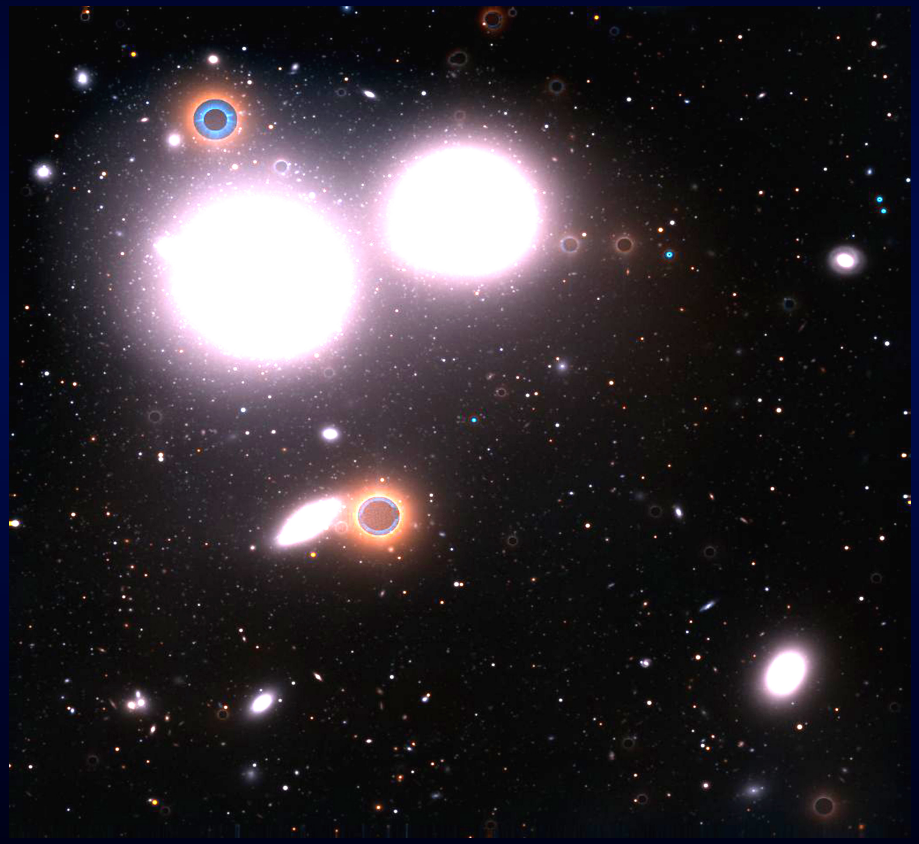
Blue globular cluster in the halo of the central Hydra cluster galaxy

Michael Hilker (ESO/Garching)



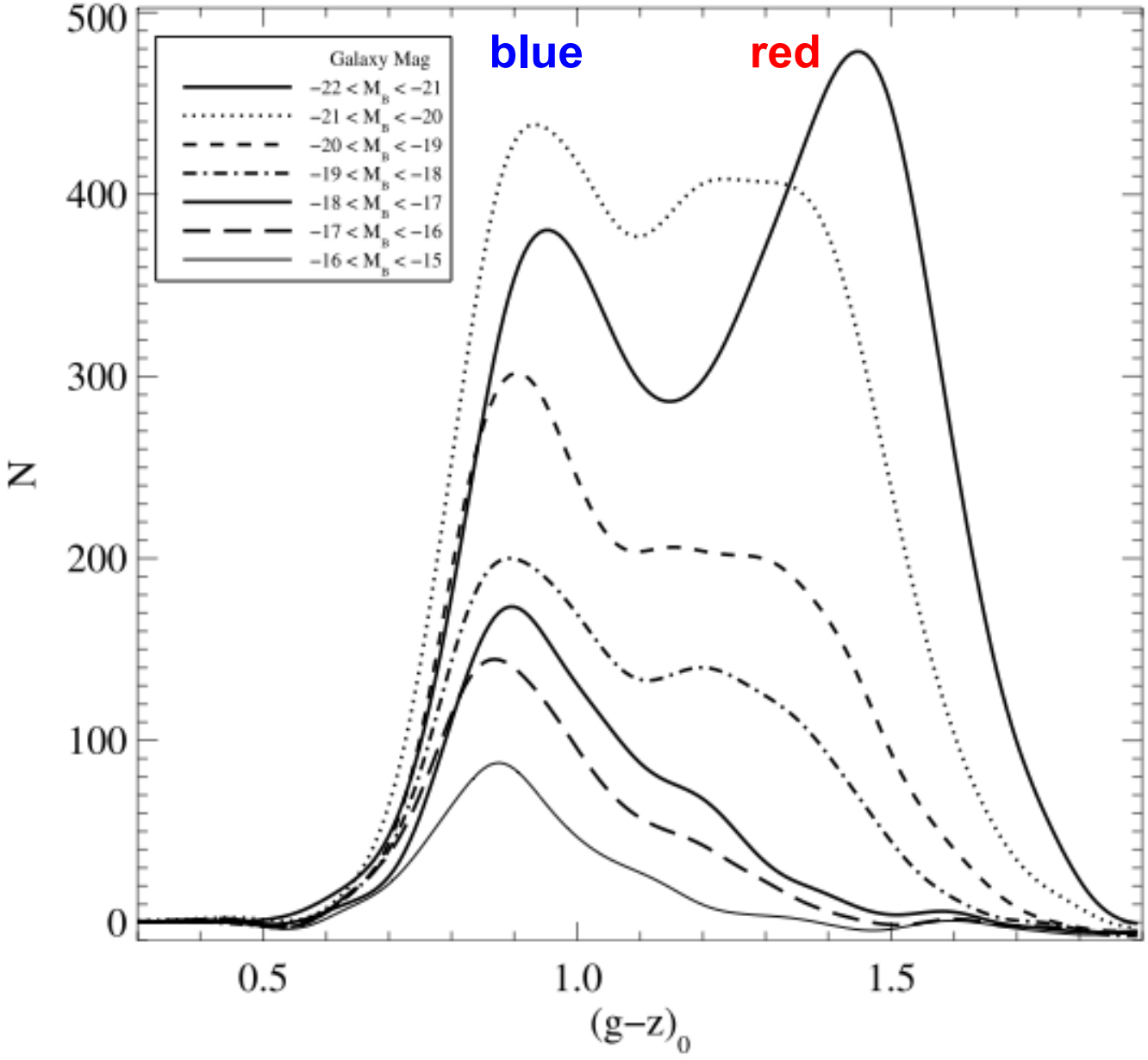
Outline:

- Blue and red globular clusters
- Blue is not the same as blue
- From red to blue GCs
- NGC 3311 in the Hydra cluster
- Two blue GC populations
- From blue to red GCs

Our team: **Johannes Müller-Seidlitz** (ESO/Garching), Steffen Mieske (ESO/Chile), Tom Richtler (Concepcion/Chile)

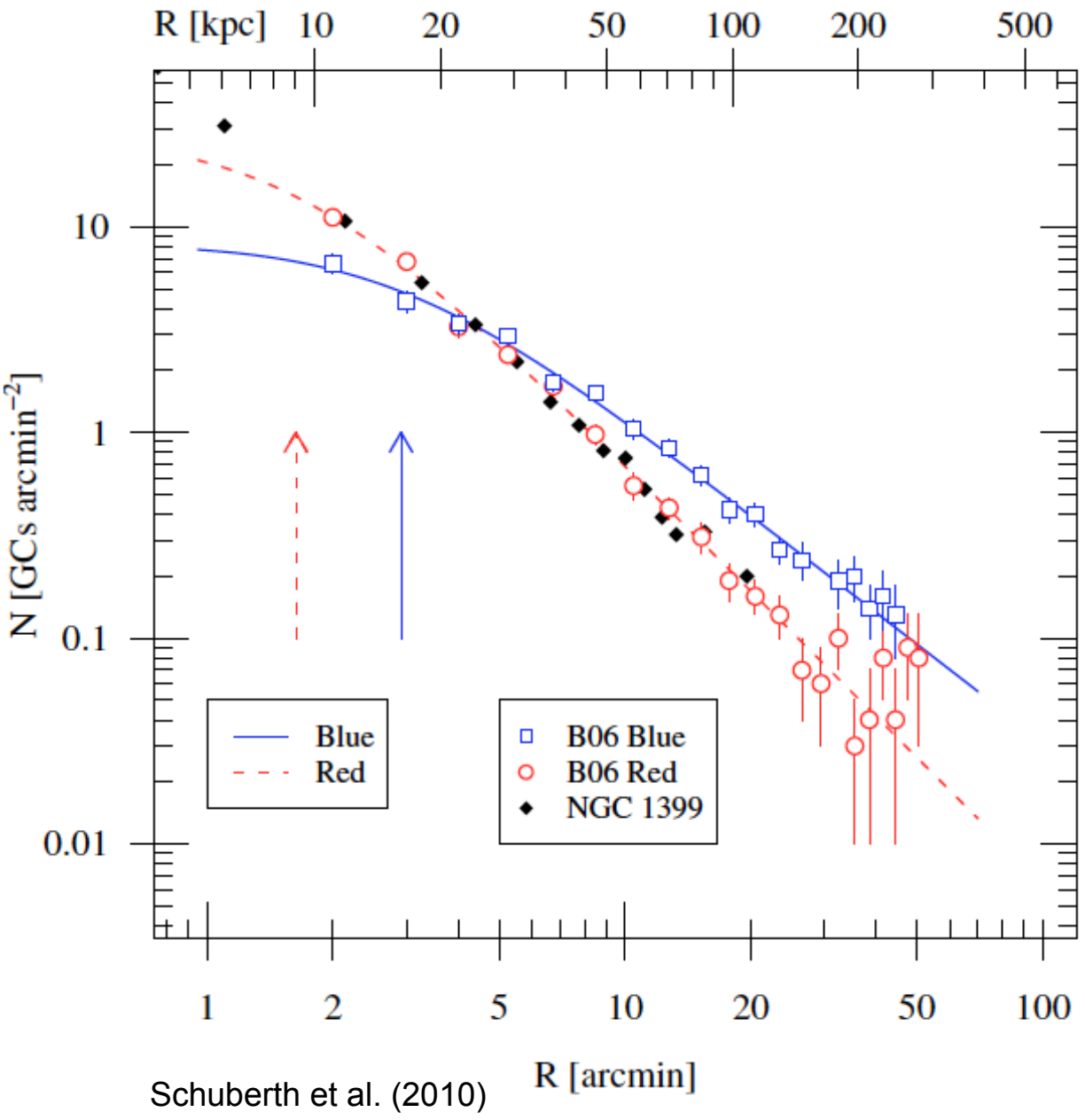
Blue and red globular clusters

ACS Virgo Cluster Survey: GC colour bimodality vs. galaxy luminosity



Peng et al. (2006)

Number density profiles of red and blue GCs around NGC 1399 in the Fornax cluster



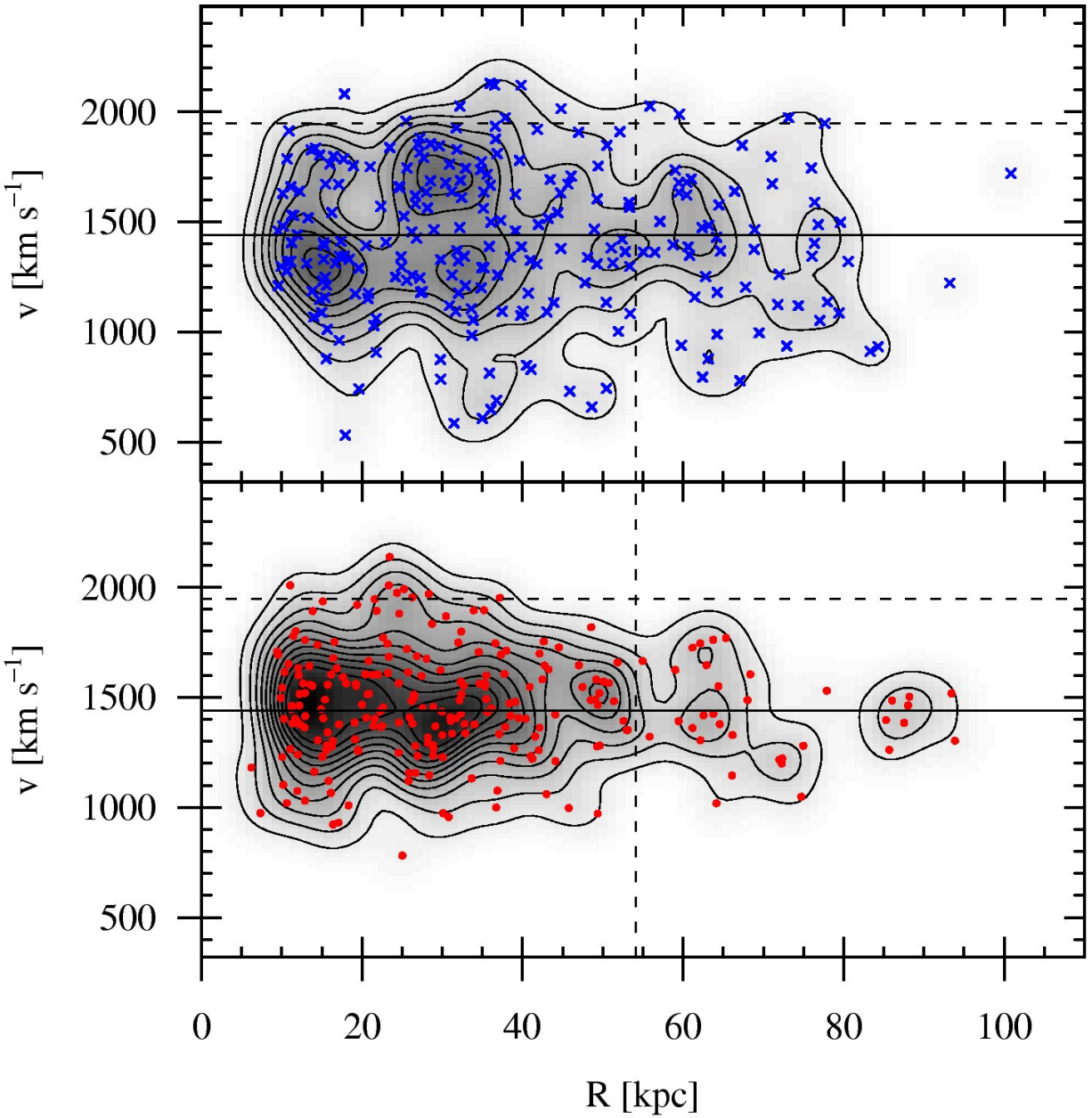
Schuberth et al. (2010)

Red GCs do follow the properties of the spheroid stellar population.

Blue GCs dominate in the halo of NGC 1399.

NGC 1399 – GC velocities

Blue GCs
(metal-poor)



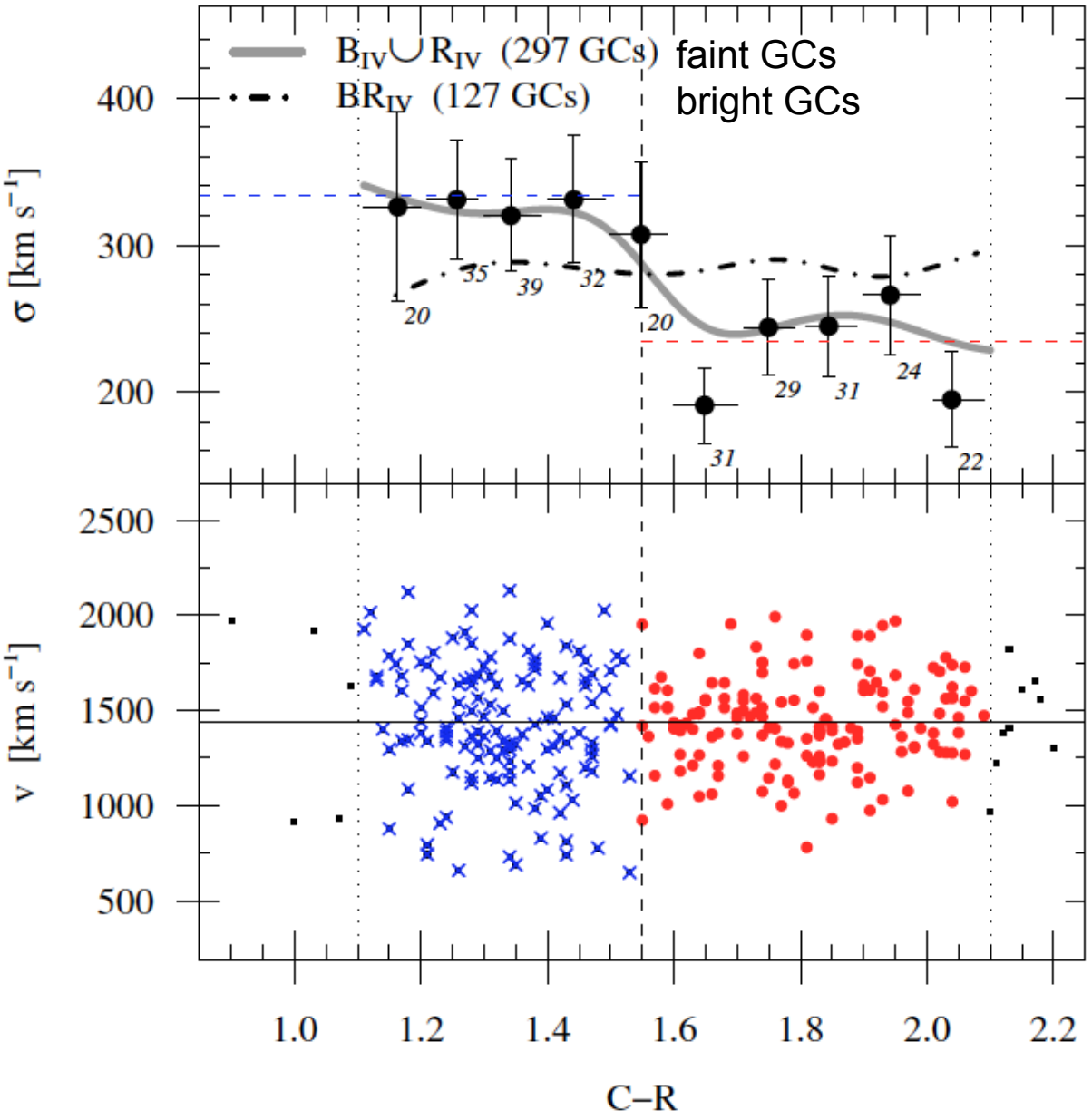
Red GCs
(metal-rich)

very **jagged**
σ_{los}(R)

smooth
σ_{los}(R)

Schuberth et al.
(2010, A&A 513, 52)

