Precise distances from Gaia DR3 astrometry and large-scale spectroscopic surveys with StarHorse

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Introduction

- Detailed studies of the Milky Way's stellar populations → availability of large spectroscopic surveys + Gaia parallaxes→ accurate distances, ages, masses and extinction for a large population of field stars
- StarHorse code → an application of a Bayesian method to estimate distances (d), ages (τ), masses (m_*) and extinction (Av) for individual stars. → combining spectroscopic + photometric + astrometric data. →priors involve morphology of main Galaxy components and clusters, age and metallicity (See Queiroz et al. 2018; Anders et al. 2022)

DATA

We Join public spectroscopic surveys such as T_{eff}, log(g), metallicities and [α/Fe] to Gaia parallaxes and photometry (infrared and optical surveys) such as 2MASS, Wise and PanSTARRS.

Survey	$N^{cat}_{objects}$	$N^{Quality\ cuts}_{objects}$	$N^{Converged}_{stars}$
LAMOST DR7 LRS	6 179 327	4 803 496	4 531 028
LAMOST DR7 MRS	738 025	457 359	425 281
SDSS DR12 (optical)	503 967	258 194	249 991
GALAH DR3	588 571	581 149	557 559
RAVE DR6	517 095	515 800	471 490
APOGEE DR17	733 901	720 970	562 424
GES DR5	114 324	75 008	67 562
Gaia DR3 RVS	5 594 205	4 833 548	4 211 087

Table 1: Spectroscopic surveys from wich we obtain StarHorse parameters. Their initial number of targets, the targets after quality cuts and the final number of targets for which StarHorse converged. Data to be available at https://data.aip.de/ on request email: aqueiroz@aip.de (See Anders et al. 2022 for full *Gaia* data without spectroscopy)

