The OCCASO survey

Open Clusters Chemical Abundances from Spanish Observatories

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on behalf of the OCCASO team

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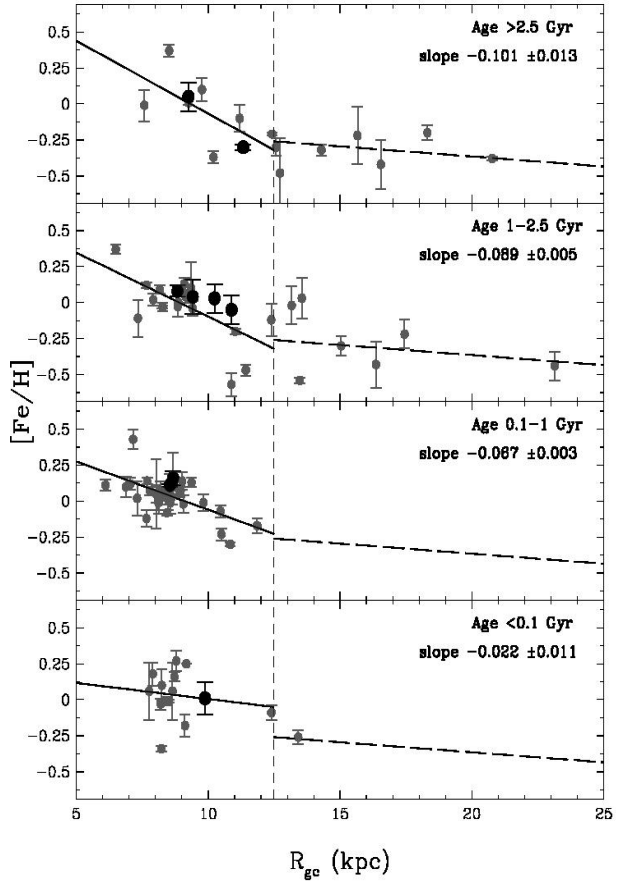
Open Clusters

- **Importance** star formation, stellar nucleosynthesis, star evolution, tracers of the galactic disc
- **Drawbacks** Few with detailed information of radial velocities ($\sim$ 24 %), metallicities ($\sim$ 9 %) and abundances ($\sim$ 4 %). Obtained heterogeneously.
- **Larger and homogeneous samples are needed!**
  - Chemical abundances from homogeneous analysis.
  - Ages from homogeneous datasets.
  - Radial velocities and proper motions.
  - Increase the number of clusters studied.



Carrera & Pancino 2011

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

A new era of the Open Clusters research: Space

The Gaia Mission

- Very precise parallaxes and proper motions.
- Radial velocities: 13 km s^{-1}@ V$\sim$15.
- Chemical abundances: V_{RVS} $<$11.5.

The Kepler Mission

- Variability: photometric precision of 80 ppm.

A new era of the Open Clusters research: Ground

Gaia-ESO Survey (GES)

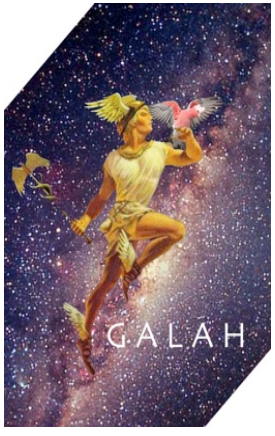
- South
- Resolution 47000 (UVES) <20000 (GIRAFFE)
- 4800 to 7000 (UVES) 6500-9000* Å (GIRAFFE)

OCs: +100 (20-30 >1 Gyr)

APO Galactic Evolution Experiment (APOGEE)

- North (and South).
- Resolution 22500
- 15000 to 17000 Å

OCs: >100 (25 >1 Gyr)



GALactic Archaeology with HERMES (GALAH)

- Coverage: South
- Resolution 28000 (normal) 50000 (slit-mask)
- 4718-4903; 5649-5873; 6481-6739;7590-7890 Å

OCs: ?

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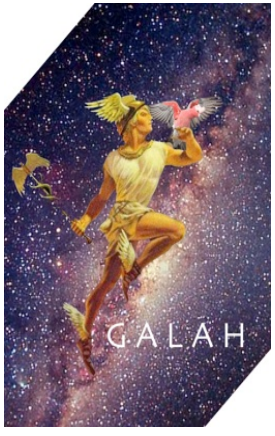

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North not properly sampled!

The OCCASO Survey

Aims

Double the number of OCs homogeneously studied.
Complement GES-UVES observations from the North.

