

# Near-Field Cosmology with the Sloan Extension for Galactic Underpinnings and Evolution (SEGUE)

**Purpose:** To unravel the structure, formation history, kinematics, dynamical evolution, chemical evolution and dark matter distribution of the Milky Way.

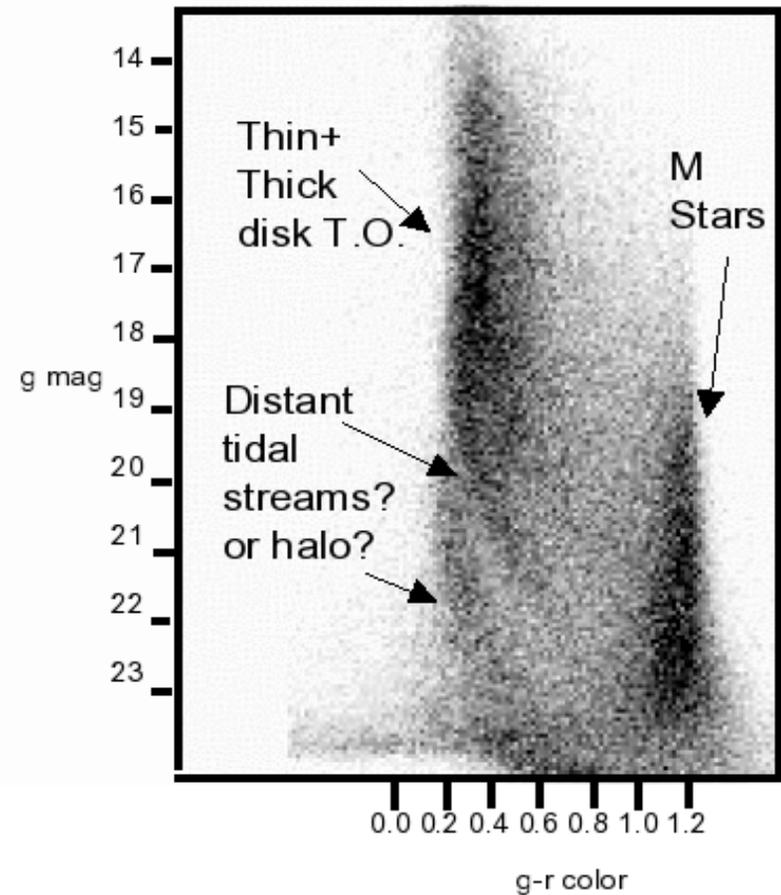
Kravtsov, Gnedin and  
Klypin DM simulation



# SEGUE Imaging Science – mapping the Galaxy

Old stellar populations carry the signature of the Galaxy's formation and evolution in their kinematic, spatial and metallicity distributions.

