

A tale of two projects: MASGOMAS and VVV Stellar Clusters

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& the VVV star cluster team

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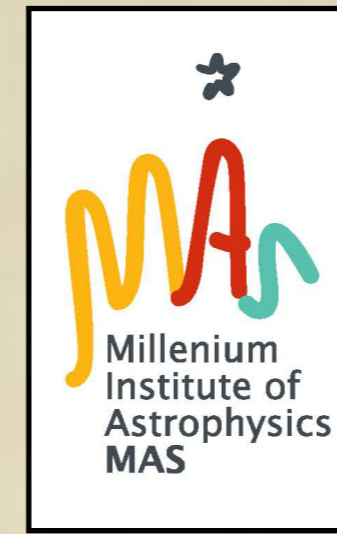
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Abstract

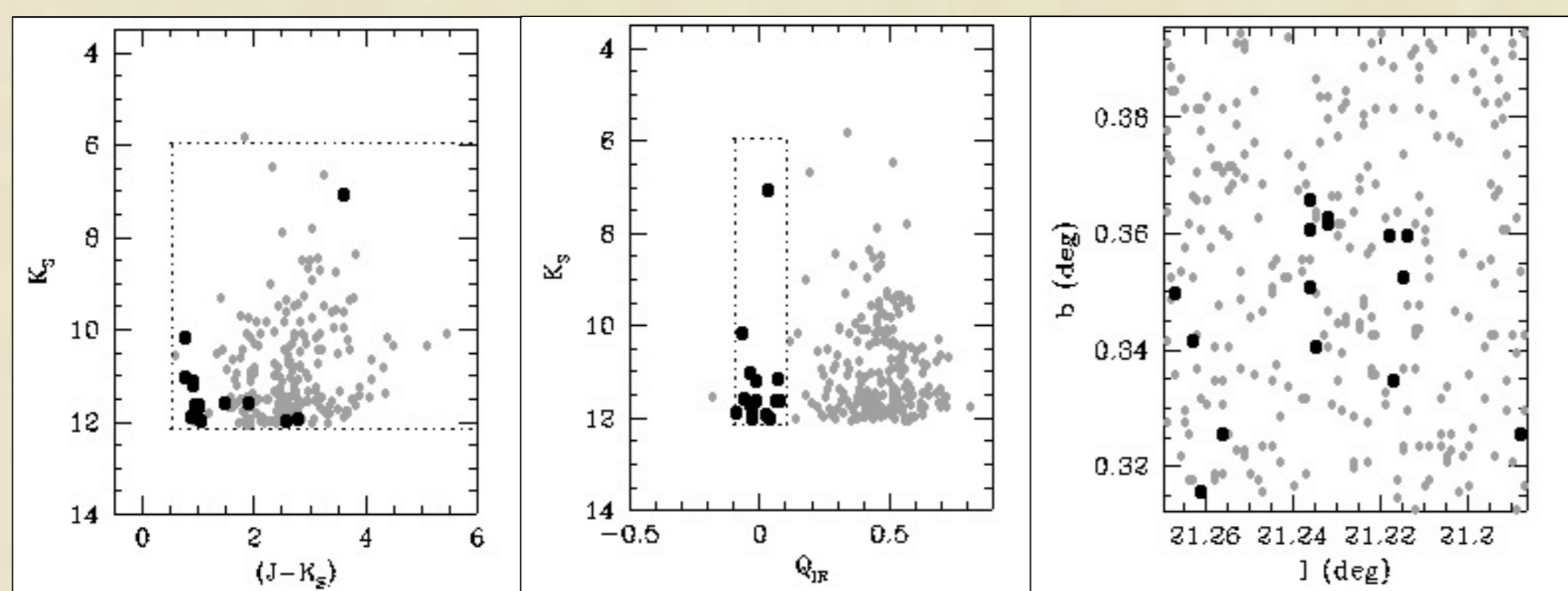
Young massive clusters are key to map the Milky Way's structure, and near-IR large area sky surveys have contributed strongly to the discovery of new obscured massive stellar clusters. In this talk, I will present the latest results of two groups dedicated to the search and characterization of young massive clusters: the MASGOMAS group (IAC, Spain) using 2MASS and the Star Cluster Group at the Astronomy Institute of the Universidad de Valparaíso (Chile), using the ESO public survey VVV.

