Unraveling UBC 274

overview of a disrupting open cluster

From open clusters to field populations
Florence 20-23 Nov 2023

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Astronomy & Astrophysics

Unravelling UBC 274: A morphological, kinematical, and chemical analysis of a disrupting open cluster★

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ABSTRACT

Context. Open clusters in the process of disruption help to understand the formation and evolution of the Galactic disk. The wealth and homogeneity of *Gaia* data have led to the discovery of several open clusters with signs of disruption. Detailed chemical information for these clusters is essential in order to study the timescales and interplay between the star formation process and cluster disruption.
Aims. We perform a morphological, kinematic, and chemical analysis of the disrupting cluster UBC 274 (2.5 Gyr, $d = 1778$ pc), to study its global properties.
Methods. We use HDBSCAN to obtain a new membership list up to 50 pc from its centre and up to magnitude $G = 19$ using *Gaia* EDR3 data. We use high-resolution and high signal-to-noise spectra to obtain atmospheric parameters of six giants and sub-giants, and individual abundances of 18 chemical species.
Results. The cluster has a highly eccentric (0.93) component, tilted ∼10 deg with respect to the plane of the Galaxy, which is morphologically compatible with the results of a test-particle simulation of a disrupting cluster. Our abundance analysis shows that the cluster has a sub-solar metallicity of $[\mathrm{Fe/H}] = -0.08 \pm 0.02$. Its chemical pattern is compatible with that of Ruprecht 147, of similar age but located closer to the Sun, with the remarkable exception of neutron-capture elements, which present an overabundance of $[n/\mathrm{Fe}] \sim 0.1$.
Conclusions. The cluster's elongated morphology is associated with the internal part of its tidal tail, following the expected dynamical process of disruption. We find a significant sign of mass segregation, where the most massive stars appear 1.5 times more concentrated than other stars. The cluster's overabundance of neutron-capture elements can be related to the metallicity dependence of the neutron-capture yields due to the secondary nature of these elements, predicted by some models. UBC 274 presents a high chemical homogeneity at the level of 0.03 dex in the sampled region of its tidal tails.

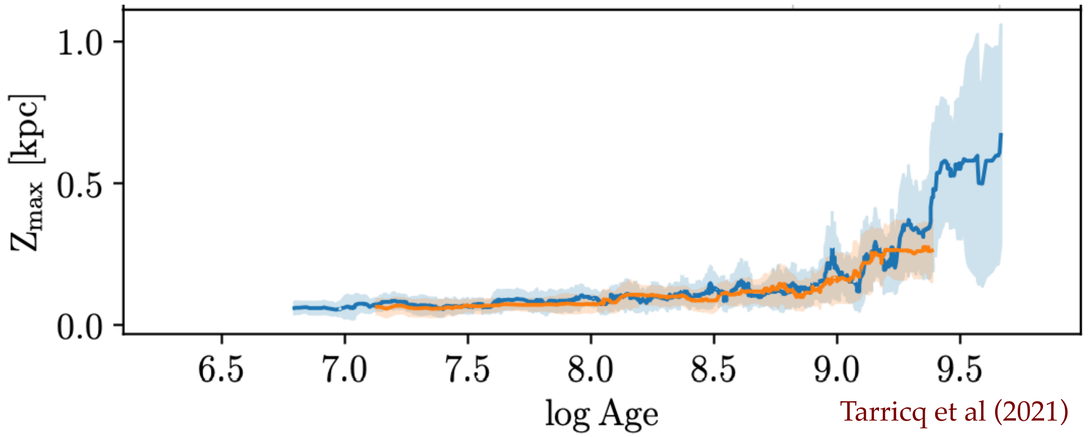
1. Context

Short-lived stellar systems, which **disrupt** ~1 Gyr

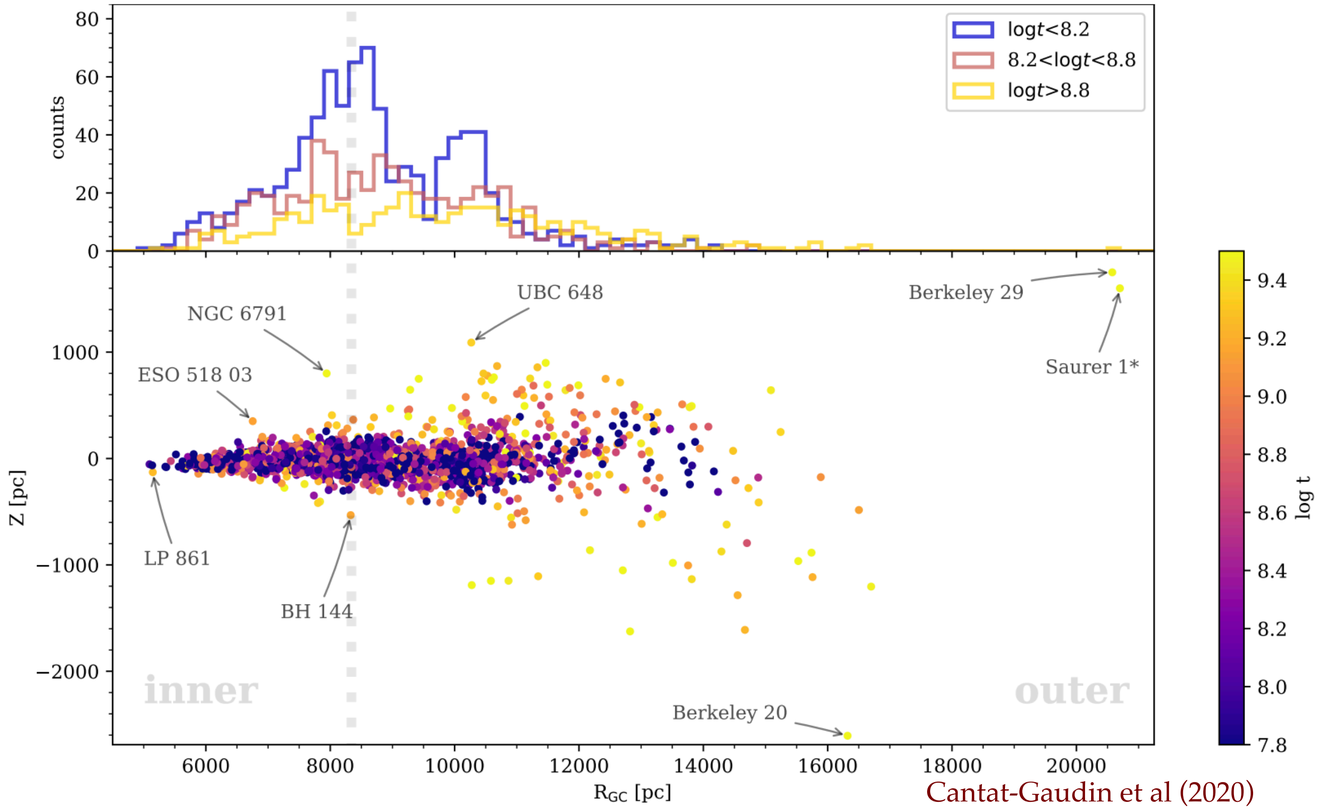
Tidal forces, interactions with non-axisymmetric structures, internal interactions…

