EUROPEAN SOUTHERN OBSERVATORY

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

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APPLICATION FOR OBSERVING TIME LARGE PROGRAMME PERIOD: **79B**

Important Notice:

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

1. Title Category: **B–2**

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

2. Abstract / Total Time Requested

Total Amount of Time: Total Number of Semesters:

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 in other places in the Universe.

3.

Run	Period	Instrument	Time	Month	Moon	Seeing	Sky Trans.	Obs.Mode
A	79	VIRCAM	27h	any	n	$\leq 1.0''$	THN	s
B	80	VIRCAM	115h	any	n	$\leq 1.0''$	THN	s
C	80	VIRCAM	172h	any	n	$\leq 0.8''$	THN	s
D	80	VIRCAM	13h	any	n	$\leq 0.6''$	THN	s
E	81	VIRCAM	72h	any	n	$\leq 1.0''$	THN	s
F	82	VIRCAM	115h	any	n	$\leq 1.0''$	THN	s
G	82	VIRCAM	172h	any	n	$\leq 0.8''$	THN	s
H	82	VIRCAM	13h	any	n	$\leq 0.6''$	THN	s
I	83	VIRCAM	72h	any	n	$\leq 1.0''$	THN	s
J	84	VIRCAM	115h	any	n	$\leq 1.0''$	THN	s
K	84	VIRCAM	172h	any	n	$\leq 0.8''$	THN	s
L	84	VIRCAM	13h	any	n	$\leq 0.6''$	THN	s

Following runs moved to box 3a, last page...

4. Principal Investigator: **M.-R. Cioni** (University Edinburgh, UK, mrc@roe.ac.uk)

CoI(s): K. Bekki (University of New South Wales, AUS), G. Clementini (INAF, Bologna Observatory, I), W.J.G. de Blok (Mount Stromlo Observatory, AUS), C.J. Evans (ATC, Edinburgh, UK), R. de Grijs (University of Sheffield, UK), B.K. Gibson (University of Central Lancshire, UK), L. Girardi (INAF, Padova Observatory, I), M.A.T. Groenewegen (University of Leuven, B), V.D. Ivanov (ESO, Santiago, ESO), P. Leisy (ING, La Palma, S), M. Marconi (INAF, Naples Observatory, I), C. Mastropietro (University of Munich, D), B. Moore (University of Zürich, CH), T. Naylor (University of Exeter, UK), J.M. Oliveira (University of Keele, UK), V. Ripepi (INAF, Naples Observatory, I), J.Th. van Loon (University of Keele, UK), M.I. Wilkinson (University of Cambridge, UK), P.R. Wood (Mount Stromlo Observatory, AUS)

5. Description of the proposed programme

A) Scientific Rationale: See extended ESO Public Proposal Form.

B) Immediate Objective: The main goal of the VMC Public survey is to obtain deep and homogeneous YJK_s-band photometry across the LMC, the SMC, the Bridge and the 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.

C) Telescope Justification: There is no other wide-field near-IR camera in the Souther Hemisphere suitable to host the VMC survey.

D) Observing Mode Justification (visitor or service): This is a Public Survey that is going to be done in service mode.

