The Age(s) of the NGC 5128 Halo

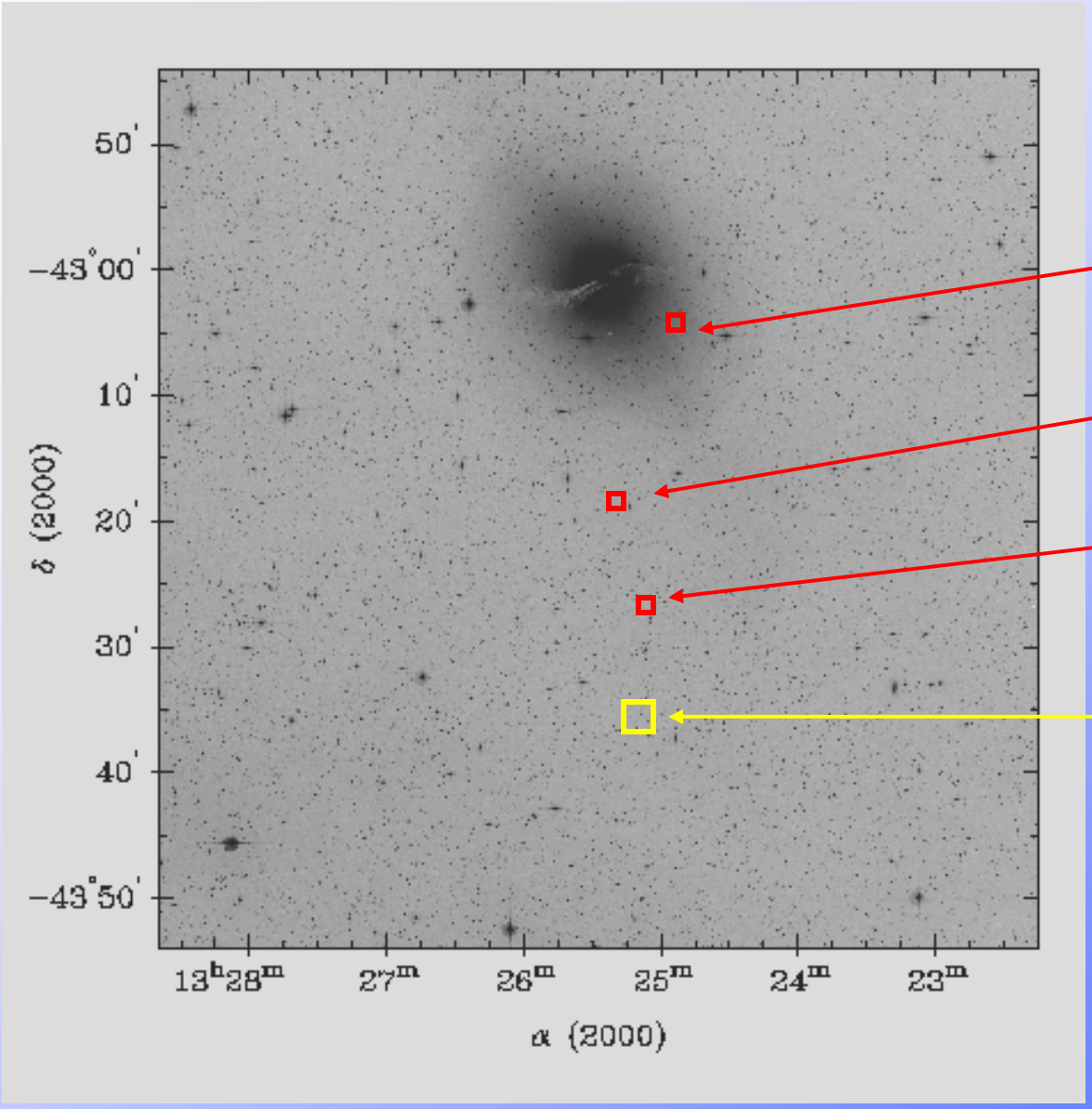
The color/magnitude distribution of the halo stars directly constrains their ***age*** and ***metallicity*** distribution

NGC 5128 (Centaurus A) is well placed for stellar population studies of this type, since it is by far the *nearest accessible giant E galaxy.*

A unique resource!

d = 3.8 +- 0.2 Mpc (TRGB, Cepheids, PNLF, SBF, LPVs)

- Obvious evidence for its most recent satellite accretion.
- But is the bulk of the galaxy classically old?
- Is there an extensive starburst history?