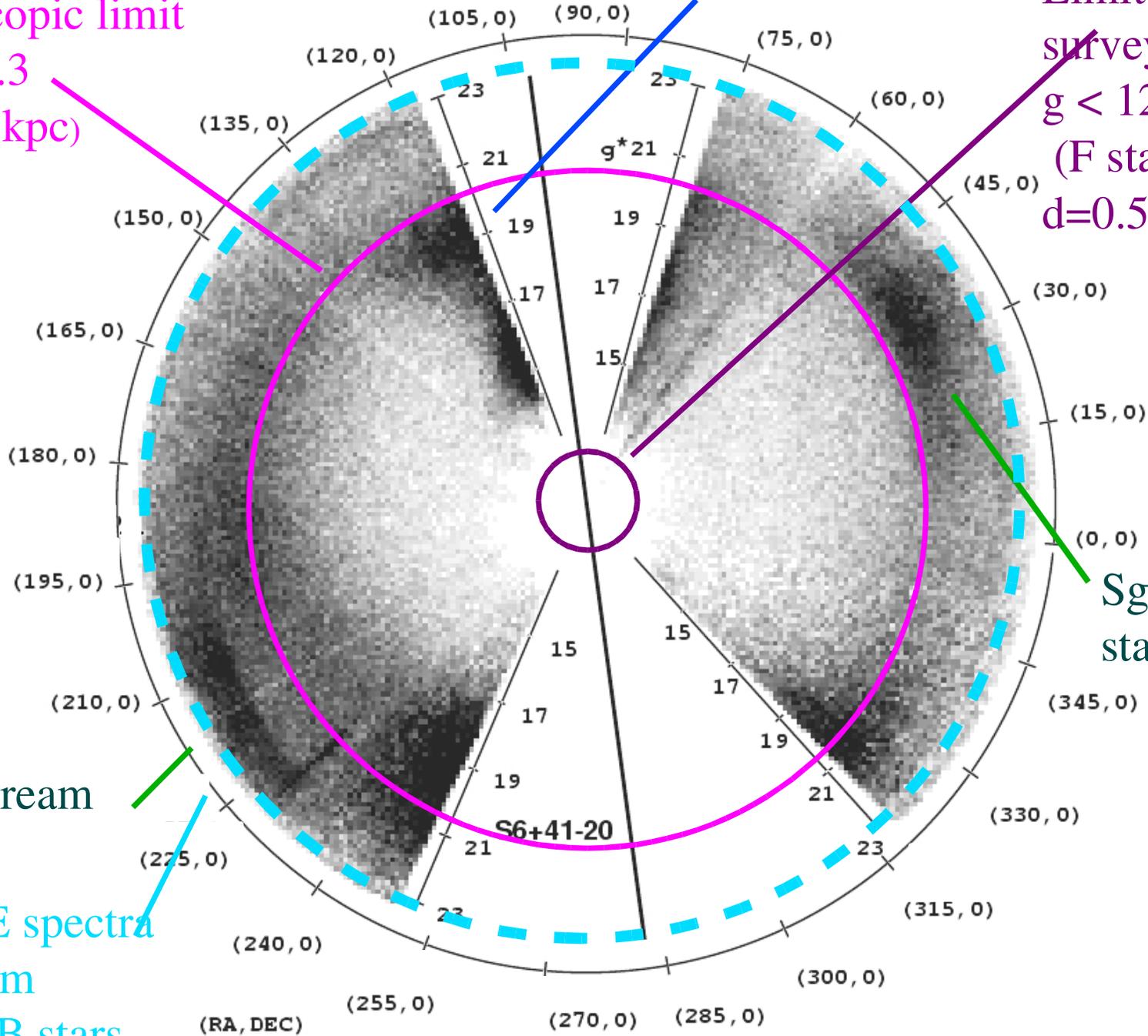
- What is the global structure of the thin disk, thick disk, bulge and spheroid?
- Are they smooth, regular structures on the largest scales?
- Metallicity gradients?
- Are there other tidal streams like Sagittarius, Monoceros/Canis Major?
- Is there a metal-weak thick disk, a flattened inner halo, ...?



SEGUE F star  
spectroscopic limit  
at  $g = 20.3$   
(to  $d=16$  kpc)

Monoceros stream stars

Limit of RAVE  
survey with  
 $g < 12.5$   
(F stars to  
 $d=0.5$  kpc)



