# Stellar chemical signatures and hierarchical galaxy formation

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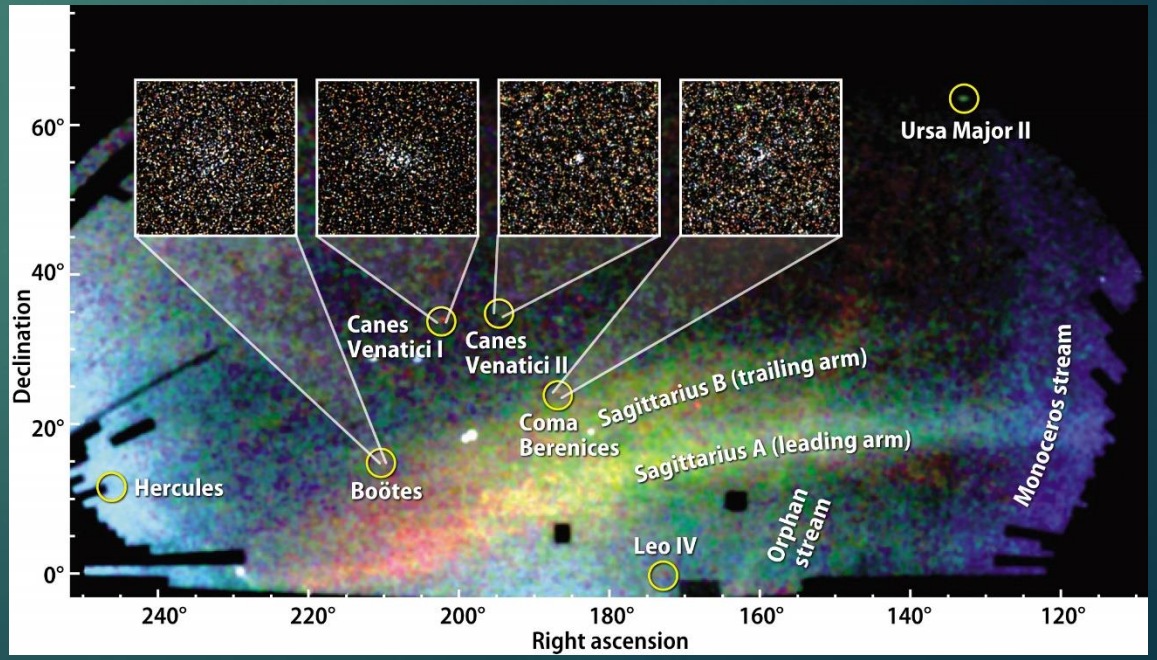
# Introduction

- Hierarchical structure formation
- Chemical composition of dwarf spheroidal (dSph) galaxies and Milky Way
- To which extend influenced dSph galaxies the Milky Way?



