Probing the formation and evolution of the Galactic halo with STREGA@VST:

Ilaria Musella
Inaf-OA Naples

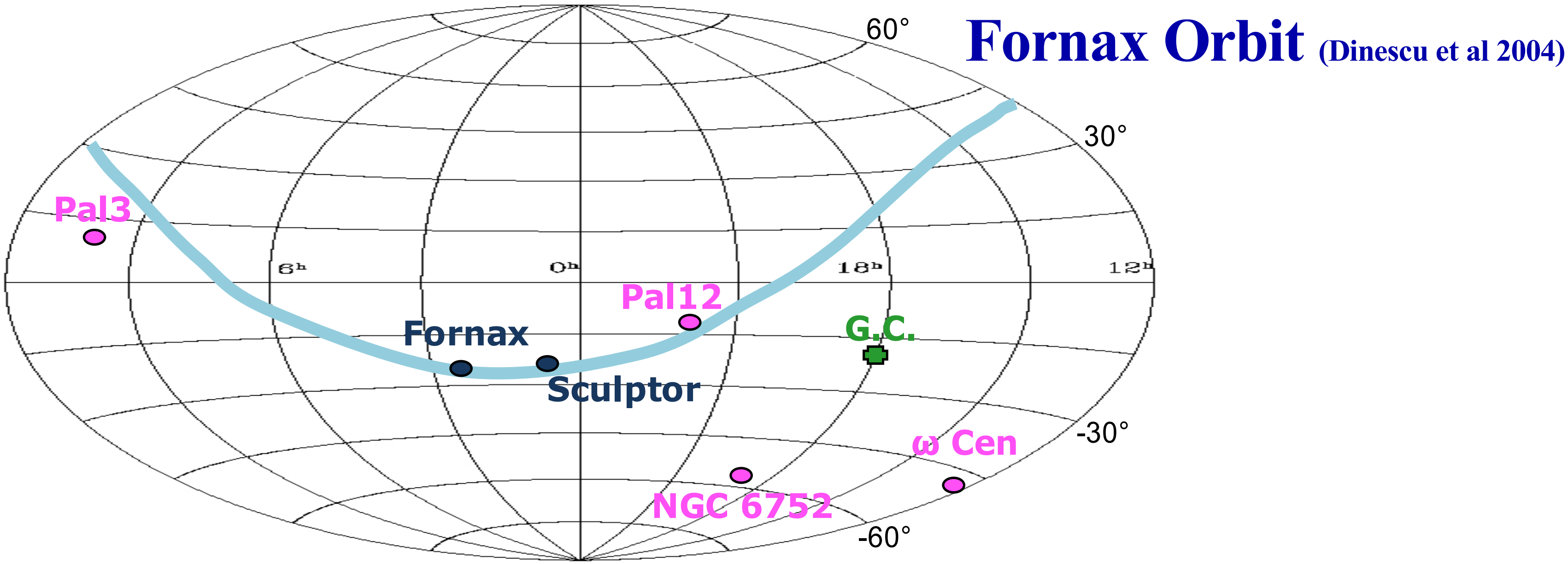
P.I.: M. Marconi/I. Musella

G. Bono, E. Brocato, M. Capaccioli, E. Cappellaro, M. Cignoni, M.-R.L. Cioni, D. De Martino, M. Dall'Ora, A. Di Cecco, M. Di Criscienzo, A. Grado, I. Ferraro, F. Getman, G. Iannicola, L. Limatola, R. Molinaro, M. I. Moretti, G. Raimondo, V. Ripepi, P. Schipani, P. B. Stetson

STREGA@VST

Structure and Evolution of the Galaxy (PI: M. Marconi/I. Musella)

Tracing tidal tails and halos around stellar clusters and galaxies **to investigate Galactic halo formation mechanisms**



VST GTO-INAF

VST with its large field (1 sq. deg.) and its high resolution (0.21 arcsec/px) is the ideal instruments for this type of investigations

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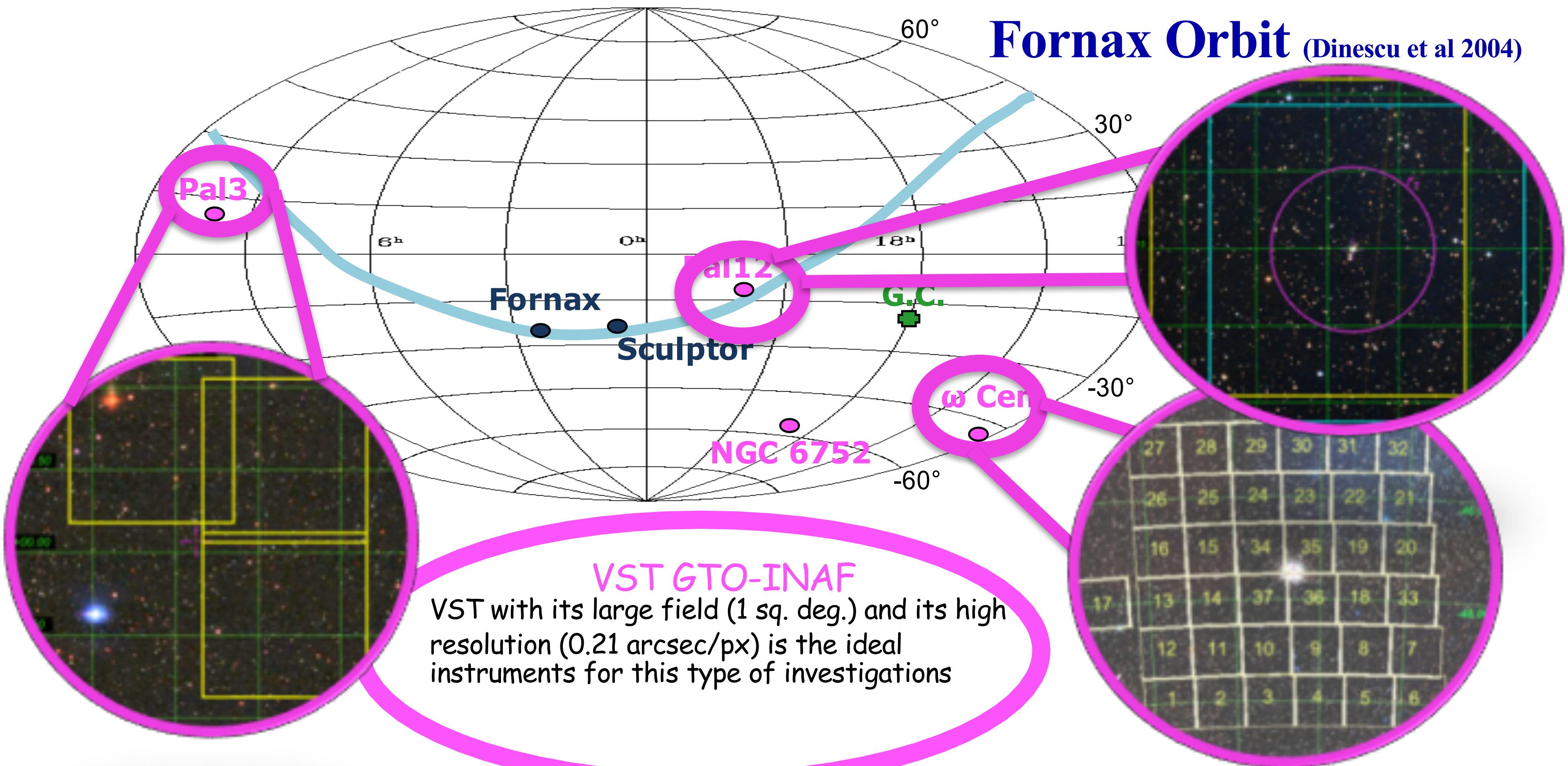

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Why STREGA?

The outer regions of the Galactic halo seem to be quite "clumpy" (e.g. Vivas & Zinn, 2002; Newberg et al., 2002) → supporting theories based on the hierarchical formation of structures in a Cold Dark Matter cosmological scenario.

The most known examples of these phenomena are

- the observed merging of the Sagittarius dsph with the MW halo and its associated stream
- the stellar over-density in the Canis Major region
- the presence of peculiar Galactic Globular Cluster with observed tidal tails or suspected halos
- the discovery of several ultra-faint satellites of the MW

MW dSphs and a number of Galactic GCs appear distributed along planar alignments reflecting distinct orbital planes interpreted as the result of the disruption of larger galaxies (one of this is the Fornax Stream).

Similar evidences have been observed also in M31

Dall'Ora's talk

STREGA

Mapping large areas (at least up to 2-3 tidal radii), in the g, r and i bands, to trace signatures between selected stellar systems and the Galactic halo

Tools:

Variable stars (RR Lyrae)

Time series at RR Lyrae magnitude level

Main-Sequence and Turn off stars

deep exposures 2-3 mag below the TO

Data Reduction

Preriduction performed with VST-TUBE, a specific imaging pipeline

PSF photometry with DAOPHOT/ALLSTAR

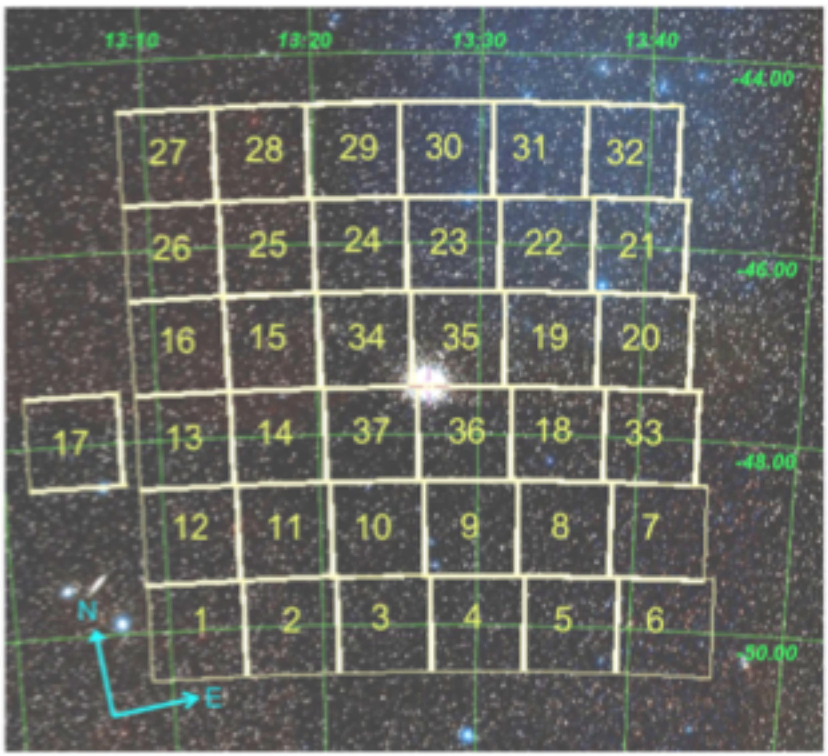
Calibration through deep and accurate UBVRI photometry transformed to the SDSS ugriz photometric system by adopting the transformations by Jordi et al. (2006).

