Open Clusters in the North: homogeneous photometry & high-resolution spectroscopy

Ricardo Carrera

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Importance of open clusters

Open clusters:

- Coeval groups of stars with the same chemical composition* at the same distance.
- Most stars formed in stellar clusters, including the Sun.
- Crucial in the study of: star formation process, stellar nucleosynthesis and evolution, dynamical interaction among stars, assembly and evolution of galaxies (e.g. the Galactic disc/s)

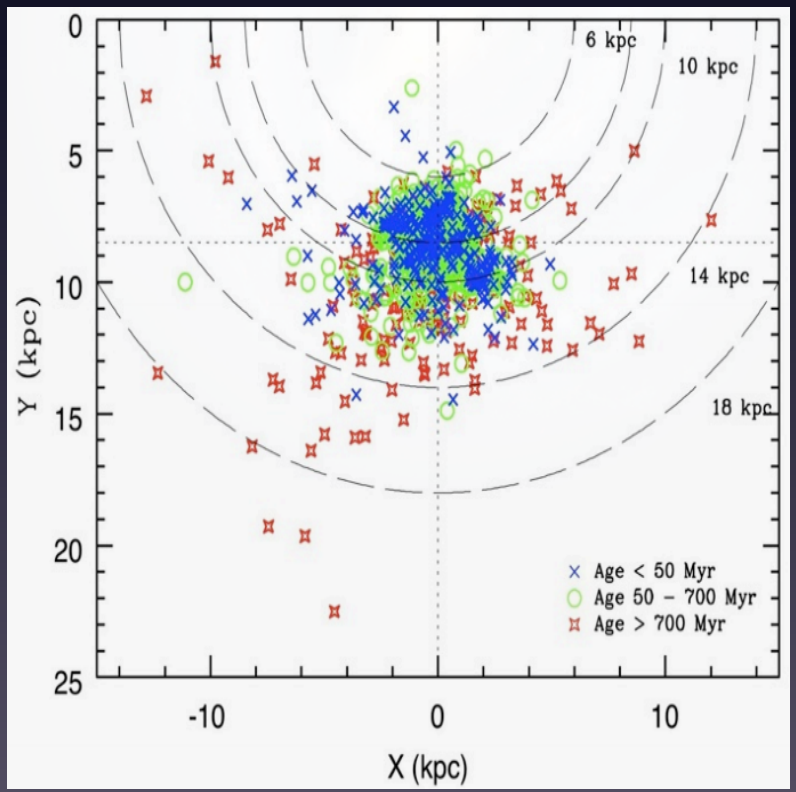
Problems:

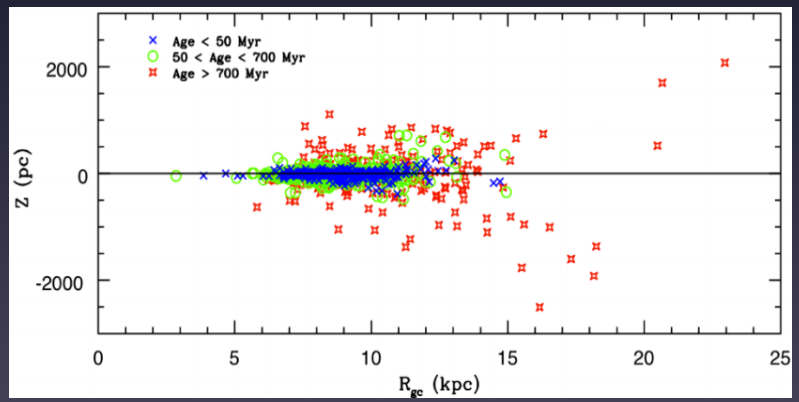
- $\sim$ 2100 Known Open Clusters in the Milky Way.
  - ◇ Ages: $\sim$70 % (mainly from isochrone fitting).
  - ◇ Radial velocities: $\sim$24 %.
  - ◇ Metallicities: $\sim$9 %, (mainly from photometry).
  - ◇ Abundances: $\sim$4 % (very heterogeneous).

Open clusters as Tracers of the Galactic disc

What OC tell us about the Galactic Disc?