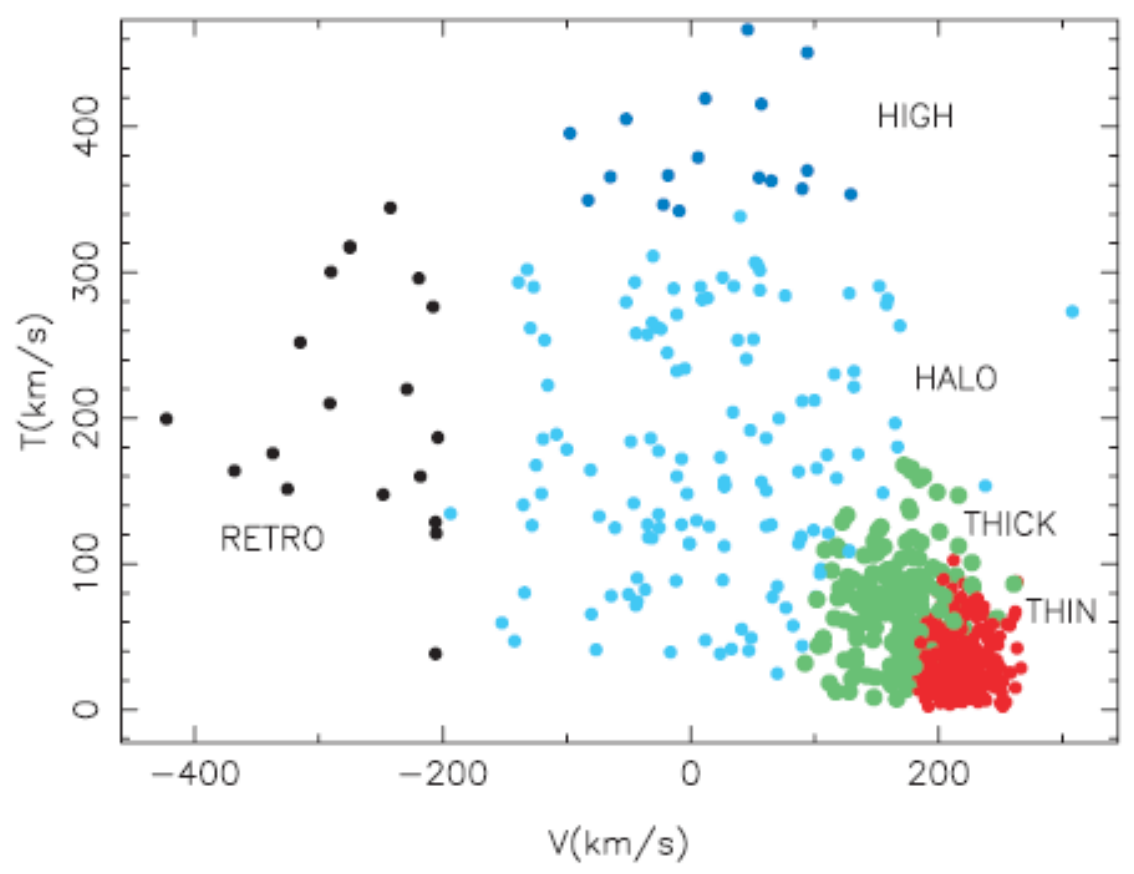
# Outline

- About the sample of stars
- Comparison of different elemental groups
- Discussion: what do results mean for hierarchical structure formation?
- Conclusions

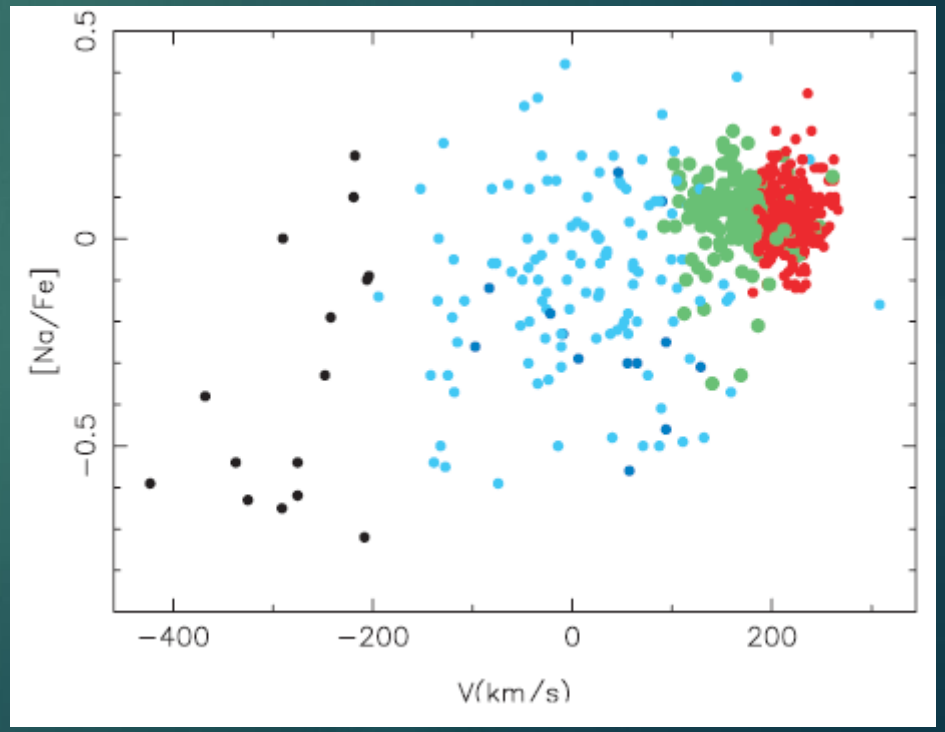
# About the sample

- Kinematic and abundance information from 8 different papers
- 781 stars
- ± 30 stars from dSph's
- Kinematically selected
- Thin disk, thick disk, halo, retrograde orbits, other high velocity stars

