Open Clusters and the Chemical Evolution of the Galactic Disk

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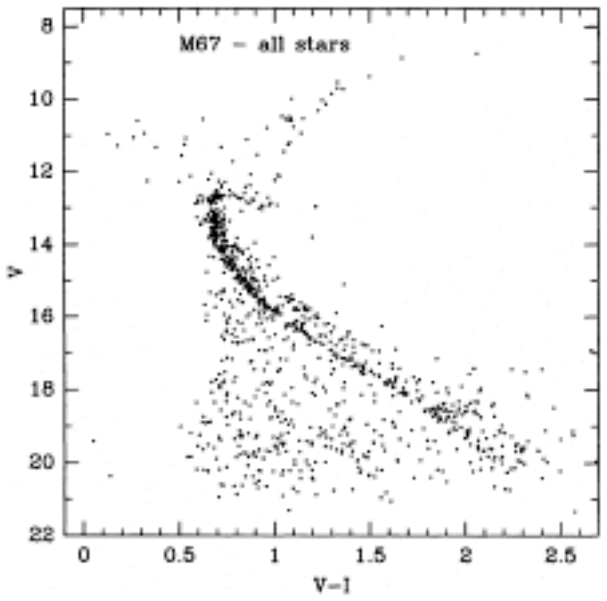
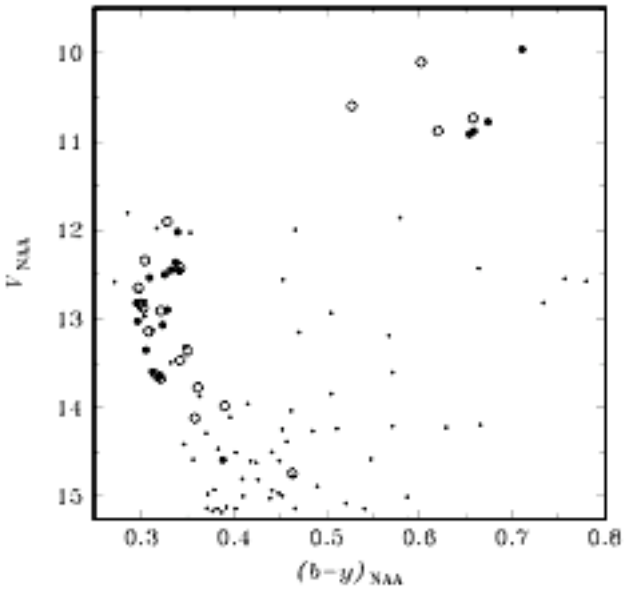
23 October 2010, JINA Frontiers

Chemical Evolution of the Milky Way Disk

- In MW and other disk galaxies, most stars reside in disk – location of much of the chemical evolution
- Spatial & temporal abundance variations in the MW disk important constraints to chemical evolution models
- MW the only disk galaxy we can study in close detail
- Combined with observations of nearby disk galaxies a complete picture of disk galaxy formation and evolution can be formed
- Probes of chemical evolution must have precise distances and ages (and preferably kinematics)