↓

Clusters with signs of disruption



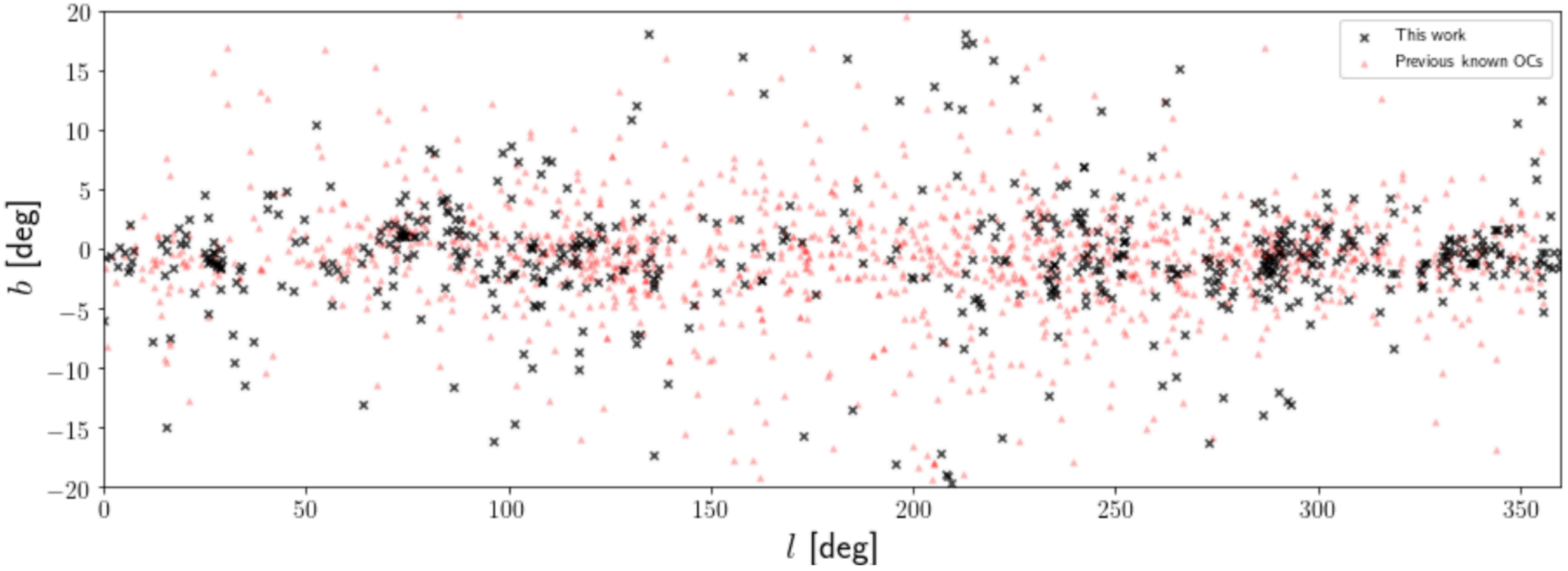
Tarricq et al (2021)



Cantat-Gaudin et al (2020)

1. Context

Systematic detection of new candidates doubling the census of known objects pre-Gaia
[e.g. Castro-Ginard et al. 2018,2019,2020; Liu&Pang 2019; Hunt&Reffert et al. 2023]



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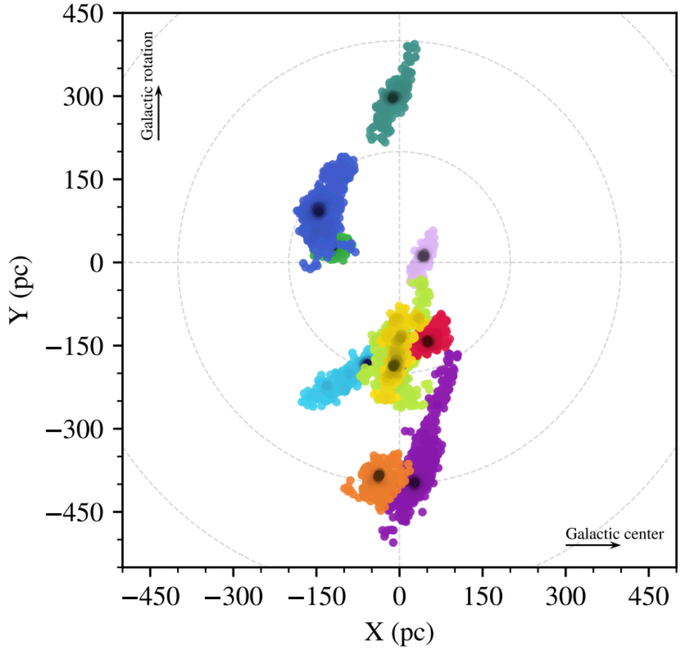
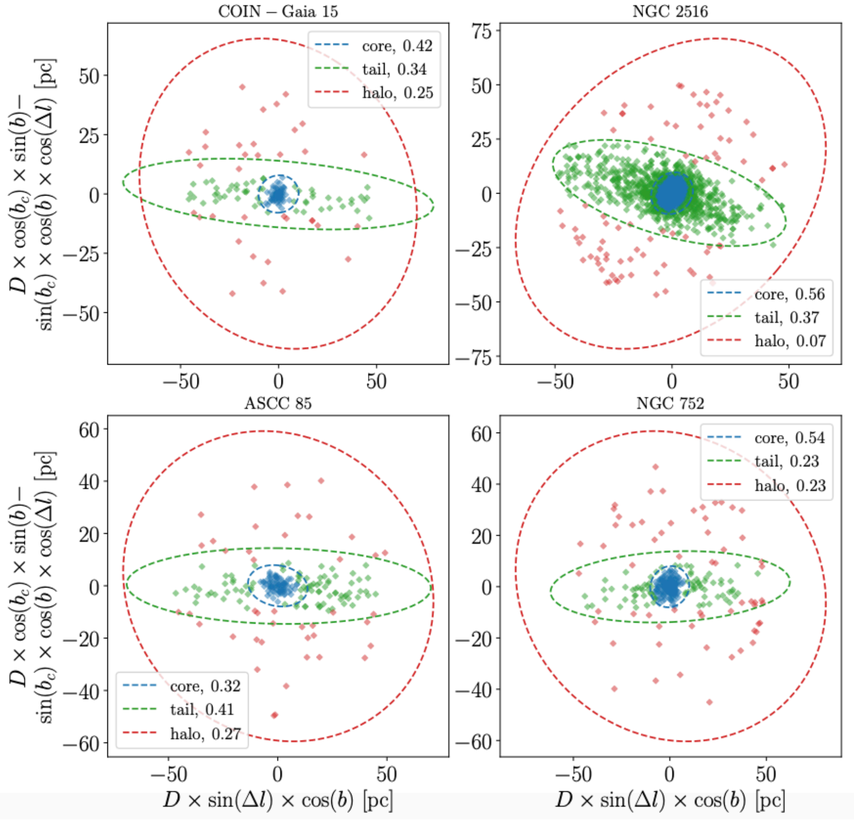
Revisited memberships and physical properties of the open cluster population [e.g. Meingast et al. 2019; Tarricq, Soubiran, Casamiquela et al. 2022]

