DIS Galactic Archaeology module

Lecture 6: Chemical evolution & hands-on session

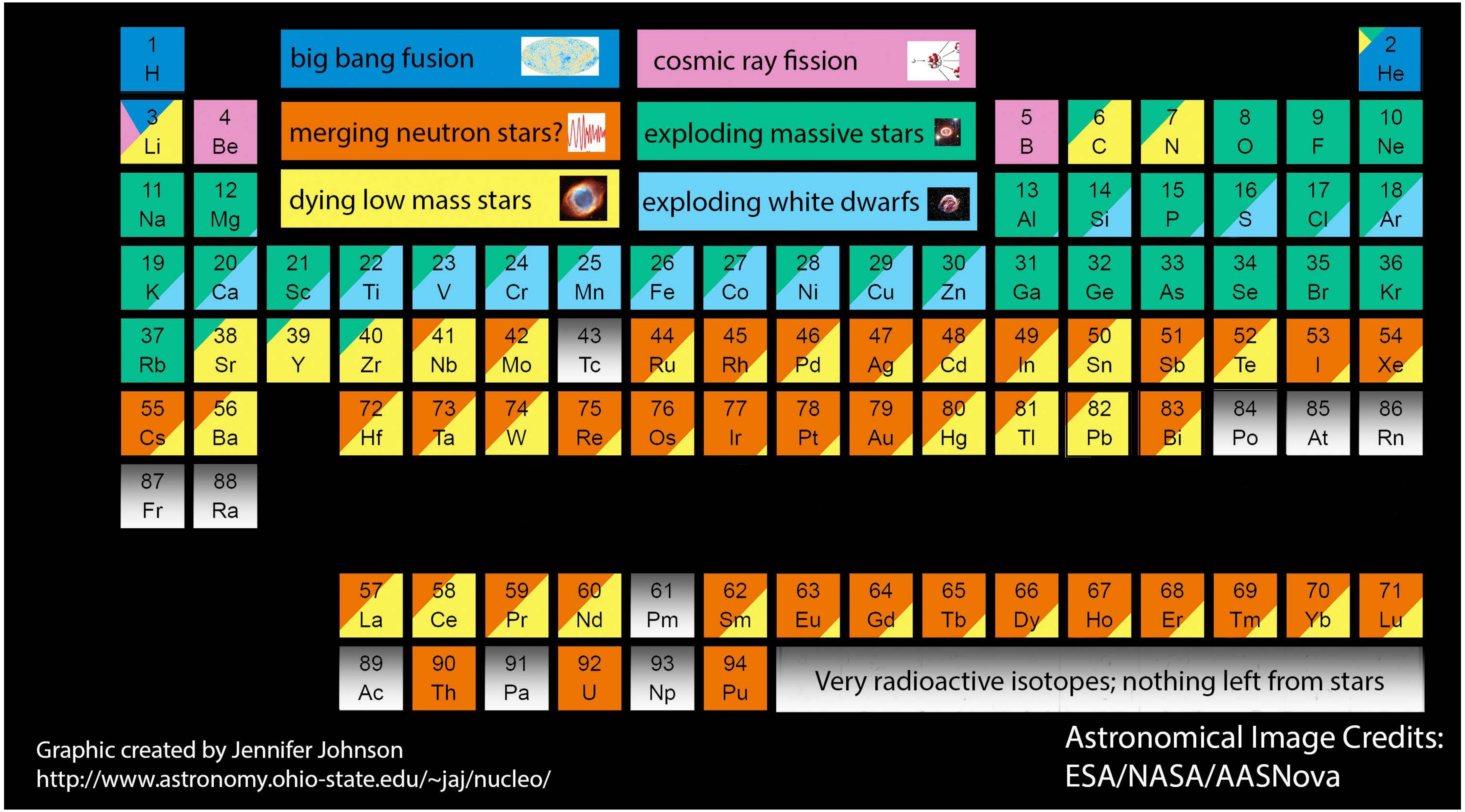
Dr Anke Ardern-Arentsen

Recap from the previous lecture

- How to build an astronomical dataset? It's a lot of effort!
- Public survey data products are extremely useful, but they are not perfect

Chemical evolution

The origin of the elements



The origin of the elements & associated timescales

Table from
Stephanie Monty

Element Group	Tracer	Mode of entry into the Interstellar Medium	Timescale	Example Elements
Alpha	High mass stars $M > 8\ M_\odot$	Core collapse (CC) supernovae	0 - 100 Myr	O, Na, Mg, Al, Si, Ca, Ti
Iron peak	Low mass stars $M < 8\ M_\odot$	mostly Type Ia supernovae (exploding white dwarfs)	100 Myr - 1 Gyr	Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn
Iron	Low AND high mass stars	CC SNe, Type Ia SNe	0 - 100 Myr 100 Myr - 1 Gyr	Fe
Slow neutron-capture (s-)process	Low mass stars $1\ M_\odot < M < 3\ M_\odot$	Winds during asymptotic giant branch phase	300 Myr - 5 Gyr	Sr, Y, Zr, Ba, La, Ce, Nd
Rapid neutron-capture (r-)process	High mass stars $8\ M_\odot < M < 22\ M_\odot$	CC SNe Neutron star mergers	0 - 100 Myr 50 Myr - 14 Gyr	Nd, Eu, Th, U

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Chemical evolution models

Key ingredients:

Chemical evolution models

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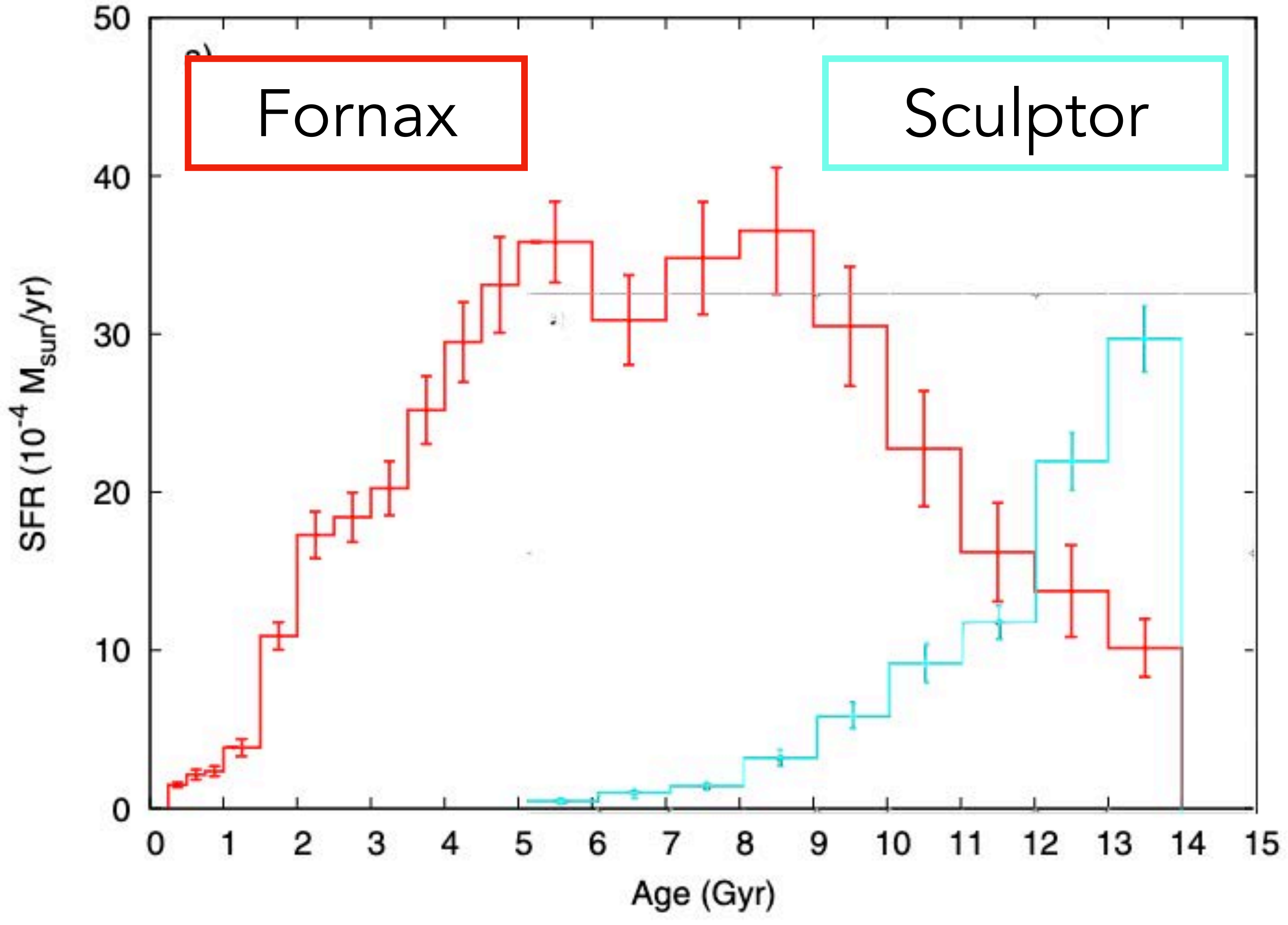
- Star formation history and efficiency: how many stars were formed at each time?

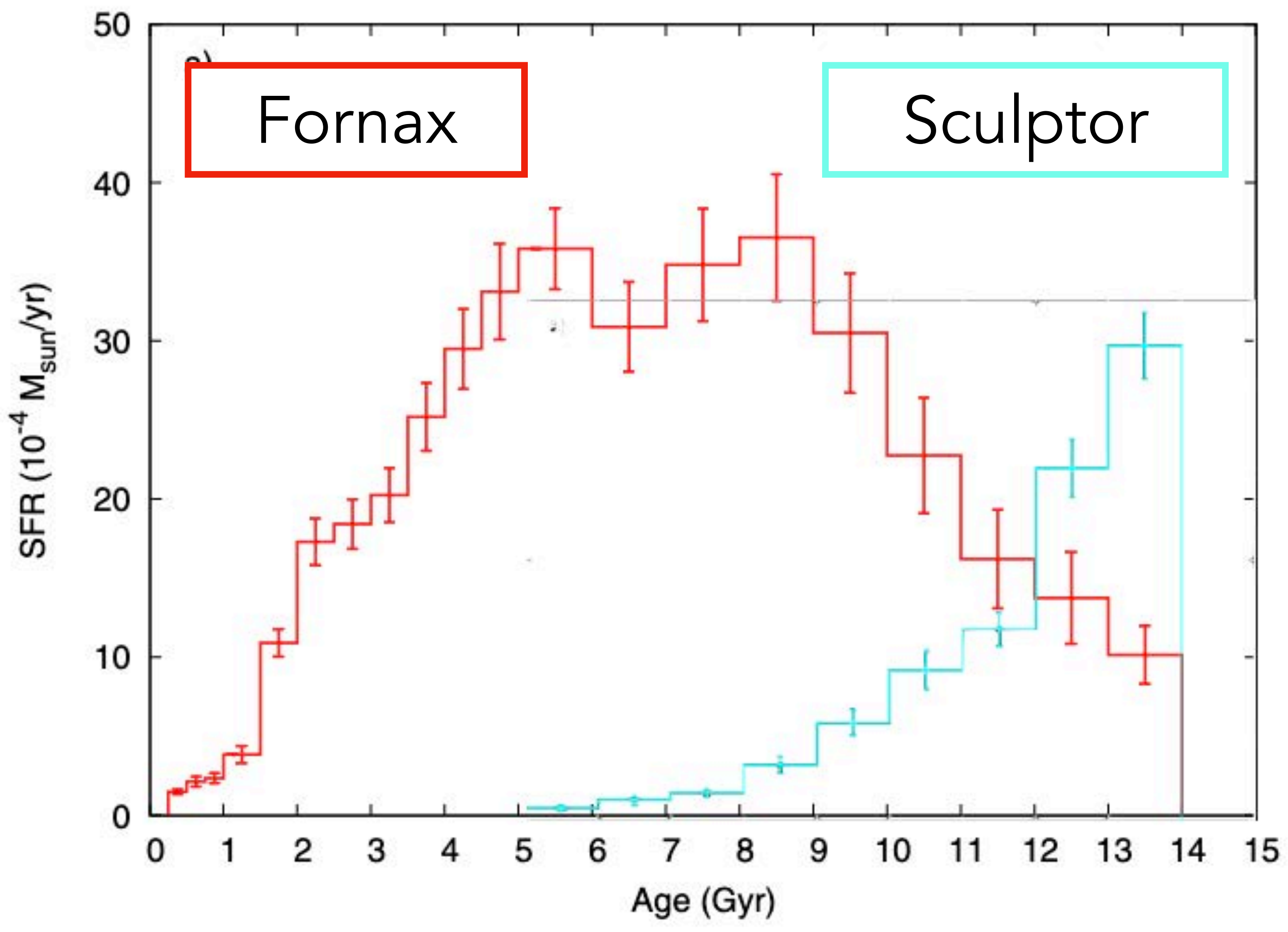


De Boer et al. 2012

Chemical evolution models

Key ingredients:

- ➤ Star formation history and efficiency: how many stars were formed at each time?
- ➤ Chemical yields: how much of each element is made in each progenitor? (model-dependent)



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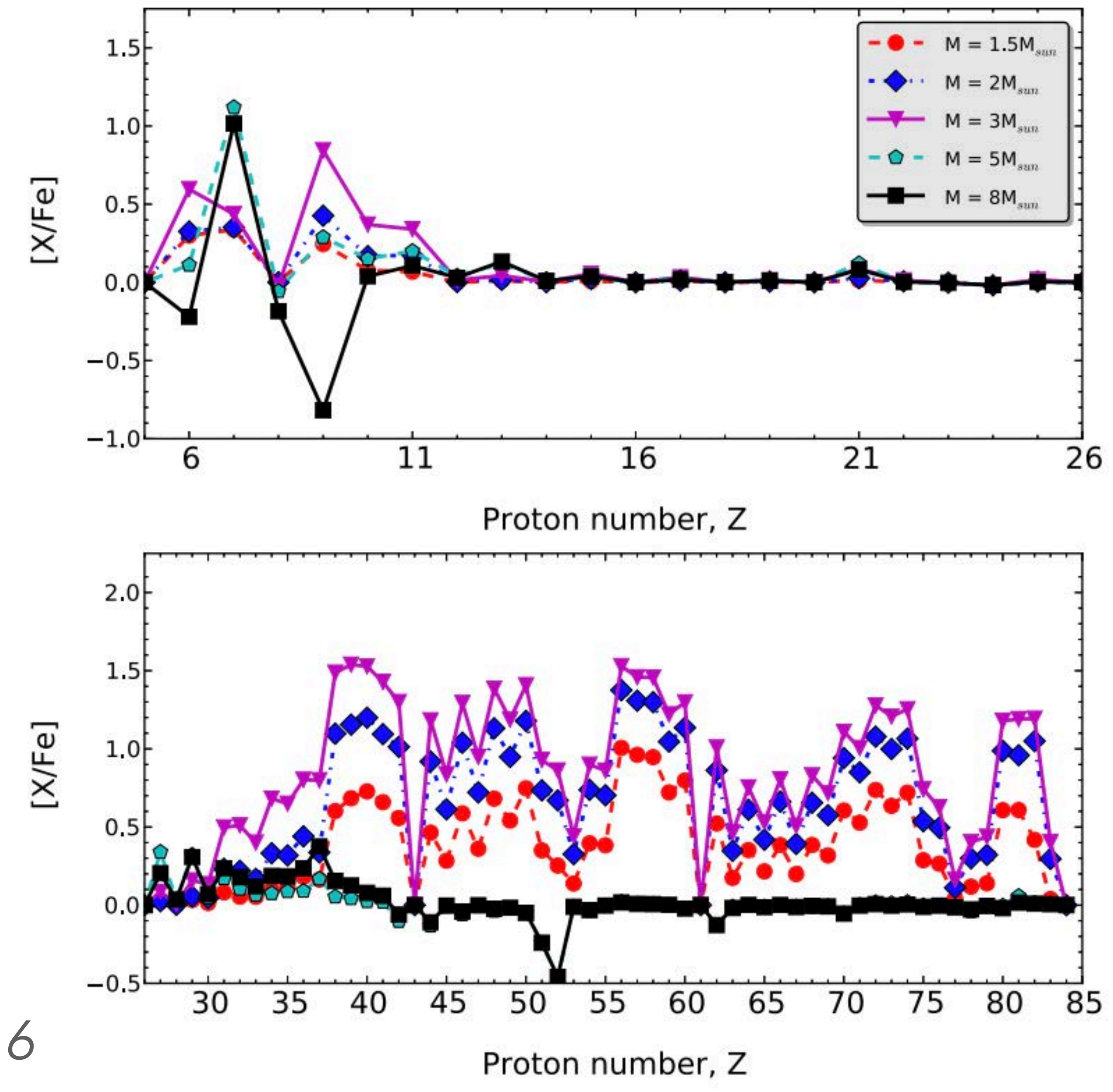
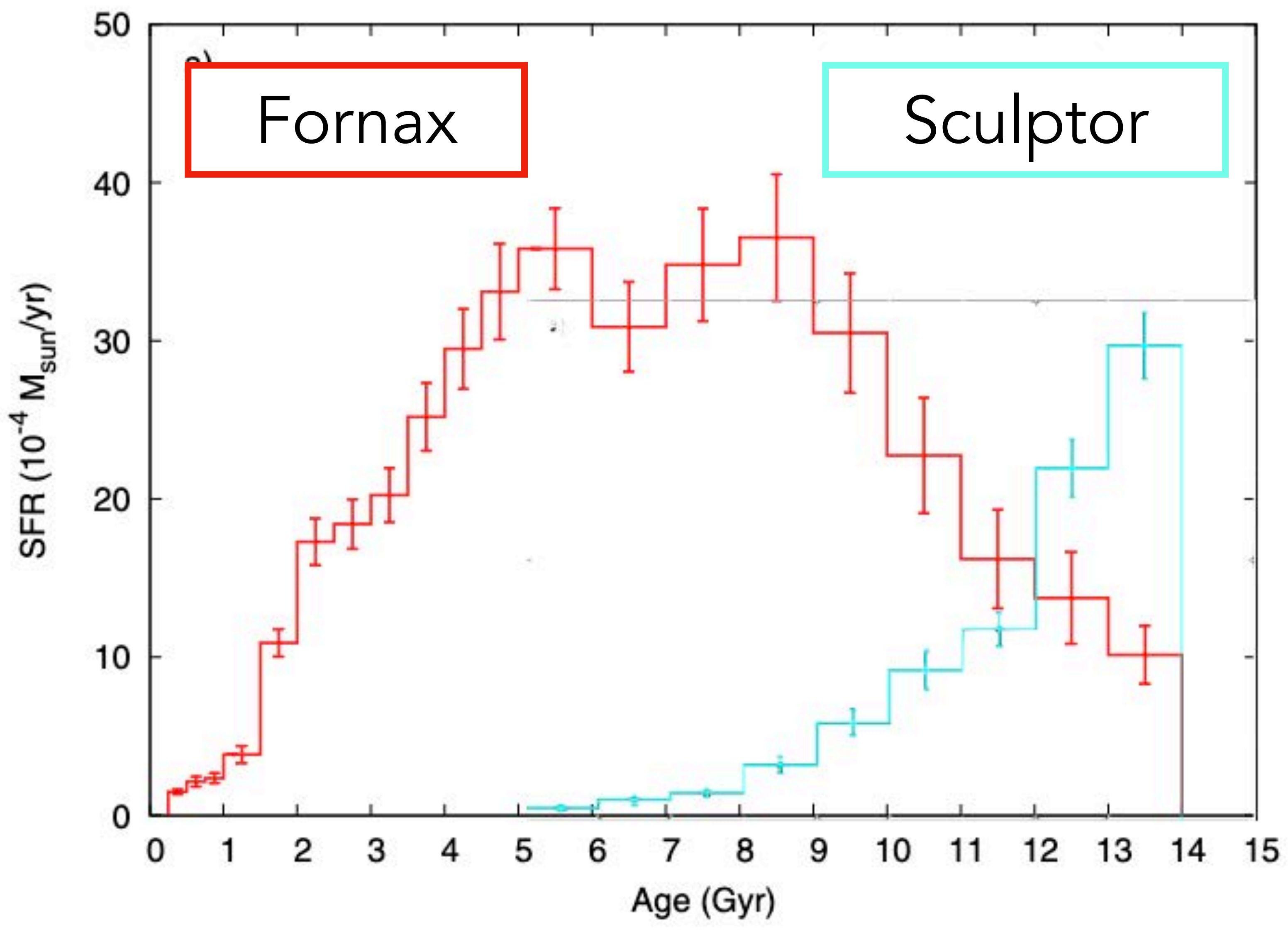


Karakas & Lugaro 2016

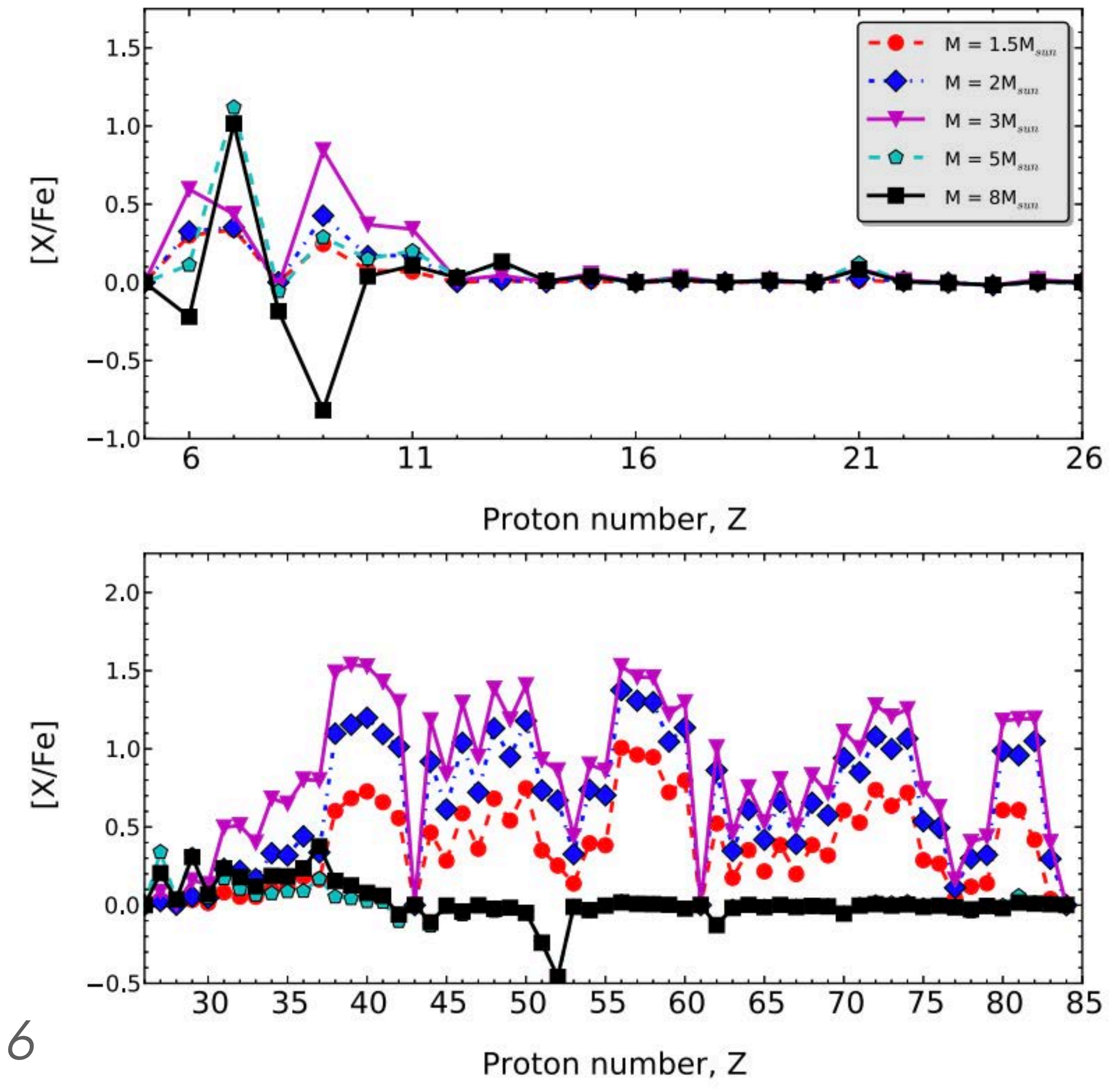
Chemical evolution models

Key ingredients:

- ➤ Star formation history and efficiency: how many stars were formed at each time?
- ➤ Chemical yields: how much of each element is made in each progenitor? (model-dependent)
- ➤ Other model assumptions: how does the enriched gas mix? Is the system closed?