# About the sample




- $T = (U^2+W^2)^{1/2}$

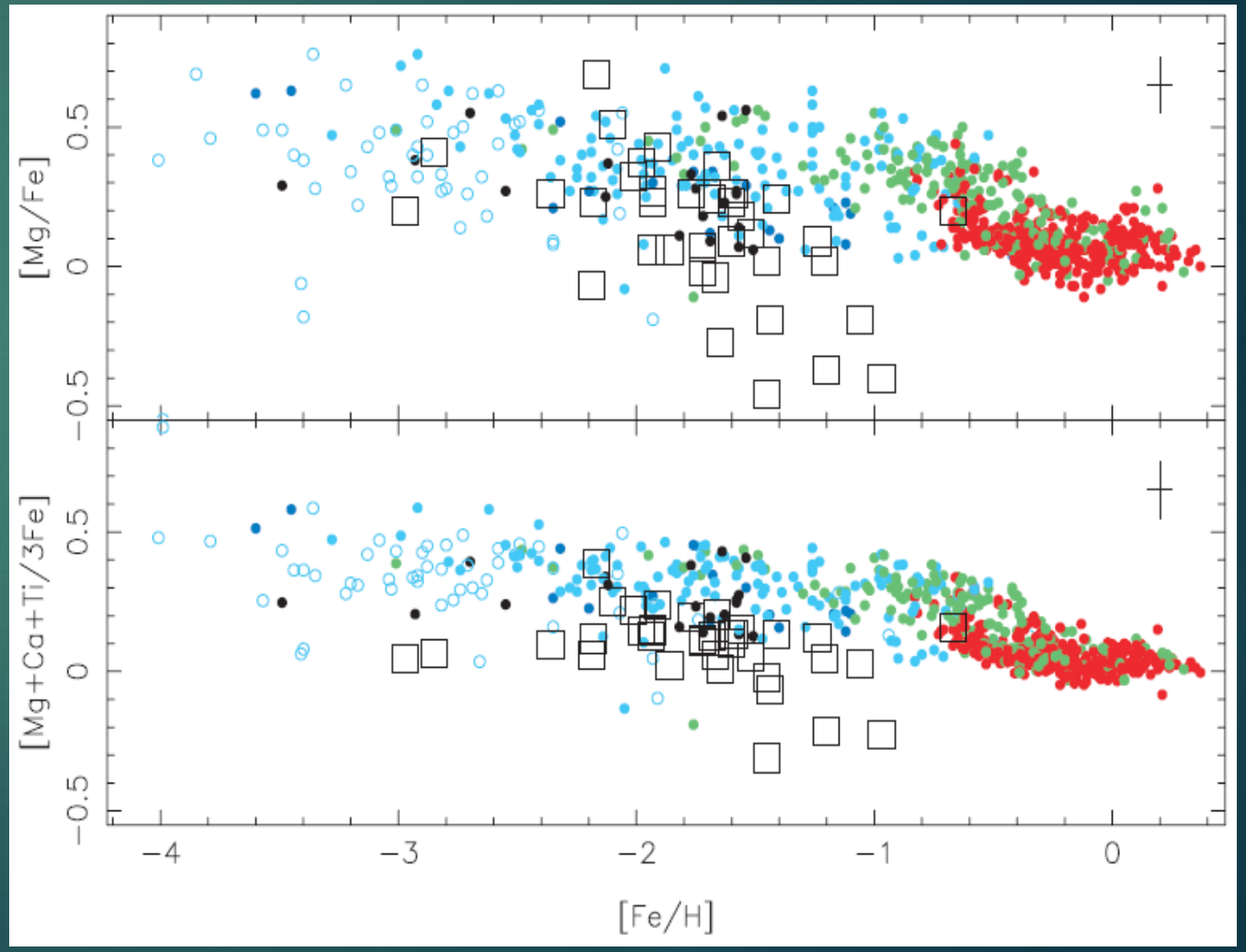


# Elemental abundances: *[α/Fe]*

- $\alpha$-elements (Mg, Ca, Ti) from SN II
- Fe from SN Ia and SN II

- High [$\alpha$/Fe] for low [Fe/H]