HST imaging

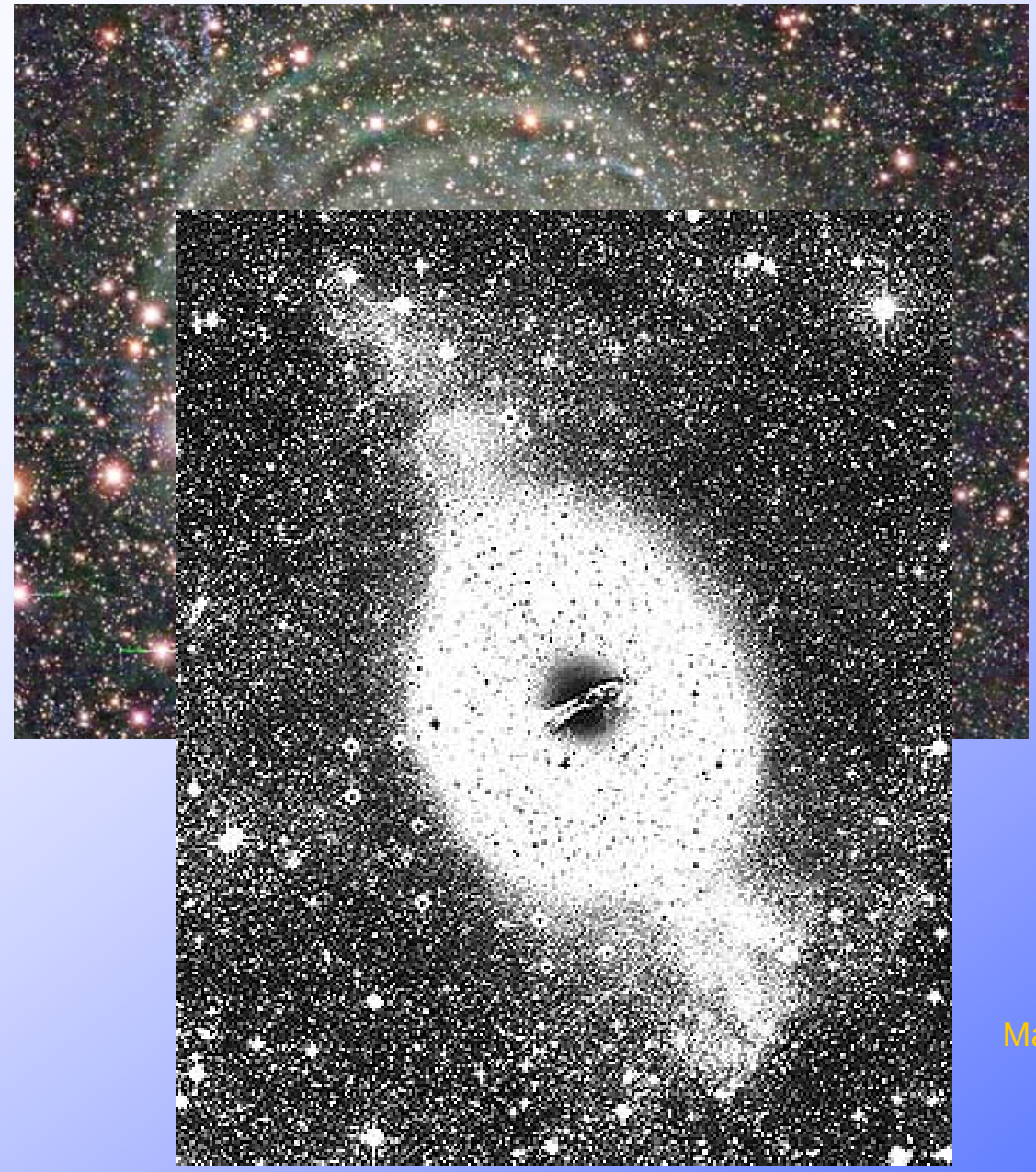
8 kpc WFPC2
1.4 R_e

20 kpc WFPC2
3.7 R_e

30 kpc WFPC2
5.4 R_e

40 kpc ACS/WFC
6.7 R_e

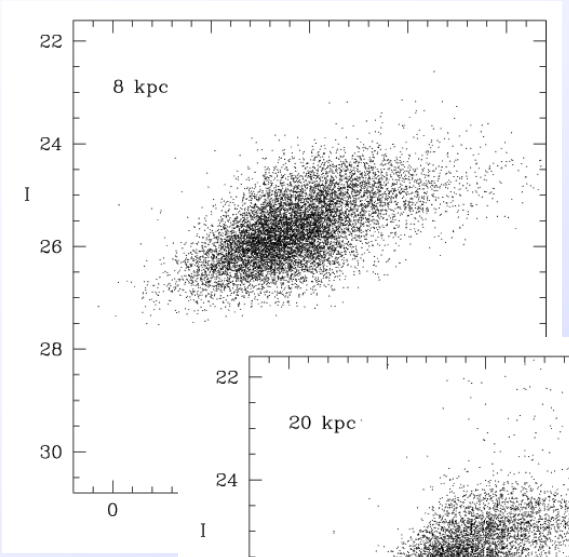
(NB: PNe extend twice this far out)

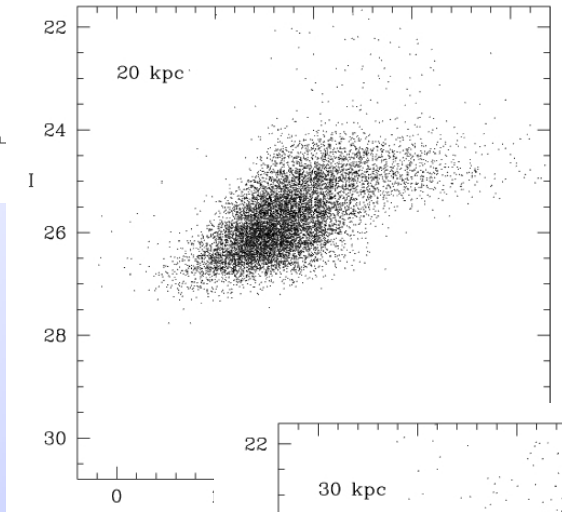


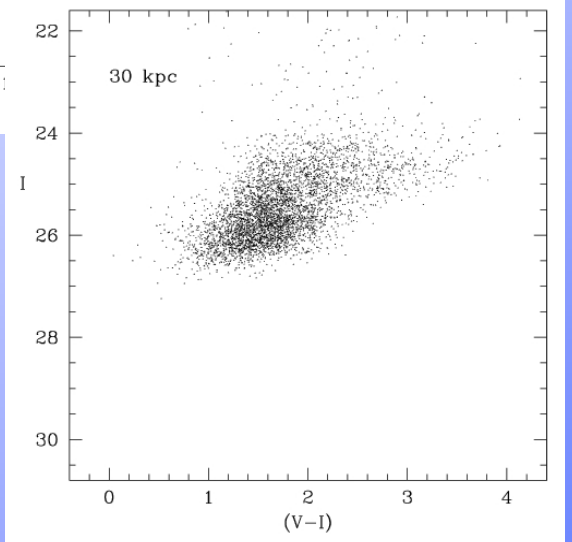
These HST target fields avoid shells and plumes (old accretion remnants)

