Unveiling the Formation of the Milky Way Disk: A Comprehensive Exploration of the old disk Star Formation History

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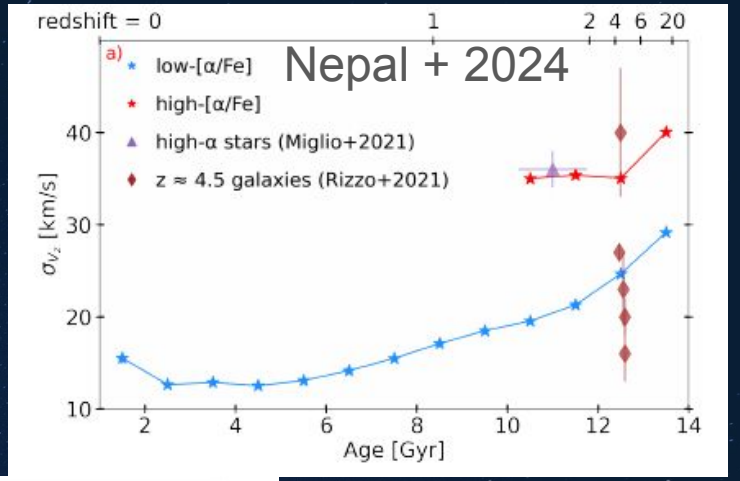
Introduction

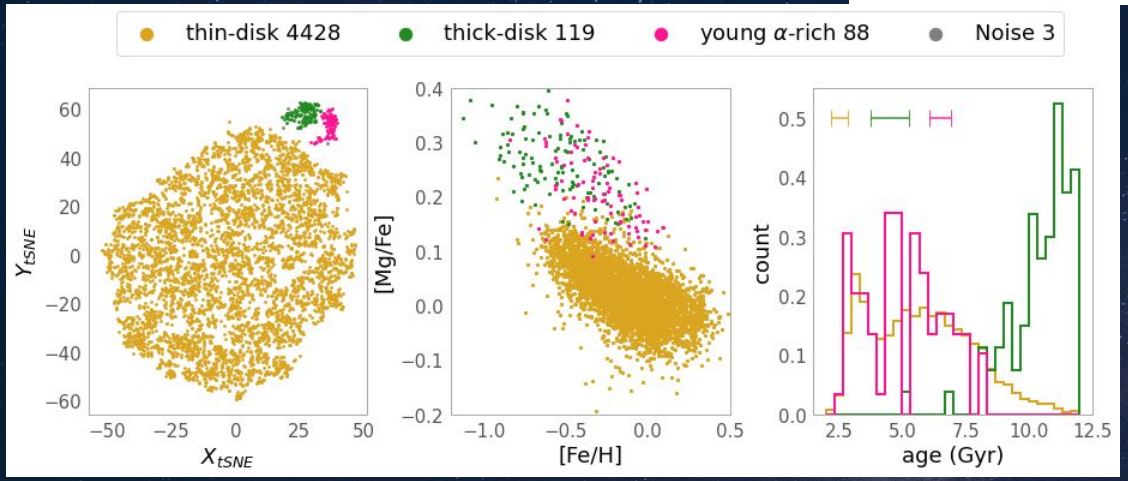
→ Old stars are fossils of the young MW

→ Recent works report metal-poor stars (old) at thin disk dynamics (e.g., Sestito+ 2020, Fernandez-Alvar+ 2021, 2024, Bellazzini+2024, Viswanathan+ 2024)

→ Low-alpha old stars (e.g. , Laporte+ 2020 Beraldo-Silva+ 2021, Nepal+ 2024b)



