Exploring the Globular Cluster – UCD Transition Region in NGC 5128

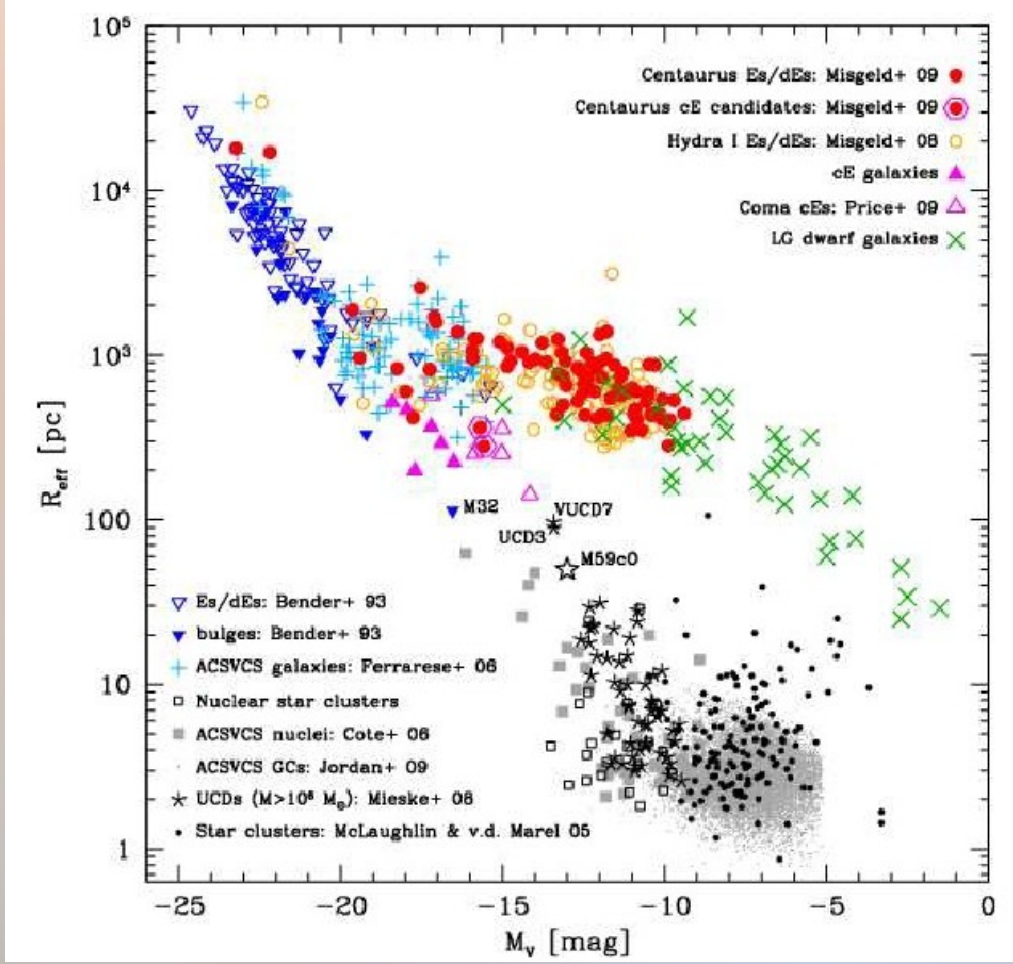
Kristin A. Woodley
University of British Columbia

Massive Globular Clusters

Formation of UCDs/massive globular clusters (GCs):

- Very massive tail of normal GC population (Drinkwater et al. 2000, Mieske et al. 2002)
- Merging of young massive star clusters (Fellhauer & Kroupa 2002, Maraston et al. 2004)
- Remnant nuclei of stripped galaxies (Bekki et al. 2001, Bekki & Freeman 2003)

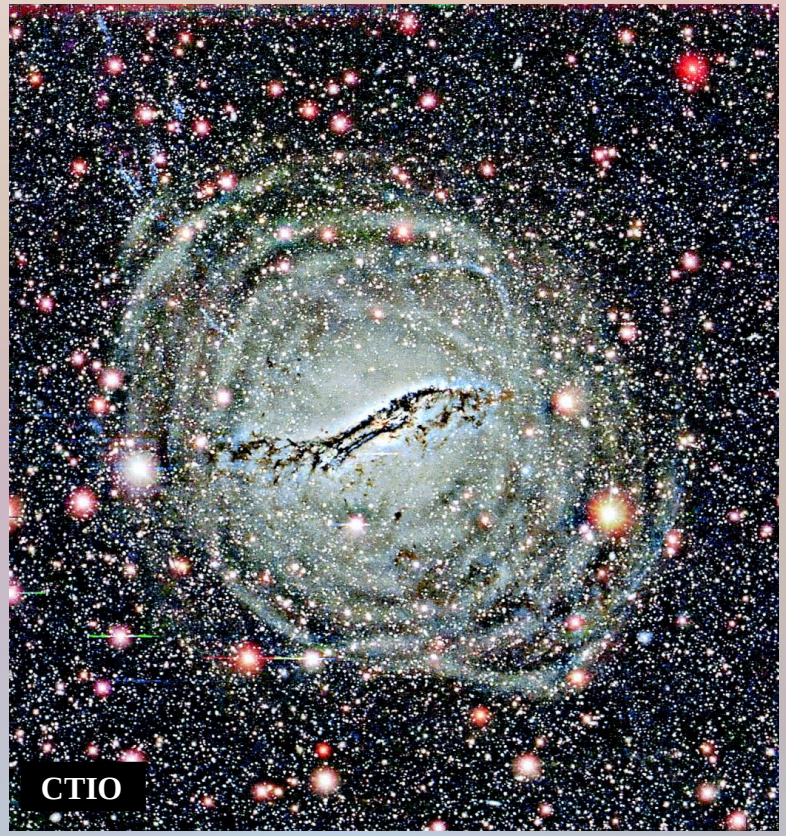
Compare the properties of massive GCs to normal GC population to try to distinguish formation mechanism



