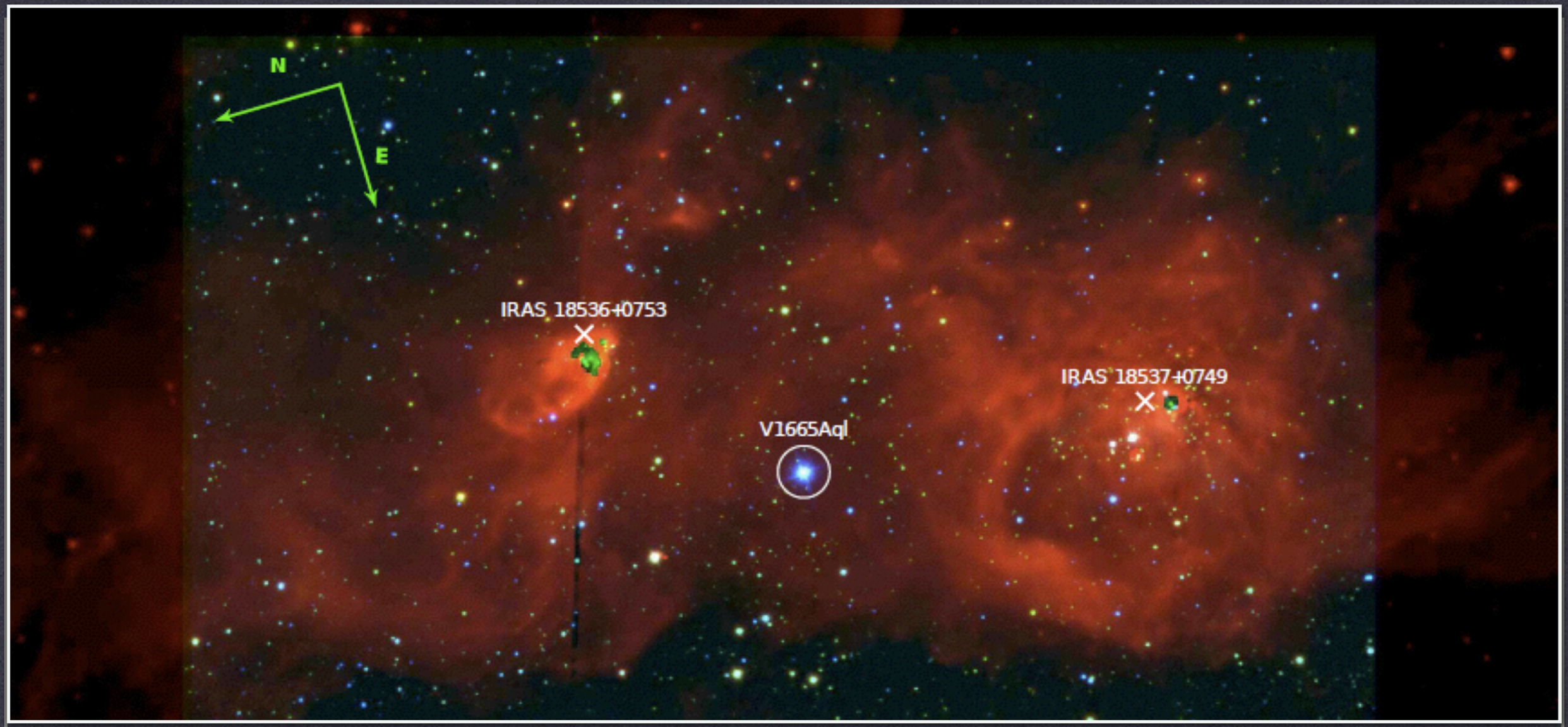


Searching for massive star clusters using NIR large surveys

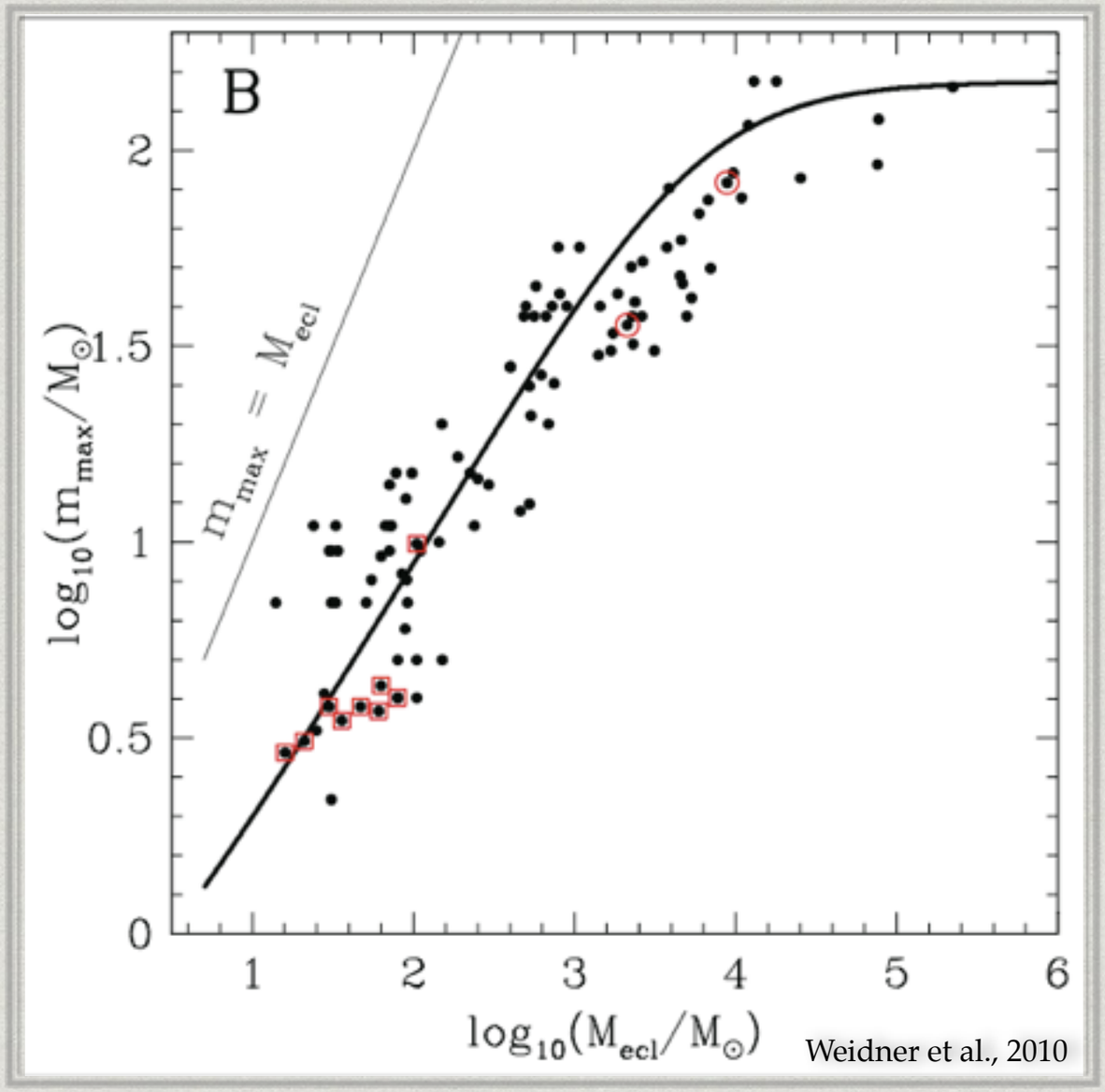
SEBASTIÁN RAMÍREZ ALEGRÍA
IA-UCN POSTDOC

Why massive clusters?

- Clusters with a total mass over 10^4 $M_\odot$. These clusters may survive a dissolution phase (*infant mortality;* Portegies Zwart et al. 2010).

- Their massive population makes them ***young, massive*** and ***obscured*** objects.

- ***Poor census:*** Less than 20 massive clusters have been reported in the MW; but about 100 are expected to exist in the Galaxy (Hanson & Popescu, 2007)



Weidner et al., 2010

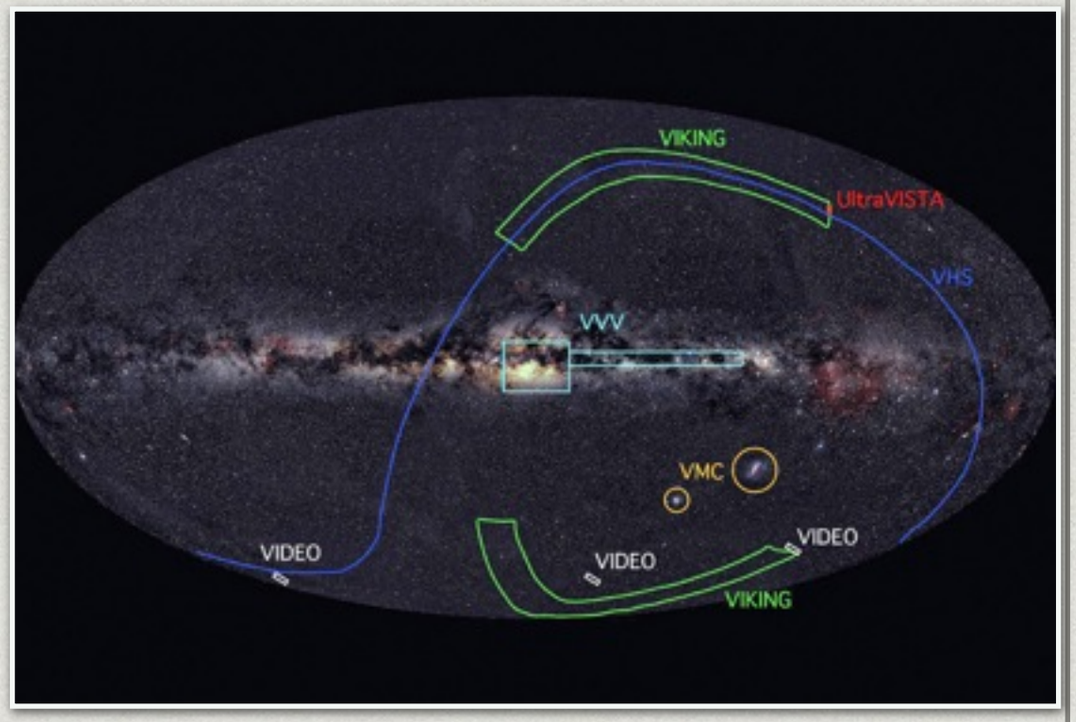
Catalogues of cluster (candidates)