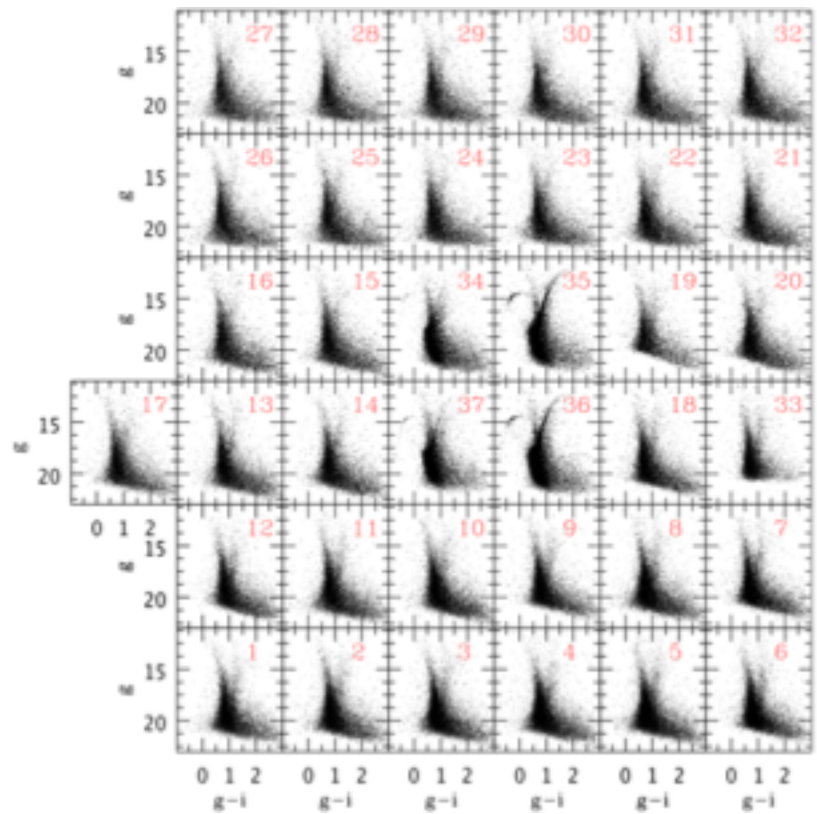
ω Cen

Monthly Notices of the Royal Astronomical Society
MNRAS 444, 3809–3828 (2014) doi:10.1093/mnras/stu1691

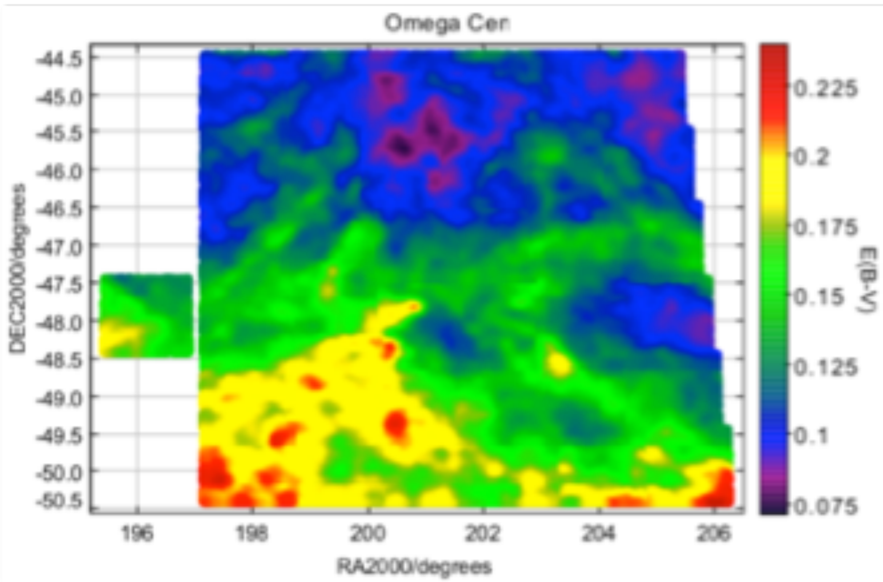
STREGA: STRucture and Evolution of the GAlaxy – I. Survey overview and first results*

M. Marconi,[1]† I. Musella,[1] M. Di Criscienzo,[1] M. Cignoni,[2] M. Dall'Ora,[1] G. Bono,[3] V. Ripepi,[1] E. Brocato,[4] G. Raimondo,[5] A. Grado,[1] L. Limatola,[1] G. Coppola,[1] M. I. Moretti,[1] P. B. Stetson,[6] A. Calamida,[2,4] M. Cantiello,[5] M. Capaccioli,[7] E. Cappellaro,[8] M.-R. L. Cioni,[9,10] S. Degl'Innocenti,[11] D. De Martino,[1] A. Di Cecco,[4,12] I. Ferraro,[4] G. Iannicola,[4] P. G. Prada Moroni,[11] R. Silvotti,[13] R. Buonanno,[3,5] F. Getman,[1] N. R. Napolitano,[1] L. Pulone[4] and P. Schipani[1]

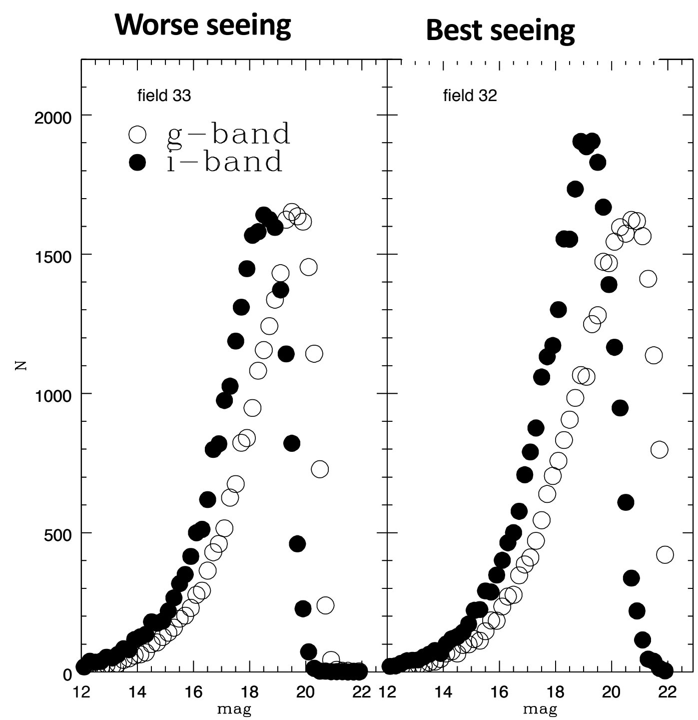




ω Cen: cumulative CMD

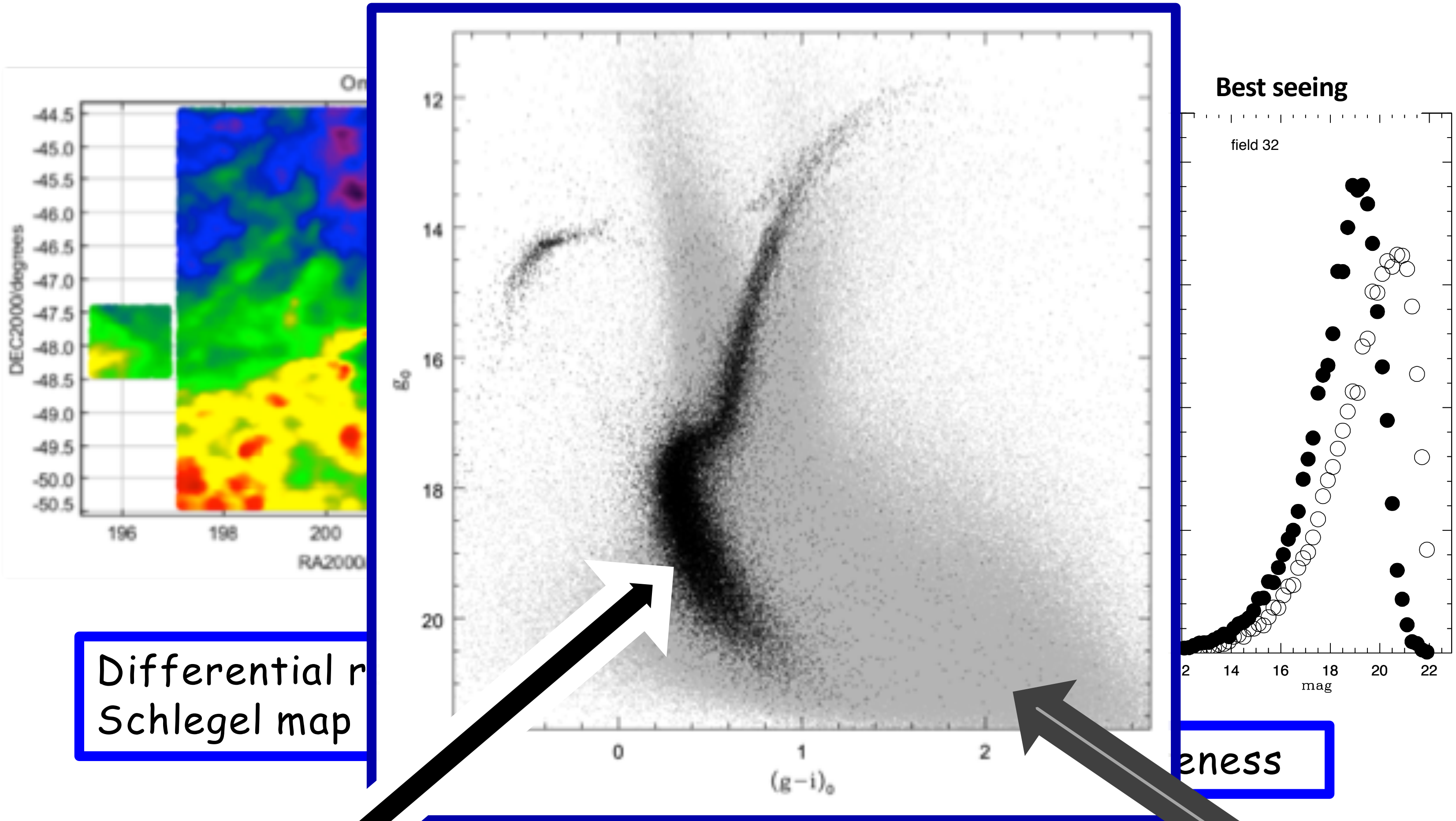


Differential reddening:
Schlegel map



completeness

ω Cen: cumulative CMD

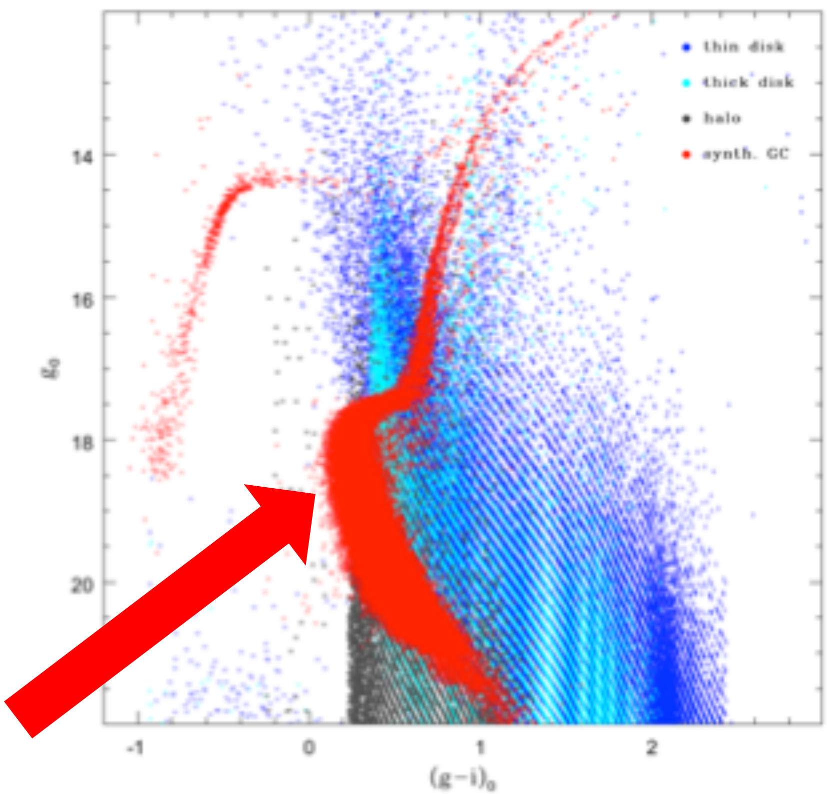


Central CMD (about 1 sq. deg.
Centered on ω Cen)