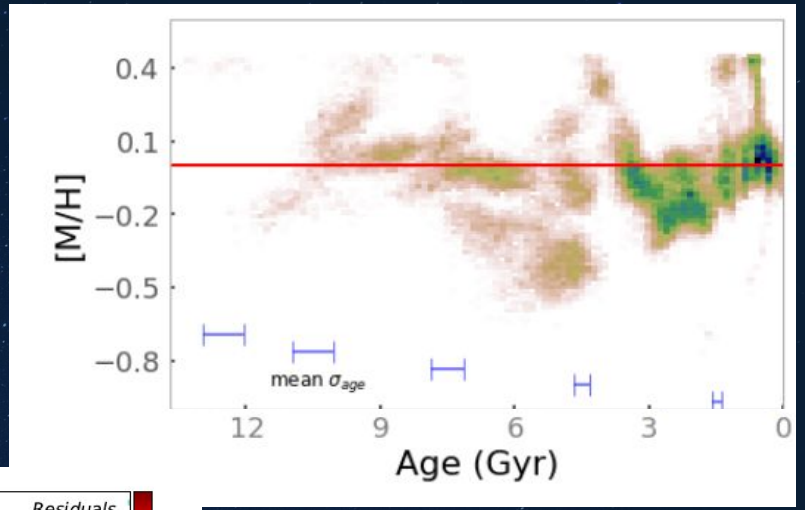
Apogee DR17

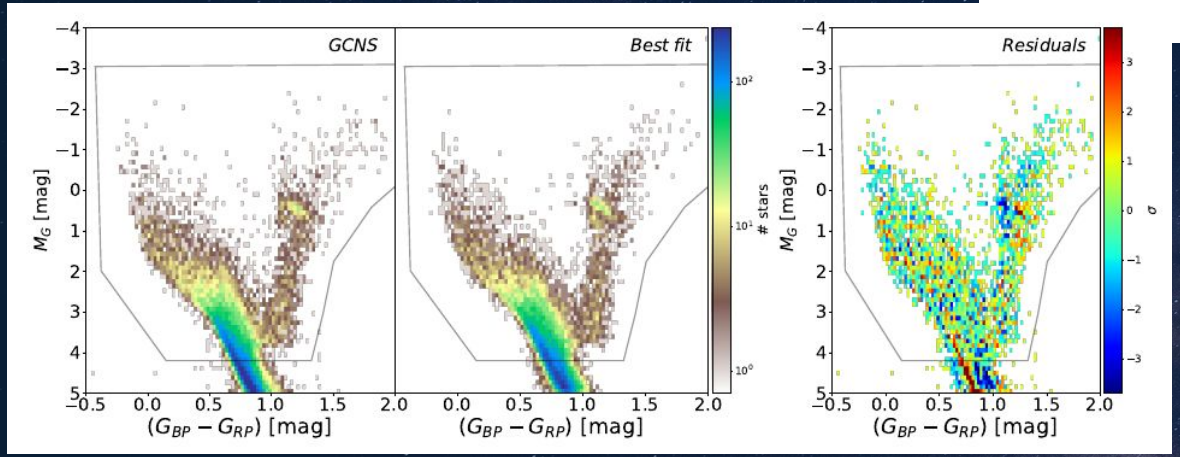


Introduction

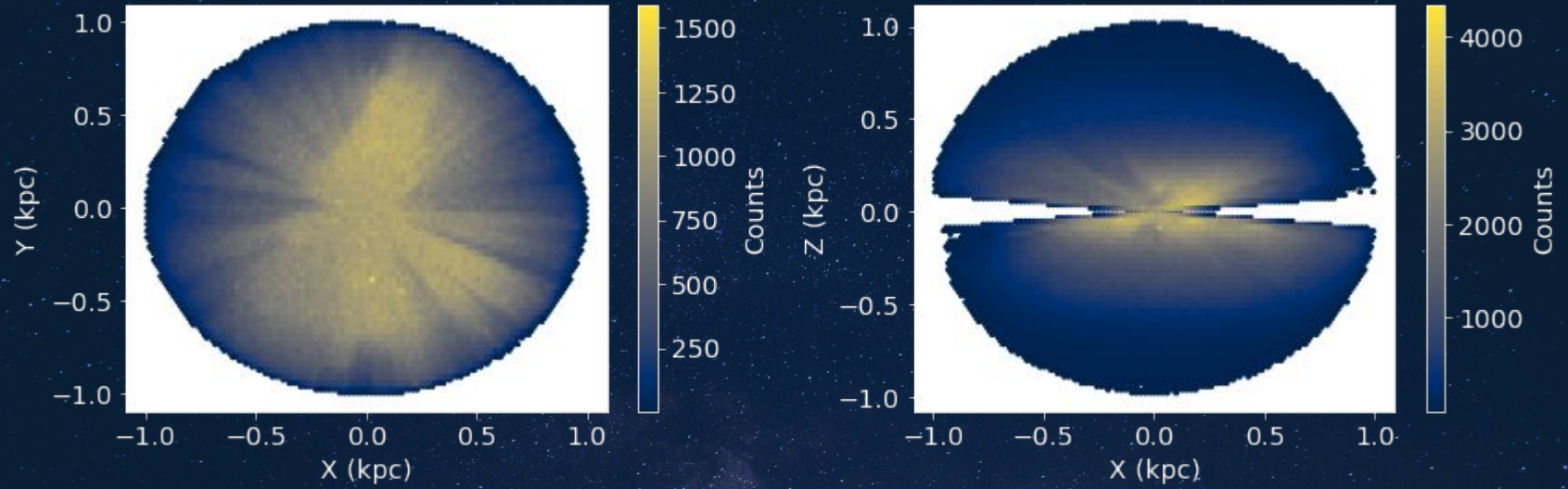
→ CMD-fitting allows us an precise age distributions (σ~10%) see Gallart's talk tomorrow!

→ We can achieve a good completeness in the solar neighborhood only using *Gaia* CMD;





Sample



→ Selection: 1kpc sphere radius (centered in the Sun) within *Gaia* DR3 available radial velocities

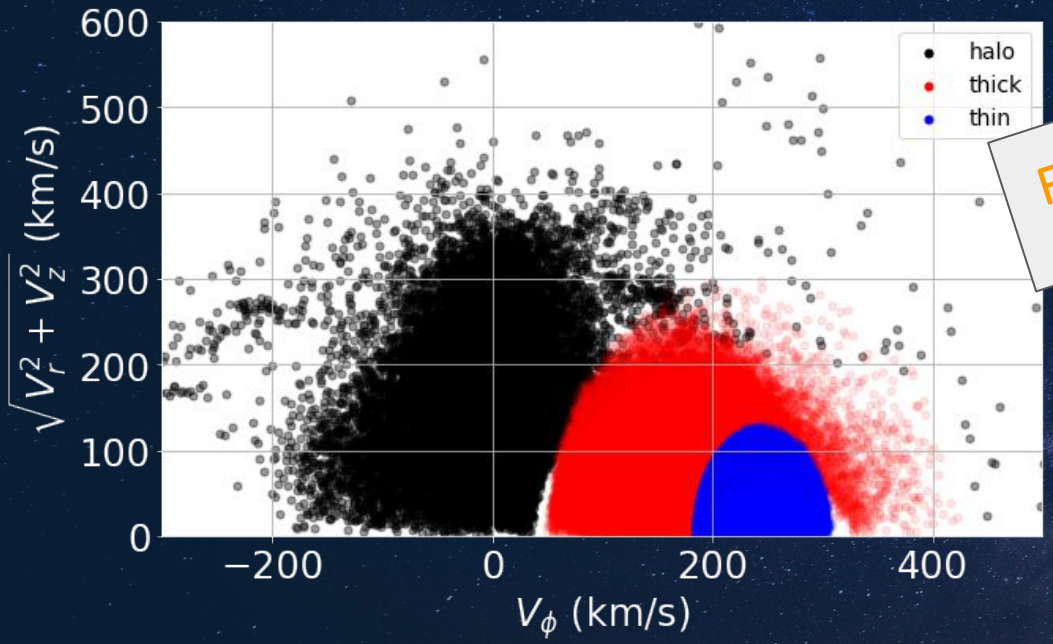
→ Cuts in quality: (Av<0.5 mag); parallax/error >5; Mg <5.5