De Boer et al. 2012



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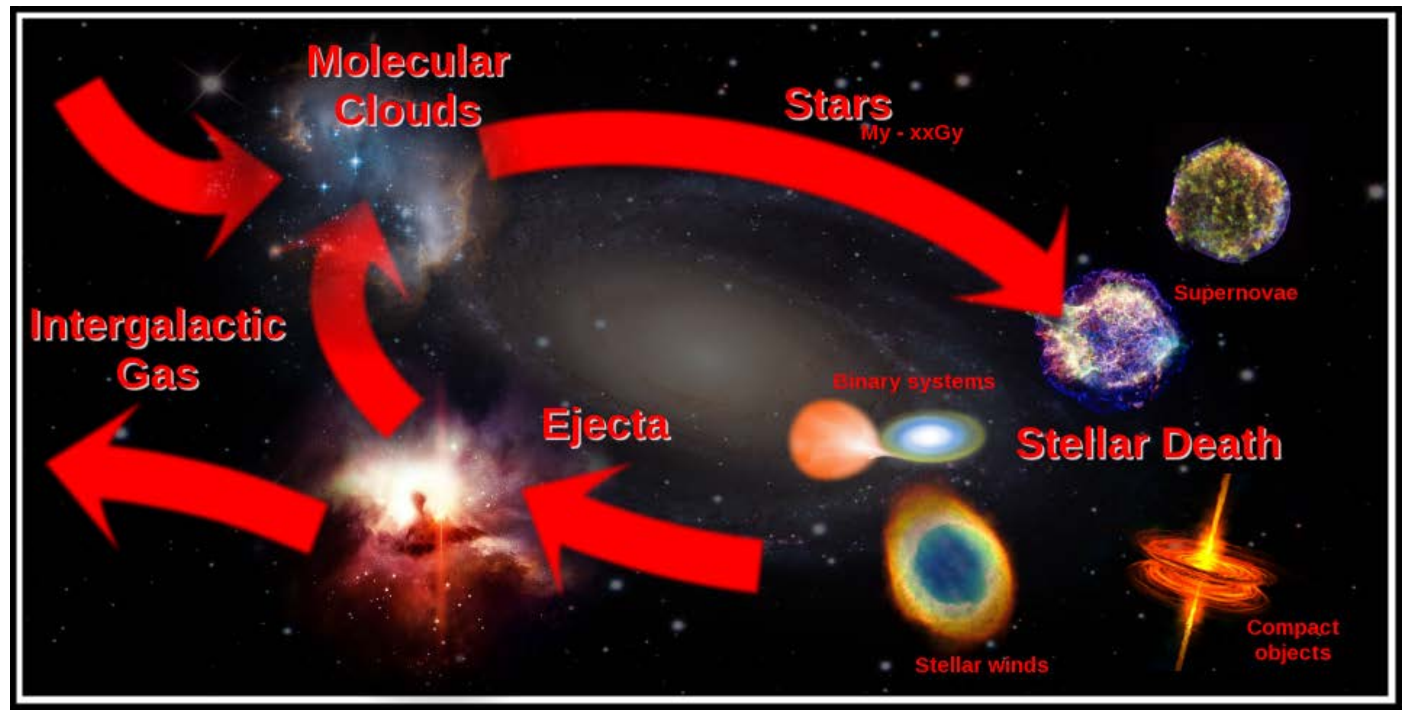
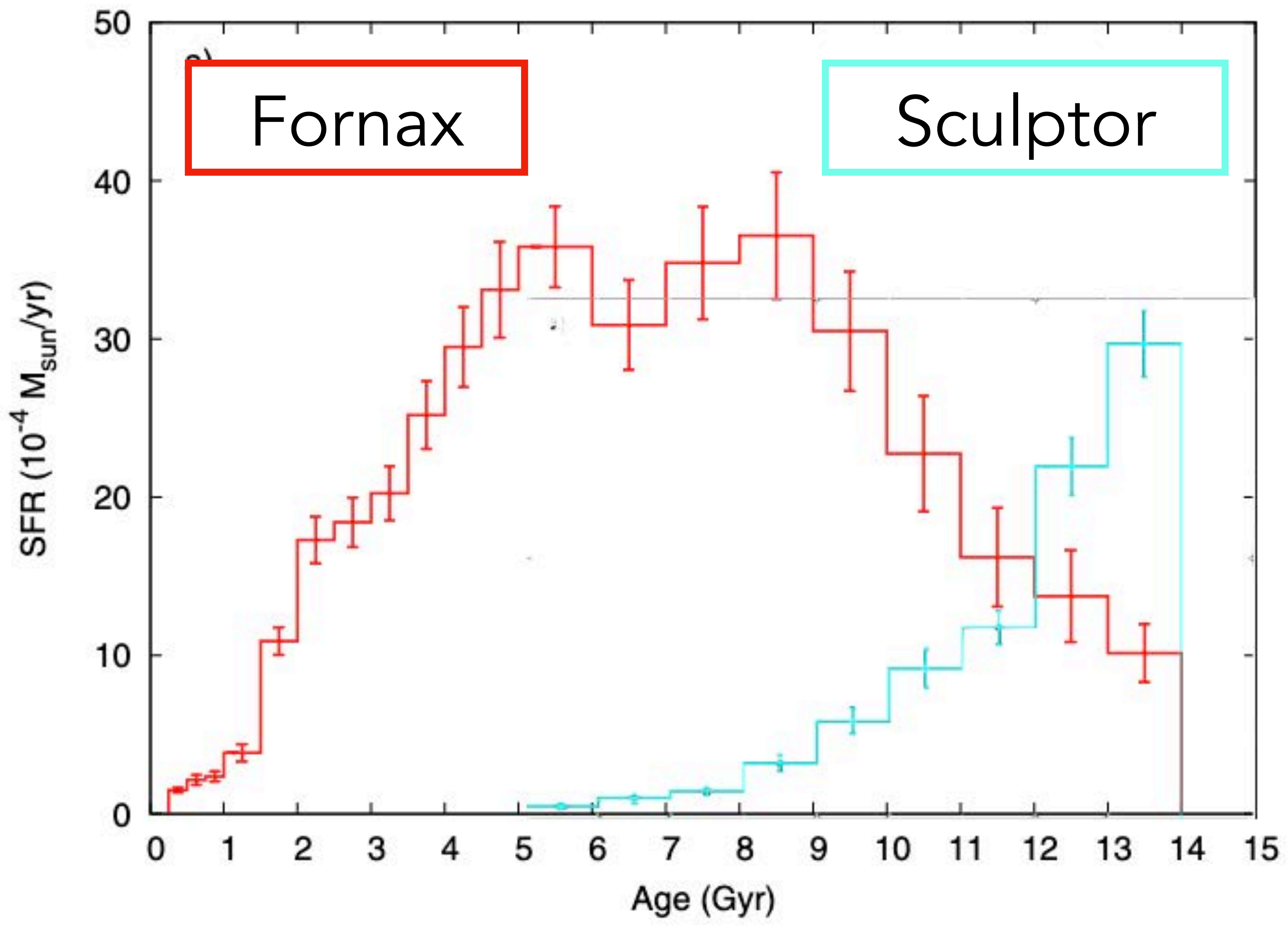


Chemical evolution — dwarf galaxies

De Boer et al. 2012



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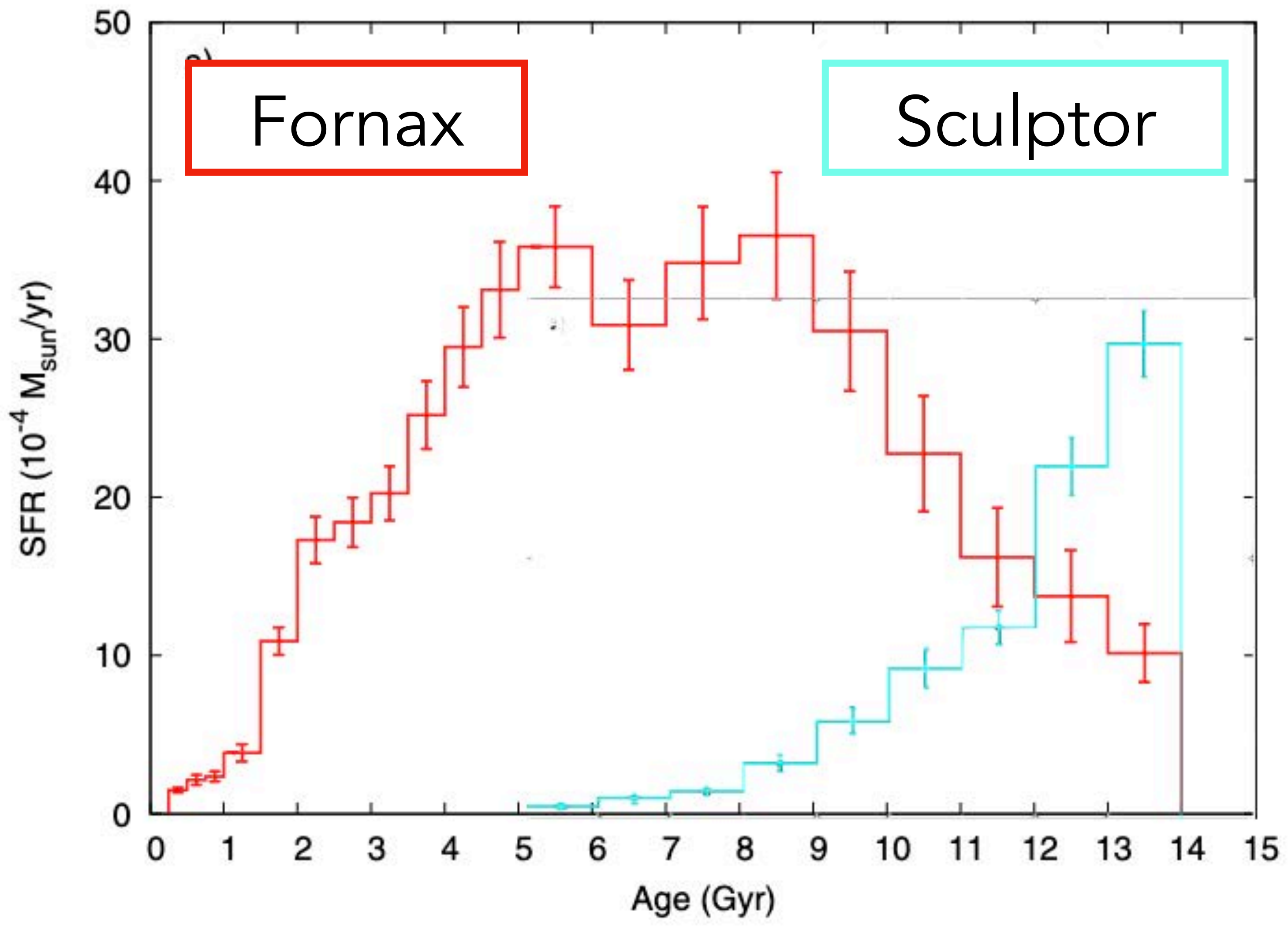
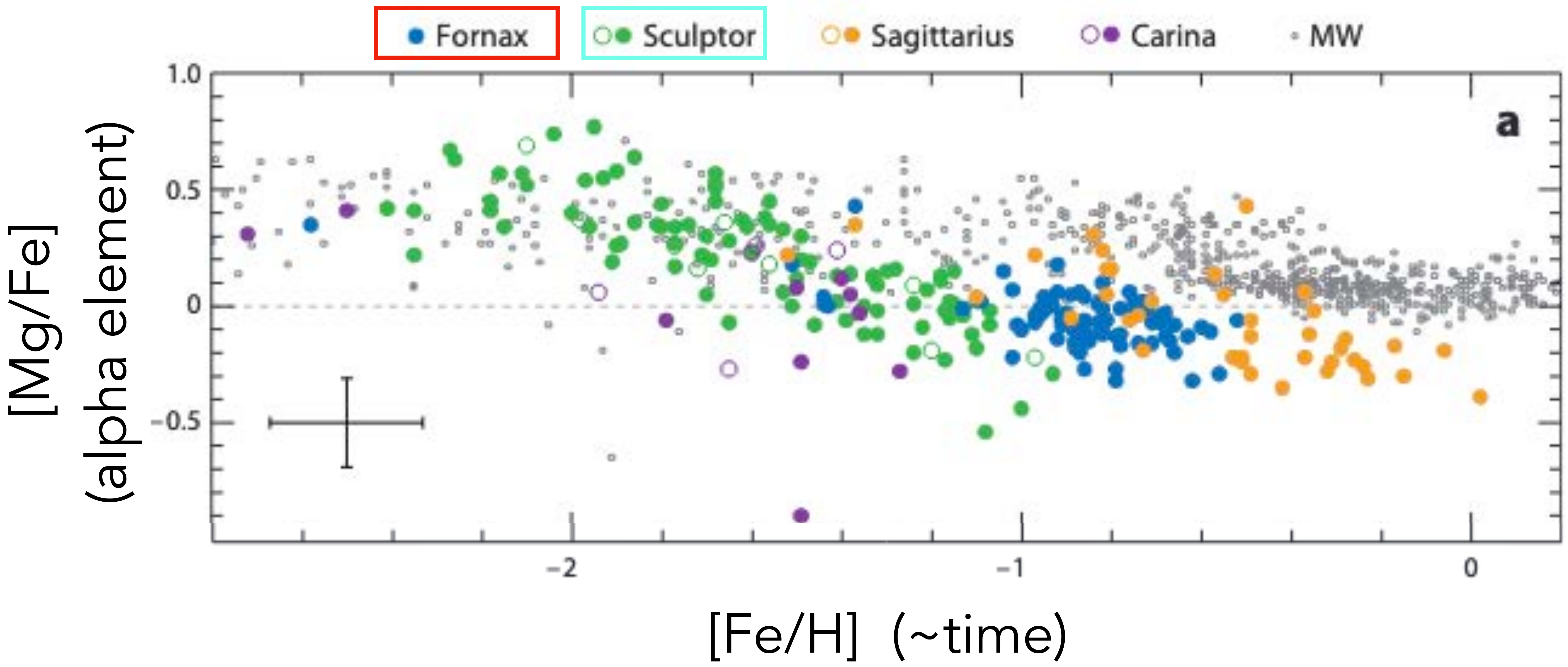


Tolstoy et al. 2009



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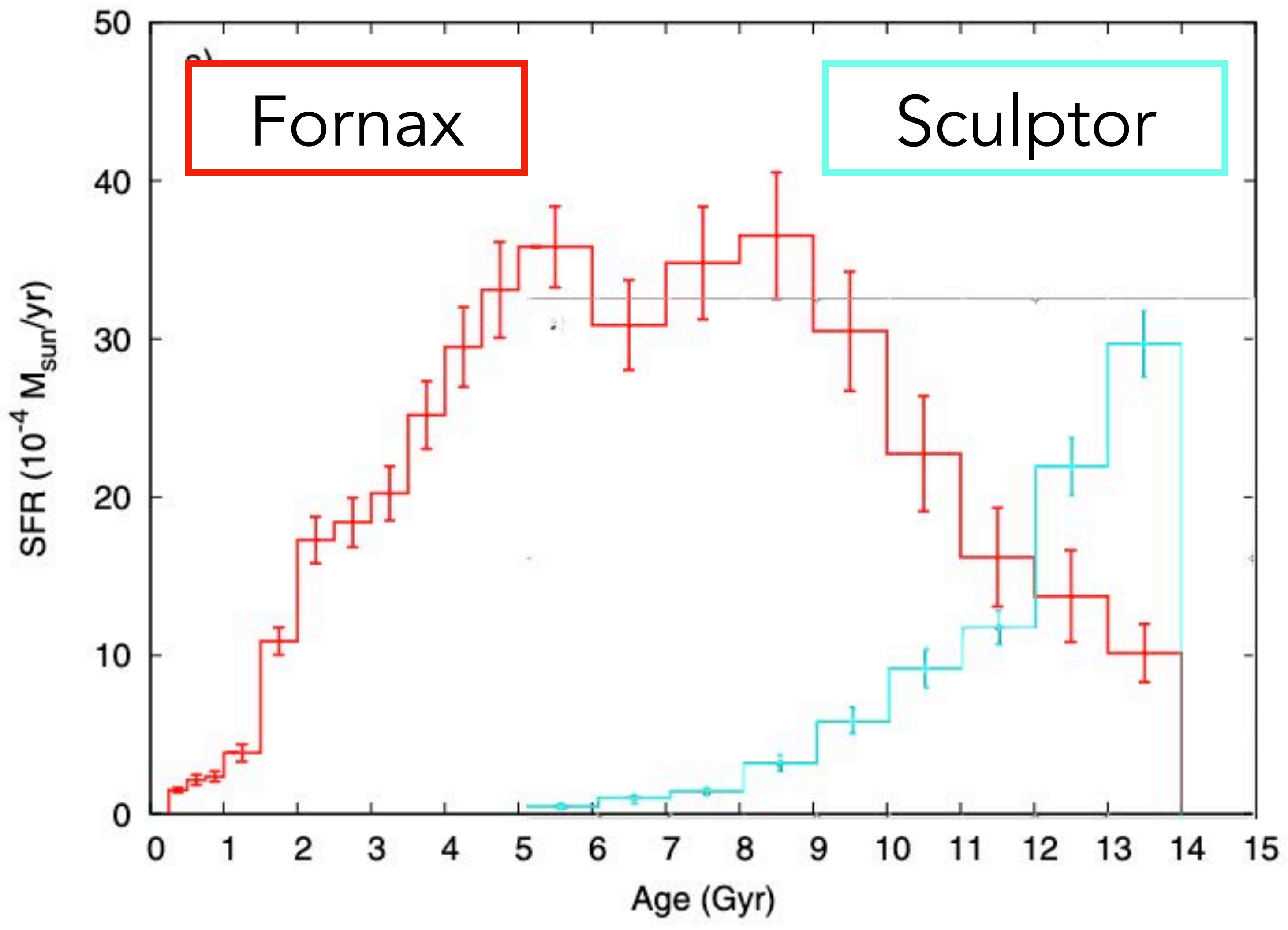

