METAL-POOR STARS

as witnesses for the first steps of the Milky Way assembly history

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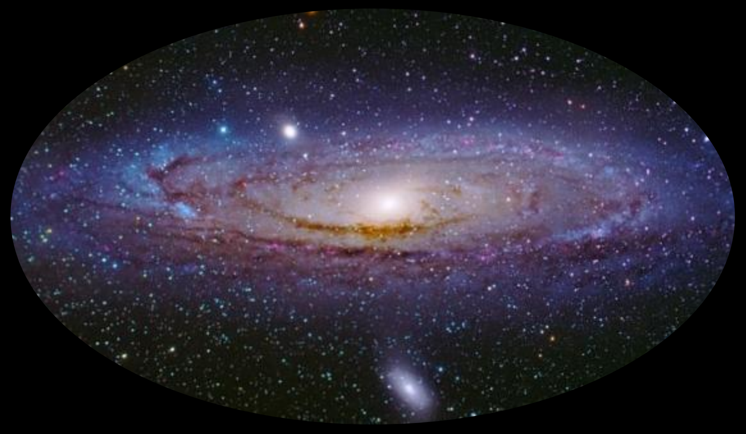
Starring:

Milky Way



What happened at the very beginning of the **Milky Way** formation?

WANTED

Metal-poor stars

REWARD: knowledge

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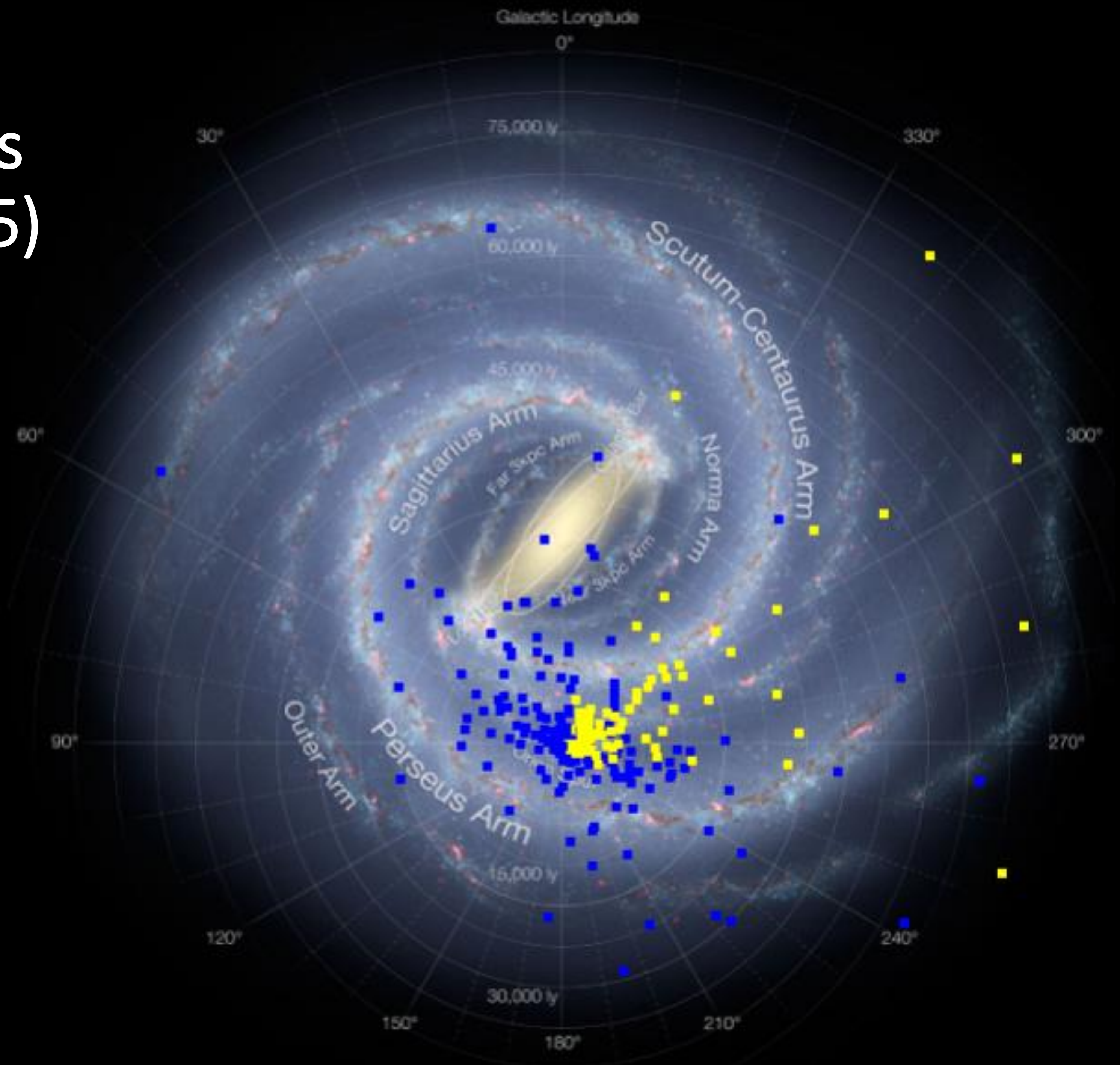
Metal-poor stars

CHARGES:
Chemical composition consistent with the initial phases of the star formation from the pristine gas

REWARD: knowledge

253 metal-poor stars (Barklem et al., 2005)



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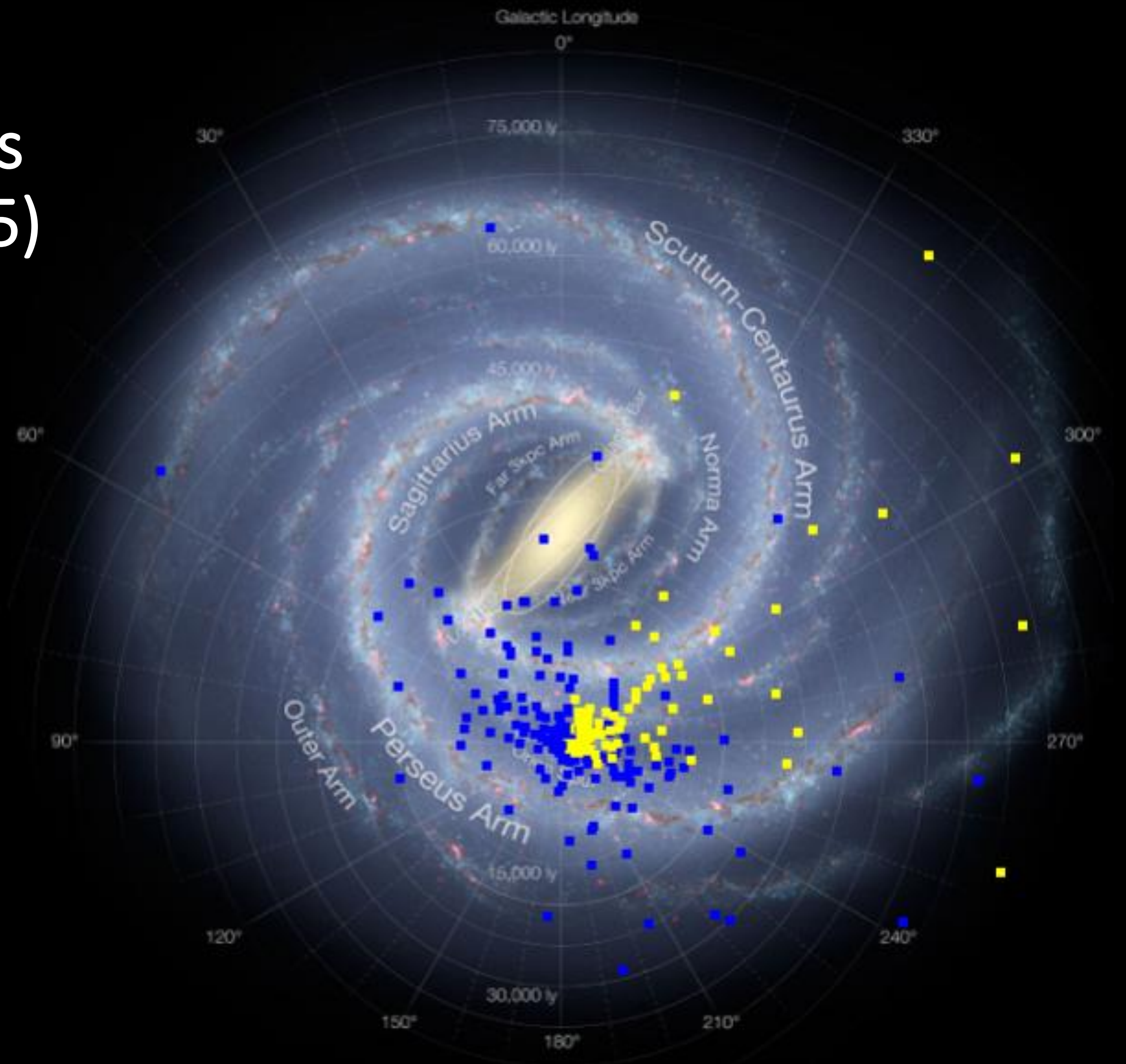
1. $\left[\frac{Fe}{H}\right] <$ -1.5



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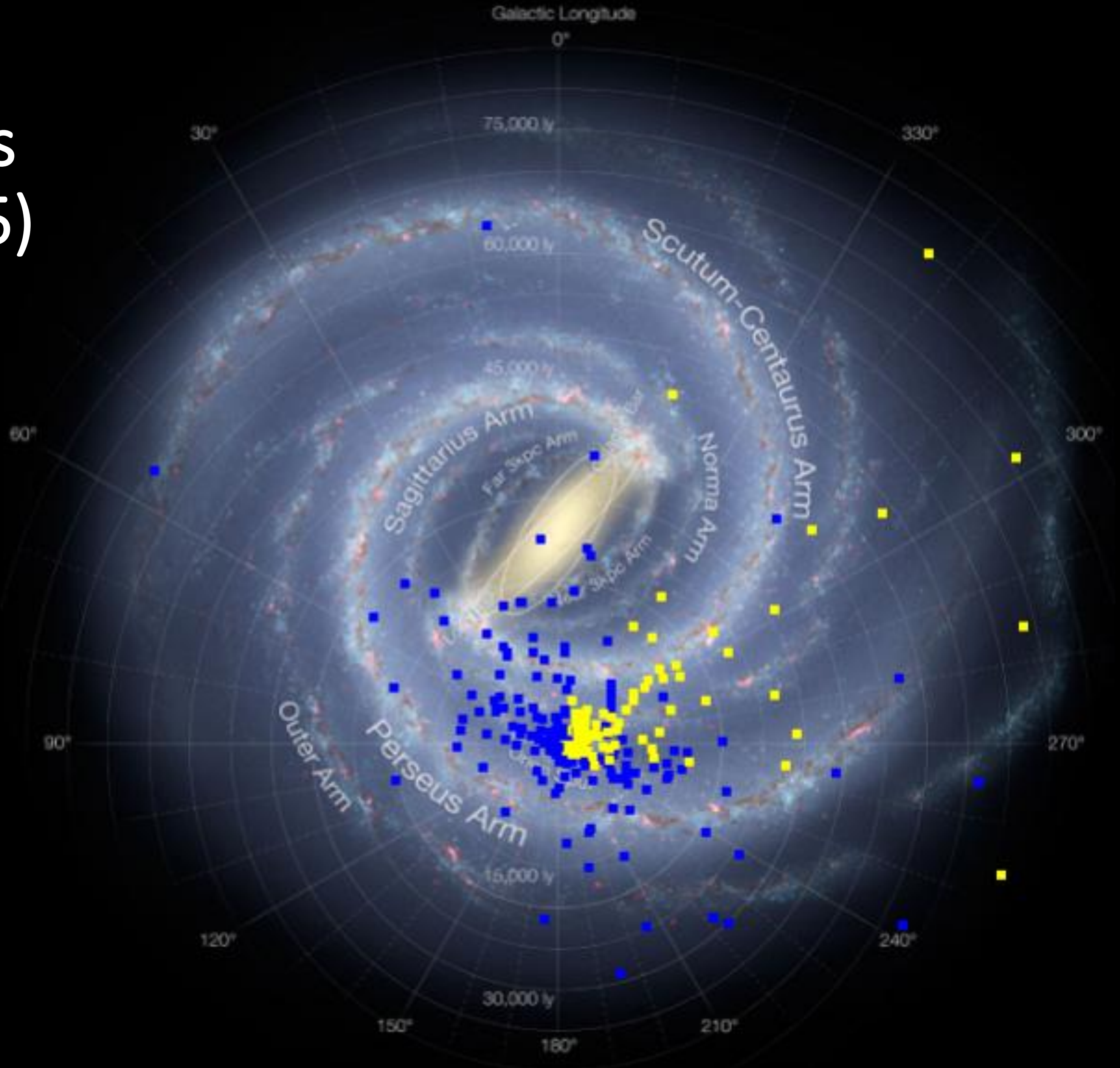
1. $\left[\frac{Fe}{H}\right] <$ -1.5

