The Gaia DR2 and the Database of Metal-Poor Stars

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Shimako Yamada, Yutaka Katsuta (Hokkaido Univ.) et al.

Good memories of stars

Stars remember their birth conditions

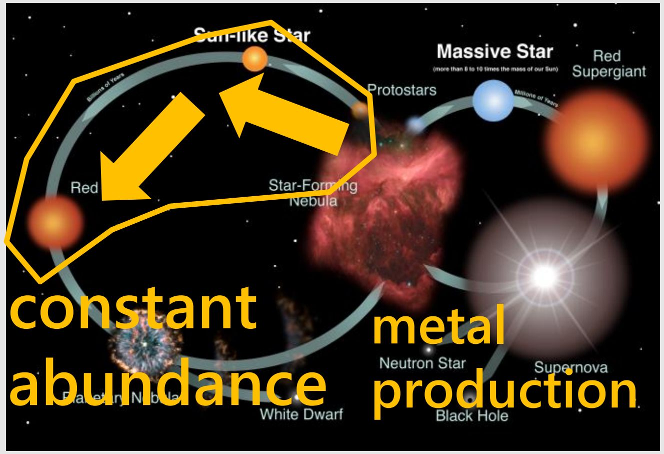
Stellar kinematics

assumptions
- negligible stellar interactions
- slowly changing gravitational potential with symmetry

There are should be conserved quantities

Stellar chemical abundances

abundance of 10Gyr-old stars
= abundance of ISM 10Gyr ago,
reflecting star formation before



Stars ➡ the Galaxy

To understand the halo formation from chemo-dynamical analysis of (very) metal-poor stars

Why metal-poor stars?

How do we study and where can we get chemical abundances and kinematics?

Metal-Poor Stars

metal-poor = old
(the Universe started without metals)

Very Metal-poor stars ([Fe/H]<-2.0)

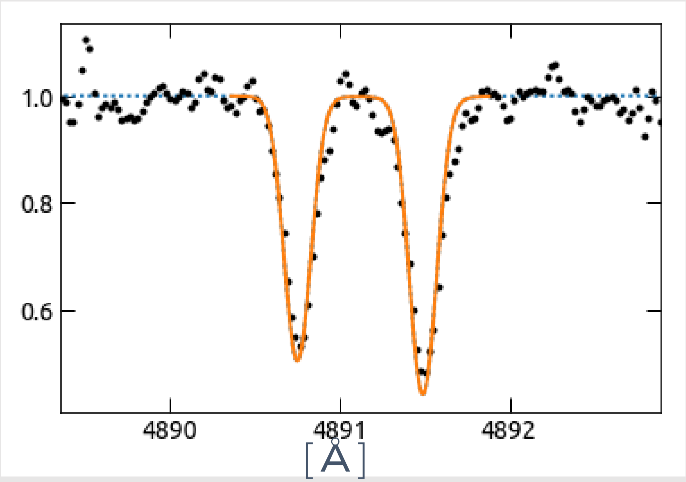
- almost as old as the Galaxy (~10Gyr old)
- mostly found in the Galactic stellar halo

Tell us about the very beginning of the Galaxy/halo formation

Note: $[X/Y] = \log \frac{N_X}{N_Y} - \left(\log \frac{N_X}{N_Y} \right)_{\odot}$

Chemical Abundances

How do we get chemical abundance of stars?



Absorption lines in stellar spectra

Requirements

- high resolution (R>20,000)
- high S/N (S/N>20)

