The Globular Clusters - Dwarf Galaxies Connection
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Old Globular Clusters in Dwarf Irregular Galaxies

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OUTLINE

- **Introduction**

  Why old GCs in dIrrs?

- **Observational Data**

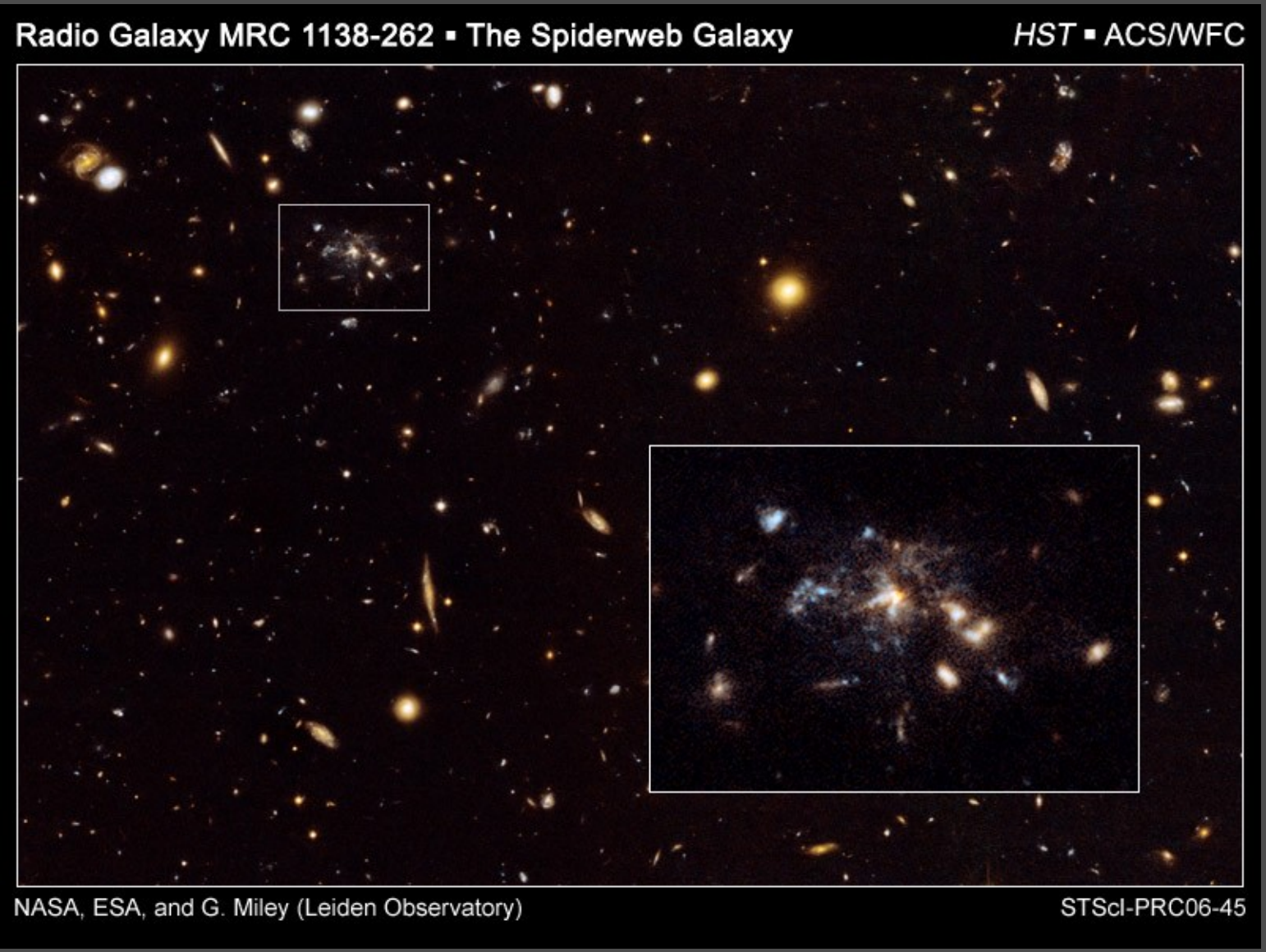
  dIrrs sample, GC selection, photometry

- **Results**

  CMDs, M_V and V-I vs. d_{proj}/r_{eff}, r_h, ellipticity relations

- **Summary**

Why old GCs in dIrrs?



Dozens of star-forming satellite galaxies as individual clumpy features in the process of merging

◊ the most abundant galaxy type in the early Universe.

◊ constraints on the hierarchical galaxies' and their GCS assembly.

◊ their GCs' properties to assess the MW 'Young Halo' and ωCen type clusters origins.

◊ but hard to study (low expected N_{GC}). Large samples, good resolution are required.

Introduction cont...

The Galactic YHs GCs accreted from dwarf galaxies?

(e.g. Zinn'93, Mackey & Gilmore'04, Mackey & van den Bergh'05, Lee et al.'07)

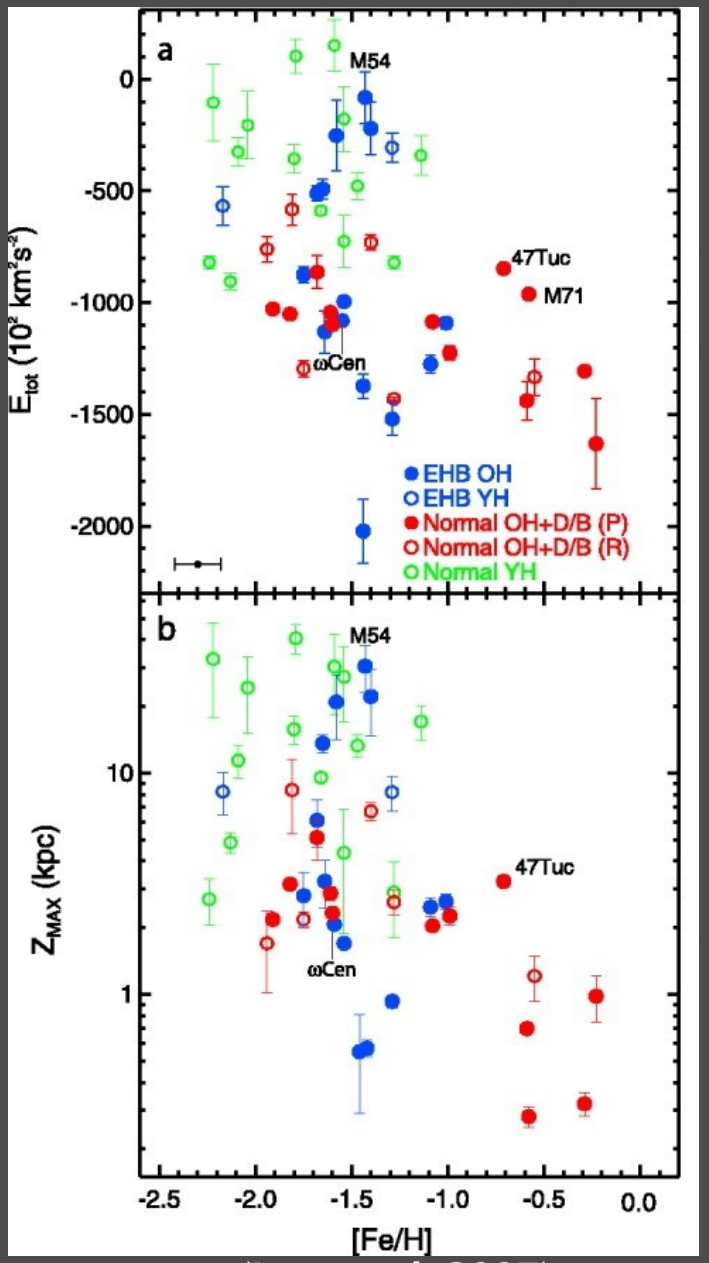
– YHs & EHBs share hot orbital kinematics (Lee et al. 2007)