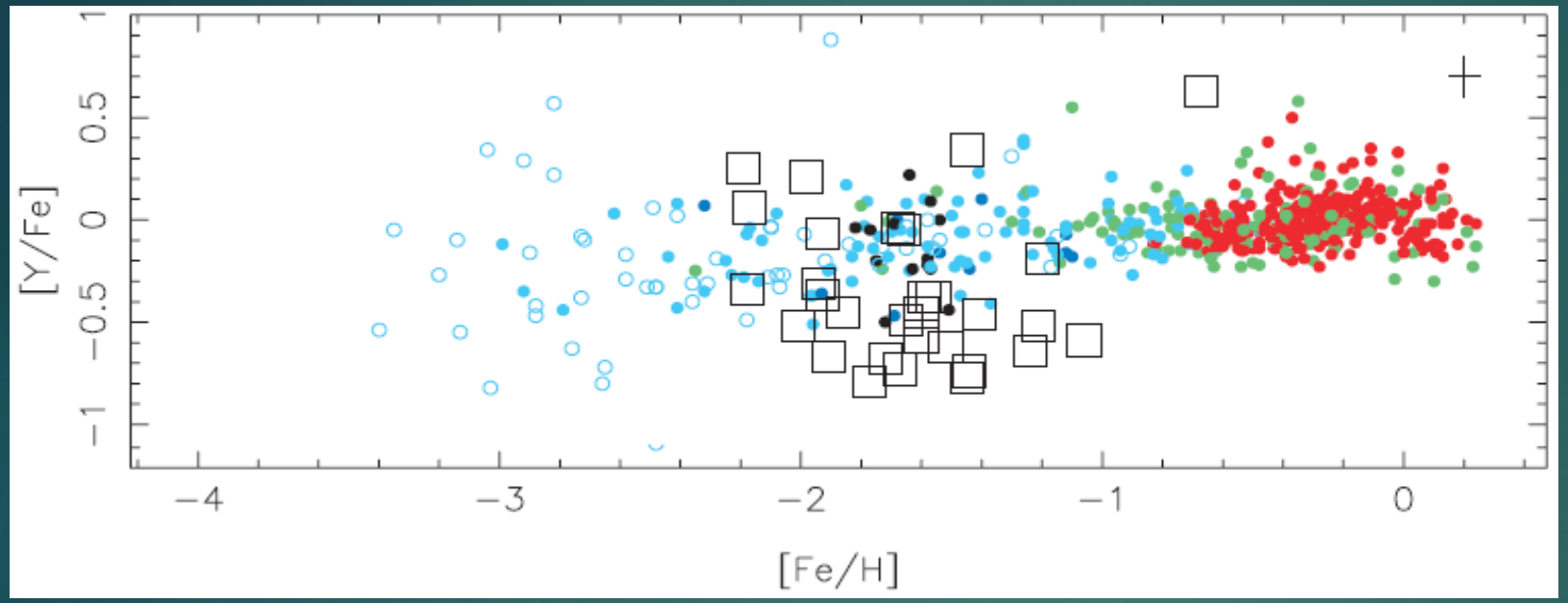
- [(Ca, Ti)/Fe] below [Mg/Fe]