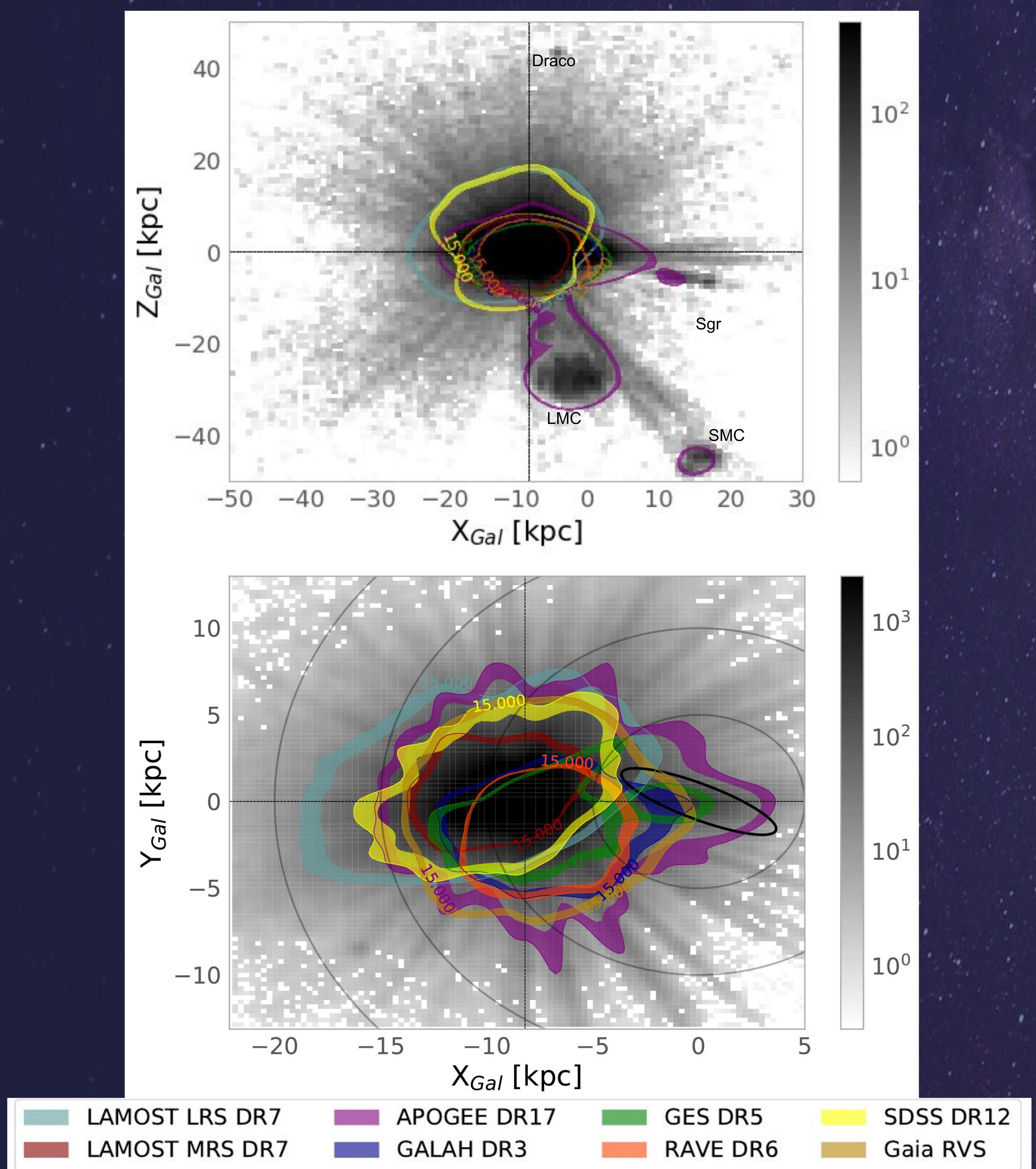

Fig. 1. StarHorse Galactocentric distances for all spectroscopic surveys combined are shown as a grey log scale. Upper panel Xgal vs Zgal for all surveys where a few overdensities can be observed as known Dwarf galaxies. The bottom panel shows the Xgal vs Ygal distribution with the contour density of each survey at 15 000 star counts. The ellipse represents the Galactic bar with a 25-degree angle to the Galactic plane. To guide the eye, gray circles are placed in multiples of 5 kpc around the Galactic centre.

Ages

- We also deliver ages for the Main sequence turn-off and Subgiant branch regimes for about 2.5 million stars in the spectroscopic surveys; those can be used to trace structures in the solar neighbourhood.

