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AIP

Spectroscopic follow-up of the VMC survey

The VISTA survey of the Magellanic Clouds system

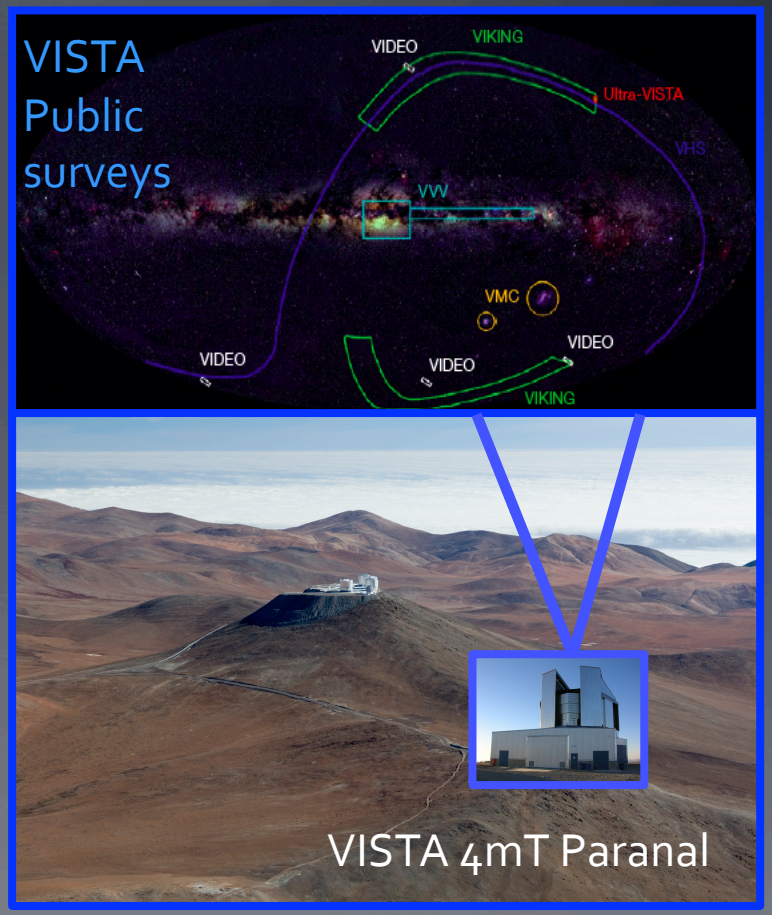
VMC

http://star.herts.ac.uk/~mcioni/vmc/

~30% complete

VMC survey

- Filters: Y, J, K_s
- Camera: 16 Rayethon detectors
- Sampling: 0.34"/pix
- FOV: 1.65 deg^2
- Area: 218 deg^2
- Sensitivity: YJK_s~22 (5σ Vega)
- Saturation: K_s~10
- Epochs: 3 (YJ) + 12 (K_s)
- Time-scale: 2009+



Cioni et al., A&A, 2011, 527, A116

VMC primary science

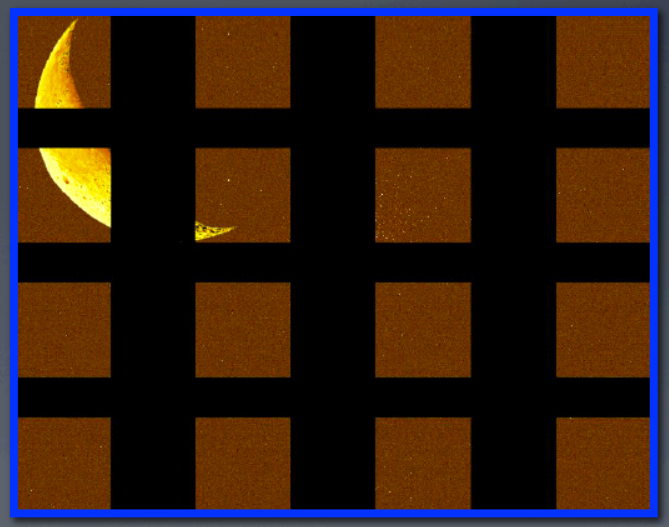
VMC is the most sensitive survey of the Magellanic system in the near-IR and with the best spatial resolution.

- Spatially resolved star formation history
  - By reaching stars below the old main-sequence turnoff
  - By interpreting colour-magnitude diagrams
- 3D geometry
  - Using Cepheids and RR Lyrae stars
  - Using red clump giant stars

VMC legacy science

- Milky Way
- Star formation
- Individual stars
- Stellar clusters
- Galaxy dynamics
- Quasars