– Chemical abundance differences

(Venn'04, Spitler'05, Johnson'06, Geisler'07)

YHs from bGCs in faint dIrrs?

- Color & magnitude distributions, structural parameters

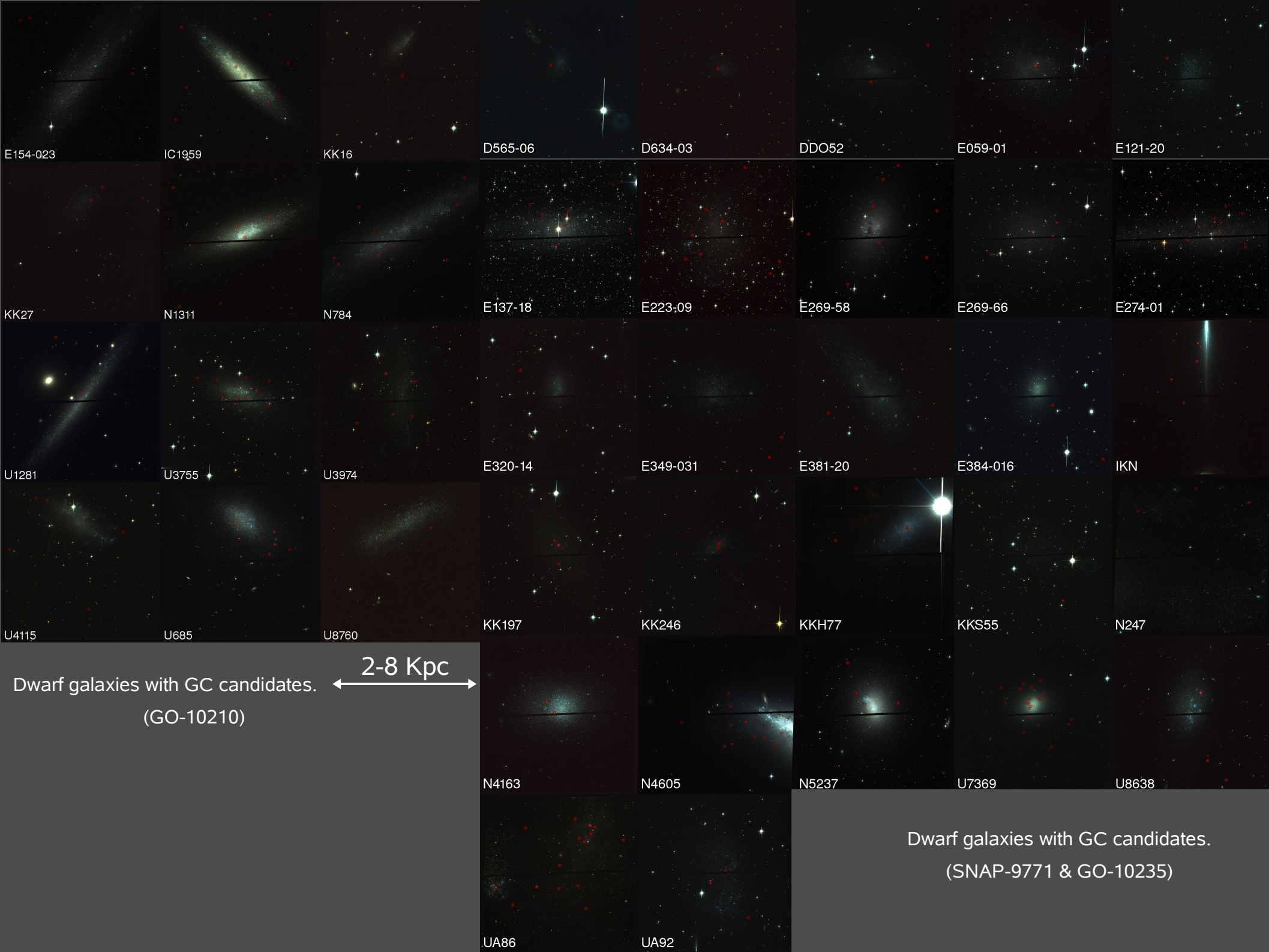


(Lee et al. 2007)

The Data

- Archival HST/ACS images in F606W and F814W (SNAP 9771, GO-10210,10235)
- Deep down to ~2 mag below the TRGB (M_V = -3 mag) at 2 – 8 Mpc.
- 70 dwarf (M_V> – 17mag) galaxies - 40 dIrrs, 2 dEs, 2 dSphs, 4 Sdm.
- GO-10210 galaxies in bound? associations containing only dwarfs.
- SNAP 9771 & GO 10235 in the very outskirts ($\Theta < 0$) of Cen A, CVn Clouds, M81, M83, Sculptor, Mafei 1 & 2, IC 342 and N2903 groups.

- ***Suitable sample of dIrrs for probing the impact of the environment on the GC formation in such systems.***



Dwarf galaxies with GC candidates.
(GO-10210)

Dwarf galaxies with GC candidates.
(SNAP-9771 & GO-10235)