Tarricq, Soubiran, Casamiquela et al. (2022)
70 clusters with elongated shapes up to 1.5 kpc

Detection of **elongated shapes**



Meingast et al. (2019)



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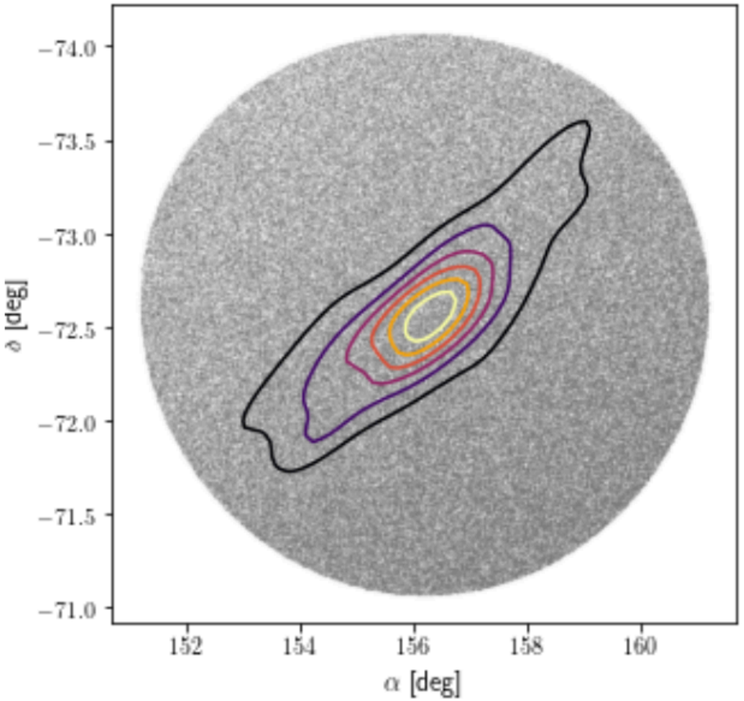
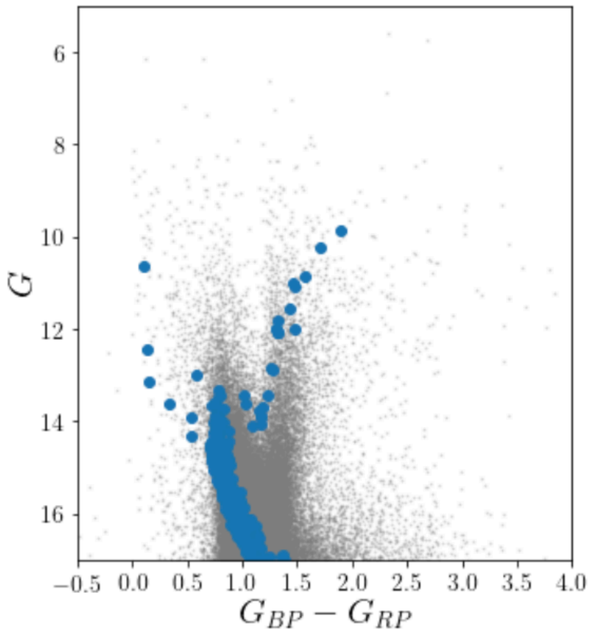
Detection of **elongated shapes** mostly in the Solar neighbourhood objects

One of the **furthest away** (d=1.78 kpc) and **oldest** cluster (2.5 Gyr, Piatti et al. 2020) with significant elongation is **UBC 274**





Castro-Ginard et al. (2020)

