ON THE AGE OF MILKY WAY HALO STARS

Paula Jofré
Institute of Astronomy, Cambridge

K. Hawkins, G. Gilmore & J. Arcangeli (IoA)
C. J. Hansen (LSW), A. Koch (LSW)
C. Sneden (Texas) & A. McWilliam (Carnegie)

halo stars

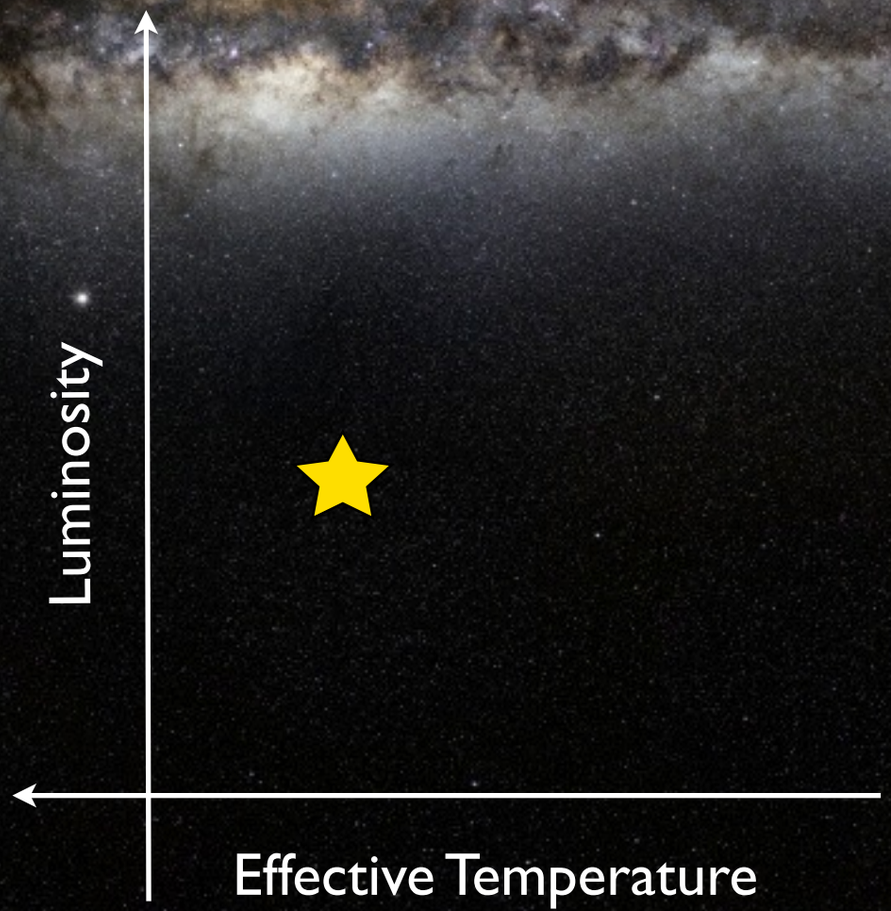
Galactic archaeology

- No gas left to form new stars —> old stars

How old?

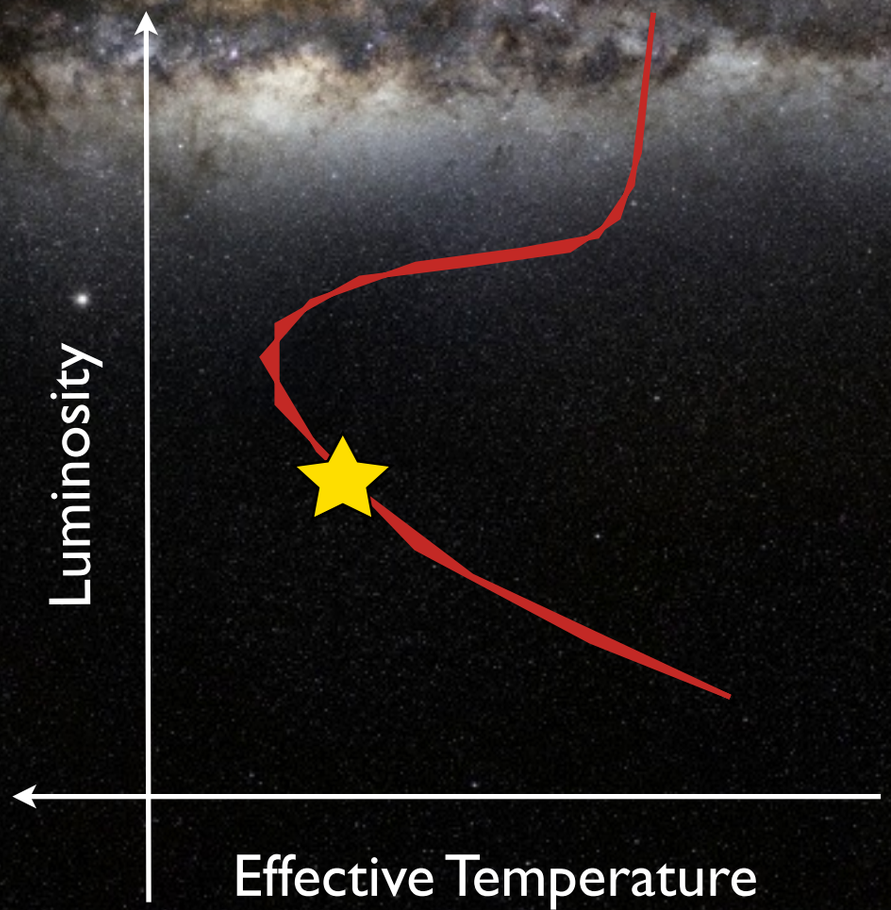
ages - Field

How old?



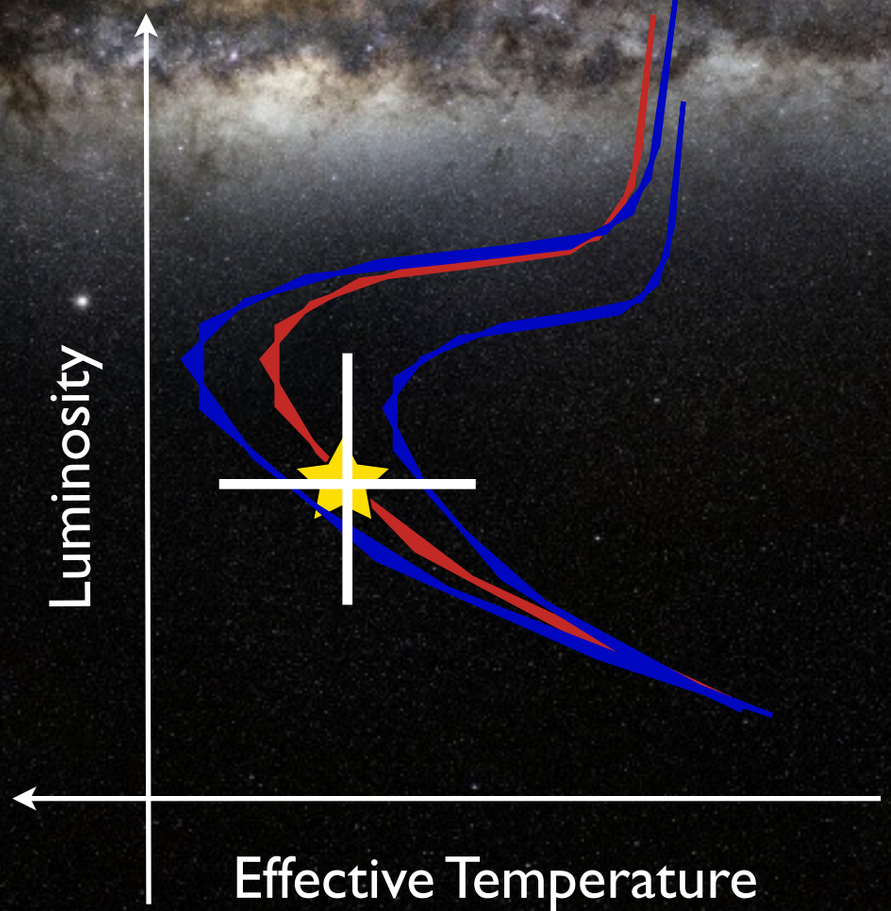
ages - Field

How old?



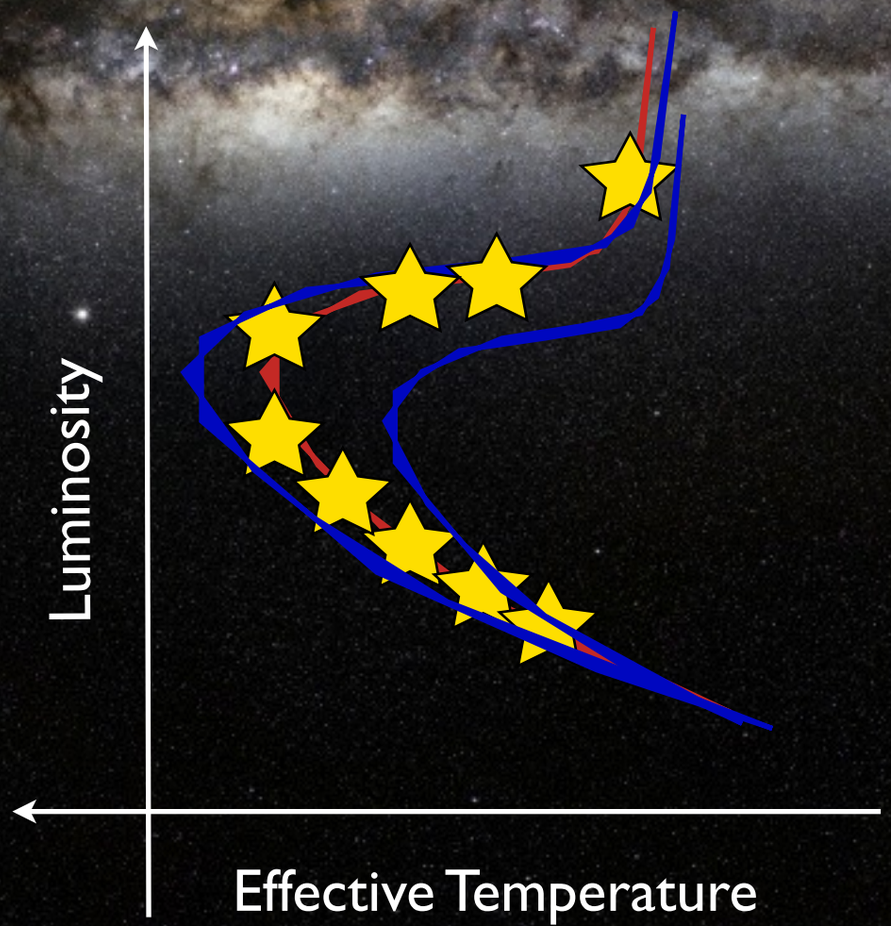
ages - Field

How old?



