Chemical Abundances in intermediate-age/old Open Clusters from the North

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Observatoire de la Côte d'Azur (France)

Open clusters as Tracers of the Galactic Disk

Pros:

- Coeval groups of stars.
- Located at the same distance.
- Homogeneous chemical composition.

Cons:

- $\sim$ 2100 Known Open Clusters in the Milky Way.
- Ages for $\sim$70 % (mainly from isochrone fitting).
- Metallicities for $\sim$9 %, mainly from Washington/Strömgren photometry, or low-resolution spectroscopy.
- Chemical abundances from high-resolution spectroscopy only for 89 systems, but in a heterogeneous way and in most cases only for [Fe/H].

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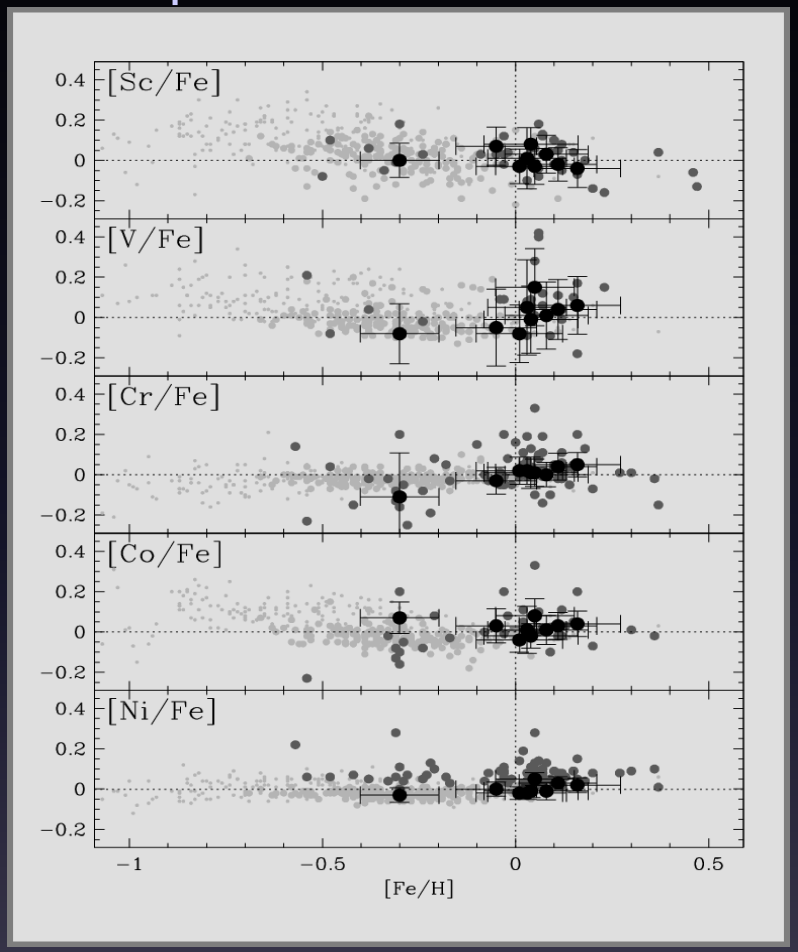
What OC tell us about the Galactic Disk?