- Not instrument with GIRAFFE capabilities (WEAVE in 2017).
- Important OCs only visible from the North
  - Oldest: Berkeley 17
  - Most metal-rich: NGC 6791
  - Kepler: NGC 6791 & NGC 6819
  - Galactic anticentre: NGC 1817

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HERMES@Mercator (1.2 m)

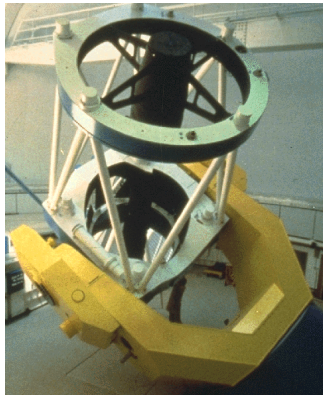
- Resolution 85000
- 3770 to 9000 Å
- V<12.5

FIES@NOT (2.5m)

- Resolution 67000
- 3700 to 7300 Å
- 12.5<V<14.5

CAFE@ 2.2m CAHA

- Resolution 60000
- 3960 to 9500 Å
- 12.5<V<13.5

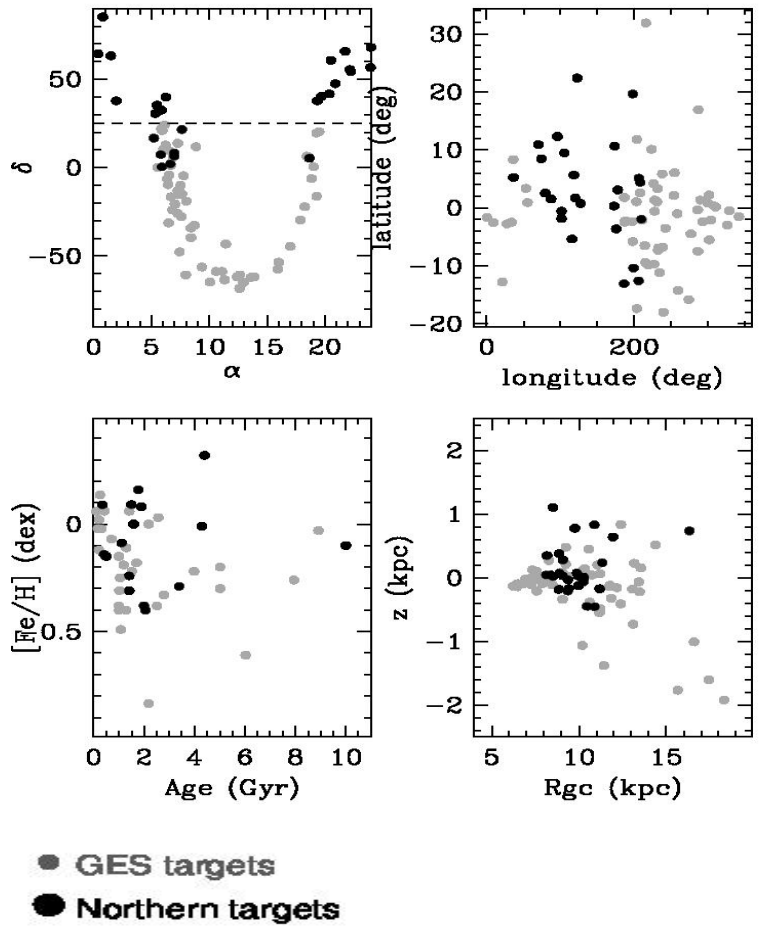


The OCCASO Survey

Replicate the GES-UVES observational strategy

Observational strategy

- Initial sample: 25 Clusters $\geq$0.5 Gyr.



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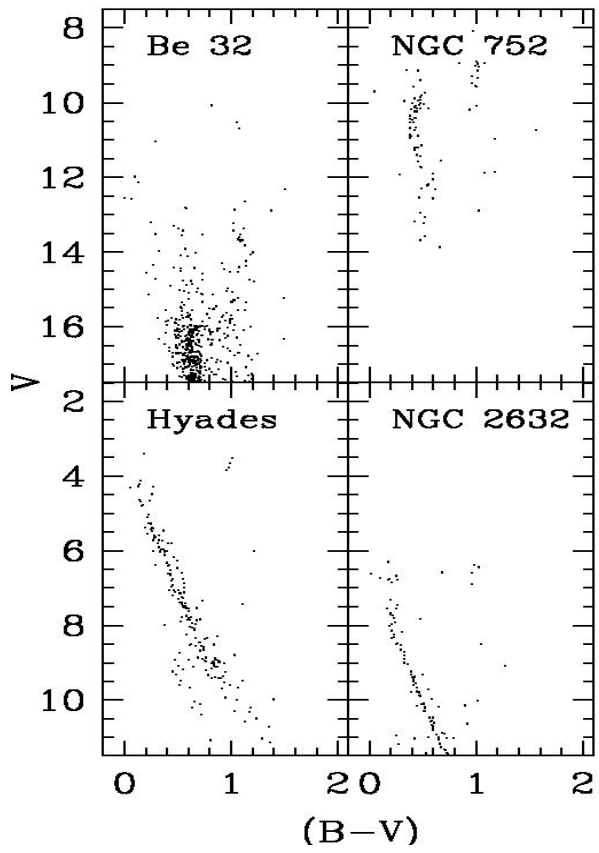