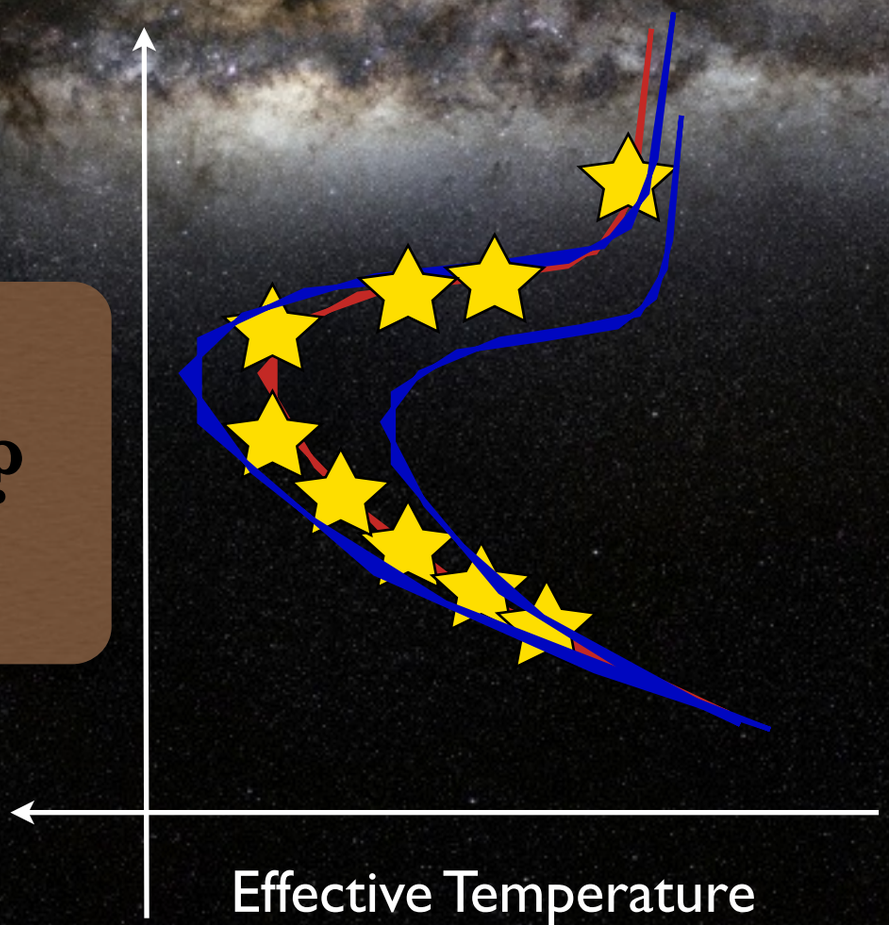
ages - Field

How old?



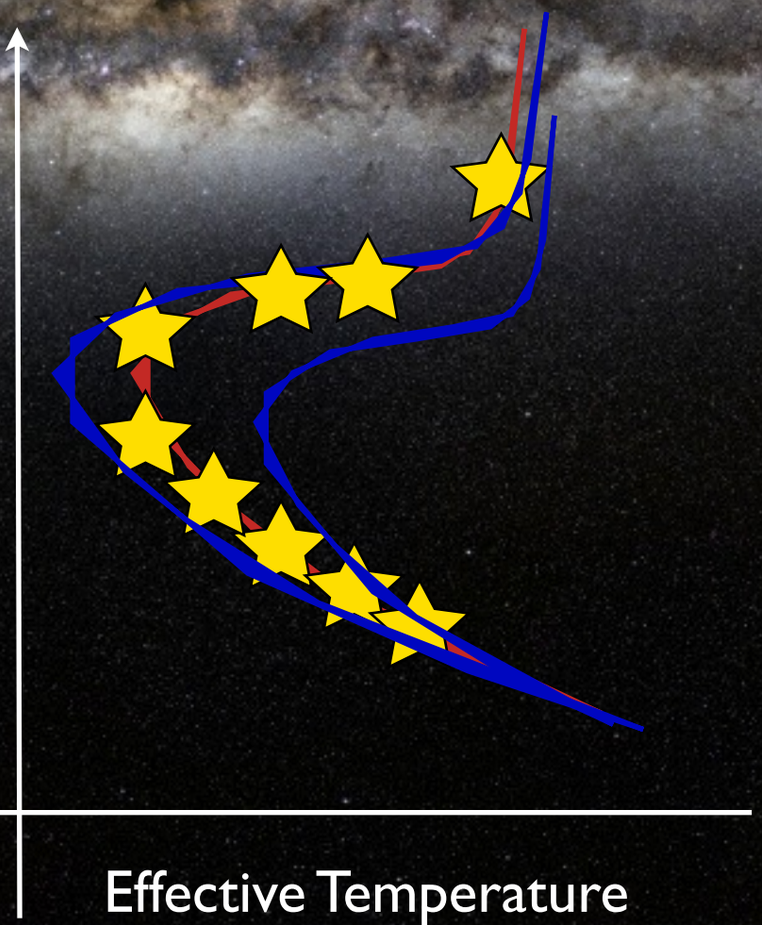
ages - Field

How old?



ages - Field

How old?

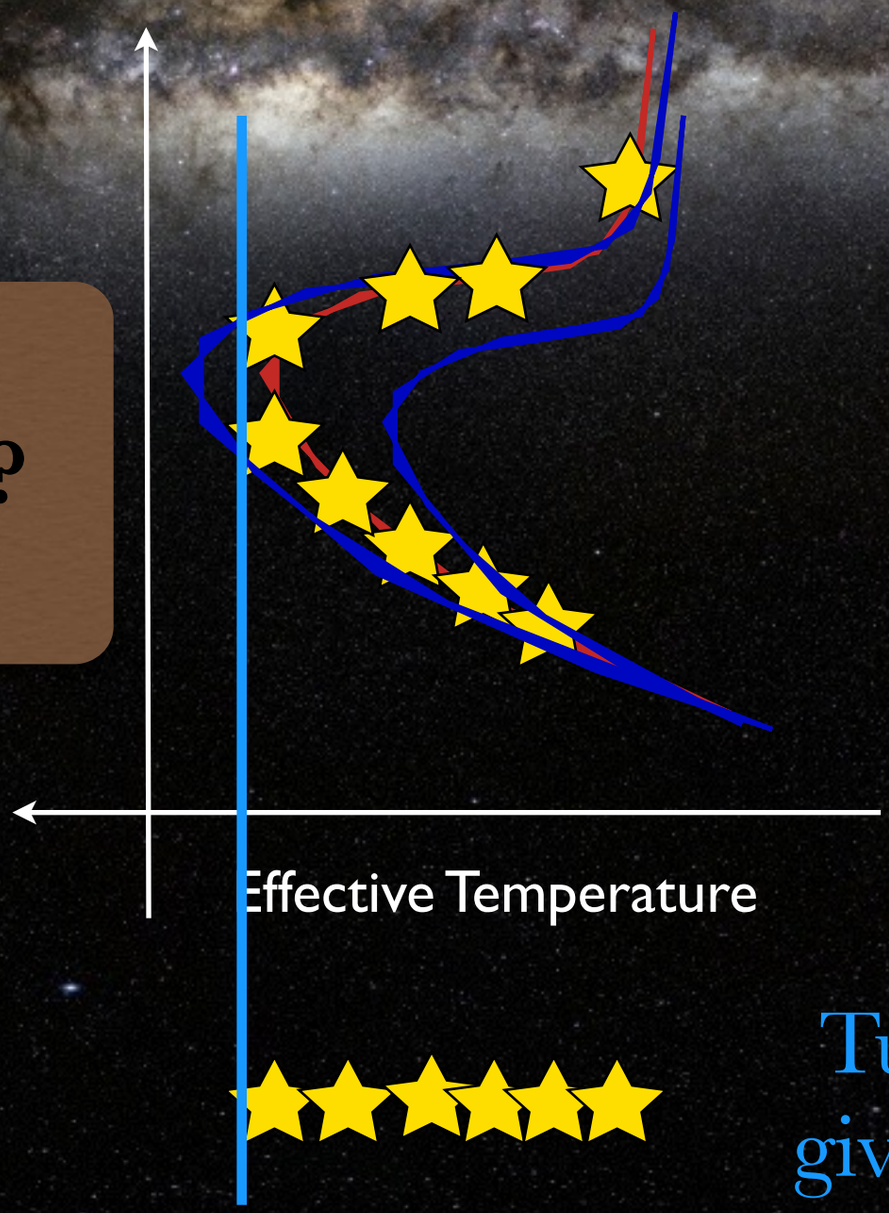


??

Effective Temperature

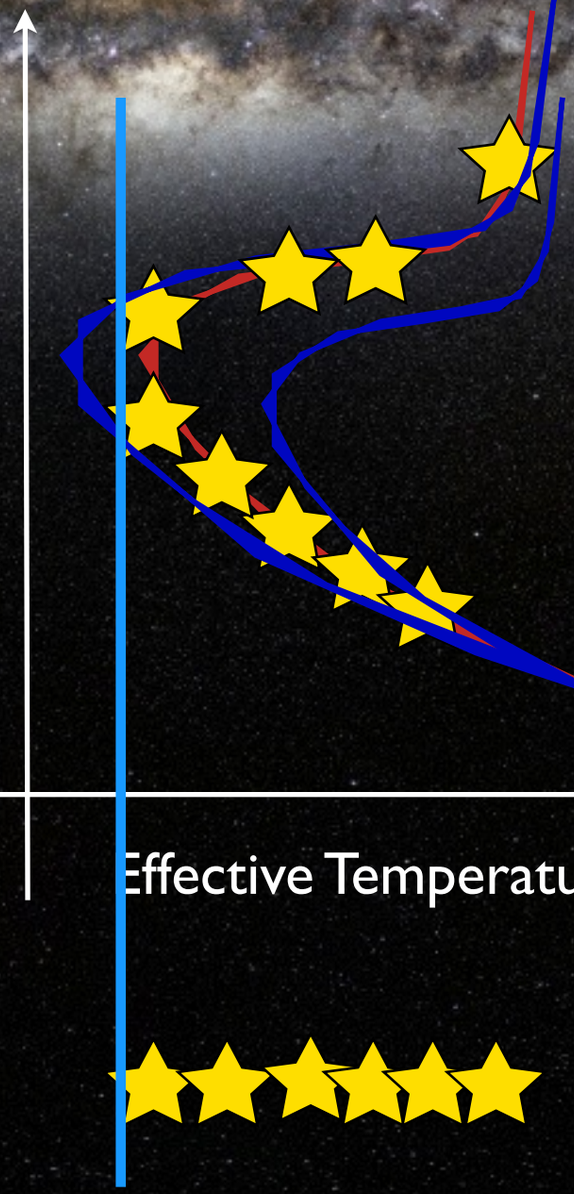
ages - Field

How old?

