UV PROPERTIES OF GALACTIC GLOBULAR CLUSTERS WITH GALEX

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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

GGCs are the best laboratory

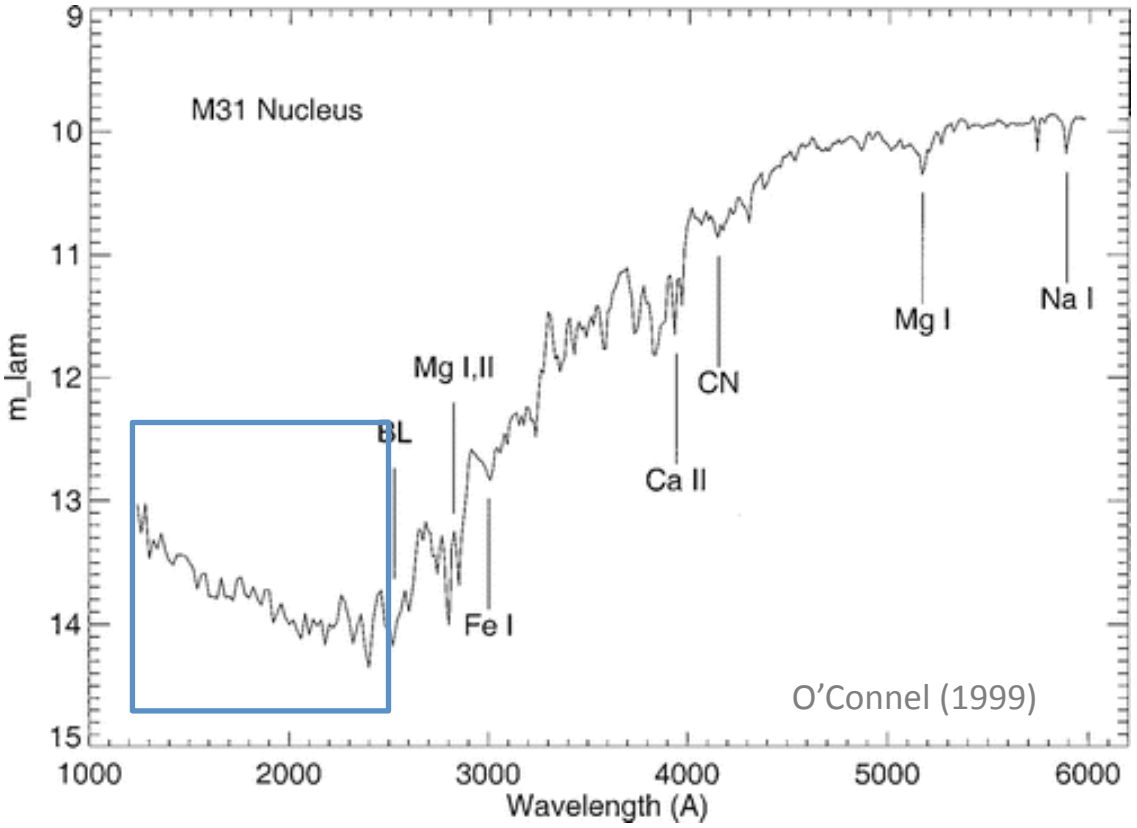
Detailed knowledge of the underlying stellar population

Integrated properties

Why an UV survey?

The UV upturn

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.

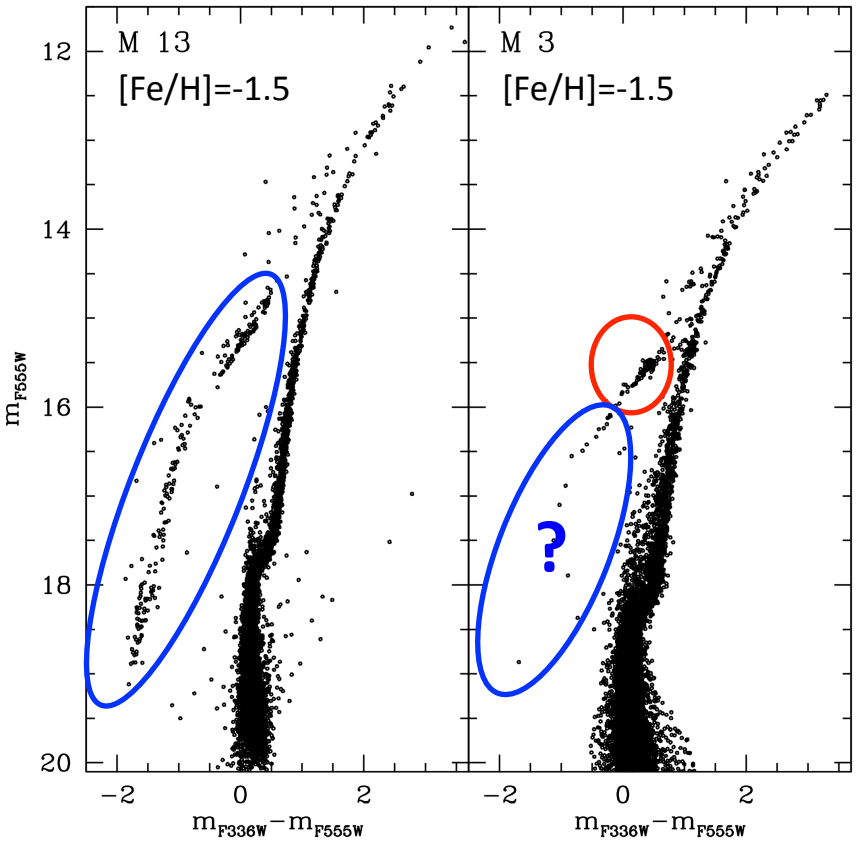


Hot stars have been suggested to be responsible of the UV upturn in the spectrum of elliptical galaxies and bulges

(Greggio & Renzini 1990)

Why an UV survey?