5. Attachments (Figures)

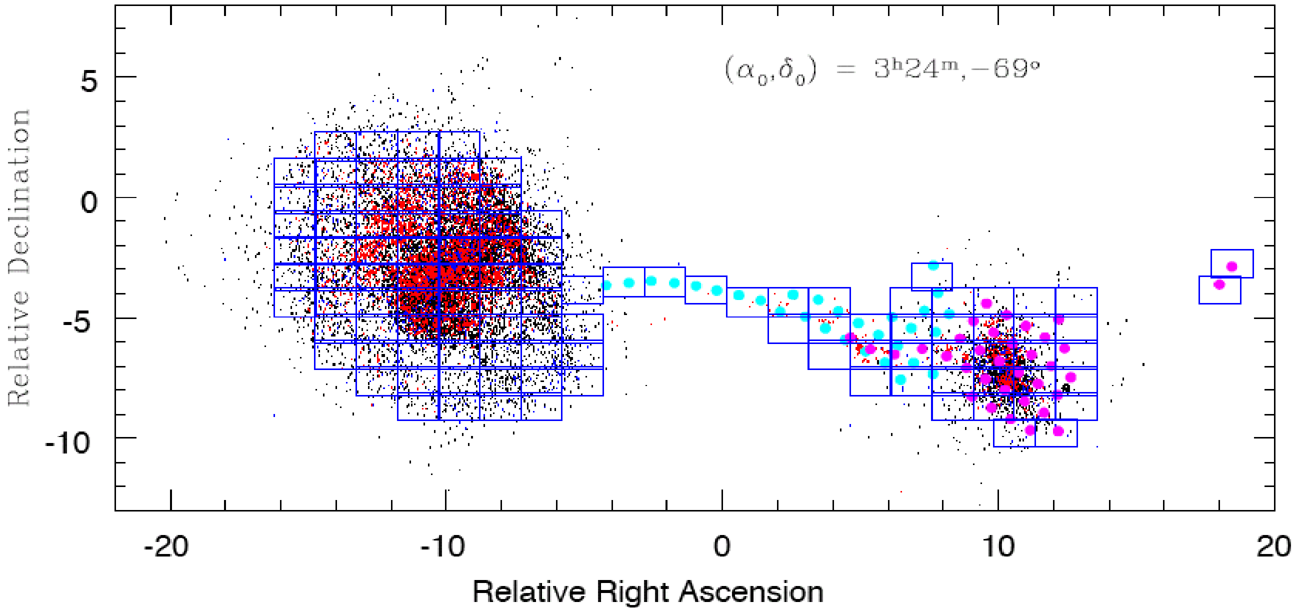
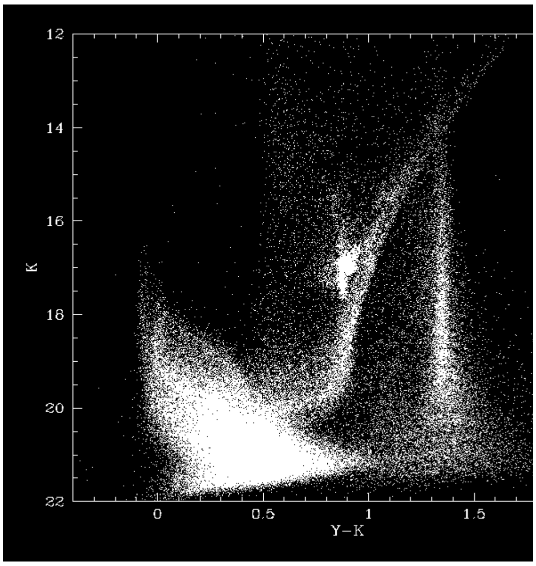
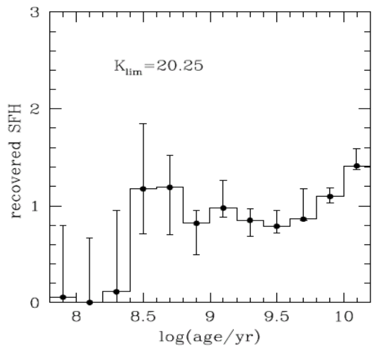


Fig. 1: Distribution of VISTA tiles across the Magellanic System. Underlying small dots indicate the distribution of C stars (black), clusters (blue) and associations (red) while thick dots (light blue & magenta) show the location of VST pointings.

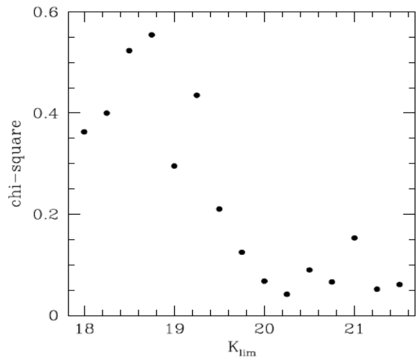


Simulated colour-magnitude diagrams for a 0.6 deg^2 LMC area close to Hodge 10, whose SFH is known from HST data (Holtzman et al. 1999, AJ 118, 2262). The simulation uses UKIDSS filter curves, a uniform extinction of $A_V = 0.18$ mag, and the photometric errors expected from our targeted S/N. Clearly 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 $0.5 < (Y-K) < 1.5$.