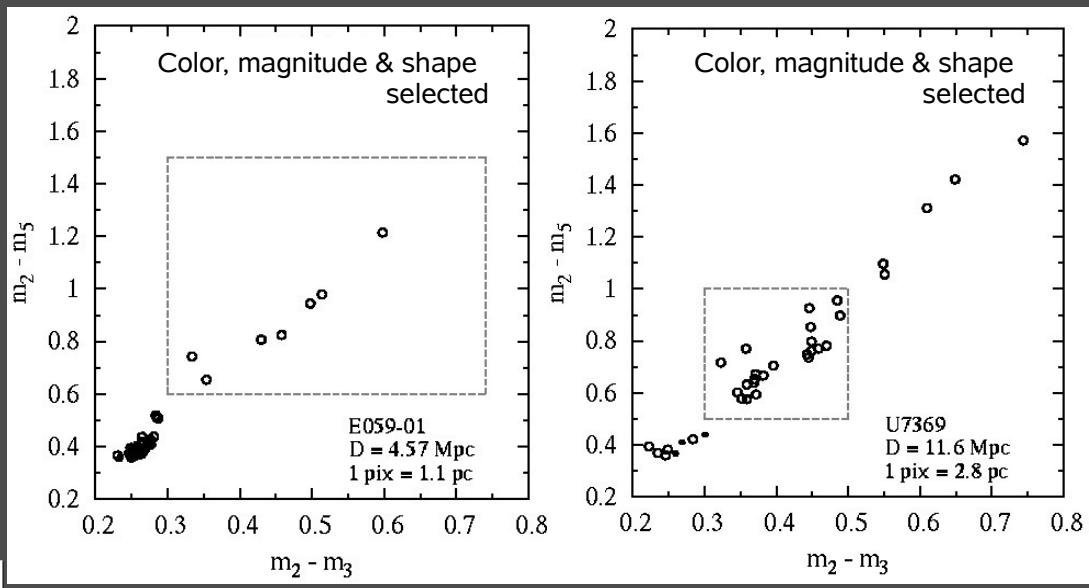
Selection & Photometry

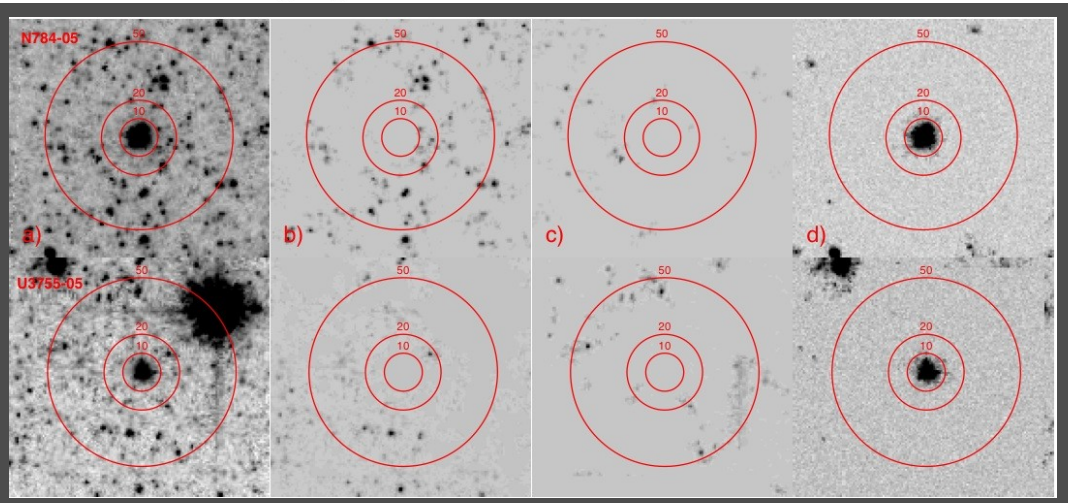
◊ GC candidates selection was based on color, magnitude and morphology criteria.

◊ Iterative cleaning of the photometric apertures from contaminating neighboring objects.

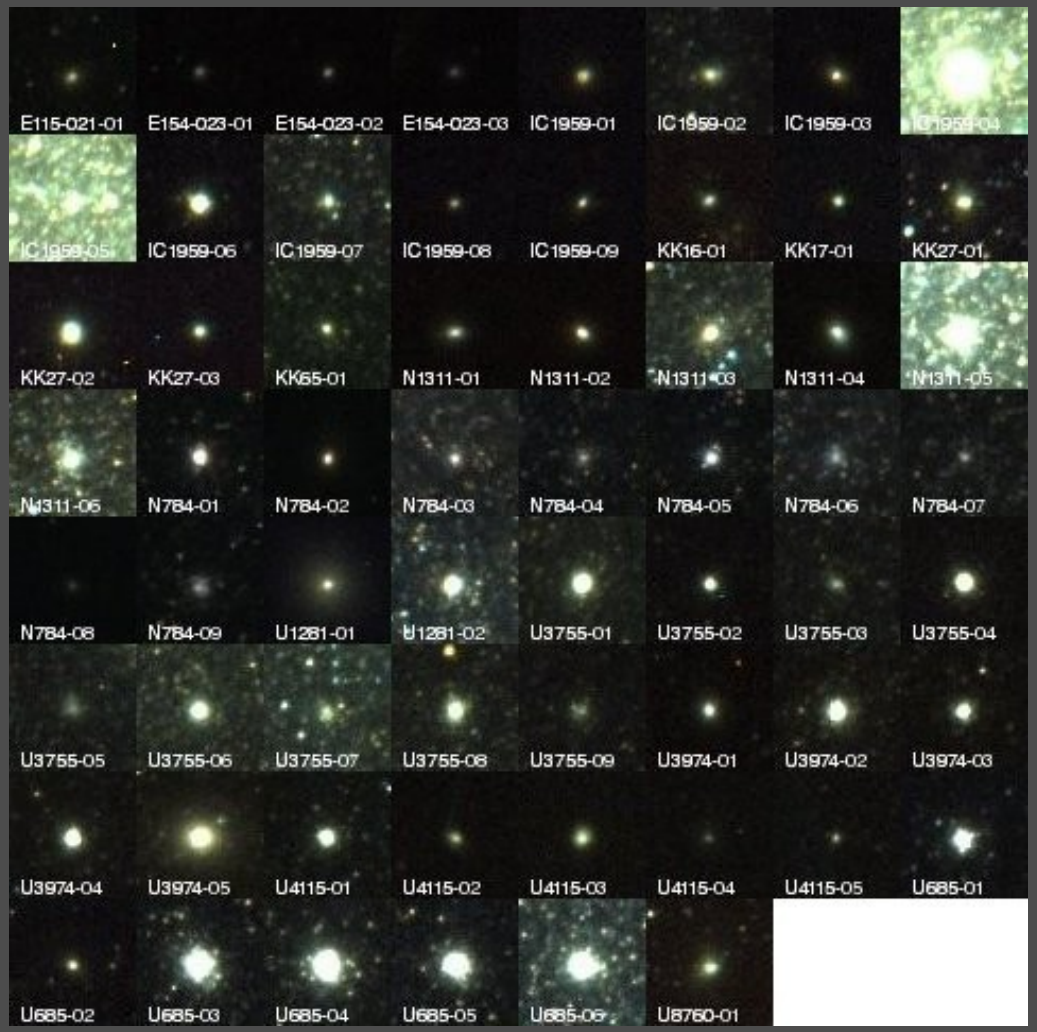
◊ Curve of growth analysis for every GC candidate was performed to yield their integrated magnitudes.

◊ Structural parameters were measured with ishape for the best χ^2 King model using ACS tailored TinyTim PSFs.