# Elemental abundances: *s- and r-process*

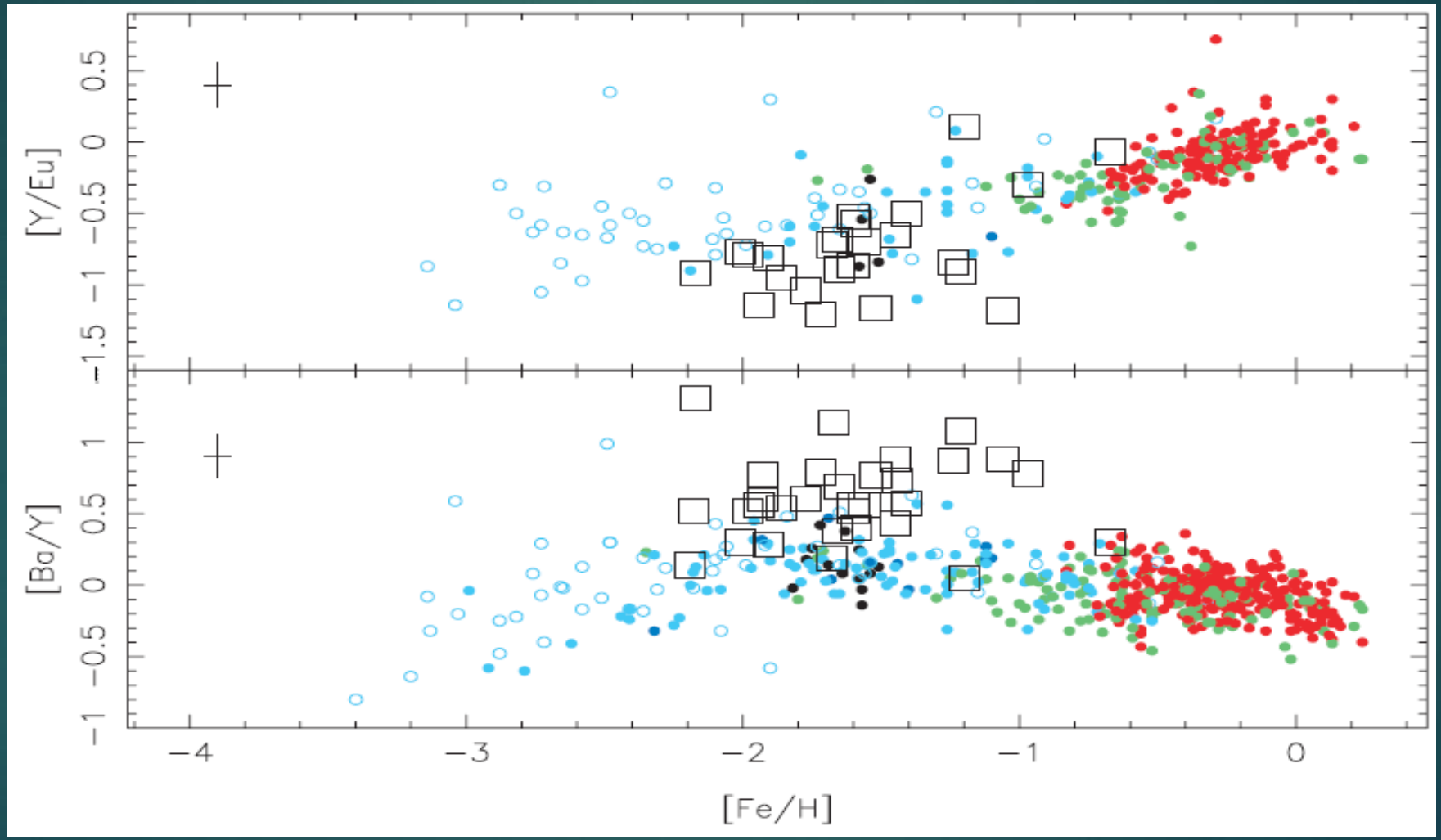
- s-process: low-mass AGB and He-burning massive stars
- r-process: SN II and neutrino winds
- dSph: low star formation efficiency
- Yttrium, barium, lanthanum

# Elemental abundances: *s- and r-process*




- Large range
- Inhomogeneous mixing?