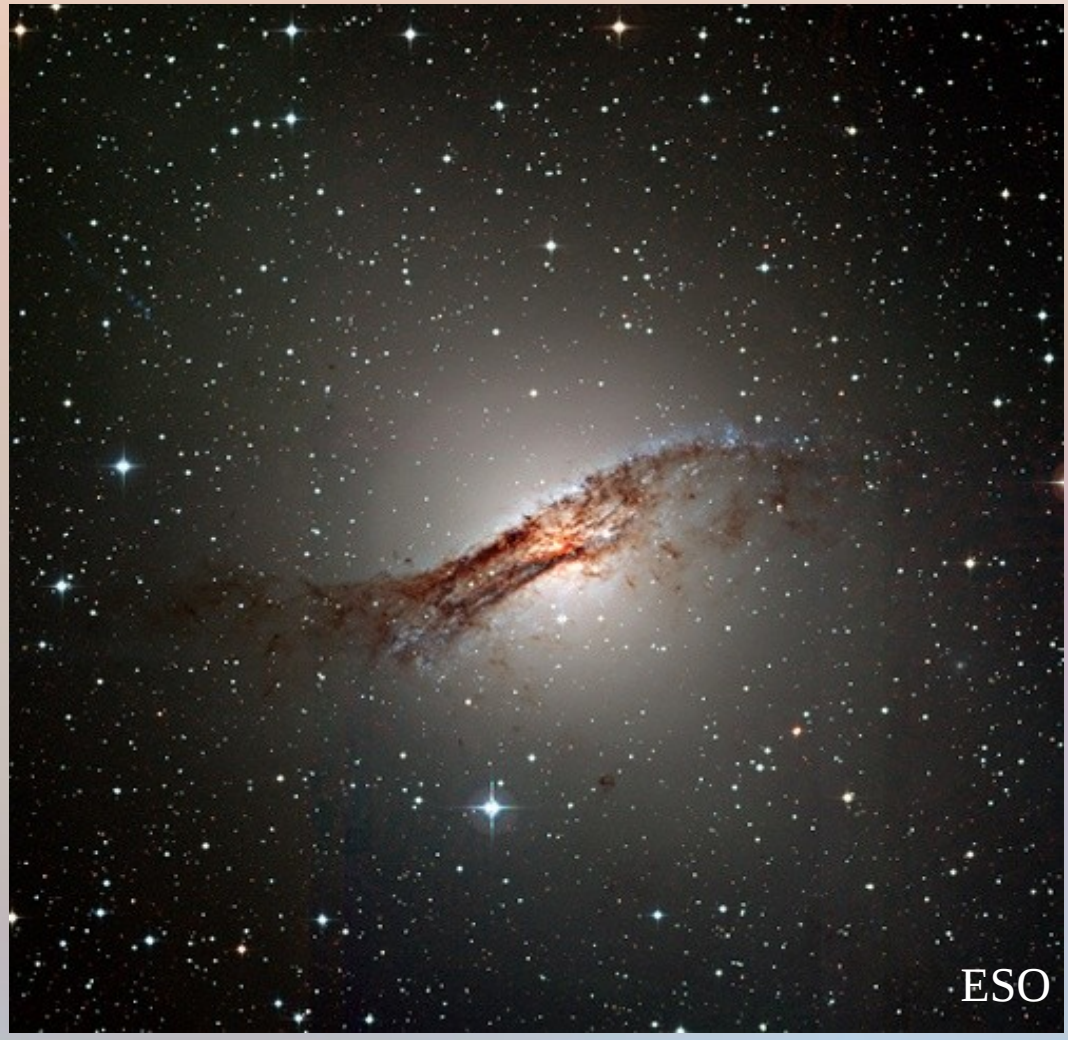
Milsgeld & Hilker 2011

NGC 5128: Centaurus A

- Giant elliptical, 3.8 Mpc (Harris et al. 2010, PASA, 27, 457)
- M_V = -21.4 mag
- Brightest galaxy in Group environment

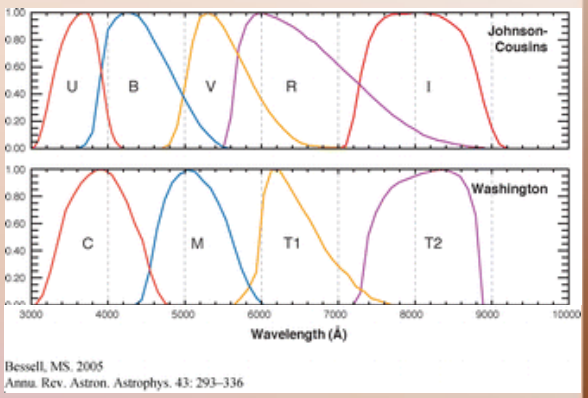


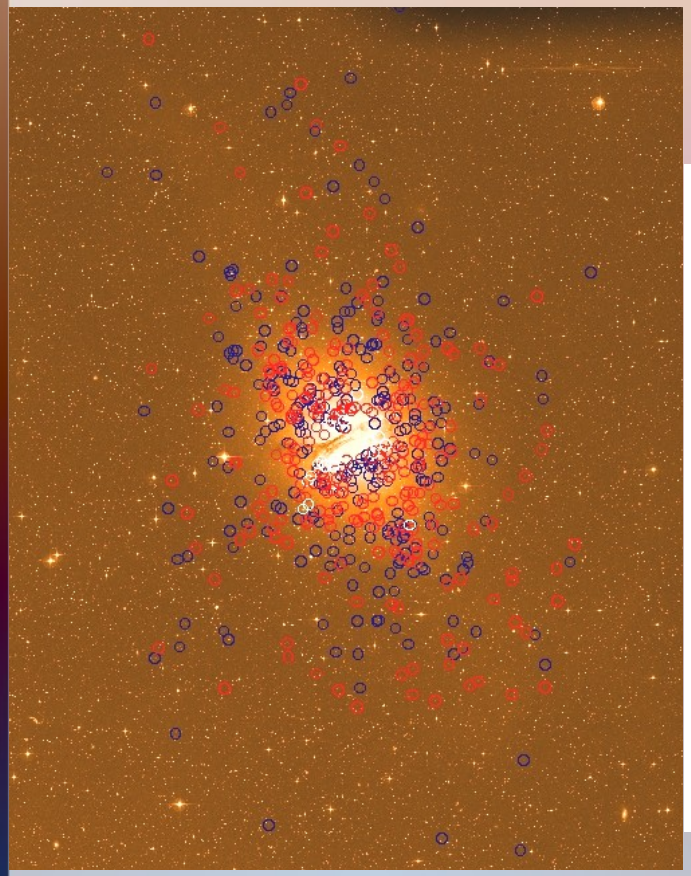
Peng et al. 2002, AJ, 124, 3144

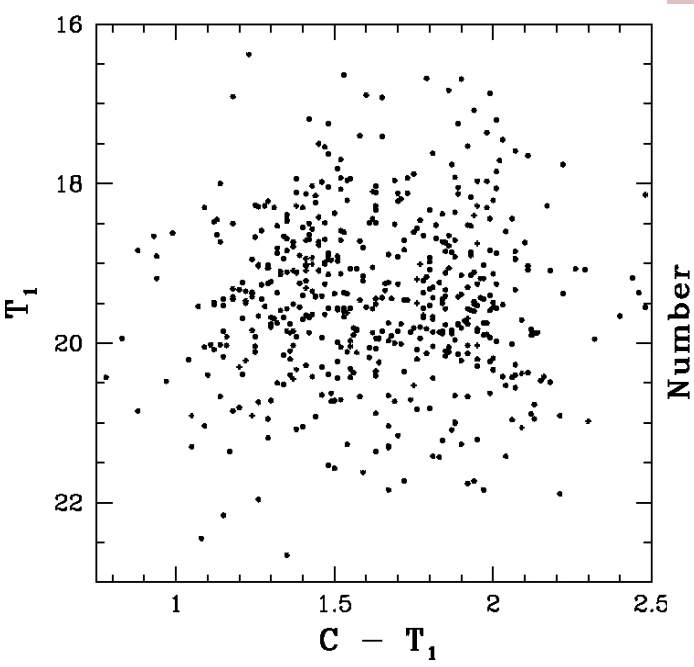


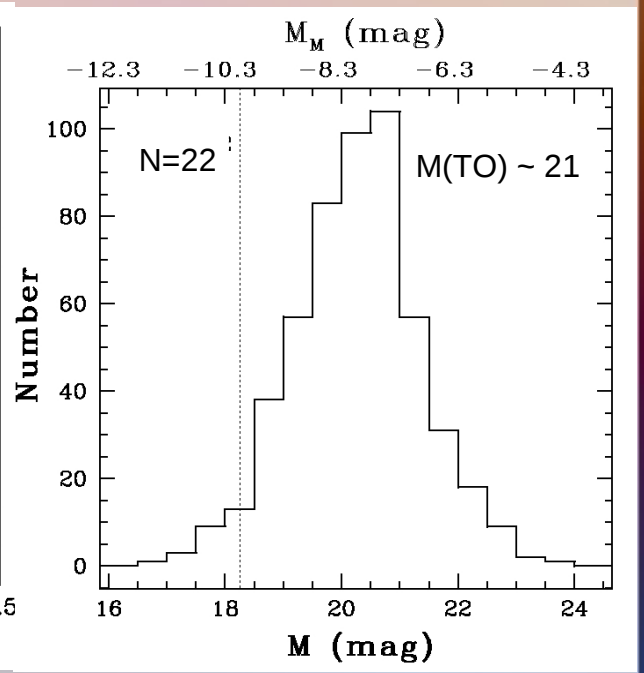
The Globular Cluster System (GCS)