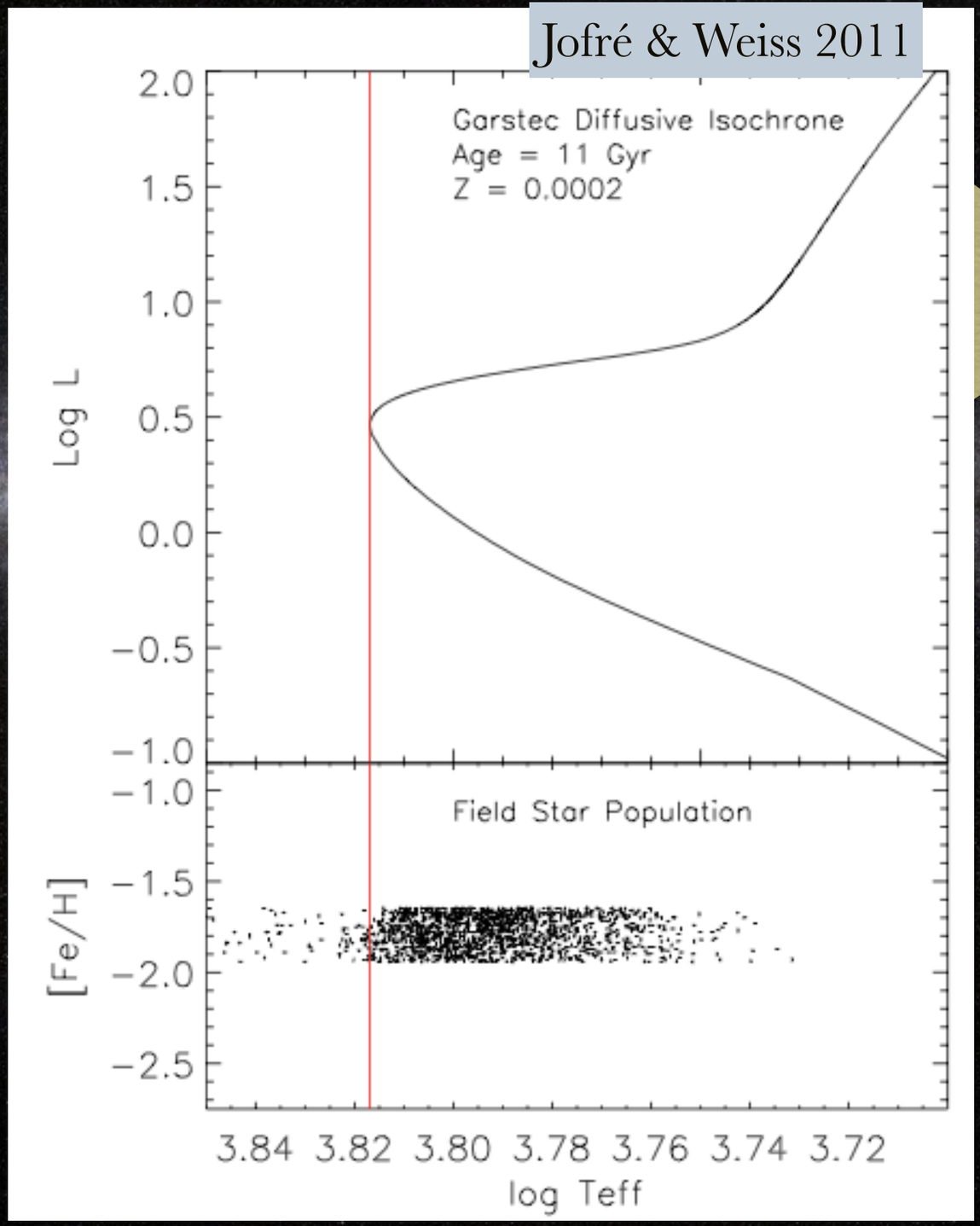


Turn-off temperature
gives age of population

??

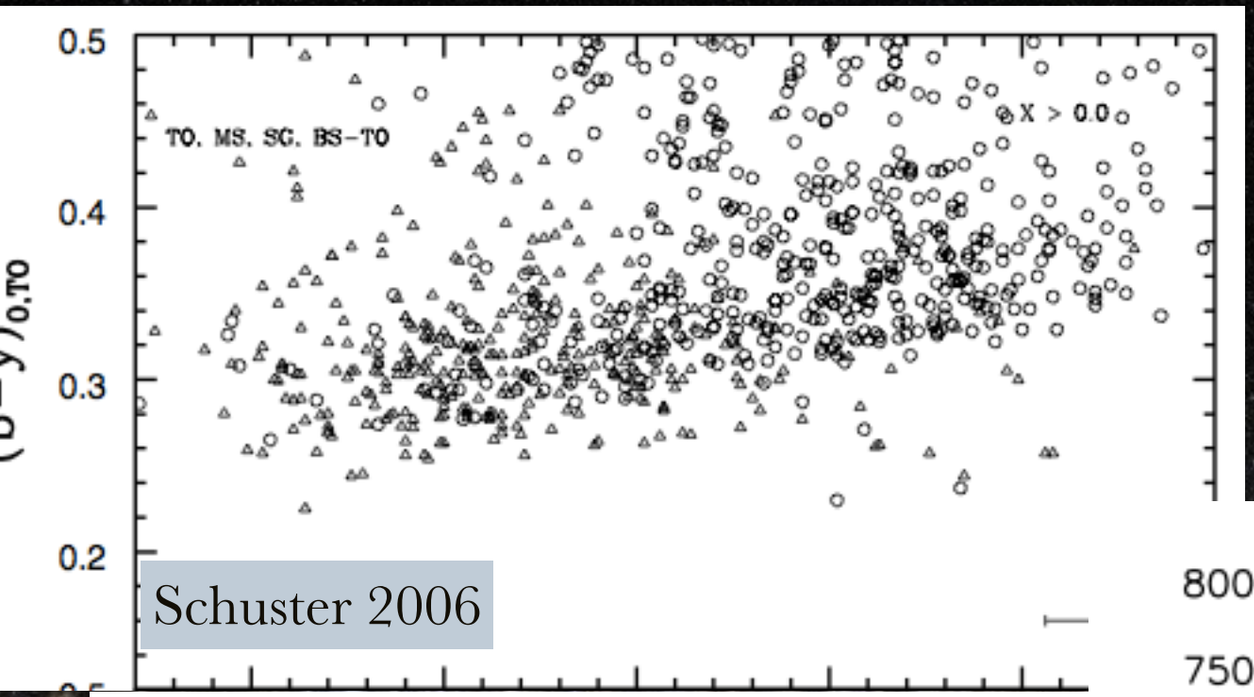


Jofré & Weiss 2011



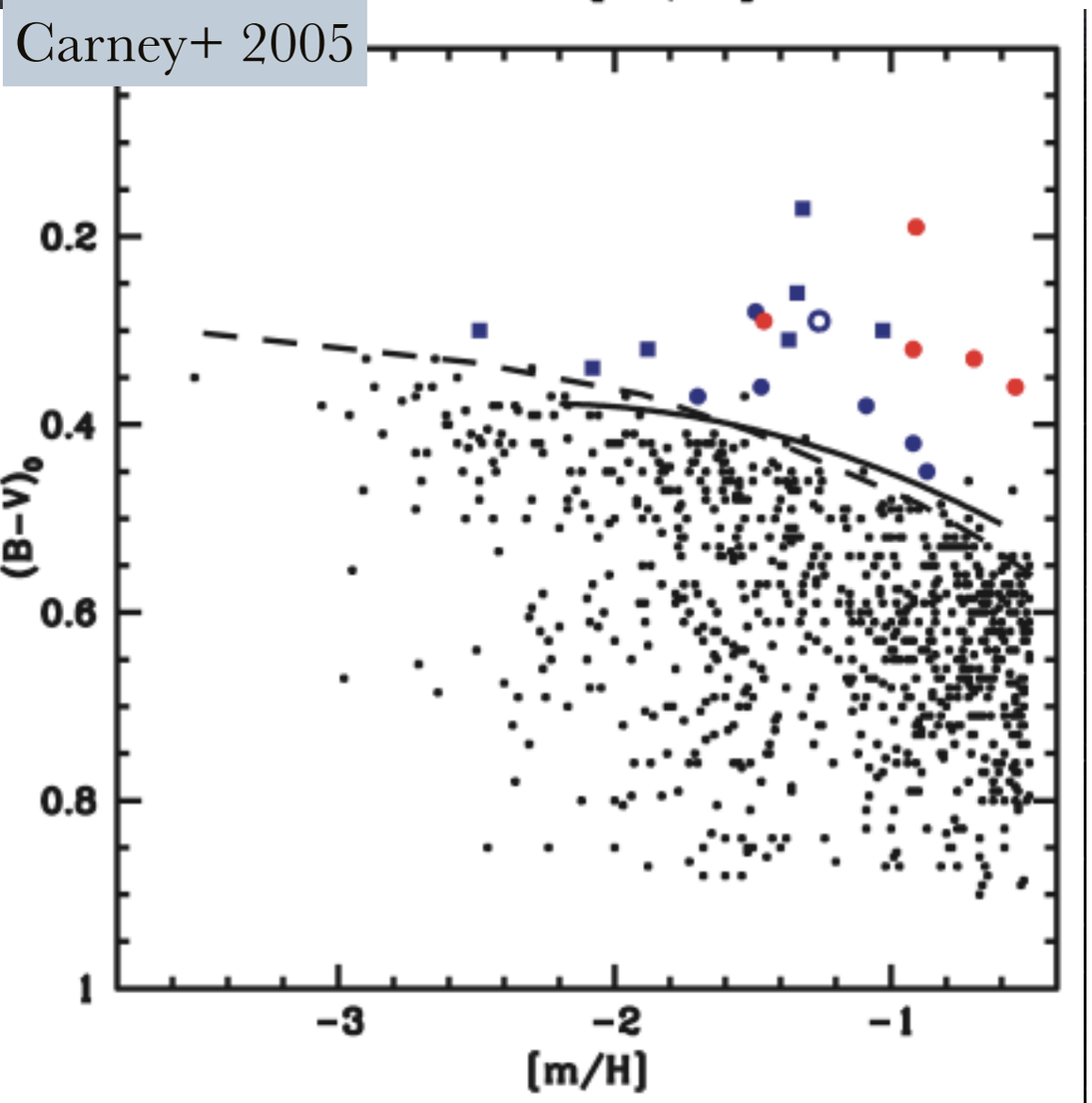
Turn-off temperature
gives age of **population**