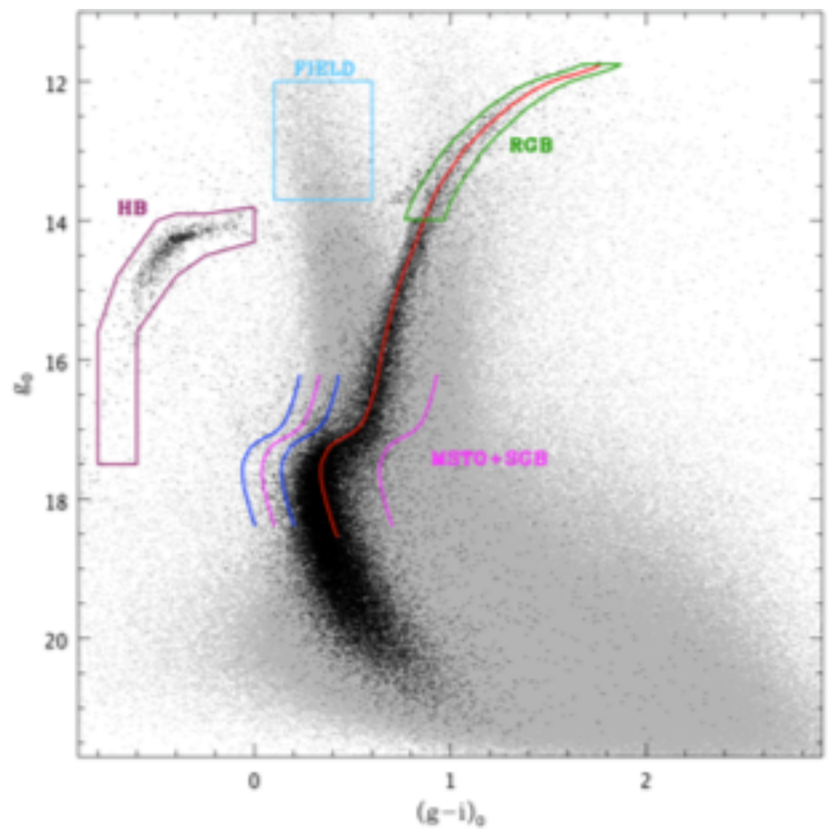
Cumulative CMD

ω Cen: Data Analysis

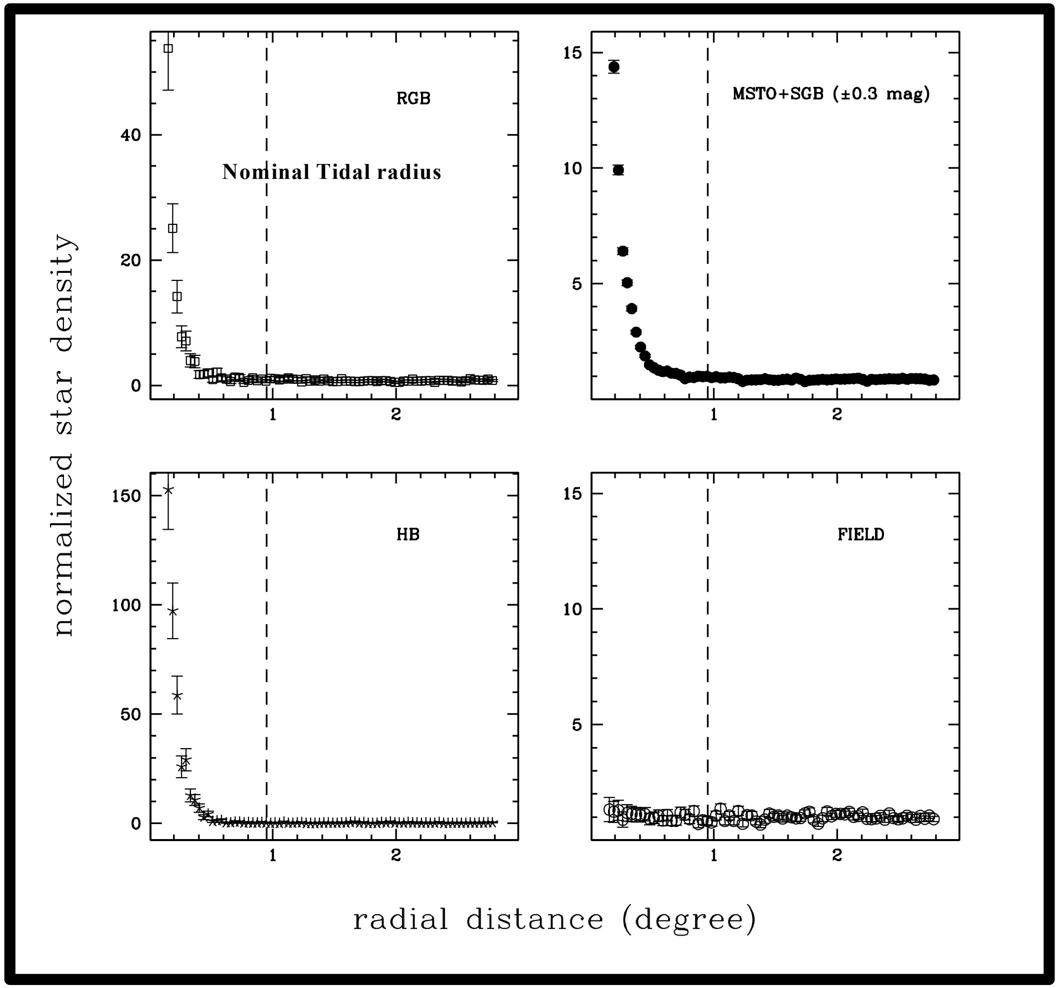
Theoretical tools: Galactic simulations (blue, cyan and grey dots, updated Castellani et al. 2002) compared with the synthetic CMD of ω Cen (red dots, SPOT code: Teramo Stellar POpulation Tools, Raimondo et al. 2005).



Observational tools: To detect extra-tidal stars, we performed star counts on the area observed around ω Cen in various evolutionary phases…….