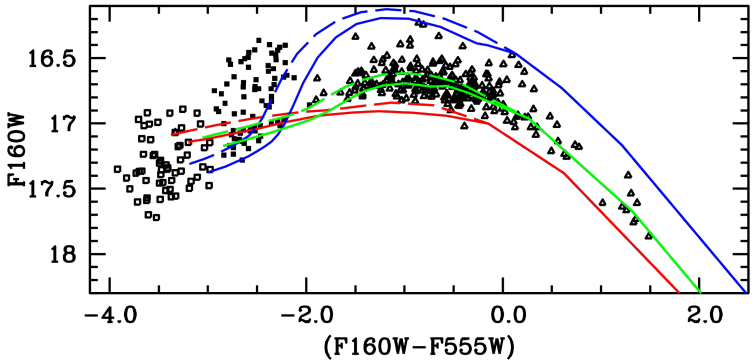
Looking for the HB second parameter



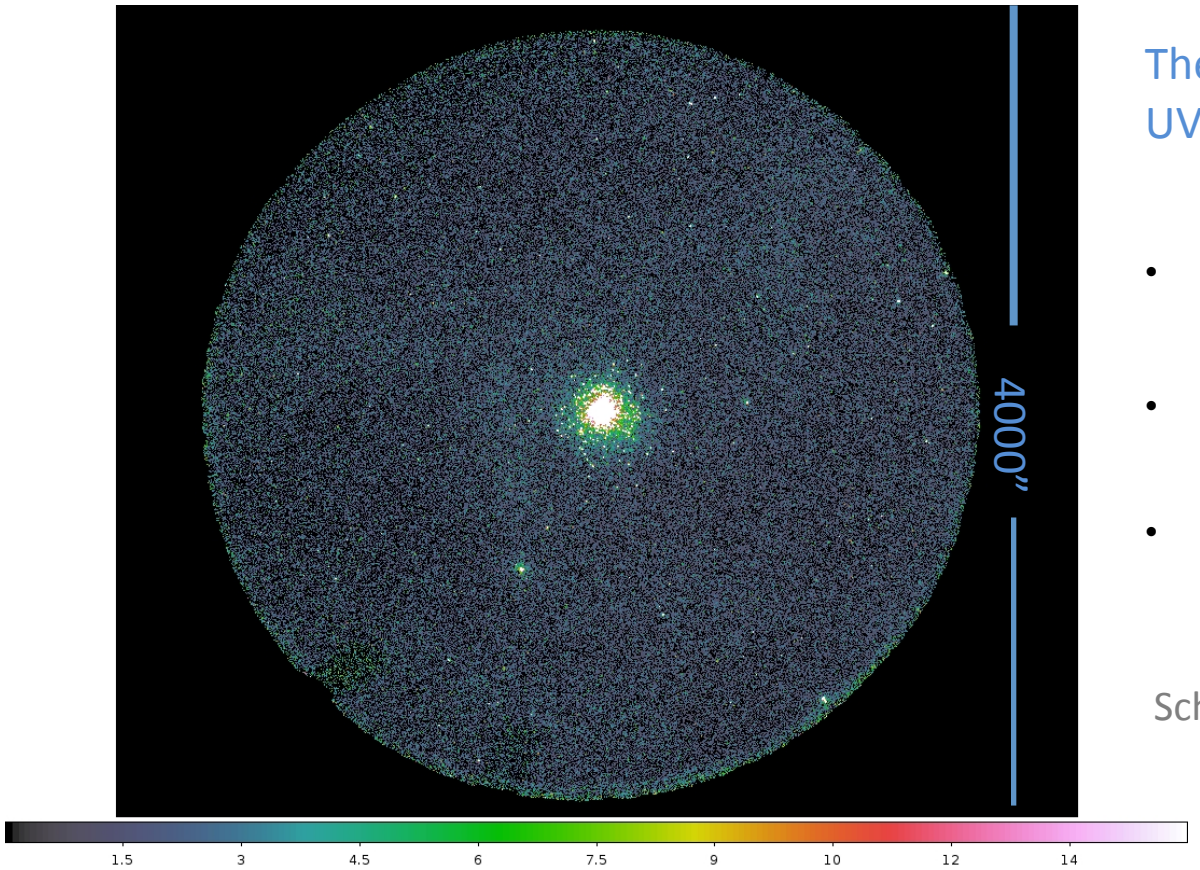
Caloi & D'Antona 2005

For a review Catelan 2009,
Gratton et al. 2010; Dotter et al. 2010

UV CMDs are ideal for comparison with theoretical models



Dalessandro et al. 2011

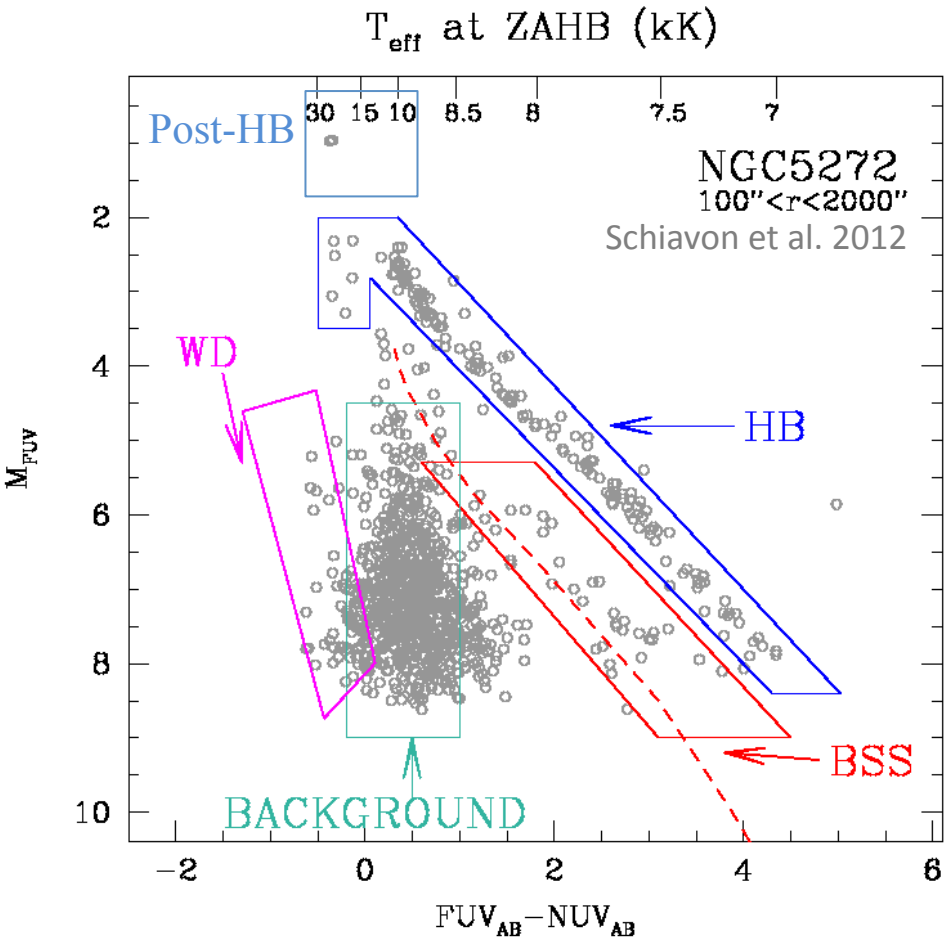


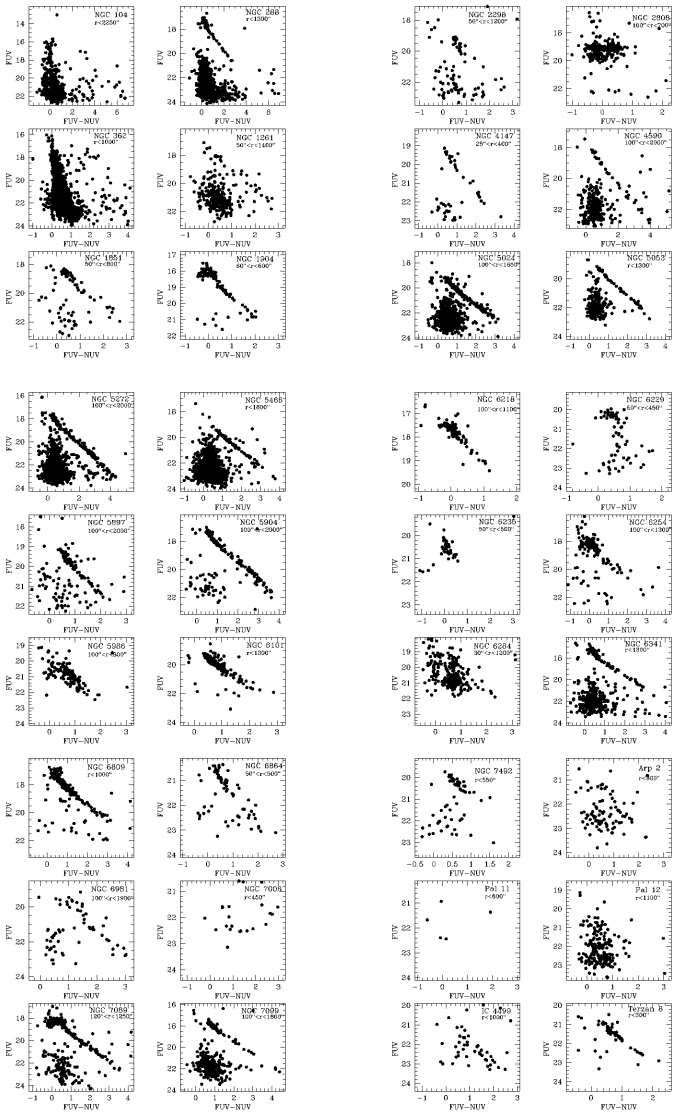
The largest homogeneous dataset of UV GGCs ever collected

