The double RGB in M2 seen through MODS spectroscopy

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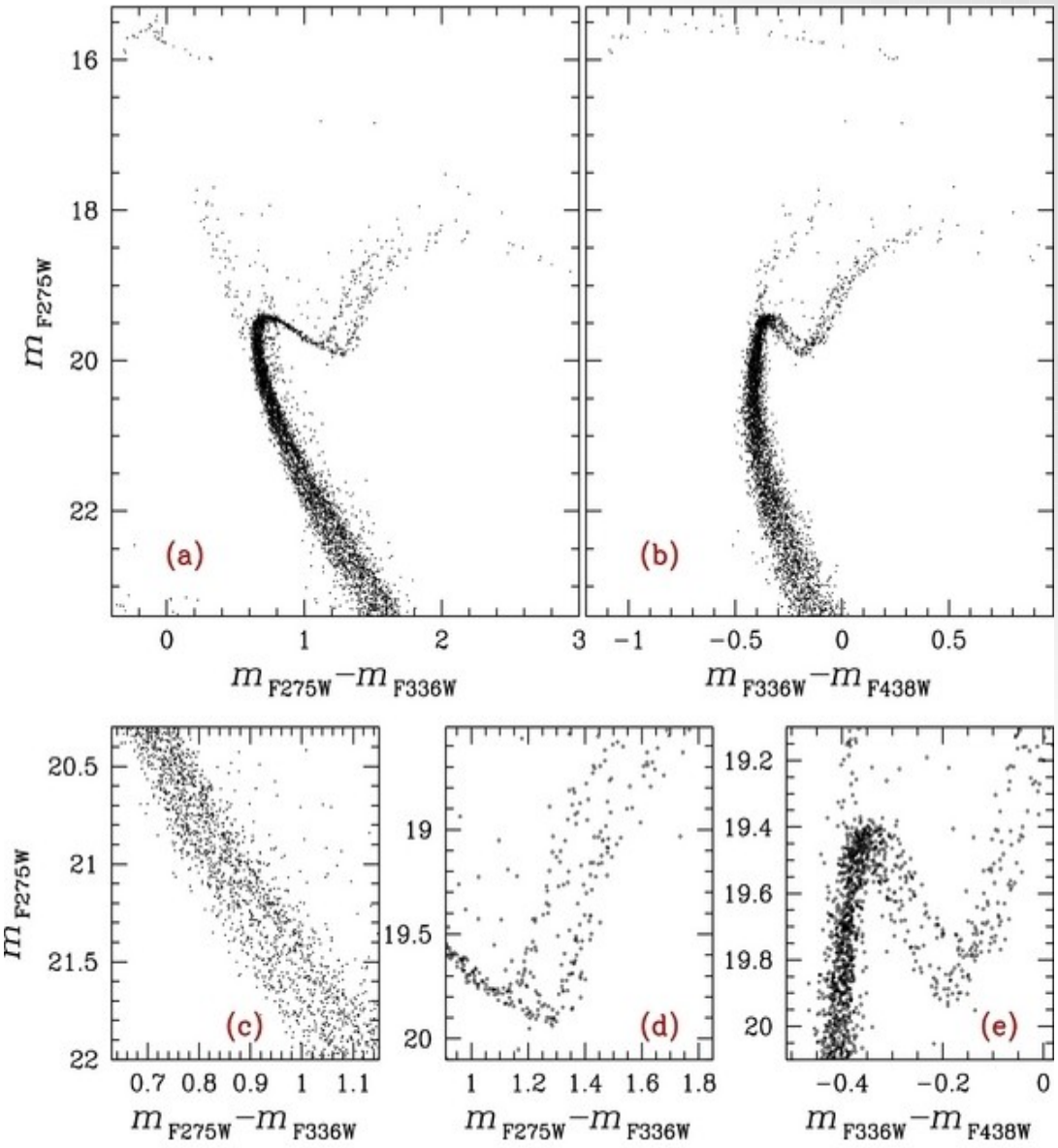
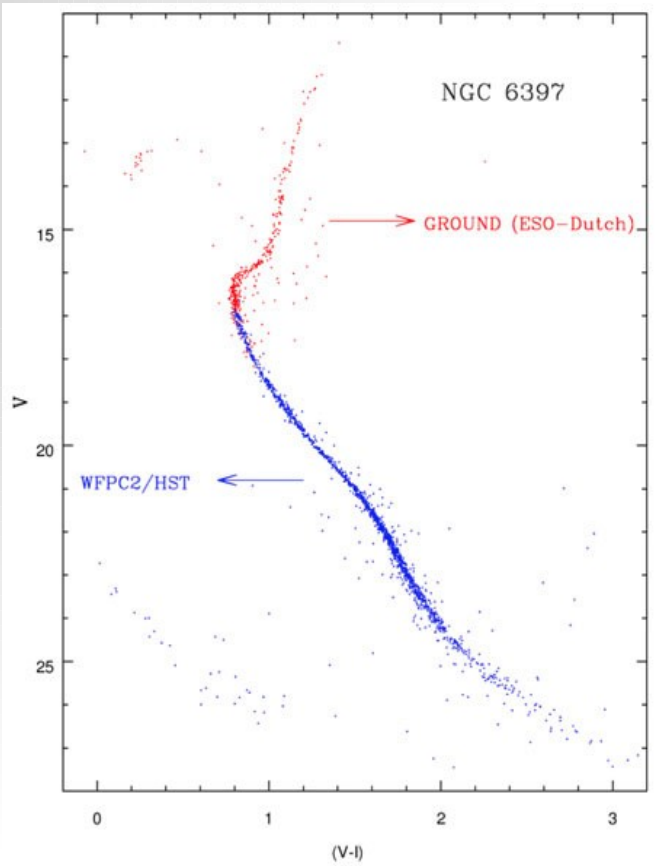
The photometric evidence of MPs

NGC 288 Piotto et al. 2012





NGC 6397 Piotto et al. 2007

The spectroscopic evidence of MPs

Stars **depleted** in C and **enhanced** in N are also **depleted** in O and Mg and **enhanced** in Na and Al !