2. $|b| > 20^o$

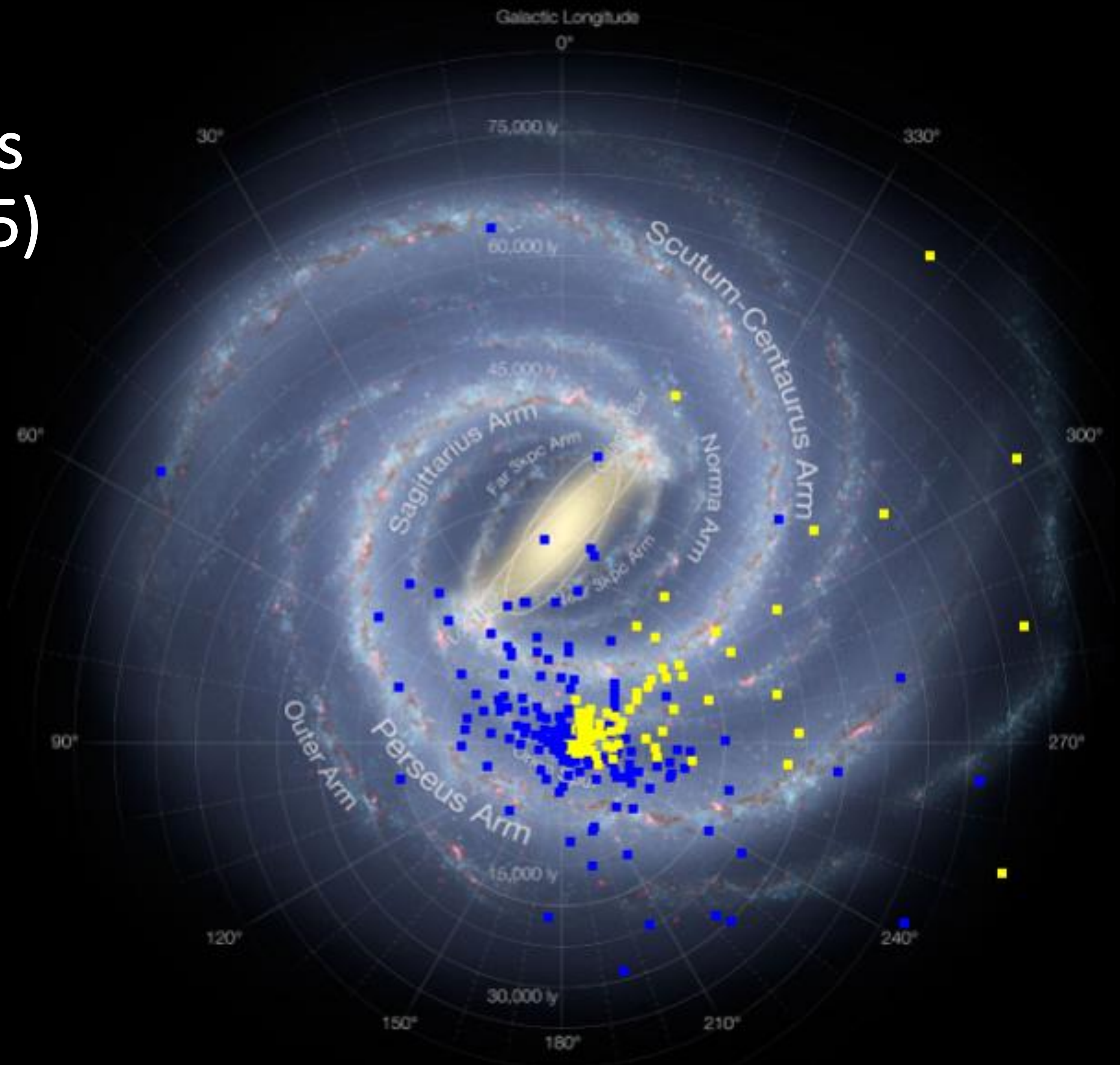


253 metal-poor stars (Barklem et al., 2005)

1. $\left[\frac{Fe}{H}\right] <$ -1.5

2. $|b| > 20^{o}$

3. 22 elemental abundances

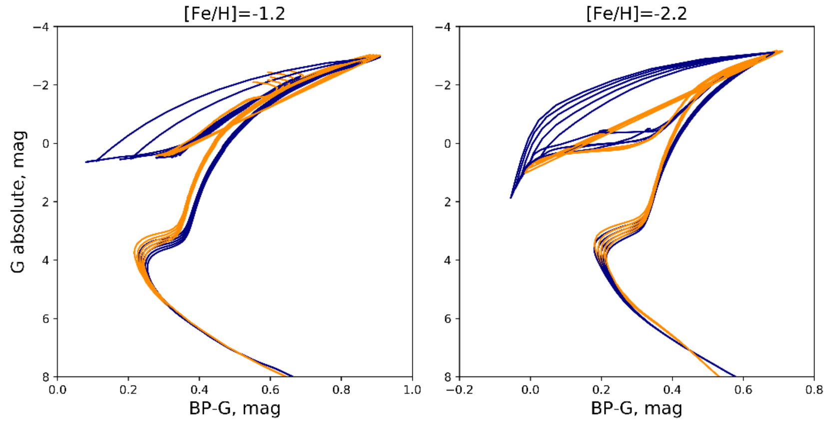


AGE

Isochrone fitting

Age

Padova and BaSTI isochrones



Age

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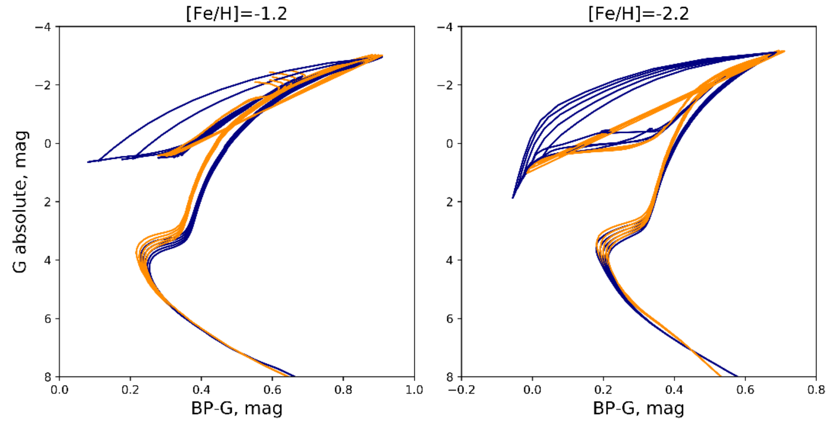
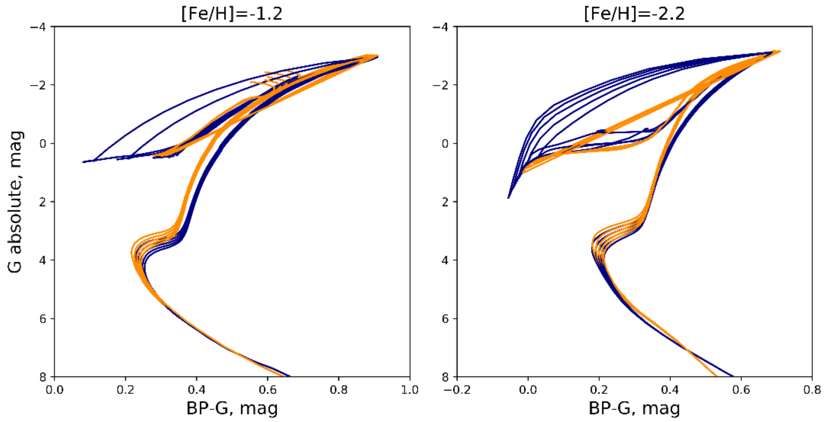


Metallicity correction:

Salaris et al. 1993

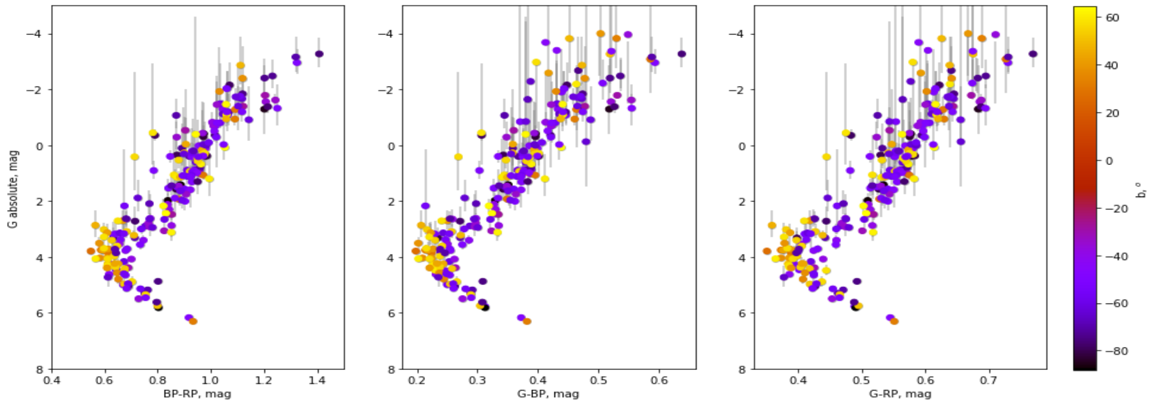
Age

Padova and BaSTI isochrones



Gaia photometry:

