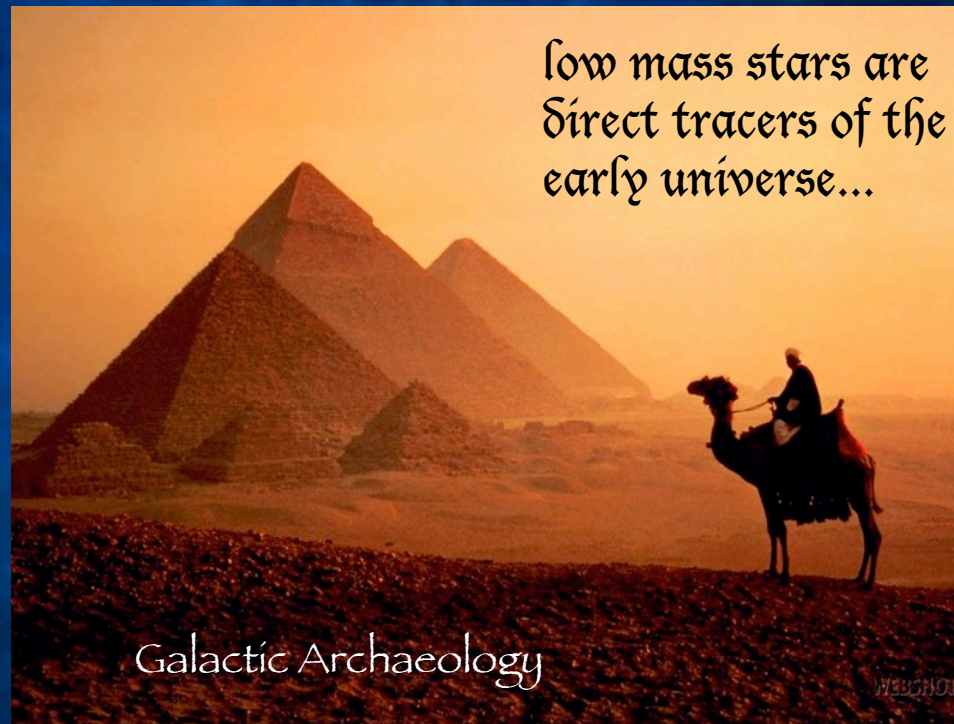


Resolved Stellar Populations in Local Group Dwarf Galaxies

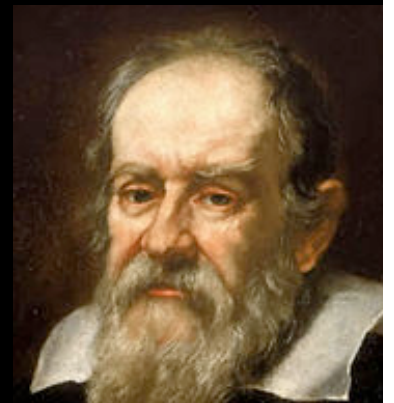


Elaine Tolstoy
Kapteyn Astronomical Institute

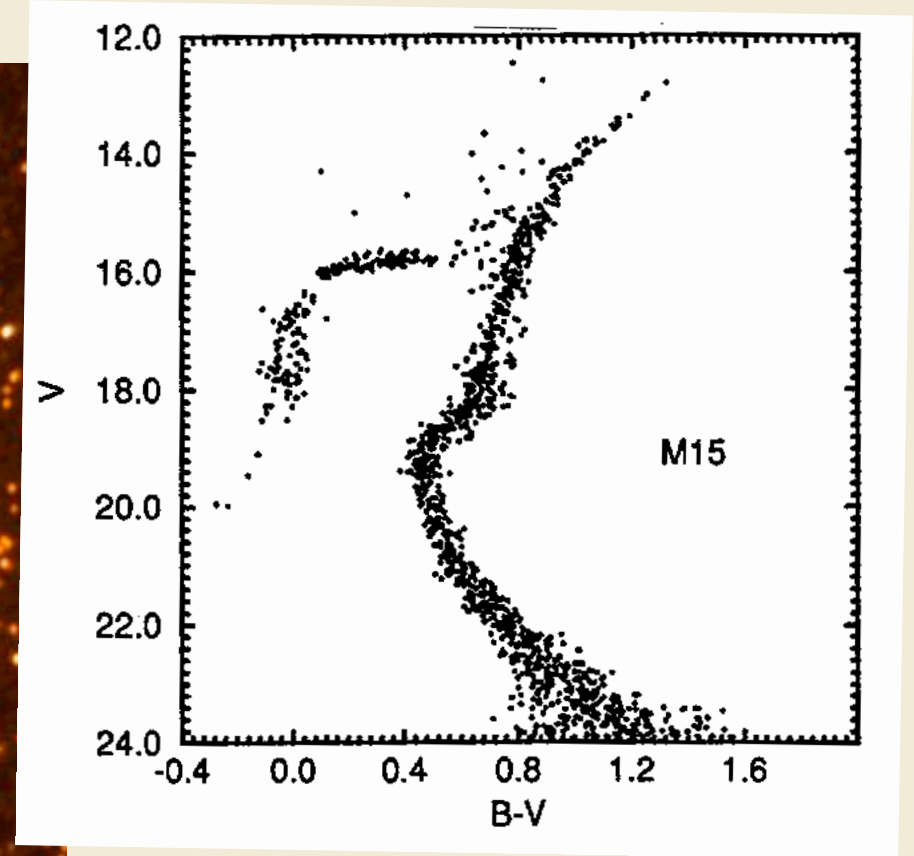
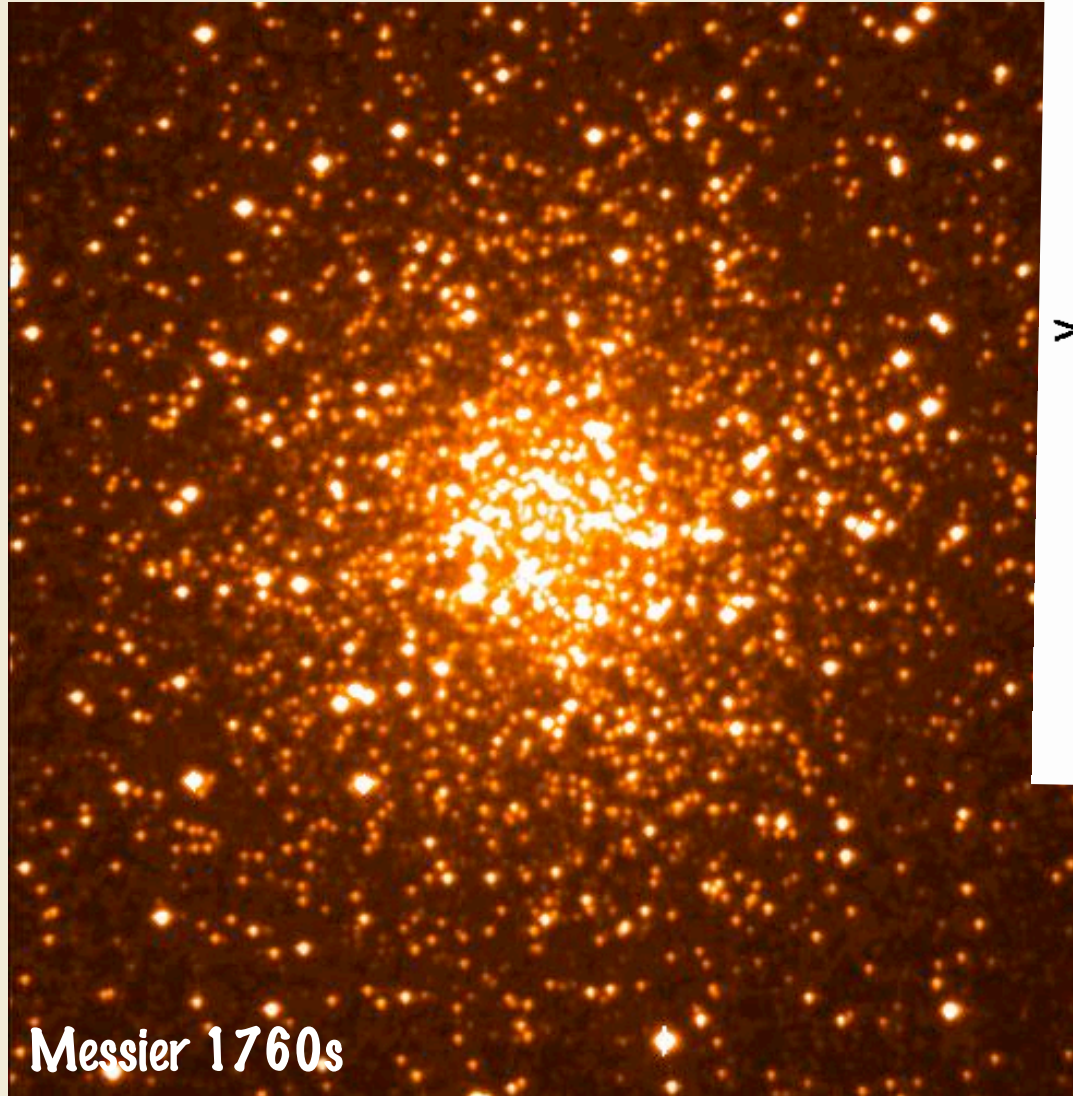
The Closest Galaxy



...una congerie di
minutissime stelle...

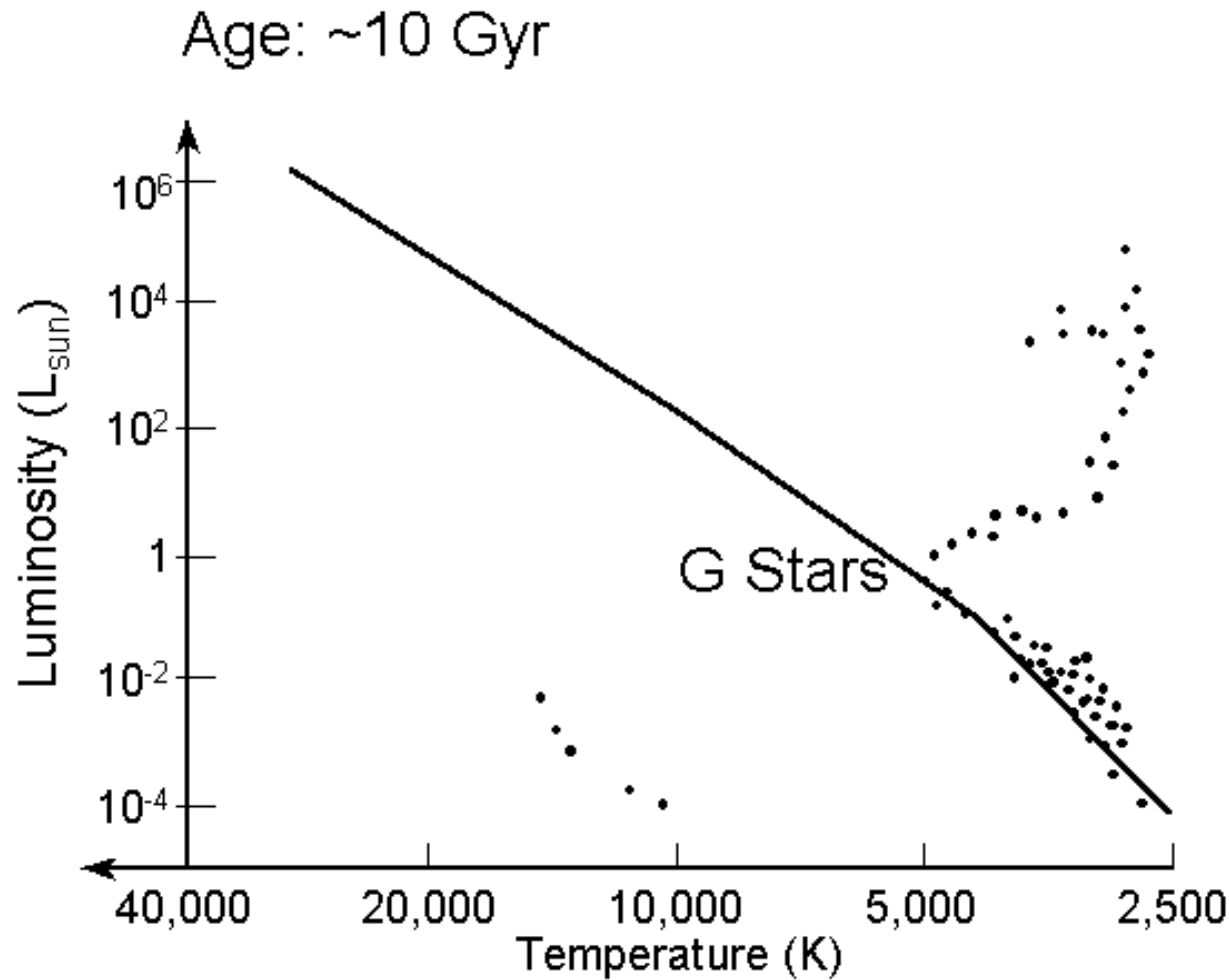


Mapping our Galaxy



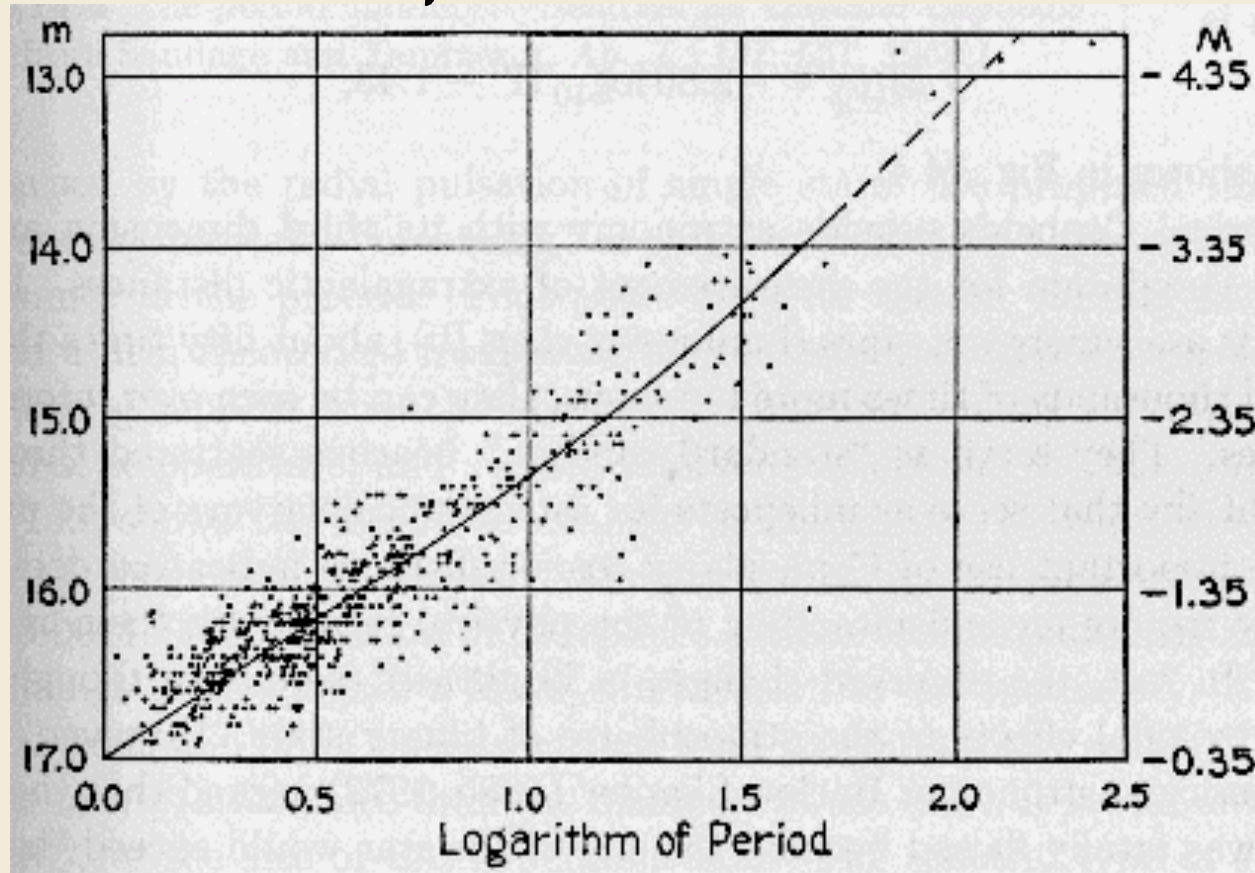
star clusters (globular and open)

The Hertzsprung-Russell Diagram



STARS CAN LIVE A VERY VERY LONG TIME!

