

Invited speakers include:

- Jay Anderson
- Patrick Cox
- Pierre-Alain Duc
- Bruce Elmegreen
- Maria Geth
- Gelad Gilmore
- Andres Jordán
- Andreas Kroupa
- Pavel Kroupa
- Søren Larsen
- Tom Richer
- Riccardo Scarpa
- Matthew Walker

**Dynamics of Low-Mass Stellar Systems**  
- From Star Clusters to Dwarf Galaxies -

ESO workshop, Santiago, April 4-8, 2011  
<http://www.eso.org/sci/meetings/dynamics2011/index.html>

SOC:

- Holger Baumgardt
- Giovanni Carraro
- Michael Fellhauer
- Mark Geisler (co-chair)
- George Hsu
- Michael Hilker
- Helmut Jansen
- Steffen Miecke (co-chair)
- Yazan Momany
- Leo Sparre
- Michael West
- Mark Wilkinson

dynamics2011@eso.org

“DYNAMICS OF LOW-MASS STELLAR SYSTEMS”, SANTIAGO, CHILE,

4-9 APRIL, 2011

# AGES AND METALLICITIES OF NUCLEAR CLUSTERS IN DWARF GALAXIES

and their relation to massive Galactic GCs

ISKREN GEORGIEV  
(AIFA, BONN)



THOMAS **PUZIA**, MICHAEL **HILKER**, PAUL **GOUDFROOIJ**, HOLGER **BAUMGARDT**

# OUTLINE

THE NOT SO NORMAL GALACTIC GCS

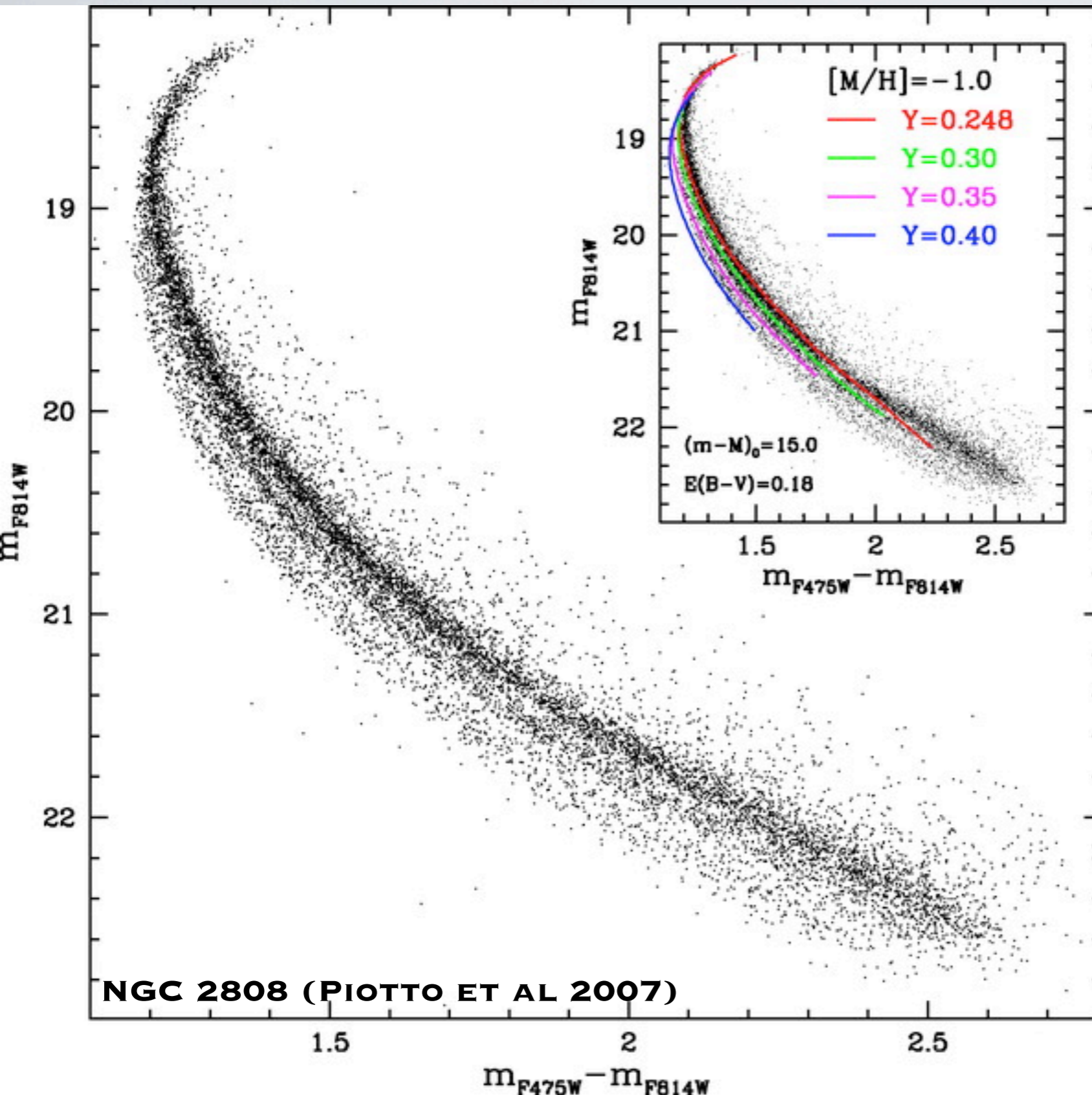
NUCLEAR GCS IN DWARF GALAXIES

BOTH FORMED IN SIMILAR  
ENVIRONMENT?

# THE NOT SO NORMAL GALACTIC GCs

## COMPLEX POPULATIONS

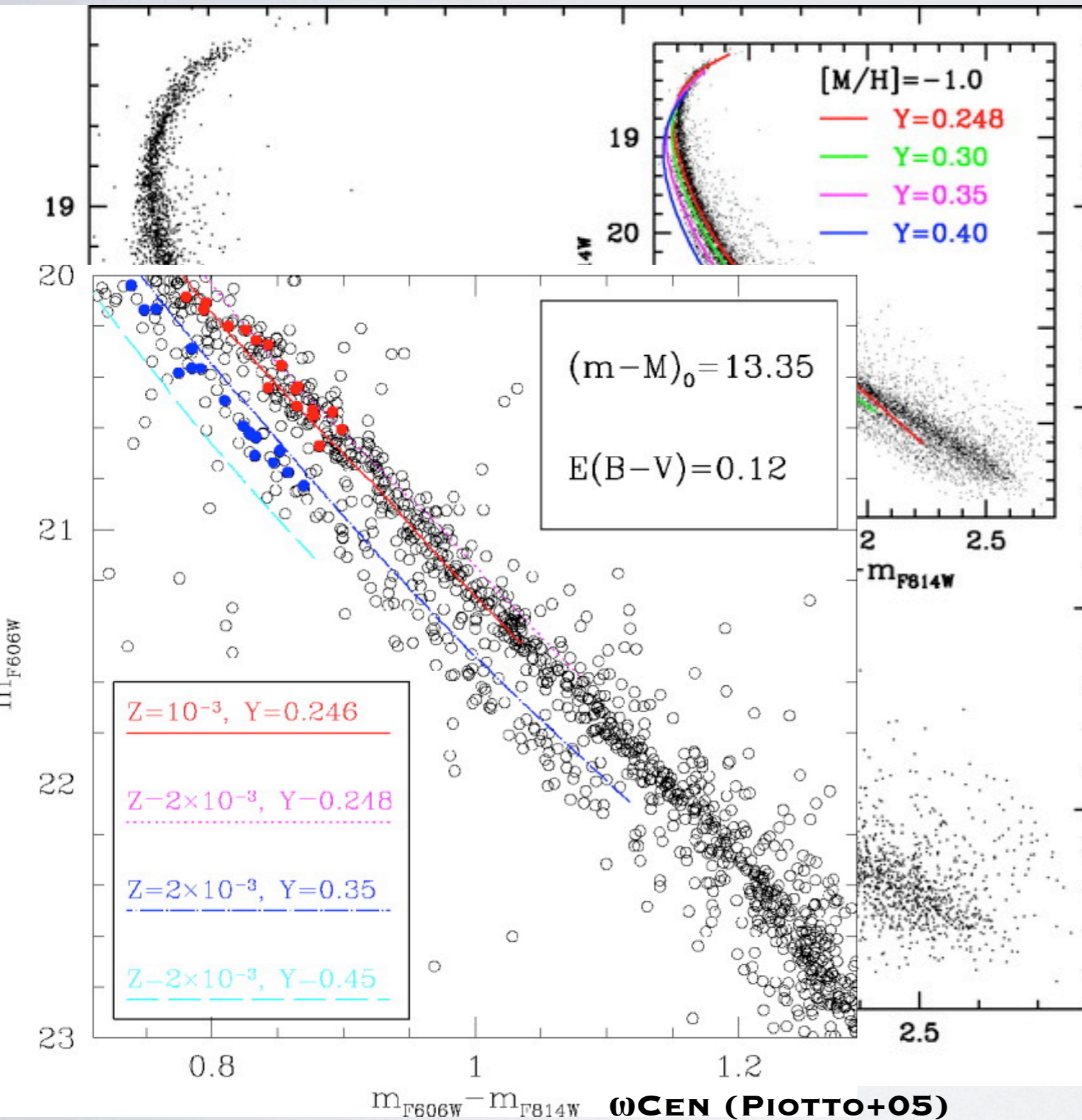
- SPLIT IN MS, RGB, SGB, HB
- LARGE SPREAD IN LIGHT ELEMENTS
- HIGH HELIUM ABUNDANCE
- ONE DOMINANT POPULATION  
(E.G. 75%  $\omega$ CEN, 65% NGC 2808)



