The Ages of the α-Rich and α-Poor Populations in the Galactic Halo

Keith Hawkins
Collaborators: P. Jofre, T. Masseron, G. Gilmore
ING Multi-object Spectroscopy in the Next Generation
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Hawkins+2014, MNRAS 445 2575; Hawkins+2015, in prep

Big Question(s)

- What is the assembly history of our Milky Way?

- What is the importance of accretion vs 'in situ' formed stars

Toward Answering these Questions:

- Ages: Stellar Ages in the (Halo) Field
- Chemistry: The importance of [α/Fe]
- Ages/fractions of α-rich and α-poor populations

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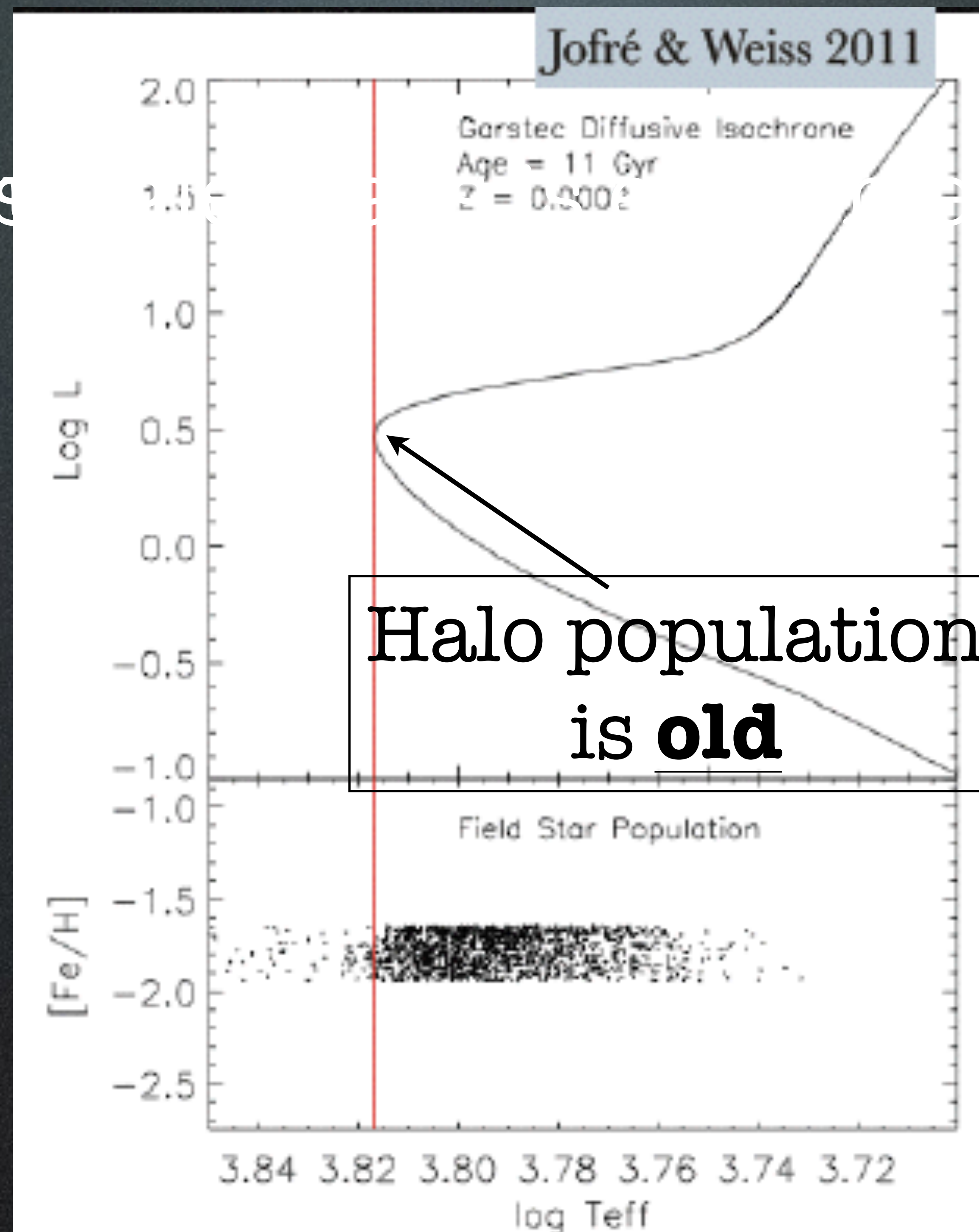
Ages of Stars

Age-dati... Ass... ...difficult!

Luminosity



Halo population is **old**

...ure

Turnoff temperature/ Main-sequence turnoff (MSTO) give age of stellar **population**

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- **Chemistry: The importance of [α/Fe]**
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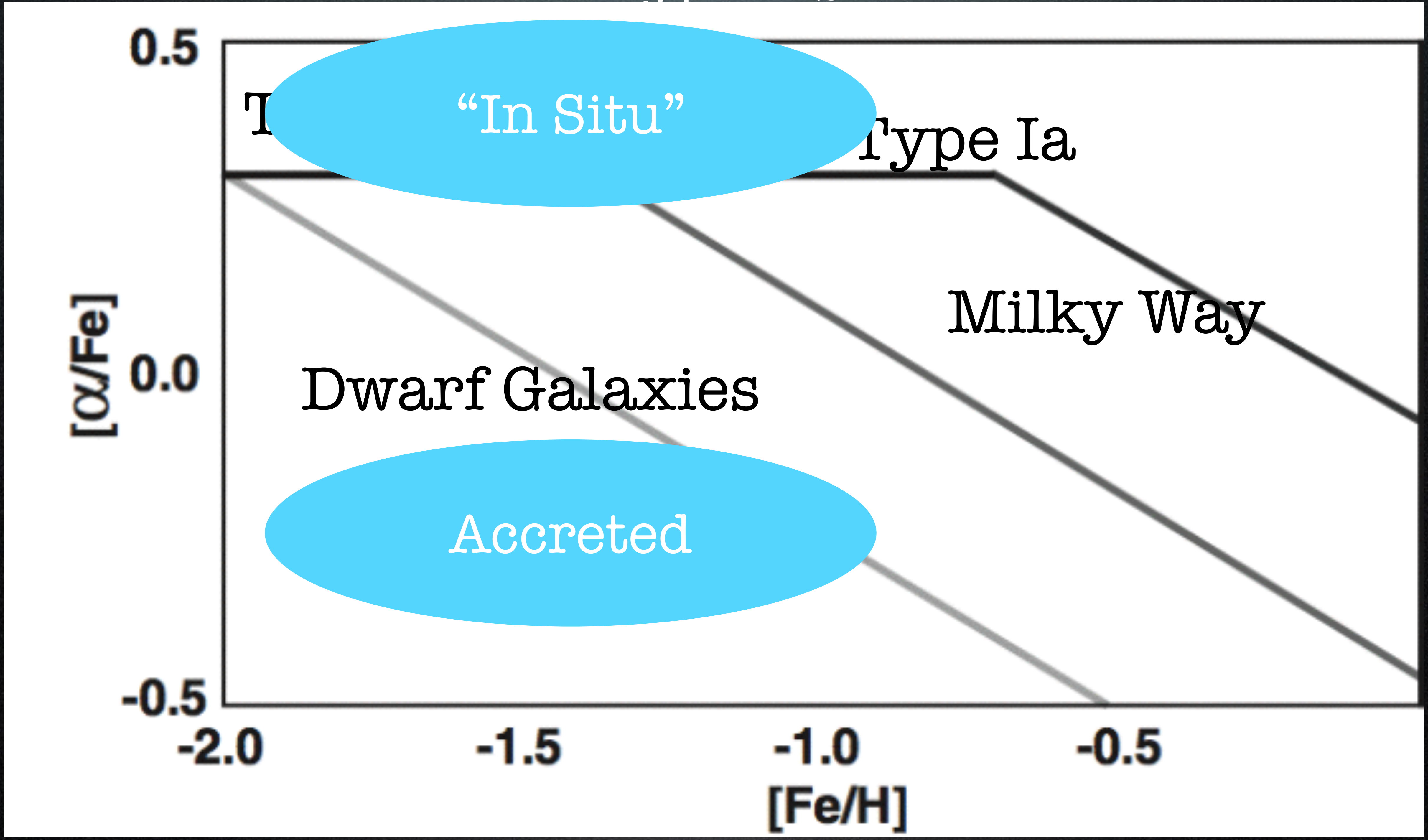
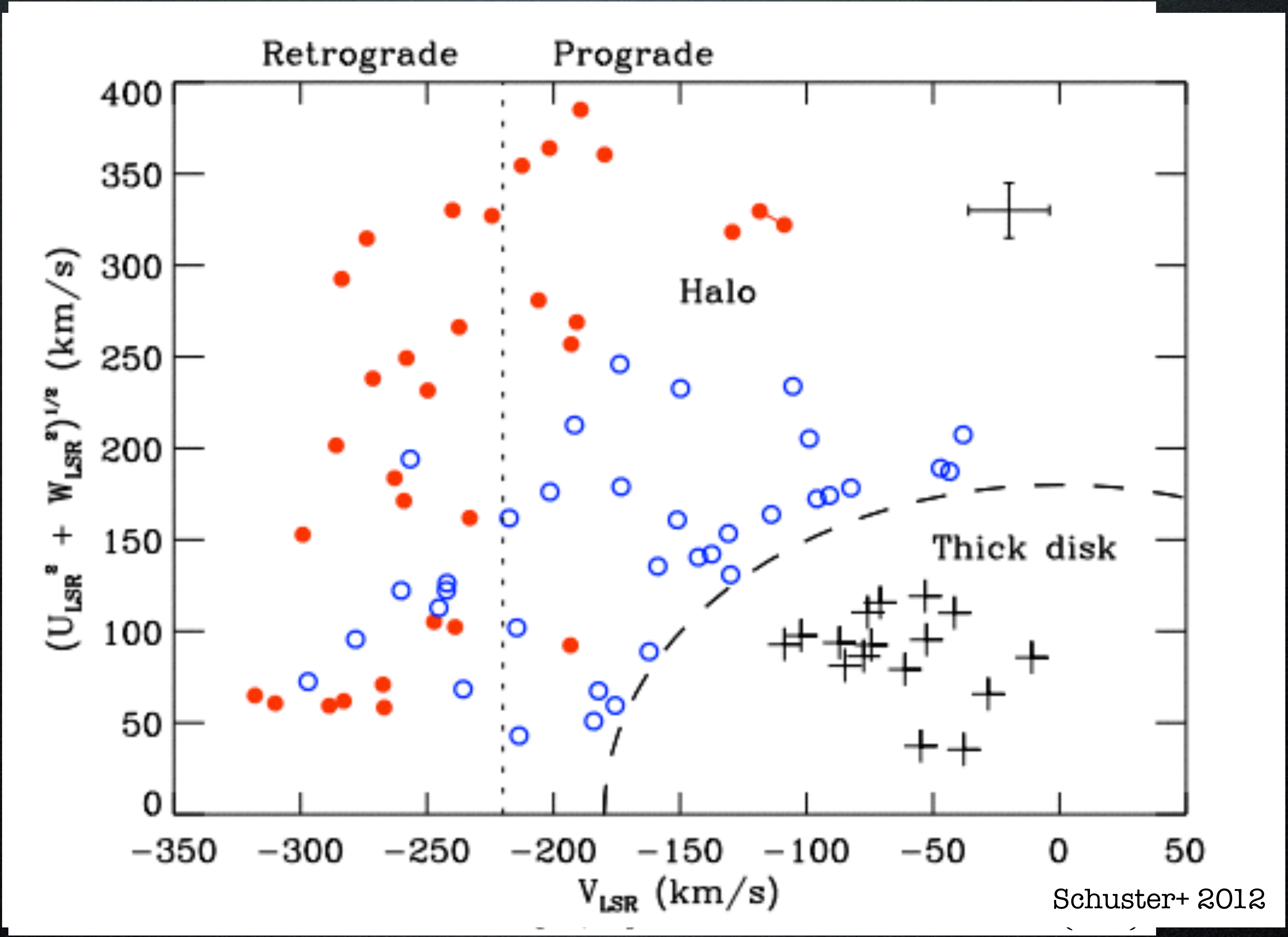
Chemistry: The Importance of [α/Fe]

