Unconventional views of stellar populations

Part II
Statistical properties of stellar populations

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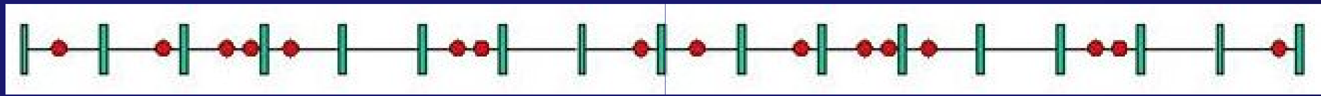
What a Photometric Entropy theory is for?

Entropy is a measure of the **intrinsic "variance"** of a stellar aggregate along the different spectral range of observation.

- Surface-brightness Fluctuations
- Crowding
- Diagnostics from Narrow-band Spectroscopy

Some Fundamentals

$$p(x) = \frac{e^{-\lambda}\,\lambda^{x}}{x!} \quad \text{for } \lambda > 0 \text{ and } x = 0, 1, 2\ldots$$



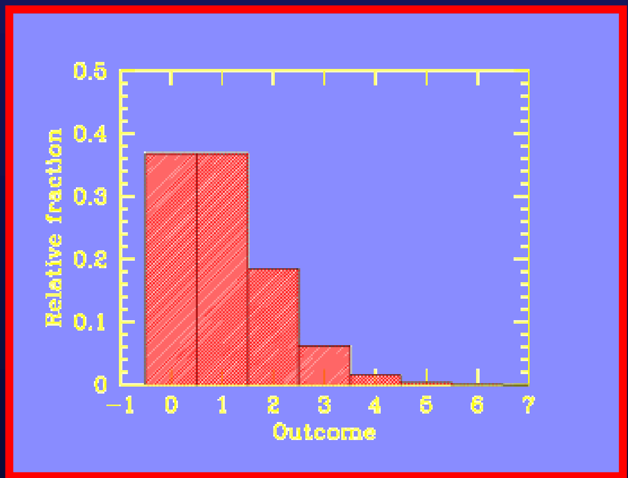
1, 2, 3, ... N_{tot}

➡ $N = 1 \pm 1$ for each cell

$\sigma(N_{tot}) = \sqrt{\Sigma 1} = \sqrt{N_{tot}}$

$L_{tot} = \Sigma\, \ell_* = N_{tot}\, \ell_*$

$\sigma(L_{tot}) = \sqrt{\Sigma \ell_*^2} = \ell_* \sqrt{N_{tot}}$



$$\sigma(L_{tot})/L_{tot} = 1/\sqrt{N_{tot}}$$

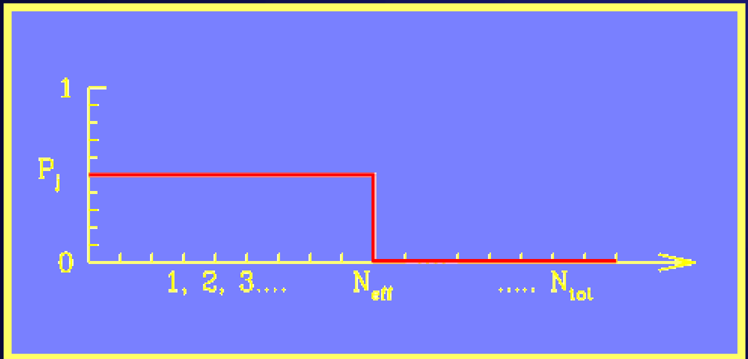
More generally, if ℓ_* is NOT a constant, we can still define

$$\sigma(L_{tot})/L_{tot} = 1/\sqrt{N_{eff}}$$

where, always,

$$N_{eff} \leq N_{tot}$$

⇒ N_{eff} will depend on λ as ℓ_* depends on λ



$$S = \mathrm{Log}\,(N_{eff}/N_{tot})$$

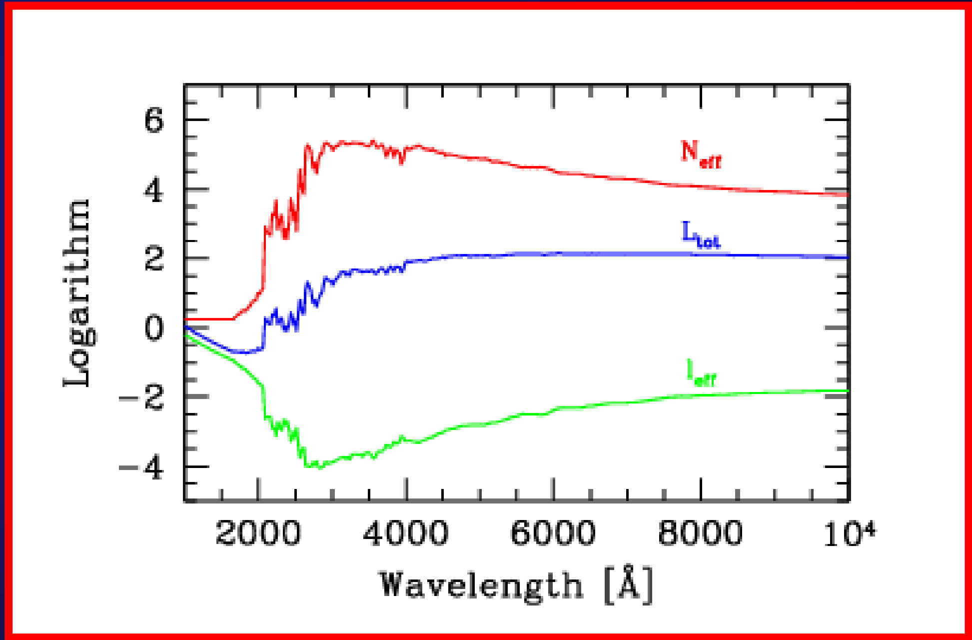
Quite importantly, $S = S(\lambda)$

In order to fix N_{eff} (and Entropy) we need a photometric argument:

$$\sigma^2(L_{tot}) \,/\, L_{tot} = \Sigma \ell_*^2 / \Sigma \ell_* = \ell_{eff}$$

At every λ, it must be:

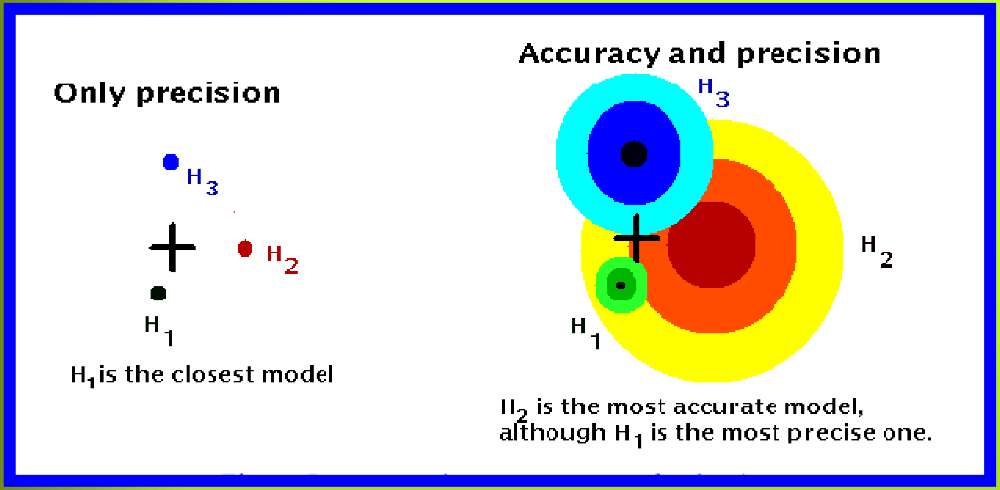
$$N_{eff} \times \ell_{eff} = L_{tot}$$



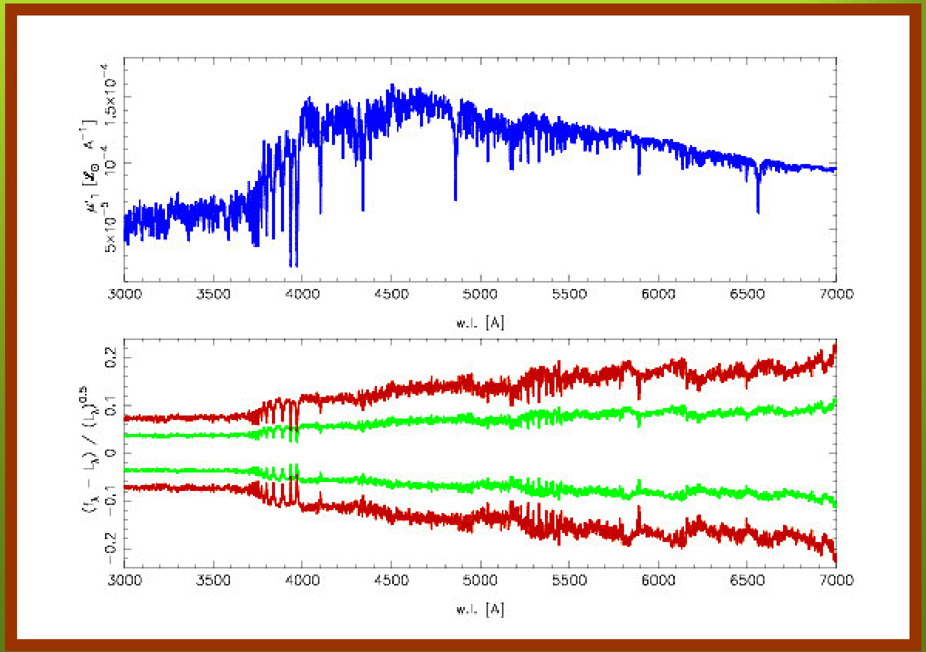
Buzzoni (1993)

Buzzoni (1993), A&Ap, 275, 433
Buzzoni (2005), Astro-ph/0509602
Cerviño et al. (2002), A&Ap, 381, 51
Cerviño & Luridiana (2007), Astro-ph/0711.1355