Peng, Ford & Freeman 2002

Malin 1983





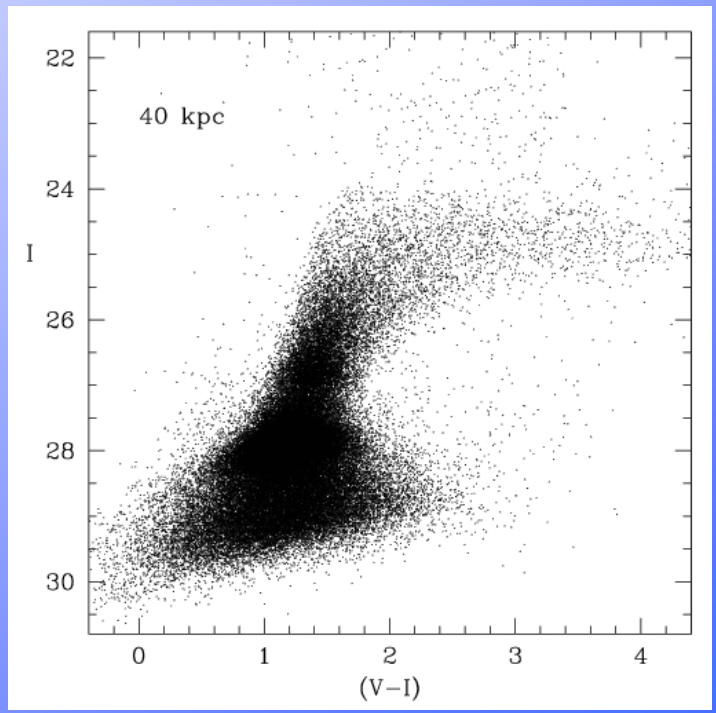


Harris, Poole, & Harris 1998, AJ 116, 2866

Harris, Harris, & Poole 1999, AJ 117, 855

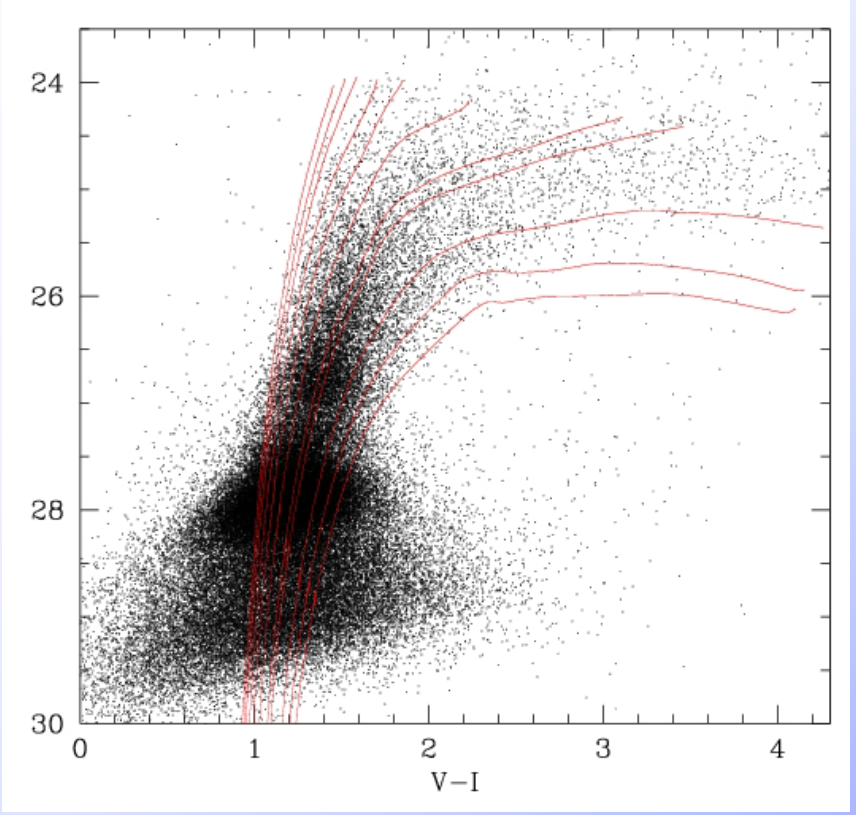
Harris & Harris 2002, AJ 123, 3108

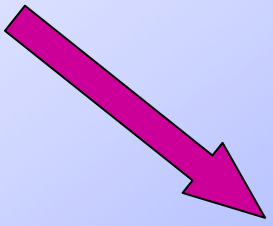
Rejkuba et al. 2005, ApJ 631, 262

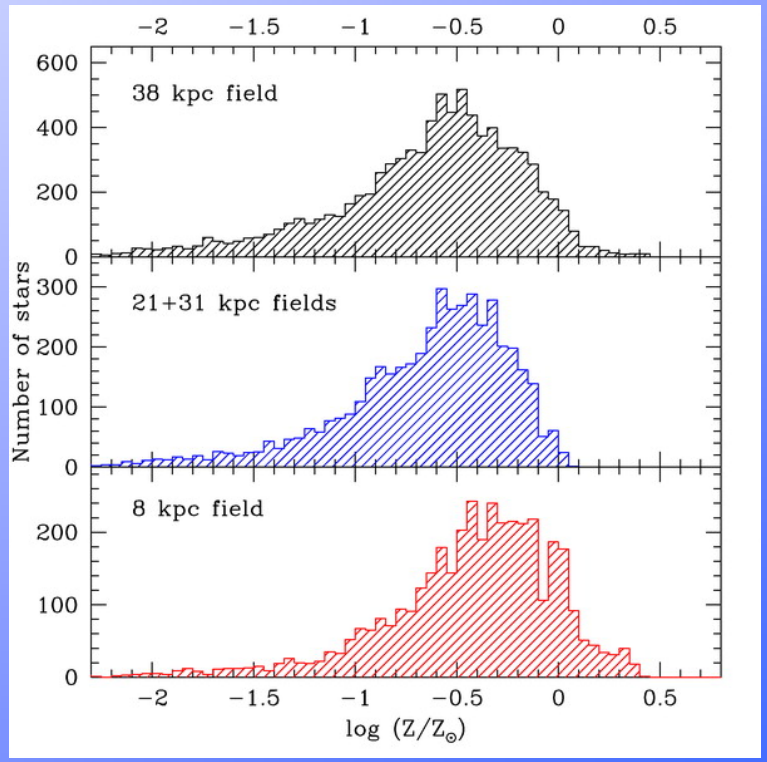


CMD data for halo fields: (V,I)

A unique dataset for gE's

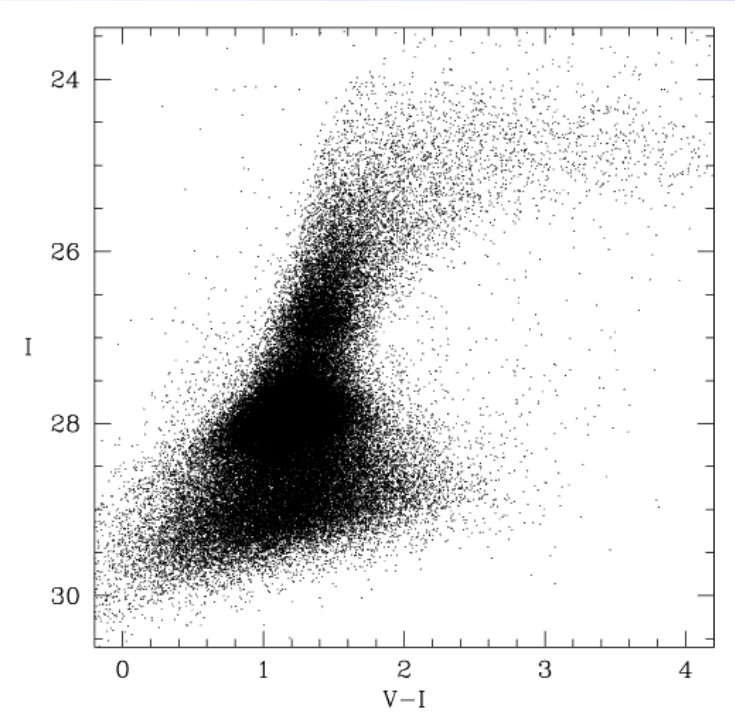






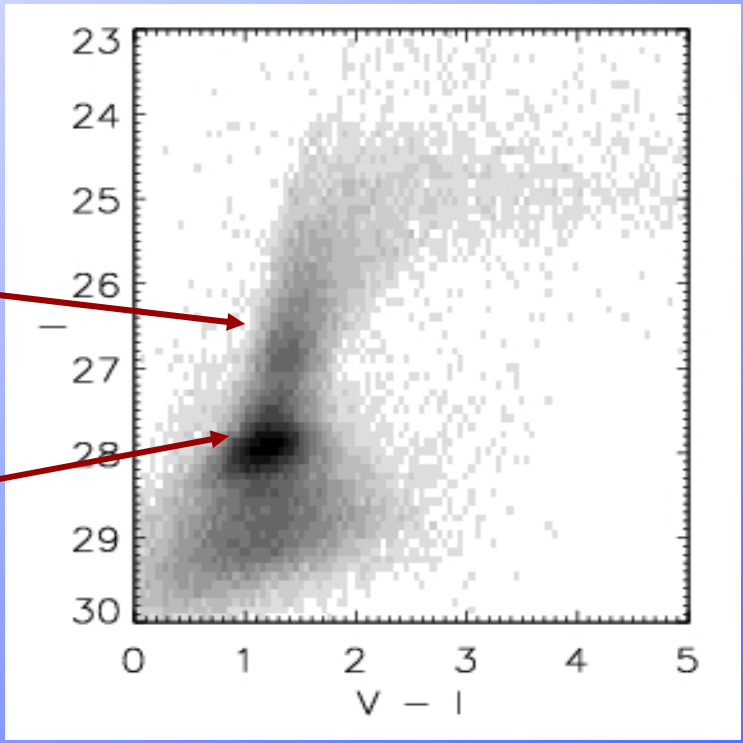
RGB stars: → Broad and predominantly metal-rich MDF with little radial gradient

Various features of CMD sensitive to metallicity and/or age: RGB, RC, AGB -- at the moment, only the 40 kpc field has enough leverage for both age and metallicity distributions simultaneously



AGB bump

RHB (red clump)