Cepheid Variable Stars



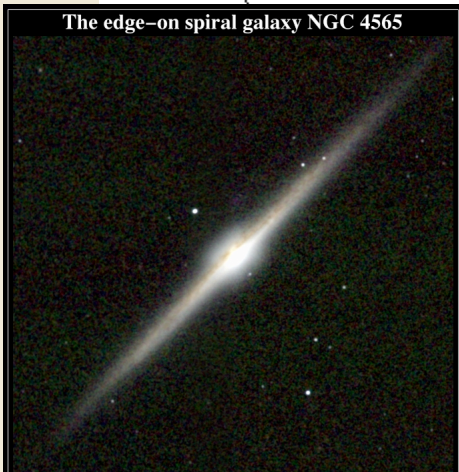
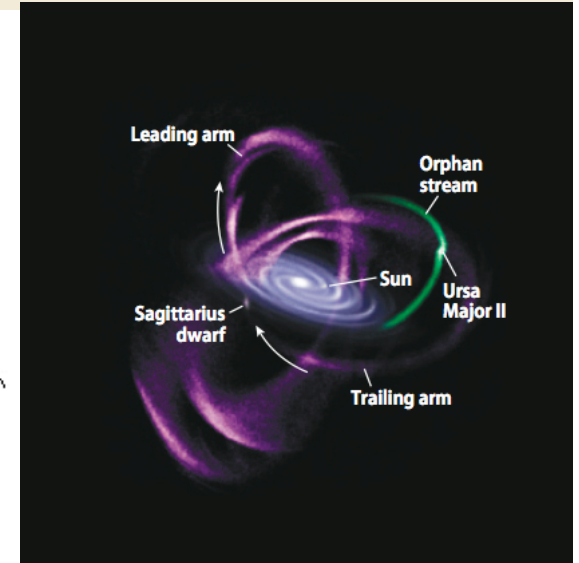
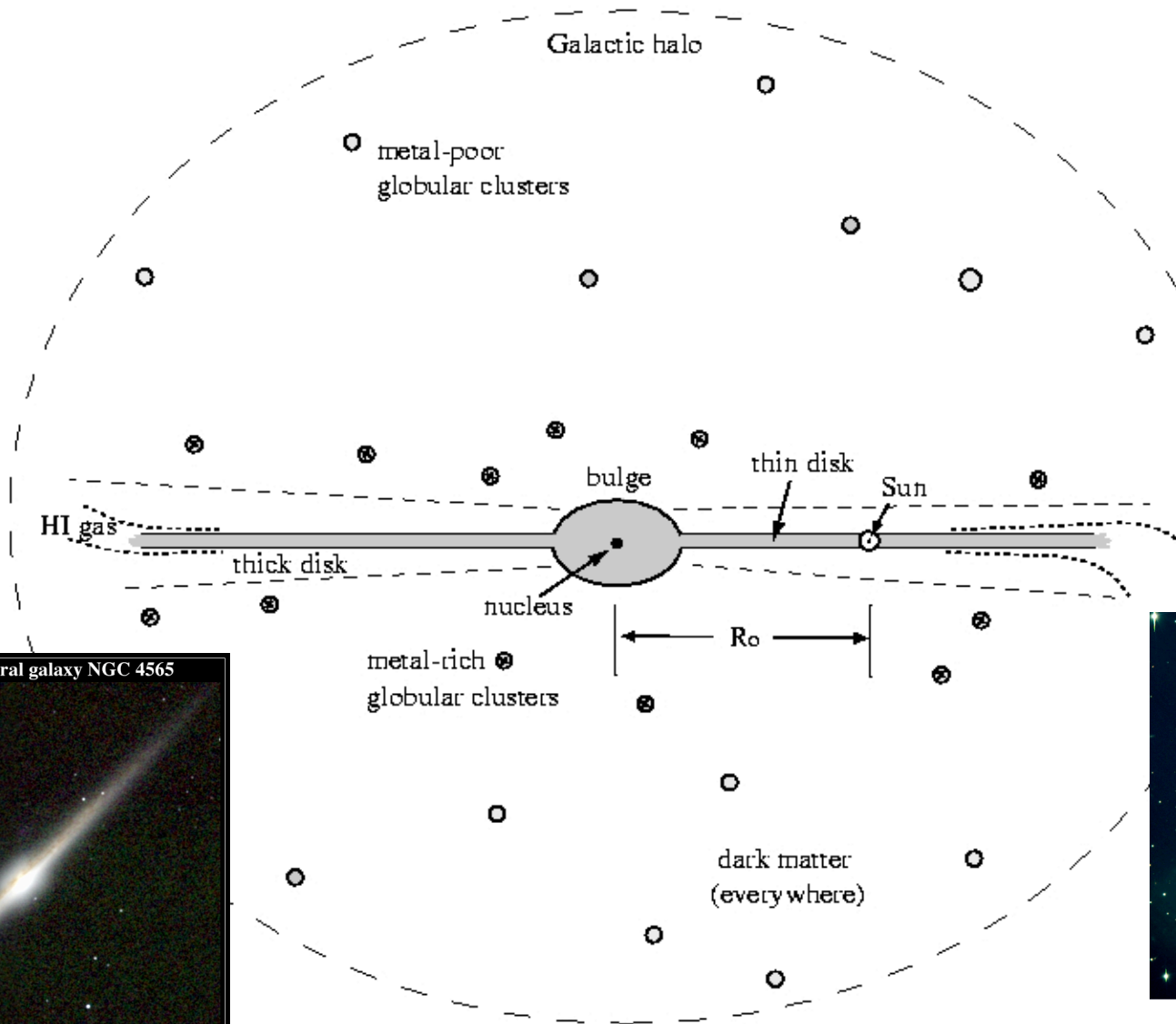
Leavitt 1912

$$M_V = -2.80 \log_{10} P - 1.43$$

$$(m - M_V)_0 = 5 \log_{10} d(\text{pc}) - 5 (+A)$$

Birth of Extra-galactic astronomy!

The Structure of a Galaxy

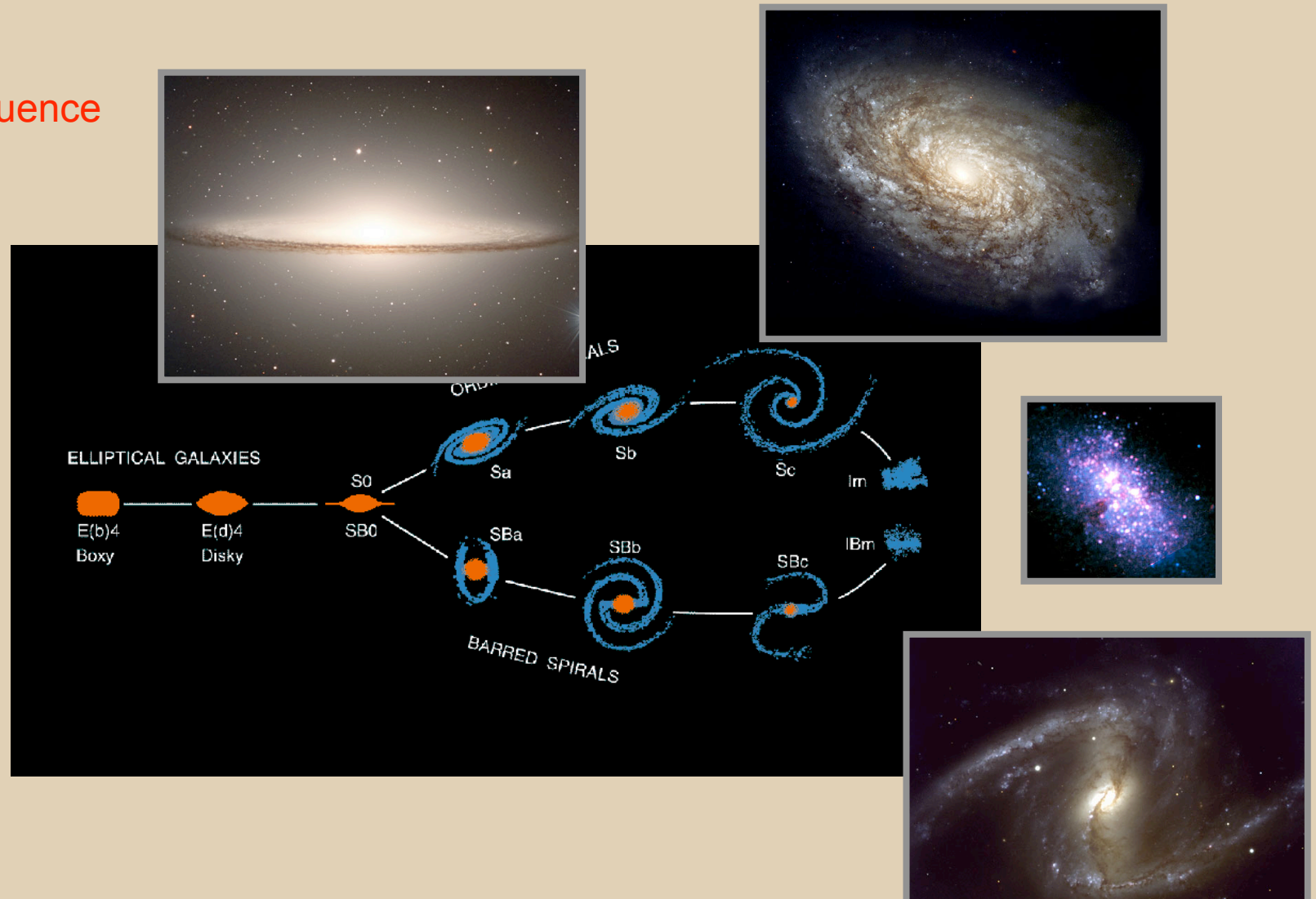


Spiral Galaxy NGC 2613
(VLT MELIPAL + VIMOS)

Galaxy Formation & Evolution

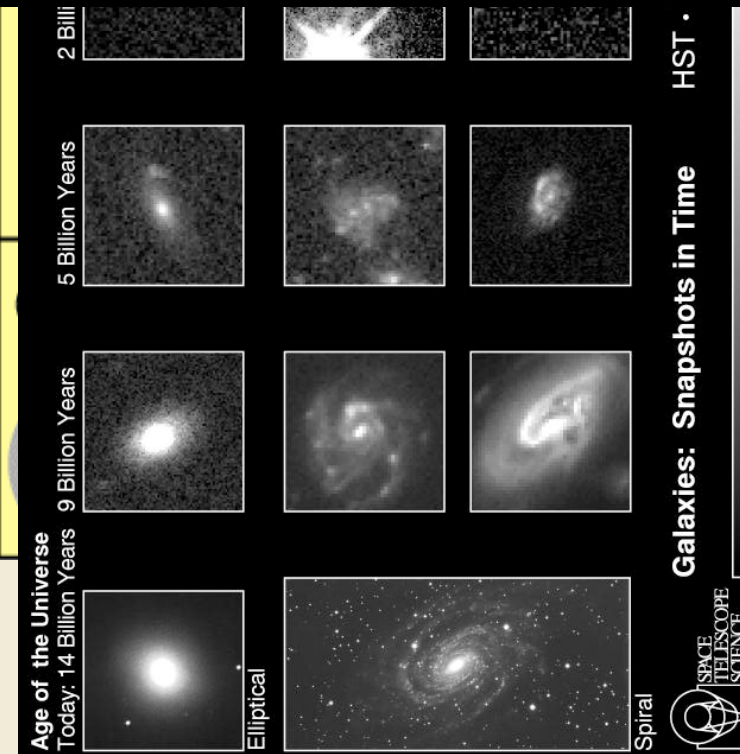
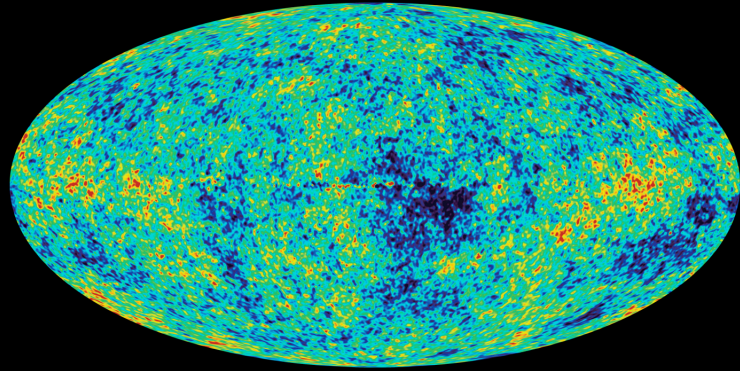
To understand the **formation** of the various types of galaxies have to investigate the properties of their **stellar components**.