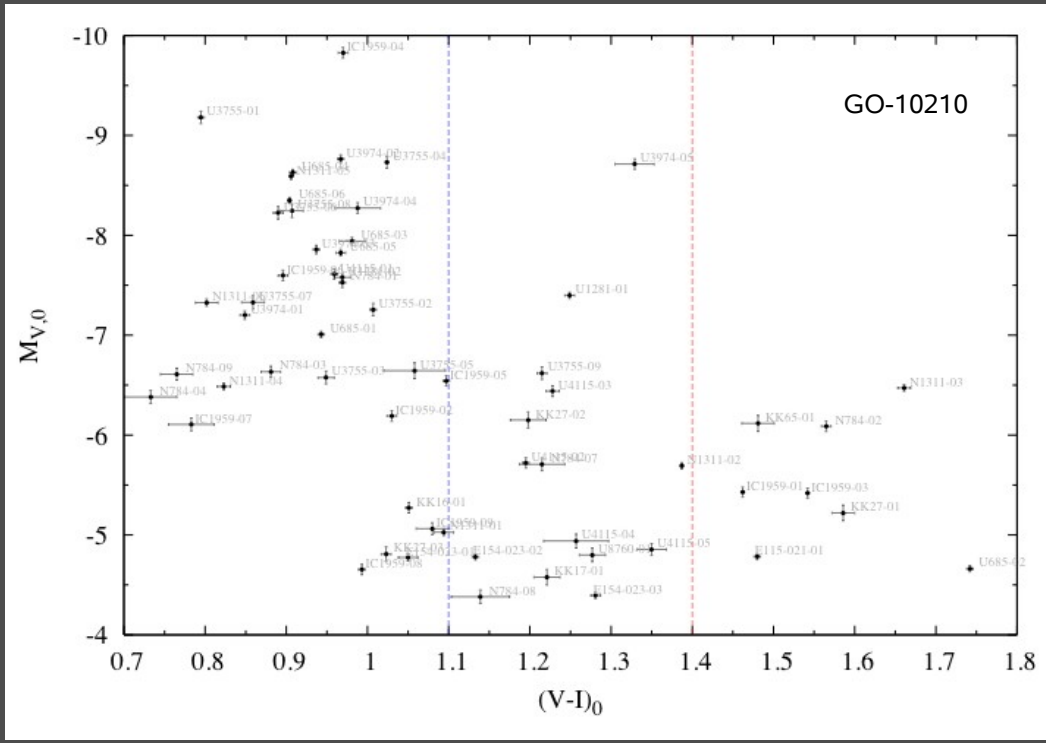


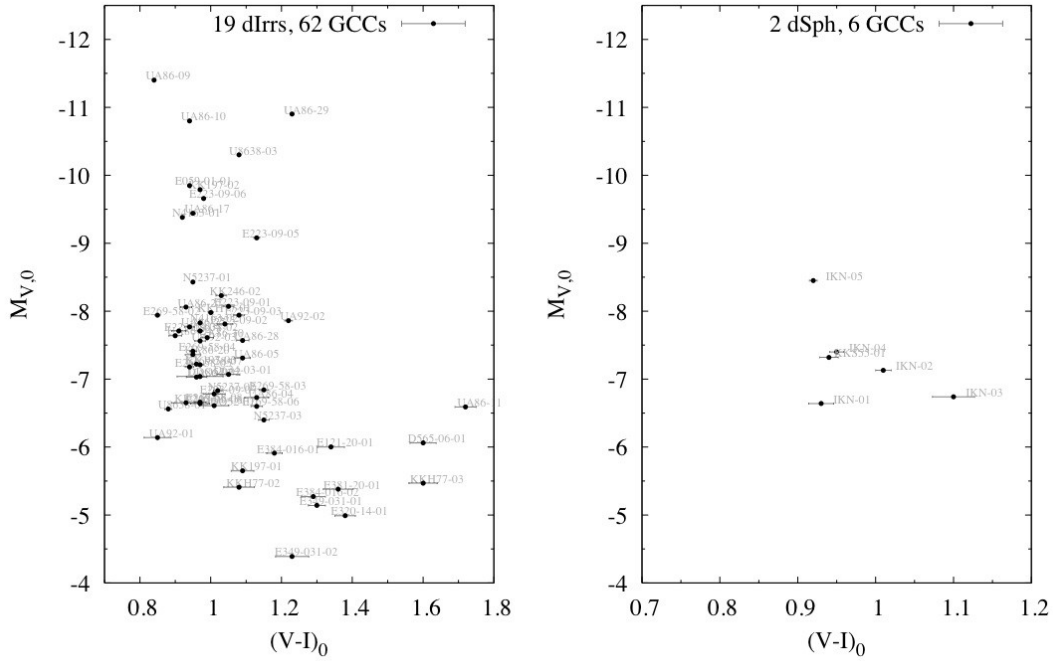


Old Globular Clusters in Dwarf Irregular Galaxies

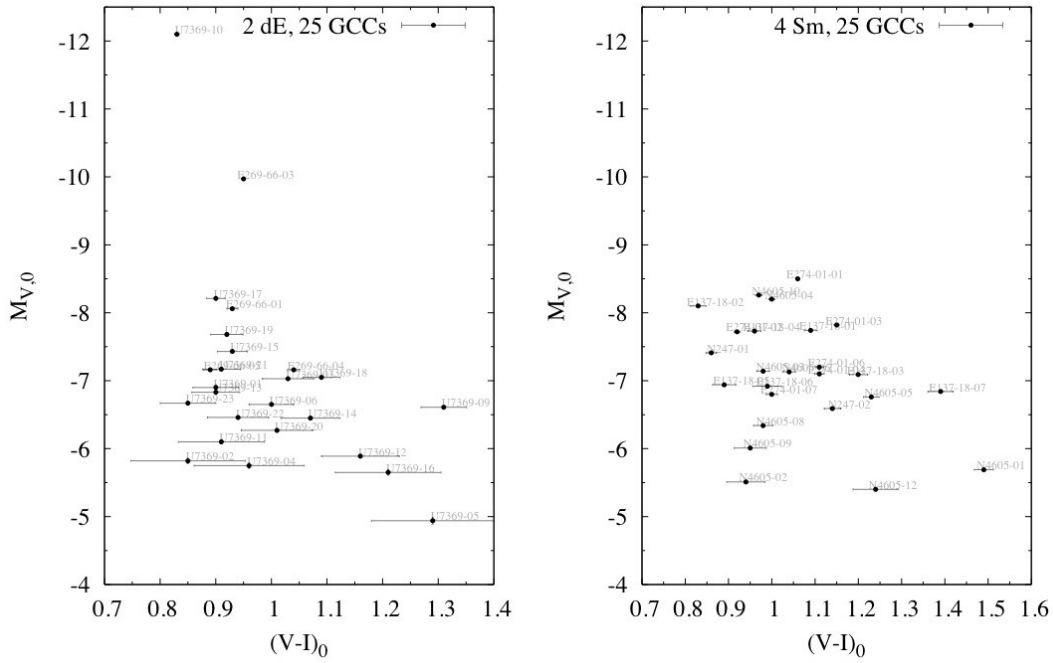


CMDs





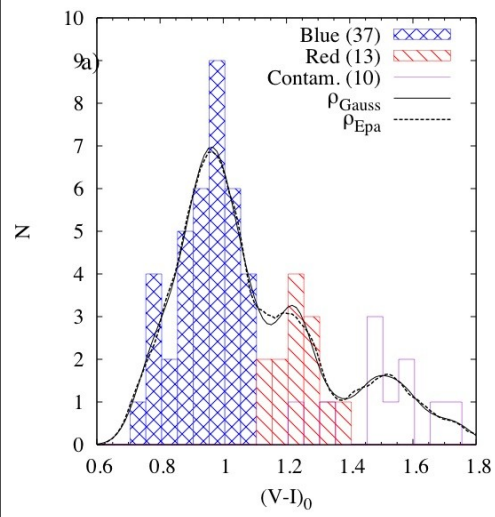
SNAP 9771 & GO-10235

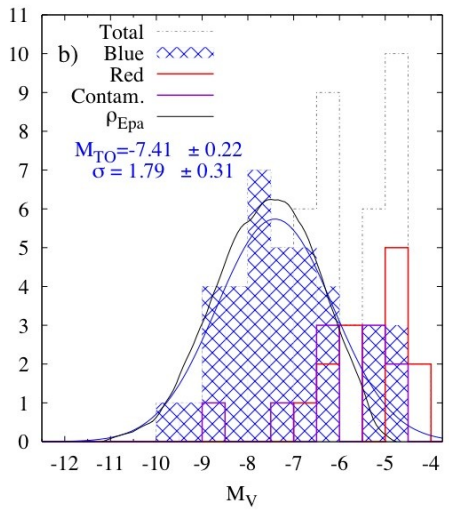


- Not many faint bGCs are observed in dIrrs
- Bright nuclear GCs are observed.