-Luminosity function in both I and V

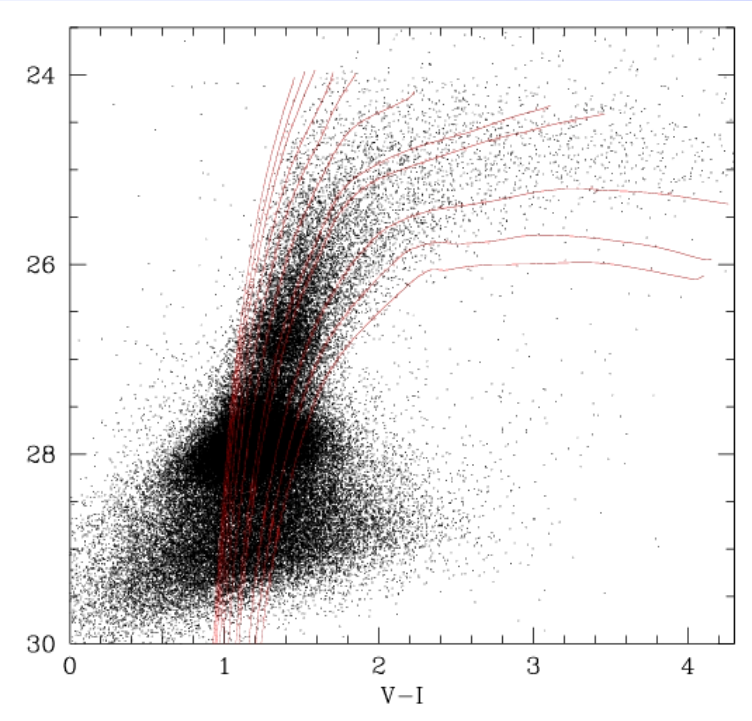
-Full distribution across CMD

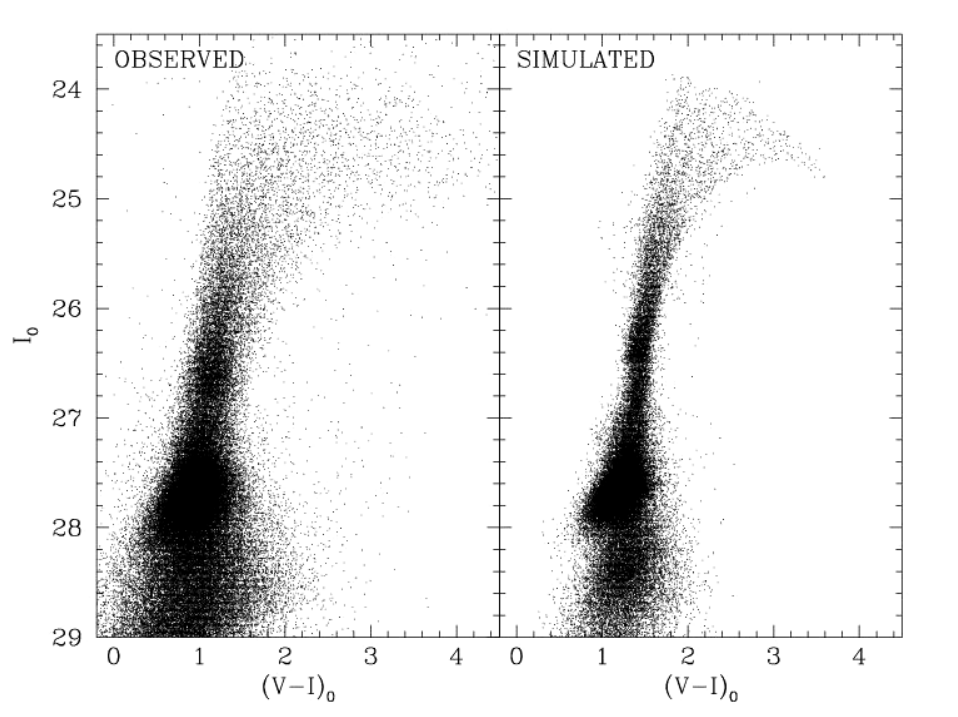
CMD simulations and analysis: Rejkuba, Harris, Greggio, & Harris: in progress

Generate simulated CMDs from evolutionary model tracks:
Teramo models (Pietrinferni et al. 2004 + later papers)

-full evolutionary phases through AGB++

- 11 distinct metallicity values x α-enhanced or scaled Solar



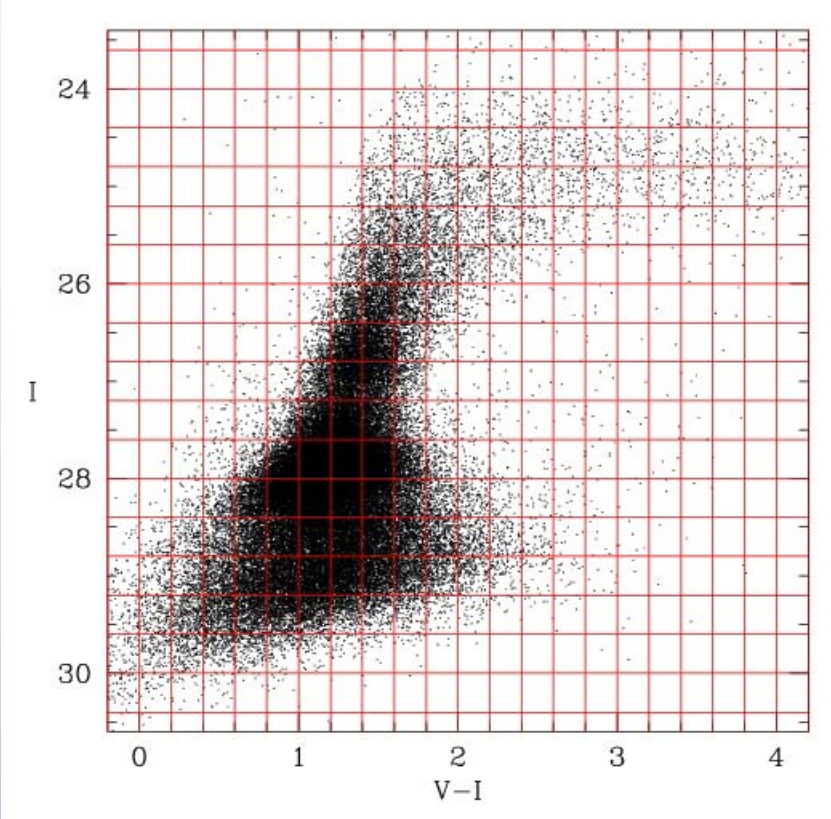


Each simulation convolved with ***observational measurement scatter*** and ***completeness function*** of the photometry

Compare two CMDs divided into grid elements:

- numbers of stars $n_1(i,j)$ (actual data) and $n_2(i,j)$ (simulation) in each grid element