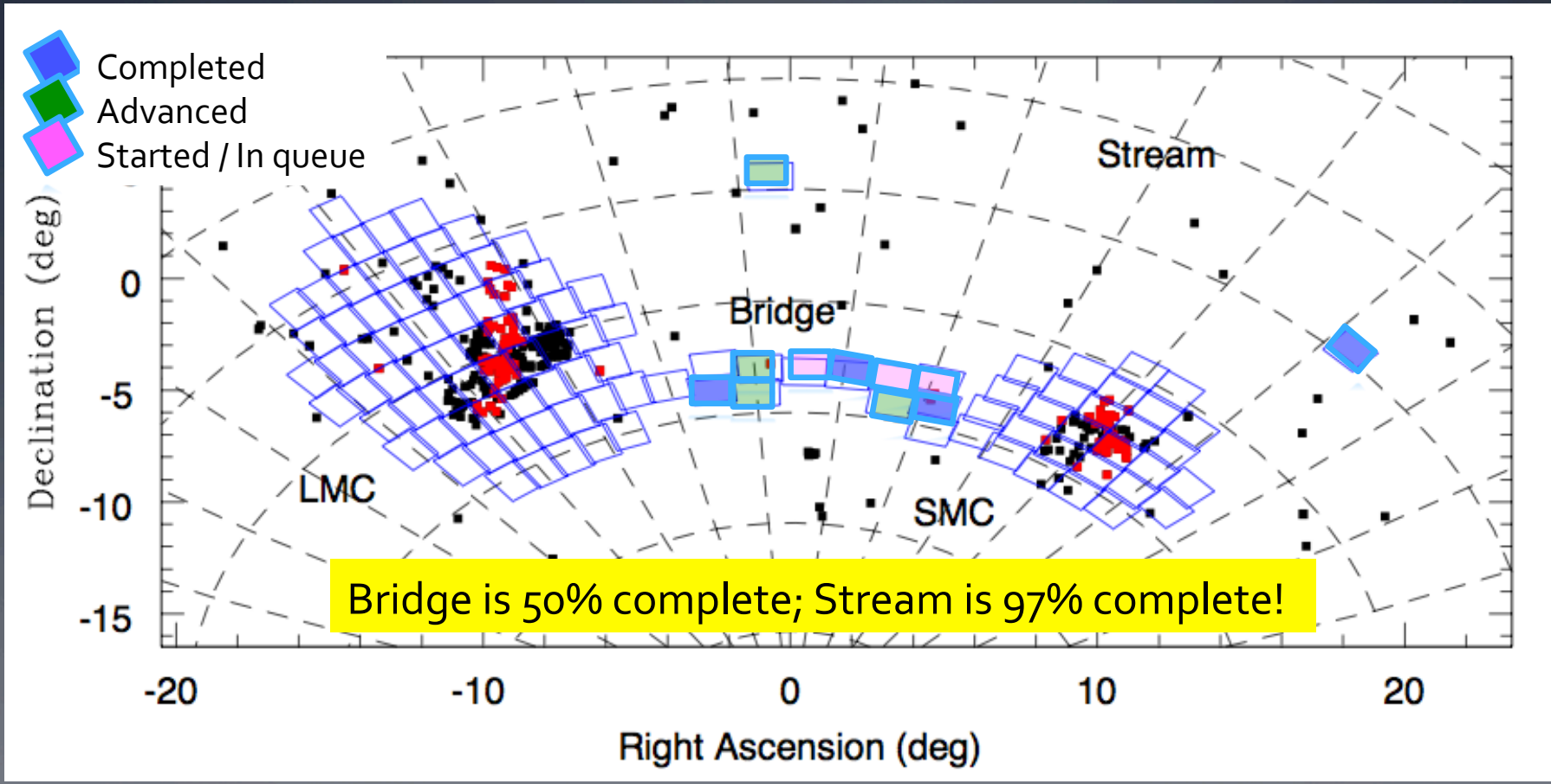
VISTA field of view



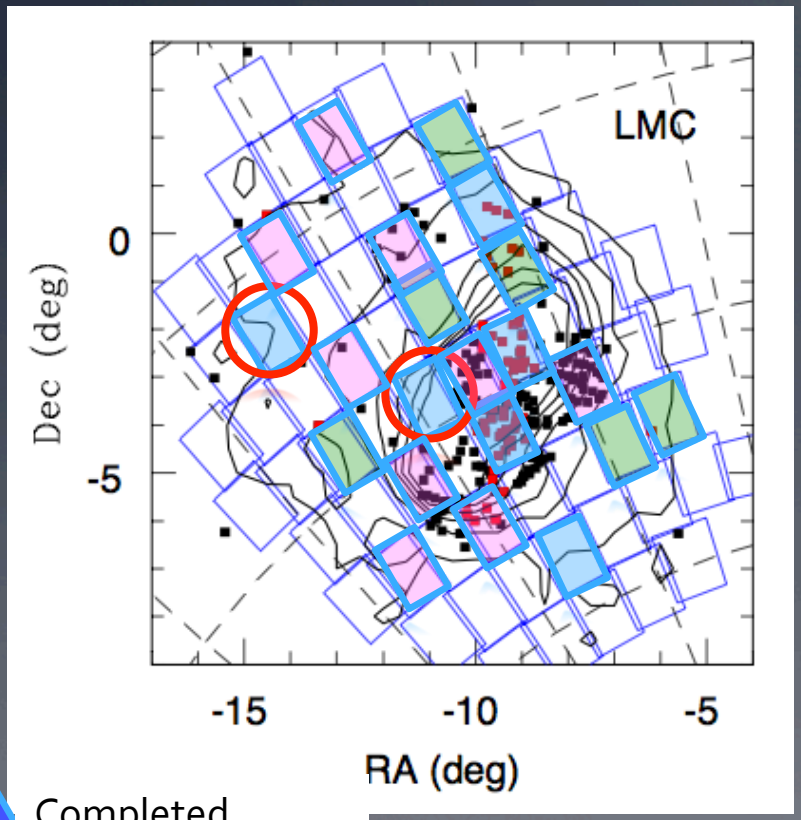
Average quality of VMC individual epochs

Filter	FWHM	Ellipticity	Zero-Point	Mag. Limit
Y	0.98 (0.13)	0.06 (0.01)	23.16 (0.22)	20.00 (0.89)
J	0.96 (0.11)	0.06 (0.01)	23.26 (0.33)	19.85 (0.70)
Ks	0.93 (0.10)	0.06 (0.01)	23.02 (0.13)	19.28 (0.26)

