Photo Credit: Pablo McLoud

Keck Observatory and Metal-poor stars

David Lai (UCSC)

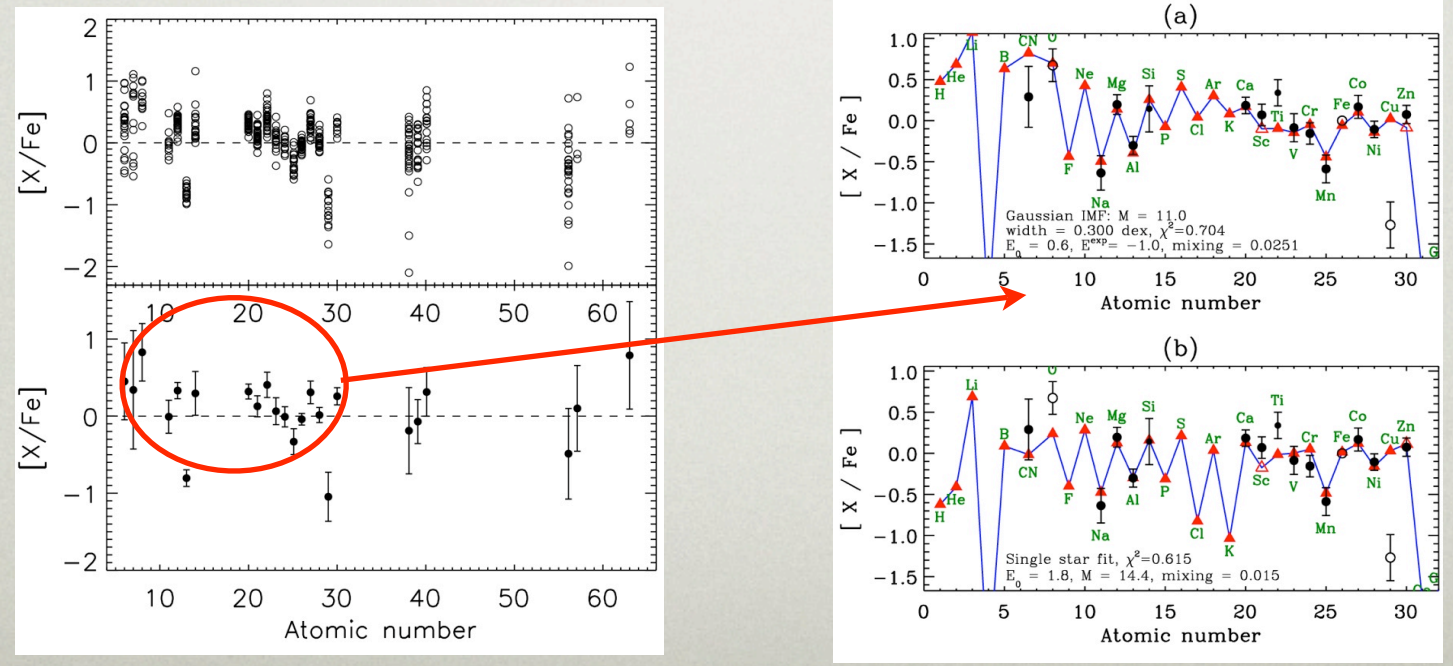
JINA GCE Workshop

HIRES and very detailed abundance work

- Capable of resolution from R~ 25,000 to 90,000
  - recent detector upgrade gives a wide wavelength coverage
- Workhorse instrument for abundances

Nearby metal-poor stars

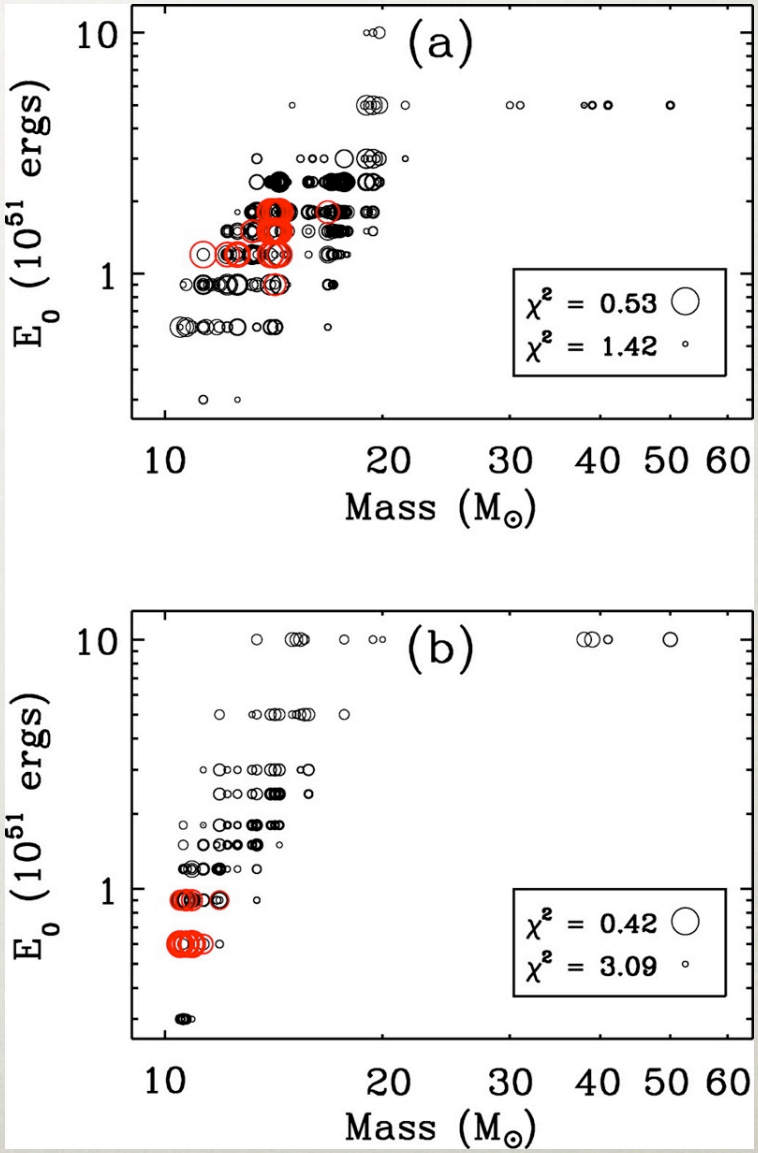
- [Fe/H] ≤ −2.0
- Can provide a window into early star formation environments, possibly even the first stars.