ioa

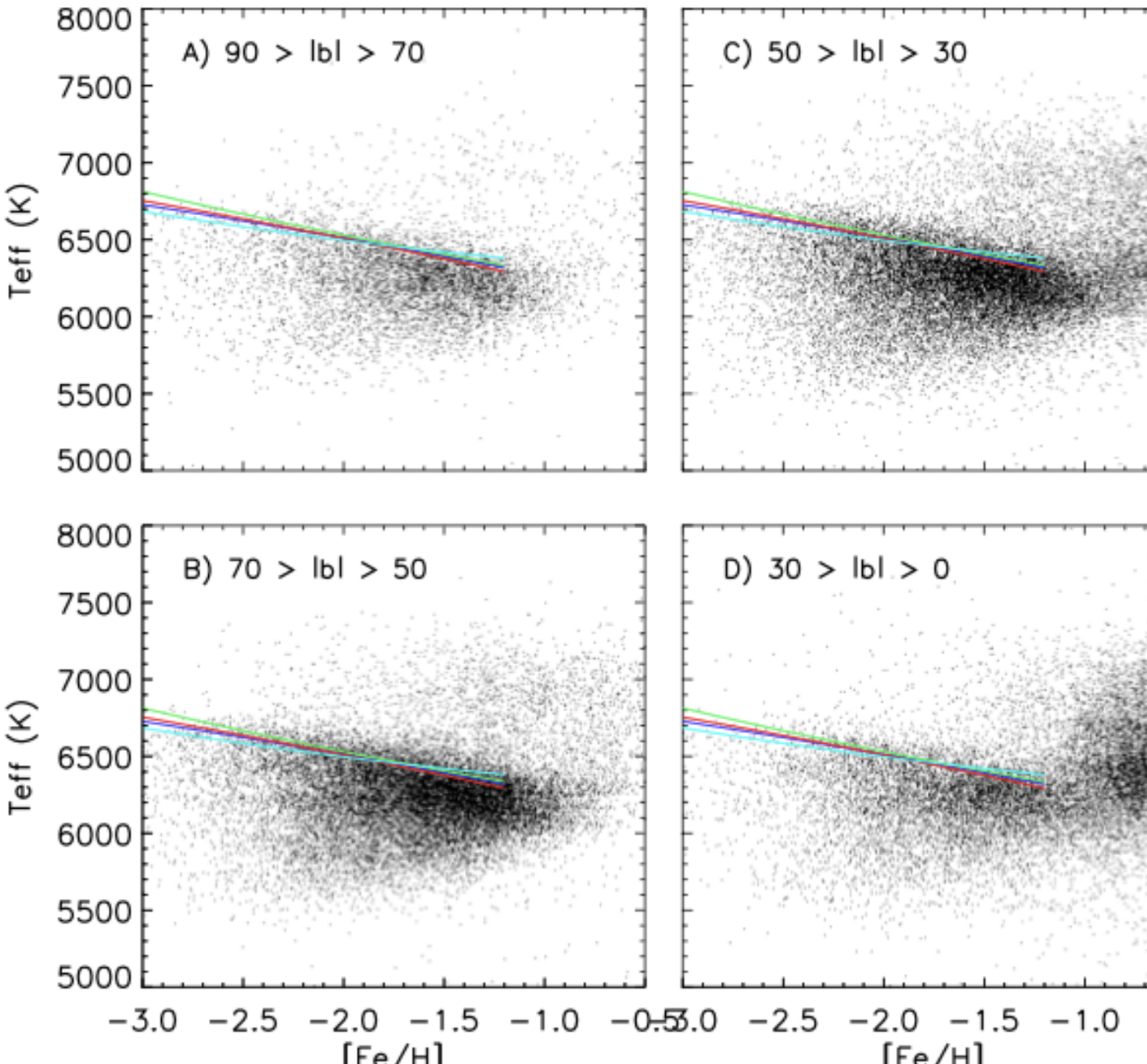


Schuster 2006

Carney+ 2005



Hov Jofré & Weiss 2011



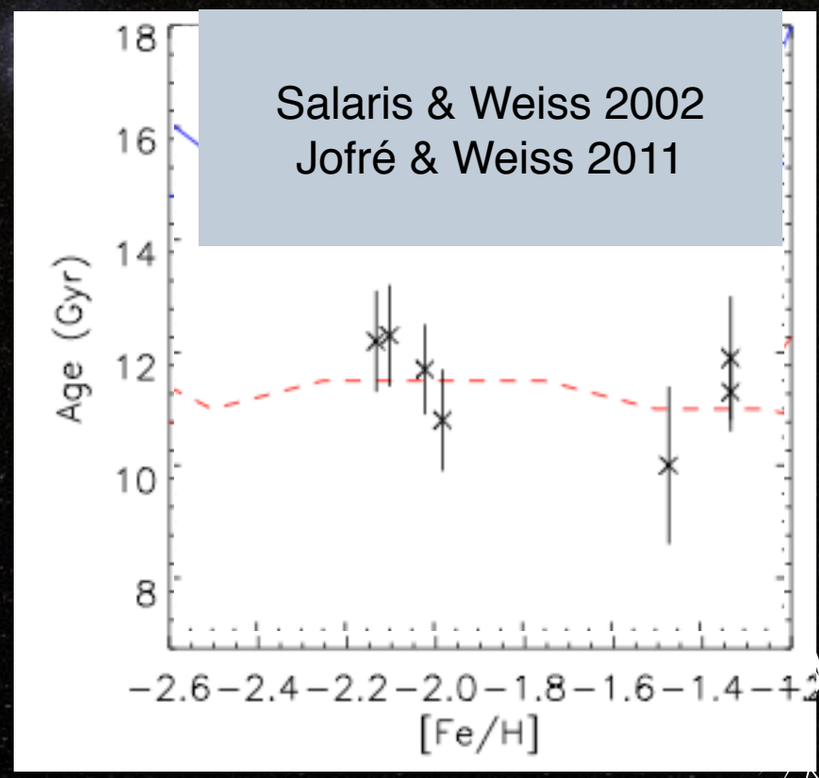
one dominant population

How old?

Similar ‘no-gradient’

Similar absolute value (same physics used in isochrones)

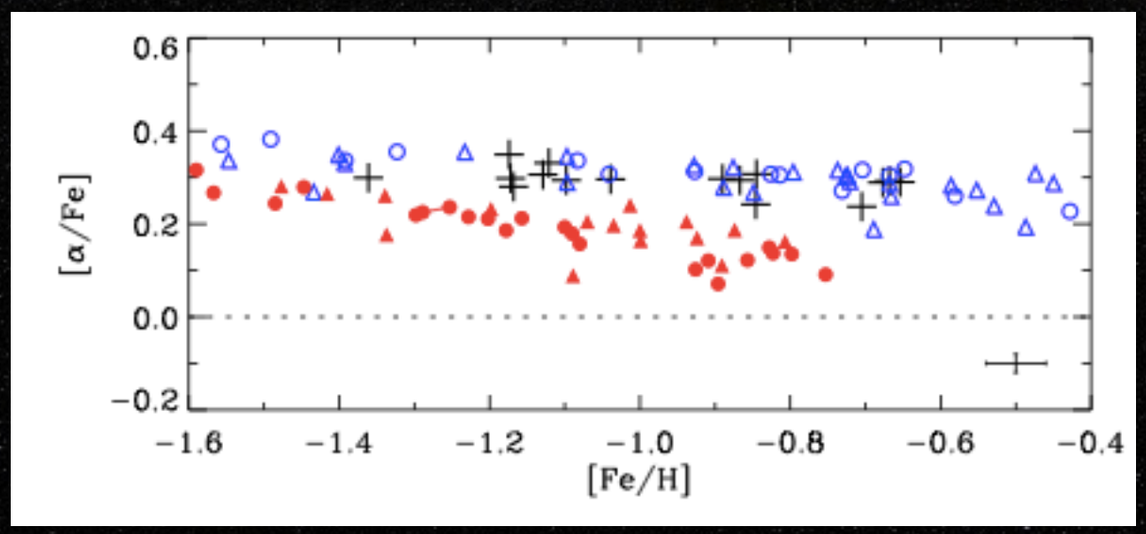
‘This halo’ has one dominant population of 10-12 Gyr, with field and clusters formed together