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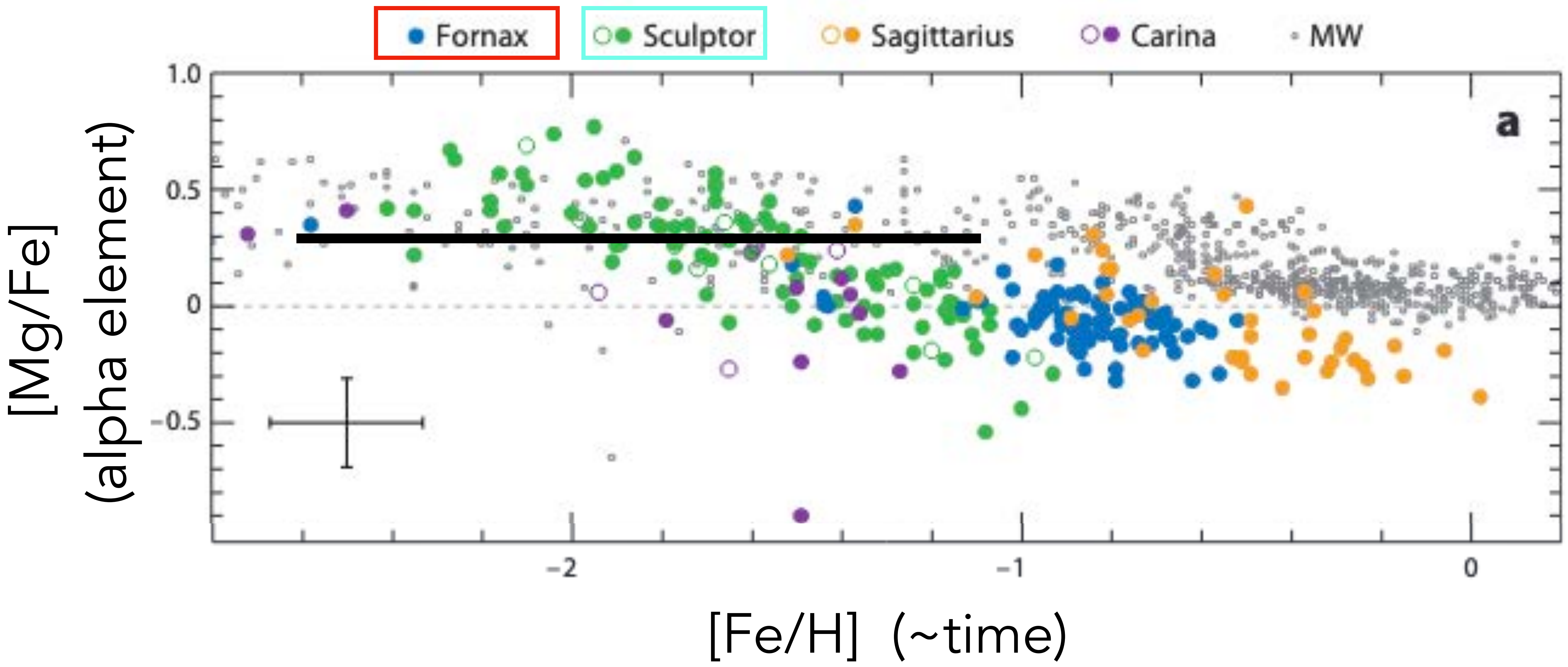

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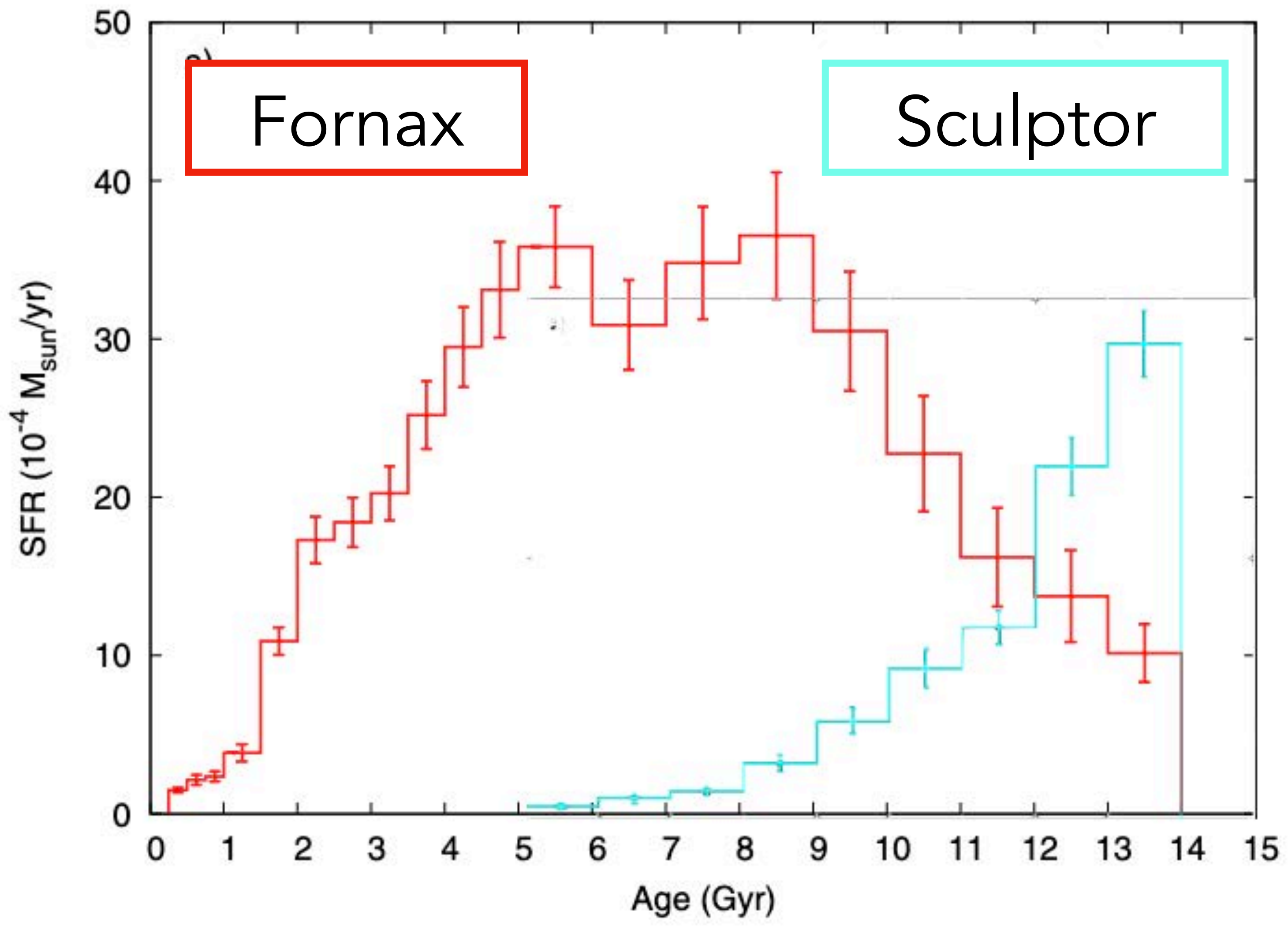

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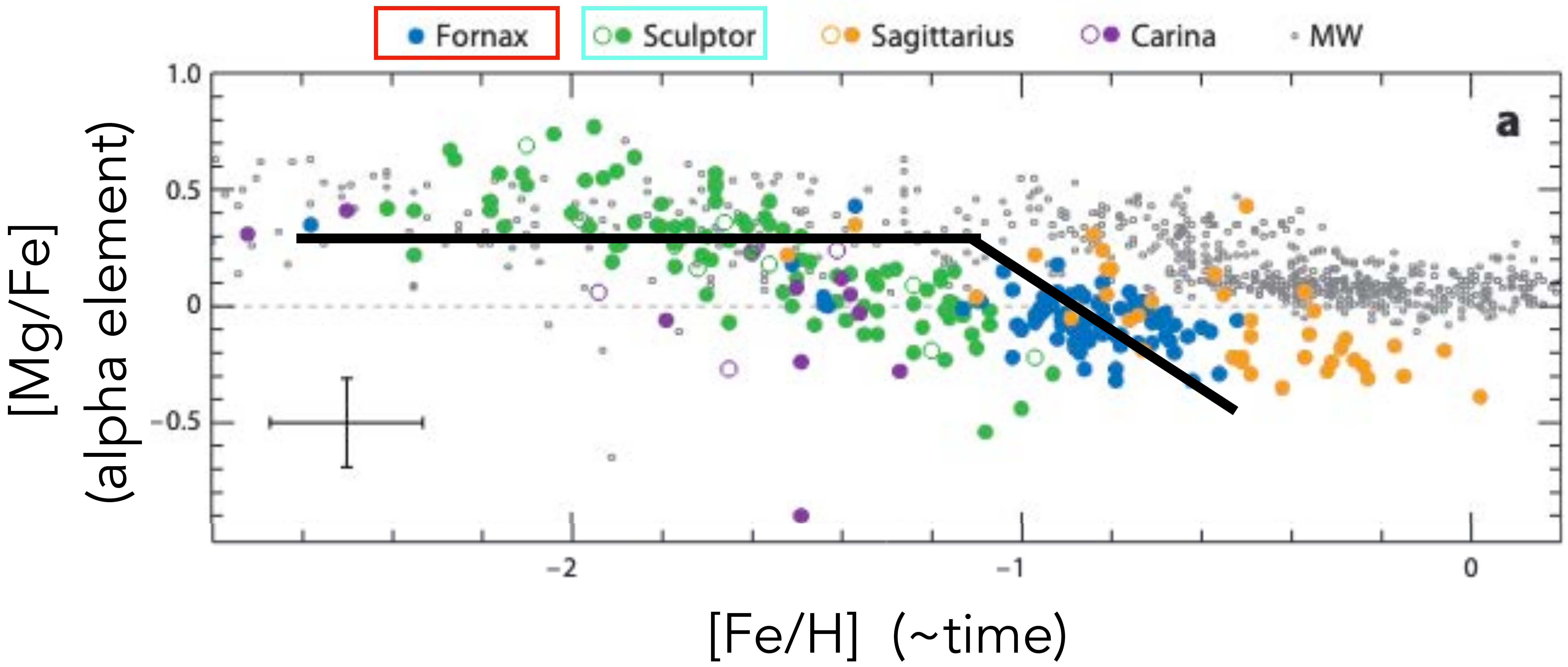

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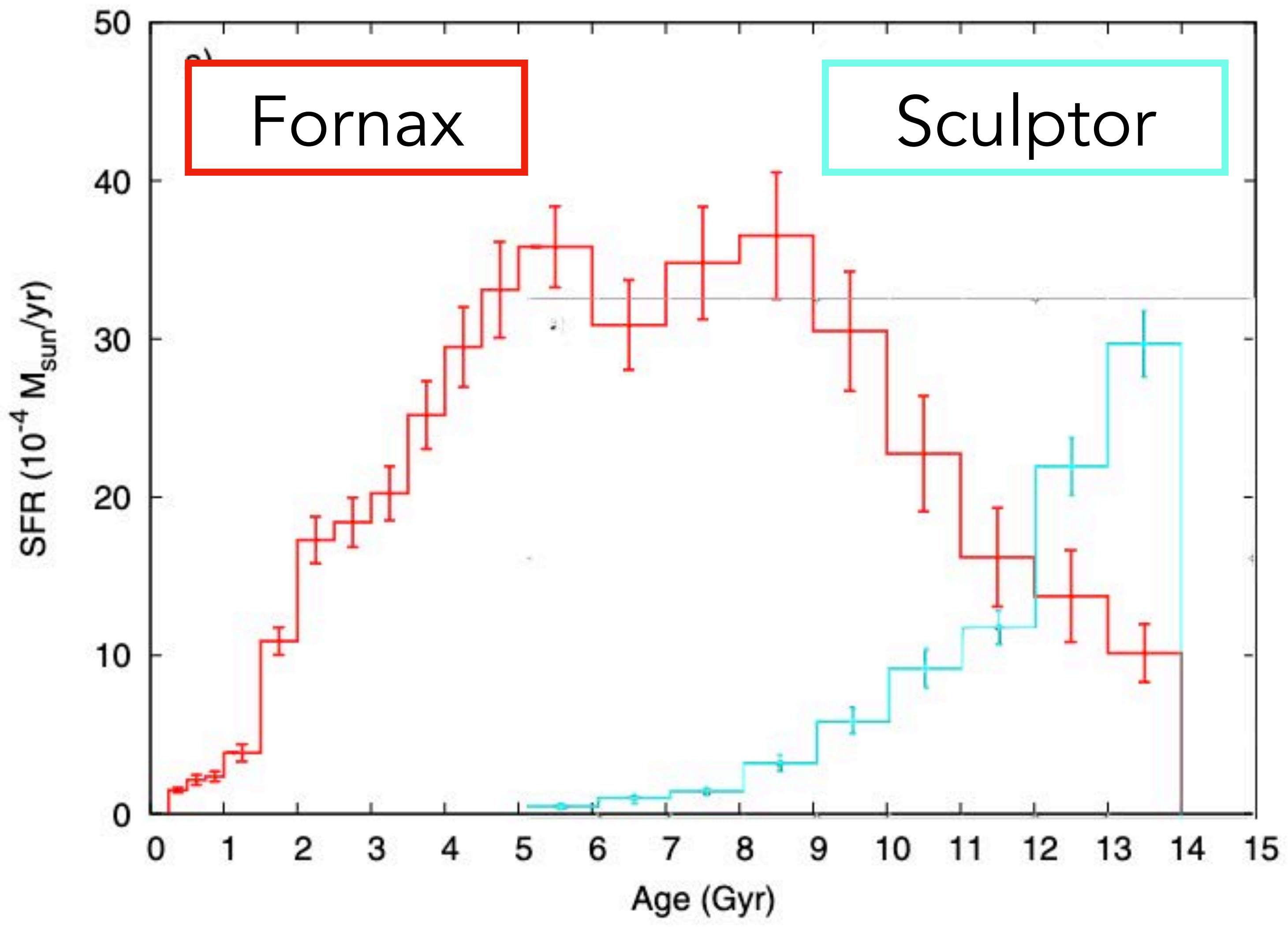

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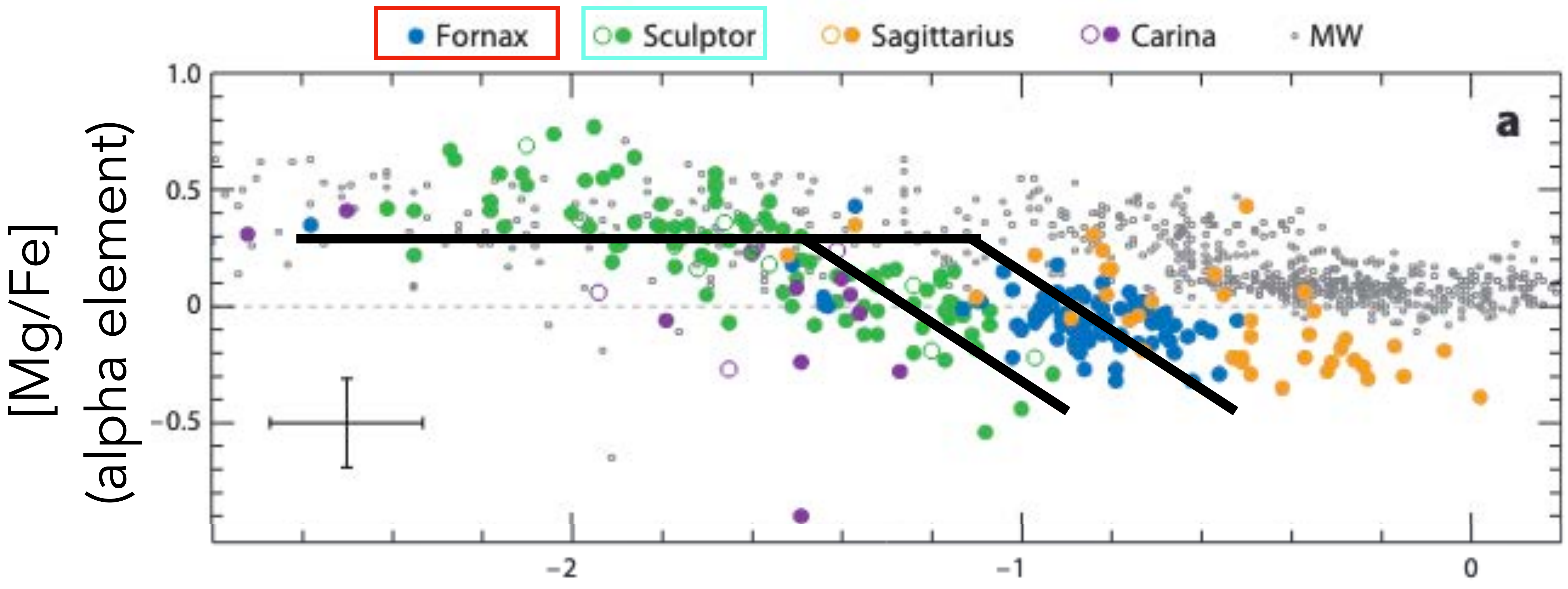

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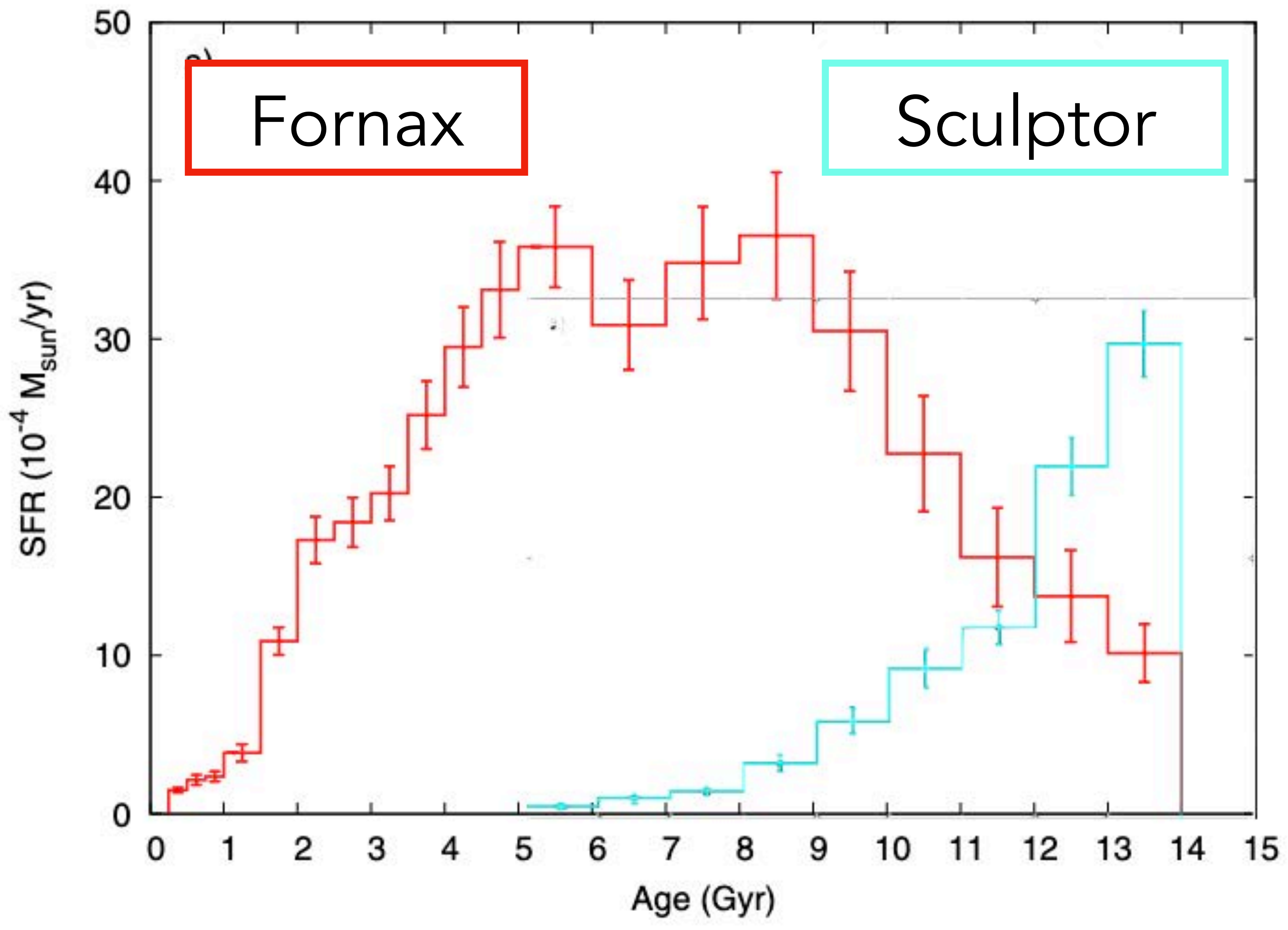

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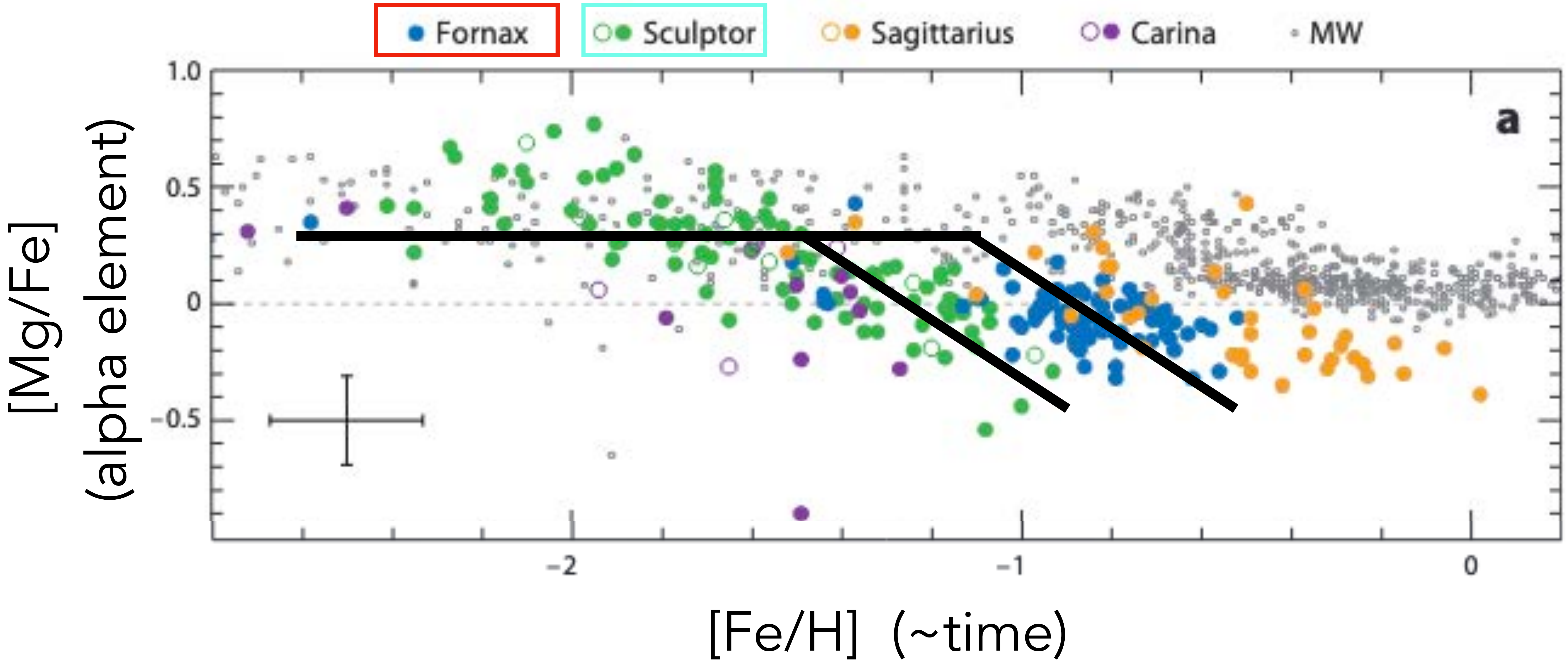