Lai et al. 2008

Keeping it "simple"

- Used Heger & Woosley models assuming only zero-metallicity progenitors
- A way to deal with degeneracies, assume a characterstic progenitor

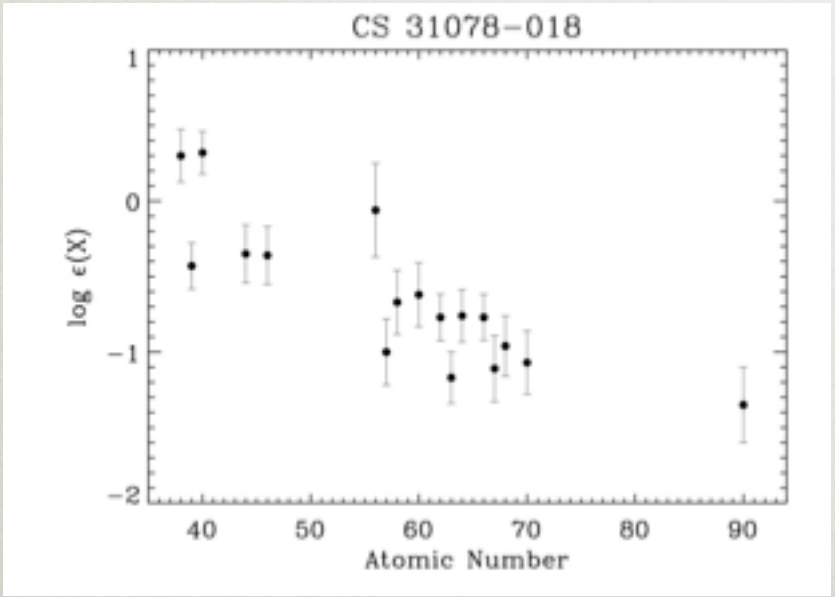


Lai et al. 2008

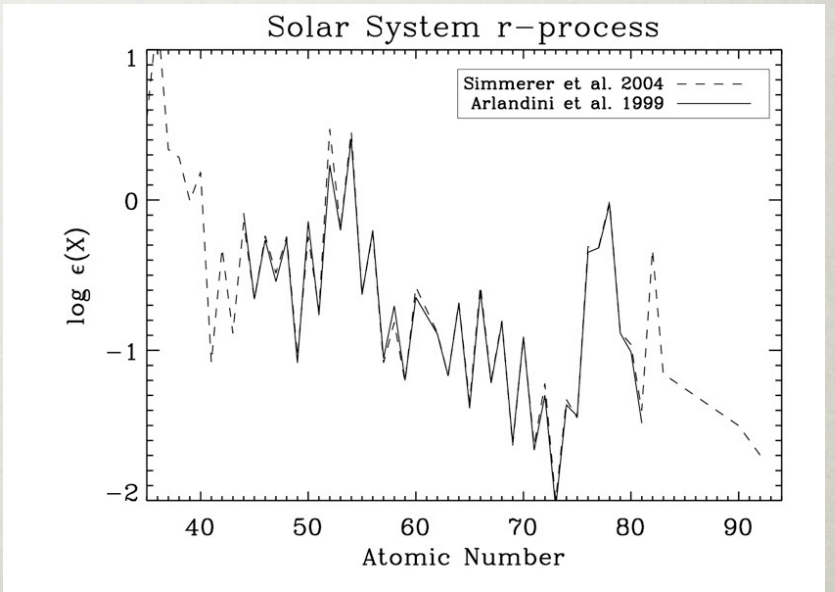
Nearby metal-poor stars

- Origin of the elements and nucleosynthesis sites, e.g. the *s*-process and the *r*-process