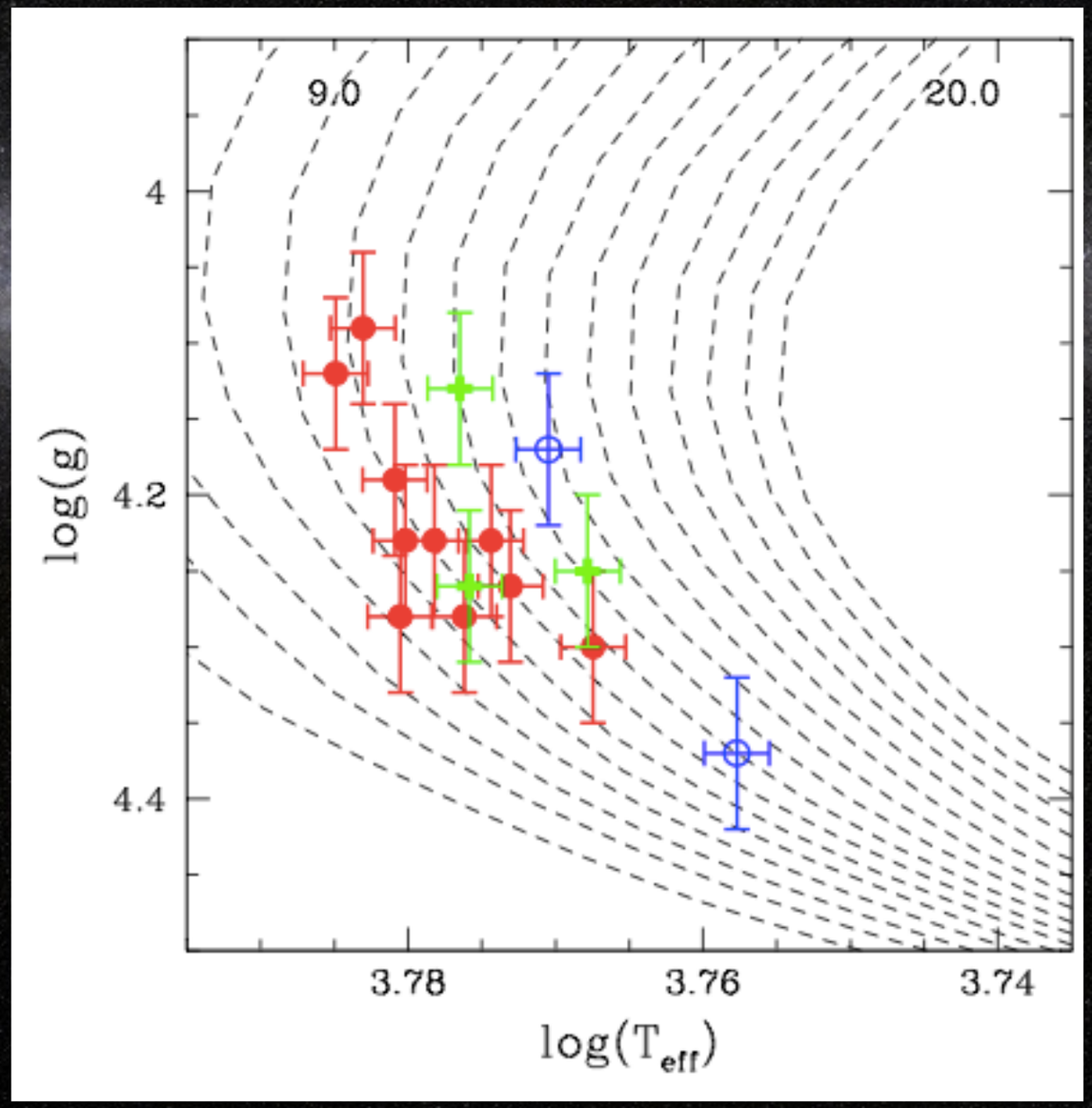
ioa

Adding Chemistry

2 sequences in alpha elements



Schuster & Nissen 2010

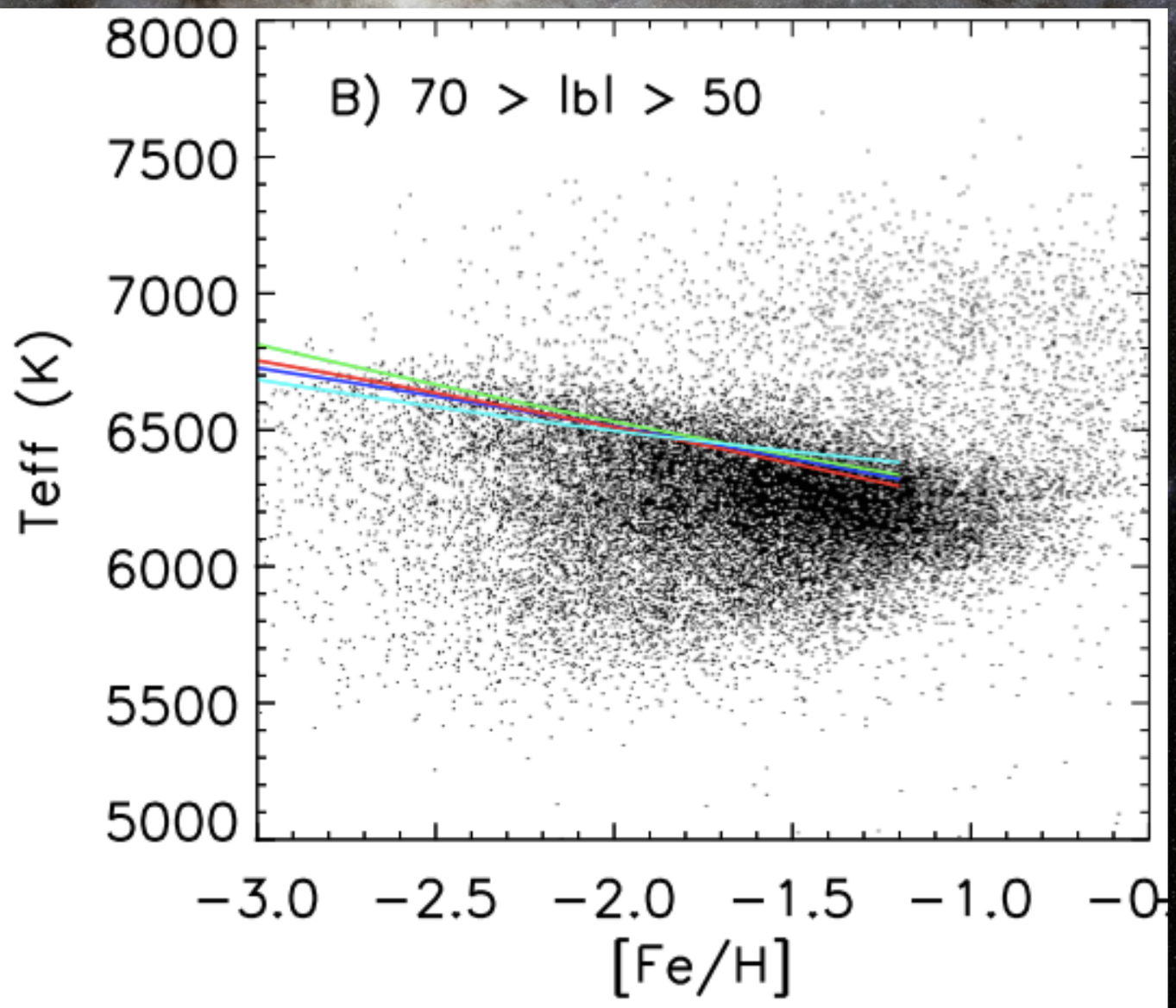


Schuster+ 2012

low-alpha: younger
high-alpha: older

ioa

Adding Chemistry

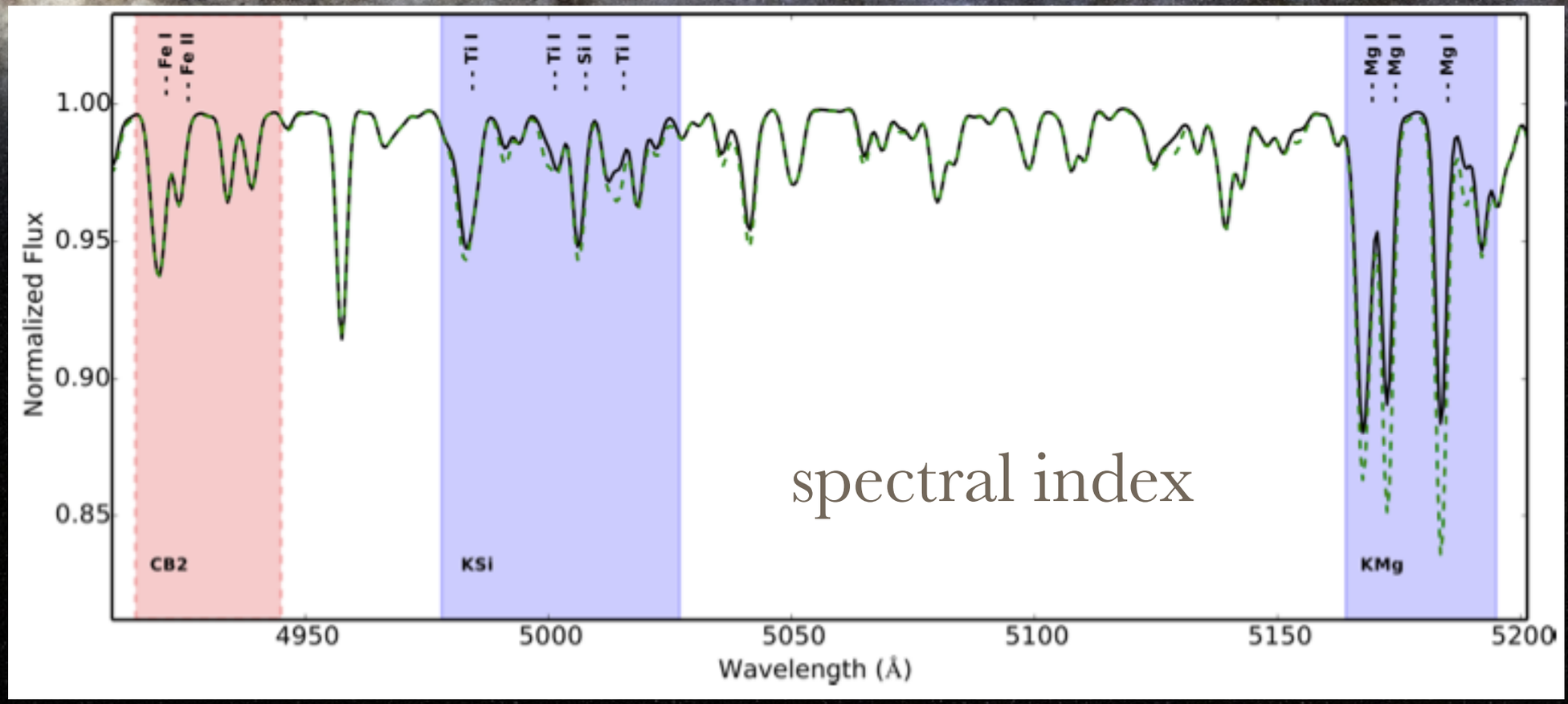


How is the turn-off for high-alpha and low-alpha populations?

Can we tag low-alphas and high-alphas in SDSS spectra?