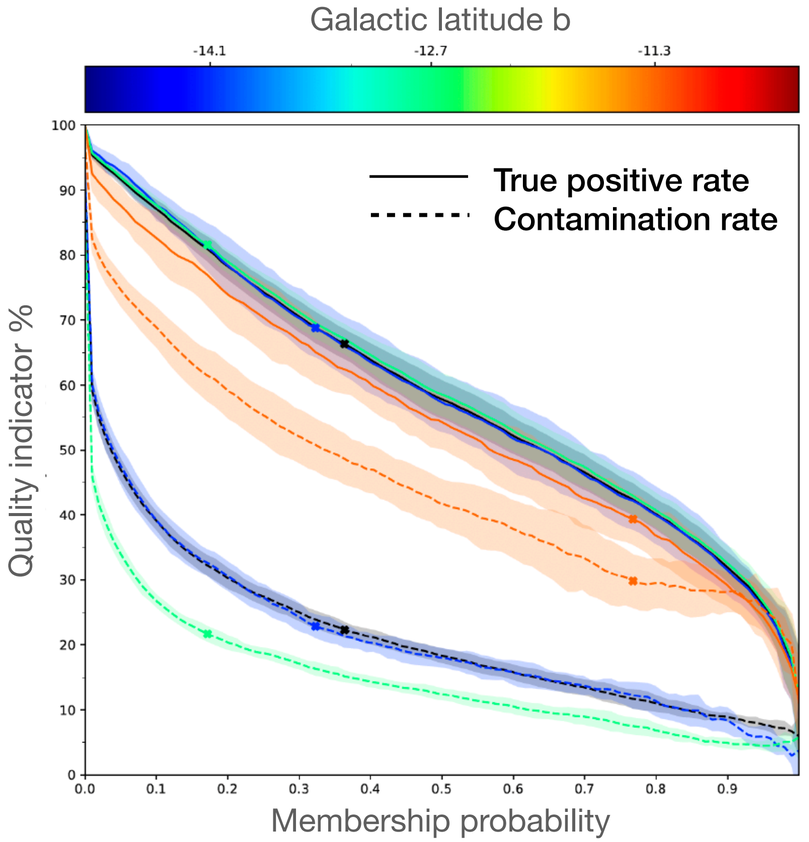
2. Morphology & kinematics of UBC 274

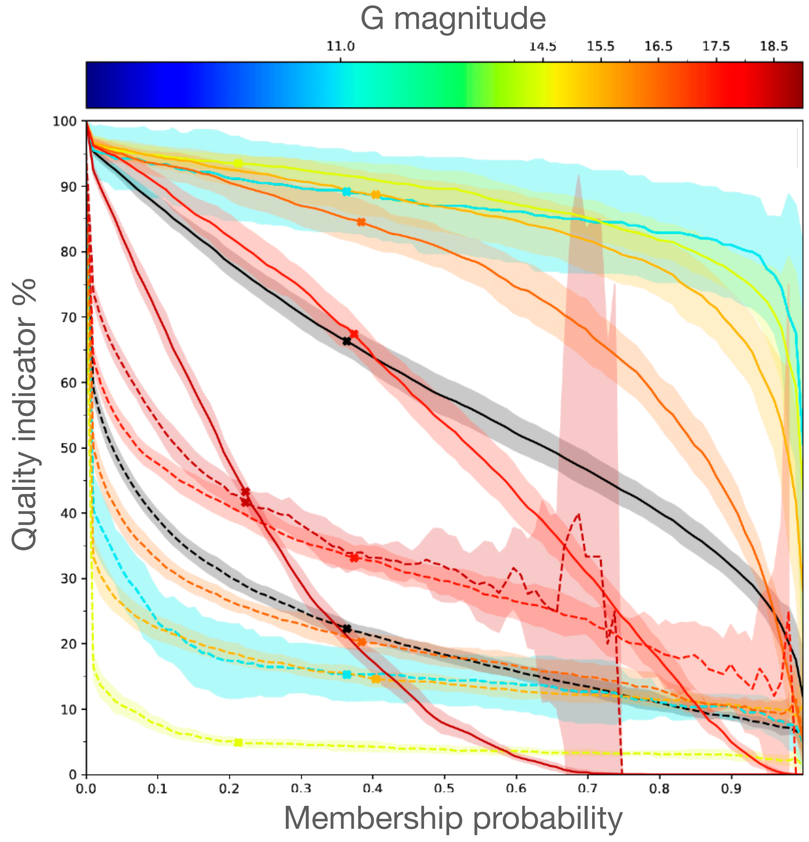
***Gaia* eDR3** membership of the cluster up to **G=19** and with a radius of **50 pc** around the center: **HDBSCAN**

- Membership probability cutoff **based on the performance** of the algorithm on synthetic cluster + simulated Galactic field using GOG/GUMS

  - >85% recovery at G<17
  - ~45% recovery at G=19

  - ~80% recovery at the center
  - lowers in surrounding regions
  - ~45% recovery close to the Gal. plane

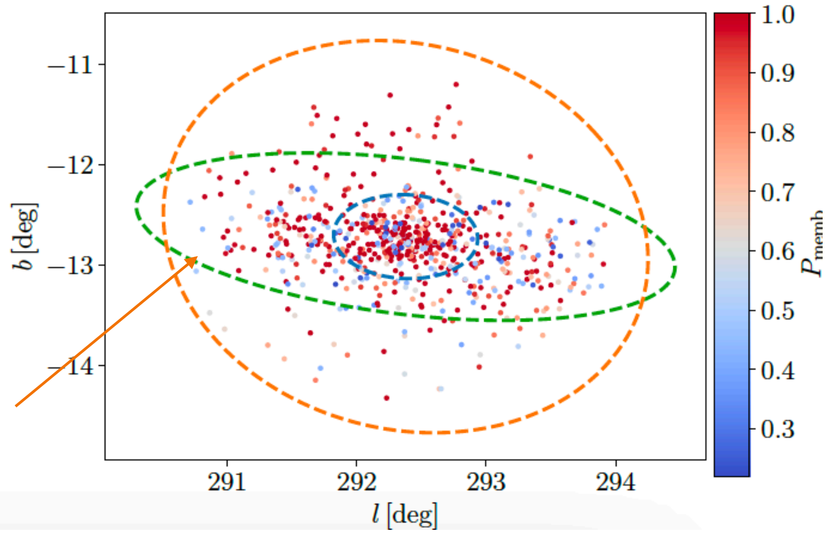




2. Morphology & kinematics of UBC 274

- Fit of a **Gaussian Mixture Model** with 3 components to sky distribution

Tilted component ~10 deg: tidal tail with **high eccentricity** (0.9)



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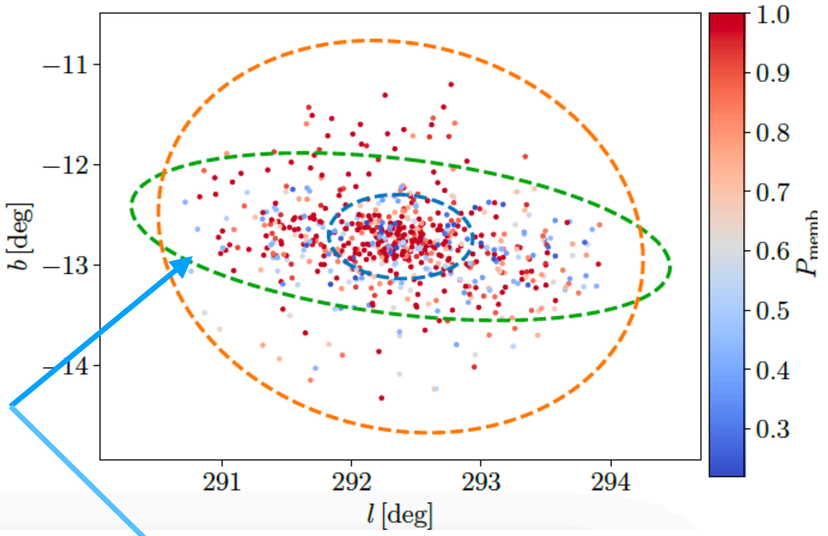
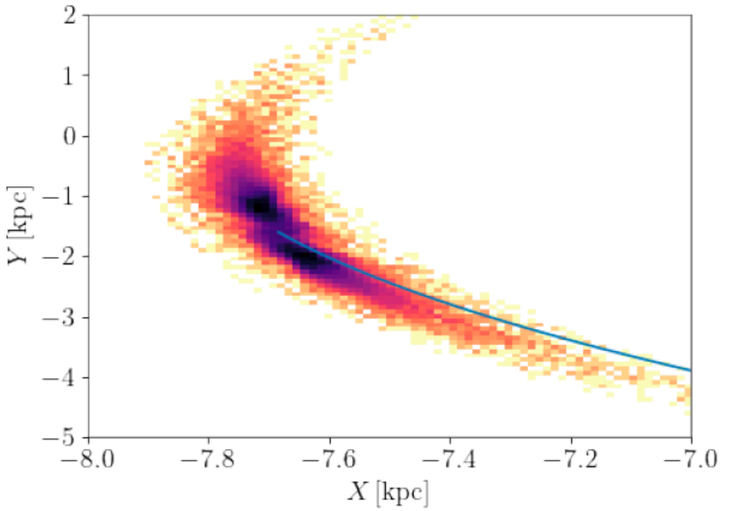
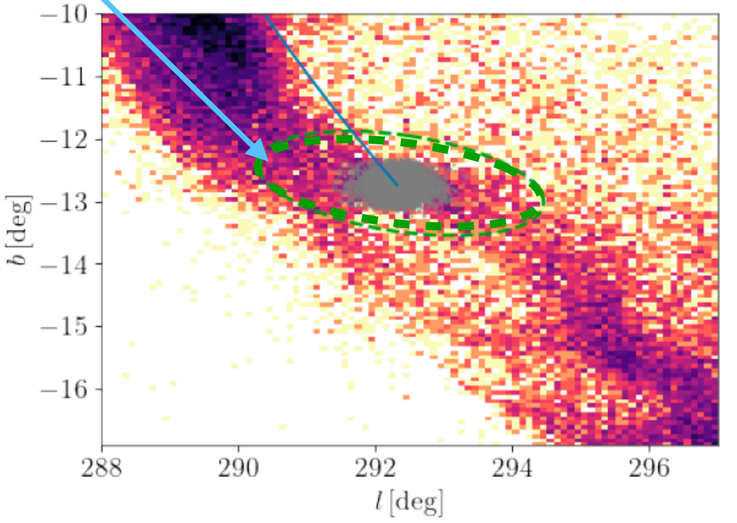