- Few rGCs are present, unexpected for dIrrs.

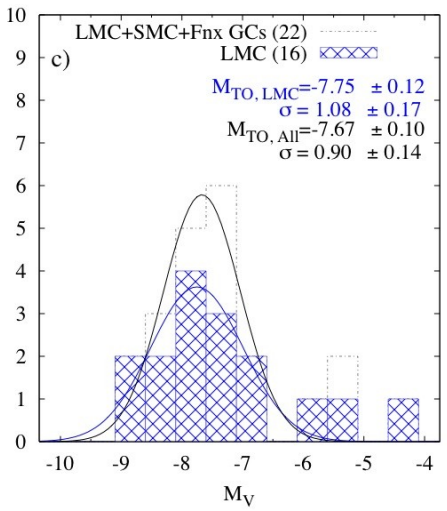
Color and Magnitude distributions

dIrrs



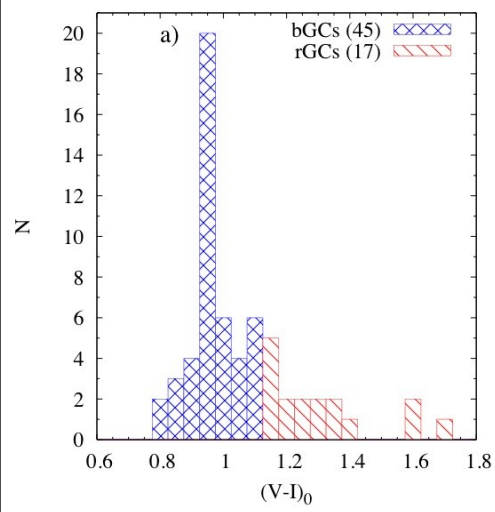


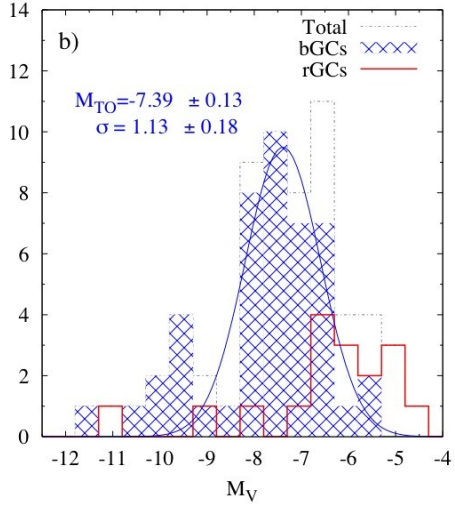
LMC



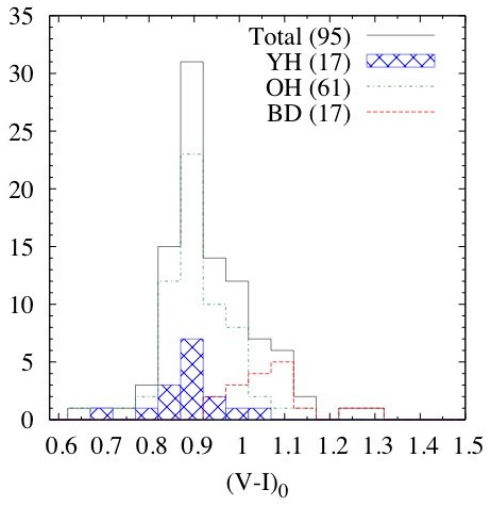
The bGCs in dIrrs show similar color but brighter magnitude distributions than the YHs.

