RASPUTIN

Resolved And unresolved Stellar PopUlaTIoNs

Globular Clusters in UV: from the Horizontal Branch to integrated colors

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Cosmic-Lab

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Cosmic-Lab

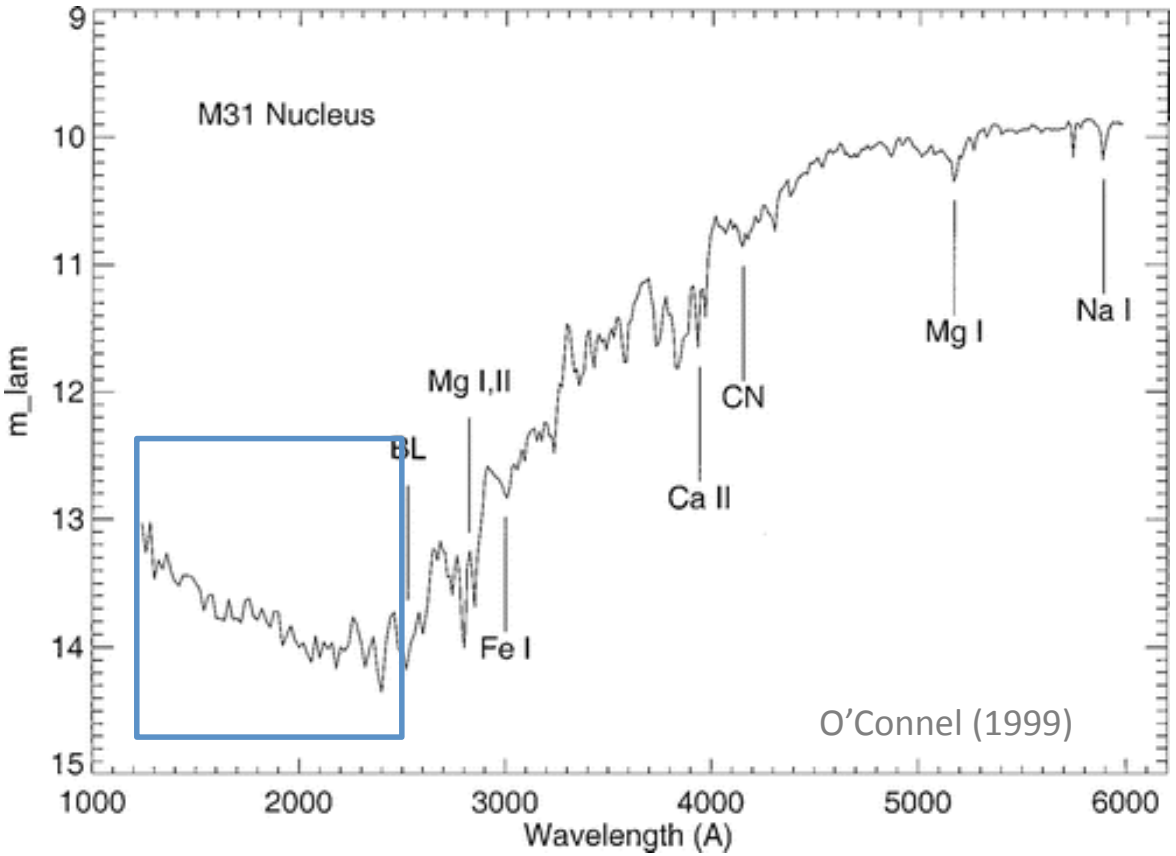
- 5-year project
- *Advanced Research Grant* funded by the European Research Council (ERC)
- PI: Francesco R. Ferraro (Dip. of Physics & Astronomy – Bologna University)
- AIM: **to understand the complex interplay between dynamics & stellar evolution**
- HOW: using **globular clusters** as cosmic laboratories and

Blue Straggler Stars
Millisecond Pulsars
Intermediate-mass Black Holes

} as probe-particles

Old Stellar Populations in UV

Understanding the origin and the frequency of hot stars is not simply a problem of understanding the evolution of old, low mass stars. It has important implication on the interpretation spectra of galaxies.



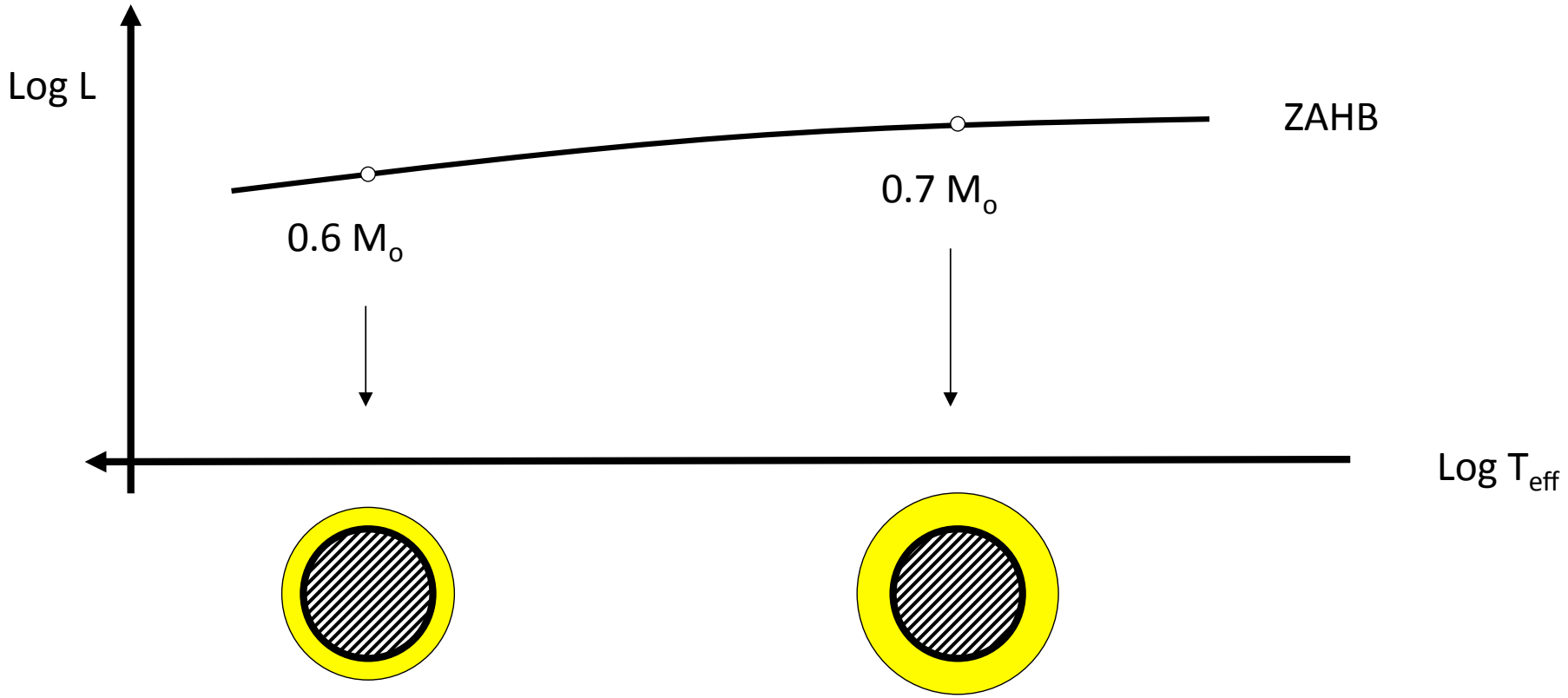
Hot stars have been suggested to be responsible of the UV upturn in the spectrum of elliptical galaxies and bulges (Greggio & Renzini 1990)