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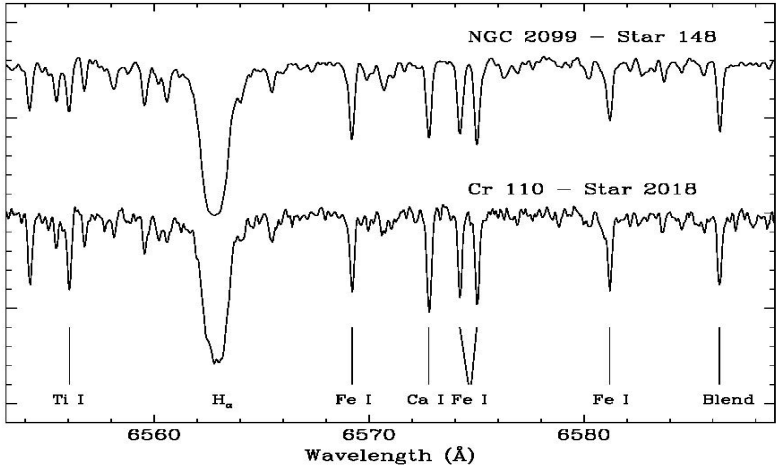

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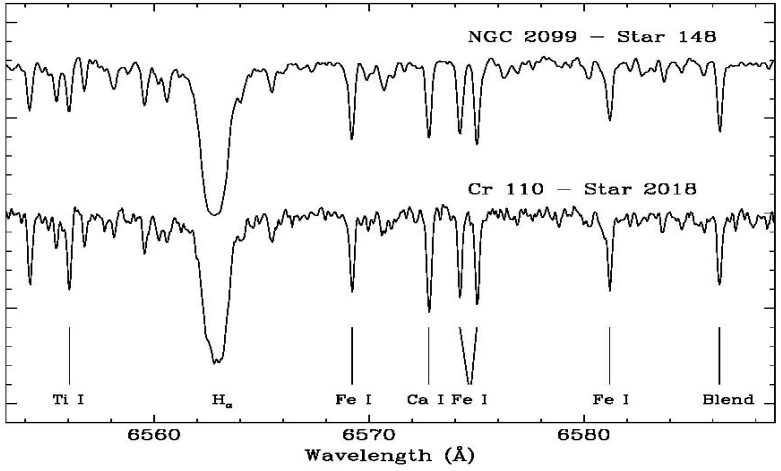
- S/N $\geq$70.



The OCCASO Survey

Observations

- Started Summer 2013
- NOT & Mercator:
  5 nights/telescope/semester
  till summer 2015
- 2.2m CAHA:
  DDT & regular time.

Telescope	NOT	Mercator	2.2m CAHA
Awarded	25	25	8
Observed	20	15	8
Time lost	30 %	15 %	50 %

- Complementary observations:
  confirm cluster members

Cluster Sample

Cluster	Stars	Survey
King 1	4	
NGC 559	1	
NGC 752	7	
NGC 1817	5	
Be 17	3	
NGC 2099	7	
NGC 2420	5	A
NGC 2682	8	A
IC 4756	6	
NGC 6633	4	
NGC 6705	7	G
NGC 6791	6	A,K
NGC 6819	6	A,K
NGC 6939	5	
NGC 6991	6	
NGC 7142	2	
NGC 7762	6	
NGC 7789	7	A