ioa

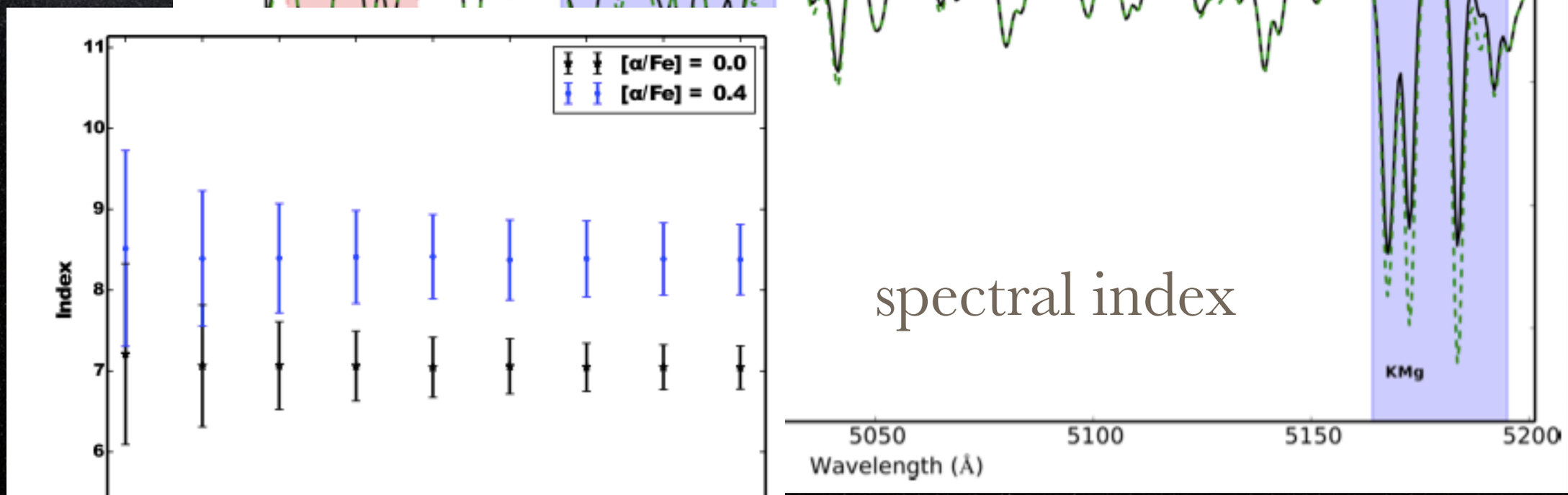
Chemistry

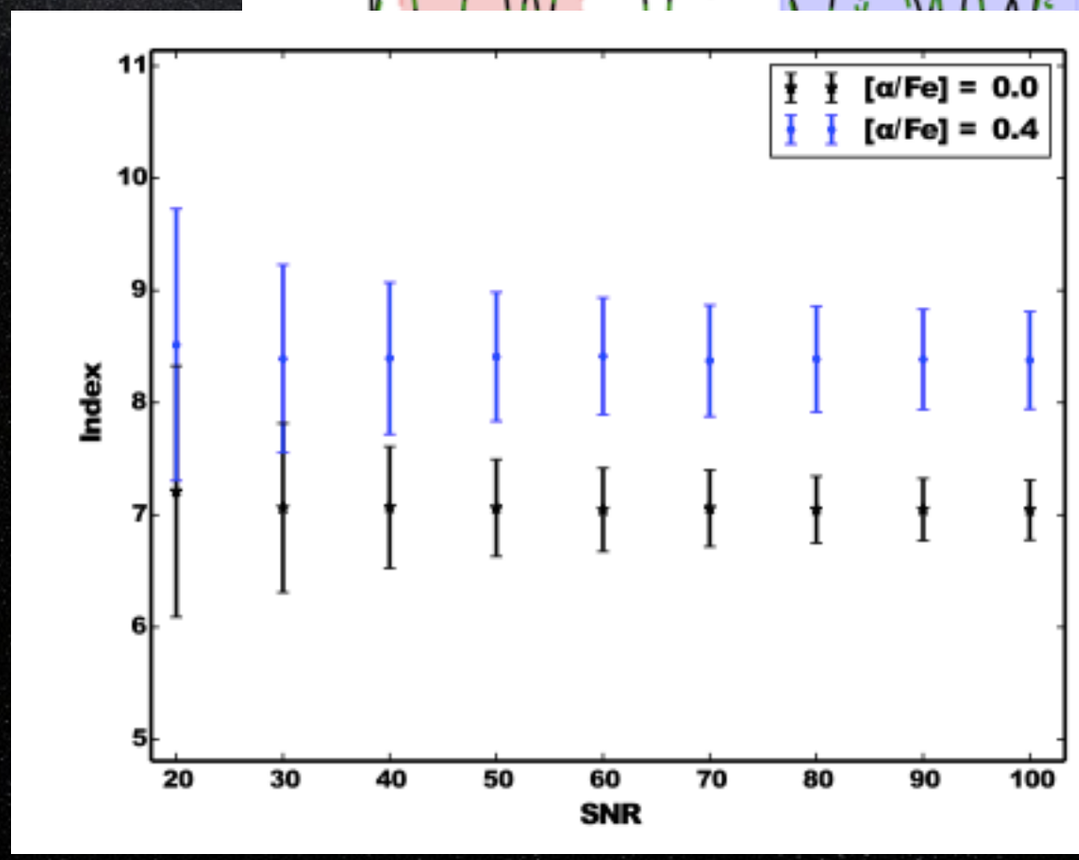


spectral index

YES we can
Hawkins, Jofré+2014

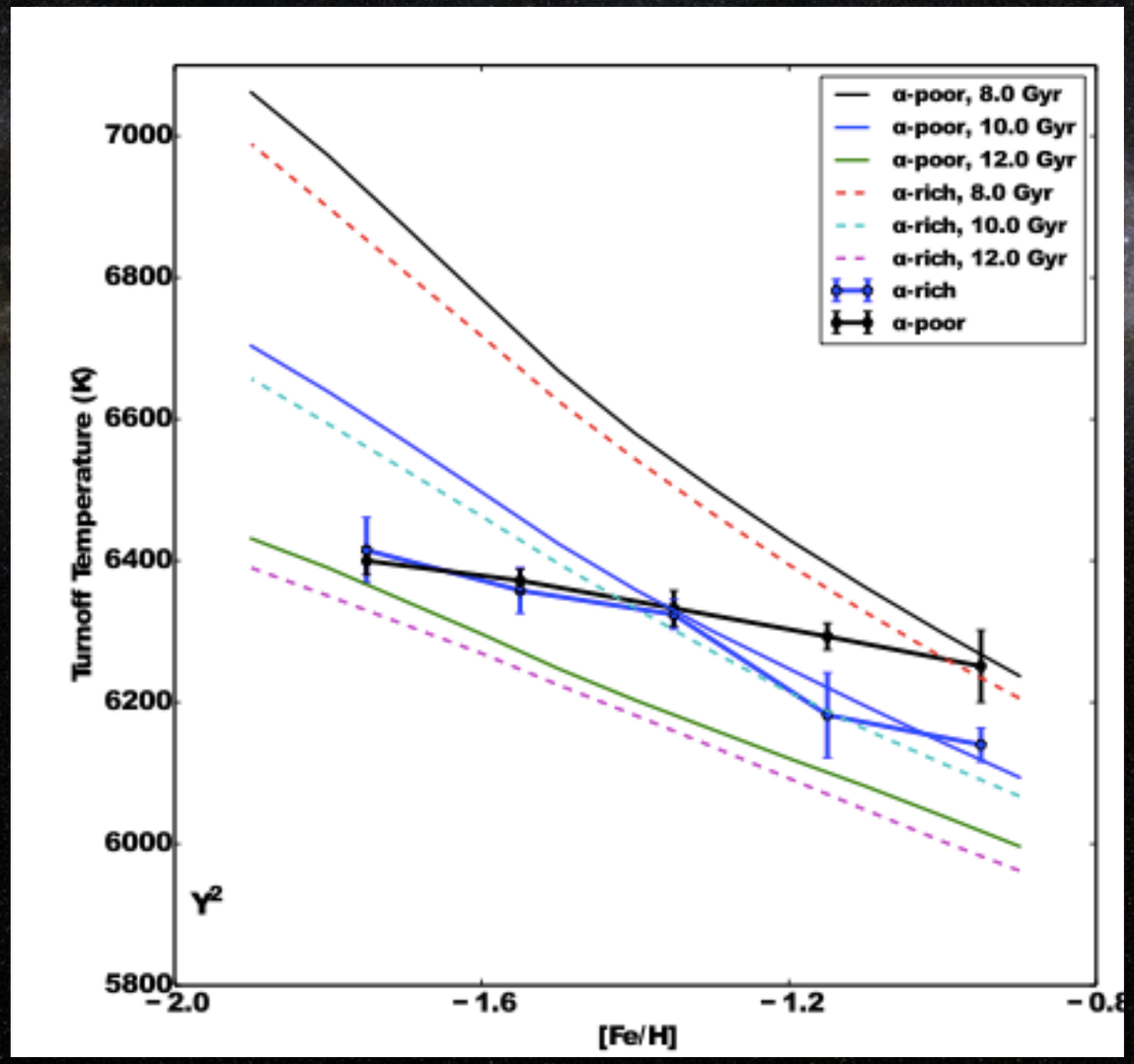
Chemistry

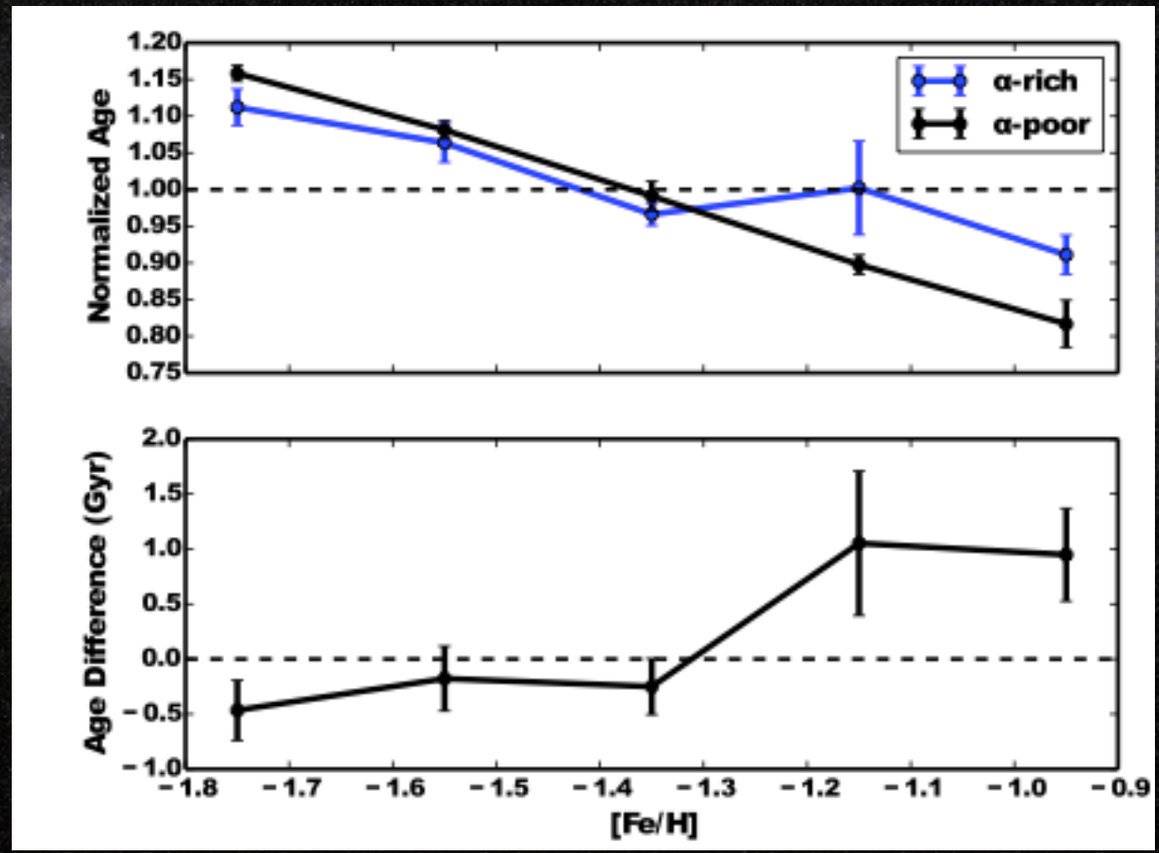




YES we can
Hawkins, Jofré+2014

two dominant populations





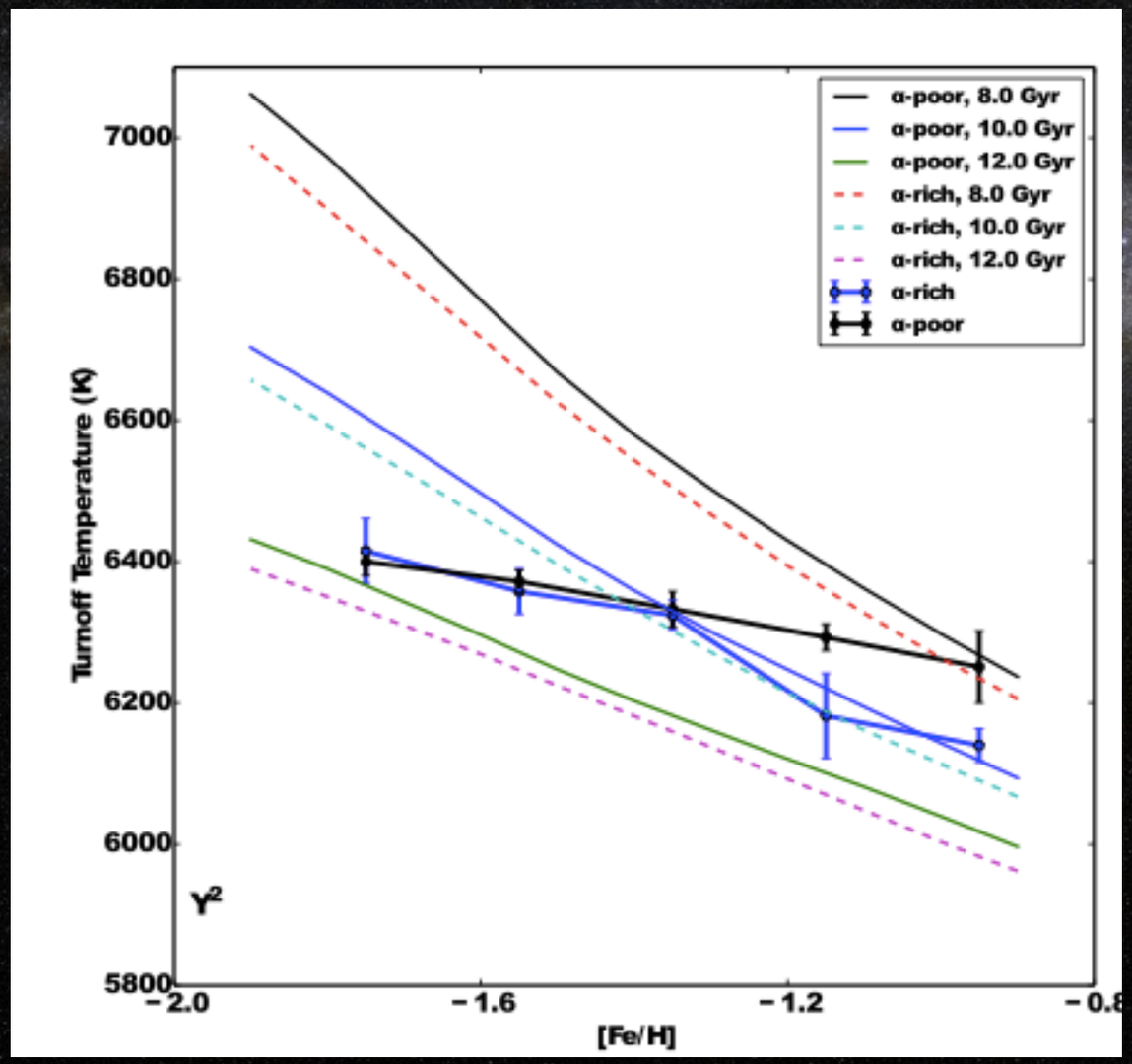
At lower metallicities, both populations are coeval