- 87 images (44 FUV + 43 NUV)
  For a total exp time ~400Ks (230 orbits)
- Wide range of metallicities
  (NGC5053 -2.3 <[Fe/H]<-0.4 Pal 11)
- Almost complete coverage of GGCs’ structural parameters space

Schiavon et al. 2012; Dalessandro et al. 2012

Resolved properties: UV CMDs





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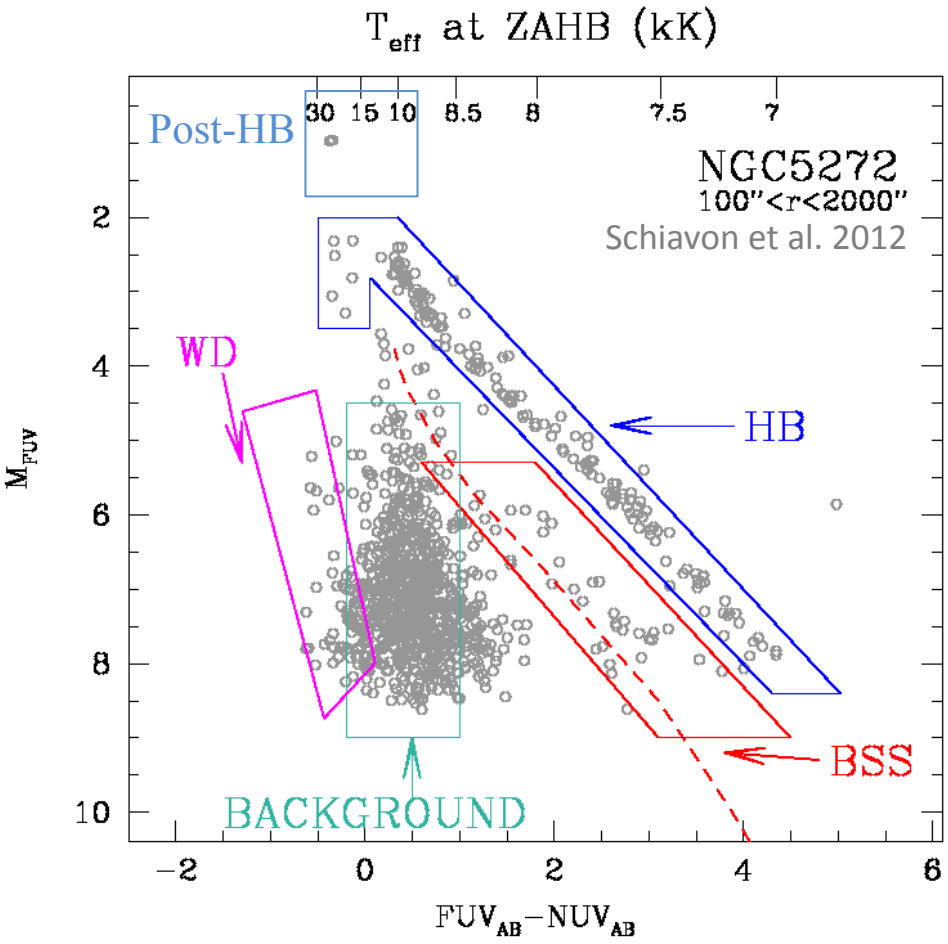
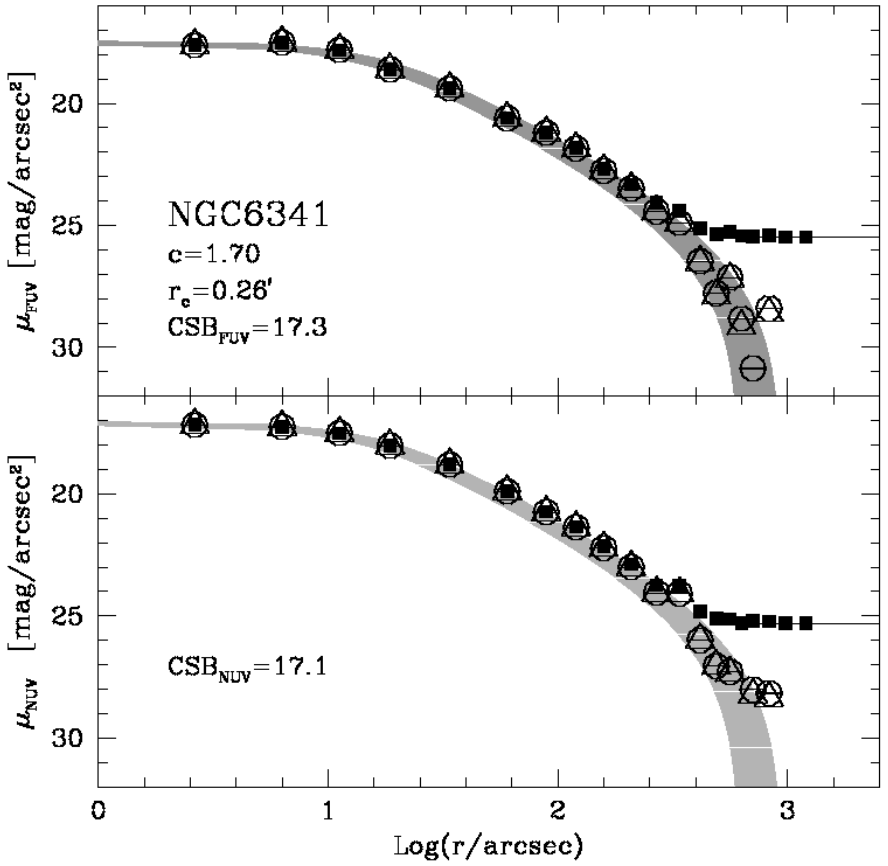