[Fe/H]=−2.8



[Fe/H] = 0.0



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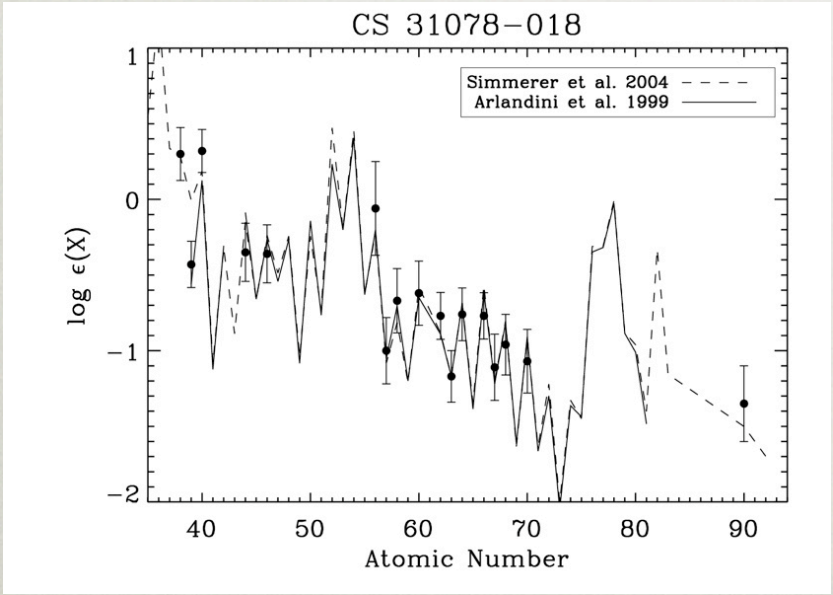
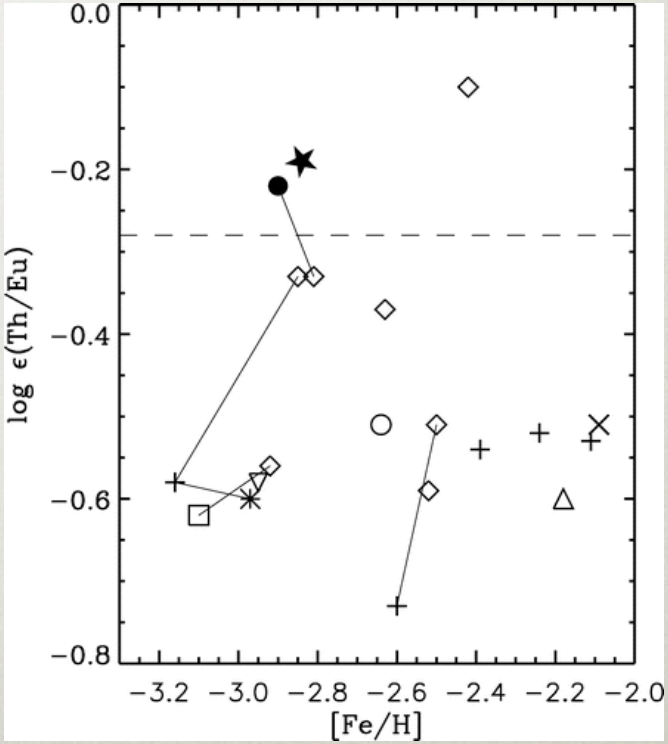
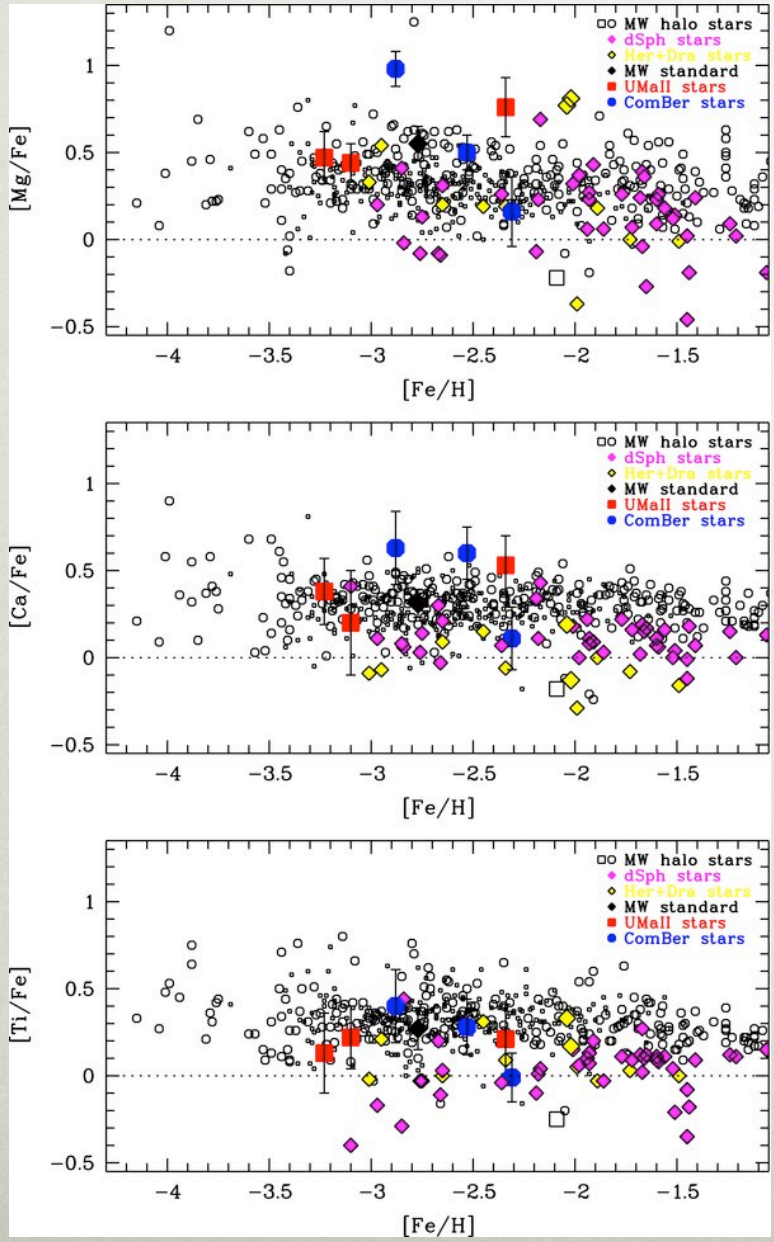
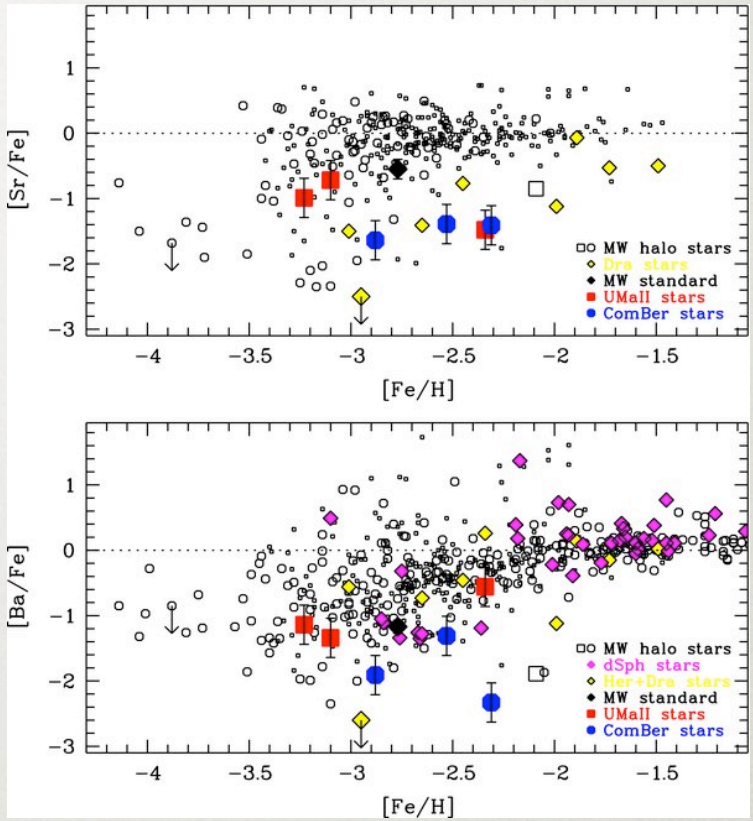