→ Select in (Z >100pc at x=1kpc) to avoid extinction problems

Sample

→ Velocities space and density profiles: (Bensby+ 2003; updated values from Bland-Hawthorn+2016) Kinematic thin, thick disks and halo

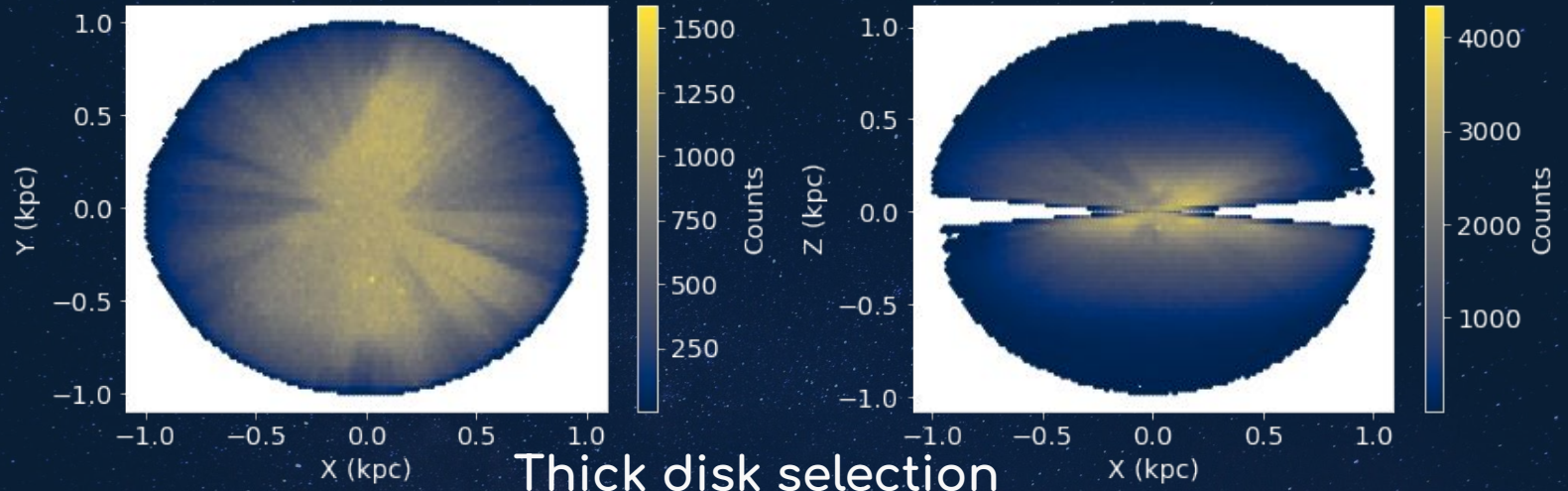
$$p = \rho(t) * \frac{1}{\sqrt{2\pi}\sigma_U\sigma_V\sigma_W} * e^{-0.5((\frac{U}{\sigma_U})^2+(\frac{(V-V_{LSR})}{\sigma_V})^2+(\frac{W}{\sigma_W})^2)}$$