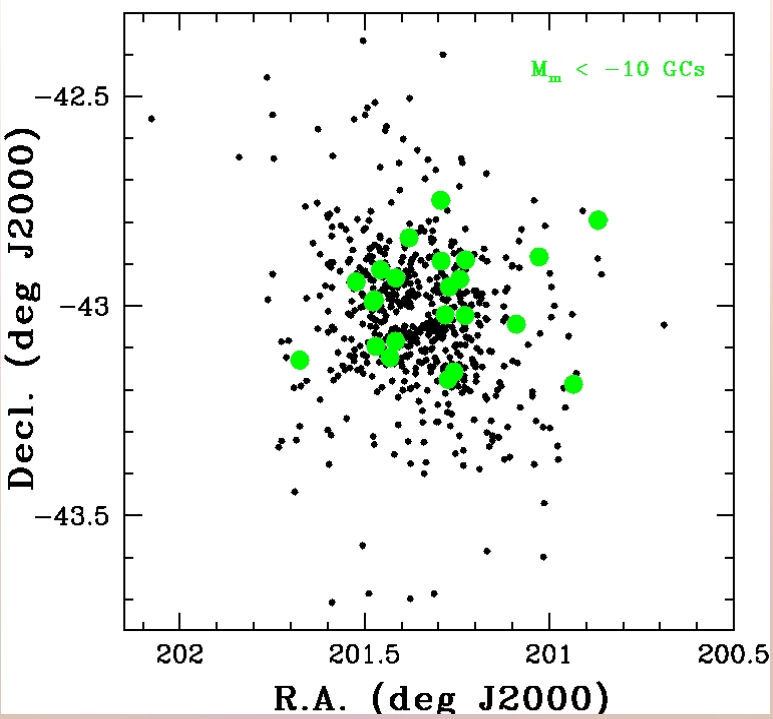
- Estimated number of GCs =1300 ± 300 (Harris G. 2010, PASA, 27, 475)
- 607 GCs (Peng et al. 2004, ApJS, 150, 367, Woodley et al. 2007, AJ,134, 494, Beasley et al. 2008,MNRAS, 386, 1443, Woodley et al. 2010, ApJ, 708, 1335, Woodley et al. 2010, AJ, 139, 1871)