GGCs are the best laboratory

Detailed knowledge of the underlying stellar population

Integrated properties

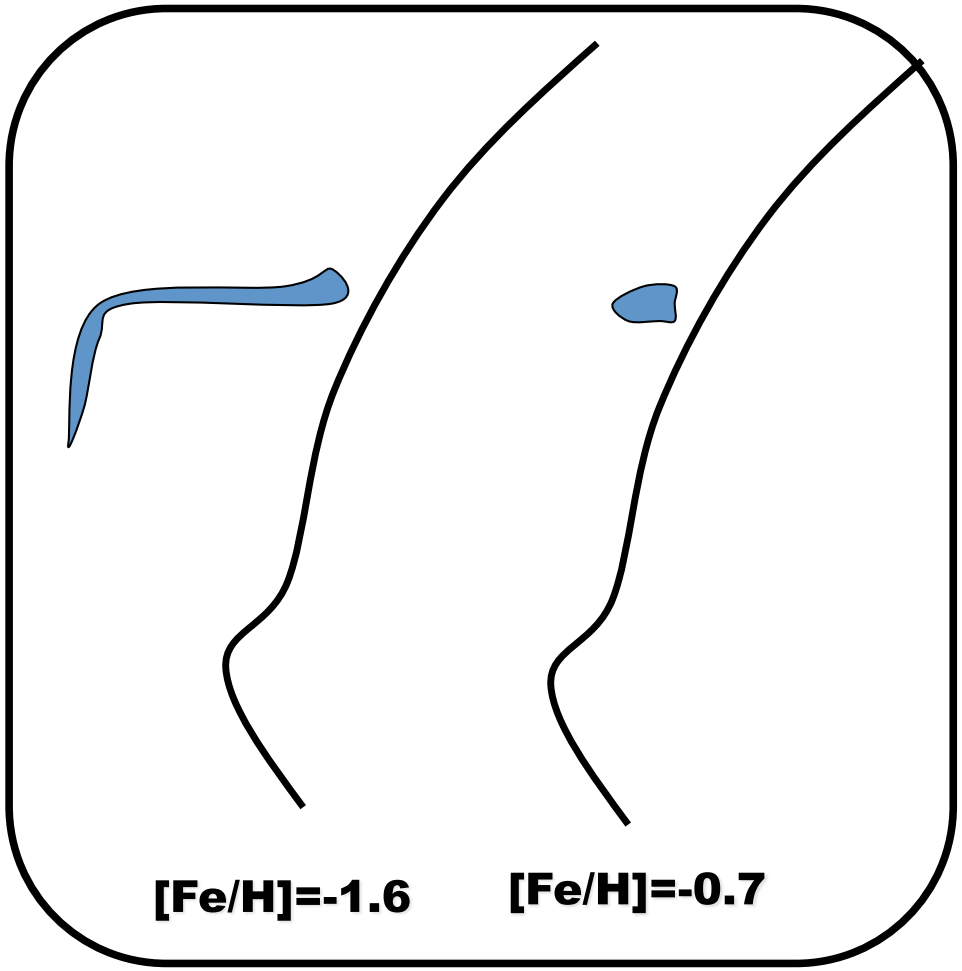
The distribution and frequency of hot stars GGCs



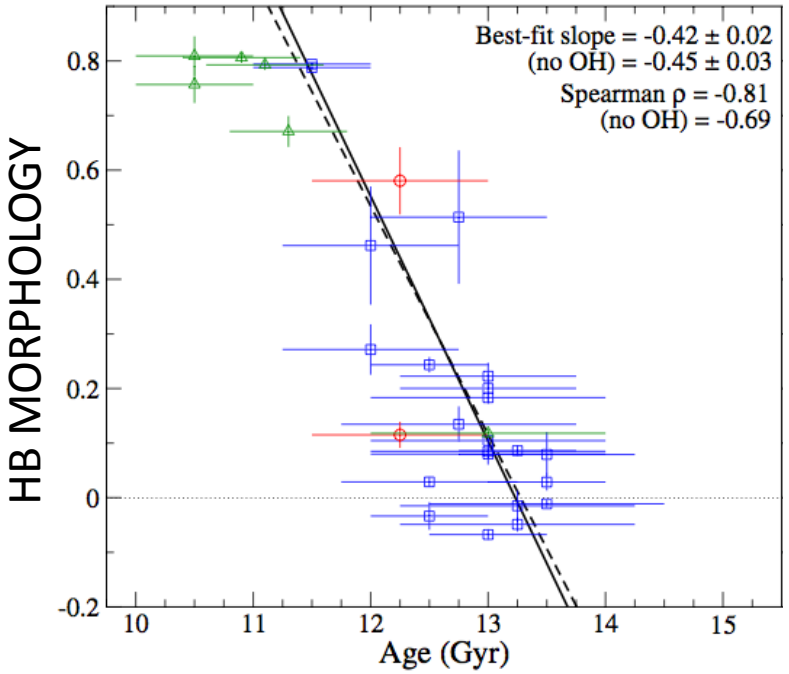
There are many culprits that can affect the temperature distribution of HB stars: metallicity, age, mass-loss, He abundance, stellar rotation …

The HB in a nutshell

Metallicity is the first parameter



Age is the second



- **They fail in many cases**
- **What's the role of He?**

A new approach for HB studies

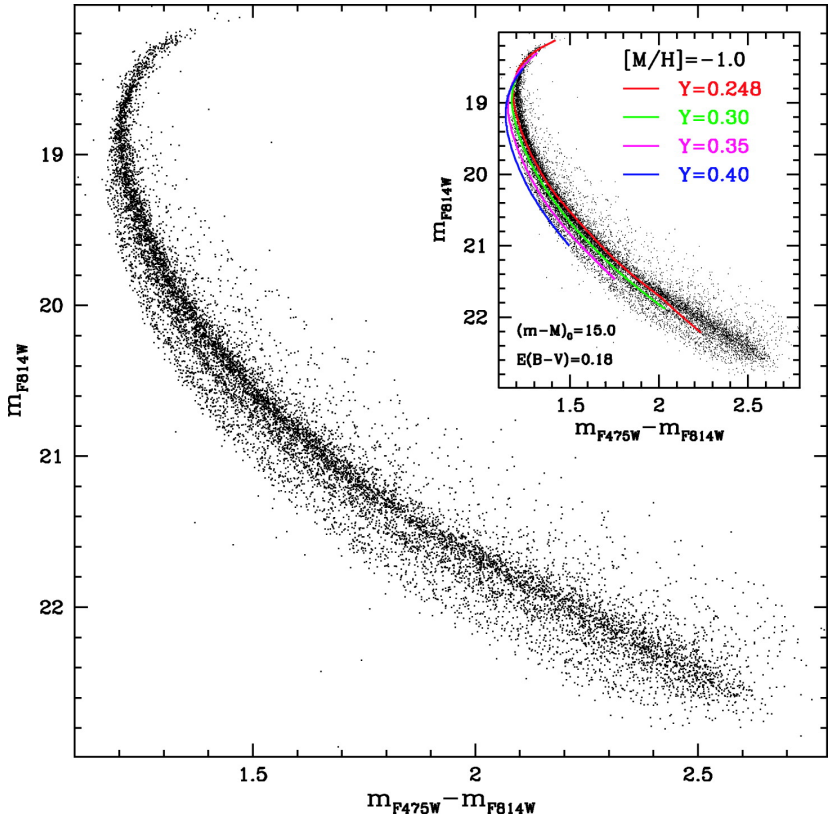
1. High quality UV photometry (see the poster by E. Lagioia)

2. A set of isochrones and HB tracks for different metallicities and Helium abundance (BaSTI; Pietrinferni et al. 2006)

3. Take into account the effect of radiative levitation (BC for [Fe/H]=0.5 for T>12000K; Behr et al. 2003; Pace et al. 2006)

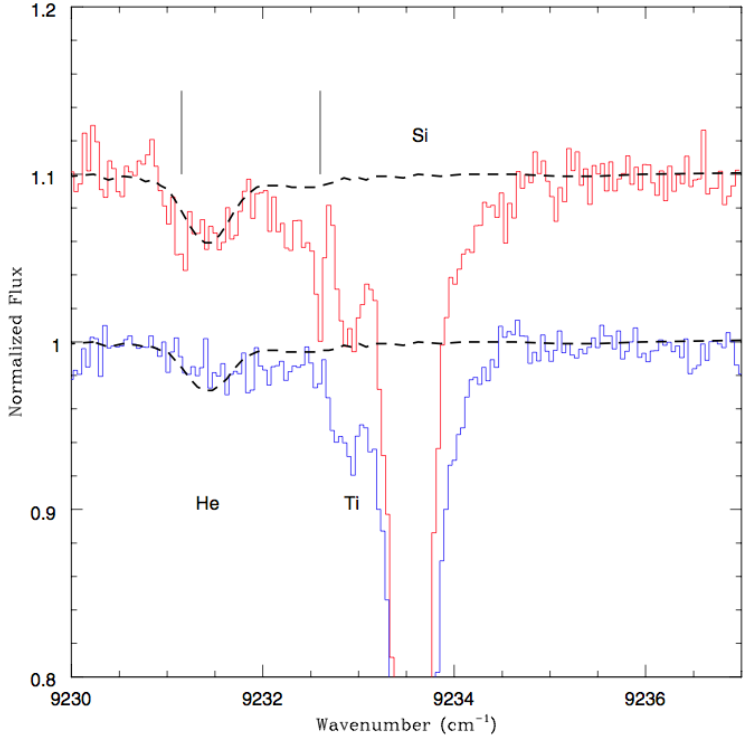
4. An extensive use of synthetic HBs obtained with two free parameters: ΔM and $\sigma_{\Delta M}$ (Y_{min}, ΔY)