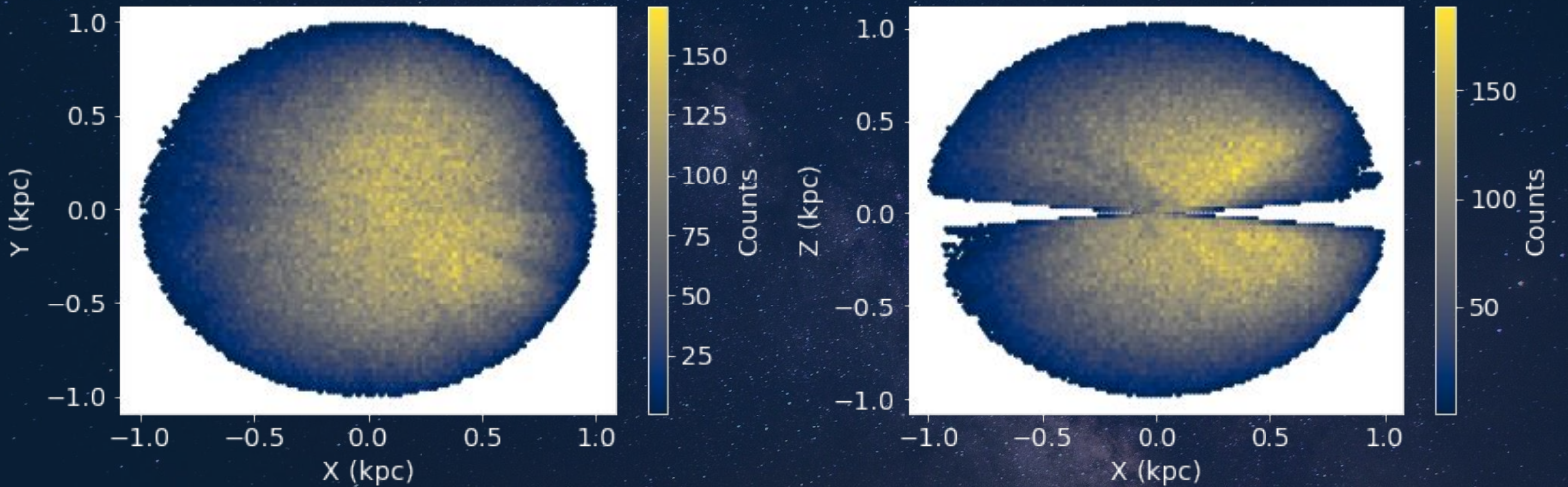
Fernandez-Alvar talk

Thin disk: 5 million*
Thick disk: 600 thousand *
Halo: 20 thousand stars *

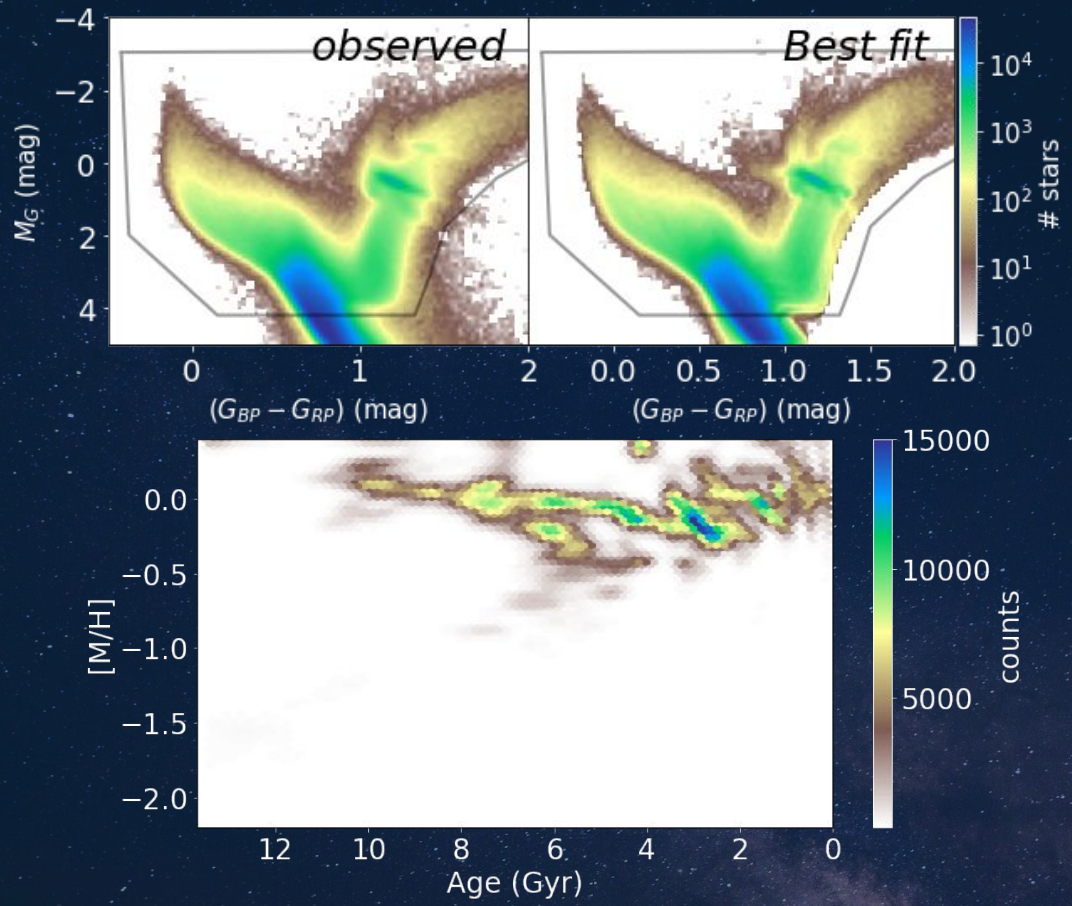
Thin disk selection



Thick disk selection



Results: Thin disk



For more about the method see Gallart et al. 2024 and talk!