VMC survey progress
Bridge & Stream



VMC survey progress
LMC & SMC



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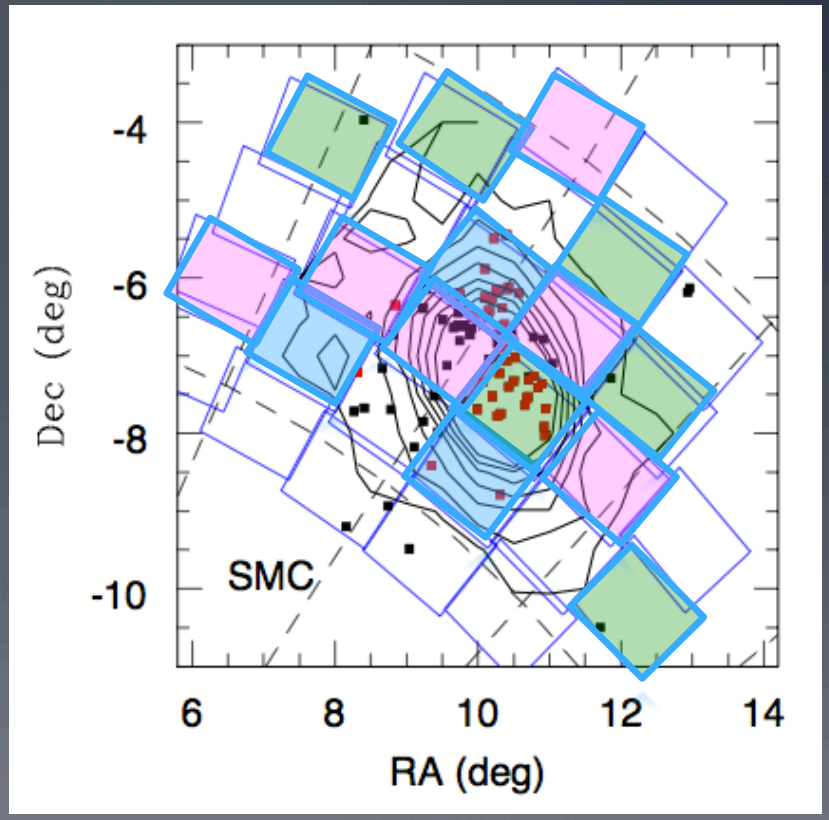


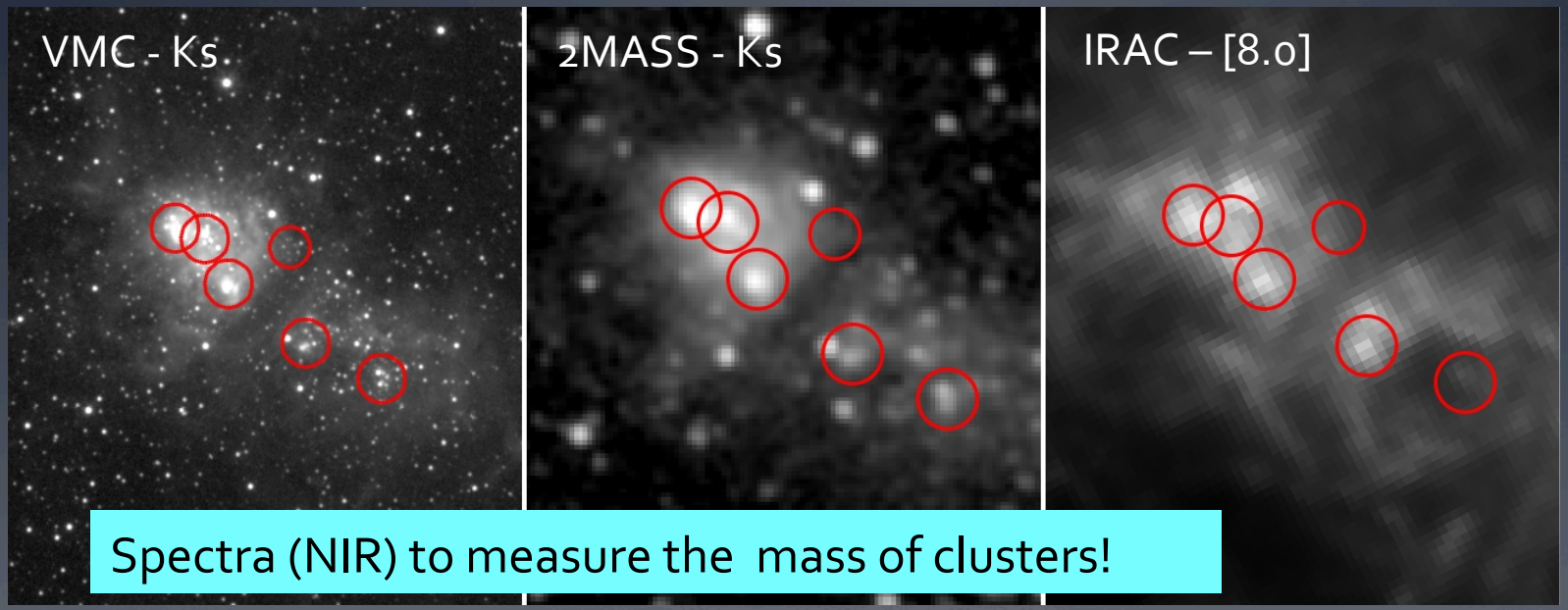
Completed
Advanced
Started / In queue

Public

LMC is 19% complete; SMC is 38% complete!