The Hubble Sequence

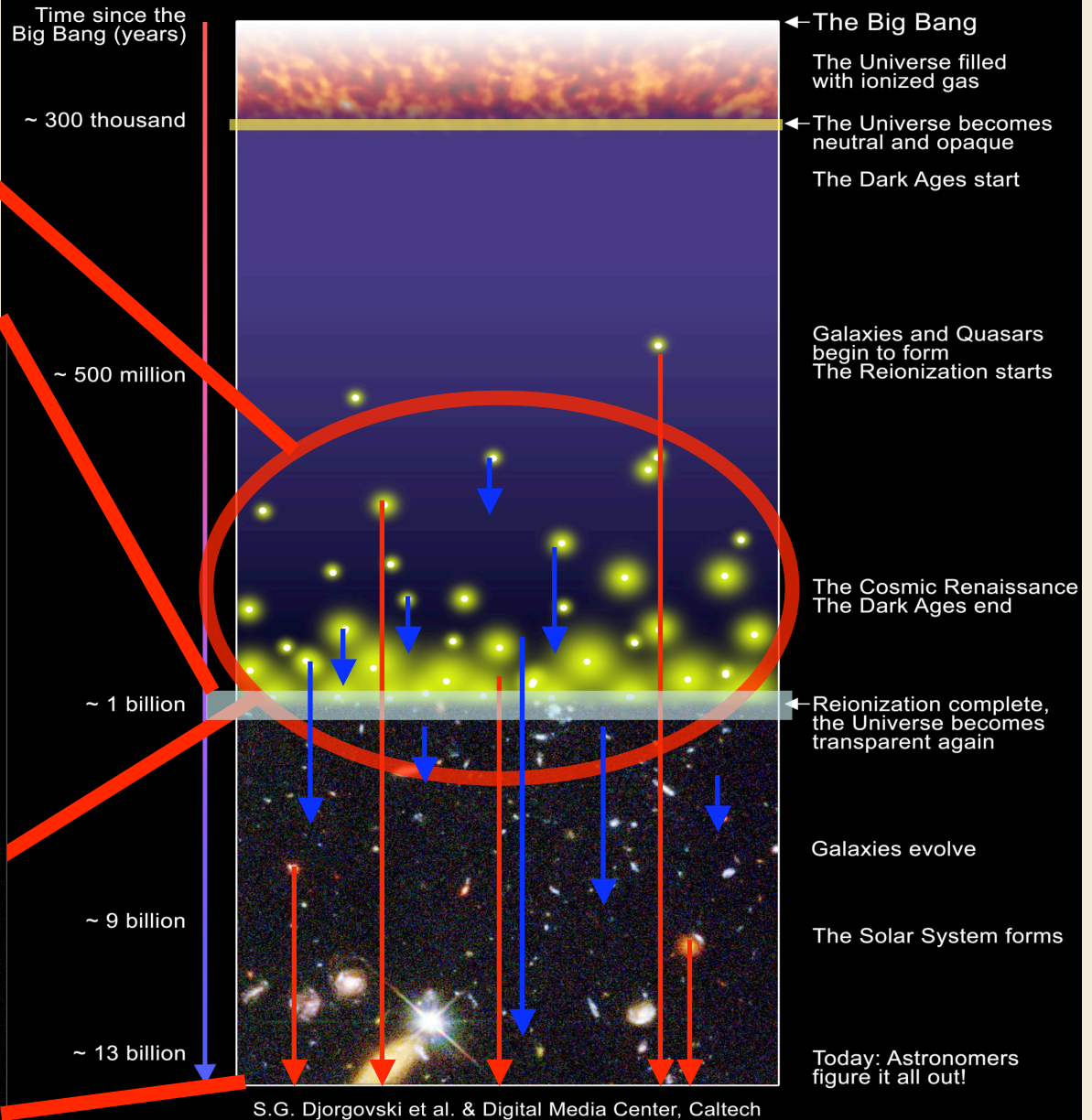


Cosmic History

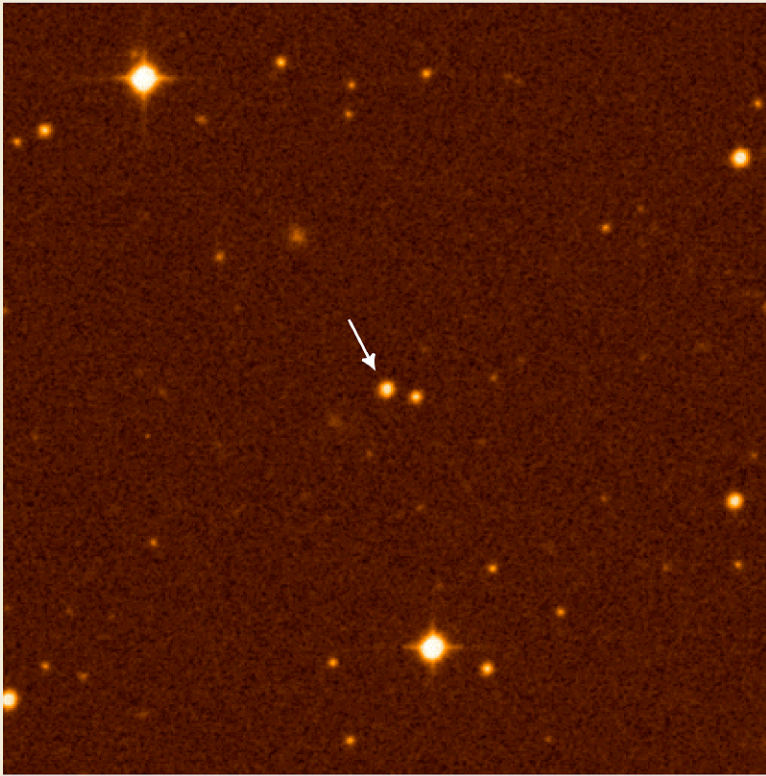
Big Bang



A Schematic Outline of the Cosmic History



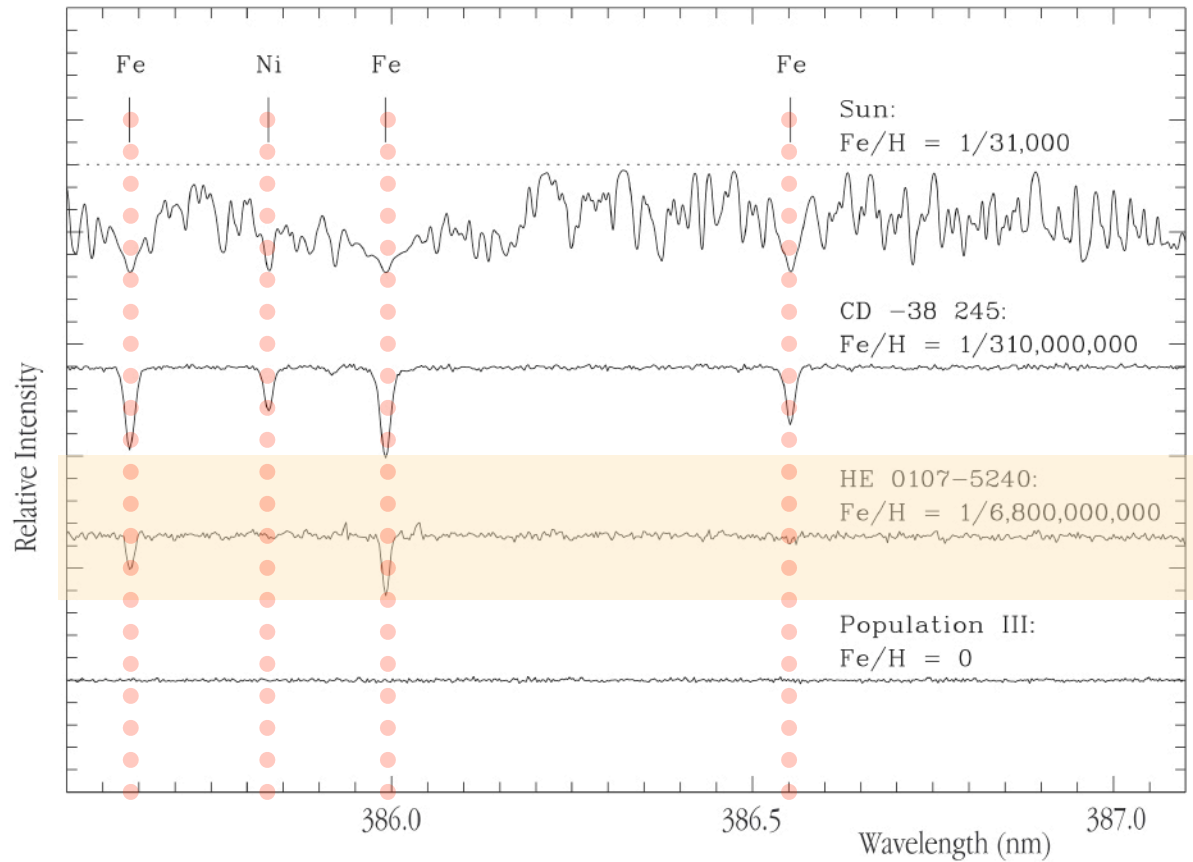
HE0107-5240: The Most ancient object we know of?



The Very Metal-Deficient Star HE 0107-5240

ESO PR Photo 25a/02 (30 October 2002)

© European Southern Observatory



Spectra of Stars with Different Metal Content

ESO PR Photo 25b/02 (30 October 2002)

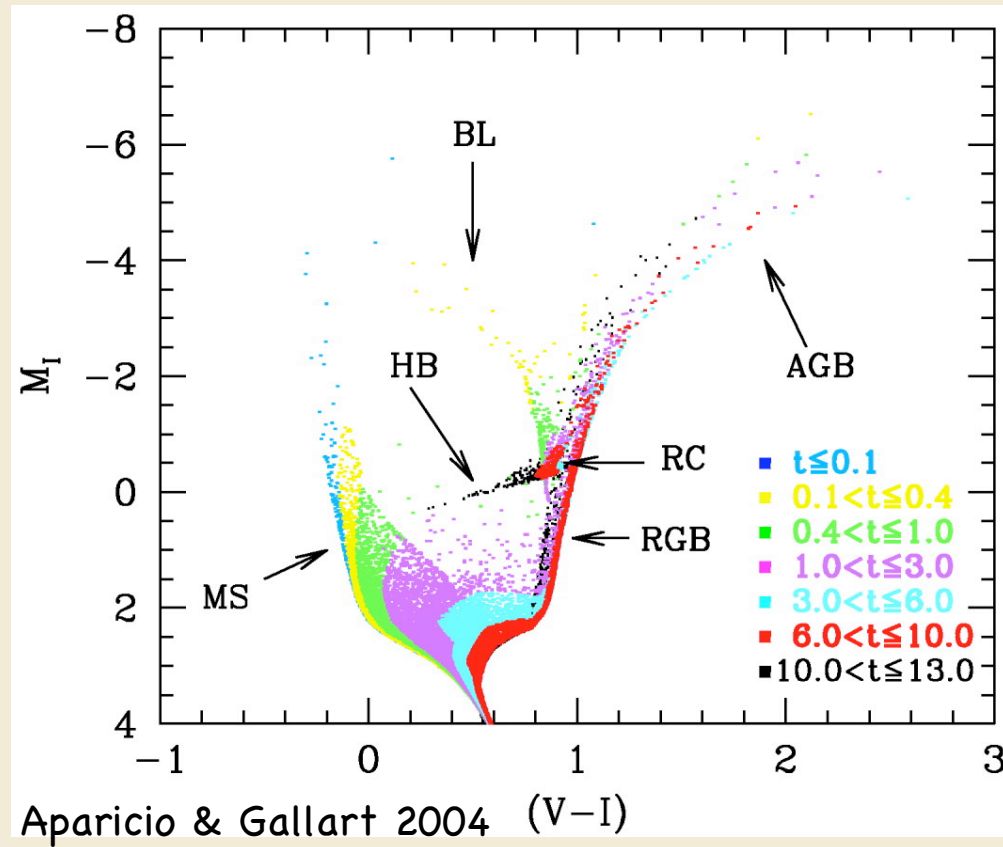
© European Southern Observatory



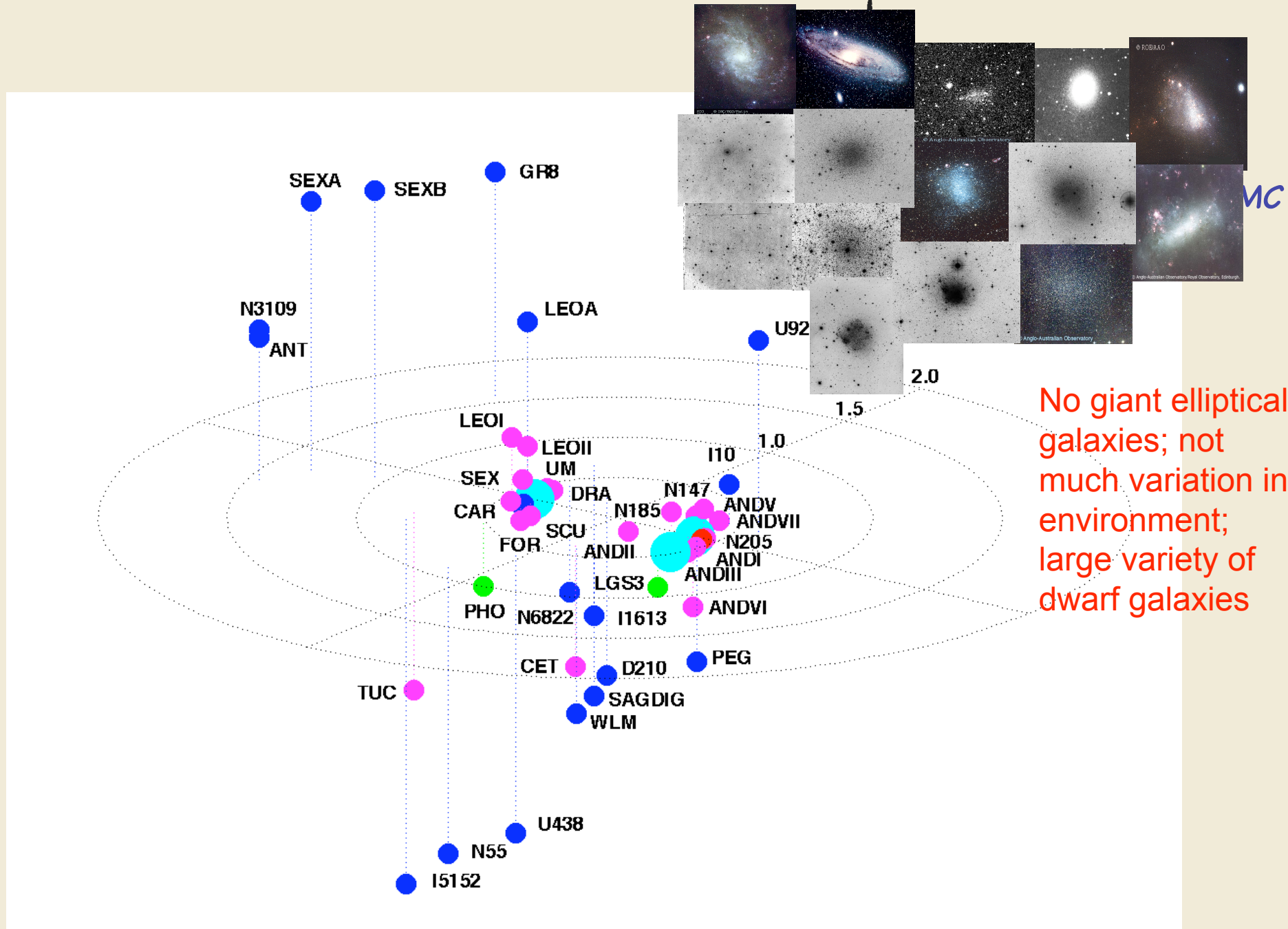
HE 0107-5240

[Fe/H] = -1.75

HST role: Extremely accurate Colour-Magnitude Diagram analysis



Old stars with HST: The Local Group



Dwarf Galaxies are “simple” and
numerous and nearby

Leo A

Cole et al. 2007

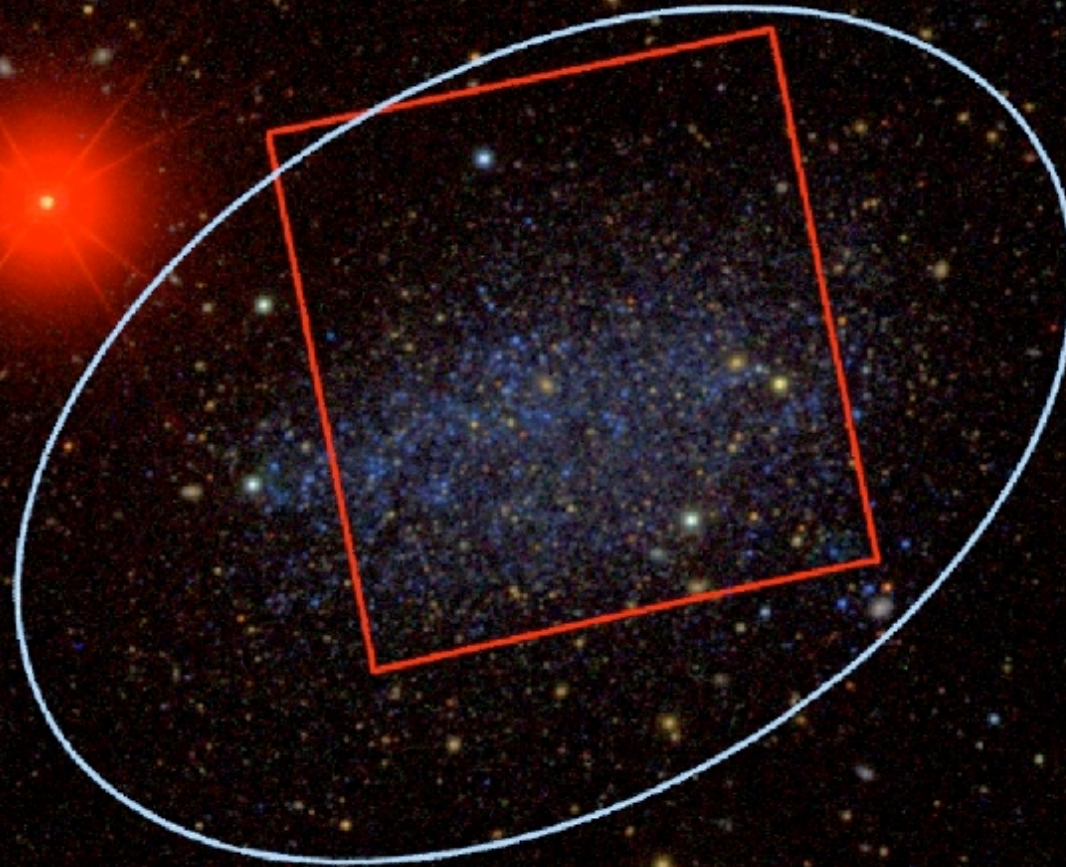


Image: SDSS gri composite.

Ellipse: Holmberg dimension.