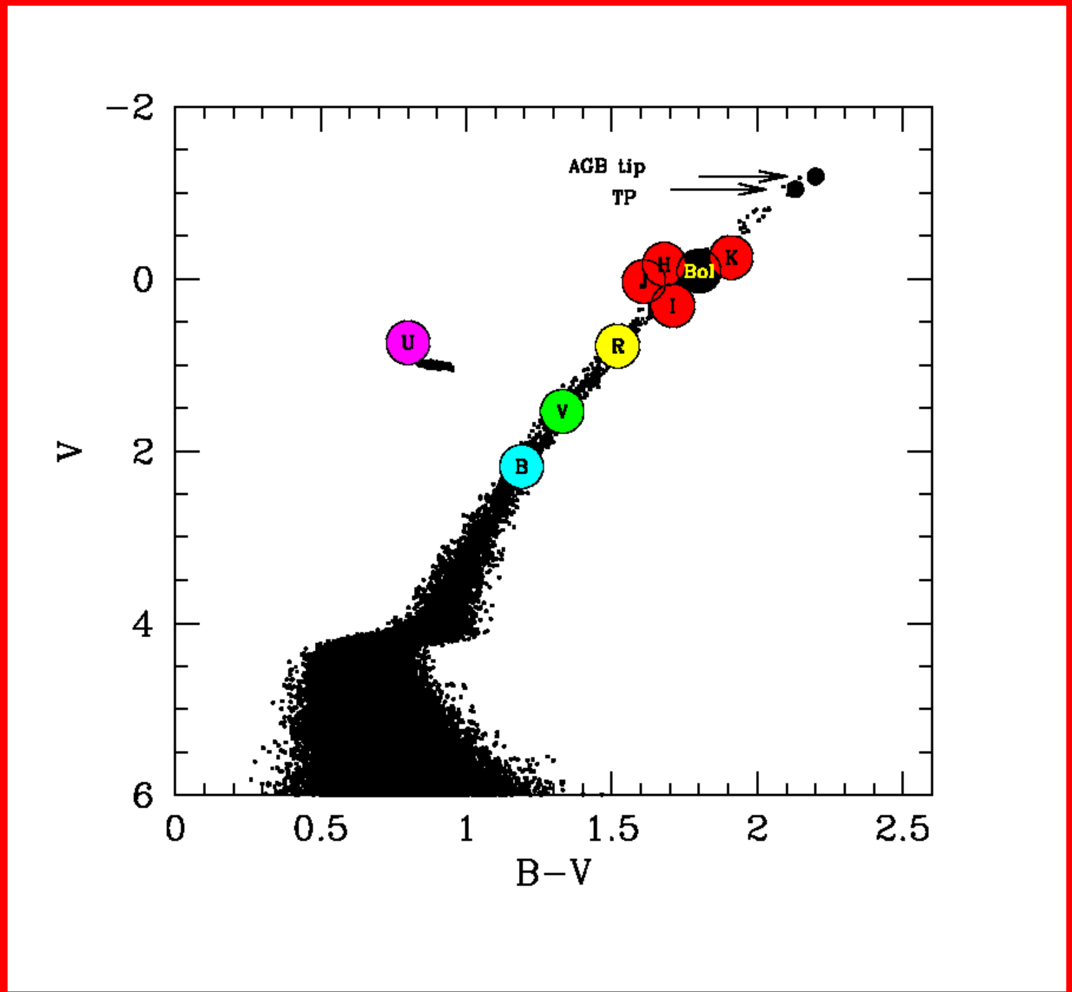
Accuracy vs. Precision



Cerviño & Luridiana (2007)



Brightness fluctuations & stellar "barycenter"



Buzzoni & González-Lópezlira (2008)

Surface-Brightness Fluctuations: an Alternative Approach for the Case of M53

2.12m @Cananea (Mexico)
6.5'x10' LFOSC (R band)

3141.8	3201.5
2885.5	3323.3

First application of the theory to galx's: Tonry & Schneider (1988) and Tonry (1991)

$$\sigma^2(L_{tot}) \,/\, L_{tot} = \Sigma \ell_*^{\,2} / \Sigma \ell_* = \ell_{eff}$$

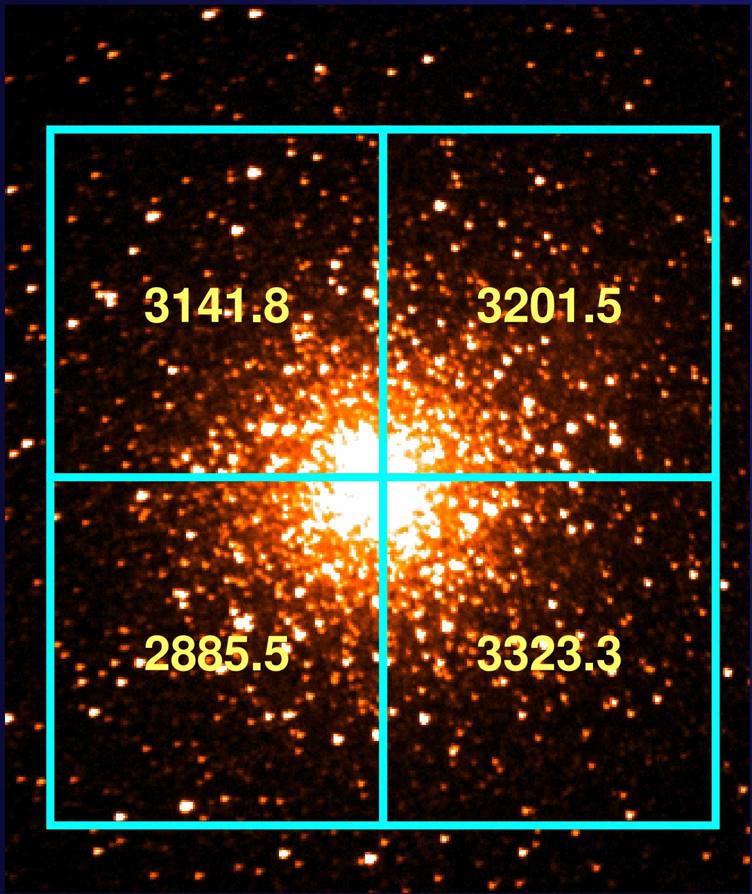
Observations

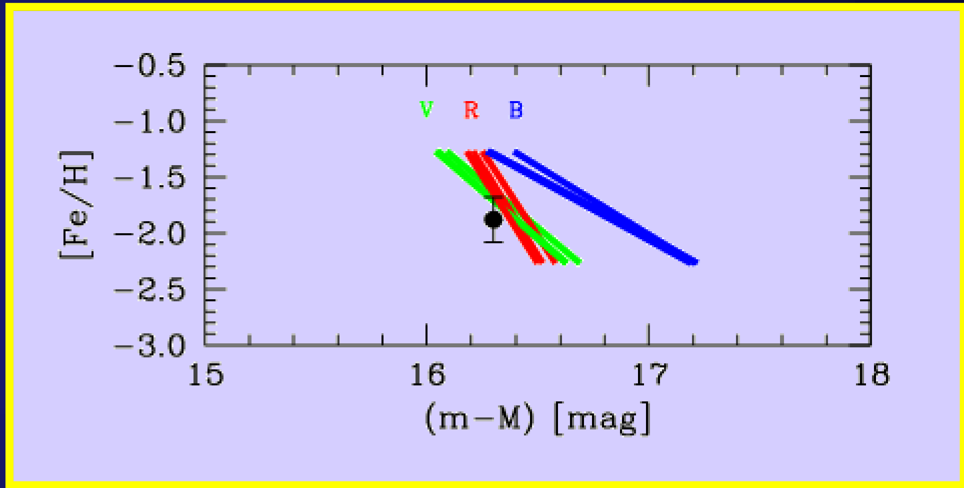
Theory: Population synthesis models → ℓ_{eff}

$$L_{(quad)} = 3138 \pm 184$$

Surface-Brightness Fluctuations: an Alternative Approach for the Case of M53

M 53 (NGC 5024)