G, BP-RP; G, BP-G; G, G-RP



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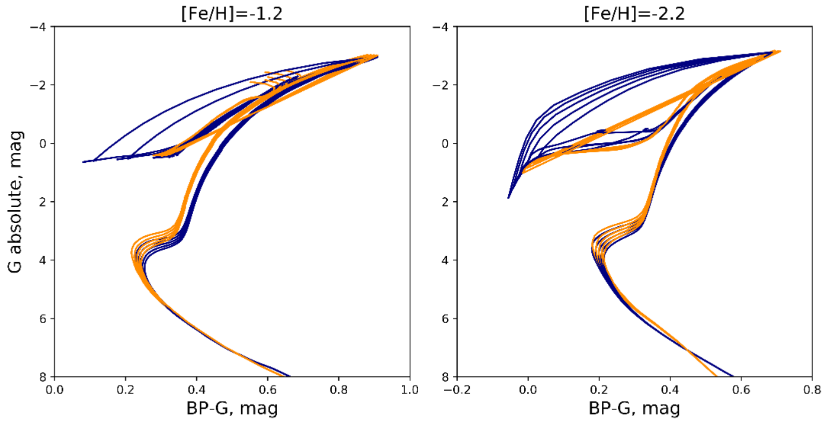

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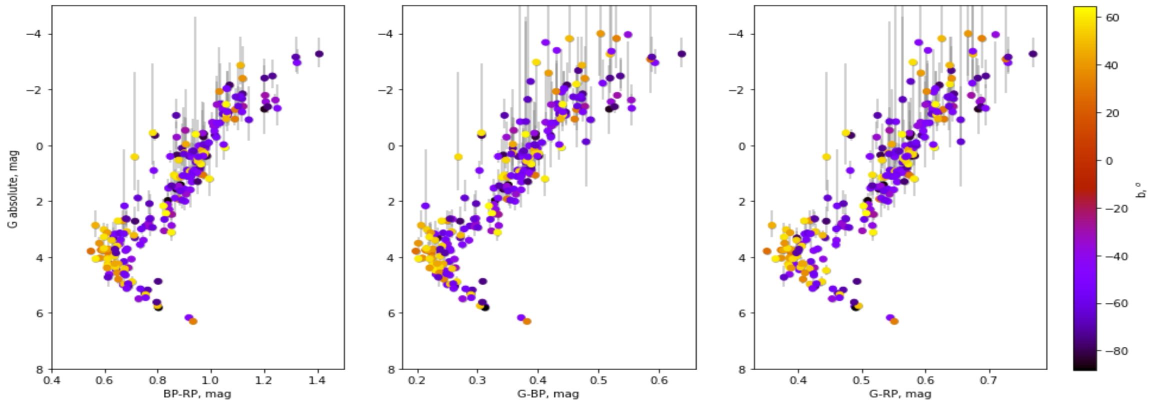

Metallicity correction:

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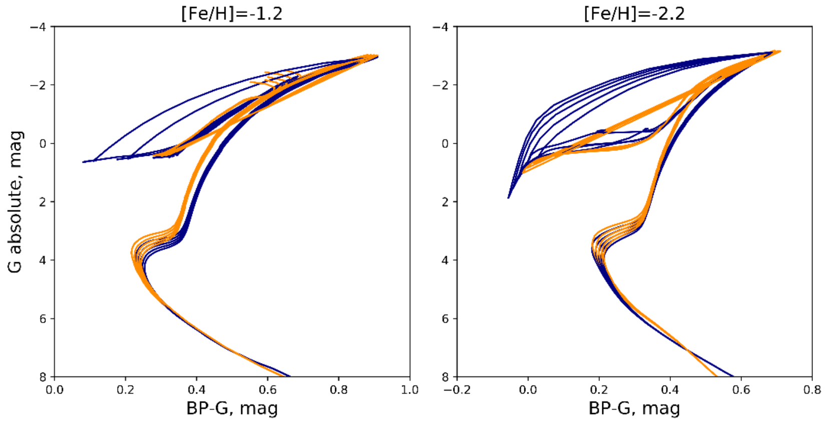
Distance:

Gaia parallaxies

Age

Padova and BaSTI isochrones



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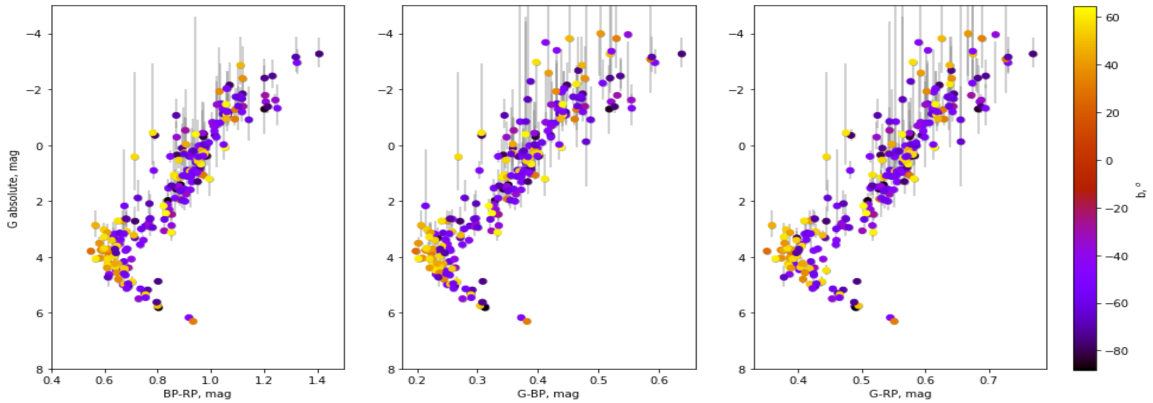

Metallicity correction:

Salaris et al. 1993

Distance:

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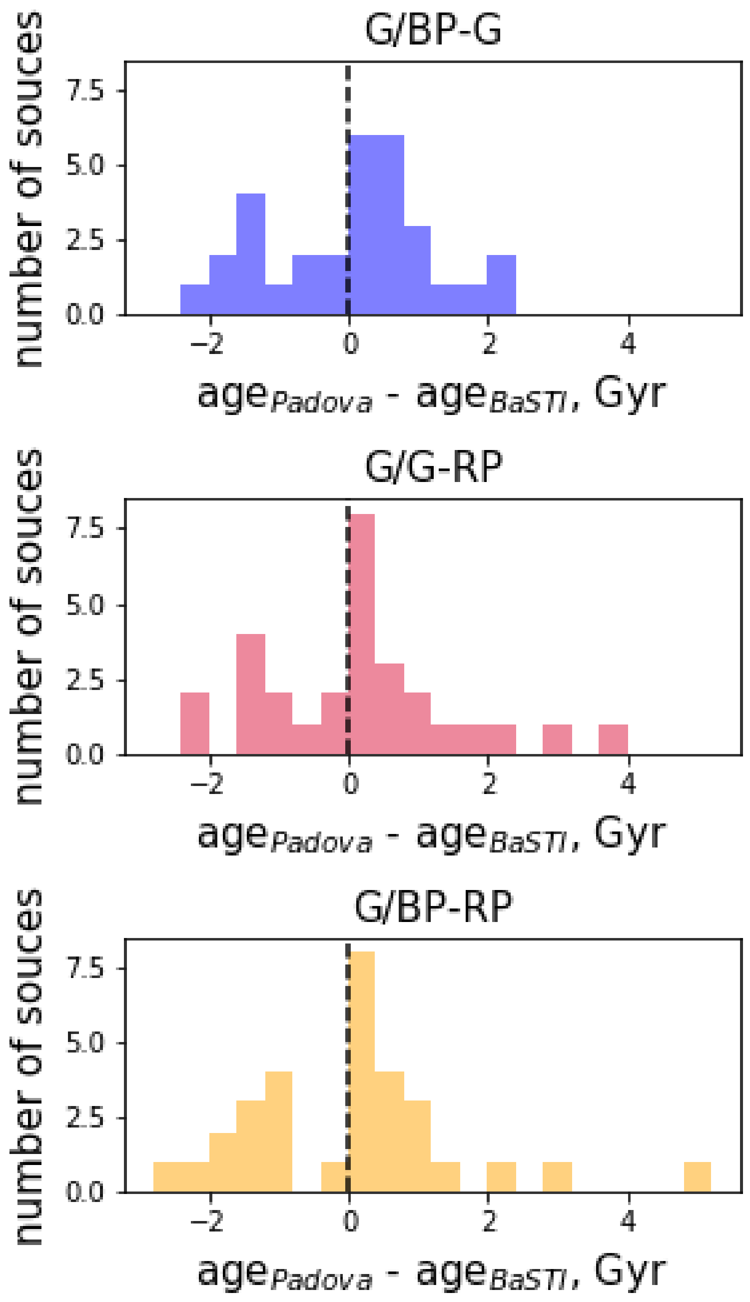
Reddening:

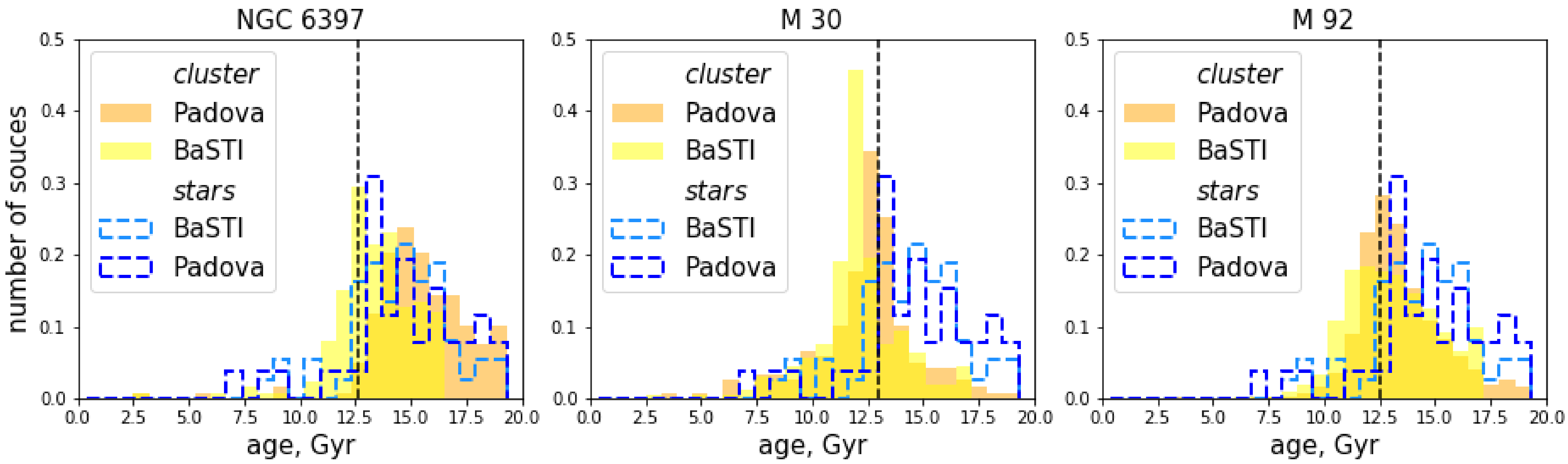
Green et al. 2018
Lallement et al. 2018 ext. by
Montalto et al. 2022

Isochrones are an additional source for uncertainties



Comparison with metal-poor GC: NGC 6397, M 30, M 92

Name	$[\frac{Fe}{H}]$ dex	age Gyr	π mas	A_v mag
NGC 6397	-1.99	12.6	0.397	0.614
M 30	-2.3	13.0	0.117	0.170
M 92	-2.3	12.5	0.108	0.072