Q **What could cause the difference between Fornax and Sculptor?**

Chemical evolution — dwarf galaxies

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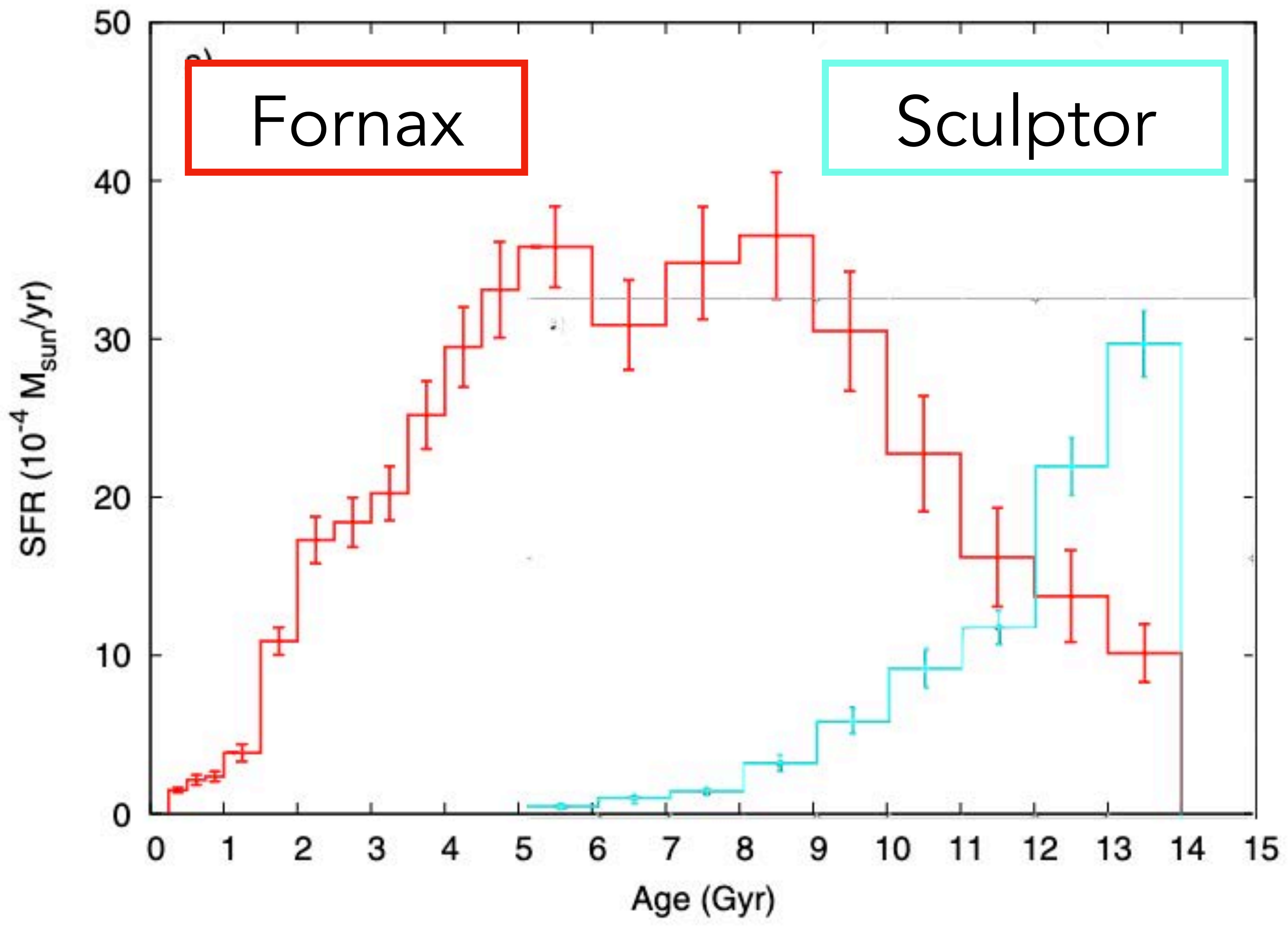
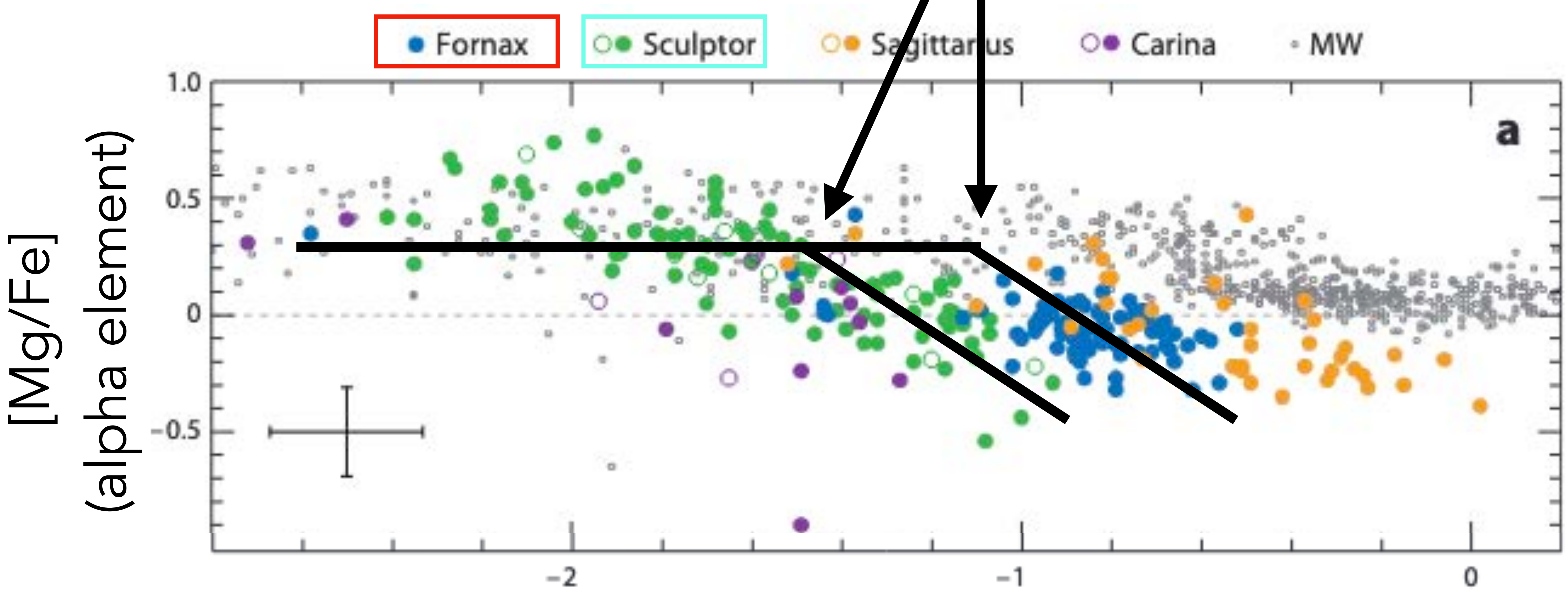


onset of supernovae type Ia

Tolstoy et al. 2009



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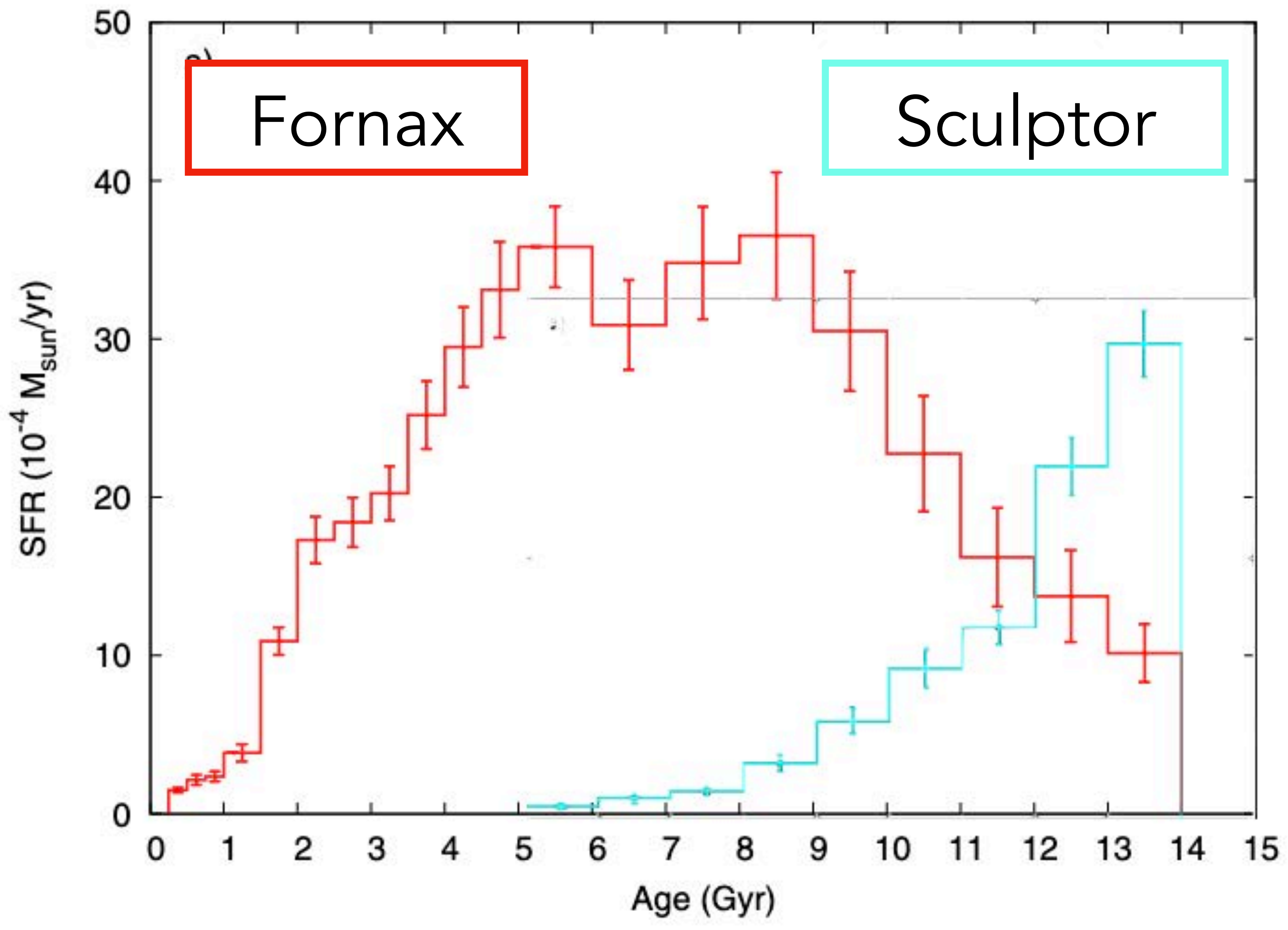

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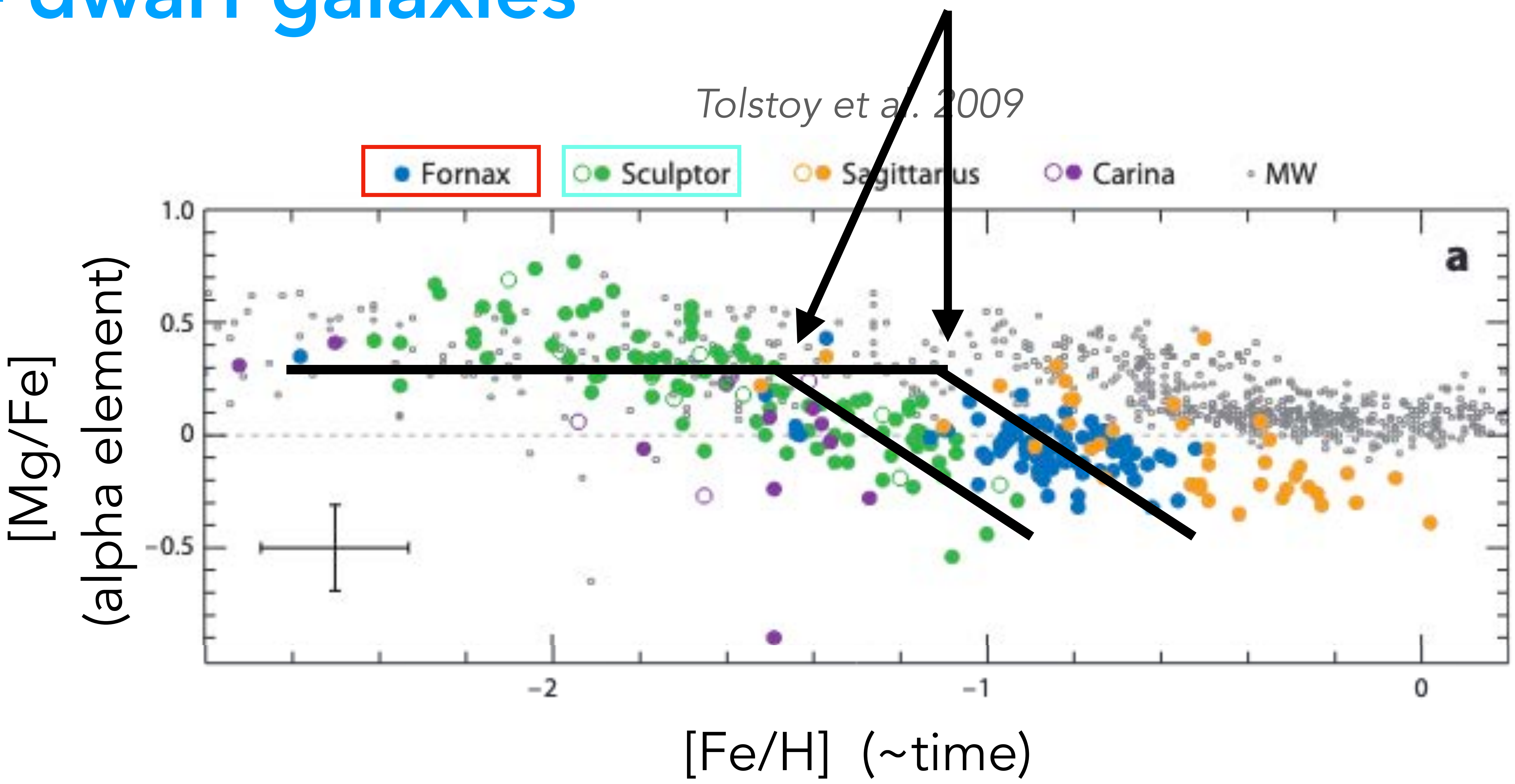
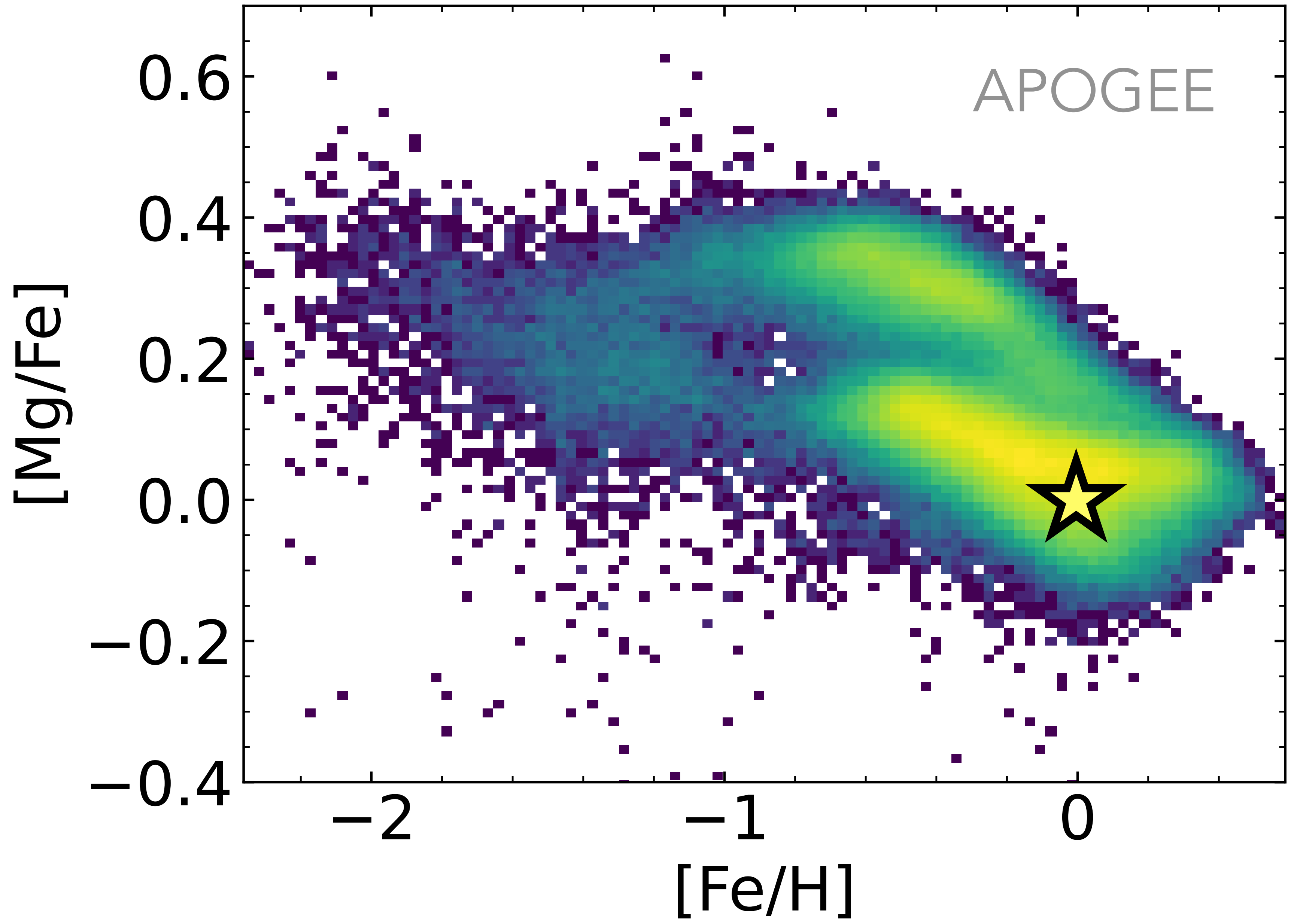


- Fornax formed stars for **longer** (higher metallicity)
- Fornax formed stars **more efficiently** ("alpha knee" location)

Chemical evolution — the Milky Way

Not a closed box… and not the same everywhere!