A complementary database of HST UV images

(GO11975 – PI: Ferraro)

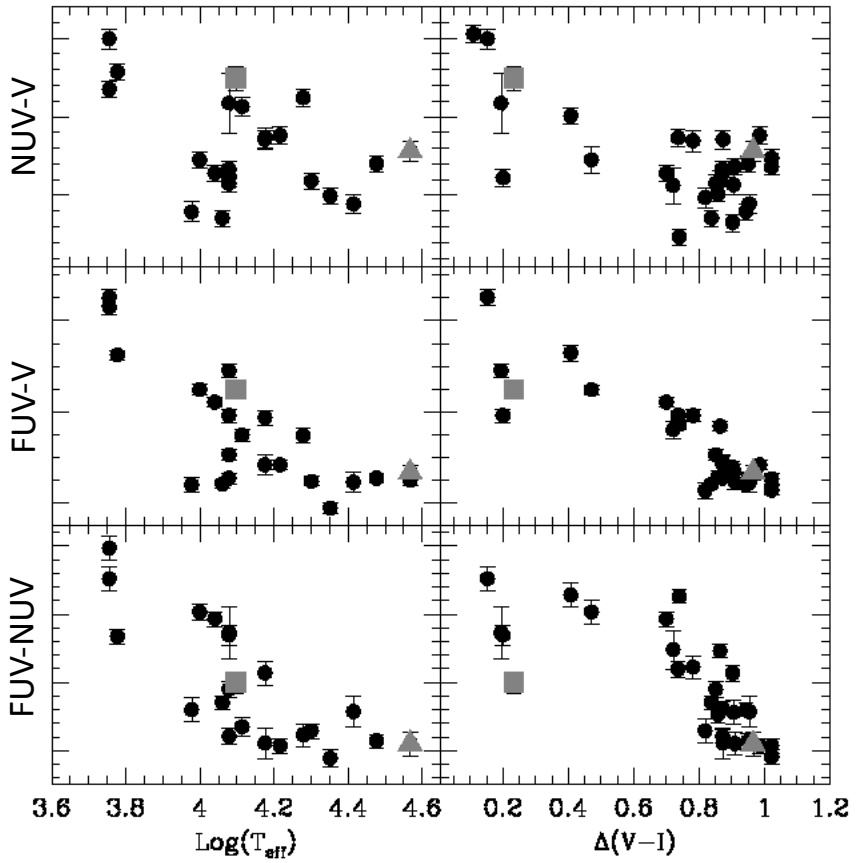
SEE POSTER BY SANNA & CONTRERAS

Integrated Colours



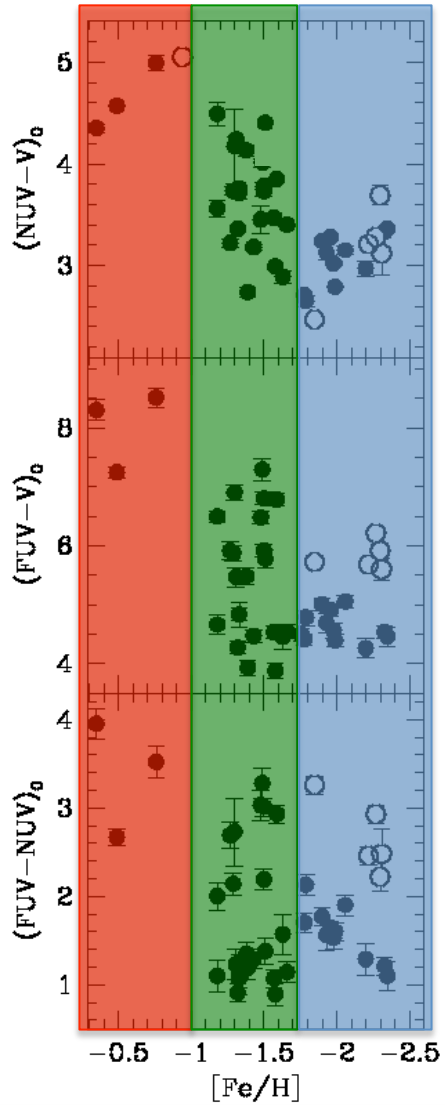
(McLaughlin & van der Marel 2005)