The MAssive Stars in Galactic Obscured MAssive clusterS (MASGOMAS) project: This project is dedicated to the systematic search and characterization of young massive clusters, using a friend-of-friends algorithm to detect overdensities of OB-type stellar candidates.

The project started as a near-IR spectrophotometric follow up of previously known catalogues of Galactic cluster candidates (Bica et al., 2003; Dutra et al., 2001), and three examples of this early phase are the works on **G61.48+0.09** (Marín-Franch et al., 2009), **NGC 7538** (Puga et al., 2010) and **Sh2-152** (Ramírez Alegría et al., 2011).

The second phase of the project corresponds to a systematic search for massive cluster candidates in the direction of the Scutum-Centaurus arm base. The systematic search is focused on OB-type star candidates, filtered using three photometric cuts:

1. $K_s < 12$ mag
2. Red (J-K_s) colour
3. $-0.2 < Q_{IR} < 0.2$



The preliminary tests of our systematic search ended in the discovery of three cluster candidates with a later spectroscopically confirmed massive stellar population: **Masgommas-1** (OB and RSG population, total mass $\sim 10^4 M_\odot$; Ramírez Alegría et al. 2012), **Masgommas-4** (a double-core cluster; Ramírez Alegría et al. 2014) and **Masgommas-6** (data under analysis. The cluster contains a star with broad emission lines).

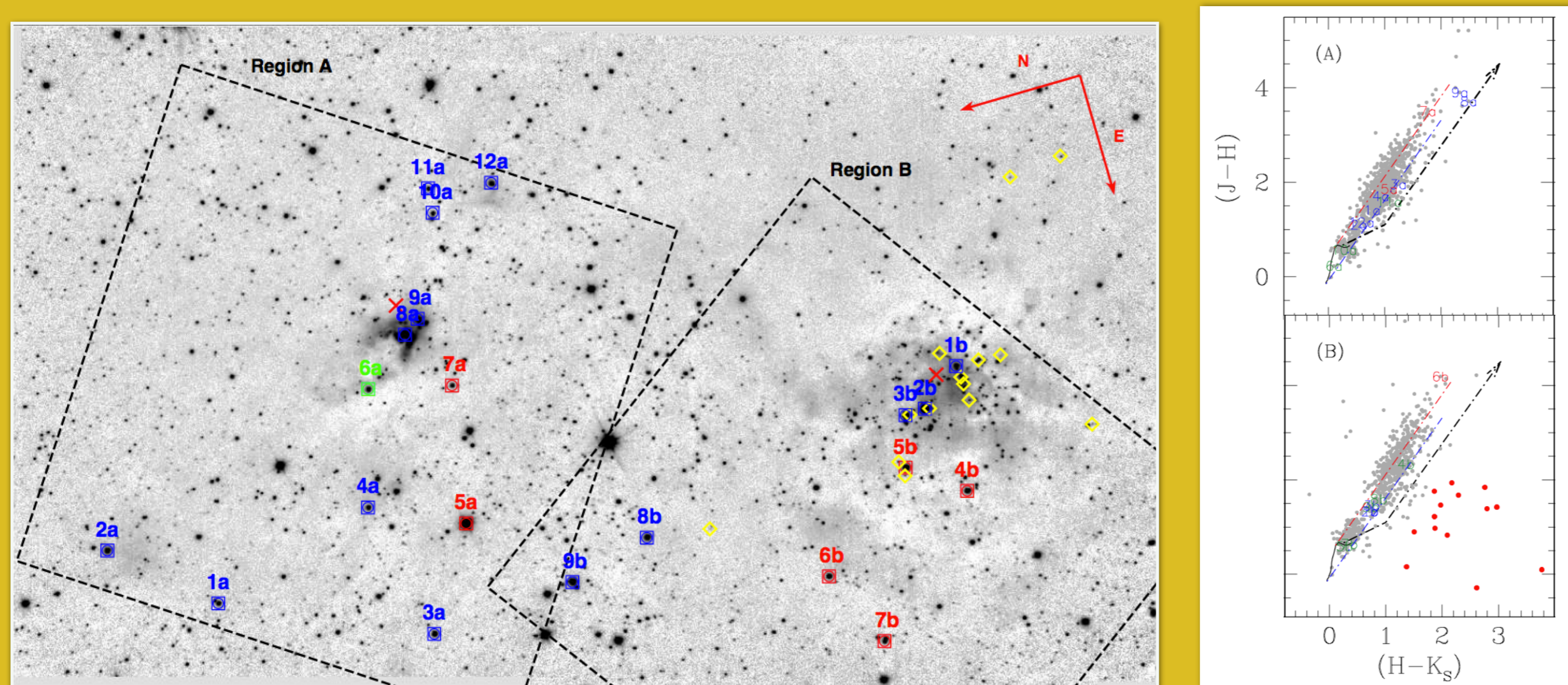
We use 2MASS photometry for the systematic search and LIRIS (Manchado et al. 2004) photometry and multiobject/long slit spectra (H and K bands) and imaging (JHK_s) for the physical characterization of the clusters. For the spectral classification we use template spectra from Hanson et al. (1996), Wallace & Hinkle (1997), Hanson et al. (1998), Meyer et al. (1998), Ranade et al. (2004 & 2007) catalogues.