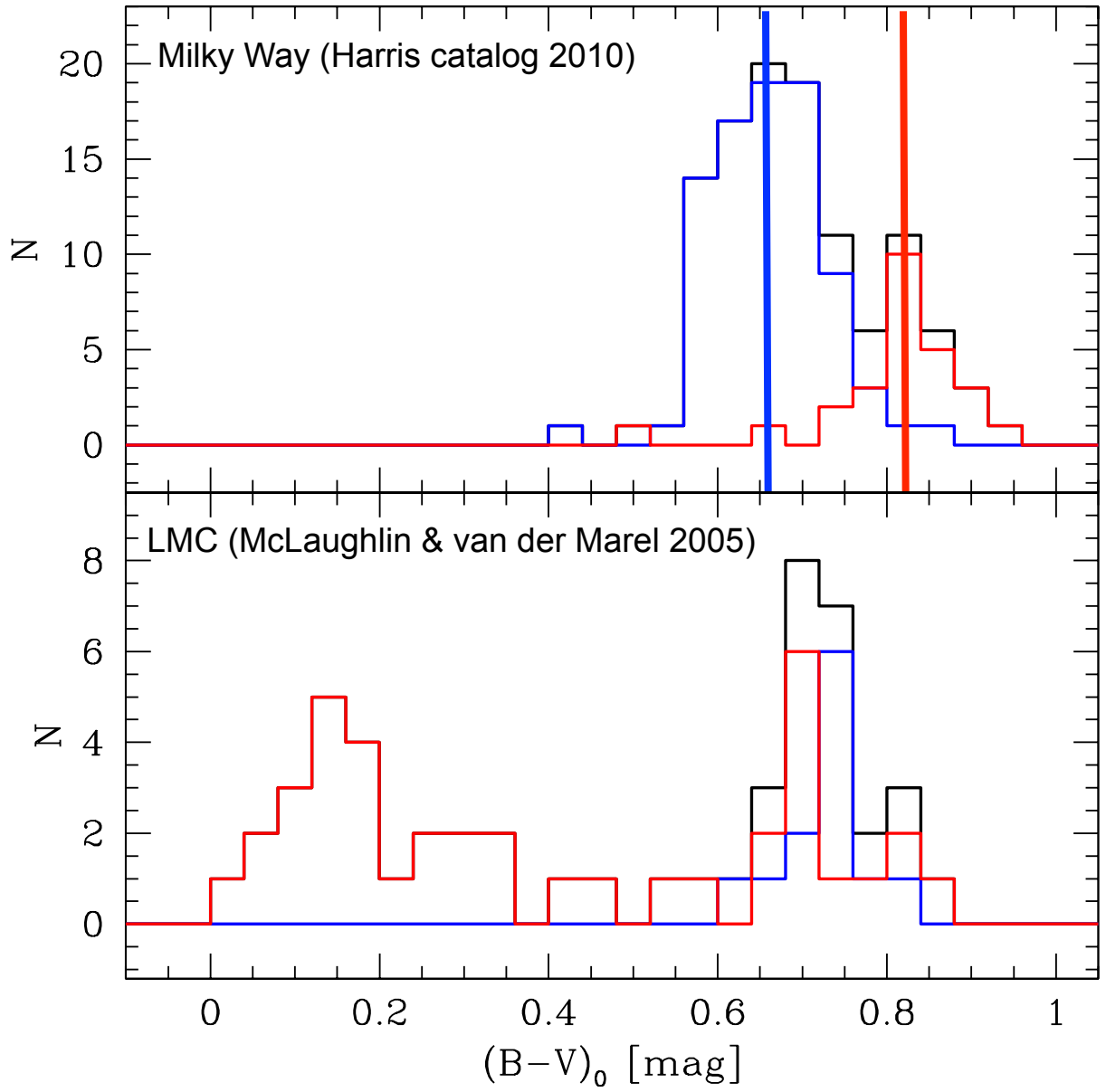
Velocity and velocity dispersion vs. colour



Schuberth et al. (2010)

Blue is not the same as blue

Colour distribution of (globular) clusters in the Milky Way and LMC

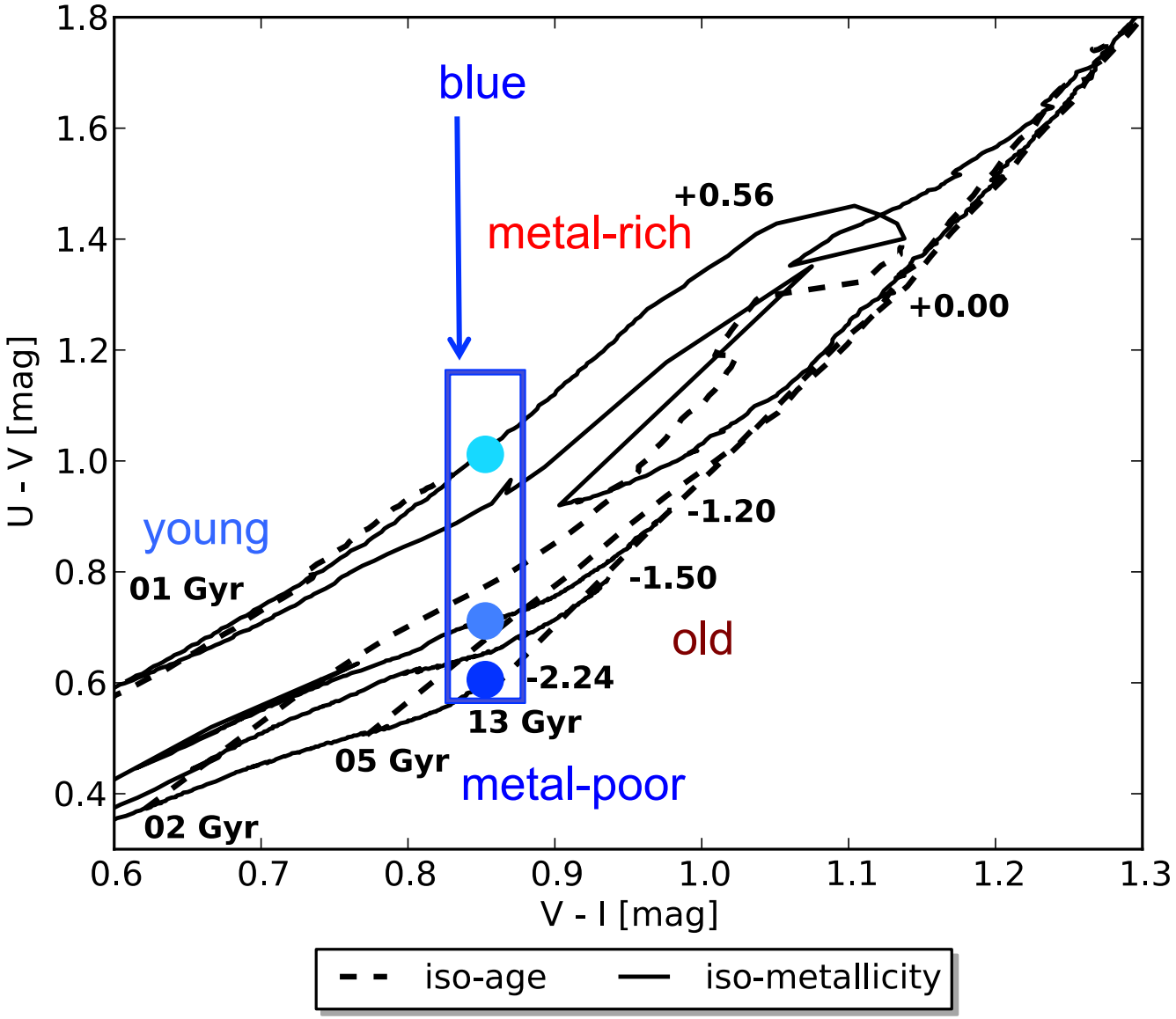


[Fe/H]<-1.0 dex

[Fe/H]>-1.0 dex

In the LMC, all metal-poor GCs are older than 10 Gyr, all metal-rich GCs are younger than 4 Gyr

Simple stellar population models in the 2-colour space



Age = 1 Gyr
[Fe/H] = +0.5 dex

Age = 4 Gyr
[Fe/H] = -1.2 dex

Age = 13 Gyr
[Fe/H] = -2.2 dex

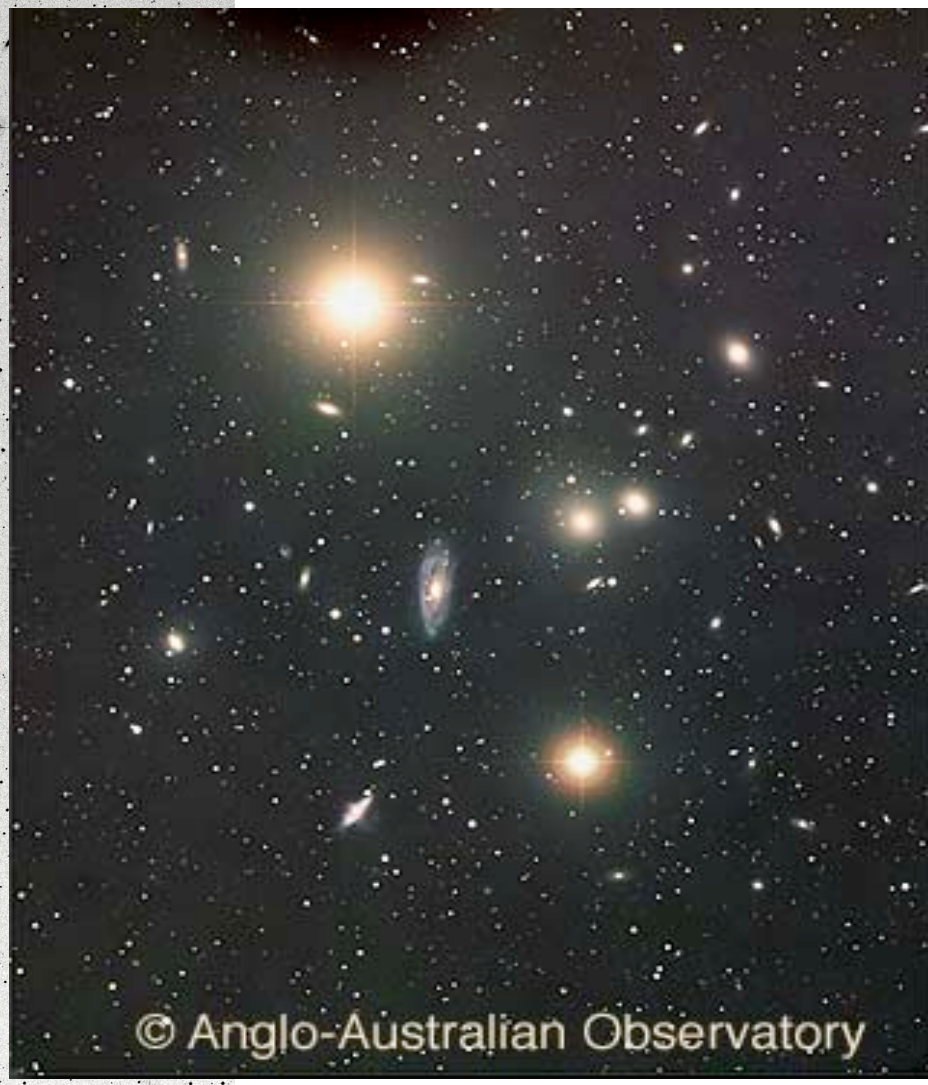
PARSEC isochrones, Bressan et al. (2012)

NGC 3311 in the Hydra I cluster

The Hydra I cluster

D = 42 Mpc

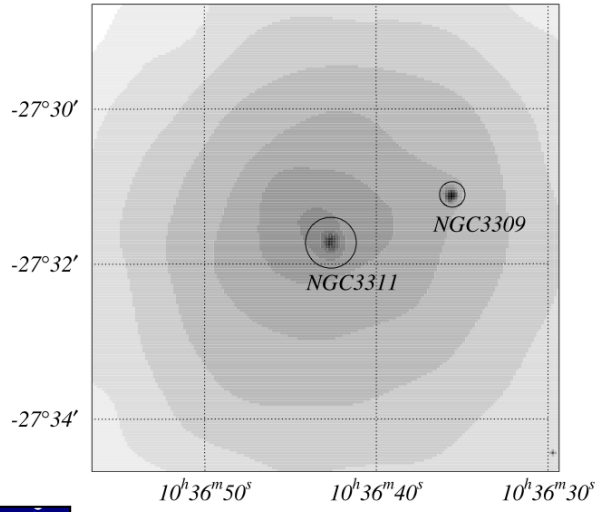
R_{core} = 170 kpc (Girardi et al. 1995)



DSS, 1x1 deg

100 kpc

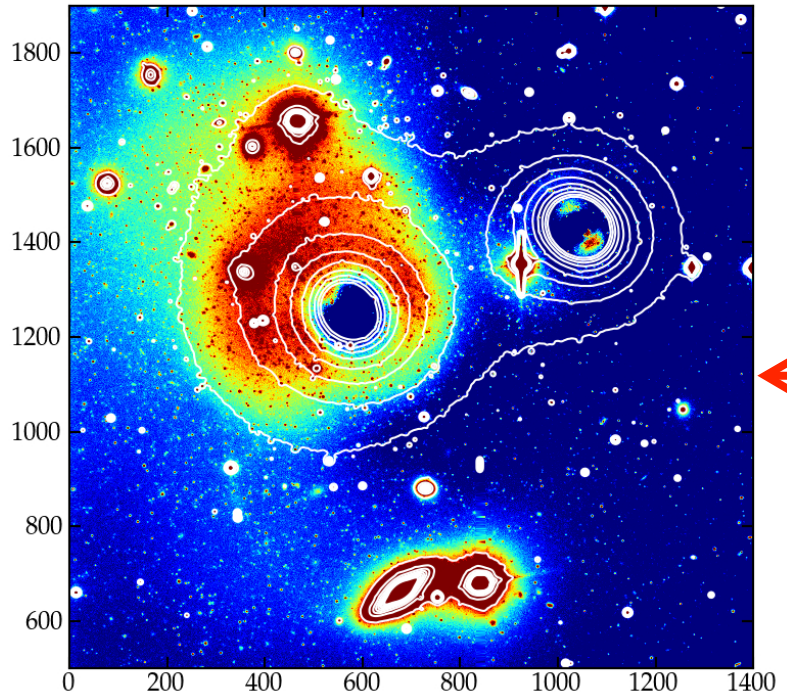
Stars and gas in the core of the Hydra I cluster



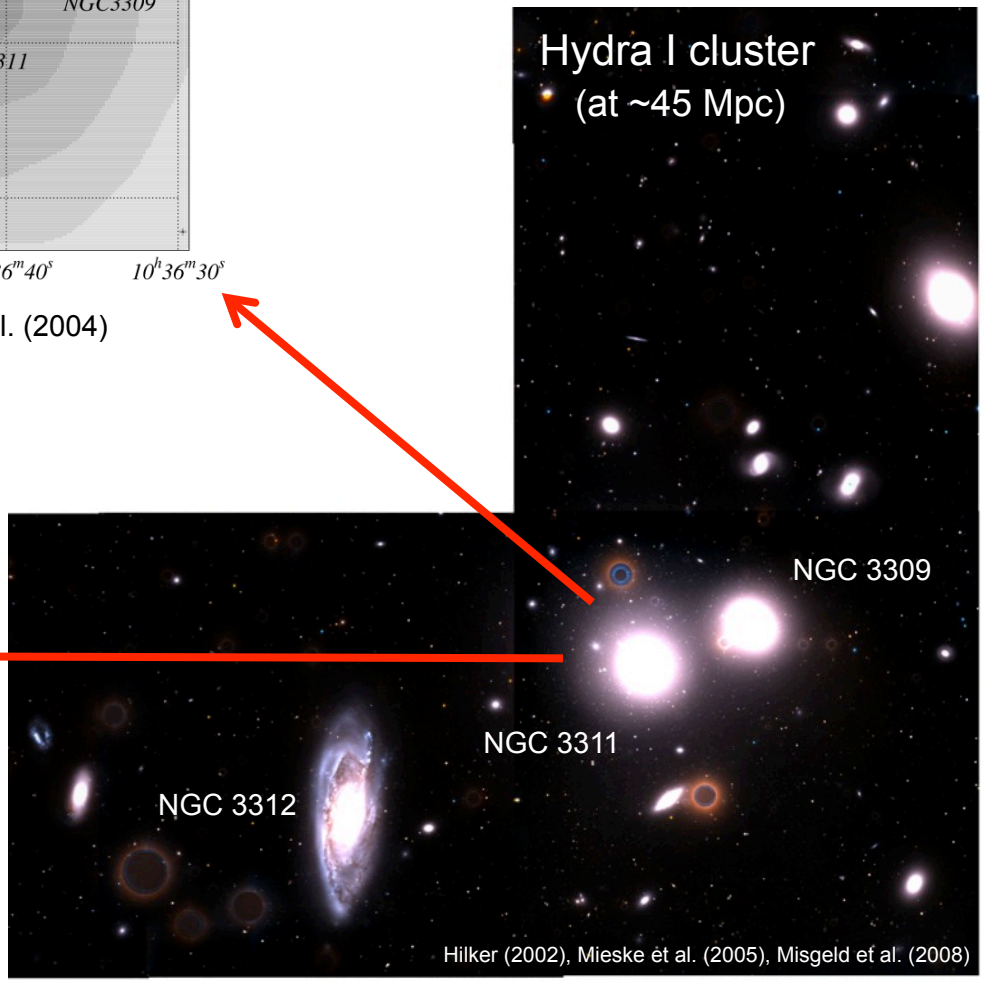
Chandra: displaced X-ray halo

Hayakawa et al. (2004)

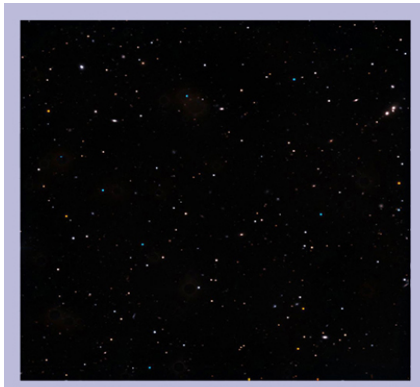
Residual map after subtraction of symmetric elliptical models of NGC 3311 and NGC 3309.