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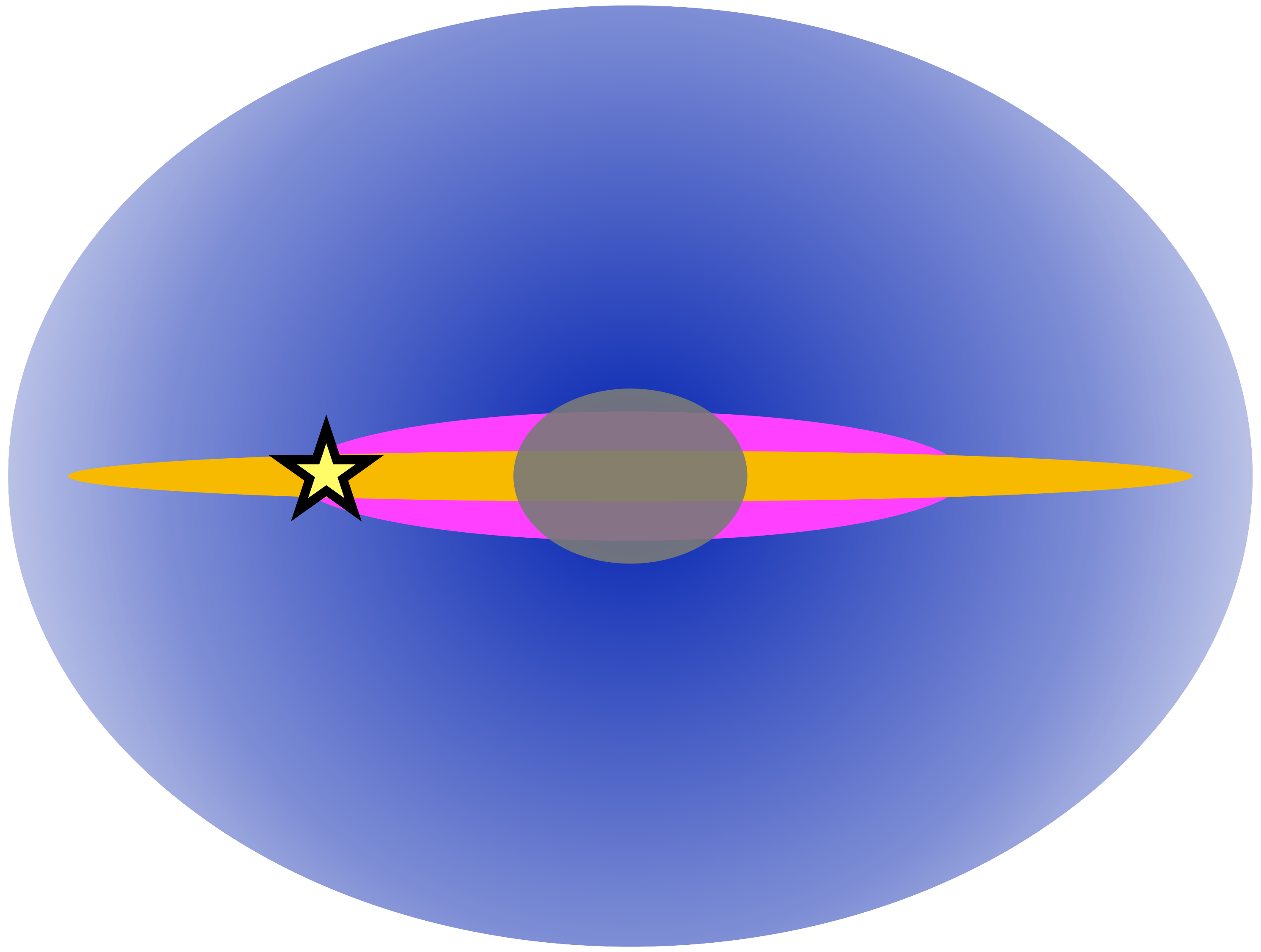

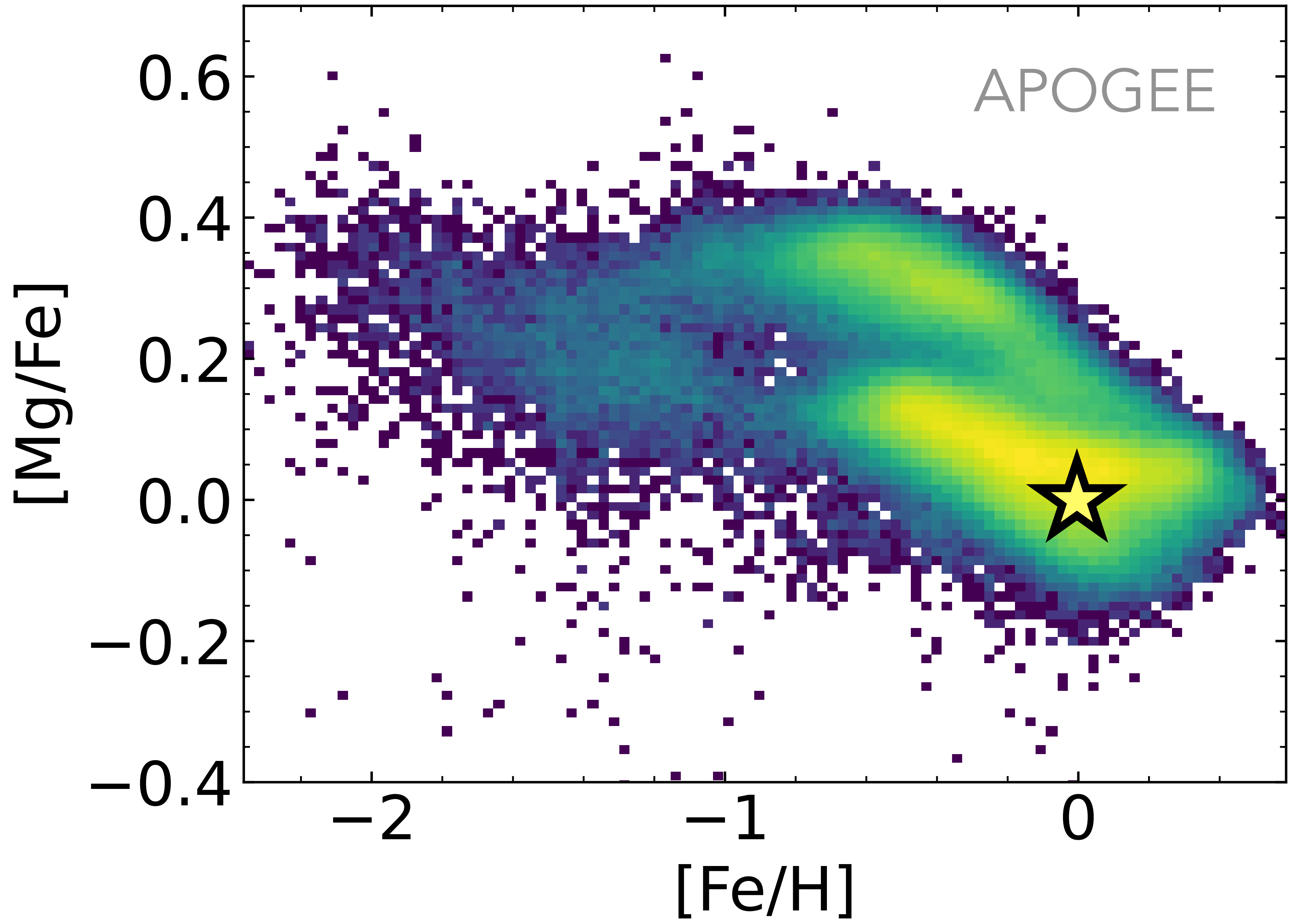

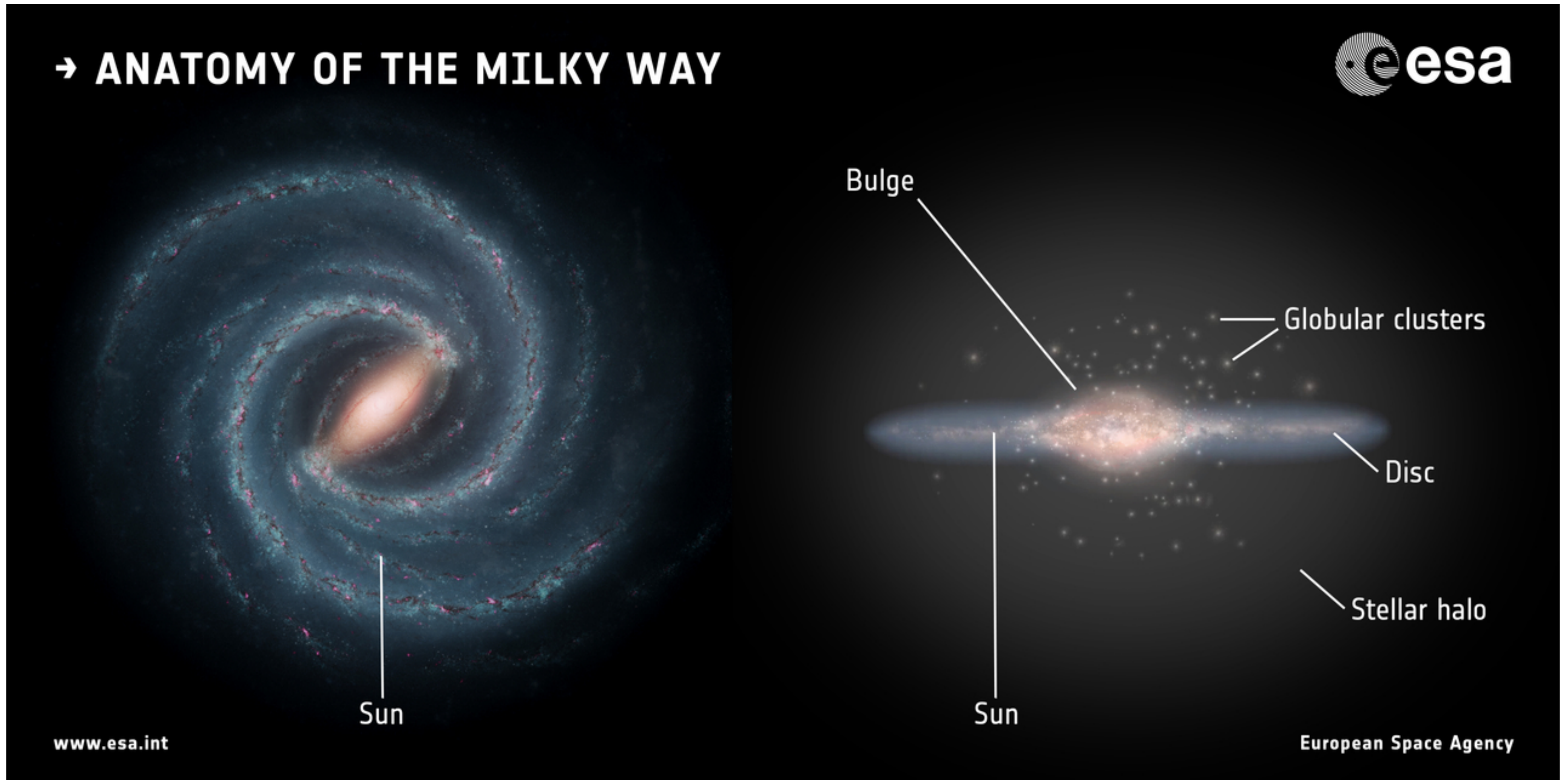

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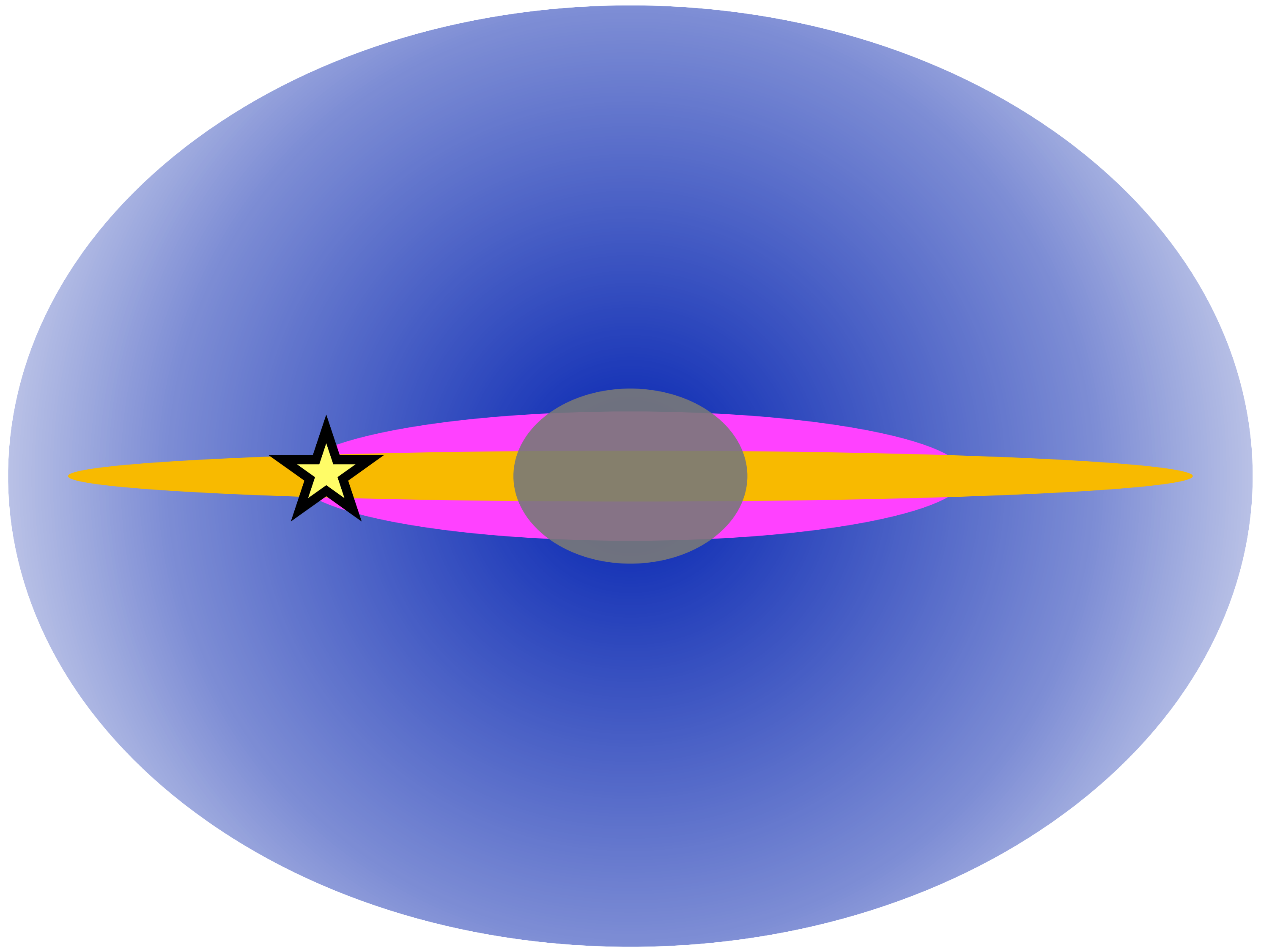
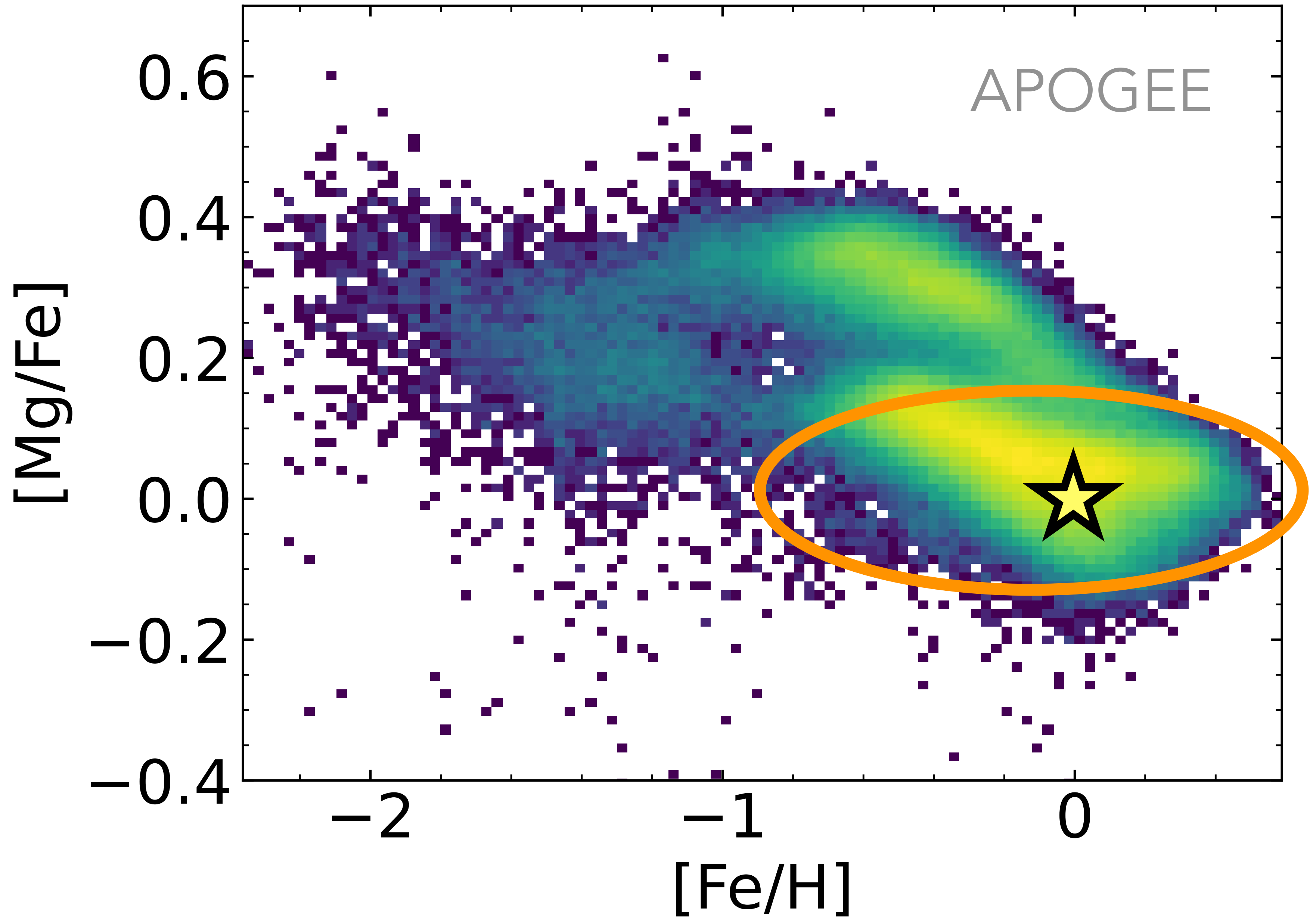
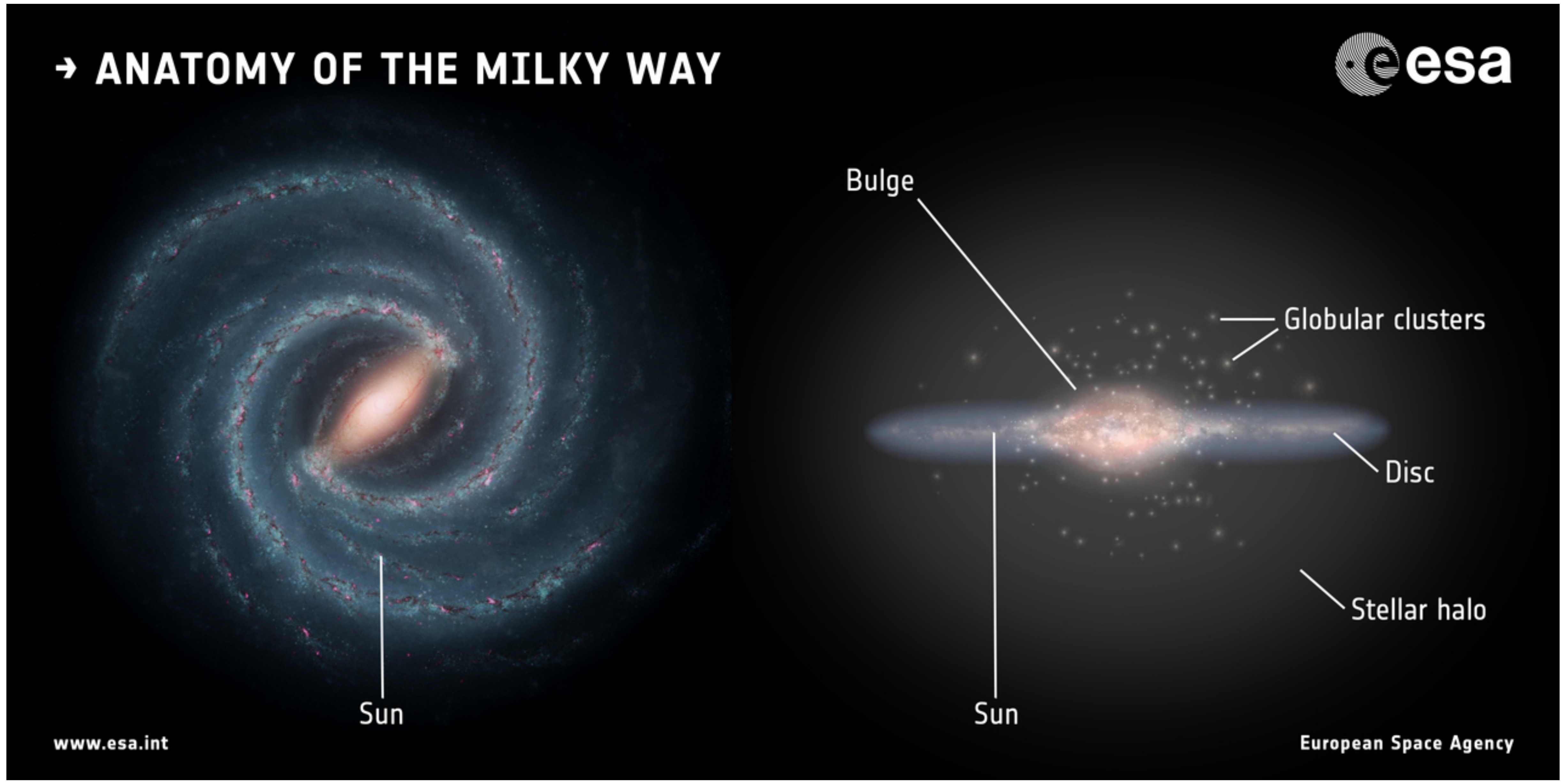
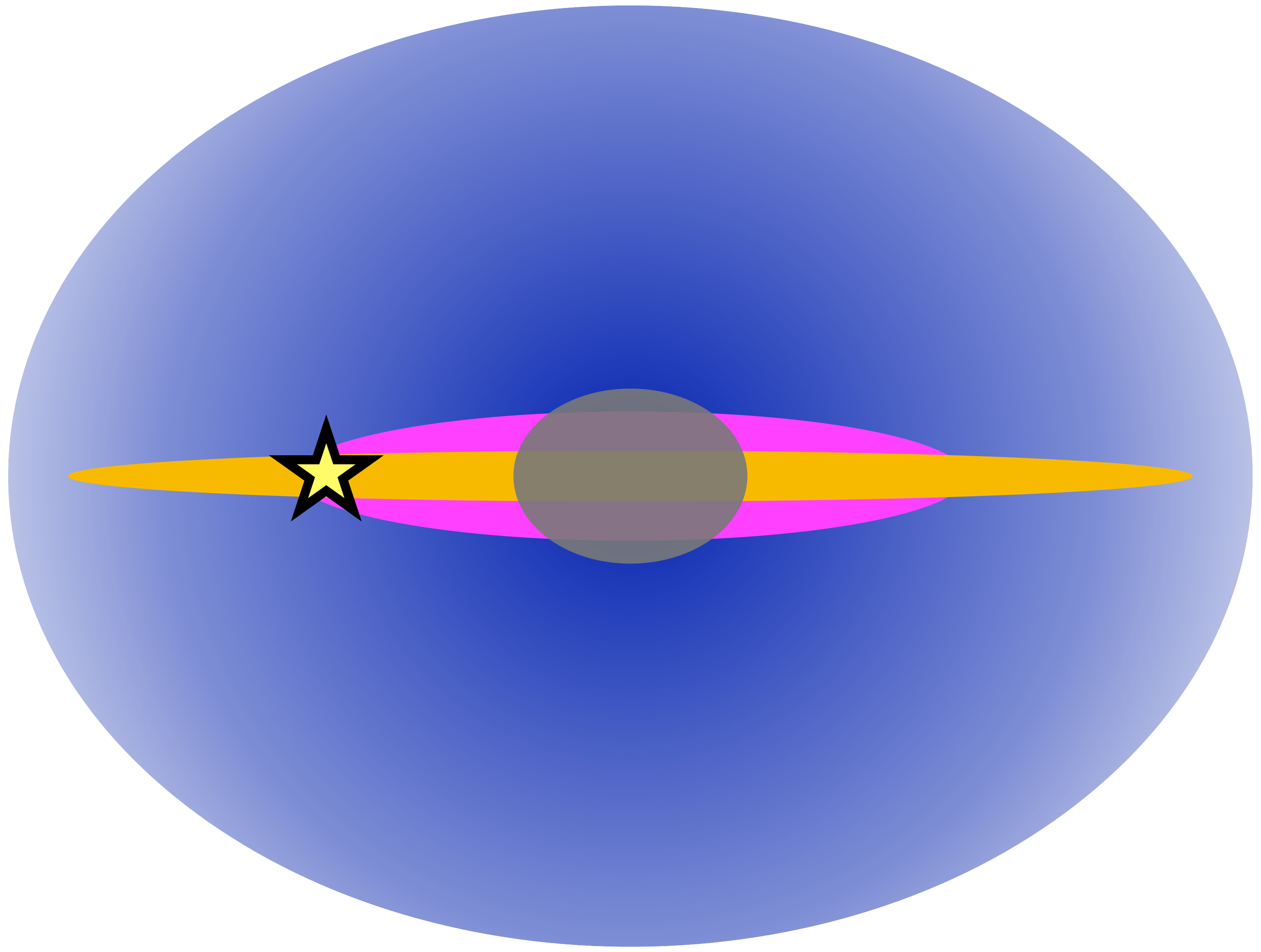