Expensive observation

SAGA database

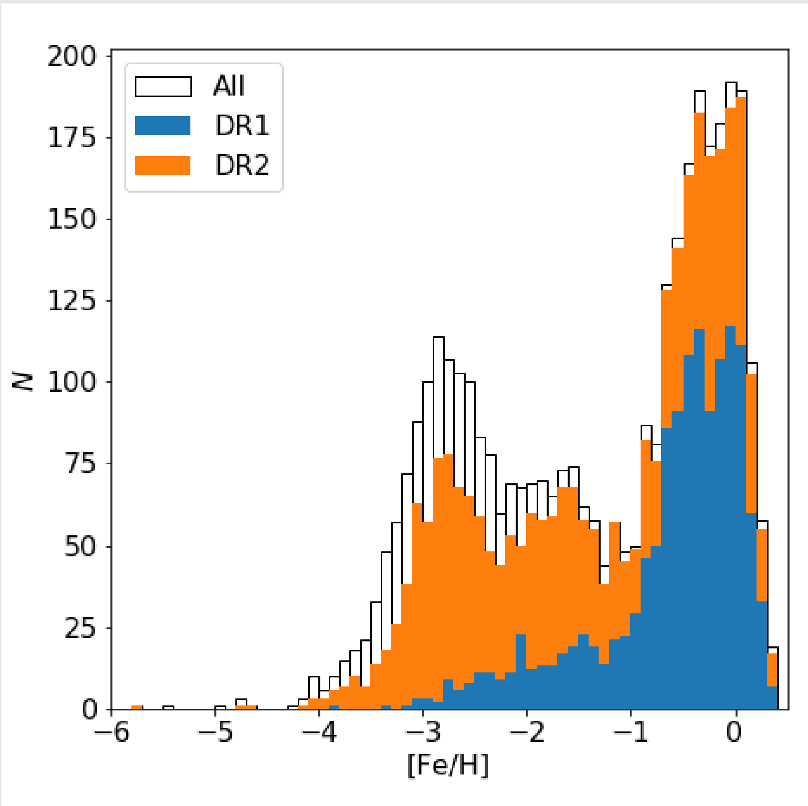
Suda et al. (2008, 2011, 2017) Yamada et al. (2013)

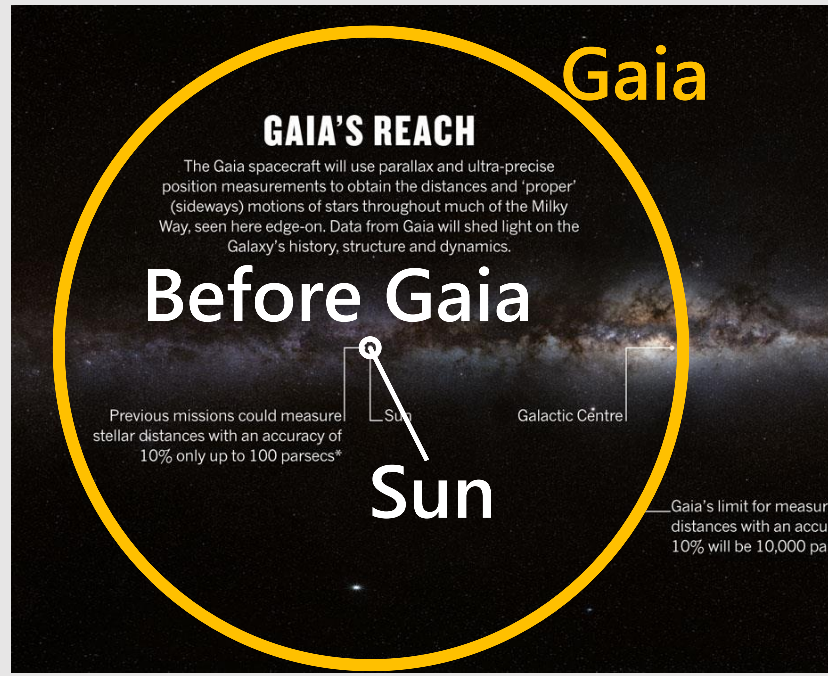
Stellar Abundances for Galactic Archaeology Database

- Compilation of abundance measurements for very metal-poor stars in literatures
- **>1300 very metal-poor stars** in >300 literatures