- Using NIR imaging to detect cluster candidates as over-densities.
  - 2MASS: Dutra & Bica (2000, 2001), Ivanov et al. 2002, Dutra et al. (2003), Bica et al. (2003), Kronberger et al. (2006), Kumar et al. (2006), Froebrich et al. (2007), Koposov Kamargo et al. (2015), Glushkova et al. (2010)
  - GLIMPSE: Mercer et al. (2005), Morales et al. (2013).
  - UKIDSS-GPS: Lucas & Samuel (2010), Solin et al. (2012)
  - VVV: Borissova et al. (2011, 2014), Solin et al. (2014), Barbá et al. (2015) -> more than 700 cluster candidates
- Some compilations: WEBDA (https://www.univie.ac.at/webda/catocl.html), Kharchenko et al. (2005), Morales et al. (2013).

VVV clusters

J. Borissova, R. Kurtev, M. Kuhn (UV/MAS), A.-N. Chené (Gemini North) + collaborators

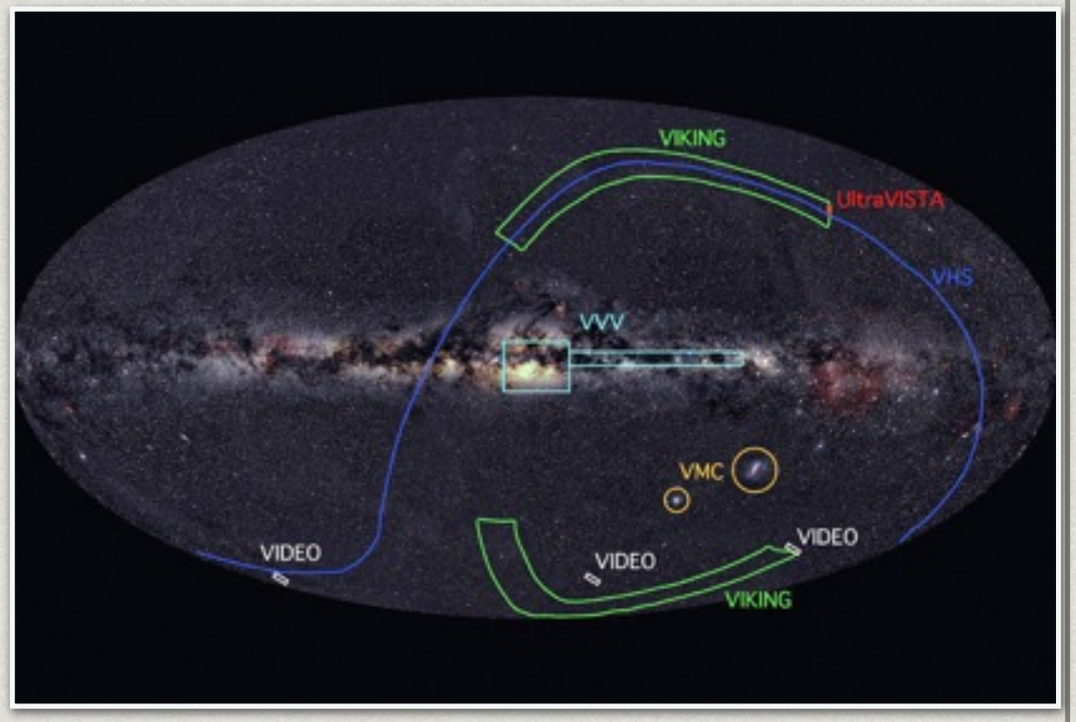
- Based on observations by the VVV Survey (520 deg^2, $ZYJHK_S$, over a timespan of ~5 years).

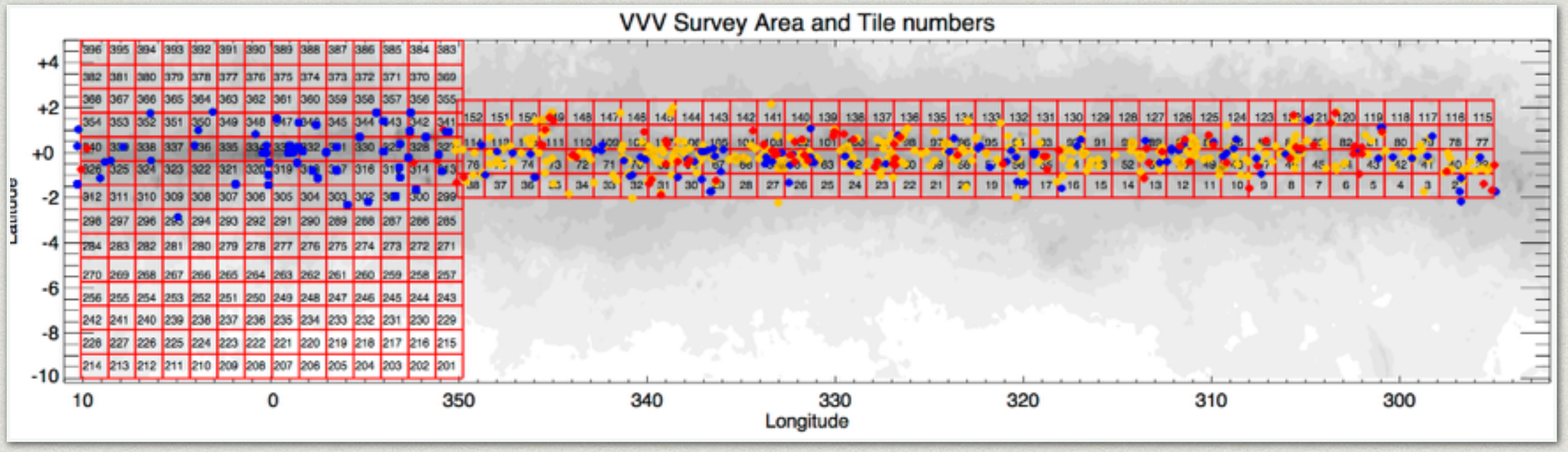


VVV clusters

J. Borissova, R. Kurtev, M. Kuhn (UV/MAS), A.-N. Chené (Gemini North) + collaborators

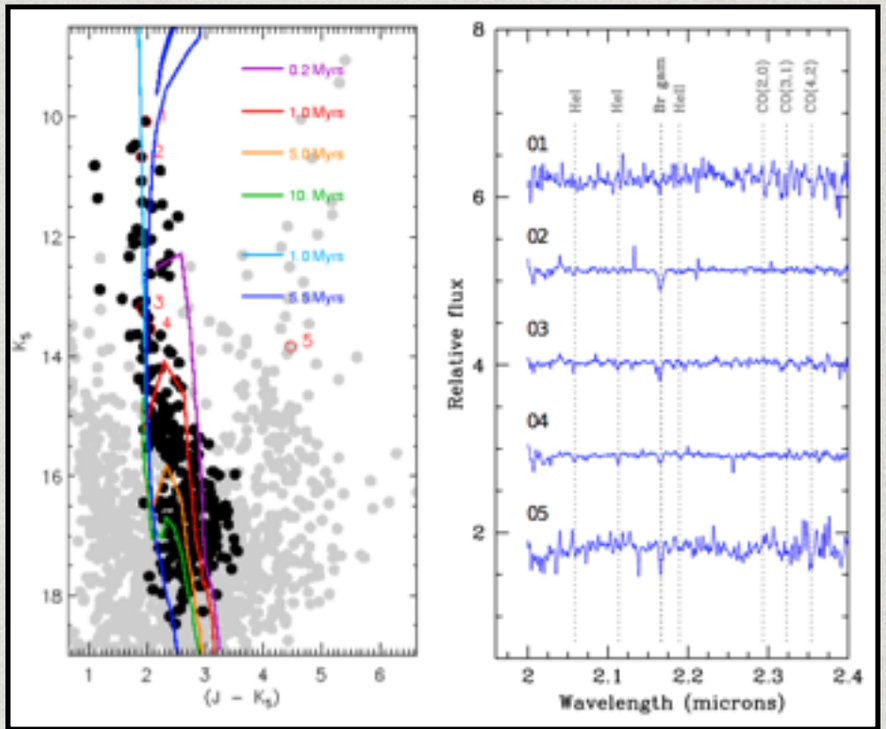
- Based on observations by the VVV Survey (520 deg^2, $ZYJHK_S$, over a timespan of ~5 years).