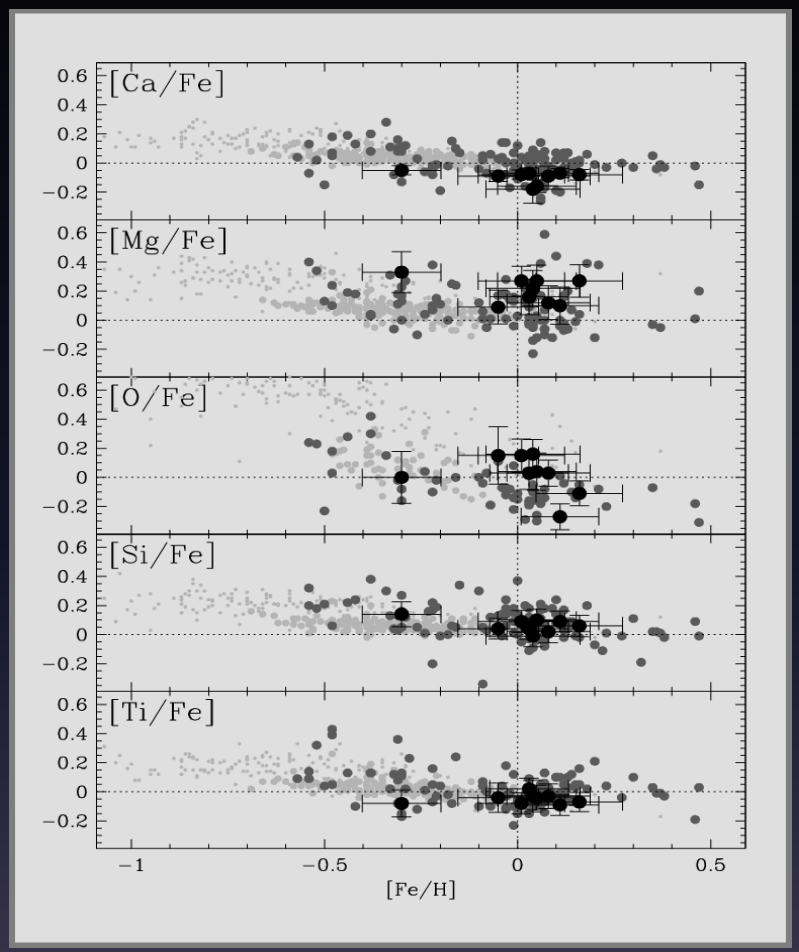
- Chemical patterns in the Galactic disk.
- Trends with radius, height or age: gradients.
- Identification of stellar populations: thin/thick disks.
- Mix of stellar populations: importance of radial migration.

Chemical Patterns in the Galactic Disk

Fe-peak elements



α-elements

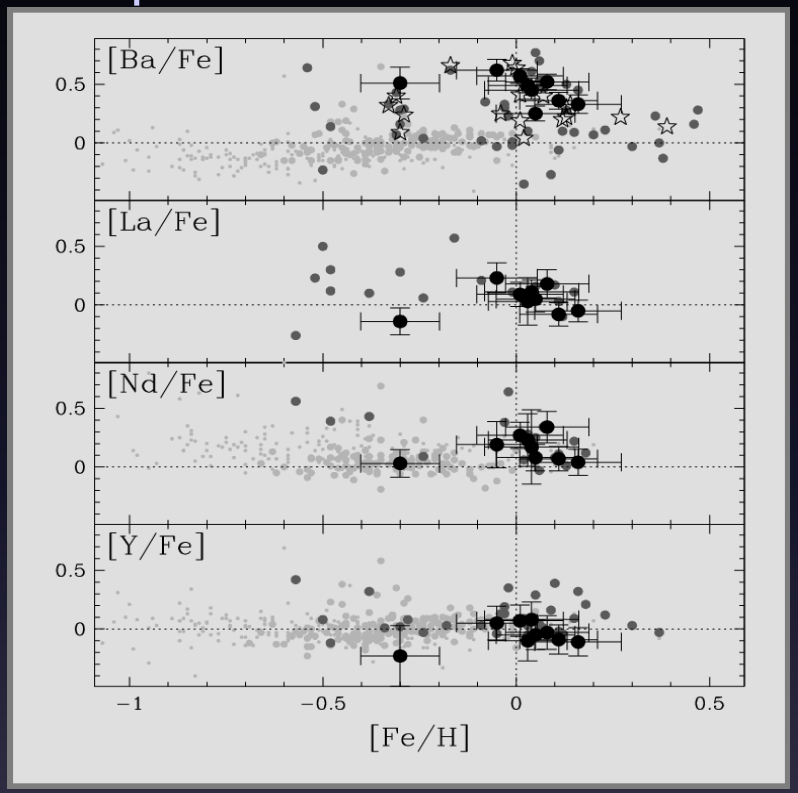


- Thin disk: Reddy et al. 2003
- Thick disk: Reddy et al. 2006
- Open Clusters: Literature
- Open Clusters: Carrera & Pancino 2011