# THE NOT SO NORMAL GALACTIC GCs

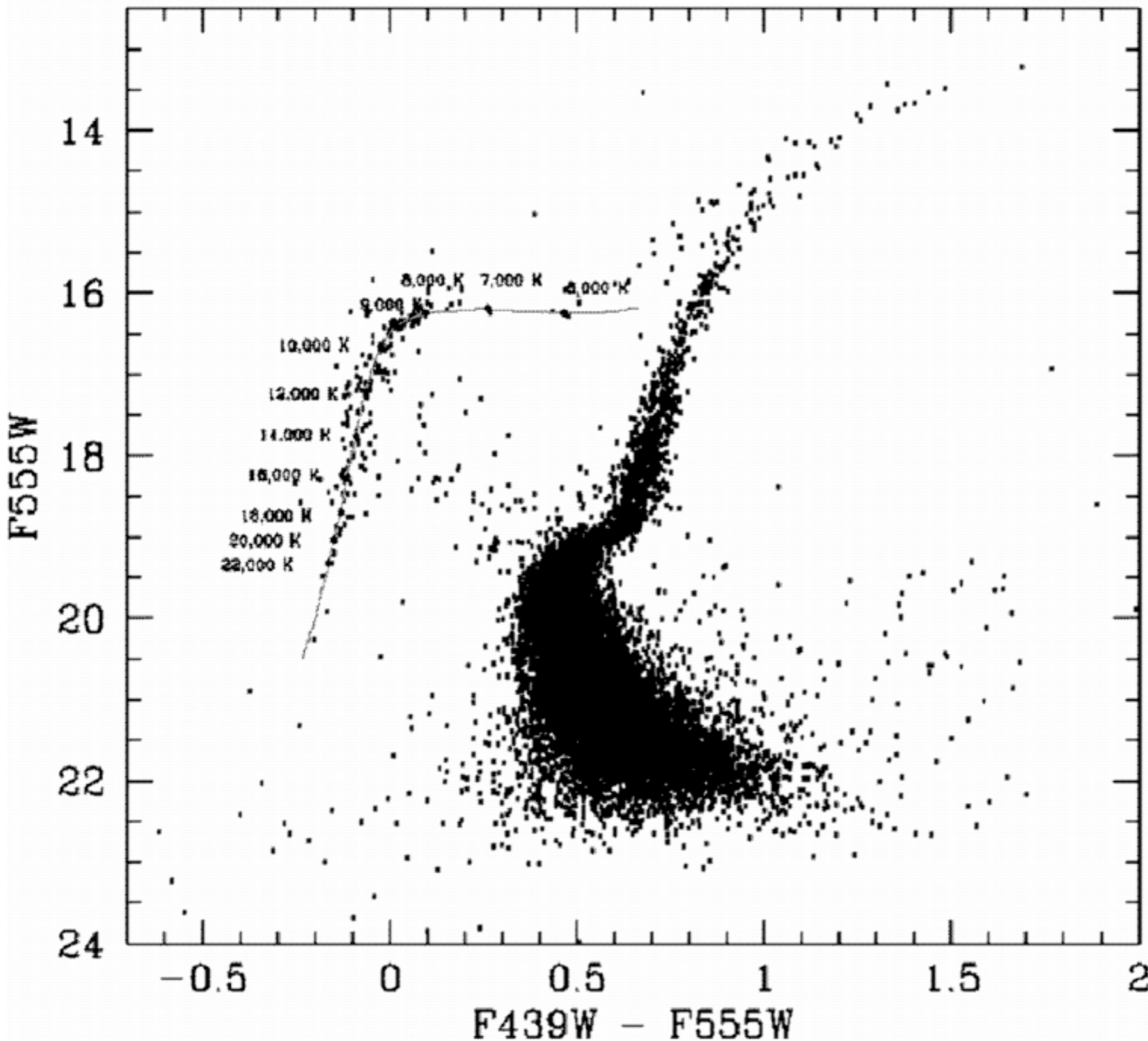
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# THE NOT SO NORMAL GALACTIC GCs

NGC 1904 (RECCIO-BLANCO+06)



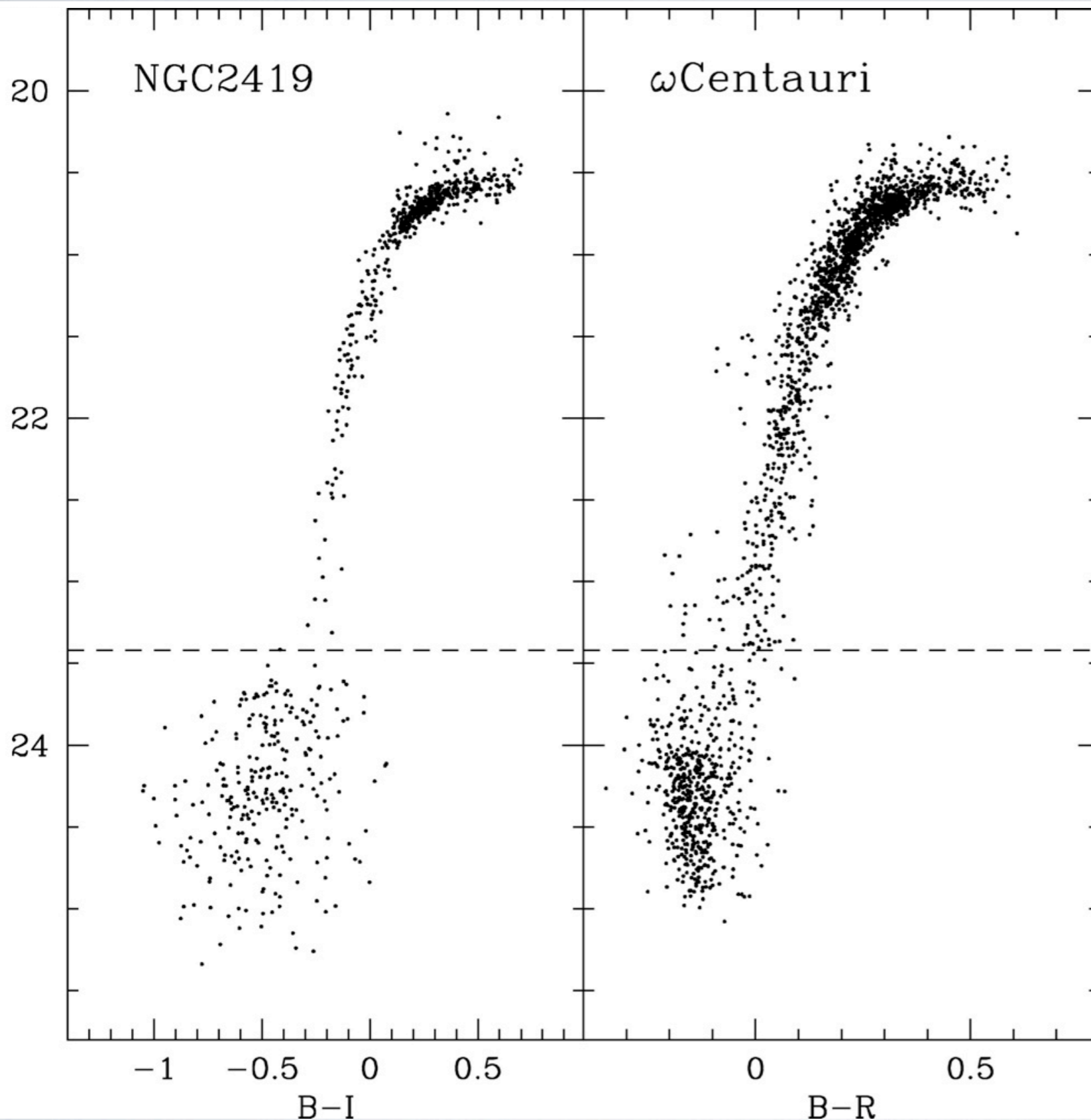
## COMPLEX POPULATIONS

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- HIGH HELIUM ABUNDANCE
- ONE DOMINANT POPULATION  
(E.G. 75%  $\omega$ CEN, 65% NGC 2808)

## HOT HORIZONTAL BRANCH

- HOT HB STARS  $T_{\text{EFF}} > 10^4$  K
- HB MORPHOLOGY STRONG FUNCTION  
OF MASS (E.G. RECCIO-BLANCO'06)

# THE NOT SO NORMAL GALACTIC GCs



DALESSANDRO+08

FERRARO+04

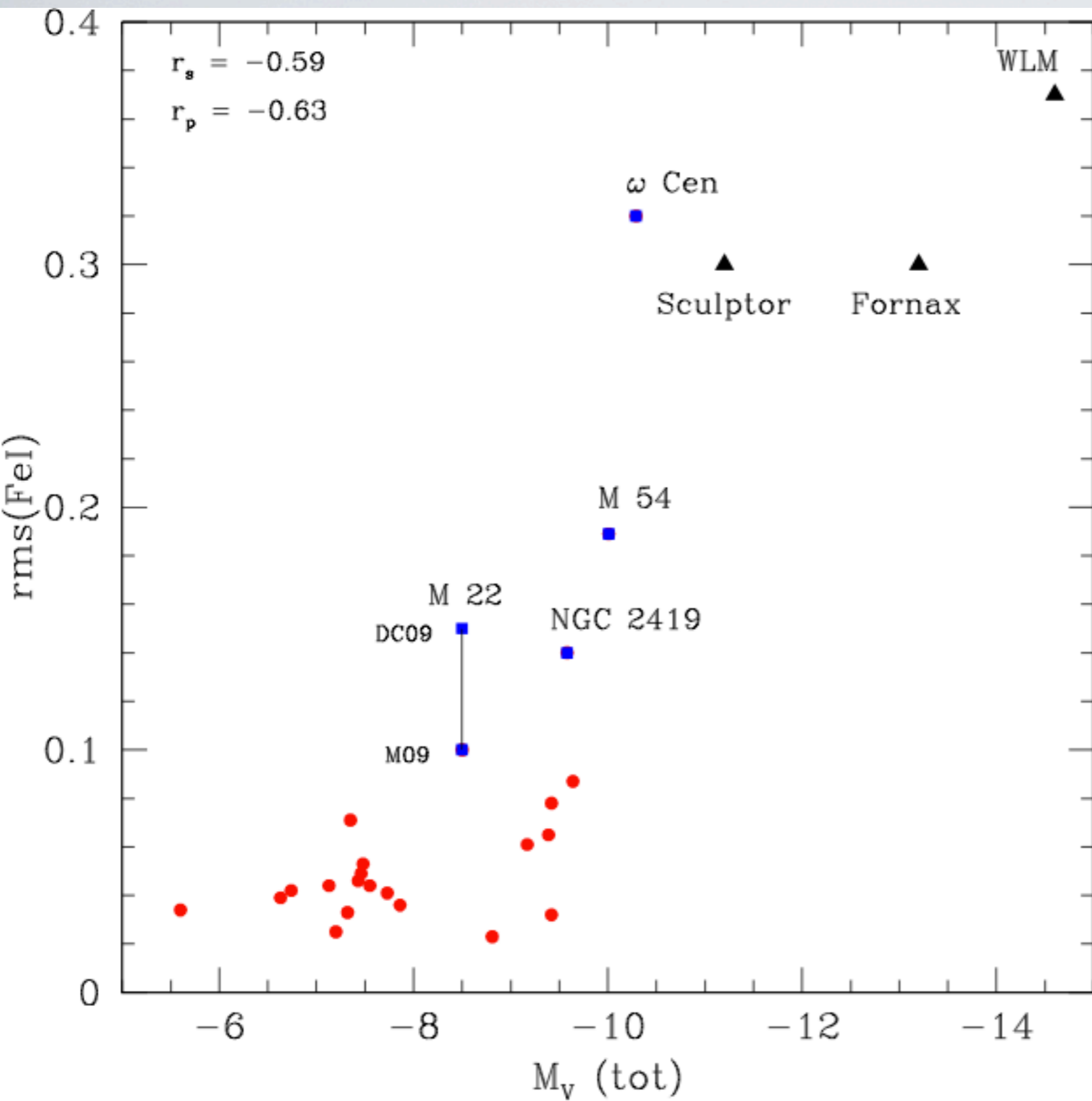
## COMPLEX POPULATIONS

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# THE NOT SO NORMAL GALACTIC GCs



CARRETTA ET AL. (2010)

## COMPLEX POPULATIONS

- SPLIT IN MS, RGB, SGB, HB
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- ONE DOMINANT POPULATION  
(E.G. 75%  $\omega$ CEN, 65% NGC 2808)