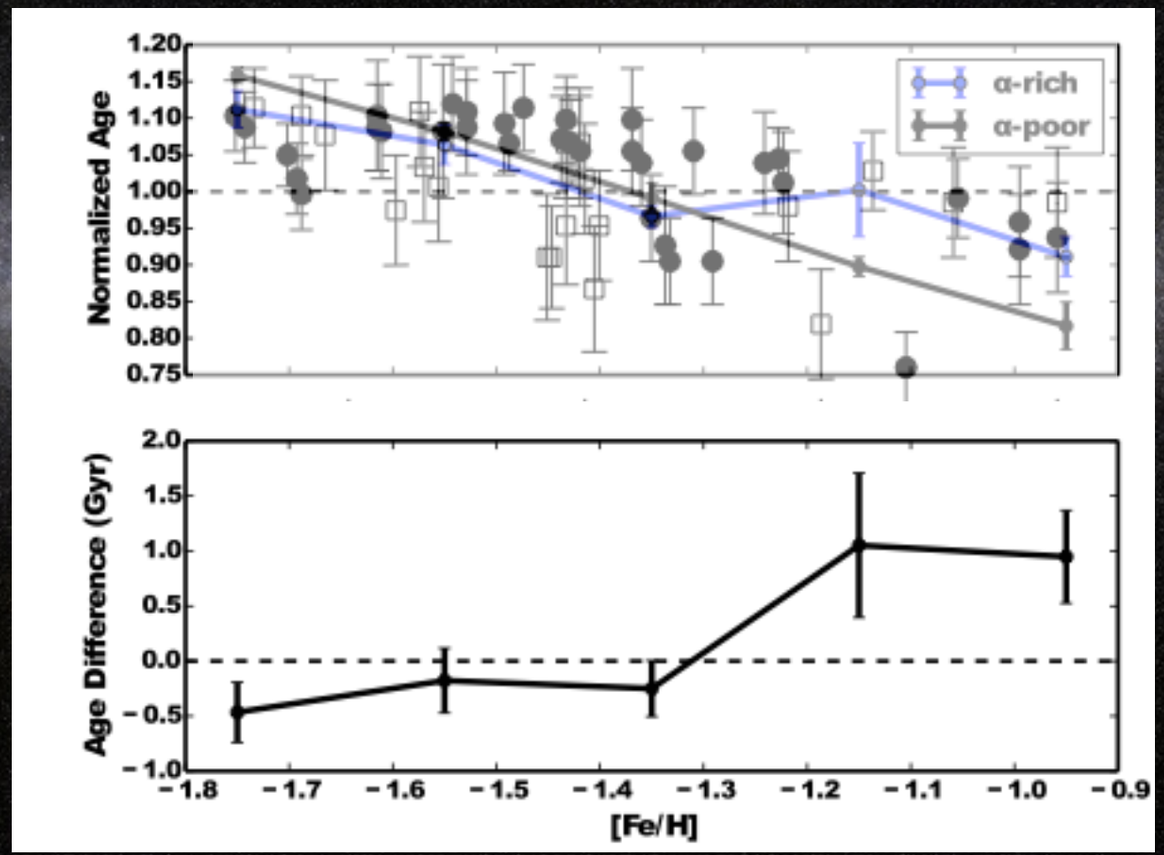
Hawkins, Jofré+2014

ioa

two dominant populations

Clusters Salaris and Weiss 2002



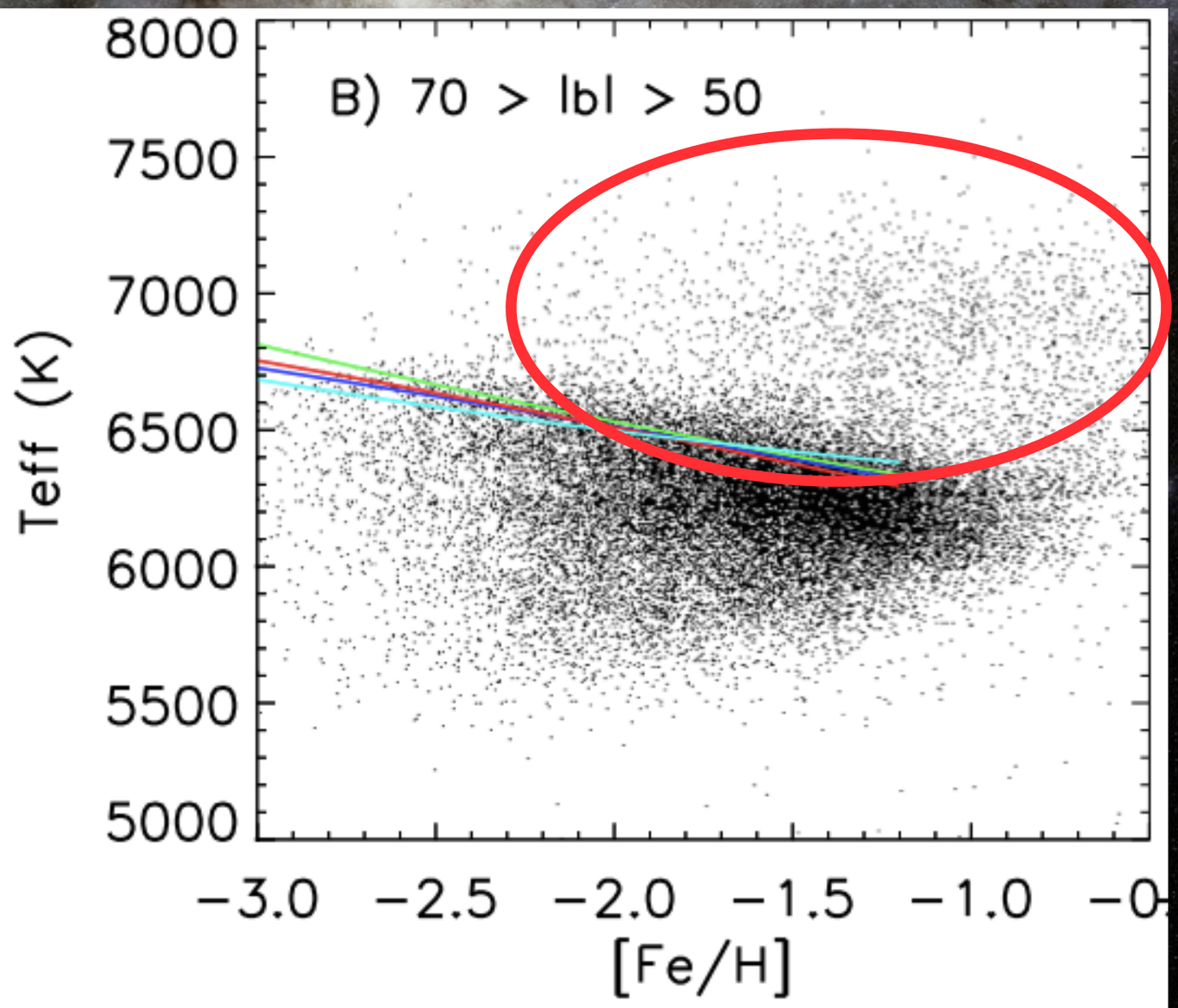


At lower metallicities, both populations are coeval

Hawkins, Jofré+2014

ioa

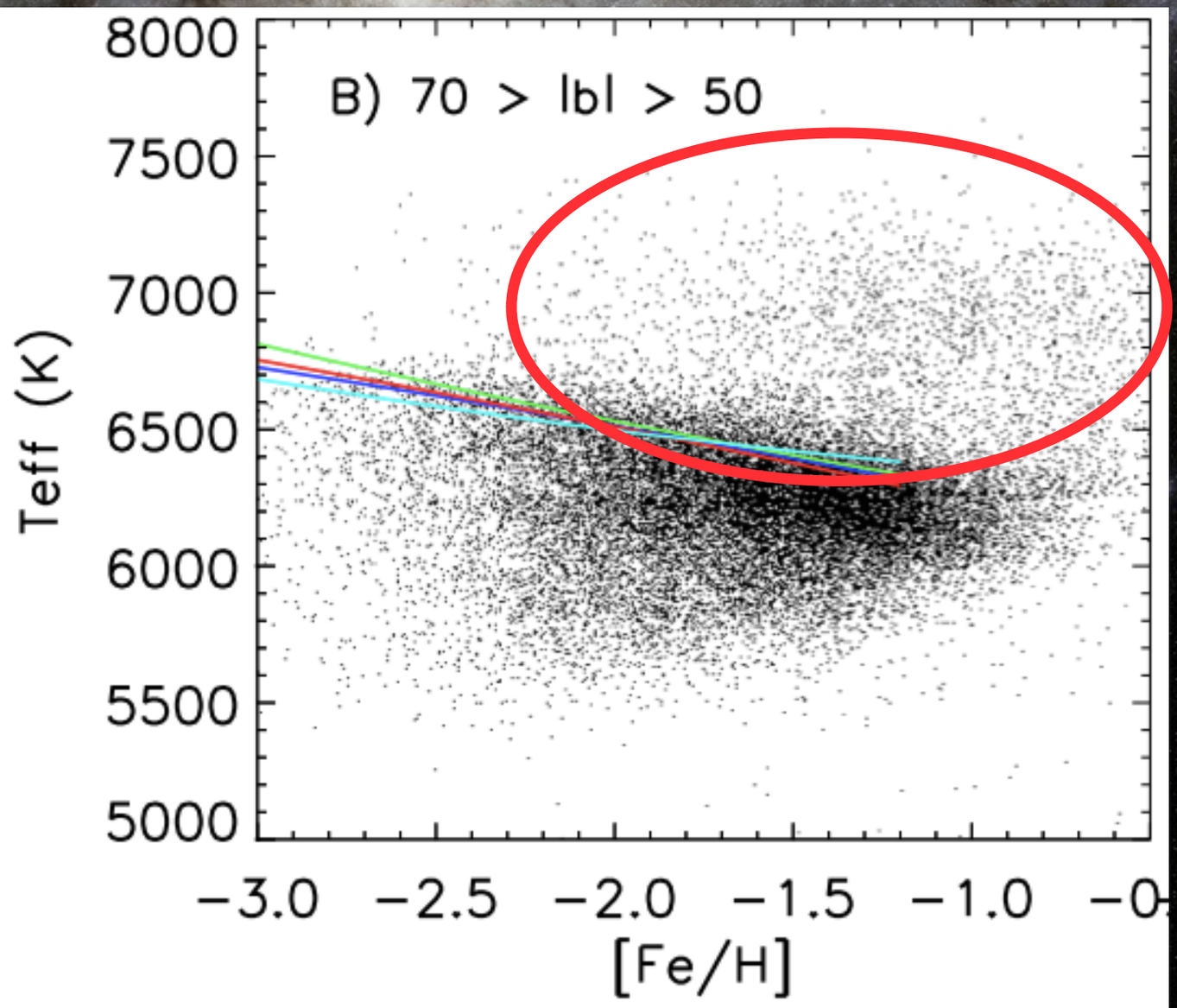
outliers - the non-dominant



what are these blue metal-poor stars?