Radial star counts. I



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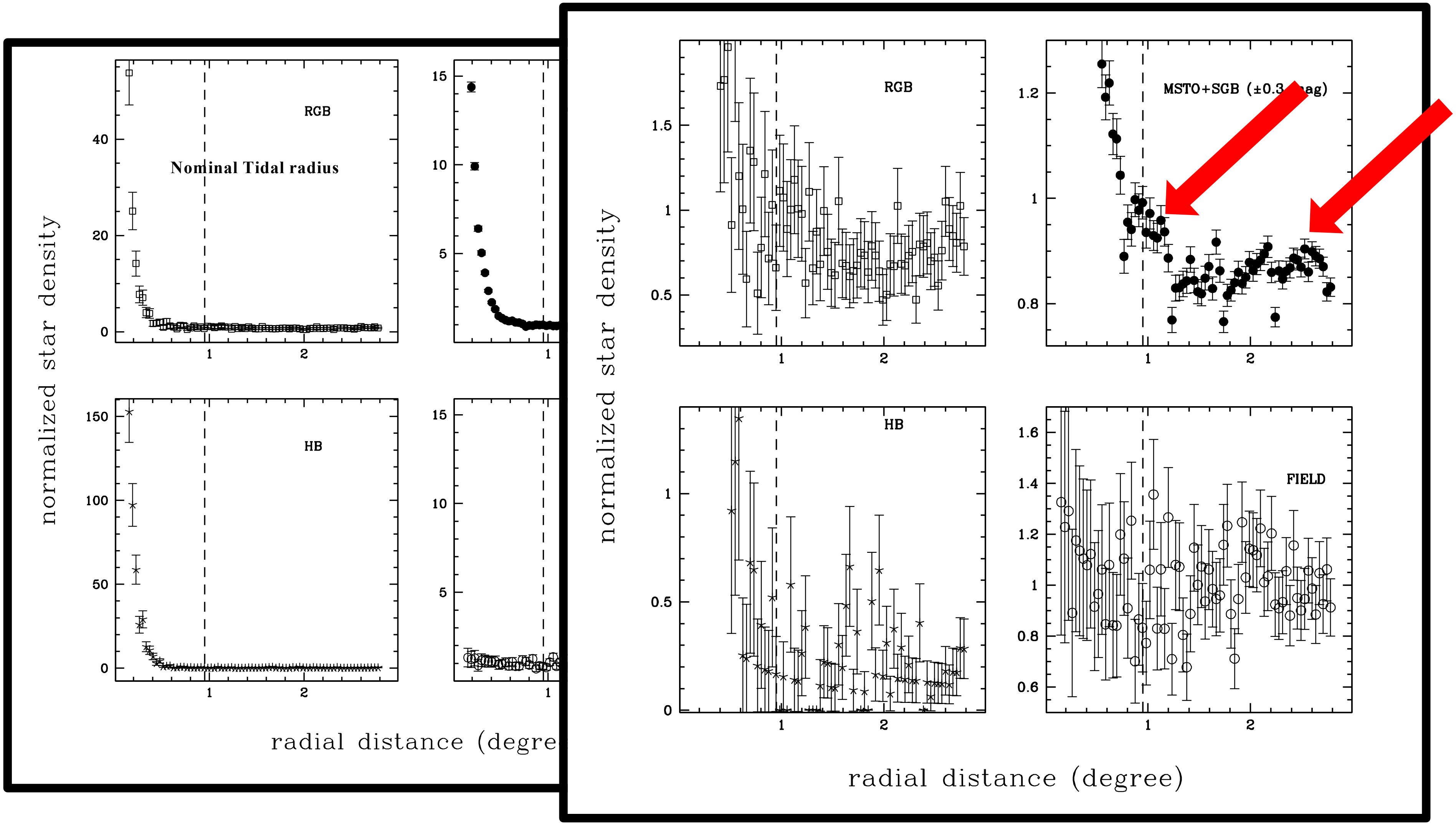
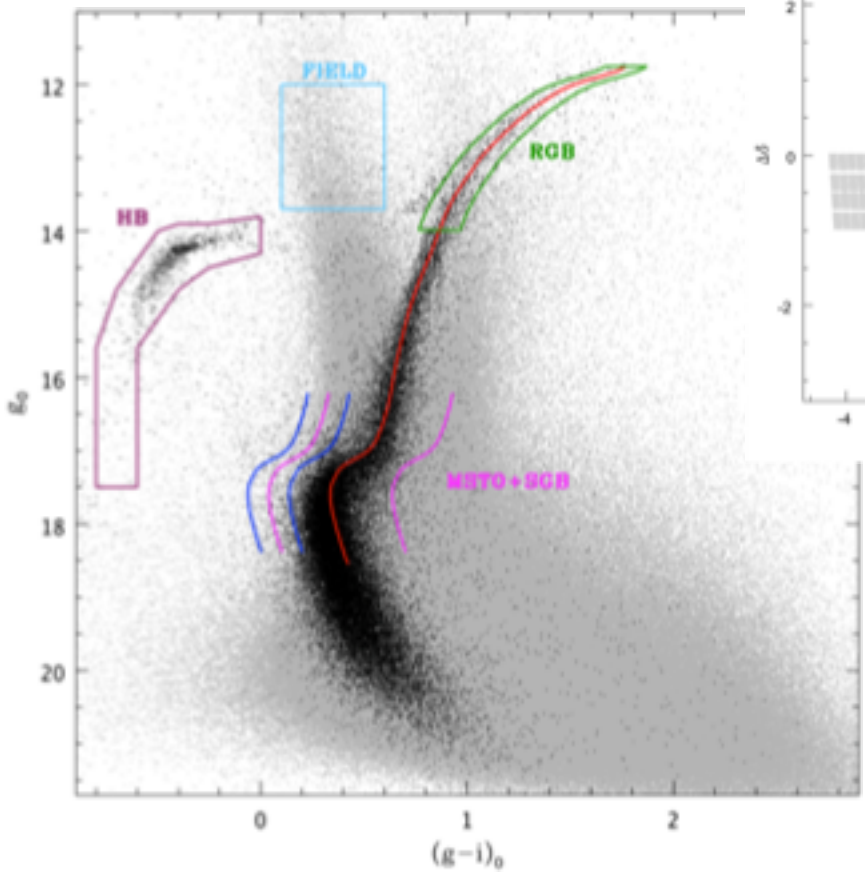
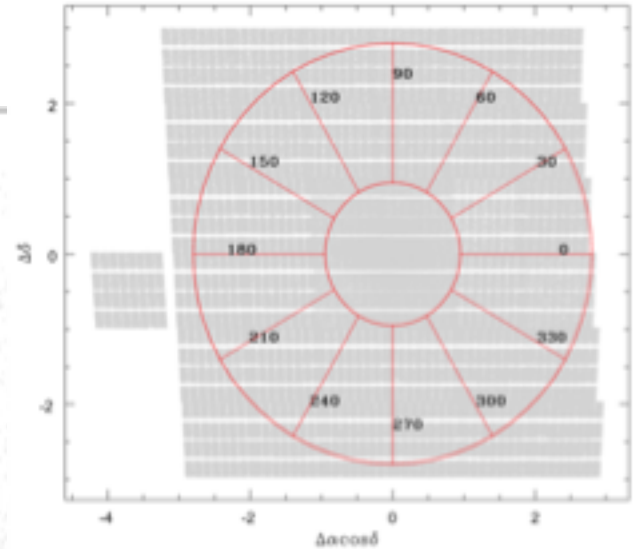
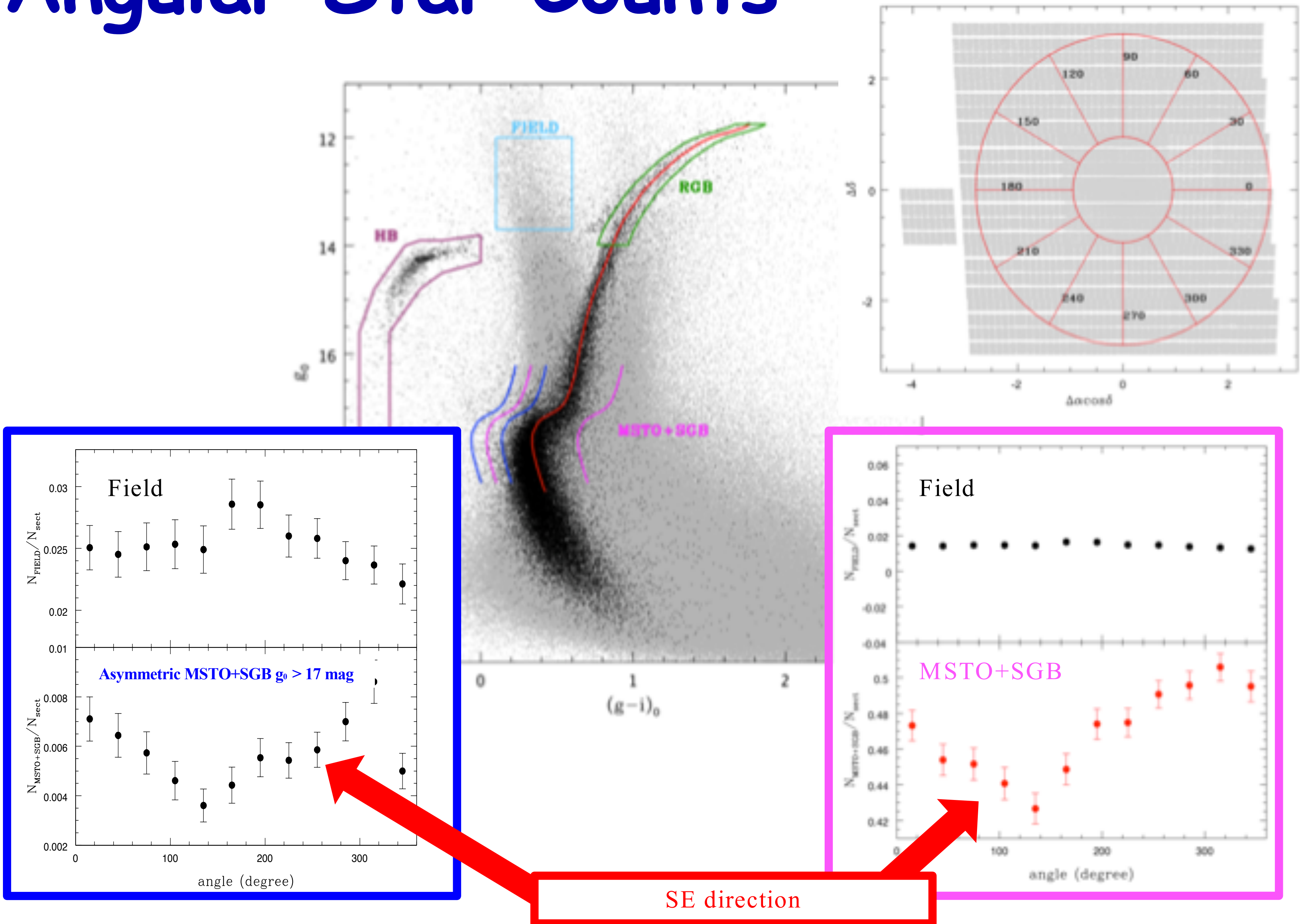