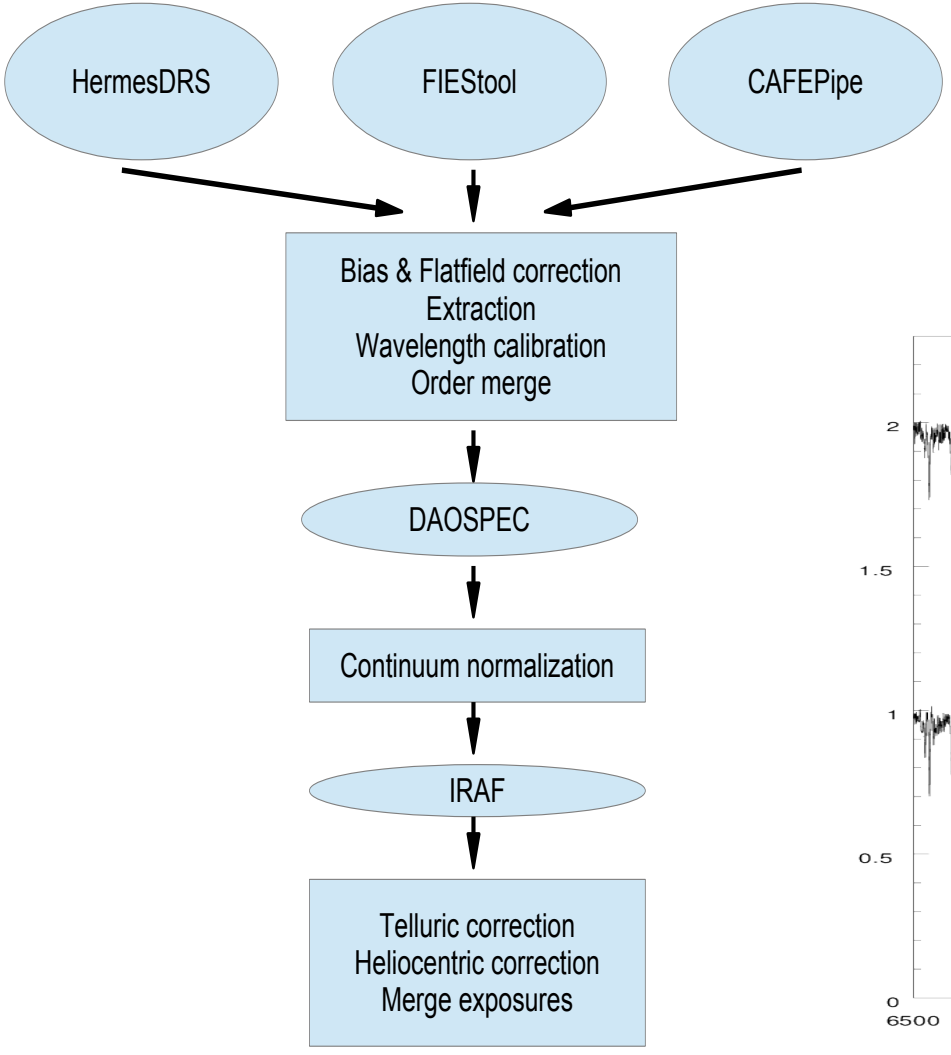
(A) APOGEE
(G) GES
(K) Kepler

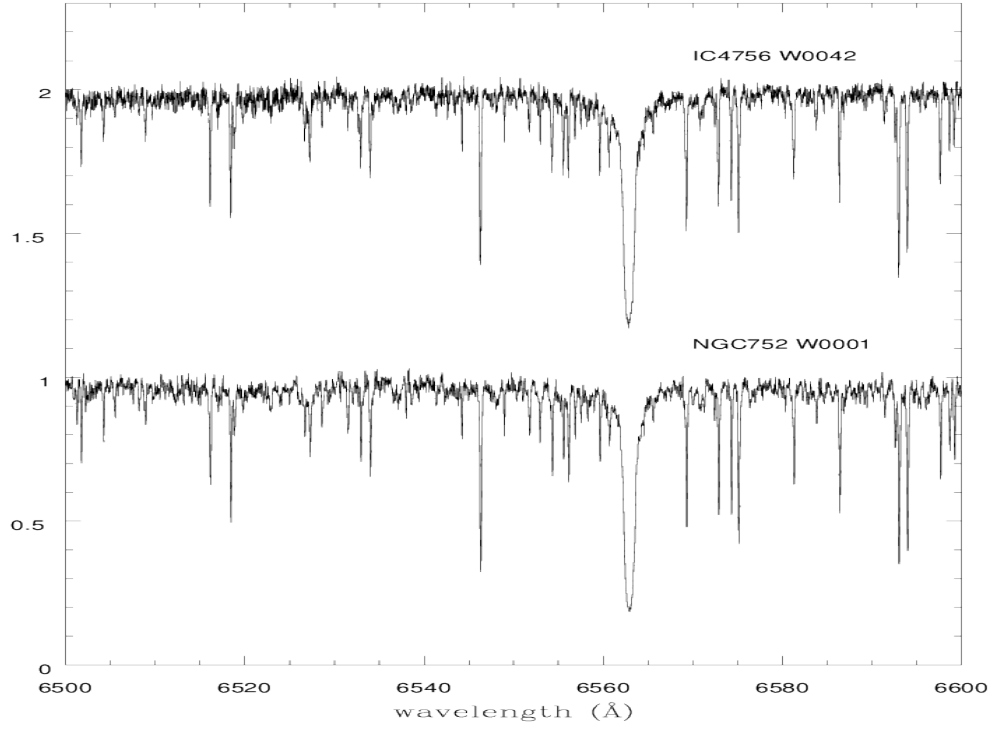
Observed: 18 clusters $\rightarrow$95 stars