Lick + Mc Donald

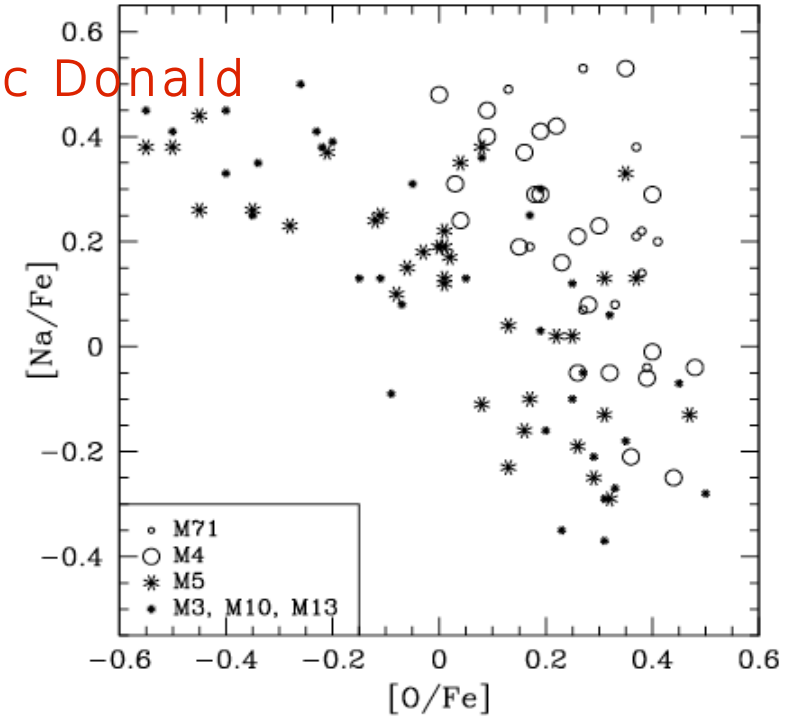
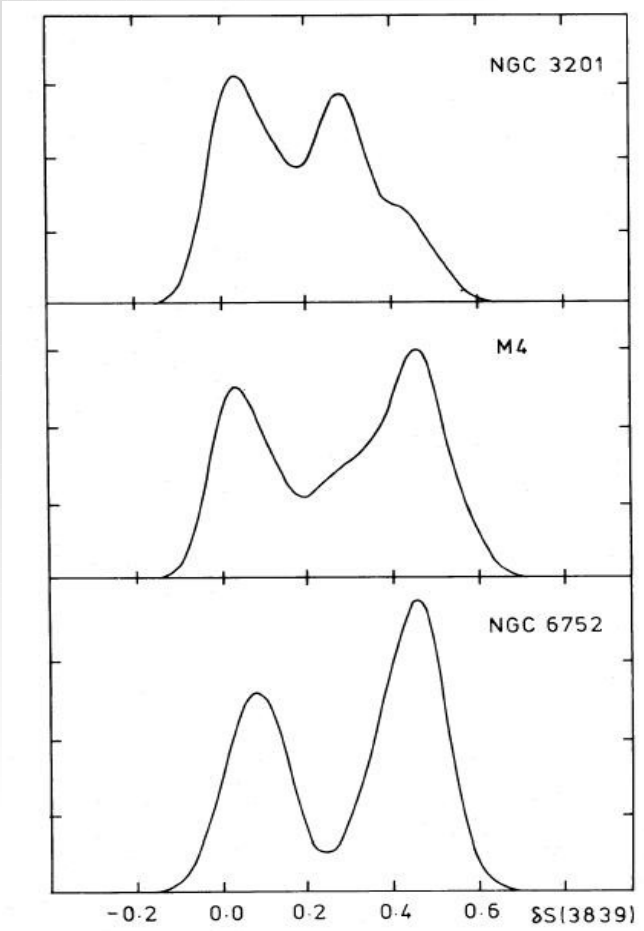


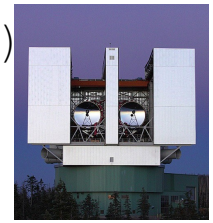
FIG. 16.—[Na/Fe] vs. [O/Fe] plots for M5 and M4 and globular clusters previously studied by the Lick-Texas group that bracket M5 and M4 in metallicity. The abundance ratio anticorrelation is divided into two groups, and the symbols are chosen accordingly, one for the M4-like clusters and one for the M5-like clusters.



Smith & Norris (1982)

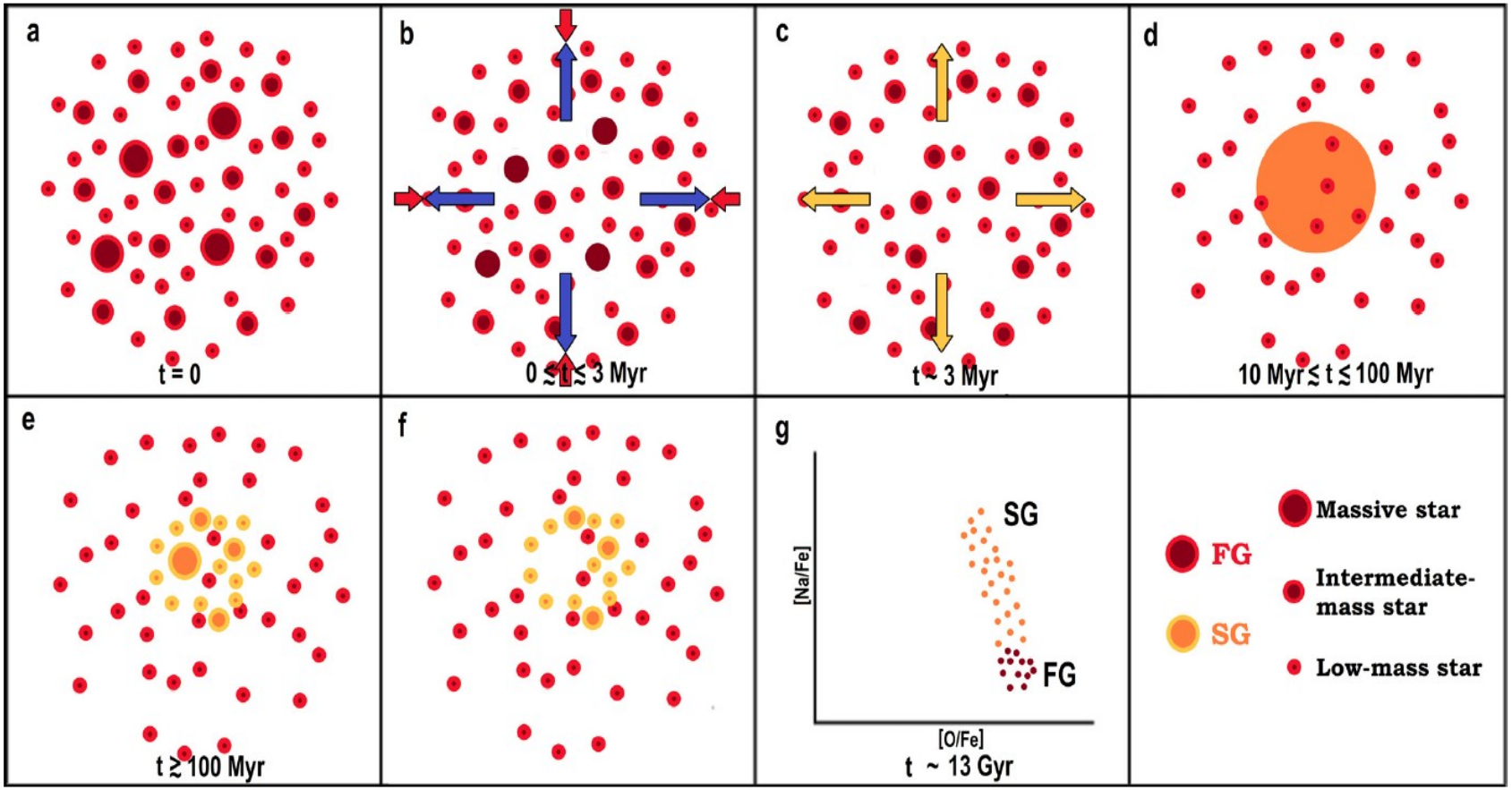
... but generally no spread in iron!