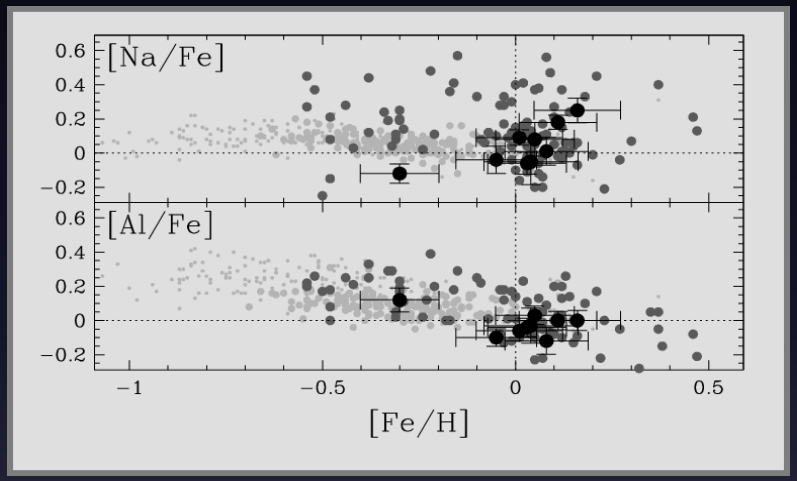
Carrera & Pancino 2011

Chemical Patterns in the Galactic Disk

s-process elements



Na & Al



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- ☆ Open Clusters: D'Orazi et al. 2009