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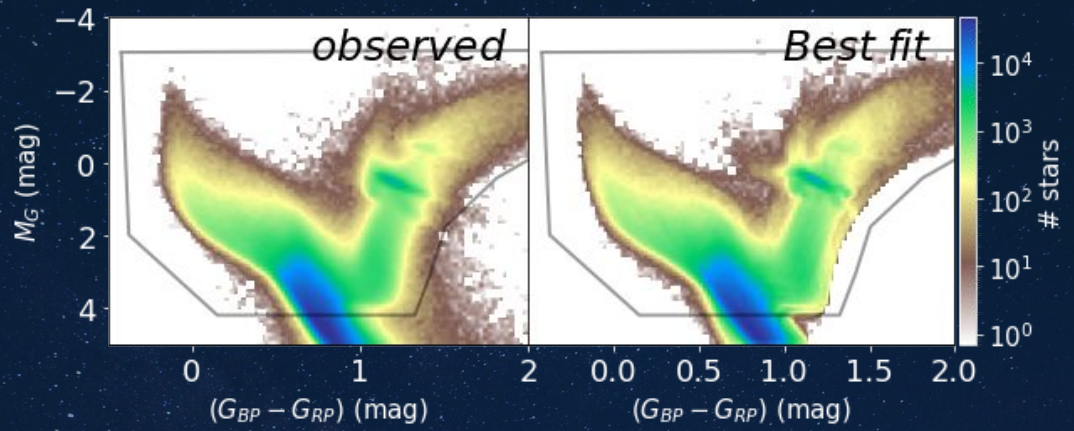
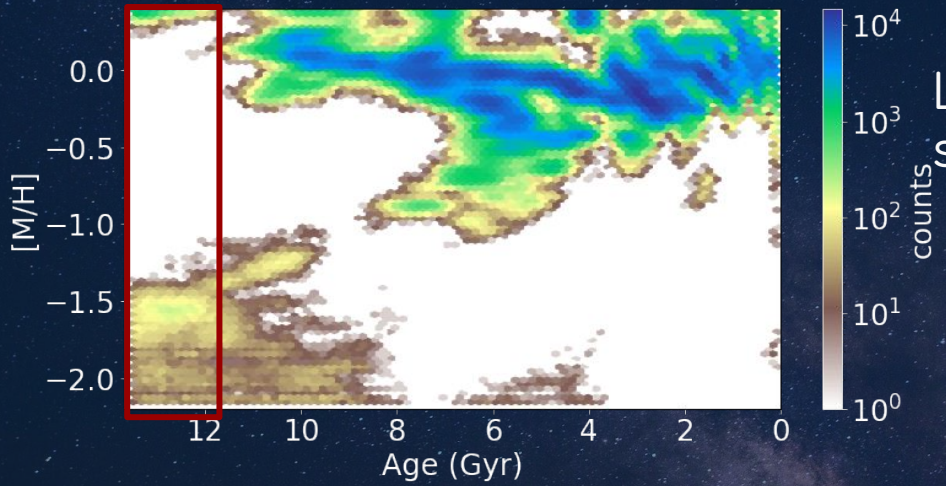
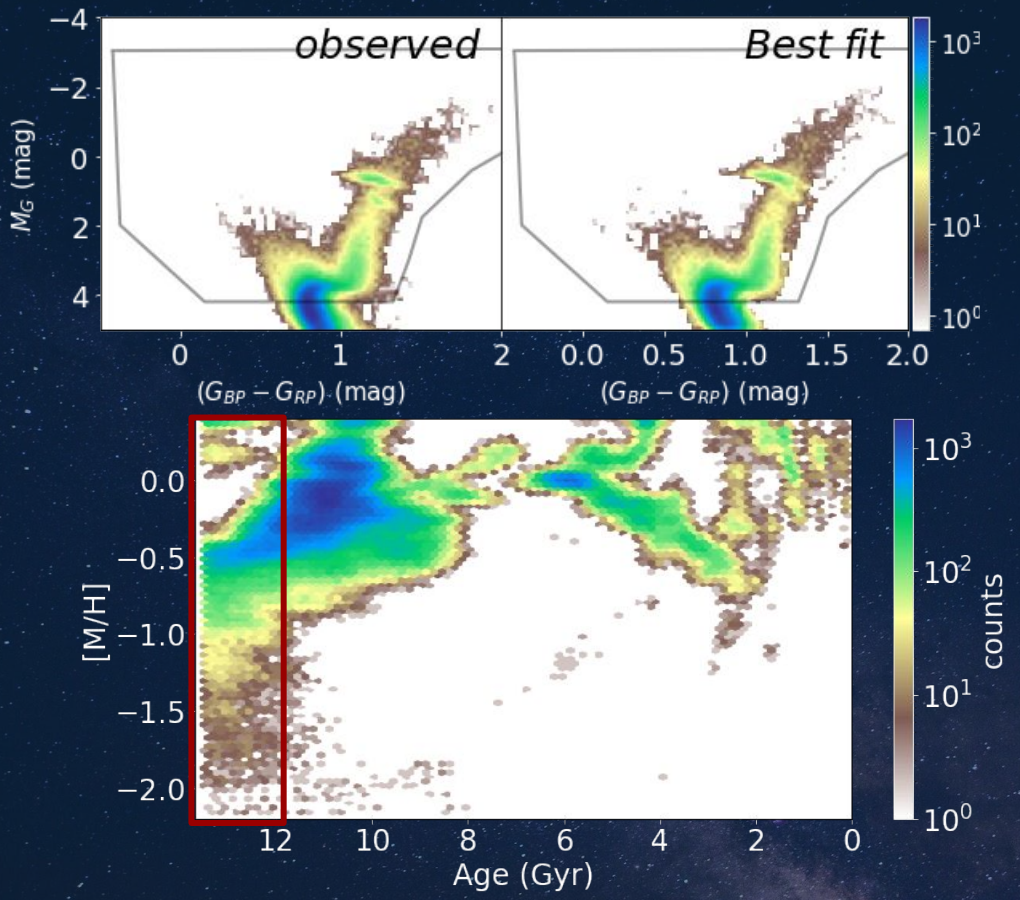