Angular Star Counts

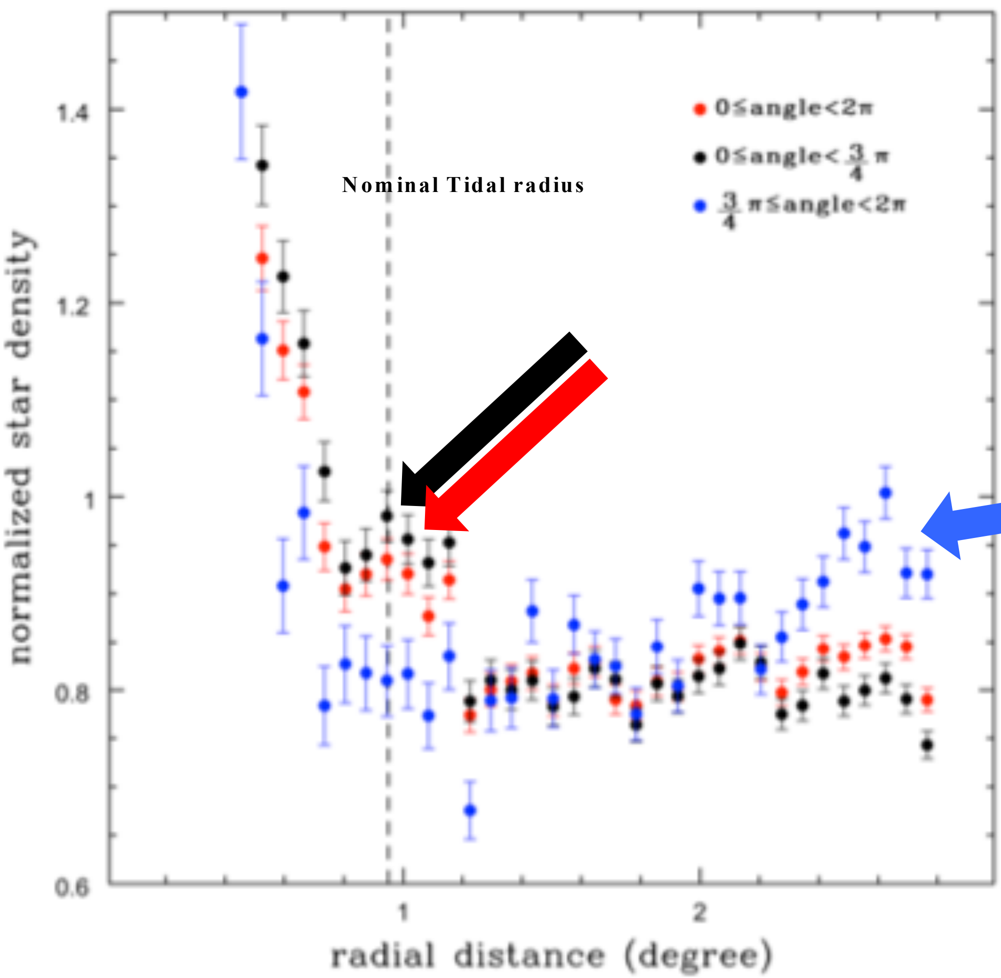


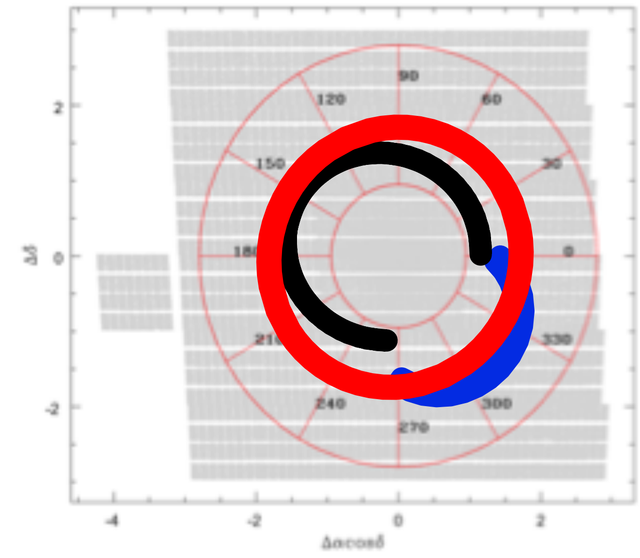


Angular Star Counts

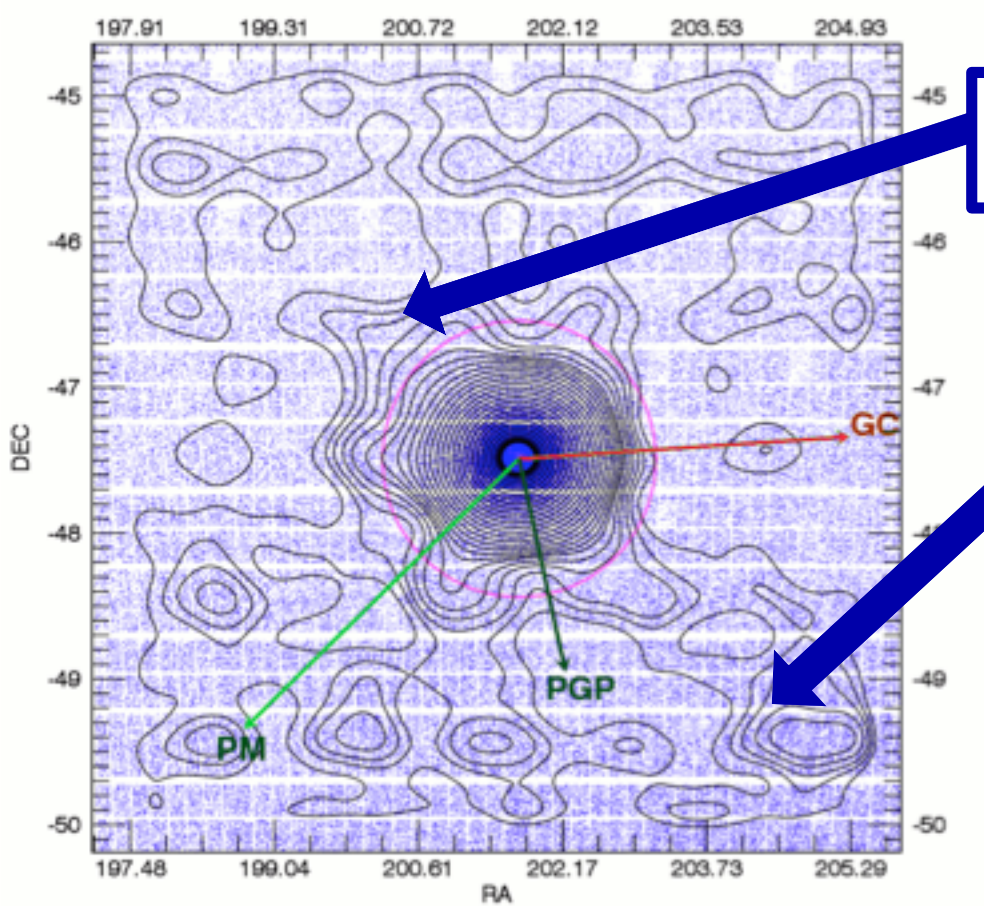


Radial Star Counts. II





Isocontours



Asymmetric, elongated shape

Our results are in agreement with existent measurements and predictions about the cluster ellipticity profile and orientation and recently confirmed by Calamida+17 mapping a region of 3°x3° around ω Cen with DECAM and ACS

Pal 12

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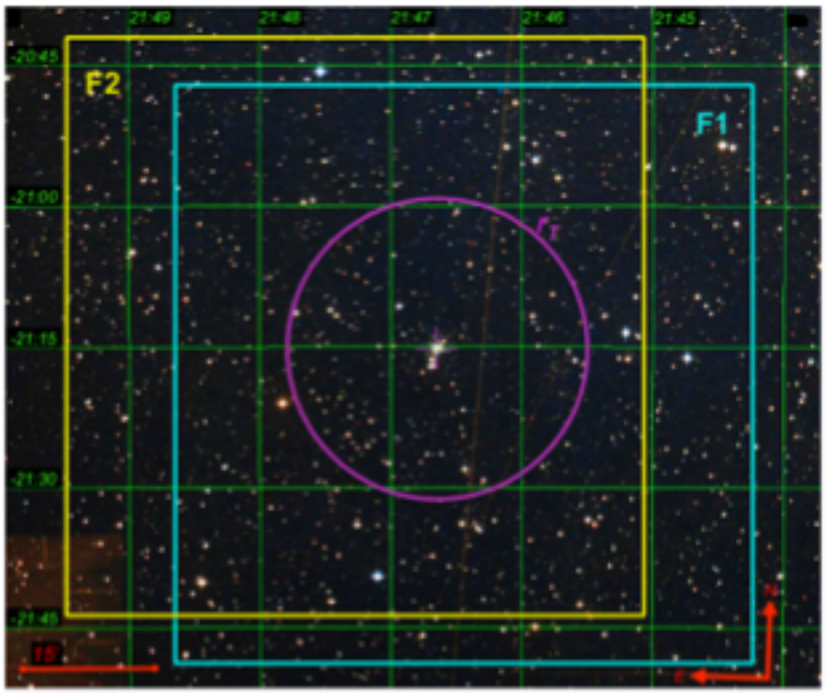
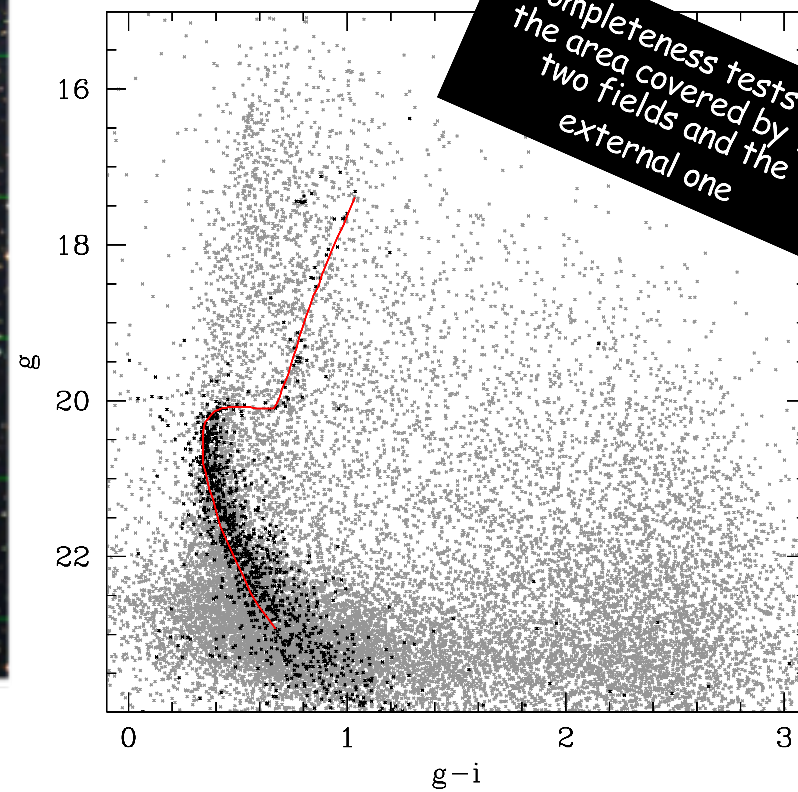
The STREGA survey – II. Globular cluster Palomar 12*

I. Musella,[1]† M. Di Criscienzo,[2]† M. Marconi,[1] G. Raimondo,[3] V. Ripepi,[1] M. Cignoni,[4] G. Bono,[5] E. Brocato,[2] M. Dall'Ora,[1] I. Ferraro,[2] A. Grado,[1] G. Iannicola,[2] L. Limatola,[1] R. Molinaro,[1] M. I. Moretti,[1] P. B. Stetson,[6] M. Capaccioli,[7] M.-R. L. Cioni,[8,9] F. Getman[1] and P. Schipani[1]





Completeness tests for the area covered by the two fields and the external one

Black dots mark the stars within the half light radius

Why Pal 12

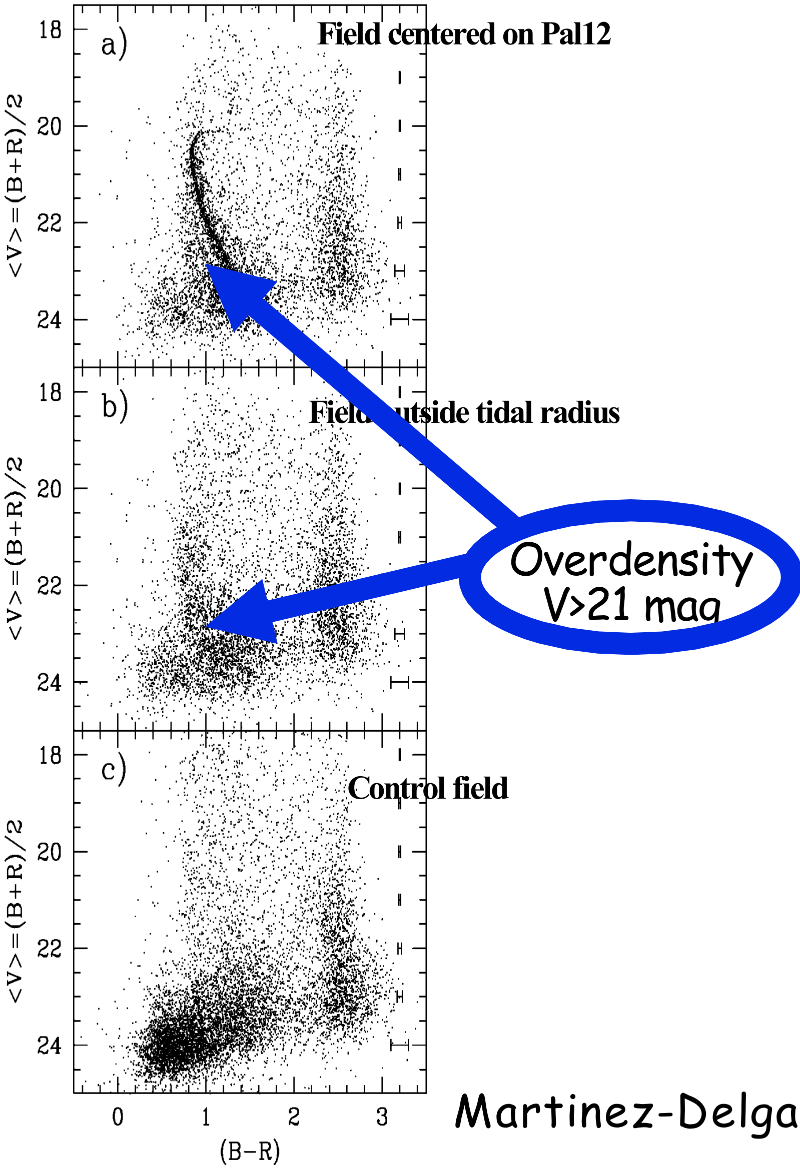
This GC is probably younger and more metal rich than the majority of the Galactic GCs (Gratton & Ortolani 1988; Stetson+1989; Rosenberg1998)

→ accreted from a surrounding galaxy such as, for example, the Magellanic Clouds (Lin & Richer 1992; Zinn 1993).

Irwin (1999) pointed out that distance and radial velocity of Pal 12 are consistent with the hypothesis that it has been captured by our Galaxy in a tidal interaction with the Sagittarius dwarf Spheroidal galaxy. This hypothesis was supported by Dinescu et al. (2000) through the determination of the proper motions and the three-dimensional orbit of Pal 12.

→The presence of an additional stellar population in the direction of this GC was detected by Martìnez-Delgado+2002 analysing a large field around Pal 12 and by Bellazzini+2003 using data from the 2-Micron All-Sky Survey.

