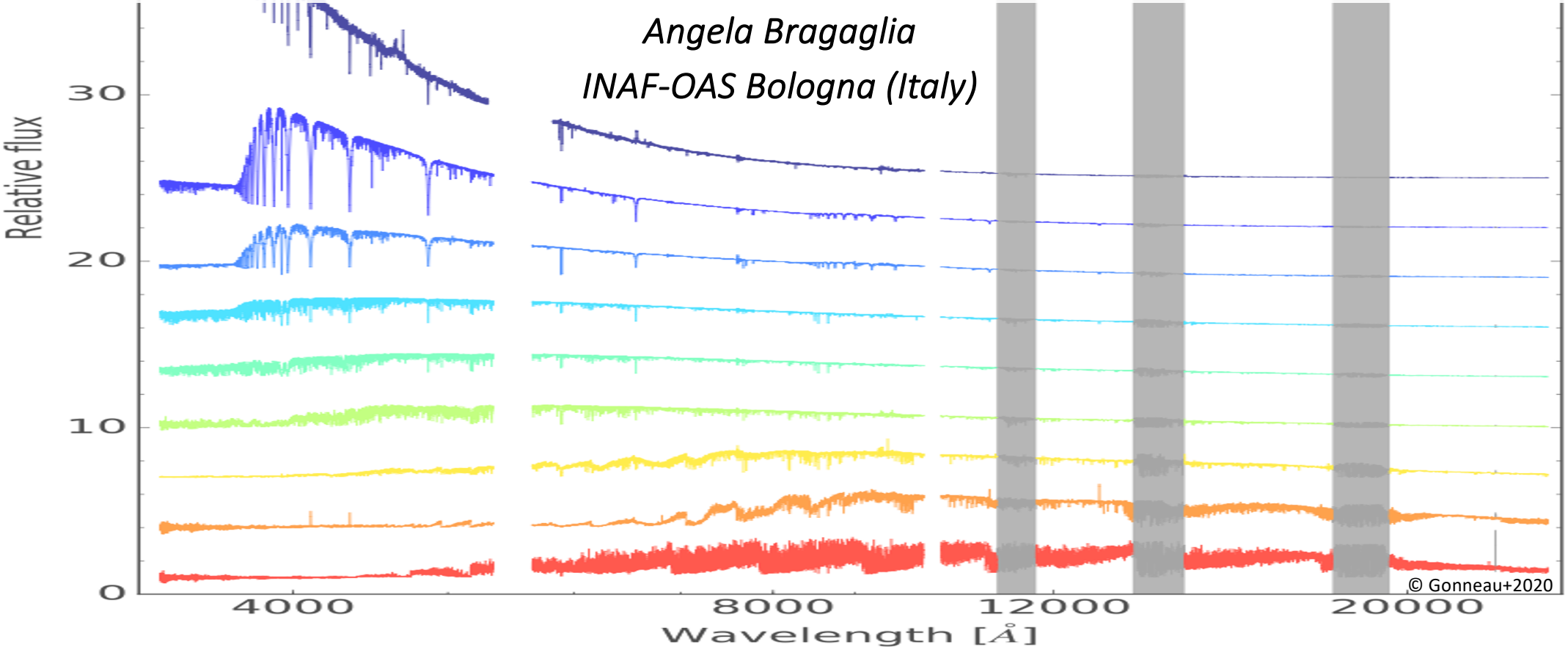
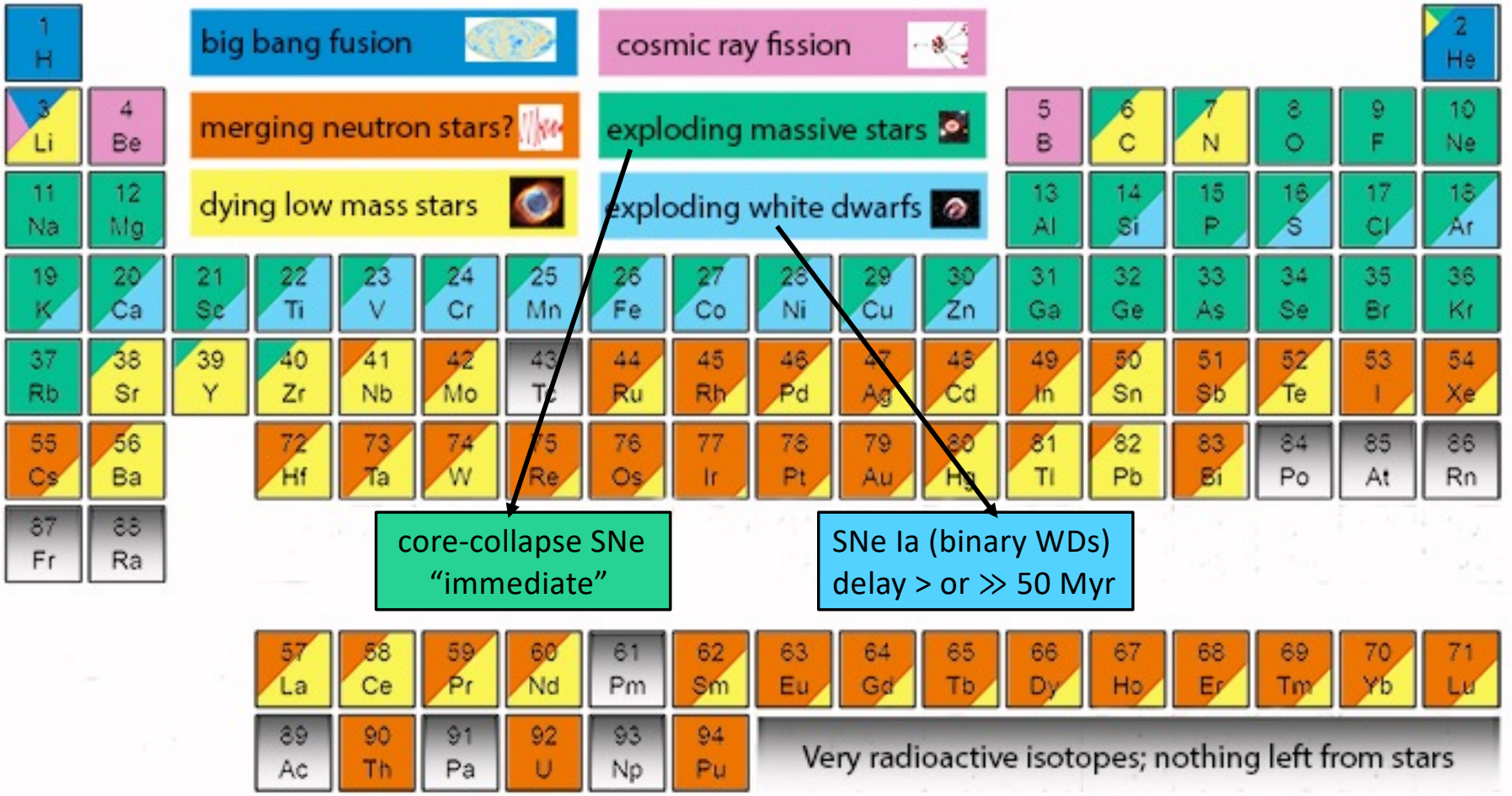
Large spectroscopic surveys: scientific cases & (a few) outcomes