ioa

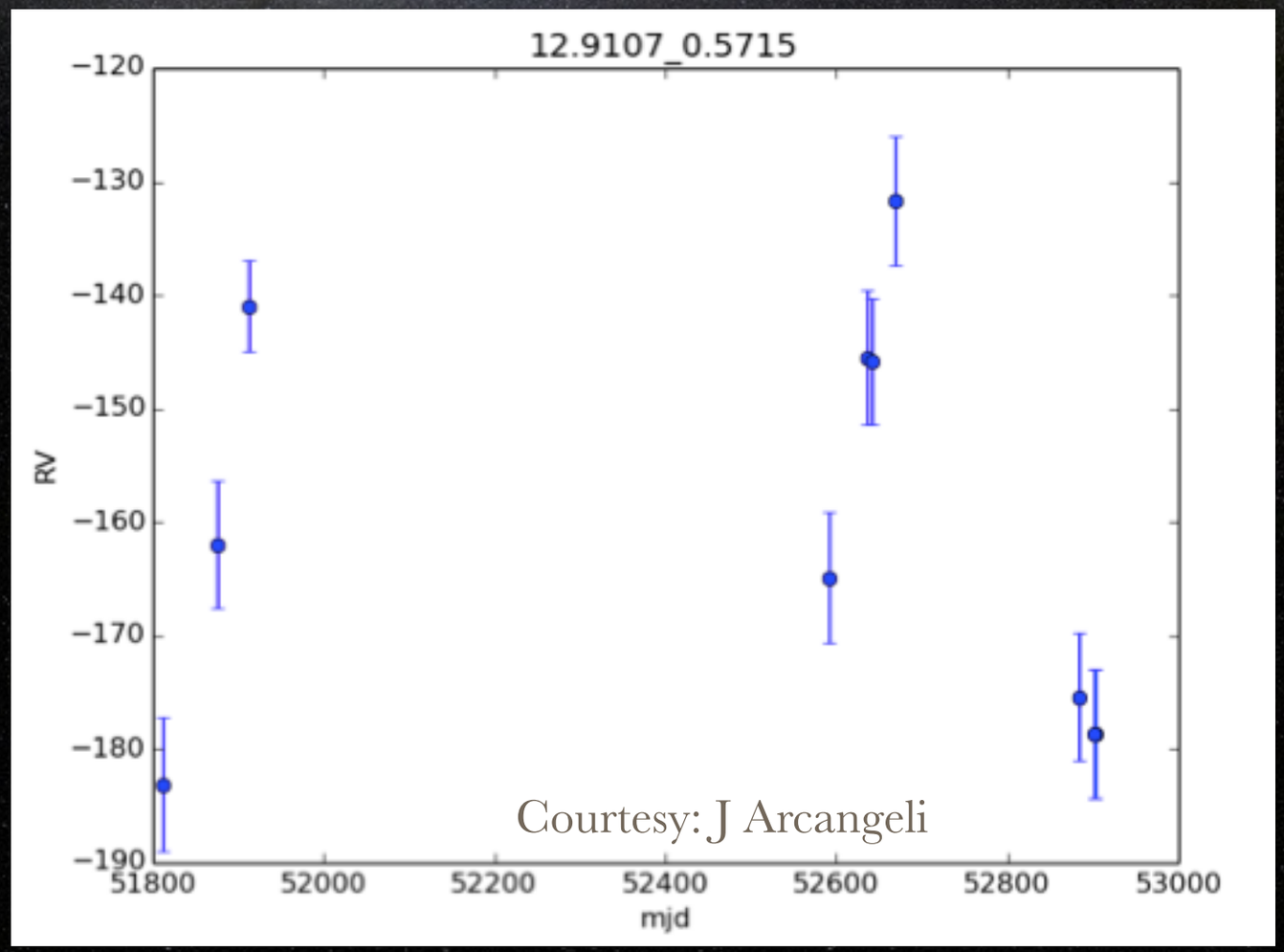
outliers - the non-dominant



1. BHB: well defined luminosity, good halo tracers although not very numerous
2. Blue Stragglers (very numerous that we should start learning on how to define better luminosity
3. younger metal-poor stars

ioa

outliers - the non-dominant



Courtesy: J Arcangeli

Blue Stragglers

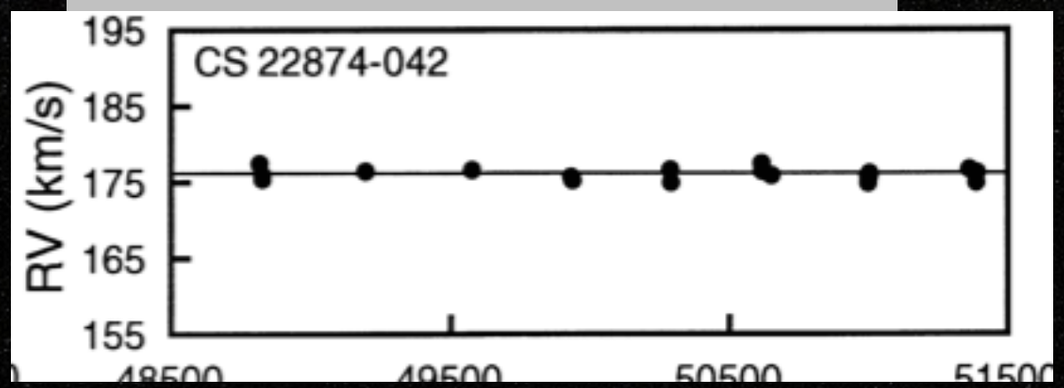
They look younger because they gained mass via mass transfer

They are still in binary systems

ioa

outliers - the non-dominant

Preston&Sneden2000



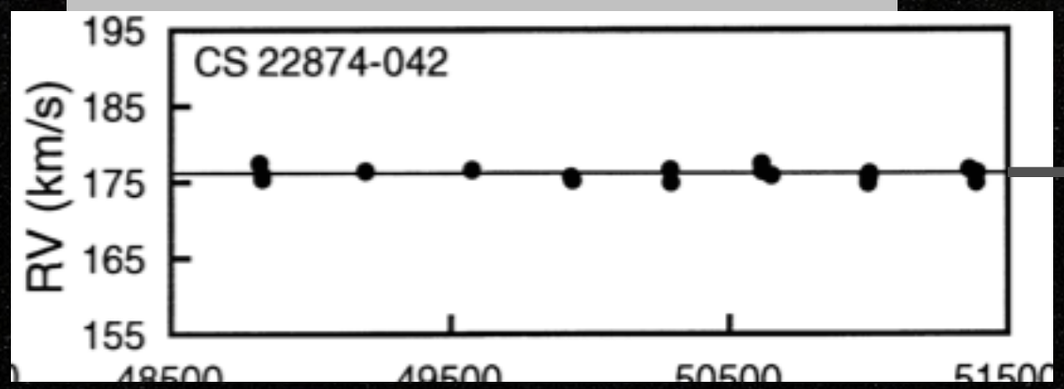
younger

They formed elsewhere
and came somehow
to the halo

They are RV constant

outliers - the non-dominant

Preston&Sneden2000



between ~1995 and 2000

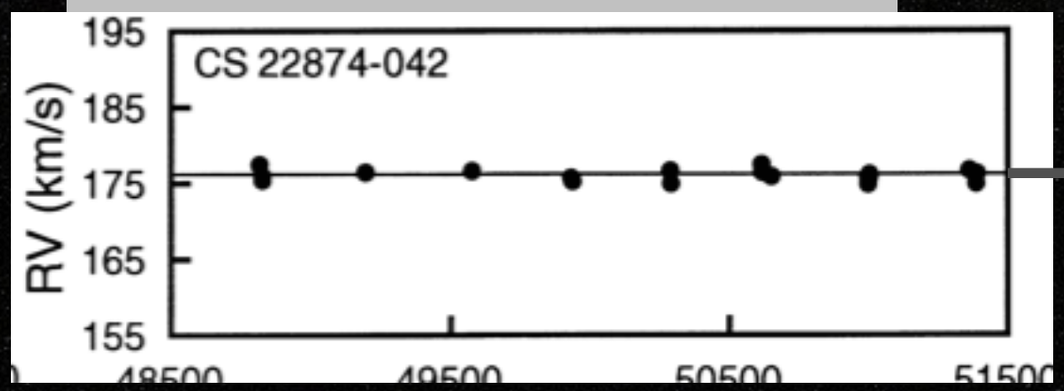
14 years later ….

outliers - the non-dominant

younger

- no chemical signatures of mass transfer (C, Ba, Sr normal values)
- no chemical signatures of extragalactic origin ([alpha/Fe] = 0.4)
- no dynamical clear signatures of thick-disk or Sgr origin

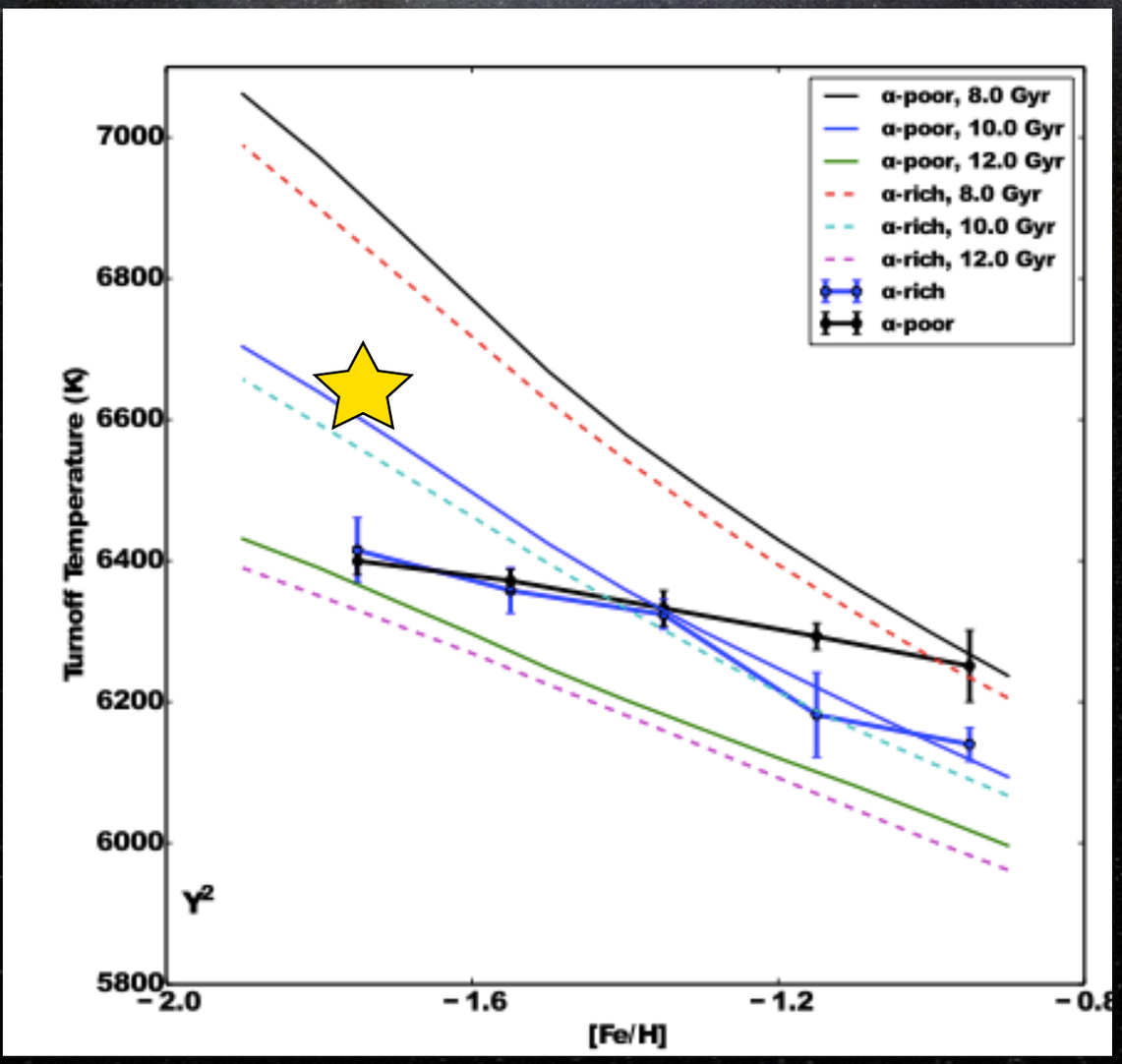
Preston&Sneden2000



between ~1995 and 2000

14 years later ….

outliers - the non-dominant



> 2 Gyr younger than bulk populations

Summary

- Bulk of (field and cluster) halo stars are is very old (10-12 Gyr), with more metal-rich stars having more stars that are younger.

- A bifurcation in age-metallicity relation is seen in clusters and field at [Fe/H] = -1.4

- It is now that large surveys are available, that we can start finding and learning more about young halo stars.