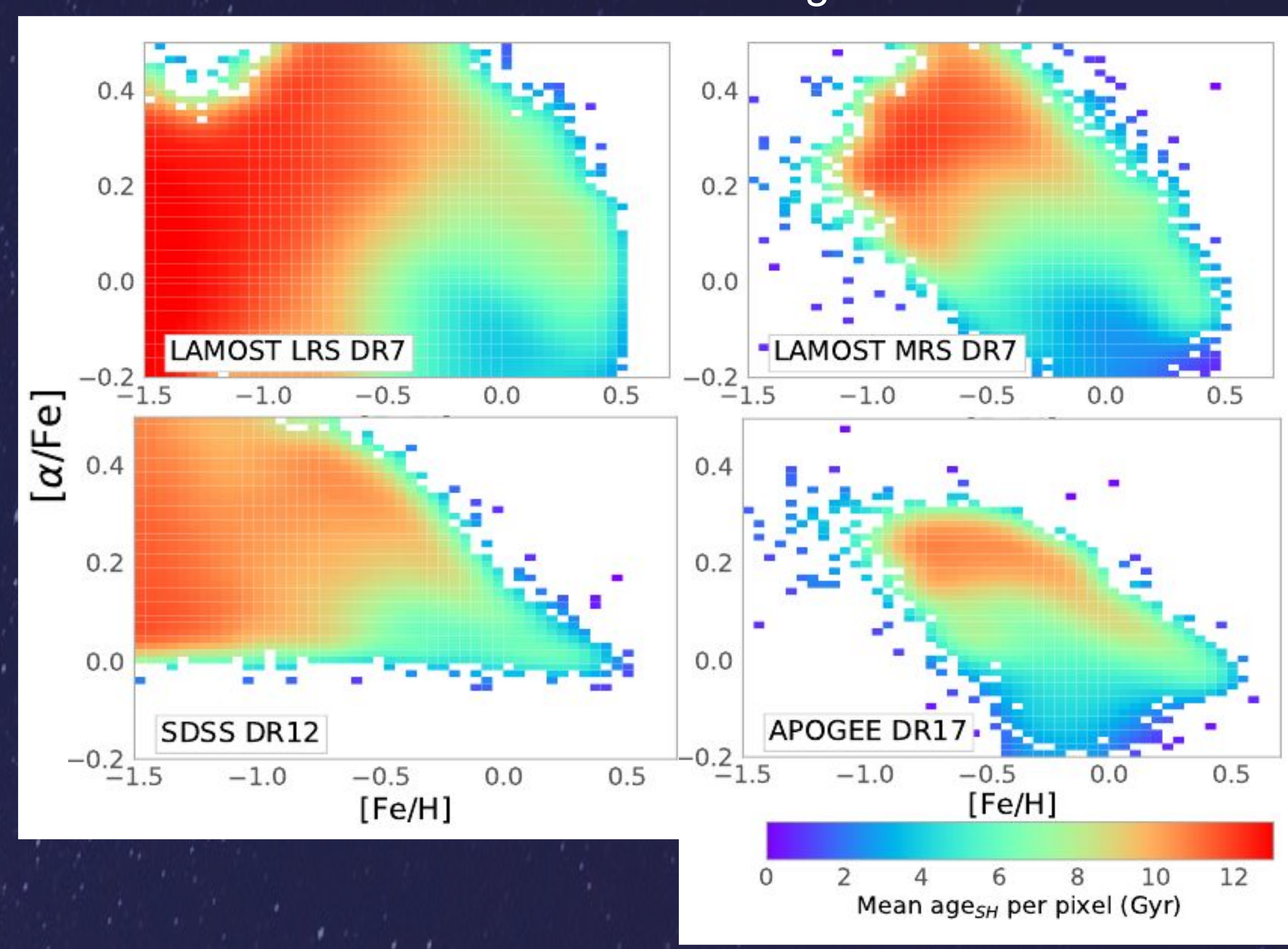

Figure 2. [Fe/H] vs. [α/Fe] colour-coded by StarHorse age for four spectroscopic surveys. For LAMOST and SDSS, many old stars can be found in the chemical range of debris and halo stars.

Accreted dwarfs

See Limberg et al. 2023 (https://arxiv.org/abs/2212.08249 ; Sagittarius)