Angela Bragaglia
INAF-OAS Bologna (Italy)



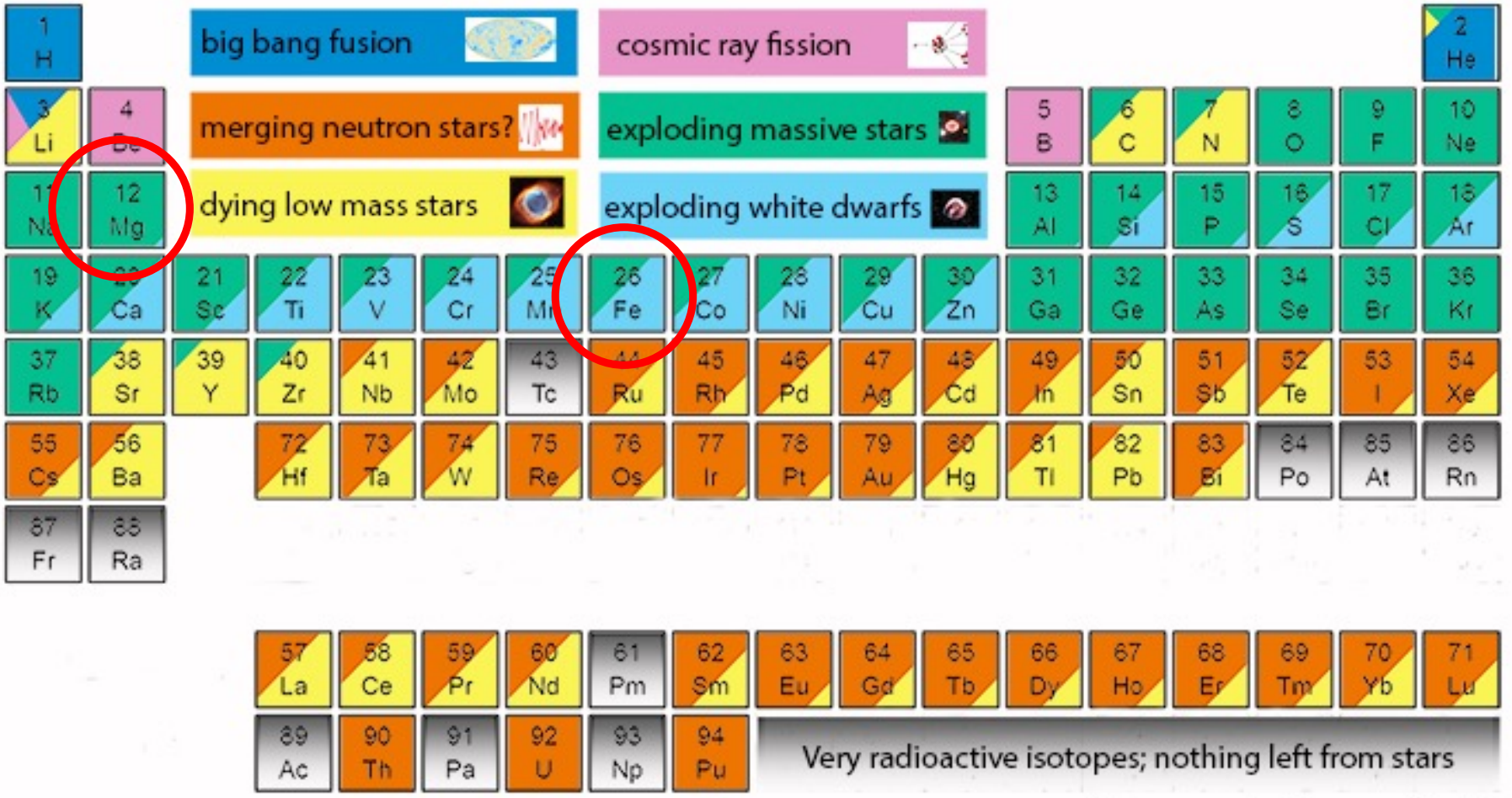
The Origin of the Solar System Elements



Graphic created by Jennifer Johnson
http://www.astronomy.ohio-state.edu/~jaj/nucleo/

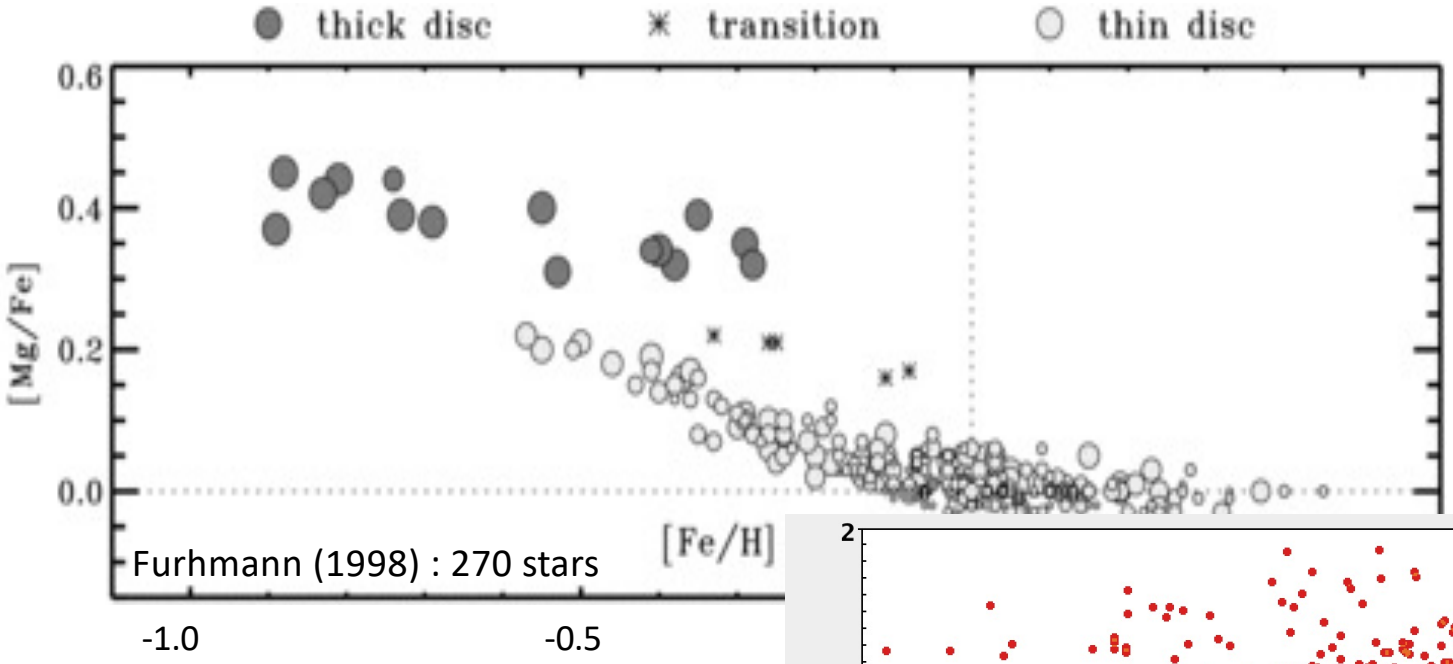
Astronomical Image Credits:
ESA/NASA/AASNova