α-elements: Mg, Ti, Si, Ca, O, etc dispersed primarily via Type II SNe



[α/Fe] reveals how fast star formation was and mass of system

Two Populations in the Inner Halo



Schuster+ 2012

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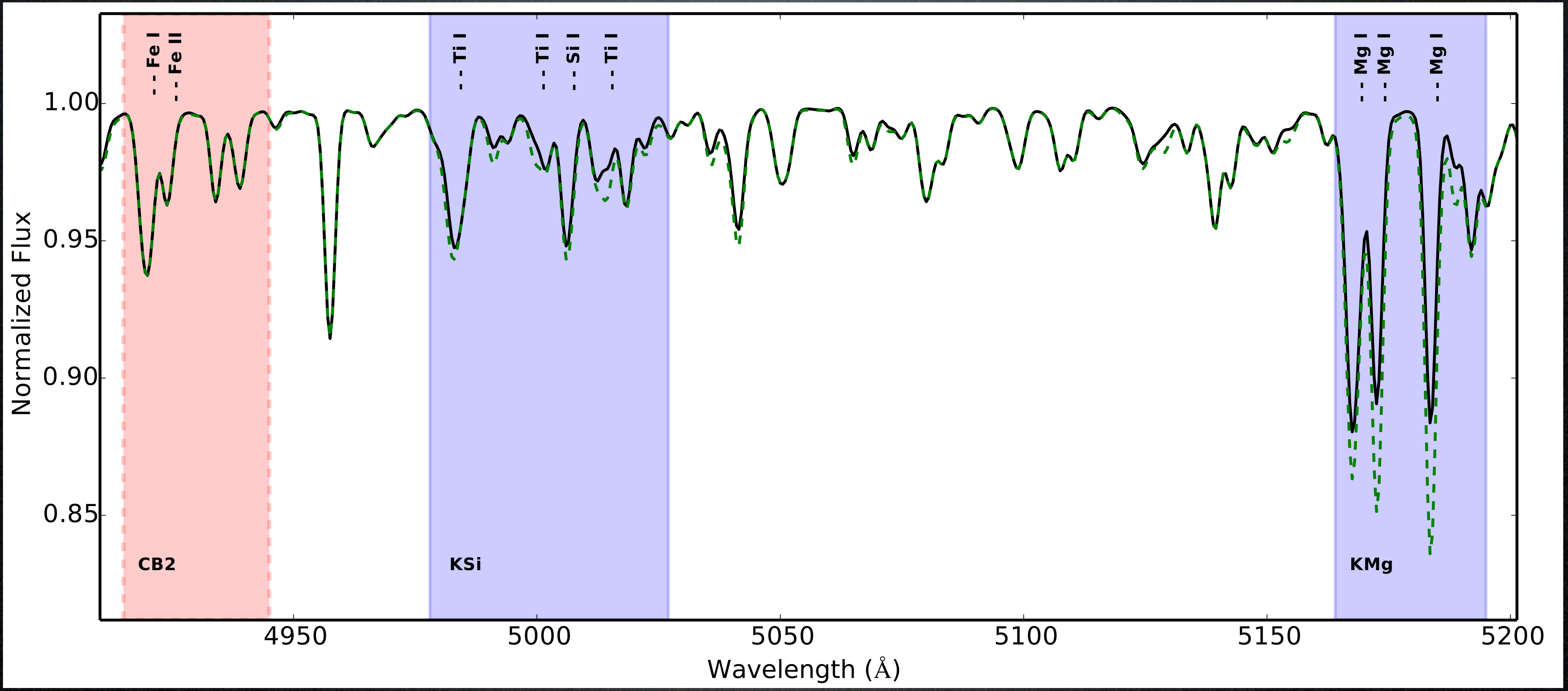
Toward Answering these Questions:

- Ages: Stellar Ages in the (Halo) Field
- Chemistry: The importance of [α/Fe]
- **Is there an Age difference for the α-rich and α-poor populations?**

Current Methods to Extract [α/Fe] in Low-Resolution Spectra

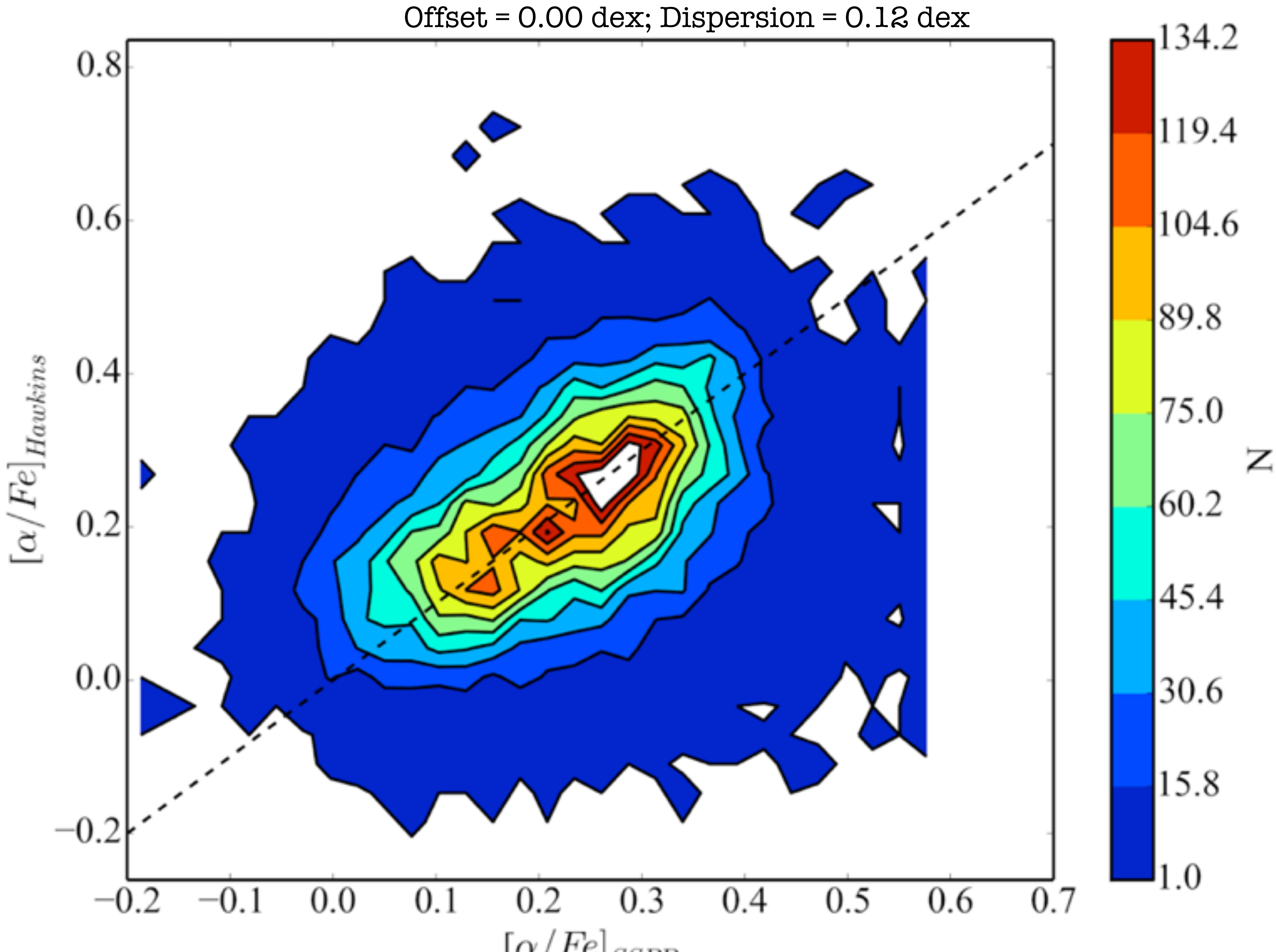
- Employ large sample from MSTO SDSS
- SSPP - Spectral Grid Matching: Lee +, (2011), obtain [α/Fe] down to [Fe/H] ~ - 1.5 dex with errors ~ 0.1 dex
  - Not in public DR9, DR10-12?
- **Spectral Index: Hawkins+2014**

[α/Fe] and Low-Resolution Spectra



Our [α/Fe] VS SSPP

Random sampling of 10,000 stars

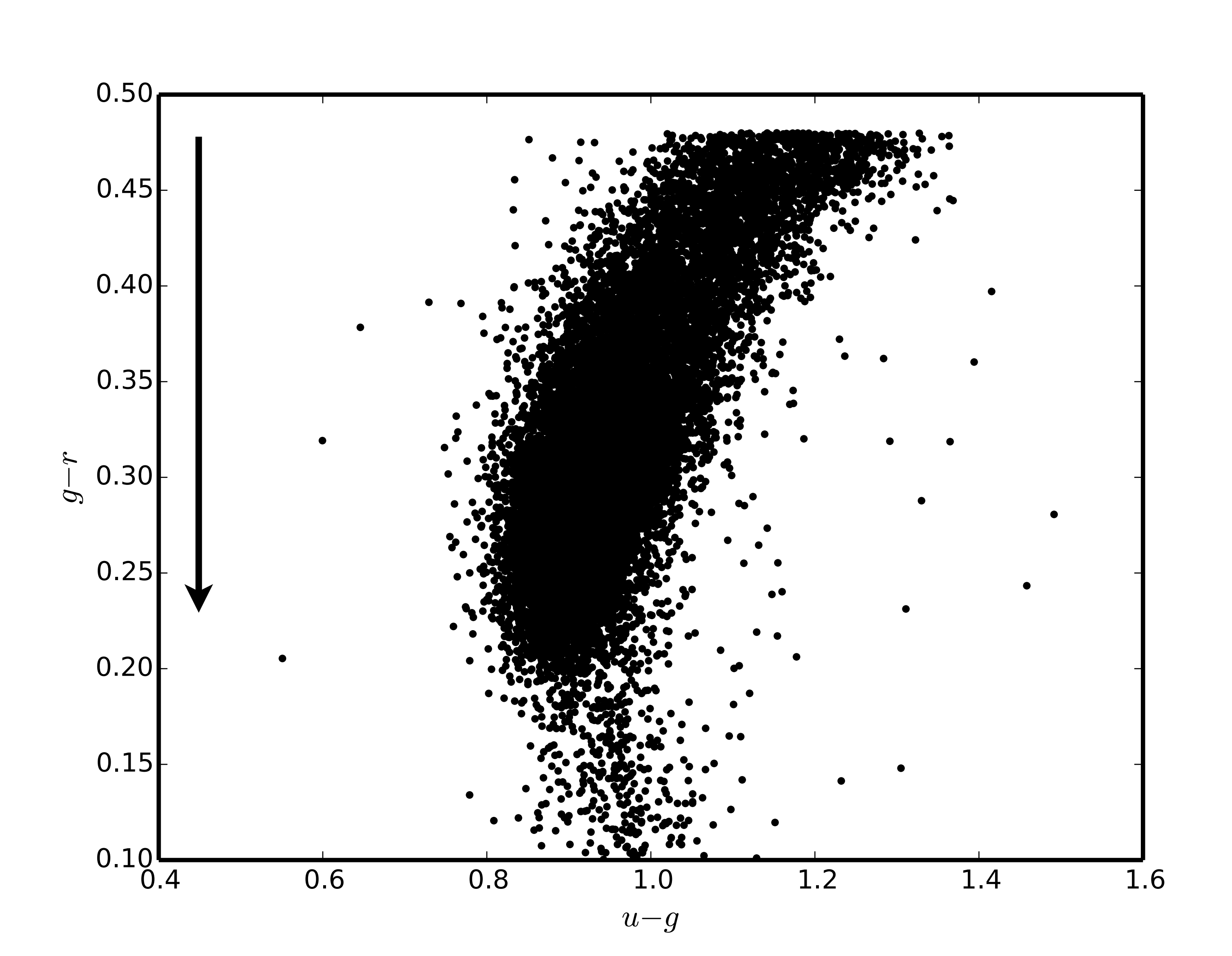


Y. S. Lee/T. Beers, private comm.

SDSS Sample: Main-Sequence Turnoff Stars (MSTO)

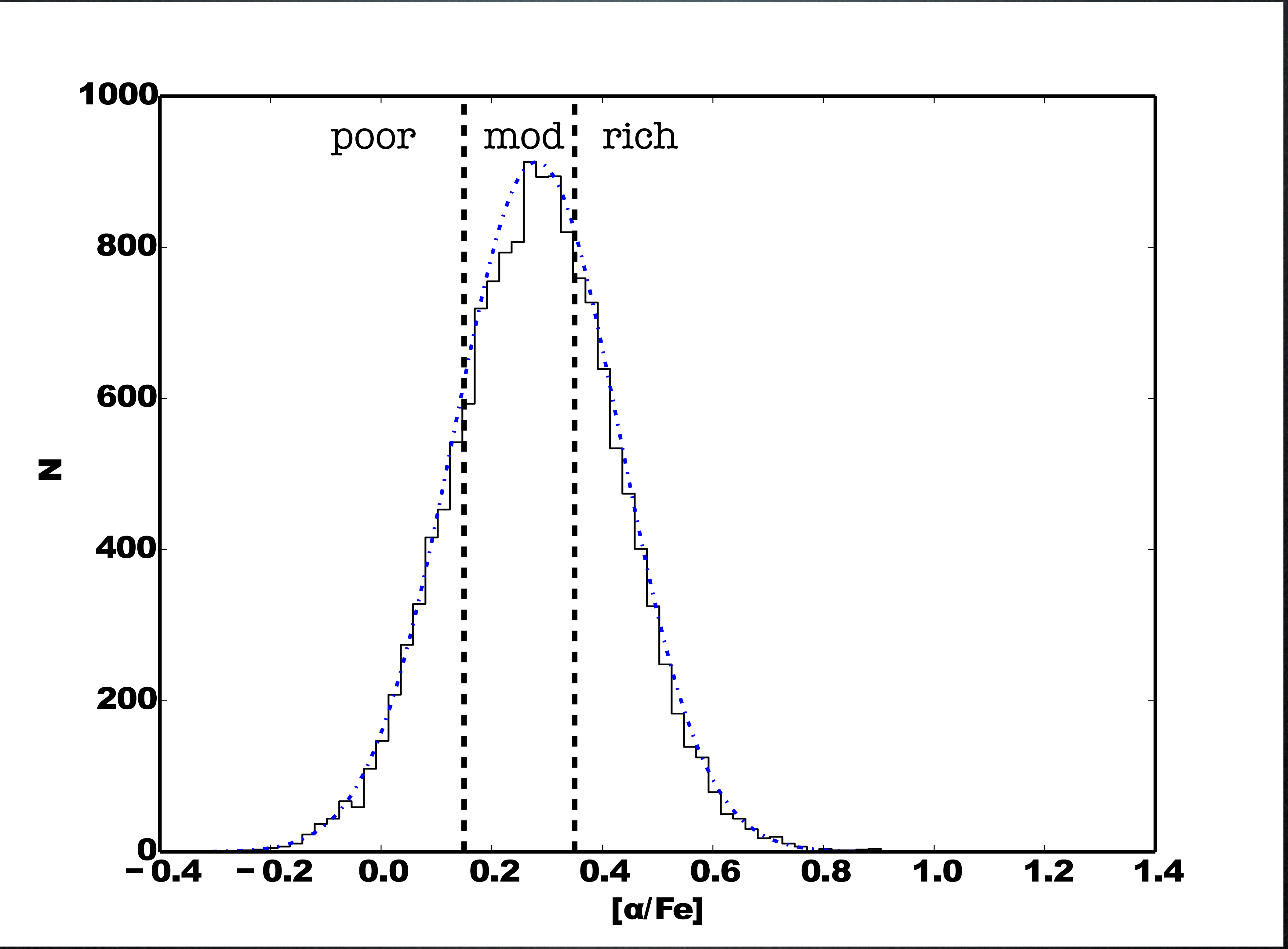
Smaller T_{eff}

- $0.1 < (g\text{-}r)_0 < 0.48$
- $-0.8 < [Fe/H] < -2.0$
- $b > 30$ degrees
- $\log g > 3.5$
- $SNR > 40$