Stellar kinematics

After Gaia DR2, on April 25, 2018





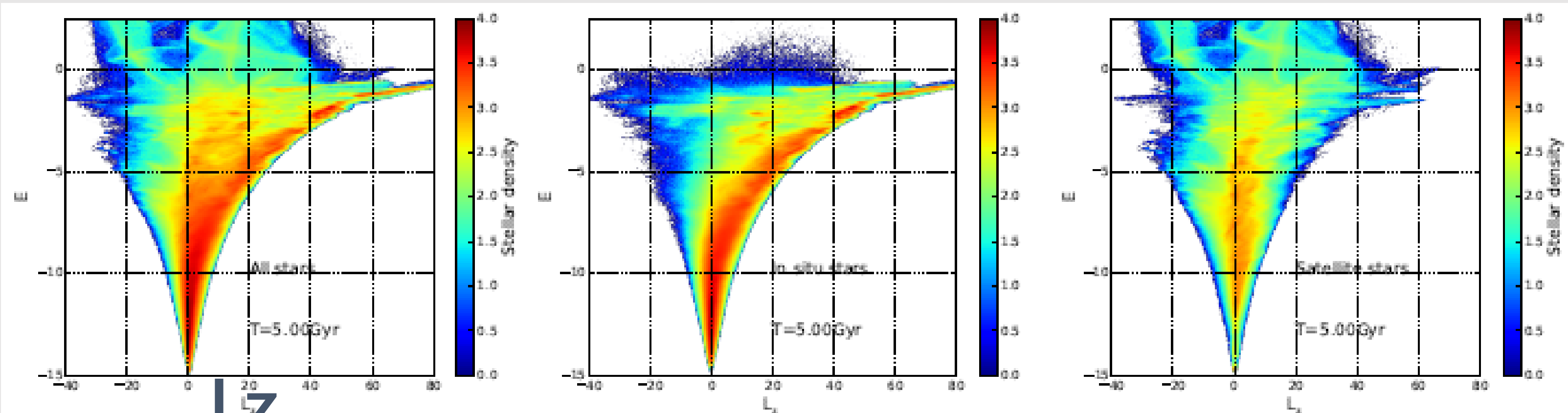
Gaia: space telescope for astrometry

We are now able to explore chemo-dynamics of very metal-poor stars for the first time

Kinematics and abundances in halo

Stellar kinematics in the halo

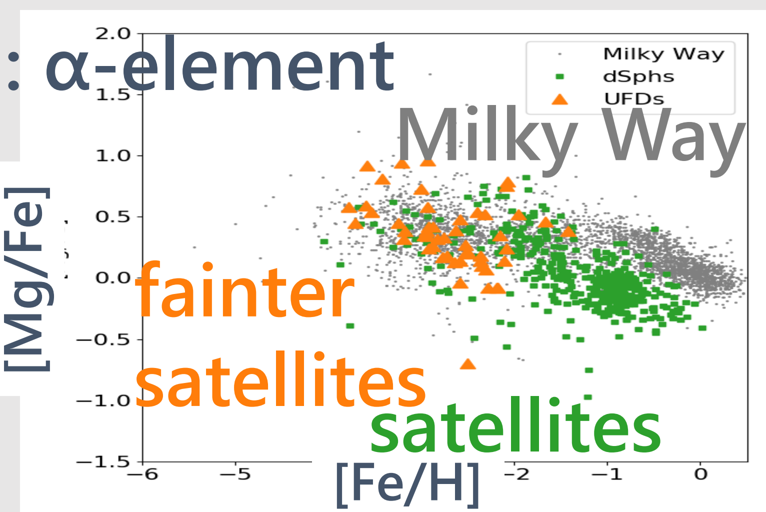
5Gyr after satellite accretion in N-body simulation by Jean-Baptiste et al. (2017)