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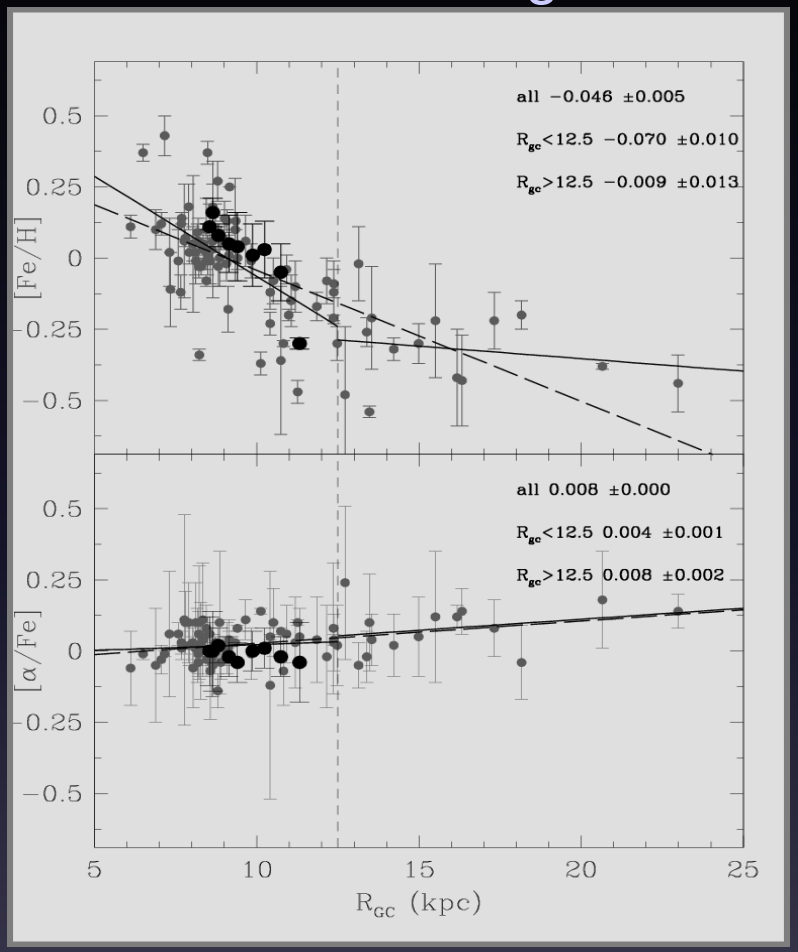
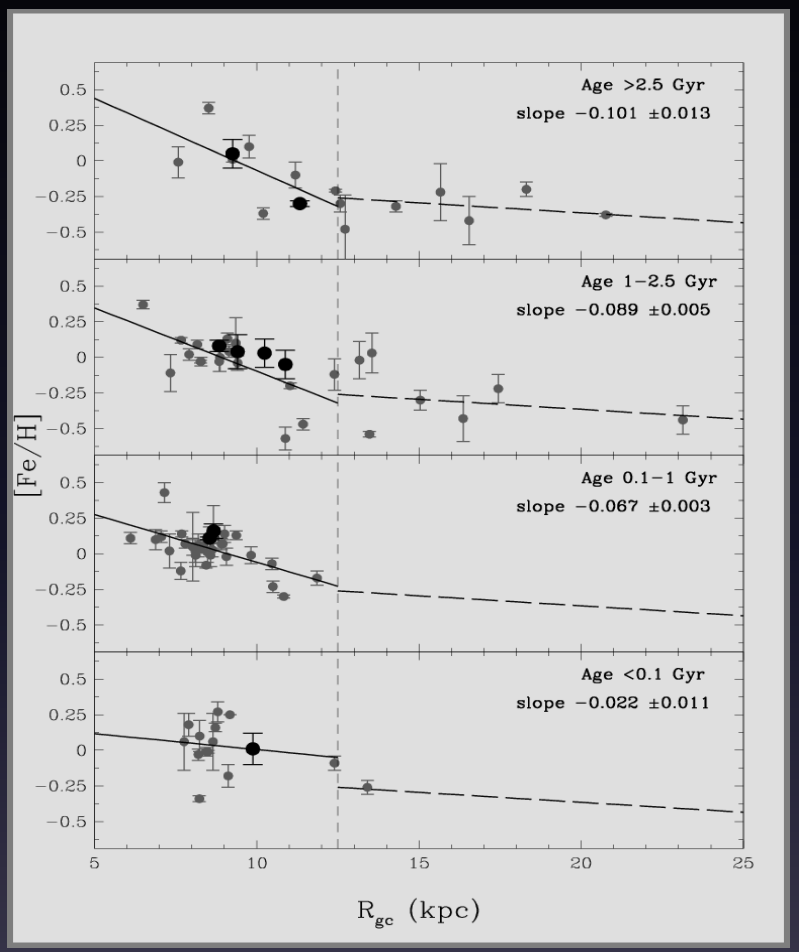
Existence of Trends in the Galactic Disk.