Thin disc

Chemical evolution — the Milky Way



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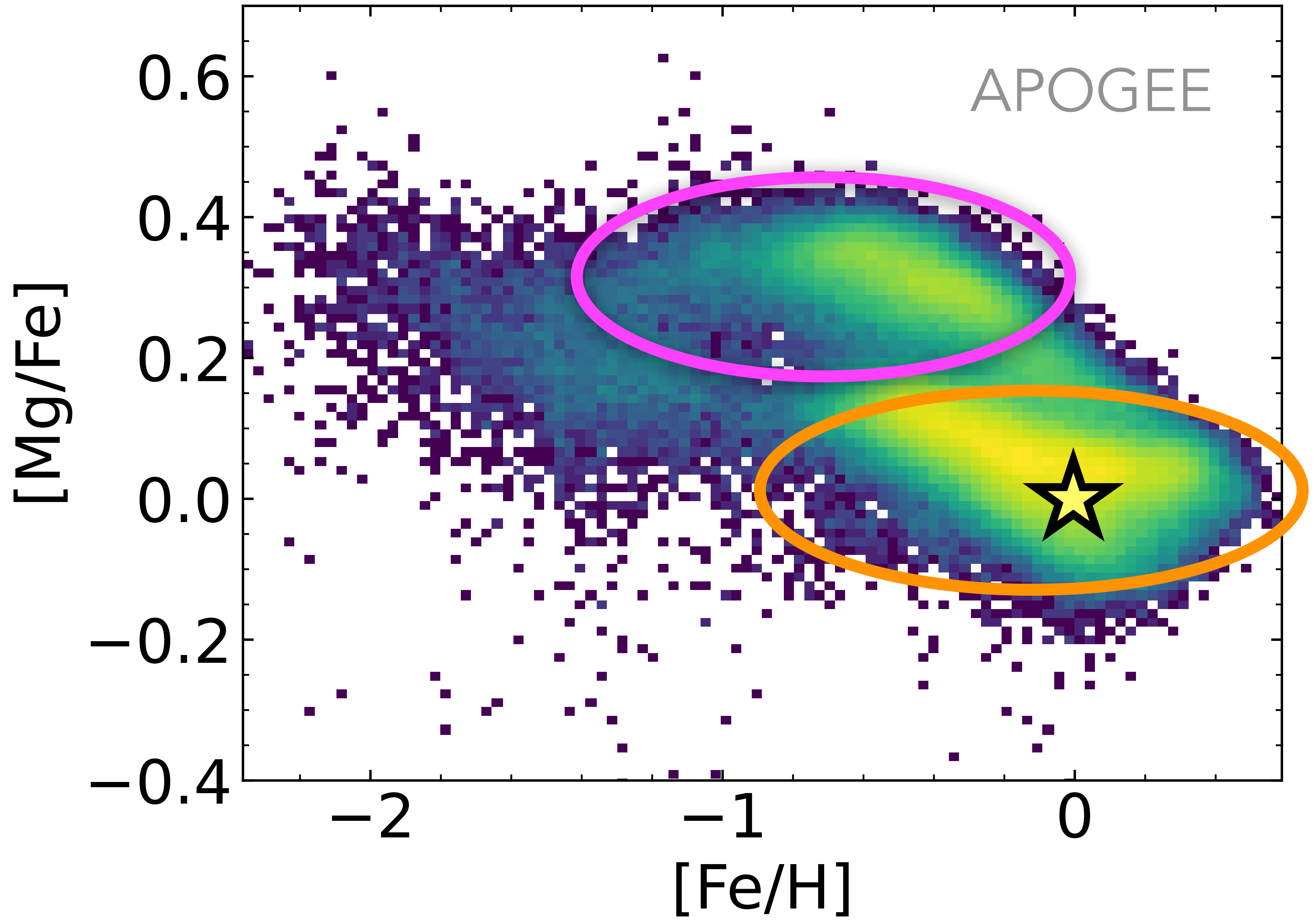
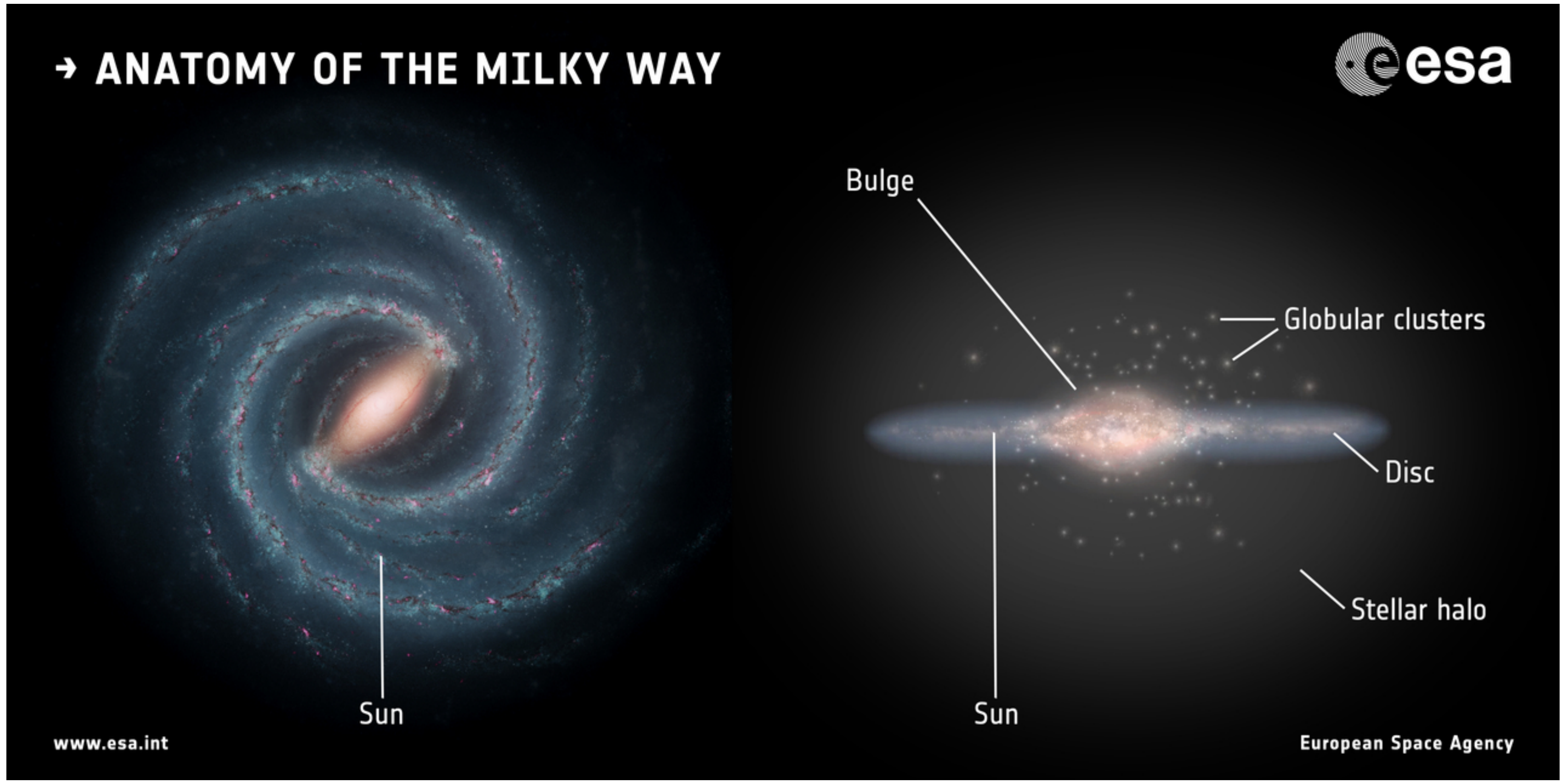


Thick disc

Thin disc



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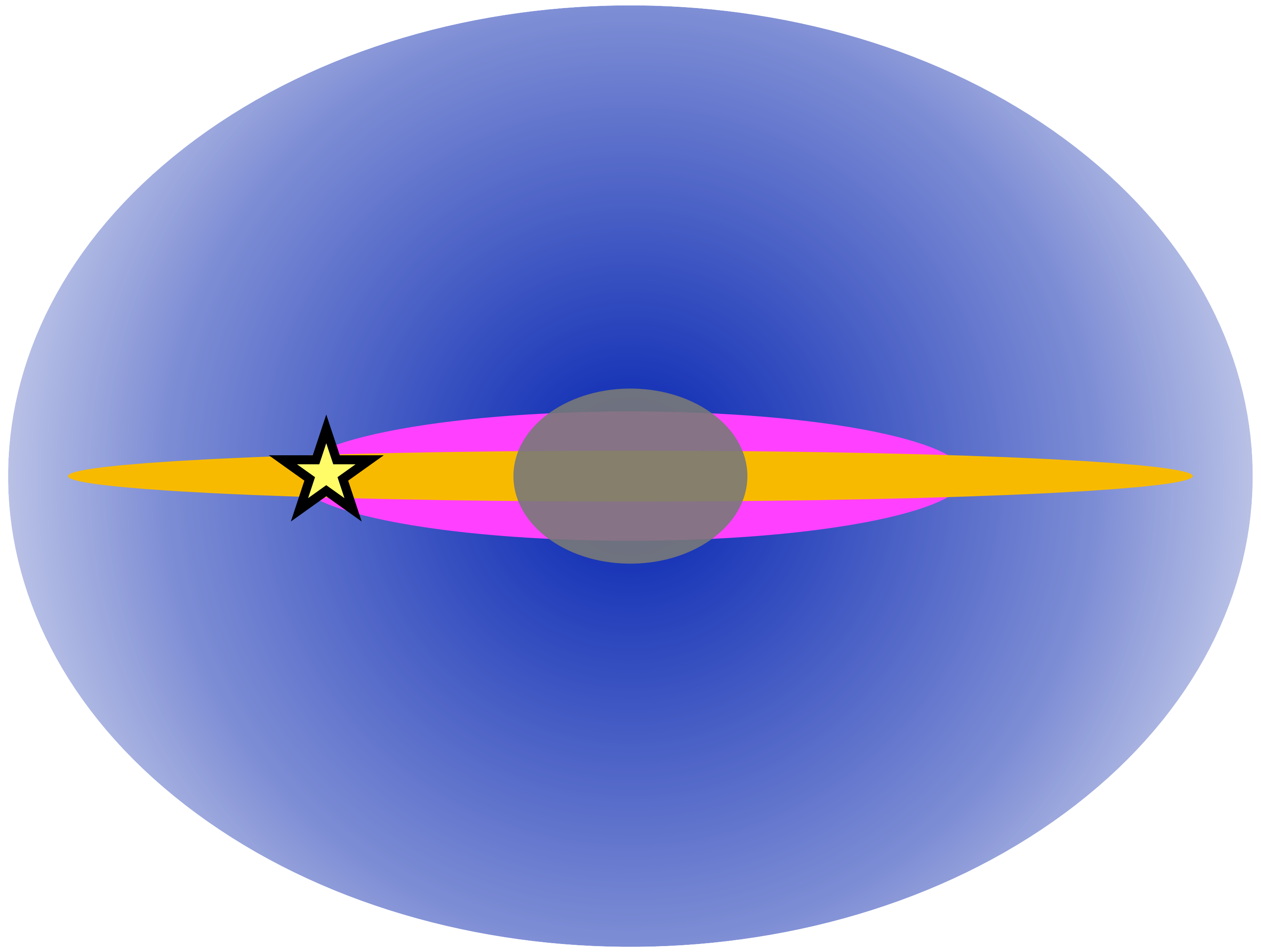

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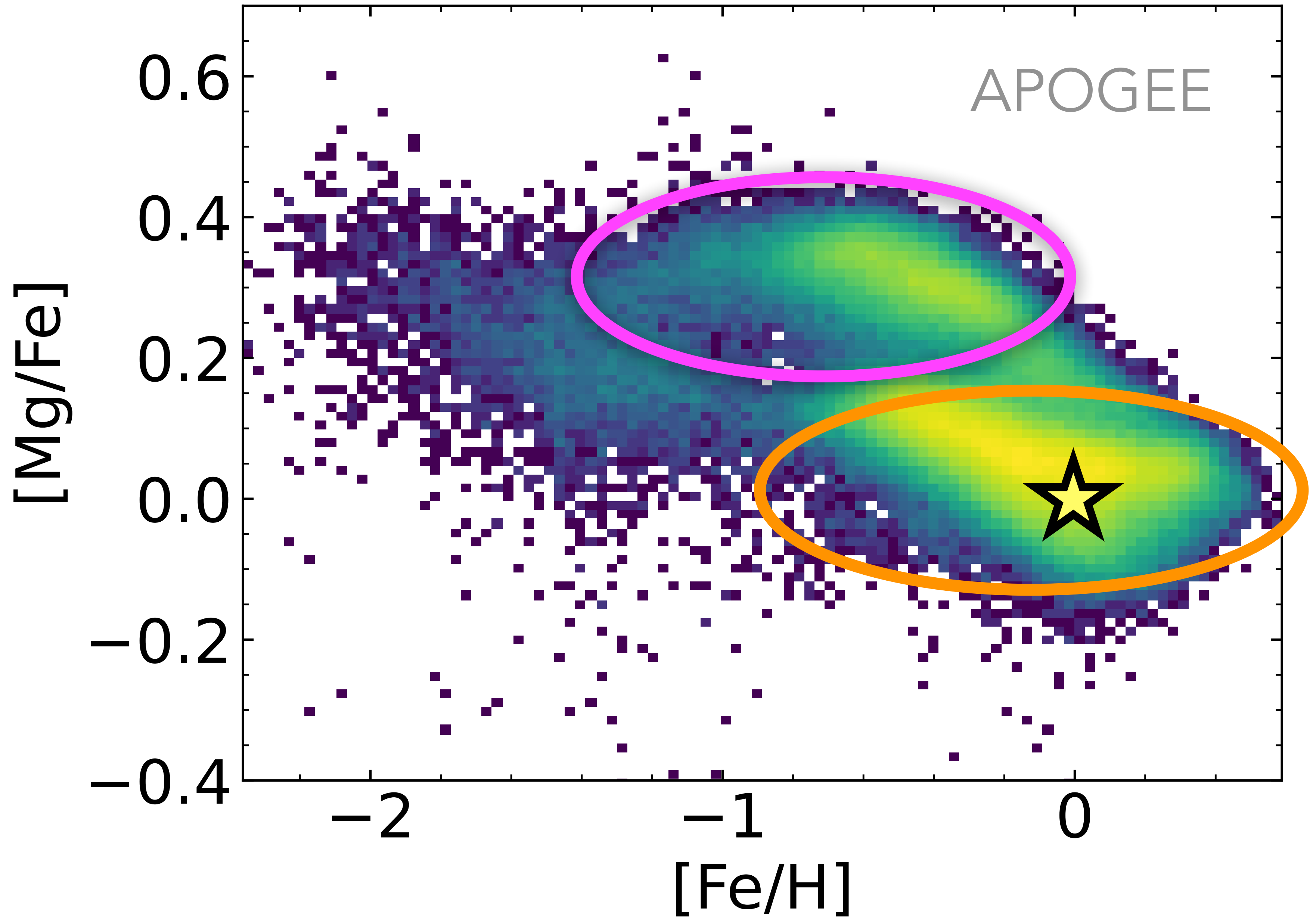
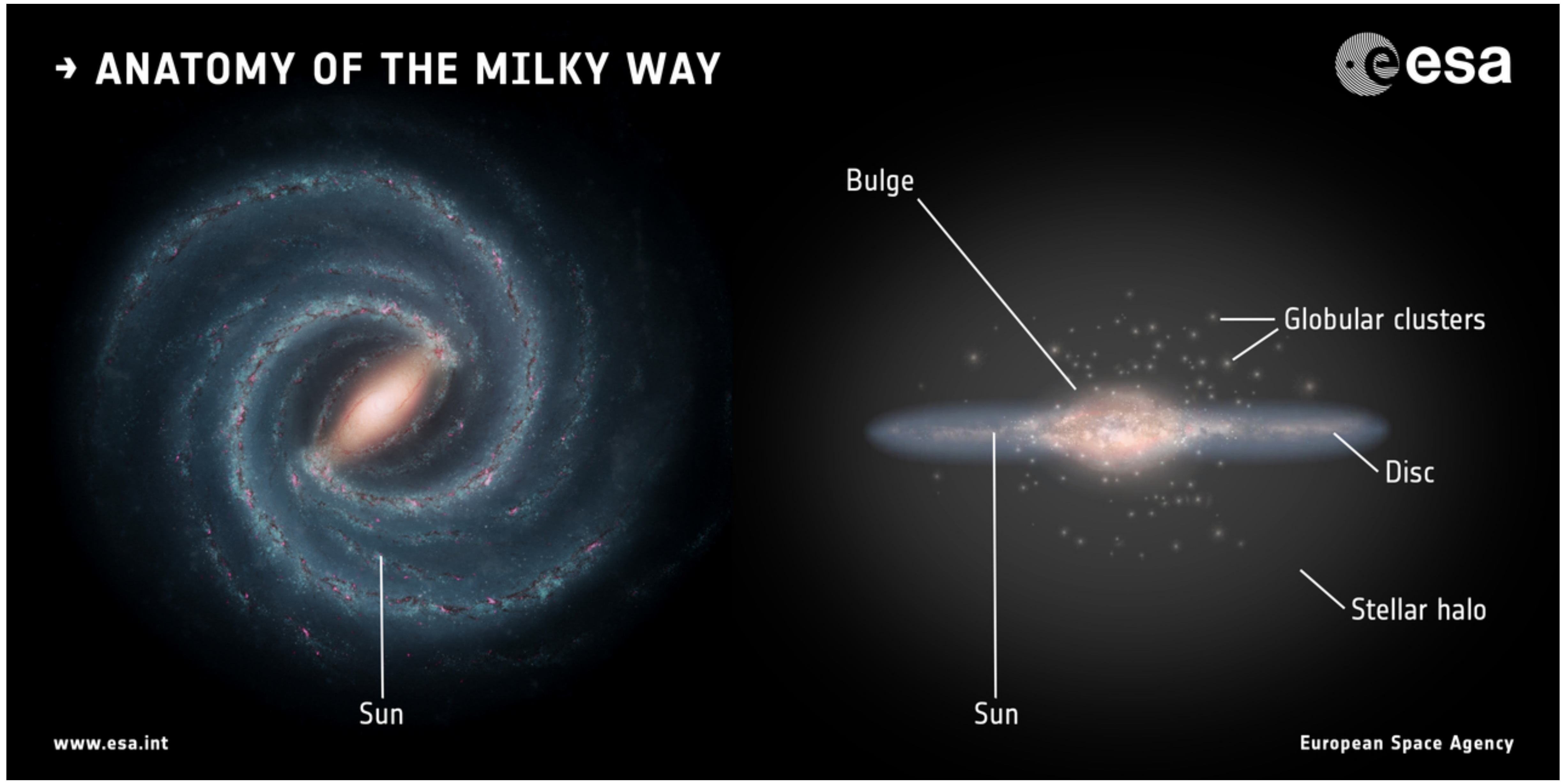


Thick disc

(bulge)