Lai et al. 2008

Detailed abundances in dSph galaxies



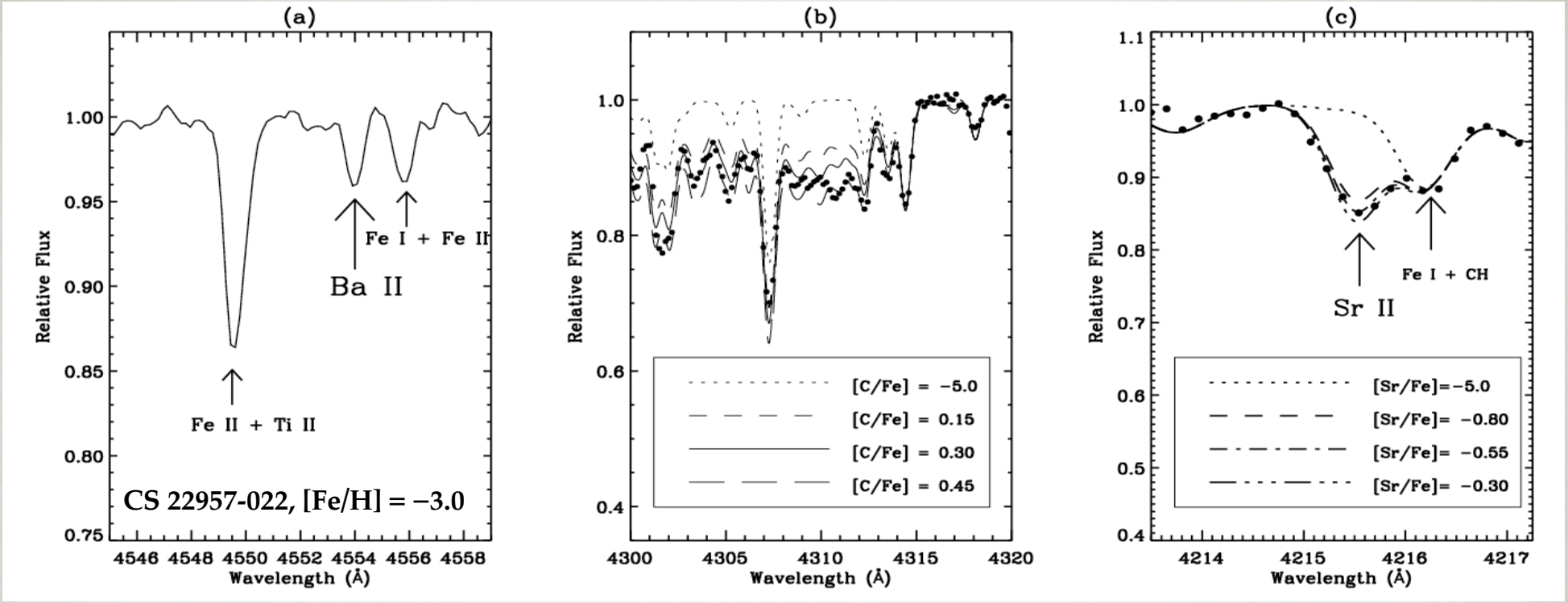


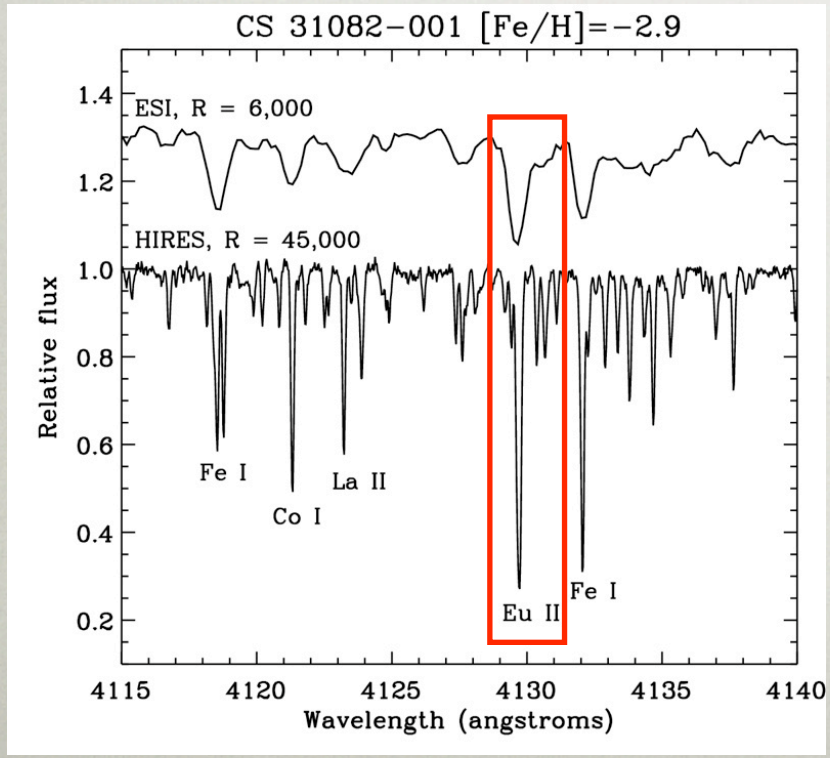
Frebel et al. 2010

- See Anna Frebel's talk

ESI and efficiency

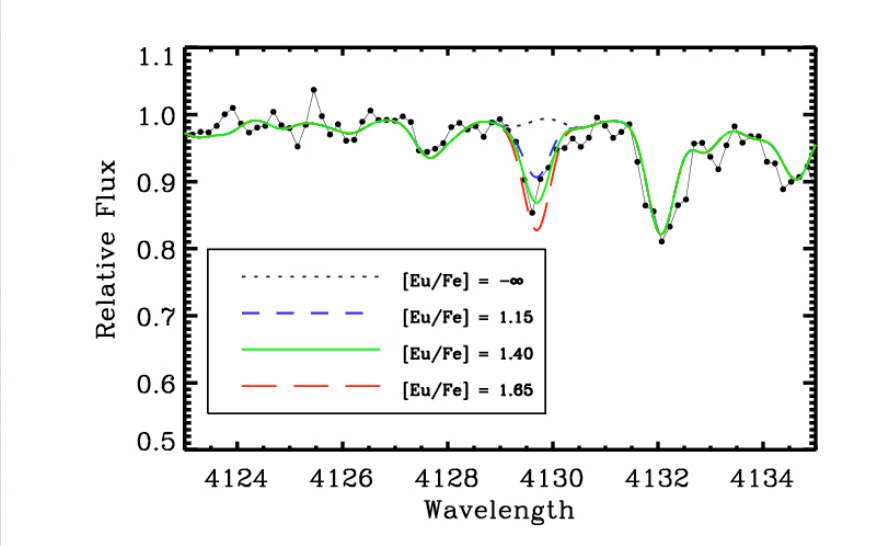
- Single object, R~6,000
- R of 6,000 ≠ R of 40,000
  - High throughput and large useable wavelength coverage (~4000 to 8000 Å)