Clusters with OBs:

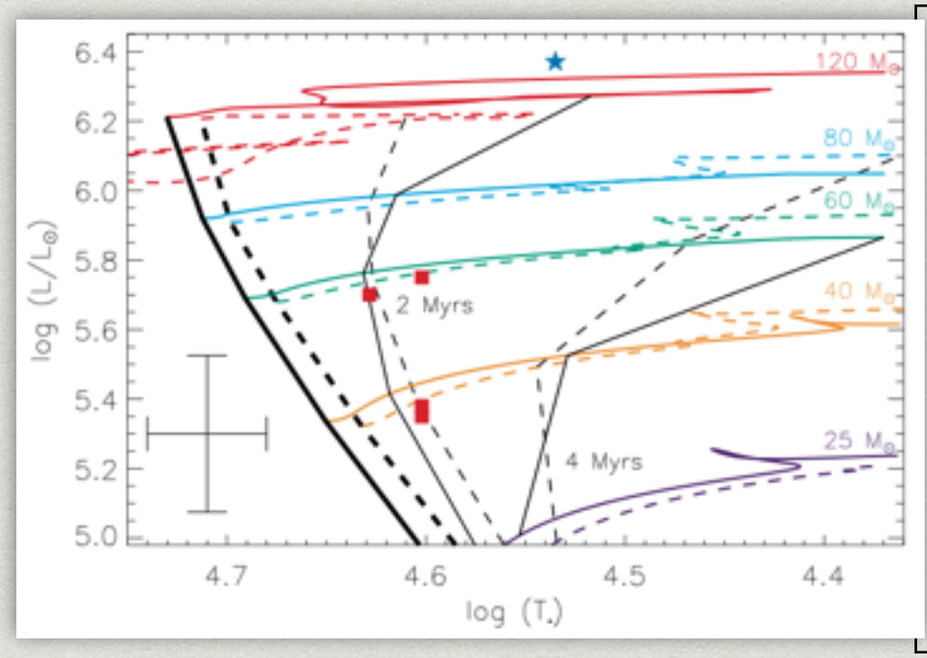
(Ramírez Alegría et al. 2014, 2016; Corti et al 2016)



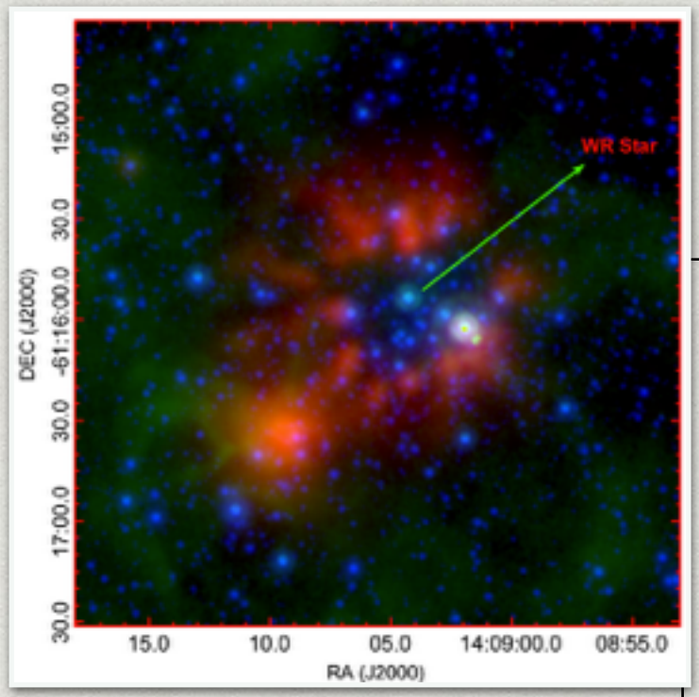
Decontaminated CMD diagram (*left*) and spectra (*right*) for the massive population of **VVV CL086**.
This cluster in the second one, after Mercer 81 (Davies et al. 2012), found in the far end of the Galactic bar.

Clusters with WR:

(Borissova et al. 2014b; Chené et al. 2013, 2015; Hervé et al. 2016; de la Fuente et al. 2016)



HR diagram for **VVV CL041**, with its O-stars (*red squares*) and the WR (*blue star*). Evolutionary tracks (Chieffi & Limongi 2013, colour) and isochrones (Ekström et al. 2012, black) are overplotted.



VVV CL036, hosting the WR60-6. Sub-mm APEX ^{12}CO(3→2) observations allow to study the surrounding shell, and estimate a age of 28000 yr.

MASGOMAS project:

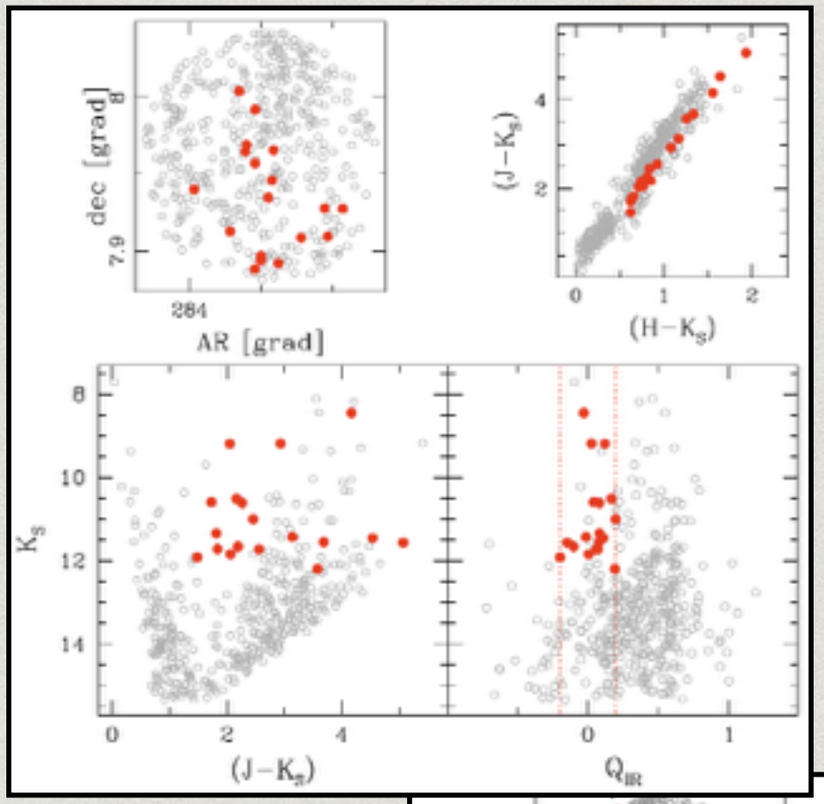
A. Herrero, K. Rübke (IAC), A. Marín-Franch (CEFCA), M. García (CSIC/INTA)

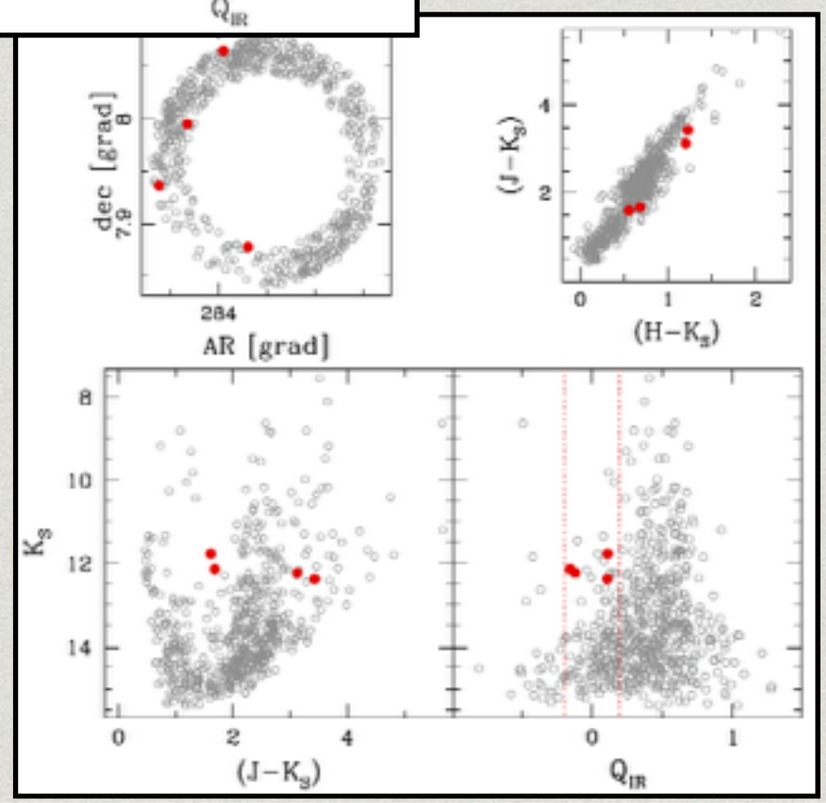
- The **MA**ssive **S**tars in **G**alactic **O**bscured **MA**ssive cluster**S** (MASGOMAS) aims to discover and characterize massive clusters and their massive stellar population.

- First searches were focused on the direction of the close end of the Galactic Bar ($l \sim 35^{\circ}$).

- The candidate search is done using 2MASS photometry and the follow-up includes spectroscopy and imaging in near-infrared.