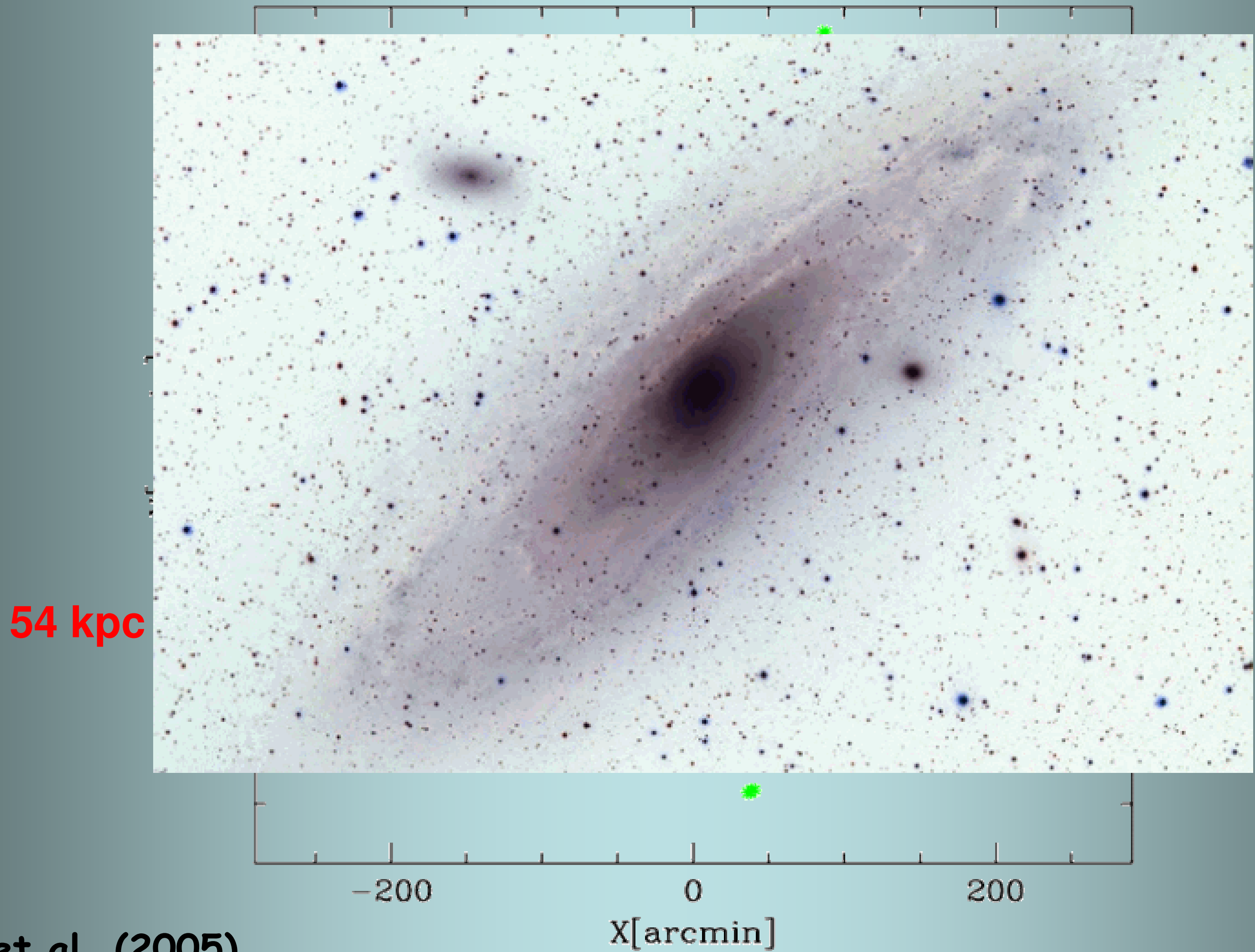


[Fe/H] = -1.88 ± 0.2 dex (Santos & Piatti, 2004)

(m-M) = 16.3 mag (Harris 1996)