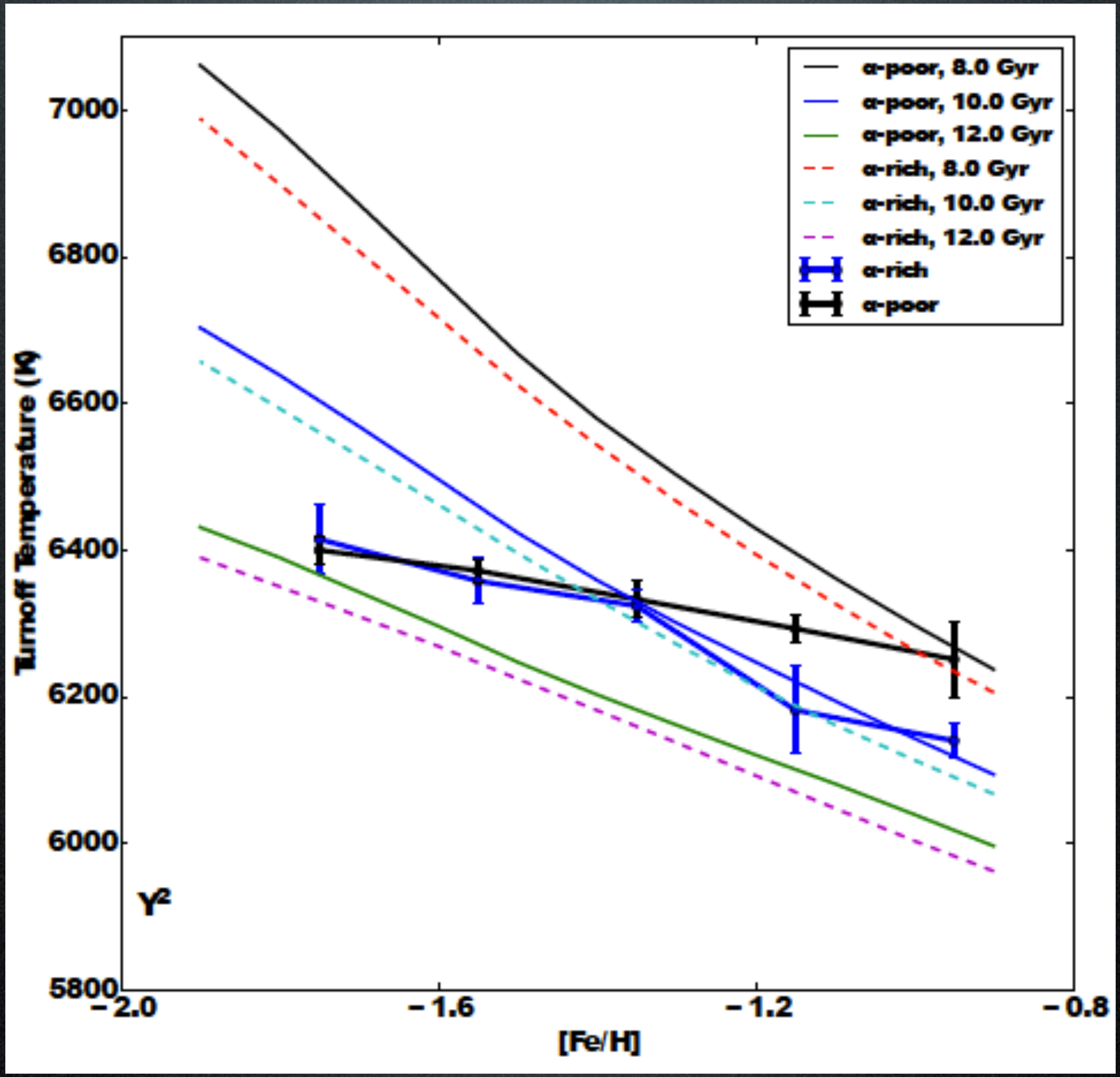


Larger T_{eff}

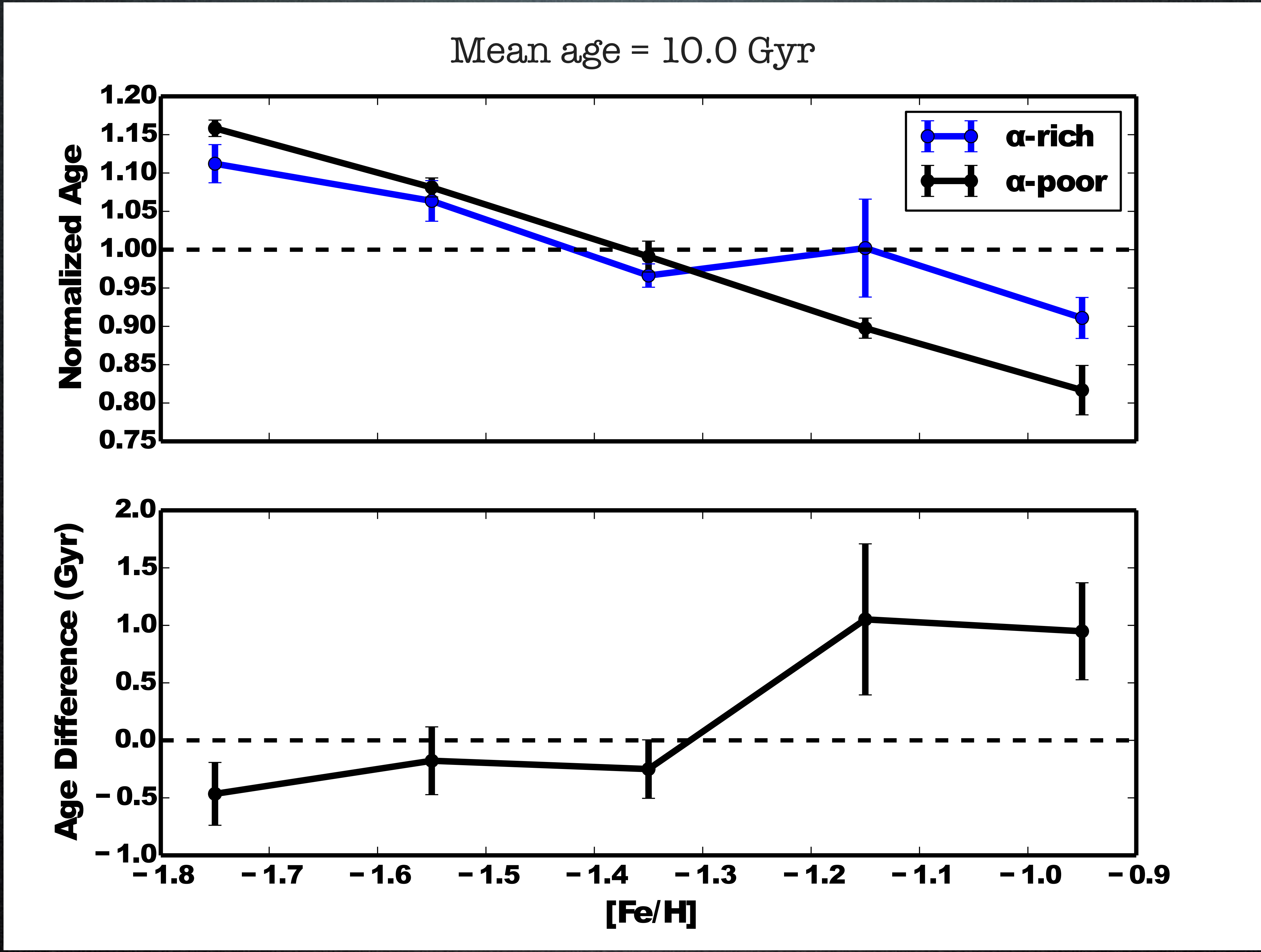
[α/Fe] Distribution



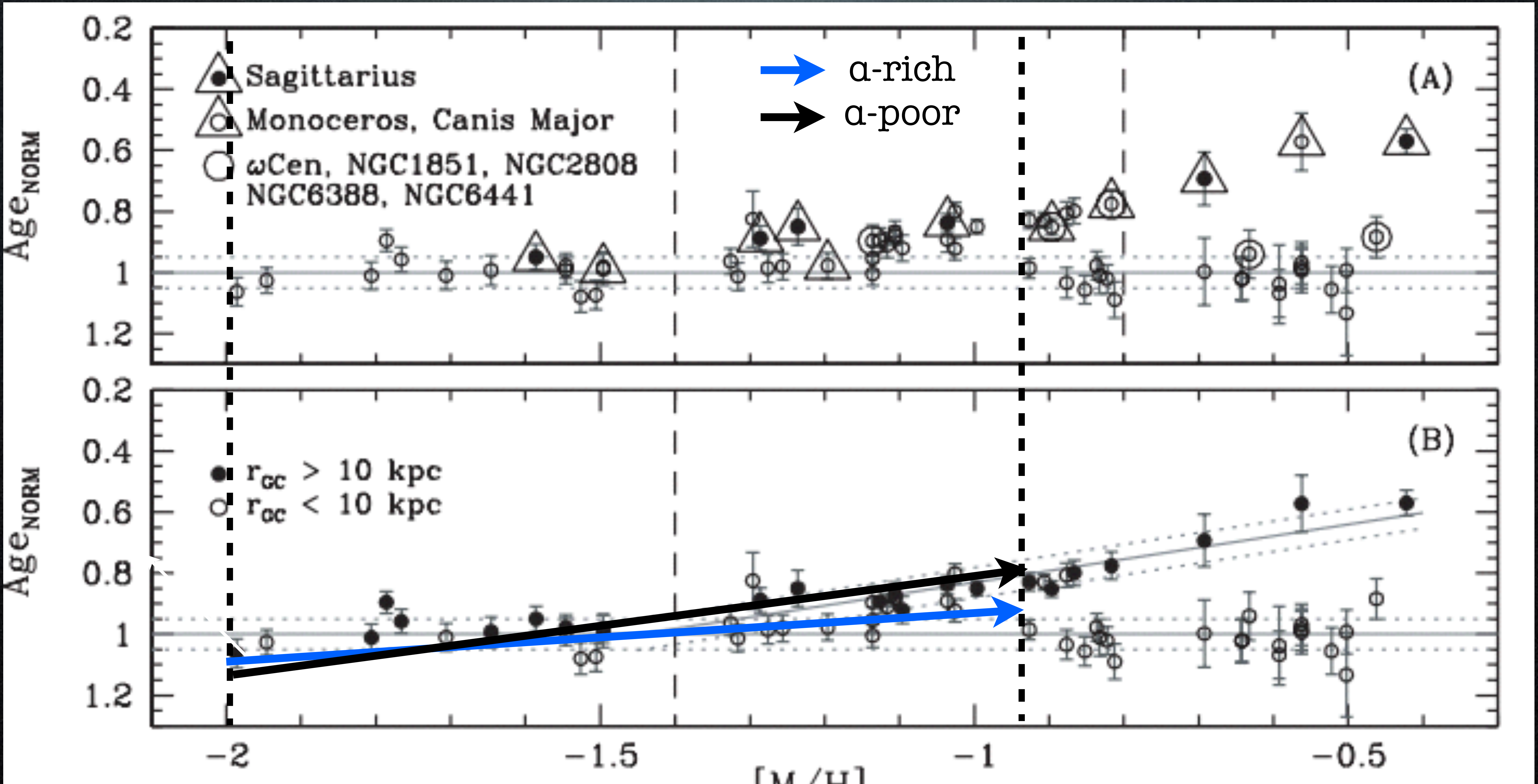
MSTO-Metallicity



Age-Metallicity Relation (AMR)