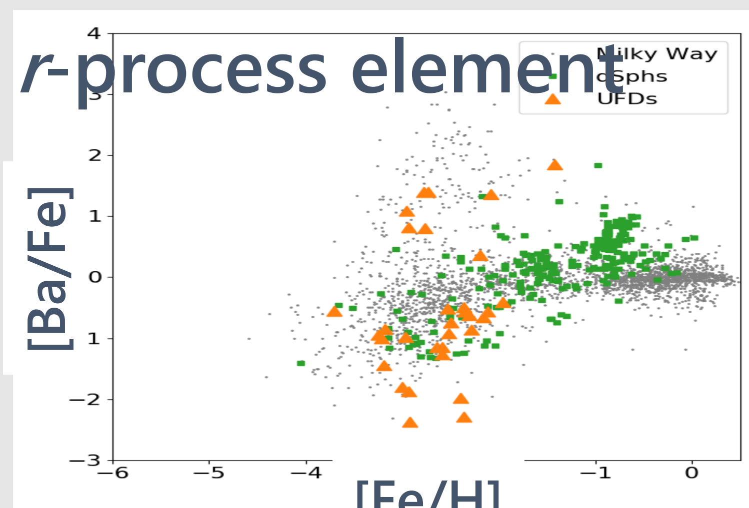
Stellar chemical abundances

data from SAGA database

Mg: α-element



Ba: *r*-process element



Results

Global property

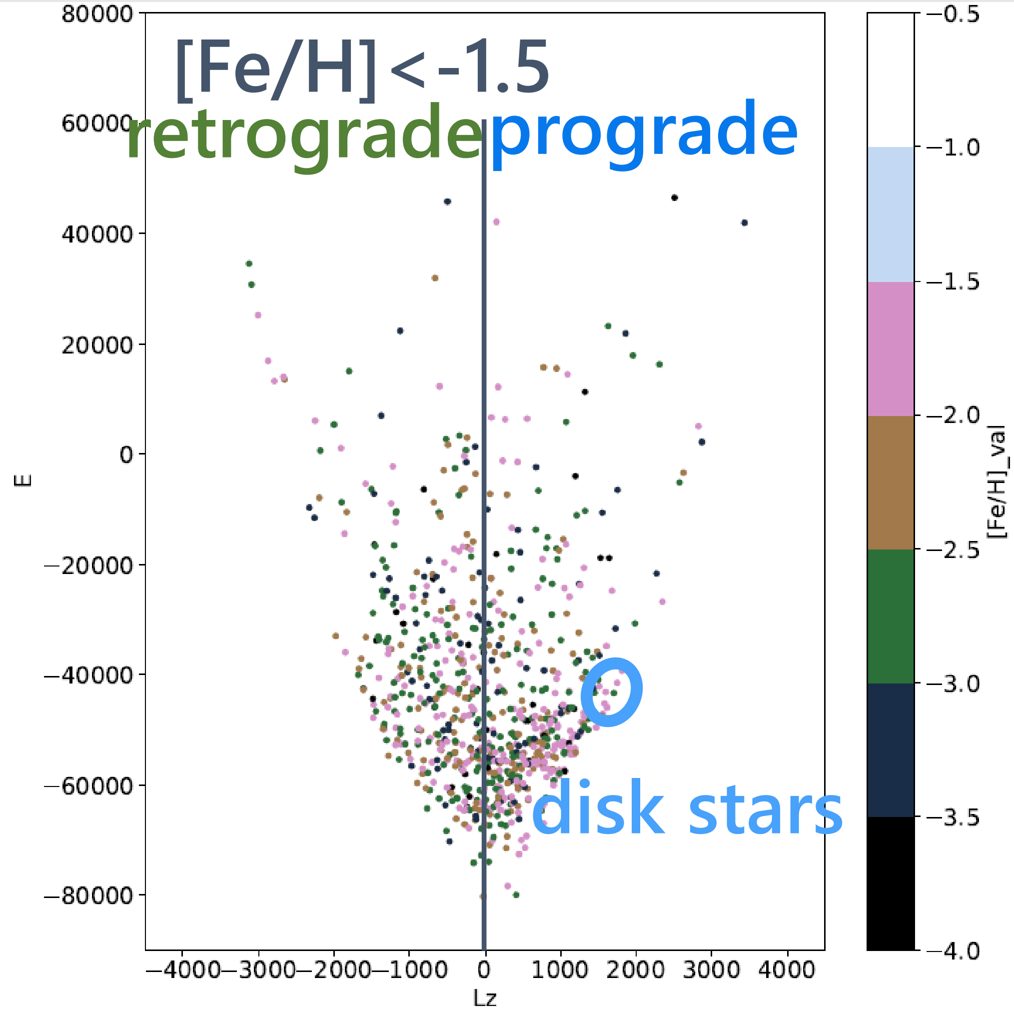
↓

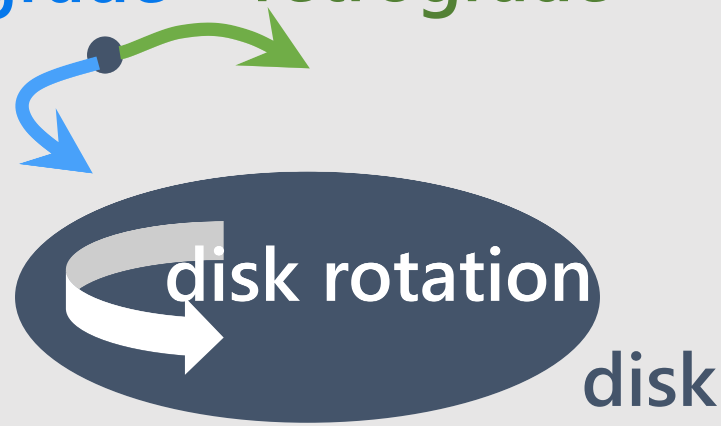
Two components

↓

Substructures

Global property of metal-poor stars