UV colors trace HBs and their progeny



Recio Blanco et al. 2009; Dotter et al. 2010

UV colours and metallicity



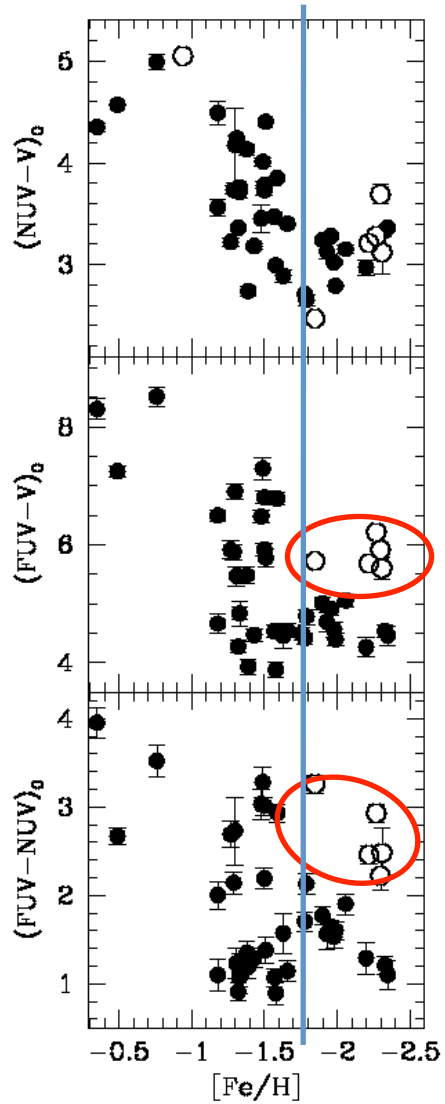
- There is a general correlation with metallicity
- Maybe three sub-groups
- Bluest colours around [Fe/H]~-1.5