# Elemental abundances: *s- and r-process*



# Elemental abundances: *Na-Ni correlation*

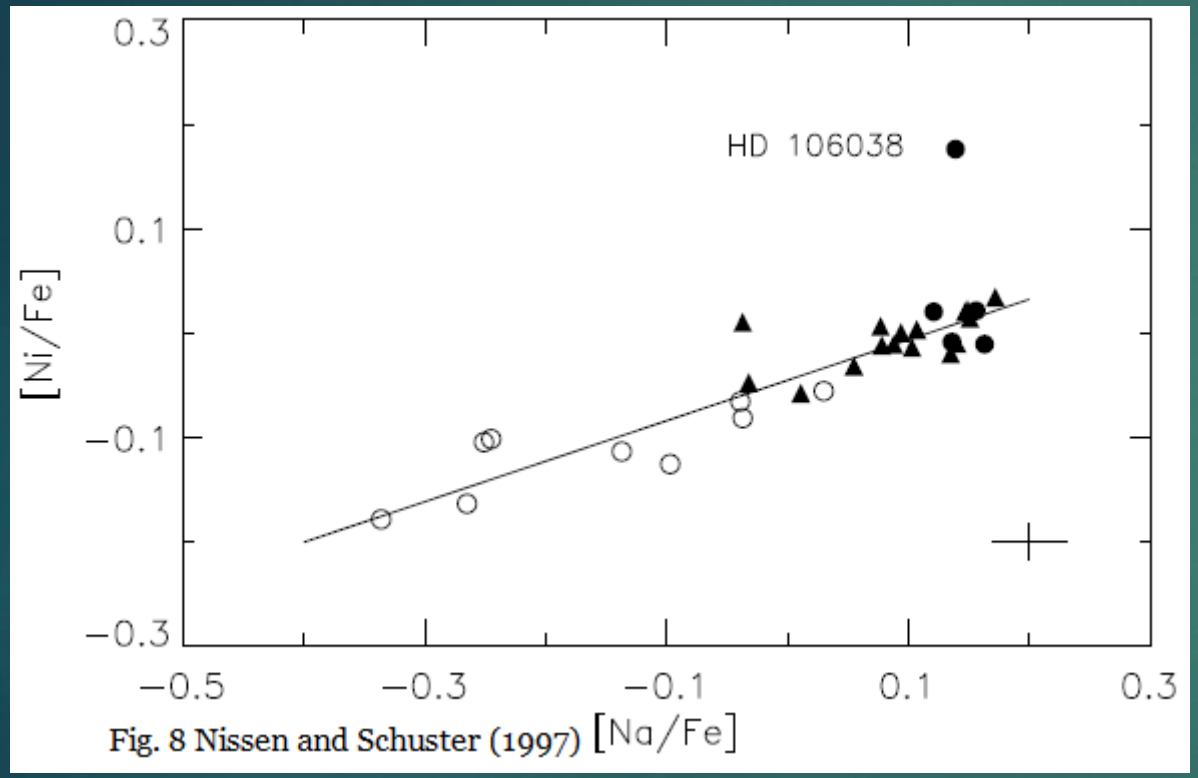
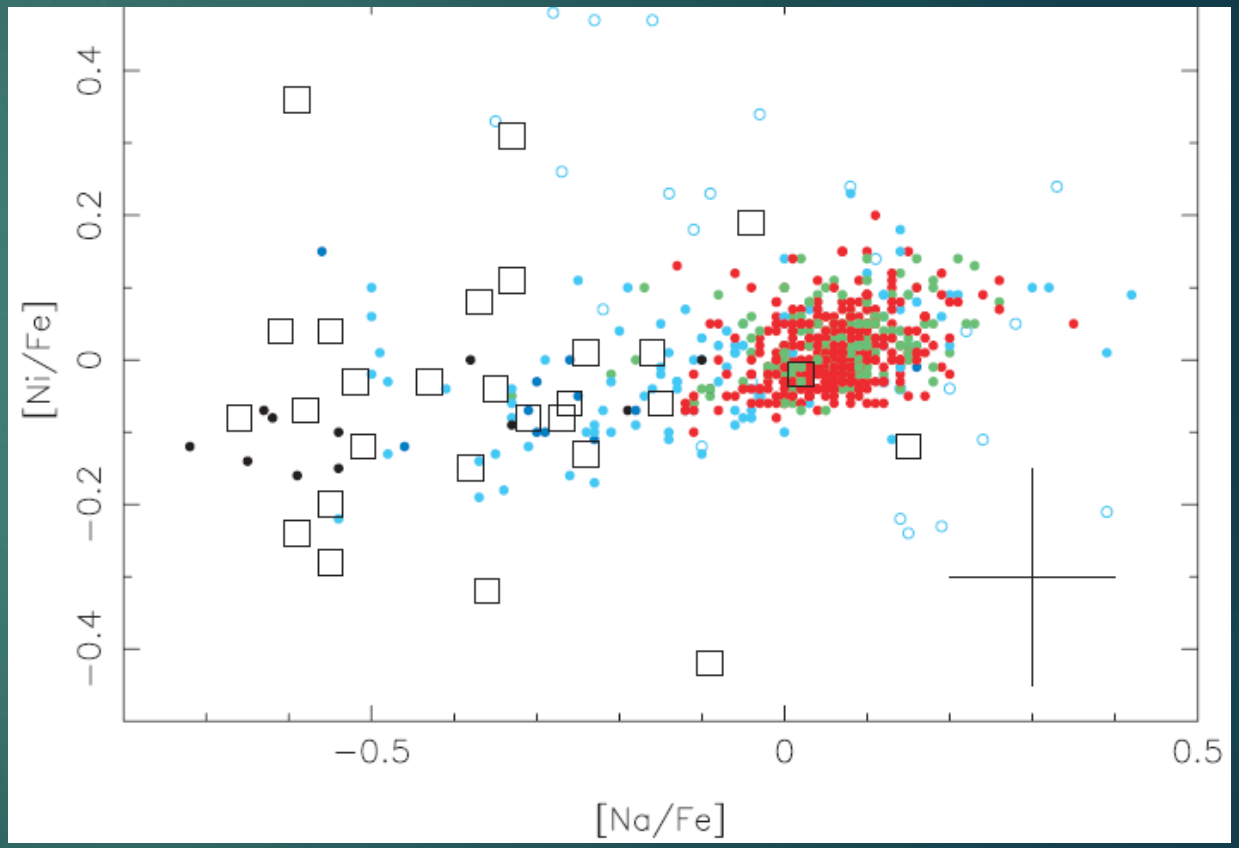