Existence of radial gradients



and its evolution with time



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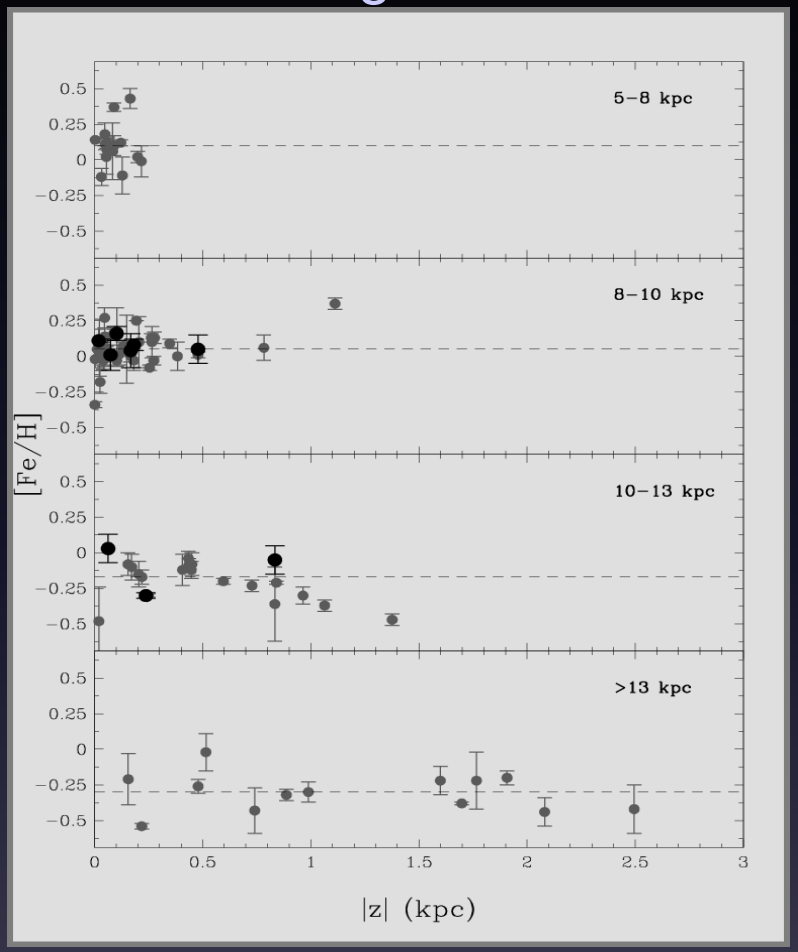
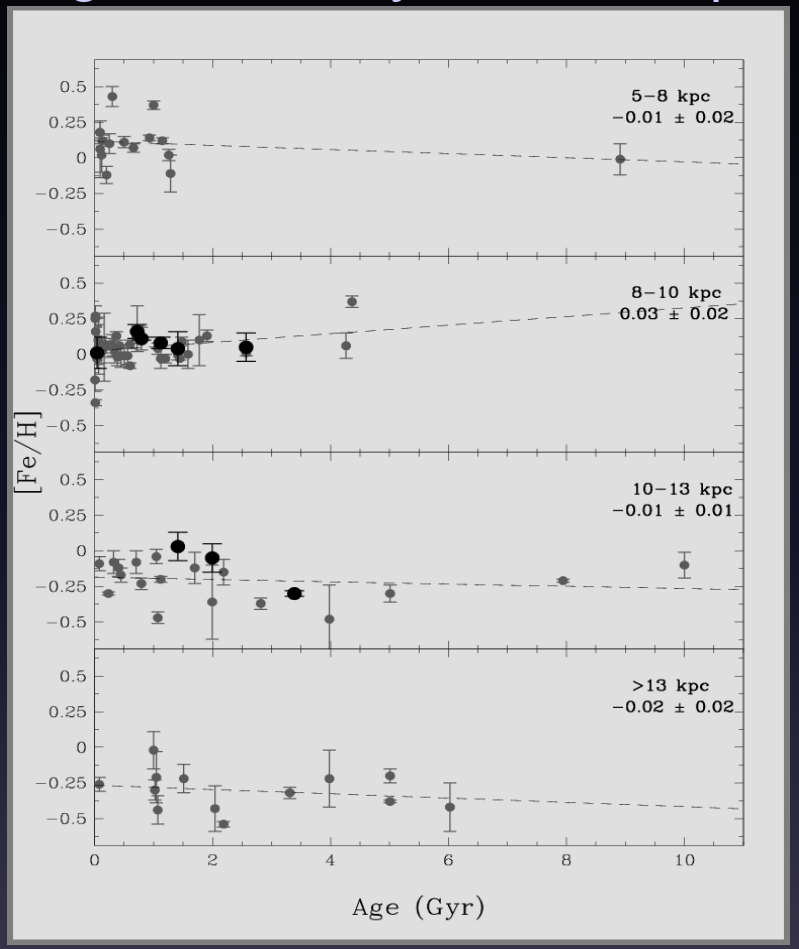
Existence of Trends in the Galactic Disk.