Arnaboldi et al. (2012)



Hydra I cluster



background field
(~1.5 degree East)

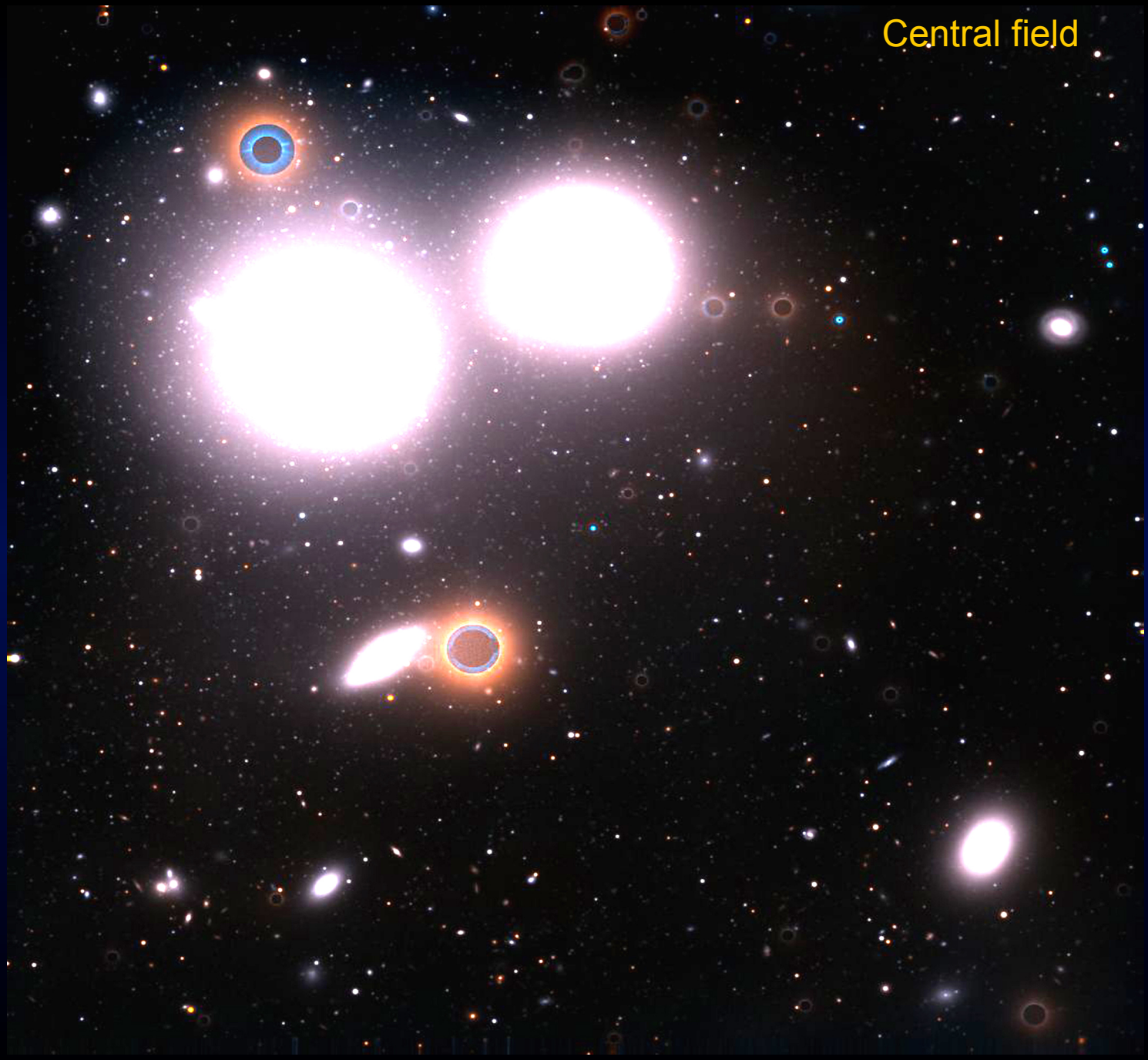
dynamically evolved cluster with regular core shape and isothermal X-ray gas halo out to about 160 kpc

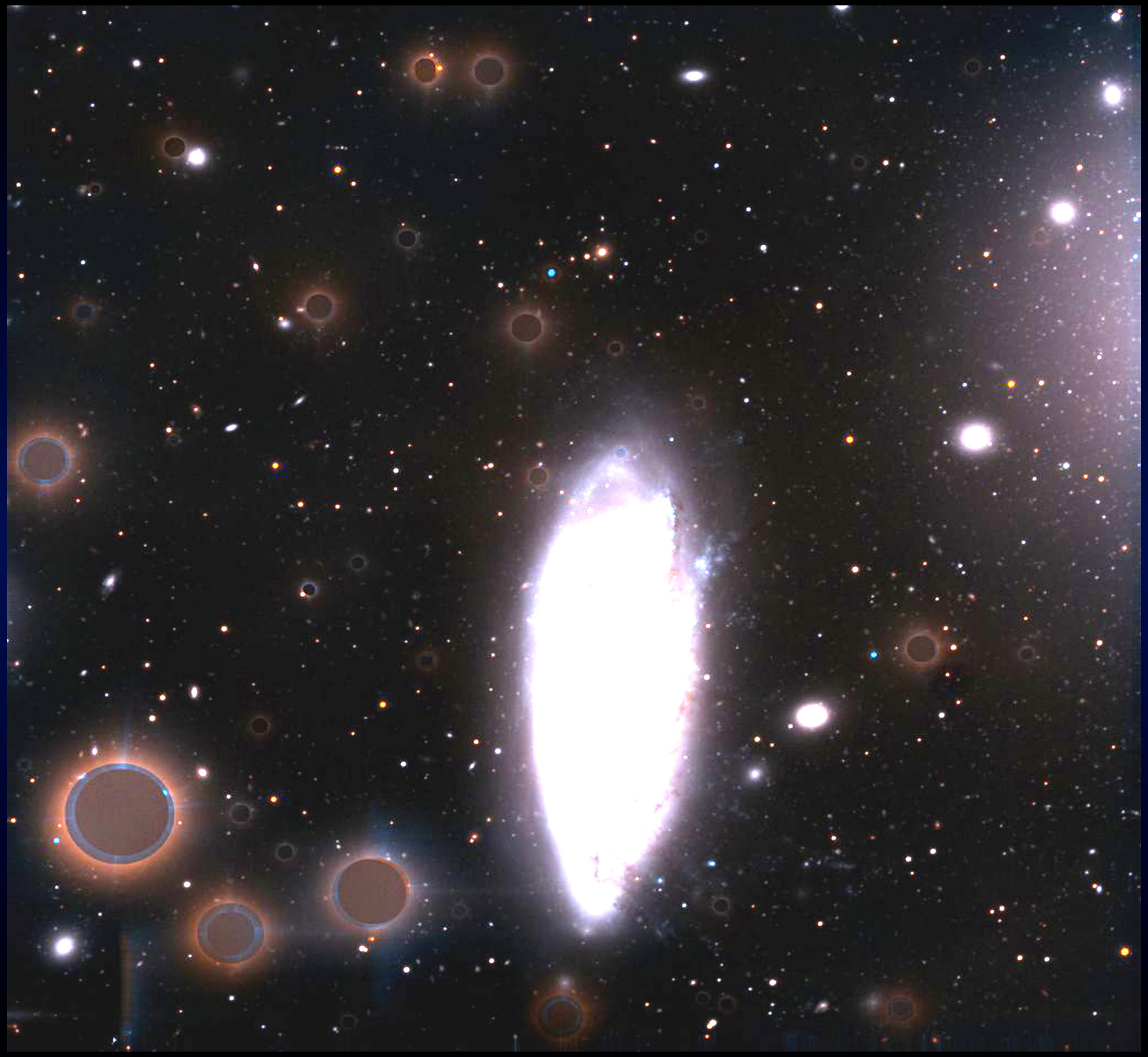
distance: m-M = 33.3
~45 Mpc, z = 0.013
v = 3400+/-610 km/s

Data: VLT+FORS1, April 2000, dark time,
~0.6" seeing, V: 24 min, I: 50 min,
limiting magnitude V~26 mag

NGC 3311:
3593 km/s

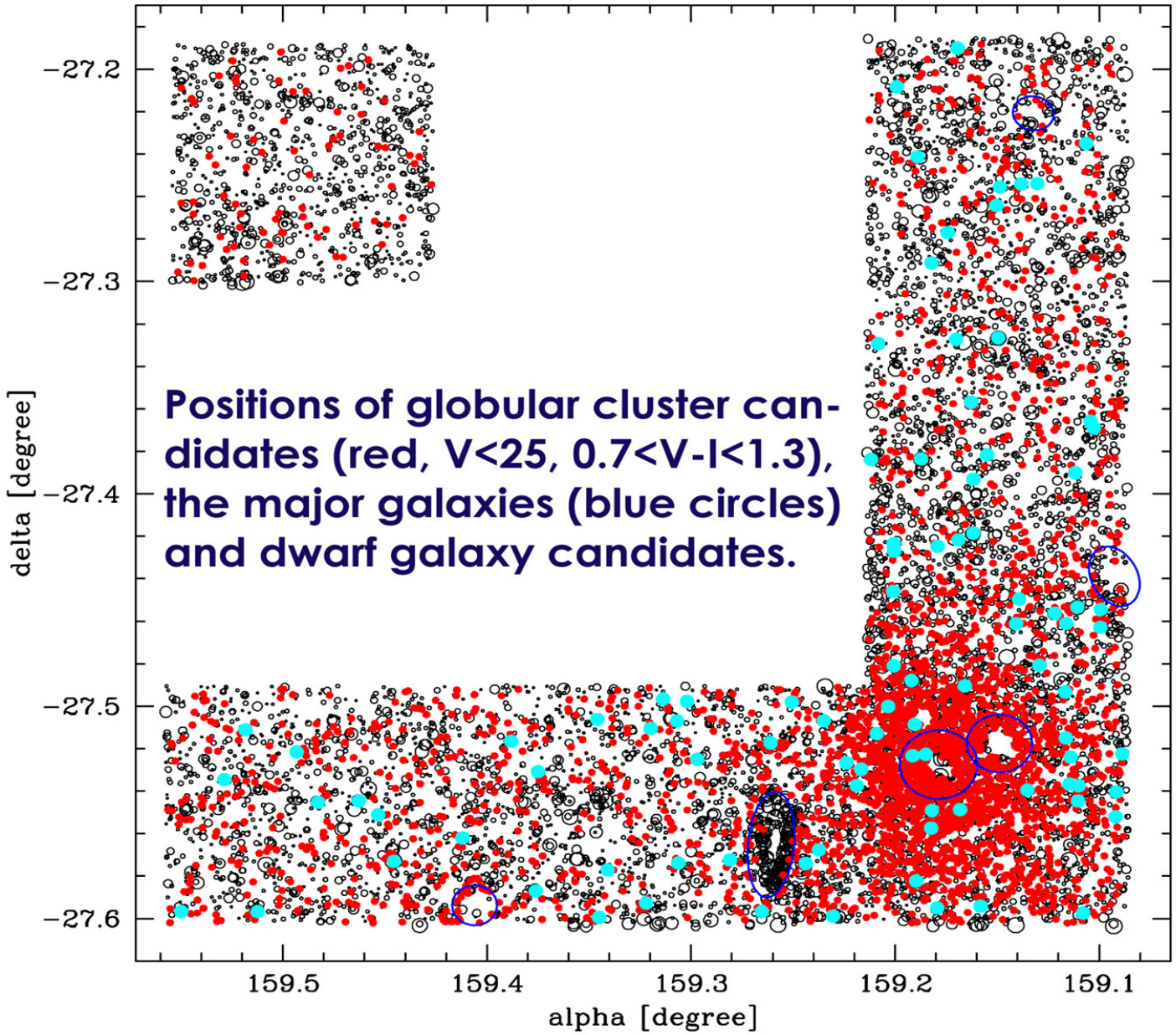
NGC 3309:
4075 km/s


Central field



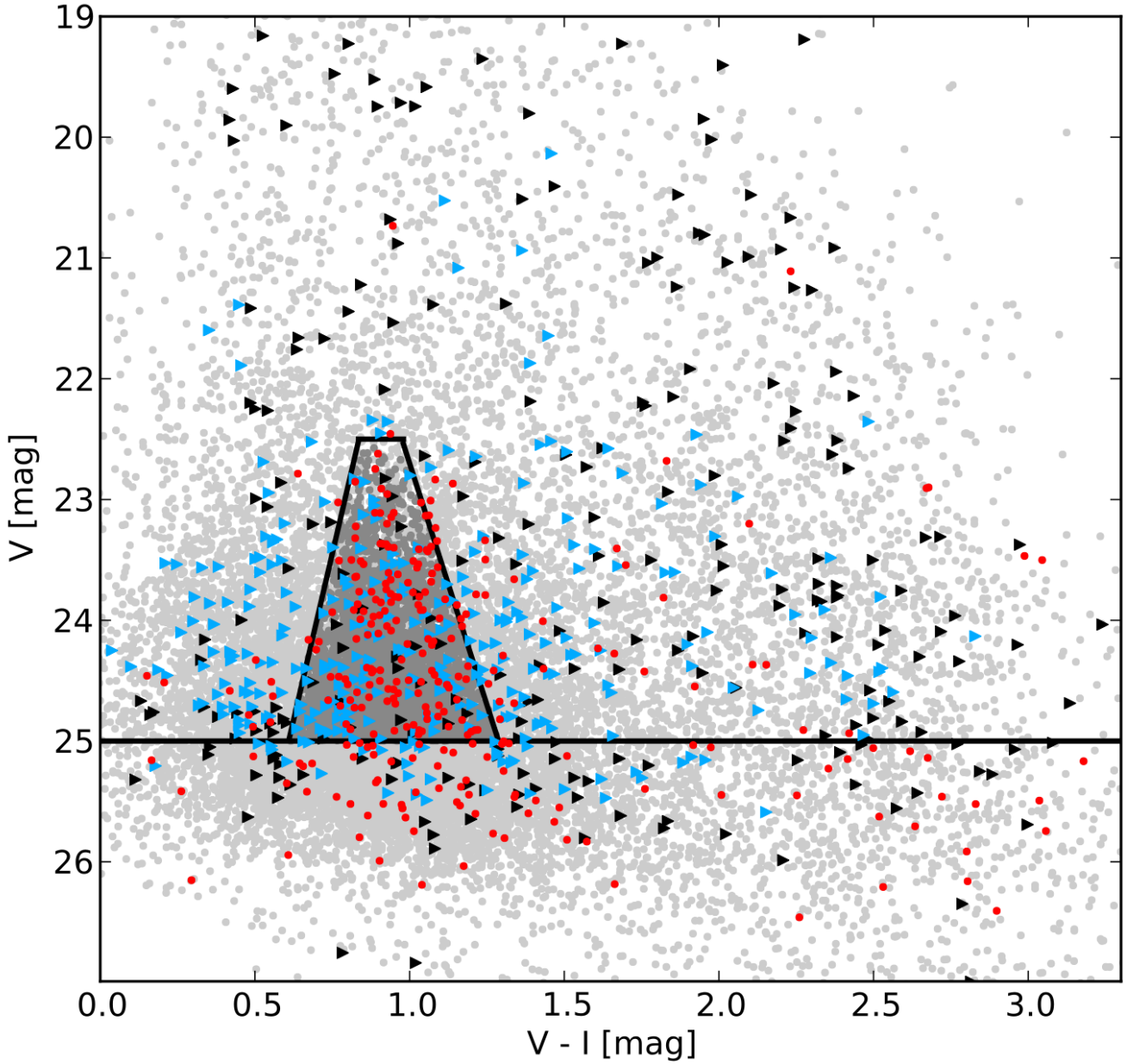
Dr. Michael Hilker (ESO/Garching)