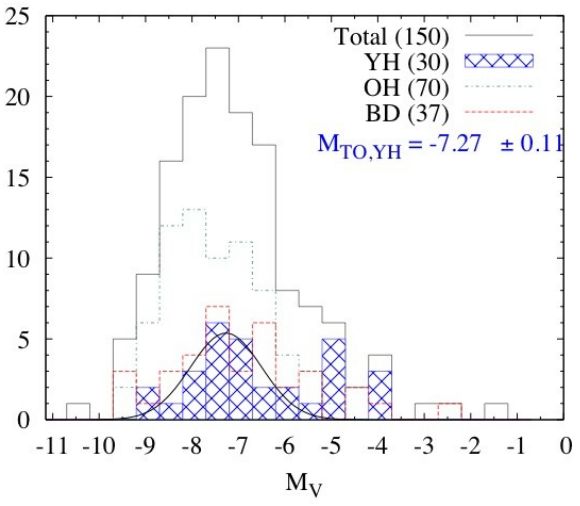
dIrrs





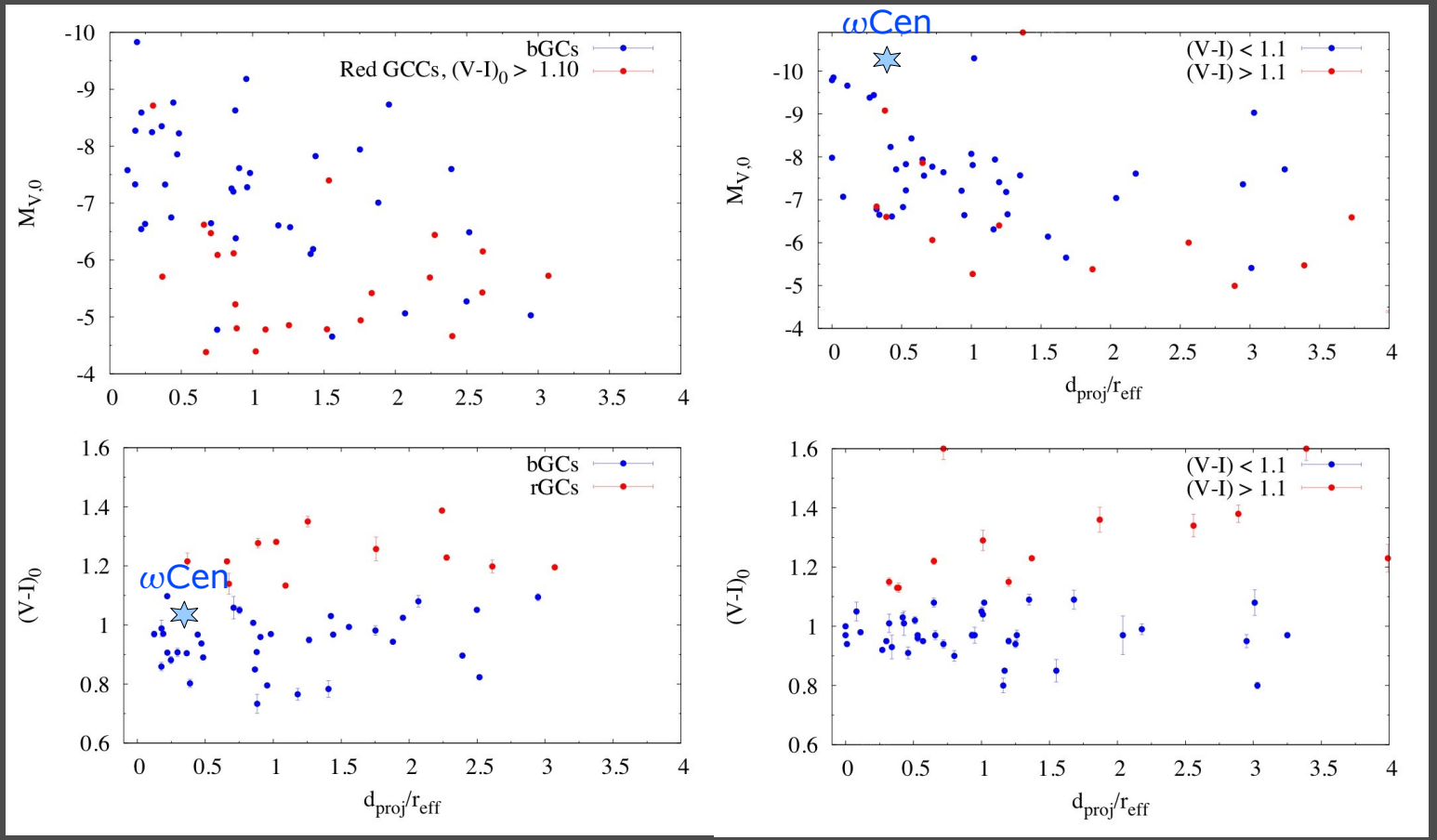
Milky Way





Projected distances

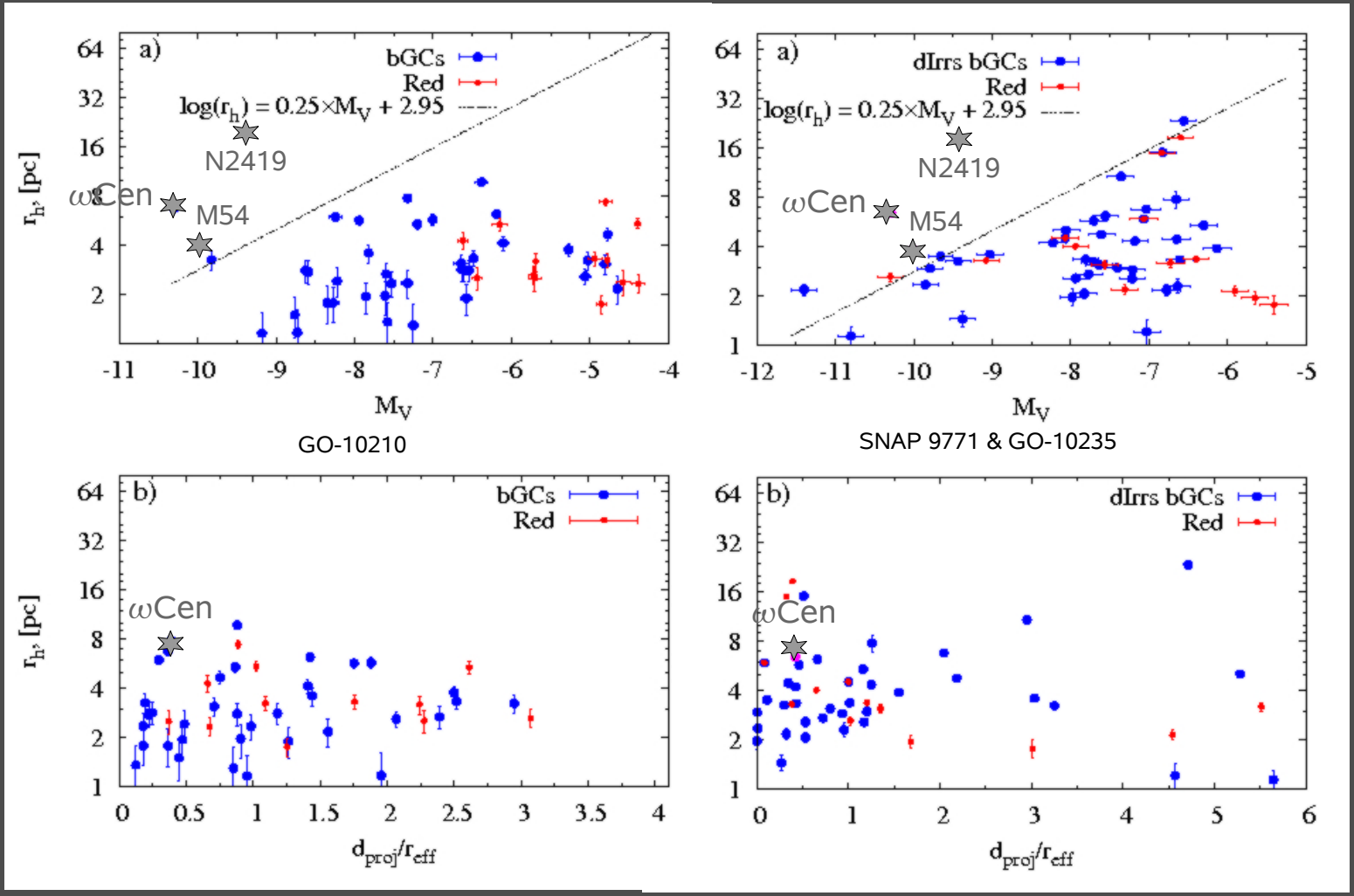
GO-10210 SNAP 9771 & GO-10235



Bright nuclear clusters are observed in dIrrs

Implications for the origin of ωCen and M54 type clusters in the MW.