MASGOMAS project:
First candidates





OB-type selection criteria:

1. $K_S < 12$ mag

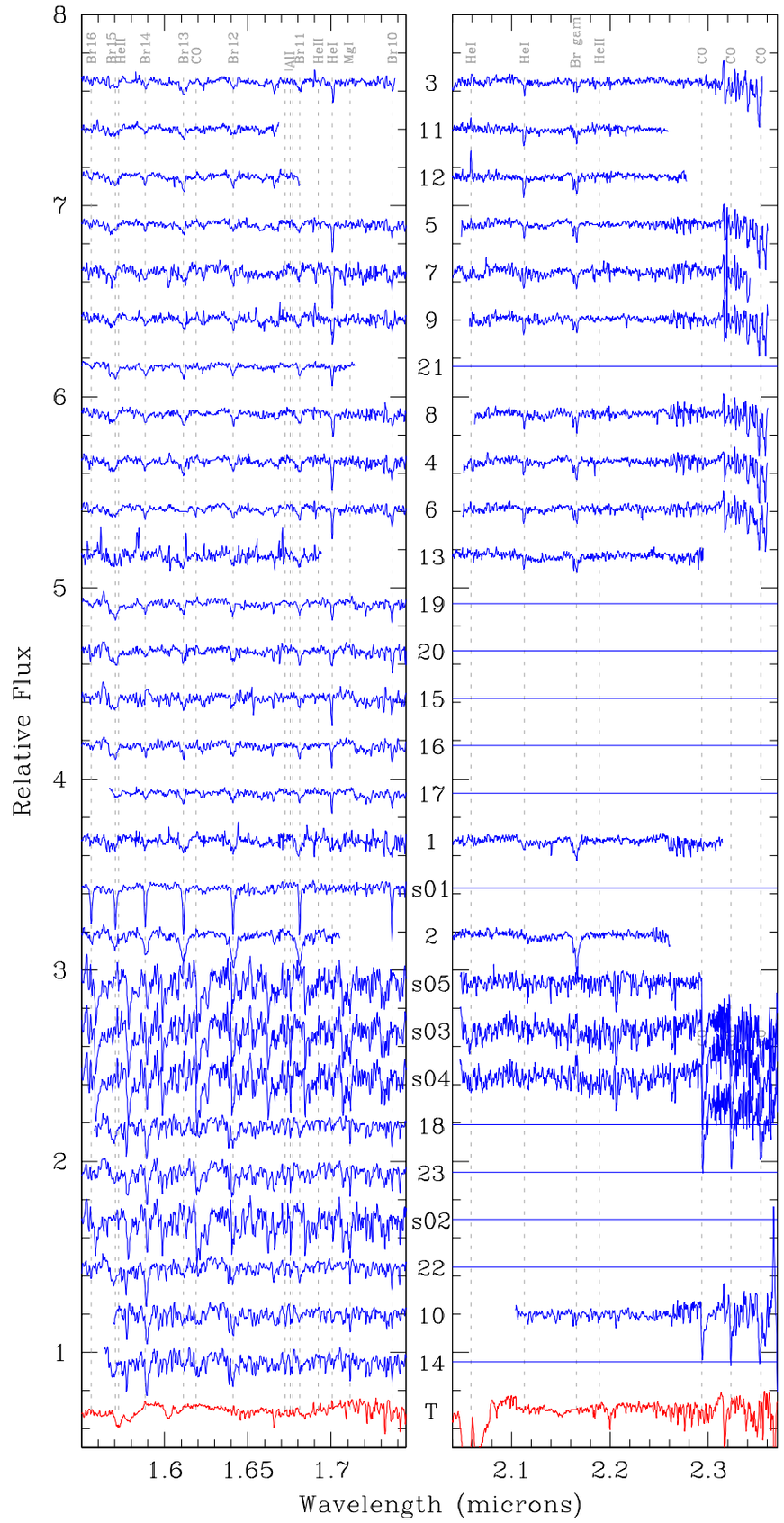
2. $(J\text{-}K_S) > 0.5$—1 mag

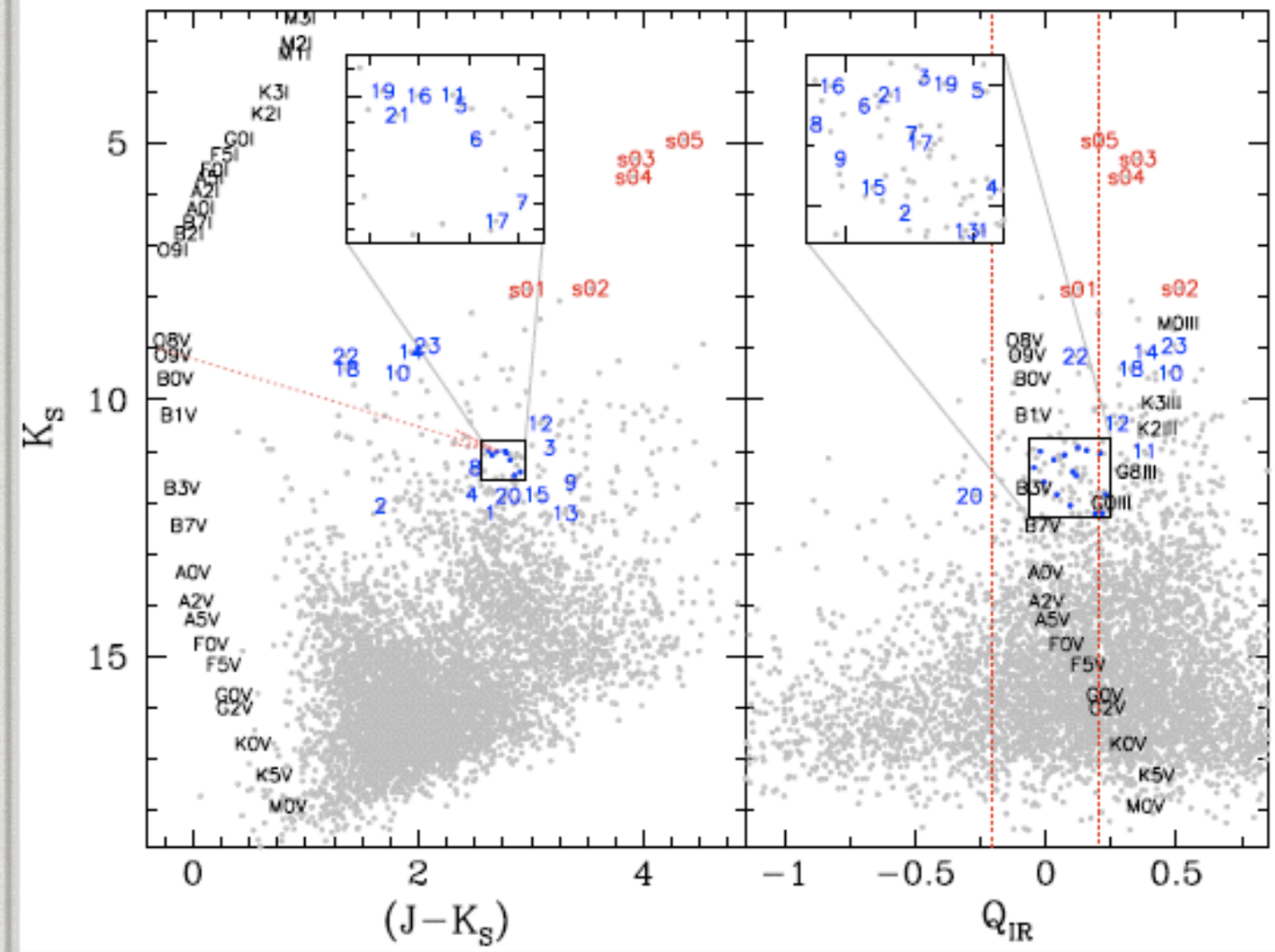
3. $-0.2 < Q_{IR} < 0.2$

($Q_{IR} = (J\text{-}H) - 1.8 \cdot (H\text{-}K_S)$;
Comerón & Pasquali 2005)