The Horizontal Branch in UV: NGC 2808



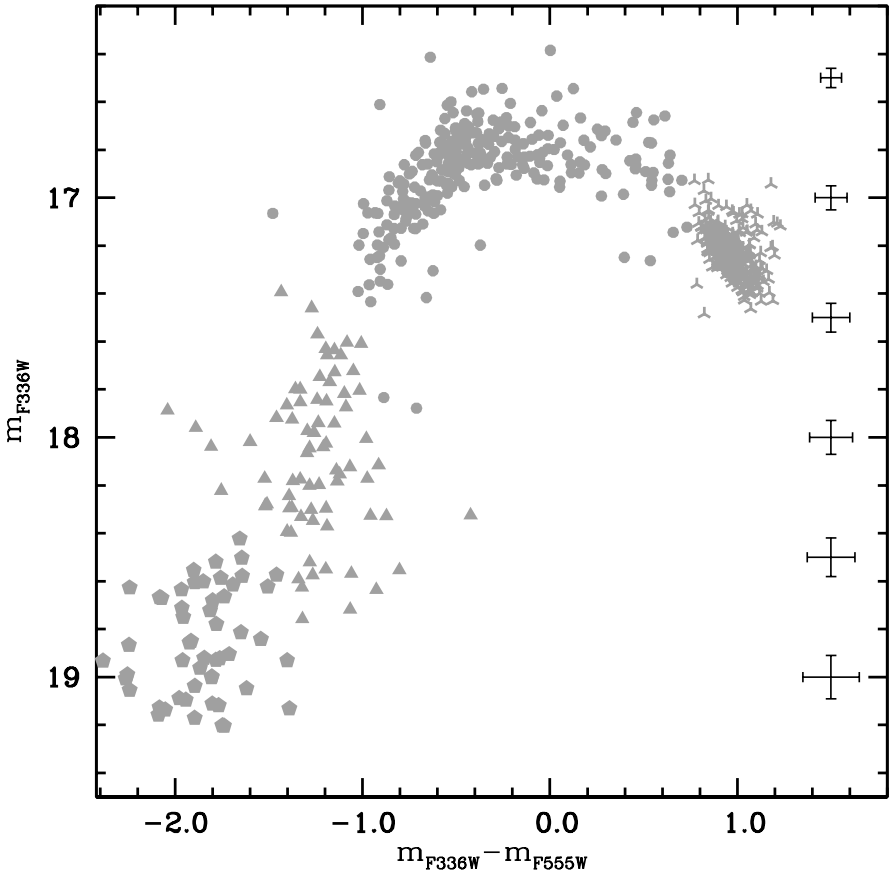
3 sub-populations with different He abundances have been observed from both photometric and spectroscopic analyses

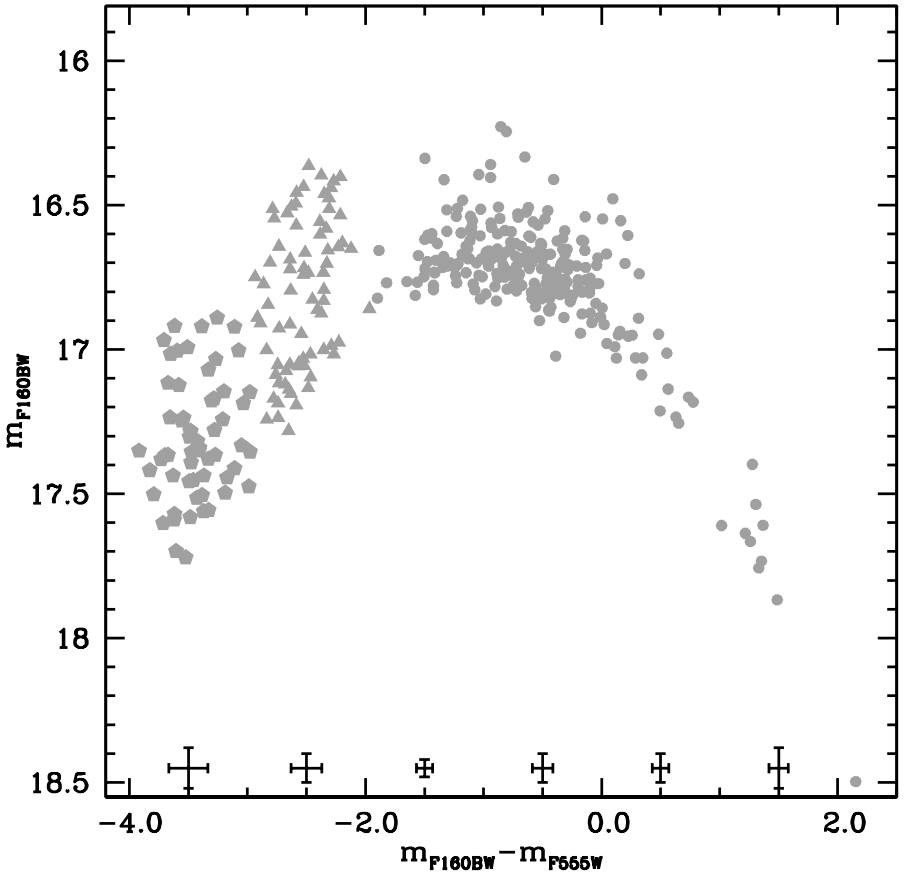
(Piotto et al. 2007; Bragaglia et al. 2011; Pasquini et al. 2011)