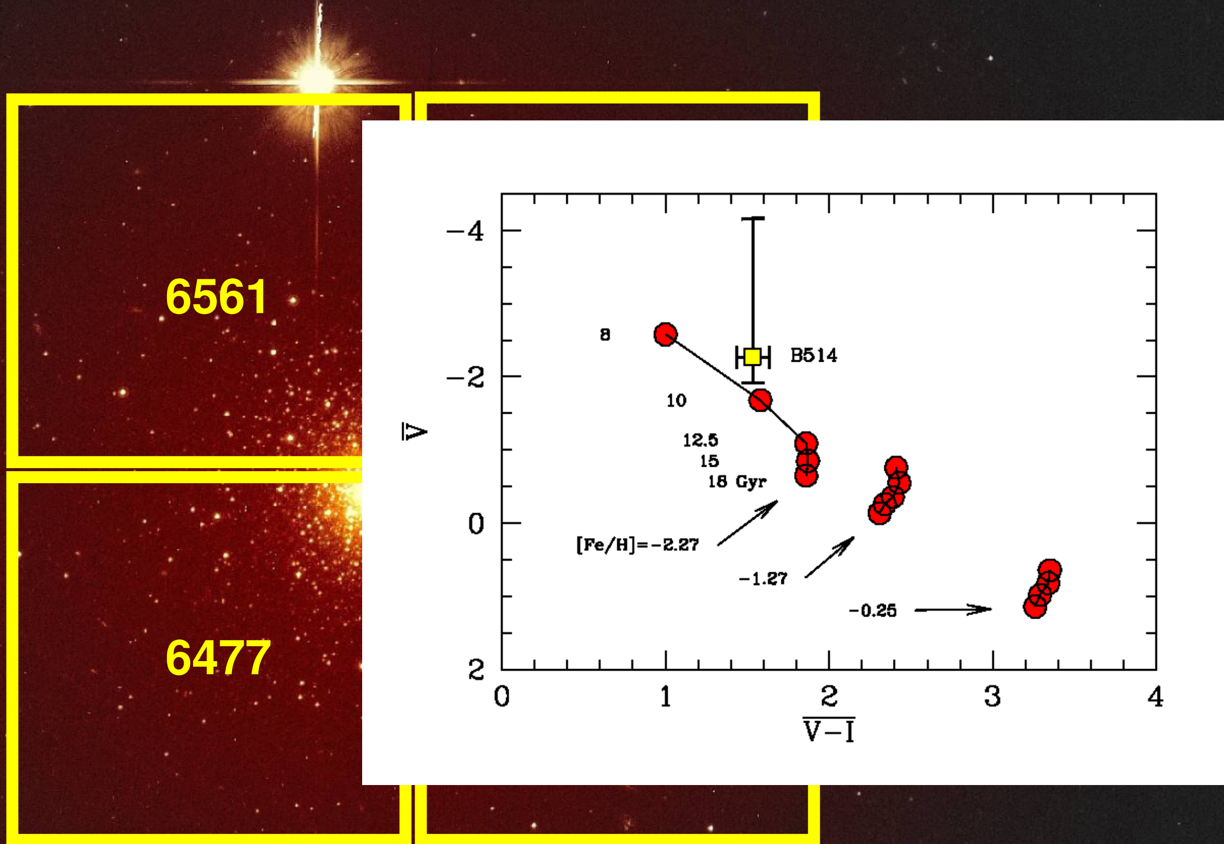
$L_{(quad)}$ = 3138 ± 184

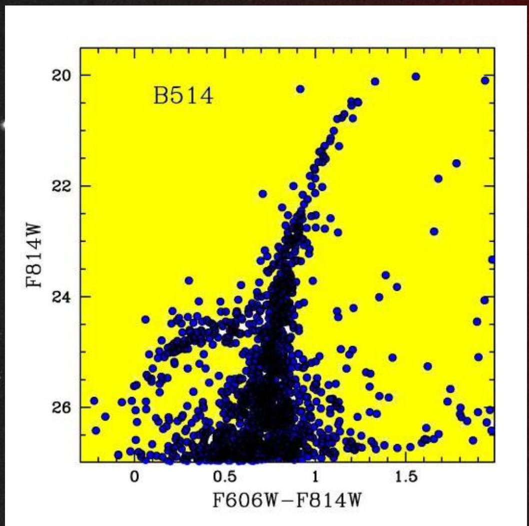
Far, far away…(around M31)



Galleti et al. (2005)

B514 - the farthest globular cluster of M31





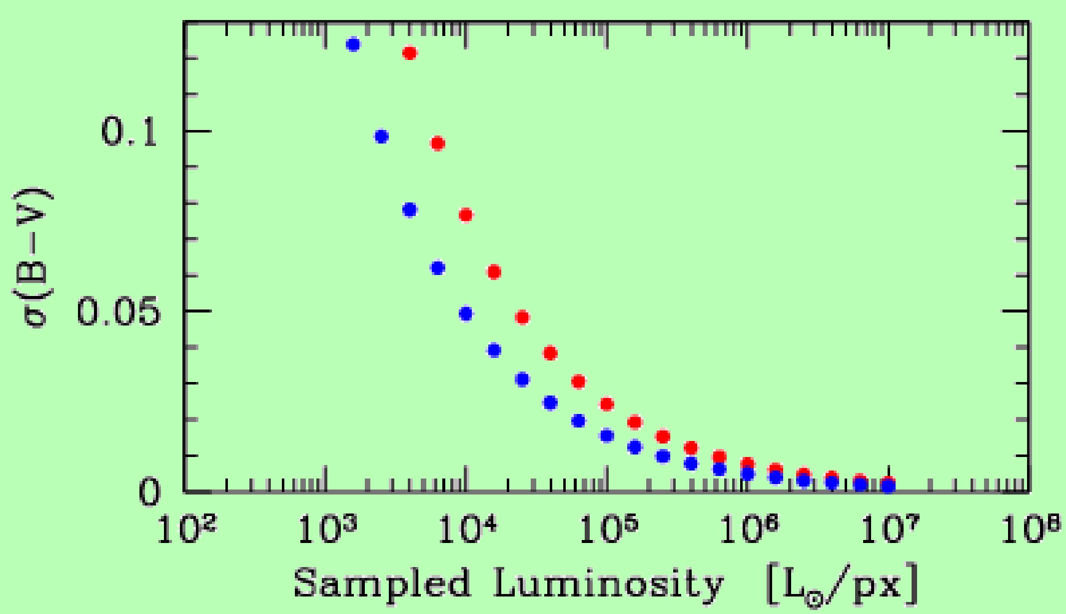
Galleti et al. (2006)

$\sigma^2(L_{tot}) / L_{tot} = 507.8^2/6128.5 = \ell_{eff}$

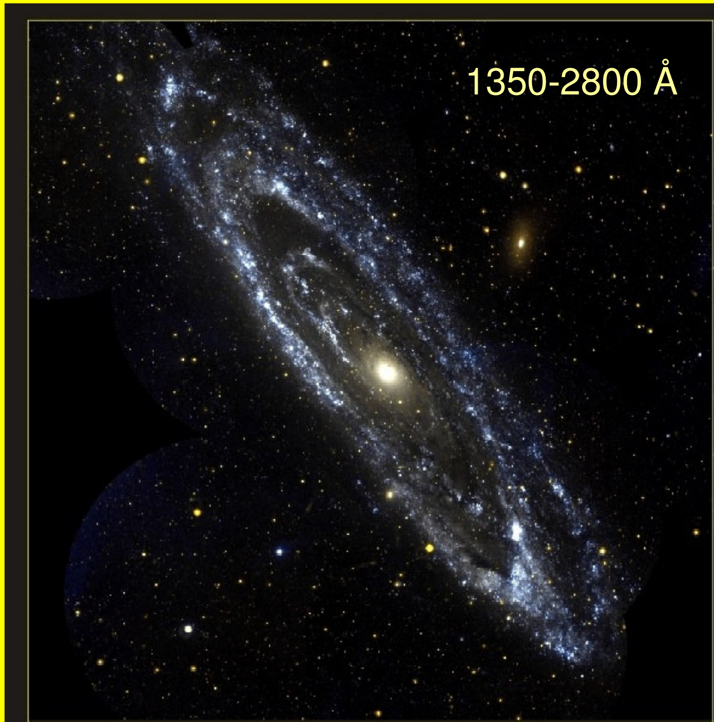
Luminosity Sampling and Intrinsic Color Fluctuations

$\Delta mag = \sigma(L_{tot})/L_{tot} = 1/\sqrt{N_{eff}}$

$\sigma\,(B-V) = [\sigma(B)^2 \pm \sigma(V)^2\,]^{1/2} = (1/\,N_{eff}^B \pm 1/\,N_{eff}^V)$



Crowd!



