High resolution observations of SEGUE stars

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SEGUE

- Observations of halo and disk to map position, composition and velocity of >300,000 stars
- Tremendous amount of information which presents fundamental contribution to the understanding of the Galaxy (~25 refereed papers to date, many more pertain SEGUE data and 23 more in preparation **just** from collaboration members!)
- Goldmine for target selection for follow up high-resolution observations (reliable atmospheric parameters and metallicities)

From spectra to compositions

- Stellar Segue Parameter Pipeline (SSPP Lee et al. 2009) uses multiple approaches to determine atmospheric parameters (6 for Teff +g-r colors, 10 for log g, and 12 for [Fe/H]) in a wide ranges of parameter and S/N

- Tested using high-resolution spectroscopy observations of globular (M2, M3, M15) and open clusters (M67, NGC2420)

- Field stars are also needed for low ([Fe/H]<~-2.5) and high ([Fe/H]>-0.5) metallicities, peculiar abundances (C rich, unusual alphas etc)..

High-resolution calibrations
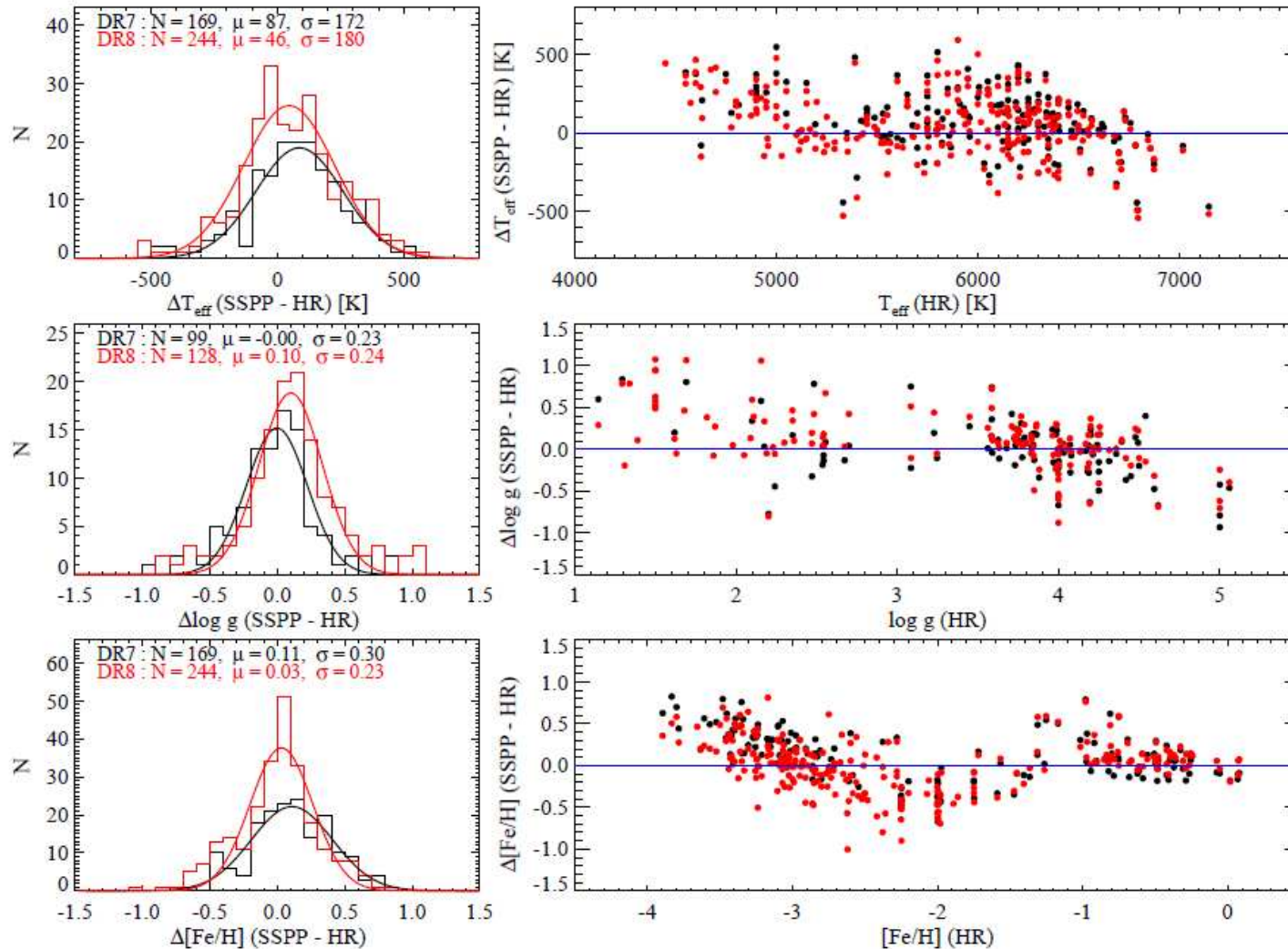
○ Collective effort, several telescopes and people involved
  - David Lai