  - Can by itself measure many interesting elements and categorize metal-poor stars
  - Devote high-resolution follow-up to interesting stars



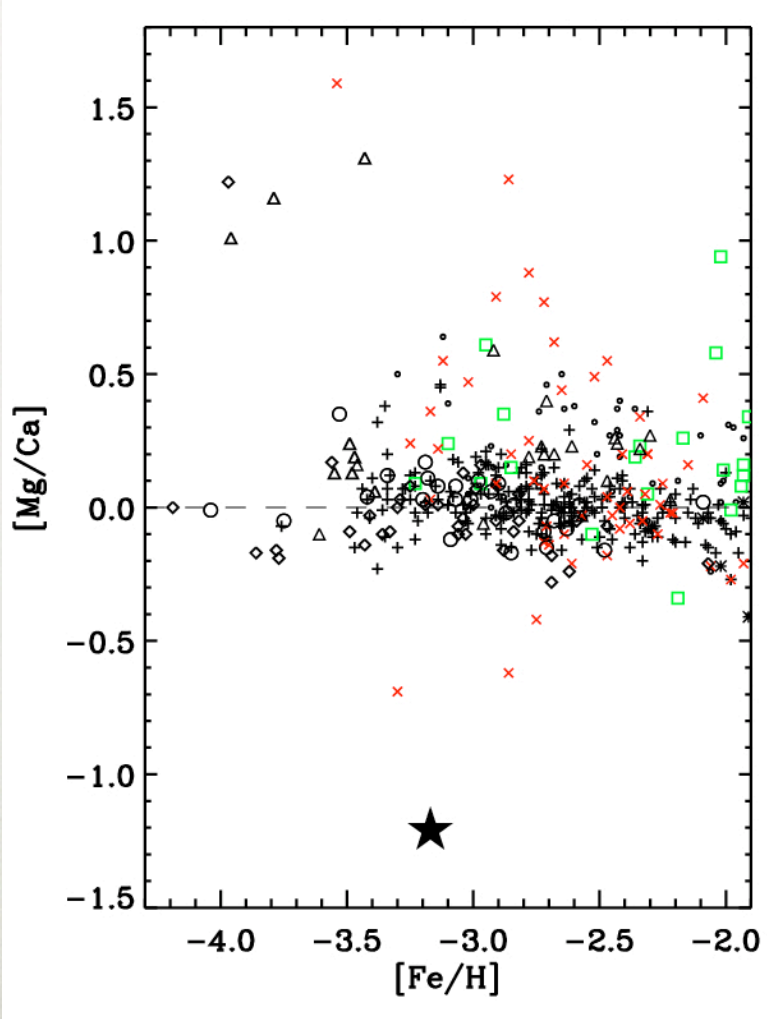


- We can measure C, Na, Mg, Ca, Ti, Cr, Fe, Sr, Ba, and Eu in metal-poor stars with ESI spectra

A Study of Outer-halo stars



ESI has enabled the discovery of new *r*-II stars and of a star with unusual (and sometimes unique) α-element signatures.