Andromeda Galaxy
GALEX

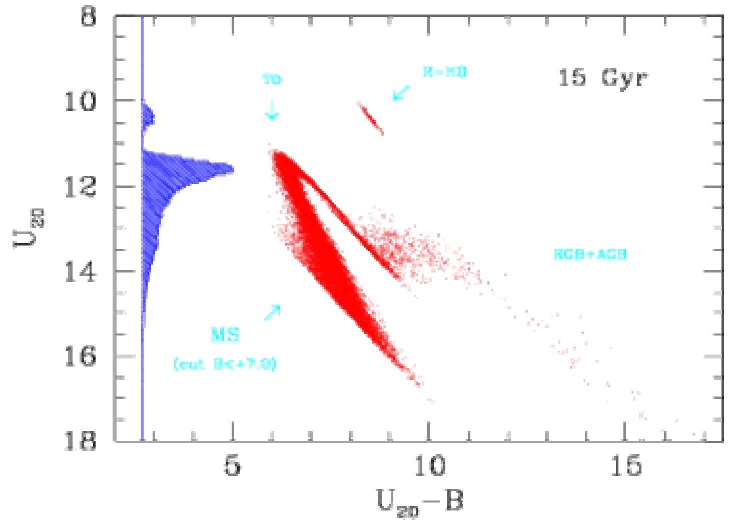
Thilker et al. (2005)

Andromeda Galaxy
Visible light image (John Gleason)