High-temperature H-burning (CNO, NeNa, MgAl cycles)

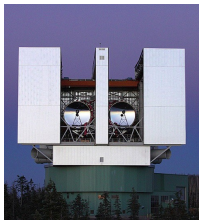


New chemical enrichment

Valcarce & Catelan 2011



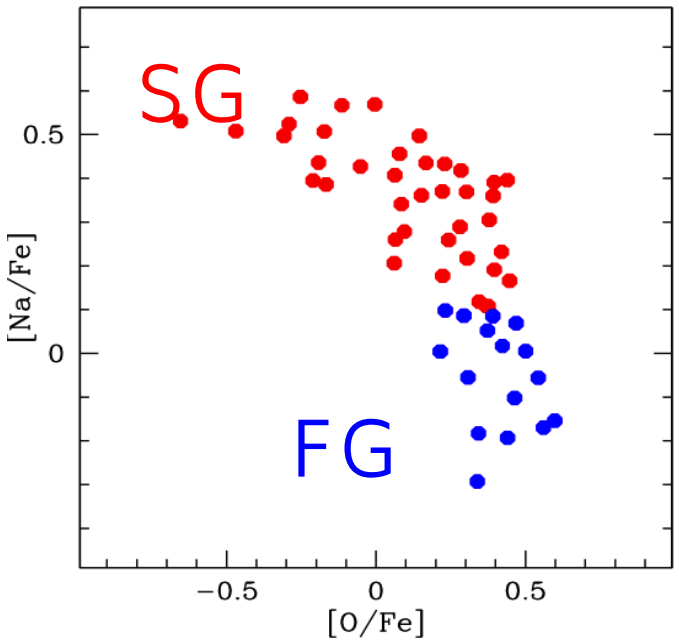
This peculiar chemical pattern must be originated in a previous generation of more massive stars in the first few hundred Myr of the cluster life, that polluted the gas from which second generation stars formed, modifying light element content but not contributing IRON!

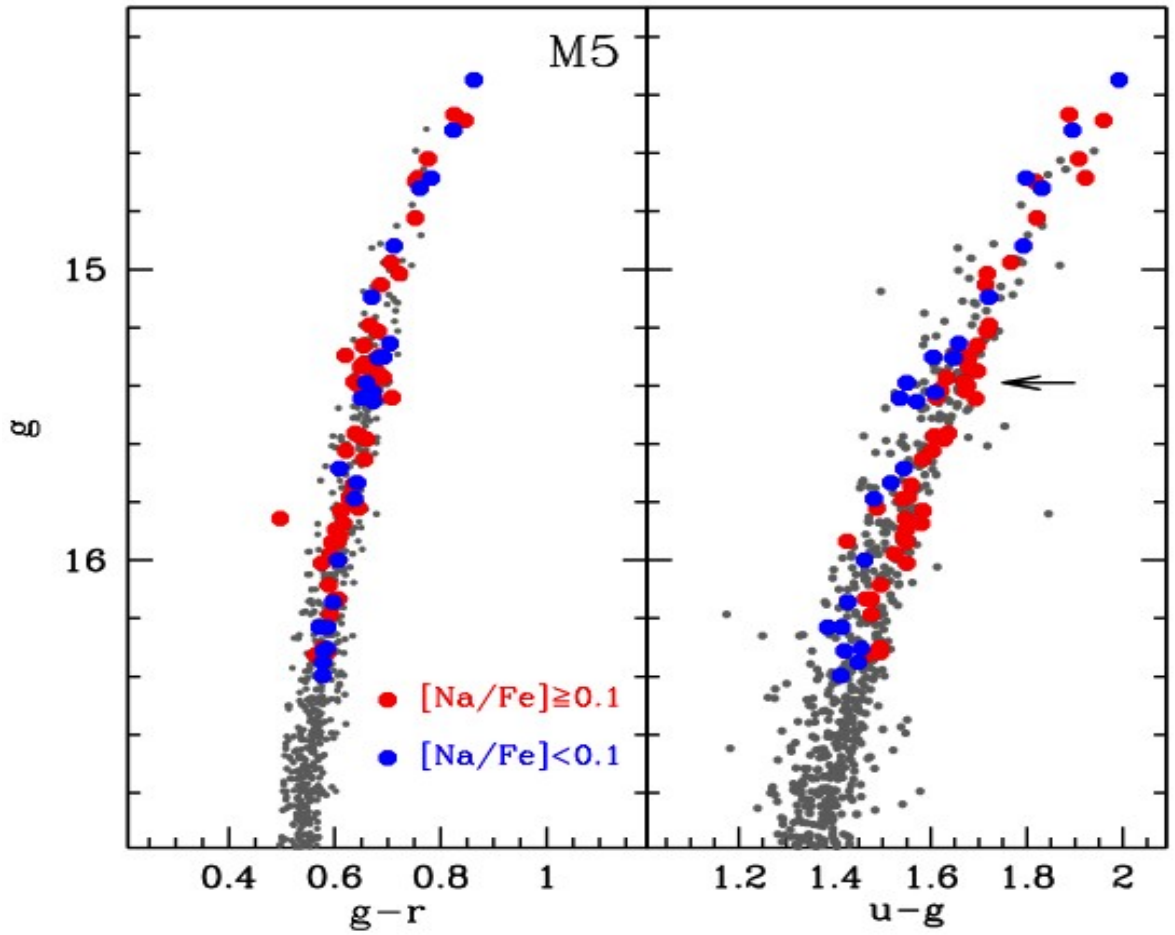


UV photometry and light element abundances

Lardo et al. 2011

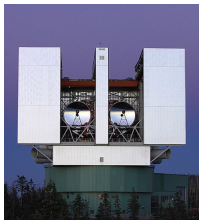
ugr SDSS photometry from An et al. (2008) public catalog