The very rich globular cluster system of the Hydra I cluster



From red to blue GCs

PSF photometry in the V-I colour magnitude diagram

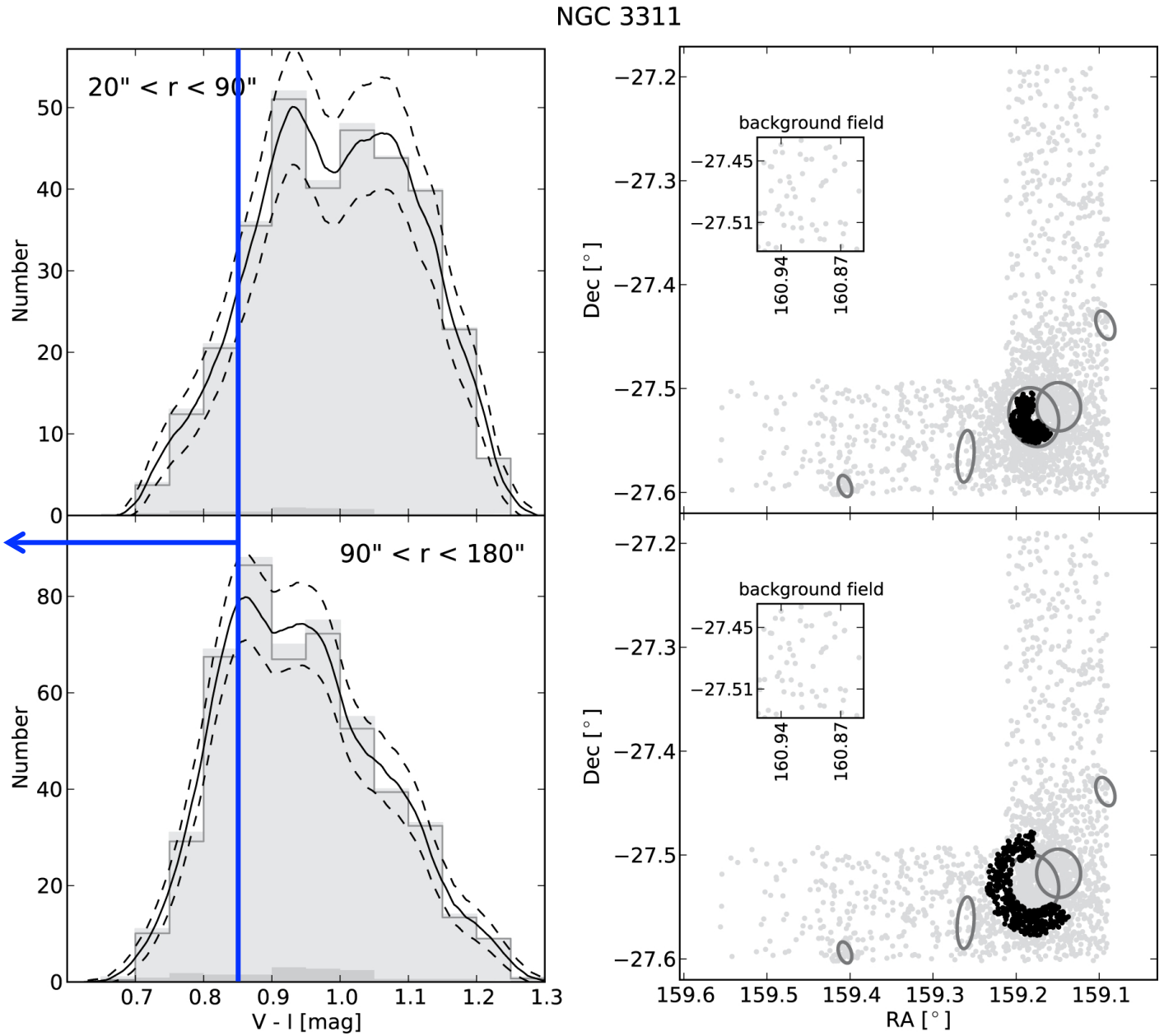


Unresolved sources in the background field

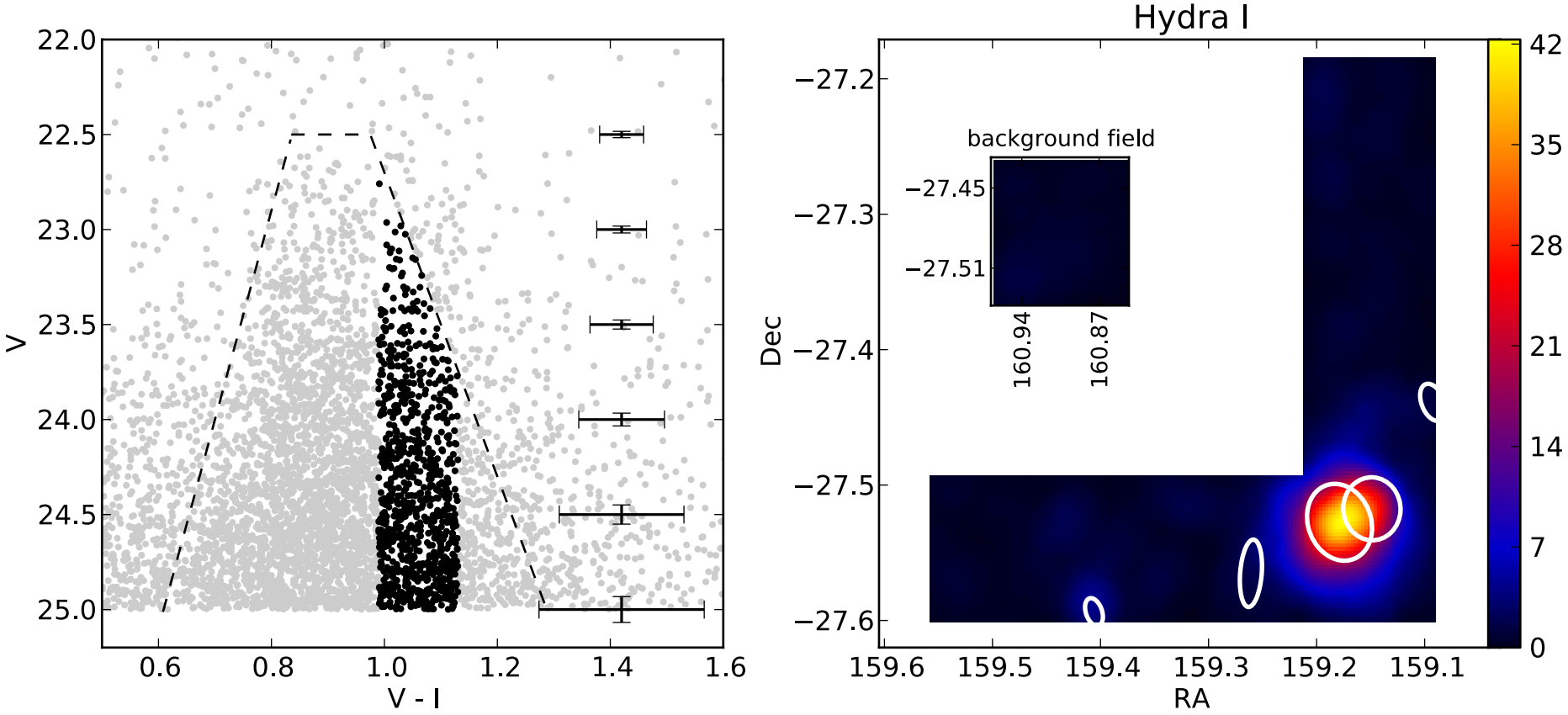
Resolved sources in the background field

Colour histograms of inner and outer GCs around NGC 3311

very blue globulars



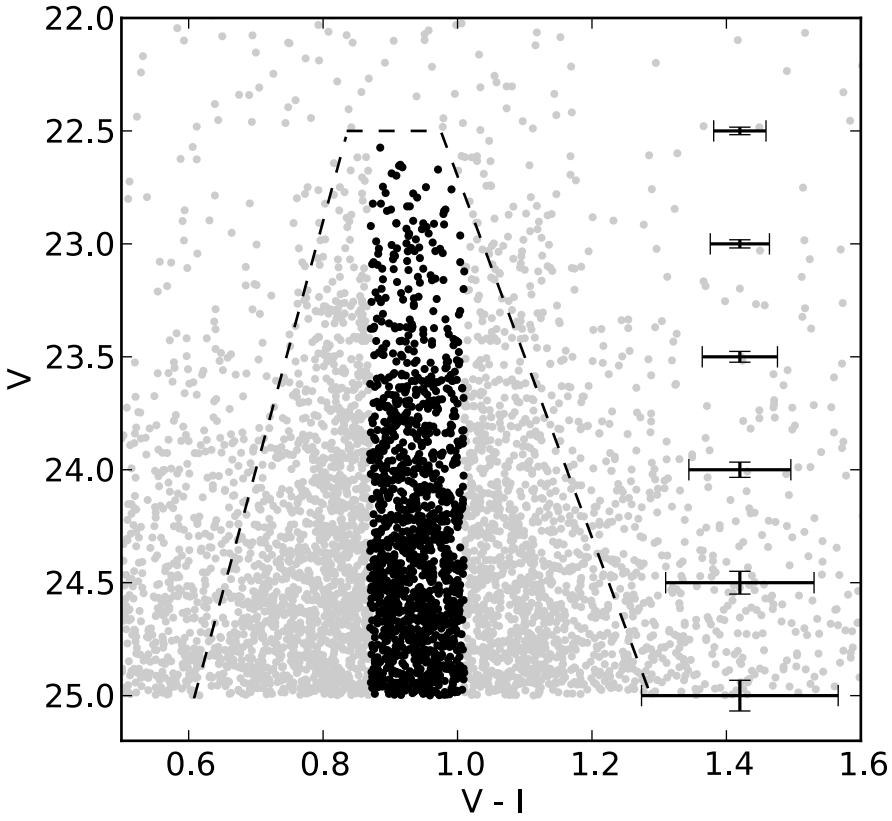
The spatial distribution of GCs in different colour bins

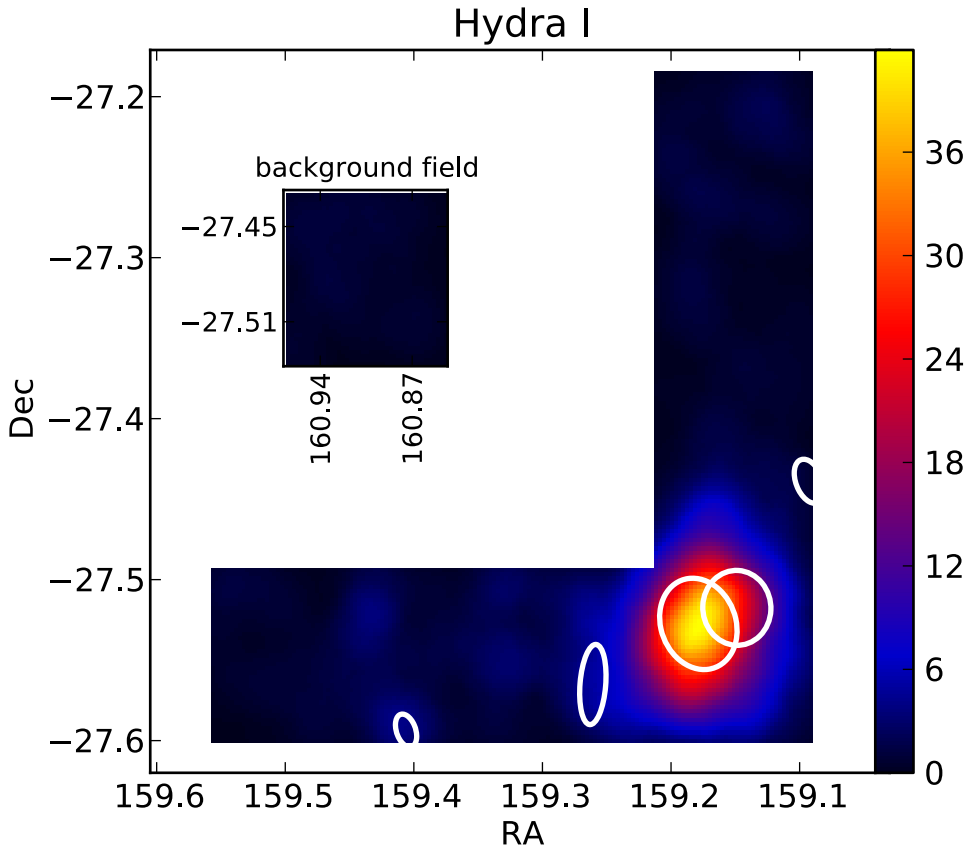


Red GCs are concentrated on galaxies

Hilker, Müller-Seidlitz et al. (in prep.)

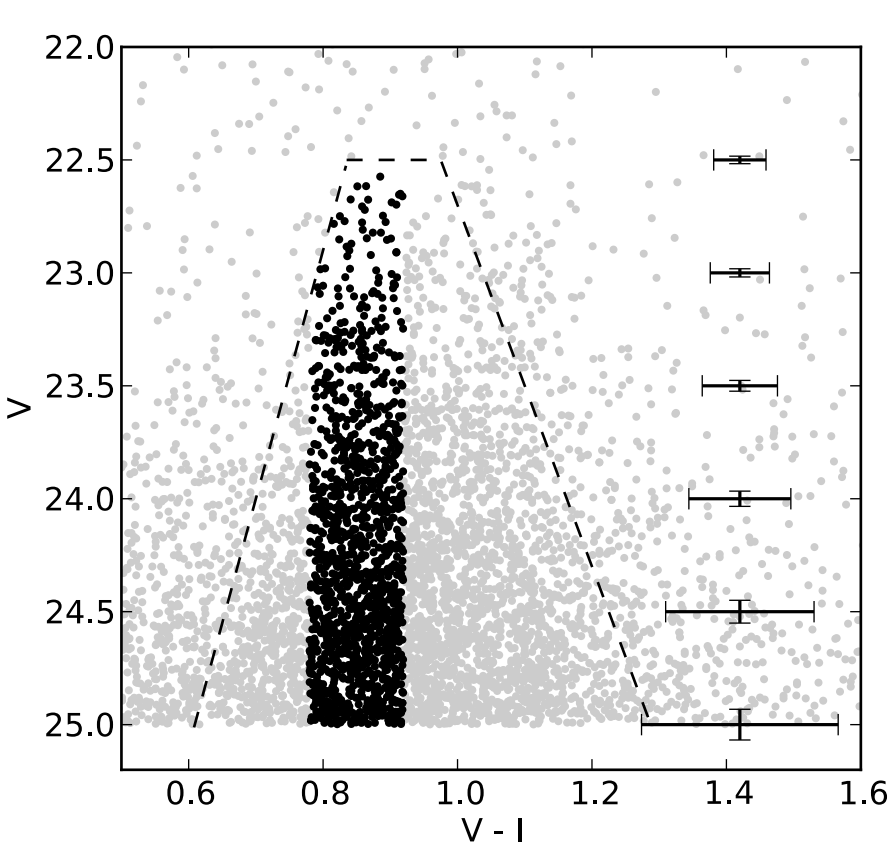
The spatial distribution of GCs in different colour bins

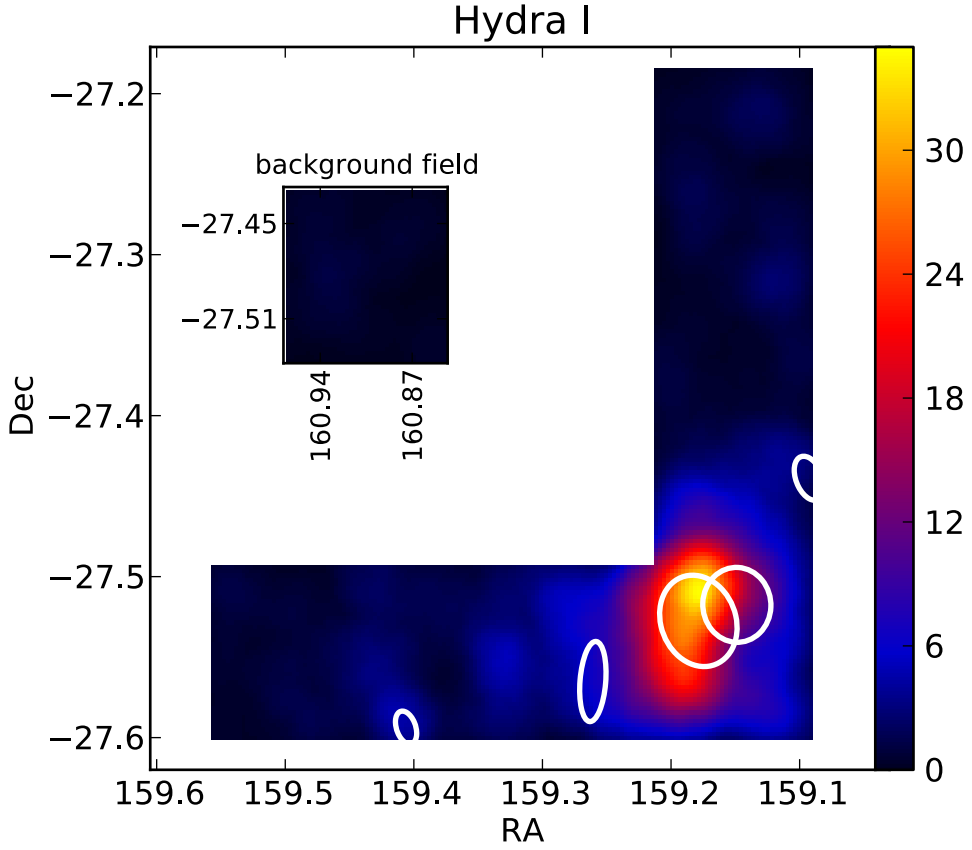




Hilker, Müller-Seidlitz et al. (in prep.)

The spatial distribution of GCs in different colour bins

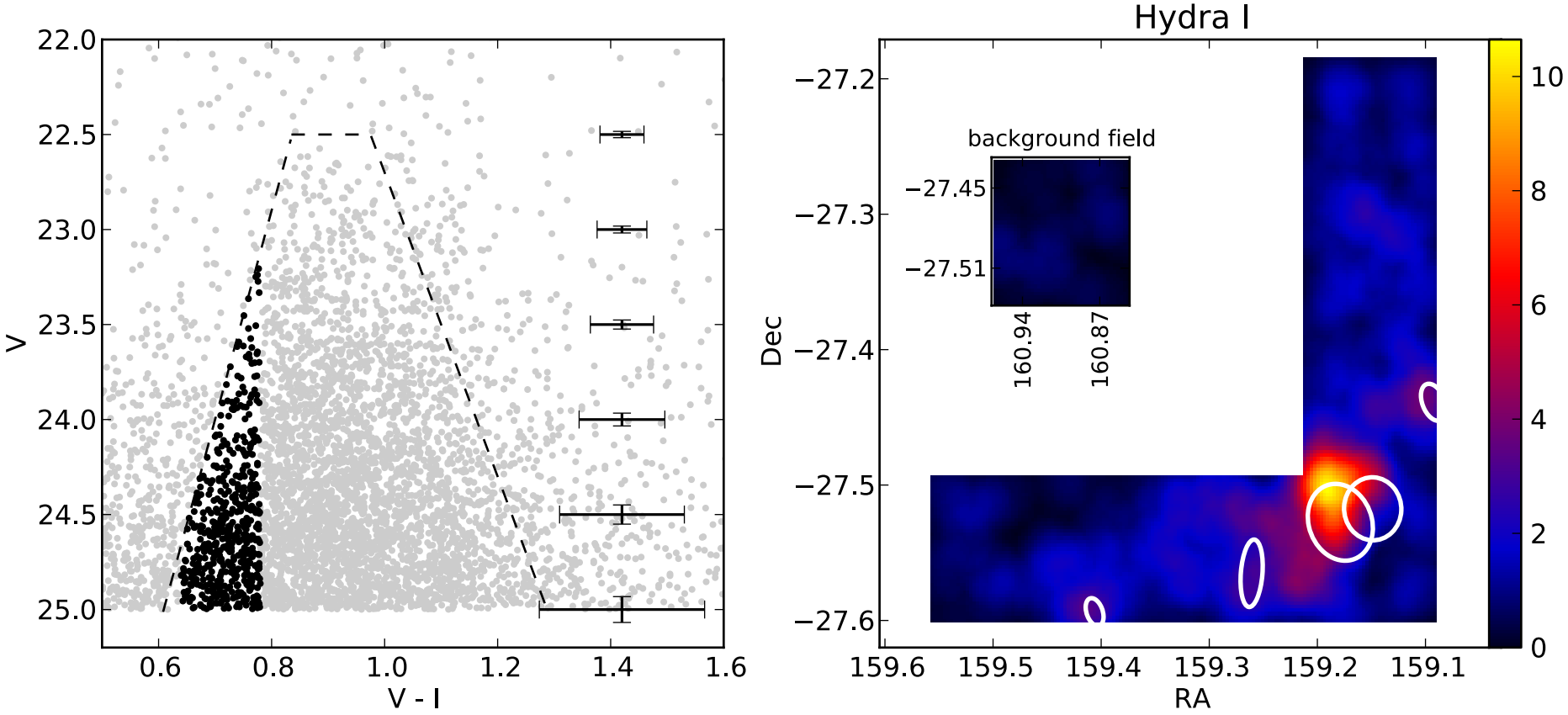




Blue GCs have a more extended distribution

Hilker, Müller-Seidlitz et al. (in prep.)