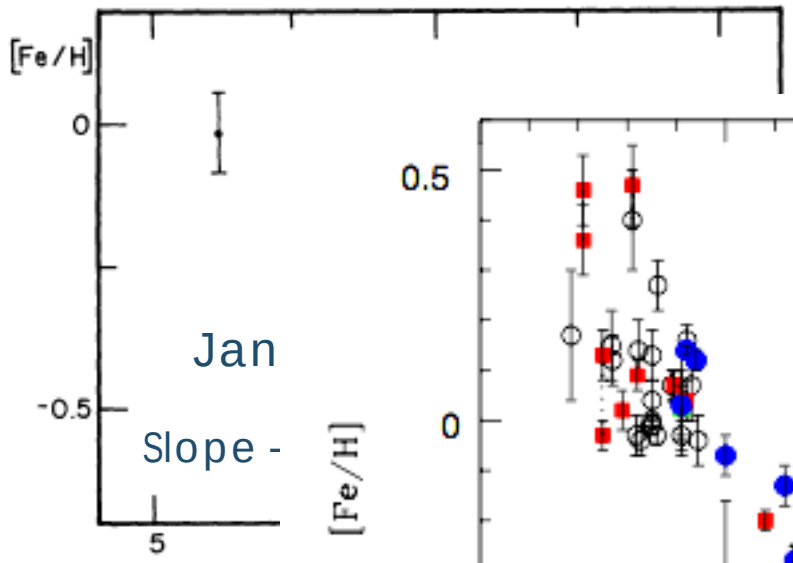
Montgomery, Marschall & Janes 1993

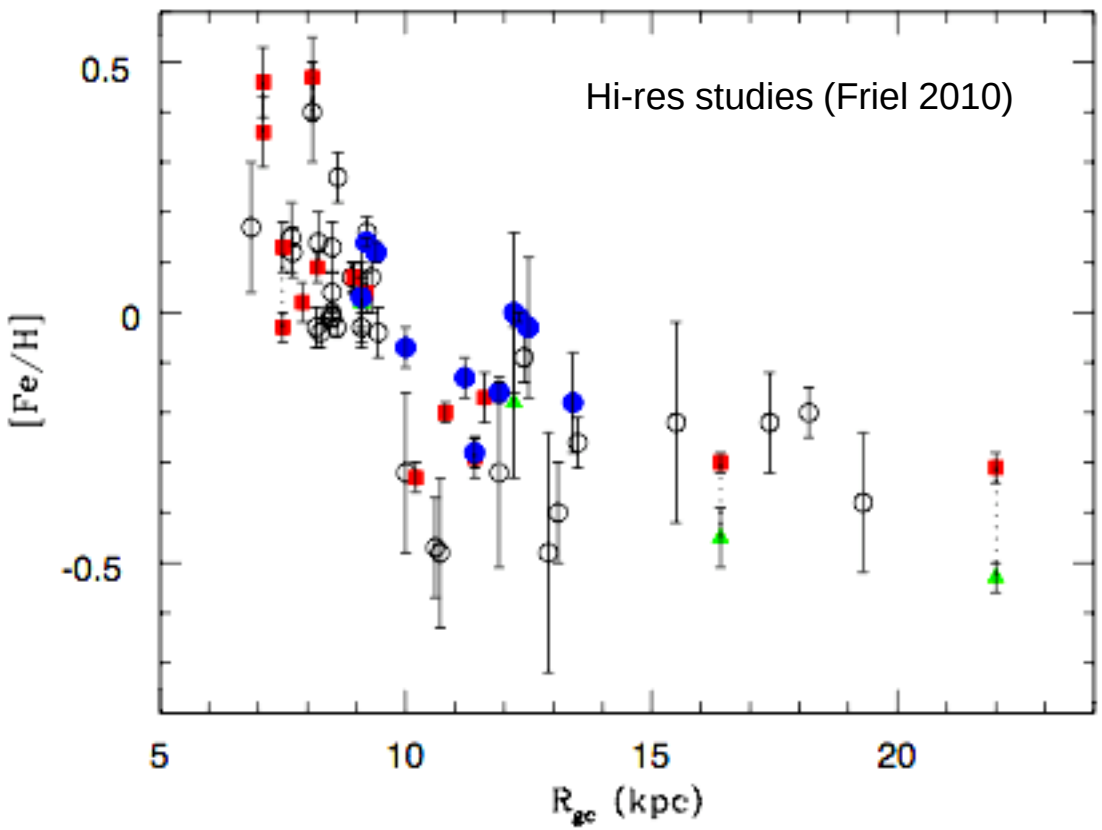


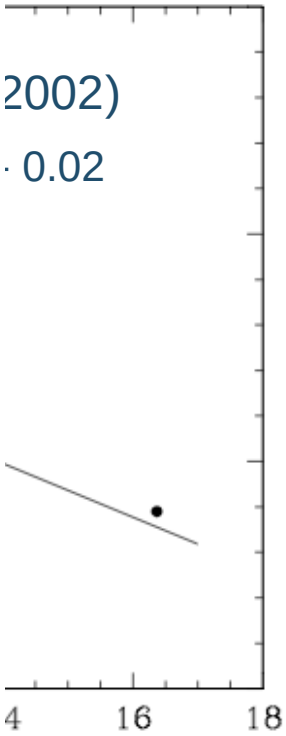
Nordstrom et al 1997

- Open clusters span full age and distance scale of MW disk
- Ages and distances precisely determined
- Are simple stellar populations
- Composition of primordial gas preserved
- Good for testing stellar evolution theories too

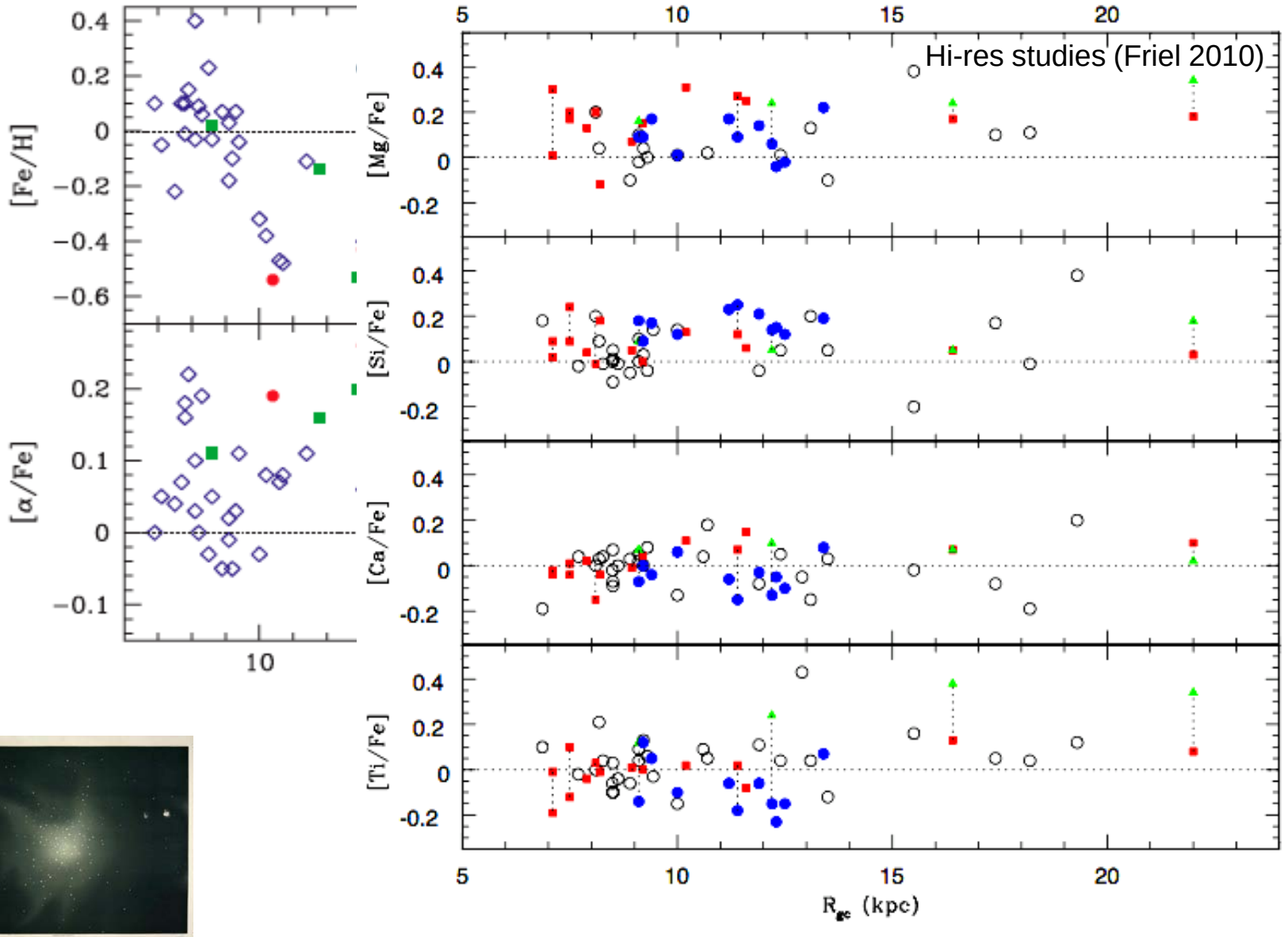
Open clusters & radial metallicity gradients



