the abundance and kinematics results, from AAOmegallan or similar projects, will "close" the picture on the global chemical and dynamical evolution of the MC system, follow-up spectroscopic studies are envisaged using large-scale telescopes (i.e. VLT) able to access sources much fainter than the RGB clump. These will be mostly devoted to the determination of the chemical abundance of peculiar stars and or the kinematics of newly discovered substructures, that are not yet targeted by other surveys. The availability of VMC data will provide a wealth of suitable targets for new VLT instruments such as the echelle near-IR spectrograph CRIRES and the multi-object near-IR spectrometer KMOS.

Concerning dust enshrouded star formation and obscured evolved stars VMC data are sensitive enough to provide counterparts to Spitzer detections. The availability of near-IR sources will immediately allow us to fully exploit the Spitzer database across the MCs. For example stellar clusters in star forming regions will be spatially resolved by VISTA but not by Spitzer. The combination of both datasets will certainly contribute to highlight targets for subsequent follow-up studies. Moreover, the fusion of the wide-field VMC & STEP photometry with spectroscopy will identify both high- and low-mass emission line stars, in particular determining the incidence of circumstellar disks via their IR excesses.

It is not excluded that the successful outcome of the VMC survey will bring to extending the near-IR coverage to outer areas providing, for example, a unique counterpart to MOSAIC data for the study of the halo of the MCs and in particular of substructures originating from the three-body interaction.

8 Other remarks, if any: (1 page max)

The VMC survey is a deep wide-area near-IR survey of the Magellanic system. Depth and coverage are unique factors truly opening up new science. Following the comments from the Public Survey Panel, the initially thought paw-print approach has been reconsidered. The current strategy (80% efficient) uses a mosaic of tiles focusing on the most representative MC areas (including the Stream) and yet being sufficiently extended to meet the most important original aims. Other points are addressed below.

The requested observing time for the survey is driven by the required depth in the K_s band (> 19.75 for the LMC and > 20.25 for the SMC) to obtain accurate SFHs which represent a significant progress over present-day optical surveys. For example, the VST depth of $i' \sim 24$ corresponds to $K_s = 21.4$ which VMC will reach with a S/N$=4$. Note that there is no near-IR counterpart for existing and planned optical surveys to this sensitivity!

The proposed bi-epoch VHS survey down to $Ks = 17.3$ mag (Vega) at S/N$= 10$ will only provide incremental science. However, in the outermost parts, not targeted by VMC, it will allow us to study the extended halo of each galaxy as well as to recognize substructures (streams and tidal tails), originating from the three-body system interactions, from overdensities of upper RGB stars. The depth necessary to meet the VMC goals (global SFH and 3D structure) would considerably limit the performace of a VHS survey.

The wide-area covered by the VMC is also vital to surpass the information that deep but spatially limited observations have already obtained across the MCs. Even if HST pointings would be targeted by the much larger VISTA tiles we will still have a biased view of the different MC components (inner and outer disk, bar, etc.) and above all we will not be able to recover the global 3D structure of the system.

Concerning secondary issues raised by the Public Survey Panel:

- The techniques of CMD analysis aim exactly at disentangling mixed populations. Available codes for optical data work equally well for near-IR data. Simulations and a detailed discussion are provided in the text of the proposal.
- Available microlensing surveys combined with VST observations will provide periodicity informations across the entire area observed by VMC. In particular, EROS-II for the LMC and VST for the Bridge, the SMC and the Stream fields. The whole SMC area is also covered by EROS-II while other surveys like MACHO and OGLE are limited to the bar regions. Therefore, there is no need to modify the present VMC strategy, optimized to measure the average magnitude of short period variables, to determine their amplitude and period of variation.
- A case to measure the proper motion of the MCs has been developed in the proposal but its feasibility largely depends on the stability and accuracy of VISTA observations as well as their combination with 2MASS observations.
- The seeing constraint has been relaxed for observations of the Bridge and the Stream as well as in the outermost parts around each galaxy where the source density is low. However, considering other observing parameters (sky transparency and airmass) it is necessary to stop at $1.0''$. In particular, the most crowded parts (about a dozen tiles) should be observed with a seeing well below $0.8''$ to beat confusion, especially in the Y band.