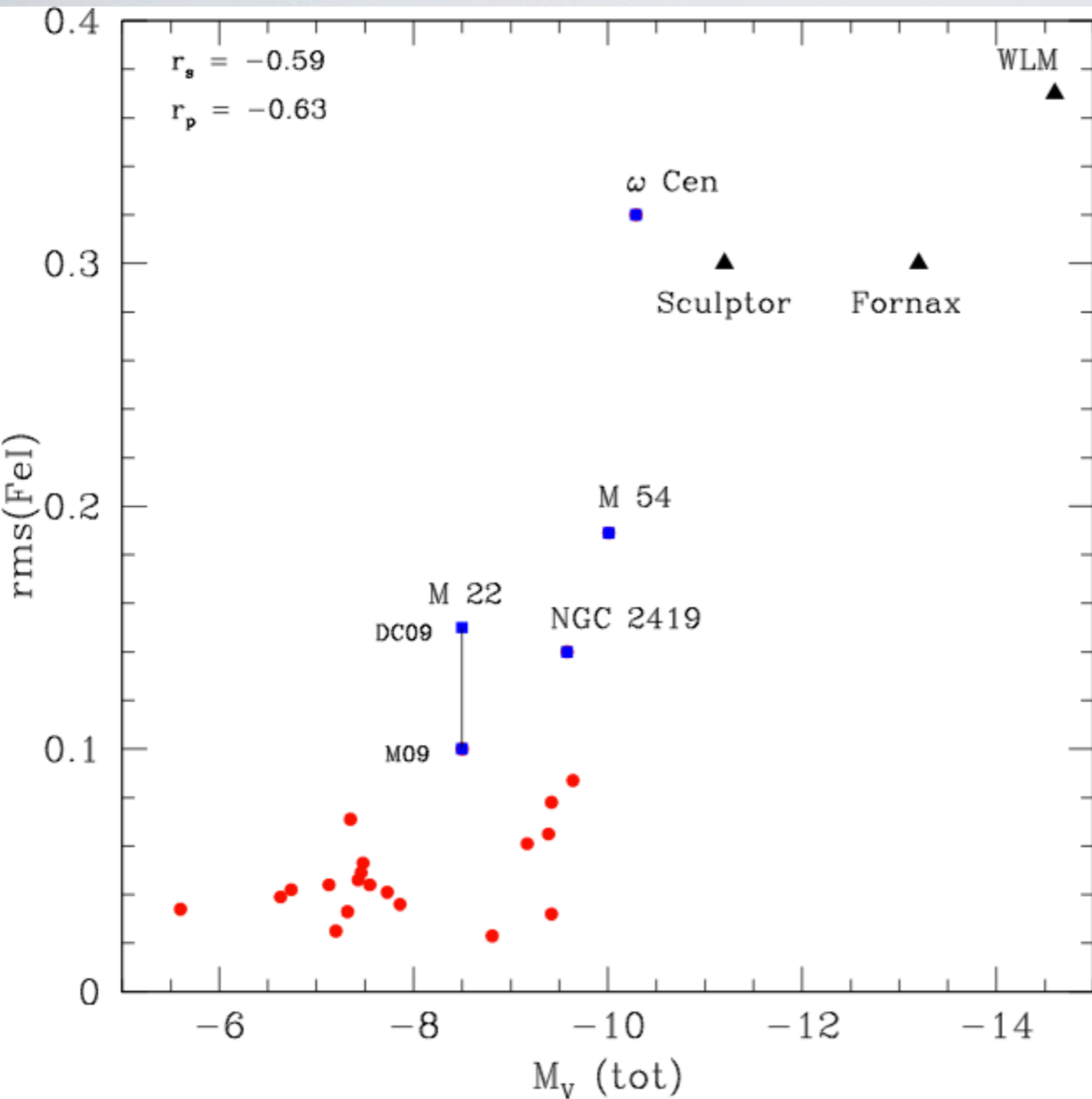
## HOT HORIZONTAL BRANCH

- HOT HB STARS  $T_{\text{EFF}} > 10^4$  K
- HB MORPHOLOGY STRONG FUNCTION OF MASS (E.G. RECIO-BLANCO'06)

## MASS - METALLICITY

SPREAD IN IRON

# THE NOT SO NORMAL GALACTIC GCs



CARRETTA ET AL. (2010)

## COMPLEX POPULATIONS

- SPLIT IN MS, RGB, SGB, HB
- LARGE SPREAD IN LIGHT ELEMENTS
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- HOT HB STARS  $T_{\text{EFF}} > 10^4$  K
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## MASS - METALLICITY