Fig. 8 Nissen and Schuster (1997)

- Farther from Galactic centre → lower [(Na, Ni, $\alpha$)/Fe]
- Accreted stars from dSph
- Na-Ni relation indicator for merging history?

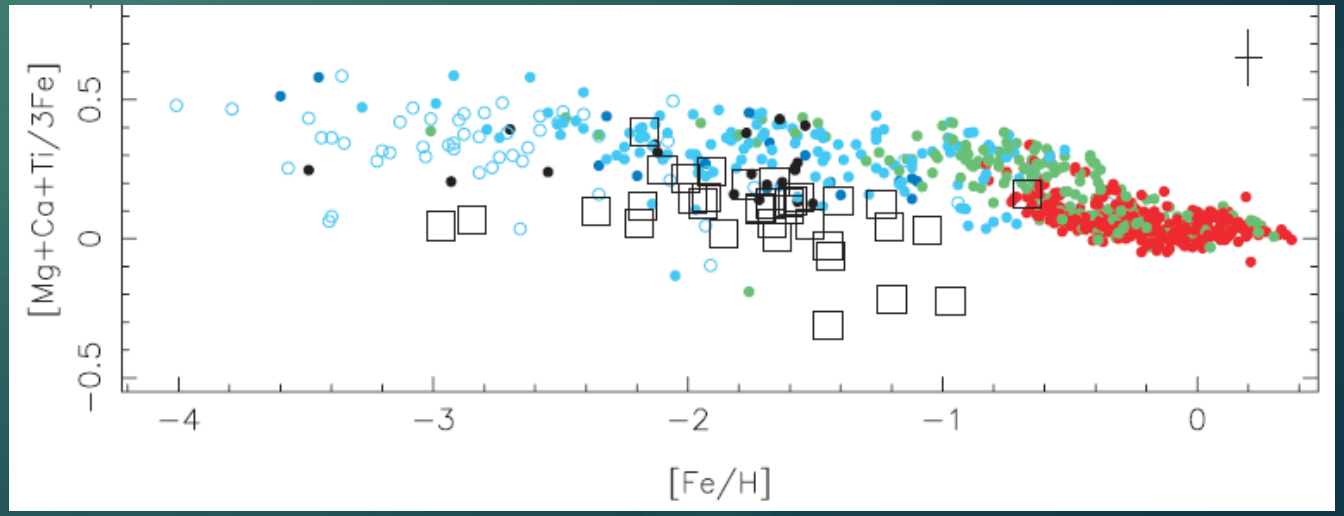
# Elemental abundances: *Na-Ni correlation*