The Horizontal Branch in UV: NGC 2808

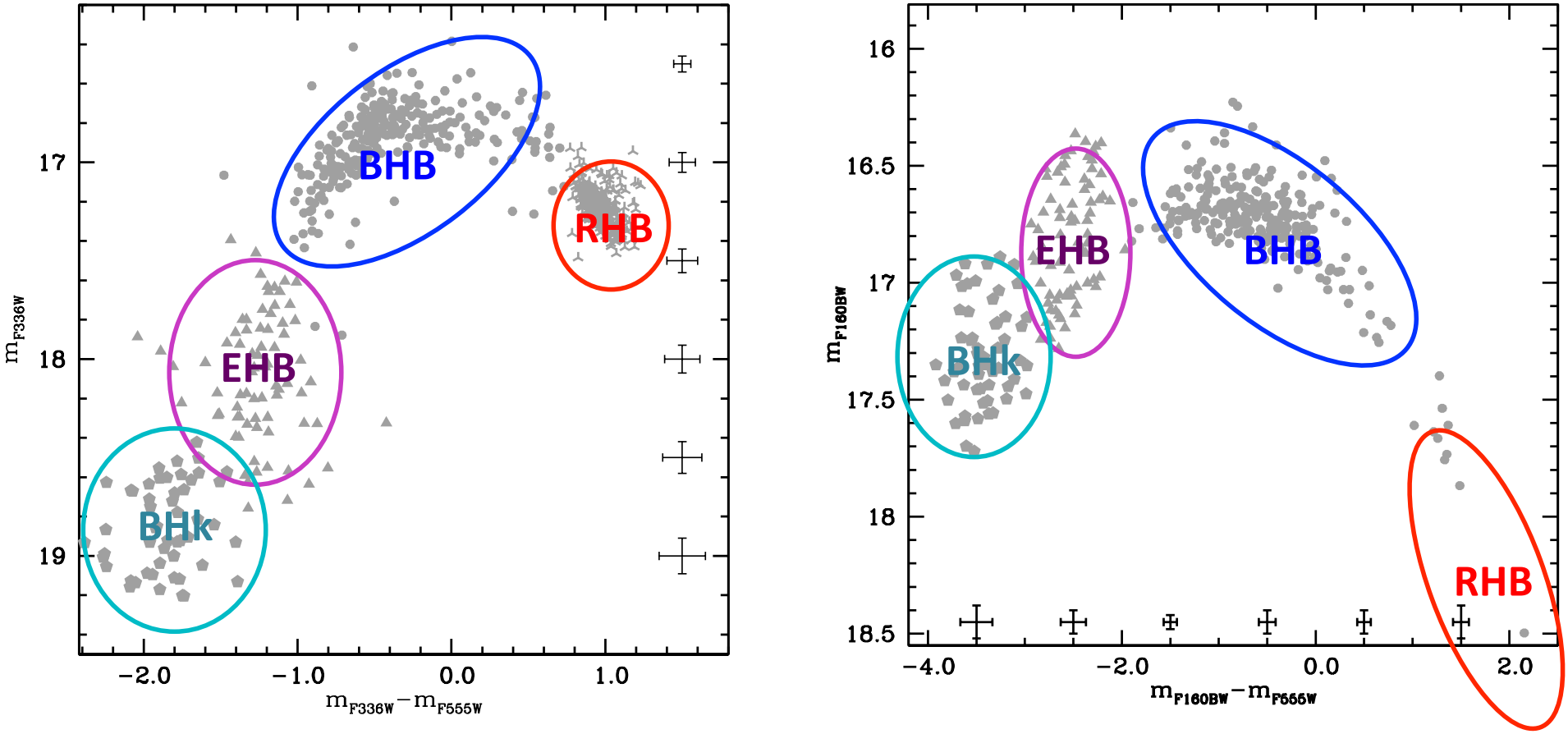
Dalessandro et al. 2011



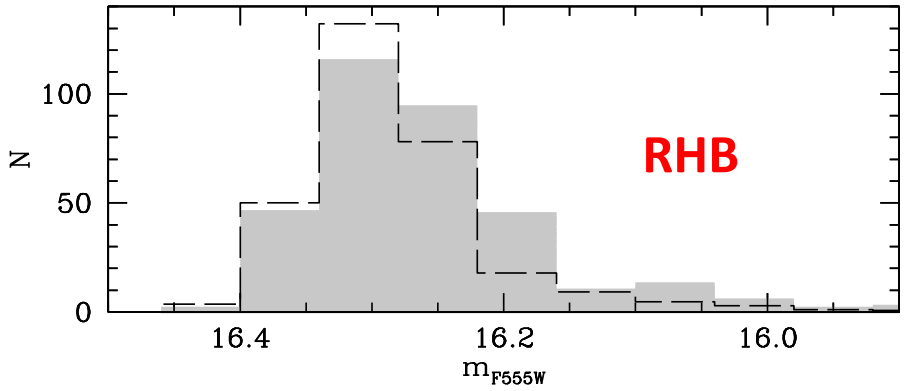


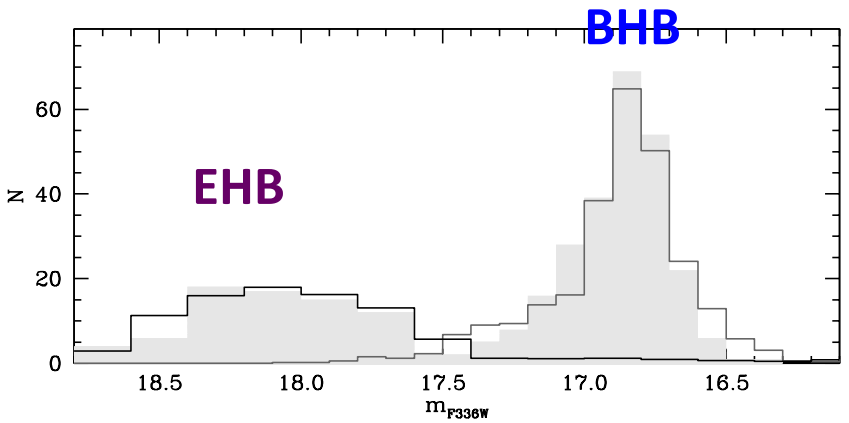
Four sub-groups along the HB of NGC2808

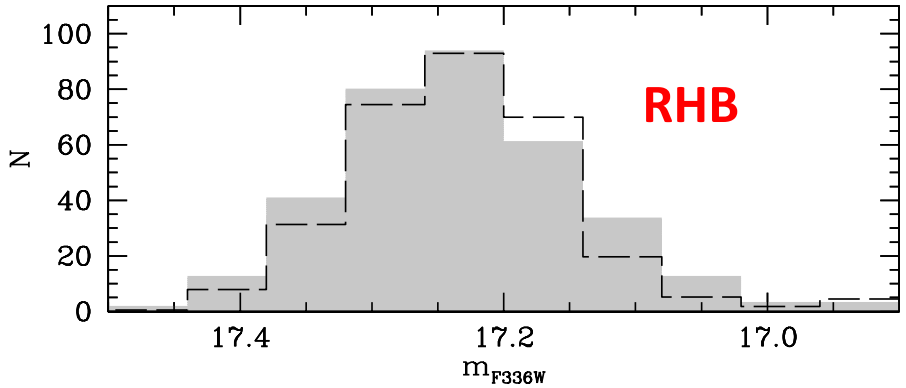
Dalessandro et al. 2011

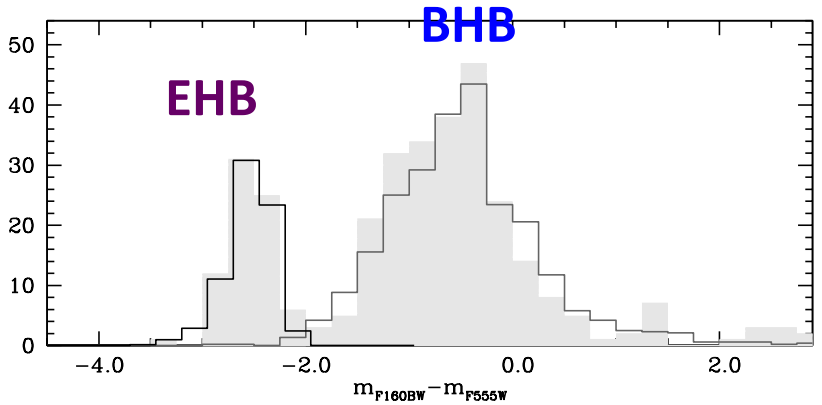


A new approach for HB studies



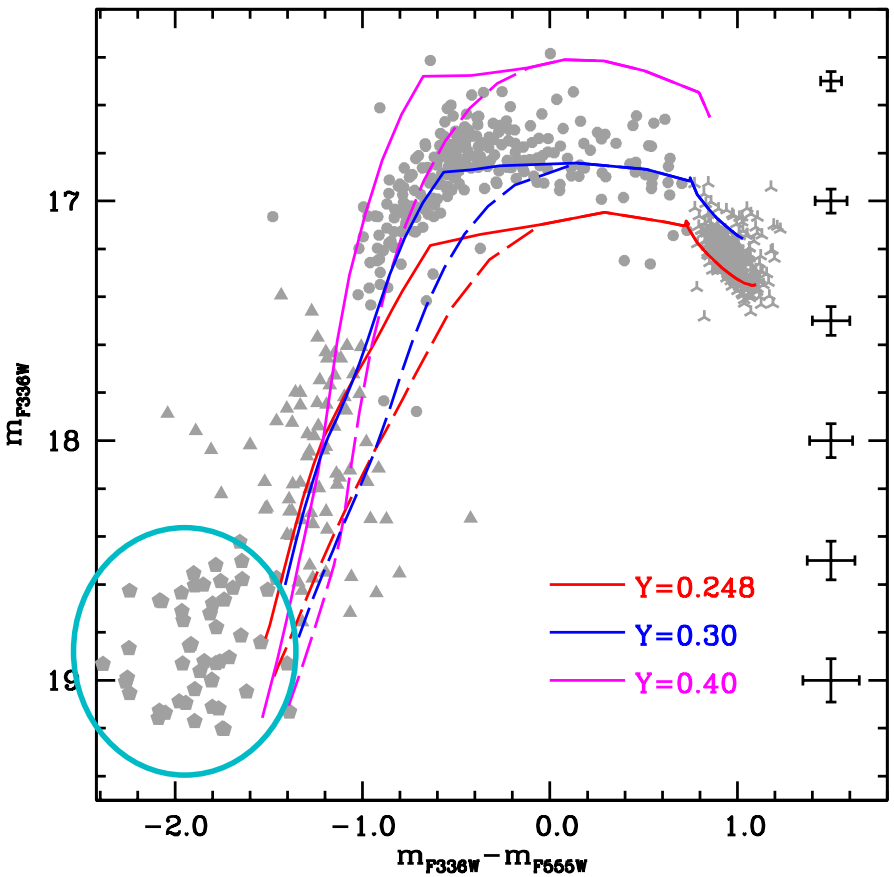


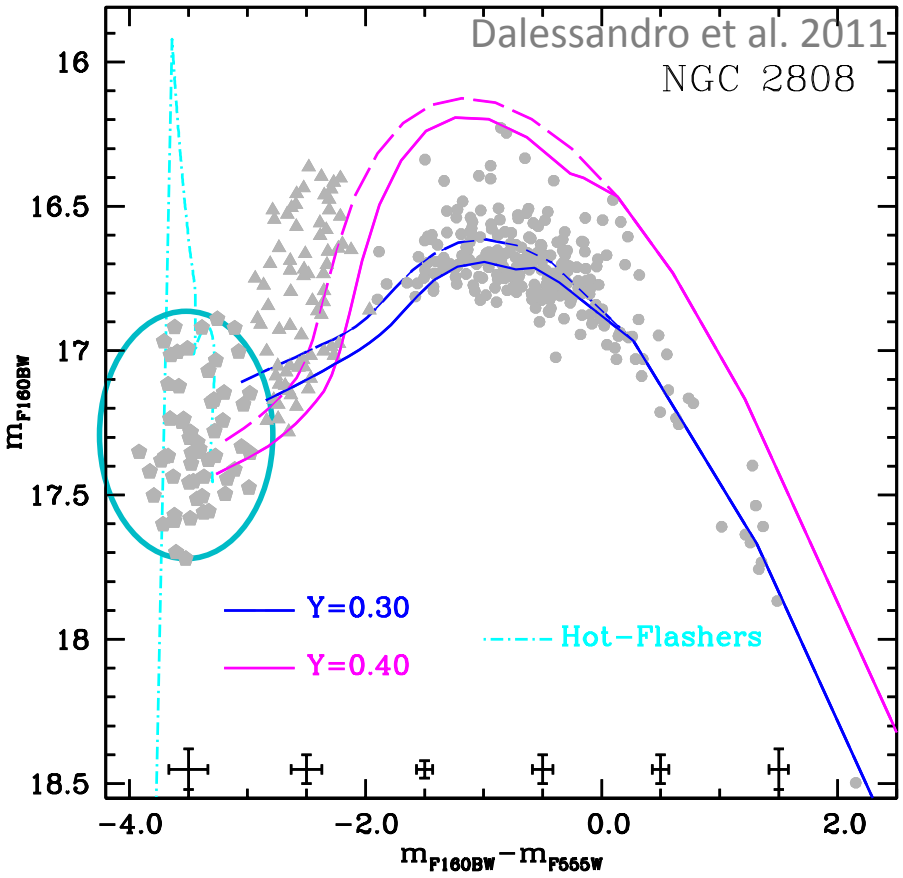




POP	Y	M_{TO}	M_{HB}	DM	T_{eff}
RHB	0.248	0.84	0.69	0.15	5400
BHB	0.30	0.76	0.565	0.195	12 600
EHB	0.40	0.627	0.479	0.148	24 000