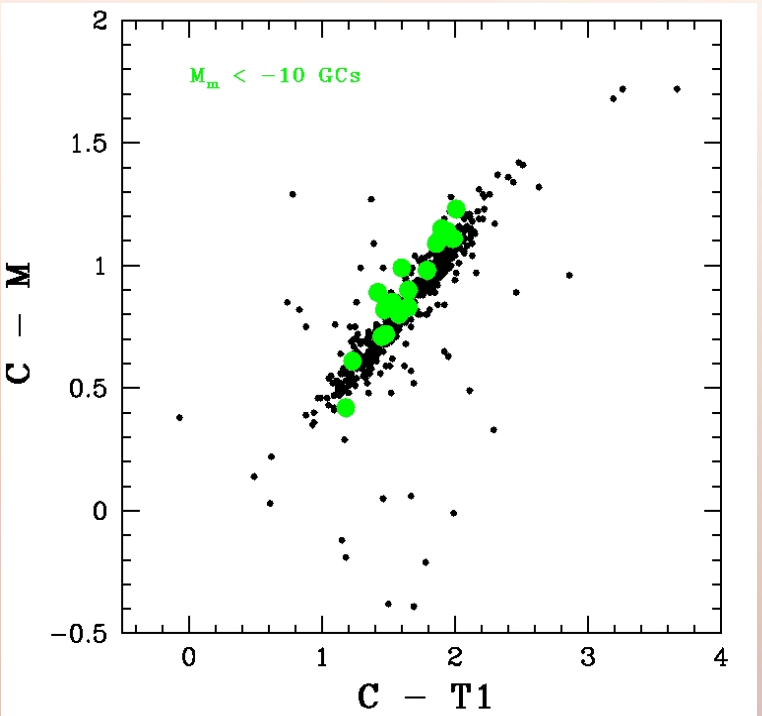




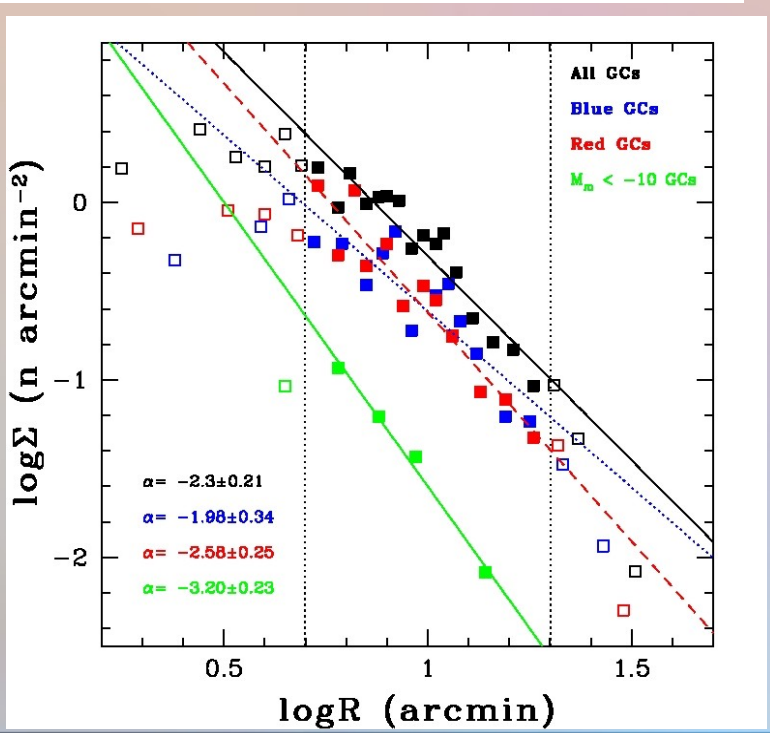






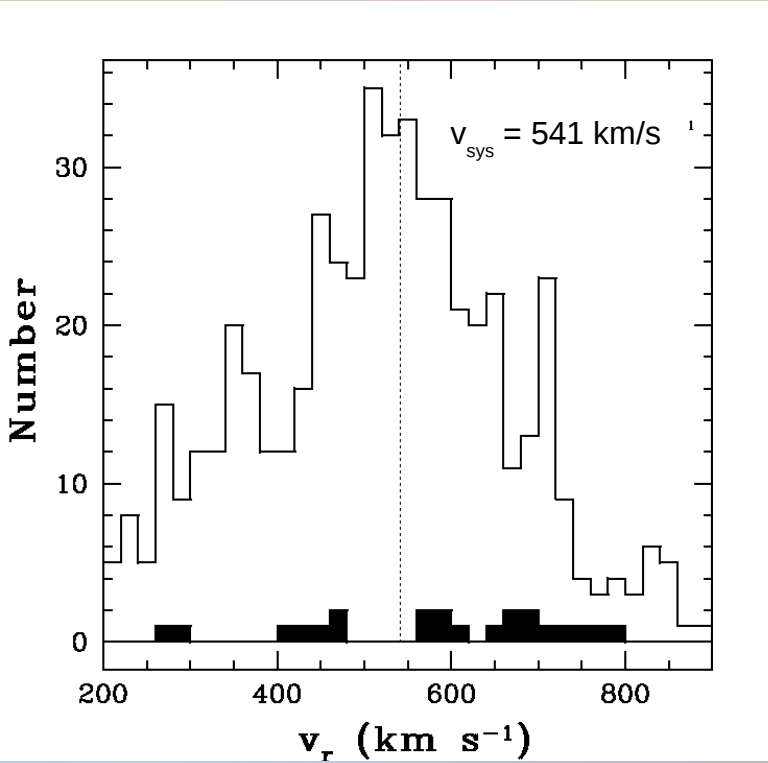


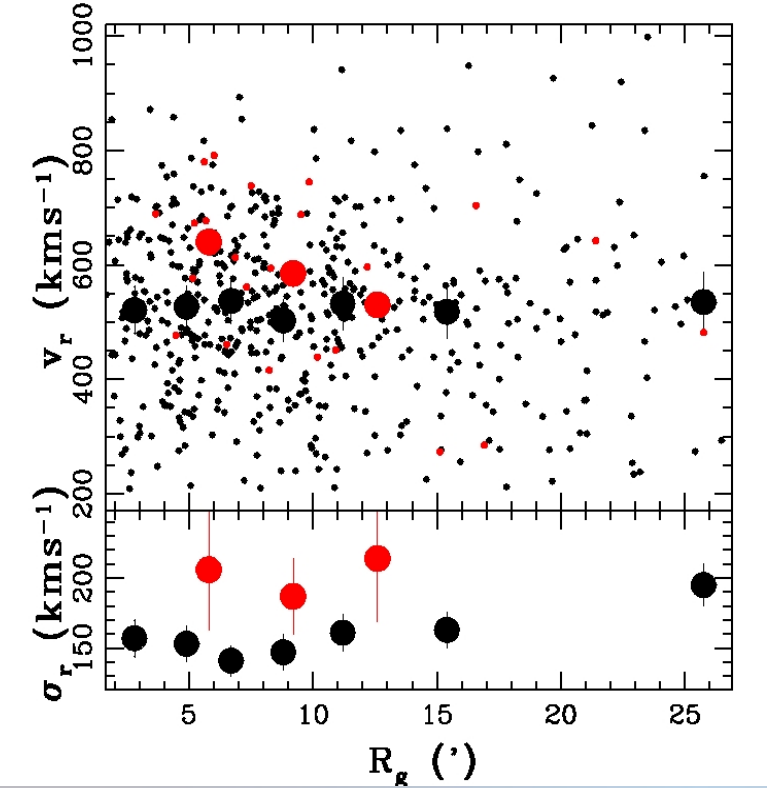
- Bright GCs share the photometric and general spatial properties of the “normal” GC population



Kinematic Signatures

Sample	Systemic Velocity	Rotation Amplitude	Rotation Axis	Velocity Dispersion	Sample Size w/ Velocities
	v_{sys} (km/s)	ΩR (km/s)	Θ_o (° E of N)	σ_p (km/s)	N
GCs M_m < -10	575 ± 33	57 ± 46	234 ± 47	187 ± 27	22 (R < 22')
GCs M_m > -10	520 ± 7	29 ± 10	174 ± 18	148 ± 5	478 (R < 22')

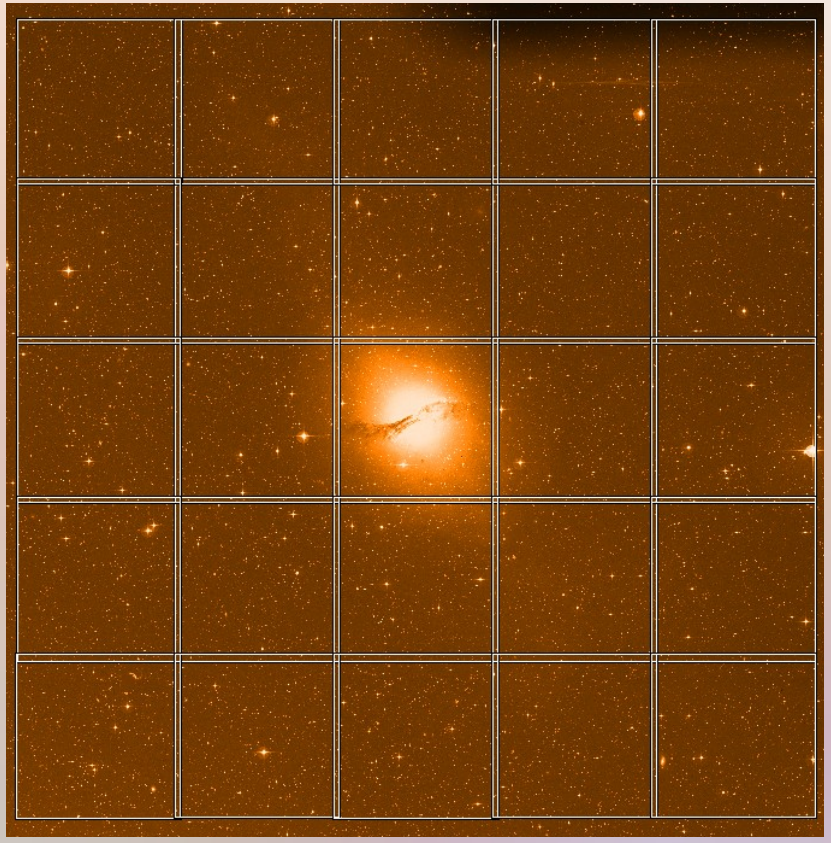


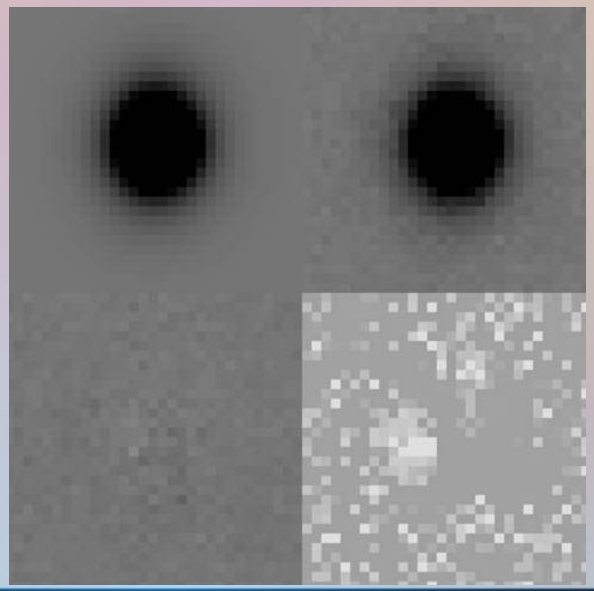


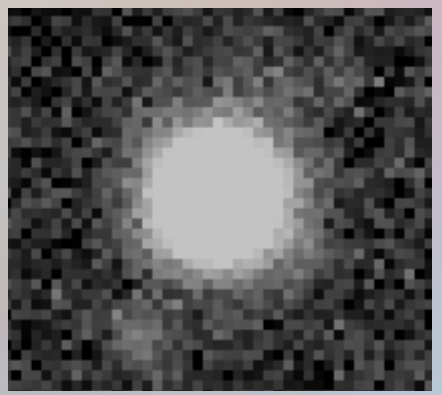
Structural Parameters

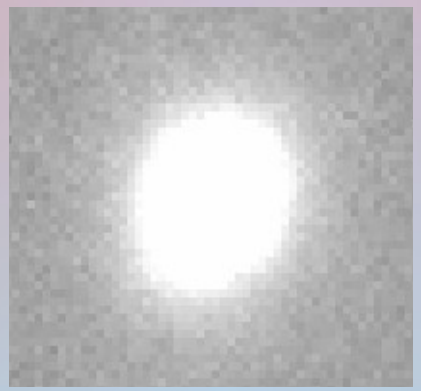
- Obtained 1.2 by 1.2 deg^2 IMACS/Magellan images in B and R (<0.5" seeing)

- ISHAPE
  (Larsen 1999, A&AS,139, 393, Larsen et al. 2001, AJ, 121, 2974)