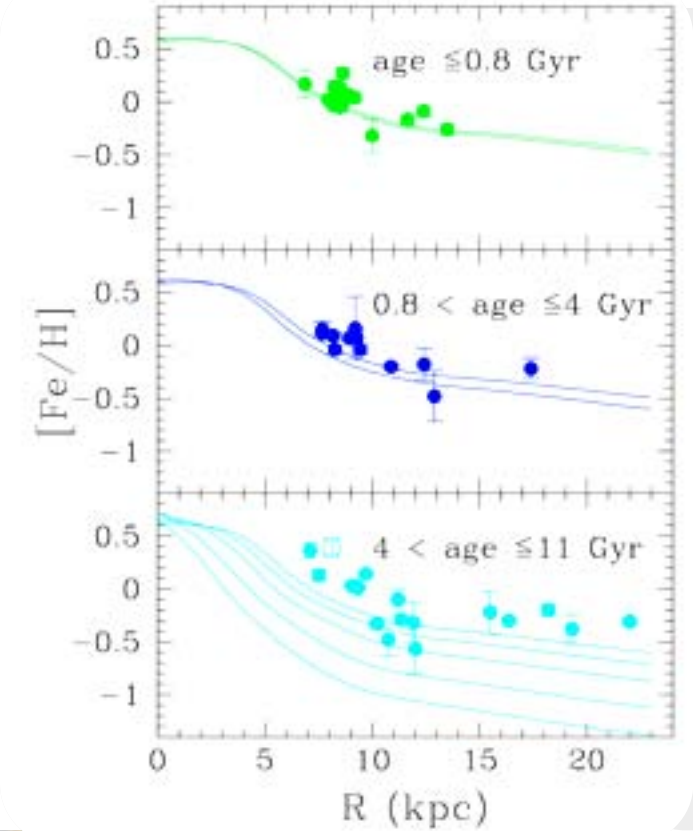


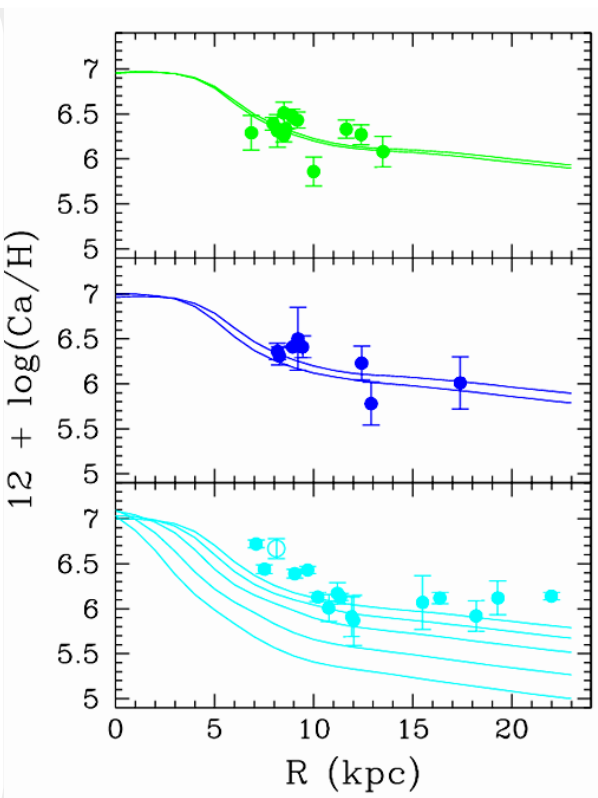


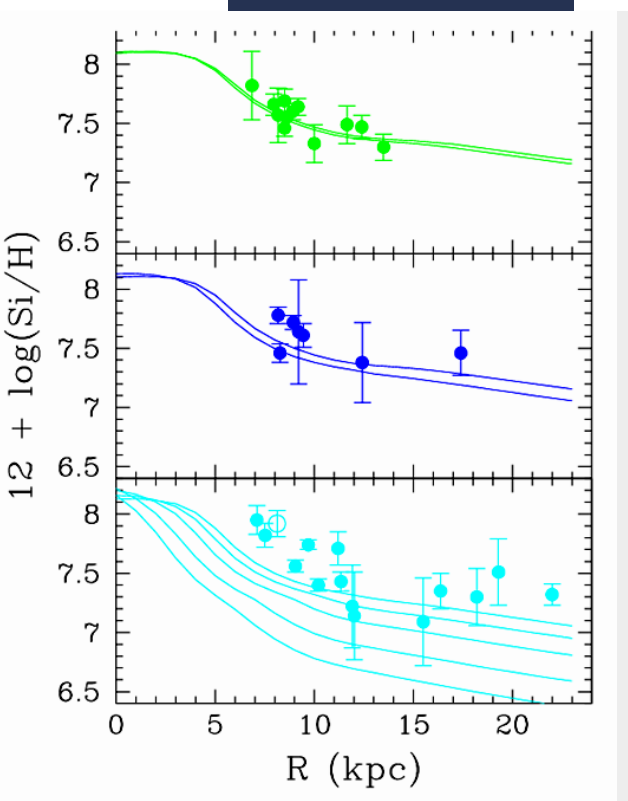
Inner versus Outer MW disk



Evolution with time





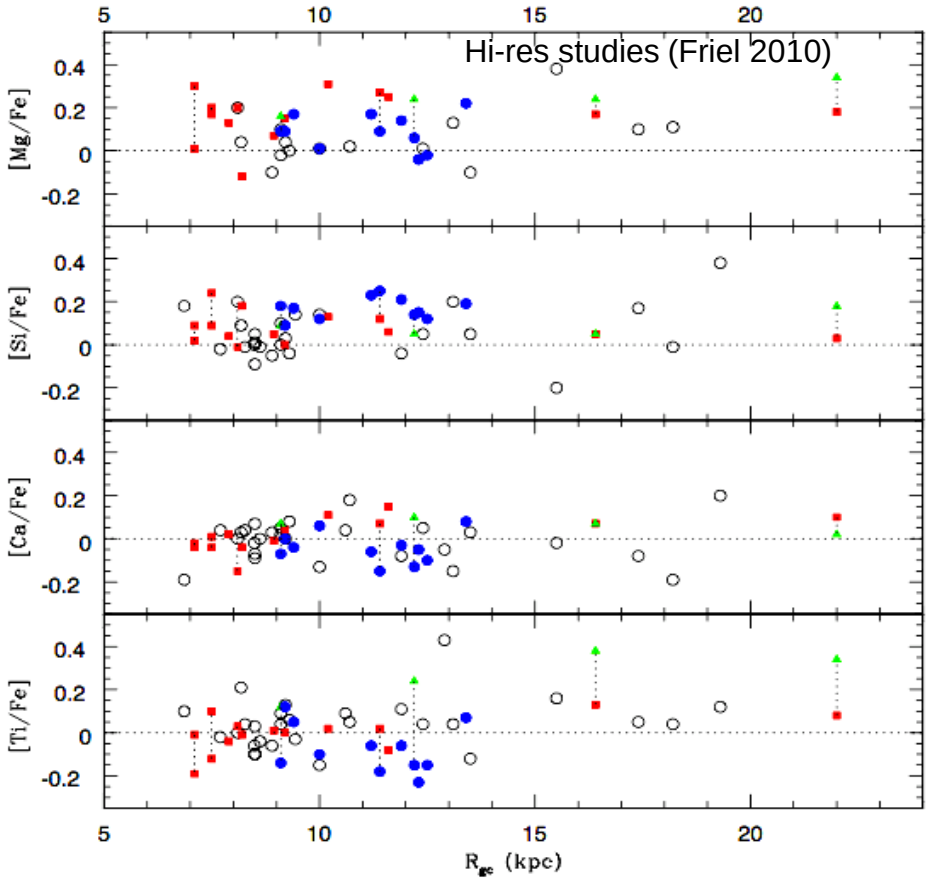


Remarkably little evolution!
1D models fit pretty well