The spatial distribution of GCs in different colour bins

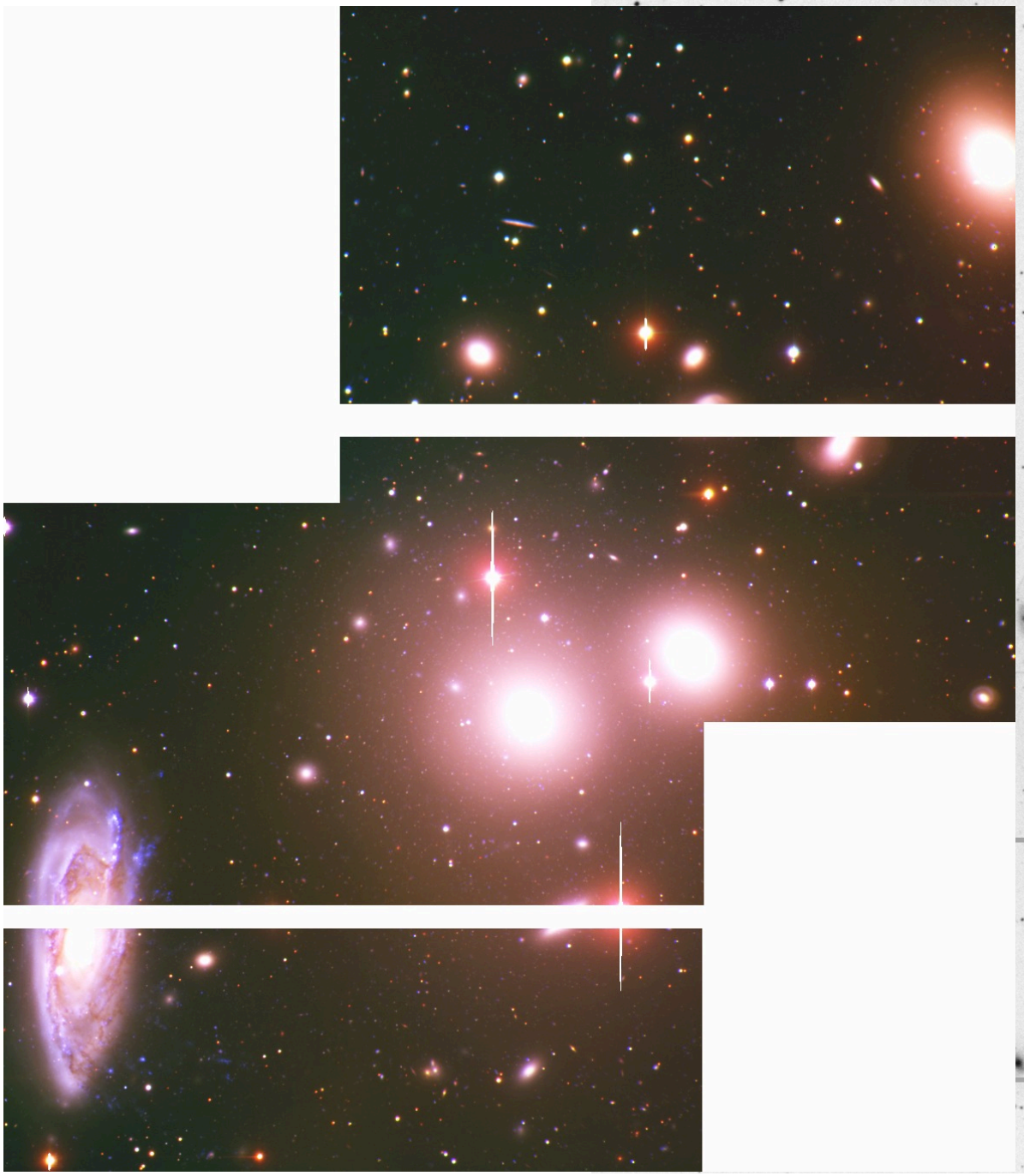


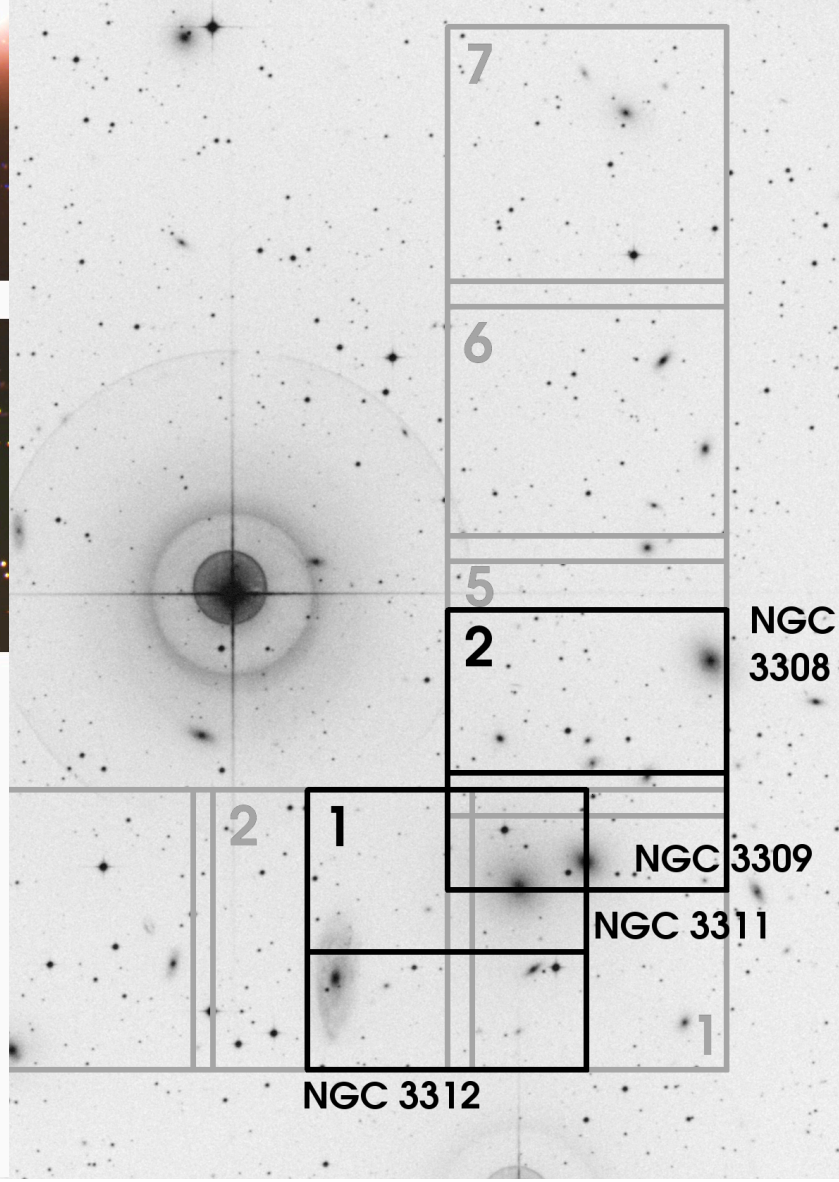
Very blue GCs are displaced towards North and East

Hilker, Müller-Seidlitz et al. (in prep.)

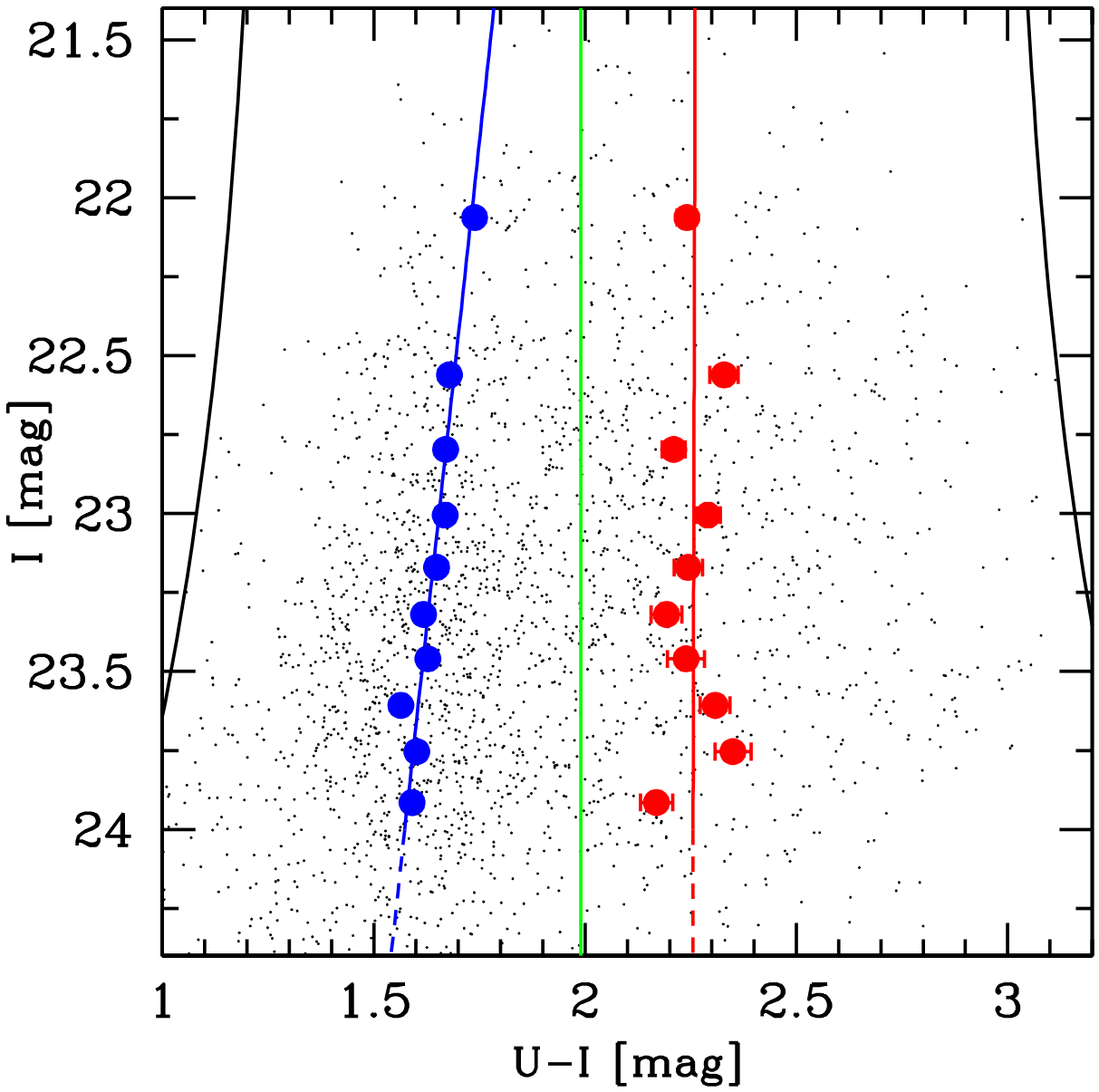
Two blue GC populations

U-band observations with FORS2



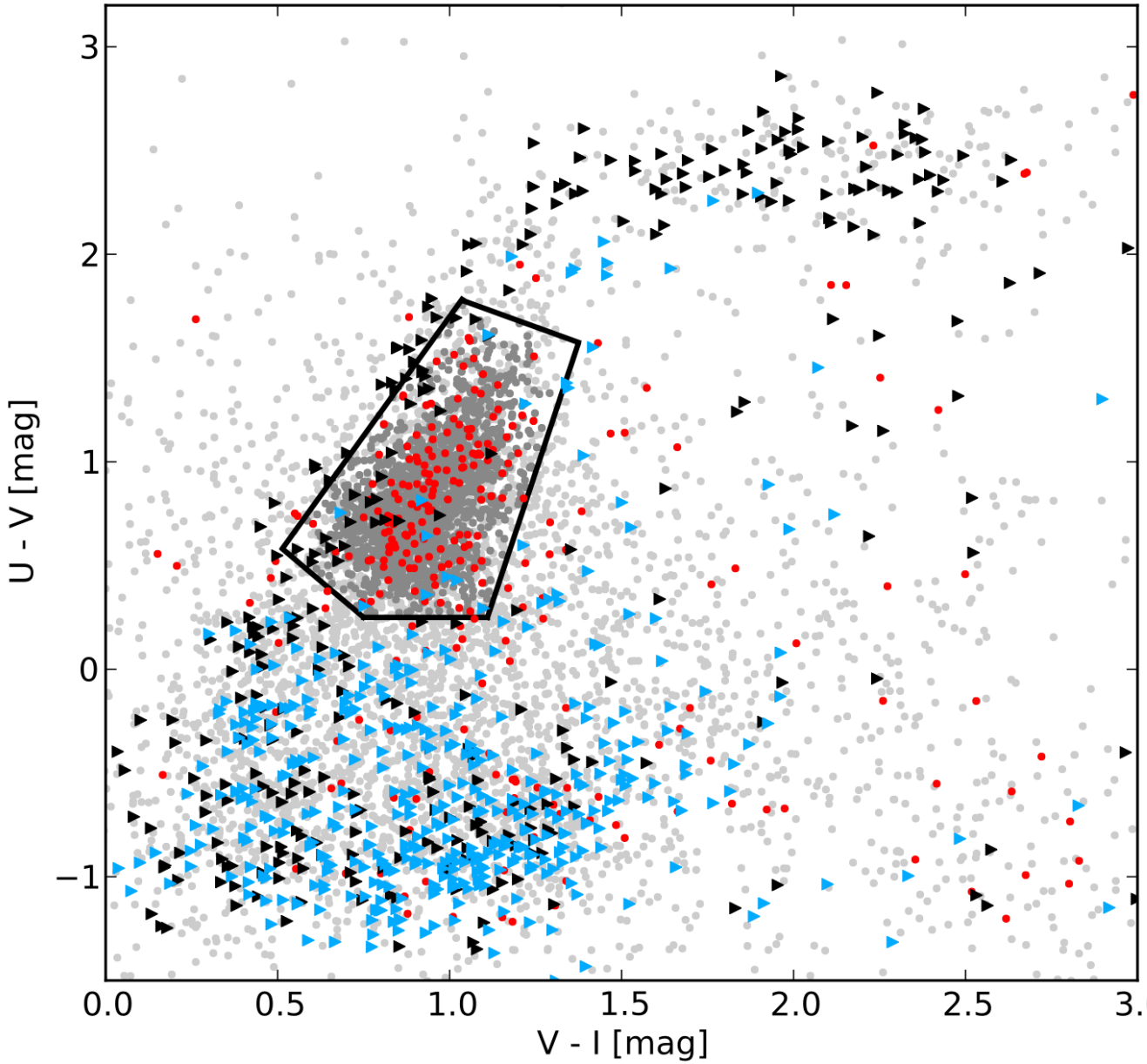


The ‘blue tilt’ in the U-I colour magnitude diagram



Fensch et al. (2015)

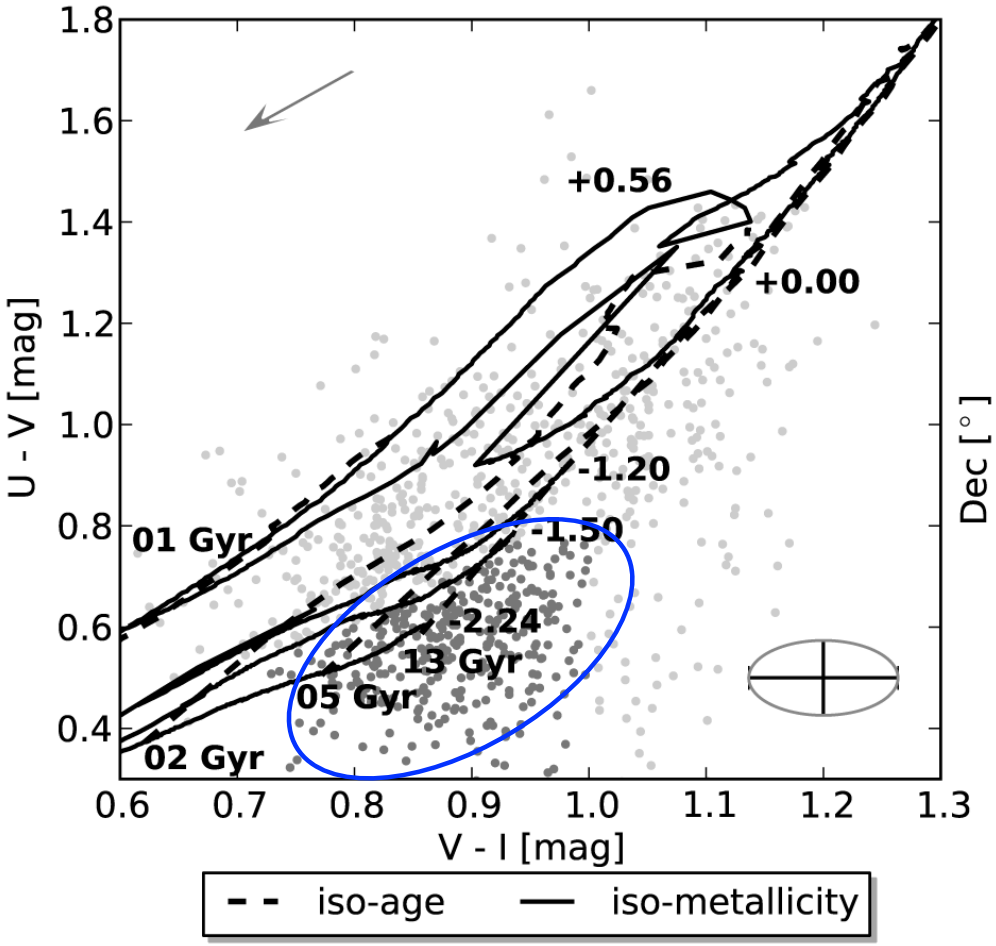
PSF photometry in the V-I vs. U-V colour space