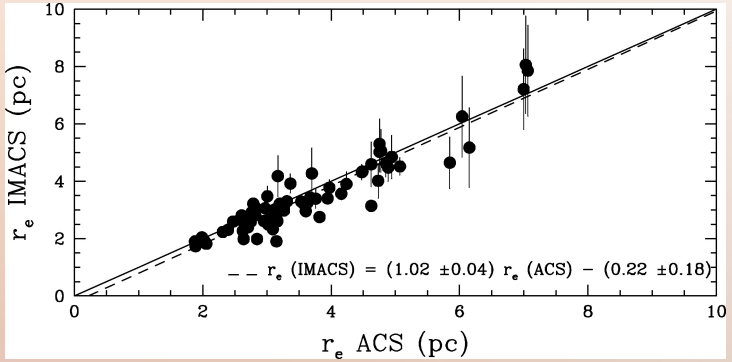




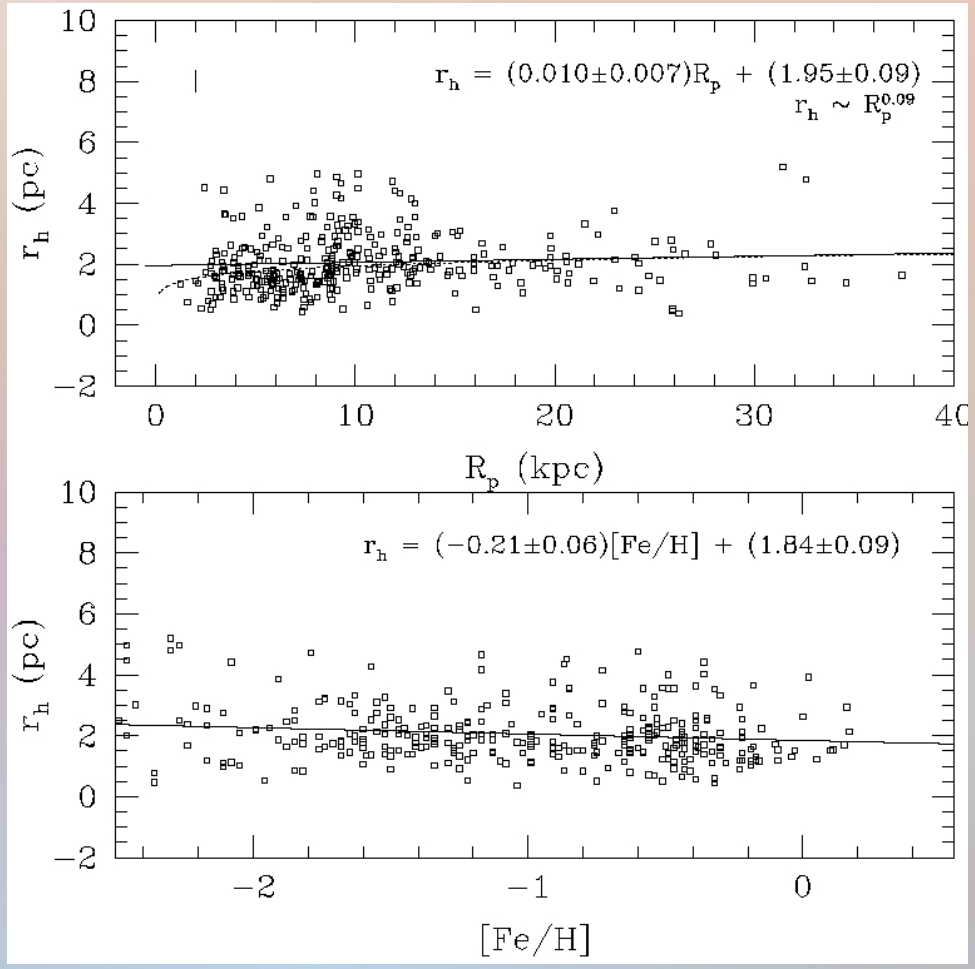


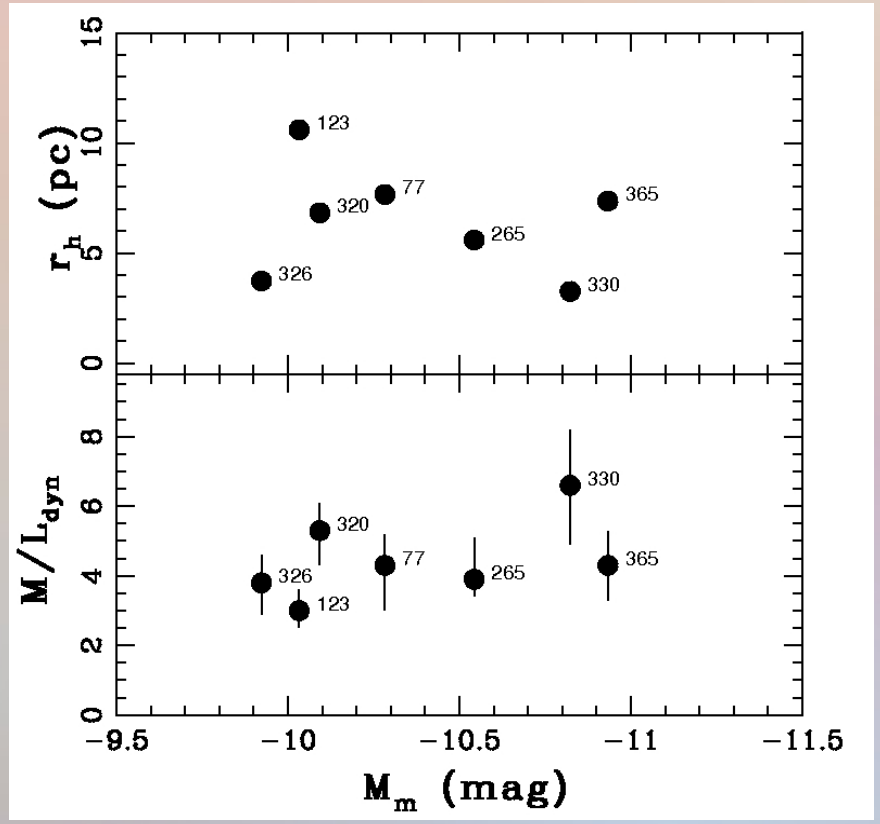


- Normal GC population: N = 337 GCs (159 blue and 106 red)
- Half-light radii with galactocentric radius: $r_h \sim R_{gc}^{0.09}$
- Half-light radii with metallicity:
  red: $r_h = 2.47 \pm 0.33$ pc
  blue: $r_h = 2.84 \pm 0.37$ pc



Gómez & Woodley 2007, ApJ, 670, 105





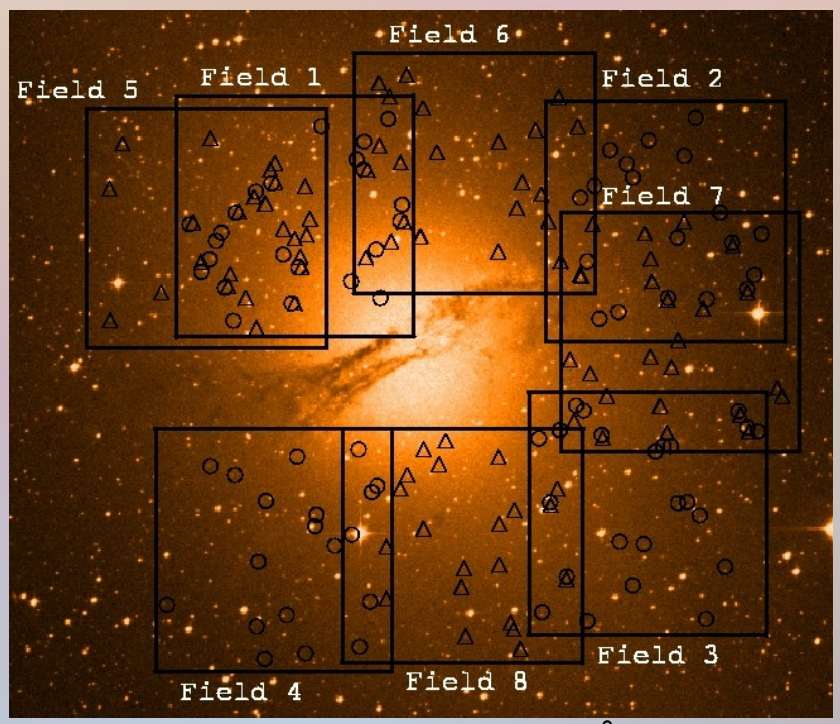
M/L_{dyn} are from Taylor et al. 2010, ApJ, 712, 1191

Harris et al. 2002, AJ, 124, 1435

Ages, Metallicities, and [α/Fe]

Gemini-S/GMOS
2005/2007 PI: Harris W./ Geisler coIs: Woodley, Harris G., Gómez
(Woodley et al. 2010, ApJ, 708, 1335)