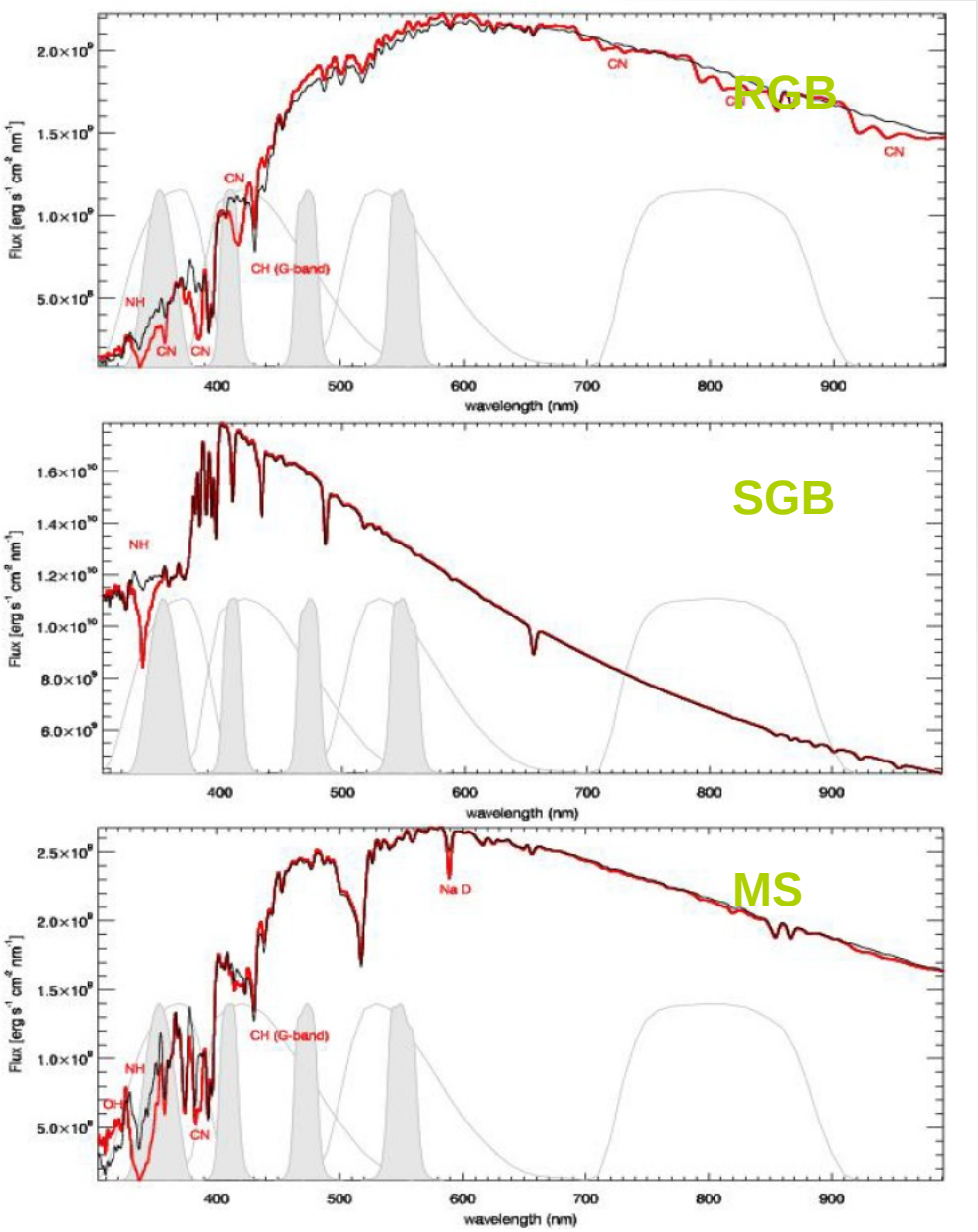


FG stars CN-weak, Na-normal

SG stars CN-strong, Na-rich



UV photometry and light element abundances



[Fe/H] = -1.62 Y = 0.246

1st generation star (black):

standard a-enhanced mixture

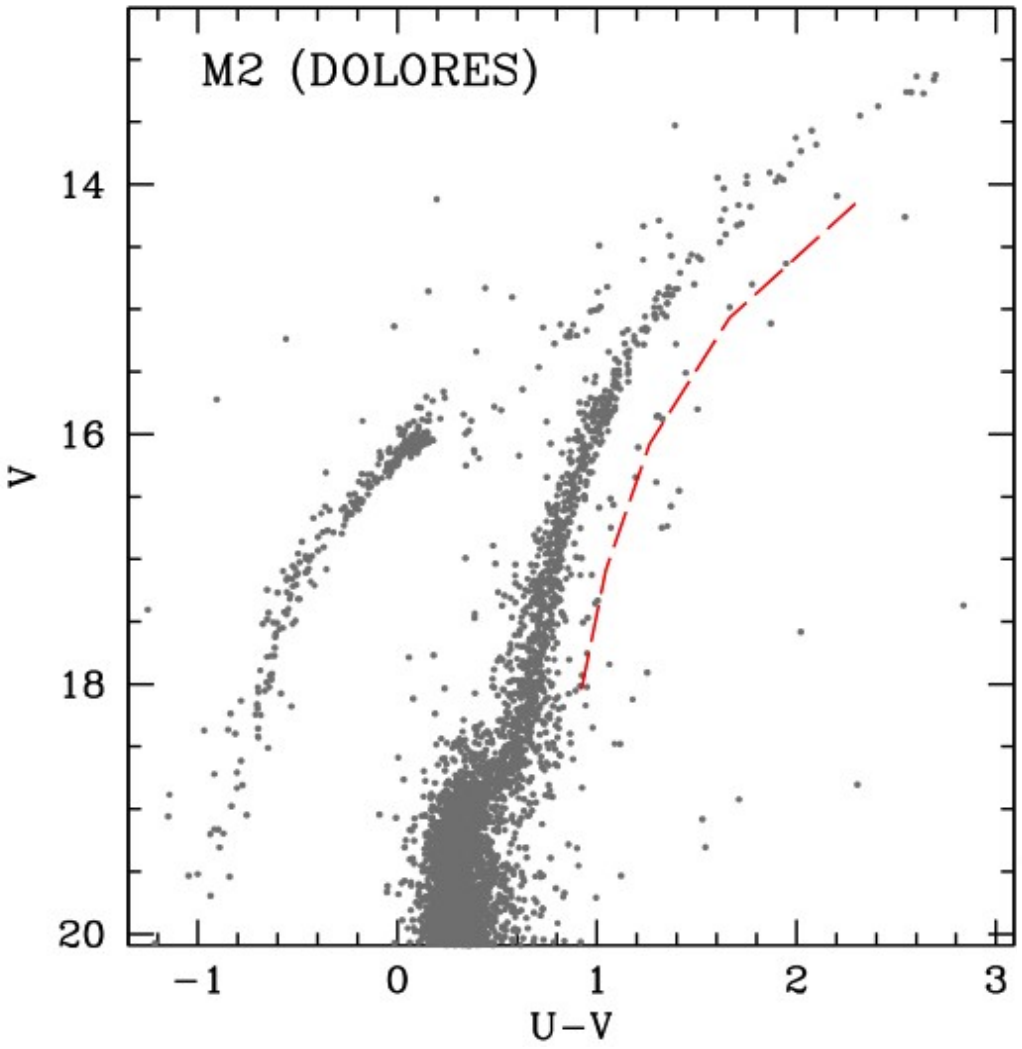
2nd generation ref star (red):