Pal 12 overdensity = Sgr stream

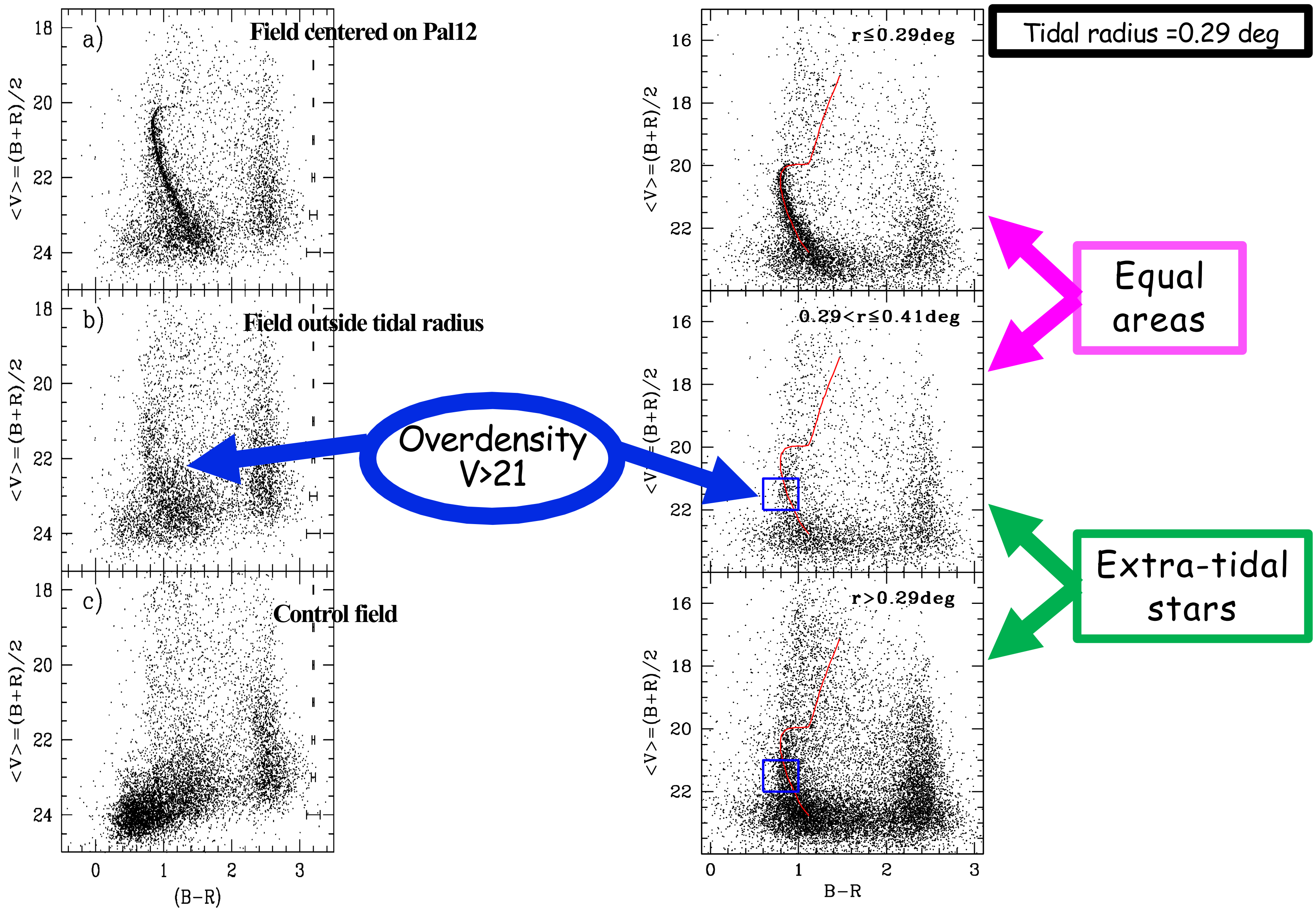


Martinez-Delgado+ 2002

This population appears to be diffuse on the field and at the same distance (within the uncertainties), but more metal poor than Pal 12, even if with a significant spread in metallicity and/or age, as expected for a dSph galaxy.

Our Pal 12 CMD

Martinez-Delgado+ 2002 | This work

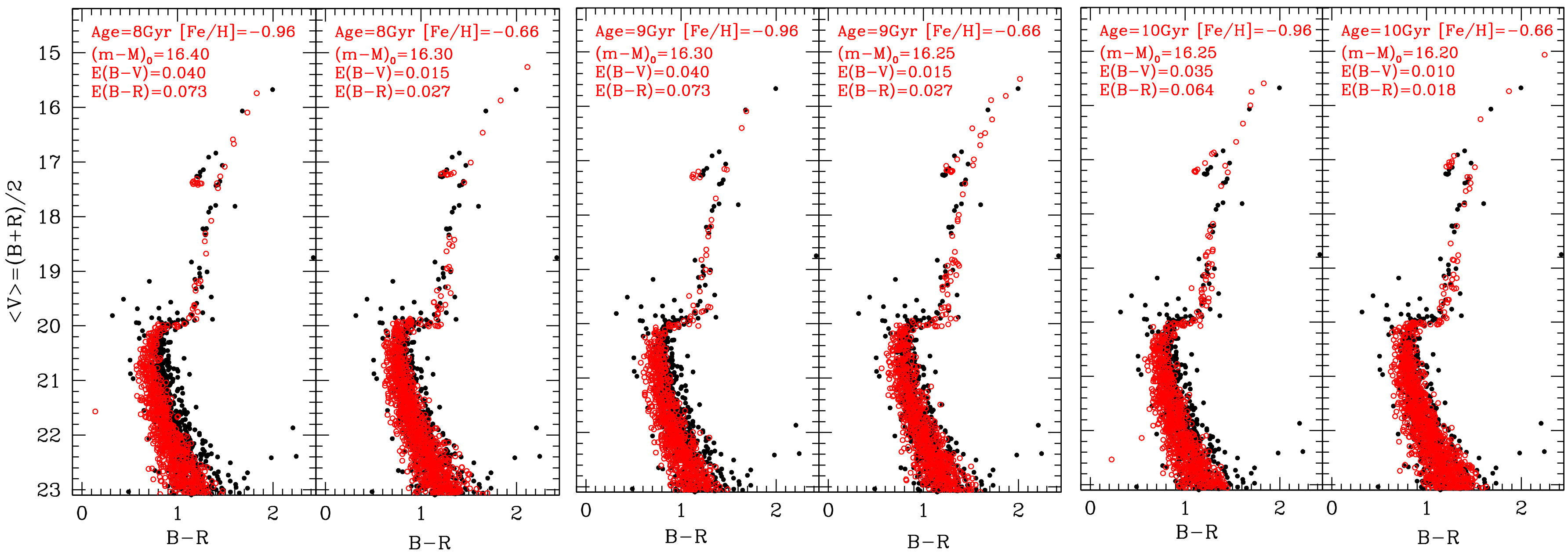


Synthetic populations for Pal 12

- Stars within Pal 12 tidal radius
- Synthetic stellar population

- *Ages and metallicities are based on previous works in literature*

SPOT code: Teramo Stellar POpulation Tools, Raimondo+ 2005).

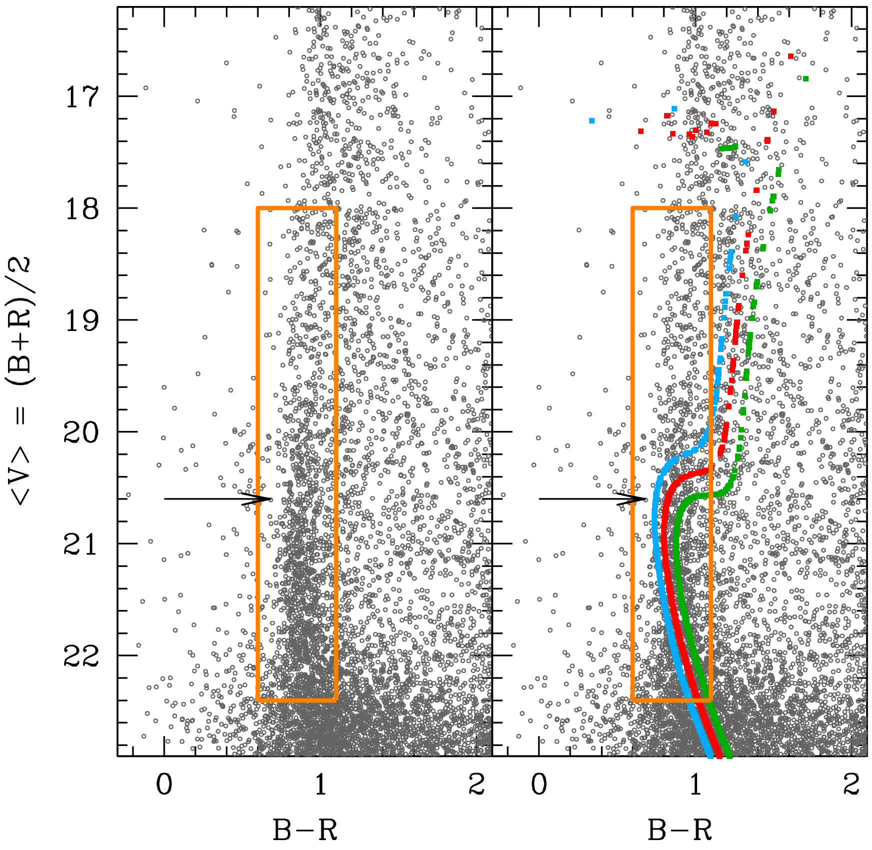


- Fitting values for distance and reddening depend on age and metallicity but the mean value for the distance is μ=16.3 ± 0.1 mag in agreement with previous values in literature and E(B-V) of about 0.03 mag in agreement with Schlegel et al. values

- we confirm an age of 8 – 10 Gyr for Pal 12, and a rather high metallicity ([F e/H] from – 0.96 to -0.66 dex) for a GC in the Galaxy's outer halo.

Synthetic populations for the overdensity

We analyze the extra-tidal stars in the orange box containing the stellar overdensity



SPOT code: Teramo Stellar POpulation Tools, Raimondo+ 2005).