One case example: Masgommas-4 (Ramírez Alegría et al. A&A, in press)

This cluster is located at the Galactic coordinates $l = 40.5^\circ$, $b = +2.6^\circ$, but the individual distance estimates of its OB-type stars indicate that it is closer than the Scutum-Centaurus arm base.

The cluster shows two cores around IRAS sources, defining regions A and B, one of them (B) hosting a known HII region (Sh2-76 E). The analysis was done separately for each region, giving similar distance and extinctions in both cases. We conclude that both cores are part of the same cluster.

The colour-colour diagrams show an extra reddened population only in region B. These objects are Herbig Ae/Be candidates (yellow rhombi) and would indicate a difference in the formation activity between regions A and B.



Masgommas-4

Discovery	Ramírez Alegría et al. (2014, A&A, in press), systematic search of OB-overdensity.
JHK Photometry	FATBOY (Eikenberry et al. 2006)+ DAOPHOT (Stetson 1994) on LIRIS images
Spectroscopy	LIRIS MOS, 21 stars (10 OBs)
Mass	2200 solar masses
Distance	1.9 kpc (not in the Galactic bar edge)
Age	5 Myr (HII region + Herbig Ae/Be candidates)

VVV Clusters (UdV group): The clusters candidates studied in this group were selected from the catalogue presented by Borissova et al. (2011), based on the visual inspection of ZYJHK_s images from the ESO public survey VVV (Minniti et al., 2010, and Saito et al., 2012). These candidates are located in the Galactic disc, with $296^\circ < l < 348^\circ$