Magrini et al. 2009

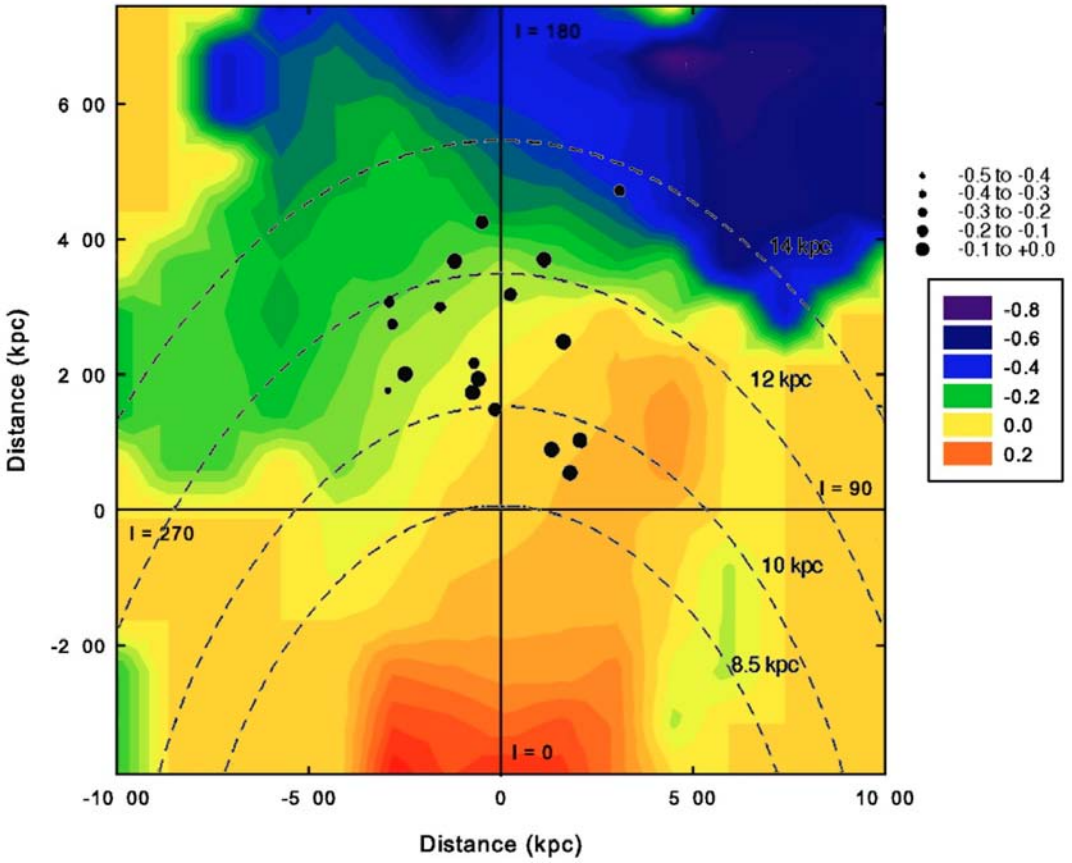
Cluster abundance dispersions

- [X/Fe] abundance distributions flat
- Dispersions vary from element to element, but not with Rgc
- Evidence of azimuthal inhomogeneities? – Maybe
- Evidence of different nucleosynthetic sites?