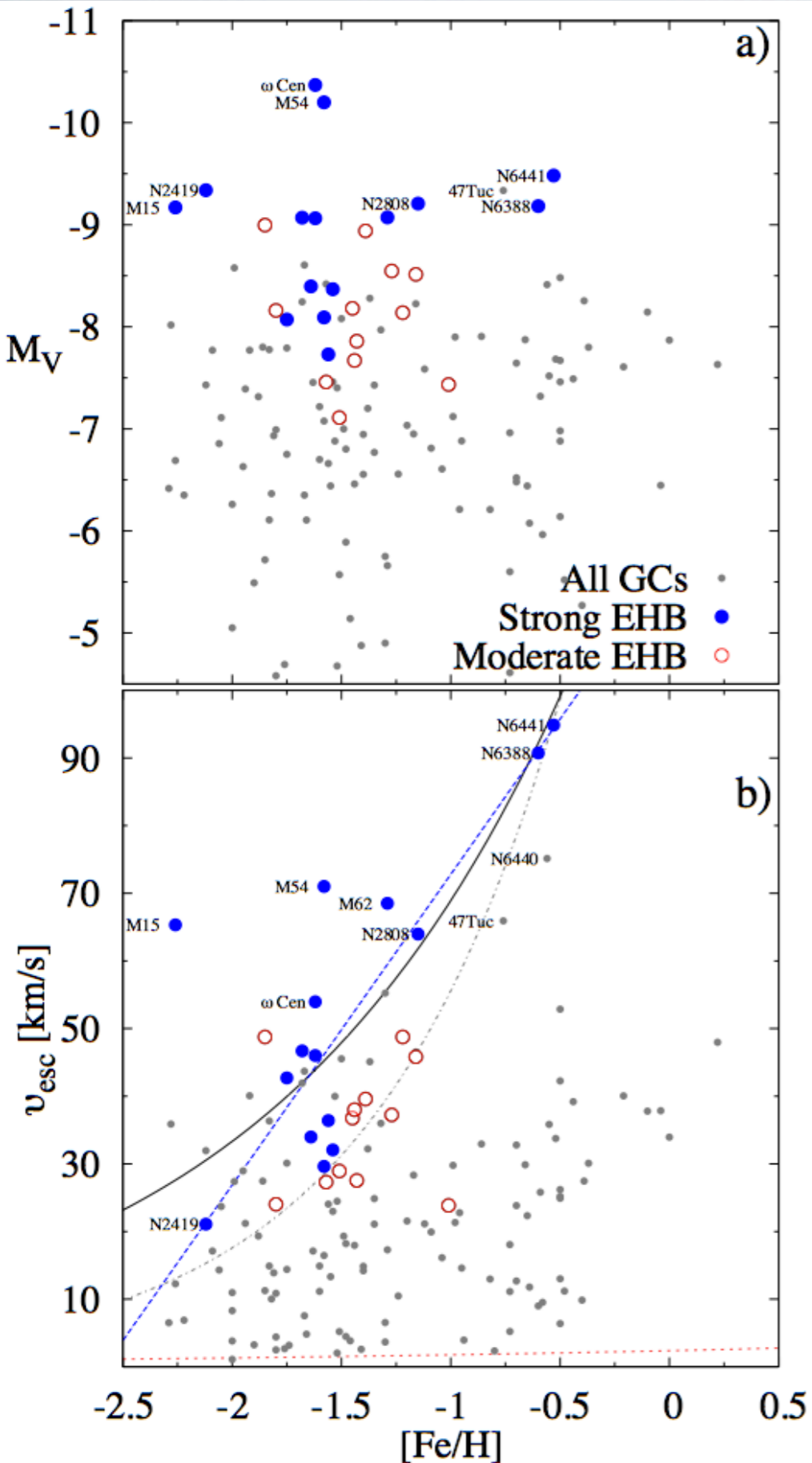
SPREAD IN IRON

## DEEP POTENTIAL

## FORMED AS NUCLEI?



# THE NOT SO NORMAL GALACTIC GCs



## CENTRAL ESCAPE VELOCITY TO TIDAL RADIUS

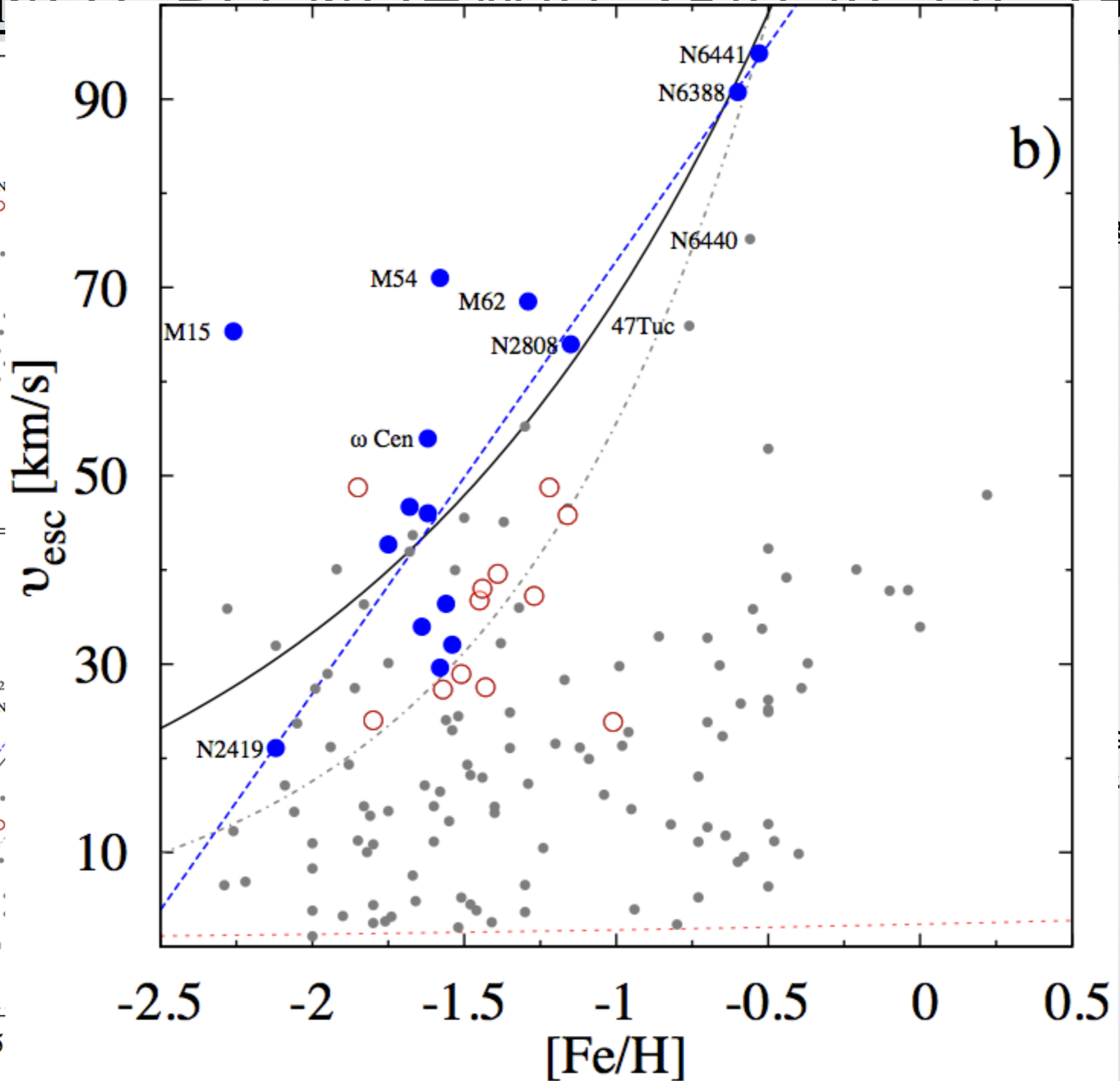
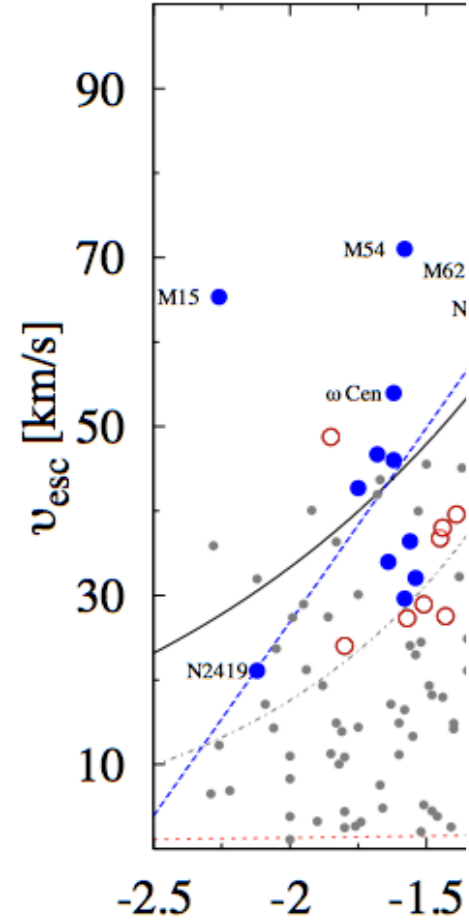
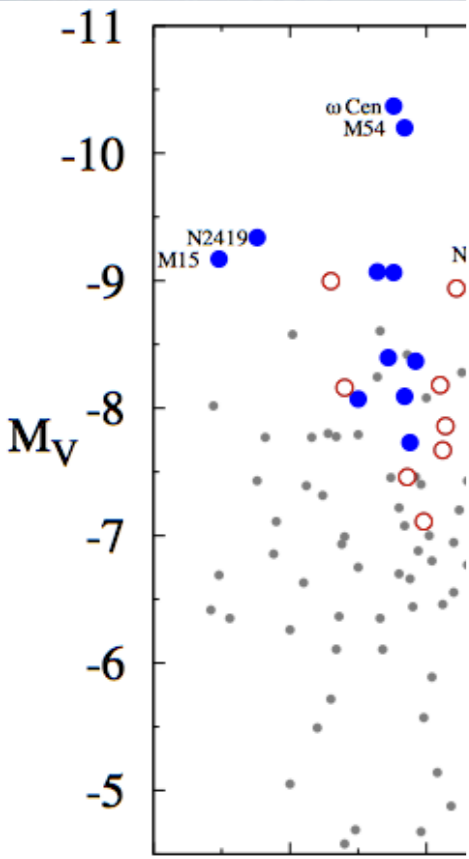
$$v_{\text{esc}} = f_c \sqrt{\frac{M_{\text{cl}}}{r_h}} \quad [\text{km/s}]$$

- **SELF ENRICHMENT** IF  $U_{\text{WIND}} < U_{\text{ESC}}$   
AGB  $\sim 20$  KM/S (D'ANTONA+01,08)  
FAST ROTATORS  $< 100$  KM/S (DECRESSIN+07)