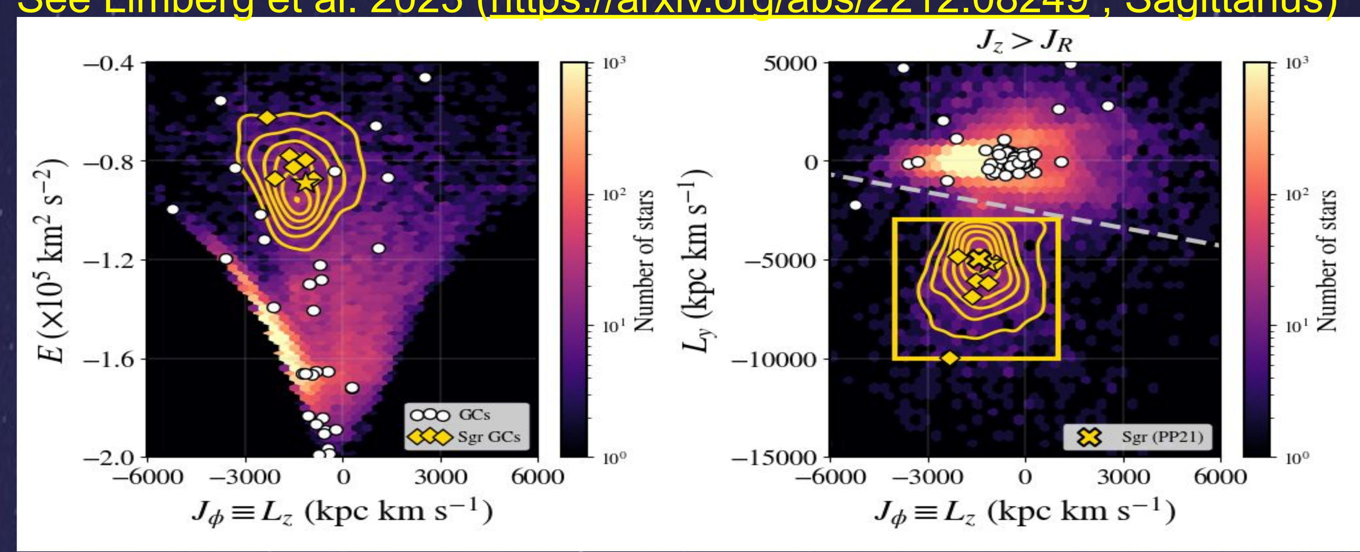

Fig. 3. . Jz > JR (predominantly polar orbits). Background density maps show the full SEGUE/StarHorse low-metallicity sample ([Fe/H]<-0.4). White dots are Galactic Globular Clusters. Those associated with Sgr dSph/stream are displayed as yellow diamonds, with M54 as the star symbol.

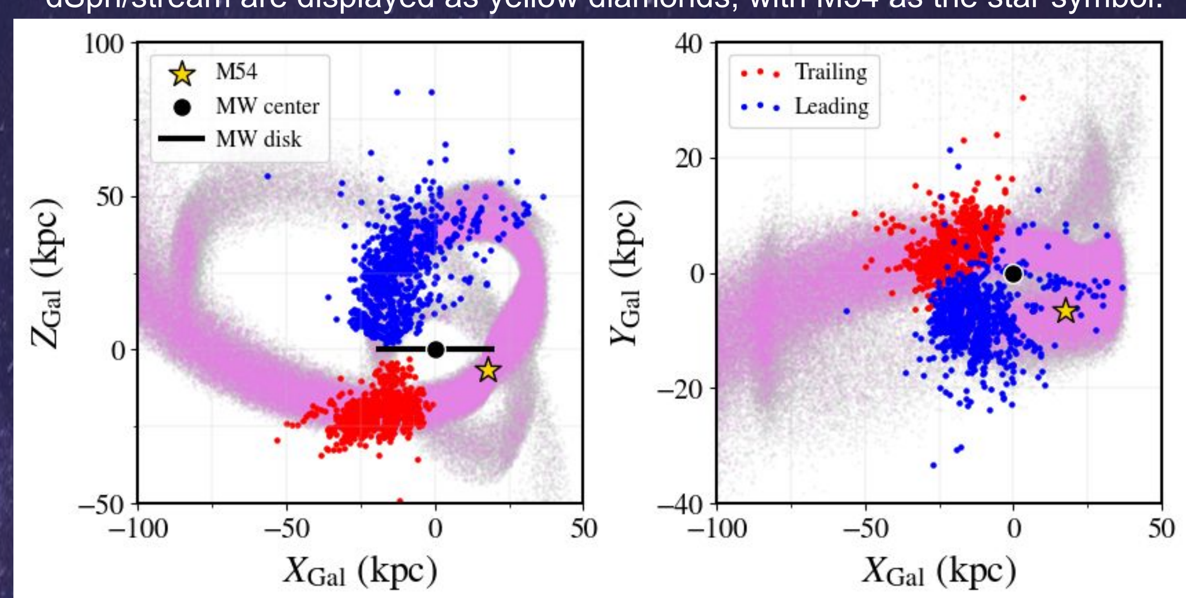

Fig. 4. Configuration space in the Galactic Cartesian coordinate system. Left: (X, Z). Right: (Y, Z). Blue and red dots are associated with the leading and trailing arms, respectively. The center of Sgr dSph, is shown as the yellow star symbol. The background Sgr model (stream+surviving core) where gray and pink dots are dark matter and stellar particles, respectively. The Milky Way's center and disk (40 kpc diameter) are illustrated by the black circle and line, respectively.