Lai et al. 2009

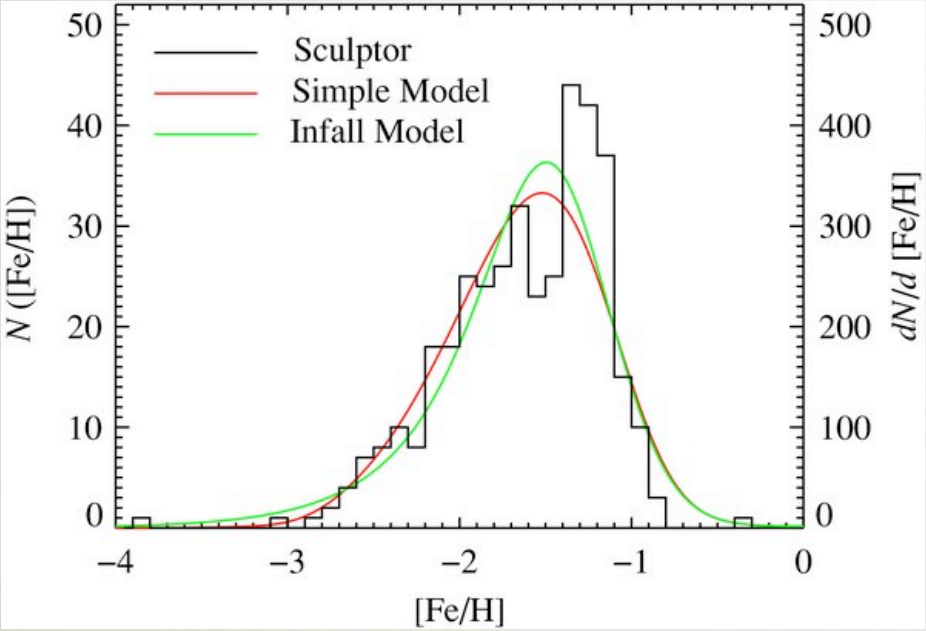
DEIMOS/LRIS and large numbers

- Multi-object / faint
- R up to 2,000 (LRIS)
- R ~ 6,000 (DEIMOS)
- The main driver of both is / was extra-galactic work.

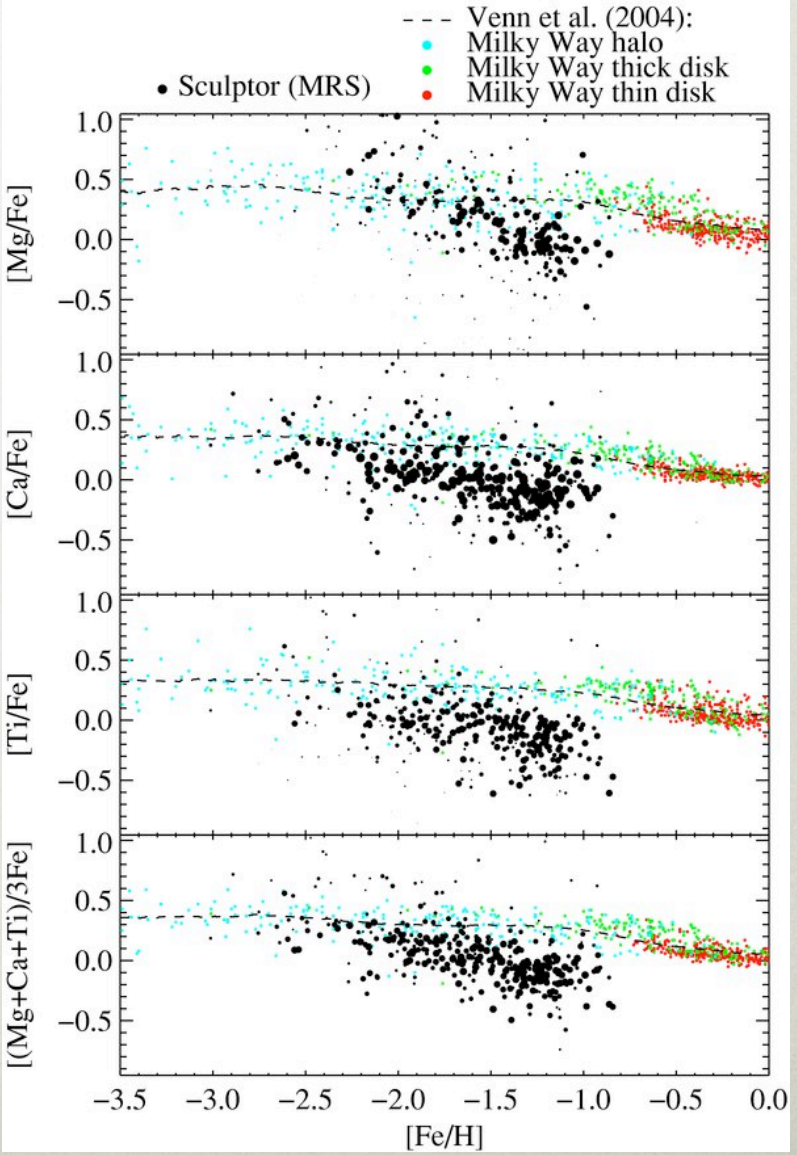
Repurposed for galactic chemical evolution

- Great tools for examining dSph galaxies
  - With new analysis methods, both overall metallicity and α-element abundances are possible
  - Larger data set can give a good statistical understanding of dSph populations
- Can give prime targets for higher resolution follow-up