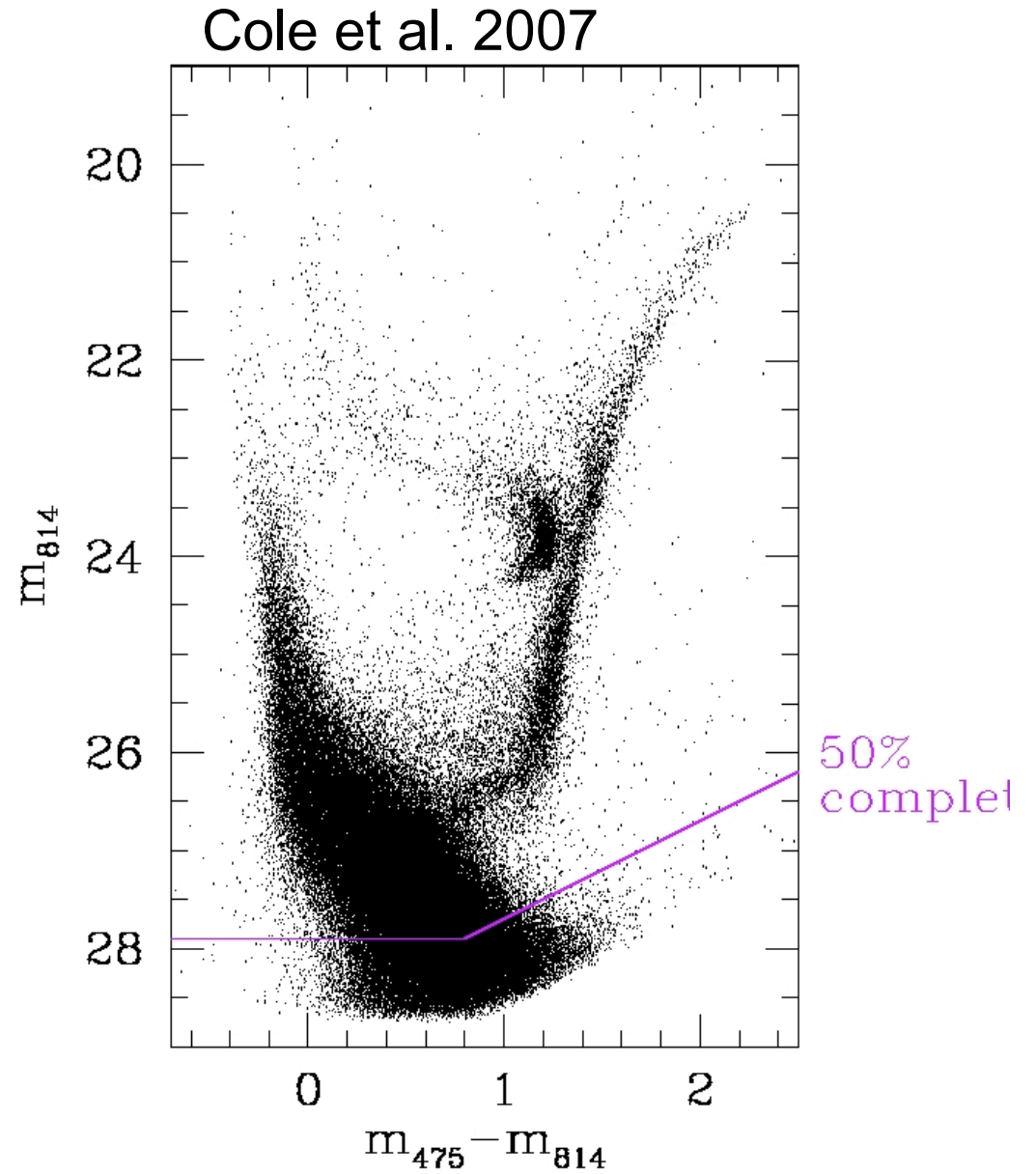
Square: ACS

Leo A

Deepest ever CMD (in absolute mag) for an isolated dwarf irregular.

$$M_{814} \approx +3.4$$

$$M_{475} \approx +4.2$$

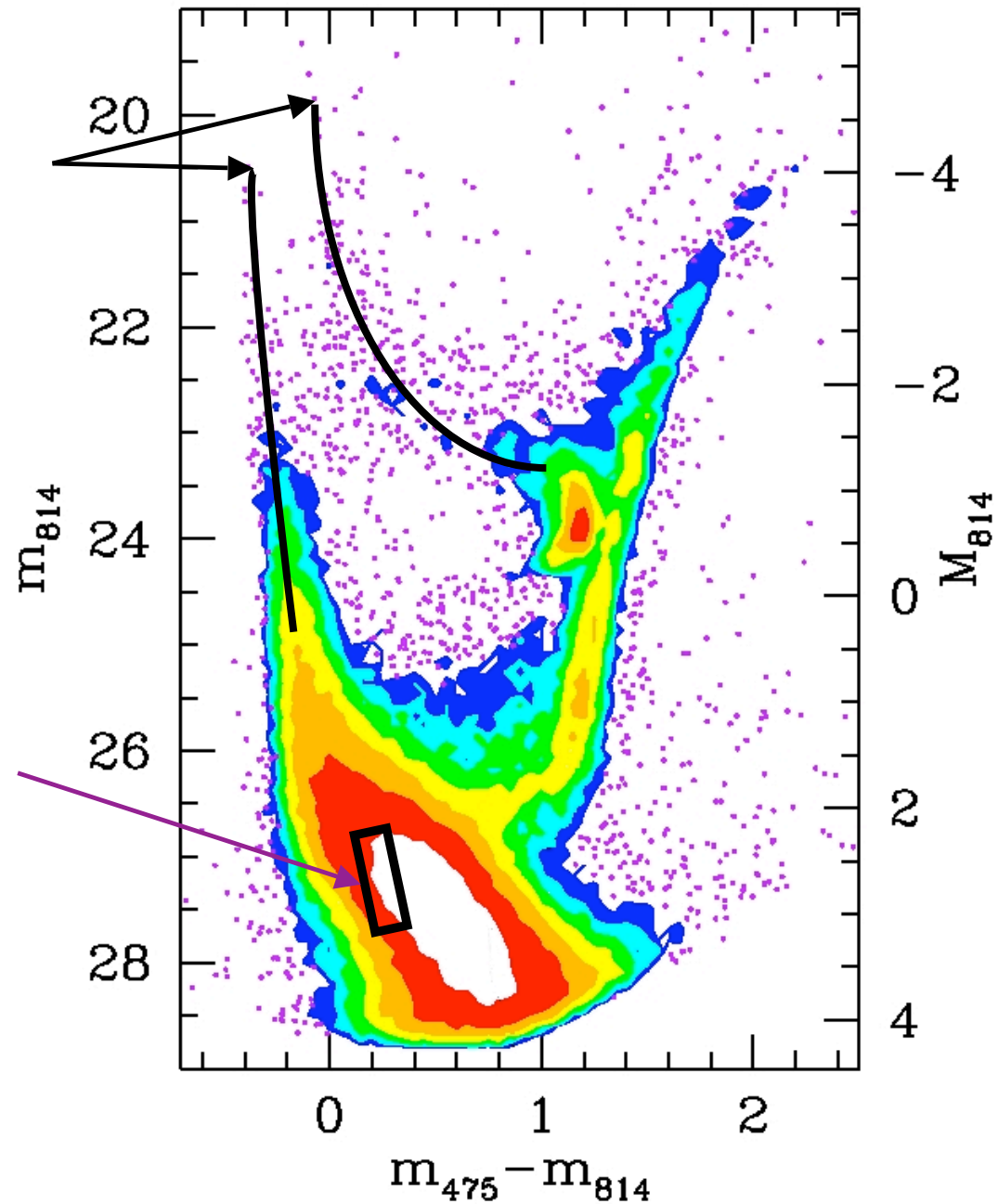


Interpreting CMD

Cole et al. 2007

Main Sequence and Core
He burning, $t > 15$ Myr

Oldest MS turnoffs,
6-13 Gyr



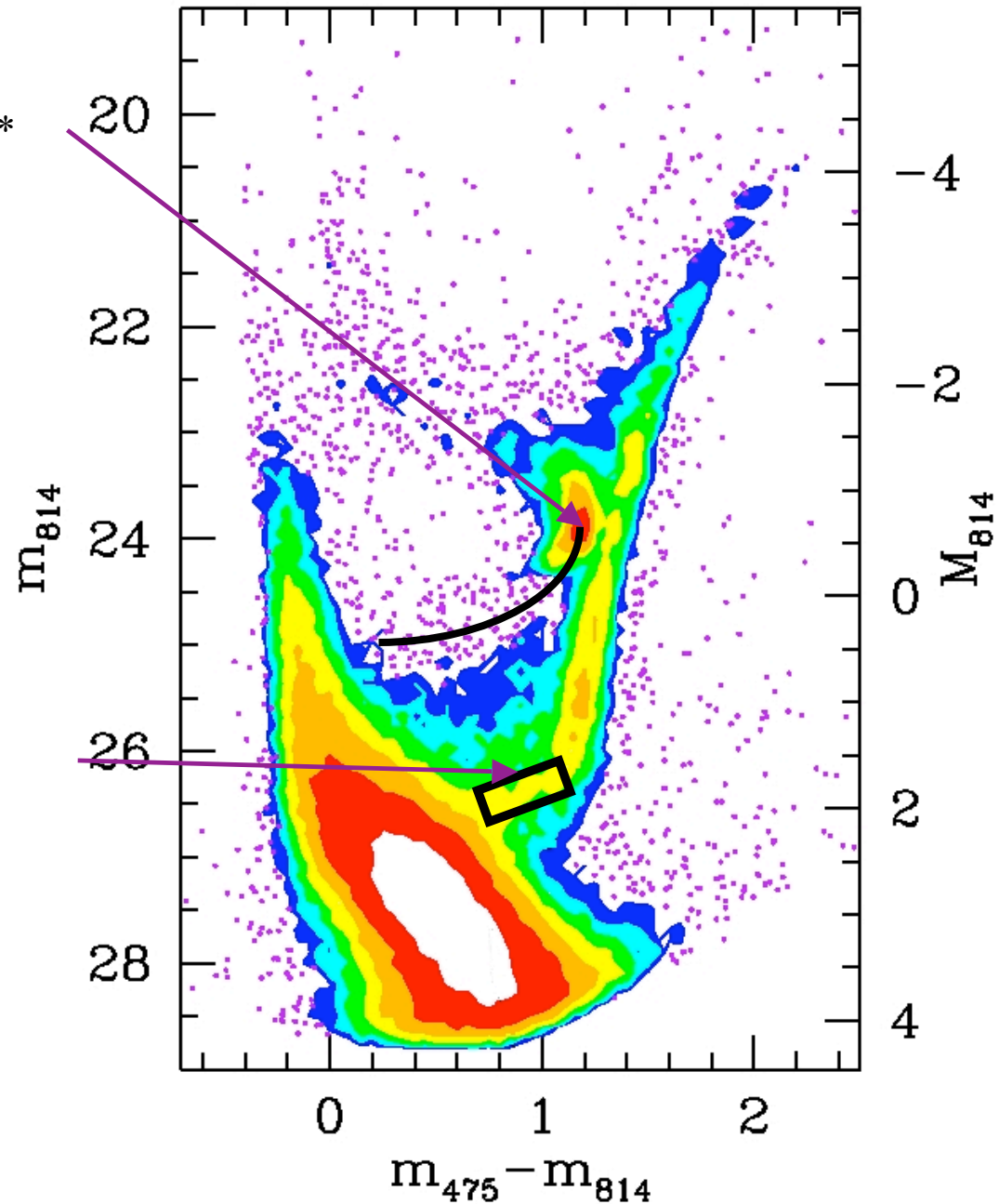
Interpreting CMD

Cole et al. 2007

Strong red clump, no serious horizontal branch*

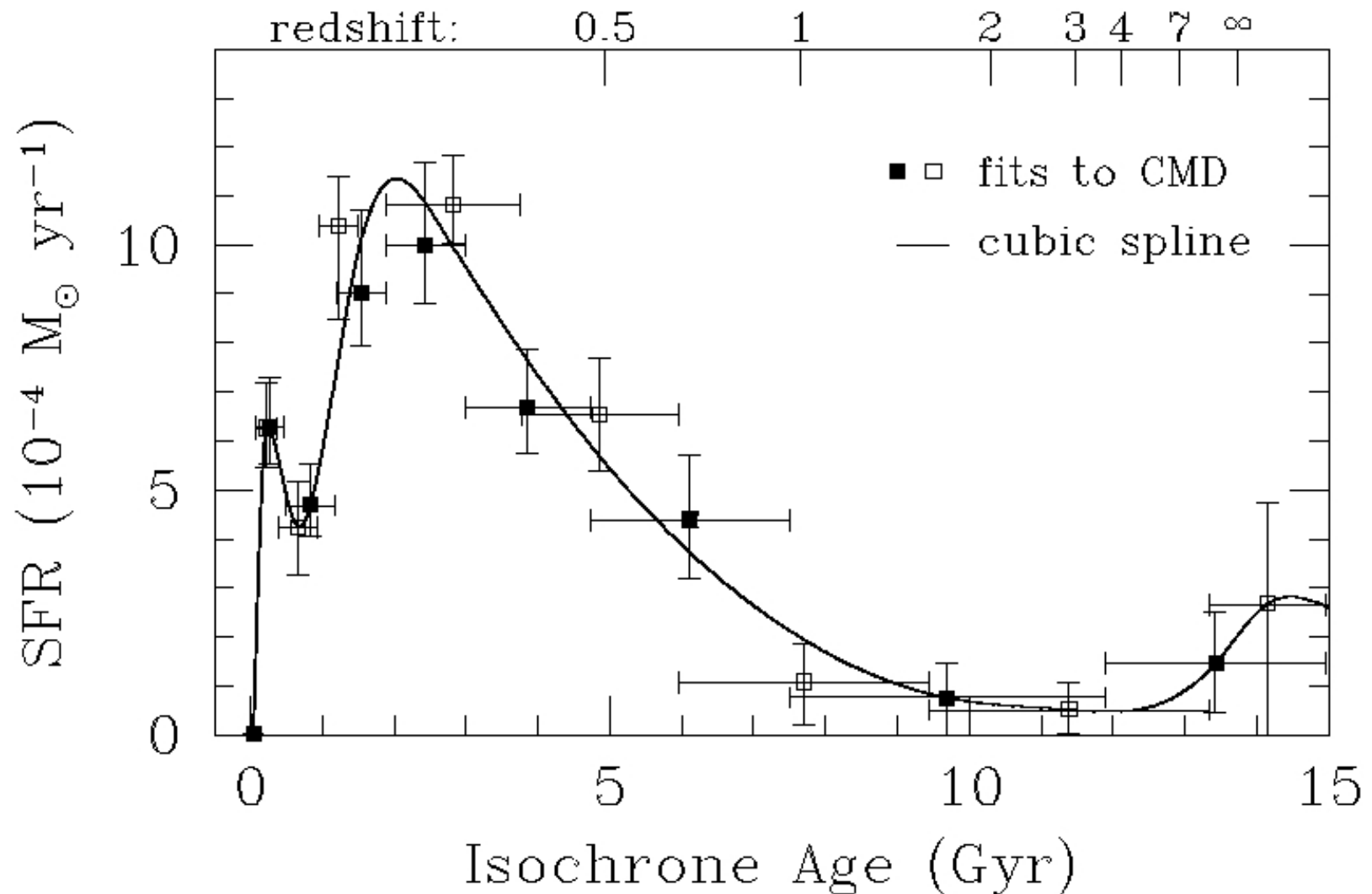
* 8 candidate RR Lyraes have been found (Dolphin et al. 2002); we hope to find more in our data.

Peak density of sub-giants at similar M_i as in 2-6 Gyr old Small Magellanic Cloud star clusters.