Tilted component ~10 deg: tidal tail with **high eccentricity** (0.9)

- Test-particle **simulation** of a disrupting cluster:

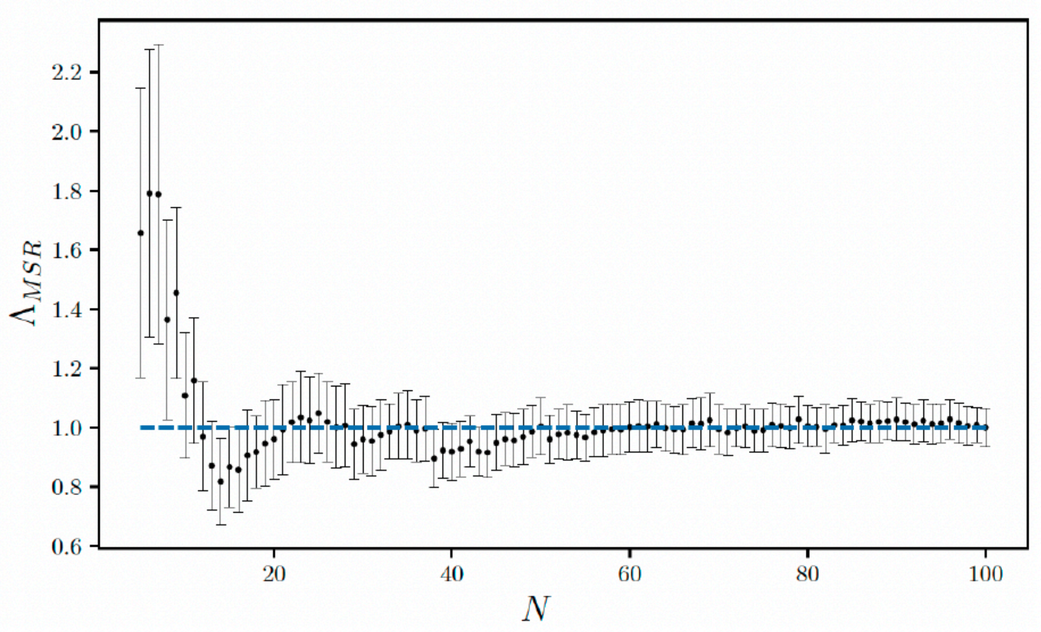




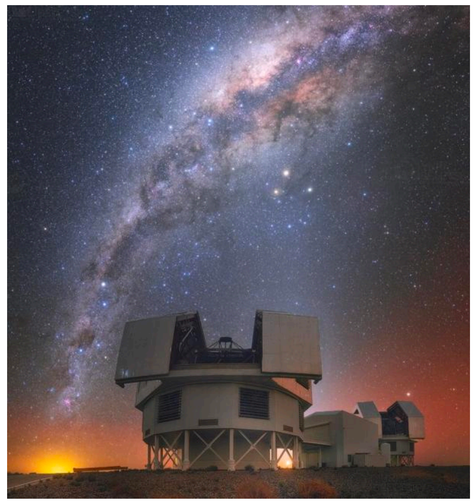
2. Morphology & kinematics of UBC 274

- Significant ratio of mass segregation: 10 most massive stars are 1.5 times closer than randomly chosen stars

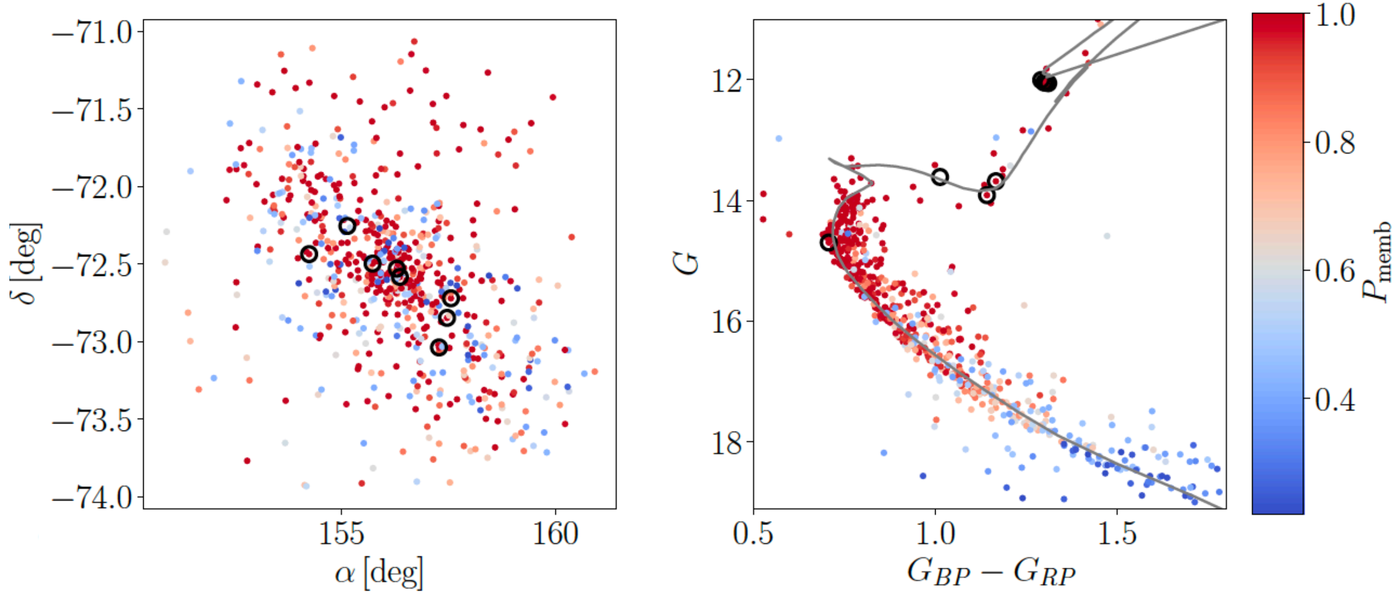
Ratio of the length of the **minimum spanning tree** of random stars compared with the N most massive stars



3. Spectroscopic follow-up



8 stars **MIKE spectrograph** @ 6.5m Clay Magellan Telescope (Las Campanas) R ~ 80,000 S/N ~ 100