Sgr. stream  
stars

Sgr. stream  
stars

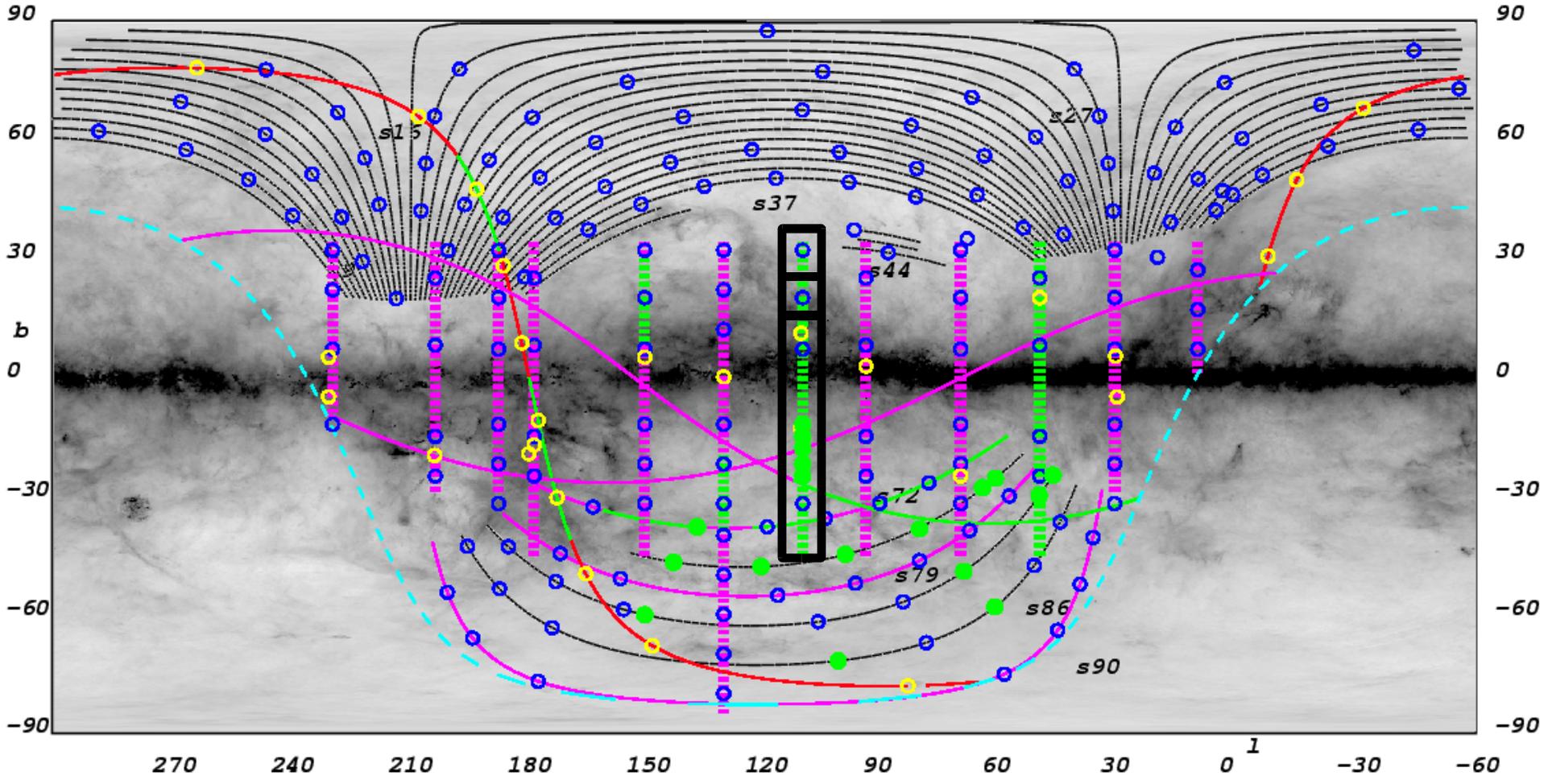
SEGUE spectra  
of stream  
BS/BHB stars

Fig 1. from Newberg et al. 2002

# Imaging Survey Design

- Image survey covers 3500 square degrees.
- Samples low galactic latitudes  $|b| < 35^\circ$ , as visible from Apache Point Observatory (southern declination limit is  $-20^\circ$ ).
- We primarily scan across the galactic plane using a spacing of  $20^\circ$  in galactic longitude.
  - sample Galactic components, spatially coherent substructure
- The photometric accuracy: 2% in SDSS *gri*, 3%-5% in *u,z*
  - calibration of stellar parameter estimates from photometry, spectroscopy
  - photometric parallax
  - star count uniformity
  - necessary for any study of stellar populations over large angle on the sky
  - 1% calibration enables more stellar population science, e.g., metallicity gradients

# SEGUE observing plan and status as of February 2005



-  SDSS Imaging scan
-  Planned SEGUE scan (3500 sq deg)
-  Sgr stream planned scan
-  Completed SEGUE imaging
-  Declination = -20 degrees
-  Planned SEGUE grid pointings (140)
-  Planned targeted SEGUE pointings(60)
-  Completed SEGUE plate pointing

SEGUE uses stellar probes of increasing absolute brightness to probe increasing distances in the disk, thick disk and Milky Way halo.