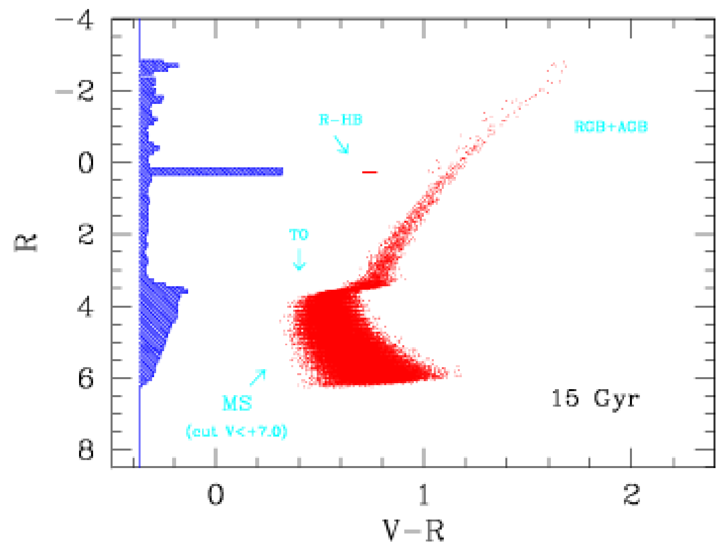
Credits: Flickr.com

Oligarchy vs. Democracy

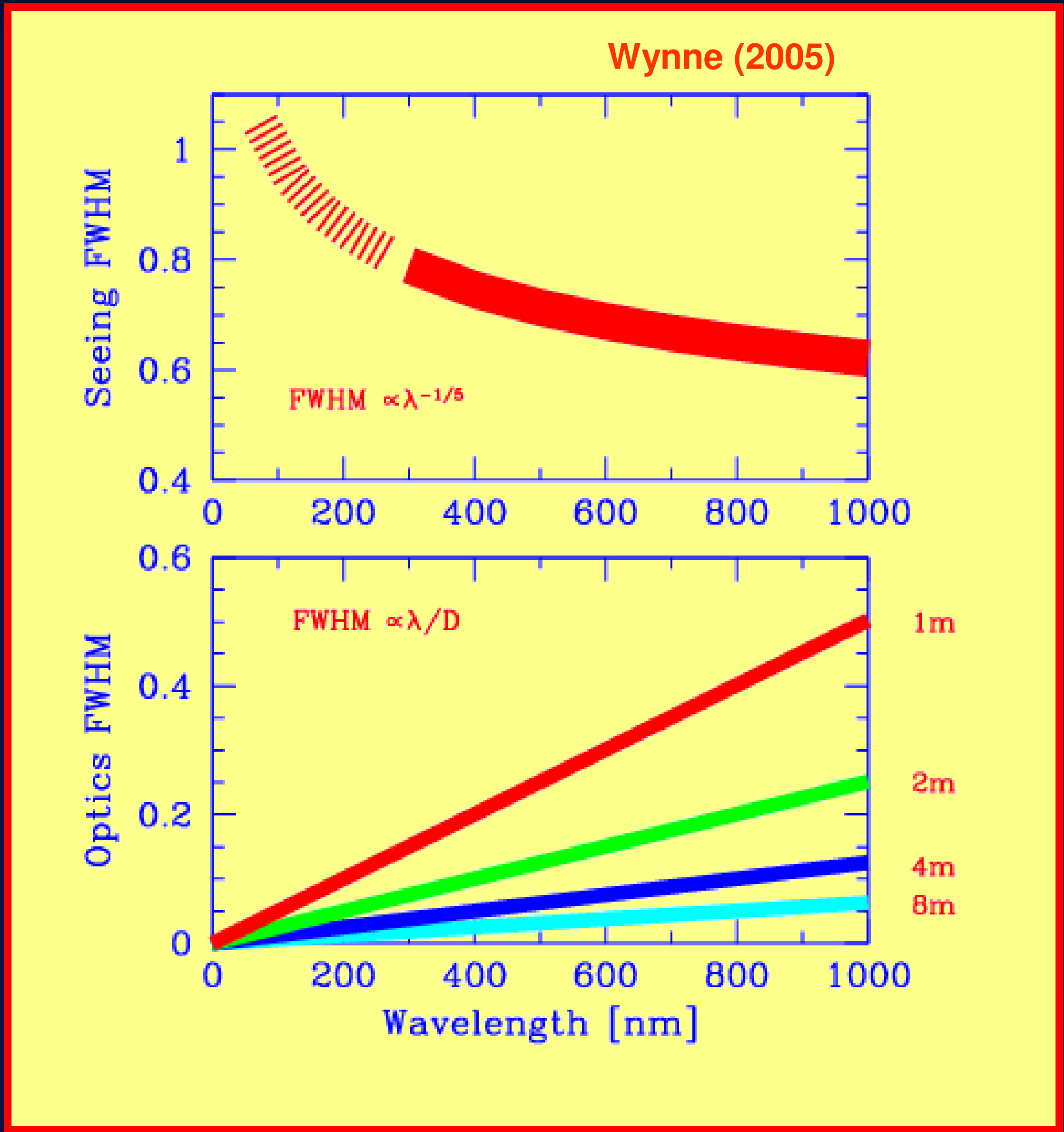
2000 Angstroms



7000 Angstroms



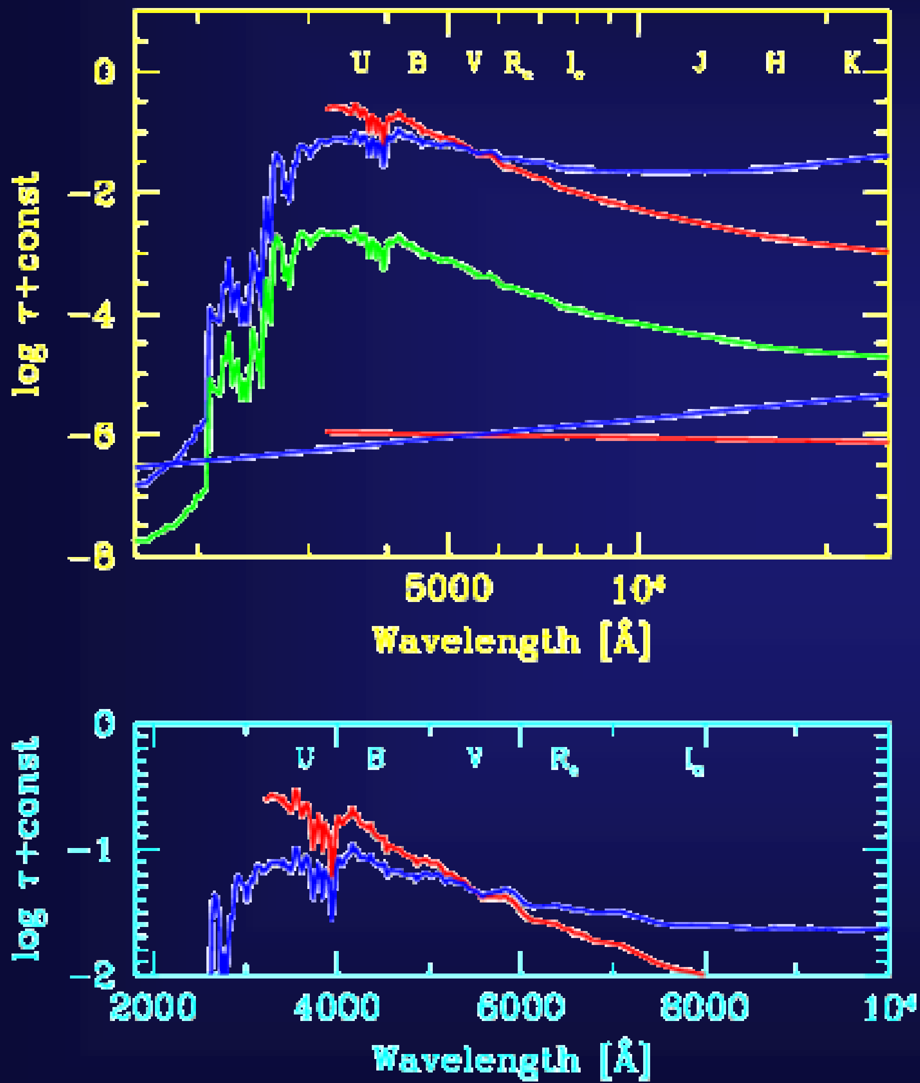
Buzzoni (2002)