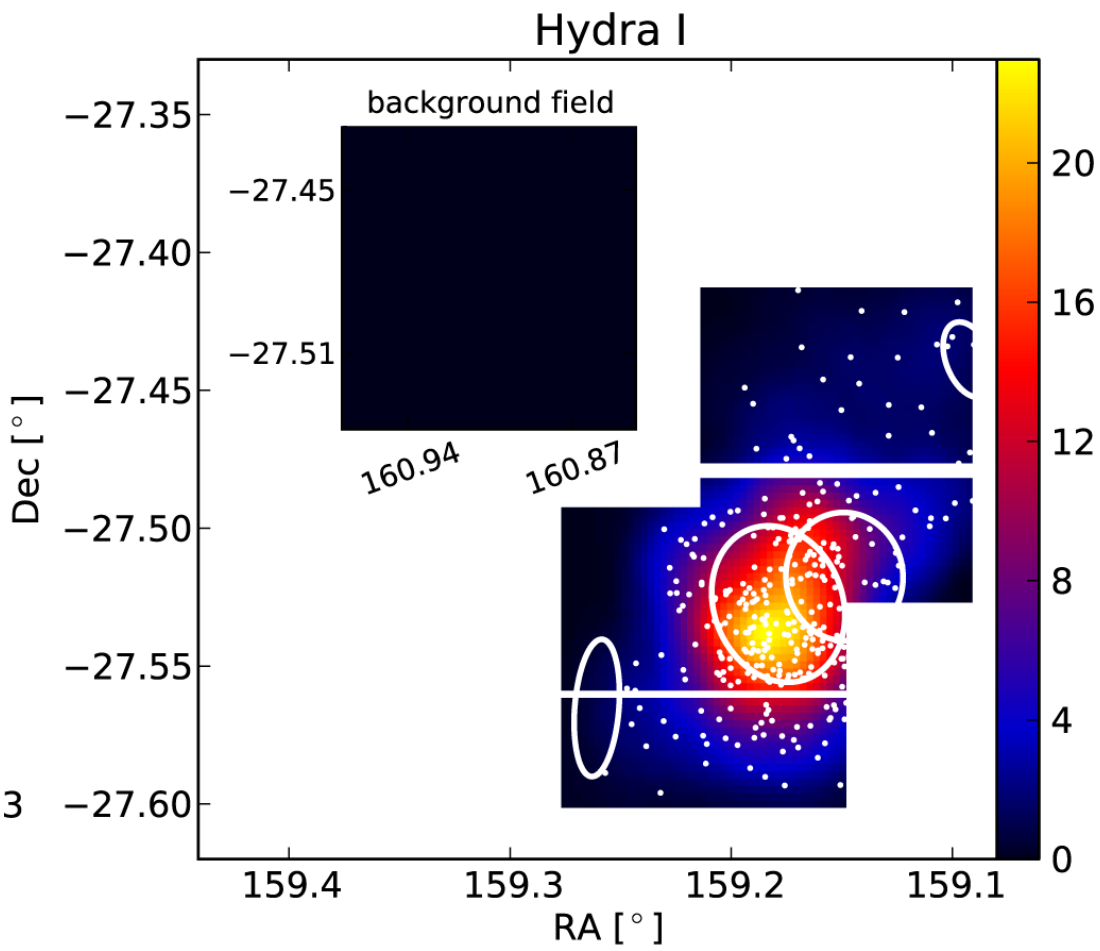


Unresolved sources in the background field

Resolved sources in the background field

Distribution of metal-poor GCs (with low photometric errors)

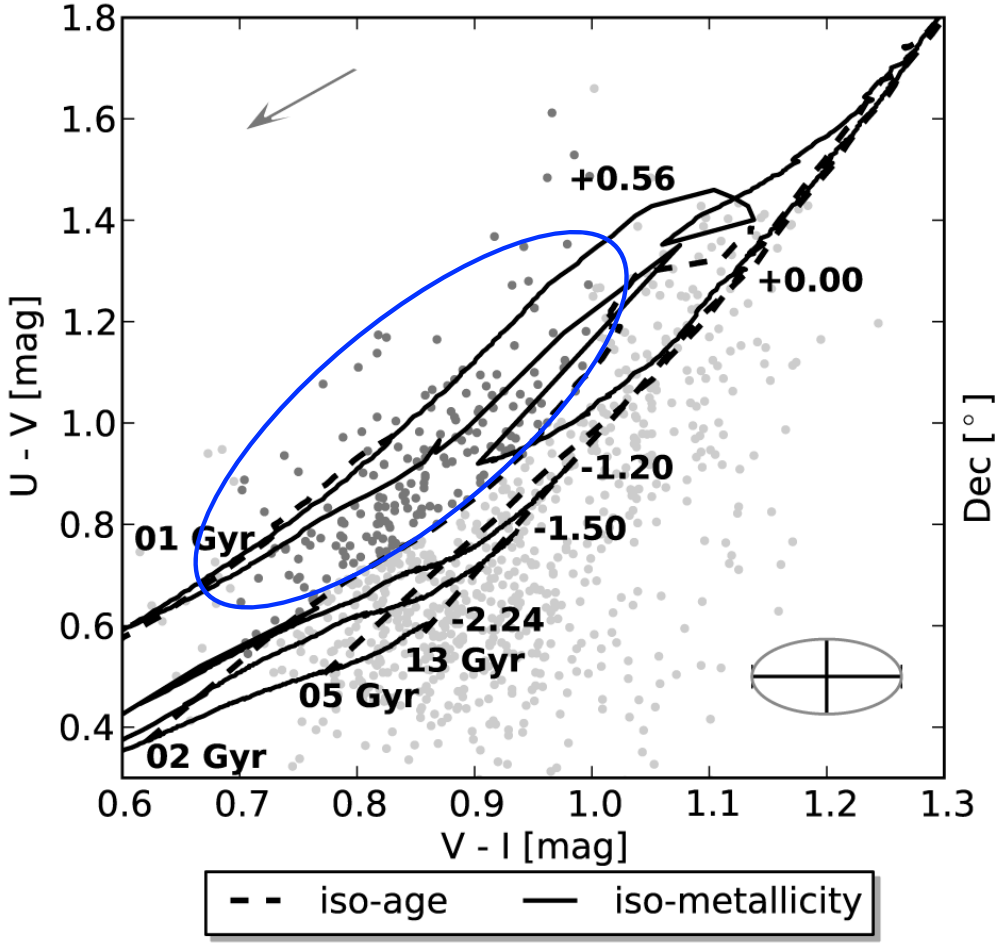


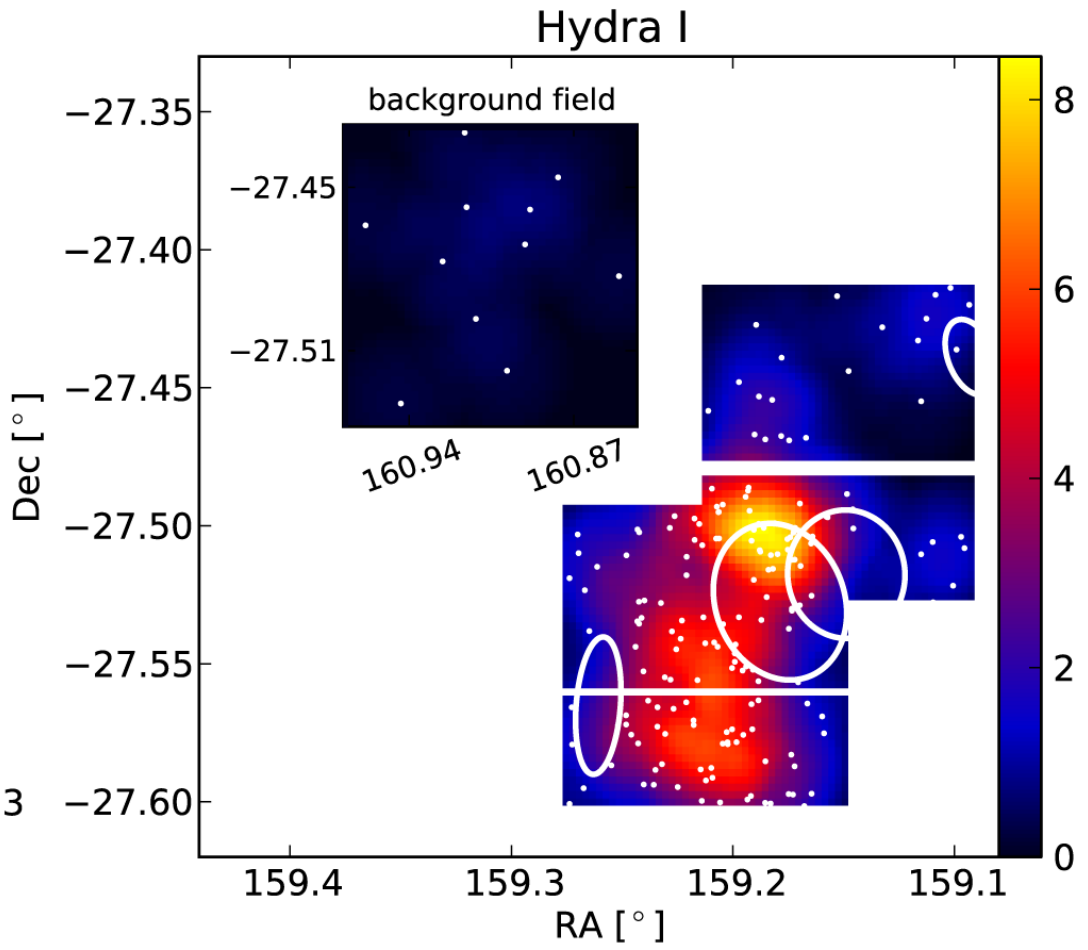


Metal-poor GCs seem to trace a smooth halo population, except an overdensity in the North-West.

PARSEC isochrones, Bressan et al. (2012)

Distribution of ‘young’ GCs (<2 Gyr, with low photometric errors)

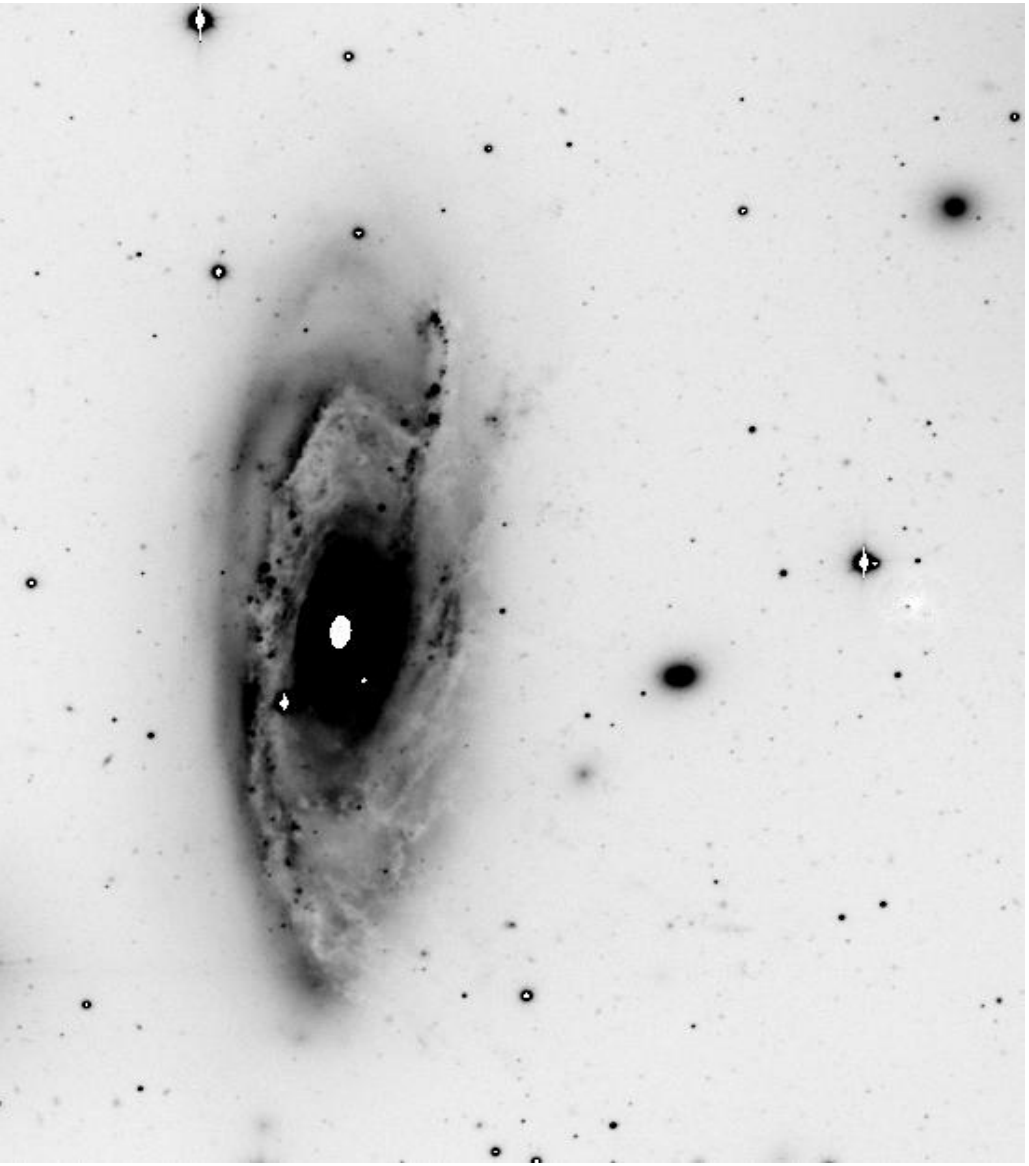


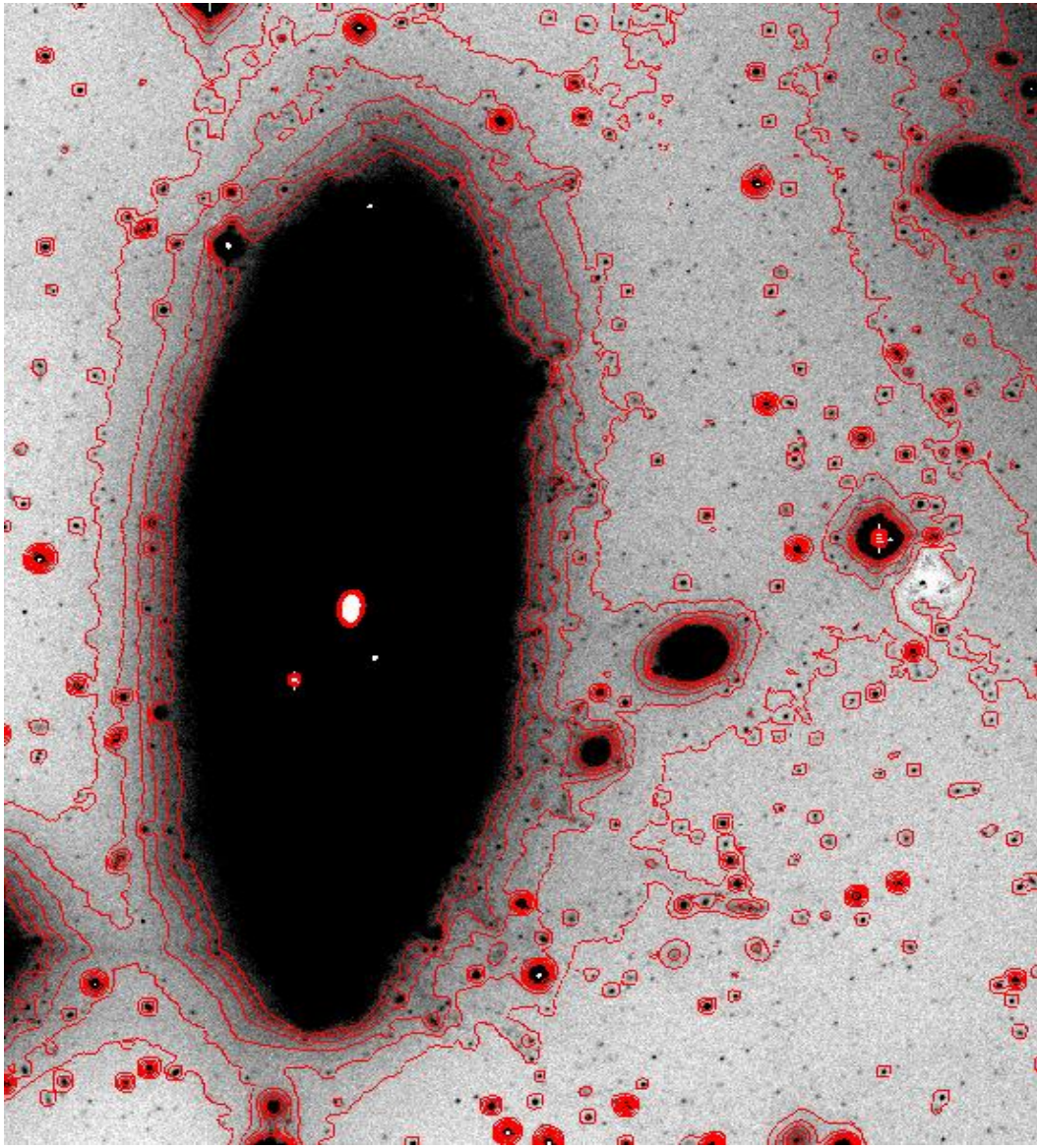


‘Young’ GCs are displaced towards the North and the South-East of NGC 3311, in the wake of NGC 3312.