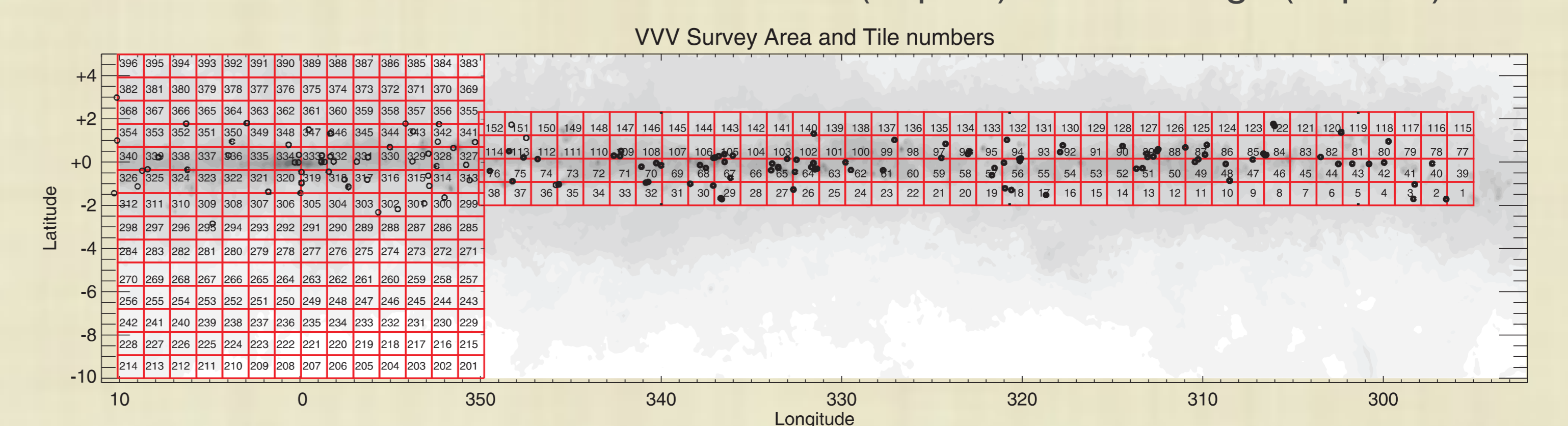
Based on the statistically decontaminated CMDs of the cluster candidates, we selected a group for spectroscopic follow-up. The spectroscopic data, used for spectral classification and individual distance estimates, is complemented with VVV-SkZ pipeline photometry (Mauro et al. 2013), an automated software based on ALLFRAME (Stetson 1994) and optimized for VISTA PSF photometry.

Spectroscopic follow-up: The near-IR spectra was obtained with ISAAC/VLT, an IR imager and spectrograph (1 to 5 μ m) mounted on the Nasmyth A focus of UT3. For the observations we have used a slit width of 0.3 arcsec, obtaining a resolution of $R \sim 3000$.

The spectra were classified using the same set of template spectra than the MASGOMAS group, but including the spectral catalogues of Martins et al. (2007), Crowther et al. (2006), Liermann et al. (2009), Mauerhan et al. (2011) & Davies et al. (2012).

Group publications:

1) **New Galactic star clusters discovered in the VVV Survey I** (Borissova et al. 2011) & **II** (Borissova et al. 2014, in press): Both papers present a list of cluster candidates discovered in the Galactic disc (Paper I) and the bulge (Paper II).