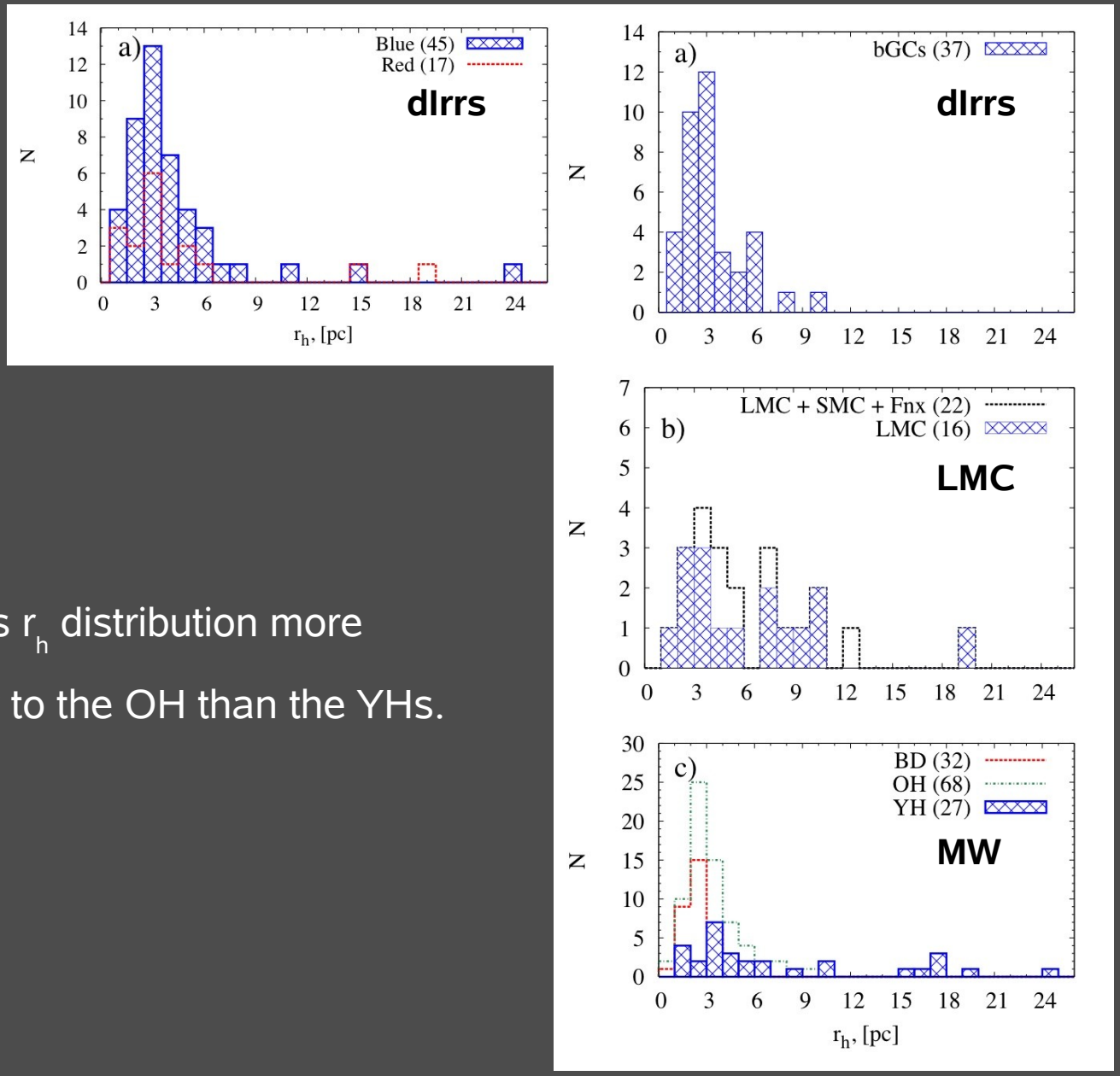
Structural Parameters



– Brightest clusters occupy the same region as M54

– M_V vs. r_h relation (the fainter the larger)

Structural Parameters

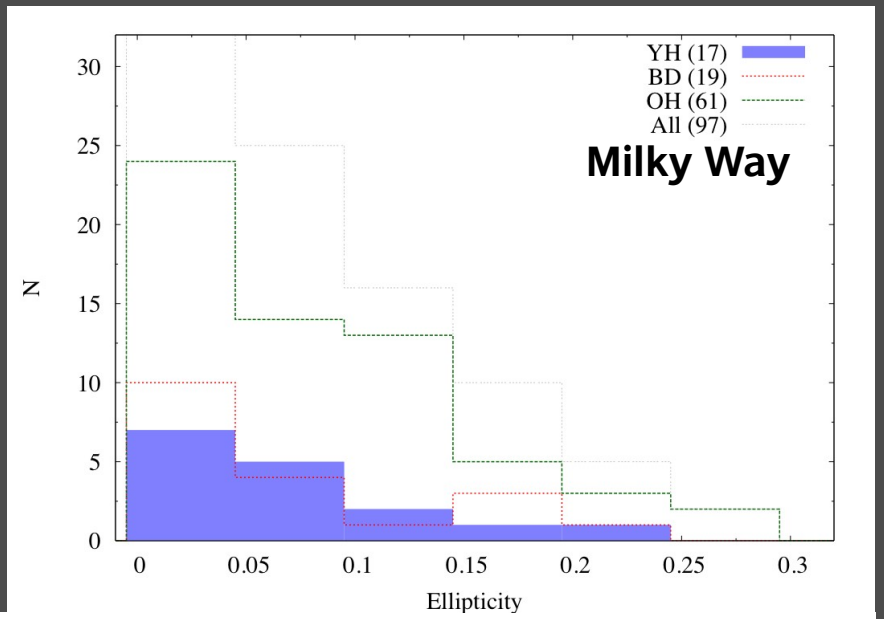


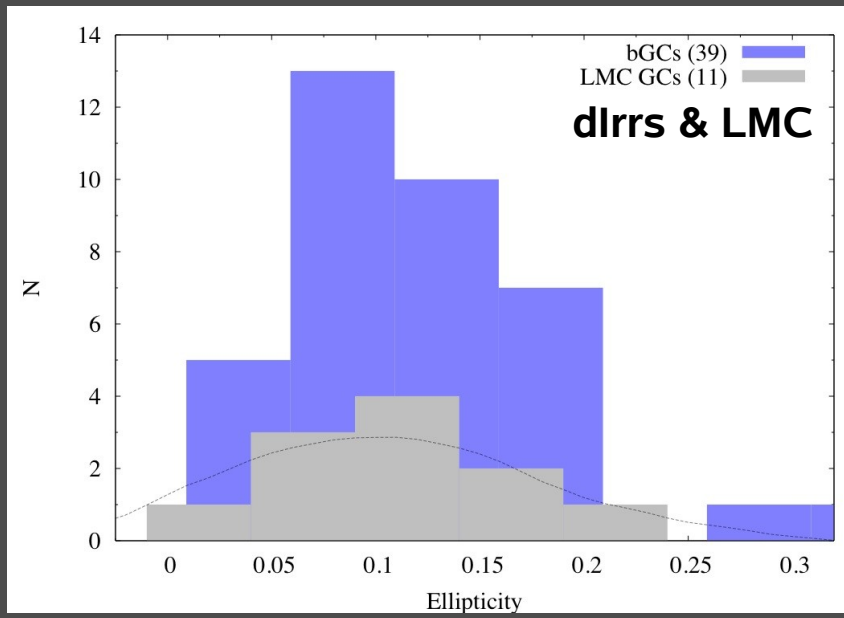
- bGCs r_h distribution more similar to the OH than the YHs.