**K III**  
 $d < 100$  kpc

**BHB/BS**  
 $d < 50$  kpc

**MSTO/F**  
 $d < 15$  kpc

Streams and outer halo stars

thin, thick  
disk stars

**G**  
 $d < 6$  kpc

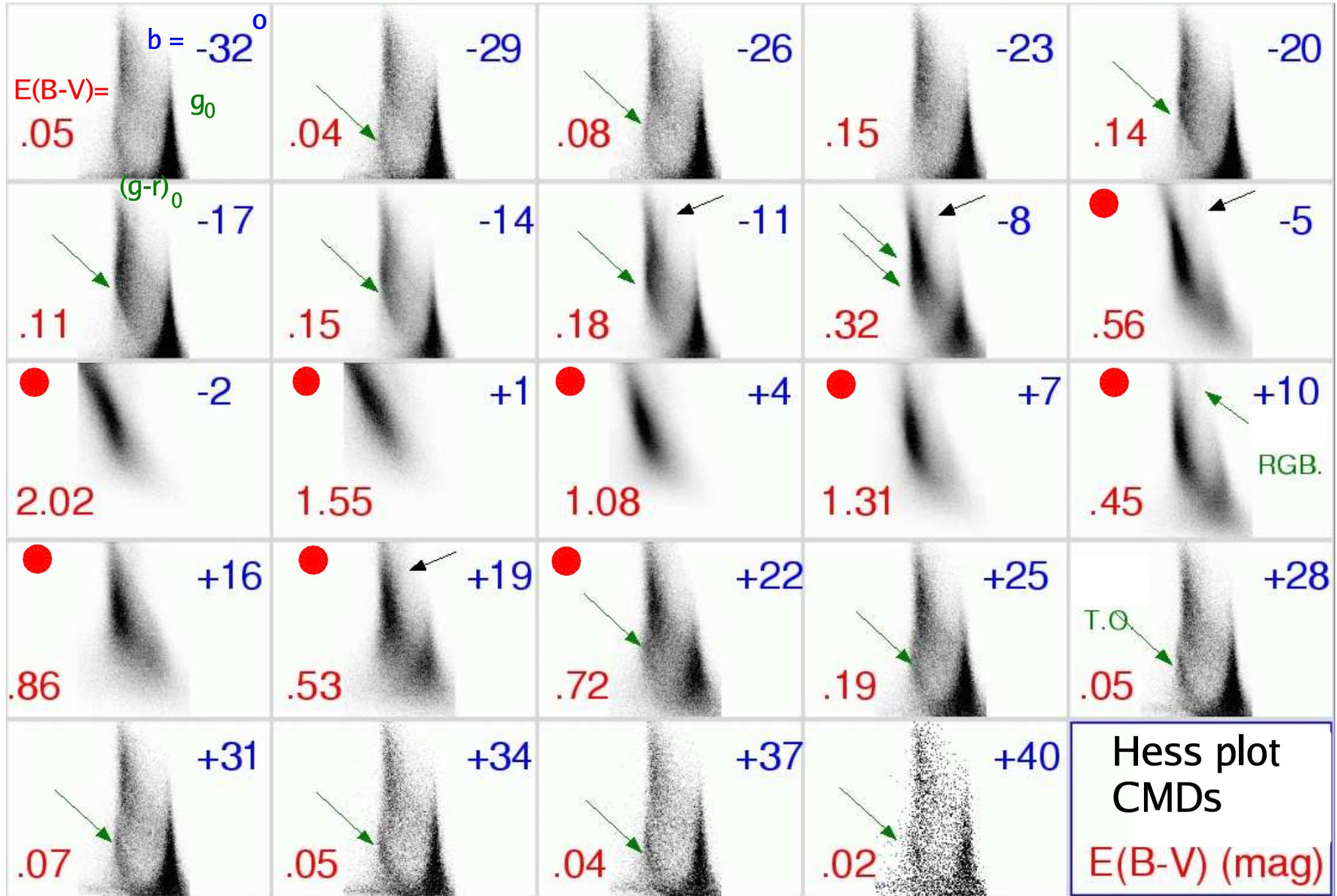
Inner and outer halo stars

**K V**  
 $d < 1$  kpc

$r = 1.5$  kpc

8 kpc

# SEGUE Imaging ( $l = 110$ deg, $-32 < b < +38$ ) (g-r,g) dered



● = region where reddening or crowding do not meet SEGUE requirements