Log scale

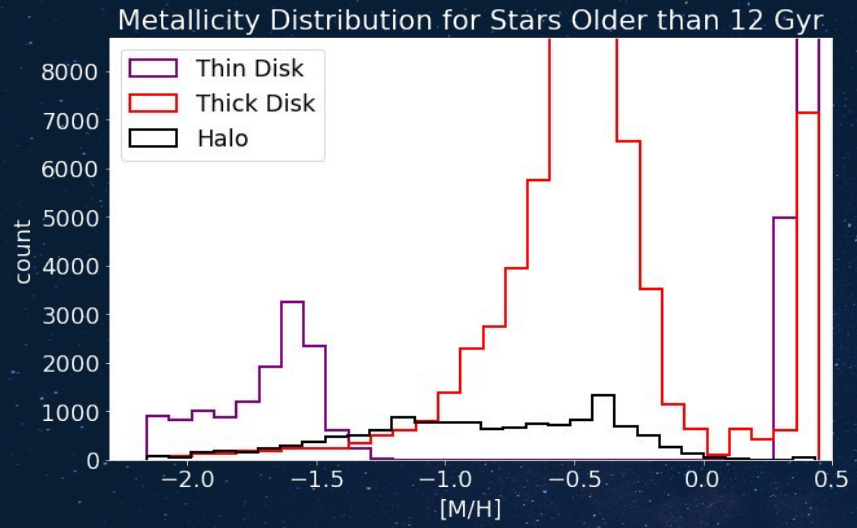
To look beyond the thick disk

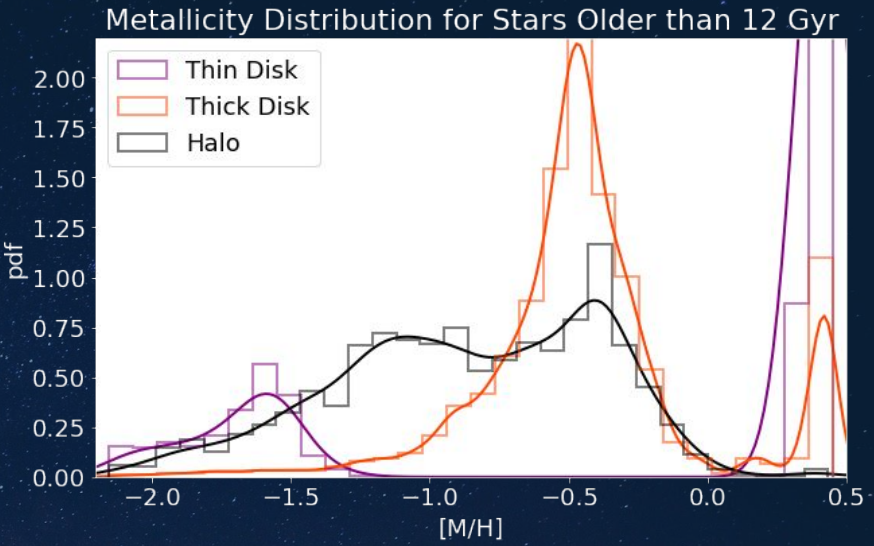
Results: Thick disk



Thick disk main formation ~11 Gyrs Miglio+ 2021, Queiroz+2023

The MDF of old disk stars





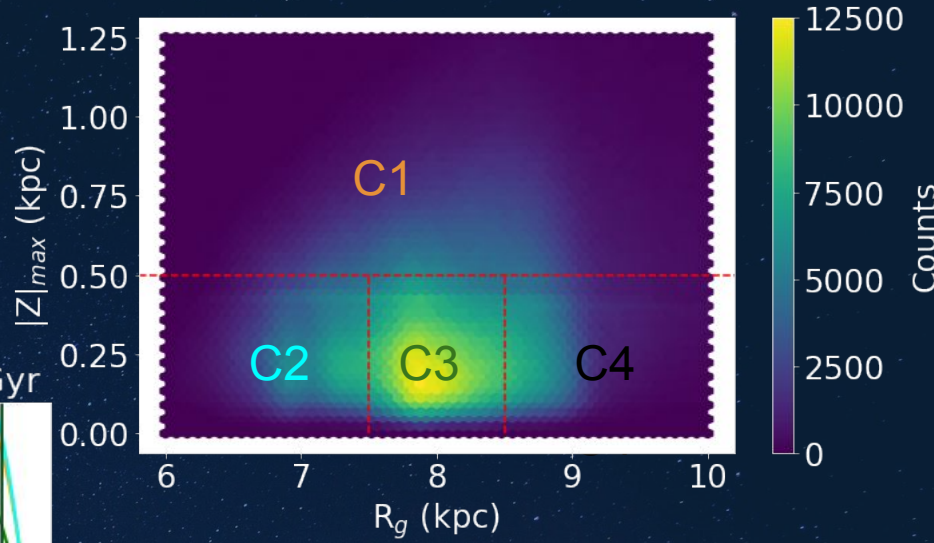
→ The thin disk seems to have a larger fraction of metal-poor at the old age range

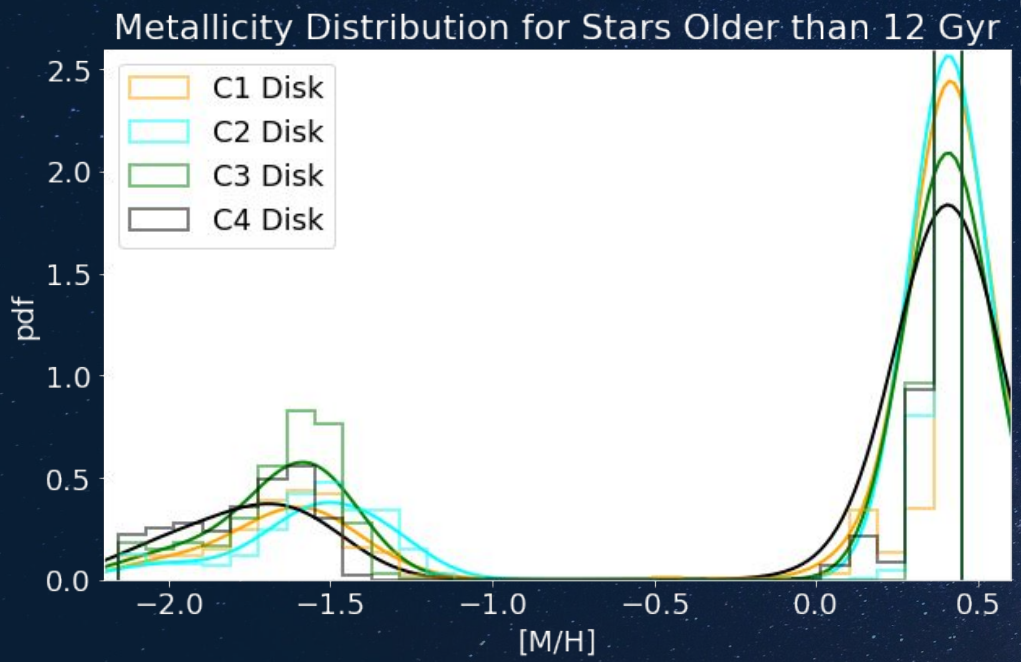
All stars older than 12 Gyr → Thin: 48%, Thick 49%, Halo 8%

→ From the old stars in the thin disk almost 20% are very metal poor ([Fe/H] <-1.5 & age>12.Gyr) → Thin: 17.4%

→ Old metal-rich stars also appear on all components, most strongly on the thin disk selection

Orbital division of thin disk



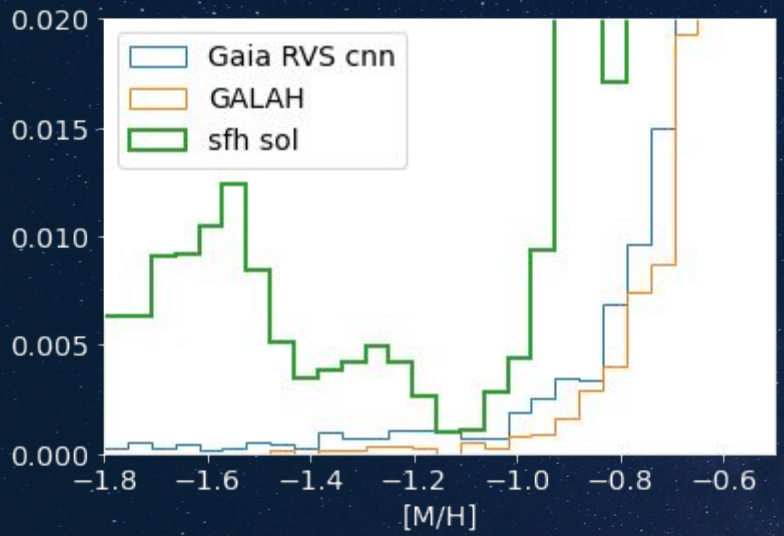


Can we find this population on spectroscopic surveys?