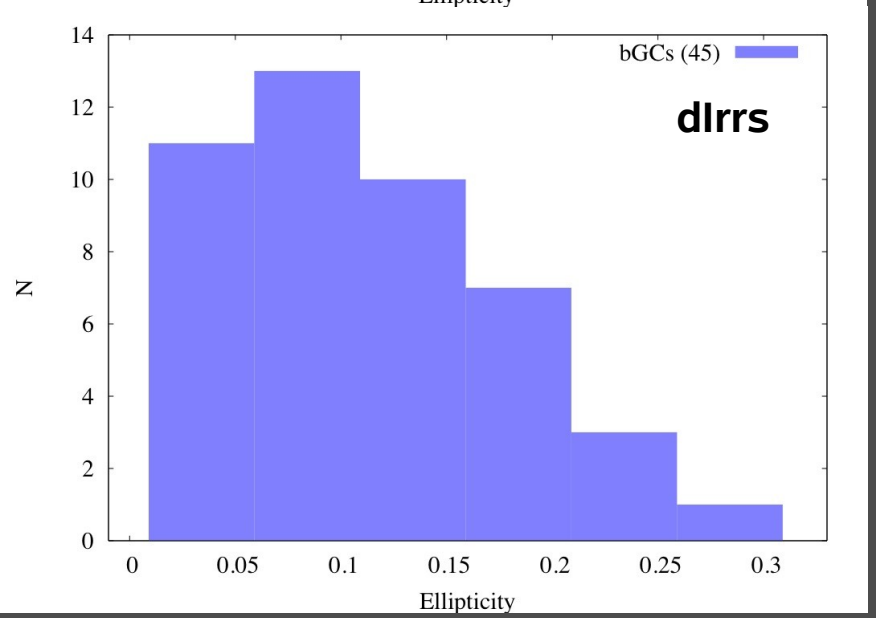
Ellipticities

– are flatter than the YHs

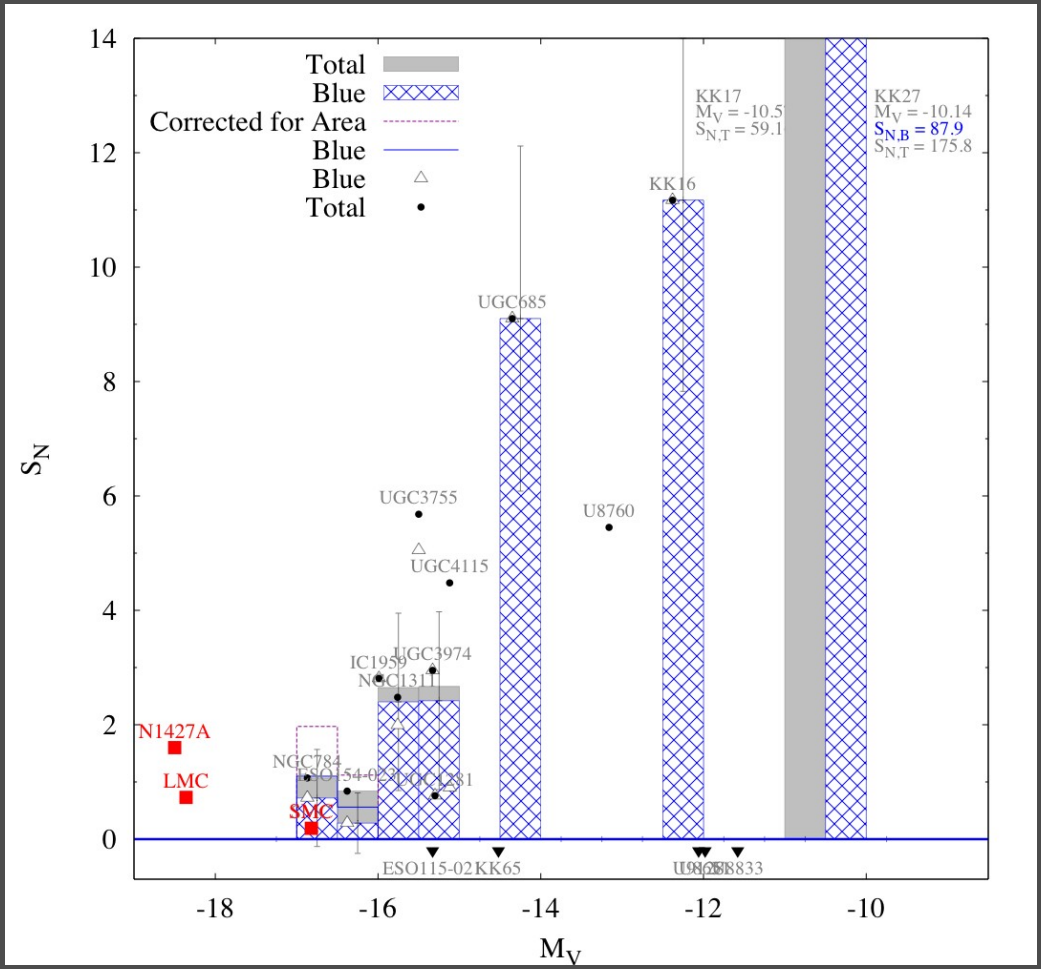
– bGC in dIrrs have similar *e* distributions as the MCs







S_N and galaxy merging



– High present day S_Ns in dIrrs

(unlike their LG analogs, e.g. Harris'91)

– S_N increases for fainter dIrrs

(Miller'98, Forbes'05, Strader'06, Geisler'07, Puzia'07)

– assuming passive evolutionary fading, S_N will increase by a factor of 2 to 16 (dE || dSph?)

– Merging by groups
$\langle M_V \rangle \approx -15$ mag, $\langle S_N \rangle \approx 14$ (dE || dSph?)

– Can contribute to the bGCs (S_N and T)

Summary

- Extremely faint dIrr galaxies do also form GCs.
- Not many faint bGCs are observed in dIrrs, but present in dEs and SBms.
- Bright nuclear GCs are observed in dIrrs.
  – analogs of the ωCen and M54 type clusters in the MW? (spectra)
- Few rGCs are present, unexpected for dIrrs. (spectra)

bGCs in dIrrs vs. YHs

- bGCs show similar color but brighter magnitude distributions than the YHs.
- r_h distribution more similar to the OH than the YHs.
- Different *e* distributions
- Such faint dIrrs can contribute to the blue GC population with insignificant contribution to their stellar component?
- About 10 such faint dIrrs are required to populate the MW YH group