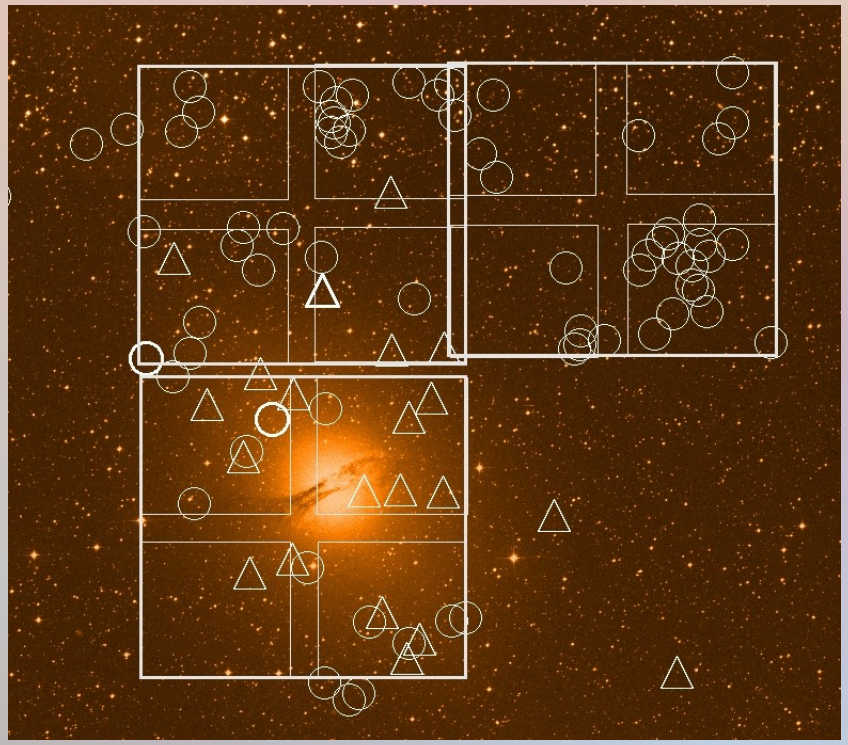
8 Fields - each field is 5.5 arcmin^2



- Wavelength: 3800 – 5800 Å

VLT/VIMOS
2009 PI: Woodley coIs: Hilker, Puzia, Gómez, Rejkuba

3 Fields with 4 quadrants - each quadrant is 7 x 8 arcmin



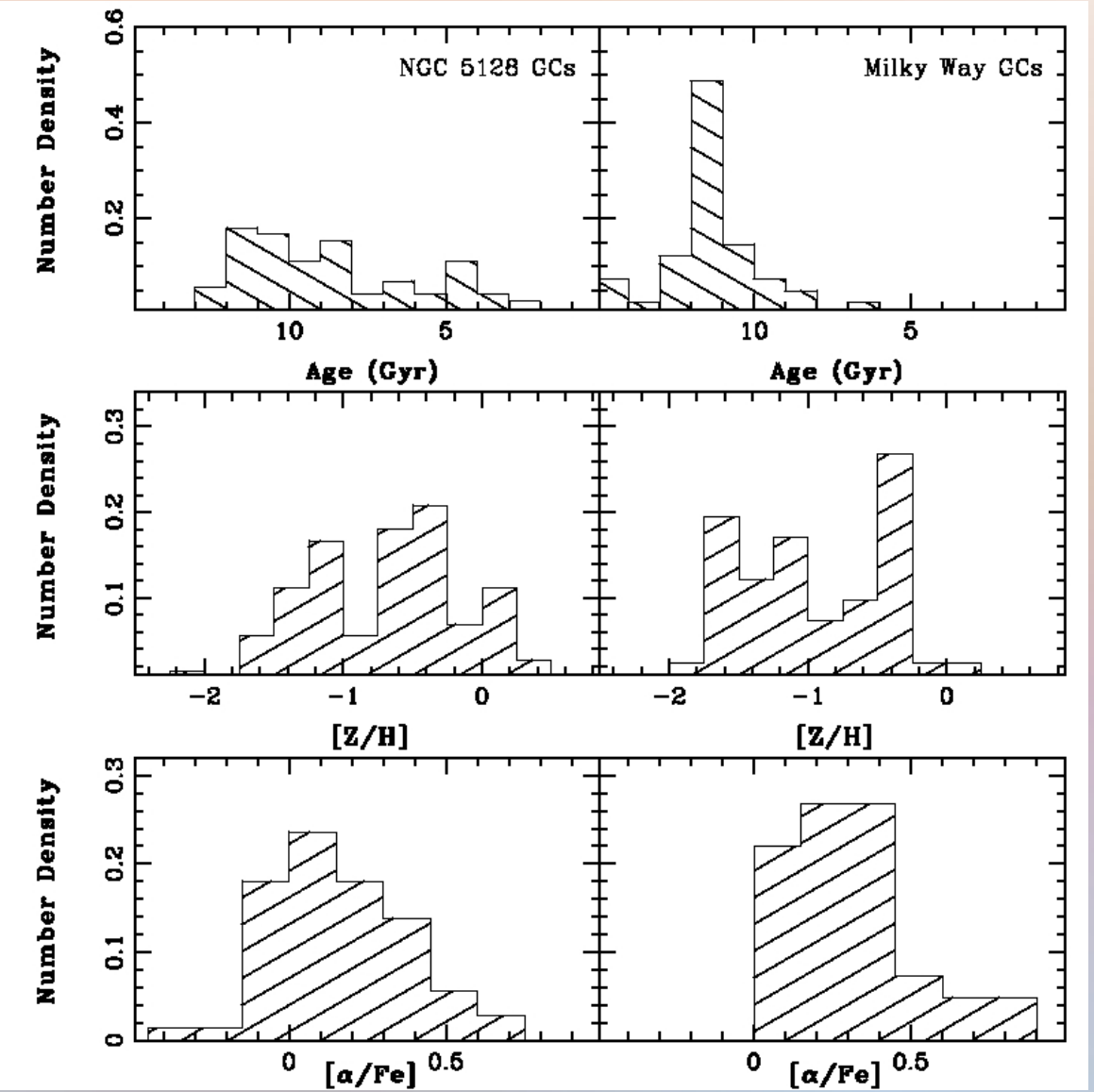
- S/N > 30 Indices: $H\delta_A$ – Fe5709

Distribution functions

- Measure indices with GONZO
  (Puzia et al. 2002, A&A, 395,45
  Puzia et al. 2005 A&A, 439, 997)
- Simple Stellar Population (SSP) Models (Thomas et al. 2003, 2004)

- Low internal consistent uncertainties: $\Delta t/t \sim 0.3$, $\Delta Z \sim 0.15$ dex, $\Delta[\alpha/Fe] \sim 0.1$ dex
- Ages: 68% old (> 8 Gyr), 14% intermediate (5-8 Gyr), 18% young (< 5 Gyr)
- Metallicities: 92% of blue, 68% of red GCs are old
- $\langle[\alpha/Fe]\rangle = 0.14 \pm 0.04$