DEIMOS Studies of dSphs

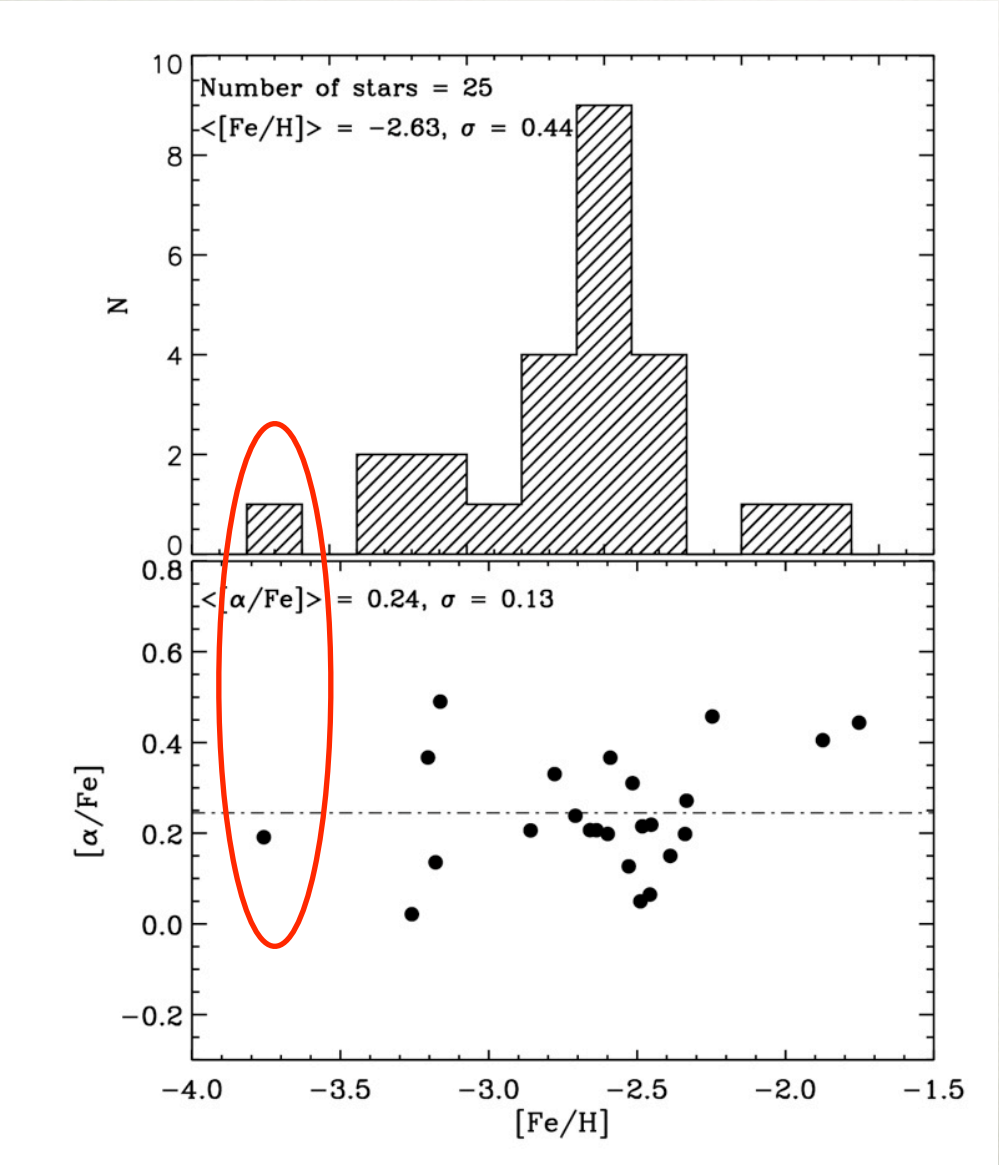


Kirby et al. 2009



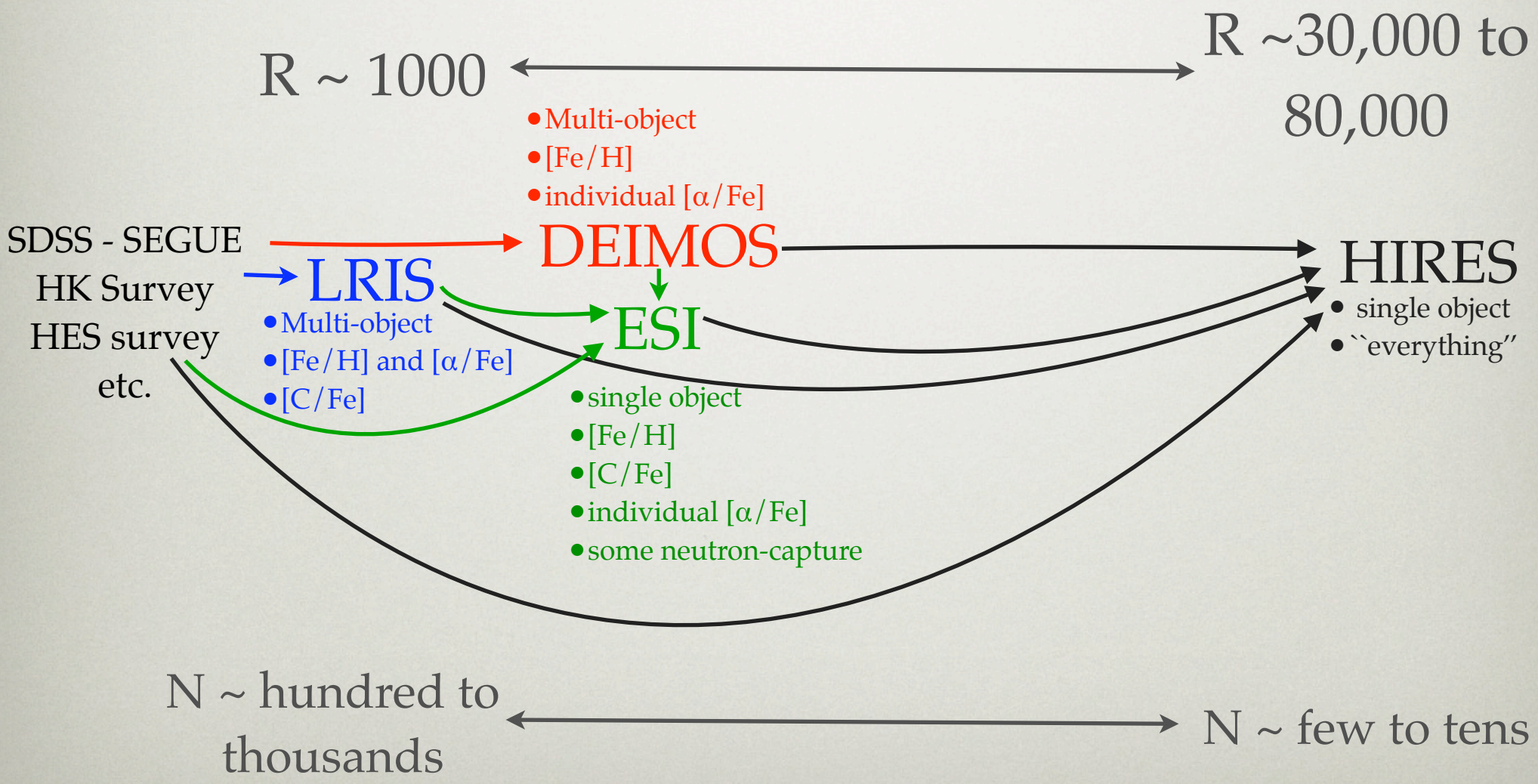
DEIMOS has now been used to survey both the bright and ultra-faint dSphs for both overall metallicity and α-elements