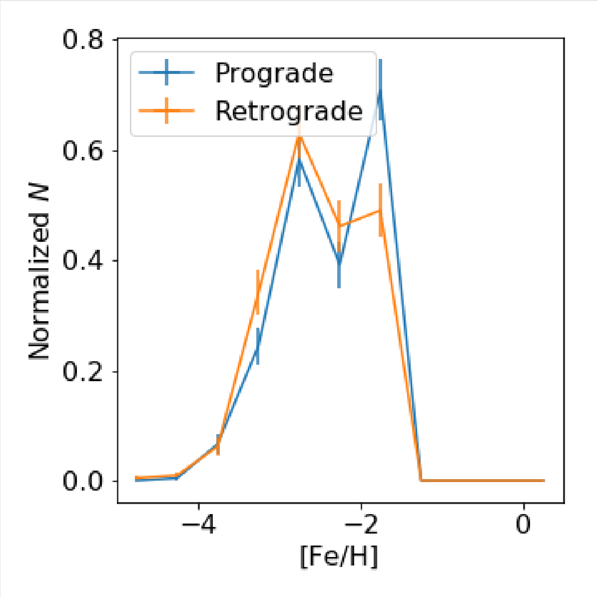


No overdensity associated with the disk

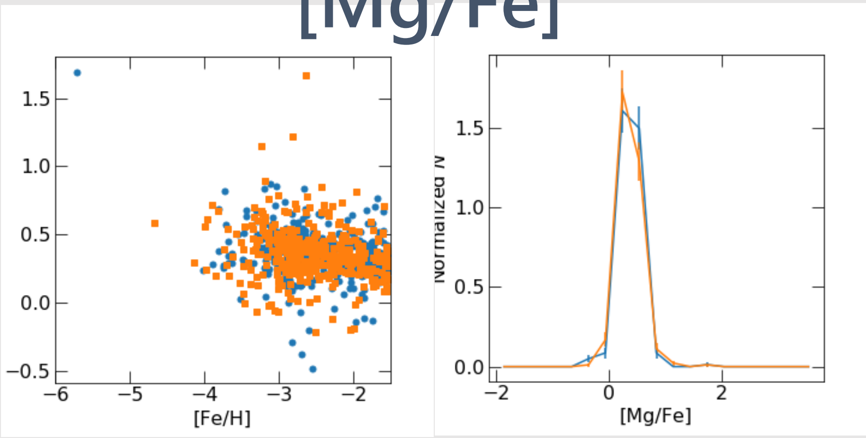
There would be a metallicity above which disk formation has started

Abundances of prograde/retrograde halo

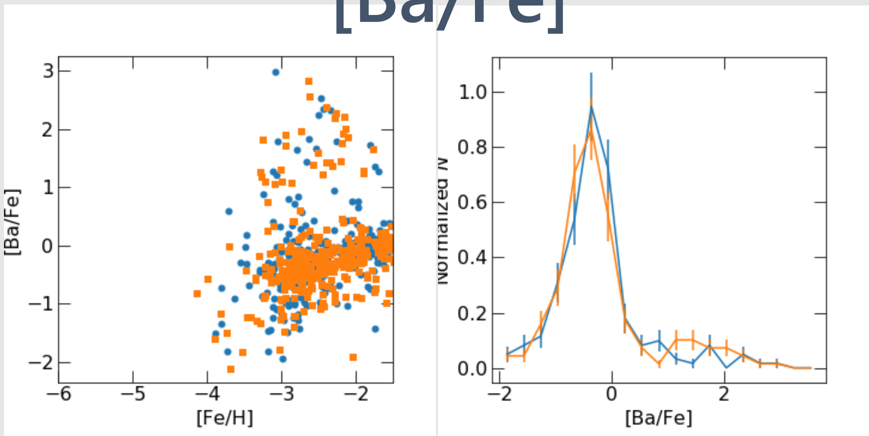
Metallicity difference



[Mg/Fe]