—> look for over-densities of OB-type candidates

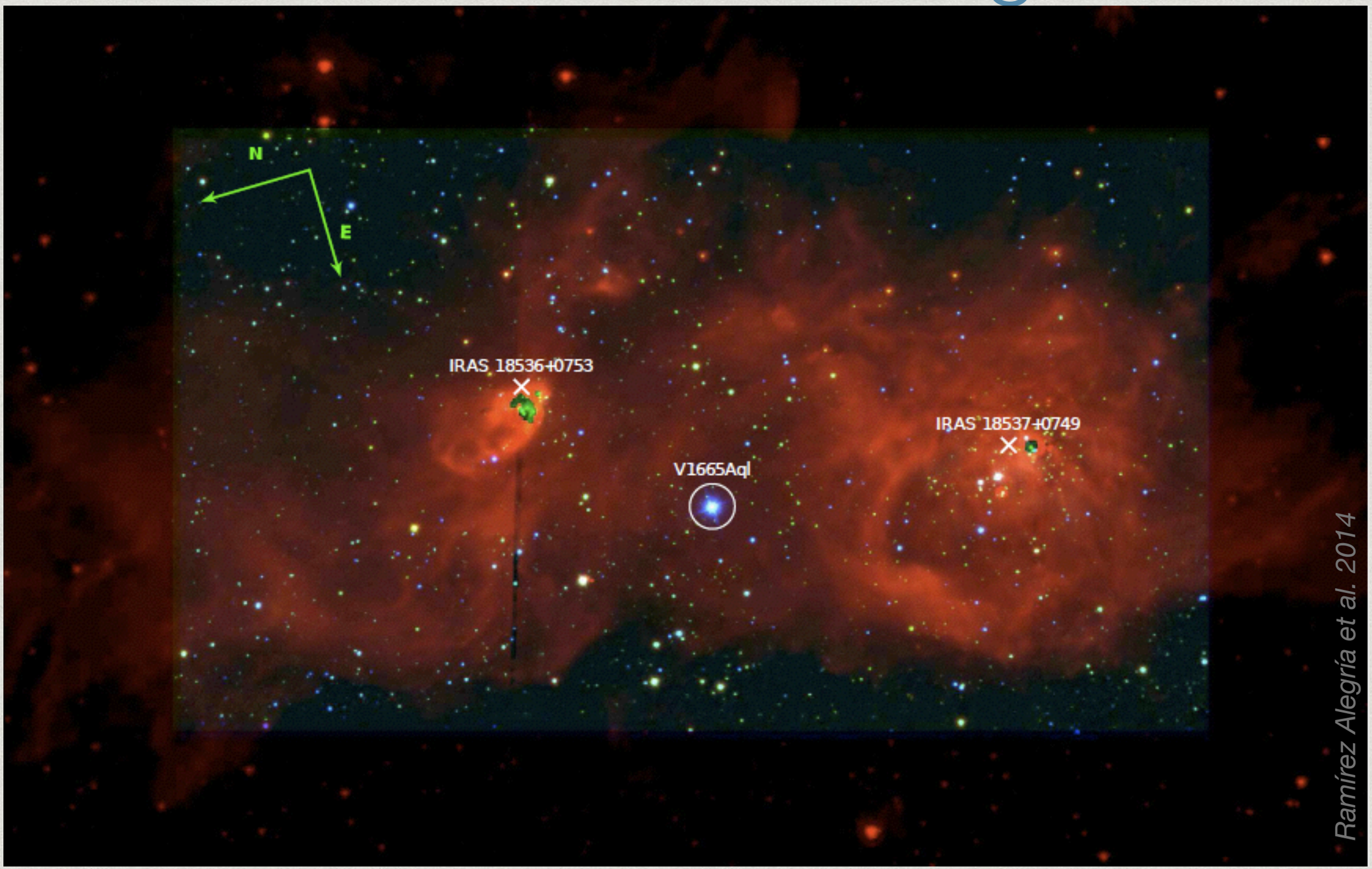
First candidates: Masgomas-1



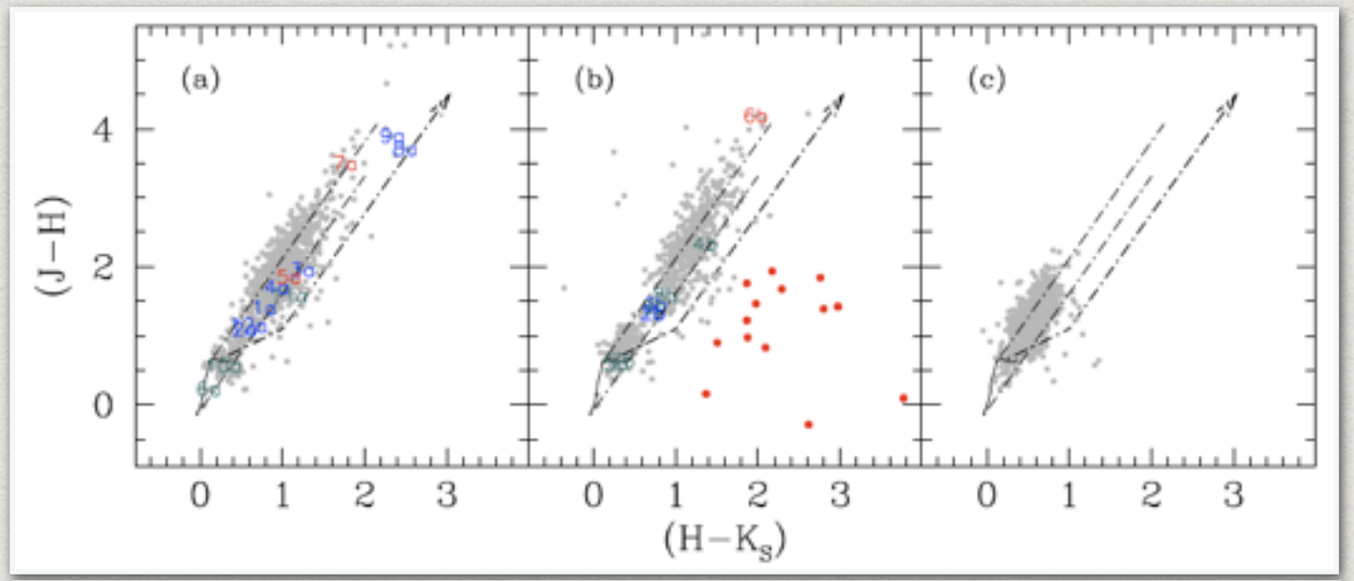


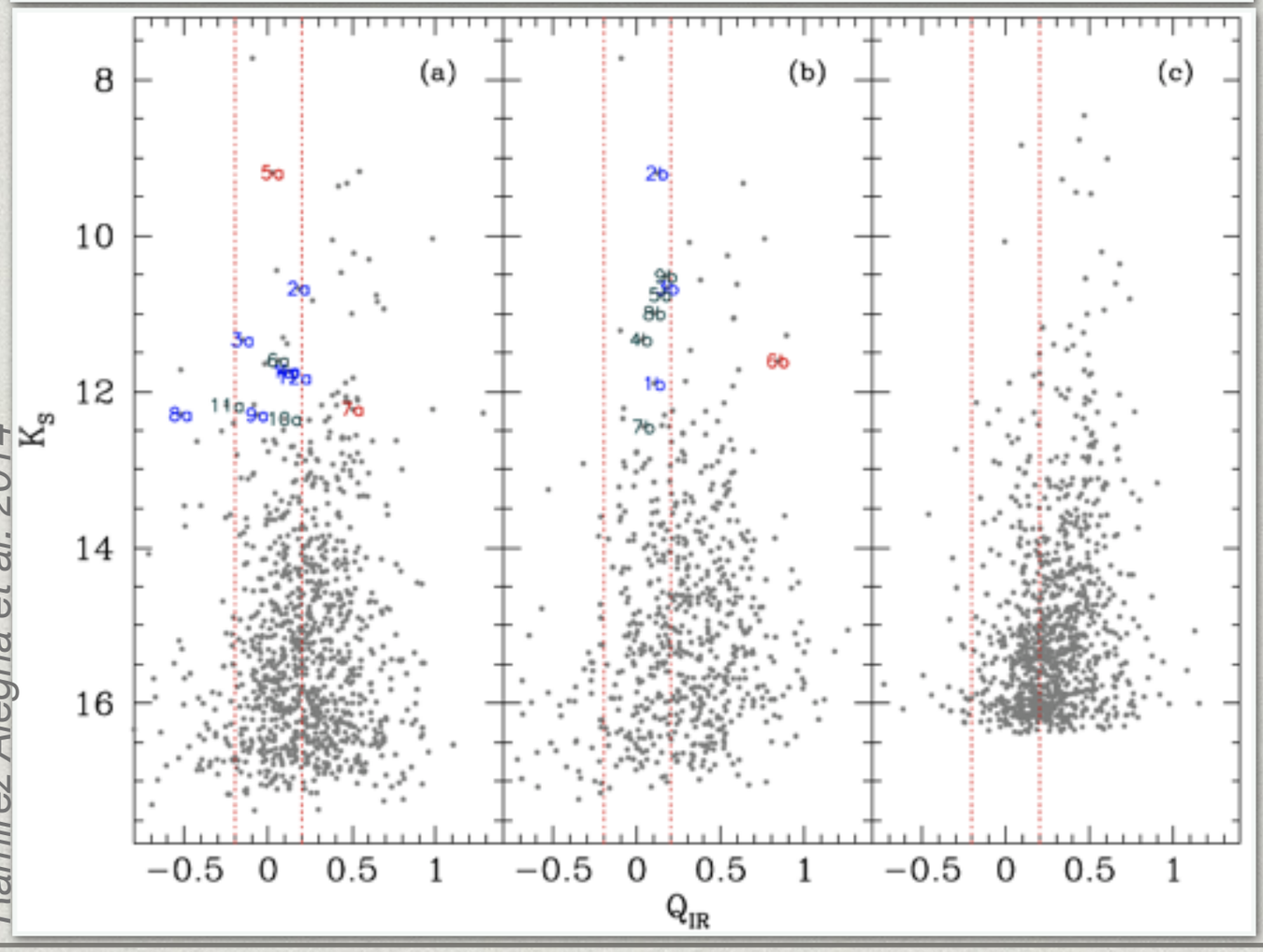
Ramírez Alegría et al. (2012)

First candidates: Masgomas-4



First candidates: Masgomas-4





Ramírez Alegría et al. 2014

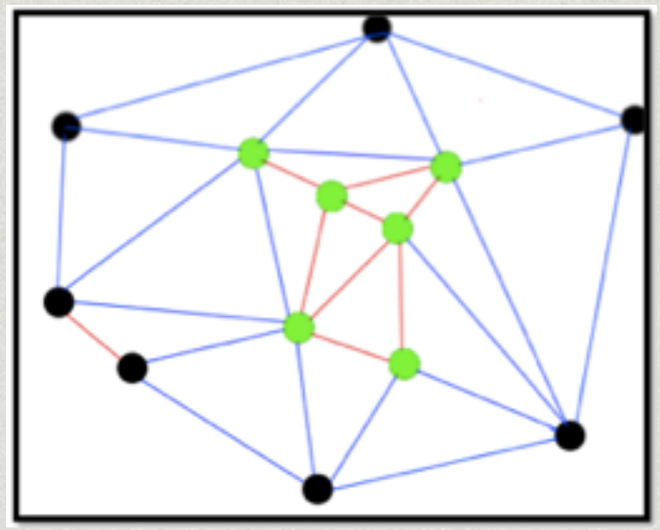
- Cores a & b share distance (~2kpc) but differ in the presence of YSO.
- Masgomas-4 is one example of embedded cluster, older than 3Myr (Pfalzner et al. 2016).

MASGOMAS project: The systematic search

- With the same photometric criteria used to select OB-type candidates, we adapted the AUTOPOP code (García et al. 2011).