Vertical gradients



Age-metallicity relationship



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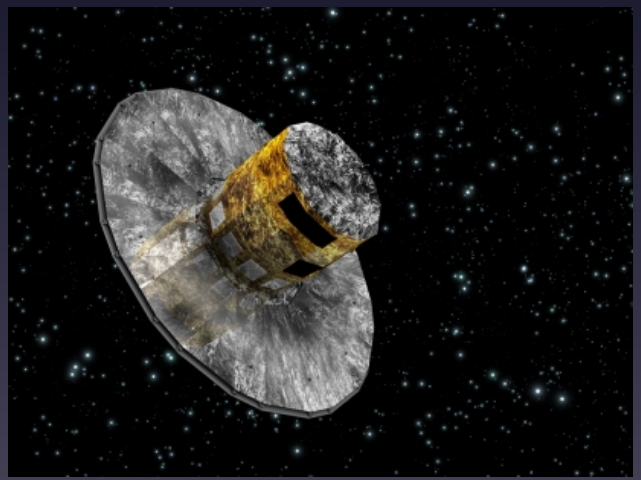
NGC 6791

The Gaia mission

Gaia products

- Parallaxes and distances: precision 2 % within 1.5 kpc.
- Proper motions and tangential velocities: 0.23 km s^{-1}).
- Radial velocities: G_{RVS} <17 (1 km s^{-1}@ G_{RVS} <14;15 km s^{-1}@ G_{RVS} ∼17).
- Chemical abundances: G_{RVS} <12.



The Gaia-ESO survey

240 nights in the next 4 years plus 60 nights in the 5^{th}

Giraffe

- 130 fibers; V$<$19; R$\sim$ 1600-2500.
- Radial velocities (uncertainty $\sim$15 km s^{-1} in the worse cases).
- Atmospheric parameters (T$_{eff}$, log^{g}).
- Chemical abundances for Fe, Ca, Mg (precision 0.2 dex).

UVES

- 6(+2) fibers; V$<$16.5; R$\sim$ 4700.
- Multi-element chemical abundances (accuracy 0.1 dex).

It will observe 30–50 Open clusters

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But limited to $\delta < +20^{o}$

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The Gaia-ESO survey

Why are Northern Open Clusters also important?

- Interesting clusters only observable from the North:
  Berkeley 17 (the oldest)
  NGC 6791 (the most metal-rich)
- Directions in the Galactic disk only observable from the North:
  the Galactic anticenter

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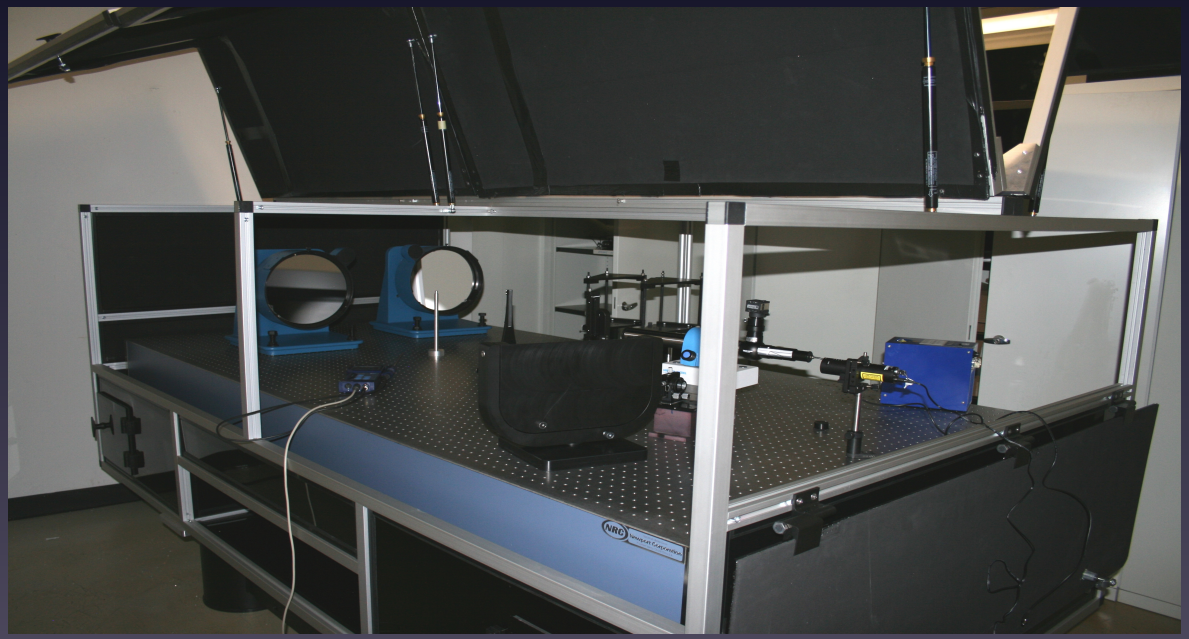
Problems