$$U_{\text{WIND}} \sim Z^{0.5} L^{0.25} \quad (\text{MARSHAL+04})$$

- **METAL ENRICHMENT BY RECURRENT GAS ACCRETION** (PFLAMM-ALTENBURG & KROUPA 2009)

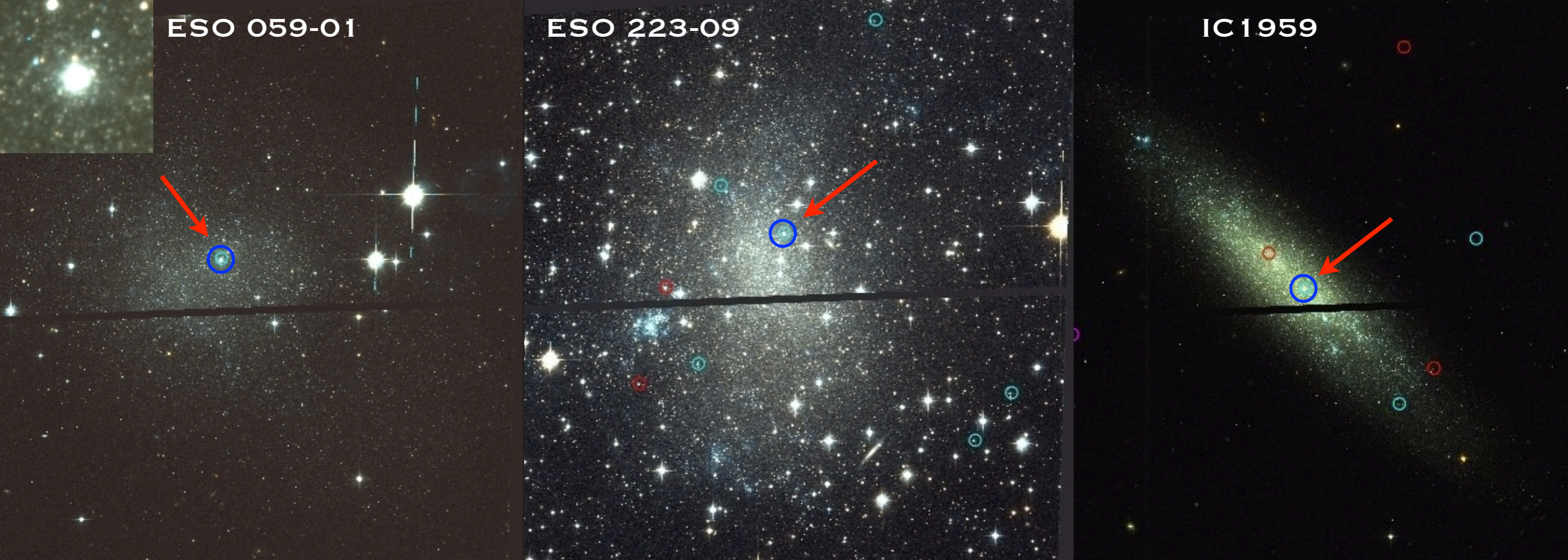
# THE NOT SO NORMAL GALACTIC GCs



RADIUS

GAS  
(2009)

(2009B)

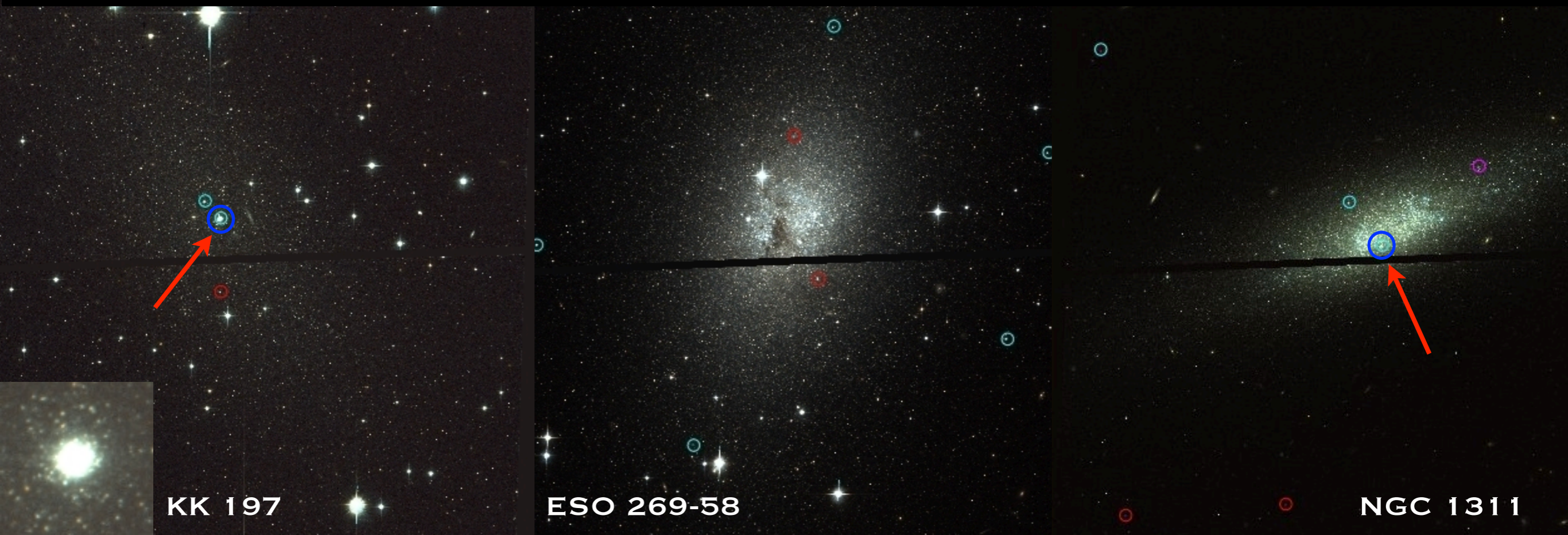


ESO 059-01

ESO 223-09

IC 1959

◆ 68 DWARF GALAXIES WITH  $M_V > -17$  MAG AT  $D = 2 - 10$  MPC (GEORGIEV ET AL. 2008, 2009A)  
 ◆ 7 (10%) “NUCLEATED” DIRRS (GEORGIEV ET AL. 2009B) ◆ HIGH  $S_L$  (GEORGIEV ET AL. 2010)