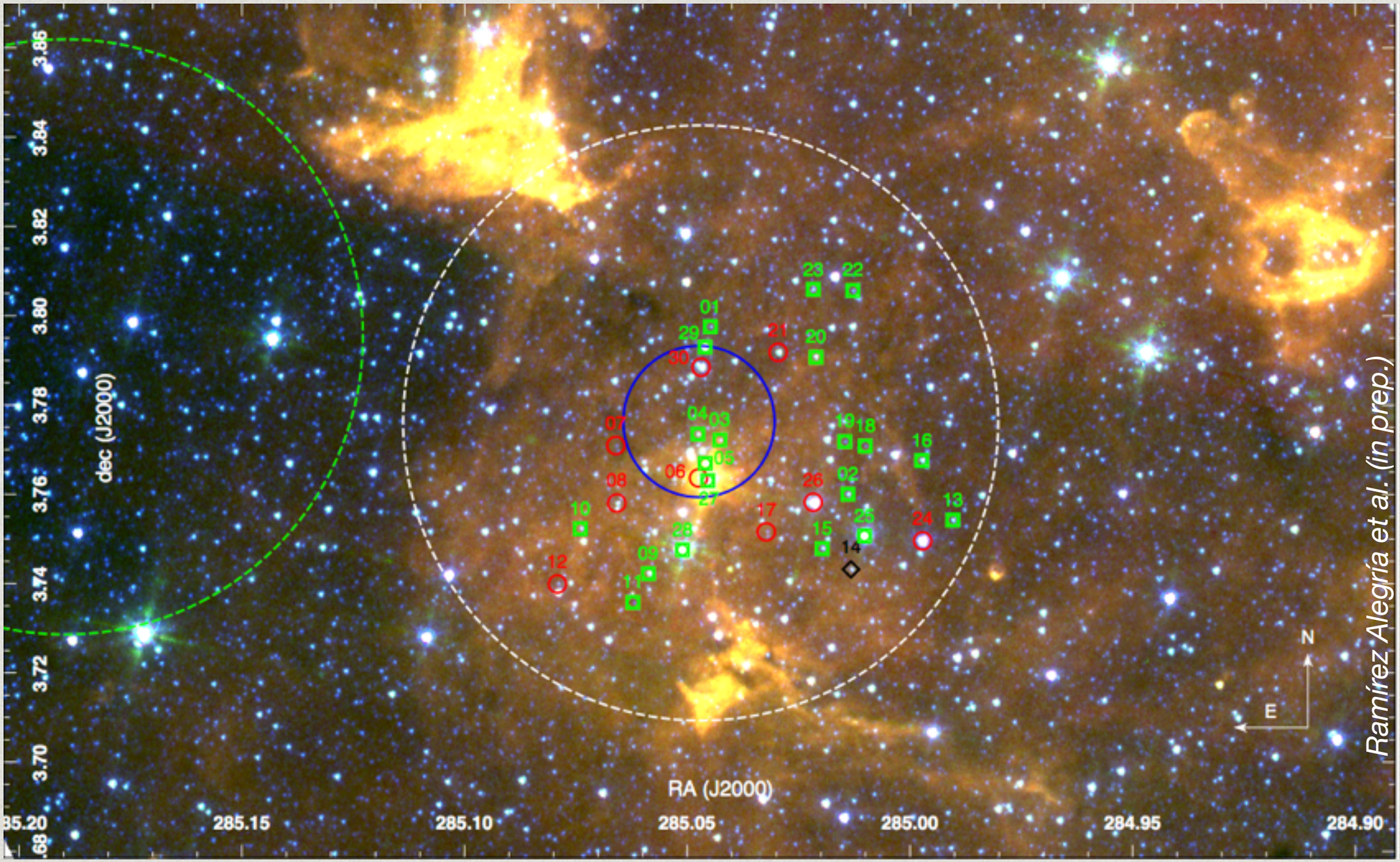
- The automatic search requires two values to consider an over-density as cluster candidate: distance $\mathbf{D_{opt}}$ and number of candidates $\mathbf{N_{min}}$.

- If a group of at least $\mathbf{N_{min}}$ stars, have one or more companion at less than $\mathbf{D_{opt}}$, it is considered cluster candidate.



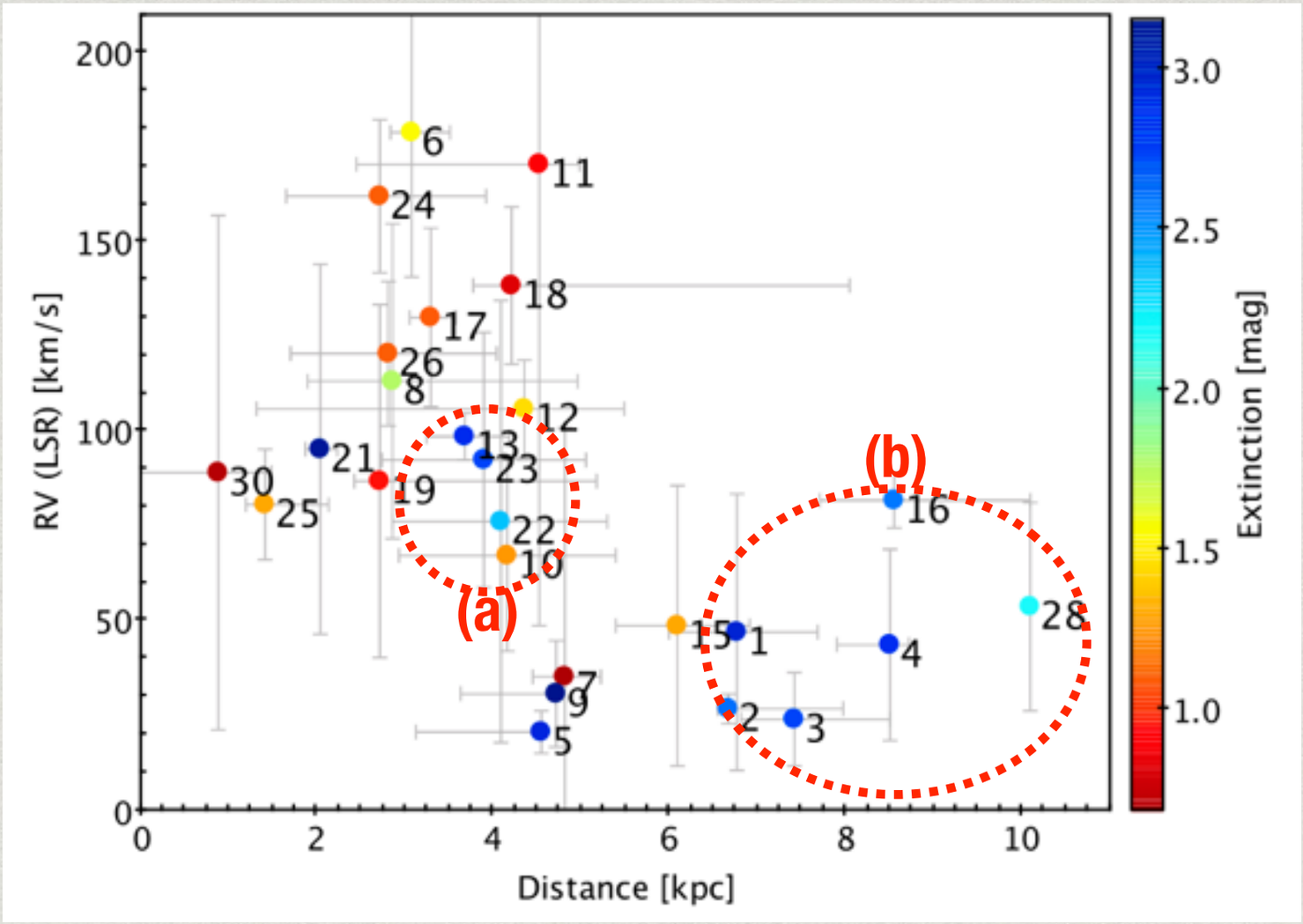
Rübke et al. 2017

AUTOPOP-b candidates: Masgomas-6



AUTOPOP-b candidates: Masgomas-6

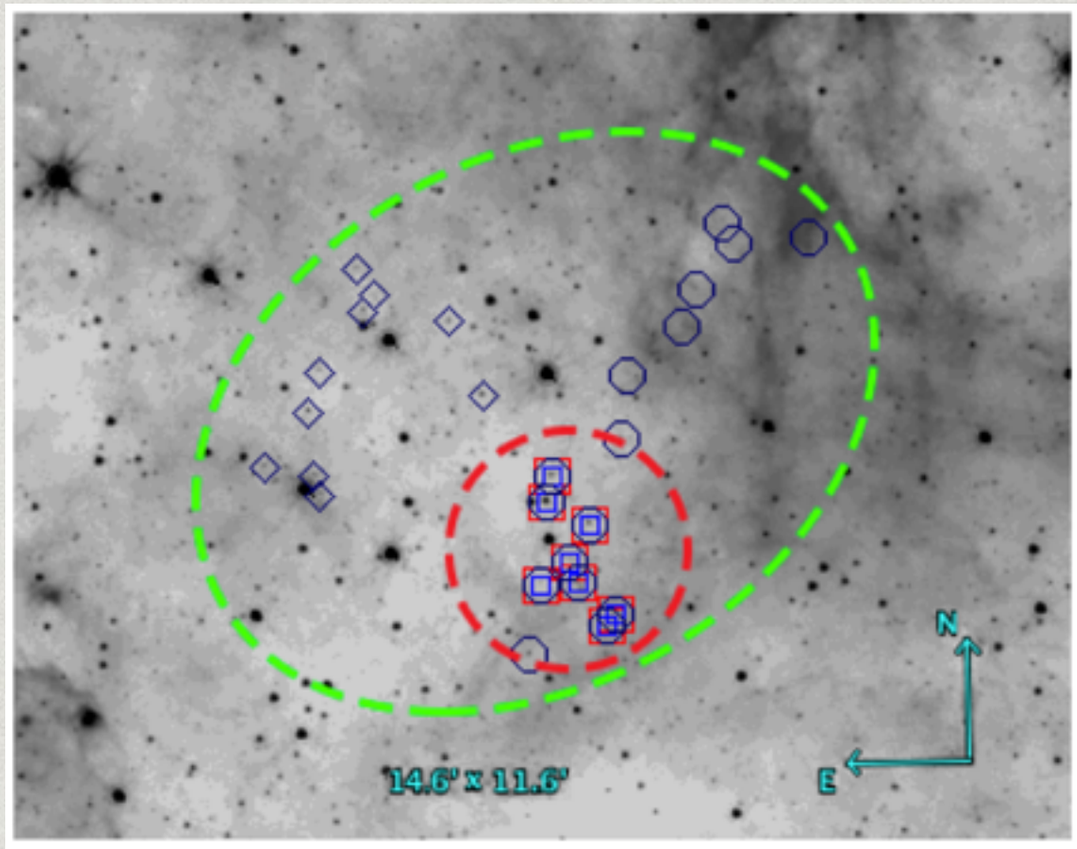
- Individual distance estimates for the 20 massive stars ranges from 2-10 kpc —> separating with RVs.