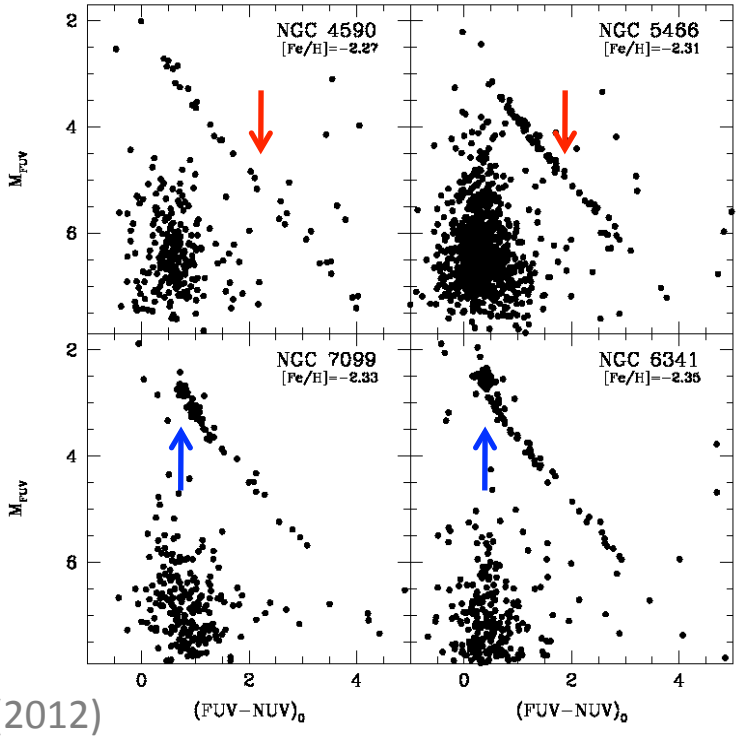
Metal-rich and red clusters

Second-parameter region

Metal-poor and blue clusters

The Sagittarius clusters



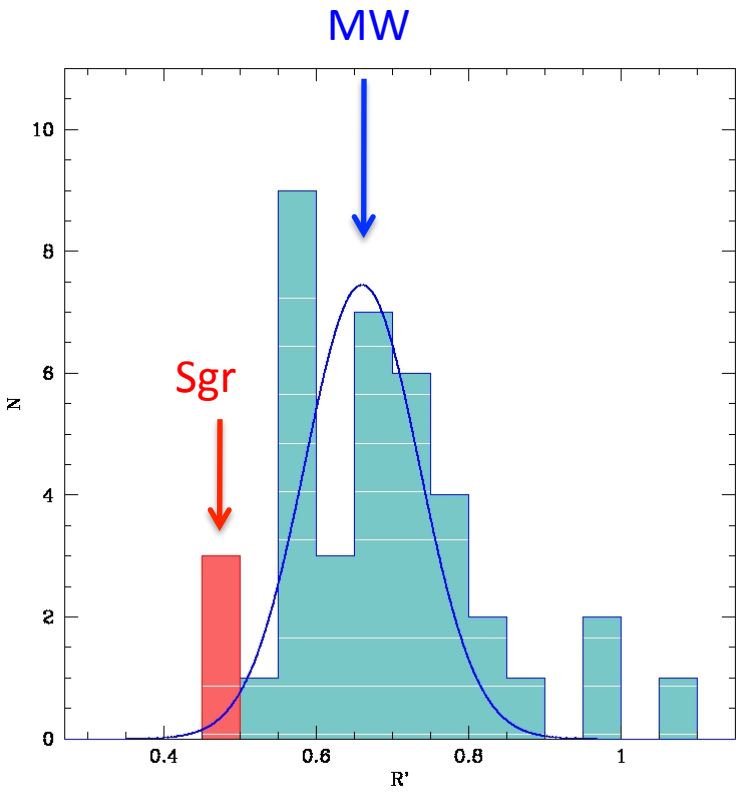


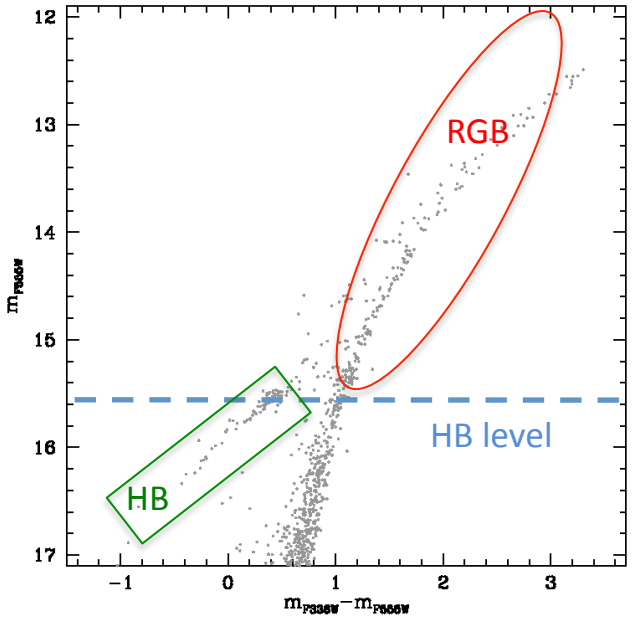
Dalessandro et al. (2012)

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

$$R = \frac{N_{HB}}{N_{RGB}}$$





<R'(Sgr)>=0.48±0.01 <R'(MW)>0.74±0.18

A t-test between these mean values gives a P~99.9% that they are different

See also Perina et al. 2012; Fusi Pecci et al. 1993

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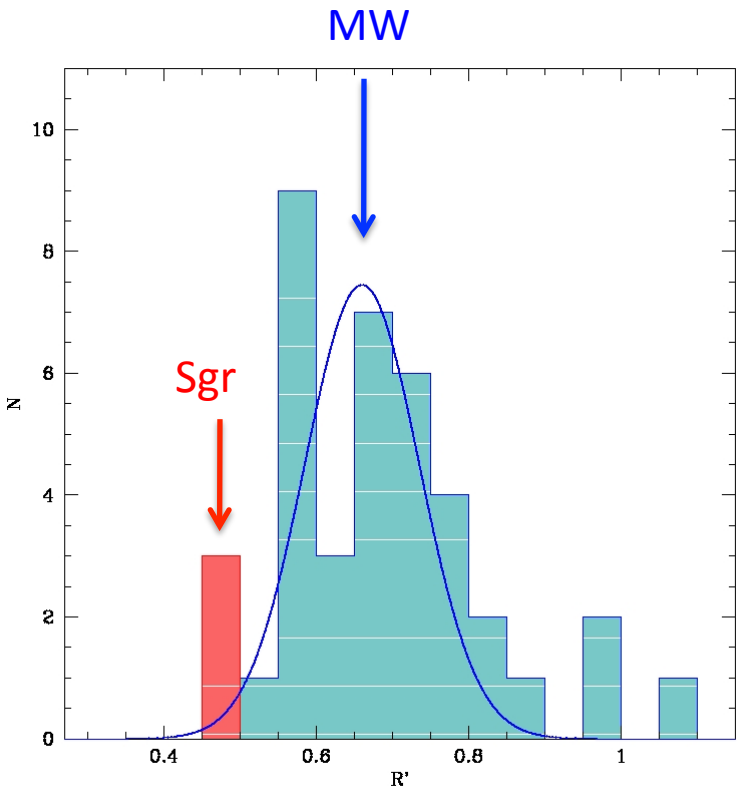

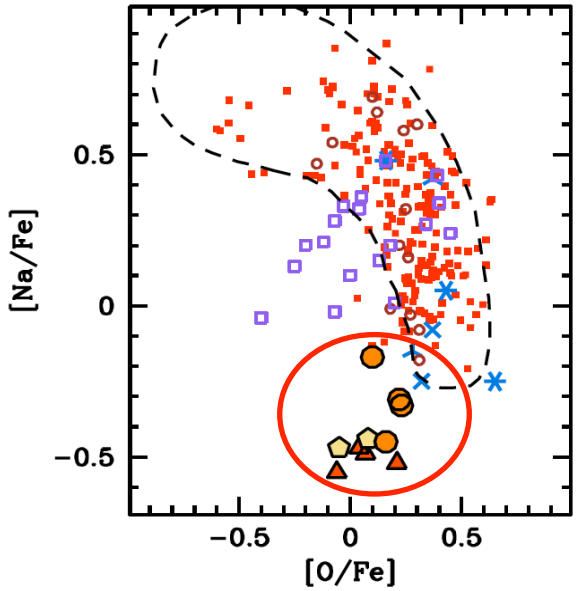

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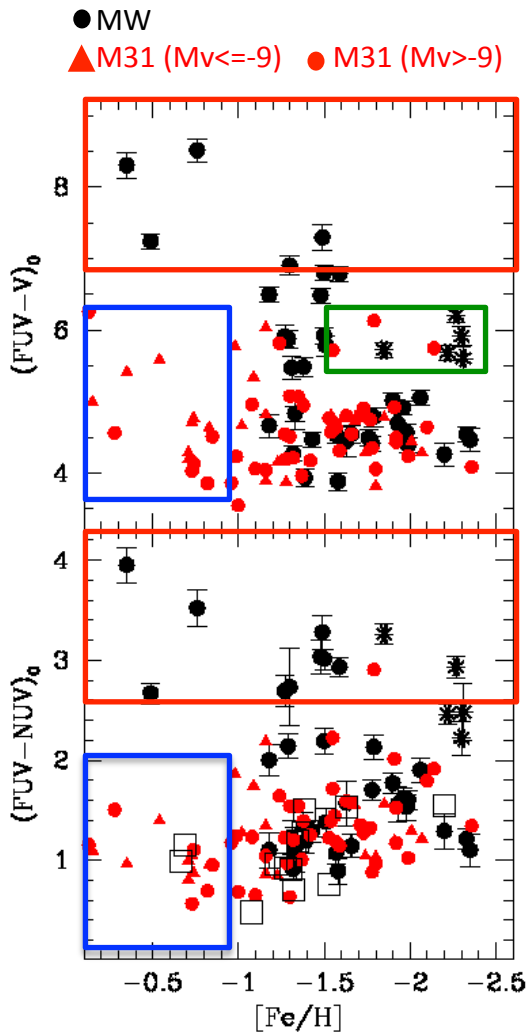
A comparison with the M31 GCs



Selection of "old" M31 clusters with E(B-V)<0.16
(Fusi Pecci et al. 2005, Rey et al. 2007, Caldwell et al. 2011)