Science highlights & spectroscopy

VMC: embedded clusters

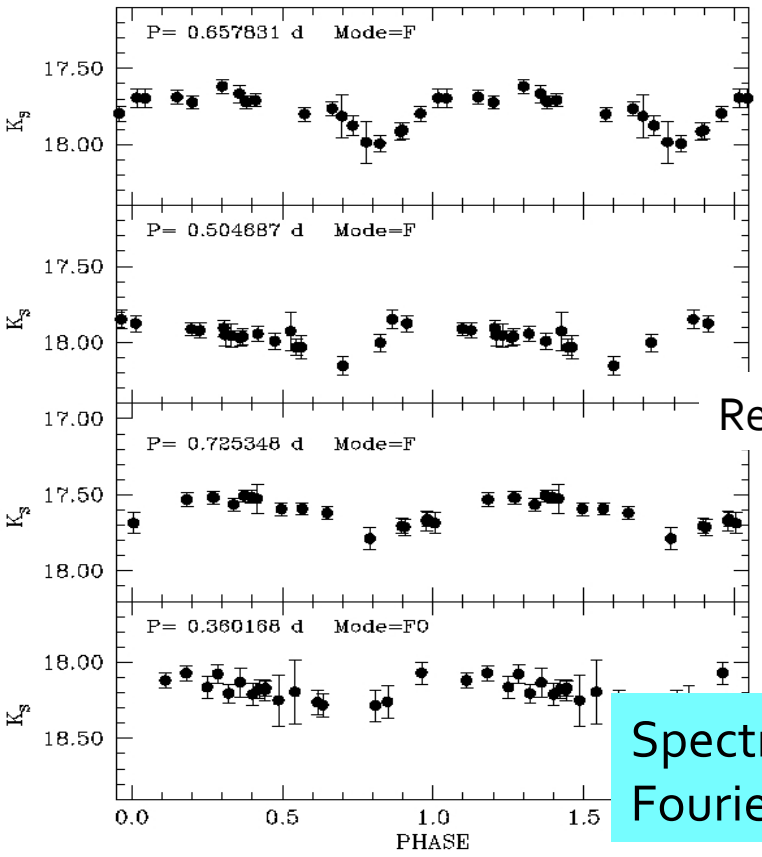


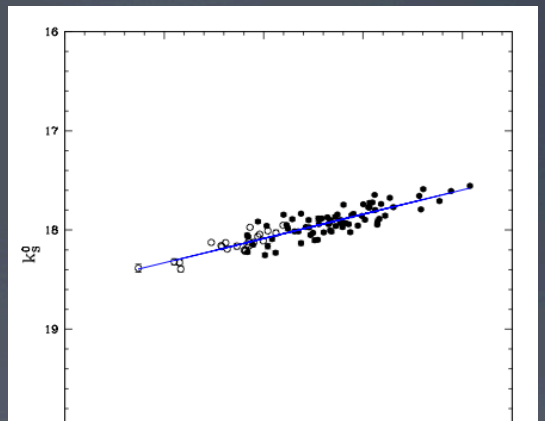
191 clusters identified by eye from VMC 30 Dor image
83 clusters with CO counterparts;
44.5% overlap with YSOs from Spitzer
69 newly discovered!

Cluster luminosity is related to cluster mass:
LMC clusters are more luminous than MW ones.

Romita et al., in preparation

VMC: RR Lyrae stars

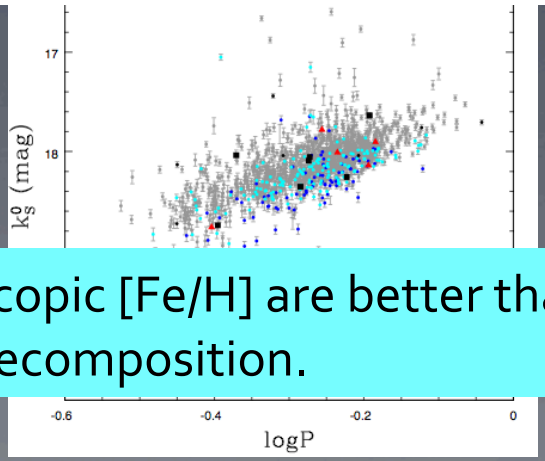




PL relation in SEP field.

Being updated with recent OGLE-IV data!

Reddening can be estimated from RR Lyrae stars.

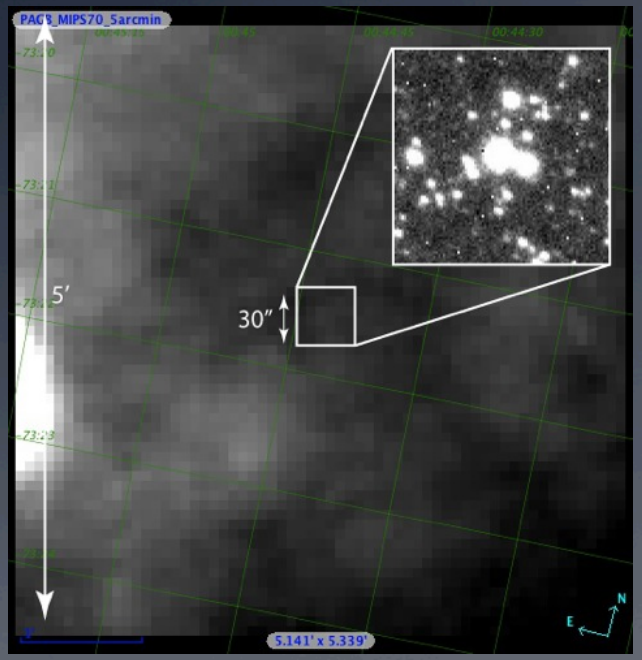


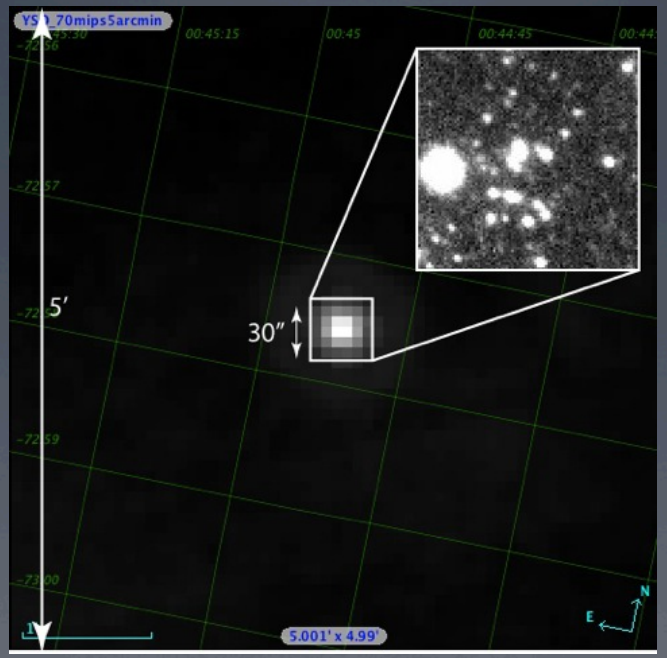
PL relation in 30Dor field.