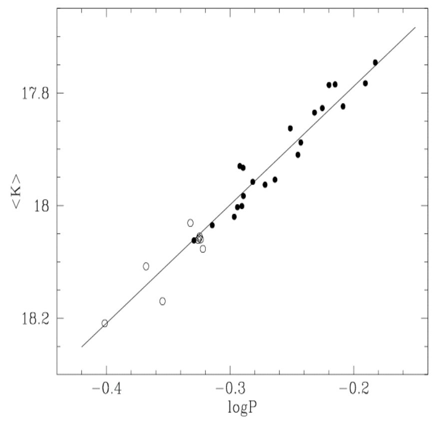
5. Attachments (Figures)



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.



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 $K_{lim} > 19.75$.



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.

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

   See extended ESO Public Surveys Proposal Form.

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

   See extended ESO Public Surveys Proposal Form.

8. Special remarks:

9. Justification of requested observing time and lunar phase

Lunar Phase Justification: The moon is always at least 80° away from the Magellanic system.

Time Justification: (including seeing overhead) See extended ESO Public Surveys Proposal Form.

Calibration Request: Standard Calibration

Convert to a normal programme? No

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

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

Cioni M.-R.L., Girardi L., Marigo P., Habing H.J., 2006, A&A 452, 195: AGB stars in the Magellanic Clouds. III. The rate of star formation across the Small Magellanic Cloud

Cioni M.-R.L., Girardi L., Marigo P., Habing H.J., 2006, A&A 448, 77: AGB stars in the Magellanic Clouds. III. The rate of star formation across the Large Magellanic Cloud

Anders P., Bissantz N., Fritze-v. Alvensleben U., de Grijs R., 2004, MNRAS 347, 196: Analysing observed star clusters SEDs with evolutionary synthesis models: systematic uncertainties

de Grijs R., Anders P., 2006, MNRAS 366, 295: How well do we know the age and mass distributions of the star clusters system in the Large Magellanic Cloud?

Bekki K., Chiba M., 2005, MNRAS 356, 680: Formation and evolution of the Magellanic Clouds – I. Origin of structural, kinematic and chemical properties of the Large Magellanic Cloud

Mastropietro C., Moore B., Mayer L., et al., 2005, MNRAS 363, 509: The gravitational and hydrodynamical interaction between the Large Magellanic Cloud and the Galaxy

Connors T.W., Kawata D., Gibson B.K., 2006, MNRAS 371, 108: N-body simulations of the Magellanic Stream

Dall'Ora M., Storm J., Bono G., et al., 2004, ApJ 610, 269: The Distance to the Large Magellanic Cloud Cluster Reticulum from the K-Band Period-Luminosity-Metallicity Relation of RR Lyrae Stars

Marconi M., Bono G., Caputo F., et al., 2005, MemSait 77, 67: Classical Cepheids as age indicators

Leisy P., Dennefeld M., 2006, A&A 456, 451: Planetary nebulae in the Magellanic Clouds. II. Abundances and element production