Thin disc



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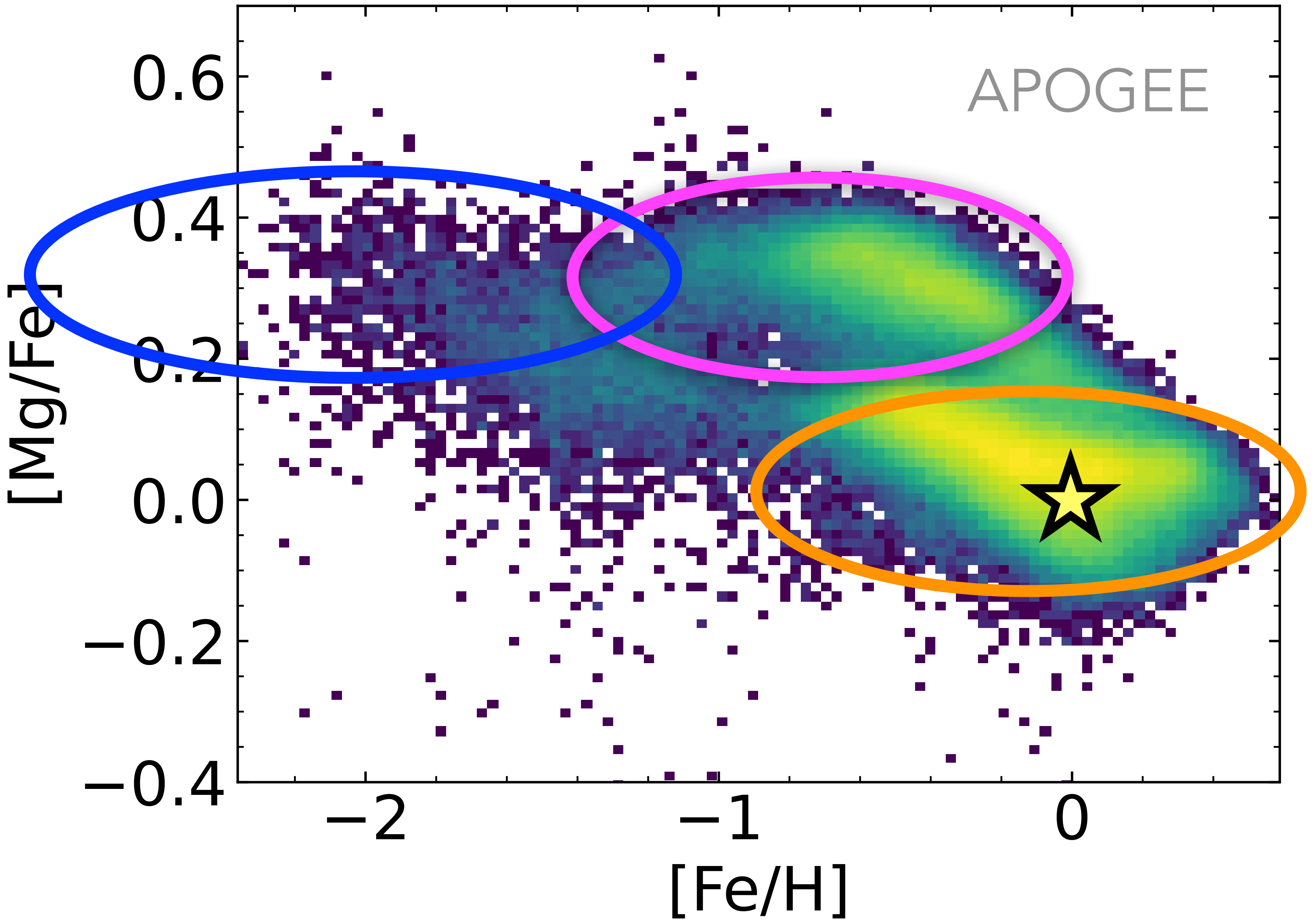
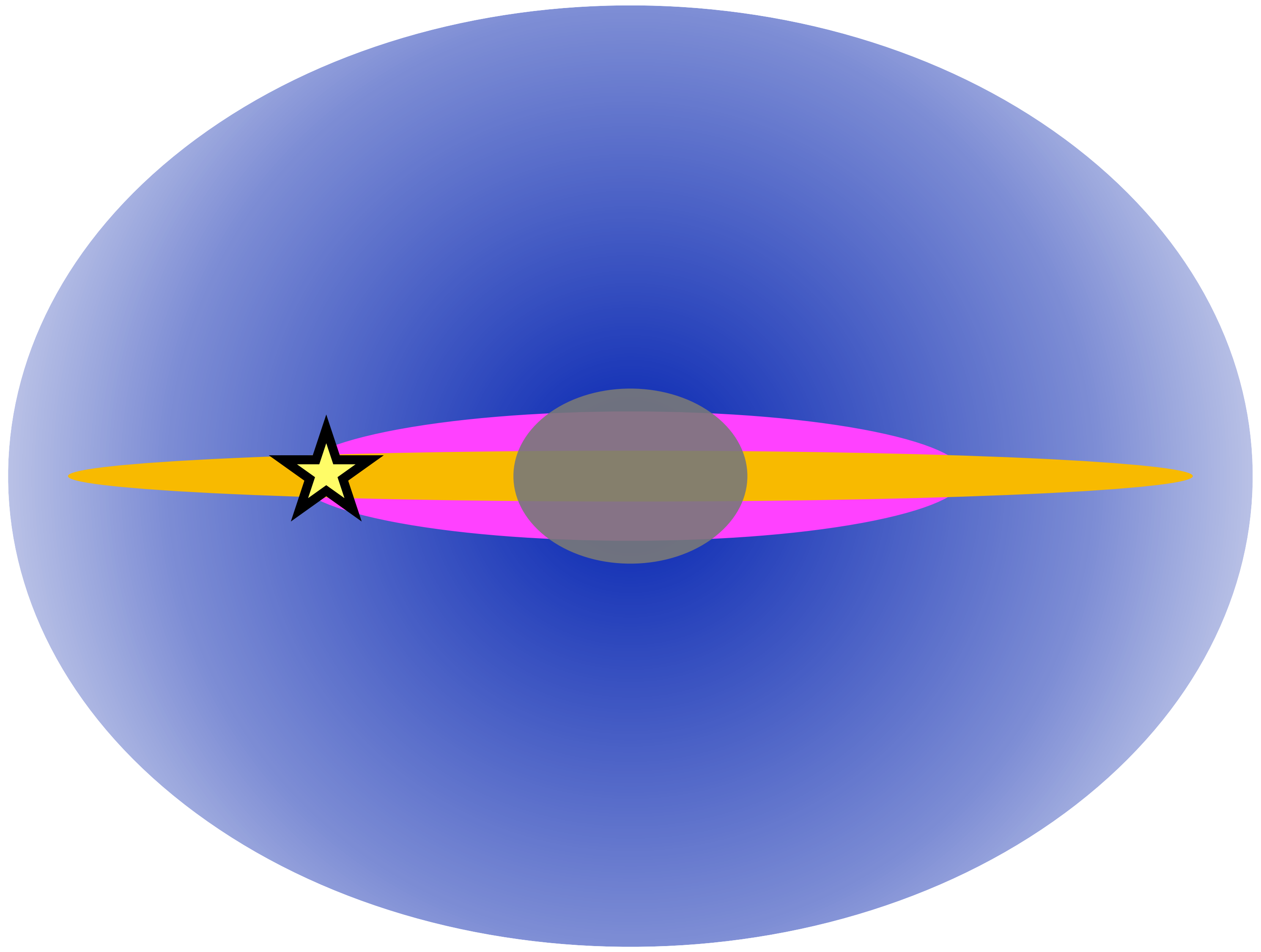


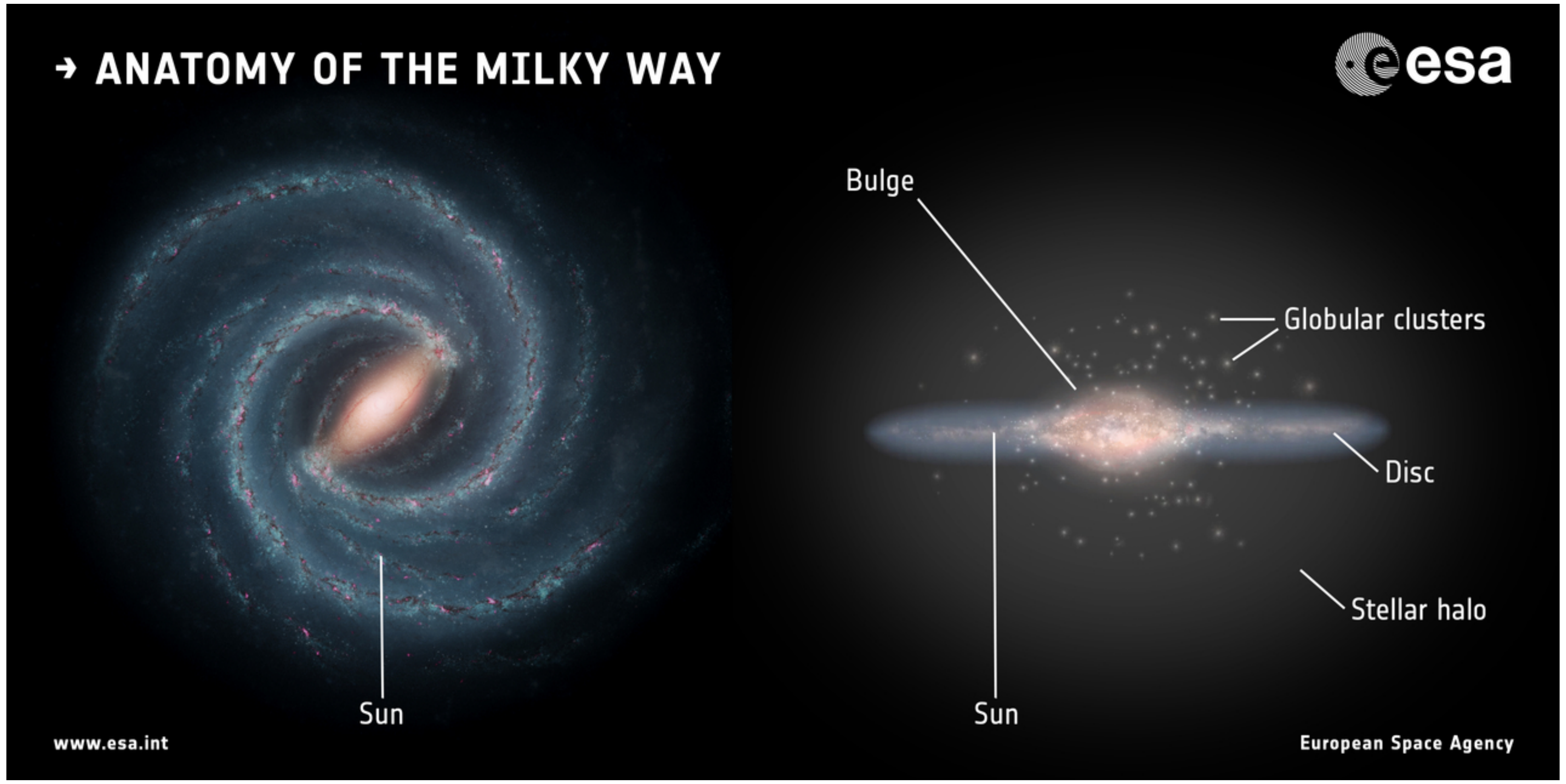
Thick disc

(bulge)

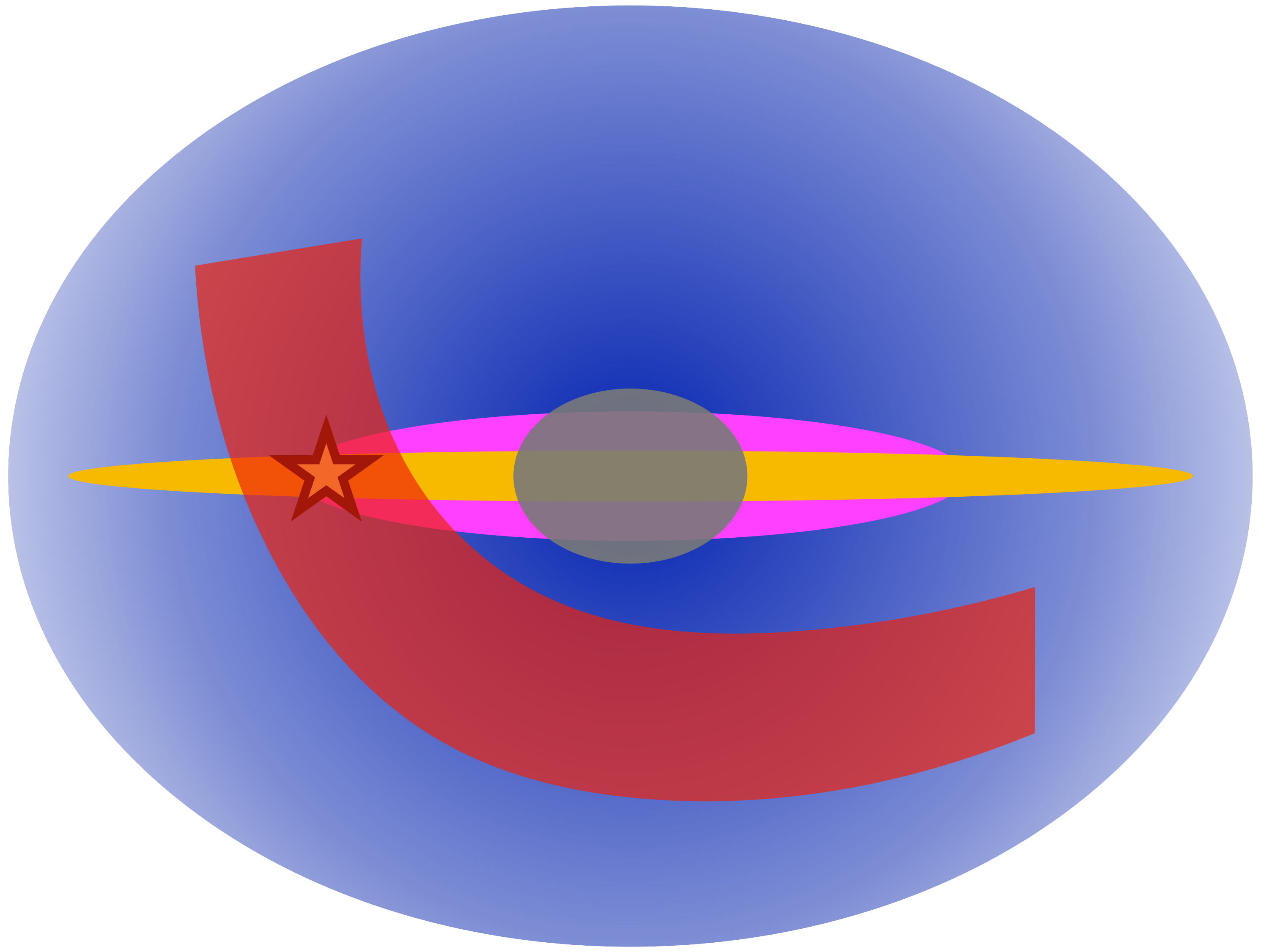
Halo

Thin disc





Chemical evolution — the Milky Way



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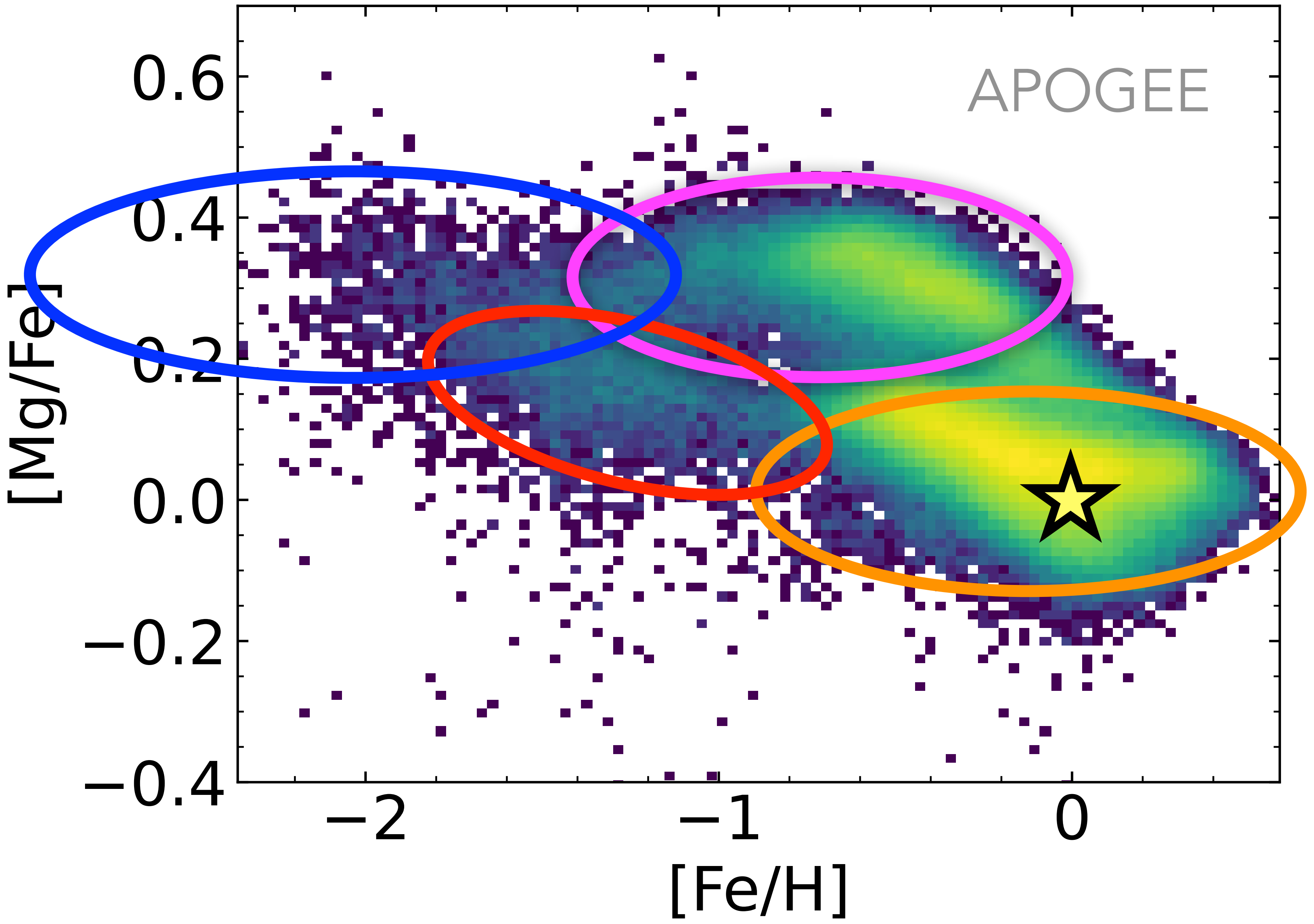
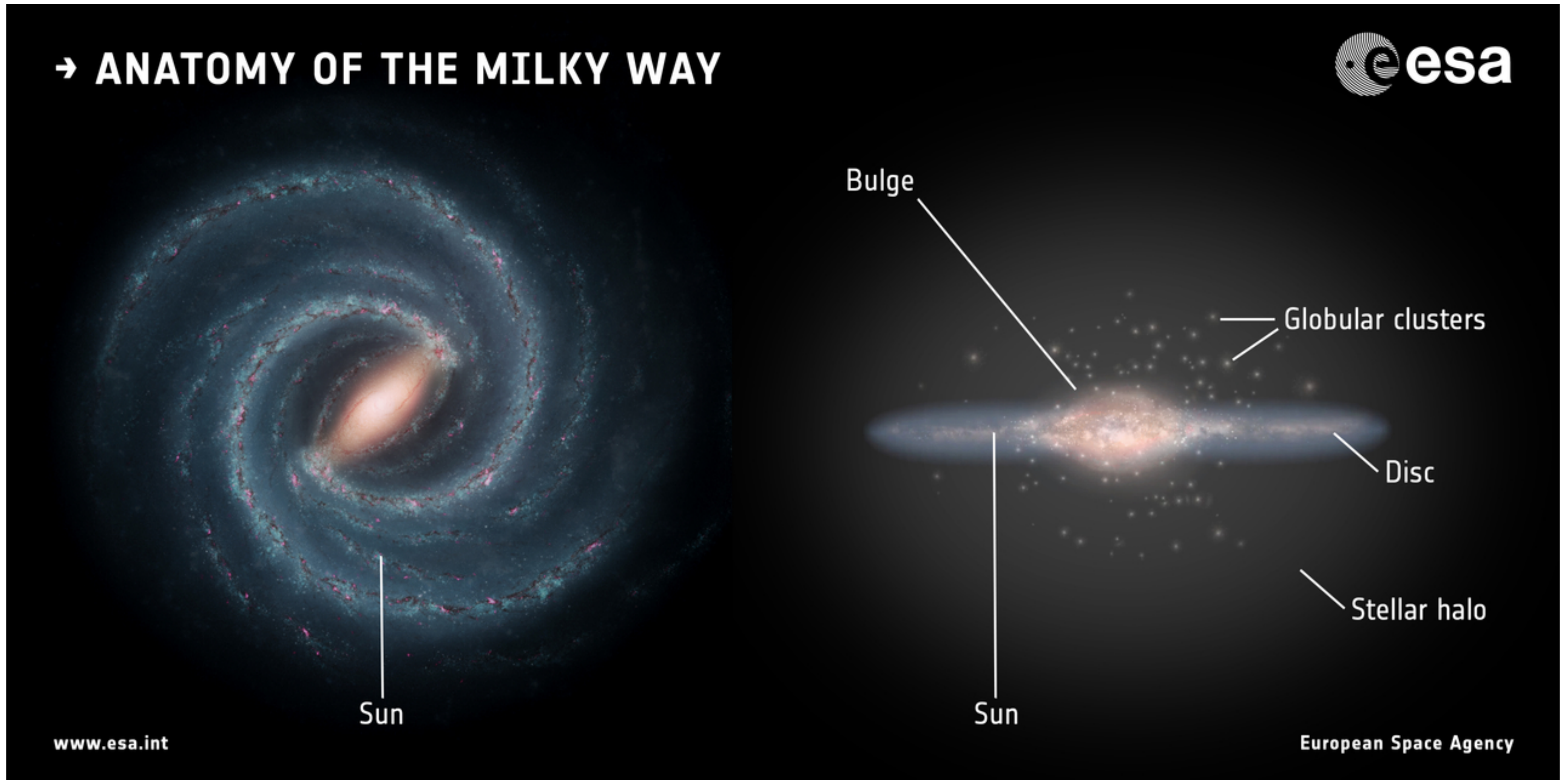




Halo

Accreted dwarf

Thick disc

(bulge)