Spectroscopic [Fe/H] are better than those from Fourier decomposition.

Moretti et al., in preparation

VMC: post-AGB stars





70 μm image from Spitzer MIPS.

30″ zoomed-in VMC Y image

YSOs as luminous as post-AGB stars are dusty and 70 μm bright.

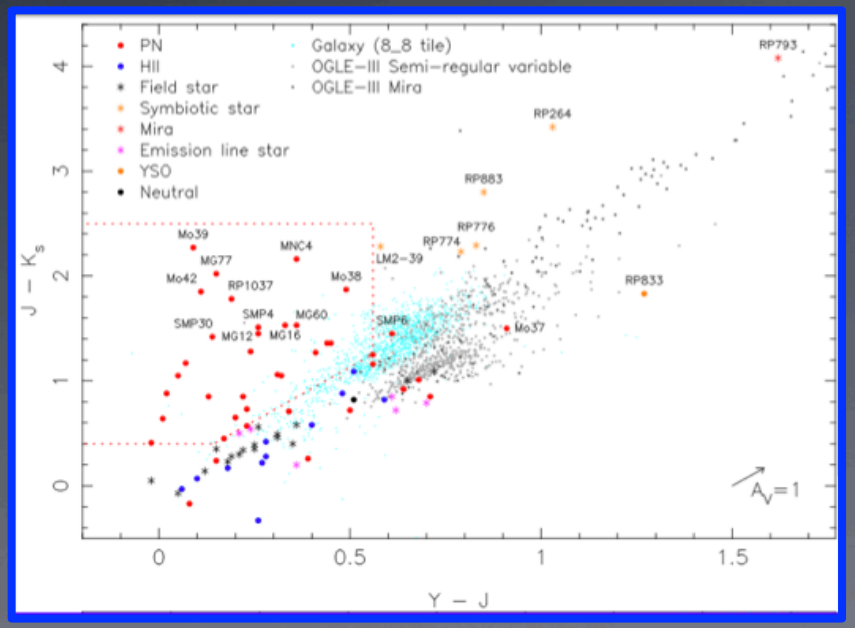
The spatial resolution of VMC data allows us to identify the post-AGB stars even in crowded regions of the Magellanic Clouds.

Spectra provide gravity that is used in the separation between YSOs and post-AGB stars.

Kasmath et al., in preparation

VMC: PNe

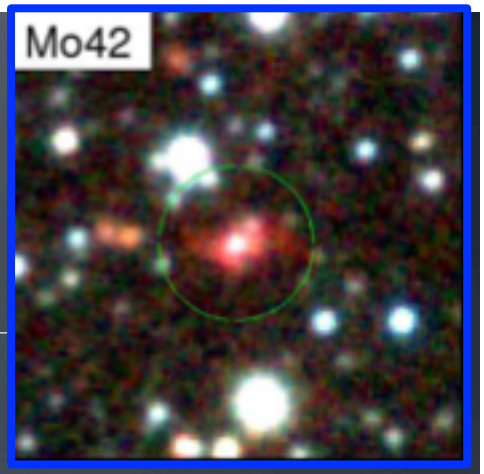
Identify non-PNe to characterize the luminosity function.
Multi-λ approach to identify PNe and symbiotic stars.

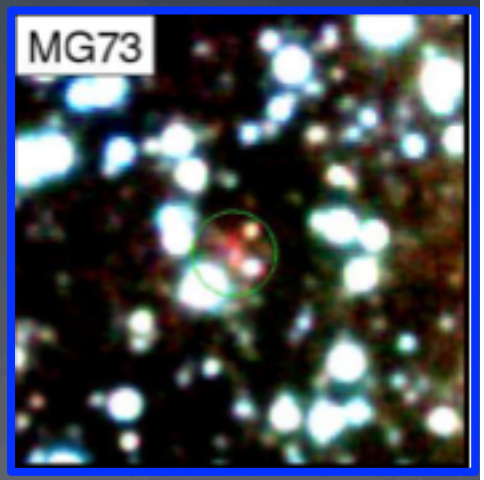


PNe occupy a specific VMC colour space.

VMC detects some PNe morphologies for the first time.

VMC finds new candidate PNe.