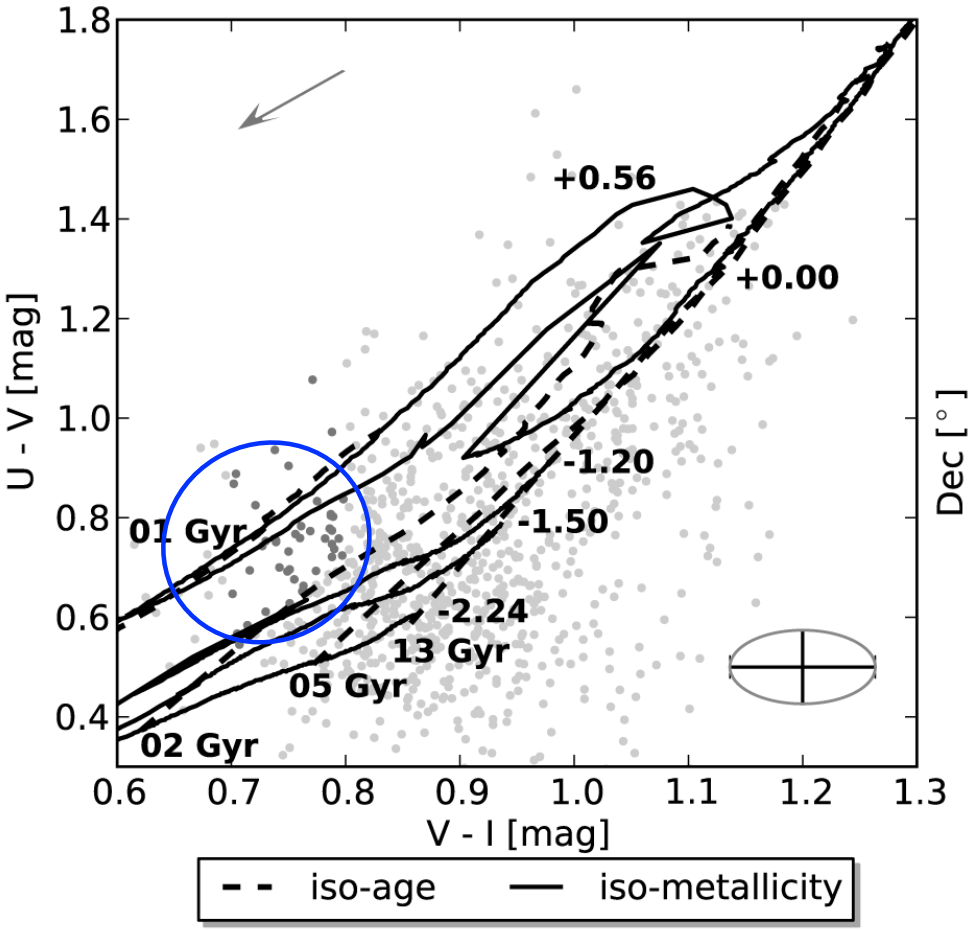
PARSEC isochrones, Bressan et al. (2012)

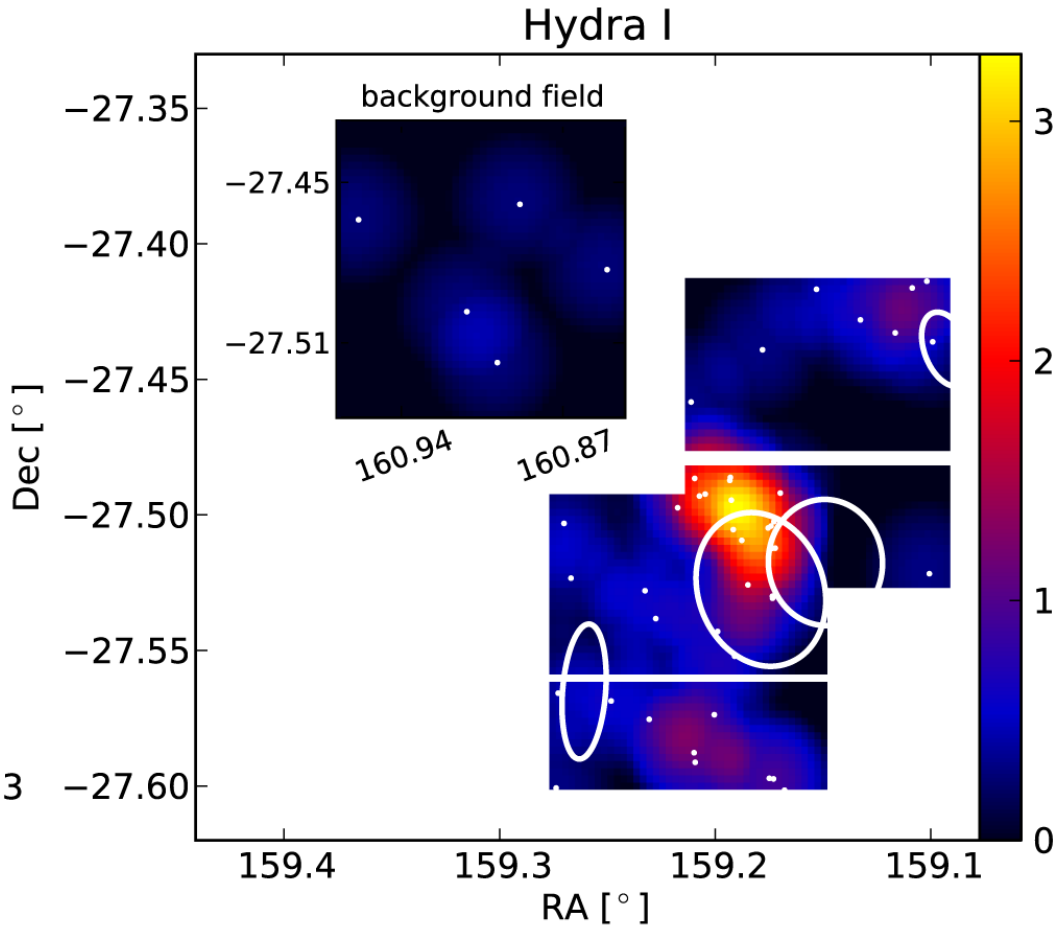
Ram pressure stripping of the spiral NGC 3312 in Hydra I





Distribution of ‘young’, very blue GCs (with low photometric errors)

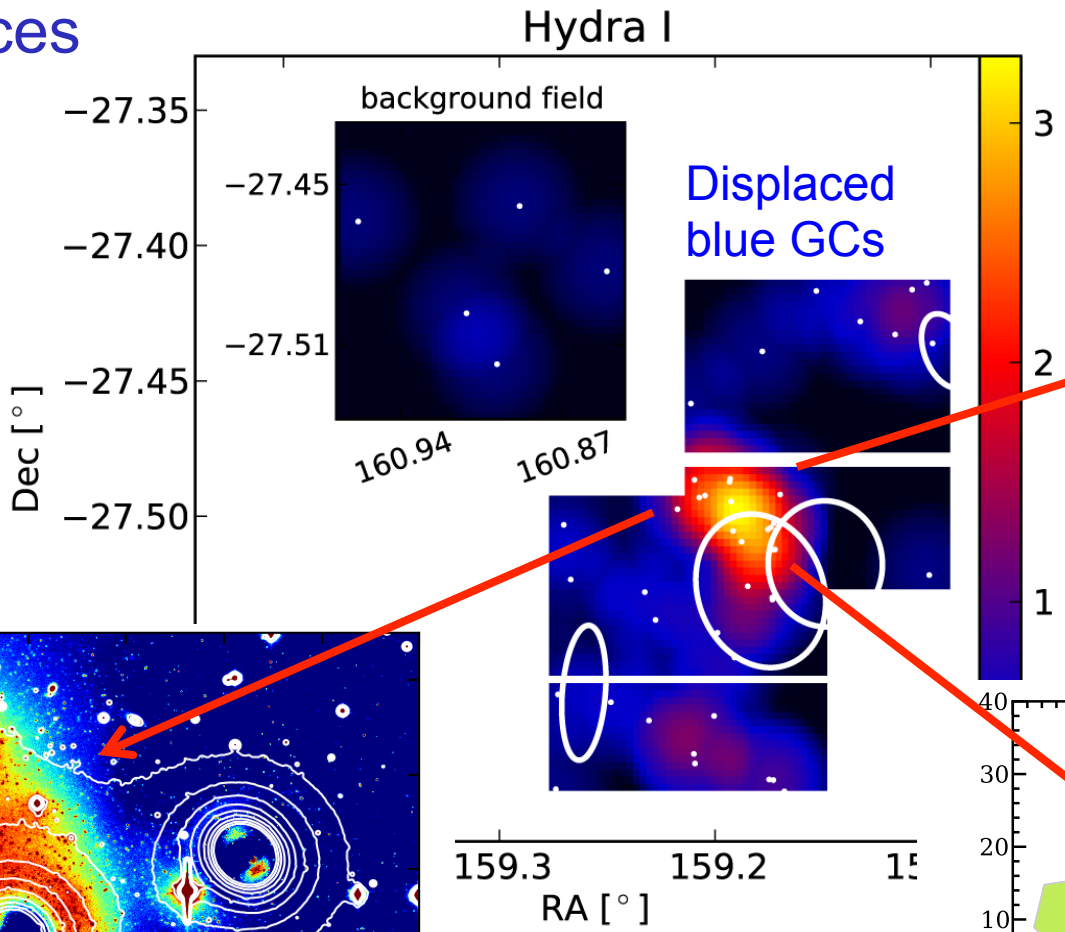




‘Young’, very blue GCs are displaced towards the North and are associated with a group of dwarf galaxies.

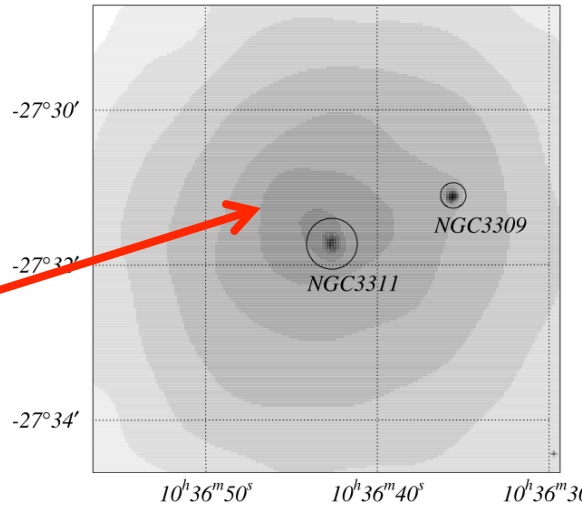
PARSEC isochrones, Bressan et al. (2012)