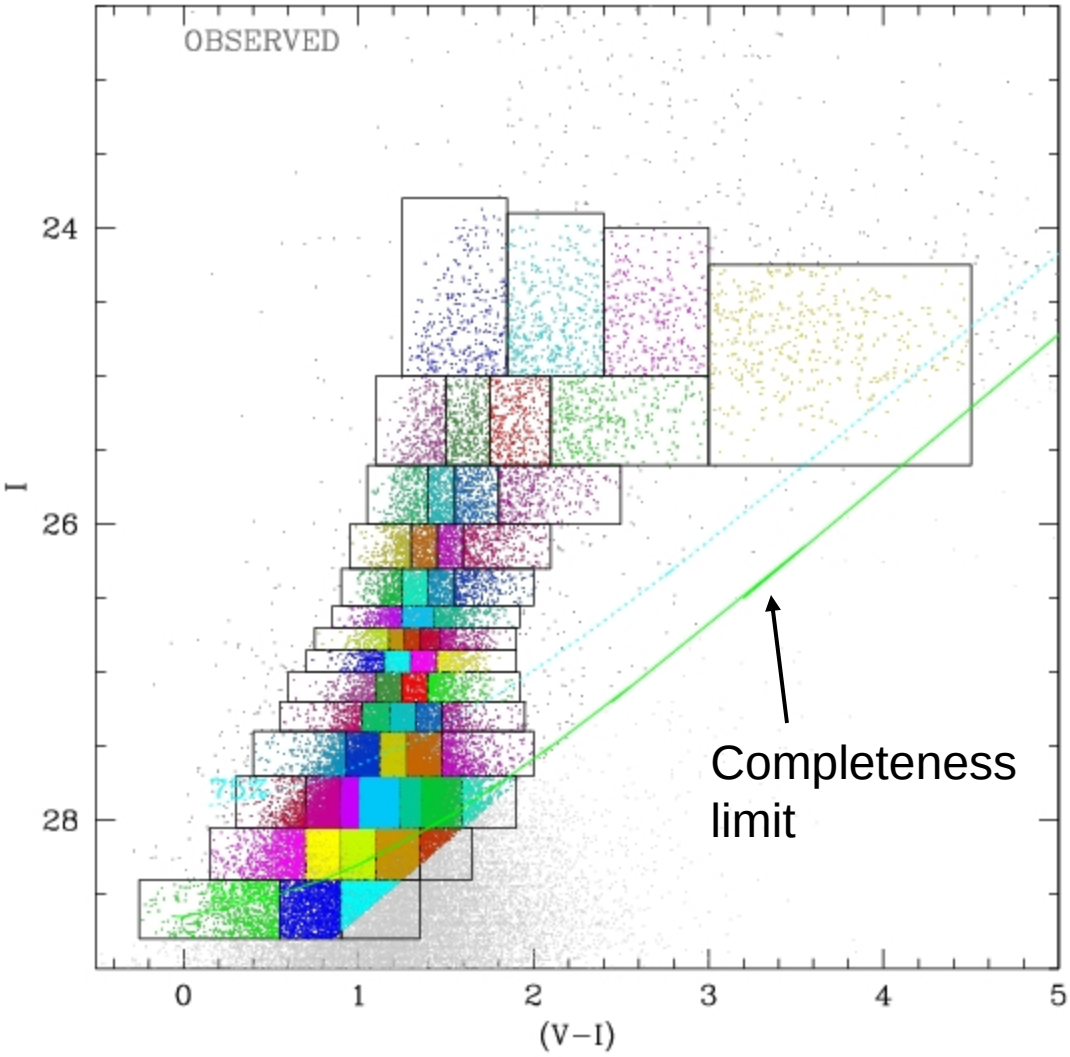
- N_{box} total grid elements



Form the total

$$\chi^2 = \frac{1}{N_{box}} \Sigma \frac{(n_1 - n_2)^2}{(n_1 + n_2)}$$

and find simulation that minimizes it by varying over input MDF and ADF



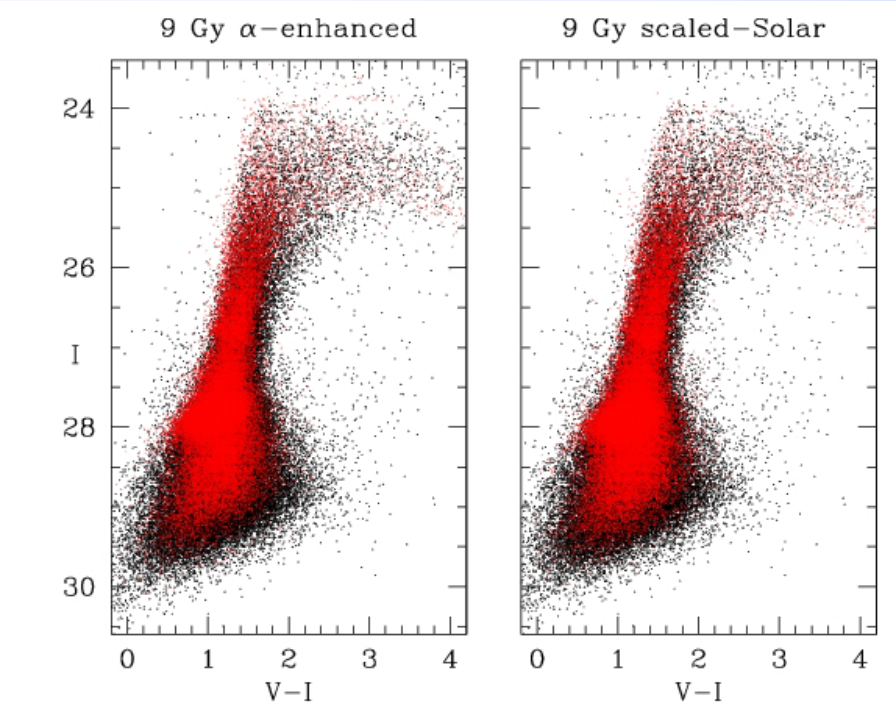
Layout with variable box size to optimize areas of best sensitivity to models

Form the total

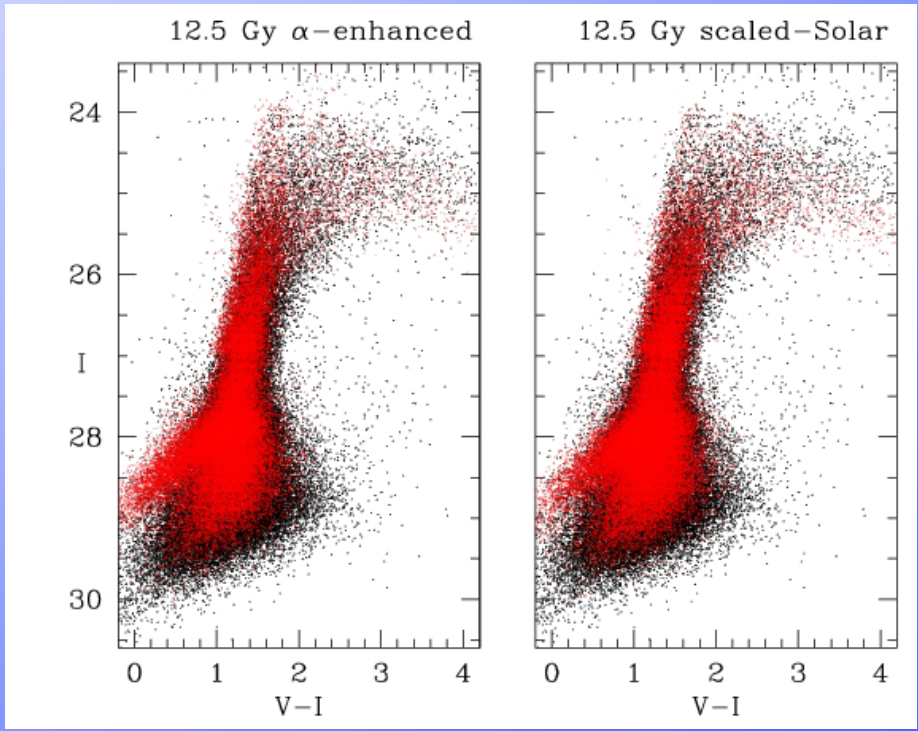
$$\chi^2 = \frac{1}{N_{box}} \Sigma \frac{(n_1 - n_2)^2}{(n_1 + n_2)}$$