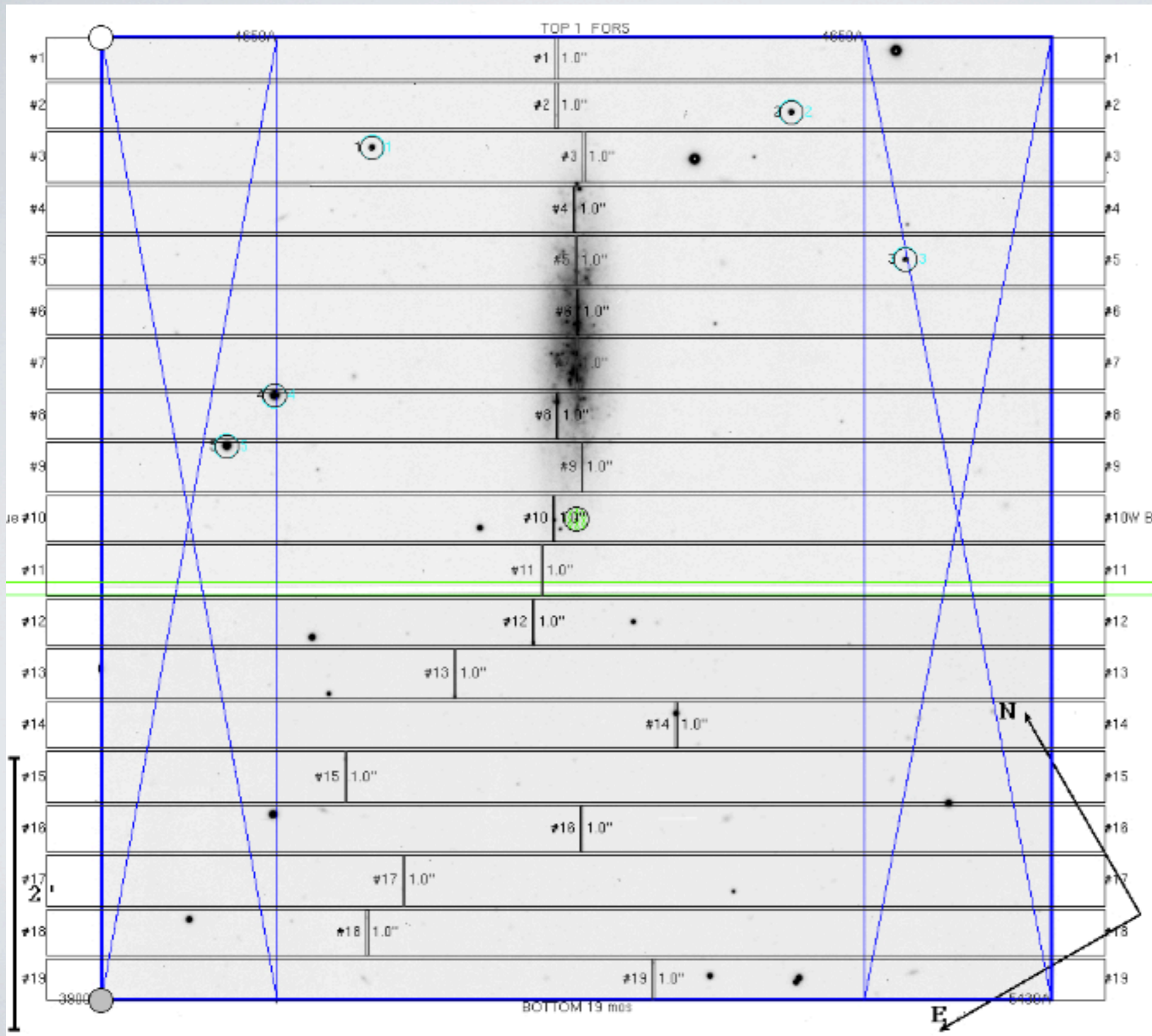


KK 197

ESO 269-58

NGC 1311

# SPECTROSCOPY OF NUCLEAR GCs



VLT/FORS2

GRISM 600B

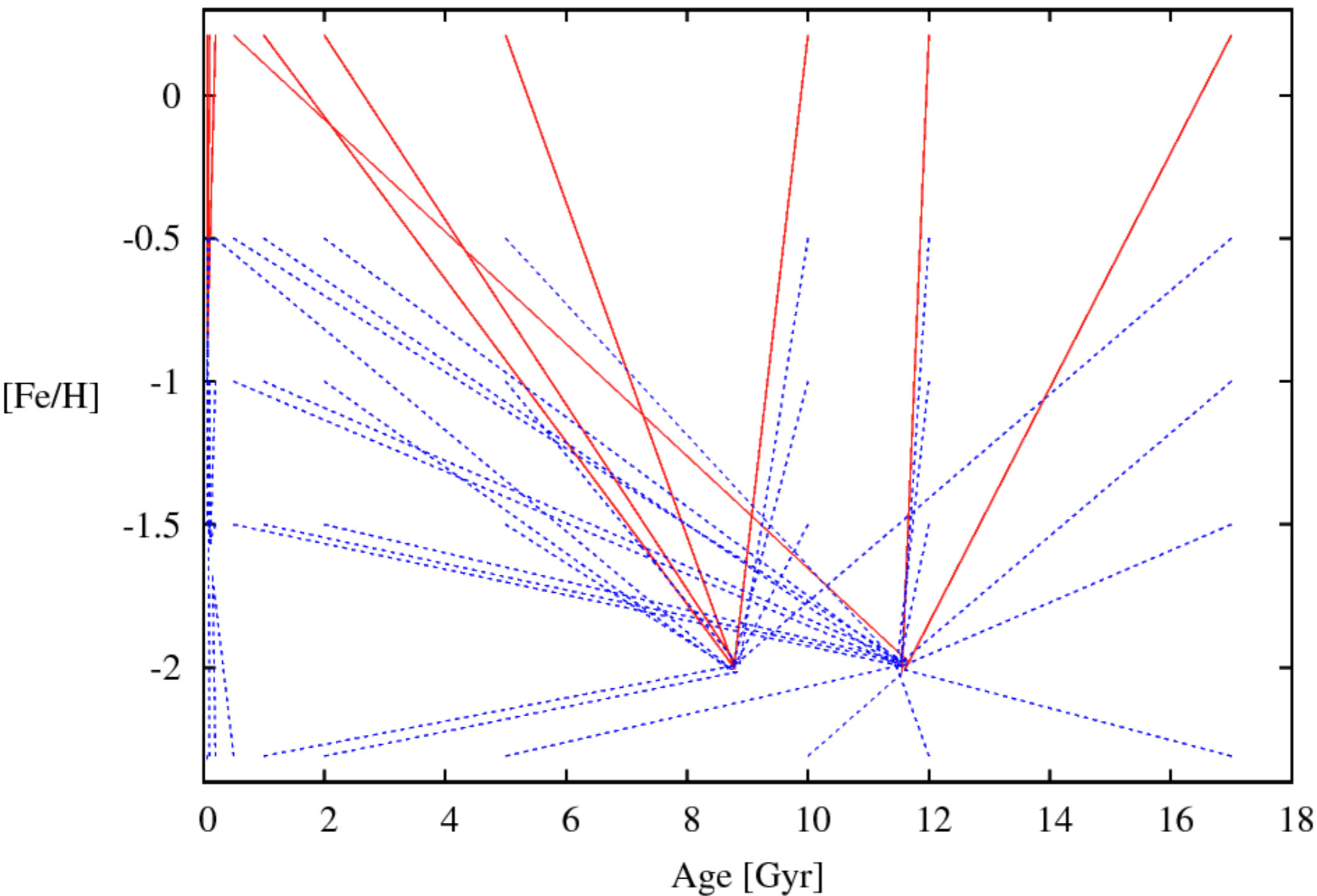
MOS

3300-6210A

1.5 A / PIX

# AGES AND METALLICITIES OF NUCLEAR GCs

KK 197

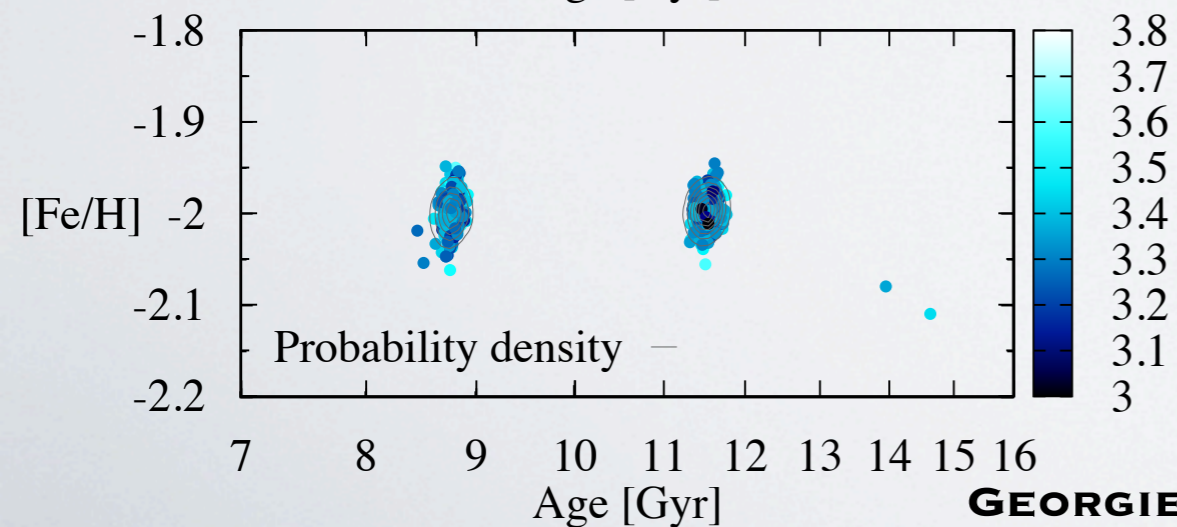
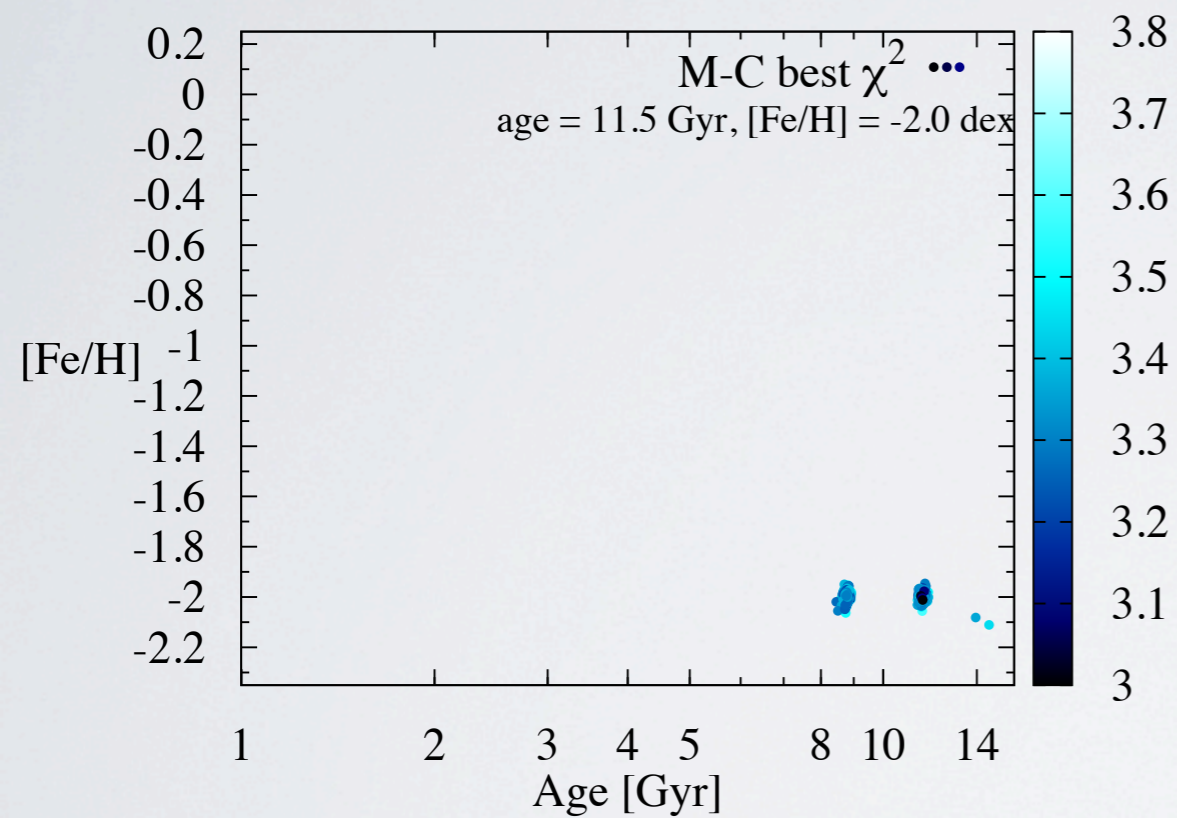
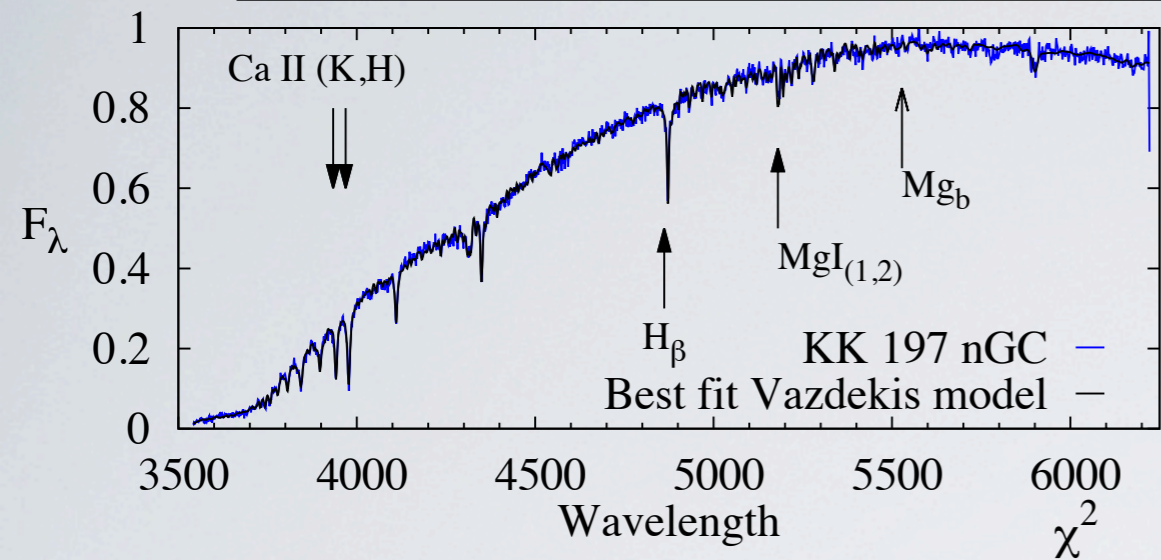