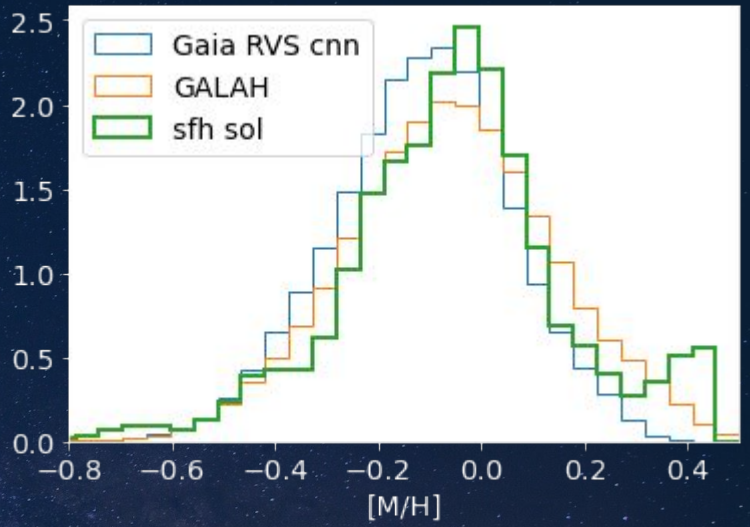
→When making the same velocity selection on known large scale spectroscopic surveys:

See Guiglion's talk

Thin disk selection

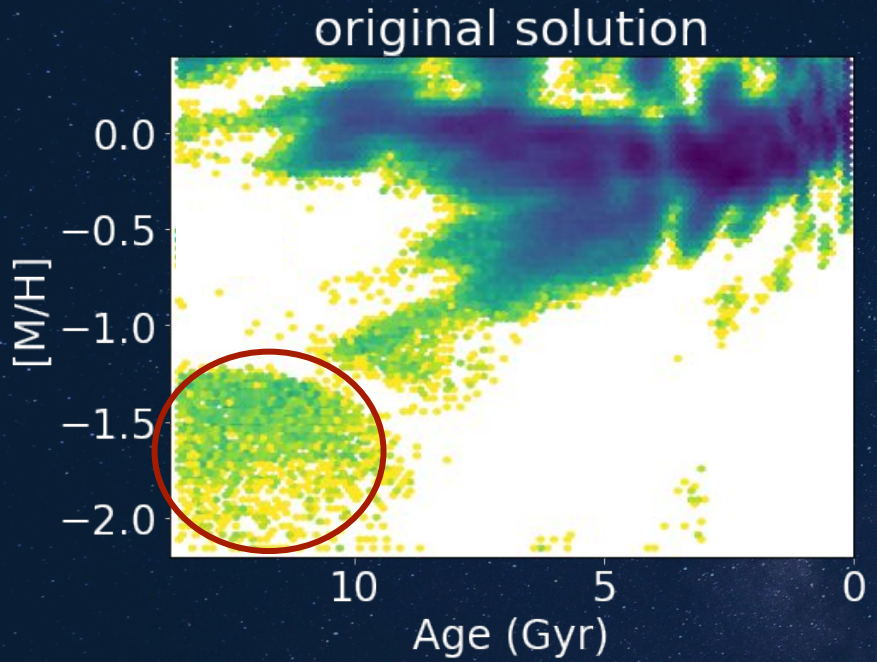


rvs cnn

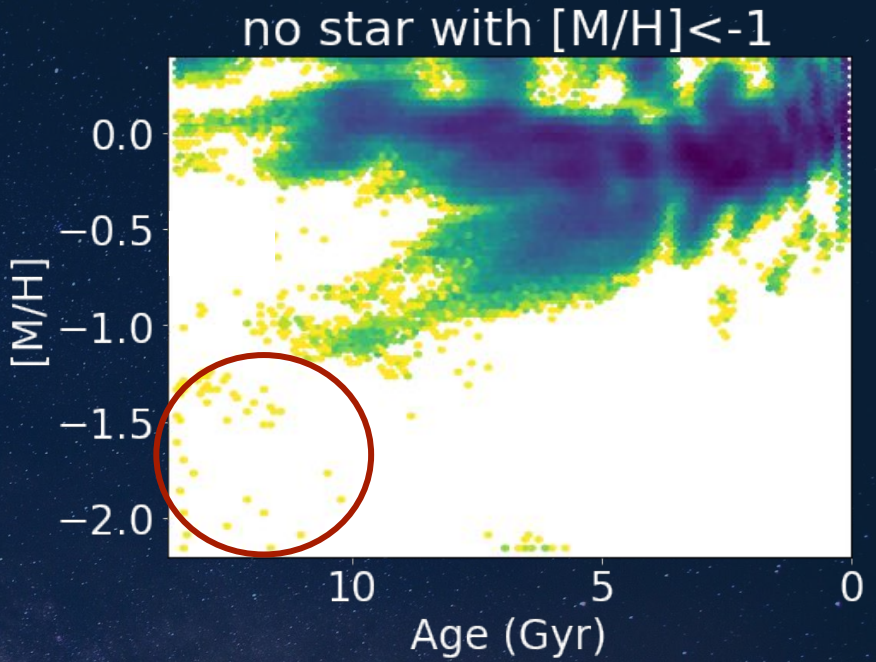


Spectroscopic surveys mostly show a tail towards low metallicity in the thin disk

Is this an artefact of the method?