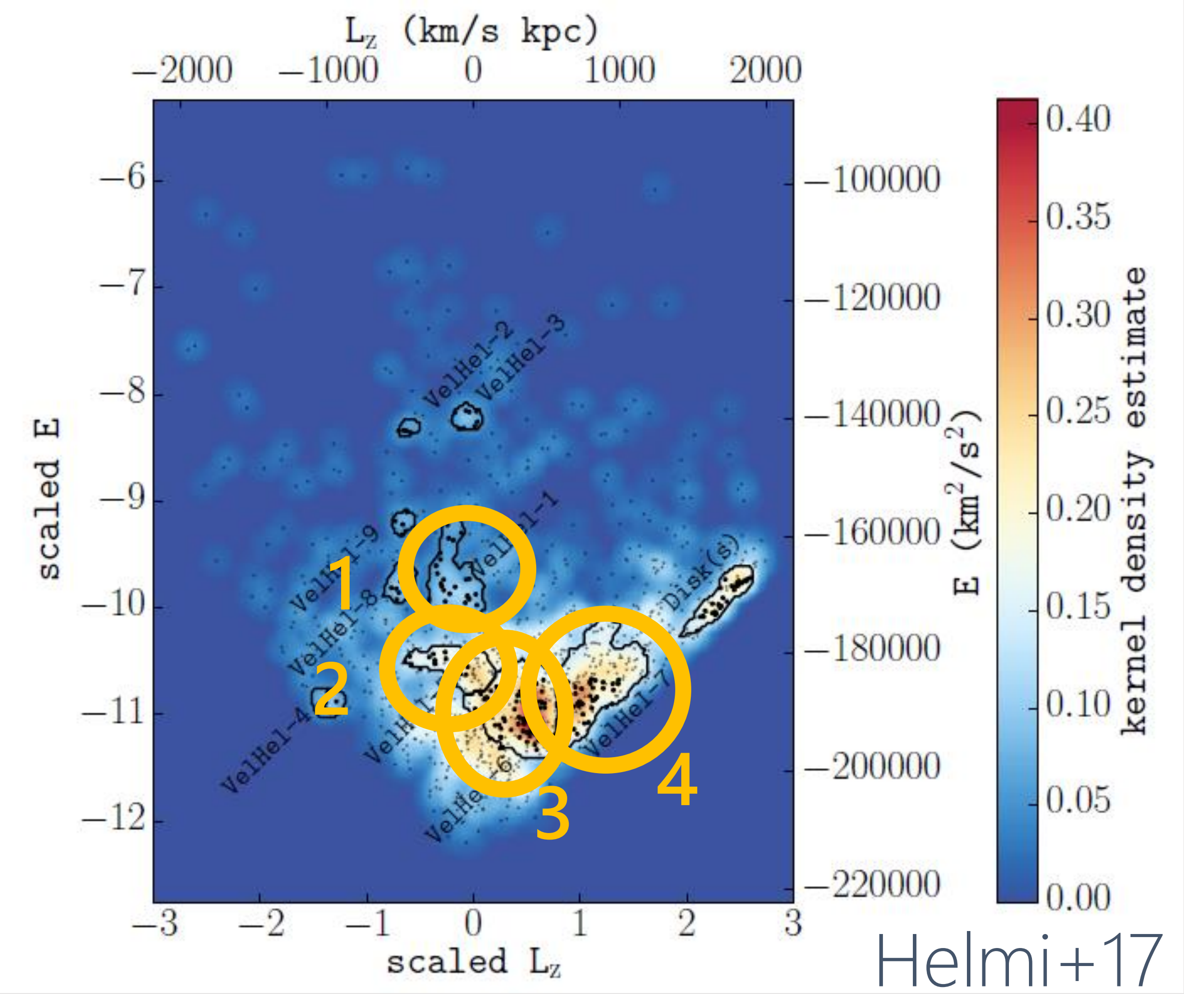
[Ba/Fe]



Lack of abundance difference at [Fe/H]<-2

The metal-poor component has formed in a similar way between prograde/retrograde halo

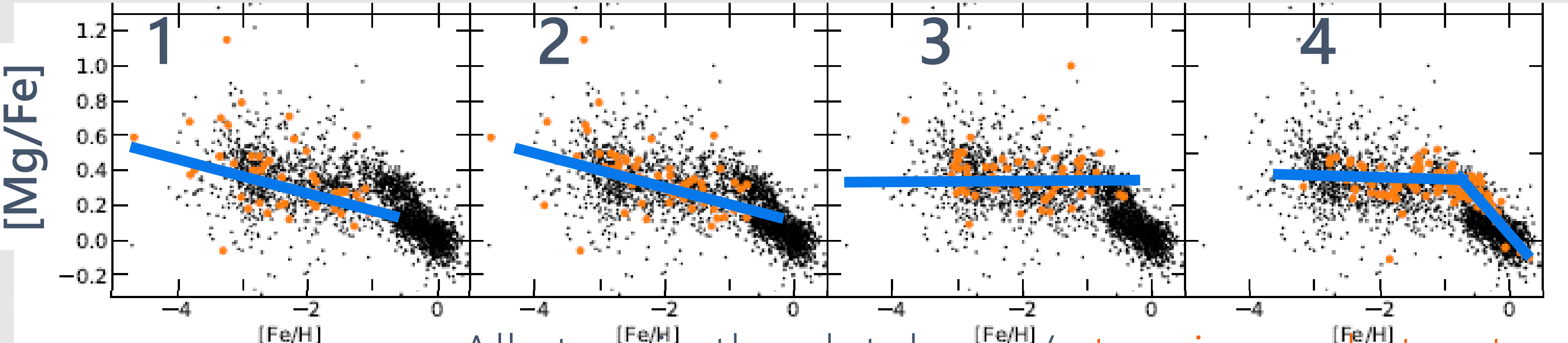
Known Substructures in the Halo



Helmi+17

What are the origins of the substructures?