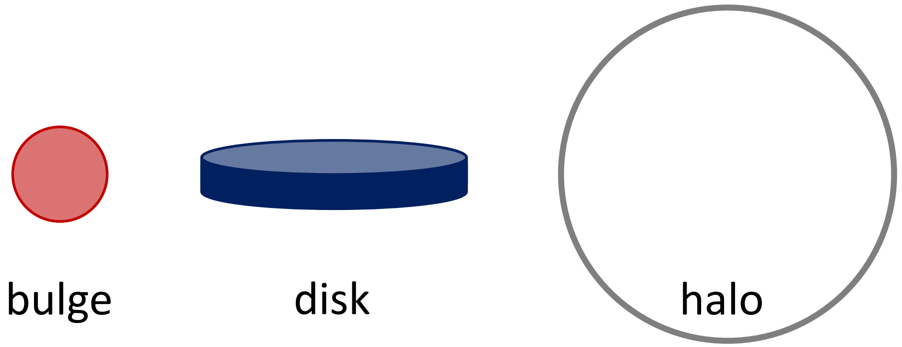
2

Kinematics

Galactic axisymmetric potential

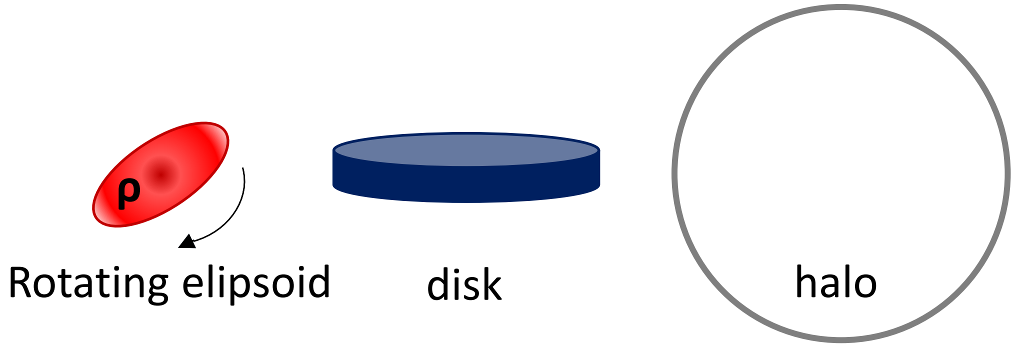
McMillan (2017)

implementation in galpy



Galactic non-axisymmetric potential

McMillan (2017) + non-axisymmetric elongated bar/bulge component:



Ferrer's formula:

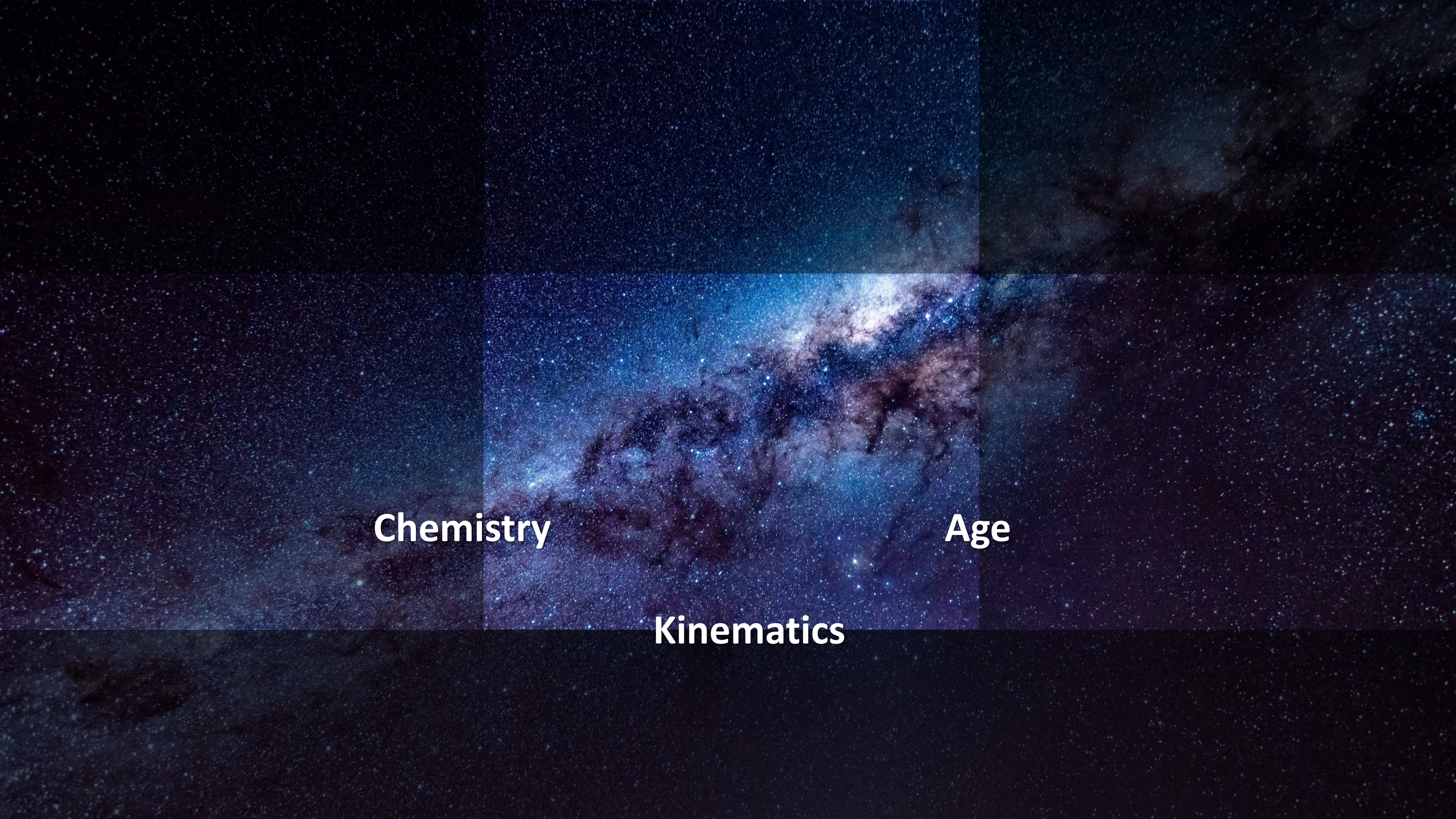
$$\rho(x, y, z) = \begin{cases} \rho_c (1 - m^2)^2 & \text{if } m < 1, \\ 0 & \text{if } m > 1, \end{cases}$$