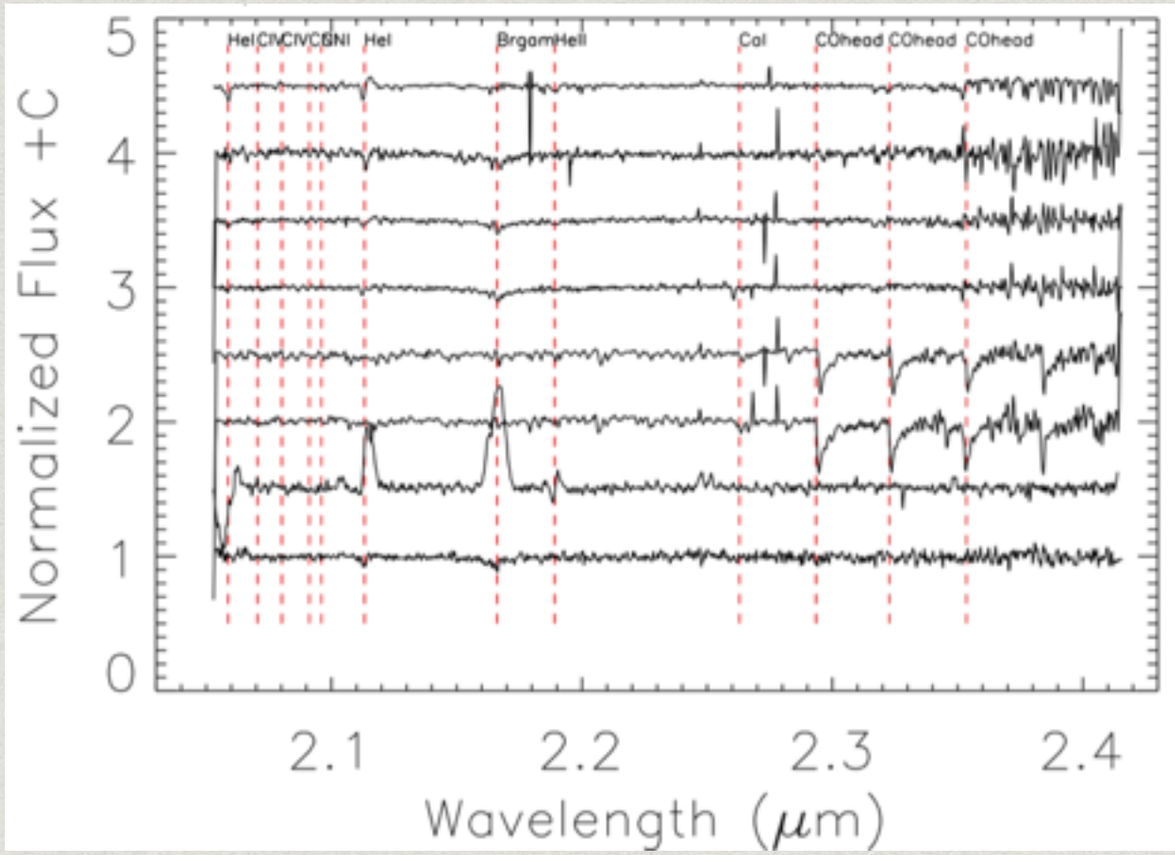


Ramírez Alegría et al. (in prep.)

AUTOPOP-b candidates: Masgomas-10

- Confirmed as massive cluster using LIRIS@WHT *K*-band spectroscopy.
- 8 early-type objects (including A0I & WN8).

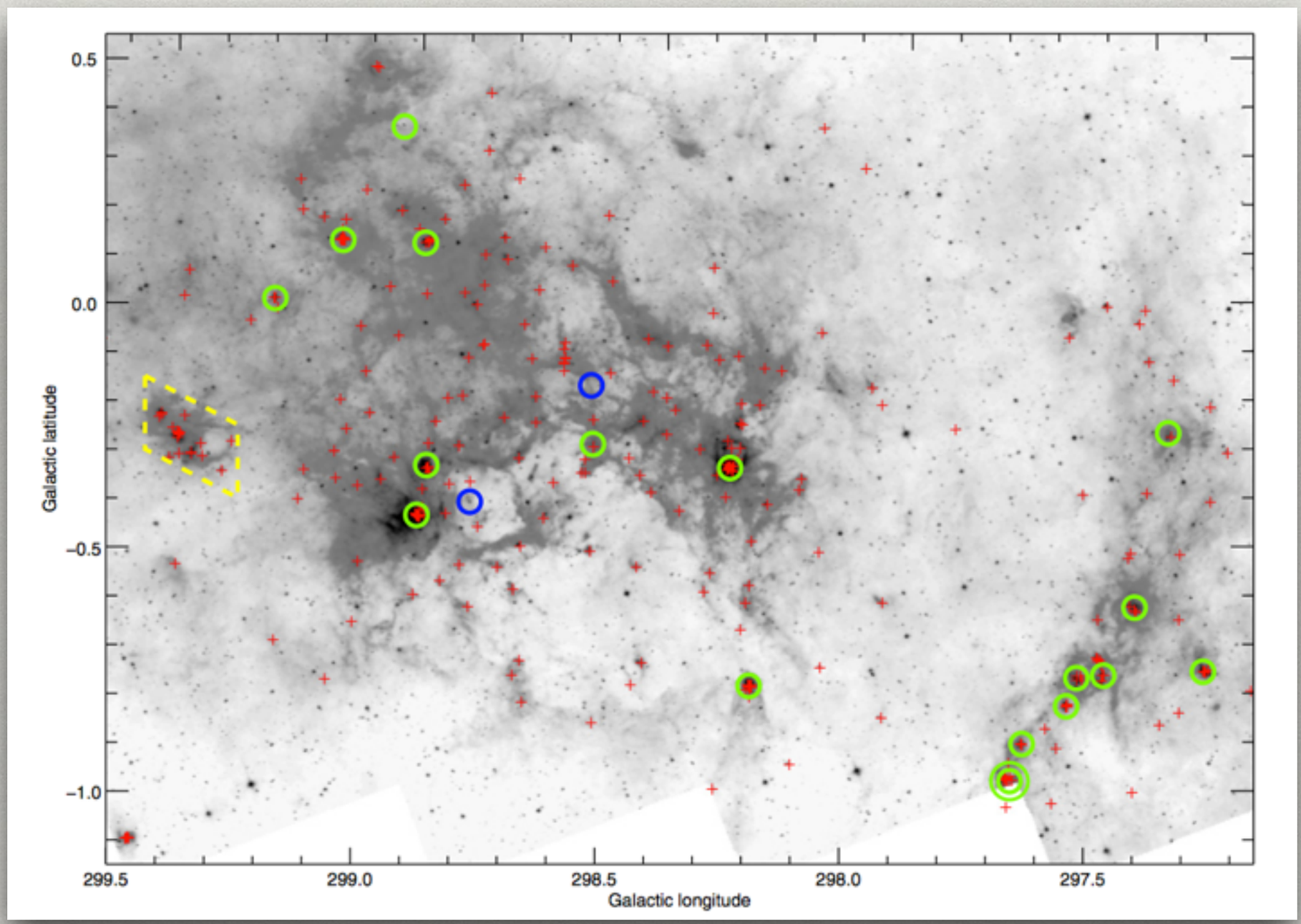




Herrero et al. (in prep.)

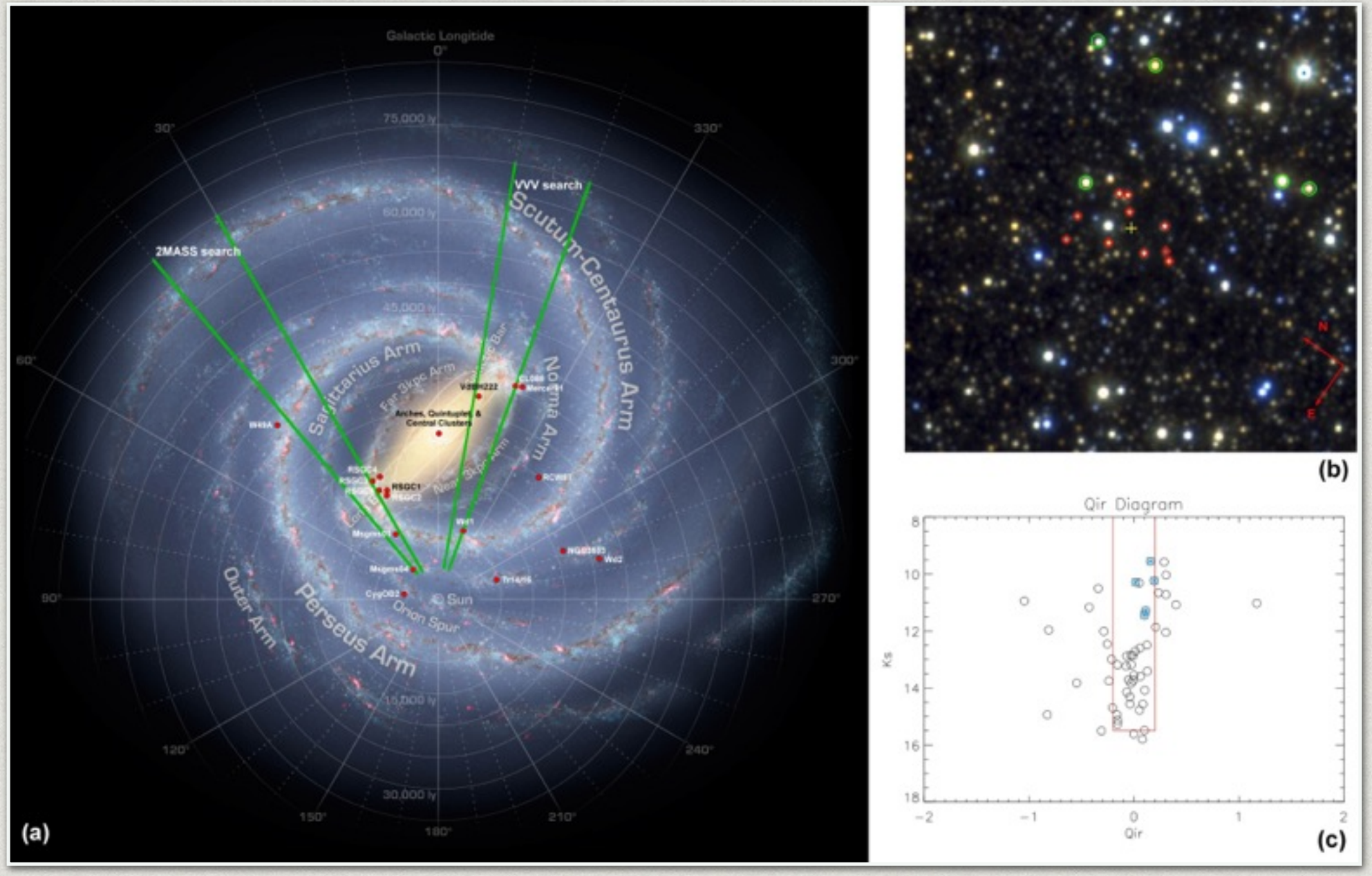
Next steps.