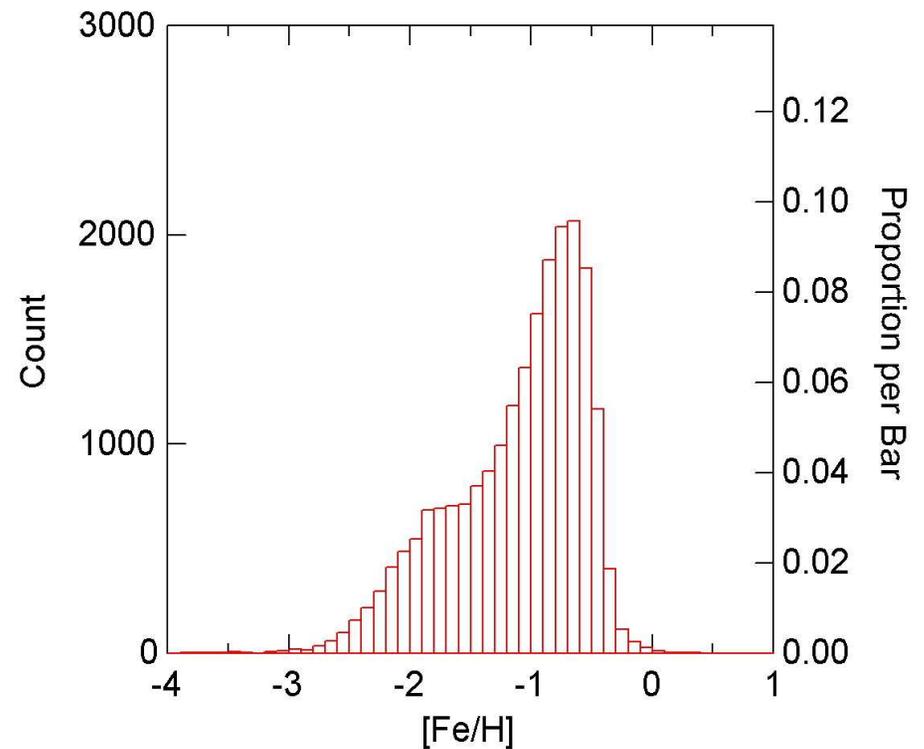
# SEGUE Spectroscopic Science – kinematics and chemical evolution

What is the shape, extent and smoothness of the Milky Way's dark matter halo?

- Map the position and velocity dispersion of tidal streams.
- Determine the velocity ellipsoid in the halo.

The chemical abundance distribution of the Galaxy is a product of its enrichment history and contains clues to its origins.