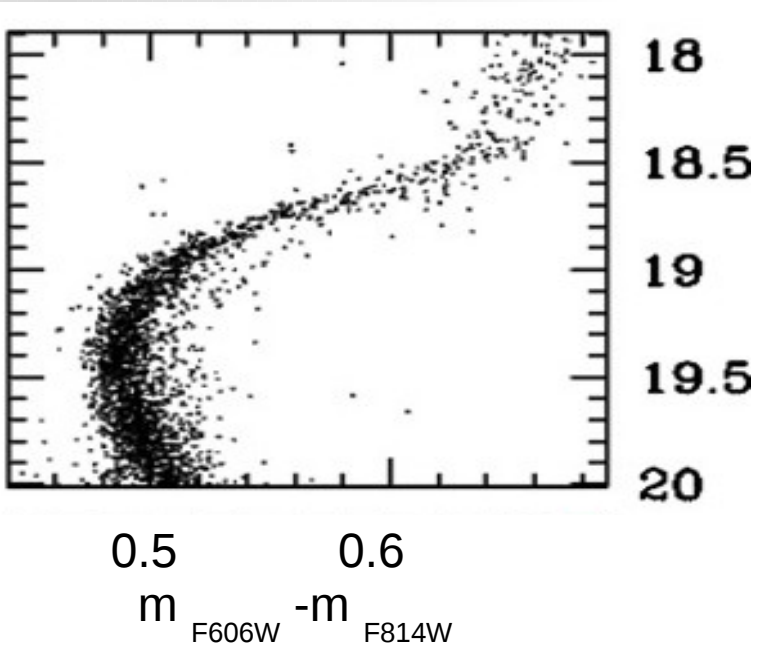
N + 1.8 dex (by mass)
Na + 0.8 dex
C -0.6 dex
O -0.8 dex

Sbordone+ 11

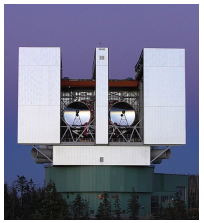
The discovery of a red RGB in M 2

Lardo et al. 2012b



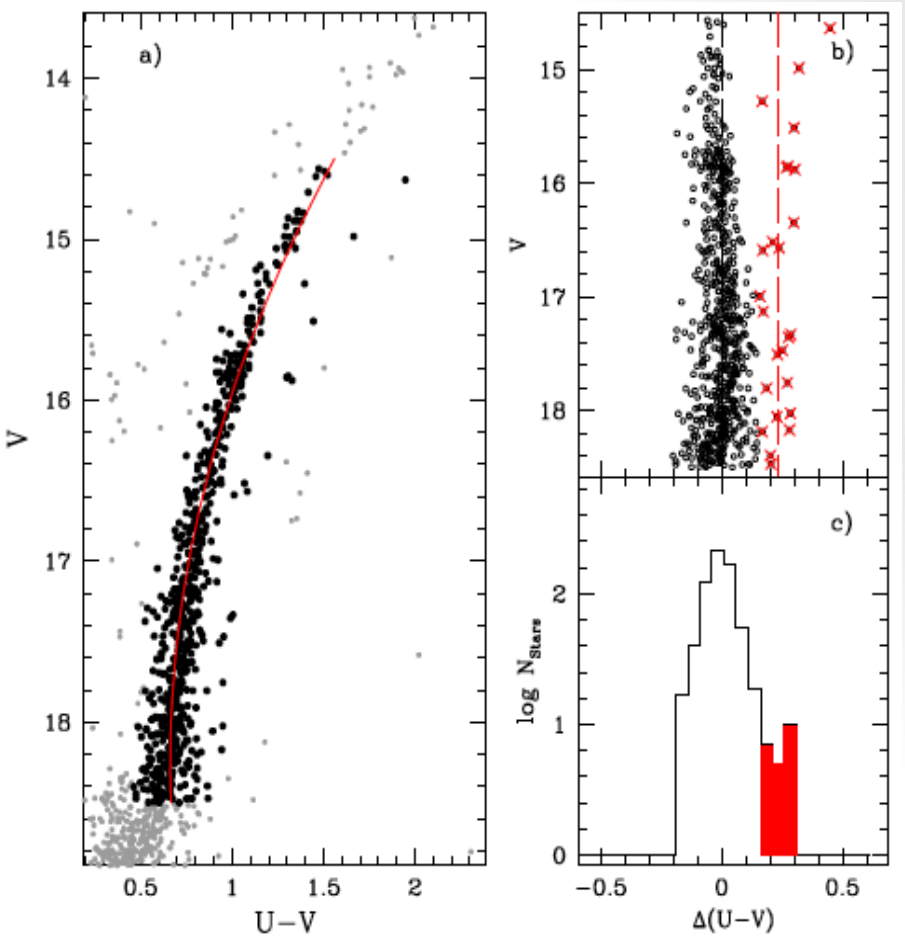


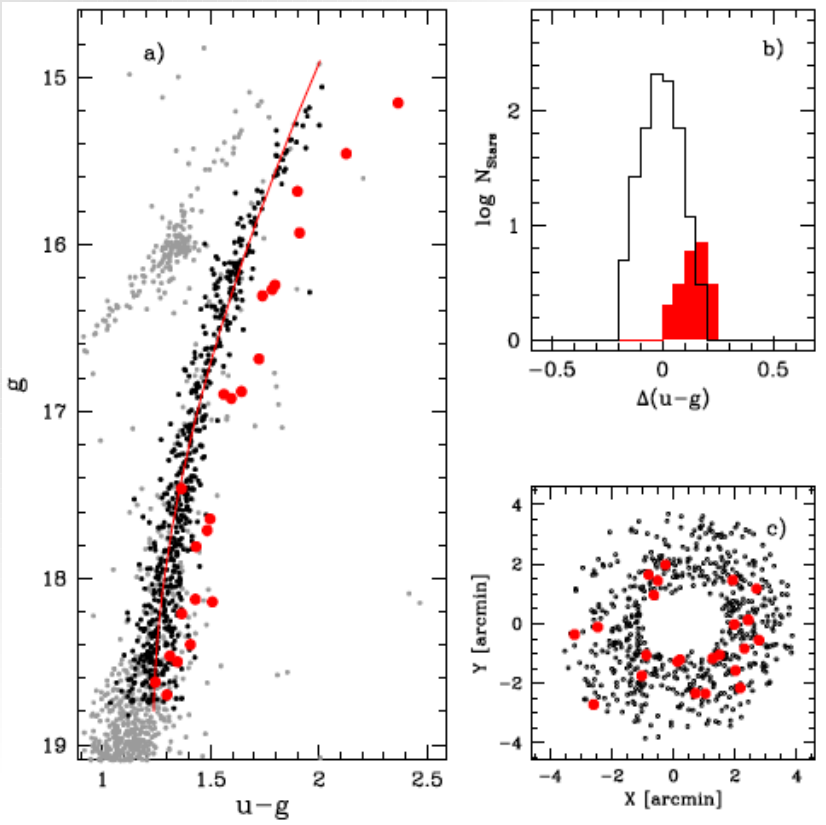
Piotto et al. 2012



The discovery of a red RGB in M 2

NOT high interstellar absorption E(B-V) = 0.06
SMALL annular field 1' < R < 4'
Contamination less than 1%