Thin disc

Chemical evolution — the Milky Way

Chemical evolution — the Milky Way

Hayden et al. 2015

Chemical evolution — the Milky Way

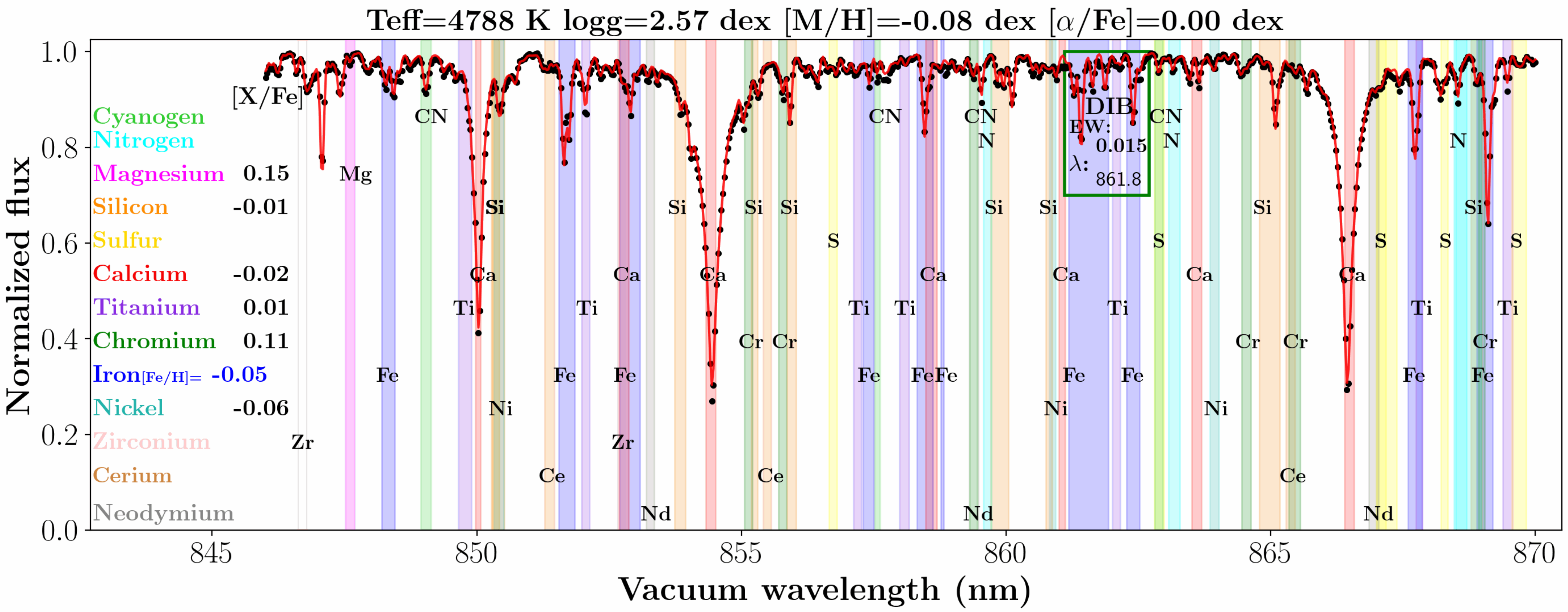
Chemical evolution — the Milky Way

more on Milky Way chemo-dynamics
in the lectures by GyuChul

Hayden et al. 2015

Hands-on session

- Via the Notebooks sub-folder on Moodle, with a link to the data inside the notebook (Lecture6_hands-on_Gaia-RVS.ipynb)
- Exploring the Gaia Radial Velocity Spectrometer (RVS) spectra



ESA/Gaia/DPAC-CU8, Recio-Blanco and the GSP-Spec team

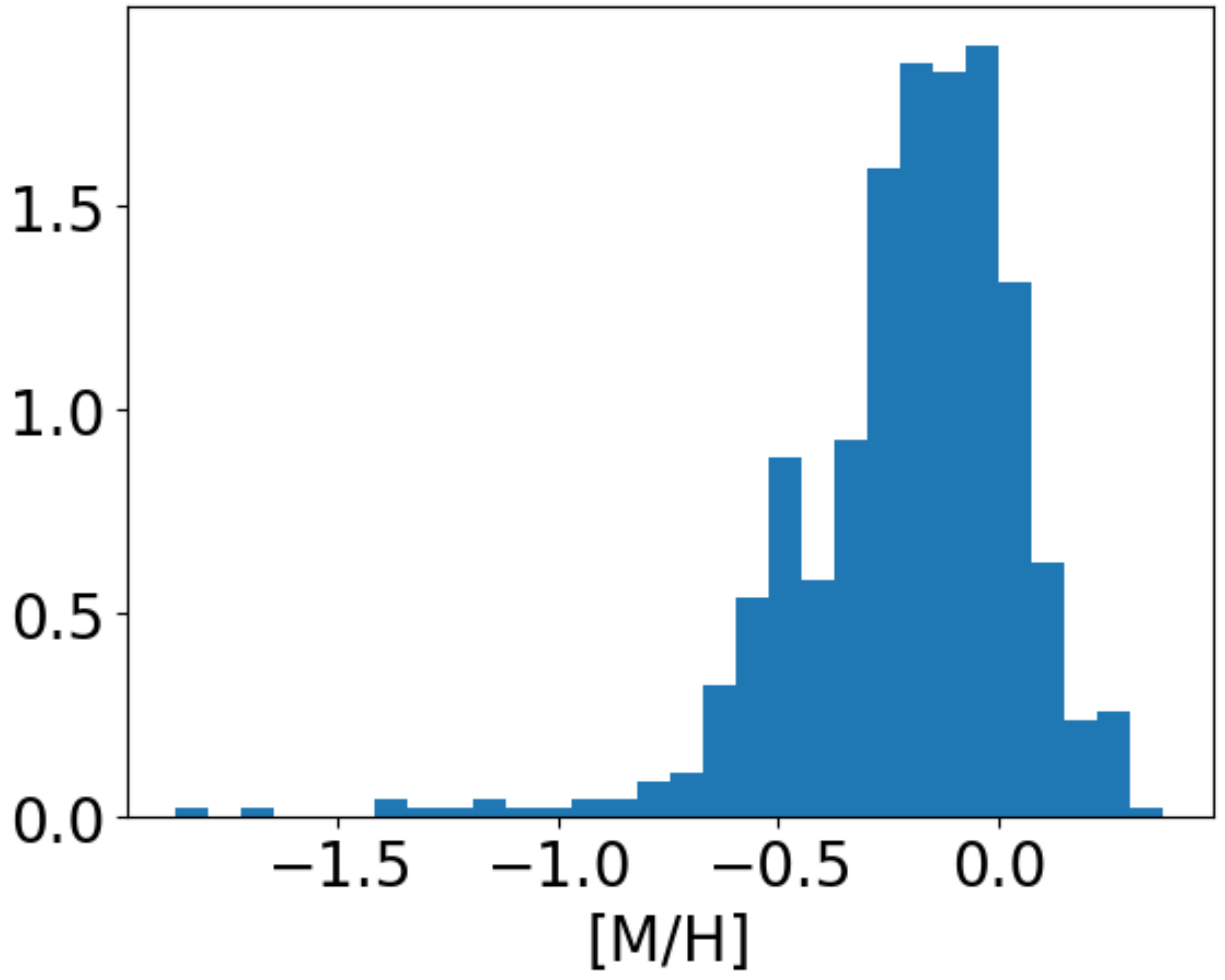
To do

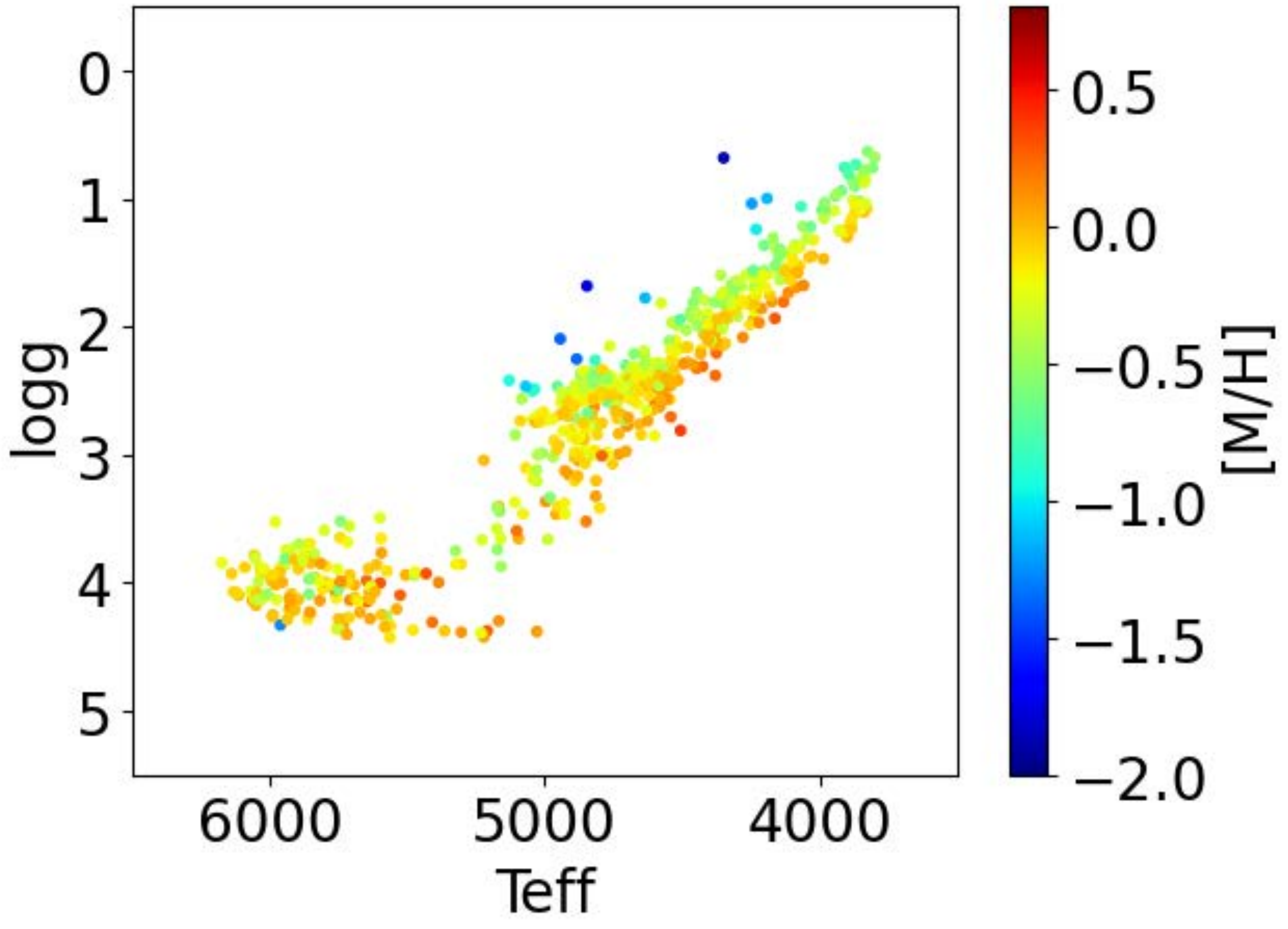
- Plot the Kiel diagram, metallicity distribution and [α/Fe] vs. [Fe/H] diagram
- Explore what the differences are in the spectra for different stellar parameters
- Run dimensionality reduction algorithms, explore trends with stellar parameters

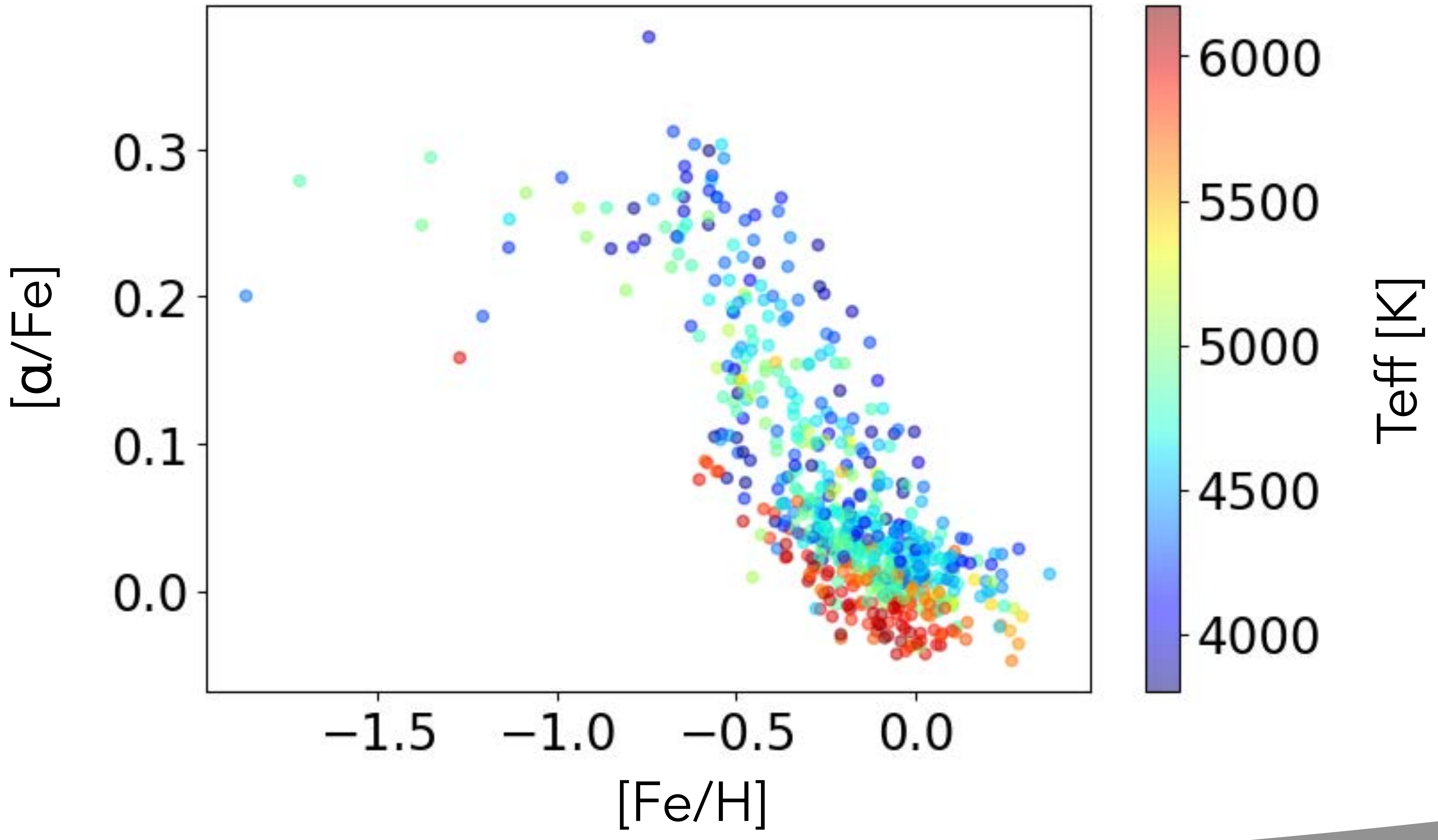
<u>Some things to try next (order up to you):</u>

- Relax or remove quality cuts on the stellar parameters & repeat the above
- Compare the Gaia collaboration & the Guiglion/CNN stellar parameters
- Vary the dimensionality reduction algorithms' parameters
- Anything else you'd like to explore

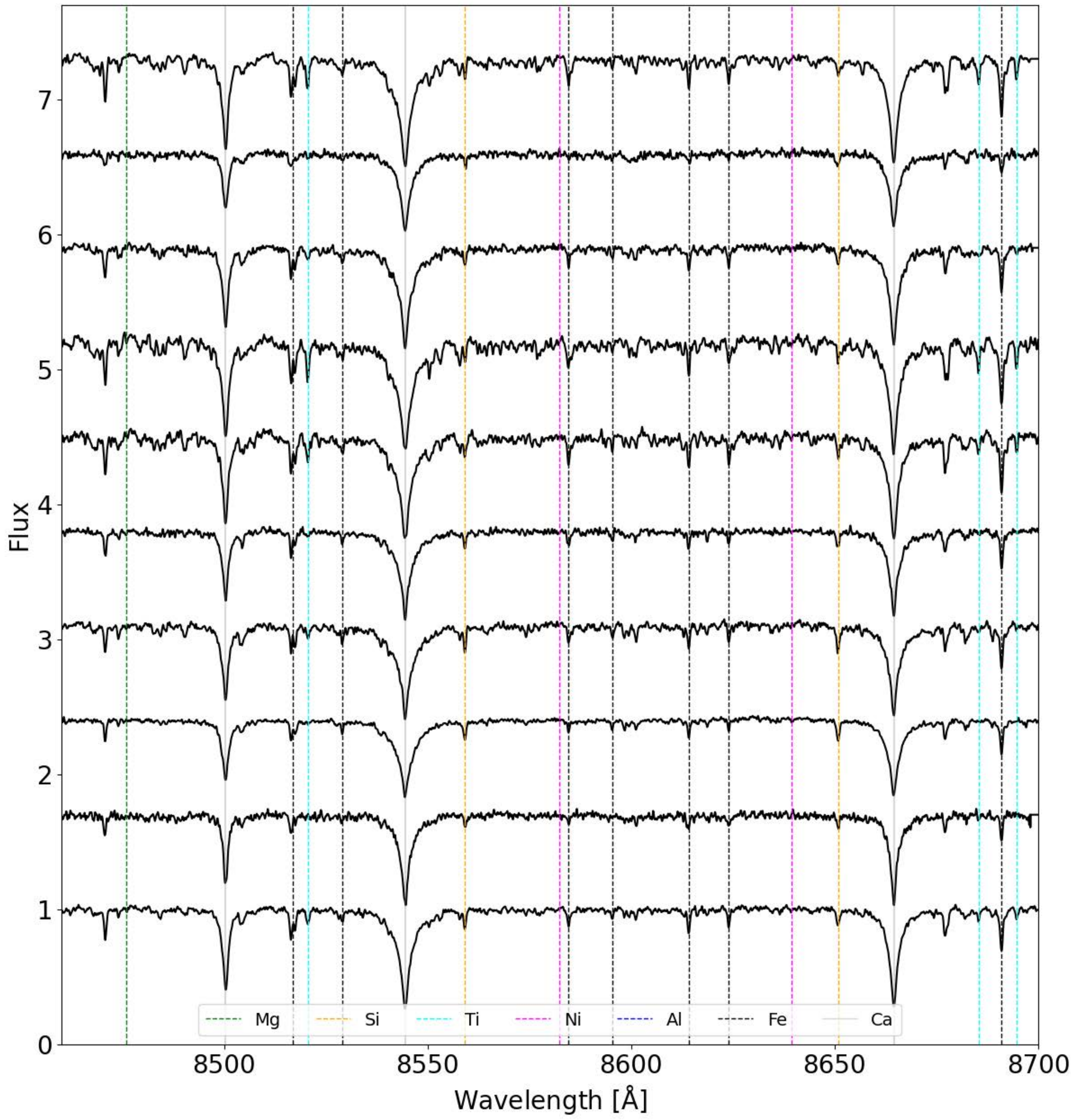
Example results



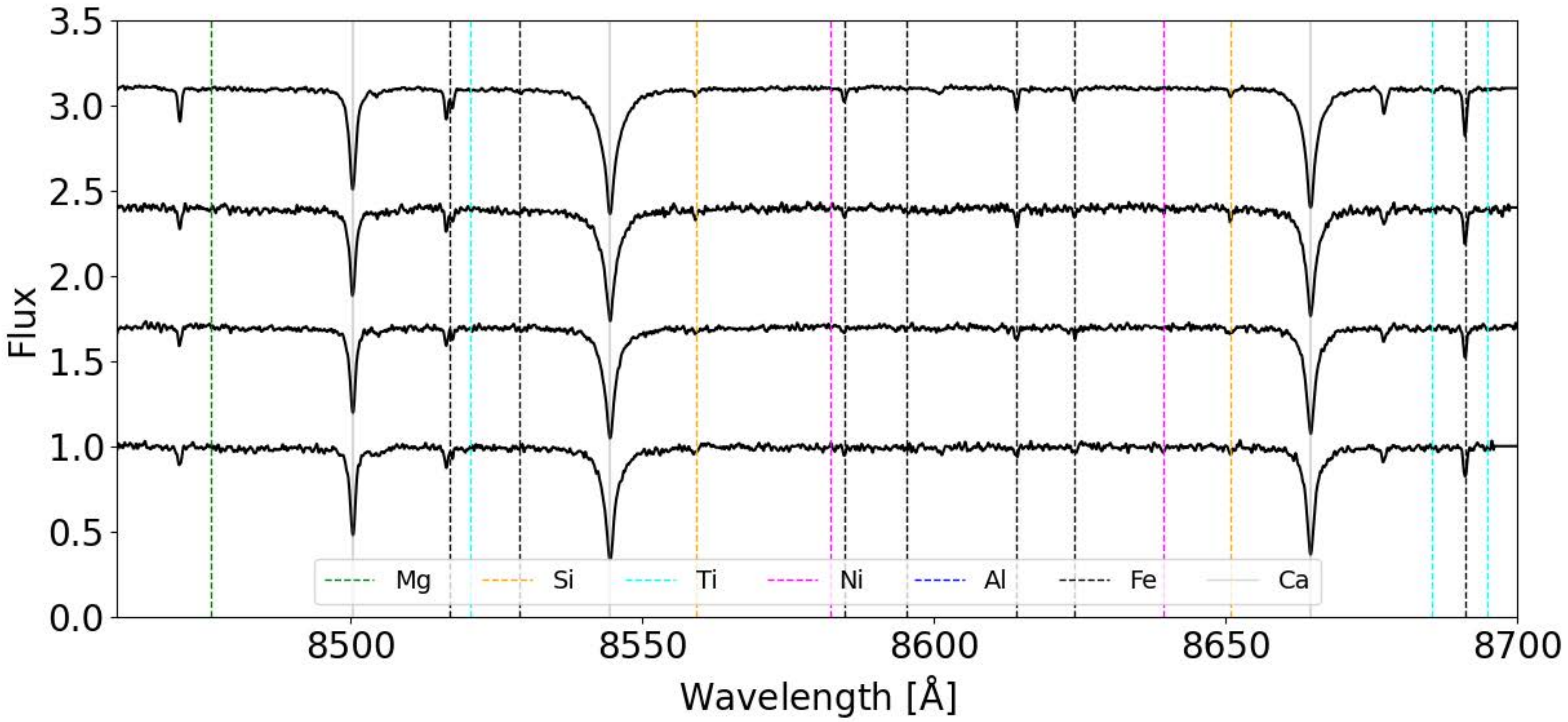




10 random spectra



[Fe/H] < -1.3



Dimensionality reduction