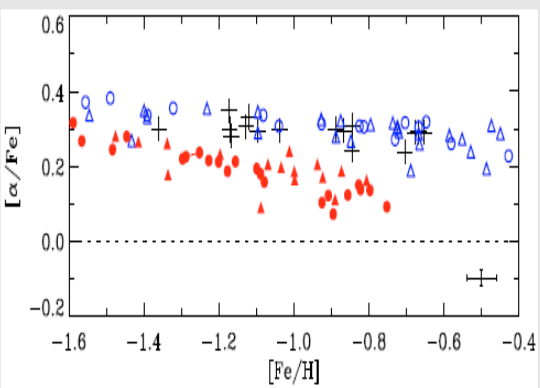
Mg abundance of substructures

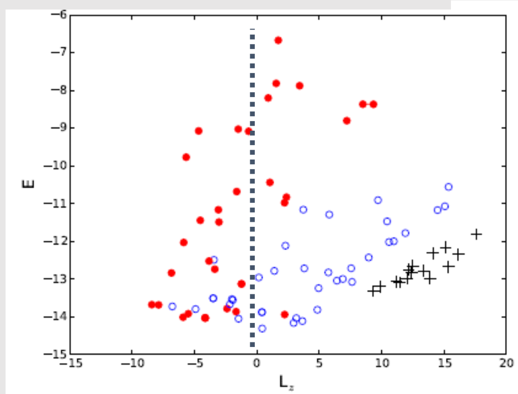


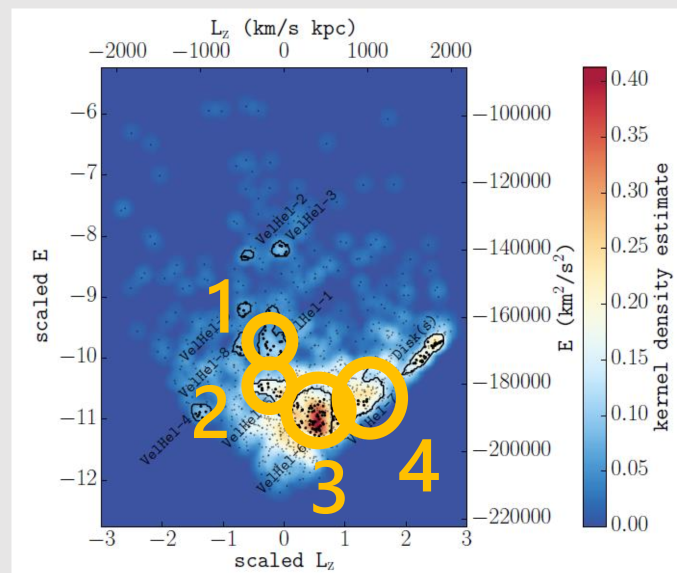
All stars in the database / stars in a substructure

Prograde substructures have higher [Mg/Fe], meaning they have formed in Milky Way