Azimuthal abundance variations in the MW disk

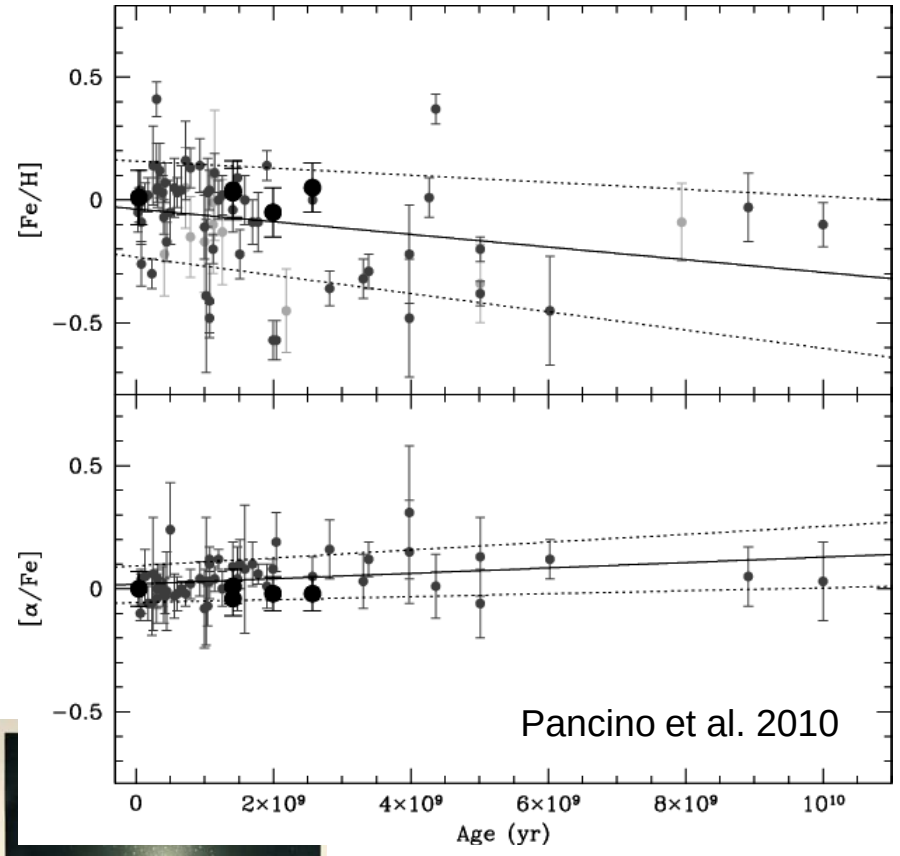
- Cepheids from Andrievsky et al., Luck et al.
- Indication of isolated areas of enriched material
- Other studies: different distributions in different Galactic quadrants (e.g., Pedicelli et al. 2009)
- n clusters don't me variations? arly to say



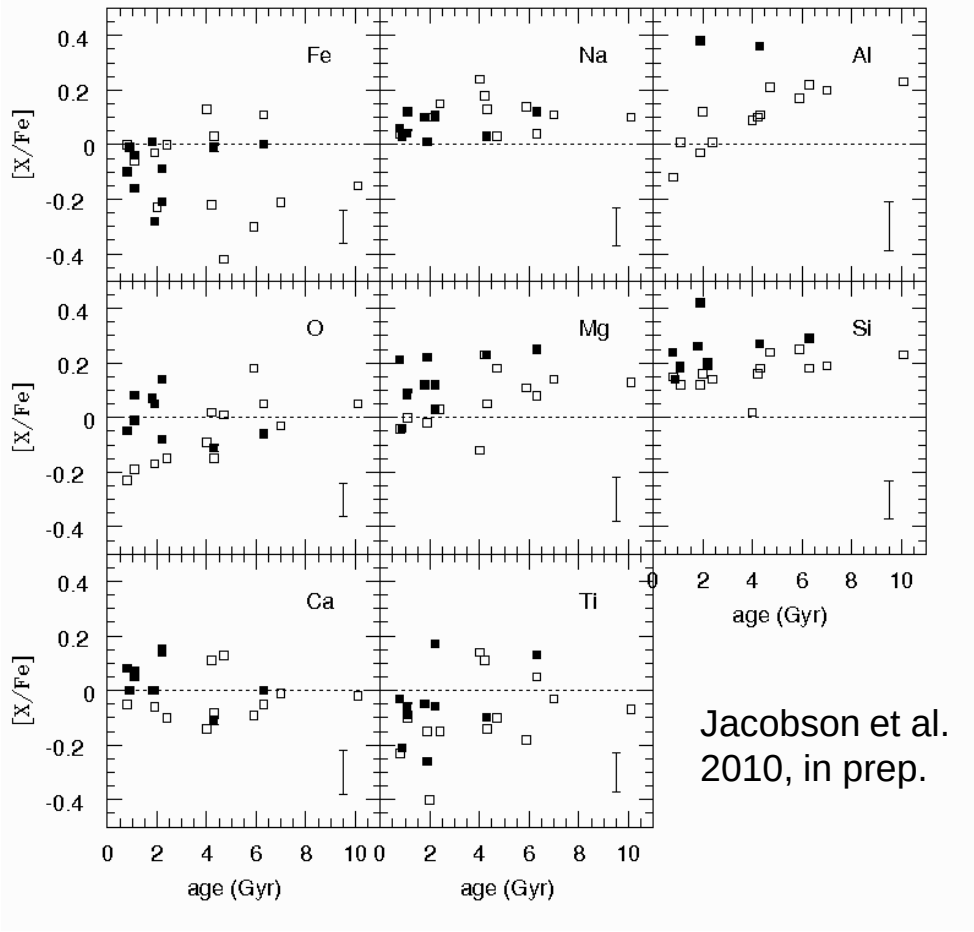
Luck et al. 2006, Jacobson 2009

Abundance variations with age

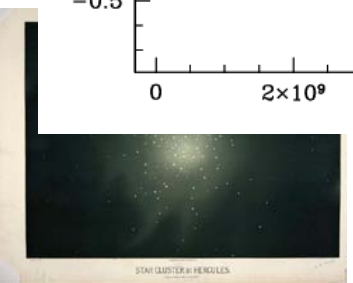
- No clear age-metallicity relation!
- Buried in errors & systematics?



Pancino et al. 2010



Jacobson et al. 2010, in prep.