GCs VS Field AMR



Marin-Franch+2012

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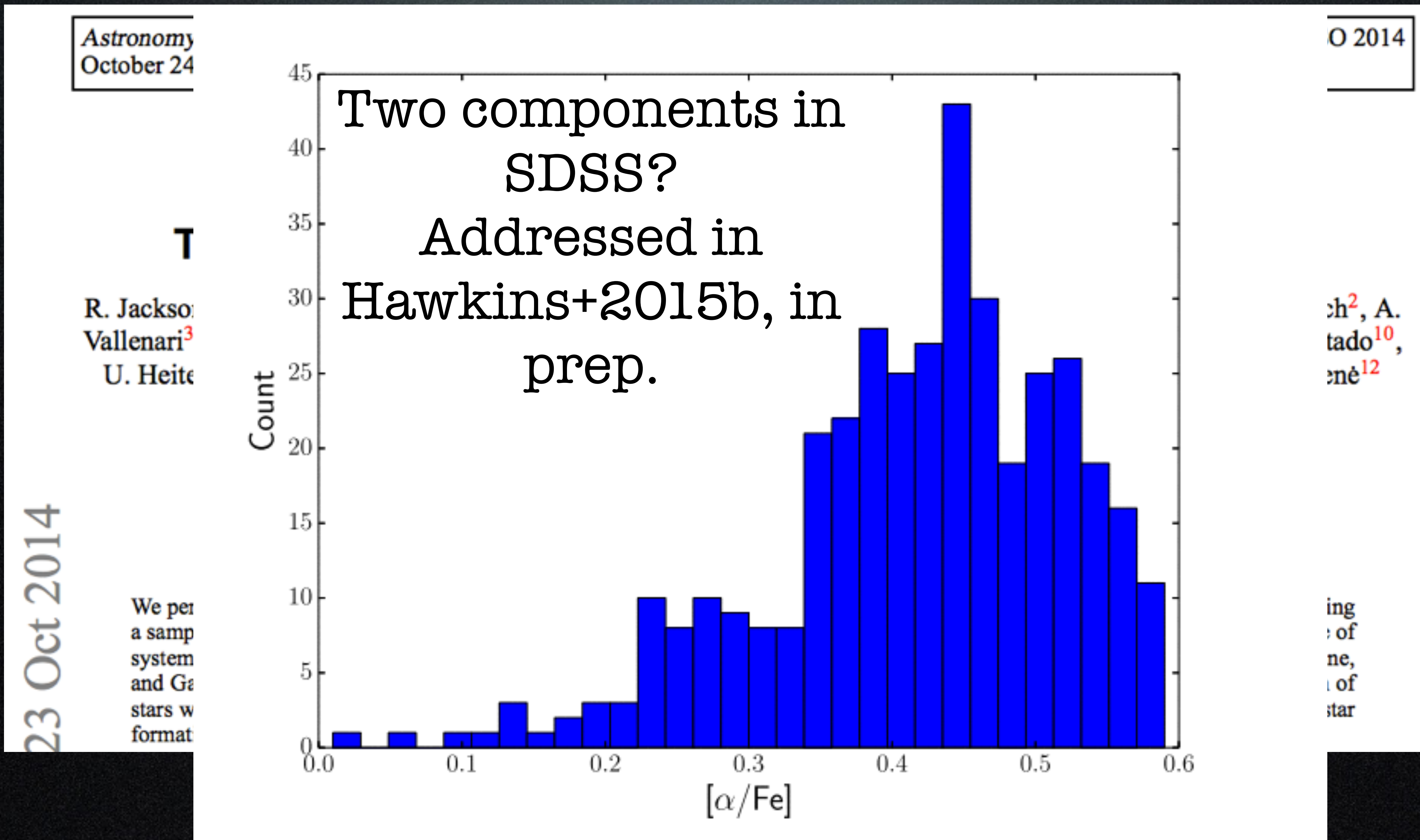
Toward Answering these Questions:

- Ages: Stellar Ages in the (Halo) Field
- Chemistry: The importance of [α/Fe]
- **What is the relative fraction of the two populations?**

Fraction of α-rich to α-poor for metal-poor stars in Gaia-ESO



Summary

- Developed simple method estimate [α/Fe] from low-res spectra
- The Galactic halo formed/assembled quickly
- At high metallicity α-rich stars are older than α-poor stars and become coeval at low metallicity
- α-poor stars may have formed in chemically slower environments than their α-rich counterparts (AMR)
- Surveys with higher precision and larger sample sizes (GALAH, 4MOST) needed to fully study the [α/Fe] distribution.

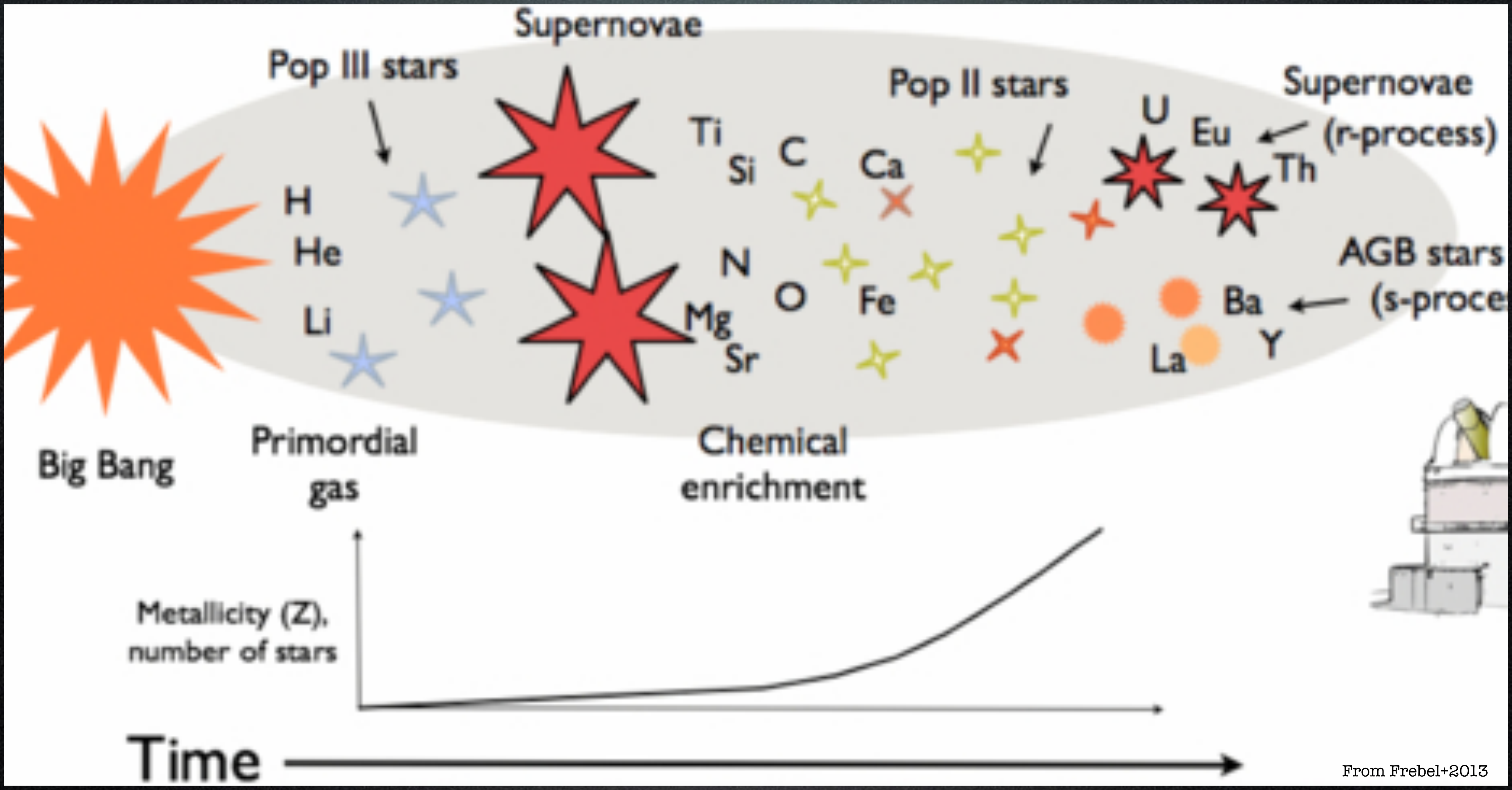
Future Work:

- Improve index to giants, more metal poor and add soft priors on stellar parameters
- Extend the index to [Ba/Fe] or an s-process index to study blue stragglers

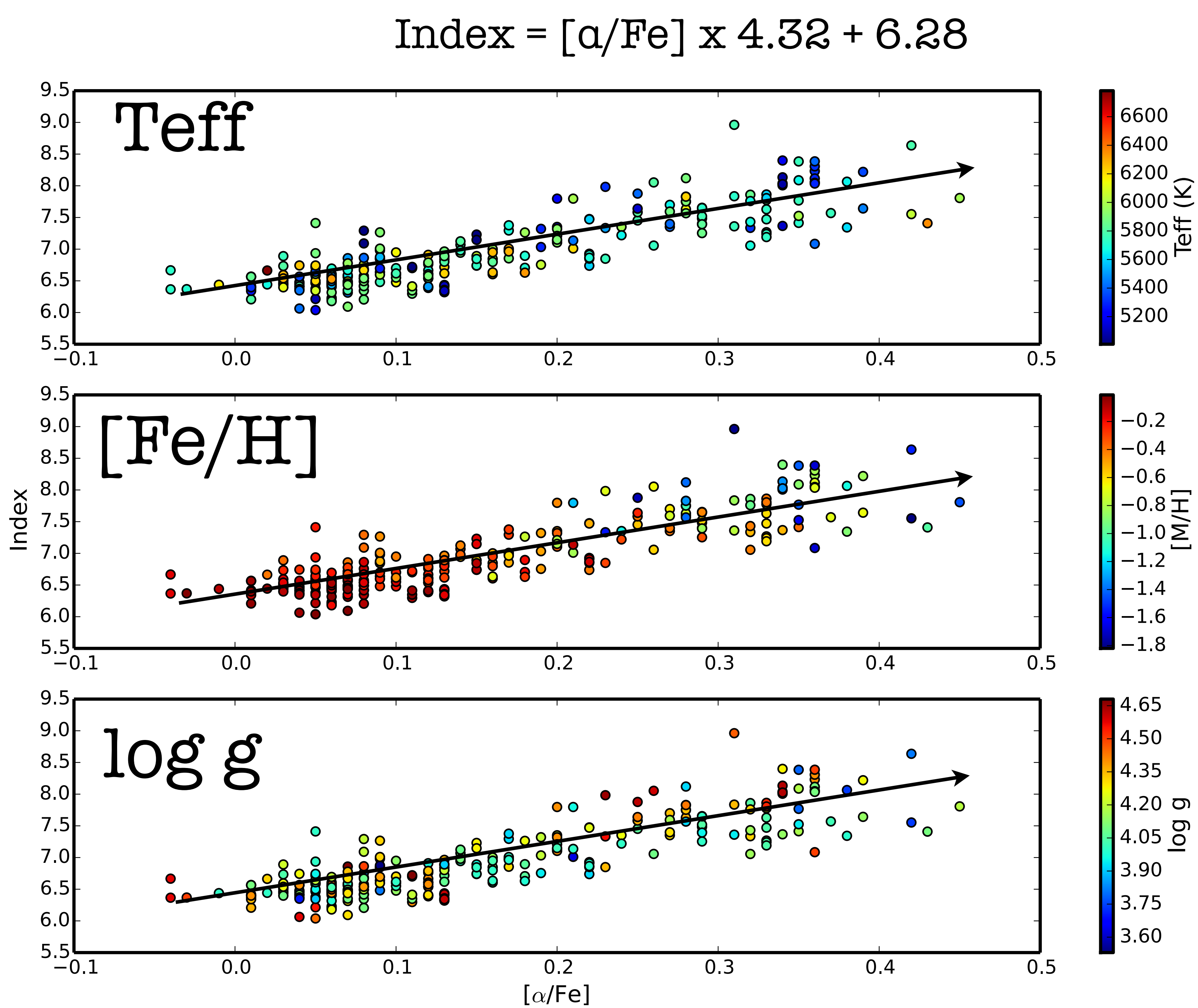
END

Chemistry: The Importance of [α/Fe]

Type II SNe | α-element | Type Ia SNe | Fe-peak/ other

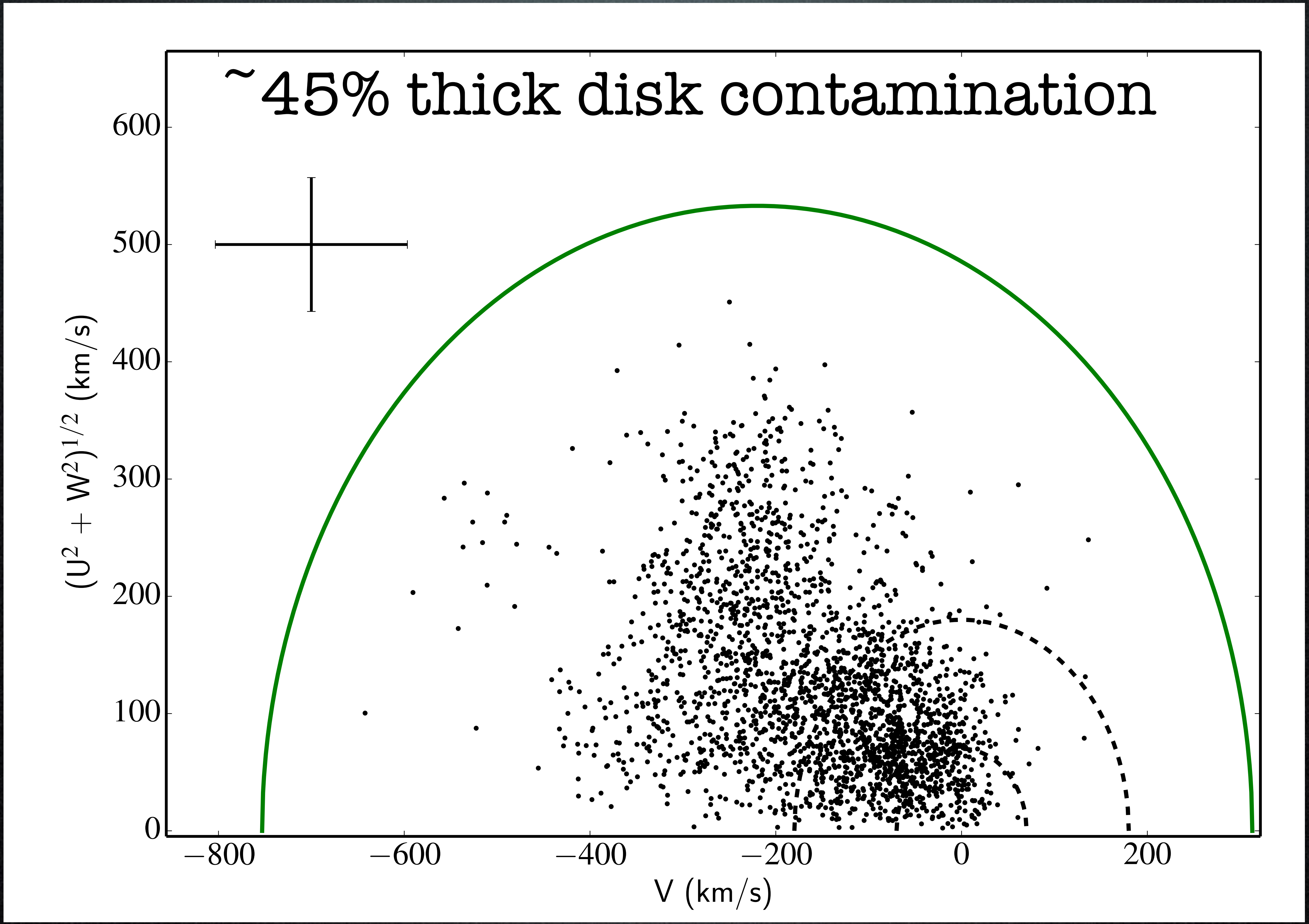


Converting the Index to [α/Fe]