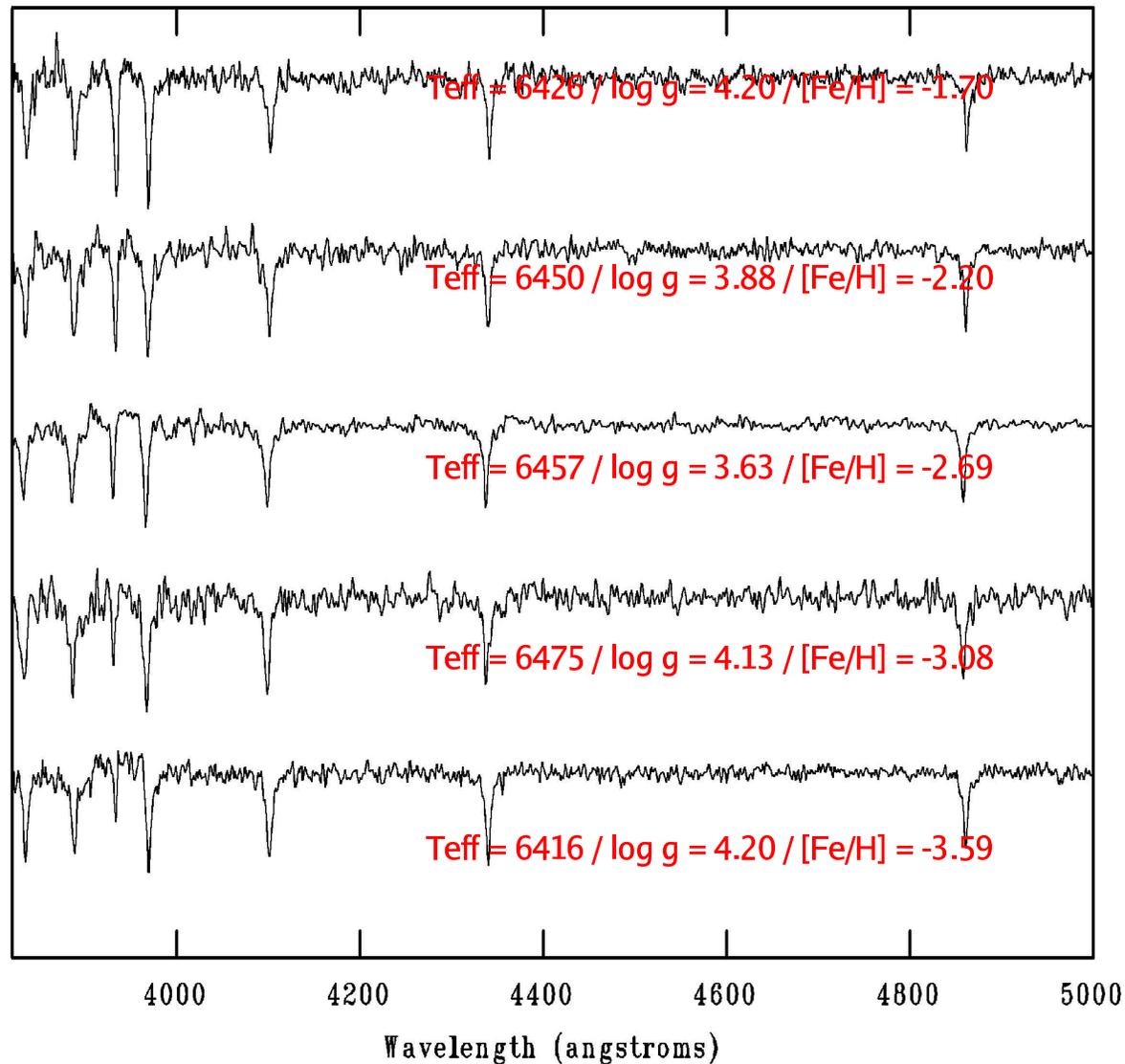
- Globular cluster vs. halo [Fe/H].  
Metallicity distributions.
- Metal-poor tail of the halo.



# Spectroscopic Survey Design

- 240,000 stars
- 200 lines of sight,  $14.5 < g < 20$
- Target evenly in  $\log(\text{distance})$  to 100 kpc+
  - 11 categories
  - large volume of Galaxy
  - probe distant halo and Galactic anticenter
- Wavelength coverage is  $3800\text{\AA} - 9100\text{\AA}$ , with a resolution of  $3\text{\AA}$
- Radial velocities to 7 km/s @  $g=18.2$
- $T_{\text{eff}}$ ,  $\log(g)$ ,  $[\text{Fe}/\text{H}]$ 
  - $\sigma_{T_{\text{eff}}} = 150\text{K}$ ,  $\sigma_{[\text{Fe}/\text{H}]} = 0.3 \text{ dex}$ ,  $\sigma_{\log(g)} = 0.5 \text{ dex}$
  - requirements based on separating populations, giants/dwarfs, measuring distances