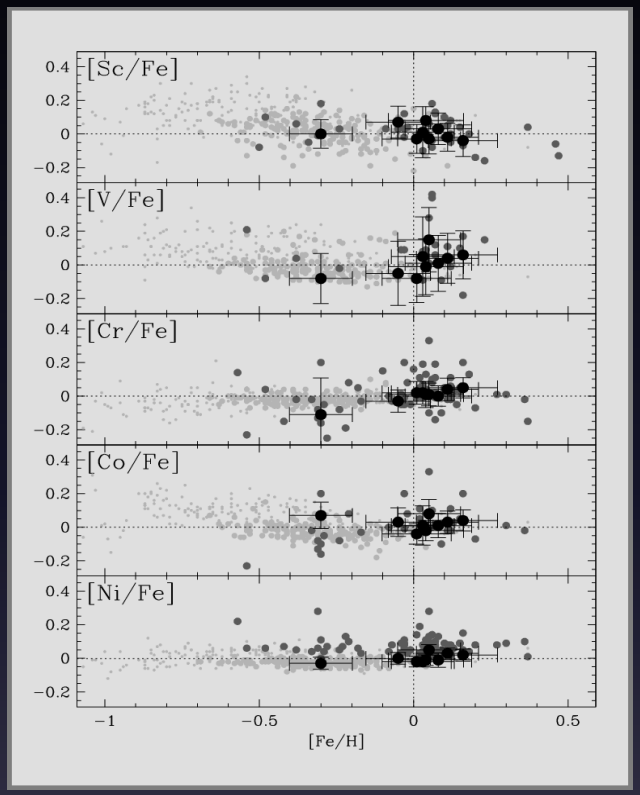
- Chemical patterns in the Galactic disc.
- Trends with radius, height or age: gradients.
- Identification of stellar populations: thin/thick discs, importance of radial migration, etc.