N* 3272



N* 500

Conclusions

→ Our selection using the Gaia velocity an CMD-fitting shows a large fraction of old metal-poor stars in cold orbits (more than in thick disk and halo);

a) a considerable fraction of accreted/halo origin that are brought to thin-disk like orbits (e.g Feuillet+2022, Re Fiorentin+2021 (Poster), Zhang+2024);

b) old the bar brings this stars into fast rotators (e.g Yuan+2023)

b) this is part of primordial disk (more insights are necessary):

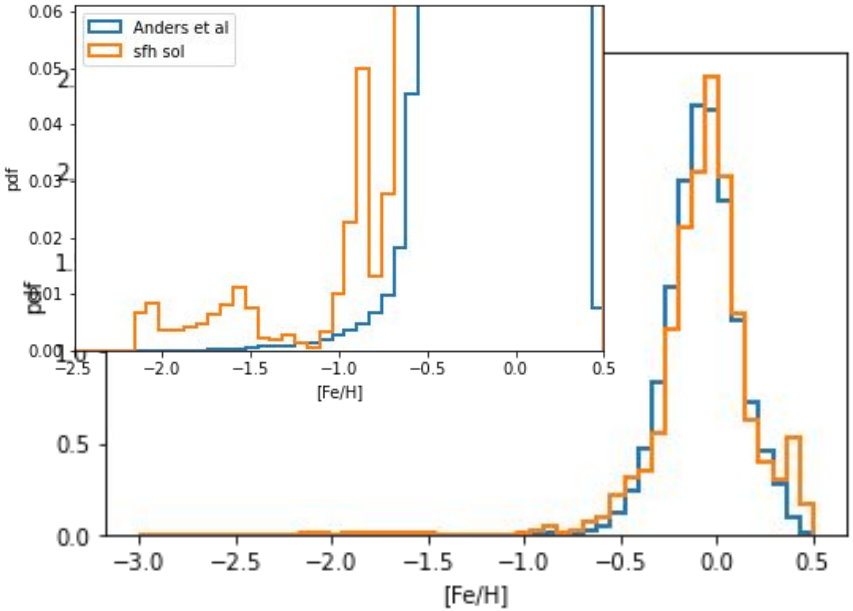
→ Metal rich stars are also present in the old age range in agreement with recent findings, larger proportions in the inner disk (Nepal+ 2024a, Queiroz+2021, Miglio+2021) ;

→ The CMD method detects the old thin disk populations (metal/poor e metal/rich) in larger fractions than spectroscopic surveys;

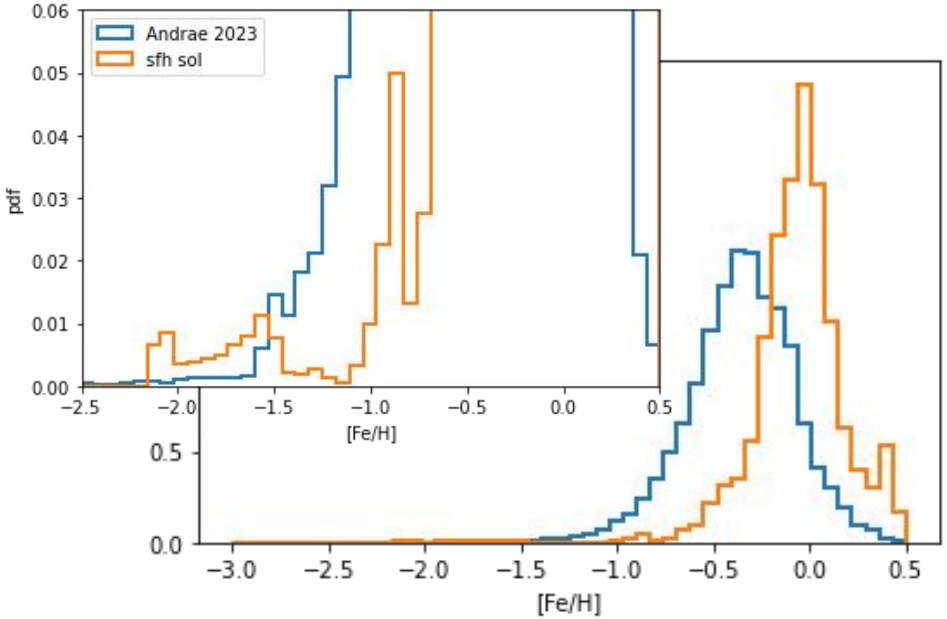
→ Dearth of thin disk (i.e. cold orbits) between the metal poor and metal rich populations found here, needs to be confirmed – metallicity limits of the models -

→ Comparing the metallicity distribution of XP spectra catalogues (which cover in number very well our input circa 1.5 million of 1.6 million)
For the thin disk:

Anders et al in prep.



Andrae et al 2023



There is no alpha on XGboost methods, but on Anders et al it is solar scaled

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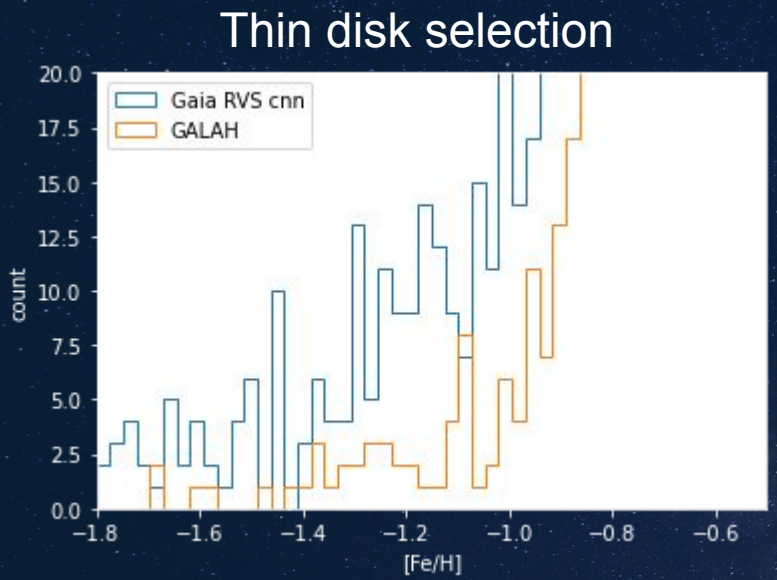

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