FULL SPECTRAL  
FITTING  
(ULYS, KOLEVA  
ET AL. 2009)

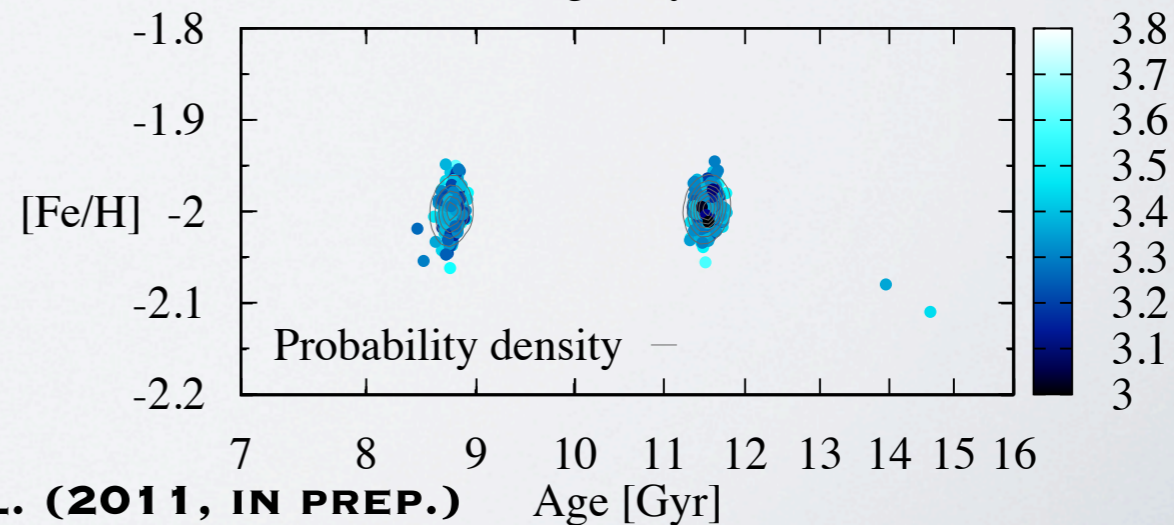
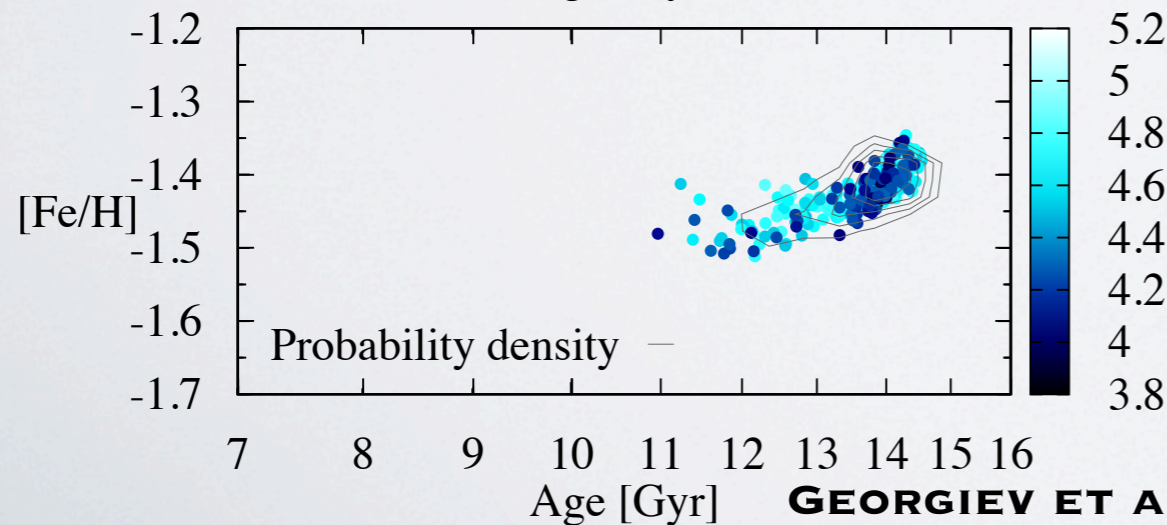
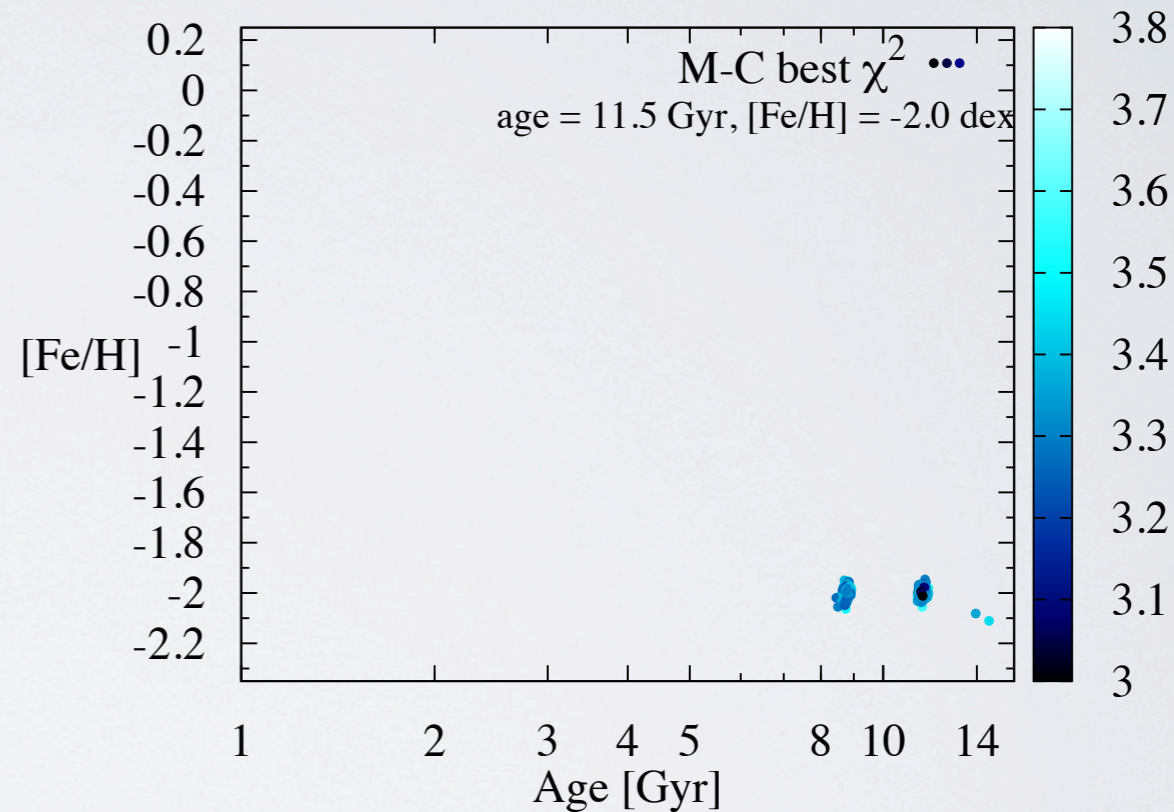
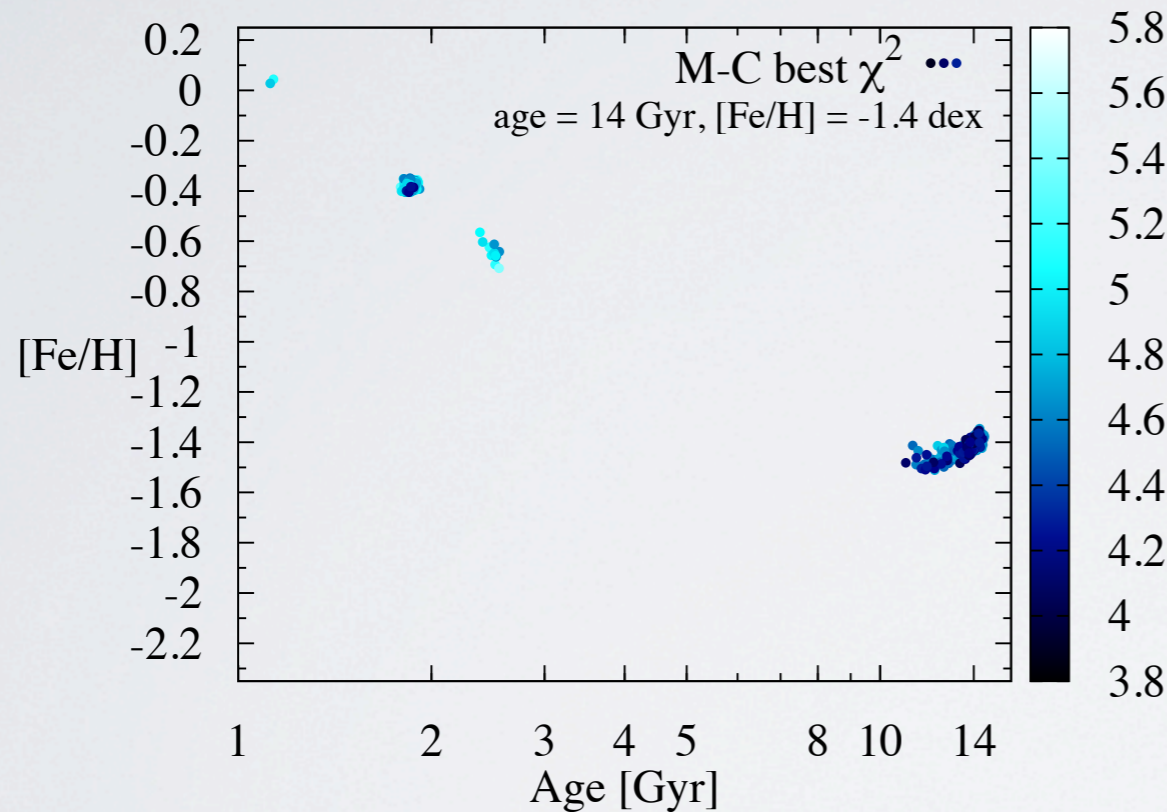
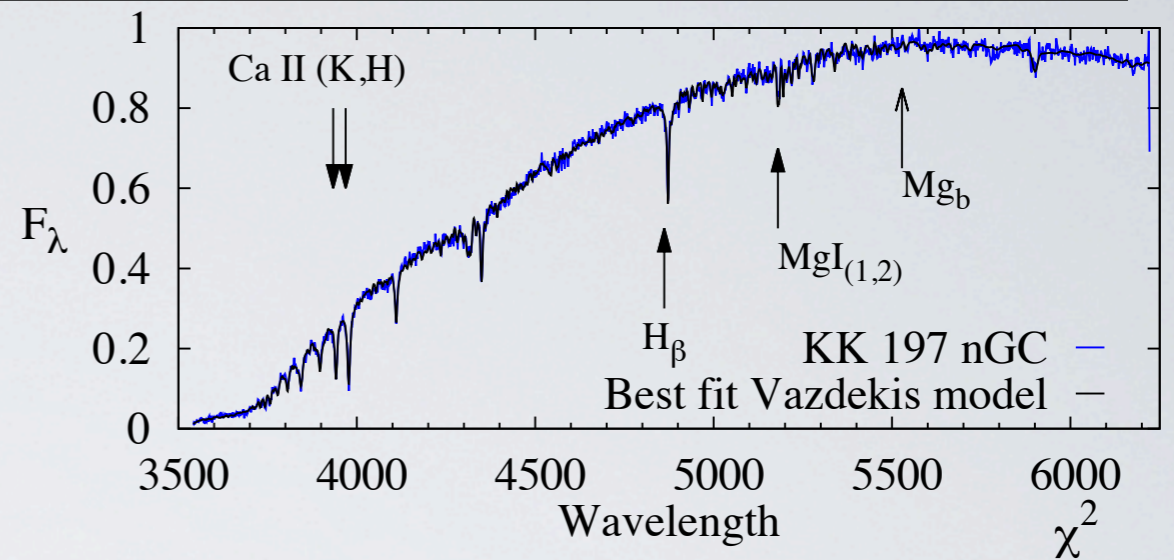
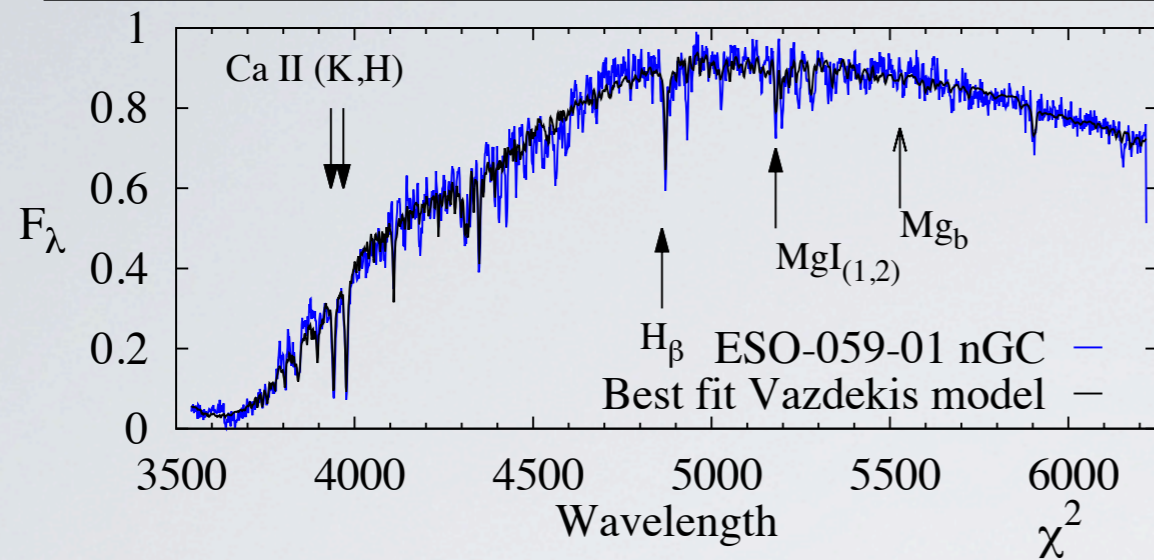
VAZDEKIS  
MODELS (2010)  
60 MYR < AGE  
< 18 GYR  
-2.3 < [FE/H] <  
0.2 DEX