Completed: 11 clusters

The OCCASO Survey

Data Reduction





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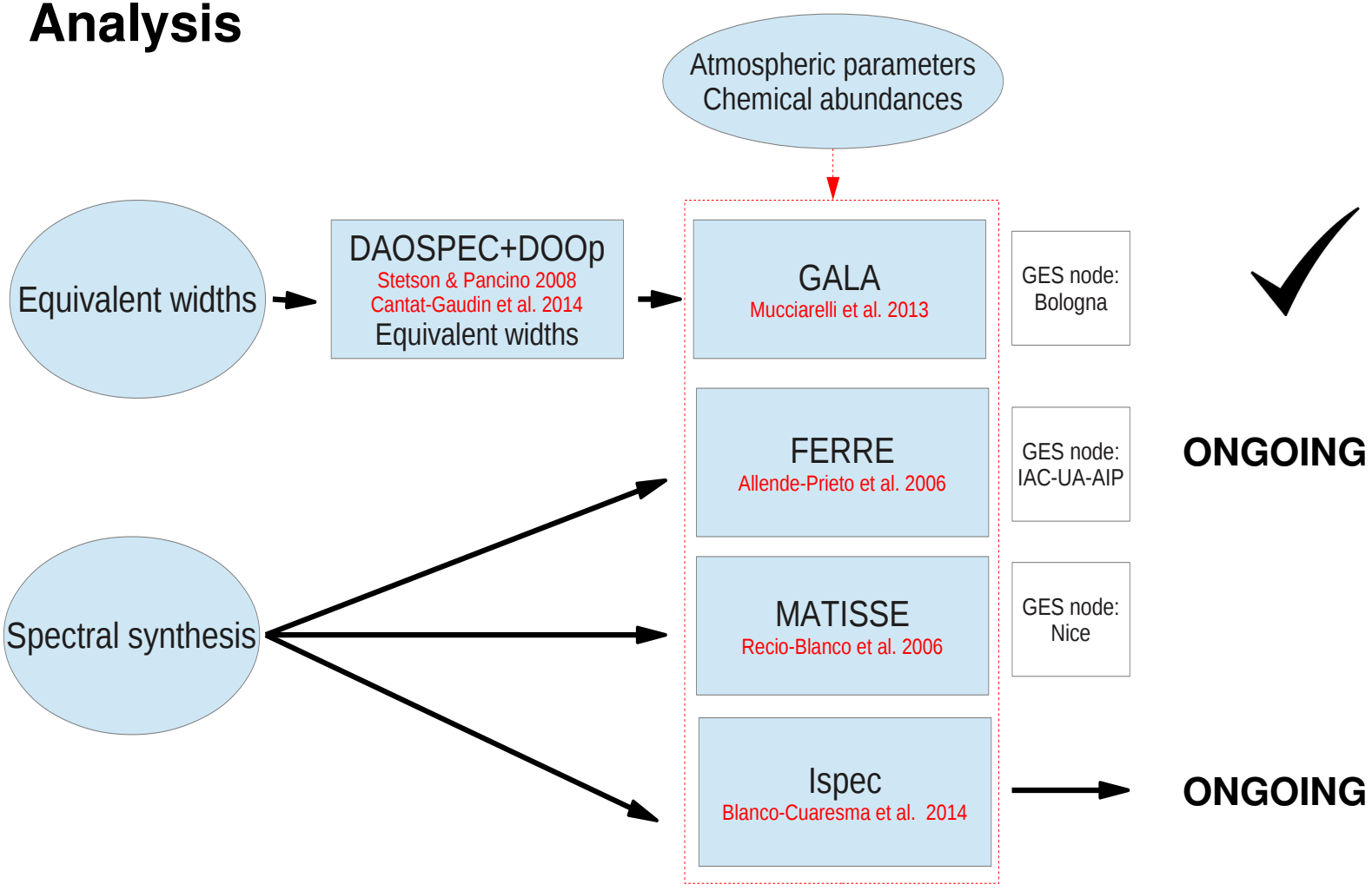
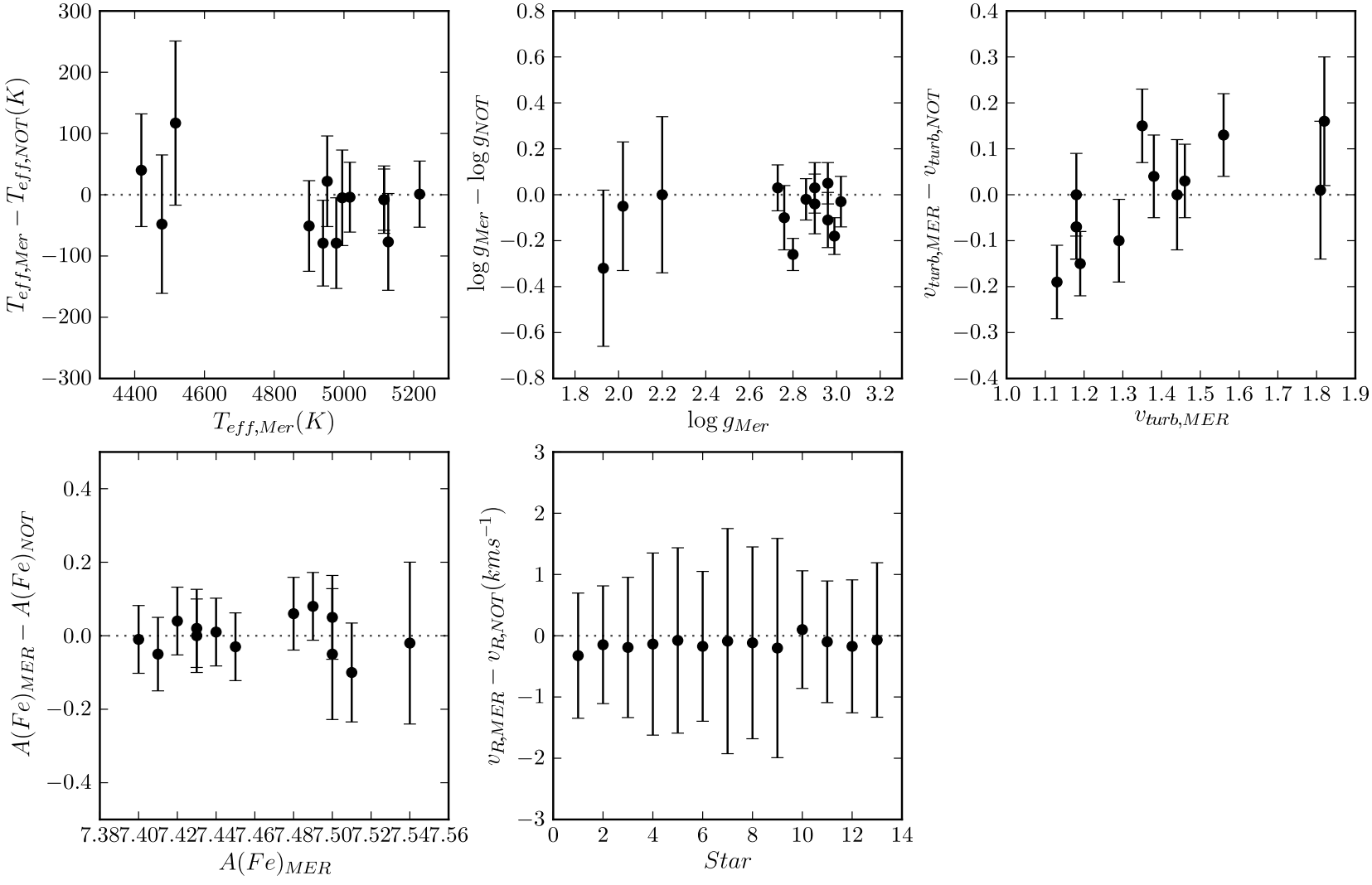
Analysis