3

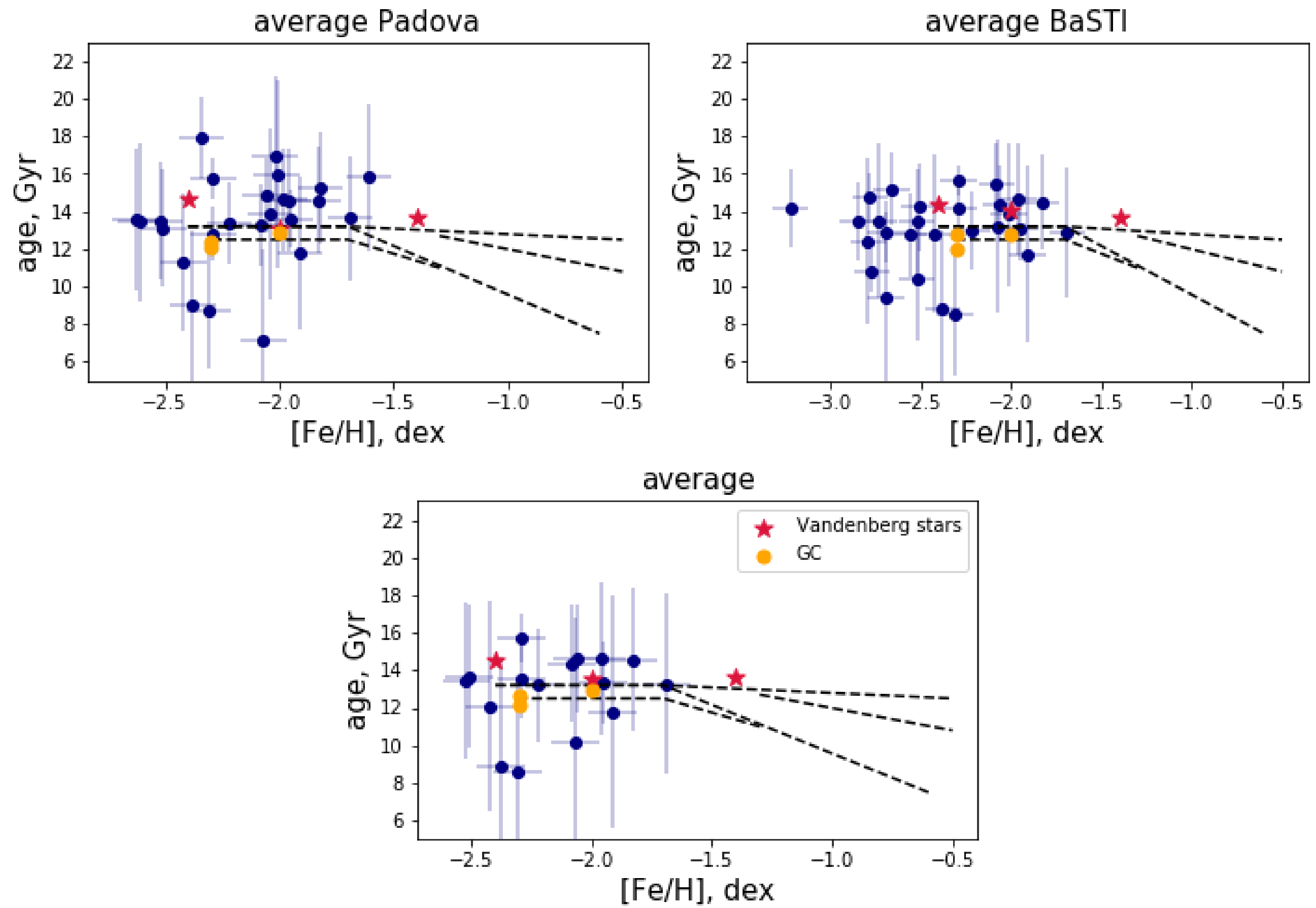
Results

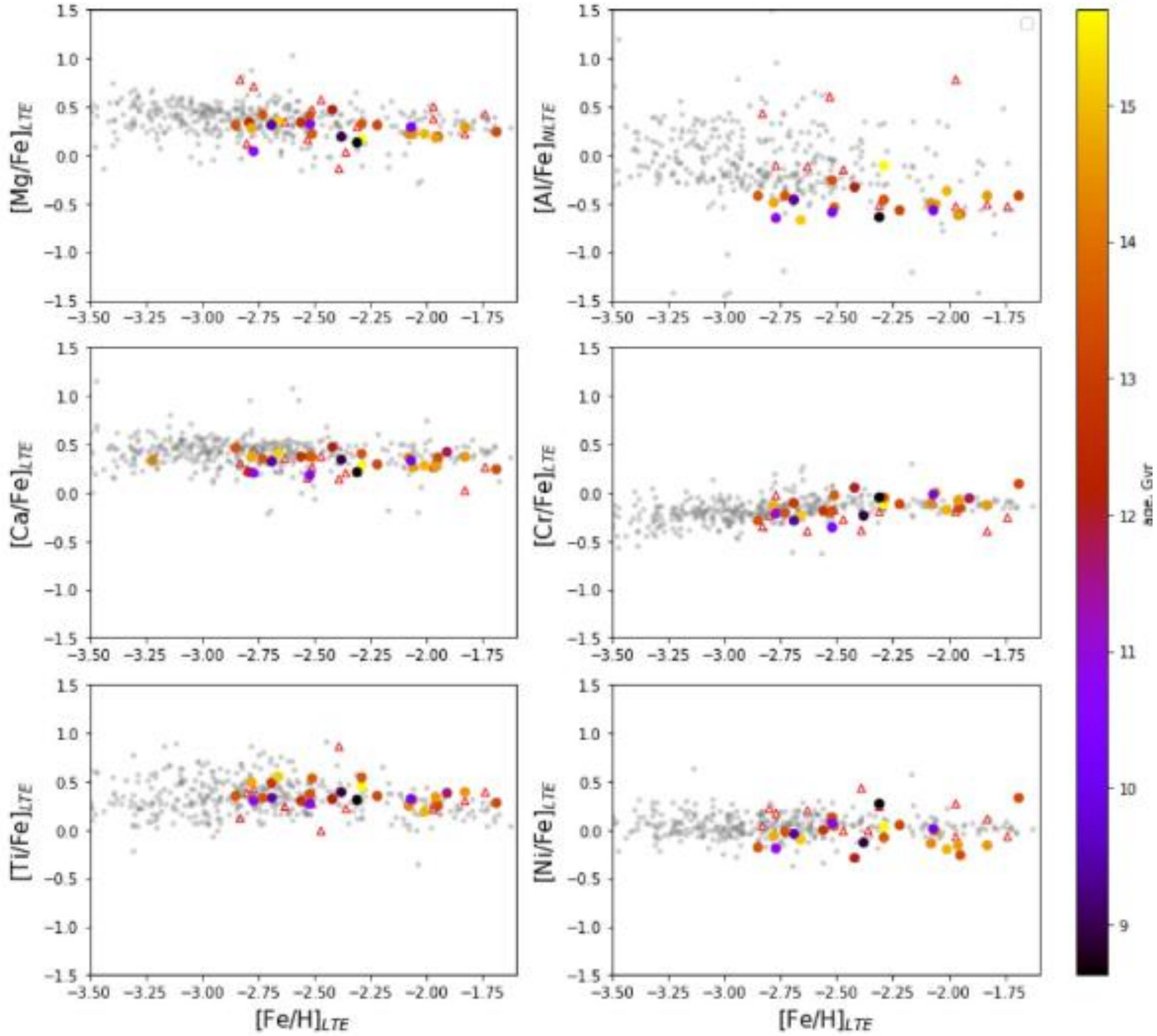
Chemistry


Chemistry
Age


Chemistry
Age
Kinematics

Age-metallicity relation

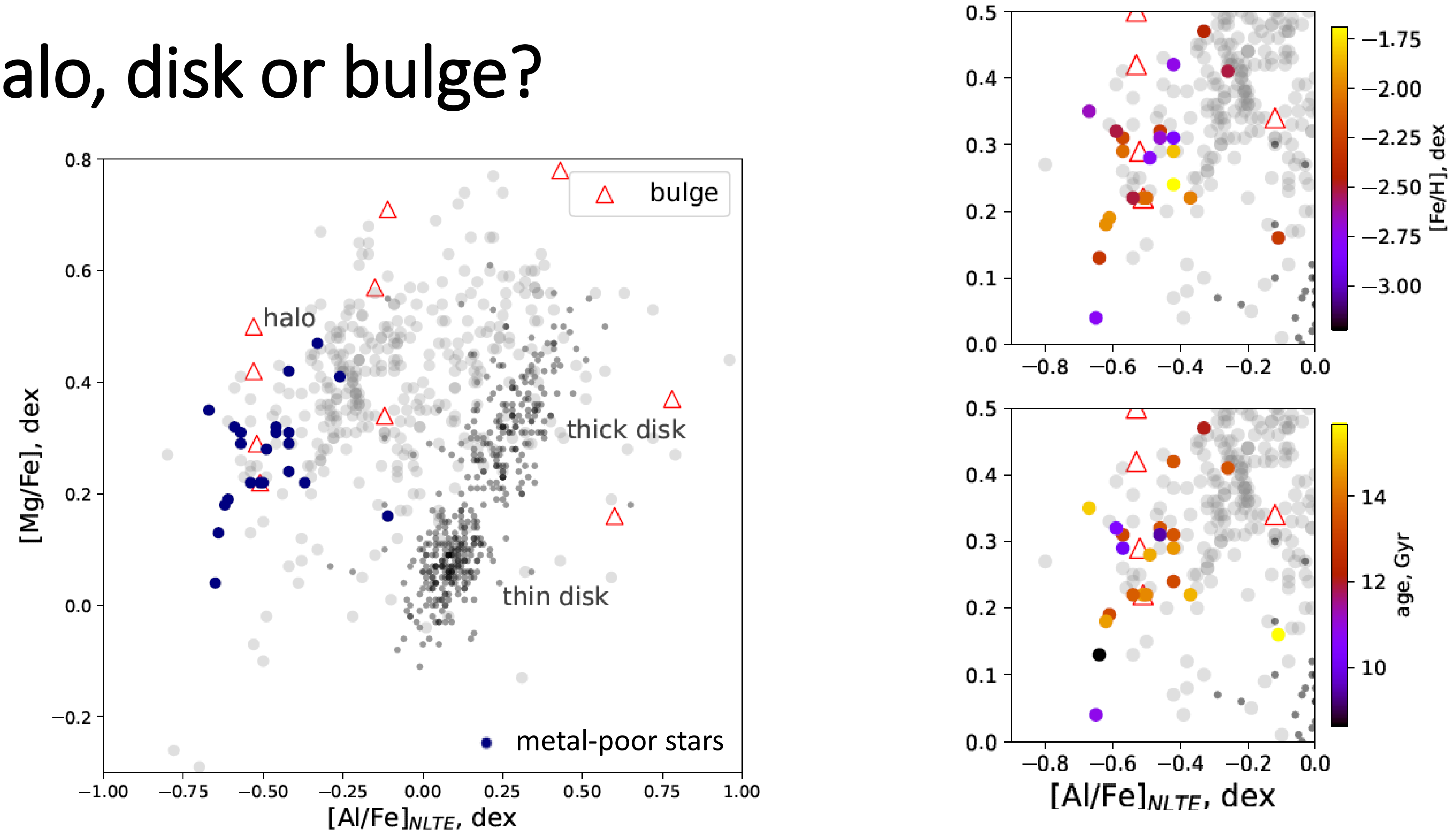




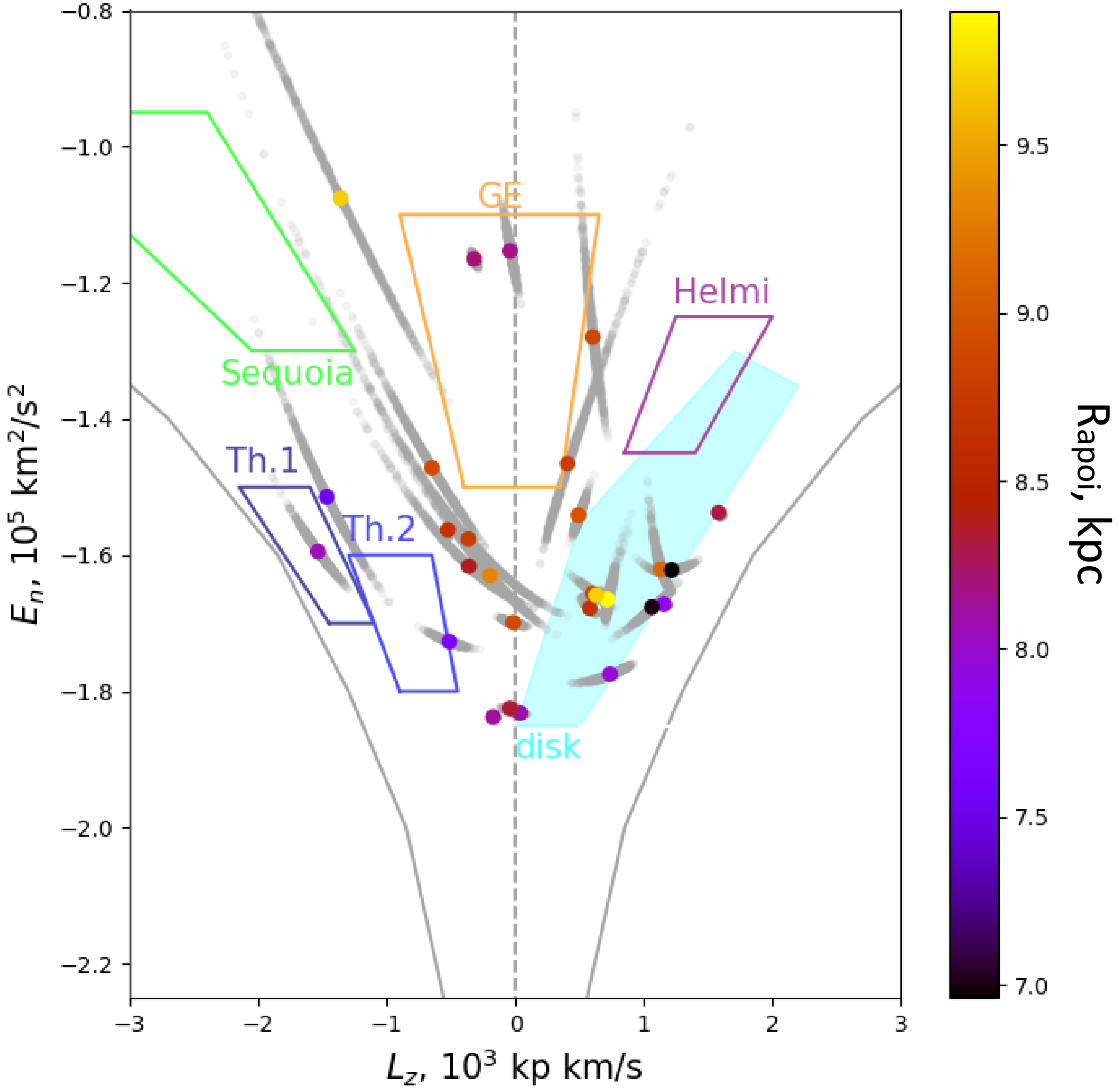
Chemistry in general

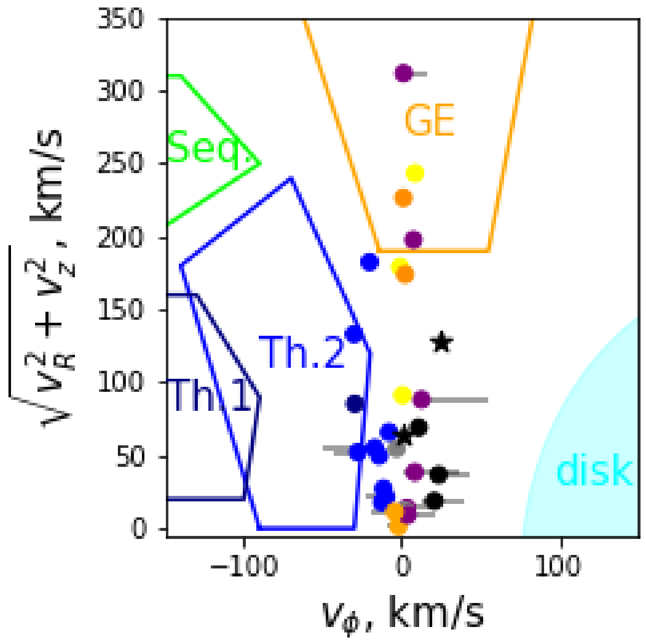
1. All stars follow **typical trends for Milky Way stars**
2. **Only Al is out for 0.2 dex** due to new way of non-LTE correction (Nordlander et al., 2017)