Summary

- Open clusters are excellent tools, but… (next slide) understanding of disk evolution incomplete…
- MW disk enriched early; uniform abundance distribution w/Rgc; no age dependence
- Outstanding issues: mergers, formation of outer disk, radial migration effects
- Just how large are intrinsic abundance dispersions?
- Is part of disk we see representative of rest of it?
- Current & future work will help address all of these issues

Open clusters as GCE probes

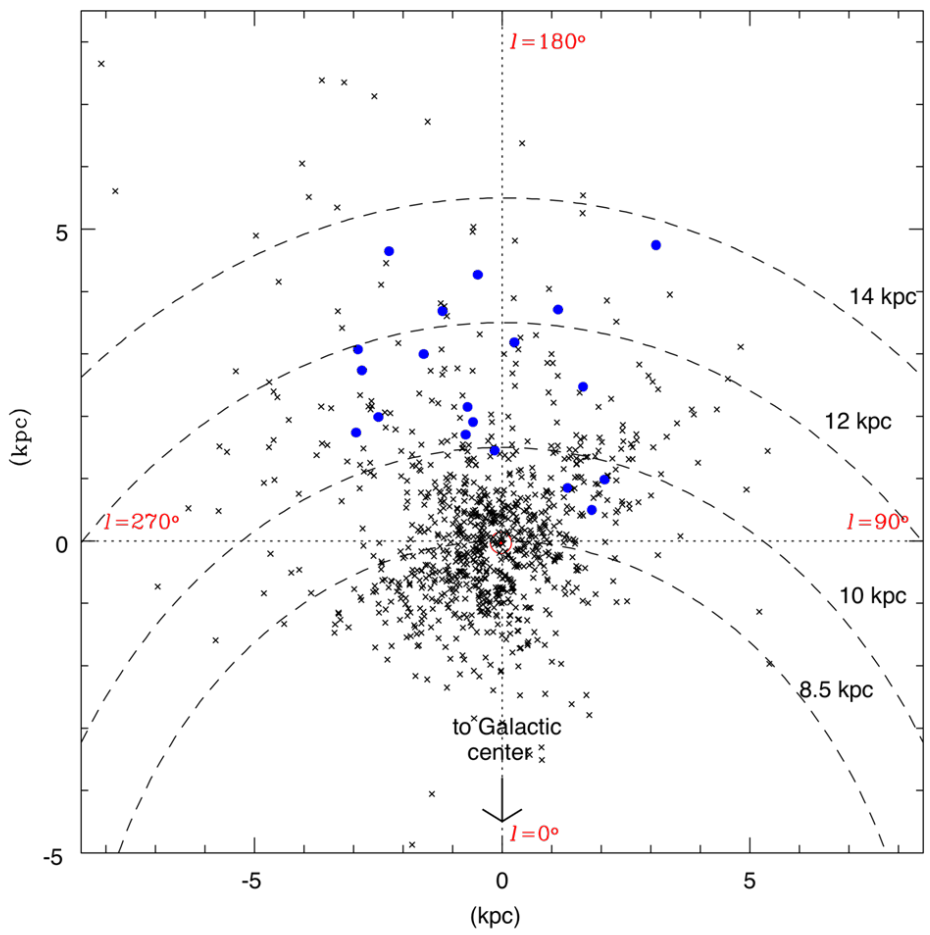
PROS:

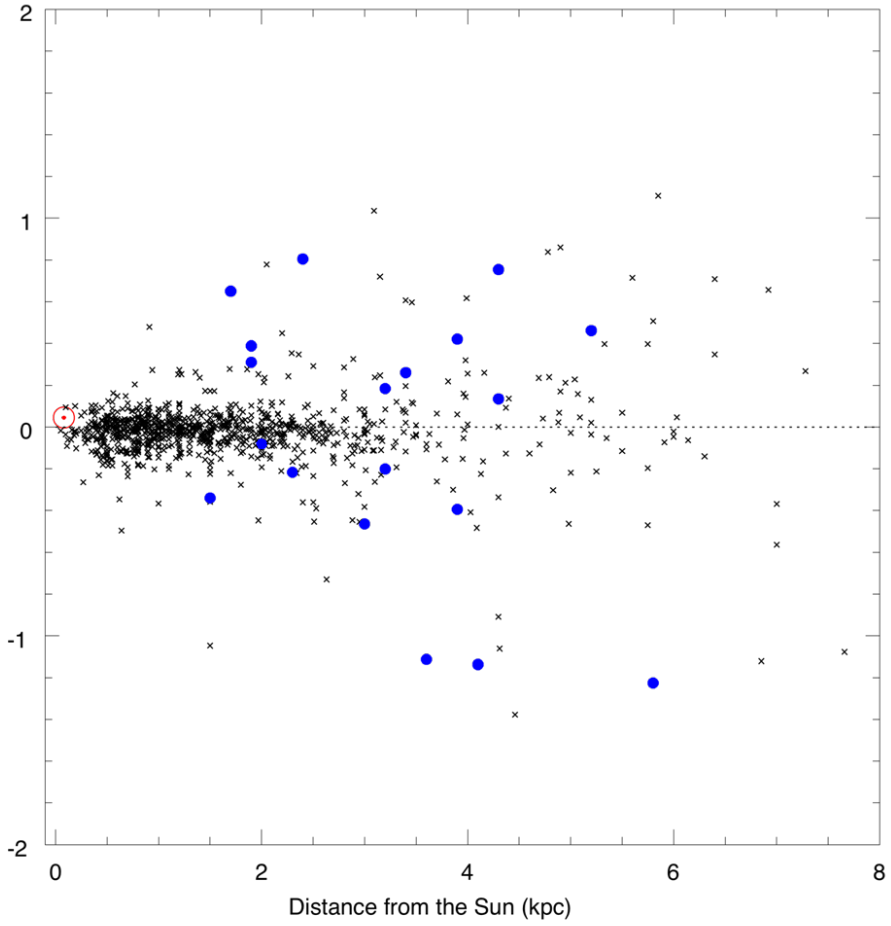
- Wide range in age & Rgc
- Easily identifiable, precise ages and distances (cf. field stars)
- Robust average element abundances (large N)
- Simple stellar populations

CONS:

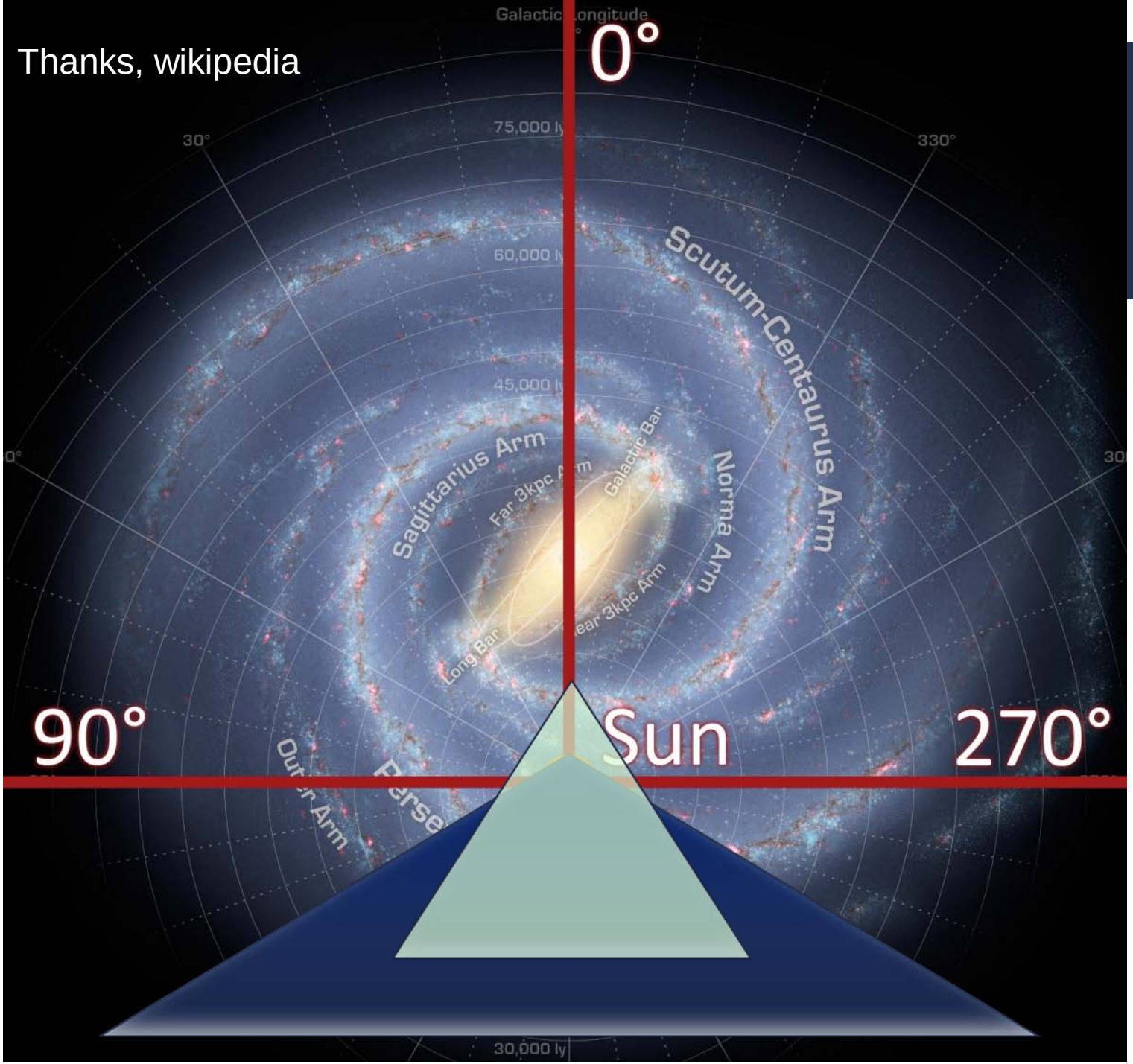
- Small population – hard to select large, unbiassed sample
- Hard to disentangle age-Rgc, Rgc-z effects
- Many areas of the disk still un(der)-studied
- Systematic effects still a large issue

Thank you!