The OCCASO survey

Consistency: comparison among telescopes

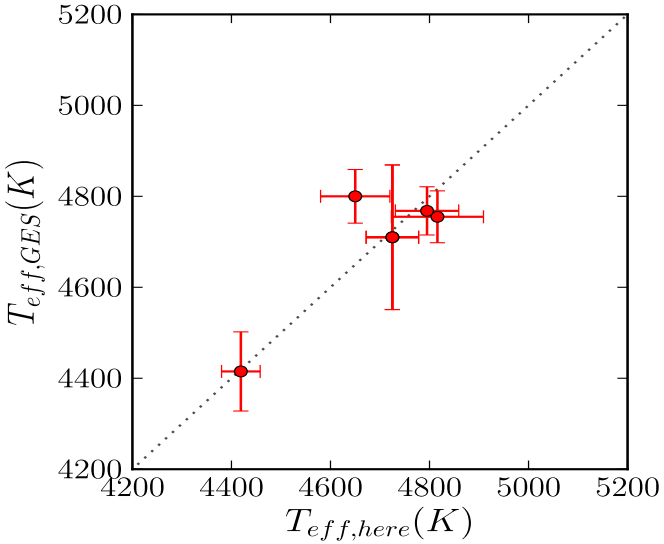
Differences NOT-Mercator: 13 stars observed with both telescopes