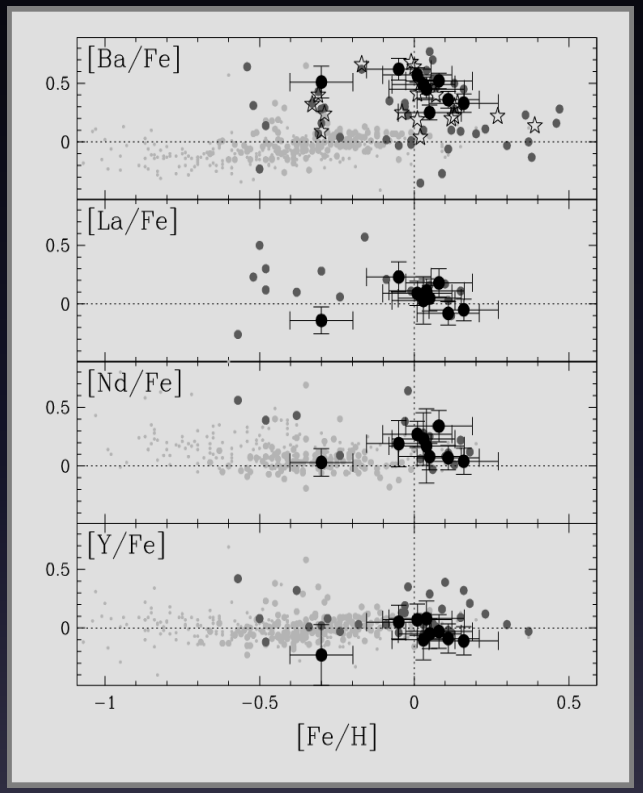


Open clusters as Tracers of the Galactic disc: patterns

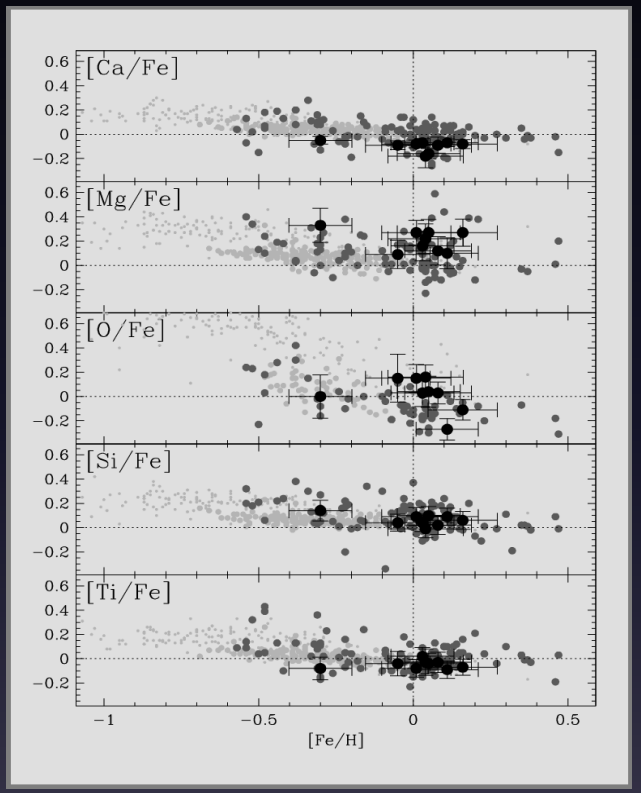
Fe-peak elements



α-elements



s-process elements



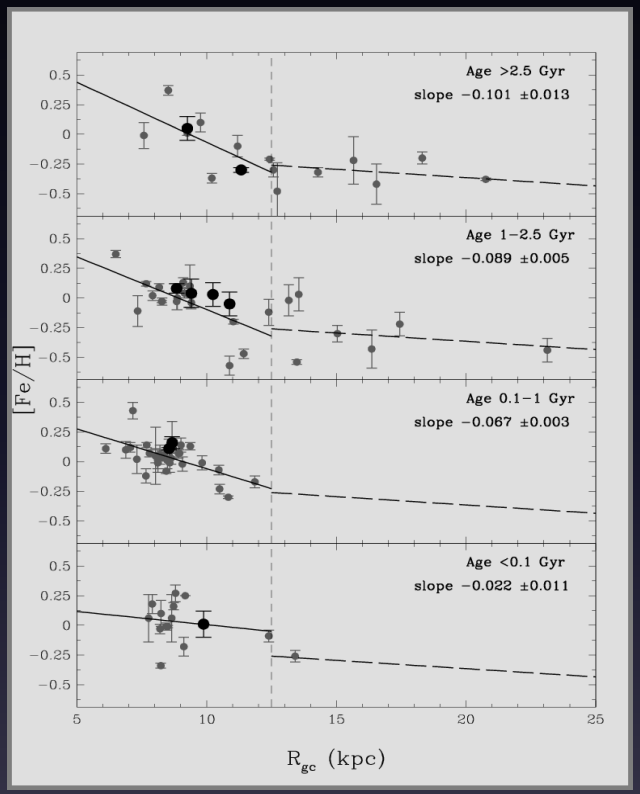
Thin disk: Reddy et al. 2003
Thick disk: Reddy et al. 2006
Open Clusters: Literature
Open Clusters: Carrera & Pancino 2011