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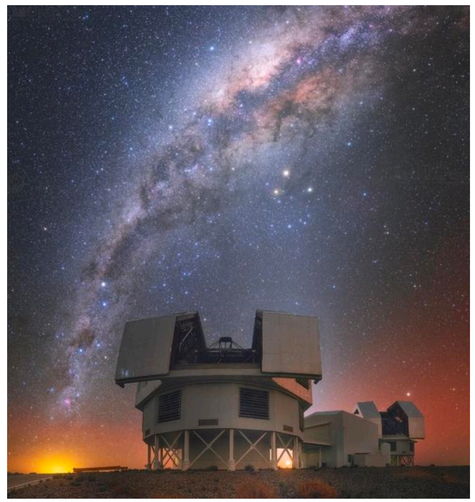

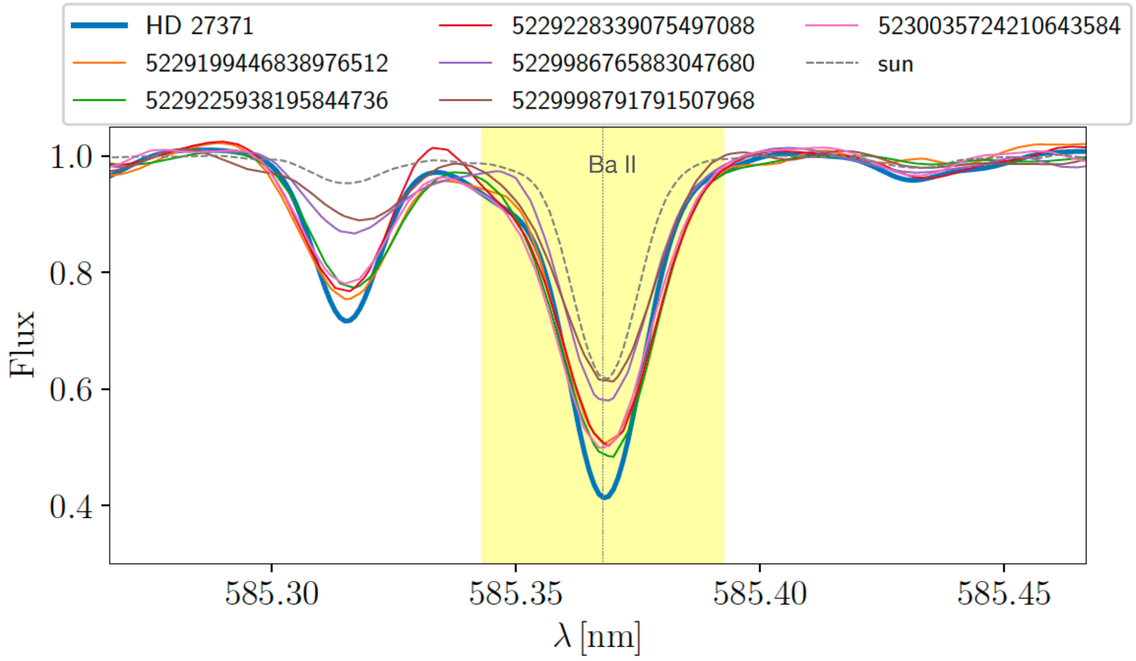

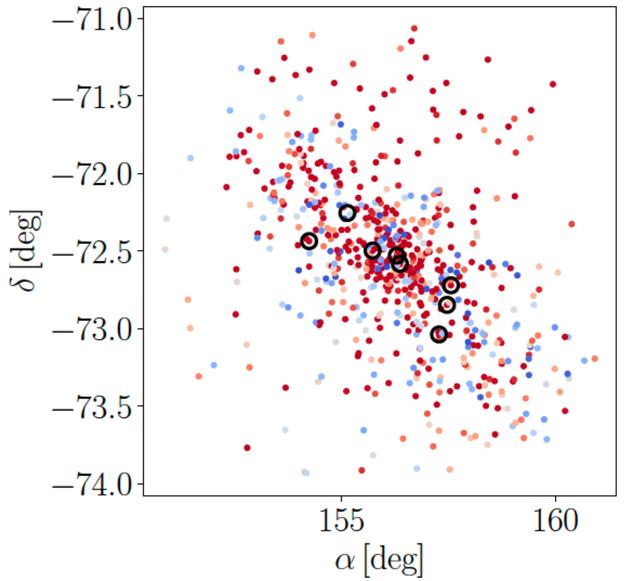

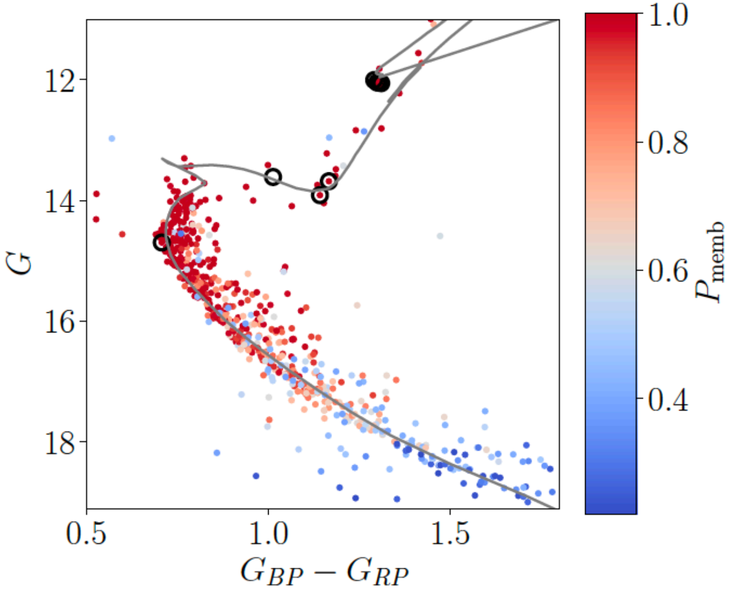

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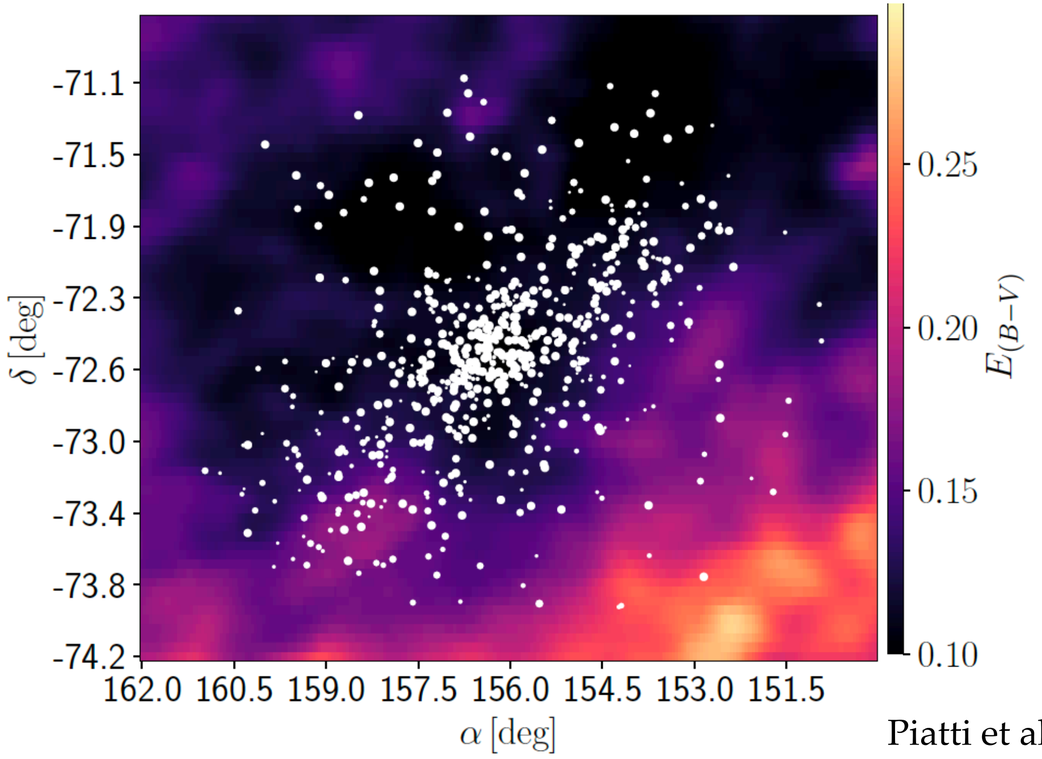
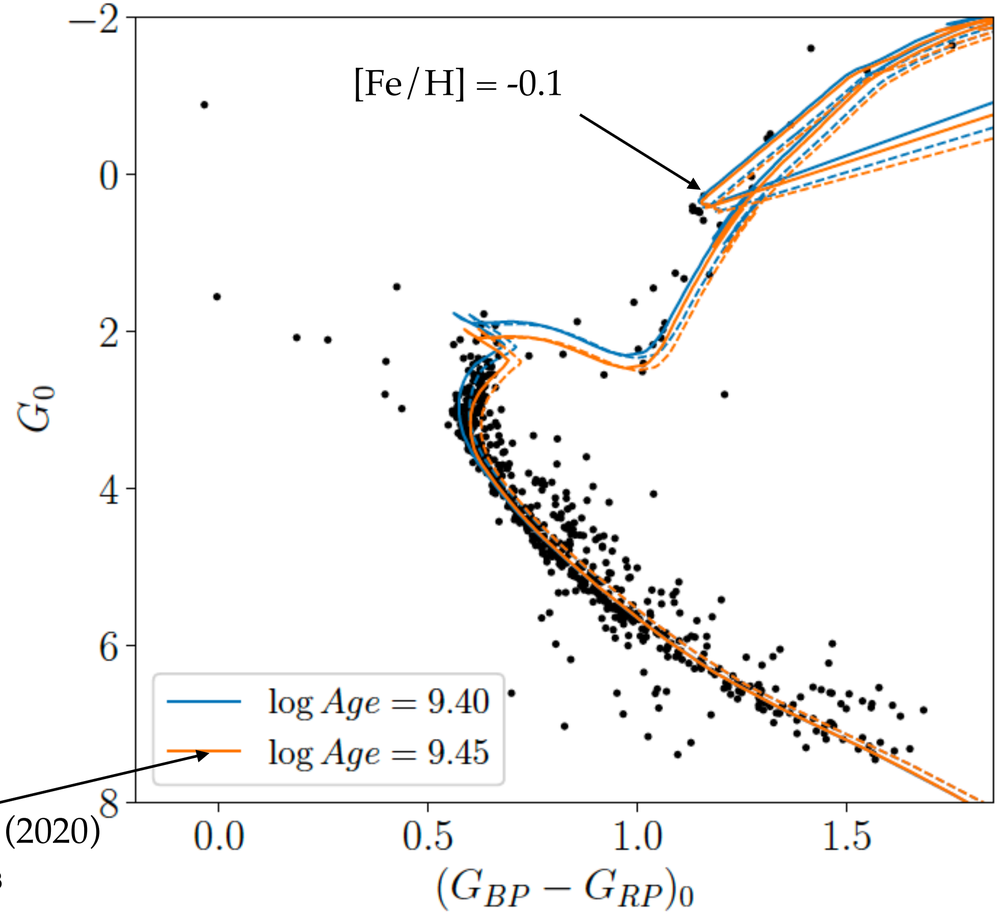