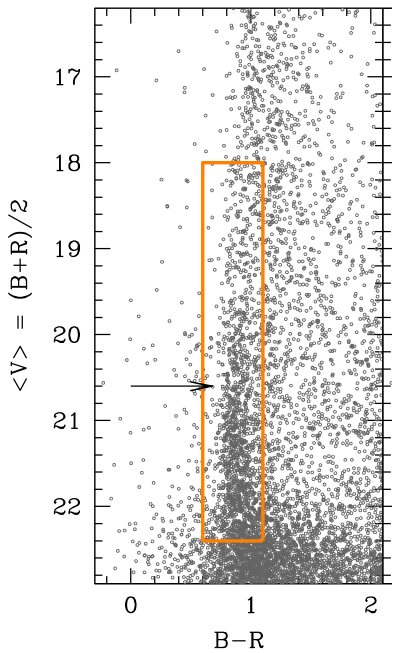
- Extra-tidal stars

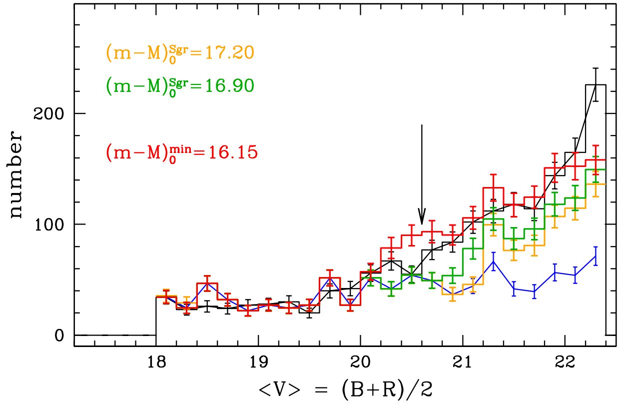
Synthetic stellar pupulations with Age=13Gyr and

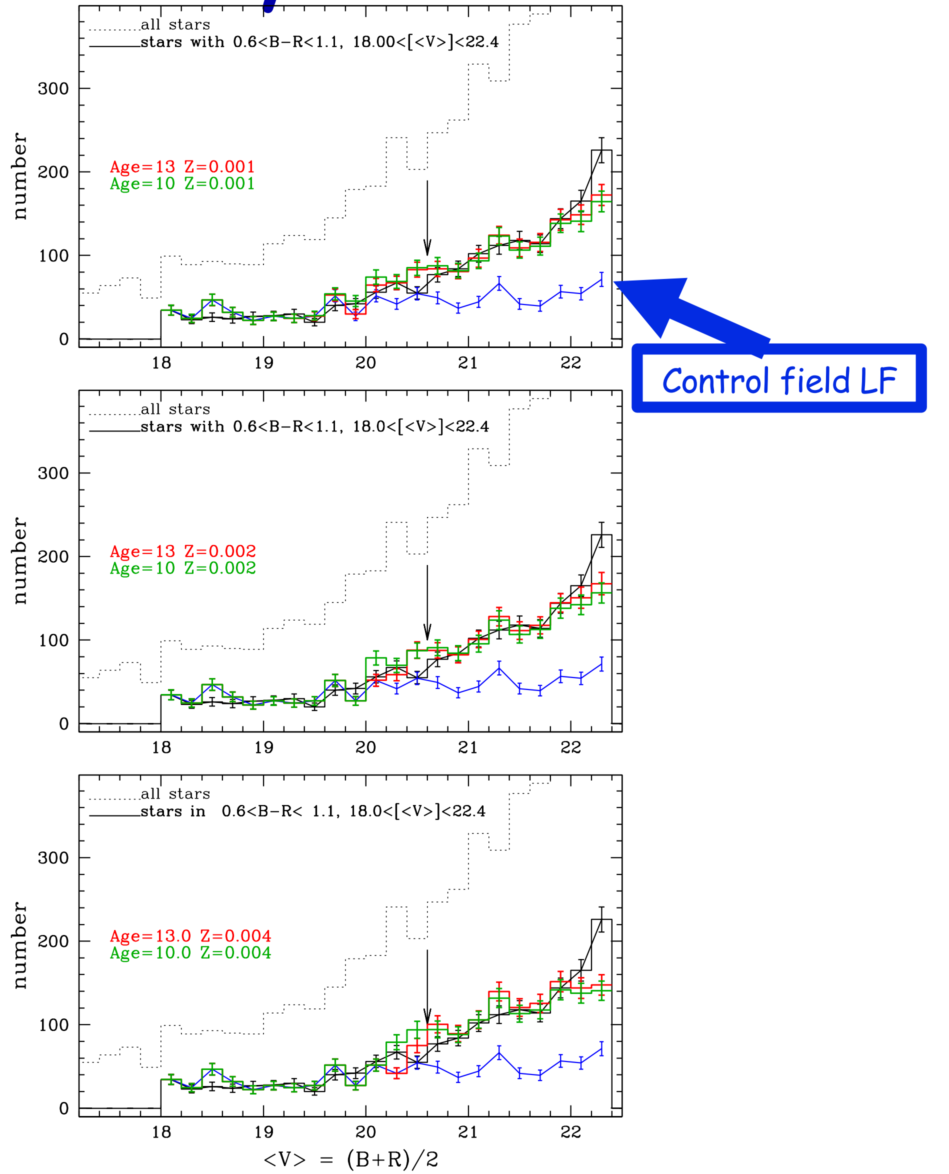
- [Fe/H]=-1.27 dex
- [Fe/H]=-0.96 dex
- [Fe/H]=-0.66 dex

representative of the old stellar component of Sgr dSph.

Luminosity functions for the overdensity







Results

- These comparisons with synthetic populations and theoretical LFs suggests the presence of a dominant stellar population older than 10 Gyr and with a mean metallicity [Fe/H] ~ –1 dex, consistent with the old stellar components in the Sgr dwarf galaxy

- Taking into account the uncertainties due to photometrical errors, reddening and distance, we cannot obtain firm constraints on the age and chemical composition of the overdensity, likely populated by a mixture of old and metal-poor/intermediate-metallicity populations (in agreement with Bellazzini+2006) →

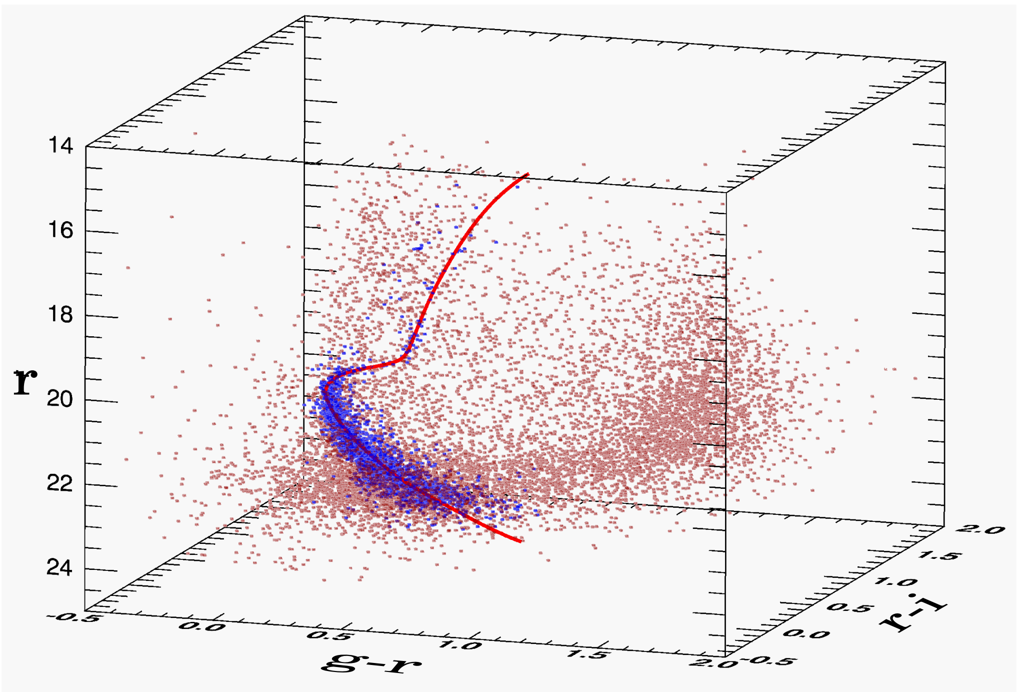
  → old and metal-poor populations appear to be preferentially stripped from the Sgr galaxy during the past peri-Galactic passages with respect to the intermediate-age intermediate-metallicity population that presently dominates its bound core.

- Also about the distance, this overdensity appear to be at the same distance of Pal 12 (~16.3 mag) but we cannot exclude the presence of a fraction of stars with longer or slightly shorter distances.

Field-cluster star selection

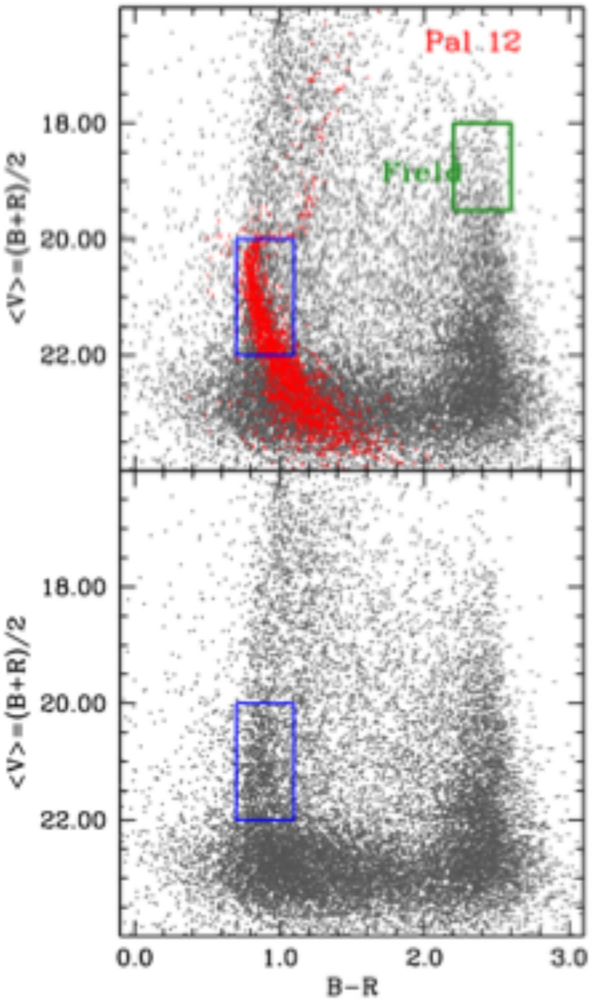
Due to the presence of the overdensity, the separation between cluster and field stars is very difficult and this can influence the star counts.

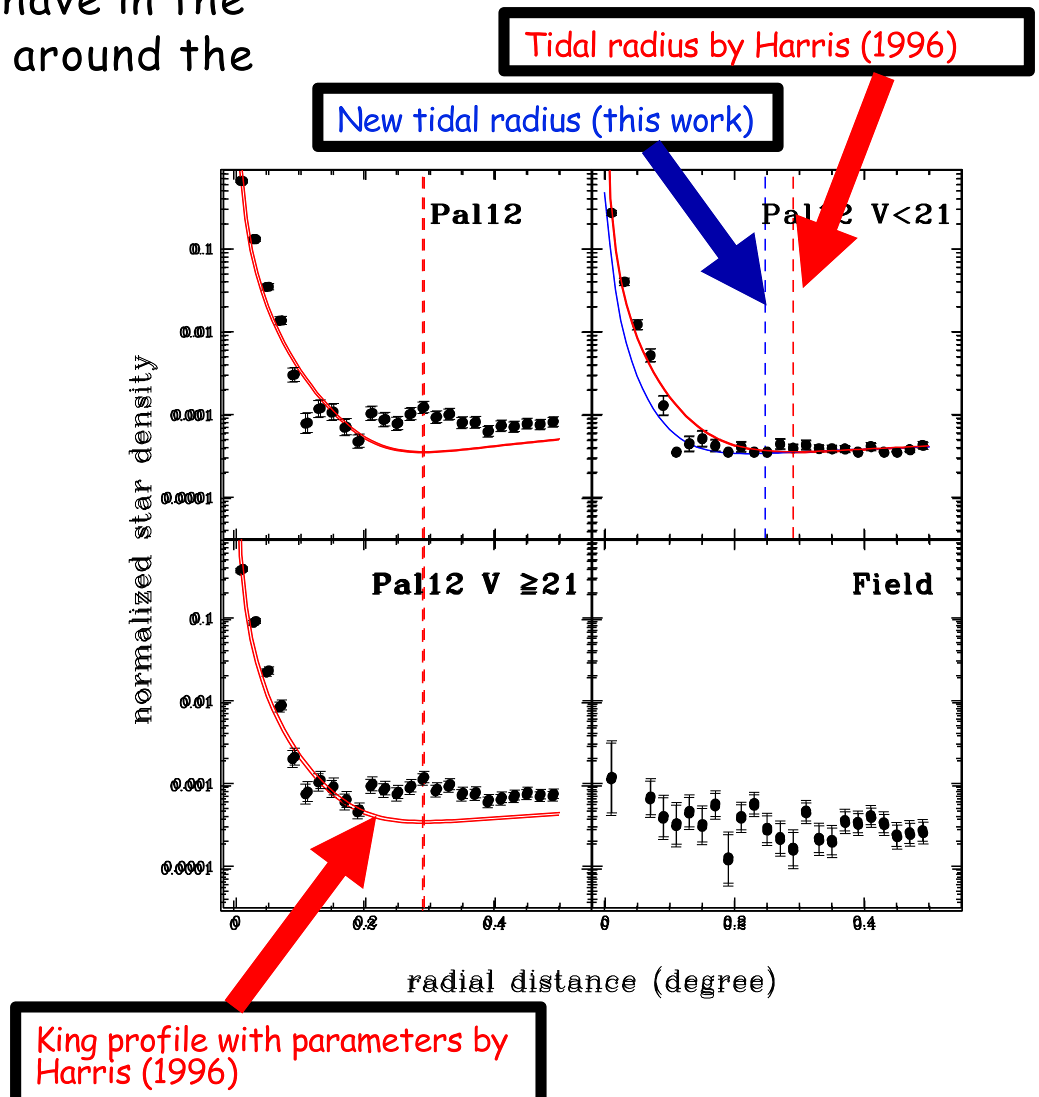
We have used an innovative multi-band method (Di Cecco+ 2015, Calamida+ 2017) based on 3D ridge line (magnitude-color-color)