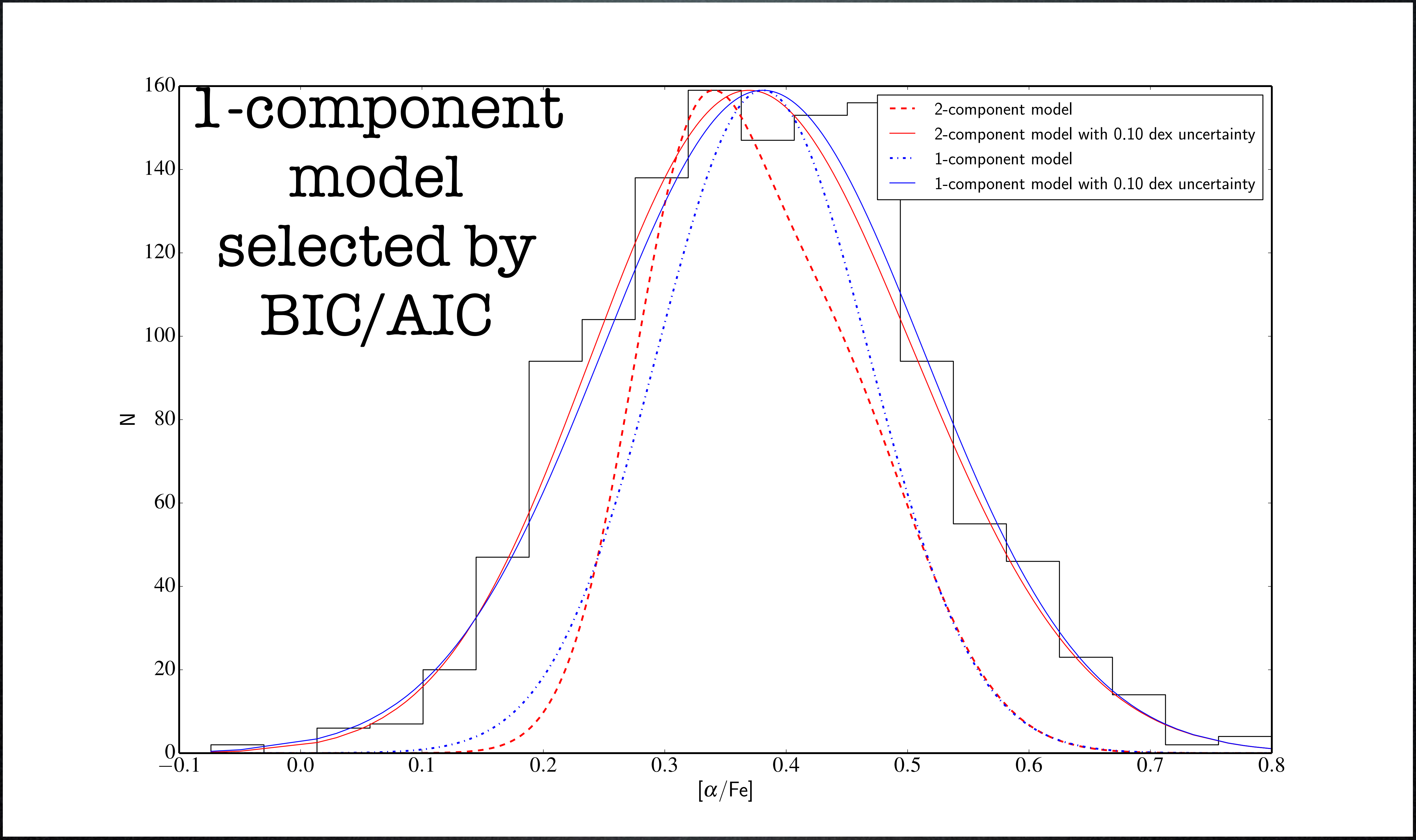


ELODIE Library Prugniel & Soubiran 2001

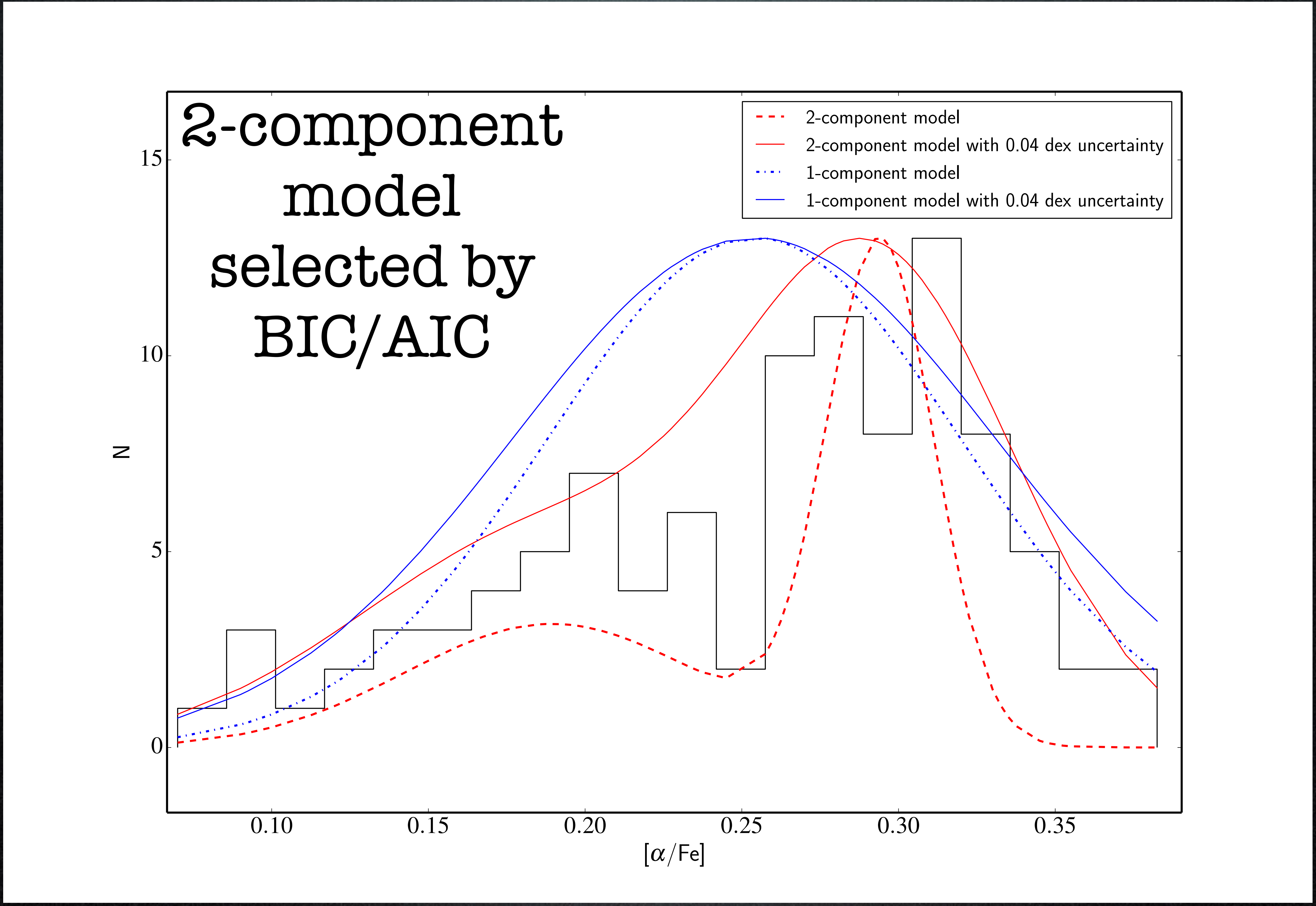
Thick Disk Contamination in SDSS G-dwarf Sample



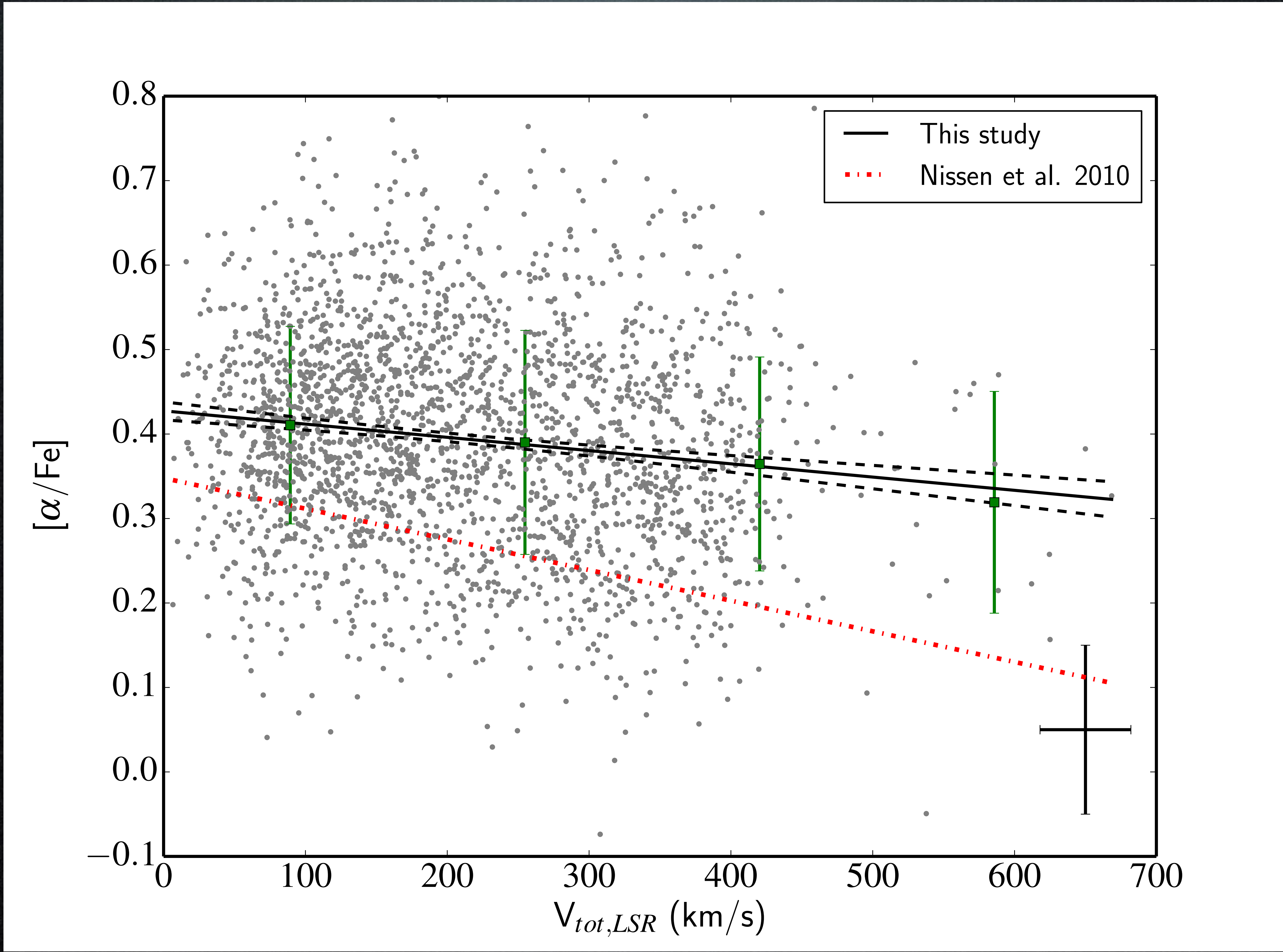
[α/Fe] Distribution in SDSS "Halo" G-dwarfs