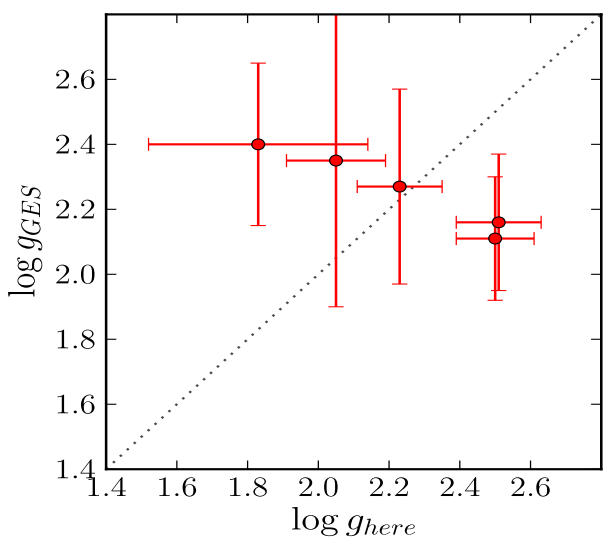


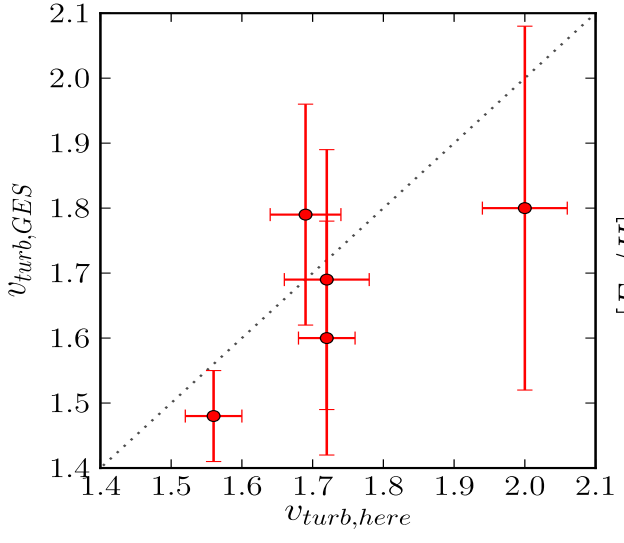
The OCCASO survey

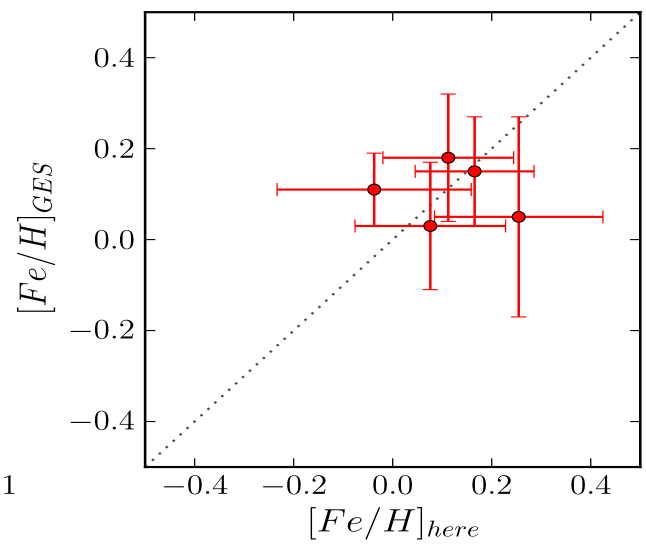
Consistency: comparison of M11 with GES

5 stars in common, comparison of atmospheric parameters and [Fe/H]