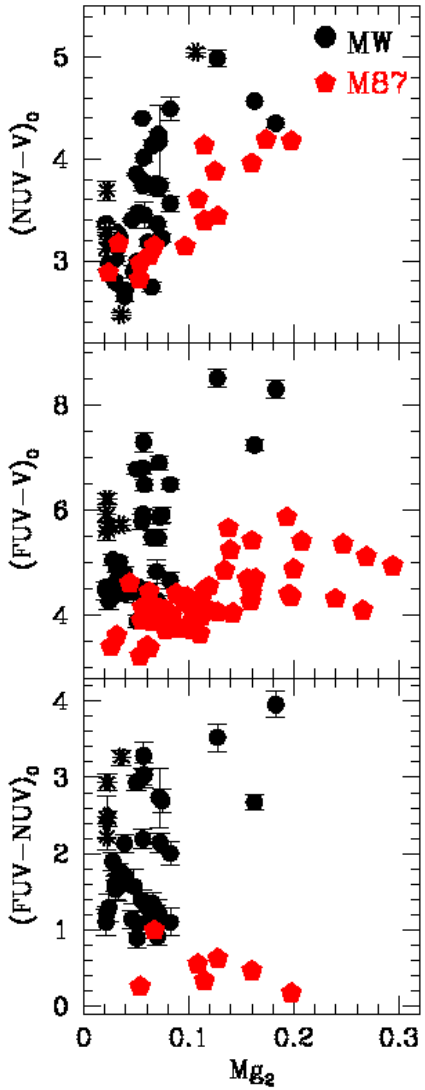
On average M31 and MW GCs have the same UV colors

Lack of red clusters due to detection limits

Blue metal-rich M31 GCs with only two know counter-part in the MW (NGC6388 and NGC6441)

3 M31 GCs in the same region as Sgr stream GCs (G327, B009 and B366; Perina et al. 2009)

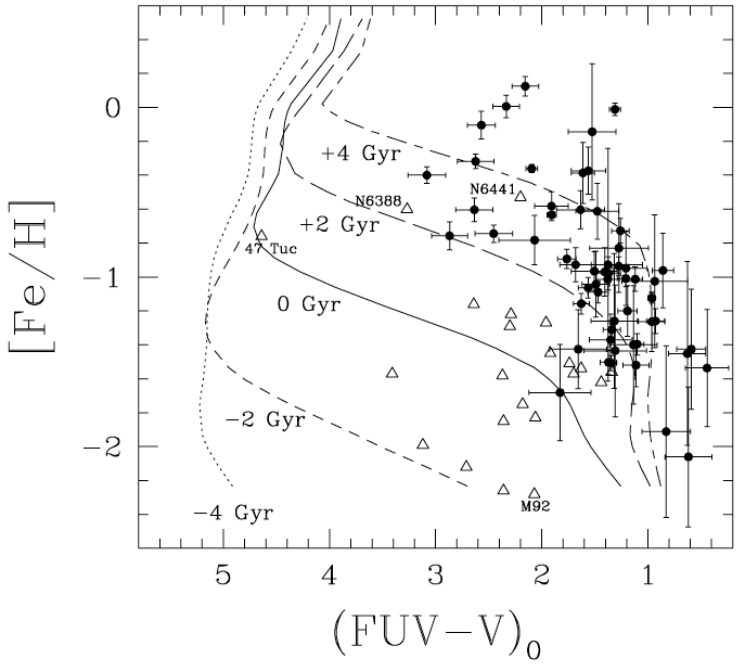
A comparison with the M87 GCs



UV colors from STIS@HST (Sohn et al. 2006)

Mg_2 for MW GCs by empirical relations (Sohn et al. 2006)