Star Formation History

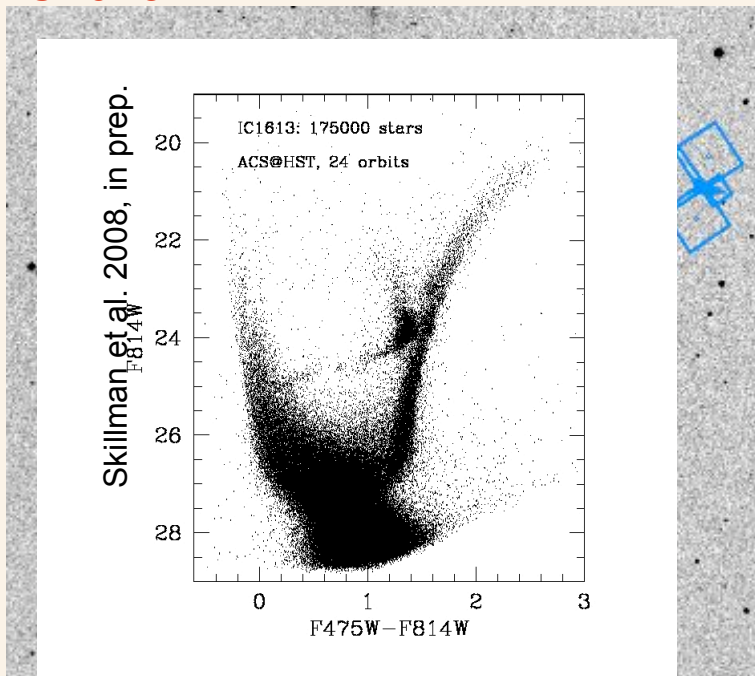
Cole et al. 2007



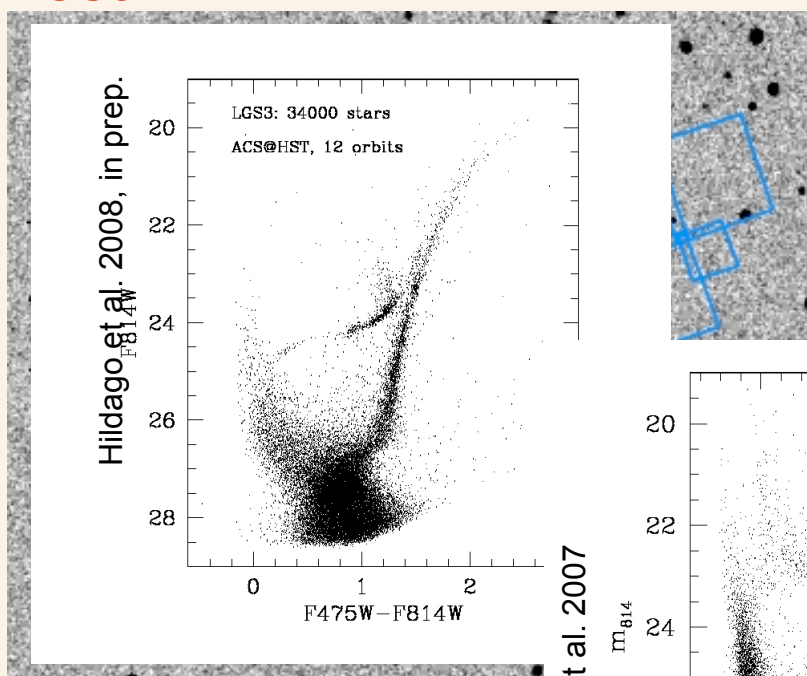
Results for 2 age binnings, with 1σ random errors on SFR

Deep HST/ACS Colour-Magnitude Diagrams

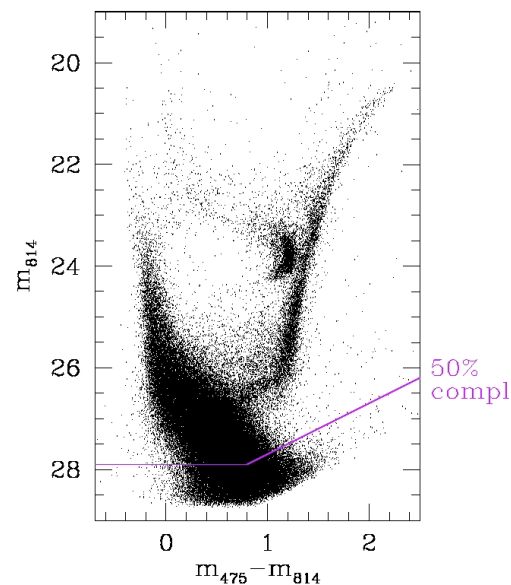
IC1613



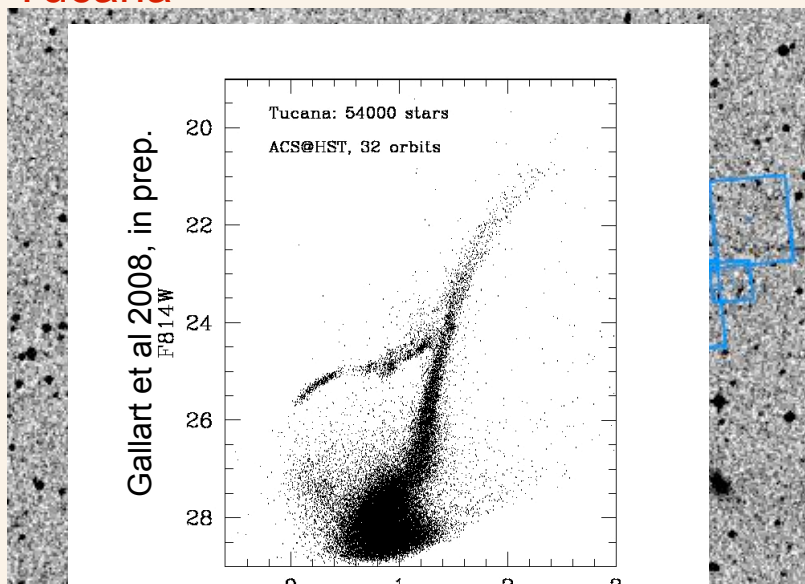
LGS3



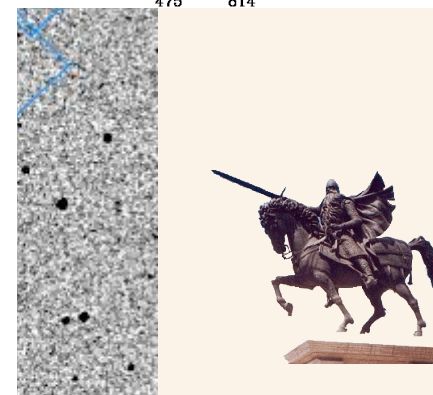
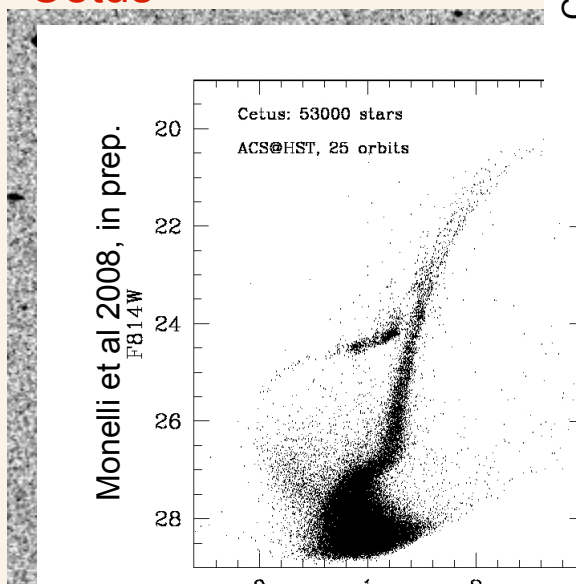
Cole et al. 2007



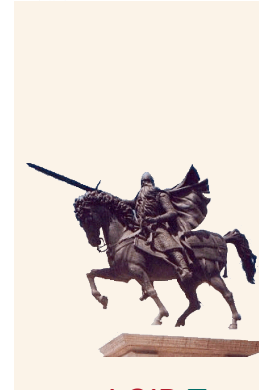
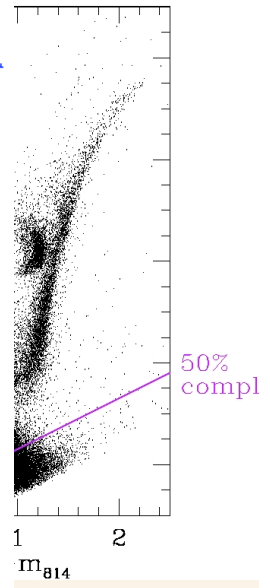
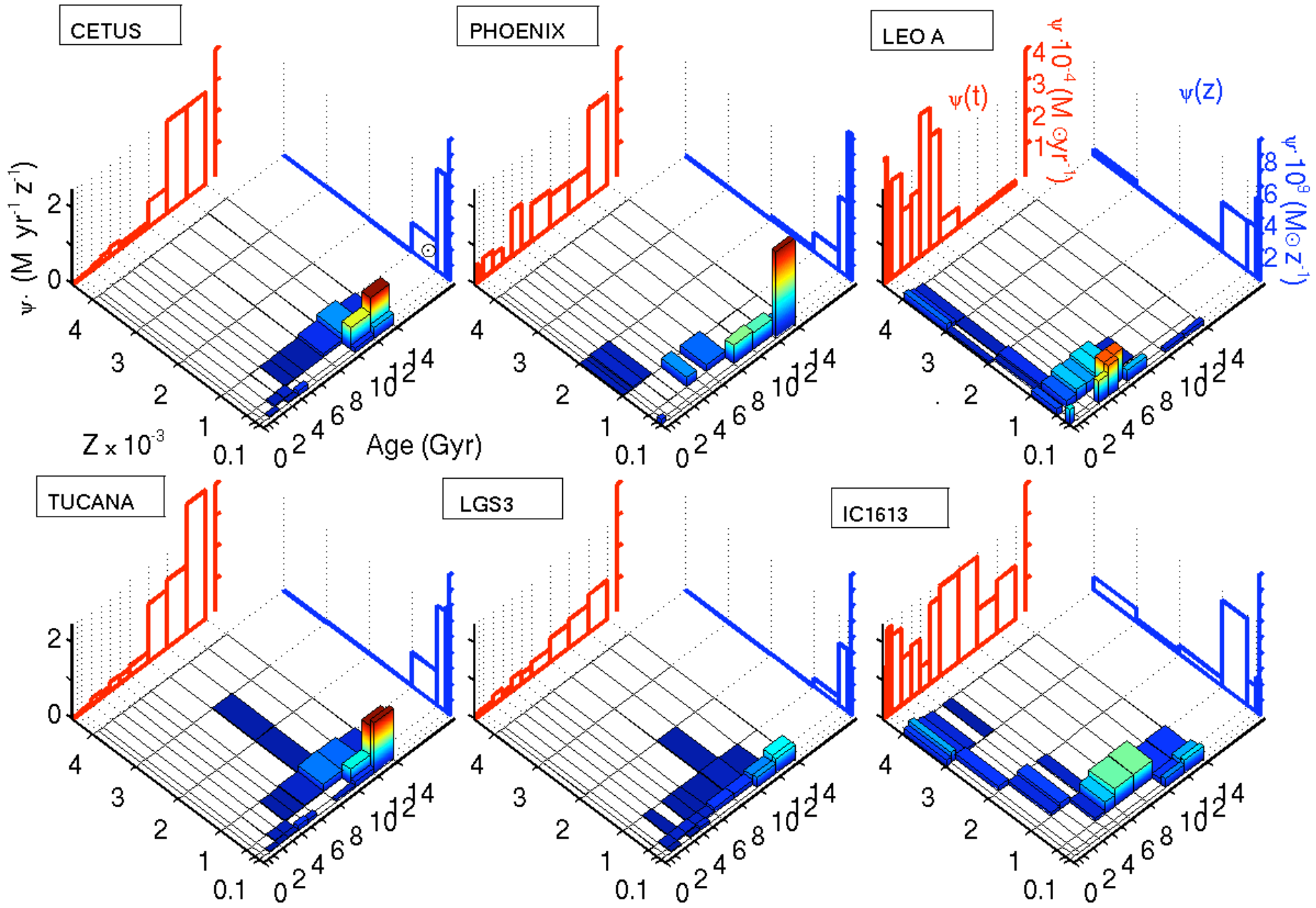
Tucana



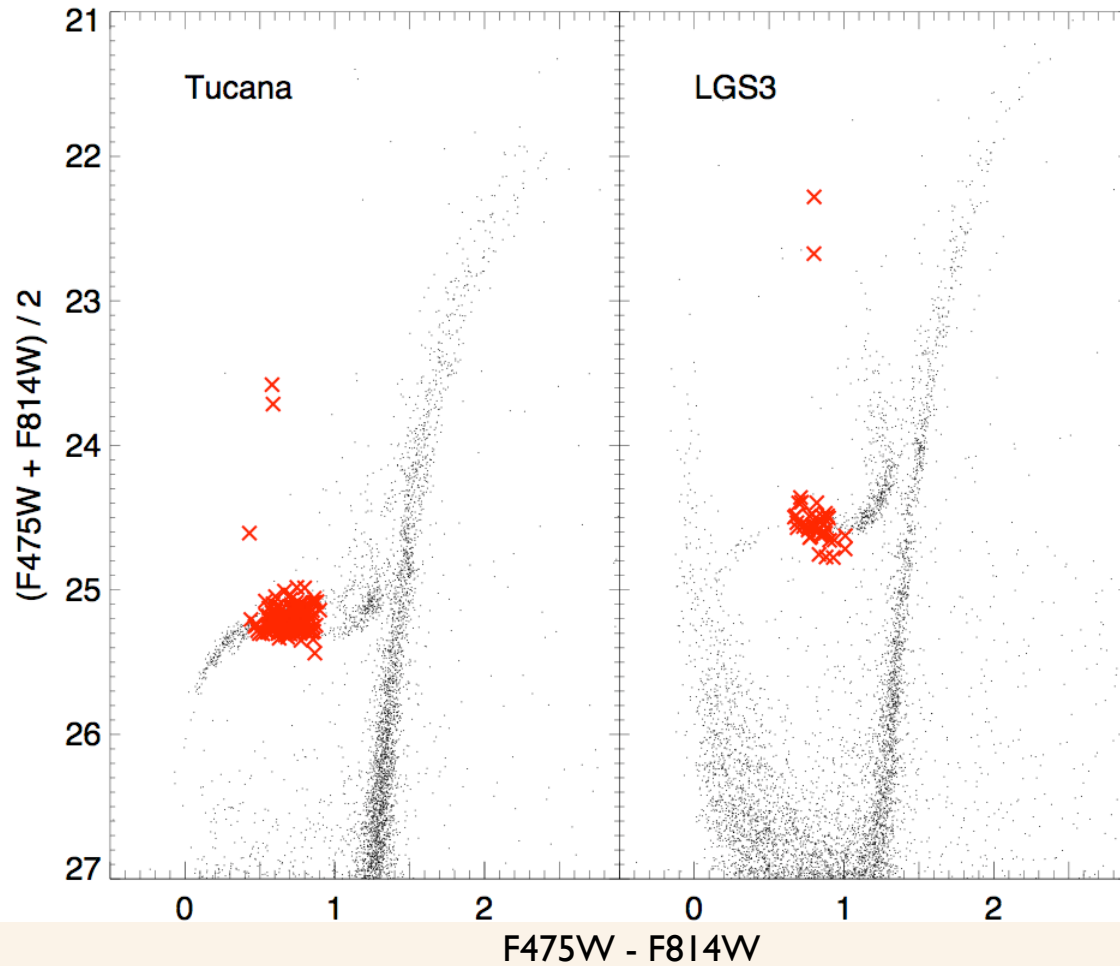
Cetus



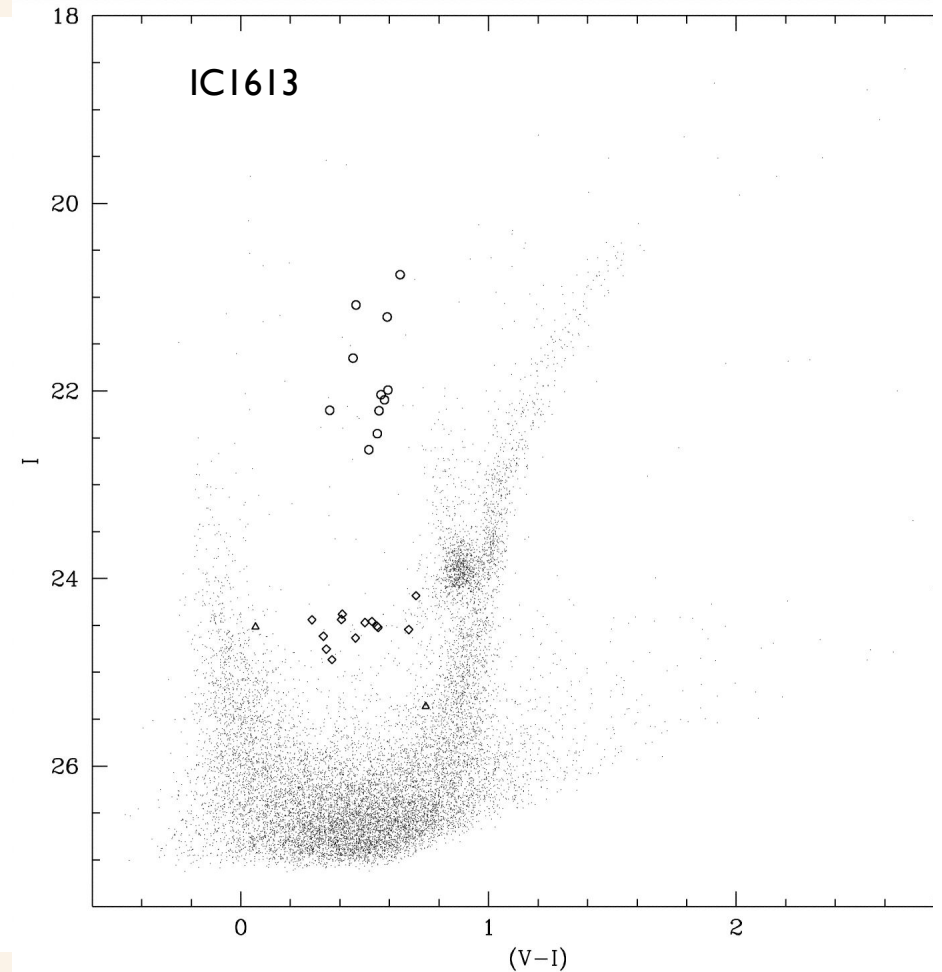
Deep HST/ACS Colour-Magnitude Diagrams



Variable Stars in dwarf galaxies (HST)