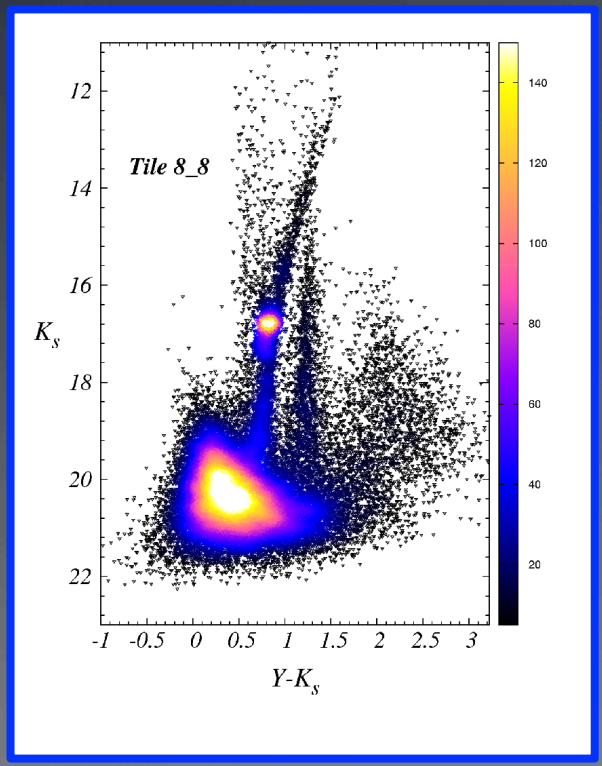


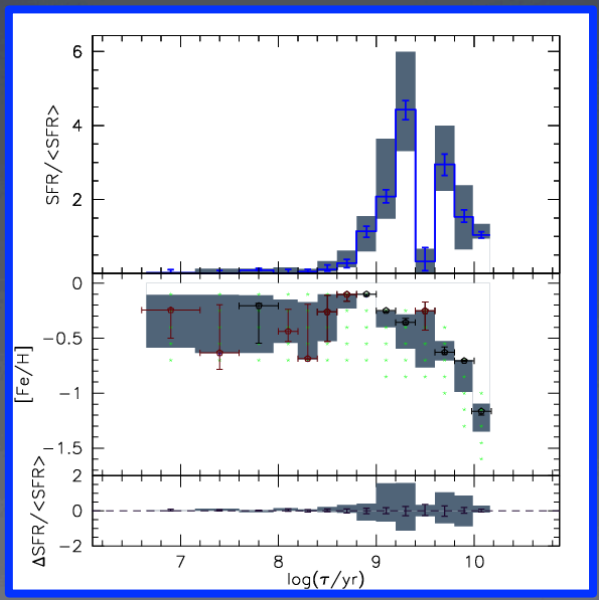
Spectra are needed to confirm PN & symbiotic nature!

Miszalski et al., A&A, 531, A157, 2011; A&A, 529, A77, 2011

VMC: SFH

Age and [Fe/H] are derived from the best fit theoretical CMDs.





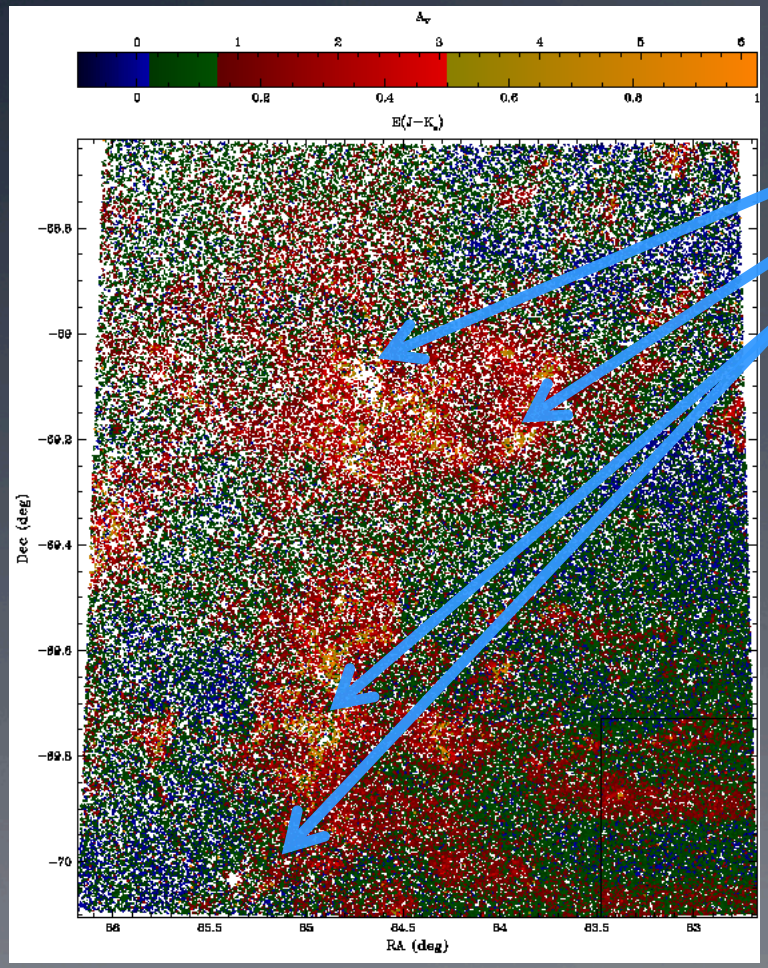
Reddening and distance modulus are also derived.

Systematic errors are reduced if geometry of LMC is taken into account.

Spectroscopic [Fe/H] would remove the degeneracy with age in the RGB!

Rubele et al., A&A, 537, A106, 2012

VMC: reddening map of 30 Dor



Extinction values for > 150,000 red clump stars. Key regions:

- R136 (Tarantula Nebula)
- SN 1987A
- HII regions (along a molecular ridge)

Highlights:

- Probes higher extinctions than optical can,
- A more detailed map than with OGLE-III,
- VMC is the only near-IR survey that resolves stars down to the red clump.