Preliminary Results: Boötes I with LRIS-B

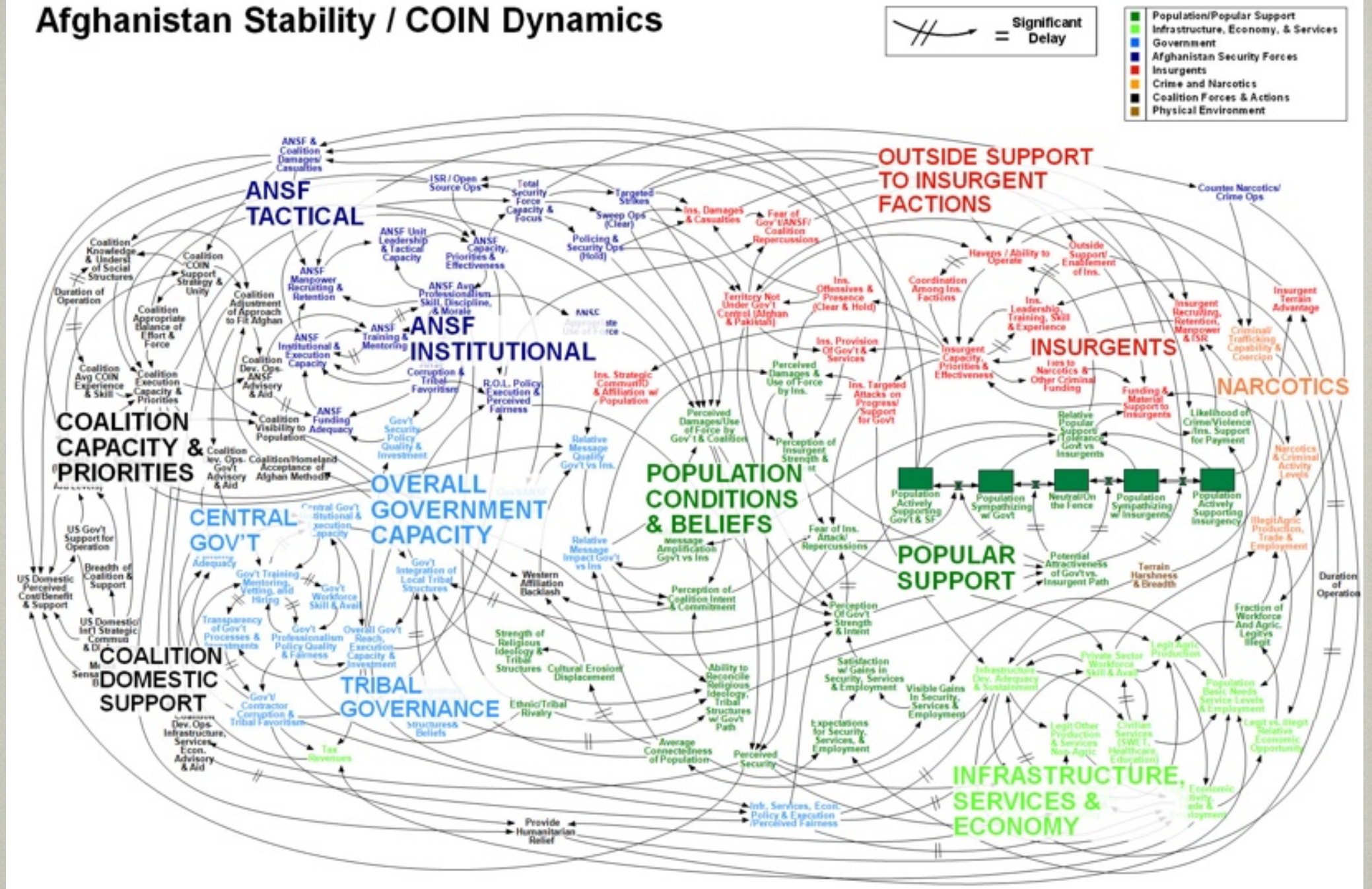


- Analyzed with the NSSPP (non-Segue Stellar Parameter Pipeline)
- It seems like [Fe/H] ~ −3.8 stars are a ``common'' feature in dSphs!

Metal-poor stars at Keck: Overview



Afghanistan Stability / COIN Dynamics



Future Directions

- Resources vs. Resolution (statistics vs. accuracy)
- Some specific topics
  - more stars from different halo populations
  - dSph stars at all resolutions
  - *r*-II stars - quantify percentages by increasing numbers and/or more detailed measurements