Telescope	Instrument	Resolving power	Wavelength coverage (Å)	Number of stars
KECK - I	HIRES	45000	3800−10000	11
KECK - II	ESI	6000	3800−10000	51
HET	HRS	15000	4400−8000	110
SUBARU	HDS	45000	3200−8000	151
VLT	UVES	60000	33000−8000	20

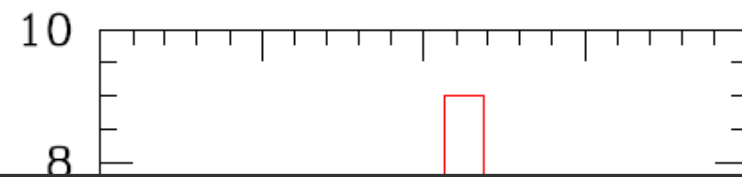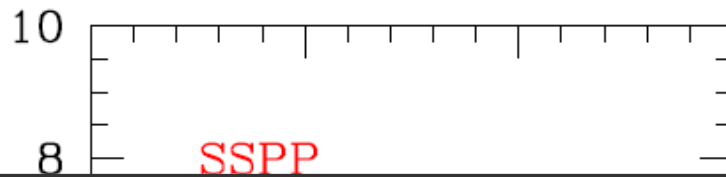Smolinski et al. 2010   Total 343 objects 240 with S/N>20

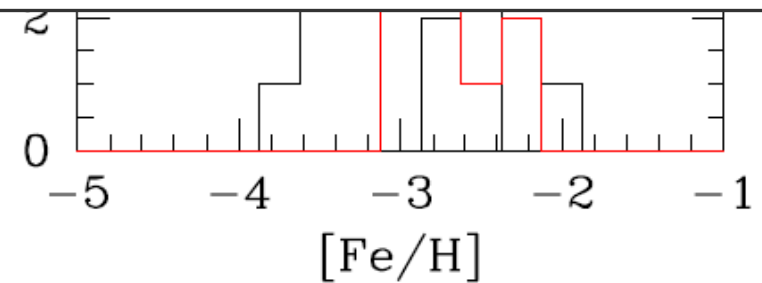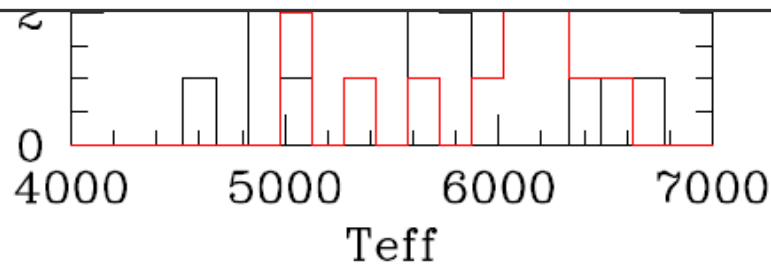# SSPP vs HR

Smolinski et al. 2010

Subaru Sample

Jennifer Simmerer, Inese Ivans et al.

SSPP

•See also Jennifer Simmerer's talk in SEGUE parallel session
•Problem of uniforming the analyses (different people use slightly different toolboxes and this introduces very hard to pinpoint offsets (J. Sobeck working on this)

Teff

[Fe/H]

EMP stars: a little background...

- EMP stars probe the characteristics of the first stars, mechanisms of metal production (incl. n-capture elements) in metal poor and/or free environments, IMF in the early Galaxy and nature of the Galactic halo

- High-R observations of local EMP stars provide a window on the early chemical evolution of the MW and the involved nucleosynthetic processes.

- Lots of open issues still exist, e.g.: discrepancy between Li measured and BBN prediction; very small scatter in alpha and Fe-peak but high in n-capture; metallicity function at the very low end..