and find simulation that minimizes it by varying over input MDF and ADF

Single-age ("single starburst") models

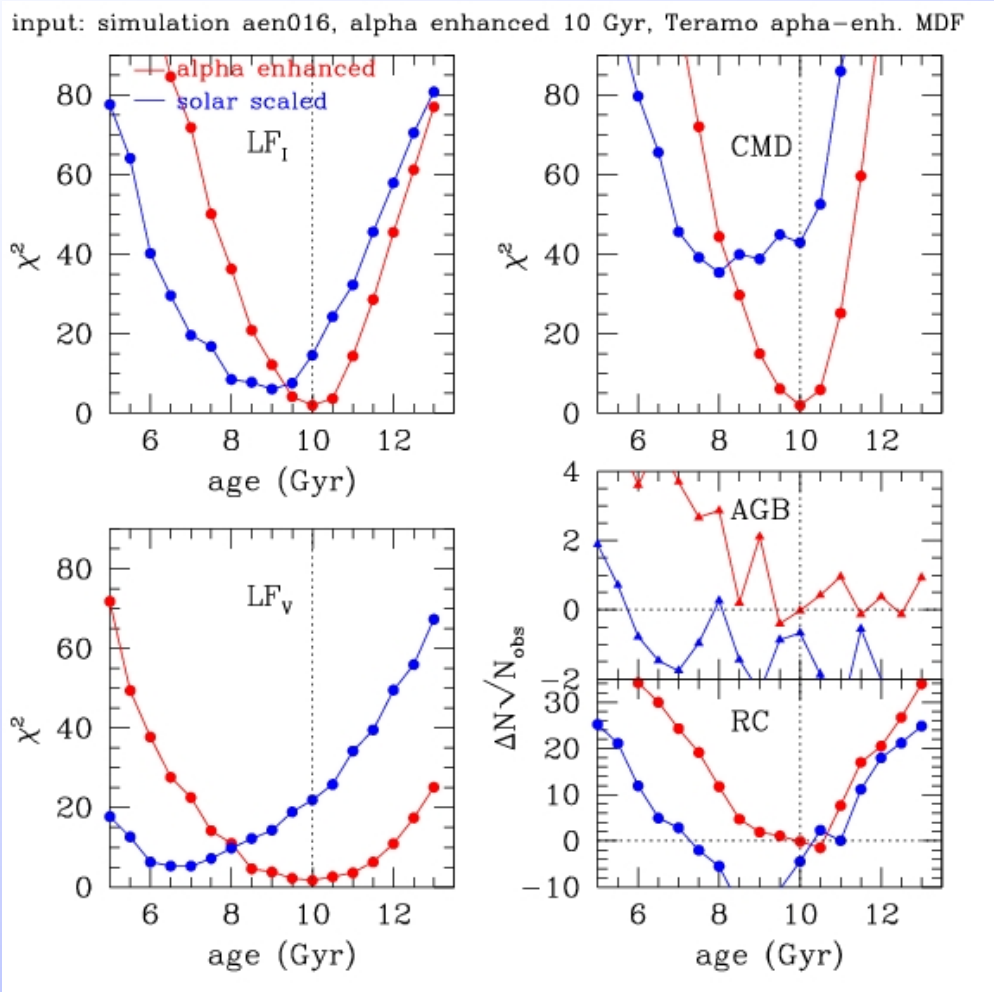


Single-age "burst" formation models with Z-mixture



Consistency is required for both luminosity functions *(I, V)*, complete CMD, and Z-distribution

Single-age ("single starburst") models

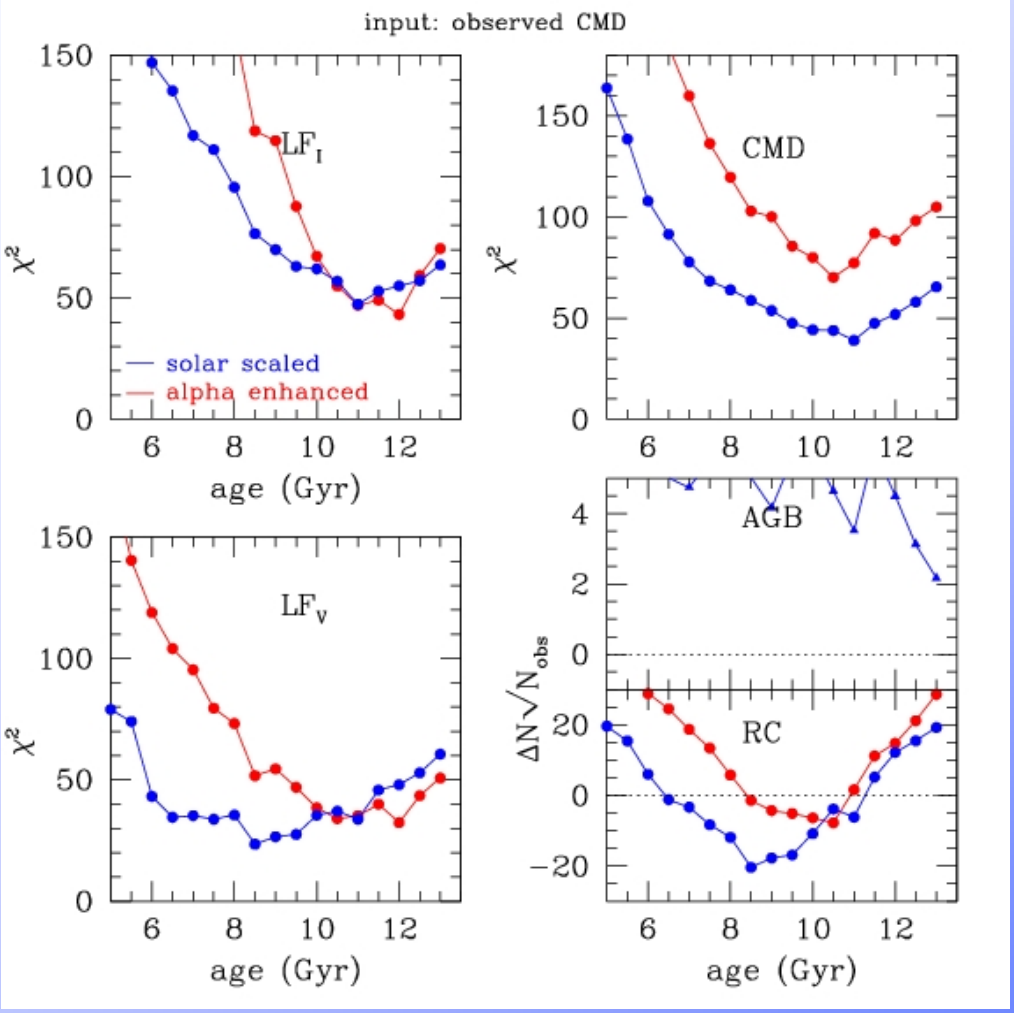


Model vs. model:

-internal age precision of +- 1 Gy

-scaled-solar → lower mean age by 1-2 Gy

Single-age ("single starburst") models



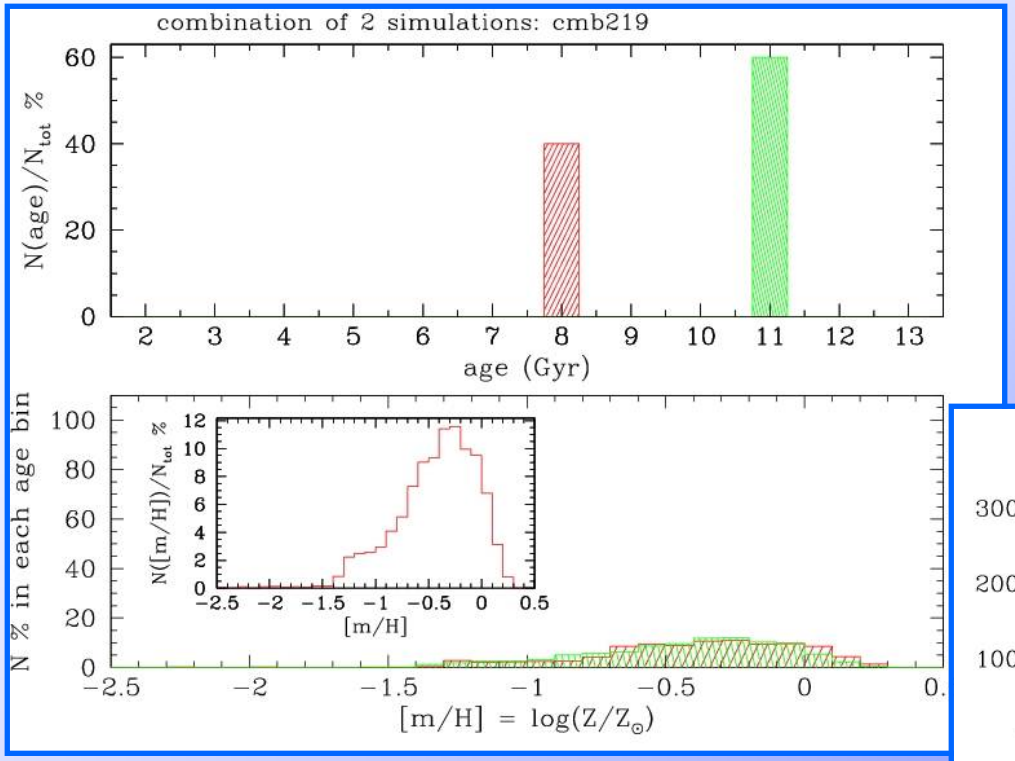
Model vs. data:

- "best guess" mean age near 11 Gy

- LF(I) more sensitive than LF(V)

-LF(I) and total CMD are most useful indicators

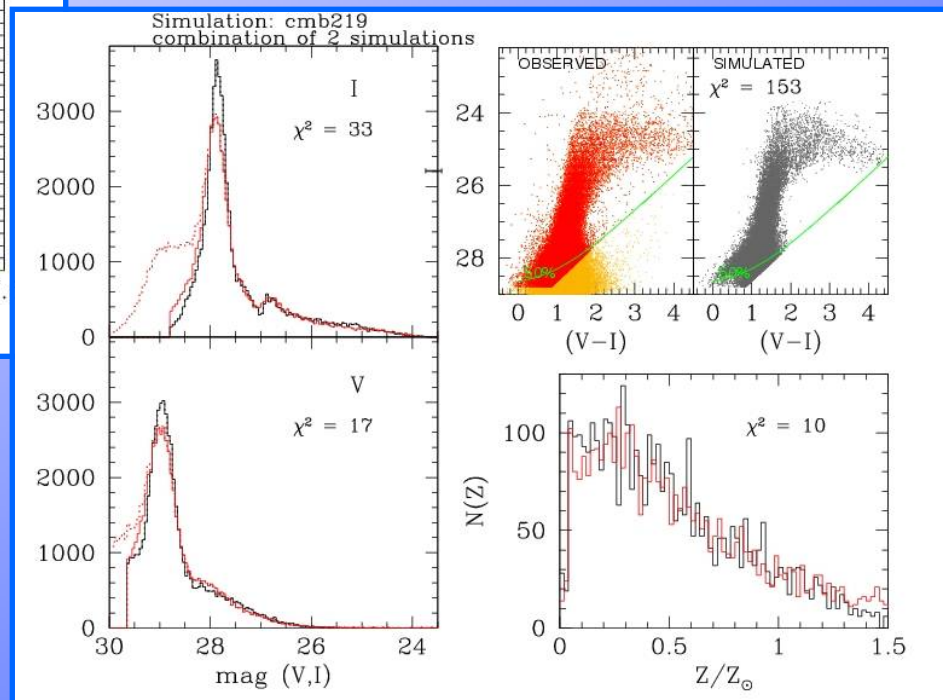
Two-starburst models



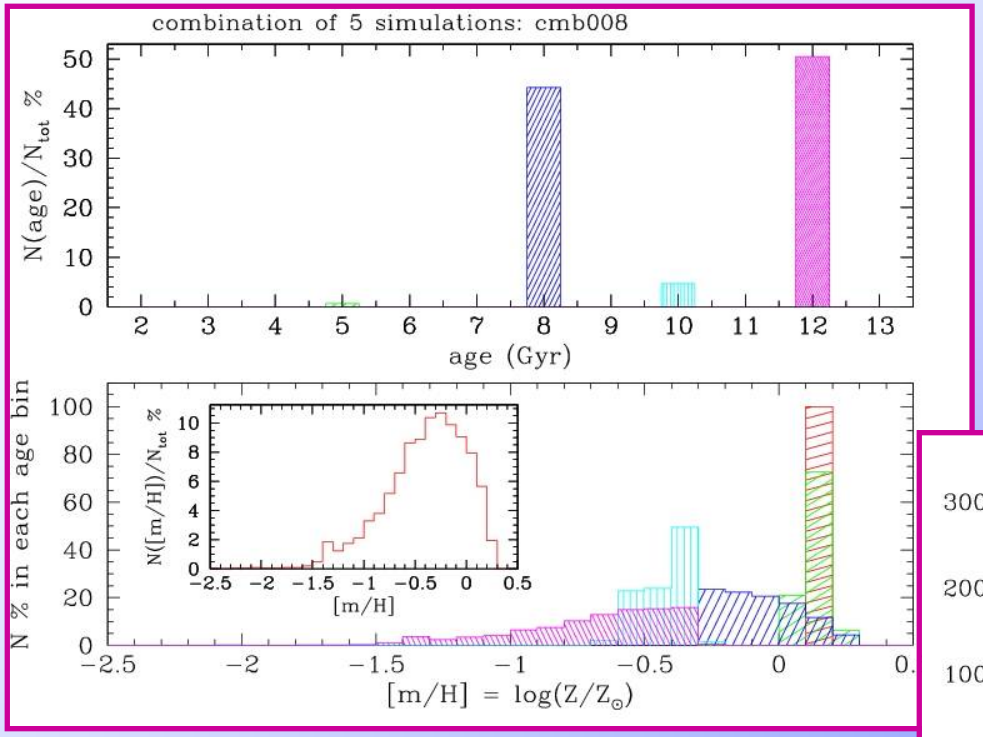
60% at 11 Gy

40% at 8 Gy

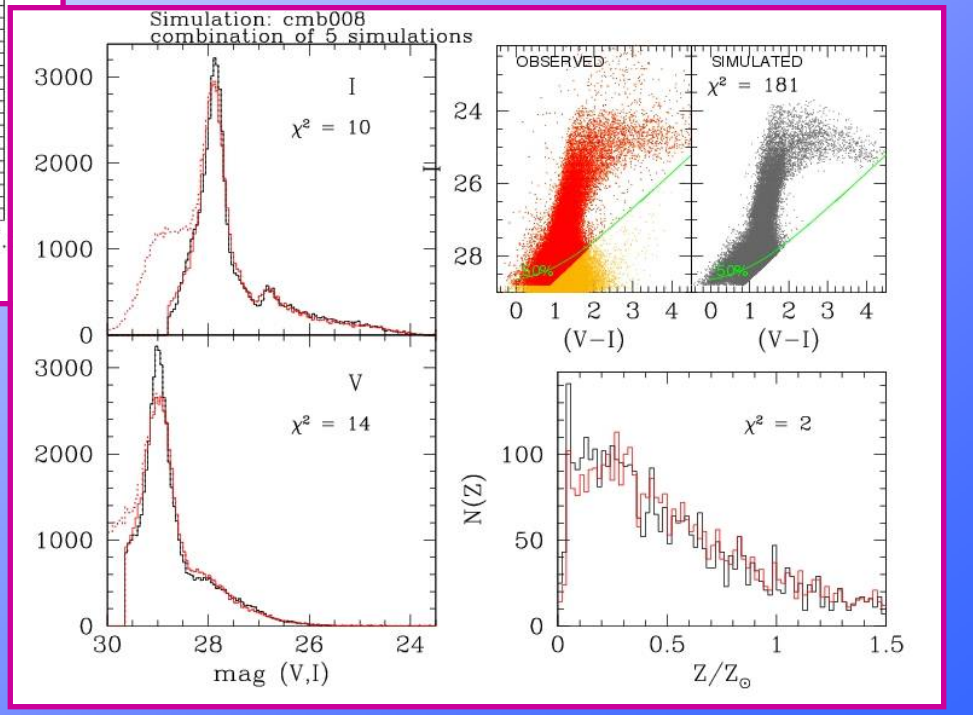
both have same MDF



Multiple-starburst models

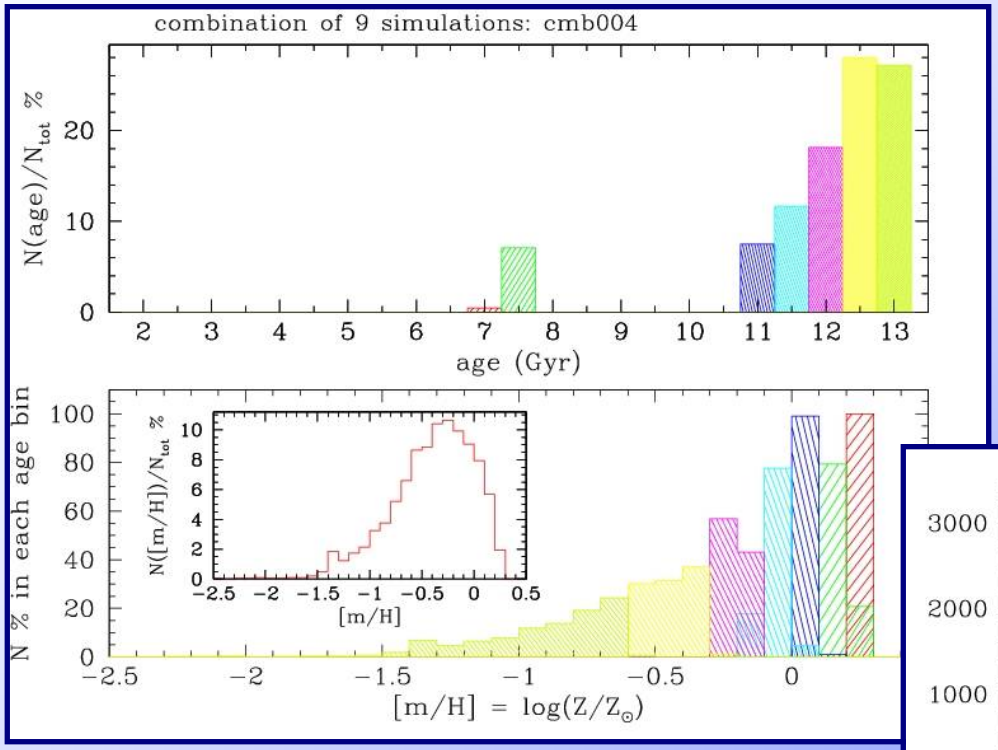


5 components, dominated by bursts at 12 and 8 Gy; plus individual MDFs (age/metallicity relation)

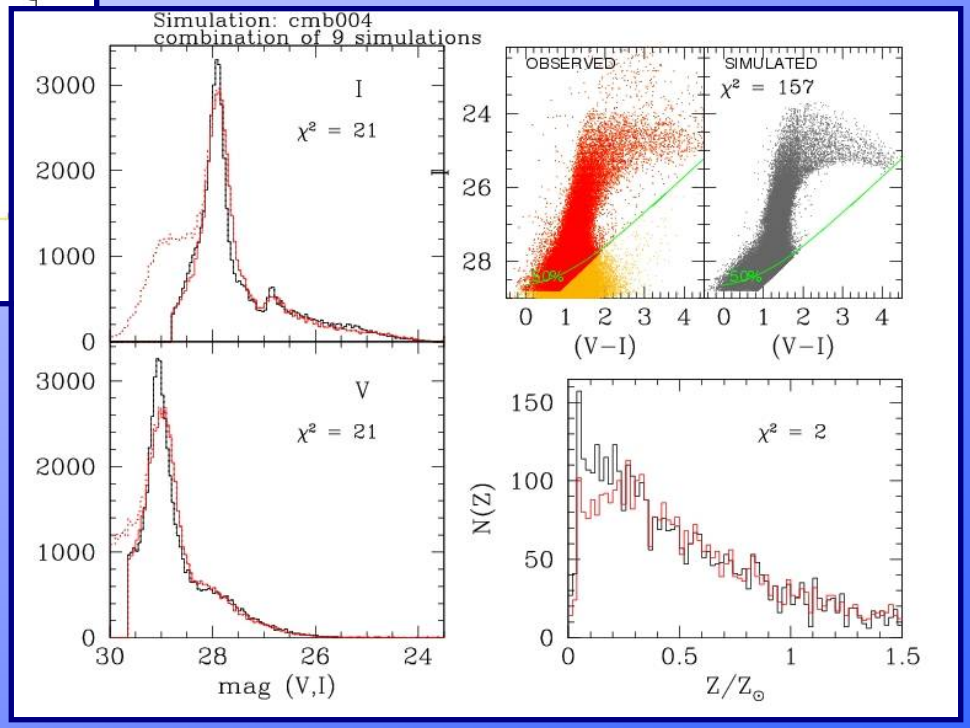


Better fits to LFs and better overall shape of CMD (though still too narrow)

More multiple-starburst models



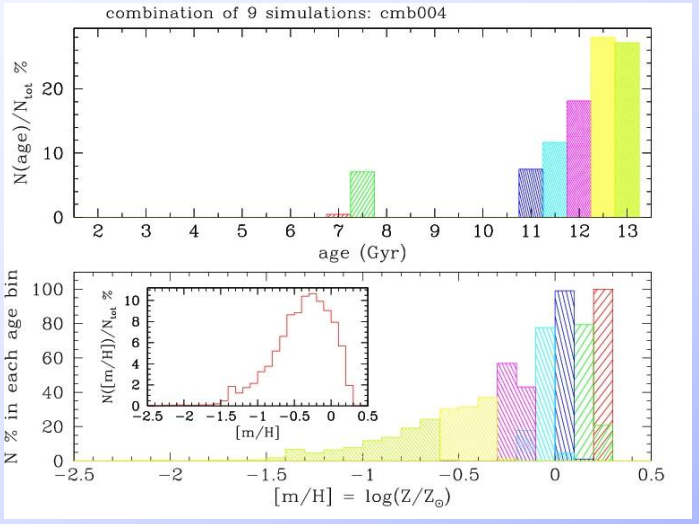