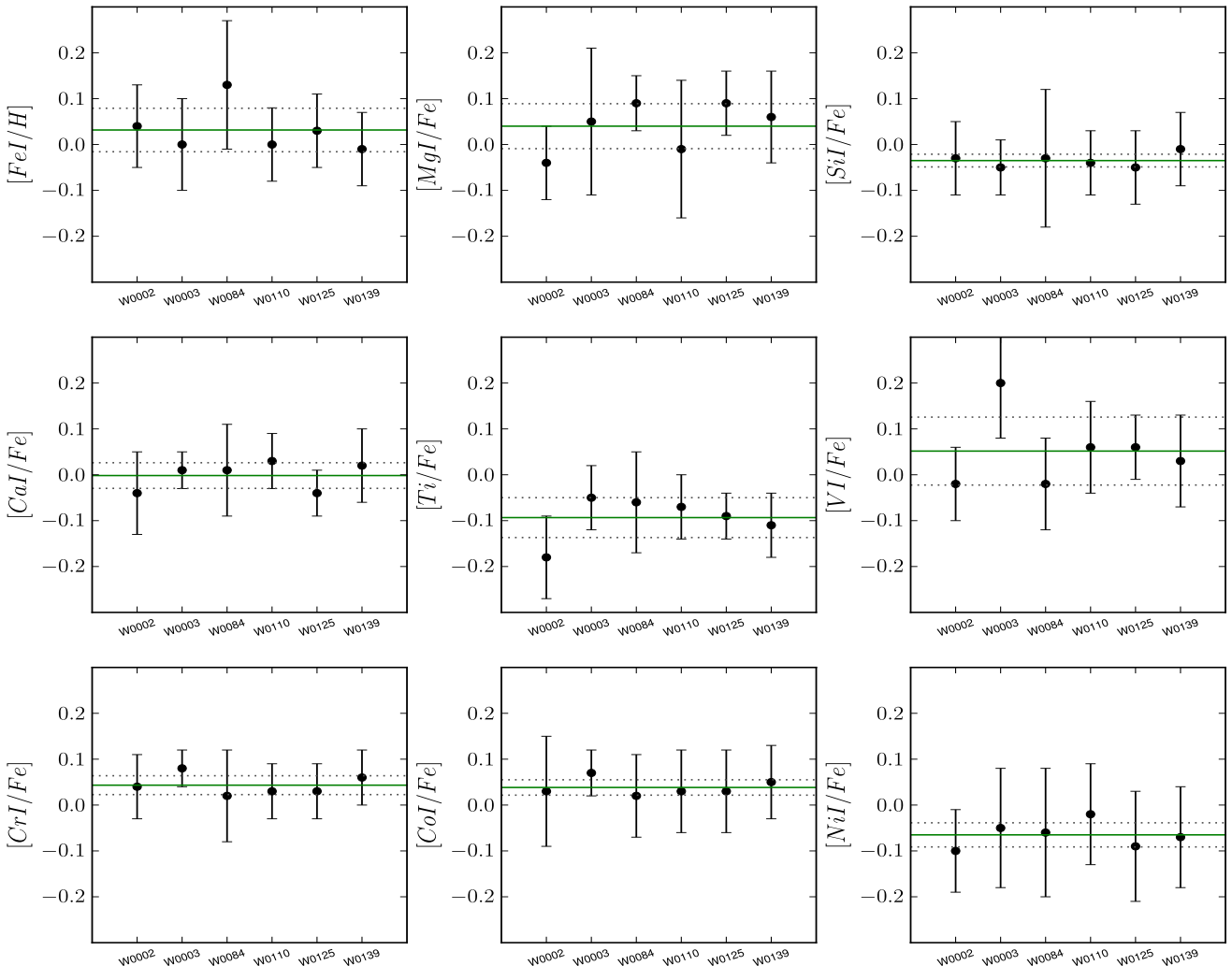


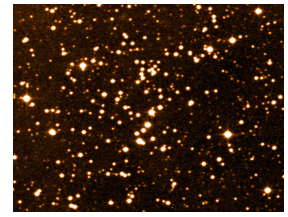
$\langle$[FeI/H]$\rangle_{OCCASO} = 0{,}11 \pm 0{,}09$
$\langle$[FeI/H]$\rangle_{GES} = 0{,}10 \pm 0{,}06$

The OCCASO survey

NGC 7762: First abundance determination!

RA	DEC	R_{gc}	Age	Z
hh:mm:ss	dd:mm:ss	kpc	Gyr	kpc
23:50:01	+68:02:18	8.89	2.00	+0.08





[FeI/H]	0.03±0.05
[MgI/Fe]	0.04±0.05
[SiI/Fe]	-0.04±0.01
[CaI/Fe]	0.00±0.03
[ScII/Fe]	0.11±0.07
[TiI/Fe]	-0.09±0.04
[VI/Fe]	0.05±0.07
[CrI/Fe]	0.04±0.02
[CoI/Fe]	0.04±0.02
[NiI/Fe]	-0.07±0.03
[YII/Fe]	0.04±0.09
[BaII/Fe]	0.20±0.05
[LaII/Fe]	0.13±0.18
[EuII/Fe]	0.3±0.1

From photometry: [Fe/H]∼-0.35

(Patat & Carraro 1995)

The OCCASO survey

Conclusions and future work

- ✓ Abundance analysis from equivalent width method for eleven clusters

  IC 4756, NGC 752, NGC 2099, NGC 2682, NGC 6633, NGC 6705, NGC 6791, NGC 6819, NGC 6991, NGC 7762, NGC 7789
- ✓ Internal consistency among telescopes
- ✓ Consistency with GES (M11)
- Analysis from synthesis methods
- Comparison among methods
- First data release: atmosphere parameters (T_{eff}, log g), radial velocities, and [Fe/H] observed stars until now ($\sim$90)
- Second data release: detailed abundance analysis of the finished clusters
- Finish observations