Seeing

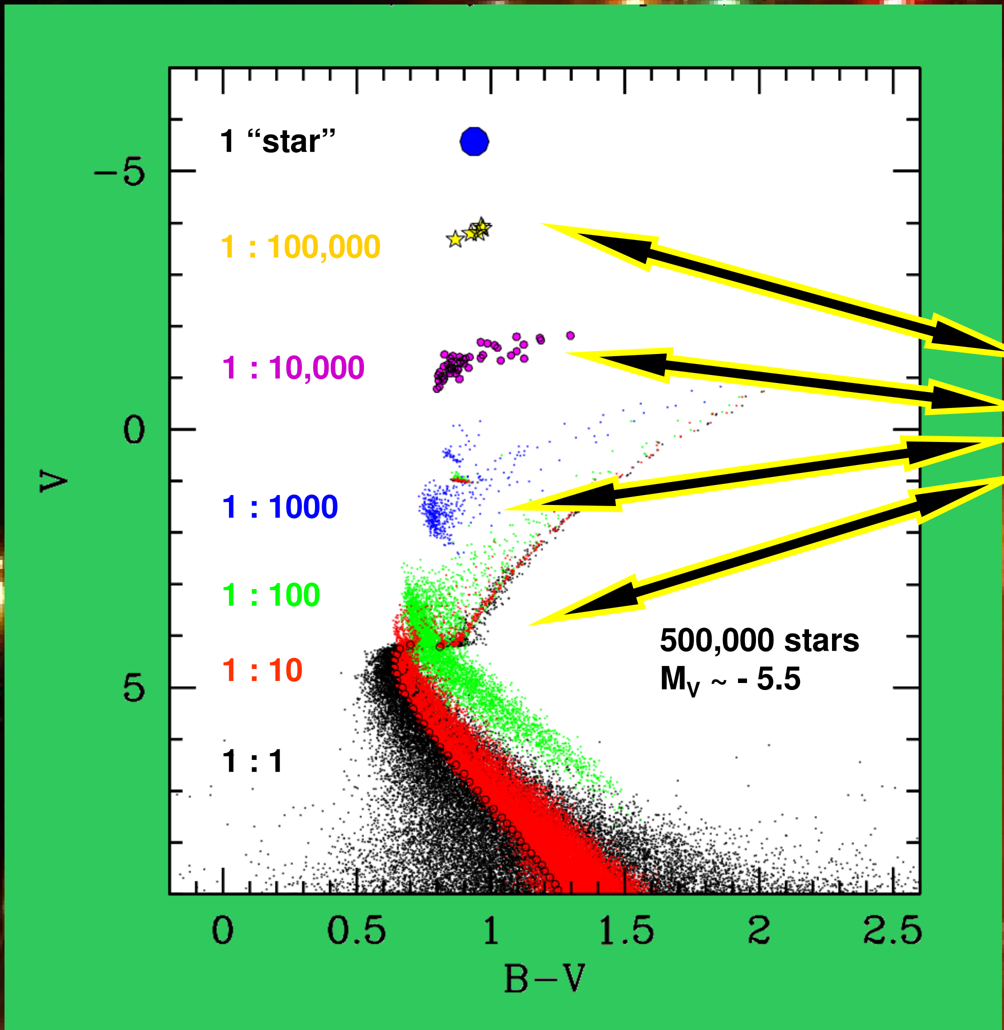
Diffraction

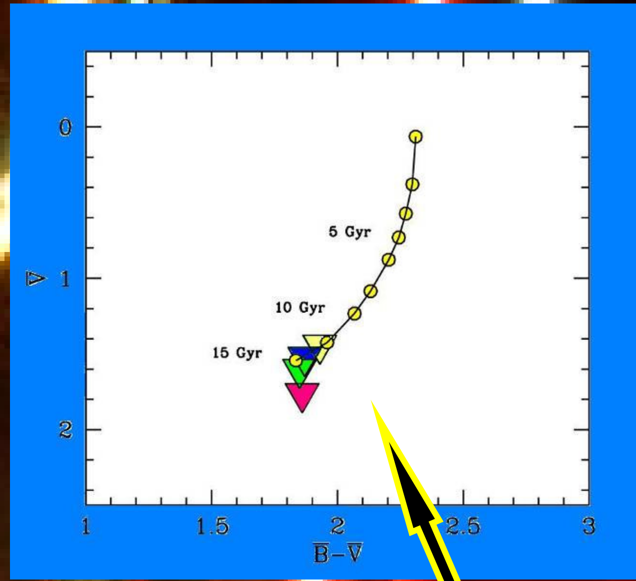
Crowding & Opacity



- from Space
- from Ground
- Entropy (N_{eff})
- Telescope Diffraction
- Seeing

Crowding, photometric entropy & surface-brightness fluctuations





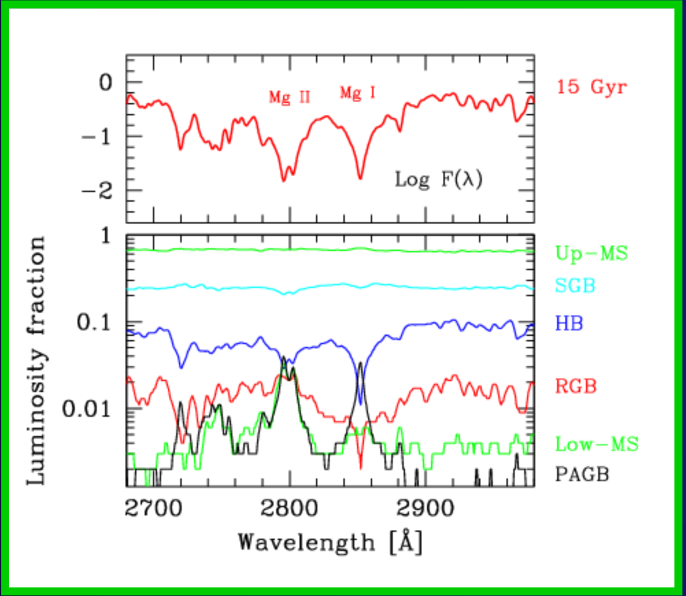
$$\sigma(L_{tot})/L_{tot} = 1/\sqrt{N_{eff}}$$

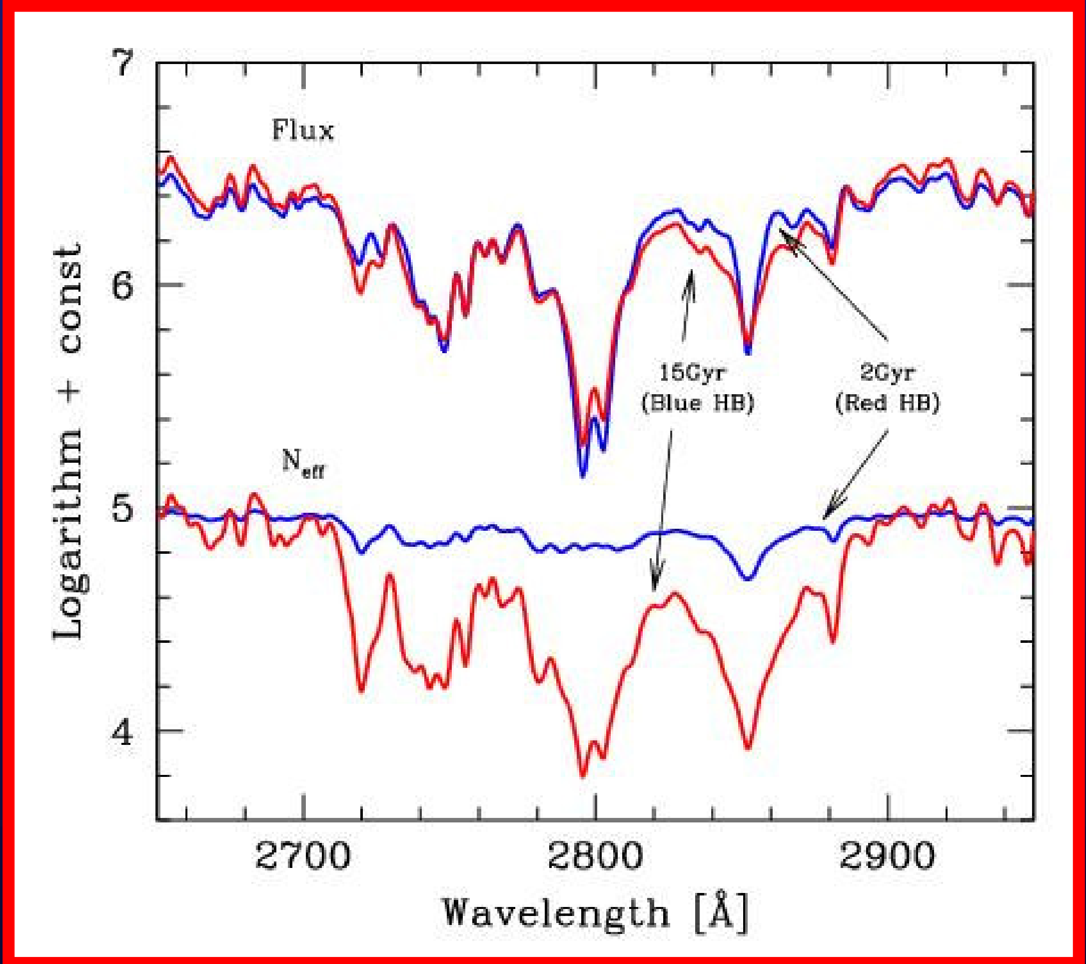
$$S = \mathrm{Log}\,(N_{eff}/N_{tot})$$

$$\sigma^2(L_{tot})/L_{tot} = \Sigma \ell_*^2 / \Sigma \ell_* = \ell_{eff}$$

$$N_{eff} \times \ell_{eff} = L_{tot}$$

An illustrative example: the 2800 Å Mg feature





Buzzoni (2008)

The End (Part II)