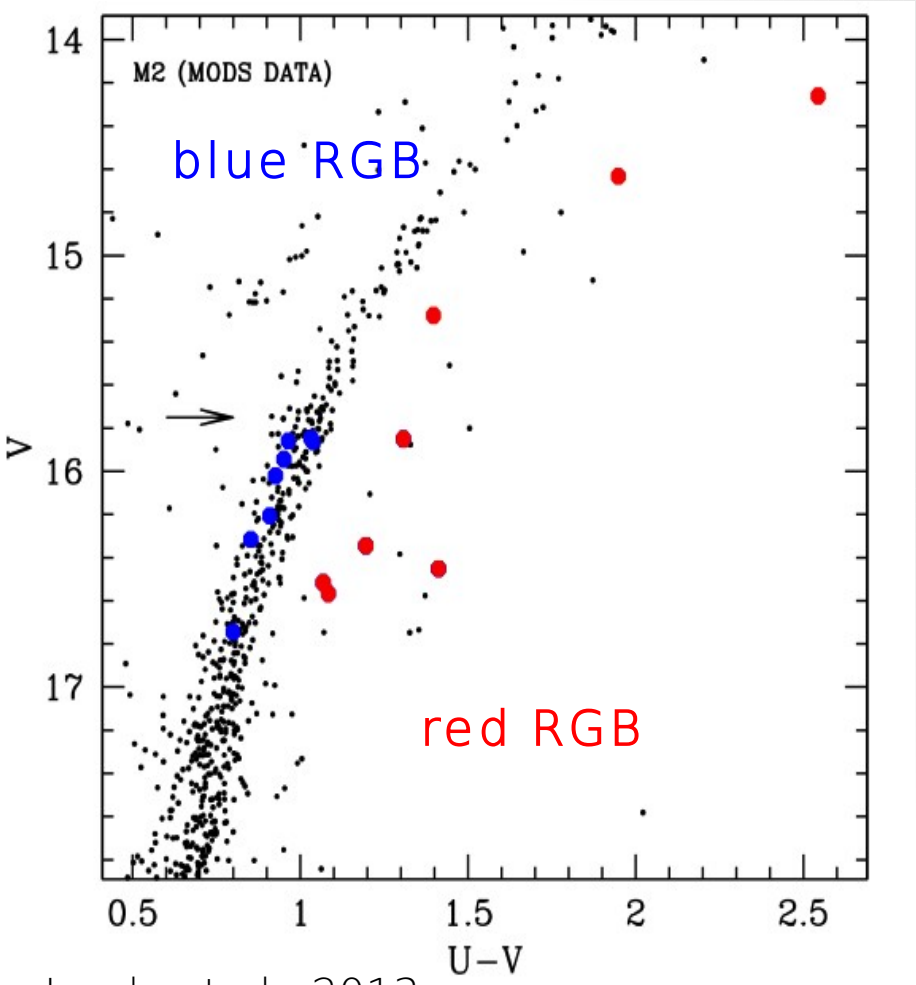




Lardo at al. 2012b

M 2: characterizing the red RGB with MODS

MODS@LBT SPECTRA 15 low-res spectra of RGB stars (PI: C. Lardo)



Lardo et al. 2013

6 x 6 arcmin^2 FoV
400 line mm^{-1} reflection grating (3200–5800 Å)
R ~ 800, 950 and 1030 at 3360, 4000 and 4300 Å.

slit width 1.0 arcsec,
sllit length 12 arcsec

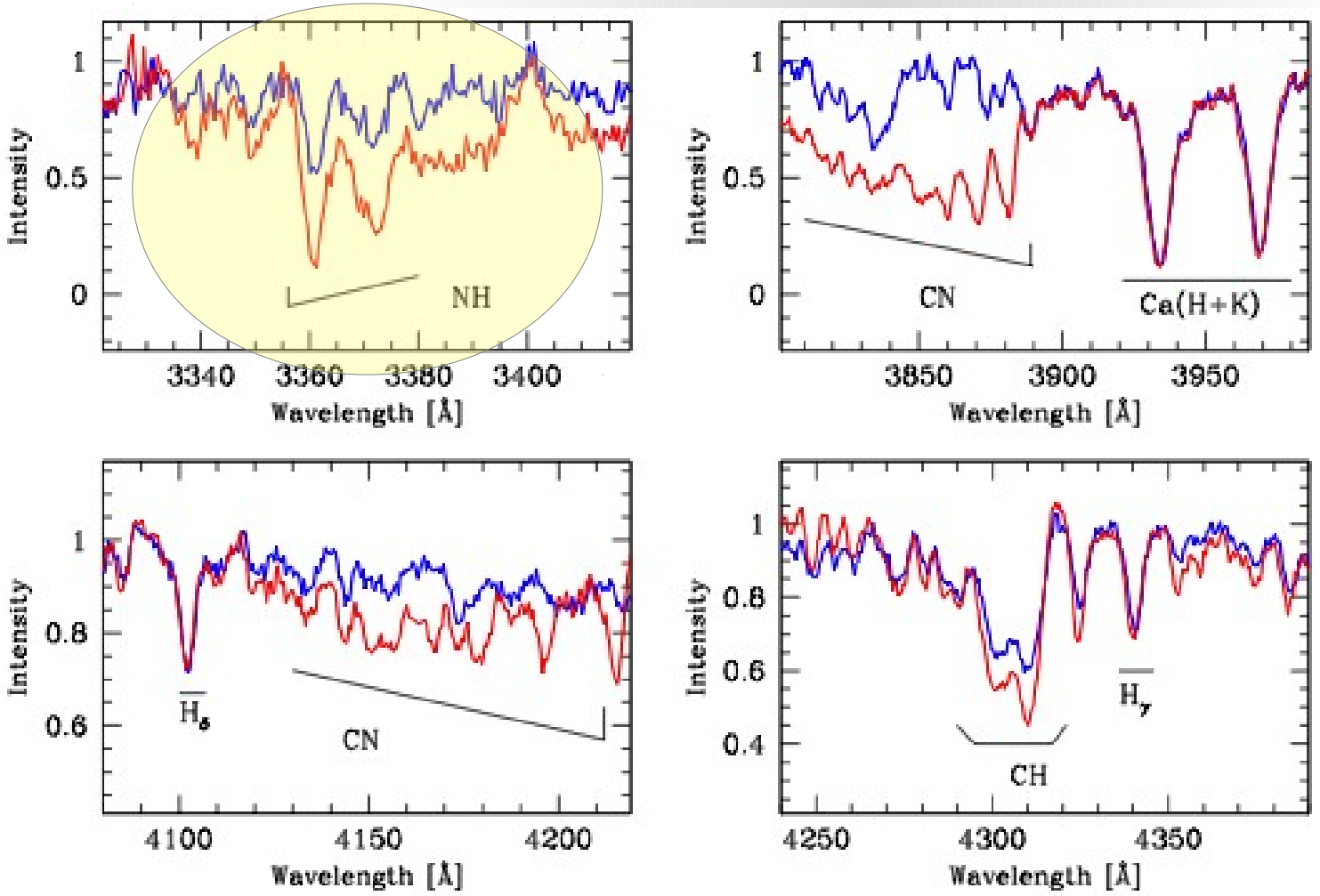
3 x 1200 sec (1hr in total)

SNR(@4000) ~ 50/60

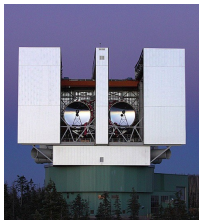
Spectra extraction and wavelength calibration performed by the Italian LBT Spectroscopic Reduction Center