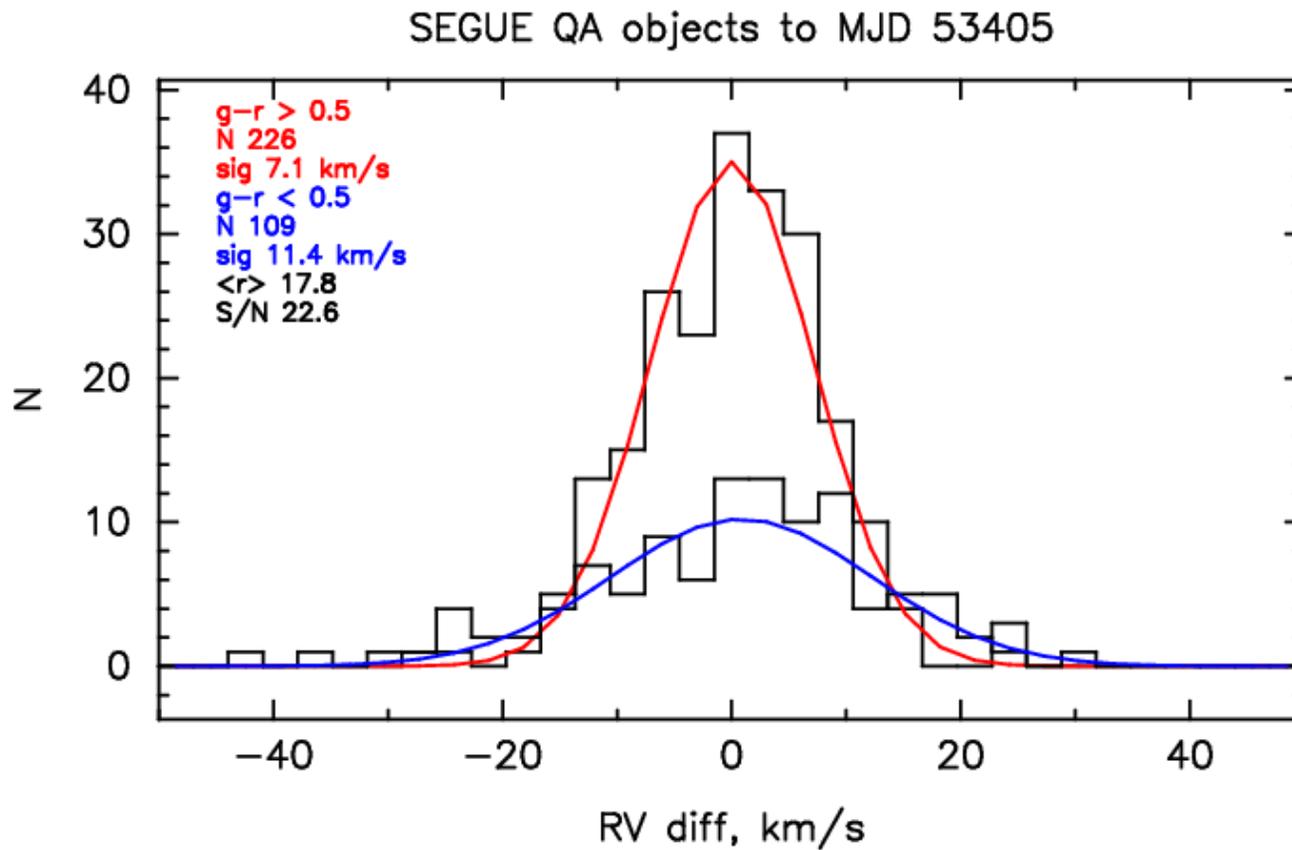
# Example Main-Sequence Turnoff Stars of Low Metallicity



# Radial Velocity Accuracy

Adjusted spectra S/N to reach required RV, stellar parameter accuracy for faint (below SDSS magnitude limits) plates.

Current RV accuracy: 7 km/s for  $g-r > 0.5$ , 11 km/s for  $g-r < 0.5$  at  $g=18.2$ , S/N 22.5



# LANL Specific Interests

- The SDSS Open Cluster Survey (SOCS) – see talk by J. Allyn Smith.
  - Age/metallicity determination
  - Star formation
  - Calibration
- Formation, metallicity and magnetic activity of low mass stars and brown dwarfs.
- Structure of the local ISM.
- Abundance patterns in the first stars .
- Alexander Heger (T-6)
- Falk Herwig (T-6)
- Peregrine McGehee (LANSCE-8)
- J. Allyn Smith (ISR-4)