- There is not an instrument with similar capabilities than FLAMES, even in 2-4m class telescopes.
- This is particularly true for Giraffe (WEAVE will not be ready before 2016).
- A handful of instruments have similar features than UVES but they can observe only one target in each exposure: SARG, CAFE.

Open Clusters Chemical Abundances from the North

CAFE features

- Spectral range: 3900-9600Å (similar to UVES).
- Spectral resolution: $\sim$45000 (similar to UVES).
- Limited to brightest targets V$<$15 (V$<$16.5 for UVES).
- Only one target in each exposure.

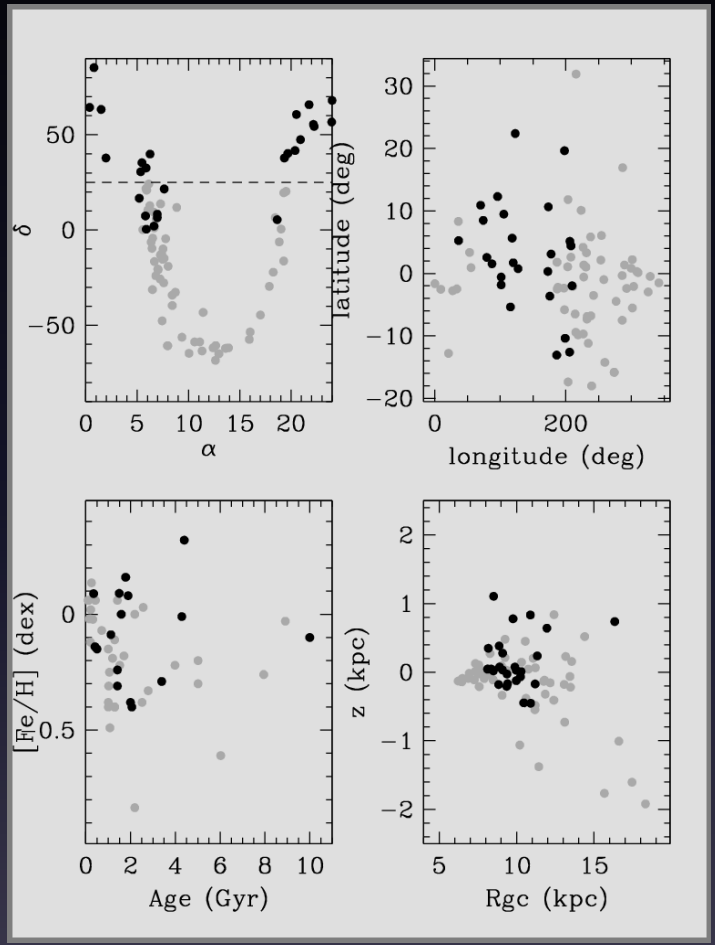


Open Clusters Chemical Abundances from the North

We will follow a similar strategy than in the Gaia–ESO Survey

Strategy

- 20 Clusters older than ∼0.5 Gyr (form a red-clump).