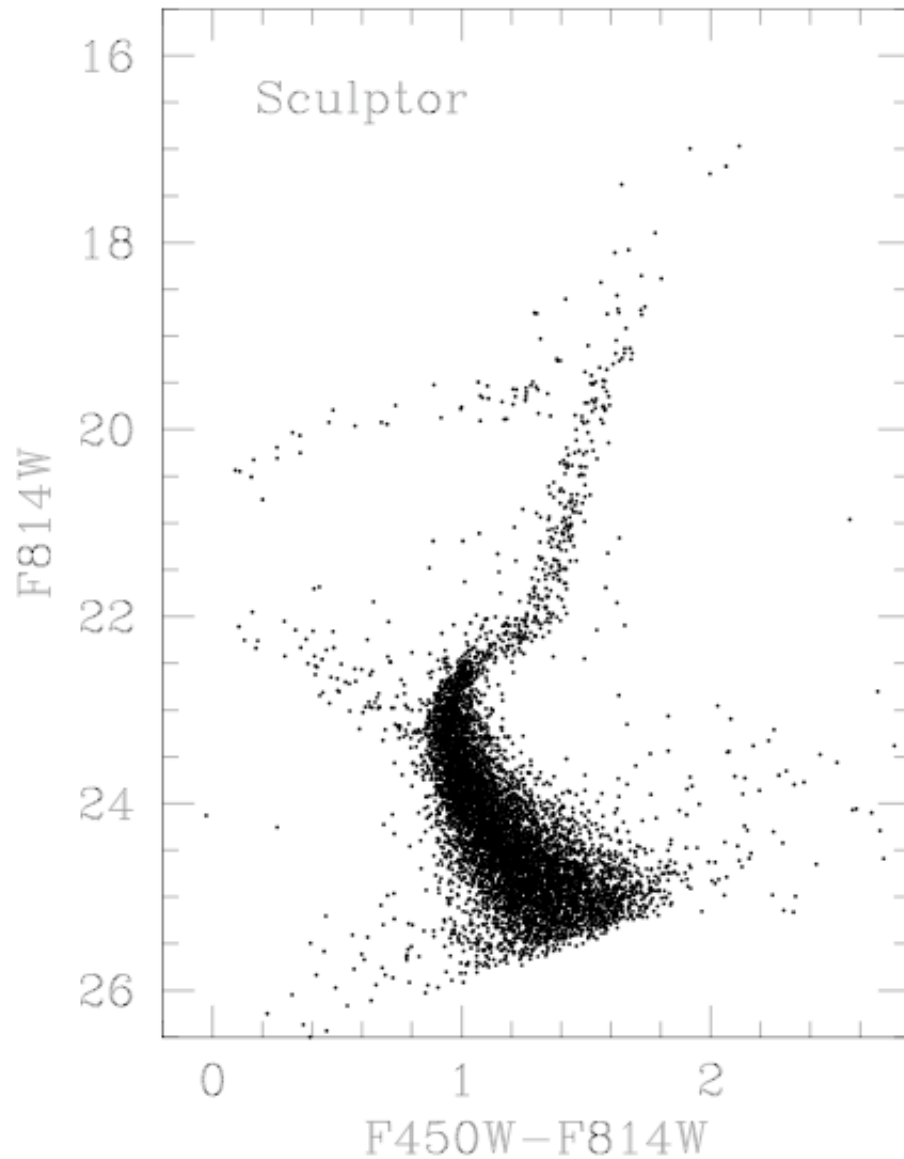
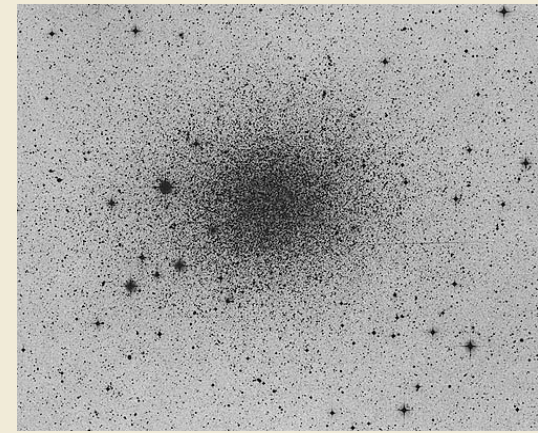


Bernard et al. 2007, astro-ph/0701729

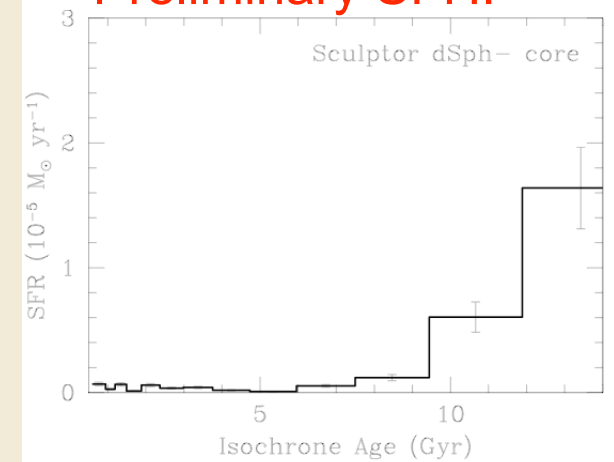


Dolphin et al. 2001, ApJ, 550, 554

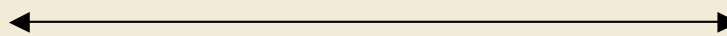
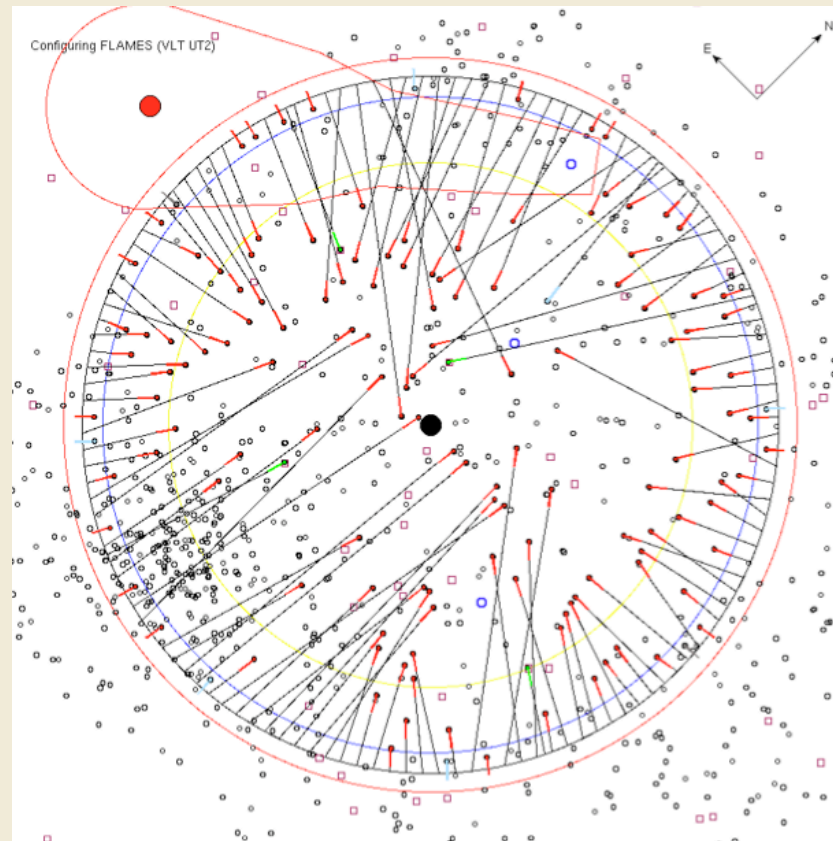
Sculptor dSph



Preliminary SFH!



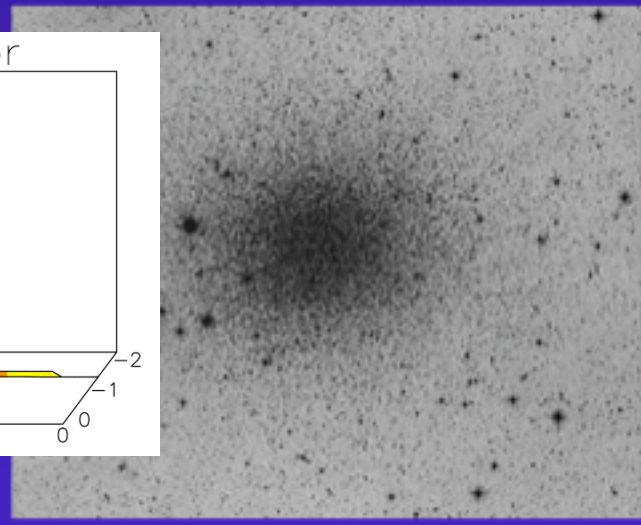
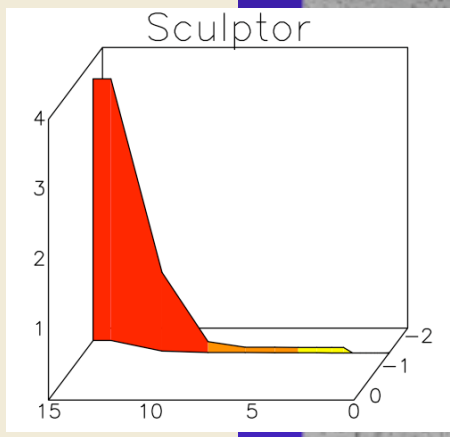
Complementary Ground Based Spectroscopy (High & Low Resolution)



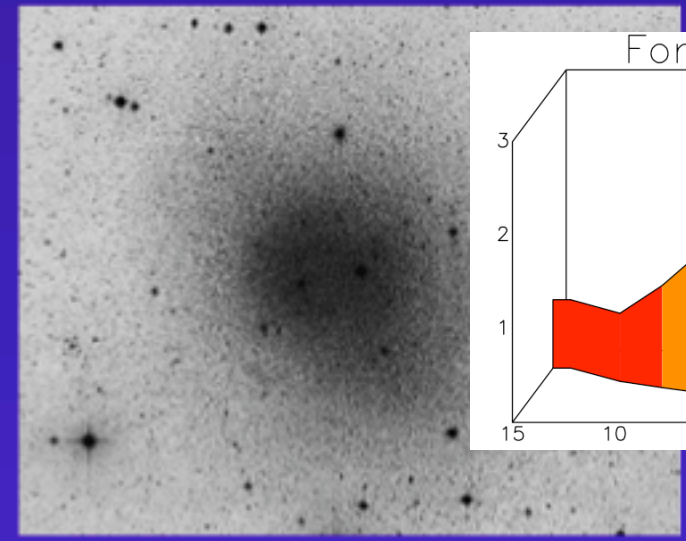
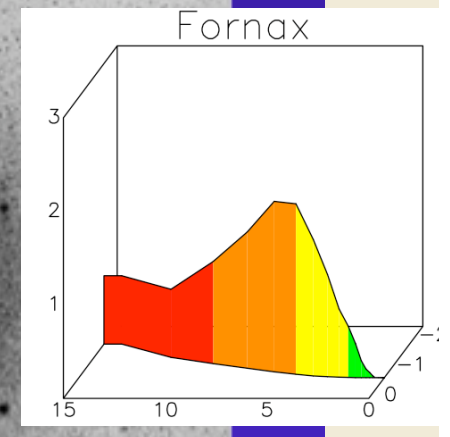
25 arcmin

VLT/FLAMES

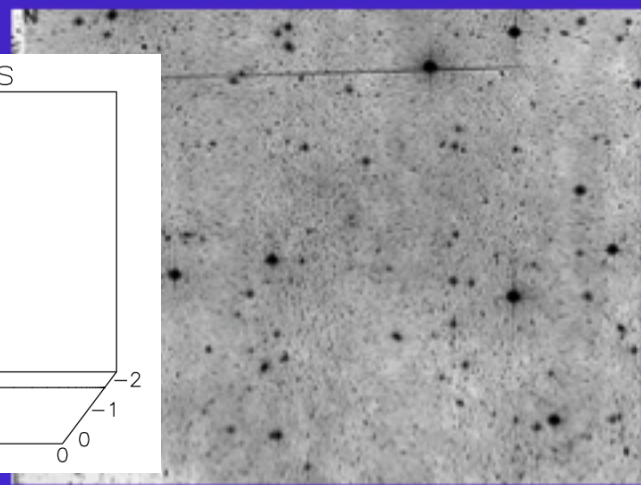
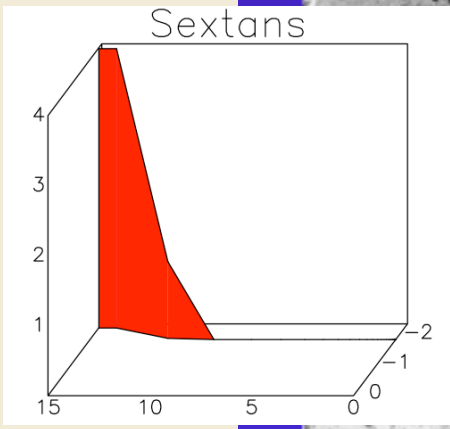
Local dSph studied with FLAMES



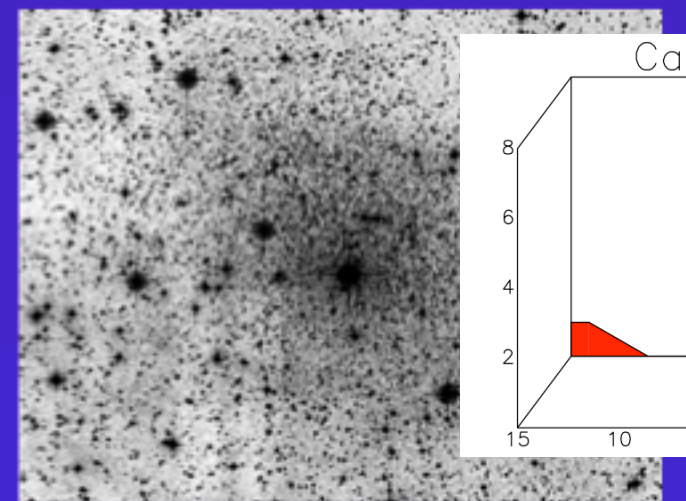
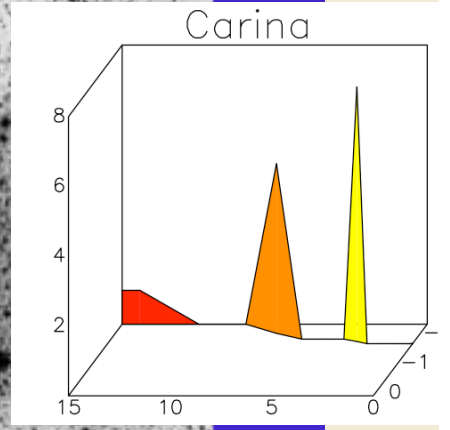
Sculptor