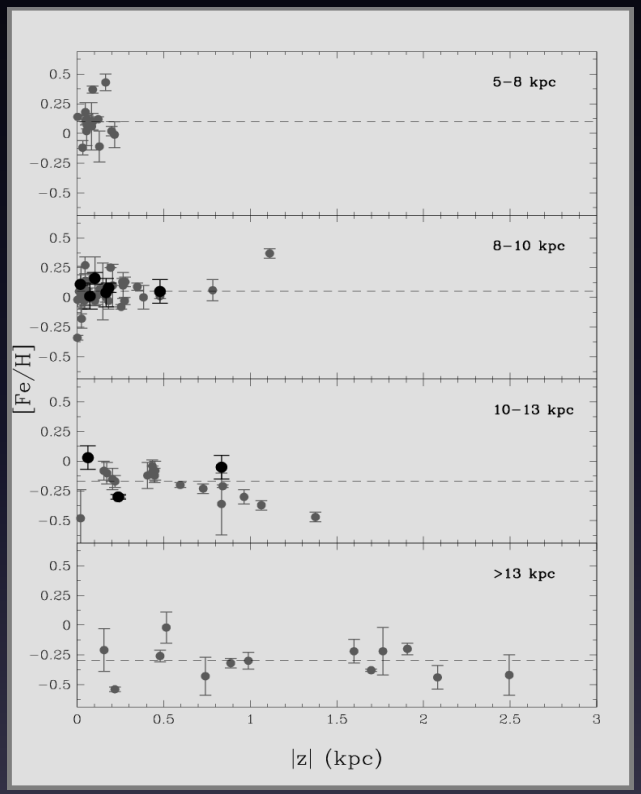
Carrera & Pancino 2011

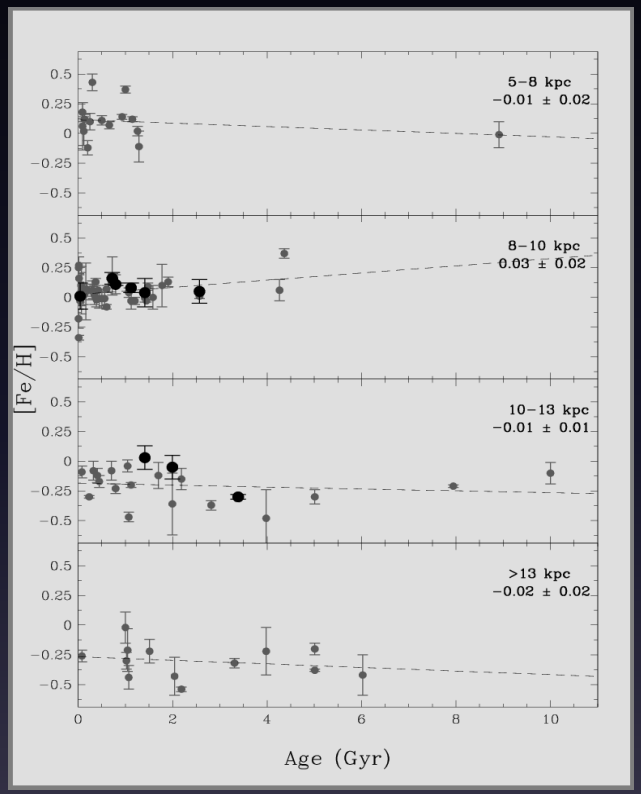
Open clusters as Tracers of the Galactic disc: trends

Radial and vertical gradients

Age-metallicity relationship







Open Clusters: Literature

Open Clusters: Carrera & Pancino 2011

Carrera & Pancino 2011

Open clusters as Tracers of the Galactic disc

Caveats

- Only a handful of clusters have been studied homogeneously.
- Larger samples are very heterogeneous.
- Larger and homogeneous samples are needed
  - Ages from homogeneous datasets.
  - Radial velocities and proper motions.
  - Chemical abundances from homogeneous analysis.
  - Increase the number of clusters studied.

The Gaia Mission and Gaia-ESO survey

Gaia Mission

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

Gaia-ESO Survey (GES)

- $\sim$100 OCs (50 older than$\leq$0.5 Gyr).
- Radial velocities (V$<$19).
- Multi-element chemical abundances (V$<$16.5).
- Limited to $\delta < +20^{o}$ (No Galactic anticenter, NGC 6791, Be 17).

Others (High-resolution spectroscopy Abundances).

- APOGEE (North).
- HERMES (South).