9-component model (two major *eras* of star formation) and smoother age/metallicity relation

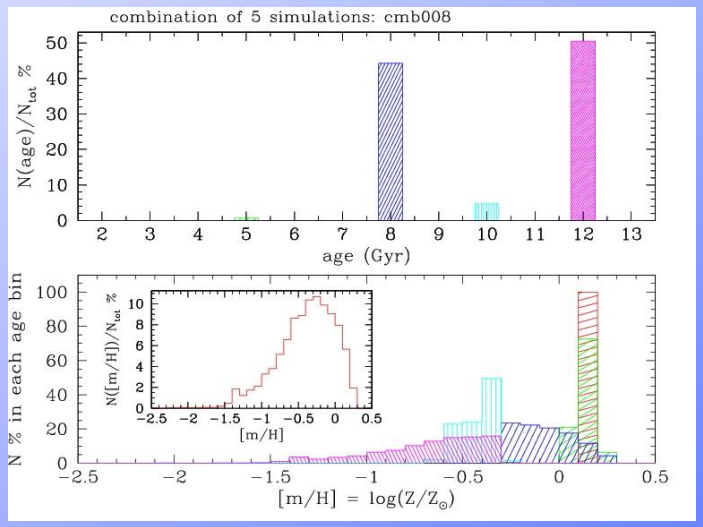


Too high a proportion of very old material here (12-13 Gy)

Emerging directions (where do we stand now?)

Age range ~8-12 Gy seems appropriate for the bulk of the halo population
(i.e., classically "old" is working reasonably well)





-No significant component with age < 8 Gy is needed

- What is *minimum* age spread required?

- What about incorporating an age/alpha relation?

- ***Globular clusters*** give an independent route to measuring the age distribution from all over the halo → *see* Woodley's talk