Fornax



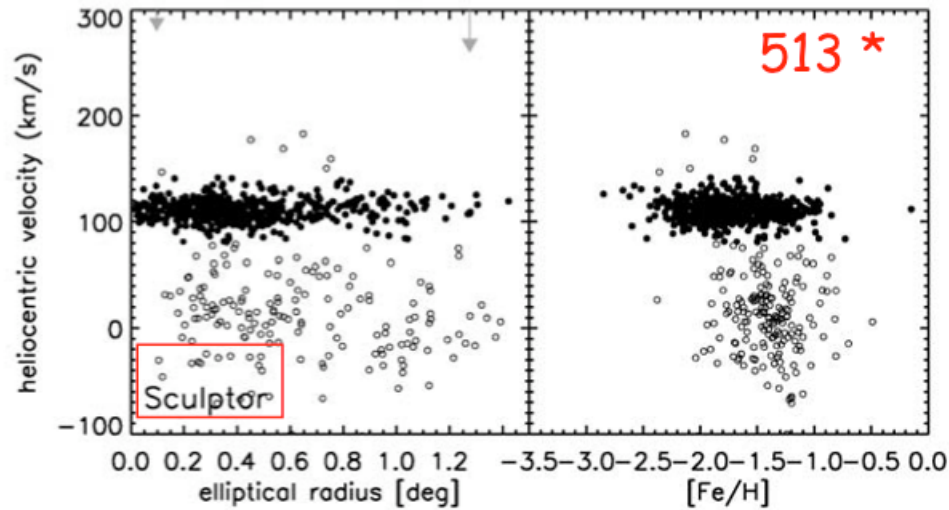
Sextans



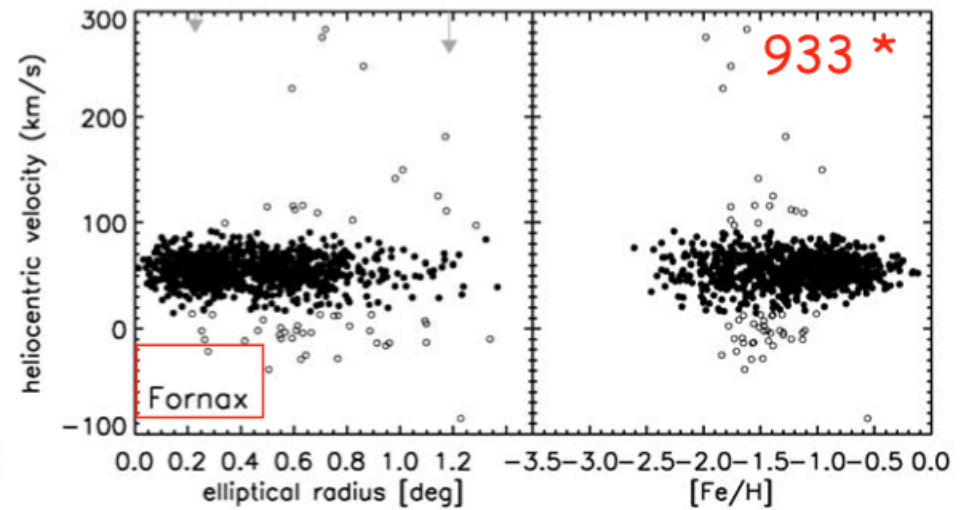
Carina

VLT/FLAMES LR results

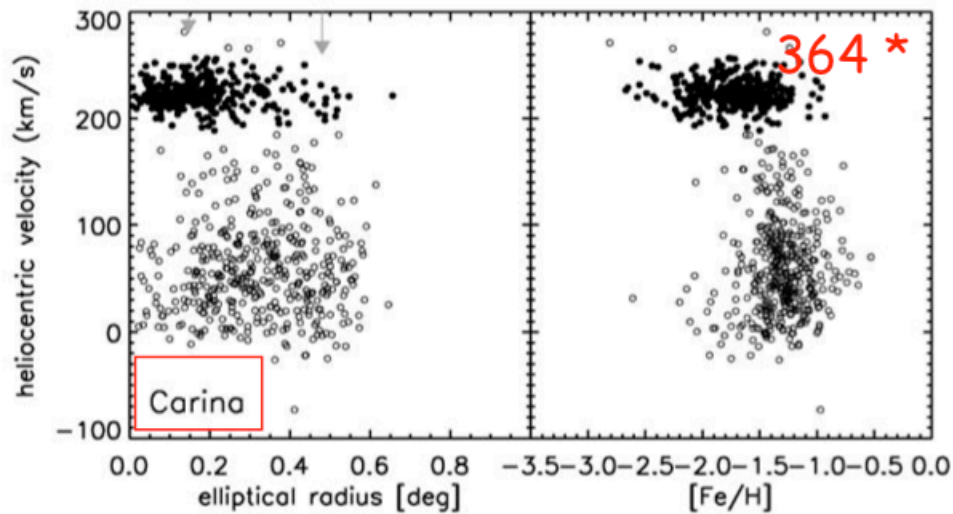
Compilation from Helmi et al. 2006



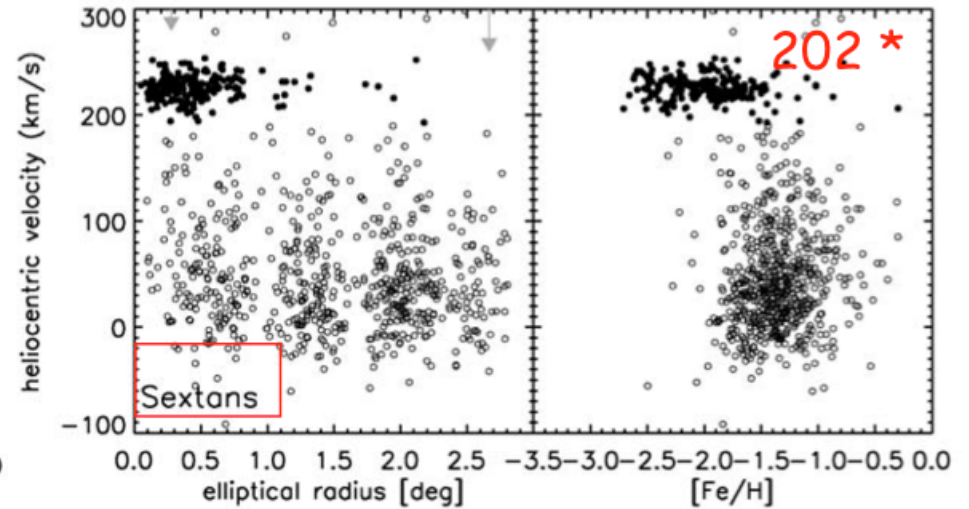
Tolstoy et al. 2004; Battaglia et al. 2007



Battaglia et al. 2006



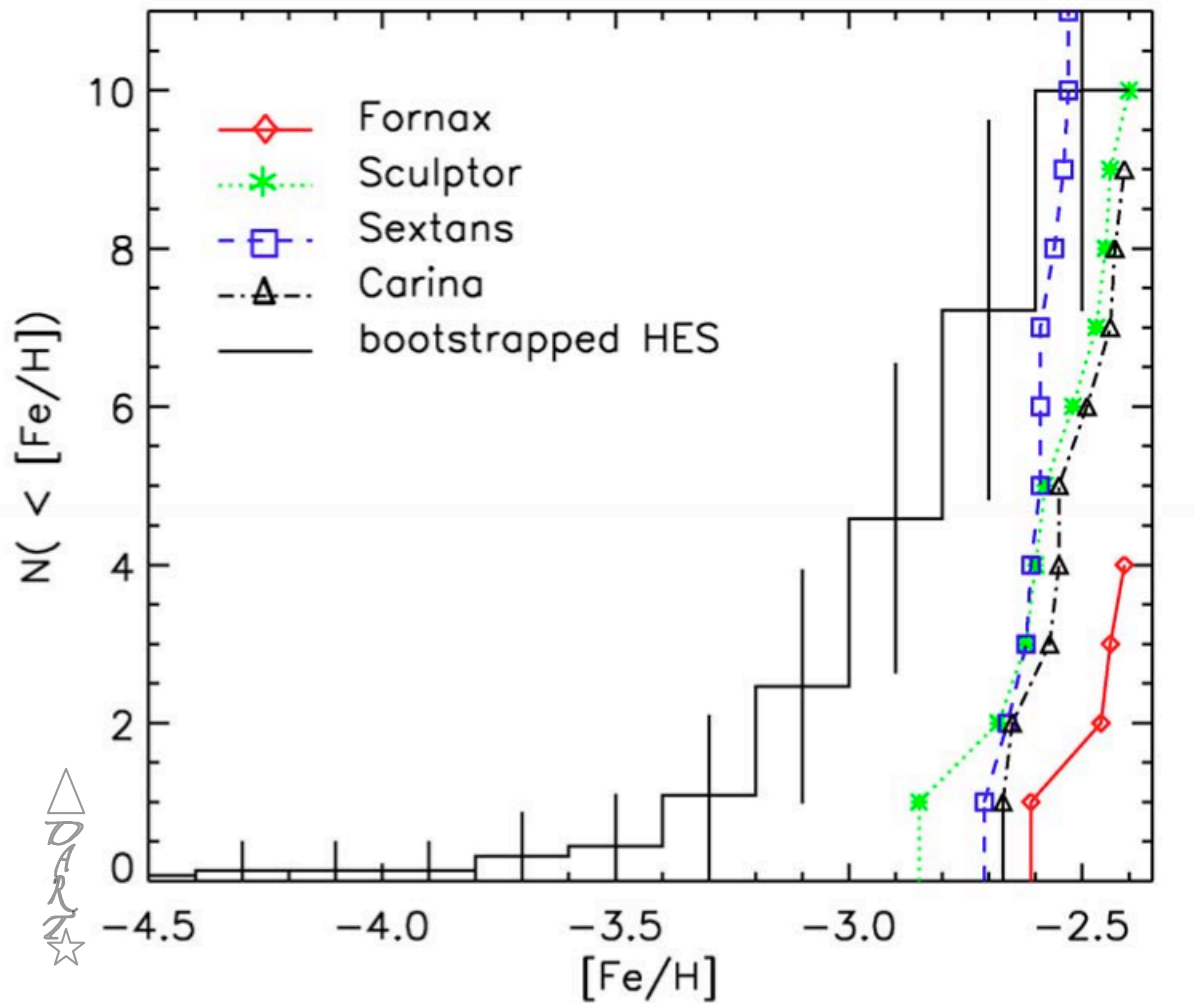
Koch et al. 2006



Battaglia et al.

No Low Metallicity Tail...

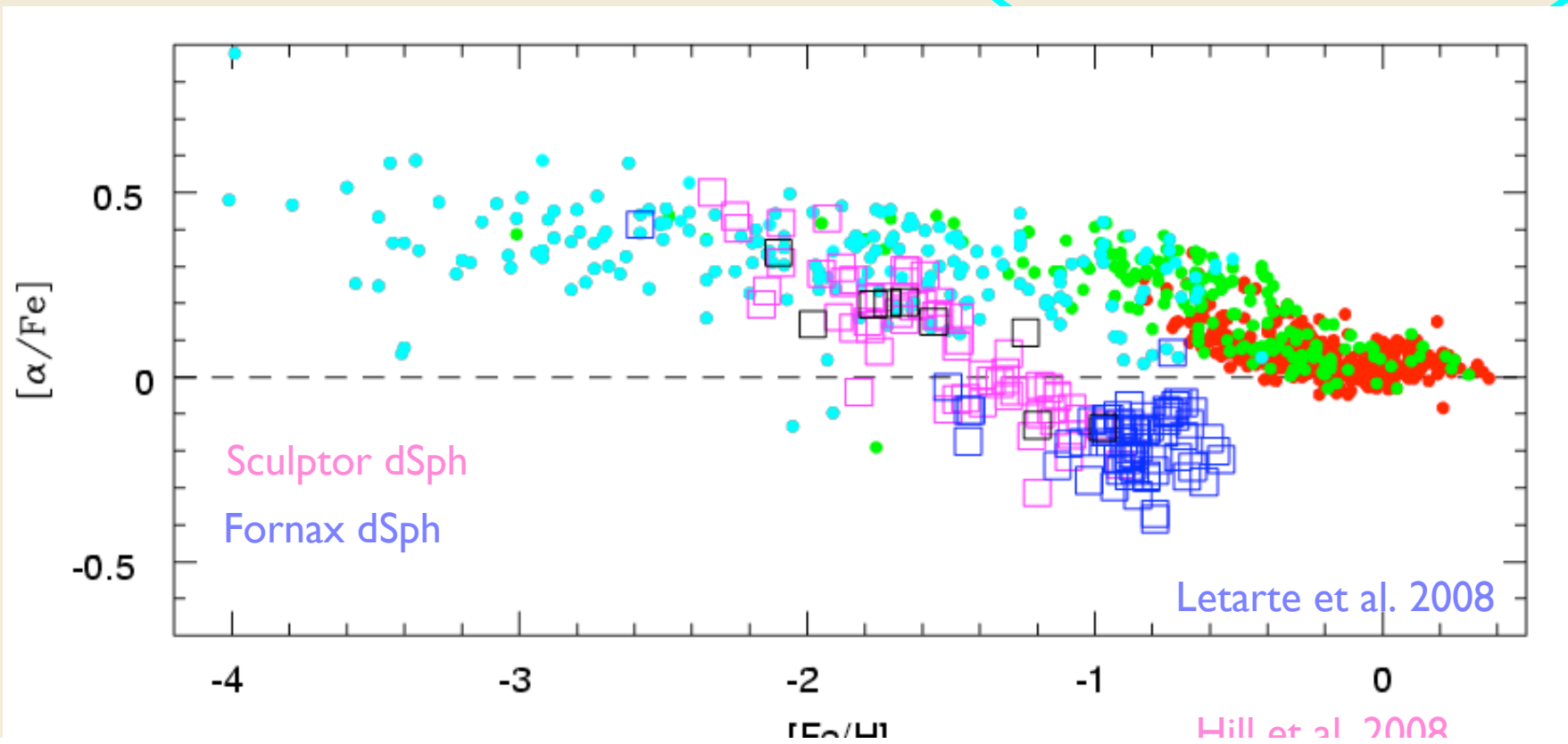
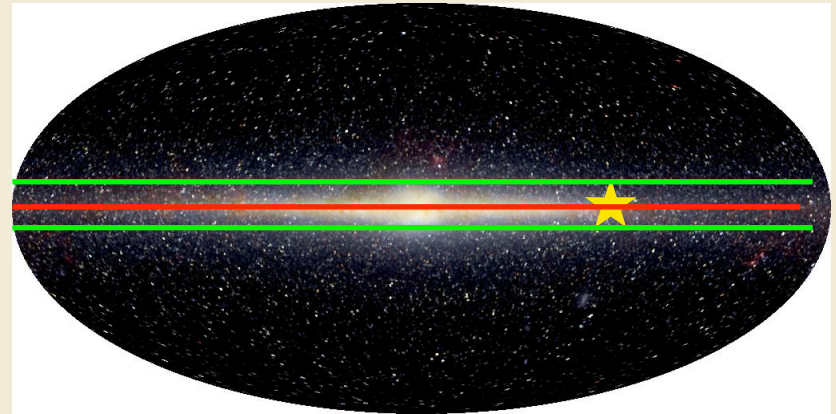
Halo & dSph distributions
significantly different



If drawn from the same population would expect 25% of the metal poor stars in dSph to have $[\text{Fe}/\text{H}] < -3$ i.e. 35/135

We find no stars $[\text{Fe}/\text{H}] < -3$ (so far)

Stellar Abundances in the Local Group



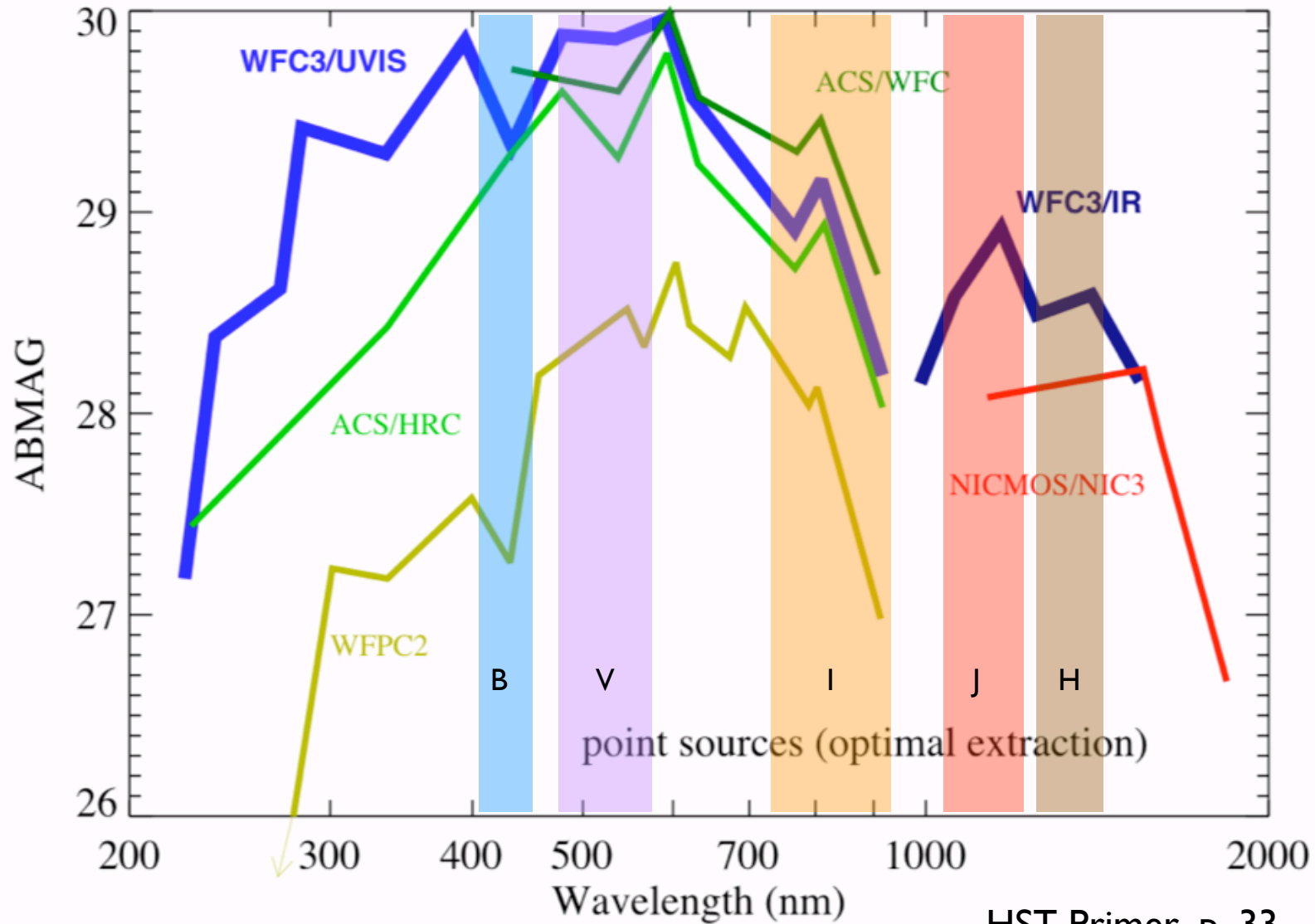
So... What next with HST?