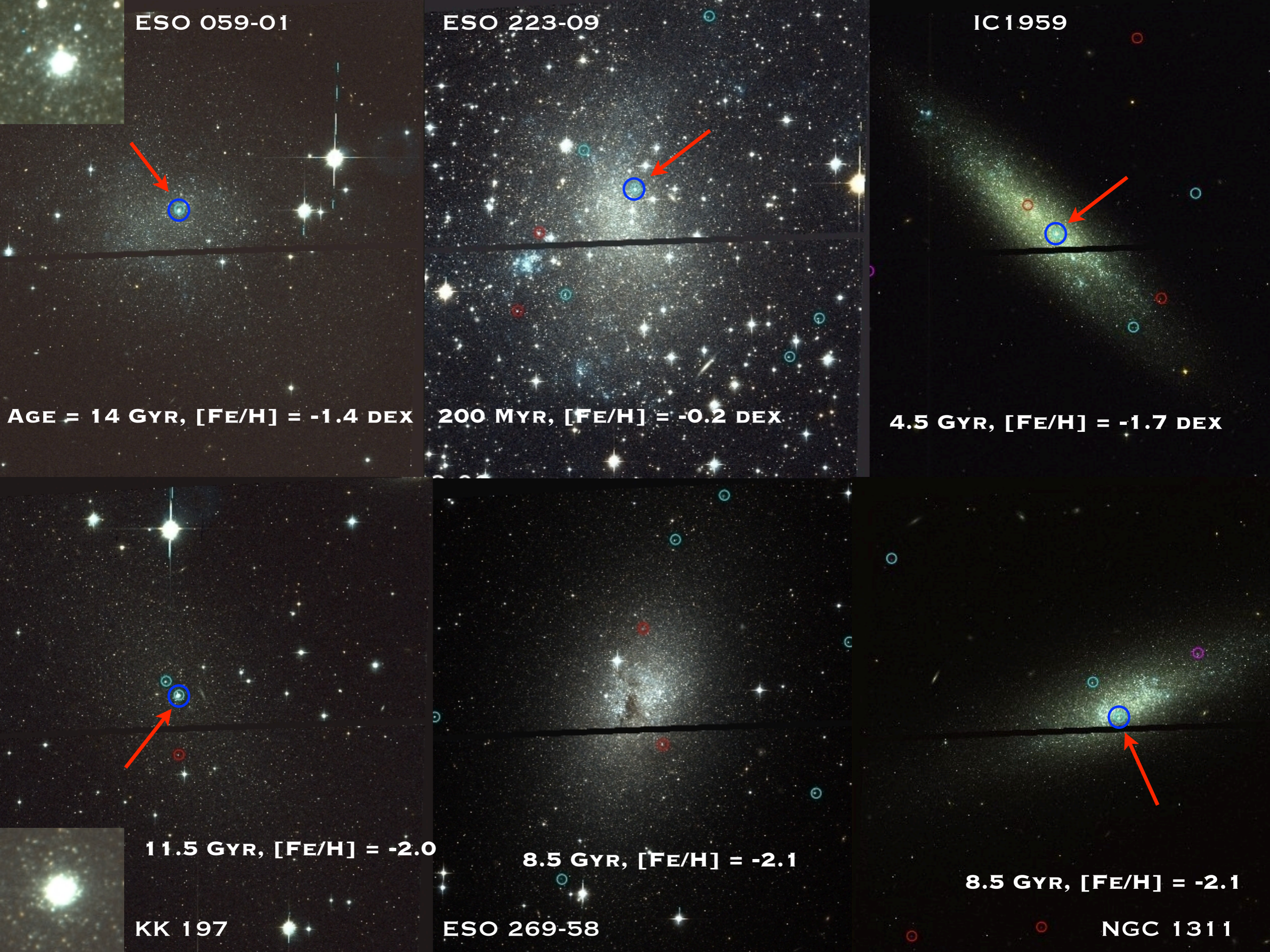
**GEORGIEV ET AL. (2011, IN PREP.)**

# AGES AND METALLICITIES OF NUCLEAR GCs



# AGES AND METALLICITIES OF NUCLEAR GCs





ESO 059-01

ESO 223-09

IC 1959

AGE = 14 GYR,  $[Fe/H] = -1.4$  DEX

200 MYR,  $[Fe/H] = -0.2$  DEX

4.5 GYR,  $[Fe/H] = -1.7$  DEX

11.5 GYR,  $[Fe/H] = -2.0$

8.5 GYR,  $[Fe/H] = -2.1$

8.5 GYR,  $[Fe/H] = -2.1$

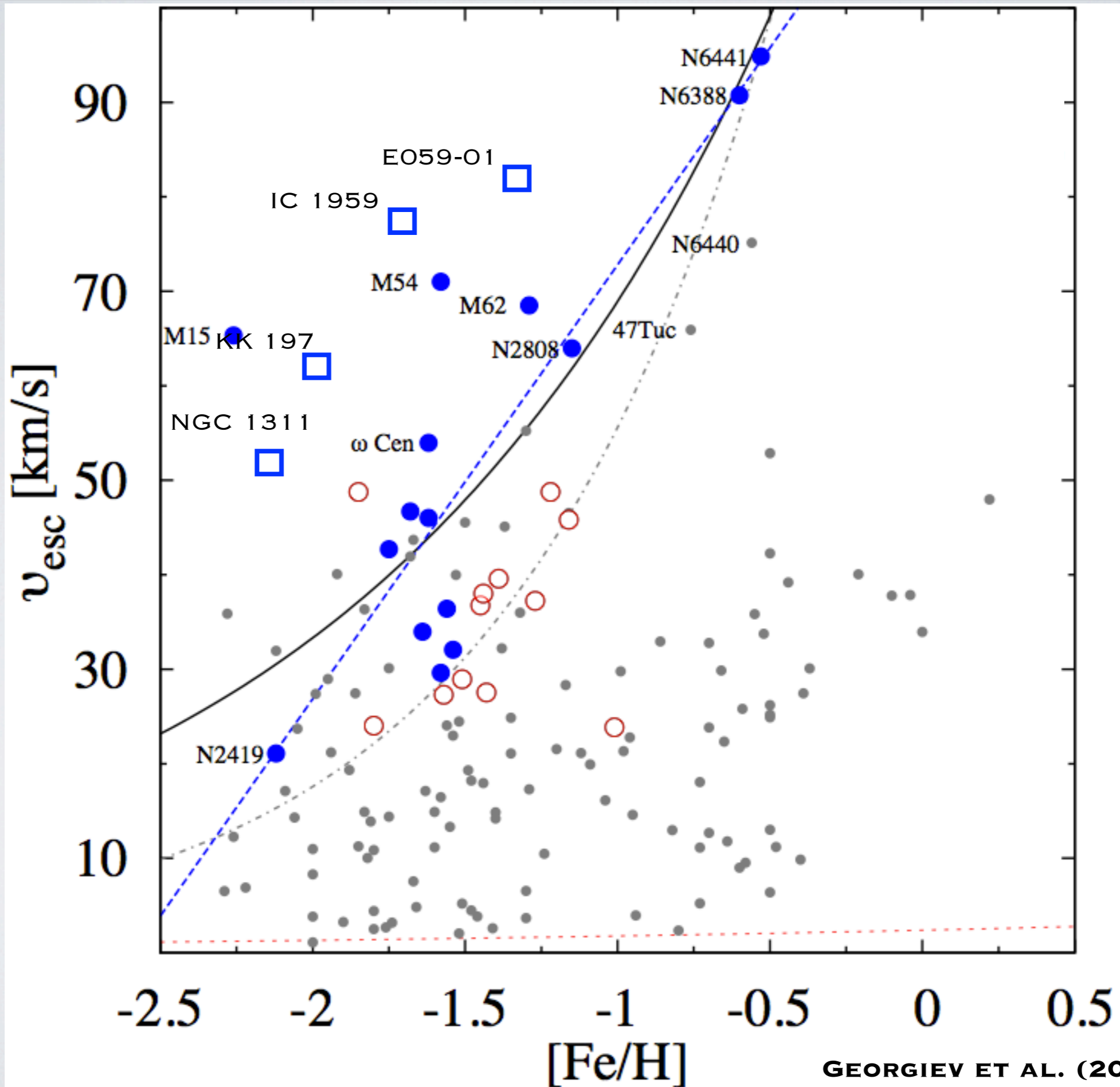
KK 197

ESO 269-58

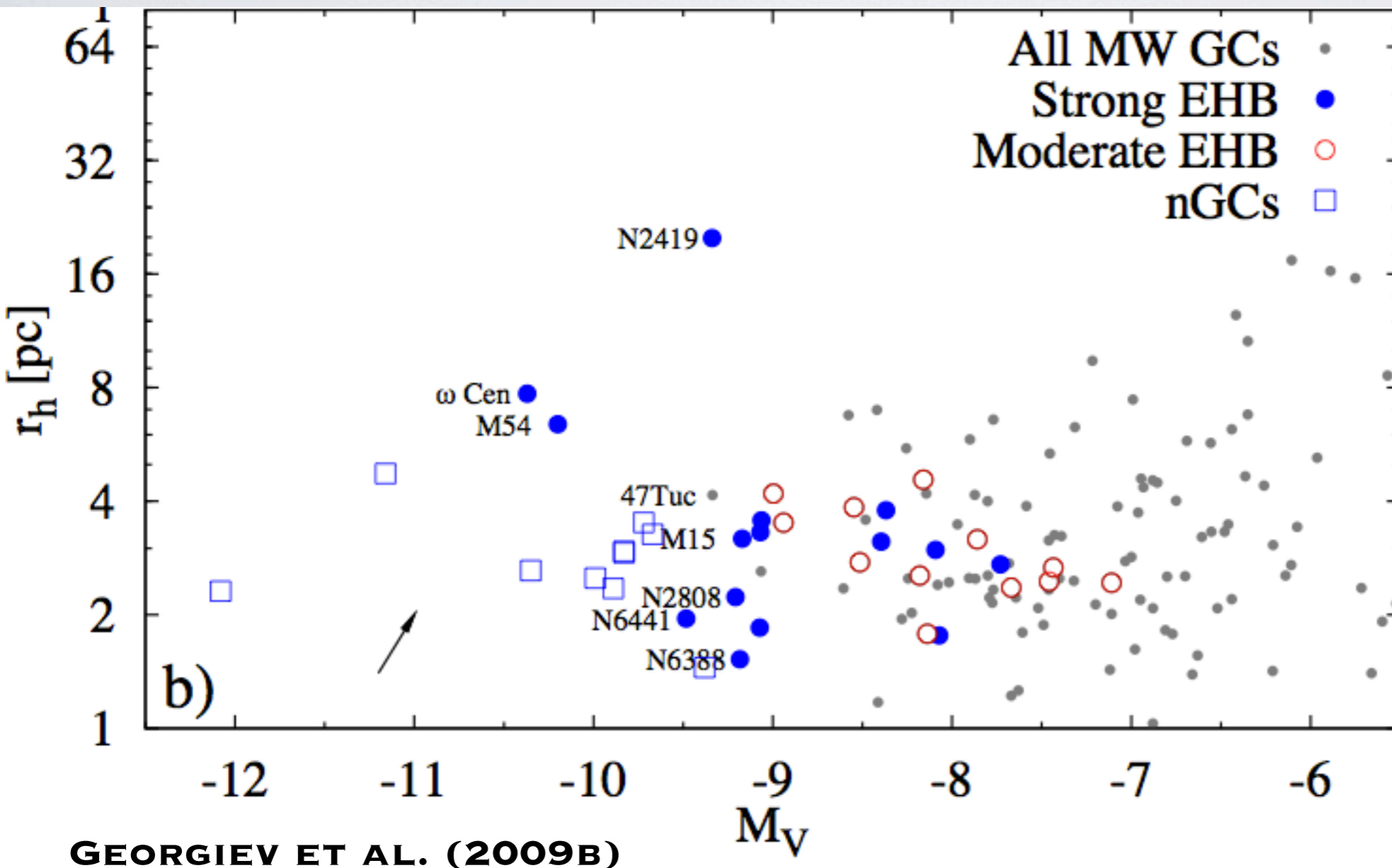
NGC 1311



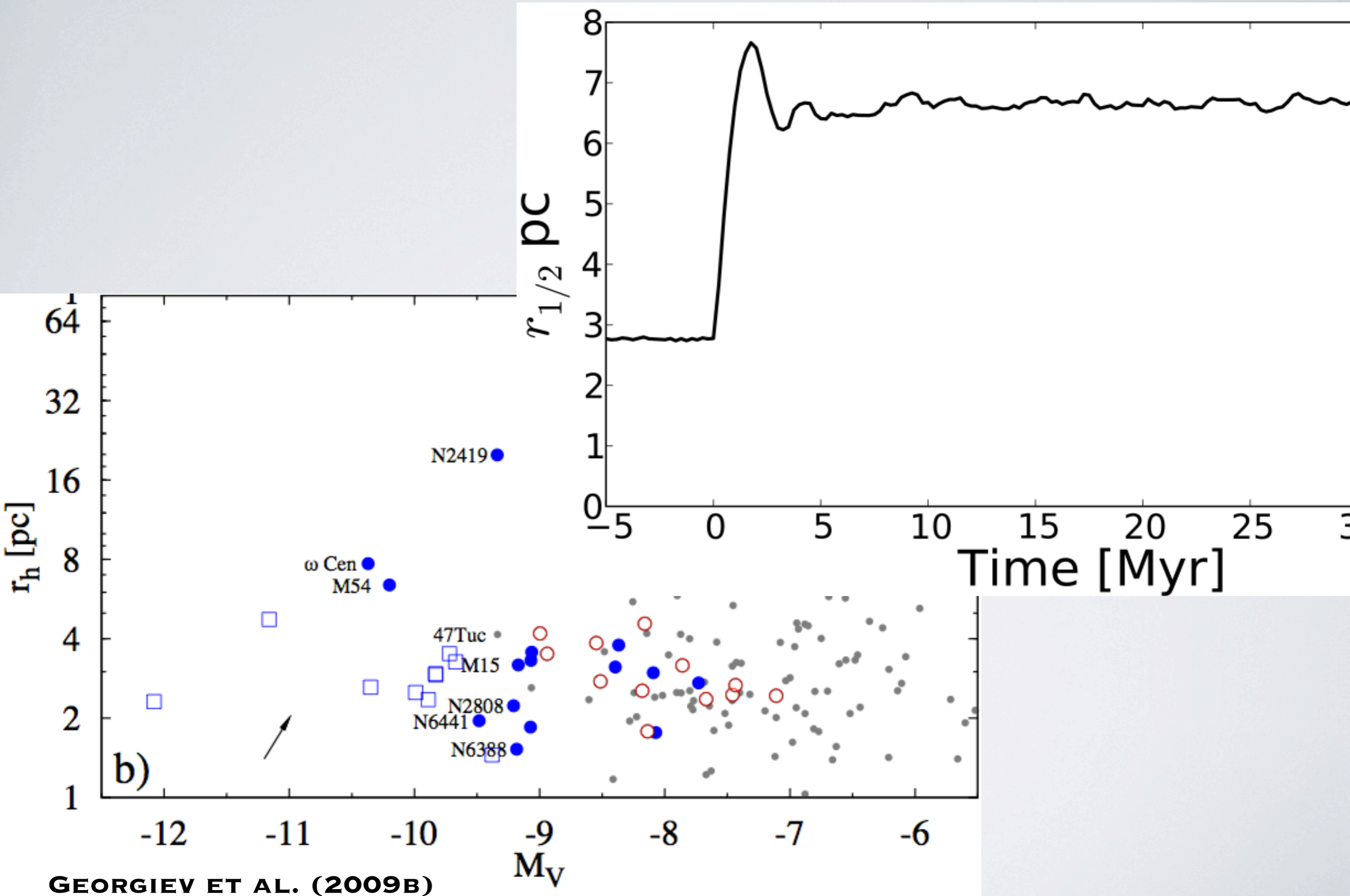
# $V_{\text{ESC}}$ VS. METALLICITIES FOR NGCS AND EHB-GCS



# EXPANSION OF NGCS BY POTENTIAL REMOVAL



# EXPANSION OF NGCS BY POTENTIAL REMOVAL



# CONCLUSIONS

## AGES AND METALLICITIES OF NGCS

COVER A WIDE RANGE

- IN AGE, BUT MOSTLY OLD (~ FEW GYRS TO 14GYR)
- METALLICITY, BUT MOSTLY METAL POOR ( $[Fe/H] < -1.5$  DEX)
- MULTIPLE POPULATIONS, BLUE HBS?

## MASSIVE GALACTIC GCs

REQUIRE A FORMATION IN “HEAVY” ENVIRONMENT

## STAY TUNED

- NGCS DYNAMICAL MASSES (UVES)
- DWARF GALAXIES KINEMATICS