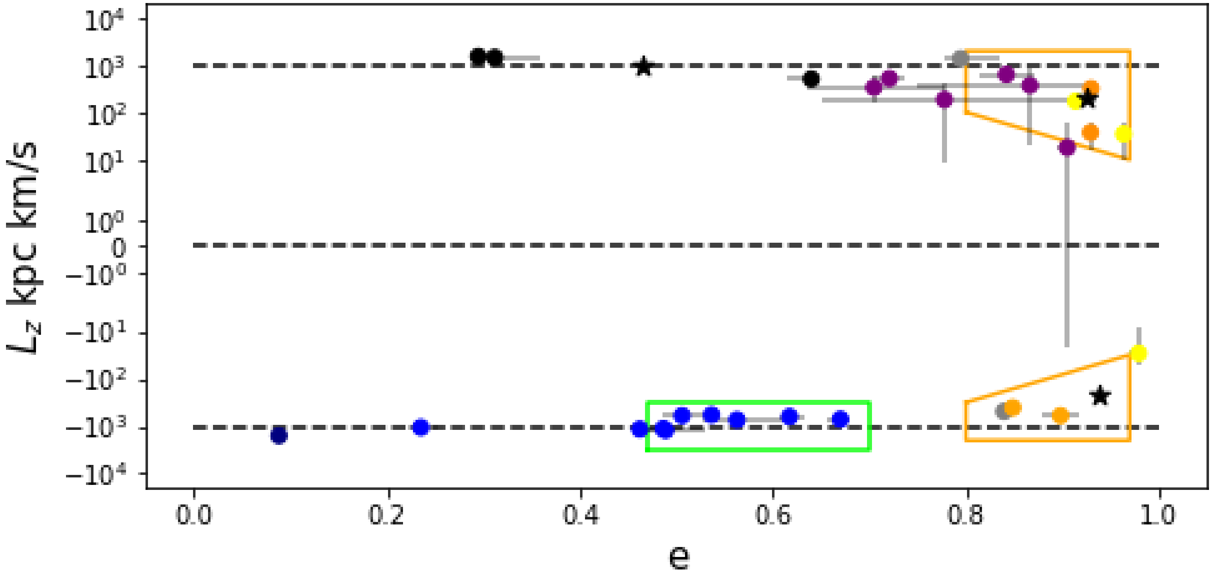
Halo, disk or bulge?



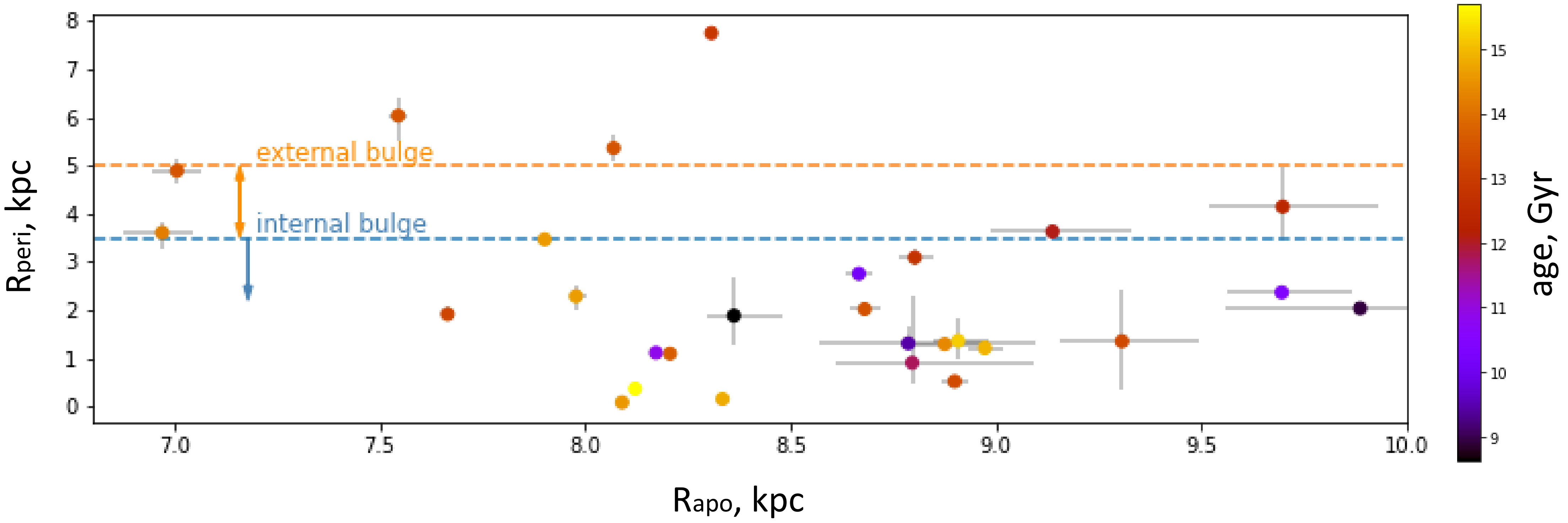
In-situ halo or accreted events?



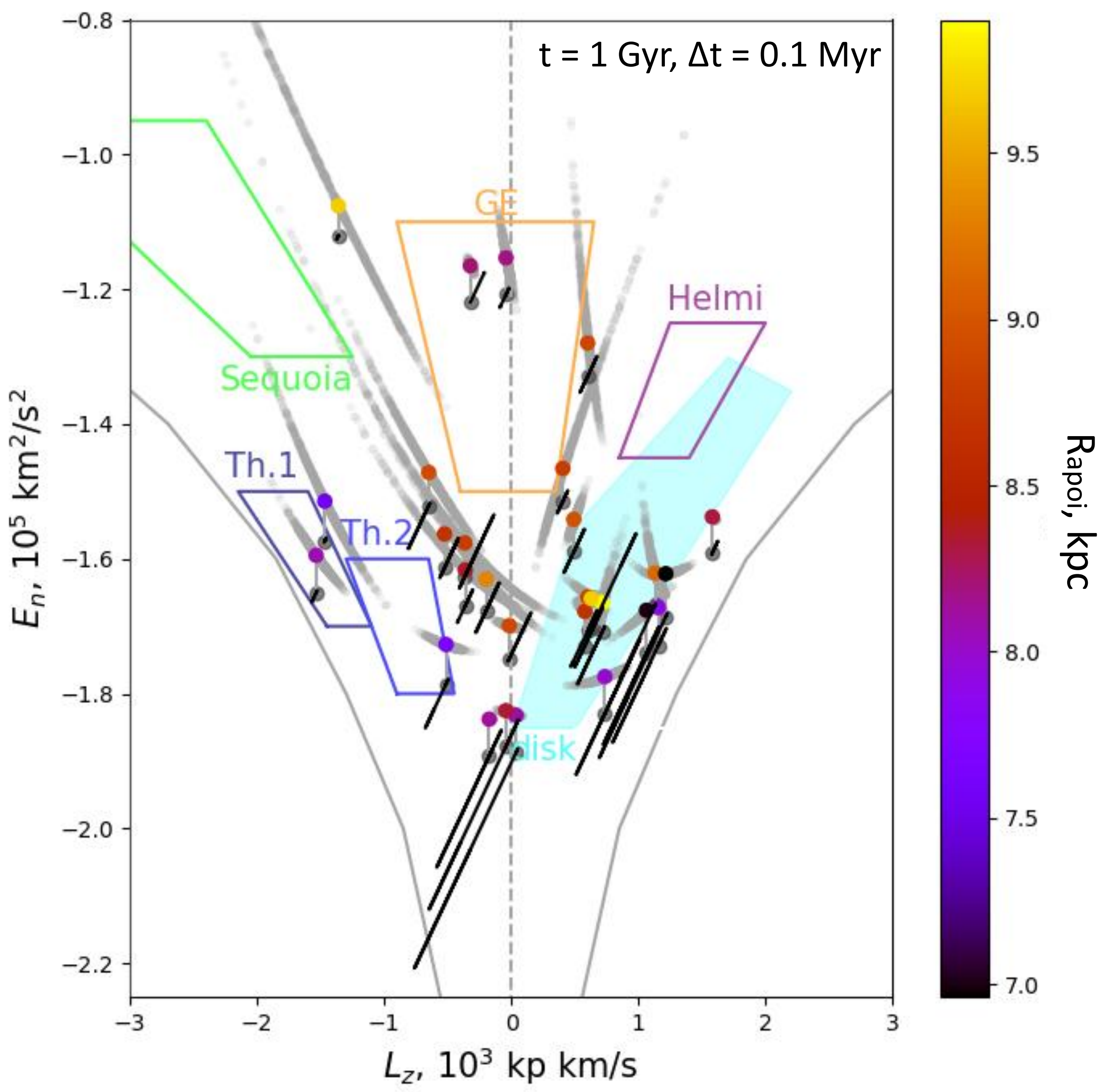




Orbital parameters



Almost all stars go **through** the **bulge region =>** **bar perturbations**



Effect of Galactic non-axisymmetric potential

Positions of stars move along the tilted parallel lines but for stars associated with known accretion events it still lies inside its event region

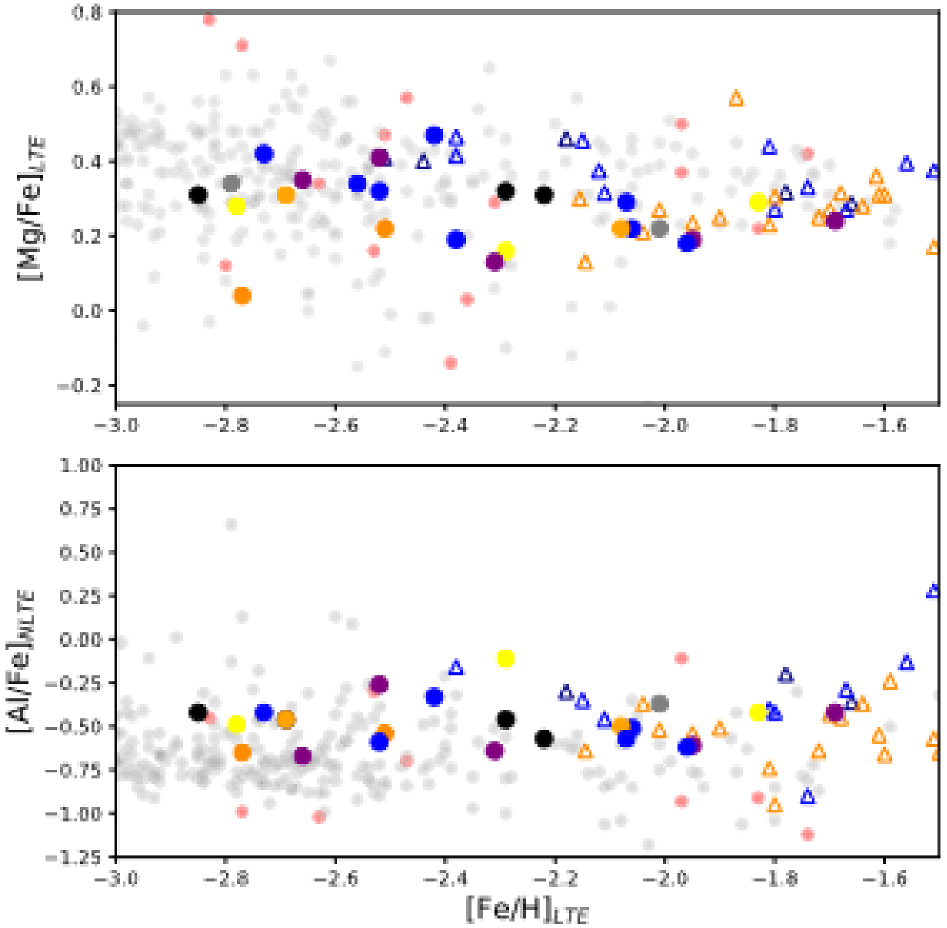
Accreted events?