[Fe/H] $= -0.08 \pm 0.02$ + correction of the differential reddening provides a better fit of turnoff and RGB of 2.5 Gyr





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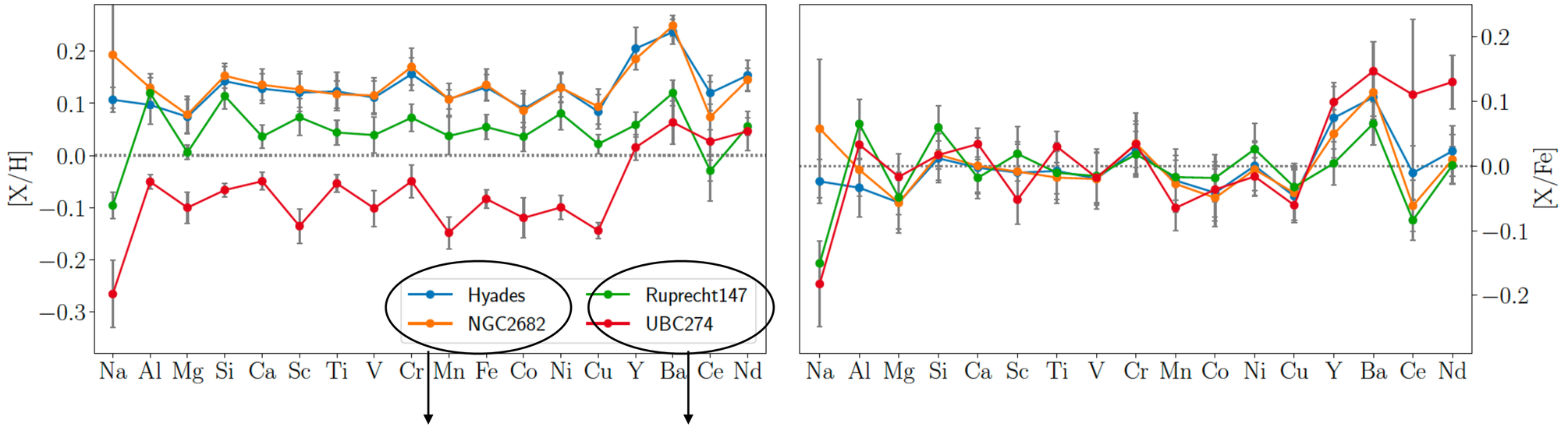
Small scatters (~0.03 dex) + chemical pattern [X/Fe] similar to other clusters with similar age



Same **age 0.7 Gyr**
(solar neighbourhood)