- Sample size and sample spatial distribution are two issues, too few targets (rare objects) and not far enough out in the halo

CASH survey
Chemical Abundances of Stars in the Halo

J. Hollek, A. Frebel, I. Roederer, T. Beers, C. Sneden et al

- Aim of constraining early Galactic chemical evolution and look of HMP stars ([Fe/H]<-5)

- Collected spectra of ~500 stars with HET (R~15,000) and Mike@Magellan (R~35,000) obtained viable spectra for ~30 SEGUE-I targets (more targeted but very low S/N)

- SEGUE targets spectra have only preliminary analysis

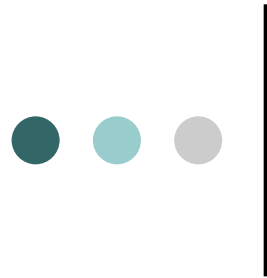- Measurements for Fe, Li, C, O, Mg, Ca, Sc, Ti, Ni, Sr and Ba
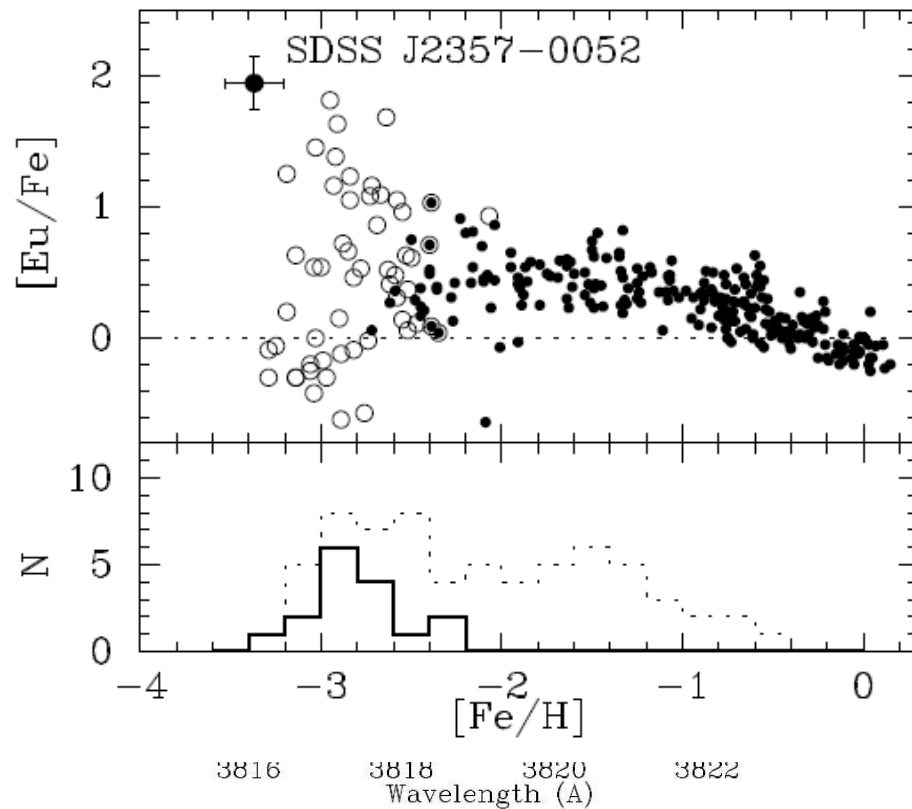
First stars group

Bonifacio et al.

- Contributed to calibration stars observations (20 objects with VLT@ESO)
- Obtained GTO time on XSHOOTER@VLT to observe ~10 faint targets selected from SEGUE database (public releases)
- Do not rely on SSPP for selection
- So far two targets observed

Subaru effort

W. Aoki, T. Beers, S. Honda, D. Carollo et al.

oTwo stars selected from SEGUE on basis of SSPP metallicity and CH band strength

oSnapshot style spectra (S/N~30 R~30,000) confirmed them as subdwarfs and found strong Ba lines in one target

oHigh Res (R~60,000) found very strong Eu features in SDSS 2357-0052

o[Fe/H]=-3.4 [Eu/Fe]=1.9 Most metal poor r-II star, first r-II stars <-3

Aoki et al.(2010)

Moving into the outer halo

- SEGUE provides targets and samples a much larger volume reaching the outer halo

- Observational (from SDSS Carollo et Al. 2007, Bell et al. 2008, An et al. 2010) evidence and theoretical models (Bullock & Johnston 2005) suggest that outer halo and inner halo are chemically different

- Probing the outer halo *in situ* provides a more complete picture (local halo stars tagged as outer halo on the basis of kynematics might not be representative)