Studying the environment around clusters

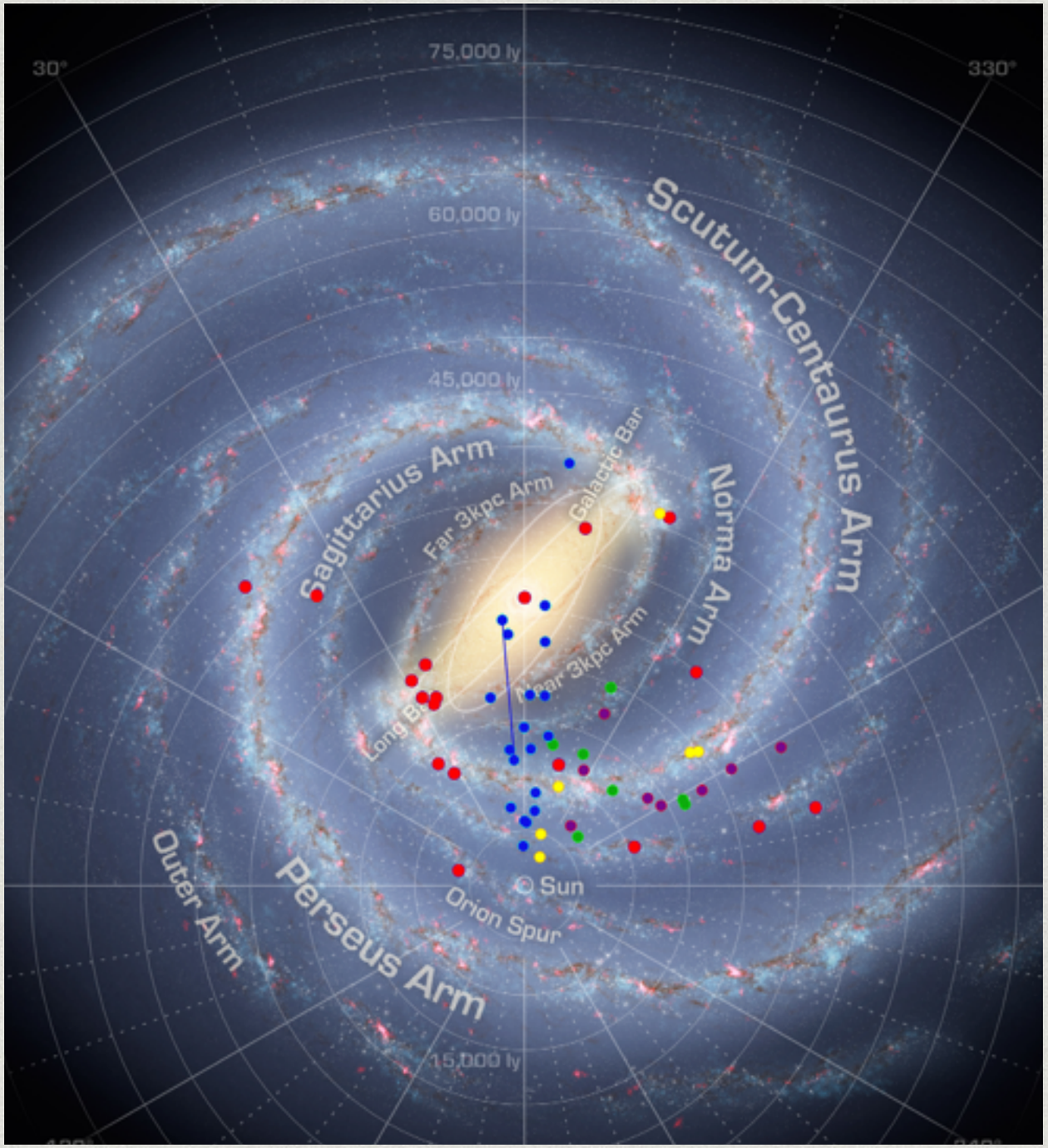


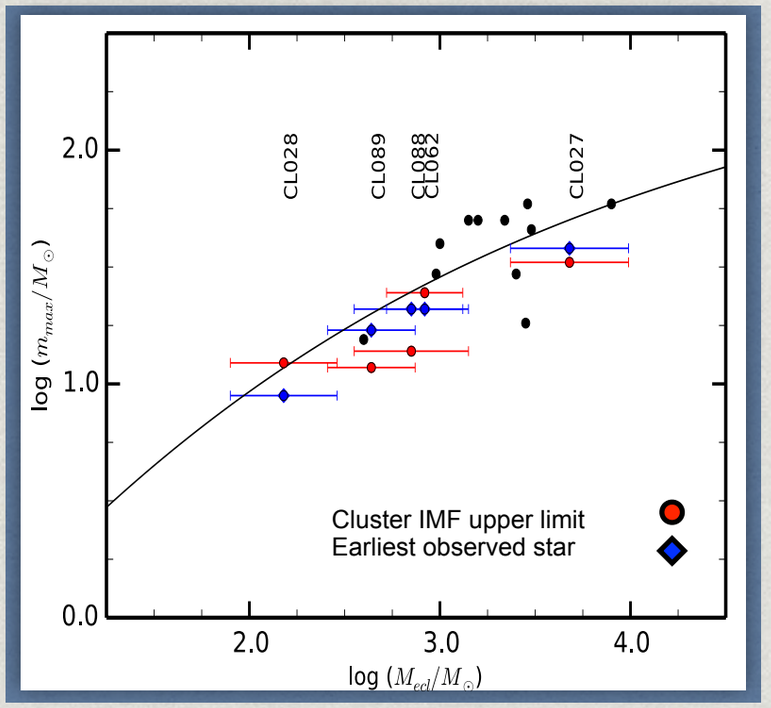
Mercer30 & the Dragonfish nebula
(de la Fuente et al. 2016)

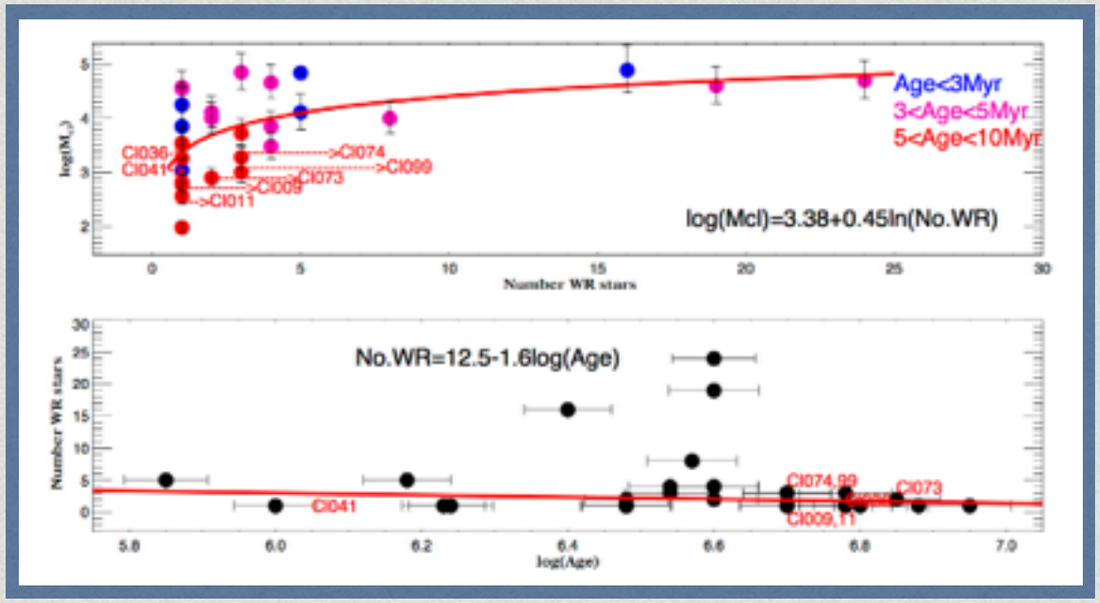
AUTOPOP-b candidates: Southern extension



Using the database of cluster parameters







Conclusions + open questions

- Near infrared surveys are a useful resources to find stellar cluster ***candidates.*** Extra data required to confirm real clusters

- The use of $K_S+Q_{IR}+(J-K_S)$ selection criteria is effective to find massive star cluster candidates (once the extinction law is determined).

- Is a cluster always an over-density?
  In which (minimal) space (RA, dec, $UVB+Q$, $JHK+Q_{IR}$, MIR, sub-mm, PM, RV, …)?