- Correlation for stars from Galaxy
- No correlation for dSph stars
- Na-Ni no good indicator



# Discussion: *[α/Fe]*

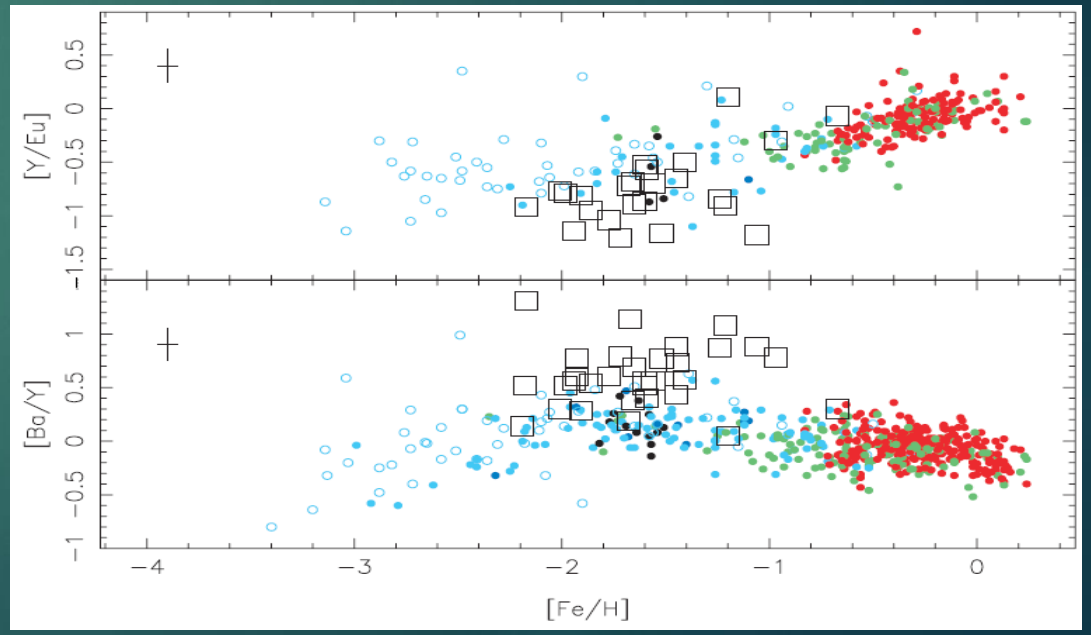
- [α/Fe] as indicator for accretion
- Different star formation history for dSph's
- Use many stars from individual dwarf galaxies



# Discussion: *[Ba/Y]*

- [Fe/H] < -1.8: different sources for Y and Ba or time delay
- [Fe/H] ≥ -1.8: low metallicity AGB stars

- Other explanation:
  $\alpha$-process production of low r-process elements



# Discussion: *Hierarchical galaxy formation*

- Chemical signatures of dSph galaxies quite similar
- "No significant component of the Galaxy formed primarily through the merger of galaxies similar to these low-mass dSph's"
- Not ruled out:
  - Mergers at earlier times
  - Mergers of higher mass dwarf galaxies

# Discussion

- Only 7 dSph's were studied
- Assumed to have always been in the dark matter halo

# Conclusion

- Kinematics can be used to distinguish different components
- dSph have different [$\alpha$/Fe], no stellar component in the Galaxy represents them
- Low [Y/Eu] in dSph's
- Na-Ni correlation for stars from the Galaxy, no good indicator of accretion

# Conclusion

- Formation of significant part of Milky Way from merging low-mass dSph's ruled out
- Other ways of hierarchical structure formation not ruled out
- Further research: large samples from individual dwarf galaxies

# Questions?