Coincidences

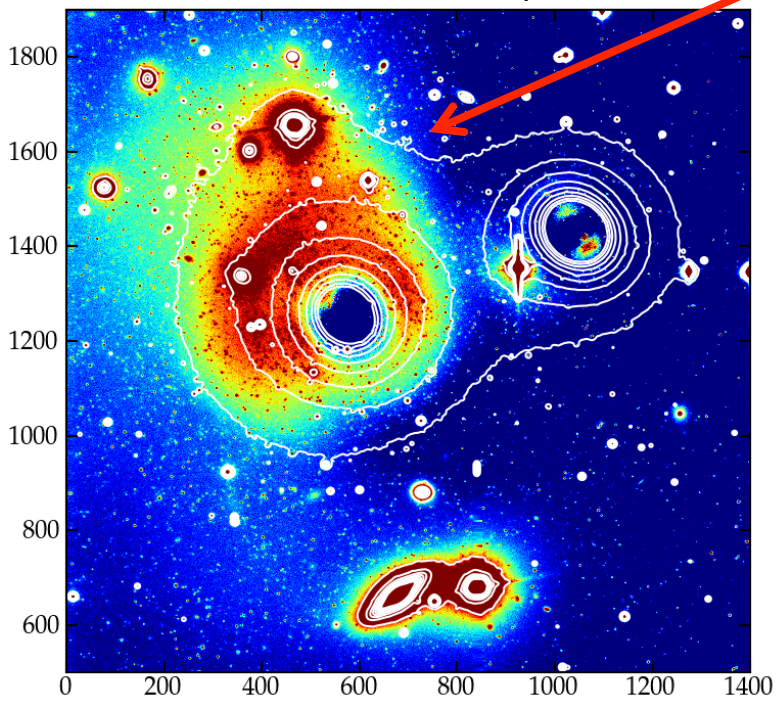


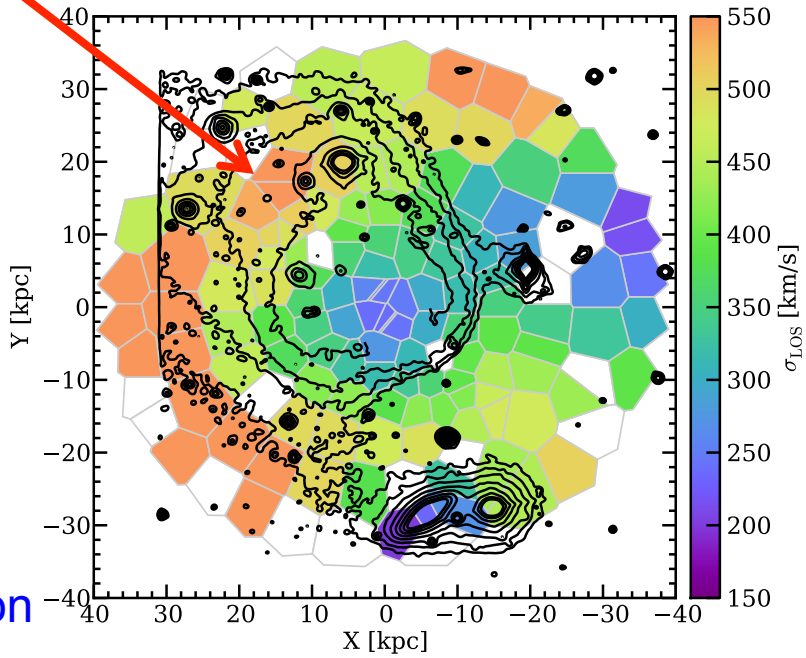
Displaced blue GCs

Displaced X-ray halo



Displaced stellar halo

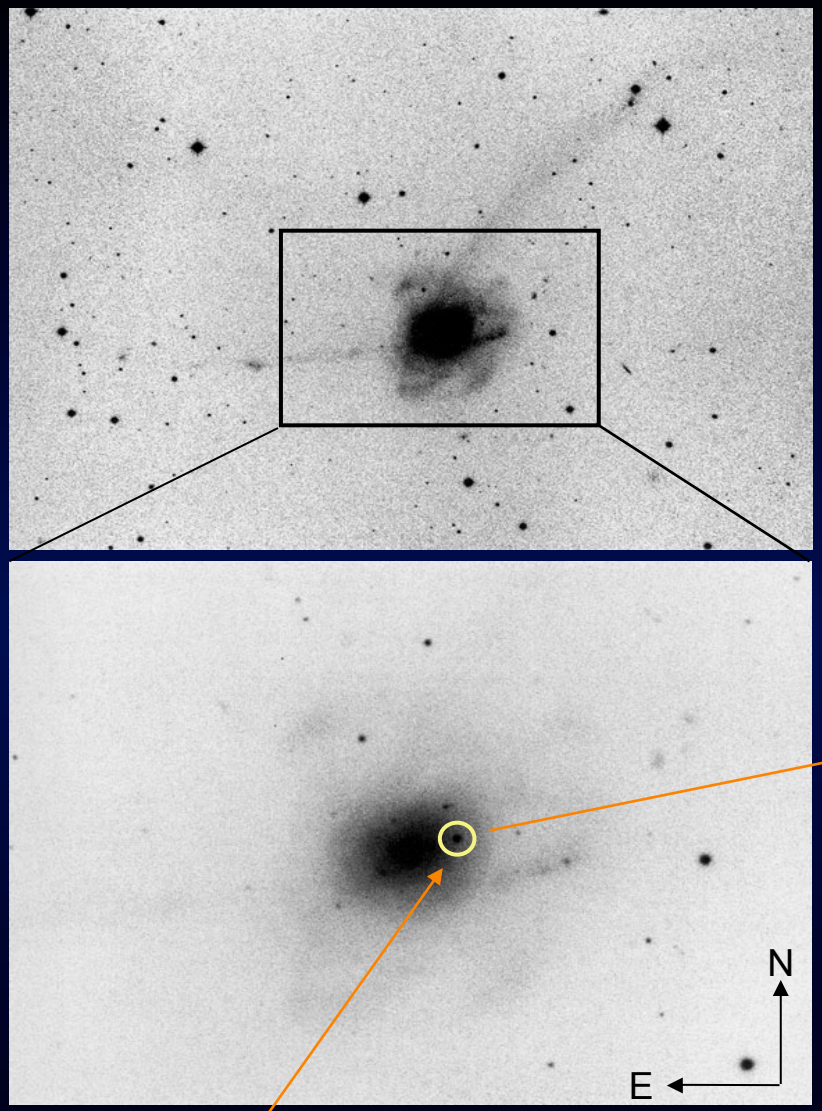


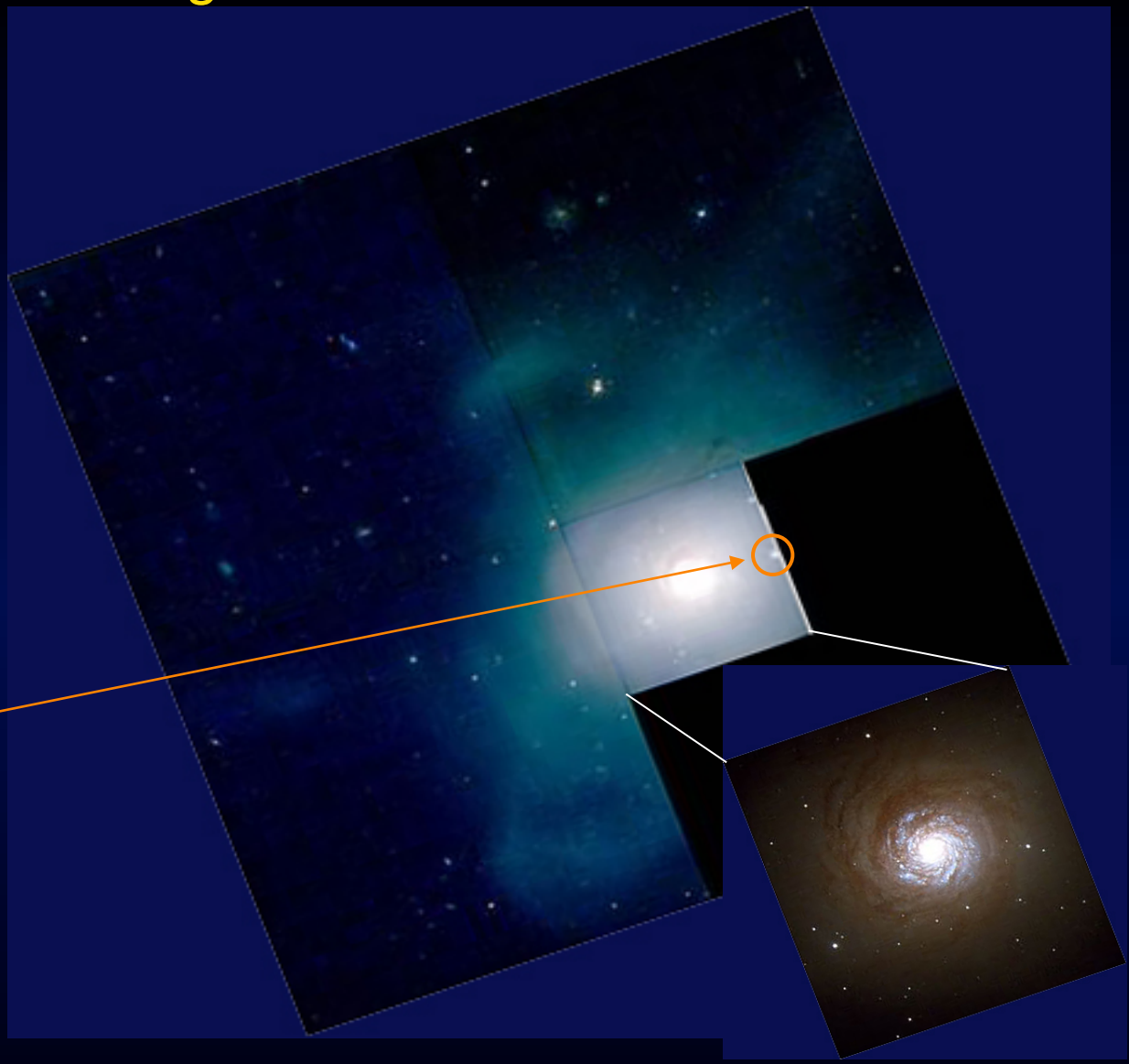


High velocity dispersion region

From blue to red GCs

The recent merger NGC 7252

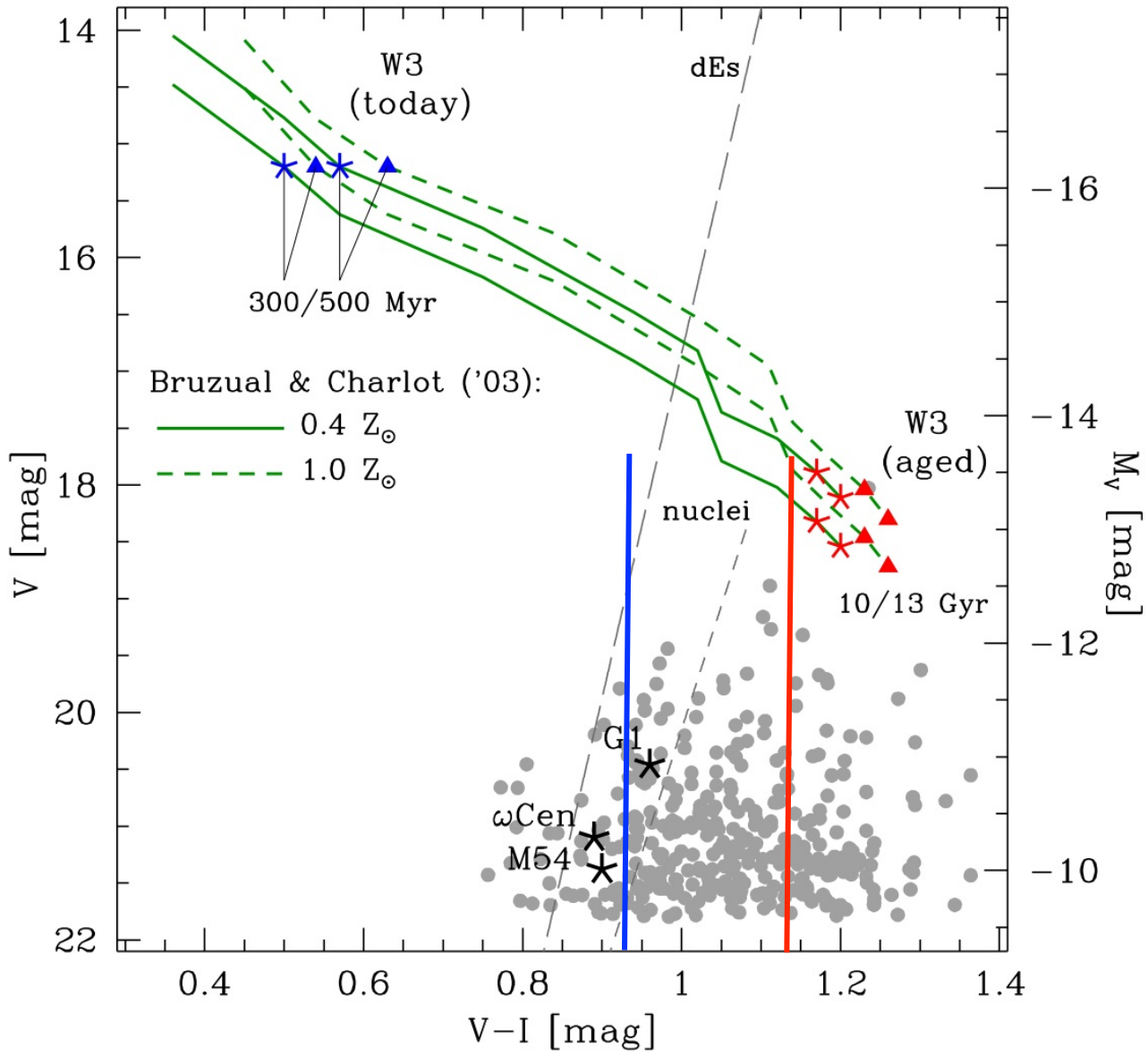




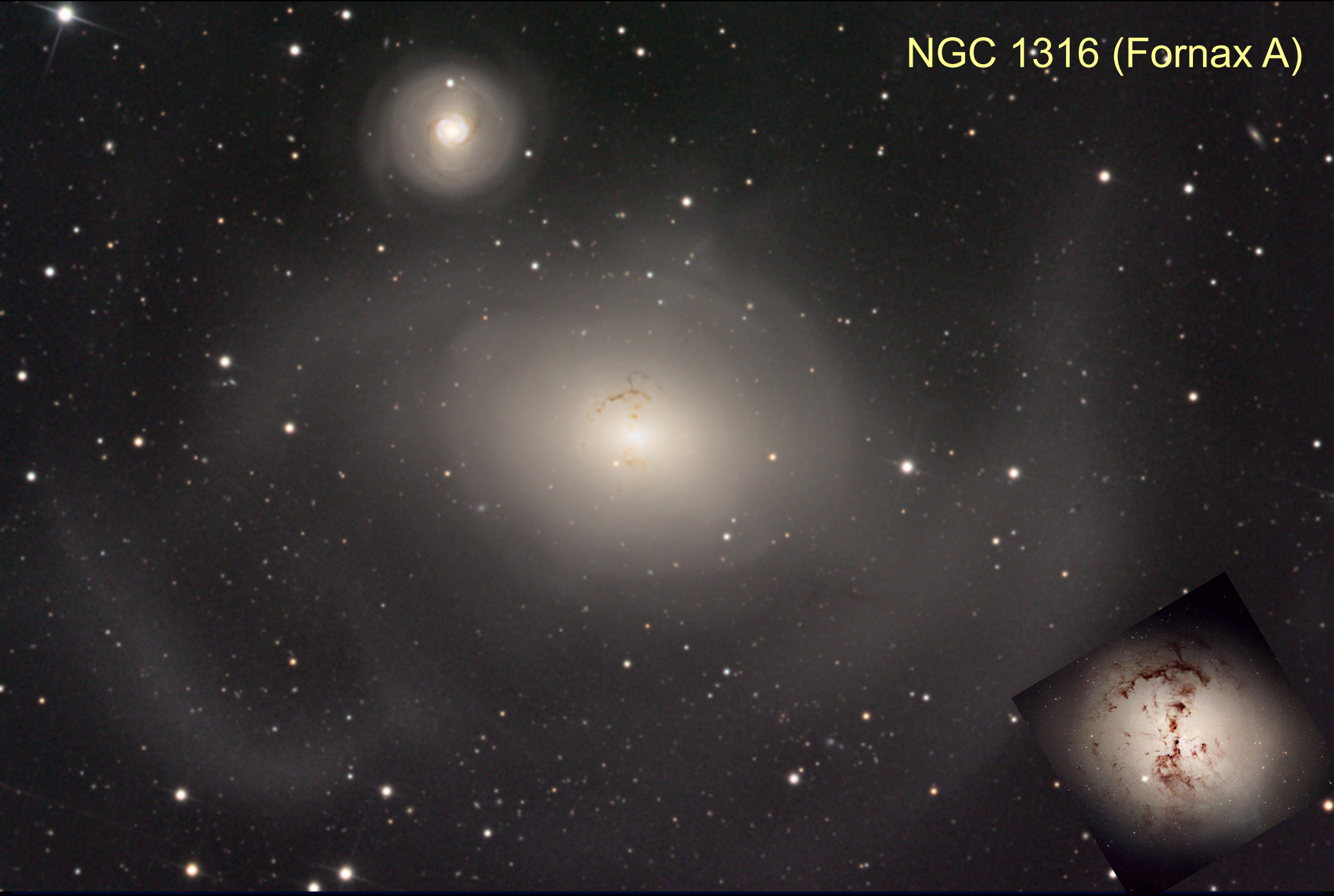
W3: a supermassive young cluster – progenitor of an UCD?

mass: 8 x 10^7 M_o, age: ~300-500 Myr, M_V = –16.2, σ_0 ~ 45 km/s (Maraston et al. 2004)

The future evolution of W3

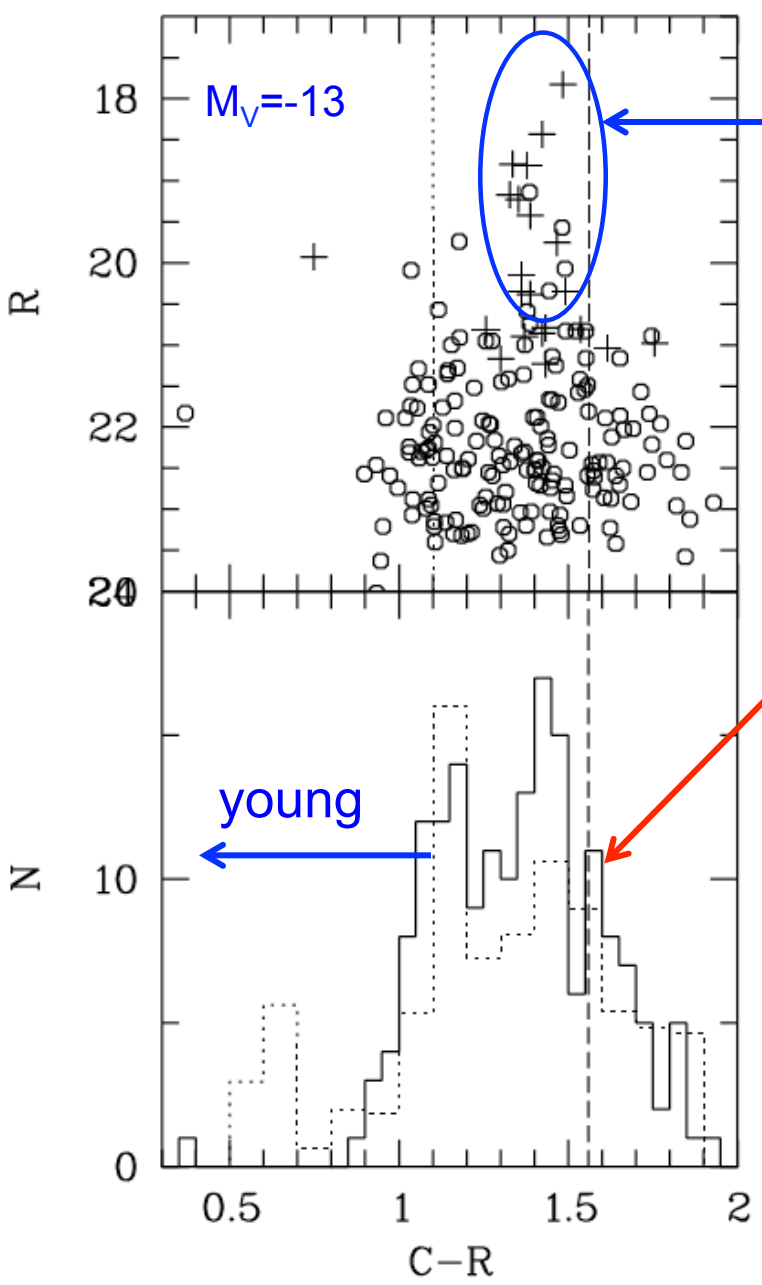


NGC 1316 (Fornax A)



Dr. Michael Hilker (ESO, Garching)

The colour, magnitude and velocity distribution of GCs in NGC 1316

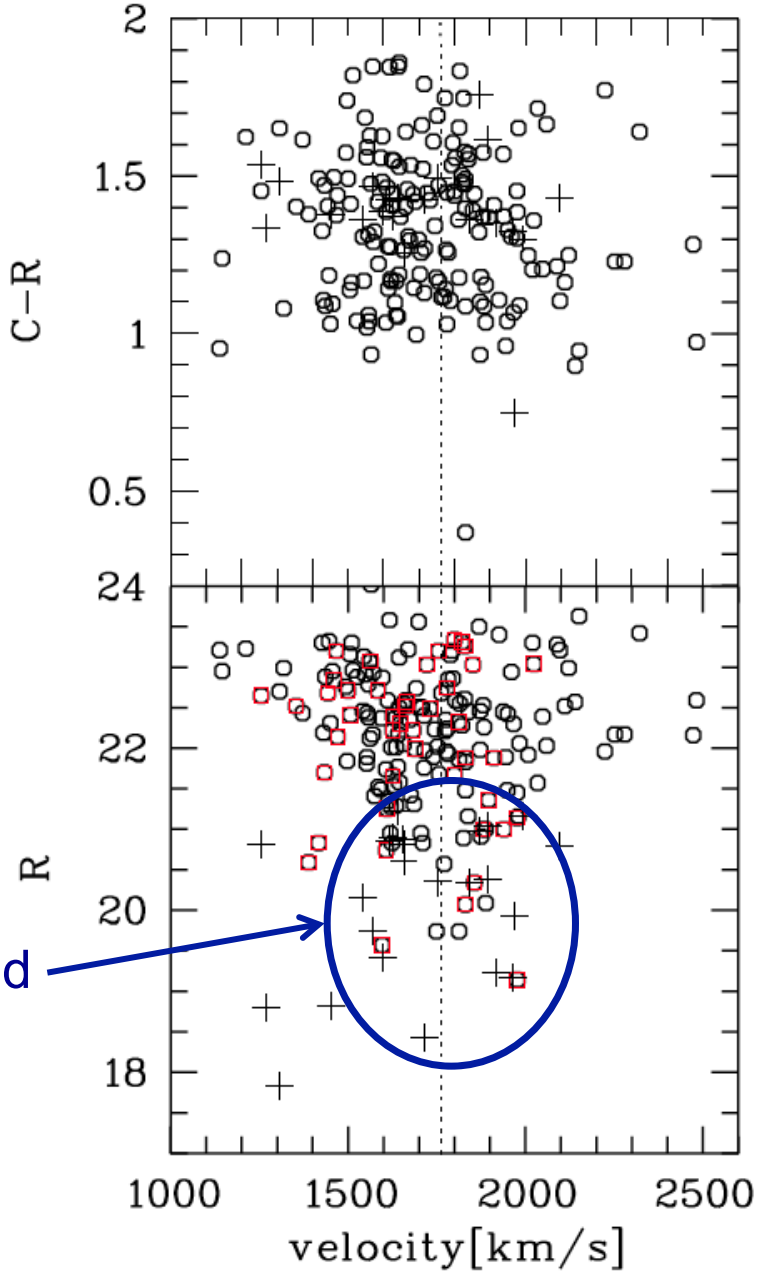


intermediate-age GCs

red, metal-rich GCs

young

bright GCs avoid the systemic velocity



The need for more models of GC system stripping

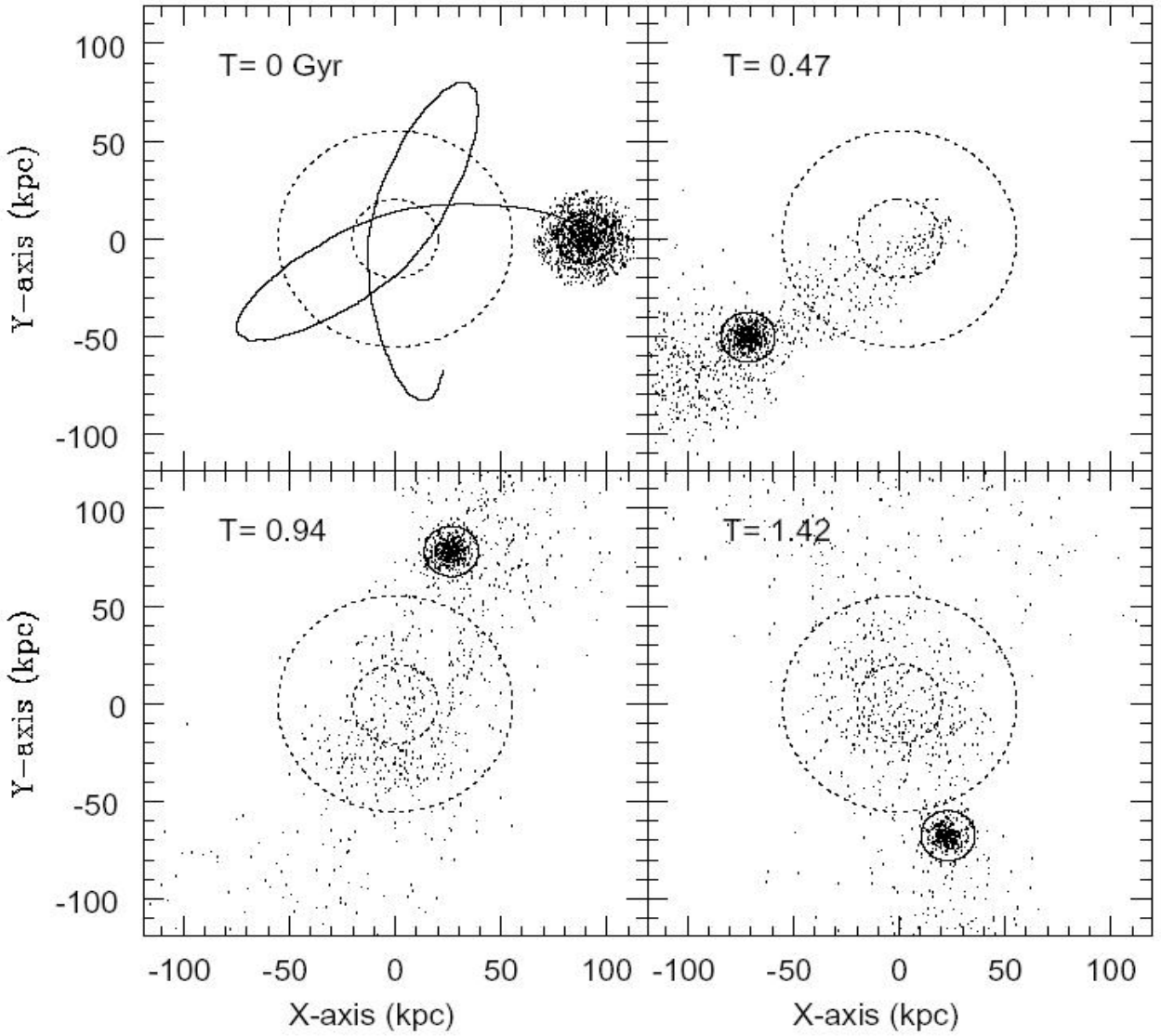


Figure 1. Morphological evolution of the globular cluster system of NGC 1404 orbiting within the Fornax cluster. here we show the fiducial model (Model 3) with $e_p = 0.76$ and $a_{gc} = 2.0$ projected onto the x-y plane. The time T (in Gyr) represents the time that has elapsed since the simulation started. The larger and smaller dotted circles represent the cluster scale radius r_s of the adopted NFW mass profile and 5 R_e (where R_e is effective radius) of the central NGC 1399, respectively. Solid lines represent the orbit of NGC 1404 (for $0 \leq T \leq 1.42$ Gyr) and 5 R_e of NGC 1404.

Bekki et al. (2004)

Summary

- In general, old globular clusters are good tracers of spheroid (red GCs) and halo (blue GCs) populations of ellipticals.
- The predominant GC population in the outer halo regions are the blue GCs. They trace the halo assembly history.
- Blue GCs can be old and metal-poor, but some of them also 'youngish' and metal-rich.
- In an appropriate 3-colour space, sub-populations of blue GCs can be identified.
- The existence of in-situ and newly added GCs can directly be traced in recent mergers.
- Please model the assembly of globular cluster systems as function of galaxy mass and environment!

Blue is not the same as blue!