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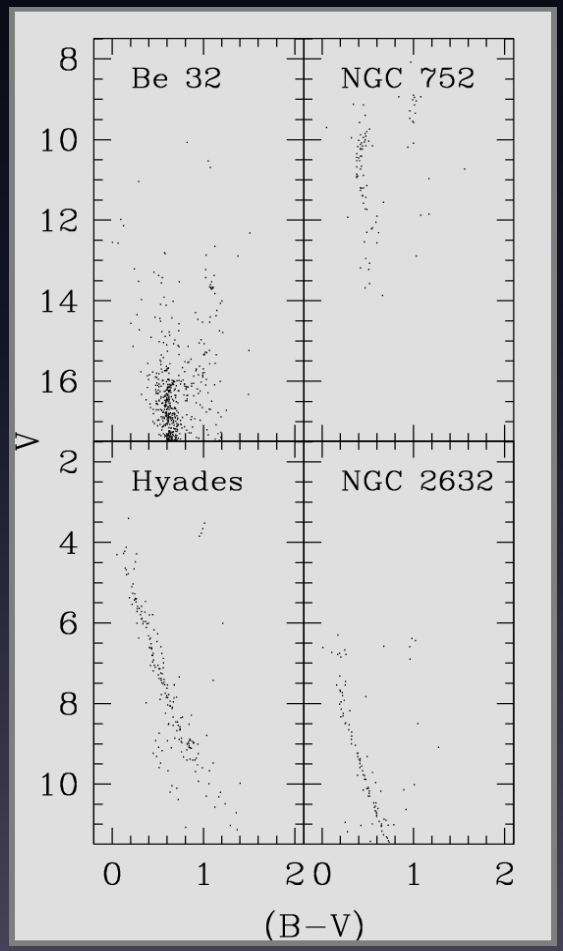

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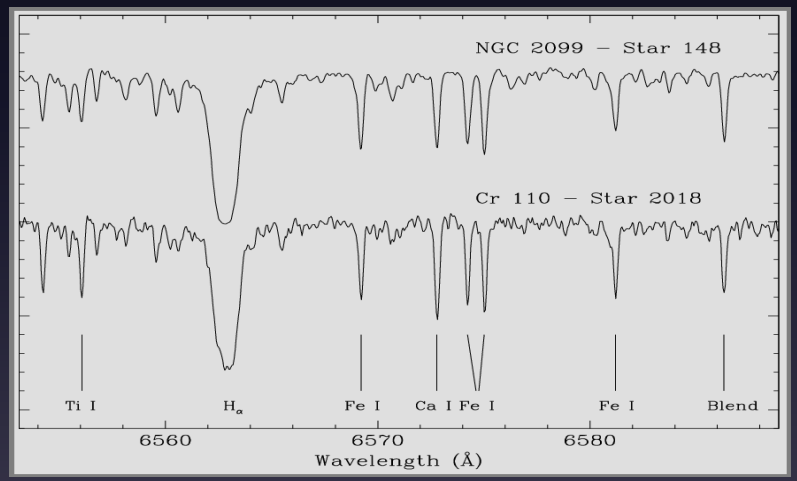
- Less line-crowded and easier to analyse than brighter giants.



Open Clusters Chemical Abundances from the North

Methods to derive chemical abundances.

- **DAOSPEC+GALA** Classical method based on EW.
  Stetson & Pancino (2008); Carrera & Pancino (2011); Mucciarelli et al. (in prep.)
- **MATISSE & DEGAS** Compare the observed spectrum to a grid of synthetic spectra.
  Kordopatis et al. (2011); Recio-Blanco et al. (2006)
- **FERRE** Interpolate in a grid of synthetic spectra and compare them with the observed spectrum.
  Allende-Prieto et al. (2006)

They will be also used by Gaia-ESO Survey.

Summary

- Open clusters are key particles to study the formation and evolution of the Galactic disk: i.e. chemical patterns; radial gradients, etc.
- The heterogeneity of available data forces us to be extremely cautious when drawing any conclusion.
- This picture is going to change in the next years with Gaia mission (parallaxes and proper motions) and the Gaia-ESO Survey (radial velocities and chemical abundances).
- However, the Gaia-ESO Survey does not cover most of the North Hemisphere including some interesting clusters (i.e. Berkeley 17 or NGC 6791) and regions (i.e. the Galactic anticenter).
- We propose to obtain chemical abundances using CAFE@CAHA 2.2m capabilities to derive chemical abundances in northern Open Clusters older than 0.5 Gyr in the same way by the Gaia-ESO Survey.