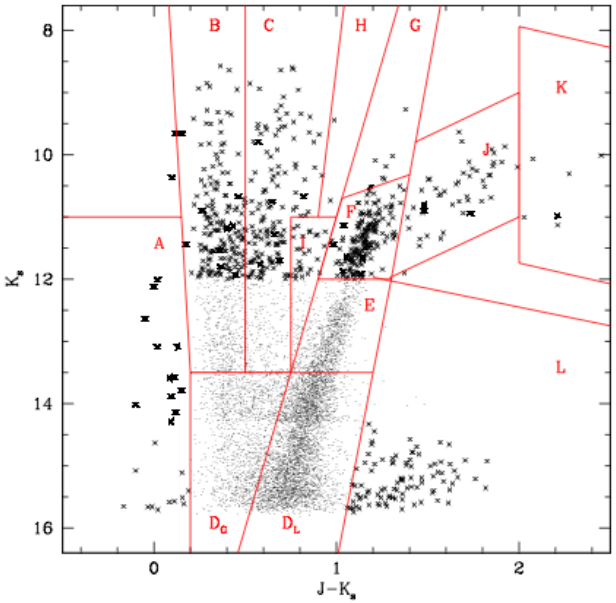
De-reddening RC stars is necessary before using them for tracing 3D geometry.

Spectroscopic [Fe/H] to correct the red clump magnitude for 3D study!

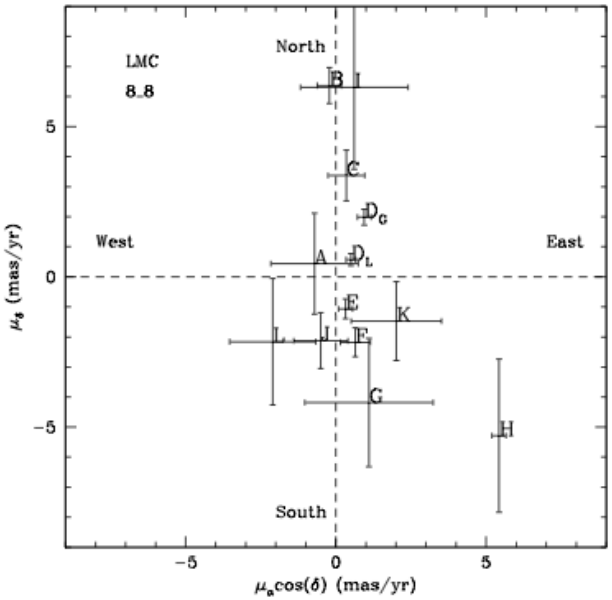
Tatton et al., to be submitted

VMC-2MASS: proper motion

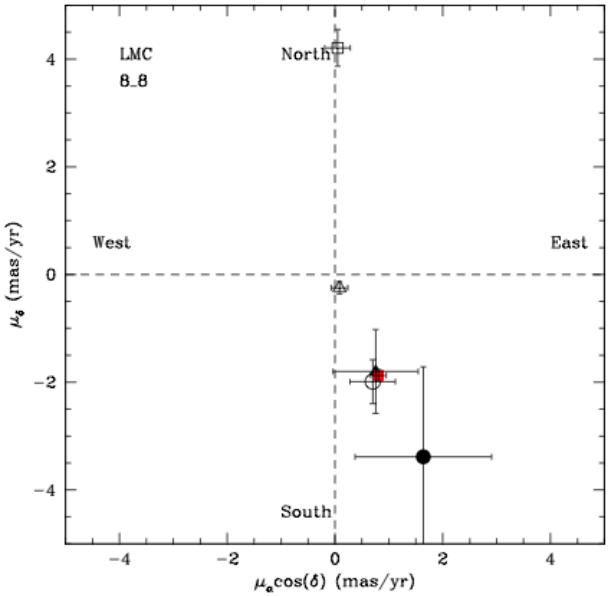
Stellar population boxes*



Proper motion per box



Proper motion per type



BCD_{MW}	2338	= MW foreground (empty square)
JK	59	= LMC carbon stars (filled triangle)
$D_{LMC}E$	5140	= LMC RGB stars (empty triangle)
AGH	32	= LMC young stars (filled circle)
FJK	228	= LMC AGB stars (empty circle)

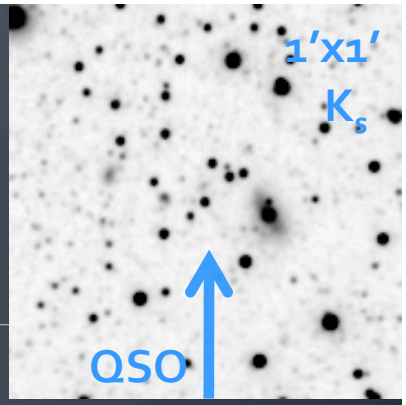
Different stars show a different proper motion in tile LMC 8_8 (outer-disk SEP) over a time range of 10 years.

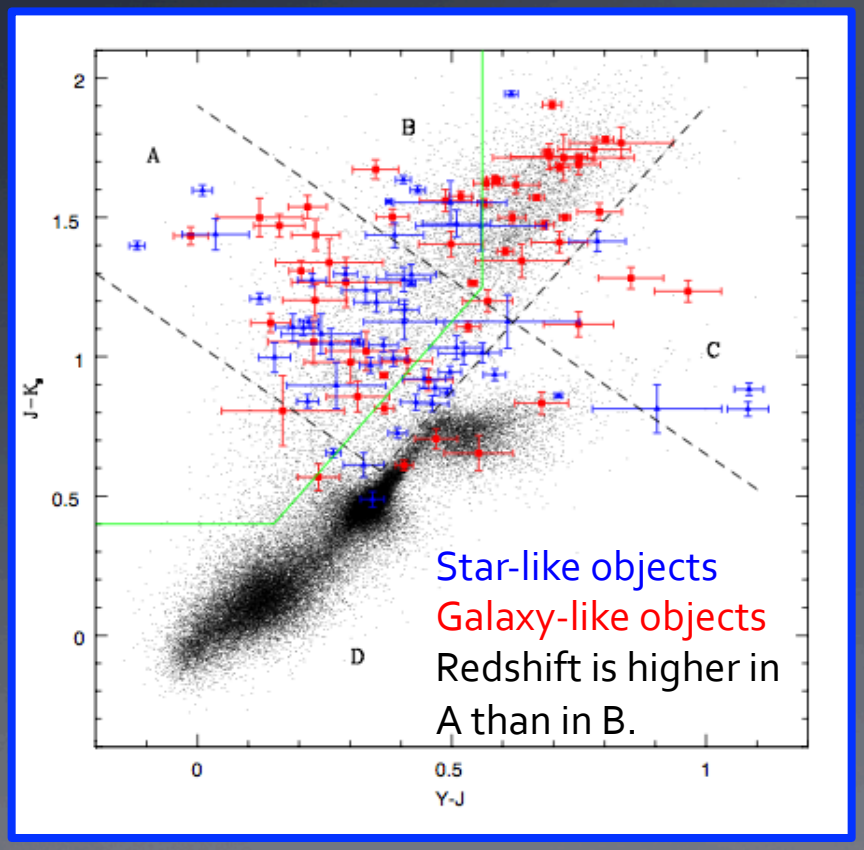
With the radial velocity sub-structures can be studied in space motion.