M 2: characterizing the red RGB with MODS

Lardo et al. 2013



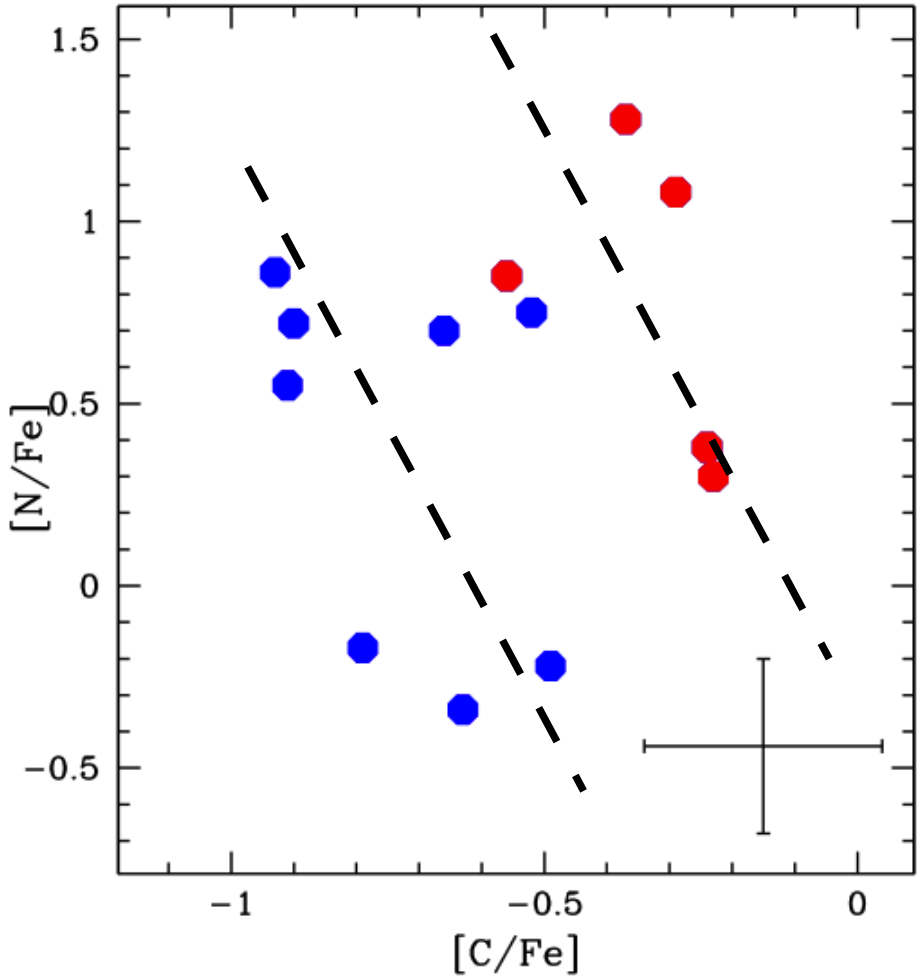
Stars with **the same temperature**, the spectra of the stars are virtually identical apart from the molecular features



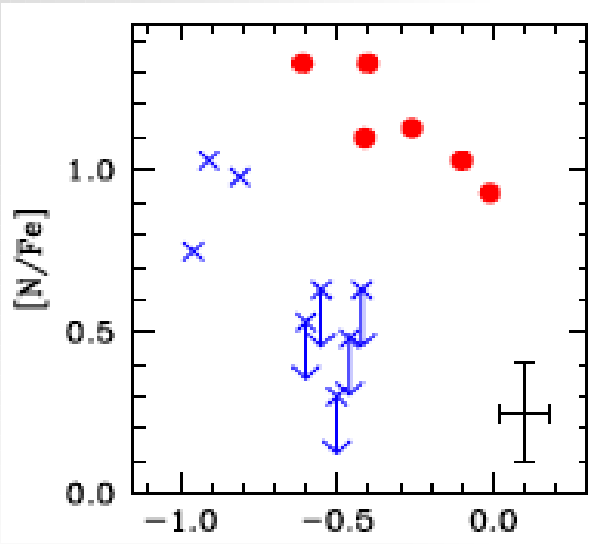
M 2: characterizing the red RGB with MODS

M2

Lardo et al. 2013



MAYBE M2 COULD RESEMBLE M22 ALSO IN OTHER RESPECTS !