Similar picture in Nissen&Schuster 10

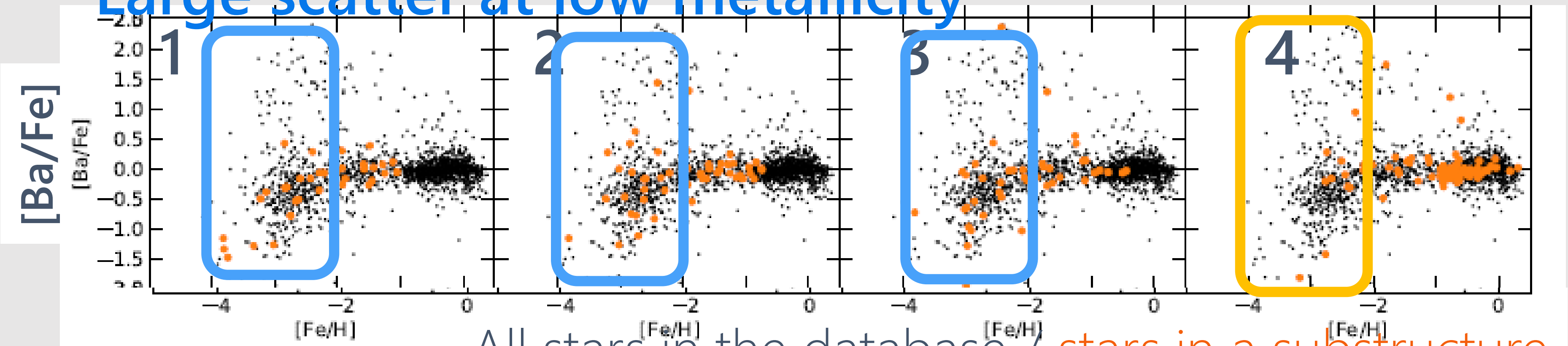






Ba abundance of substructures

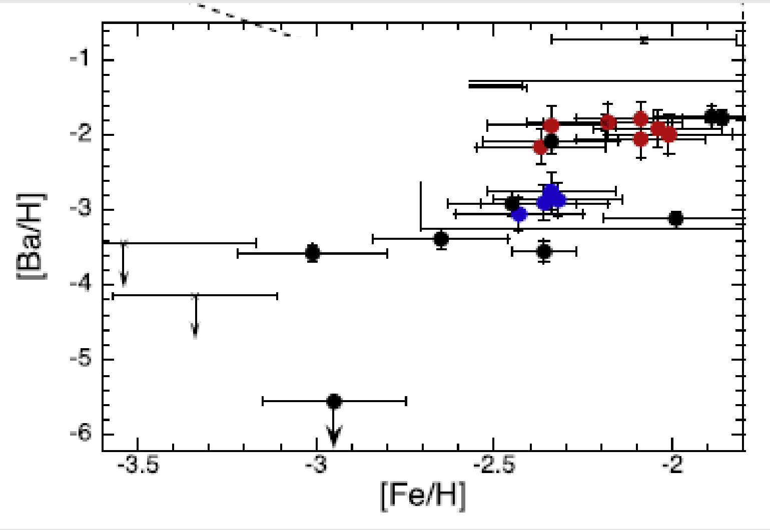
Large scatter at low metallicity

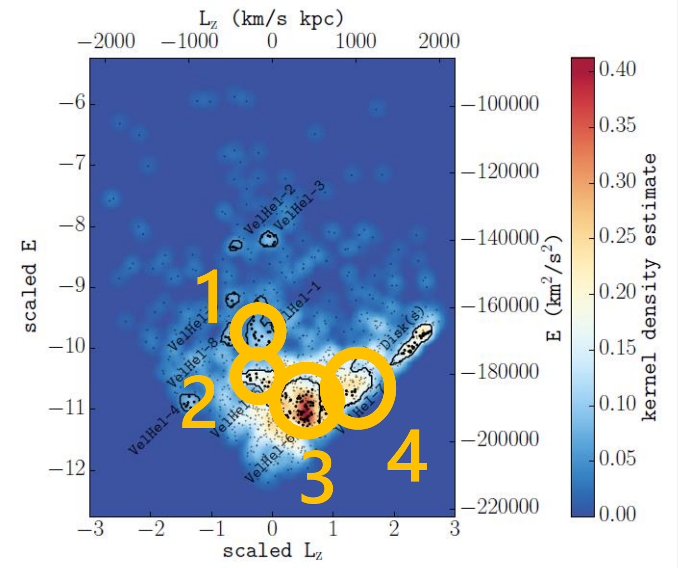


All stars in the database / stars in a substructure

A possible signature of "[Ba/Fe]" jump

Similar feature in a dwarf galaxy





Tsujimoto, Matsuno, et al. (2017)

Conclusion

First chemo-dynamical analysis for a large number of very metal-poor stars are conducted

Indications to the early phase of the Galaxy formation

- Disk formation has started above a certain metallicity

- The metal-poor component of the prograde/retrograde haloes seems to have formed in a similar way

- The most prograde kinematic substructure might be a mixture of stars formed in Milky Way and those formed in a dwarf galaxy

Future

Gaia DR2 are excellent!!

we could utilize a large potion of stars in SAGA database

Still, any chemical signatures are, at most, week

Limitations:

Abundance precision

Systematic errors could have blurred signatures

➡ **LAMOST-Subaru survey of 400 metal-poor stars**

(H.-N. Li, W. Aoki, T. Matsuno et al.)

Number of stars

cf. 400 stars in 20 Subaru nights

➡ abundance determination from lower-res. spectra