M87 GCs are on average bluer of ~1mag in color combinations involving FUV



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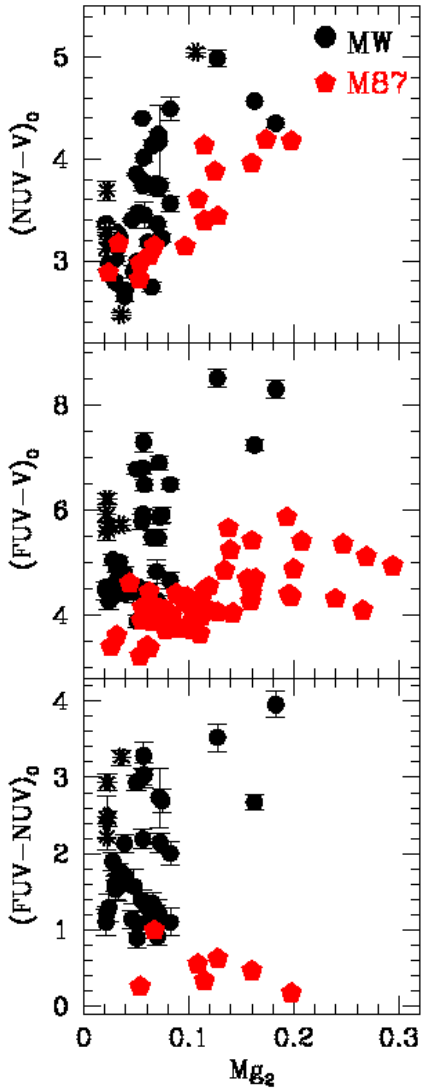
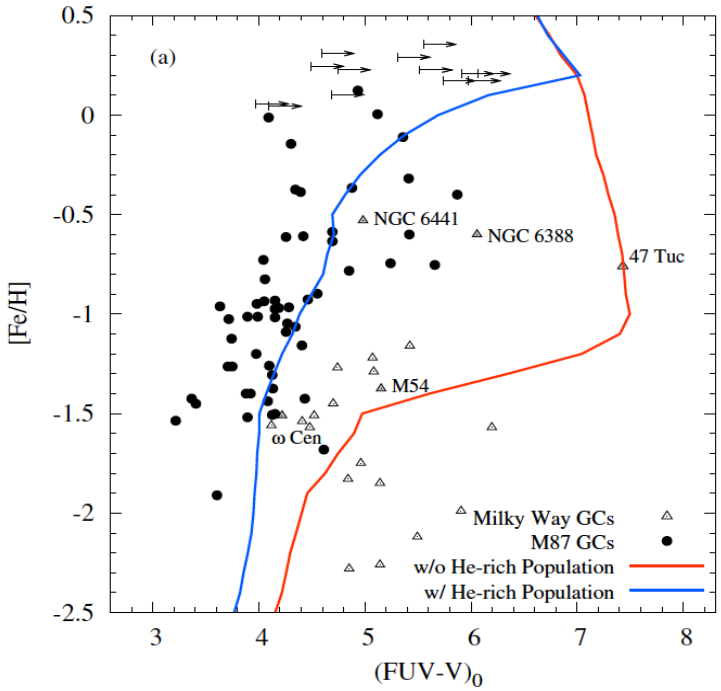
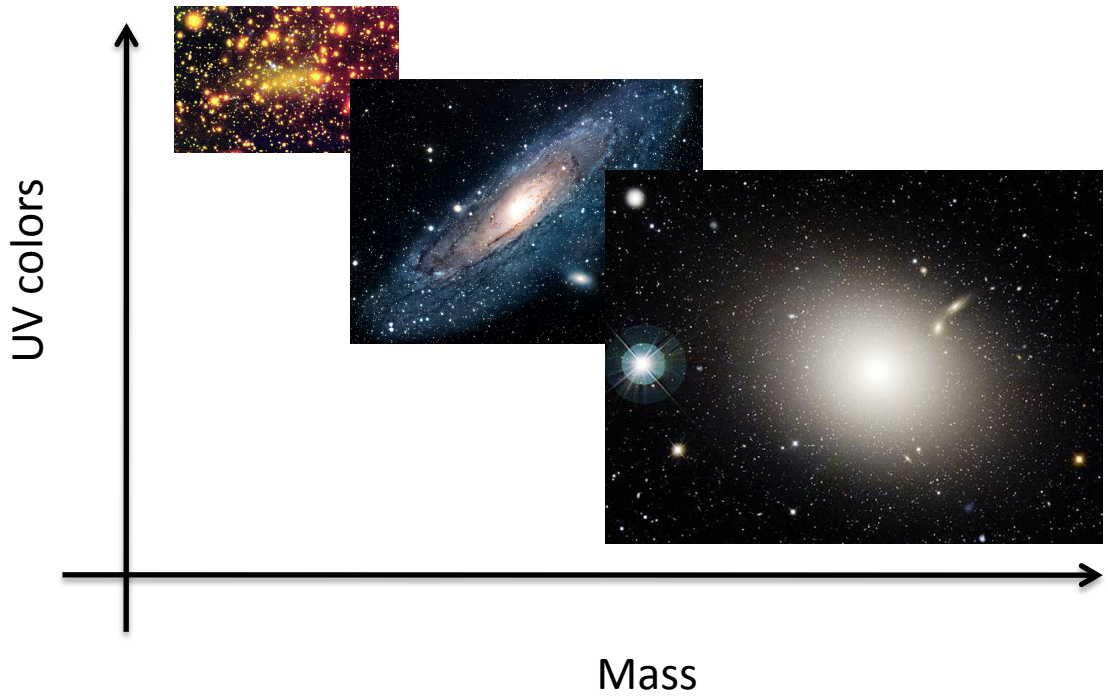


Are M87 clusters 16Gyr old!?!?
The use of UV colors to derive age is DANGEROUS!



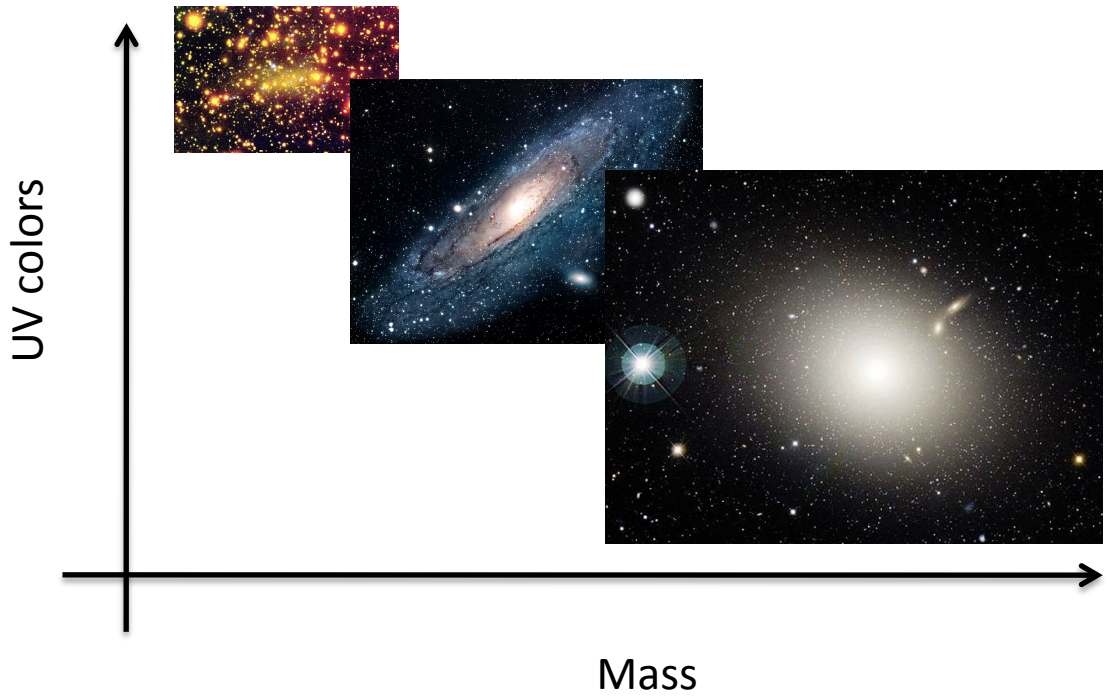
Chung et al. 2011; Lee et al. 2002

Mass really matters



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



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

GCs in more massive galaxies are likely to undergo more complex history of star formation (Valcarce & Catelan 2011)

Summary

- We have built the largest homogeneous UV catalog for GGCs, spanning a wide range of metallicities, HB and structural parameters.

- Assumptions about He abundances have strong impact on age determination in unresolved stellar systems ($\Delta Y \sim 0.05$ gives $\Delta t \sim 2$Gyr)

- GCs connected with the Sgr stream are redder than pure MW GCs with same age and metallicity

- M31 GCs behave like MW ones

- M87 GCs are systematically bluer

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

Thank you!

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