12. List of targets proposed in this programme

Run	Target/Field	α(J2000)	δ(J2000)	ToT	Mag.	Diam.	Additional info	Reference star
DHLPT	LMC bar	05 30 00	-69 00 00	48.3				
CGKOS	LMC bar	05 30 00	-69 00 00	50.7				
CGKOS	LMC north	05 30 00	-65 00 00	152.65				
AEIMQ	LMC north	05 30 00	-65 00 00	103.15				
CGKOS	LMC south	05 30 00	-73 30 00	152.65				
AEIMQ	LMC south	05 30 00	-73 30 00	103.15				
CGKOS	LMC east	06 00 00	-68 00 00	152.55				
AEIMQ	LMC east	06 00 00	-68 00 00	103.05				
CGKOS	LMC west	05 00 00	-69 00 00	152.65				
AEIMQ	LMC west	05 00 00	-69 00 00	103.15				
DHLPT	SMC bar	01 00 00	-73 00 00	16.1				
CGKOS	SMC bar	01 00 00	-73 00 00	16.9				
CGKOS	SMC north	01 30 00	-71 30 00	45.40				
AEIMQ	SMC north	01 30 00	-71 30 00	28.85				
BFJNR	SMC north	01 30 00	-71 30 00	28.90				
CGKOS	SMC south	00 30 00	-74 00 00	45.35				
AEIMQ	SMC south	00 30 00	-74 00 00	28.85				
BFJNR	SMC south	00 30 00	-74 00 00	28.90				
CGKOS	SMC east	01 45 00	-74 00 00	45.40				
AEIMQ	SMC east	01 45 00	-74 00 00	28.85				
BFJNR	SMC east	01 45 00	-74 00 00	28.90				
CGKOS	SMC west	00 45 00	-71 00 00	45.35				
AEIMQ	SMC west	00 45 00	-71 00 00	28.85				
BFJNR	SMC west	00 45 00	-71 00 00	28.90				
AEIMQ	Bridge centre	03 15 00	-73 00 00	35.75				
BFJNR	Bridge centre	03 15 00	-73 00 00	35.75				
AEIMQ	Bridge east	04 00 00	-72 30 00	35.75				
BFJNR	Bridge east	04 00 00	-72 30 00	35.75				
AEIMQ	Bridge west	02 30 00	-73 30 00	35.75				
BFJNR	Bridge west	02 30 00	-73 30 00	35.75				
AEIMQ	Stream	00 15 00	-64 00 00	16.40				
BFJNR	Stream	00 15 00	-64 00 00	16.50				

Target Notes: This list of pointings covers approximately the entire area that the VMC survey aims to observe. Times which correspond to an average number of tiles in given regions are in hours.

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

These data do not exist in the ESO Archive.

13. Scheduling requirements

14. Instrument configuration

Period	Instrument	Run ID	Parameter	Value or list
79	VIRCAM	A	IMG	YJK_s
80	VIRCAM	B	IMG	YJK_s
80	VIRCAM	C	IMG	YJK_s
80	VIRCAM	D	IMG	YJK_s
81	VIRCAM	E	IMG	YJK_s
82	VIRCAM	F	IMG	YJK_s
82	VIRCAM	G	IMG	YJK_s
82	VIRCAM	H	IMG	YJK_s
83	VIRCAM	I	IMG	YJK_s
84	VIRCAM	J	IMG	YJK_s
84	VIRCAM	K	IMG	YJK_s
84	VIRCAM	L	IMG	YJK_s
85	VIRCAM	M	IMG	YJK_s
86	VIRCAM	N	IMG	YJK_s
86	VIRCAM	O	IMG	YJK_s
86	VIRCAM	P	IMG	YJK_s
87	VIRCAM	Q	IMG	YJK_s
88	VIRCAM	R	IMG	YJK_s
88	VIRCAM	S	IMG	YJK_s
88	VIRCAM	T	IMG	YJK_s

3a. Run	Period	Instrument	Time	Month	Moon	Seeing	Sky Trans.	Obs.Mode
	...continuing from box 3, first page.							
M	85	VIRCAM	72h	any	n	$\leq 1.0''$	THN	s
N	86	VIRCAM	115h	any	n	$\leq 1.0''$	THN	s
O	86	VIRCAM	172h	any	n	$\leq 0.8''$	THN	s
P	86	VIRCAM	13h	any	n	$\leq 0.6''$	THN	s
Q	87	VIRCAM	72h	any	n	$\leq 1.0''$	THN	s
R	88	VIRCAM	115h	any	n	$\leq 1.0''$	THN	s
S	88	VIRCAM	172h	any	n	$\leq 0.8''$	THN	s
T	88	VIRCAM	13h	any	n	$\leq 0.6''$	THN	s