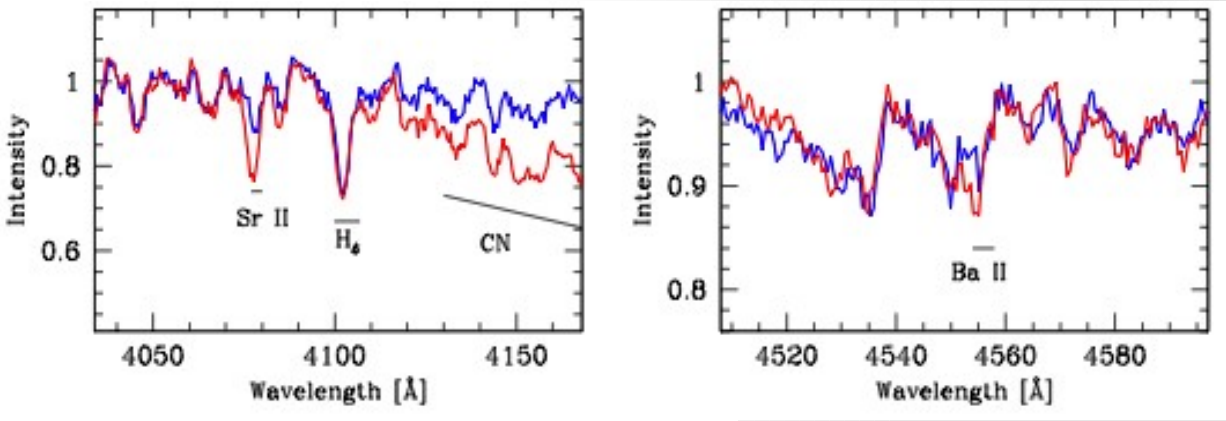


M22

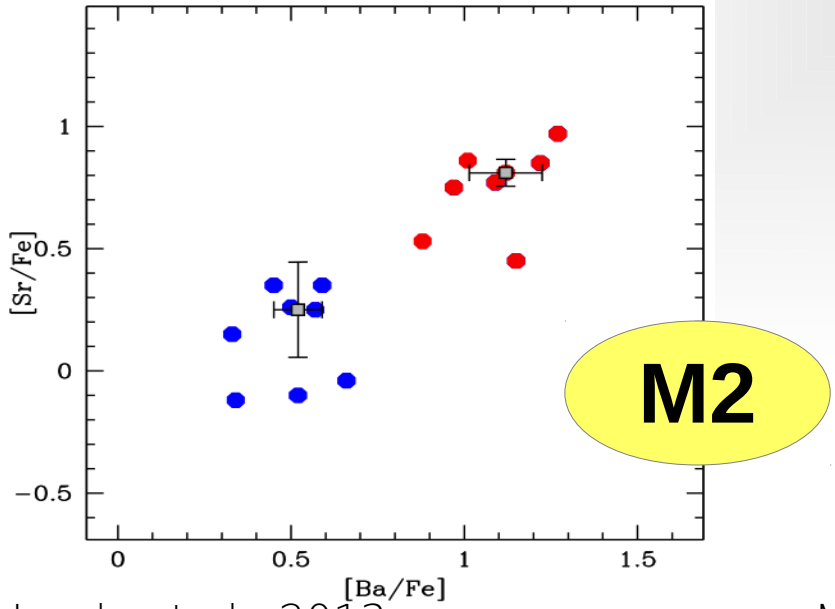
Marino et al. 2011

M 2: s-process element bimodality

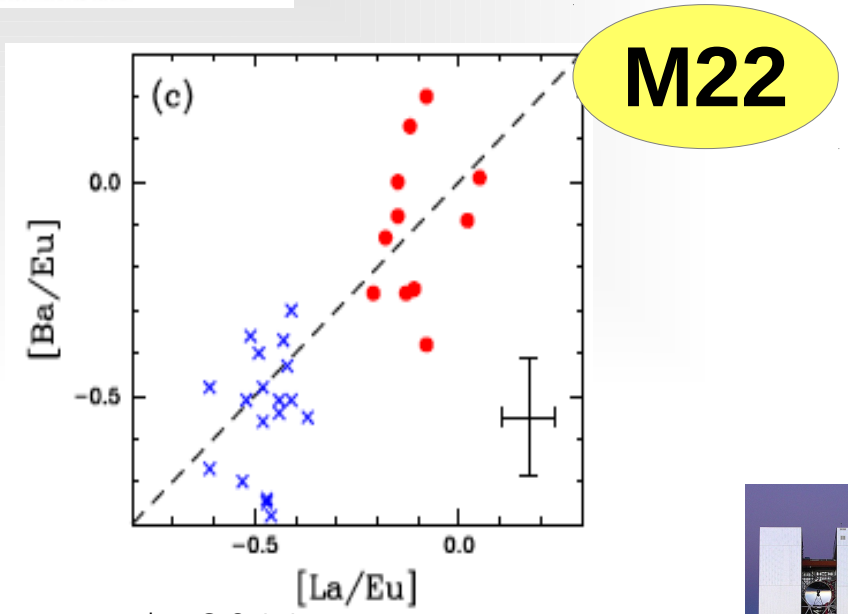
s-process bimodality: M 22, NGC 1851, NGC 362, Omega Cen
(Gratton et al. 2012, Carretta et al 2010, Carretta et al. 2013 ...)



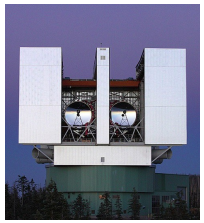
Bimodality could be found also in other clusters
(e.g., Piotto et al. 2012) ???
This pattern may be more common than previously thought



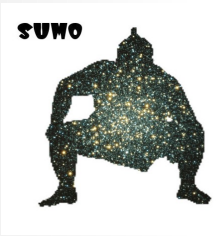
Lardo et al. 2013



Marino et al. 2011



Conclusions



U photometry (LBC, see also SUMO – M. Monelli)

Trace multiple populations phenomenon
(LARGE SAMPLES, LESS OBSERVING TIME)

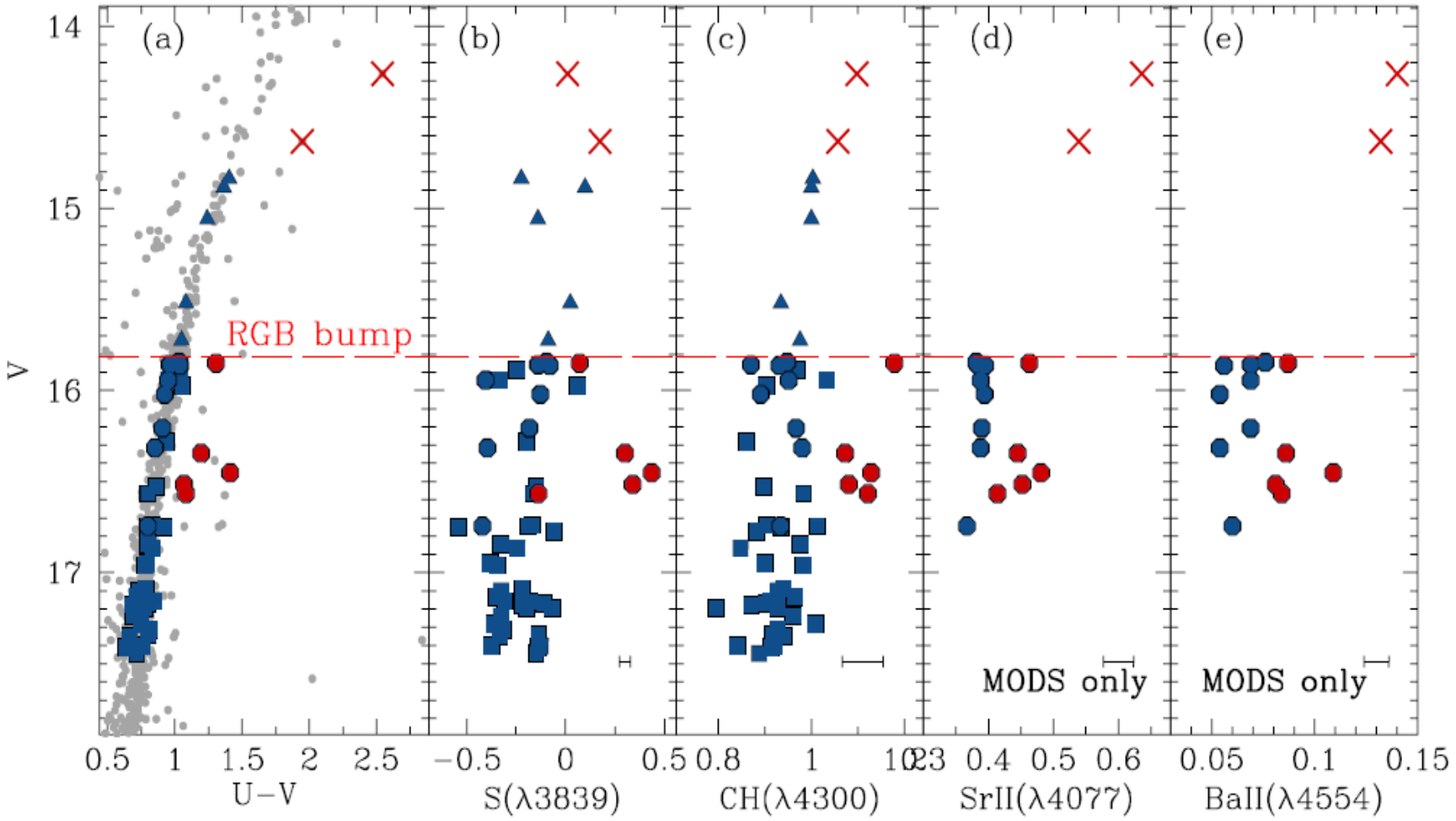
- Study radial trends
- Derive population ratios

Low–resolution spectroscopy (MODS)

Useful complement to high-resolution observations

- Study multiple populations in faint stars
- Detect multiple populations in far away clusters (extragalactic environments)

M 2: spectral indices



Lardo et al. 2013