What is still missing? Homogeneous photometry

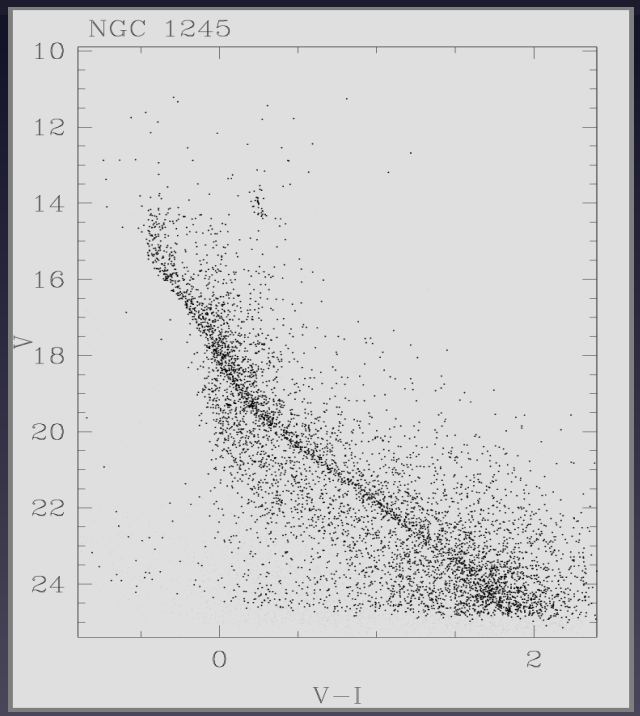
Wide-field homogeneous photometry

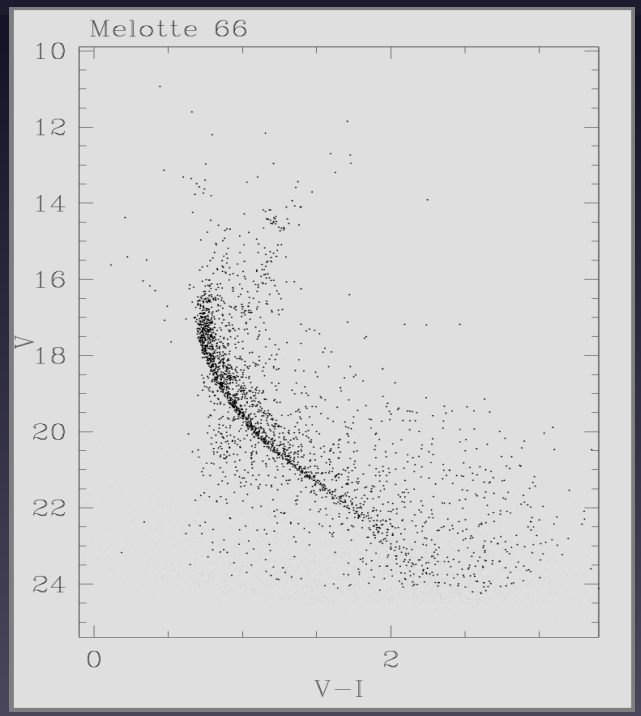
- No homogeneous samples of CMDs
  telescope; photometric calibration; spatial coverage.
- Accessible for 2m class telescopes and wide-field cameras:
  WFC@INT 2.5m; WFI@MPIA/ESO 2.2m.
- Homogeneous estimations of ages, luminosity function, spatial distributions.
- Provide targets for spectroscopic surveys.

What is still missing? Homogeneous photometry

Observational Strategy

- 100 OC older than 1 Gyr (60 North 40 South).
- Homogeneous CMD: same exposure times, data reduction, analysis.
- Cover both hemispheres: similar instrument/telescopes
- Northern observations: completed; Southern observations: midterm





Col: Aparicio; Conn; Gallart; Monelli; Murabito; Nöel; Pancino; Rosenberg; Rix; Stetson

What is still missing? Abundances Nothern OC

Open clusters abundances from the North

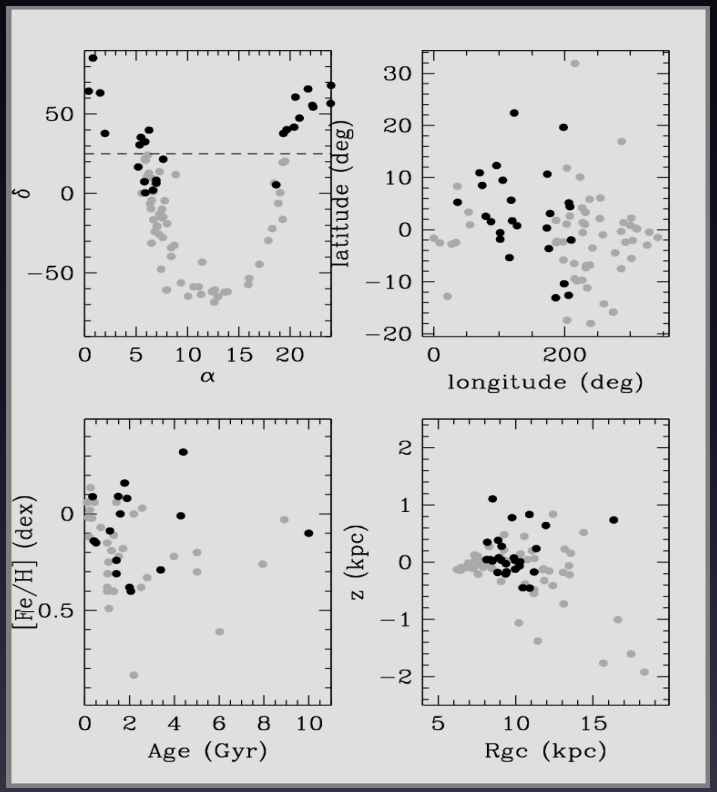
- Interesting clusters only observable from the North:
  Berkeley 17, NGC 6791, Galactic anticenter OCs
- Complement the GES-UVES observations (not an instrument with Giraffe capabilities, WEAVE will not be ready before 2016).
- A handful of instruments have similar features than UVES:
  spectral range and resolution: 3900-9600Å $\sim$45000.
- But they can observe only one target in each exposure:
  CAFE@CAHA 2.2m; FIES@NOT 2.5 m; HERMES@MECATOR 1.2m.
- Limited to brightest targets V$<$15 (V$<$16.5 for UVES).

Open Clusters Abundances from the North

We replicate the GES observational strategy and data analysis

Observational strategy

- 25 Clusters $\geq$0.5 Gyr.