See Perottoni et al. 2022 (https://arxiv.org/abs/2207.11869; Halo overdensities)

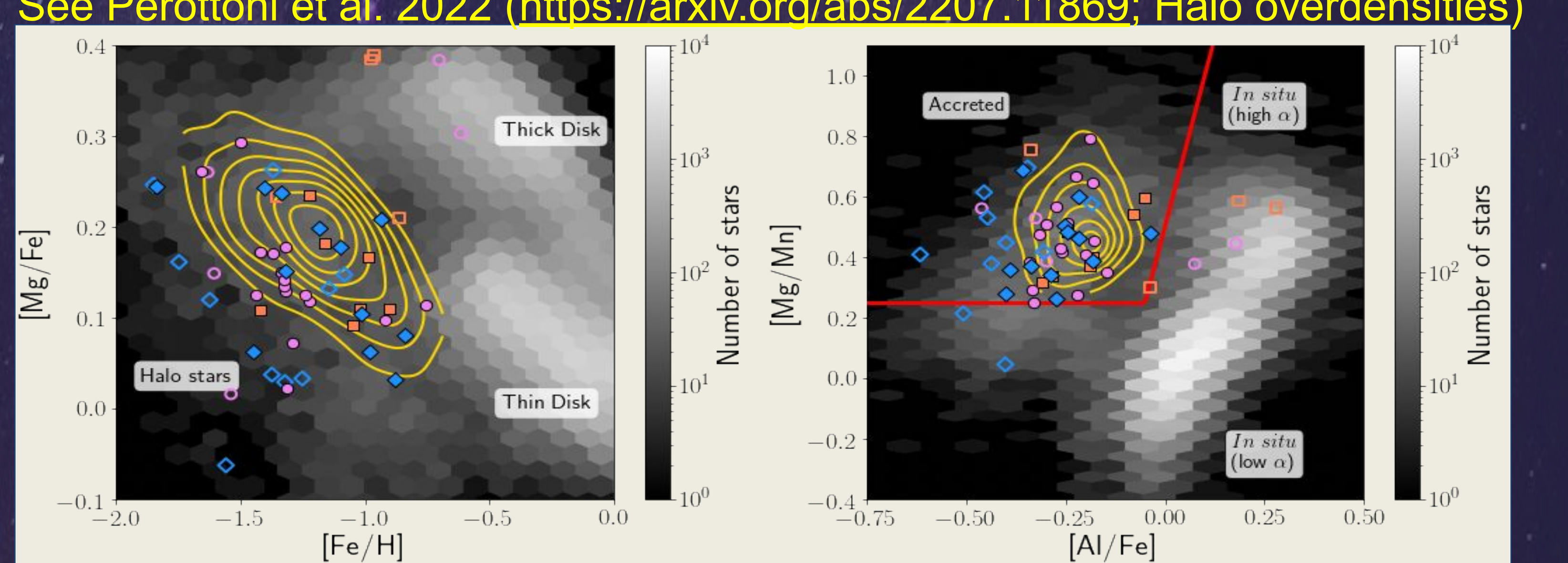

Fig. 5. Chemical abundances of Halo stellar overdensities south (orange) and north (violet) Hercules-Aquila Cloud, and Virgo Overdensity (blue) stars in the [Mg/Fe]–[Fe/H] (left), [Mg/Mn]–[Al/Fe] (right).

Conclusions and Perspectives

- We Deliver distances, extinctions and other astrophysical parameters for more than 11 million stars with good precision; these are great samples for detailed studies of our Galaxy's chemodynamical structure and the characterization of Halo and dwarf galaxies observed by spectroscopic surveys.
- The distances have typical uncertainties of 8-10% and have helped to detect as double as new members of Sagittarius Dwarf and Gaia Enceladus than previously reported in the Literature.
- Ages are also part of the newly produced catalogues (2.5 million), covering the subgiant and main sequence turn-off regimes.
- All parameters have been extensively validated against external methods in Queiroz et al. 2018, 2020 and 2023 (submitted)