The Horizontal Branch in UV: NGC 2808



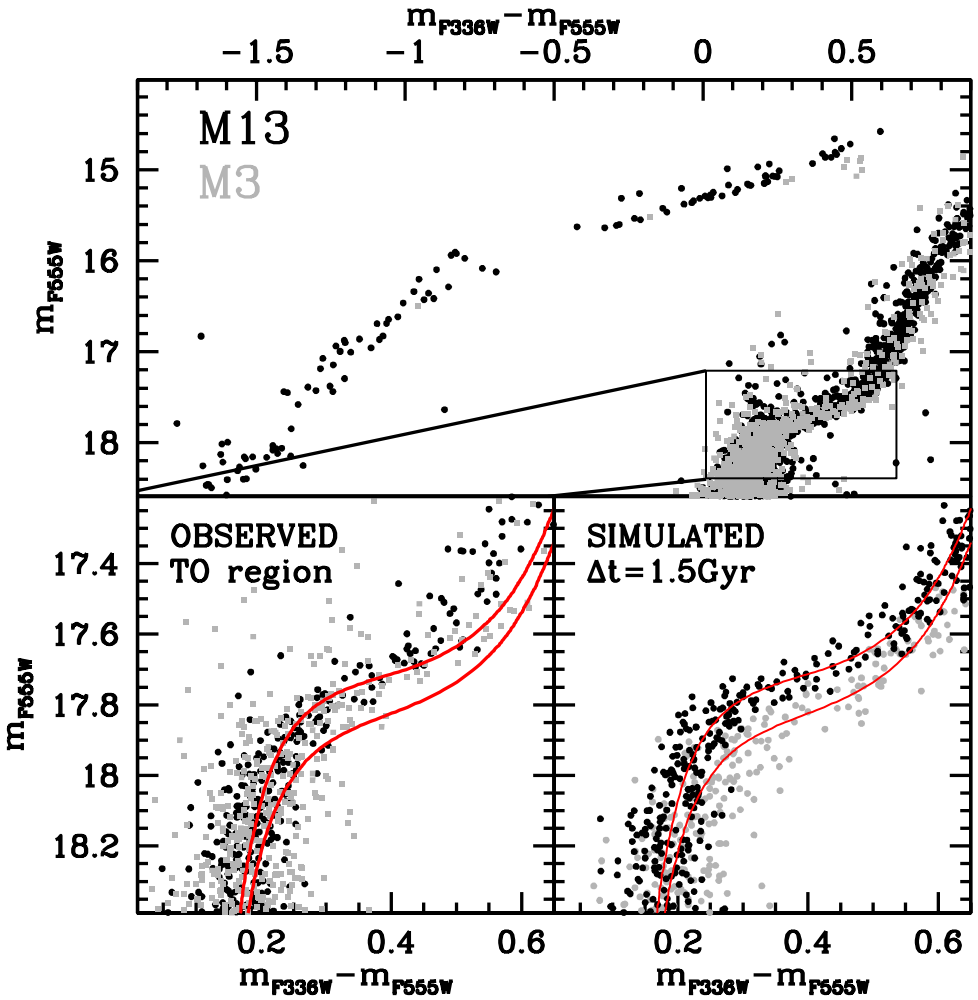


THE HB OF NGC2808 IS FULLY DESCRIBED BY USING 3 POPS WITH DIFFERENT He + HOT-FLASHERS

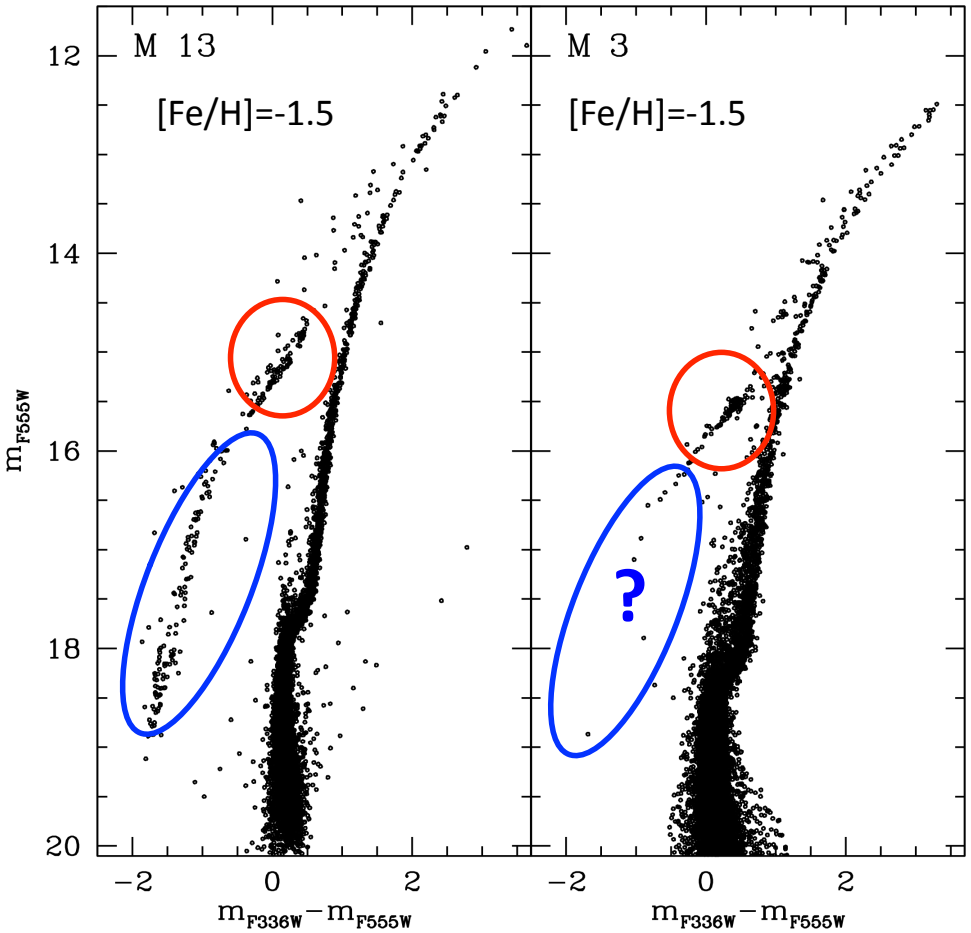
The Horizontal Branch in UV: M 3 – M 13

Dalessandro et al. 2013

SAME METALLICITY, SAME AGE

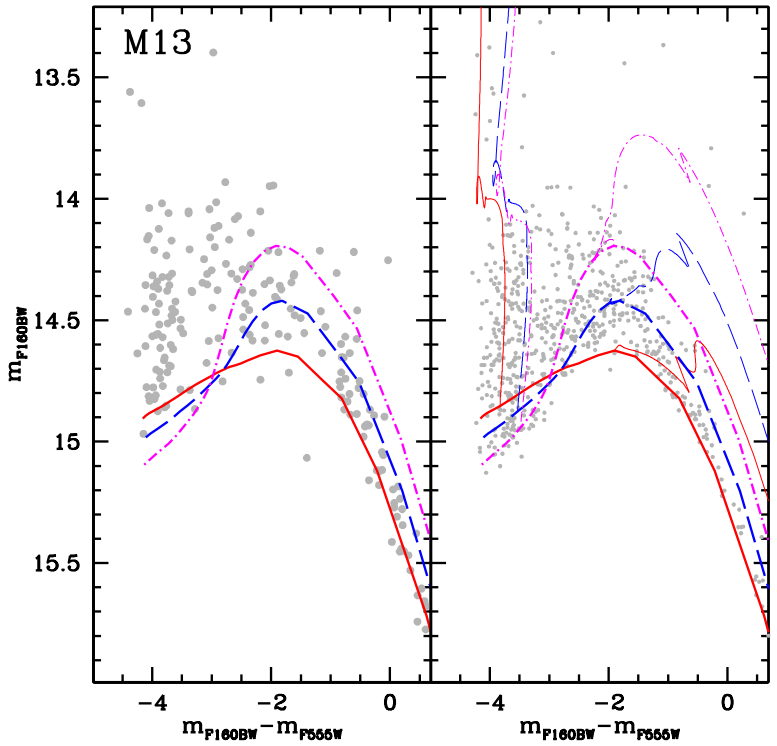


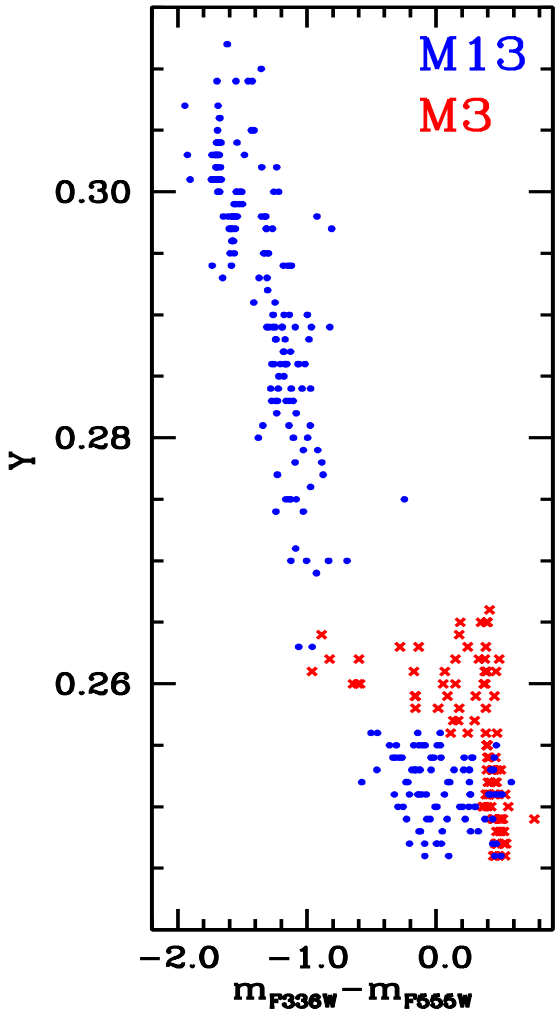
DIFFERENT HB MORPHOLOGIES



The Horizontal Branch in UV: M3 – M13