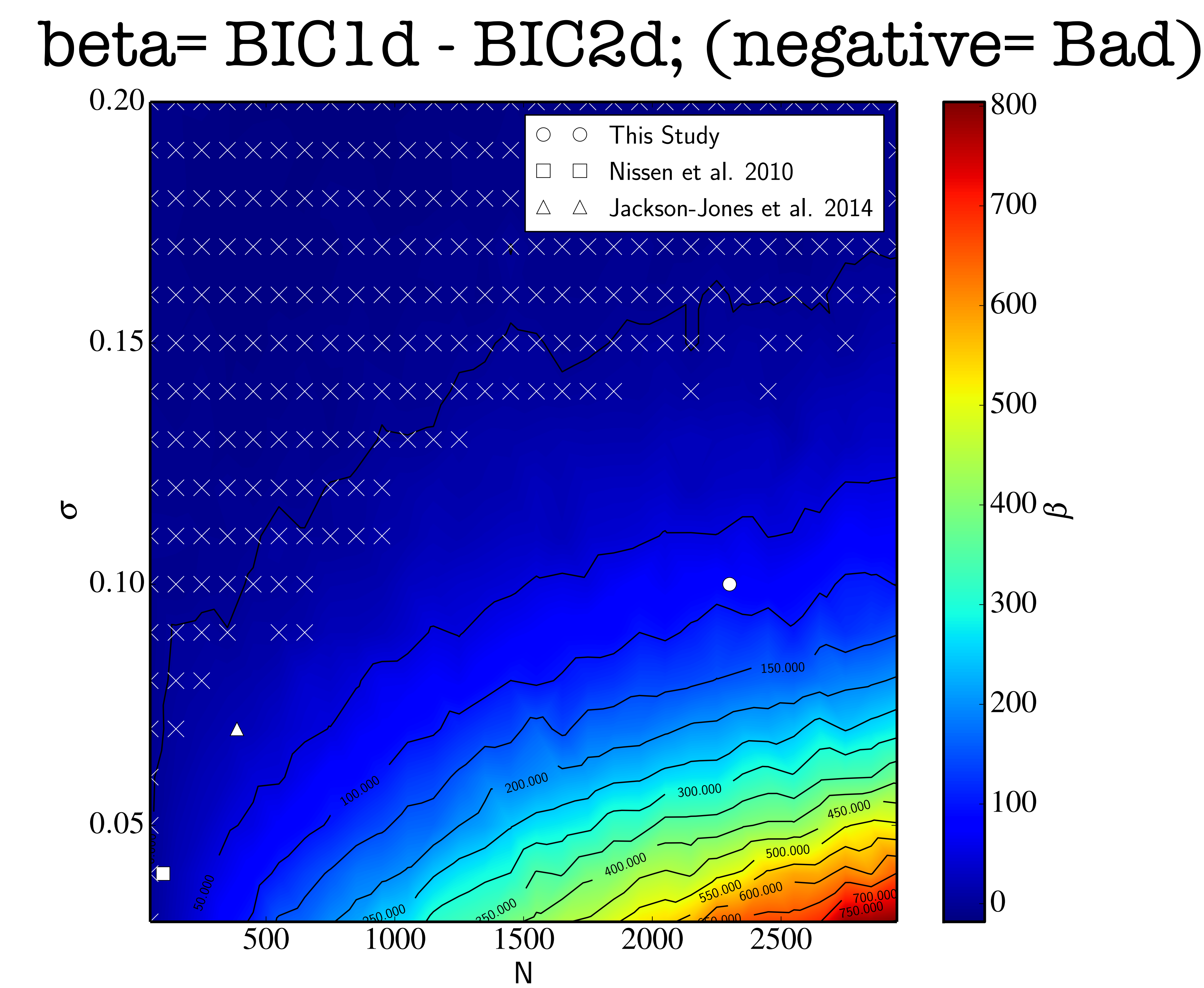
[α/Fe] Distribution Nissen +2010



Velocity-Alpha Trends

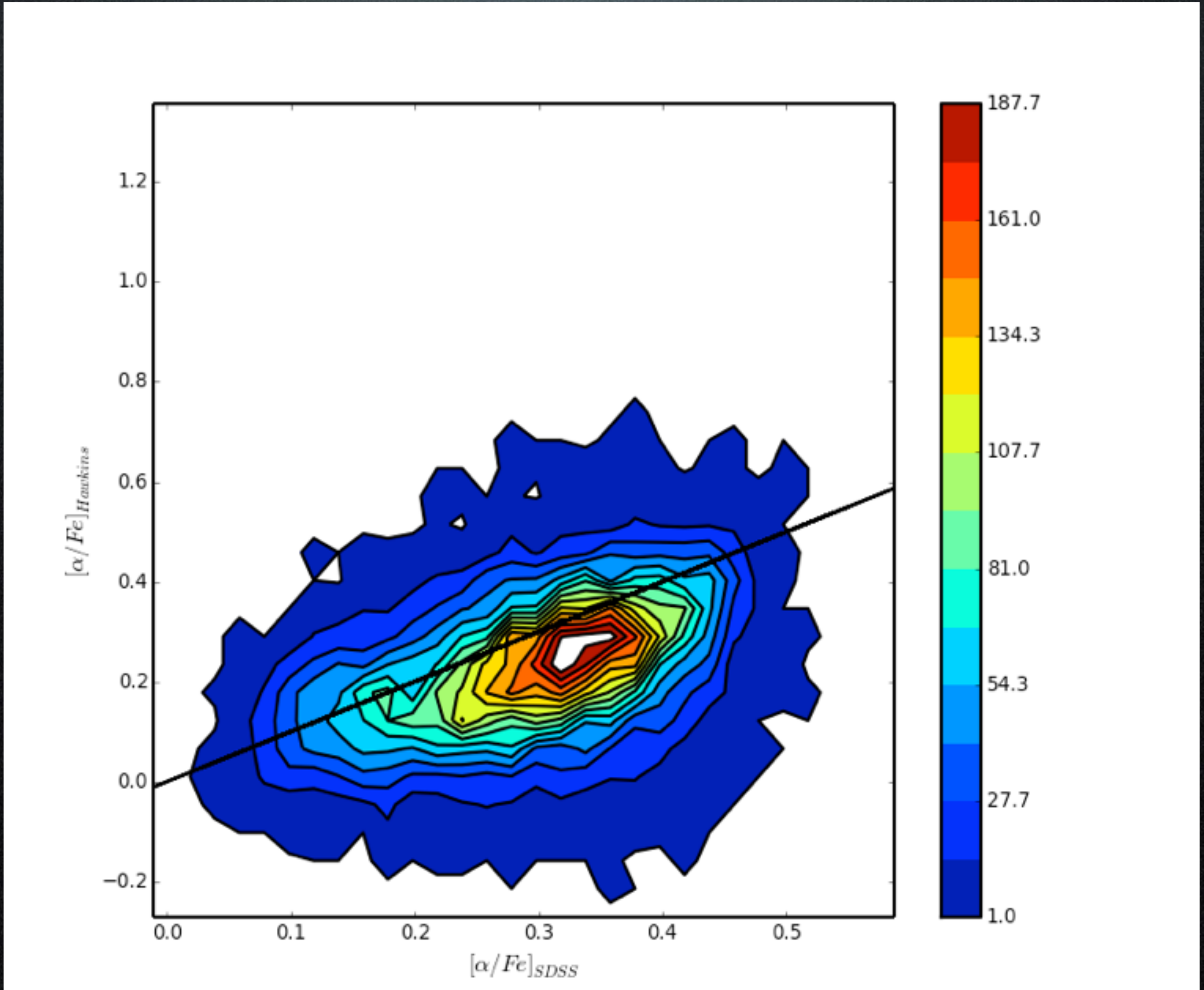


Effect of Sample Size and Precision

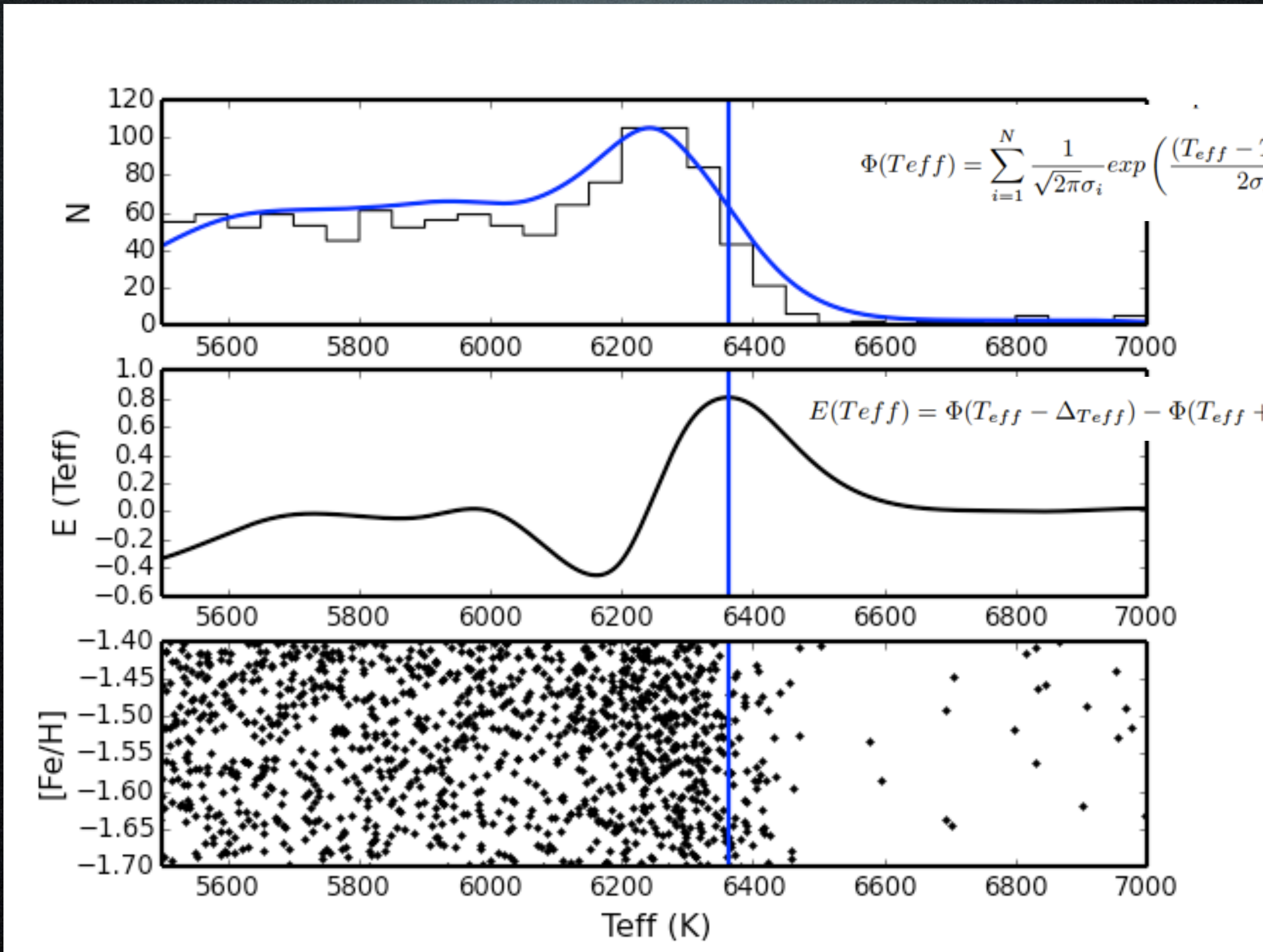


Our [α/Fe] VS SSPP DR7

Random sampling of 10,000 stars



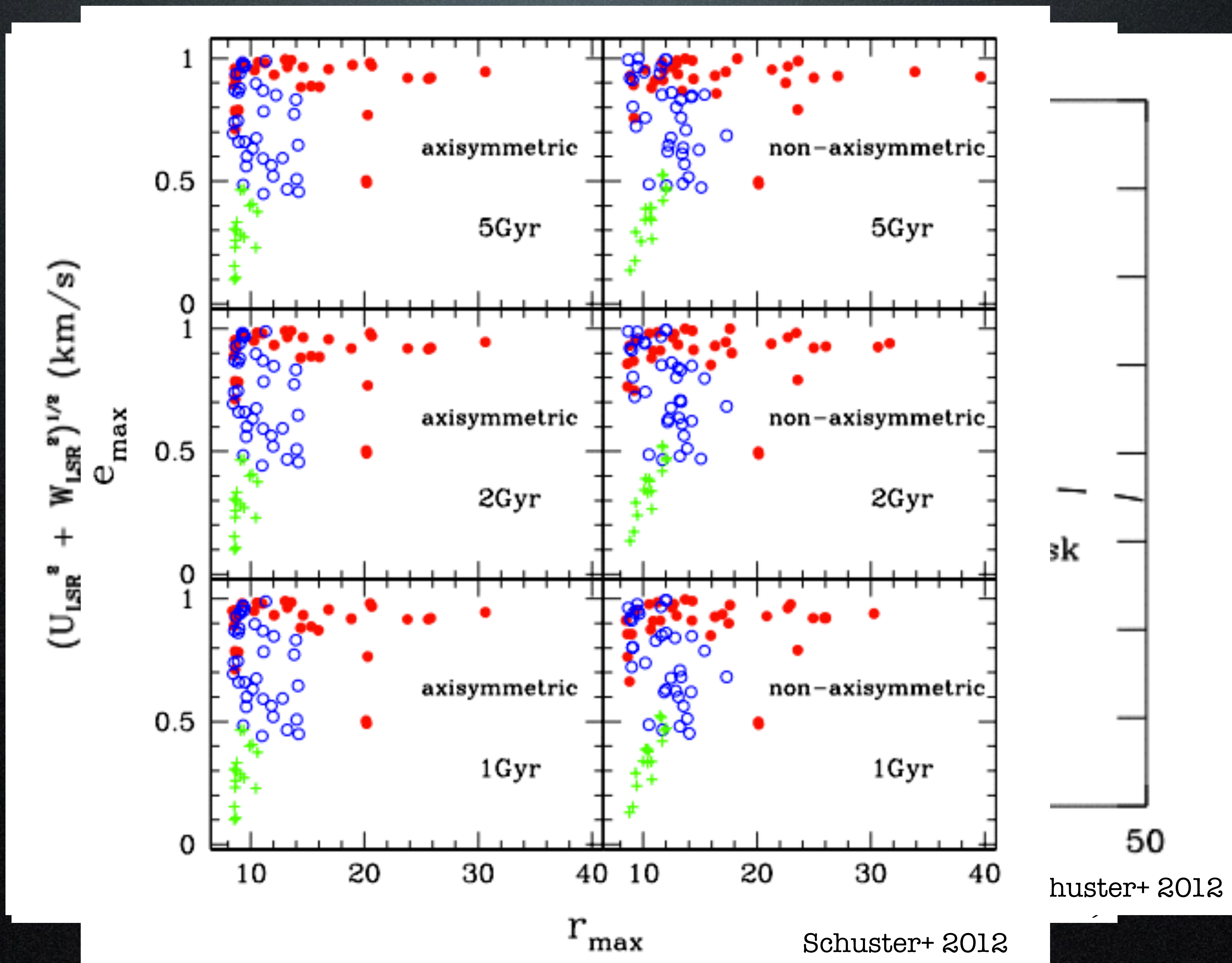
MSTO Detection: Sobel-Edge



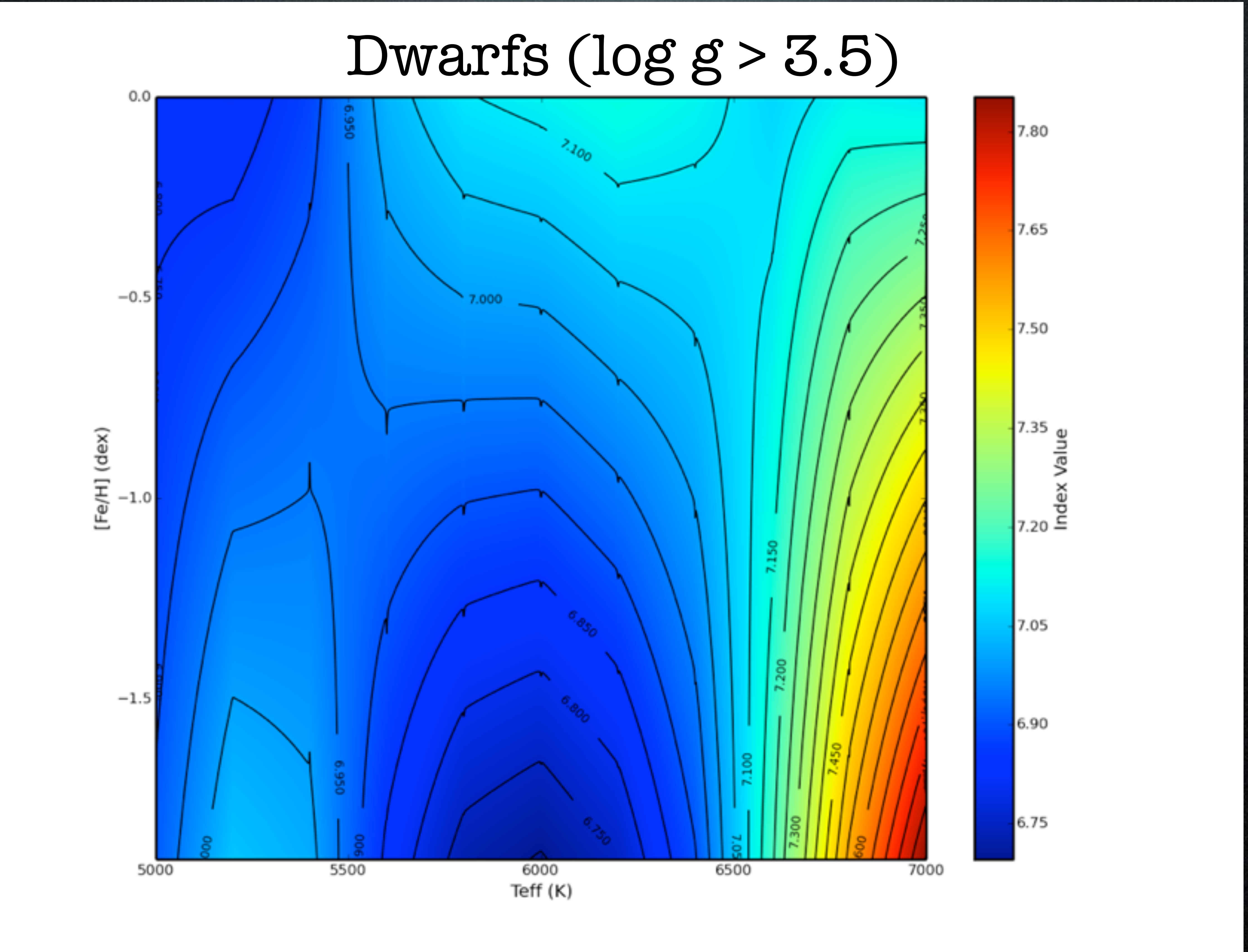