● metal-poor stars

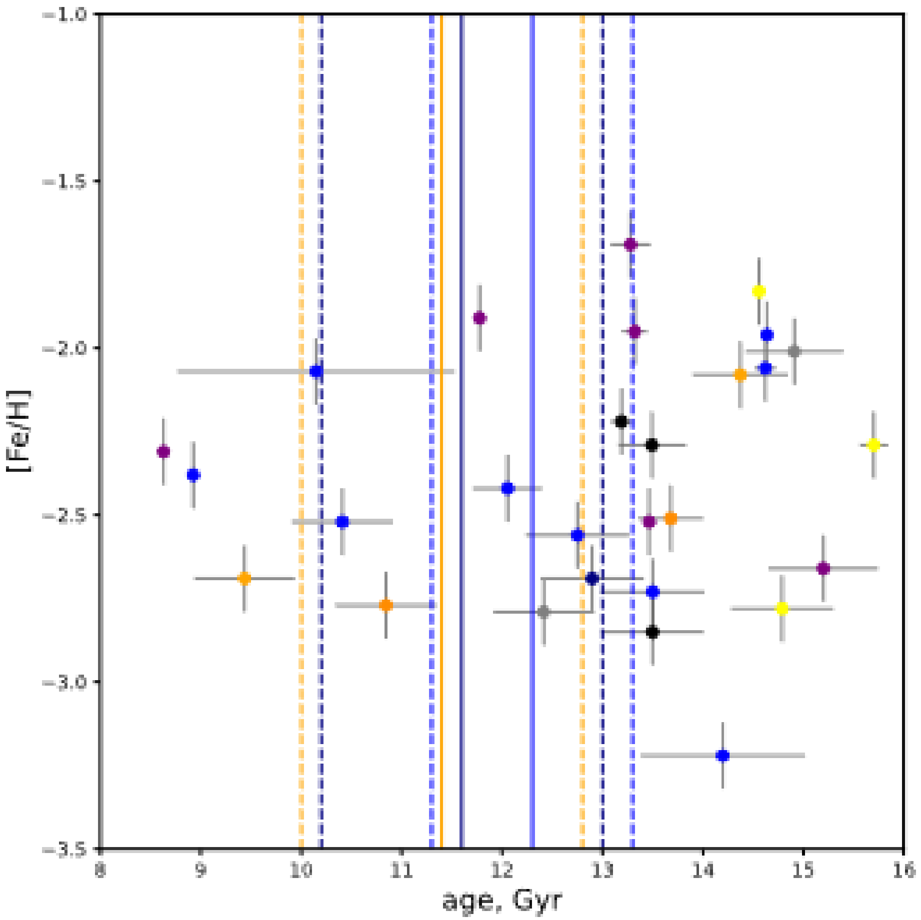
△ accretion event's stars

Gaia-Enceladus-Sausage

Thamnos 1, 2



Chemistry



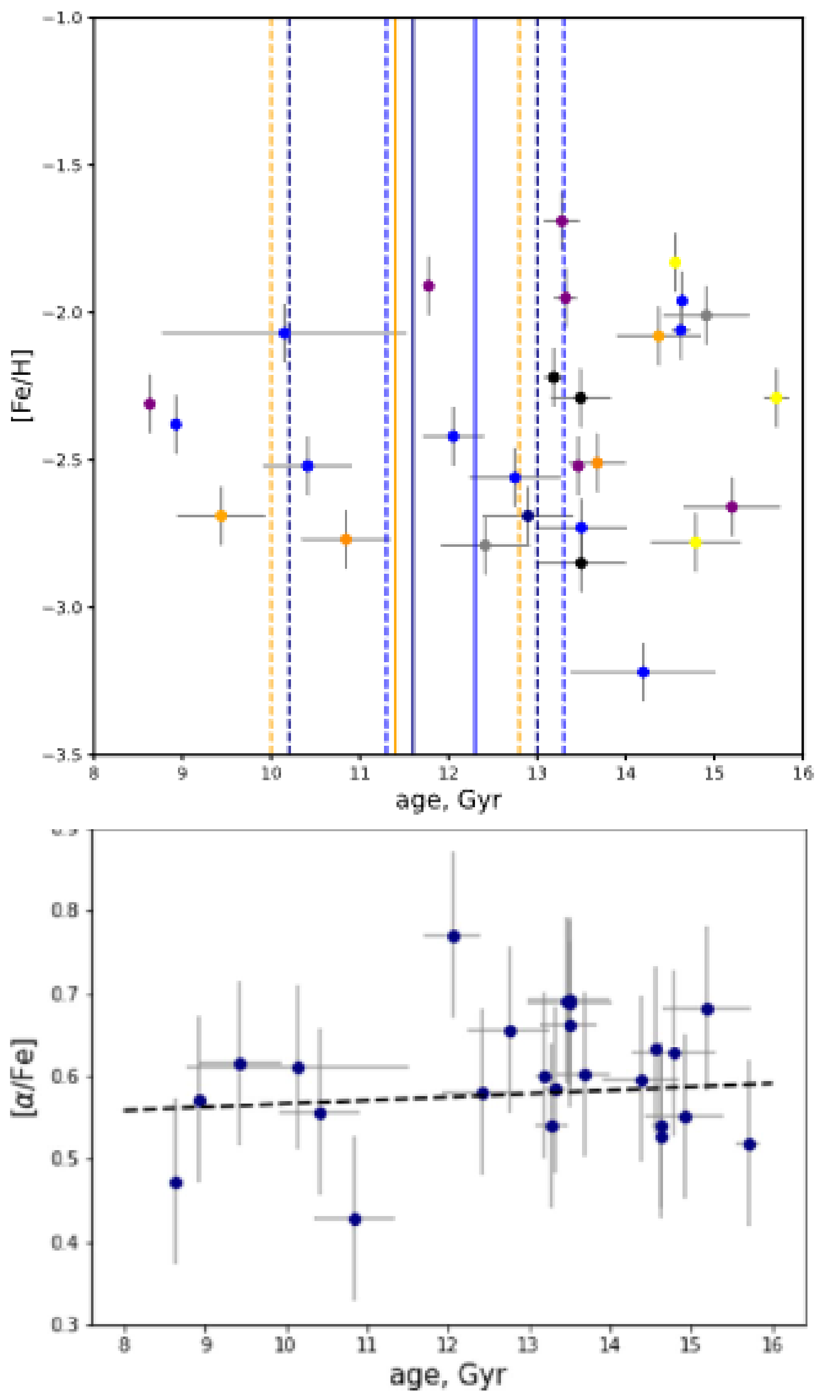
Age

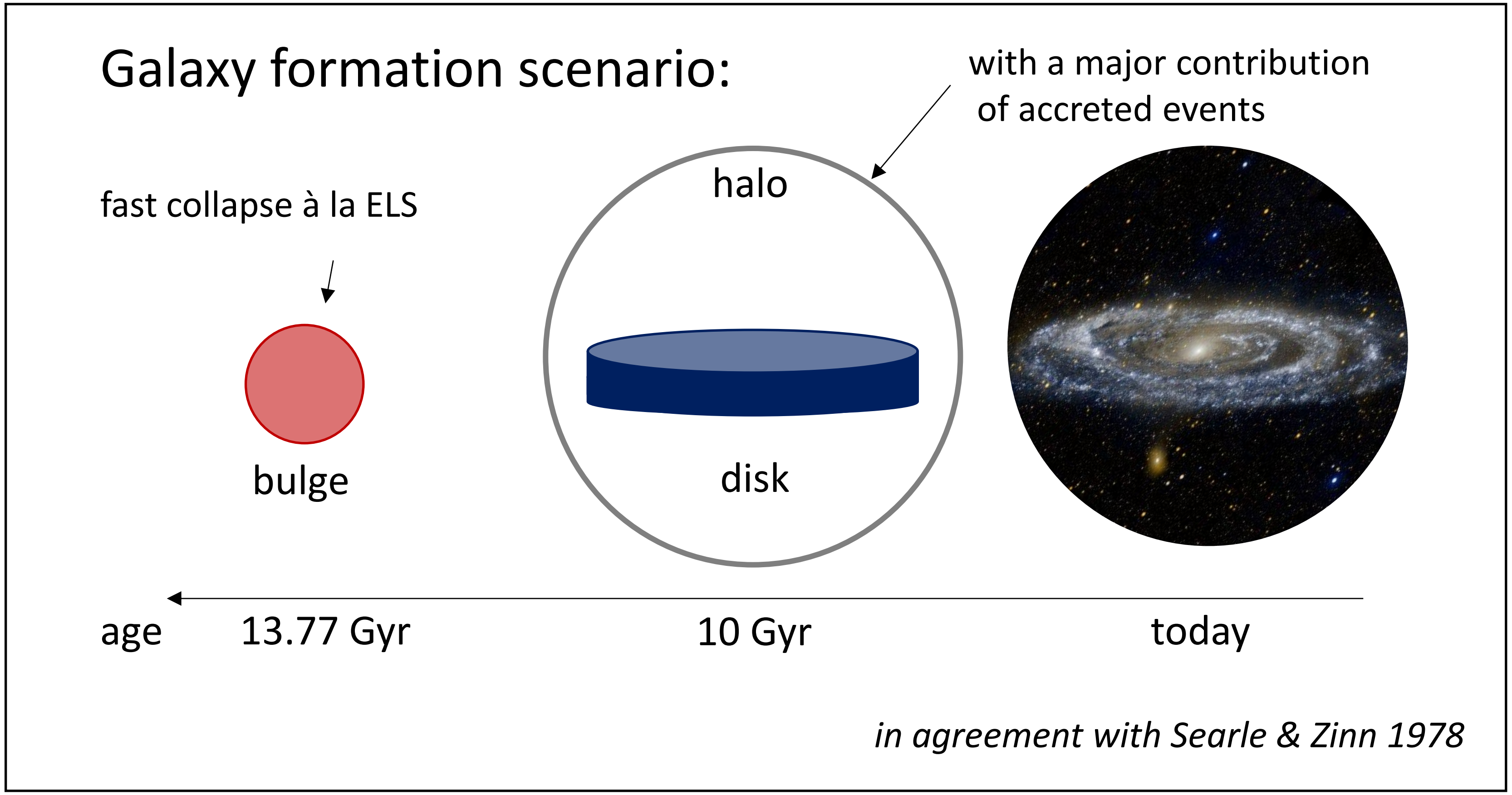
Stars older than 13.5 Gyr

1. Age => very low probability to be part of any well-known accretion events
2. Orbits – close to the Galactic Disk and pass close to the Galactic center
3. Chemistry – the same as bulge or halo
4. α-age correlation => Their origin - environment where gas density and star formation were quite high.