Cioni et al. in prep.

* adapted from Nikolay & Weinberg (2000)

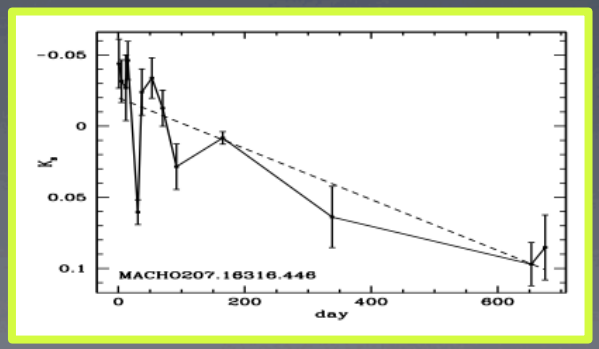
VMC: quasars





Quasars are mostly confided in region A and B of the colour space.

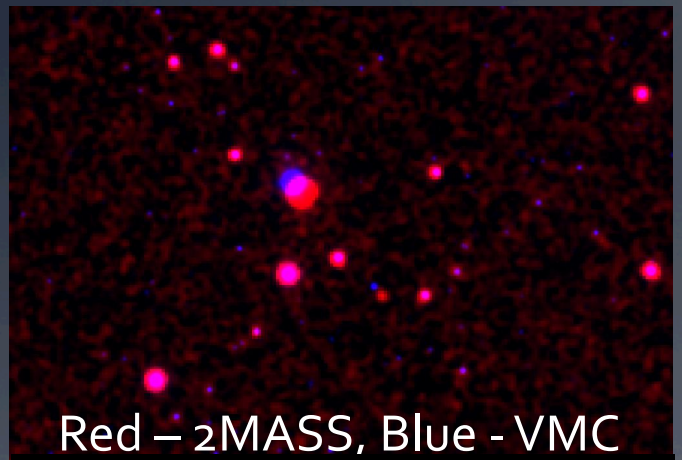
Quasars have a K_s light-curve with a slope > 10^{-4} mag/day.

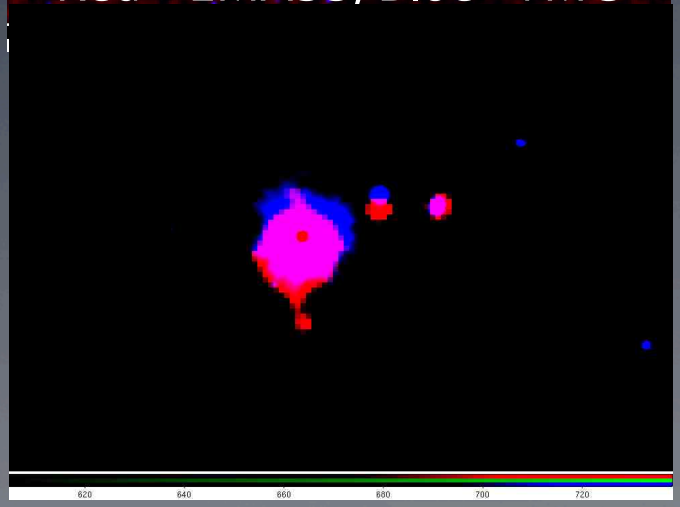


Spectra can: (1) measure the nature and z of candidates; (2) study the ISM.

Cioni et al., A&A, in press, 2012

VMC: high PM MW objects





Search for stars with a positional offset > 1" between 2MASS and VMC (>0.1"/year):

119 objects found of which 73 new!

Search for faint co-moving objects:

11 were found of which 1 brown dwarf; follow-up spectroscopy on-going.

Spectra provide the source types.

Ivanov et al., in preparation

Spectroscopic needs & outcome

- Target confirmation (PNe, Quasars, YSOs).
- Metal abundance (Cepheids, RR Lyrae and Red clump stars).
- Radial velocity (all stars as faint as the red clump).
- Area (LMC, SMC, Bridge and Stream)
- No. of targets ~ 300,000 (~1/3 of available population)

Present day studies are field limited. GAIA will not help in MCs.

- Characterization of MC sub-structures in space motion.
- Link sub-structures with merging history
- Study the chemical history of the MCs.
- Relate the SFH to the chemical evolution.

Sensitivity and resolution

• Young stars	V>12	Super-giant stars
• Intermediate-age stars	V>16-17	AGB and RGB stars
• Old stars	V>16	RGB stars and
	V>19	RR Lyrae stars

In the Magellanic Clouds

R~7,000, velocity to ~ a few km/s, S/N > 20

The largest study has ~6,000 giants (RV) and ~1,000 (CaT); 30 were found to trace a distinct population (Olsen+ 2011)

There is 1 EMP star each 100 stars with [Fe/H]<-2 (Cole)