$$\Phi(Teff) = \sum_{i=1}^{N} \frac{1}{\sqrt{2\pi}\sigma_i} exp\left(\frac{(T_{eff}-T_{eff,i})^2}{2\sigma_i^2}\right)$$

$$E(Teff) = \Phi(T_{eff}-\Delta_{Teff}) - \Phi(T_{eff}+\Delta_{Teff})$$

Two Populations in the Inner Halo

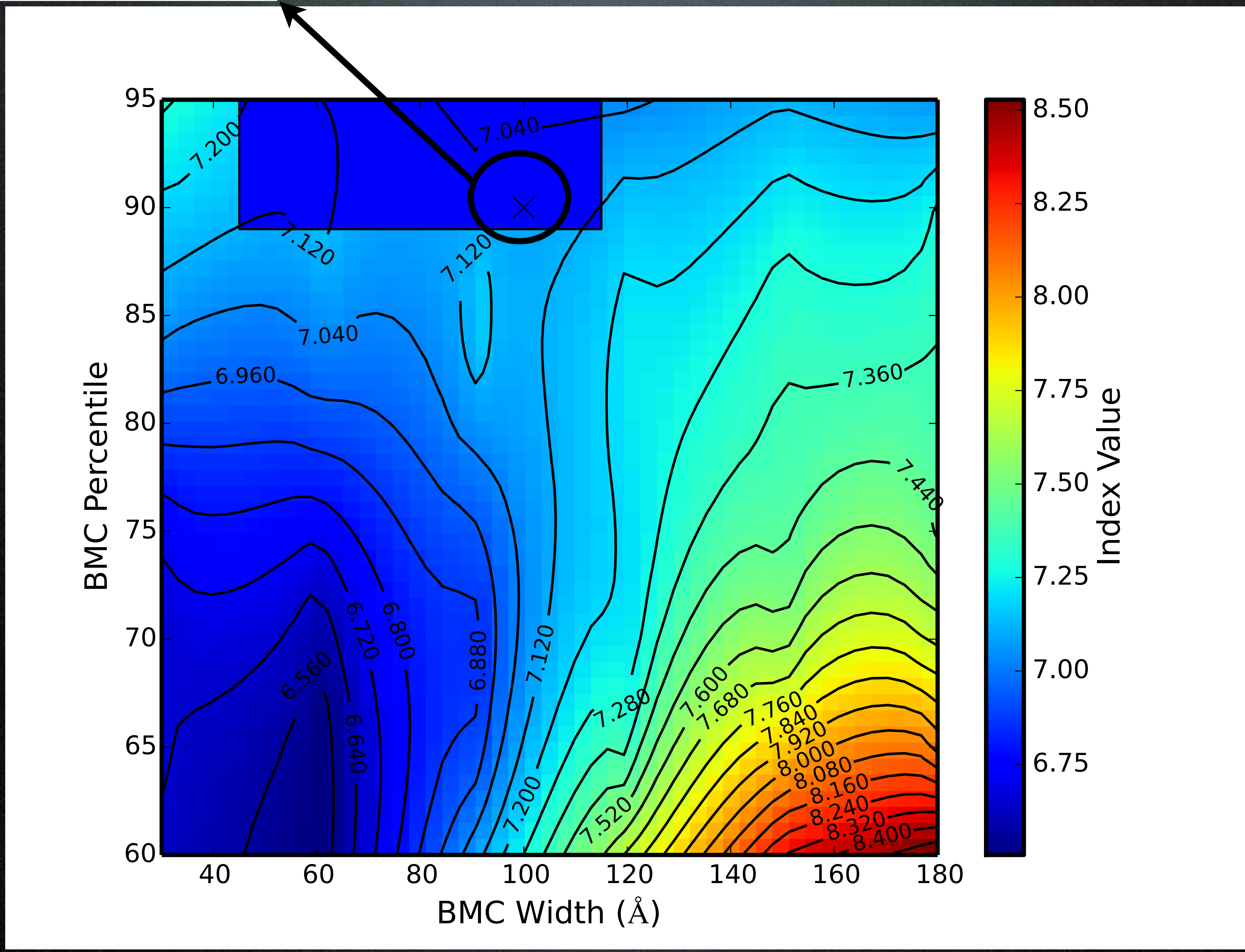


Effects of Stellar Parameters



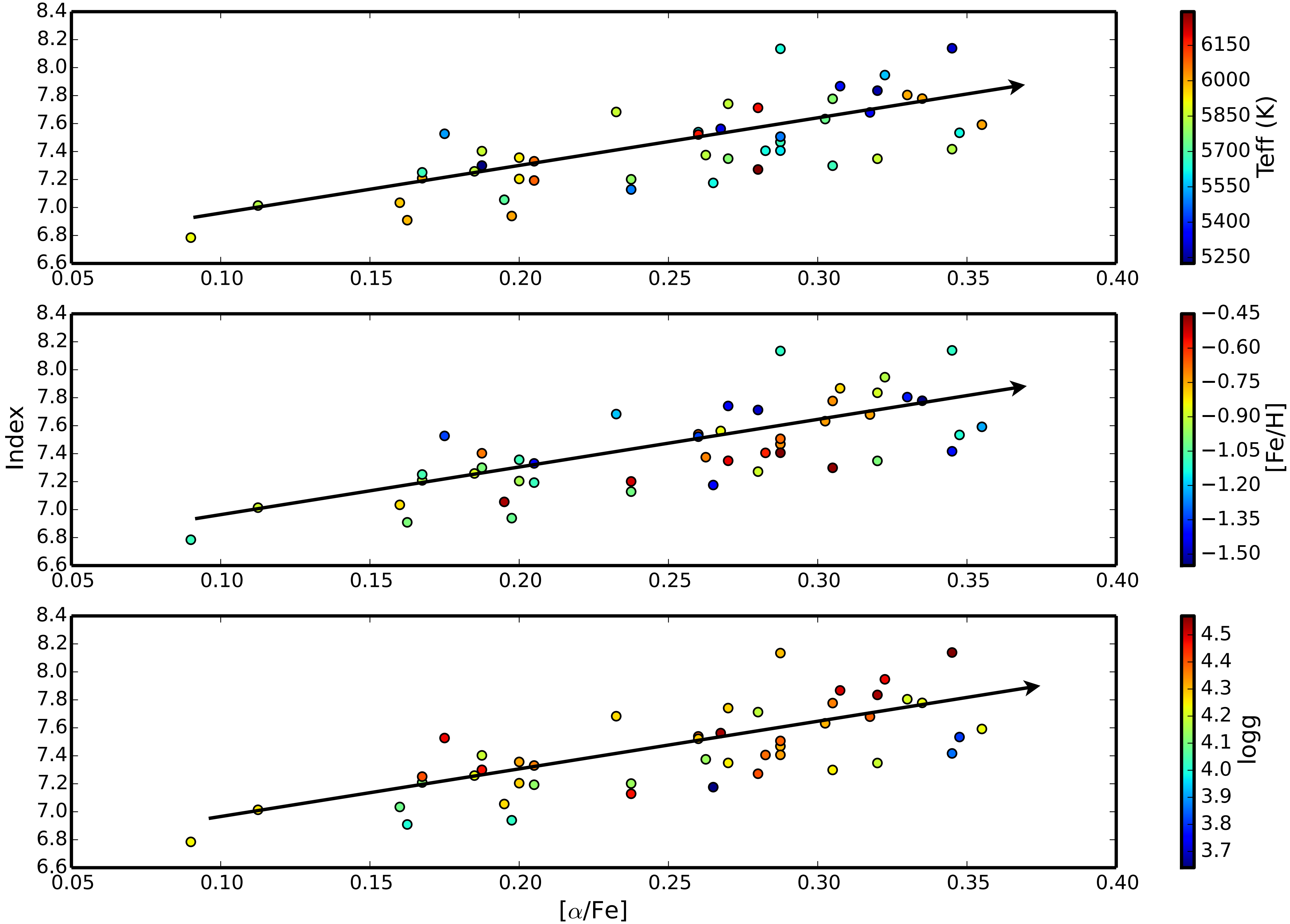
Effects of Continuum Placement

Rogers+ 2012



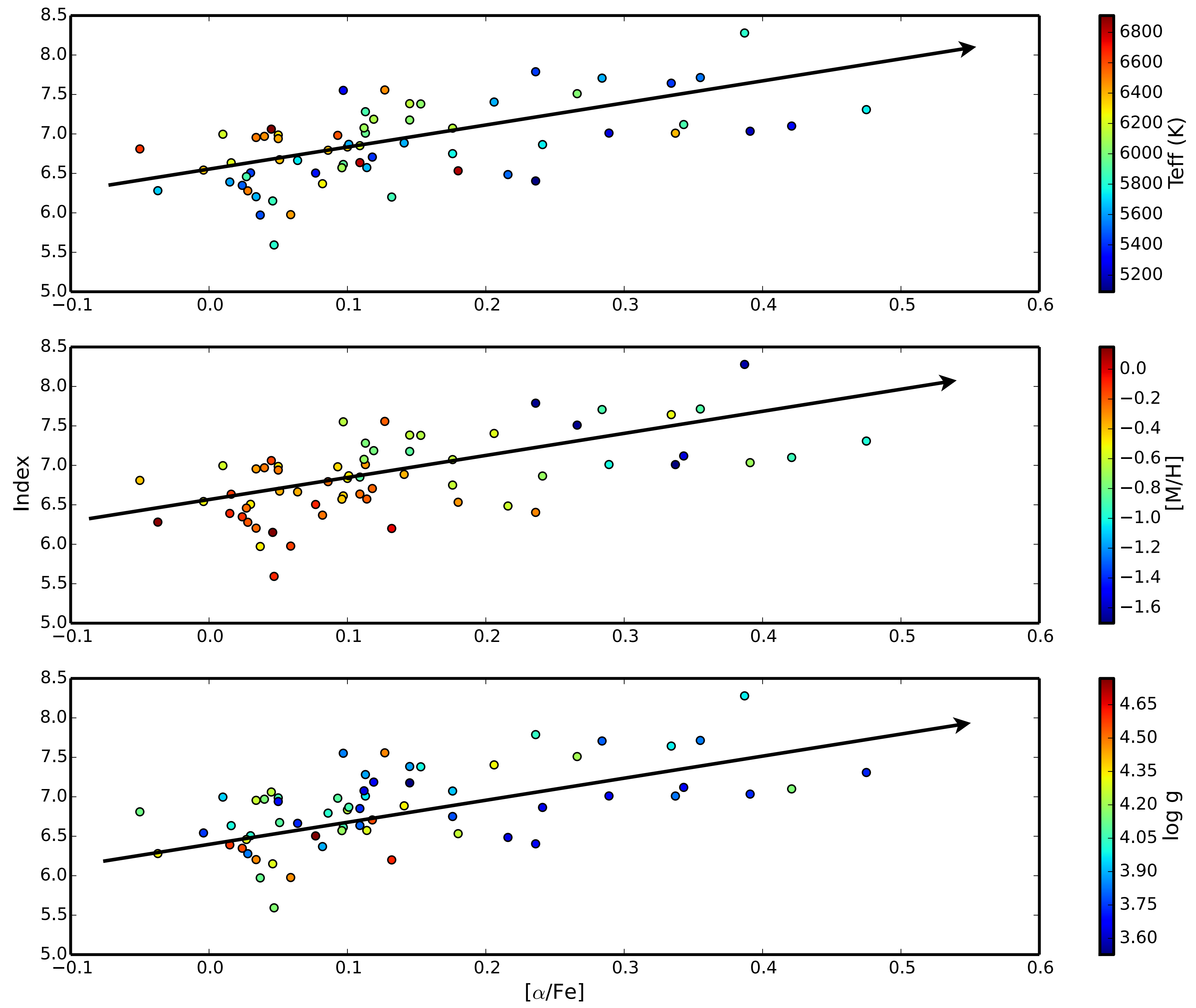
Validation: Nissen+(2010)