⬇

They may have **formed inside the very first ”building blocks”** of the Milky Way and therefore were part of the infant bulge at a time when the Disk had yet to form




Galaxy formation scenario:
with a major contribution of accreted events
fast collapse à la ELS
halo
bulge
disk
age
13.77 Gyr
10 Gyr
today
in agreement with Searle & Zinn 1978

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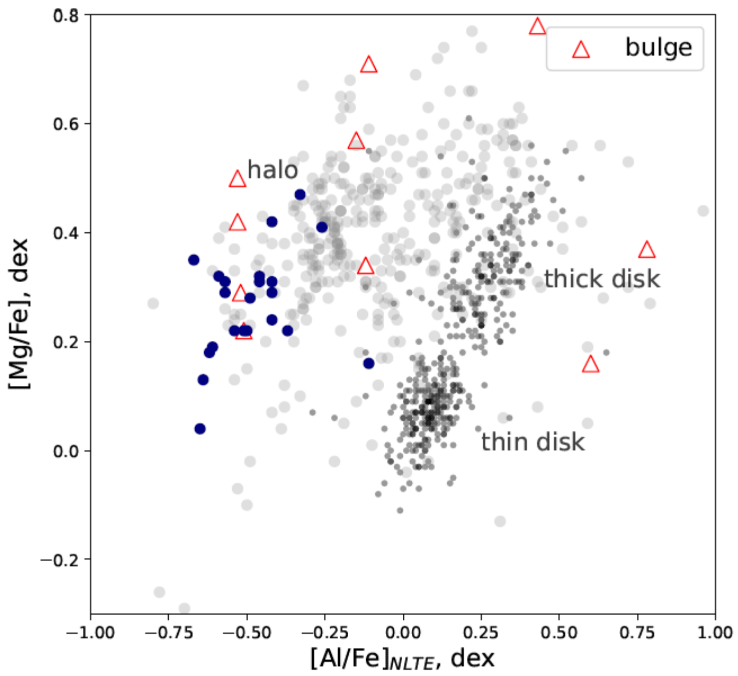
Conclusion

We identified:

1. Group of stars with **halo** chemistry, age, and kinematics.



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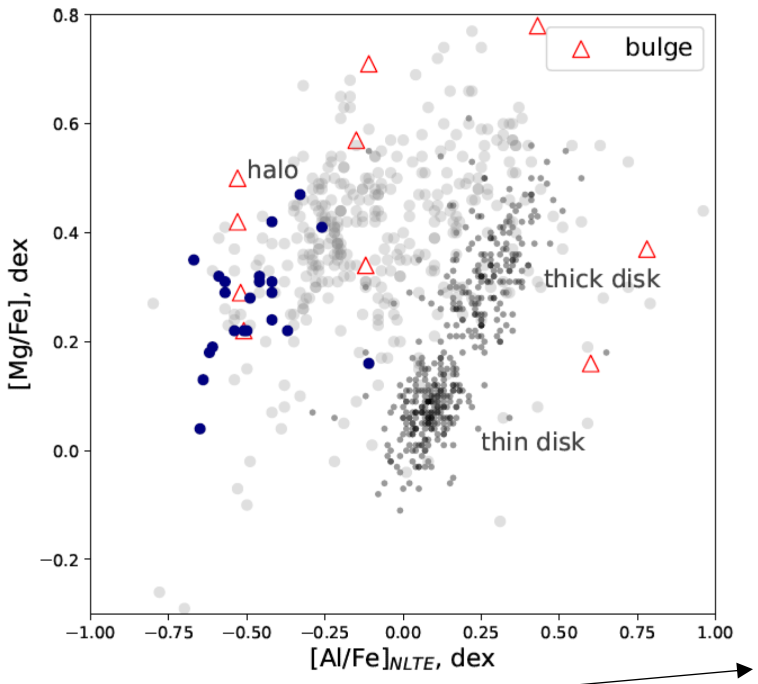
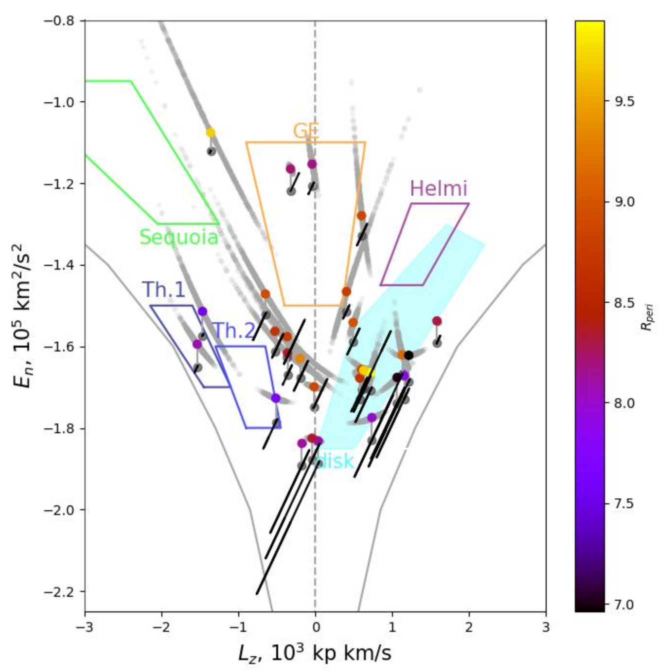


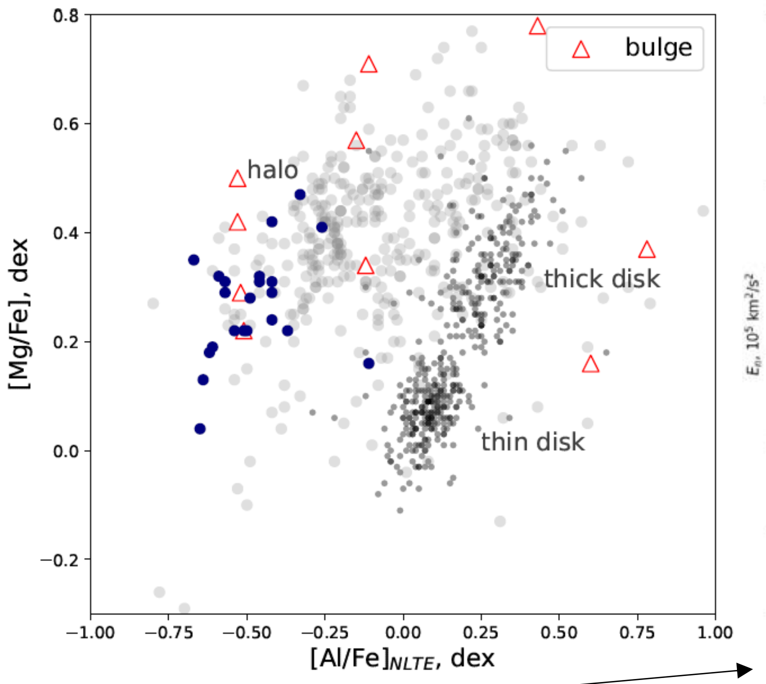
2. Another group associated with **Gaia–Enceladus/Sausage** and **Thamnos 1, 2.**

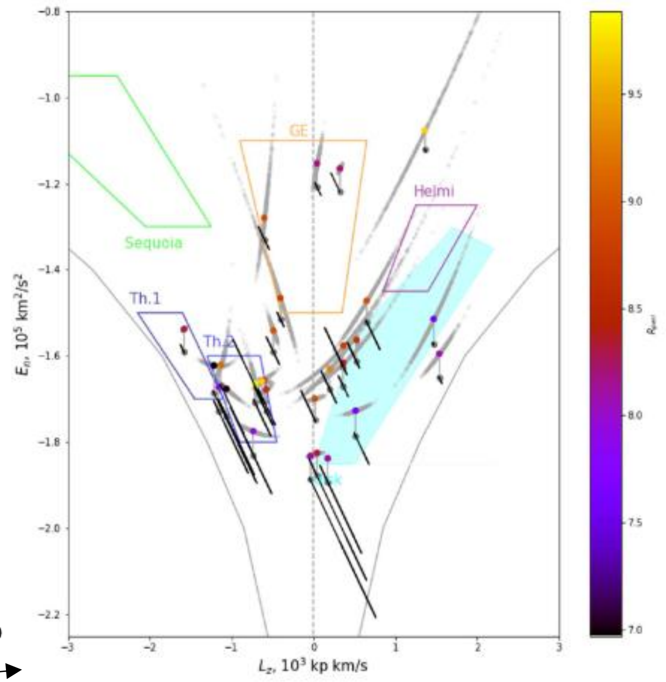


Conclusion

We identified:

1. Group of stars with **halo** chemistry, age, and kinematics.
2. Another group associated with **Gaia–Enceladus/Sausage** and **Thamnos 1, 2.**
3. Group of stars probably belonging to the **infant bulge**.





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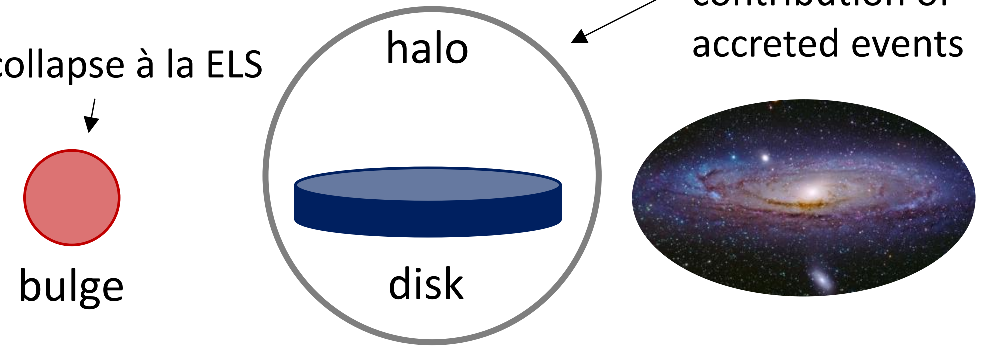

age 13.77 Gyr | 10 Gyr | today

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For more detailes:

Very Metal-poor Stars in the Solar Vicinity: Age Determination

Anastasiia Plotnikova[1], Giovanni Carraro[1], Sandro Villanova[2], and Sergio Ortolani[1]
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[2] Departamento de Astronomia, Casilla 160-C, Universidad de Concepción, Concepción. Chile
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Very Metal-poor Stars in the Solar Vicinity: Kinematics and Abundance Analysis

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Plans for the future

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SDSS-V

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4MOST

Plans for the future

SDSS-V

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WEAVE

Plans for the future

SDSS-V

4MOST

WEAVE

small observational programs

TO BE CONTINUED...

“Do You Have Any Questions?”