Dalessandro et al. 2013

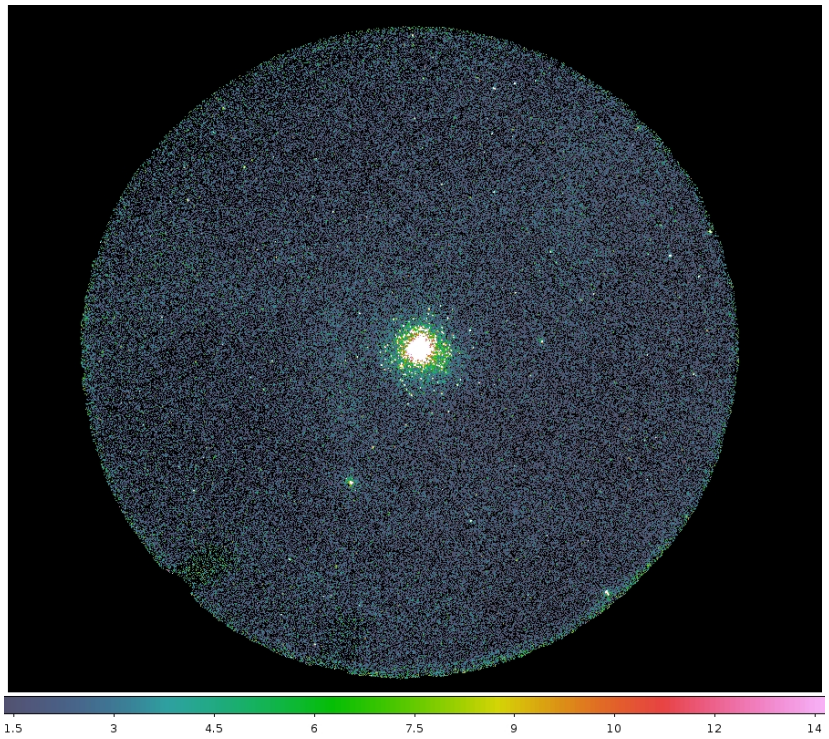


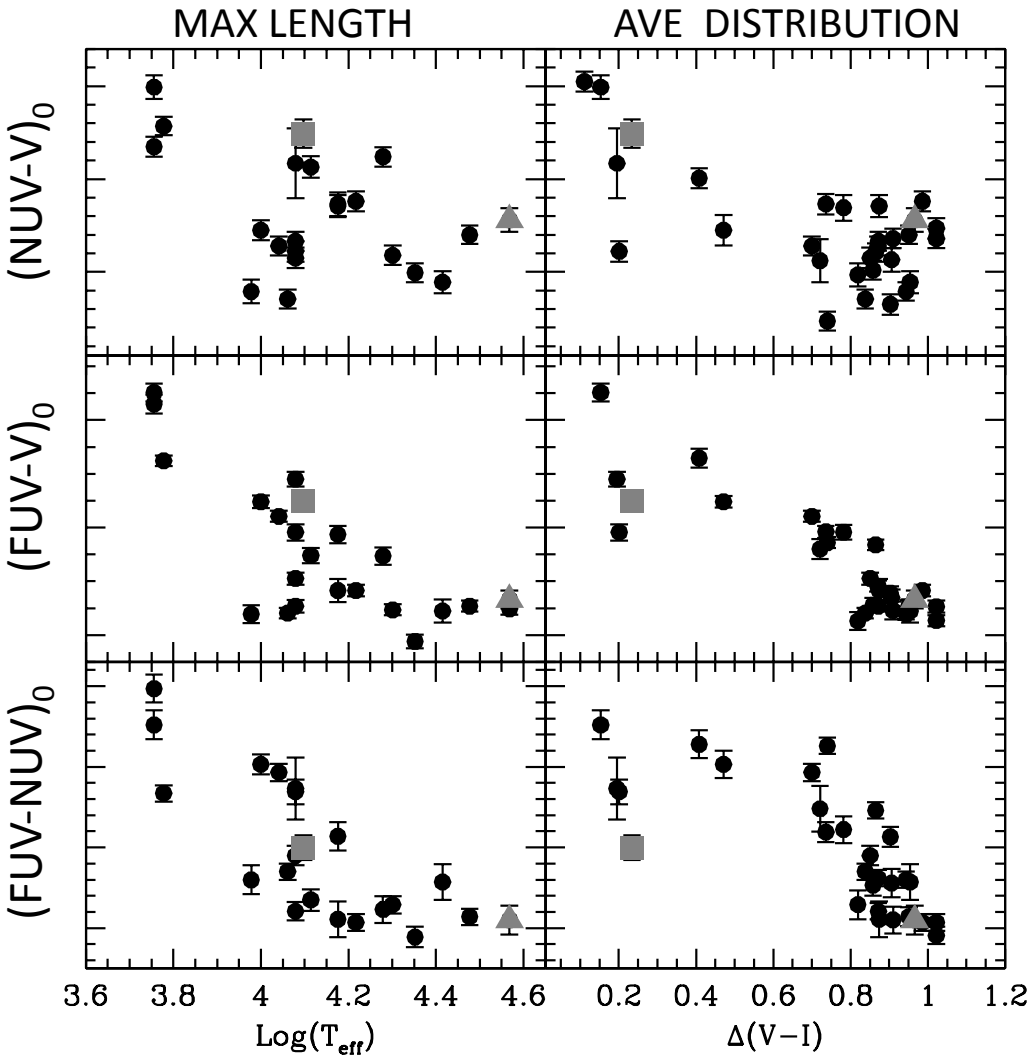


HBs are matched only with different He distributions

Integrated UV colors with GALEX

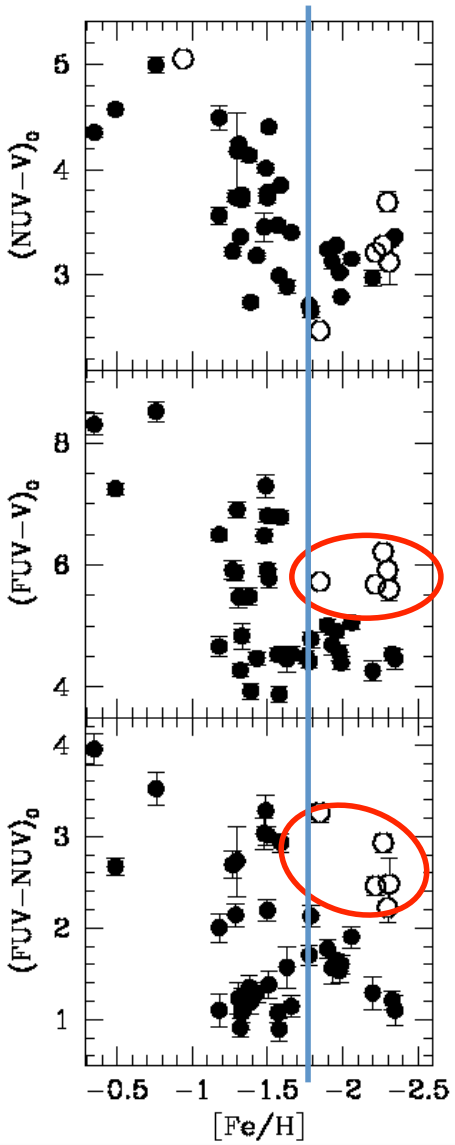
The largest homogeneous dataset of UV GGCs ever collected



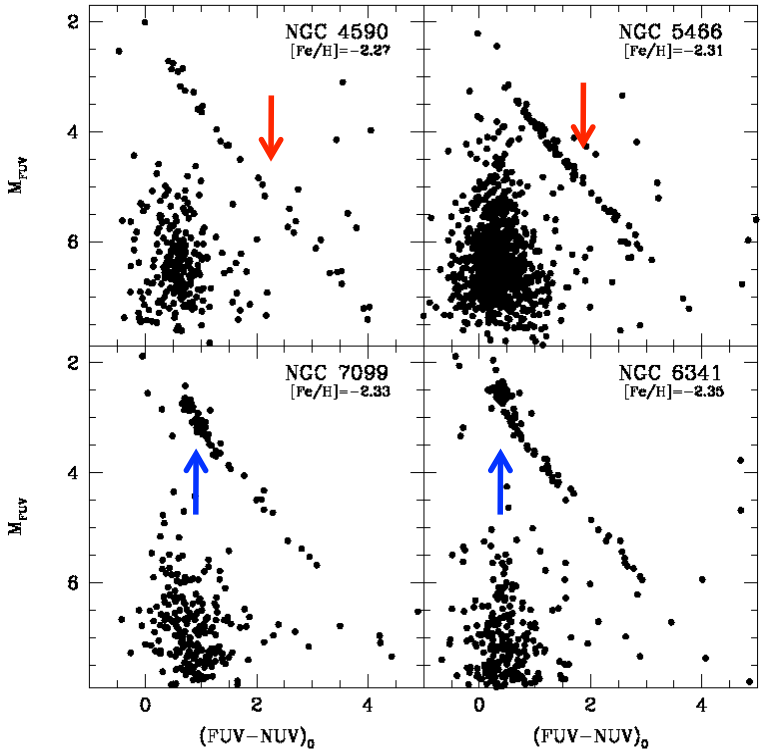


Dalessandro et al. (2012), Schiavon et al. (2012)

The Sagittarius clusters

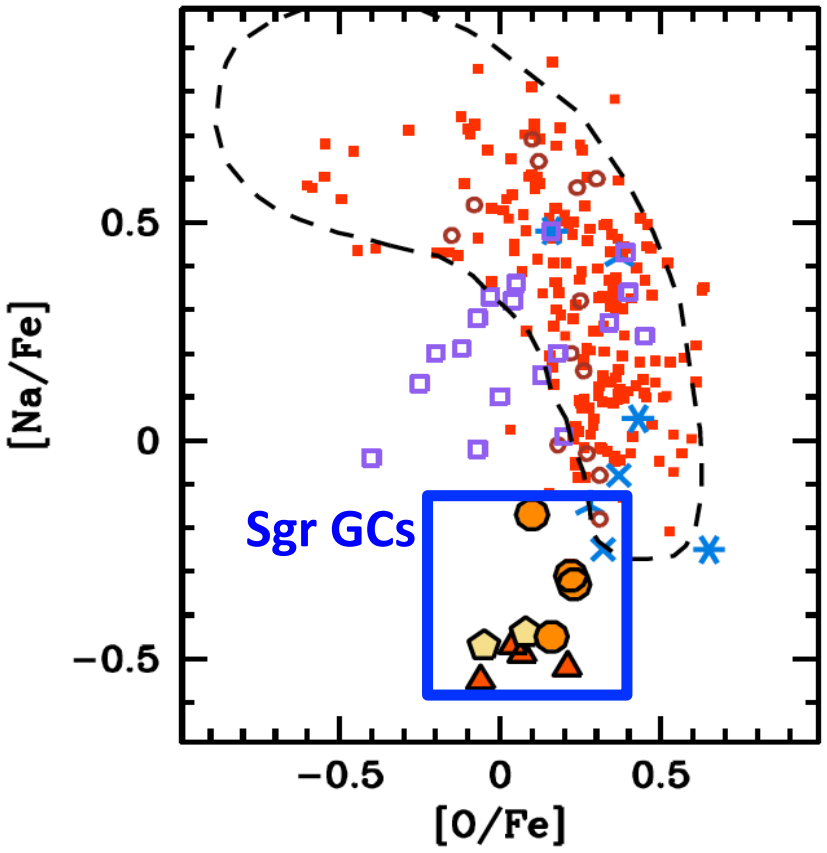