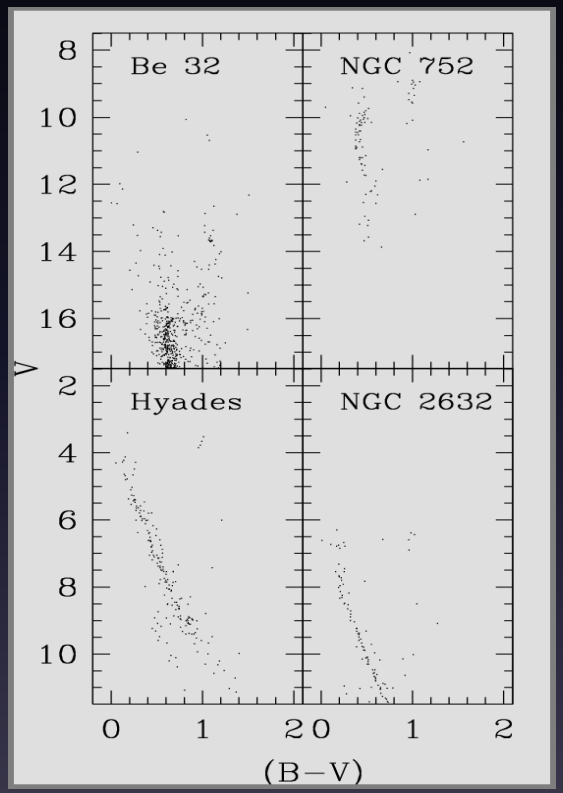


Open Clusters Abundances from the North

We replicate the GES observational strategy and data analysis

Observational strategy

- 25 Clusters $\geq$0.5 Gyr.
- $\geq$6 RC in each cluster (easily identified in the CMDs).



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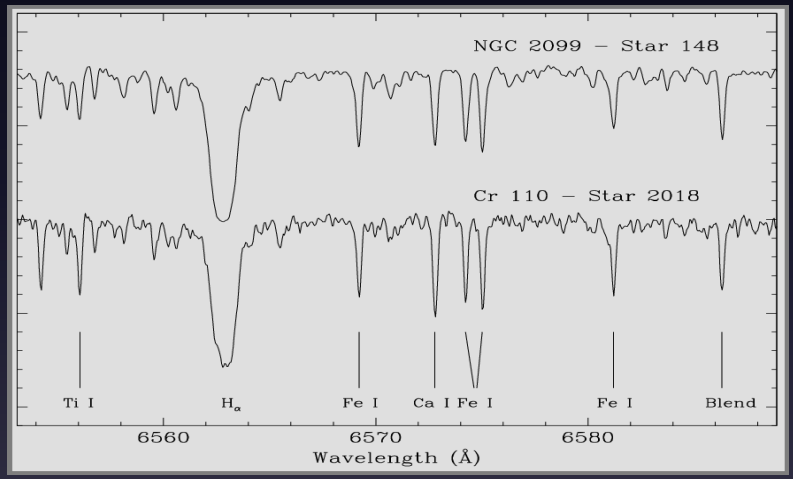
- Less line-crowded and easier to analyse than brighter giants.



Open Clusters Abundances from the North

We replicate the GES observational strategy and data analysis

Observational strategy

- 20 Clusters $\geq$0.5 Gyr (2$\times$ GES sample).
- $\geq$6 RC in each cluster (easily identified in the CMDs).
- Less line-crowded and easier to analyse than brighter giants.

Data Analysis

- **DAOSPEC+GALA** Classical method based on EW.
- **MATISSE & DEGAS** Compare the observed spectrum to a grid of synthetic spectra.
- **FERRE** Interpolate in a grid of synthetic spectra and compare them with the observed spectrum.

First observations scheduled for 13A semester.

Summary

Wide-field homogeneous photometry

- Intruments: WFC@INT 2.5 m (North) & WFI@MPIA/ESO 2.2m (South).
- Sample: 100 OC $\geq$1 Gyr (50 % of known) 60 North & 40 South.
- Status: North observations completed analysis advanced; South 45 % observed.
- Future: extension to younger ages ($\geq$0.2 Gyr).

Open clusters abundances from the North

- Instruments: CAFE@CAHA 2.2m; FIES@NOT 2.5 m; HERMES@MECATOR 1.2m.
- Sample: 20 OCs $\geq$0.5 Gyr, $\geq$6 RC in each cluster.
- Status: first observations scheduled for 13A semester.
- Future: extension to fainter (further) OC with HORUS@GTC.