Need DEEP CMDs to study the oldest stellar populations, and these need long exposure times - there is no alternative.

It is also important to combine deep CMDs with spectroscopy of the brighter stars (from the ground)- this allows a better understanding of the detailed chemical enrichment history of a galaxy and also the present day dynamical state.

Point Source Limits after SM4

Figure 4.3: Point-Source Limiting Magnitude $S/N \sim 5$; 10 hr exposure



Choosing filter combinations

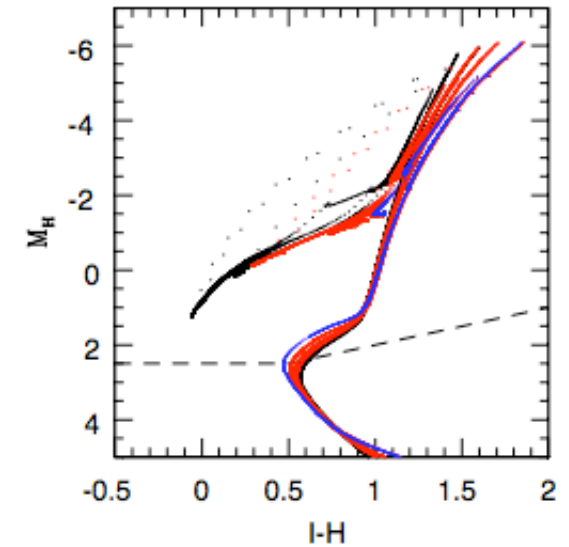
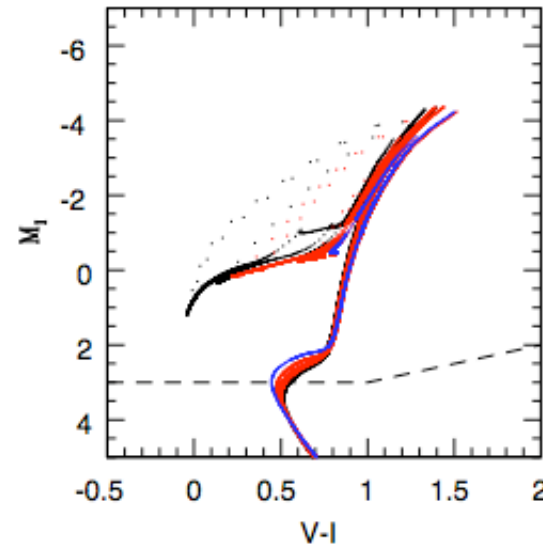
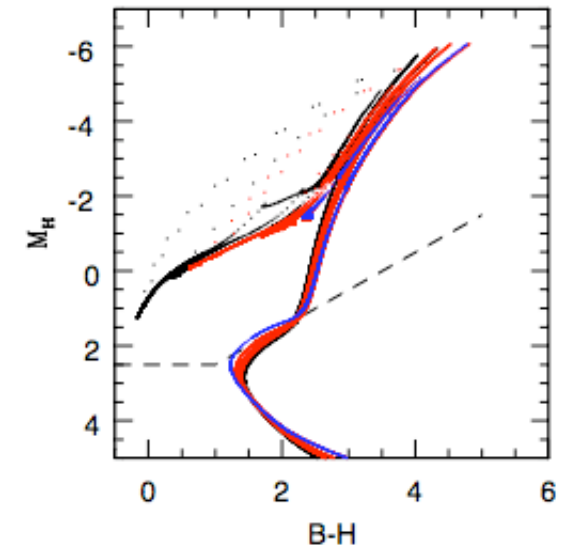
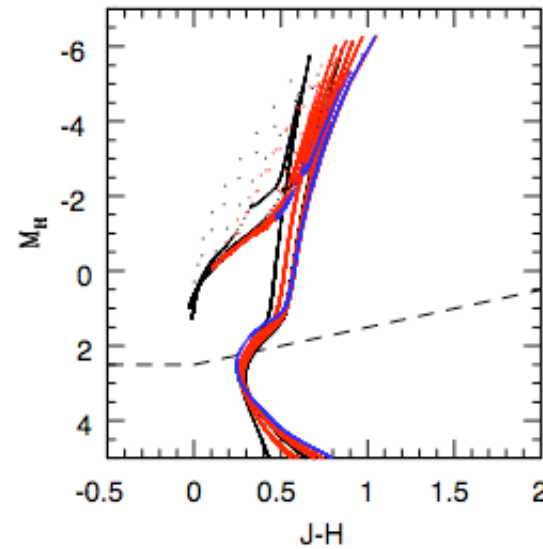
ngc55 m-M= 26.3 (1.8Mpc)

NGC3379 m-M= 30. (10Mpc)

M81/Scl m-M= 27.7 (3.5Mpc)

M31 m-M= 25. (1Mpc)

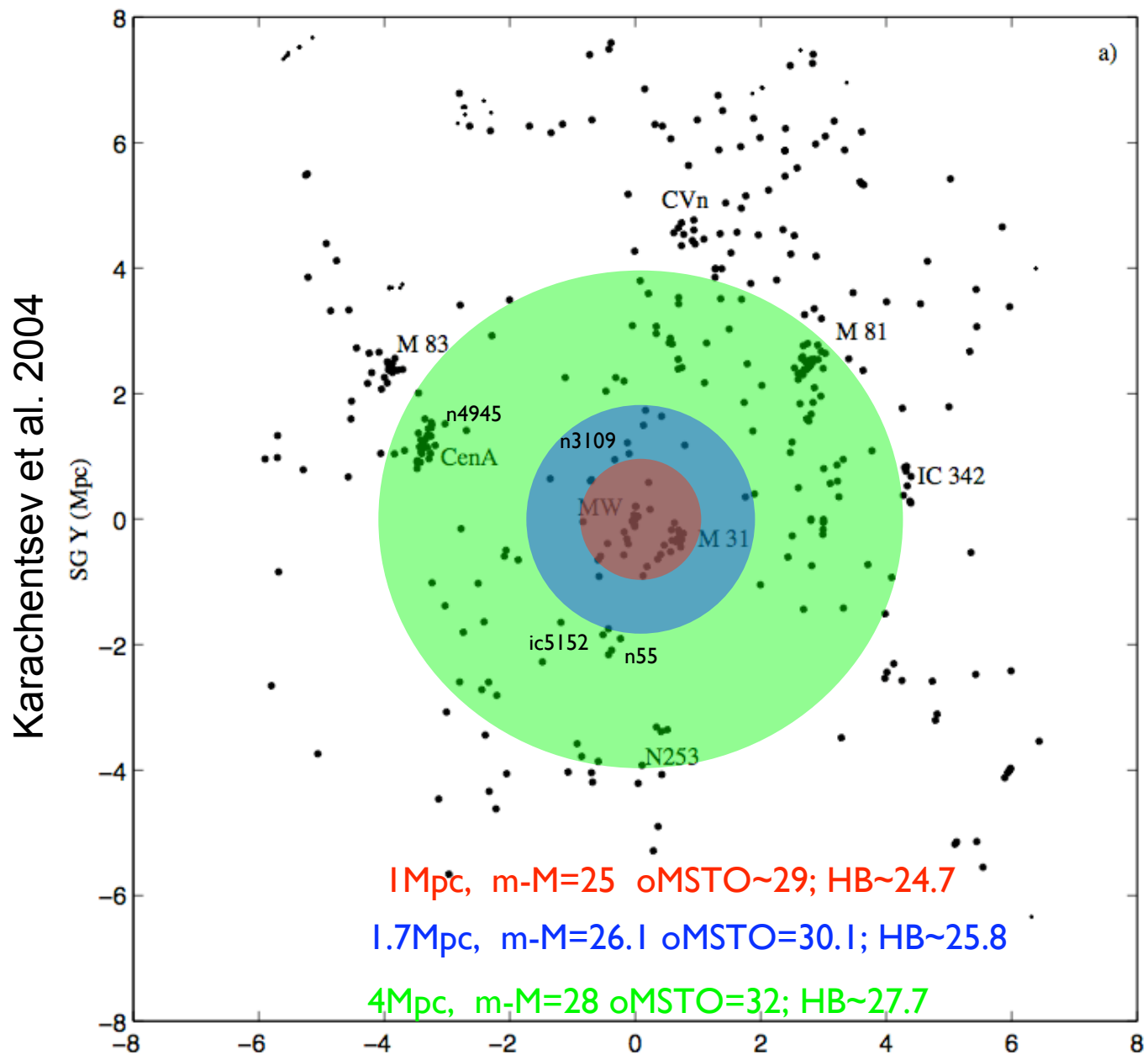
Depth in 10hrs of integration at S/N~5
at a distance of 1.7Mpc



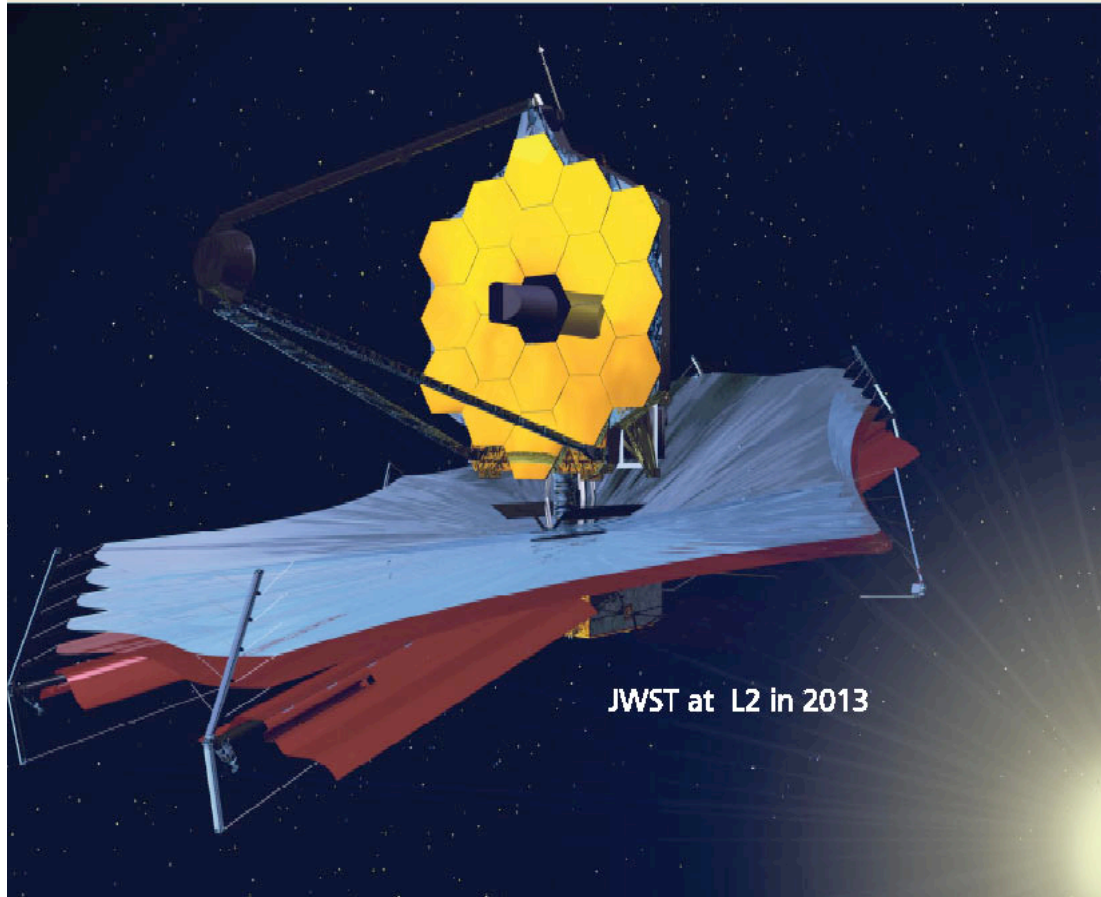
Teramo Isochrones for an low metallicity
dwarf-type galaxy, range of age (>8Gyr)

Survey Volume

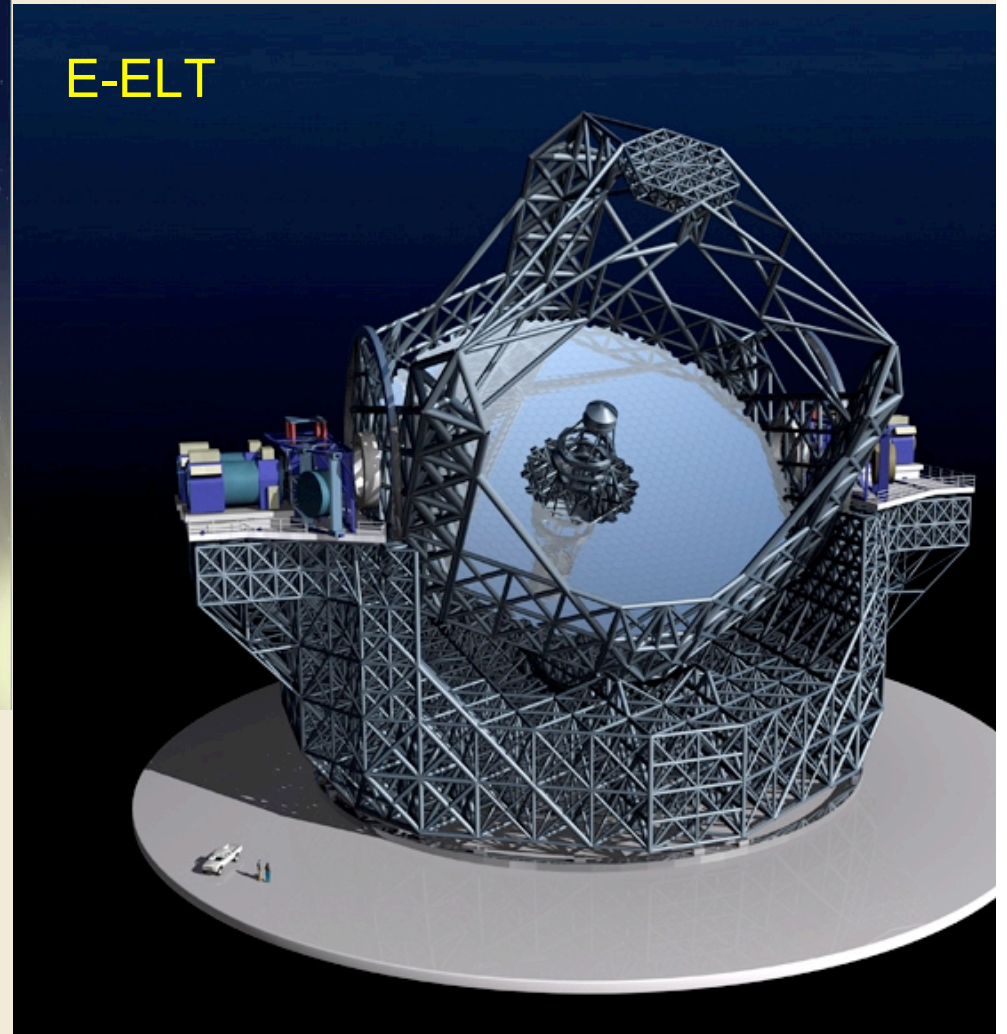
Local Galaxy catalogue, complete to ~8 Mpc distance



More Distant Future Prospects



JWST at L2 in 2013



E-ELT

So... What next for old stars with HST?

Need **DEEP CMDs** to study the oldest stellar populations, and these need long exposure times - there is no alternative, this is restricted to $\sim 1.5\text{Mpc}$

Can also study the HB population of galaxies out to about $\sim 5\text{Mpc}$

It is also important to **combine deep CMDs with spectroscopy** of the brighter stars (from the ground) this allows a better understanding of the detailed chemical enrichment history of a galaxy and also the present day dynamical state. Only possible to about 1.5Mpc .