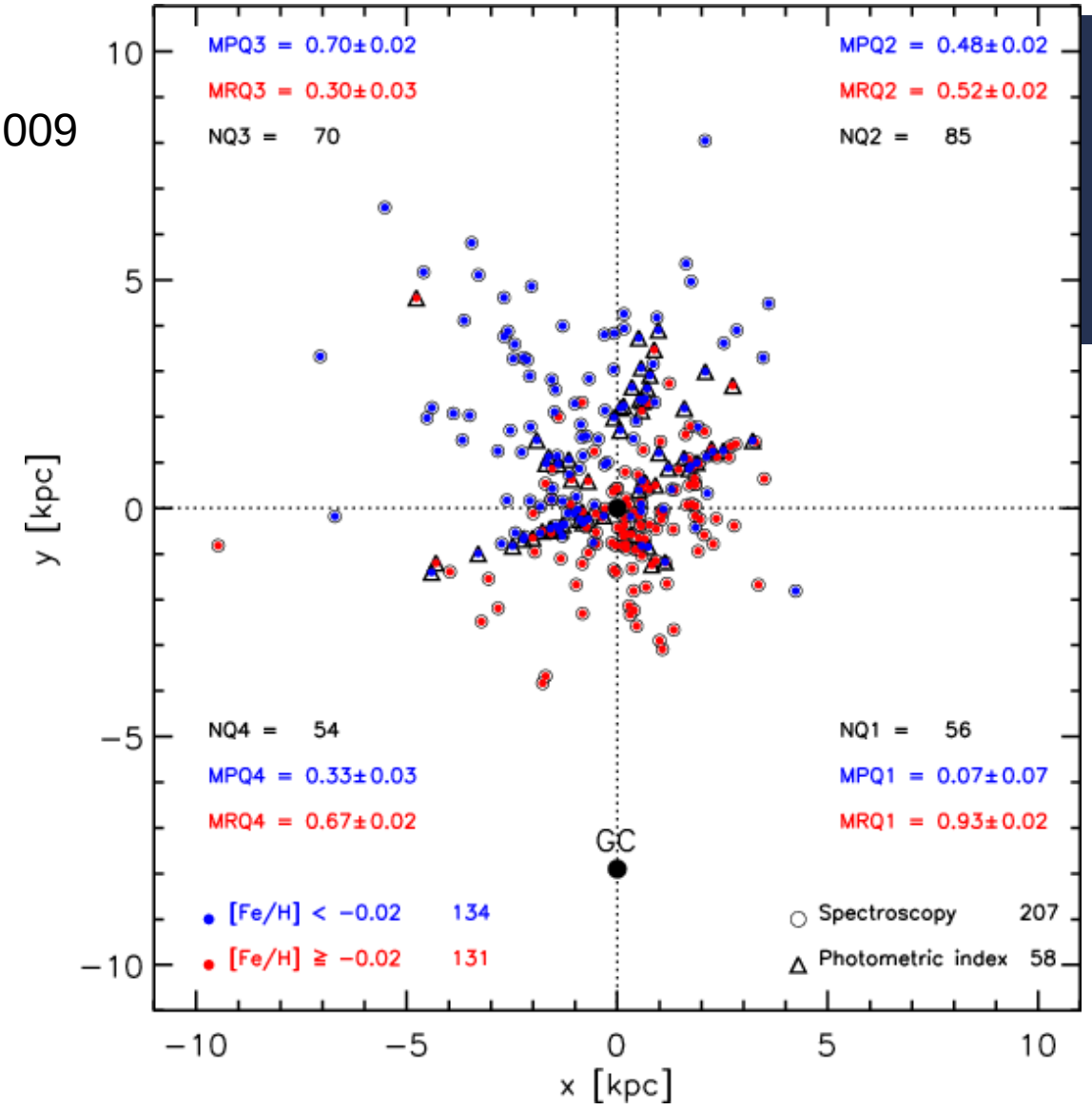


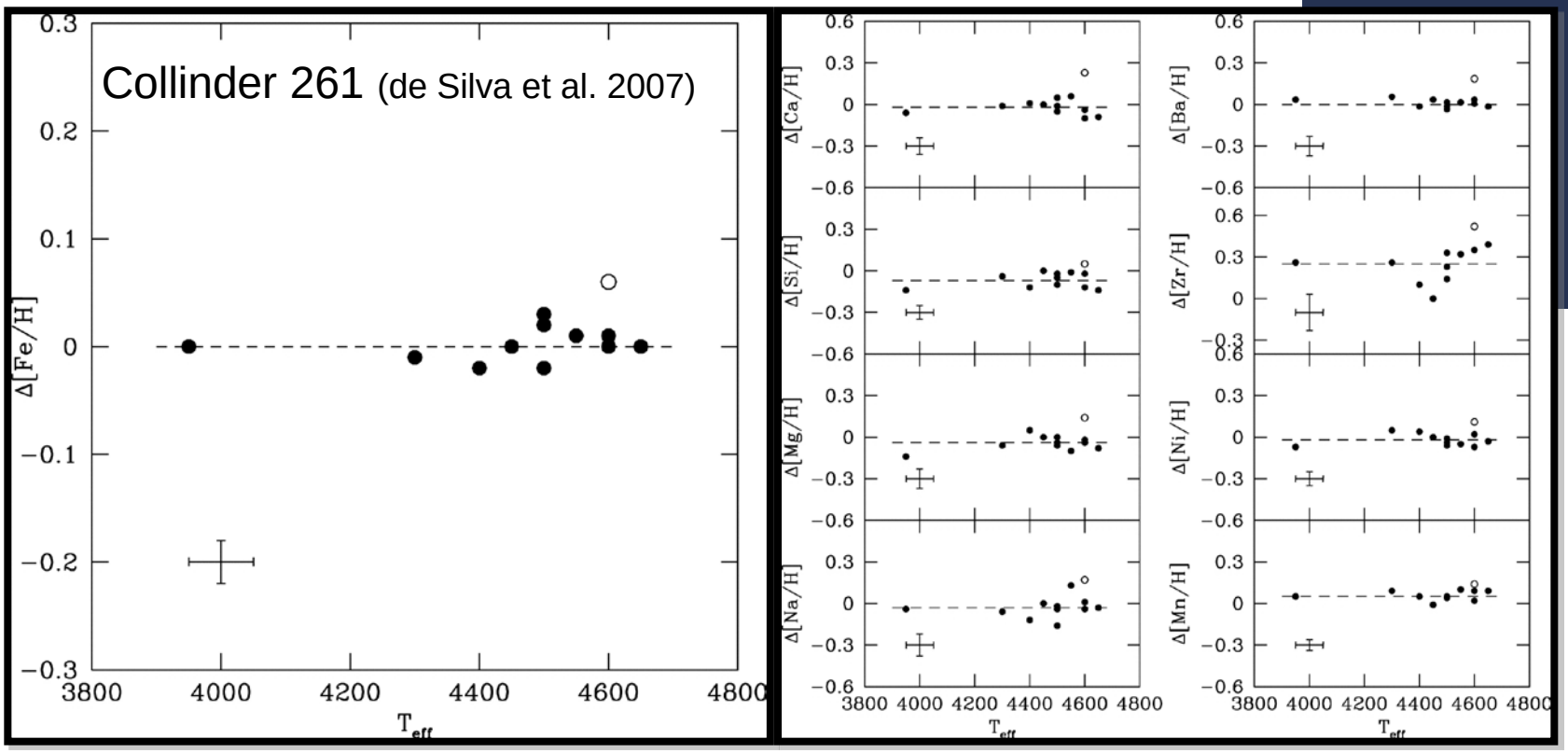


Jacobson 2009


Thanks, wikipedia
Galactic Longitude
0°
75,000 ly
30°
330°
60,000 ly
45,000 ly
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Long Bar
90°
Sun
270°
Outer Arm
Perseus Arm
30,000 ly

Pedicelli et al. 2009




Collinder 261 (de Silva et al. 2007)
Δ[Fe/H]
T_eff
Δ[Ca/H]
Δ[Ba/H]
Δ[Si/H]
Δ[Zr/H]
Δ[Mg/H]
Δ[Ni/H]
Δ[Na/H]
Δ[Mn/H]