Dalessandro et al. (2012), Schiavon et al. (2012)



NGC4590, NGC5053, NGC5466, Arp2, Terzan8 and Palomar 12 are suggested to be connected with the Sagittarius Stream (Dinescu et al 1999, Palma et al. 2002, Bellazzini et al. 2003, Lee & Majewski 2010)

The Sagittarius clusters



•Sgr GCs stars lie in a different location from GGCs

•They do no to show significant evidence for anti-correlation

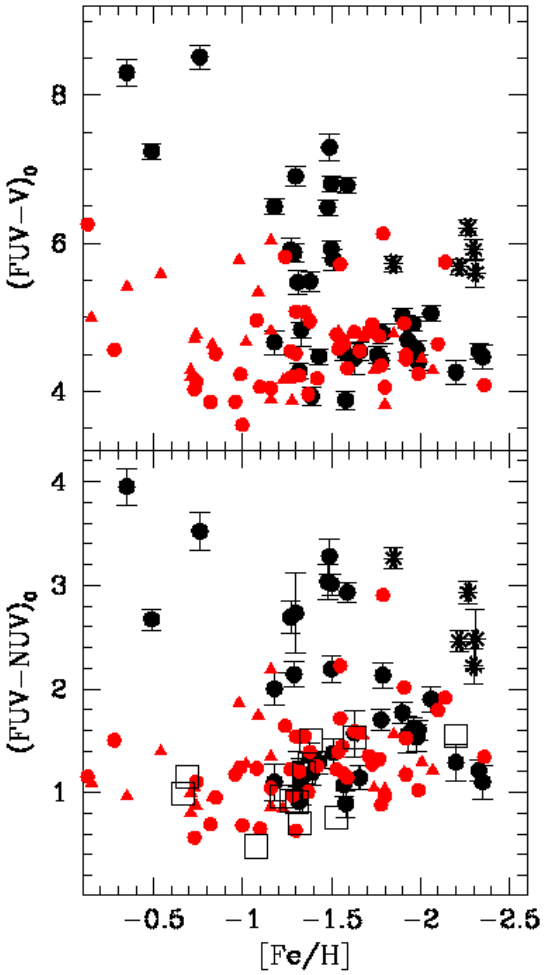
• blue HB stars tend to be Na-rich and O-poor