47 Stars

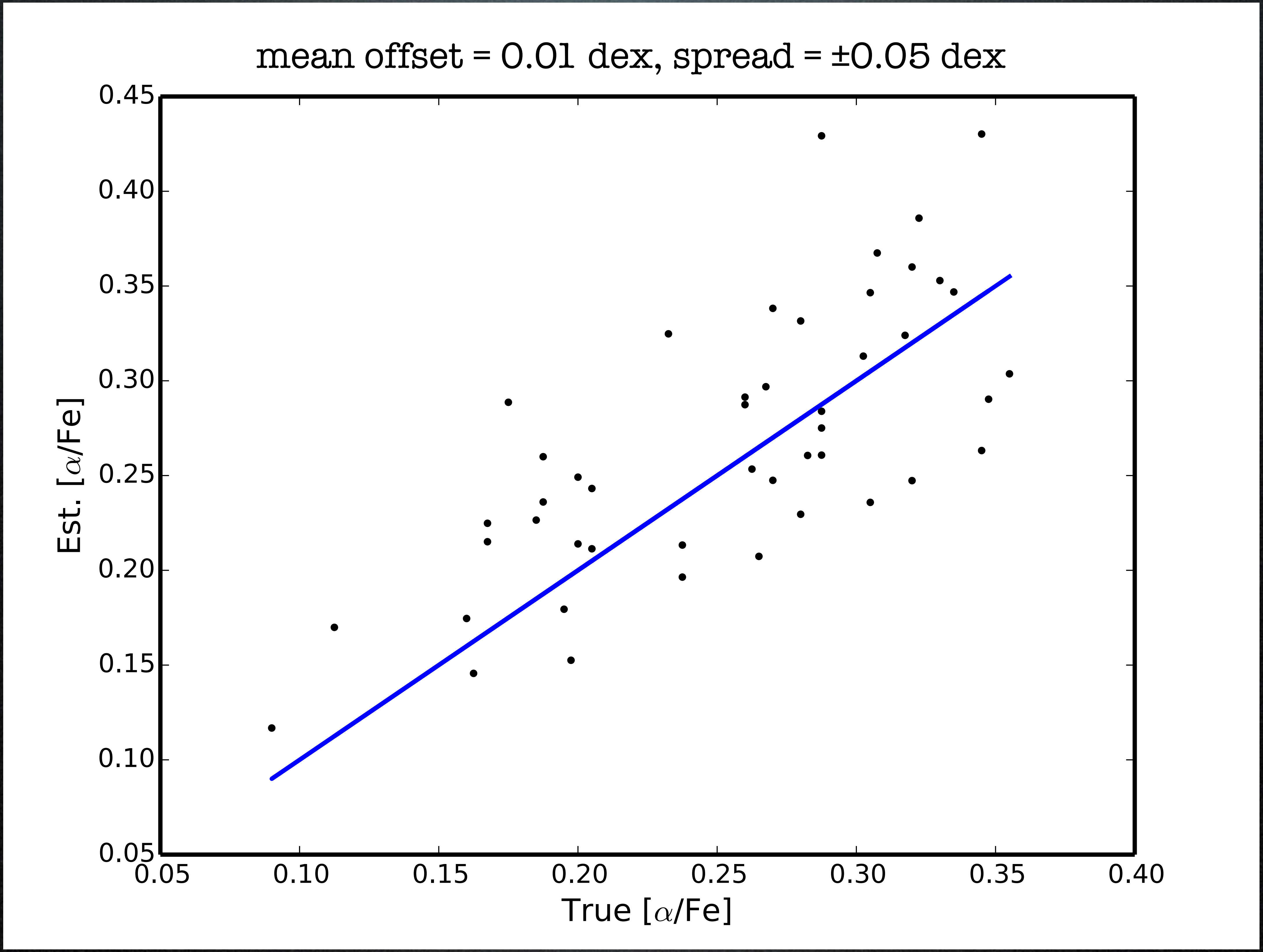


Validation: SDSS Targets

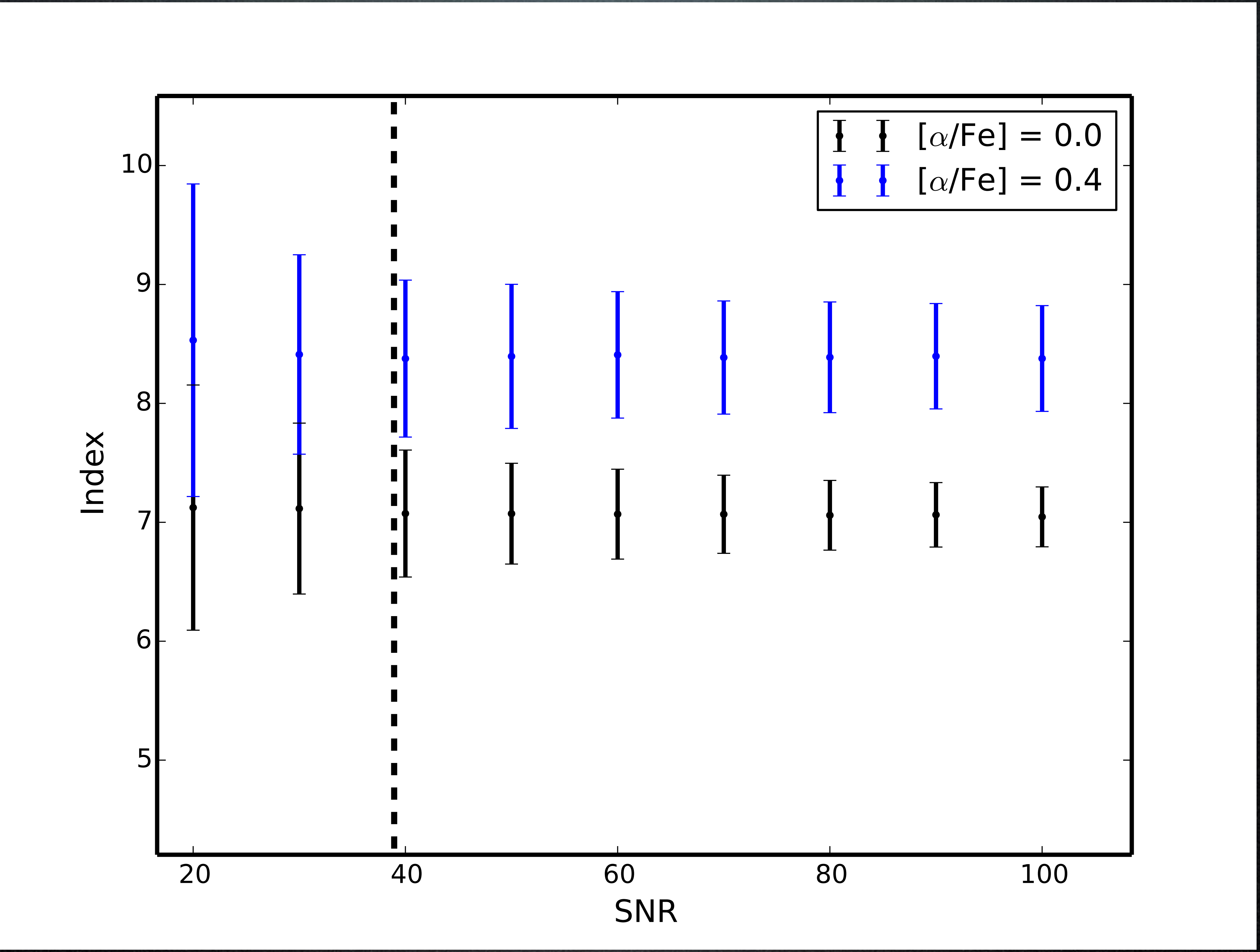
74 Stars



Validation: Nissen+ (2010)

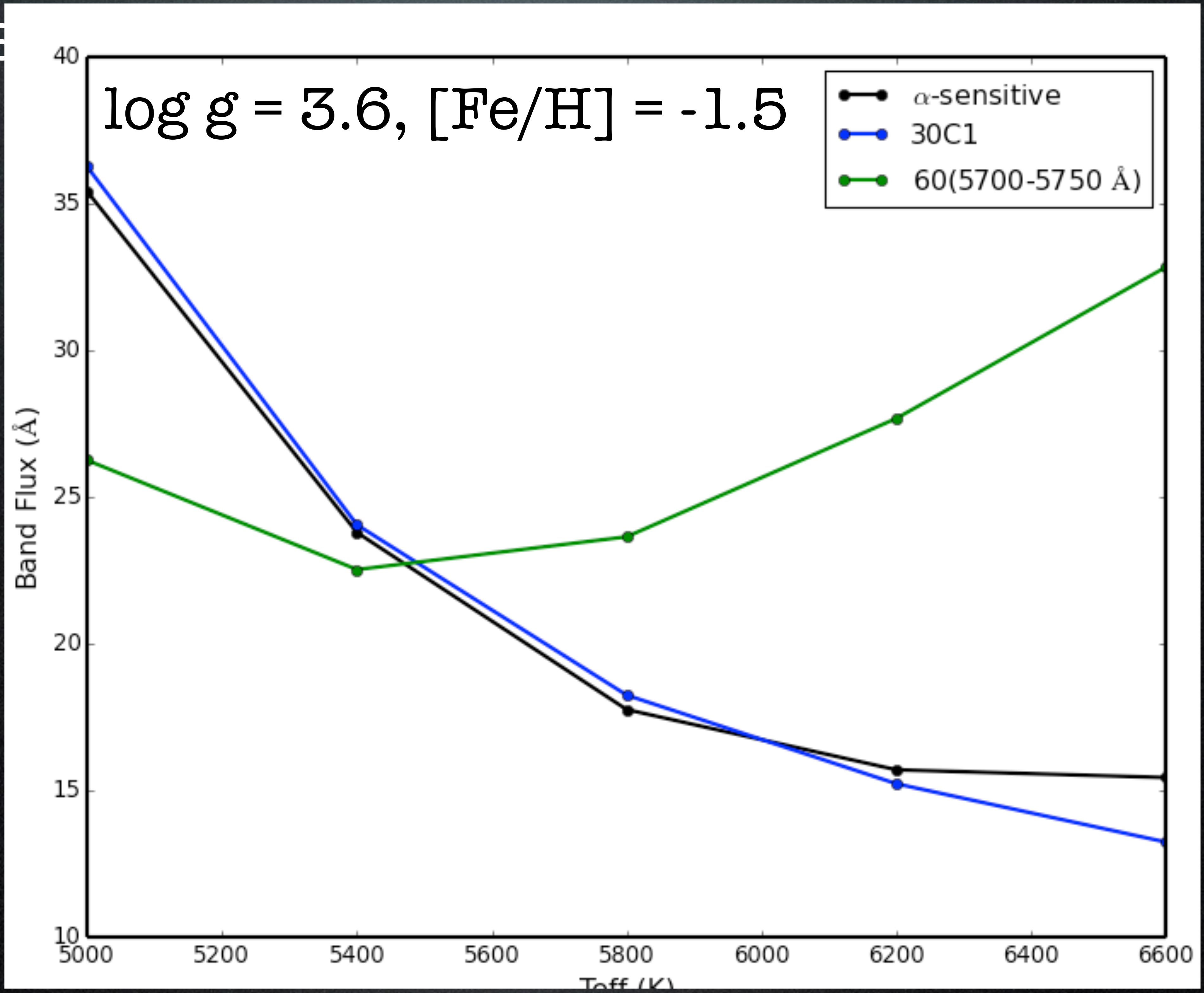


Effects of SNR



Control Band Idea

- Band that has the same or very similar response function to stellar parameters as the α-sens



Finding Control Bands

- Automated search routine:
  - Searches grid of possible bands from 4000 - 8000 A (widths ranging from 10 - 100 A)
  - Computes an index (defined as α-sensitive band over randomly selected control band)
  - Computes index over full range of stellar parameters for [α/Fe] = 0 and [α/Fe] = 0.4
  - Finds best 'control' bands which maximize distance between [α/Fe] = 0 and [α/Fe] = 0.4 and minimize spread in index at a constant [α/Fe]

Finding Control Bands

Index = α-sensitive bands/random control band