The Team

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The project

- Plan is to compare a sample of outer (d>~ 25kpc) halo stars selected from SEGUE-II with a sample of local halo stars
- ***In situ*** outer halo:

ESI@Keck	XSHOOTER@VLT
4200-8000A	3200A-1.1µm
R~ 7,000	8,000-12,000

Fe ,C, N, Ca, Ti, Na, Mg, Ba, Cr, Sr, Eu

Most interesting targets will be followed up with higher res observations

- Inner halo:

UVES@VLT+ HIRES@Keck (Lai et al. 2008) +archives

R~40,000 measure Fe, C, N, O, Na, Mg, Al, Si, Ca, Ti, lots of n-capture, Fe-peak etc
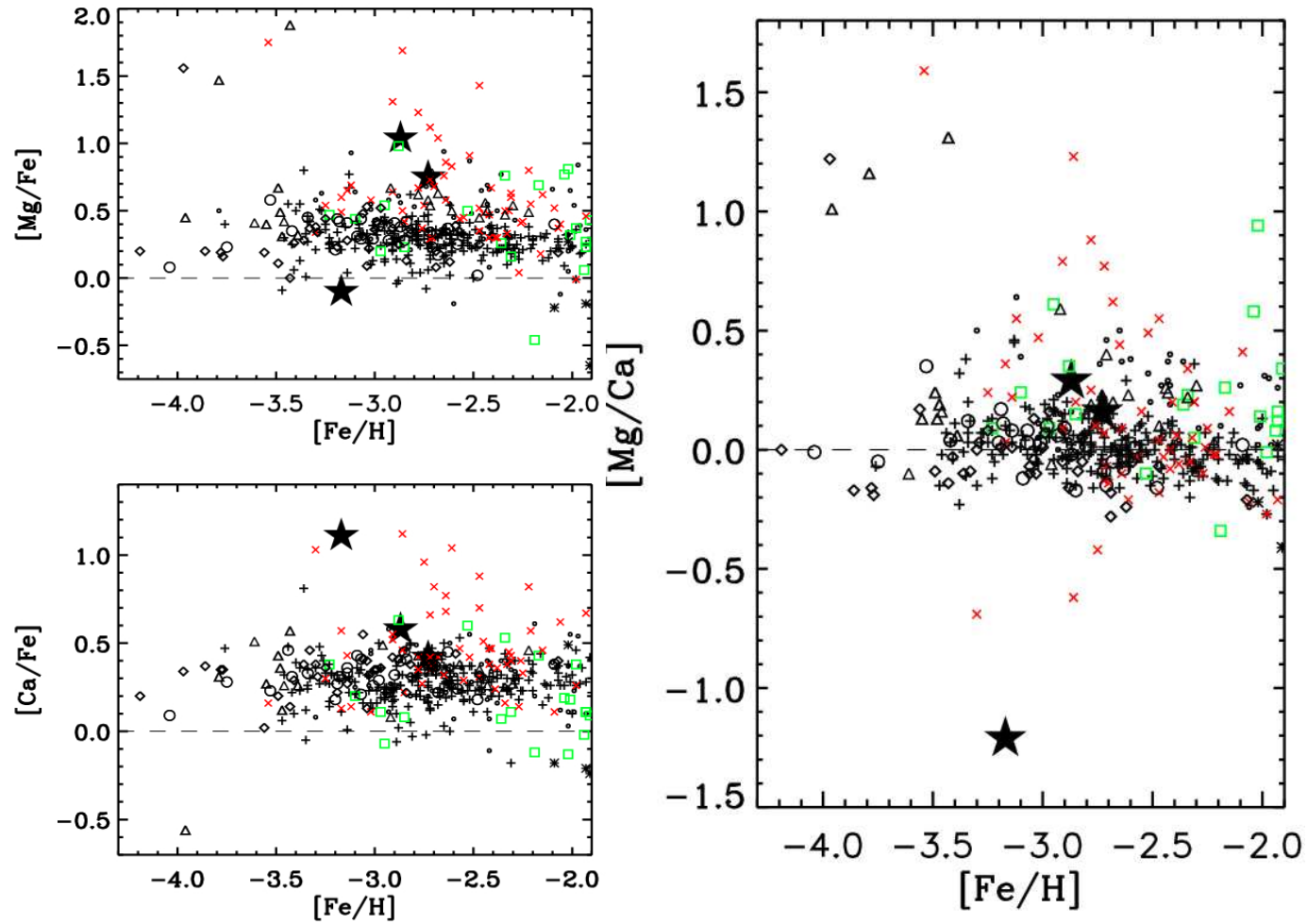
Inner vs outer