See Gratton et al. (2011, 2013) – Villanova et al. (2012)

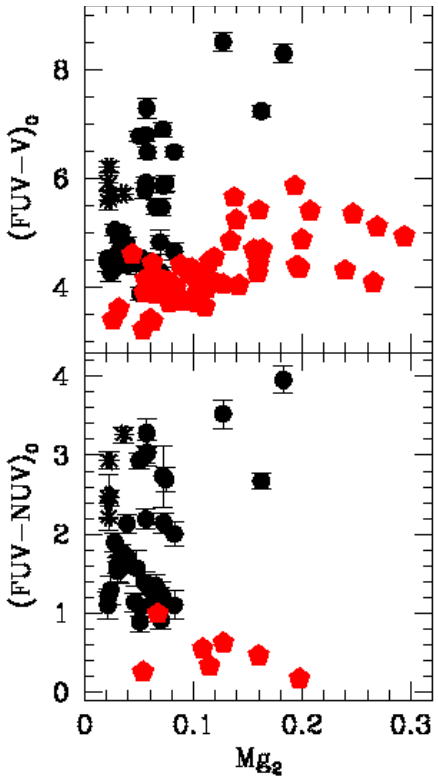
A comparison with the M31 and M87 GCs

Dalessandro et al. (2012)

On average M31 and MW GCs have the same UV colors

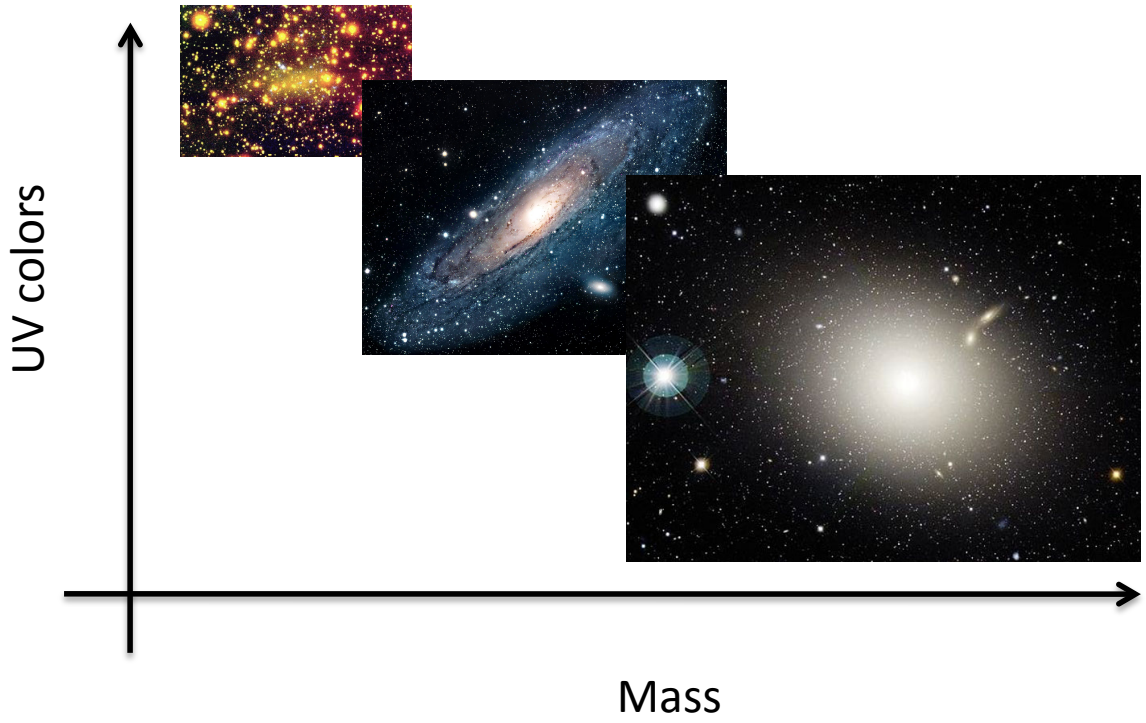


On average M87 GCs are bluer than GGCs



Mass really matters

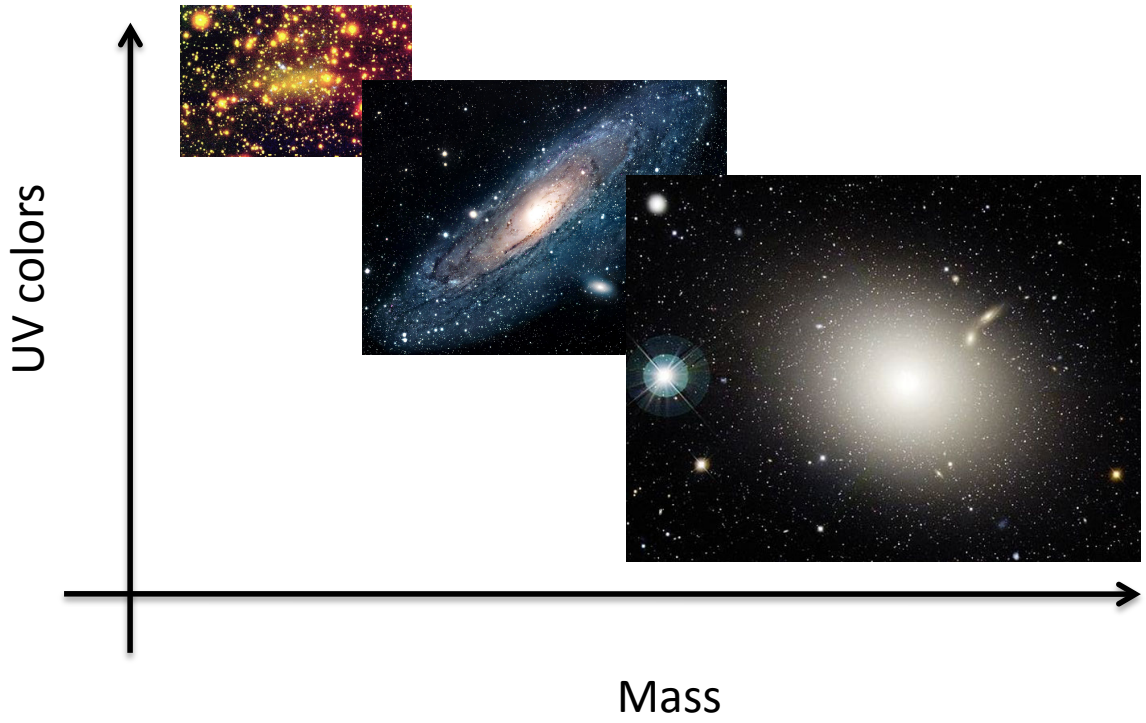
Dalessandro et al. (2012)



M(Sgr) =1.6x10^{8} M$_{sun}$ (Law & Majewski 2010)
M(MW)= 2.4x10^{11} <M$_{sun}$< 1.2x10^{12} (Little & Tremaine 1987)
M(M31)= 3.7x10^{11} <M$_{sun}$< 2.5x10^{12} (Cote' et al. 2000)
M(M87)=1.7x10^{13} <M$_{sun}$< 4x10^{13} (Fabricant et al. 1980)

Mass really matters

Dalessandro et al. (2012)



UV colors of GC systems get bluer as the mass of the host galaxy increases

Summary

- We combined UV HST and GALEX data for a sample of GGCs with the aim to link resolved to integrated properties

- We have introduced a new approach for the analysis of the HB which is based on a detailed comparison between observed and synthetic HBs in UV bands

- He content has a strong impact in shaping the HB of old stellar populations (see the cases of of NGC 2808 and M 3-M 13)

- We observe a general correlation between UV colors of GCs and mass of the host galaxies

- Differences might be linked to the survival rate of GCs in different environments

Thank you!

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