Milky Way spectra: Puzia et al. 2002, Schiavon et al. 2005



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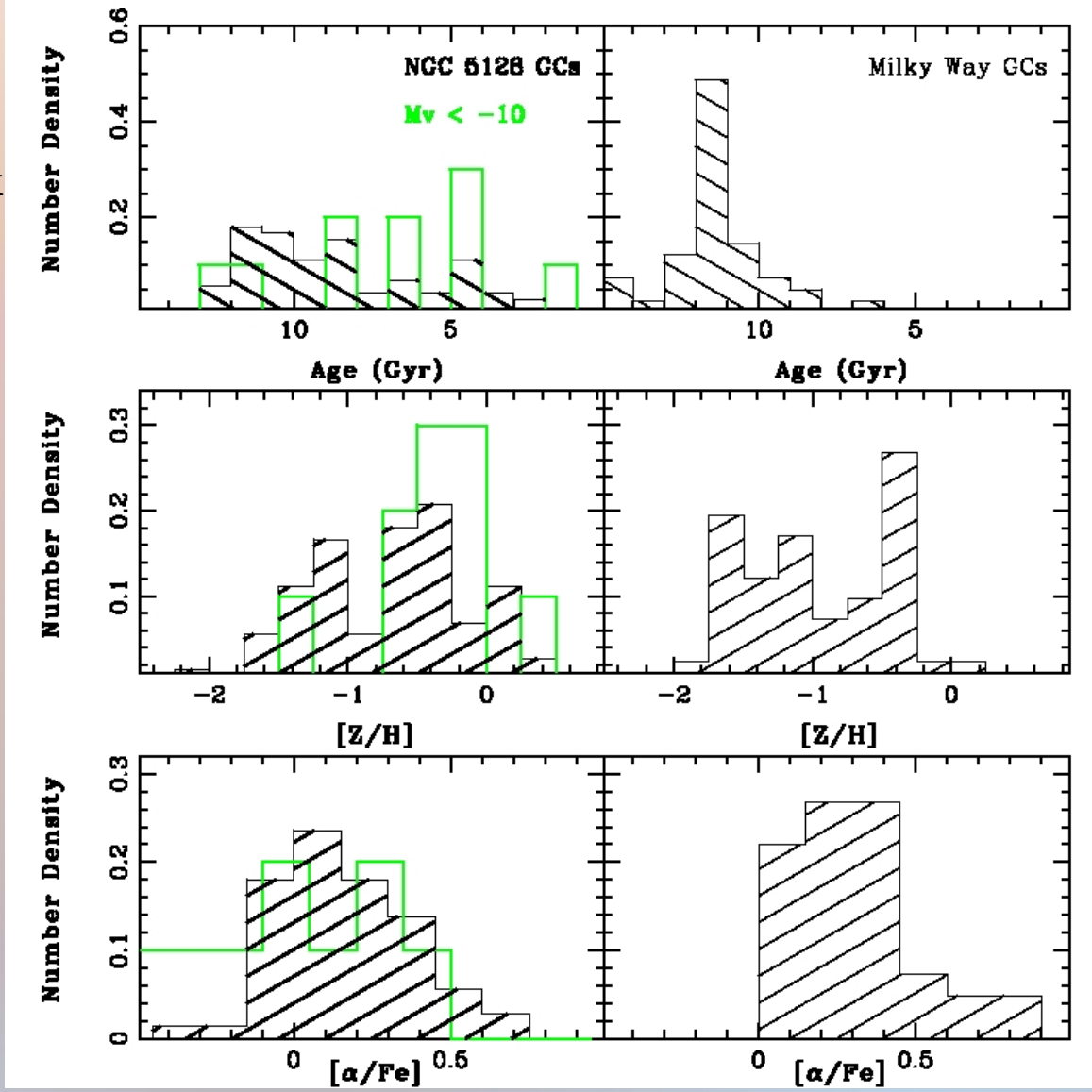
- $<[\alpha/Fe]> = 0.14 \pm 0.04$

Properties of Brightest clusters:

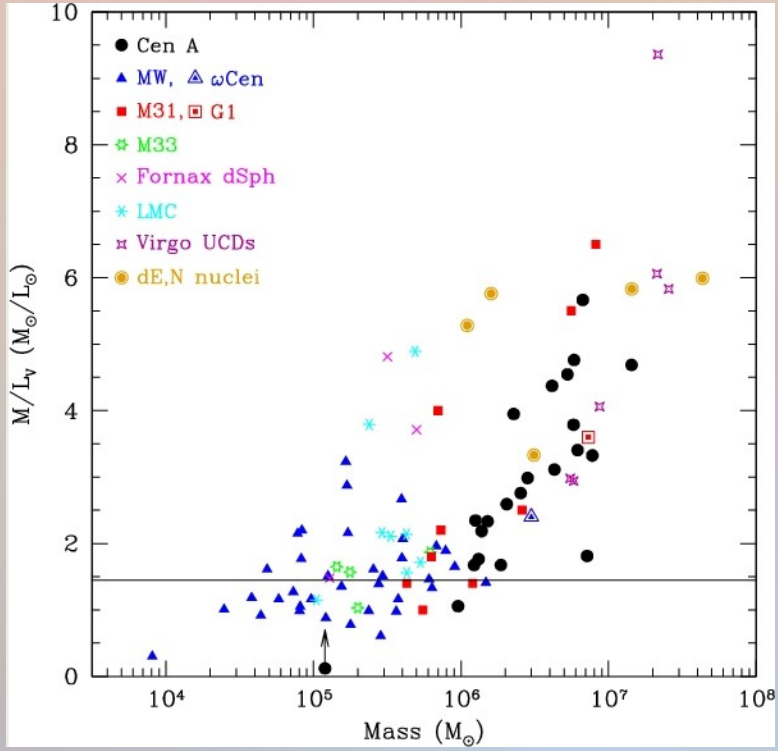
- Ages: 40% old (> 8 Gyr), 30% intermediate (5-8 Gyr), 30% young (< 5 Gyr)



Results and Further Work

GC	M_m	M/L_{dyn} (± 0.9)	r_h (pc) (± 0.1)	Age	[Z/H]	[α/Fe]	v_r (km/s)
GC0077	-10.3	4.3	7.7	12.3	-0.12	0.4	791 ± 1
GC0265	-10.5	3.9	5.6	8.6	-0.61	0.08	780 ± 1
GC0365	-10.9	4.3	7.4	4.6	-0.32	0.01	594 ± 1

- General properties of brightest GCs in NGC 5128 are consistent with the global properties of the GCS
  – consistent with bright end of the GCLF
- Work in progress:
- FLAMES/UVES: 130 GC spectra to measure central velocity dispersions
  - mass and M/L of GCs over the transition region ~ 10^6 $M_\odot$



Rejkuba et al. 2007, A&A, 469, 147

- Lick Index system (Burstein et al. 2004, Worthey et al. 2004, Worthey & Ottaviani 1997, Trager et al. 1998)

- Measure indices with GONZO (Puzia et al. 2002, A&A, 395,45 Puzia et al. 2005 A&A, 439, 997)

- Simple Stellar Population (SSP) Models:

  Thomas, Maraston, & Bender, 2003

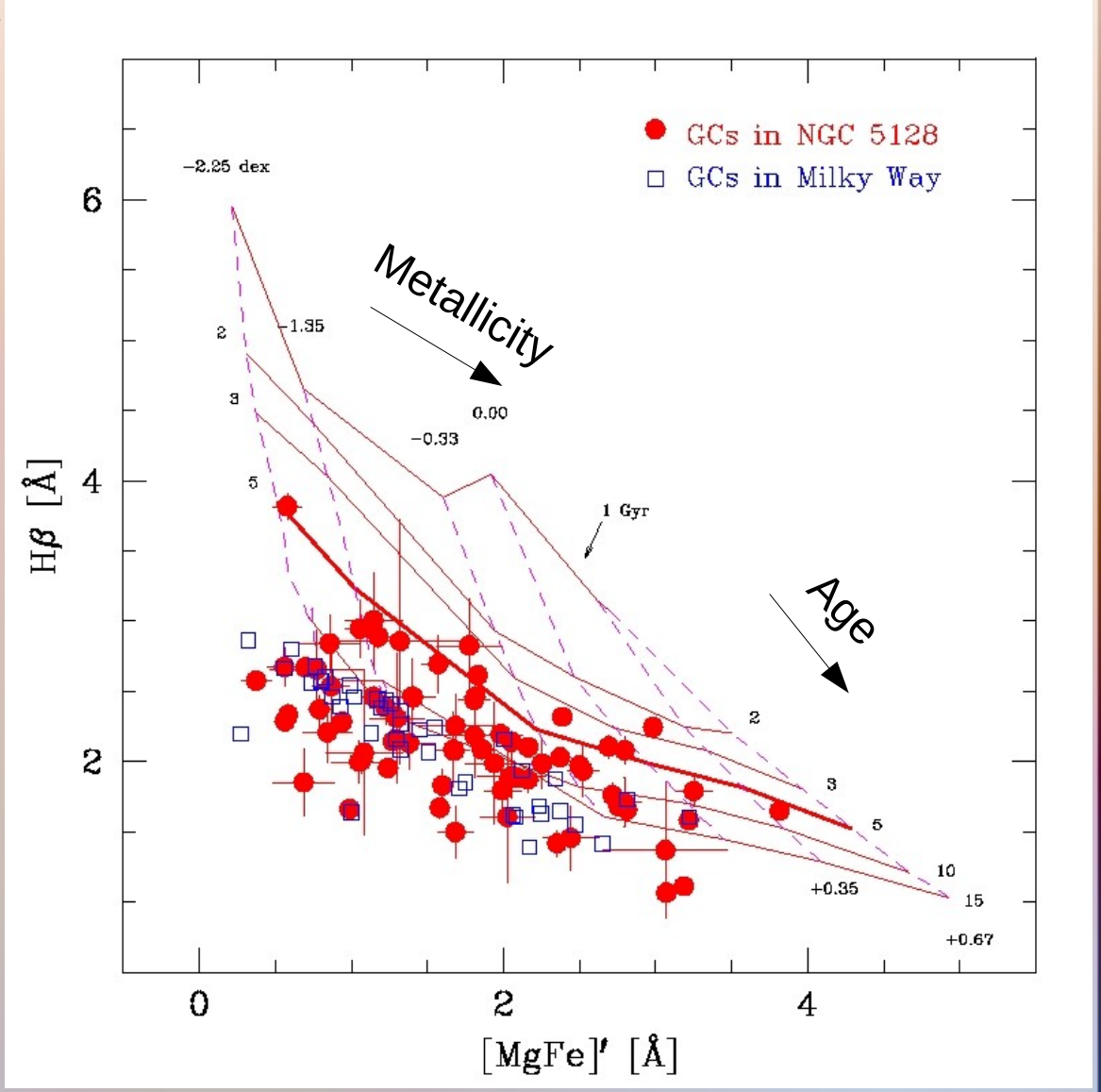
  Thomas, Maraston, & Korn, 2004

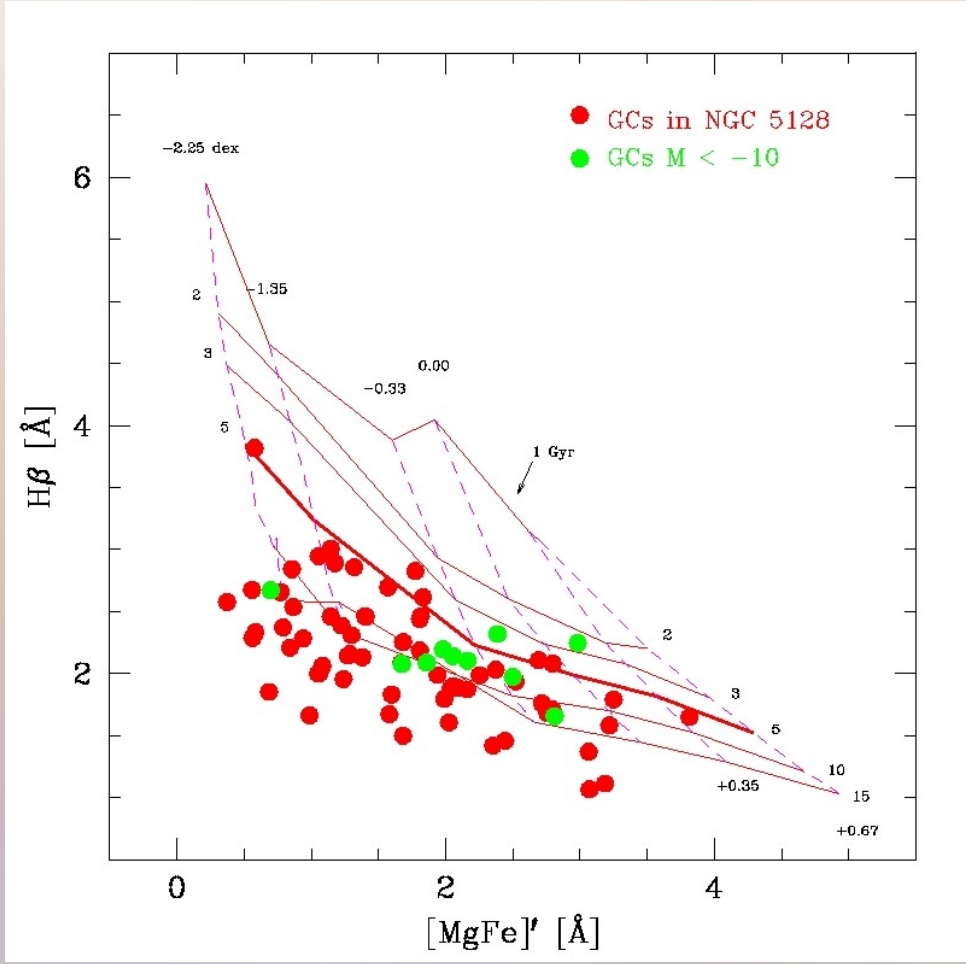
[Z/H]: -2.25, -1.35, -0.33, 0, 0.35, 0.67

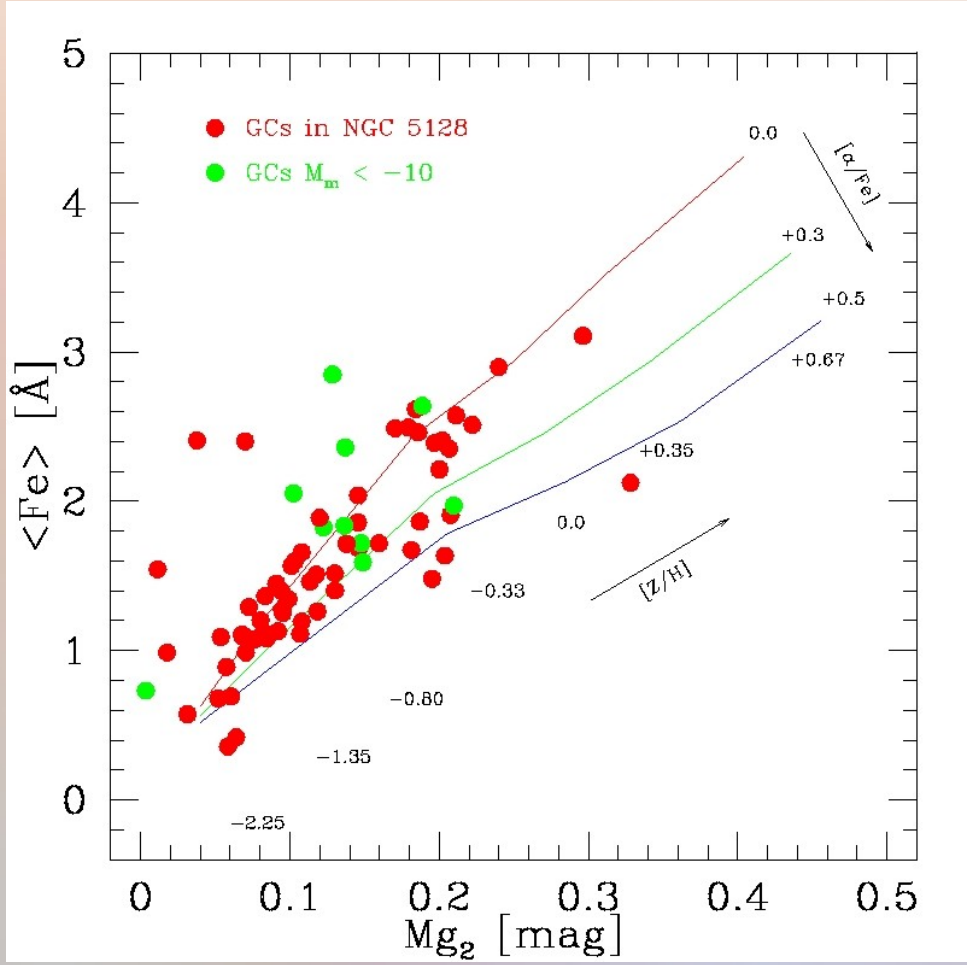
Ages: 1 – 15 Gyr

[α/Fe]: 0, 0.3, 0.5

Milky Way spectra: Puzia et al. 2002, Schiavon et al. 2005




GCs in NGC 5128
GCs M < −10
−2.25 dex
−1.35
0.00
−0.33
1 Gyr
2
3
5
10
15
+0.35
+0.67
Hβ [Å]
[MgFe]′ [Å]


GCs in NGC 5128
GCs M_m < −10
0.0
+0.3
+0.5
+0.67
+0.35
0.0
−0.33
−0.80
−1.35
−2.25
[α/Fe]
[Z/H]
<Fe> [Å]
Mg2 [mag]