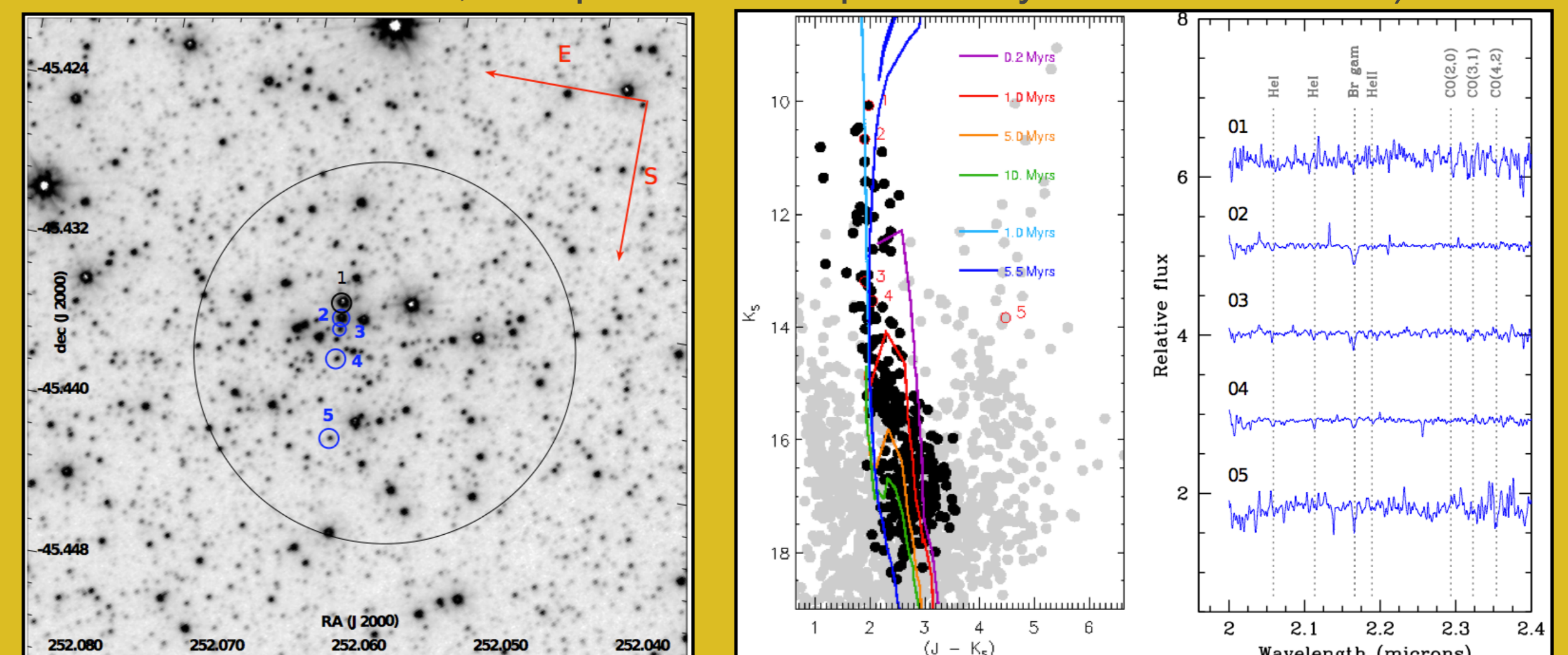


2) **Massive open star clusters using the VVV survey I** (Chené et al. 2012), **II** (Chené et al. 2013) & **III** (Ramírez Alegría et al. 2014): Series of papers which explain the general method (I), present the discovery of 6 clusters with WR stars (II) and the second cluster located in the far edge of the Galactic bar (III)

One case example: VVV CL086 (Ramírez Alegría et al. 2014, A&A, 564L, 9)

According to the individual distance estimates for two early type stars (O9 and B0V), VVV CL086 is located at the far edge of the Galactic bar ($d \sim 11$ kpc). It is known that the close edge of the bar hosts massive cluster (mostly RSG clusters), but the far edge has still remained unexplored. VVV CL086 is the second massive cluster found in this region of the Galaxy (first one is Mercer81, Davies et al. 2012).

The decontaminated CMD shows that the cluster contains earlier and more massive stars (to be confirmed spectroscopically), and its age is > 1.0 Myr and < 5.0 Myr, based on isochrone fitting to the pre-main sequence turn-on point (main sequence isochrones by Lejeune & Schaerer 2001, and pre-main sequence by Siess et al. 2000).



VVV CL086

Discovery	Borissova et al. (2011); Ramírez Alegría et al. (2014, A&A, 564L)
JHK Photometry	SkZ pipeline on VVV images (Mauro et al. 2013)
Spectroscopy	ISAAC long-slits, 5 stars (4 OBs)
Mass	2500 solar masses
Distance	10 kpc
Age	1-5 Myr (isochrone fitting to the turn-on point)

Acknowledgement:

S.R.A. was the FONDECYT project n° 3140605. Support for J.B. is provided by the Ministry for the Economy, Development, and Tourism's Programa Iniciativa Científica Milenio through grant IC12009, awarded to The MAS, and the FONDECYT project n° 1120601. A.H. thanks to the MINECO for project AYA2012-39364-C02-01. P.A. was supported by the ALMA-Conicyt project n° 31110002