- Awarded 4 ESI nights, 2.5 XSHOOTER, 2 UVES
- Total objects observed so far 59 stars (18 more queued), 45 analyzed (preliminary analysis)

89% probability of being a different population
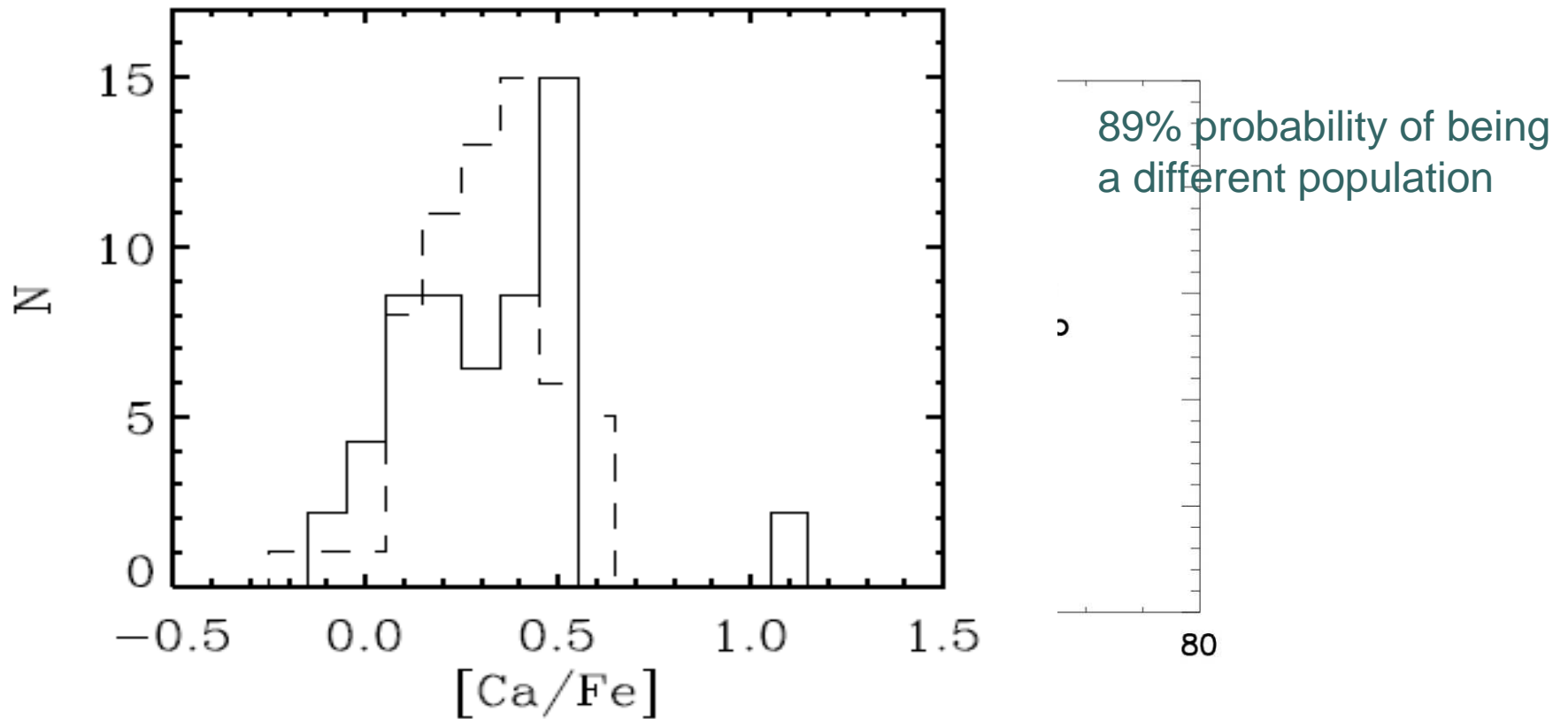
The furthest away stars

★ Distances ~40kpc

Conclusions

- We are starting to exploit the capabilities of SEGUE in pre-selecting targets for high-resolution
- Calibration is a crucial step that still needs attention
- Exciting results are emerging from taking advantage of SEGUE unique ability of reaching into the outer halo
- Best part has yet to come!