Radial star counts

Using this 3D method we do not have in the CMD of the field the typical gap around the ridge line





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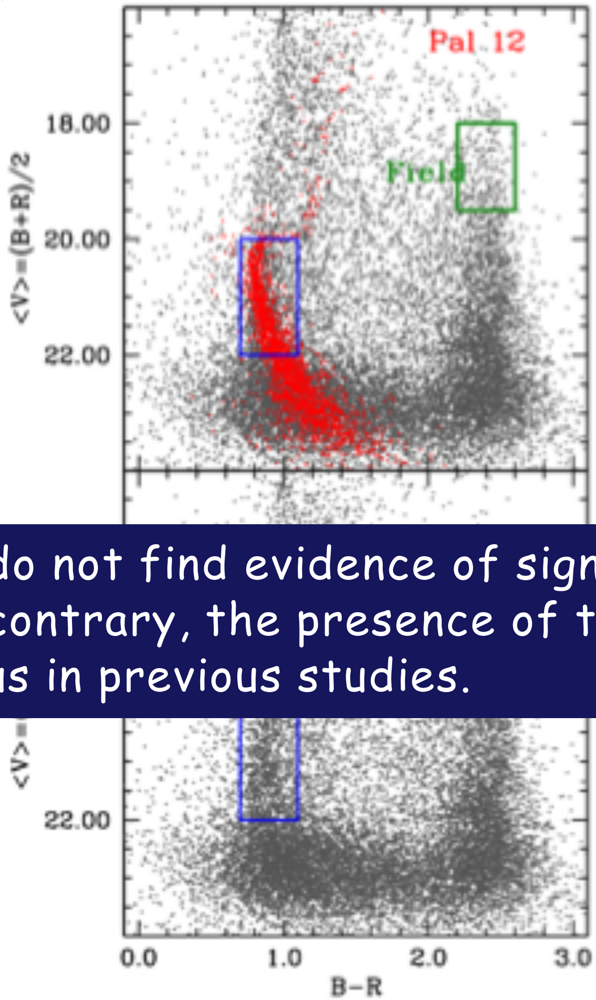
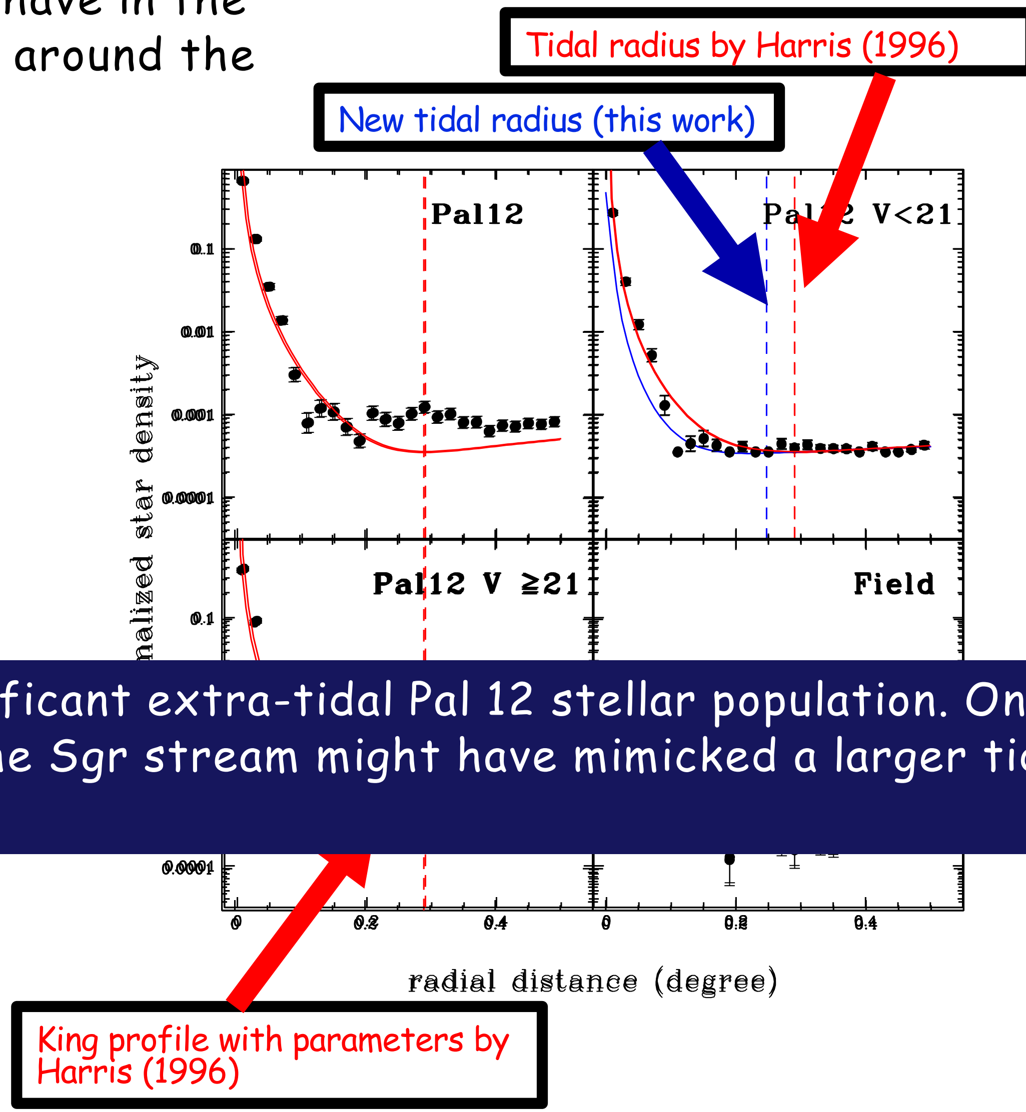


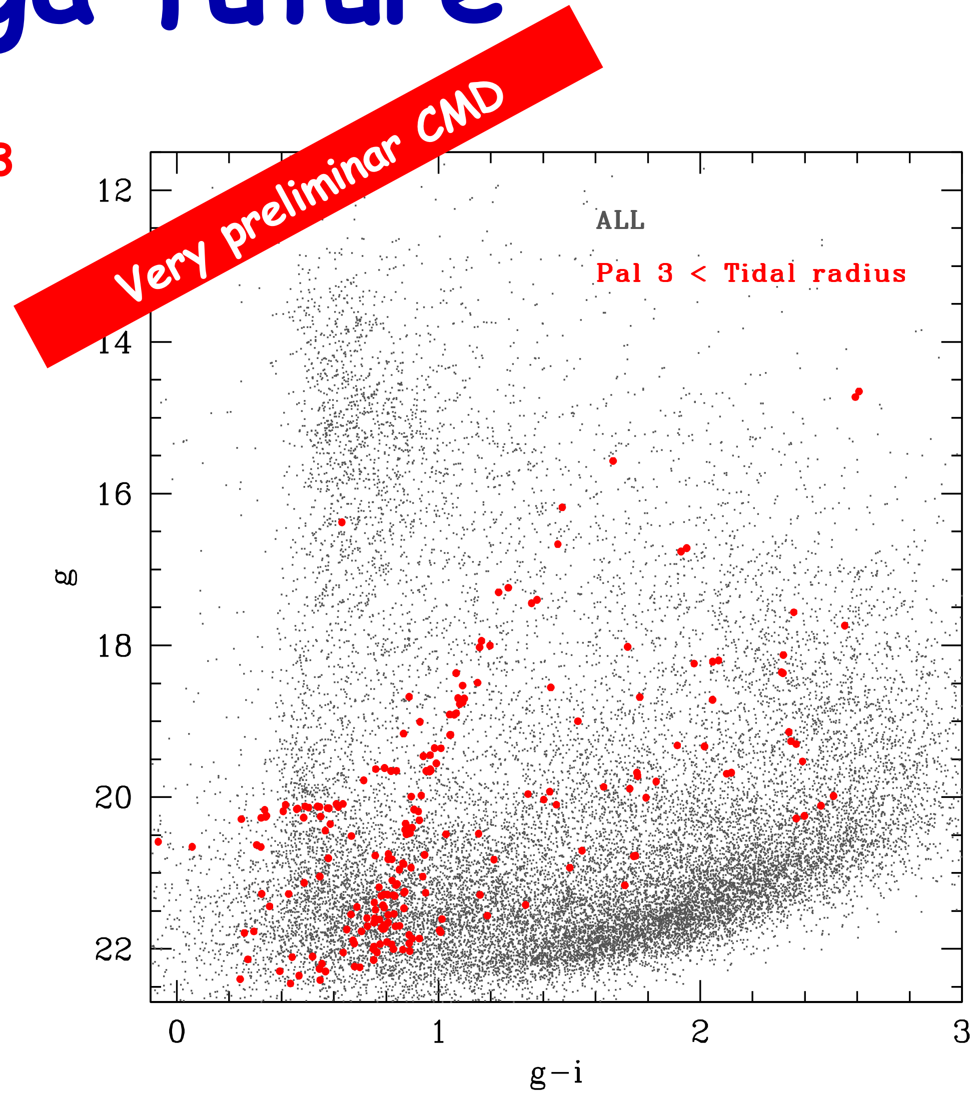


We do not find evidence of significant extra-tidal Pal 12 stellar population. On the contrary, the presence of the Sgr stream might have mimicked a larger tidal radius in previous studies.

Strega future

- Analysis of time-series for Pal3 is in advanced progress and we aim to trace over-densities finding RR Lyrae in the region out of tidal radius (as showed by Marcella Marconi)

- Reduction for NGC 6752, Fornax and Sculptor is in progress. It will be possible to trace the possible presence of interaction between Fornax and Sculptor.



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- Red … s in … be possible to … possible presence of interaction between Fornax and Sculptor.

Thank you

Very preliminar CMD