Same **age 2.5 Gyr**

3. Spectroscopic follow-up

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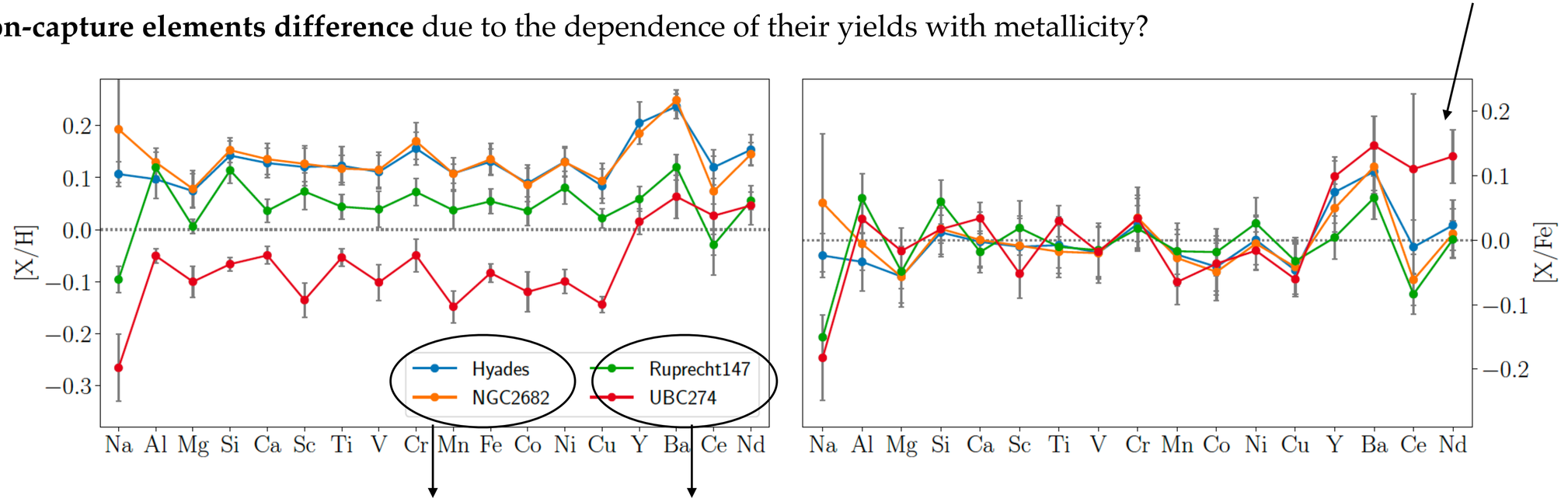
Small scatters (~0.03 dex) + chemical pattern [X/Fe] similar to other clusters with similar age

enhancement of neutron capture elements [n/Fe] ~ 0.1

Neutron-capture elements difference due to the dependence of their yields with metallicity?



Same **age 0.7 Gyr** (**solar neighbourhood**)

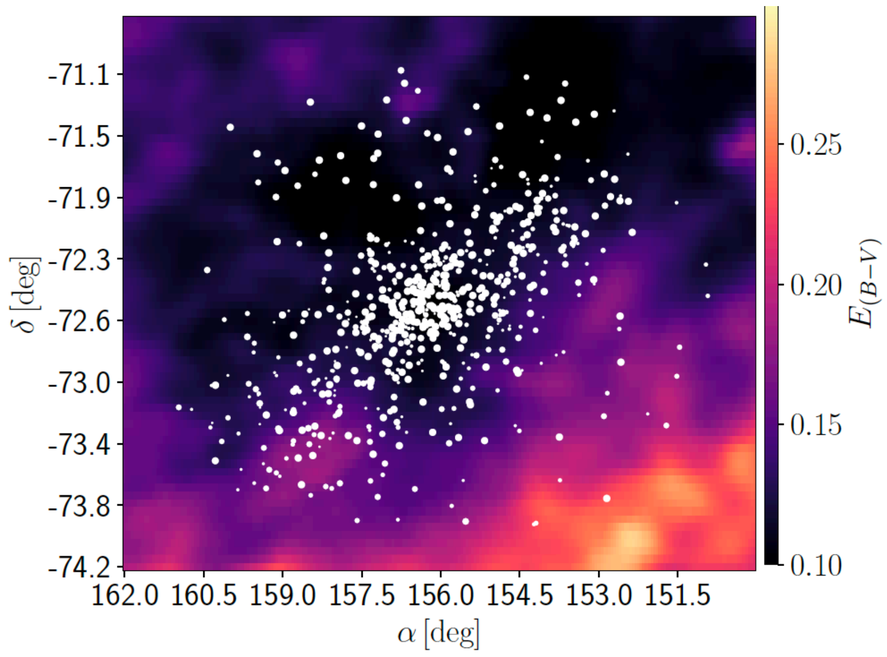
Same **age 2.5 Gyr**

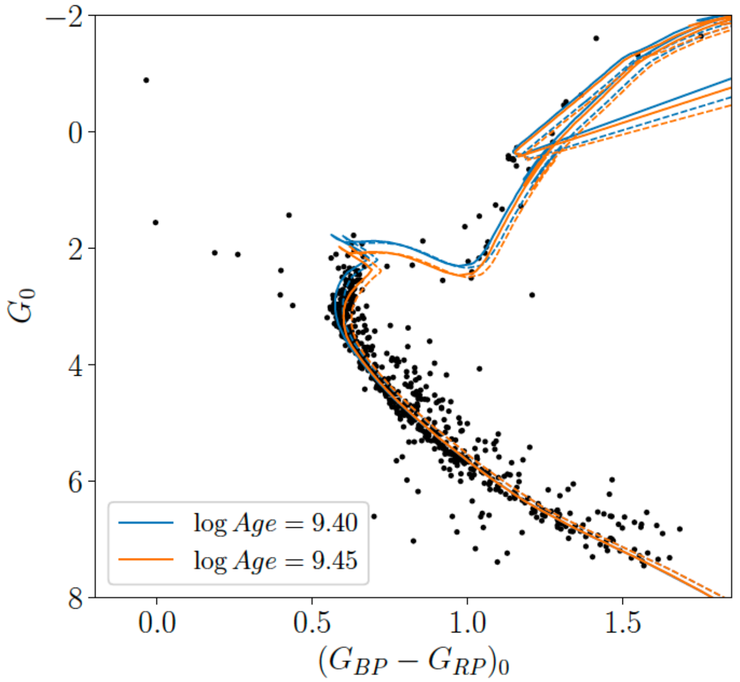
4. Conclusions

The **recent discovery** of a significant number of open clusters with **spatially elongated morphology** presents an opportunity to study the disruption mechanisms of co-natal stars, and how they populate the Galactic field

The **increasing quality of *Gaia* data releases** allows a better-constrained membership determination of these clusters and up to fainter magnitudes

Spectroscopic follow-up provide precise chemical abundances and provide an insights





Postdoc announcement
2 years

GEPI - Observatoire de Paris (Meudon)

Team: L. Casamiquela, P. Di Matteo, M. Haywood, D. Katz, D. Reese, Y. Lebreton, C. Soubiran

Morphological and kinematical properties of disrupting open clusters, comparison with numerical simulations of tidal streams (e-TidalGCs project)