The Origin of the Solar System Elements



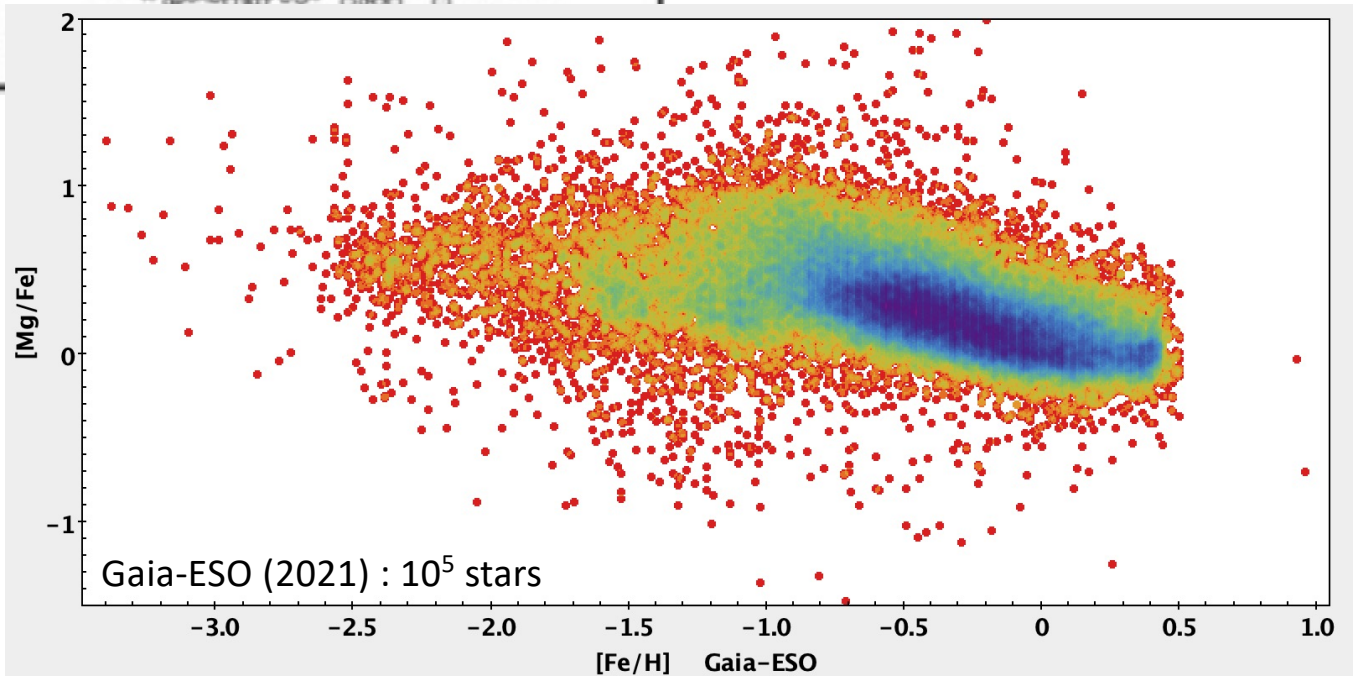
Graphic created by Jennifer Johnson
http://www.astronomy.ohio-state.edu/~jaj/nucleo/

Astronomical Image Credits:
ESA/NASA/AASNova



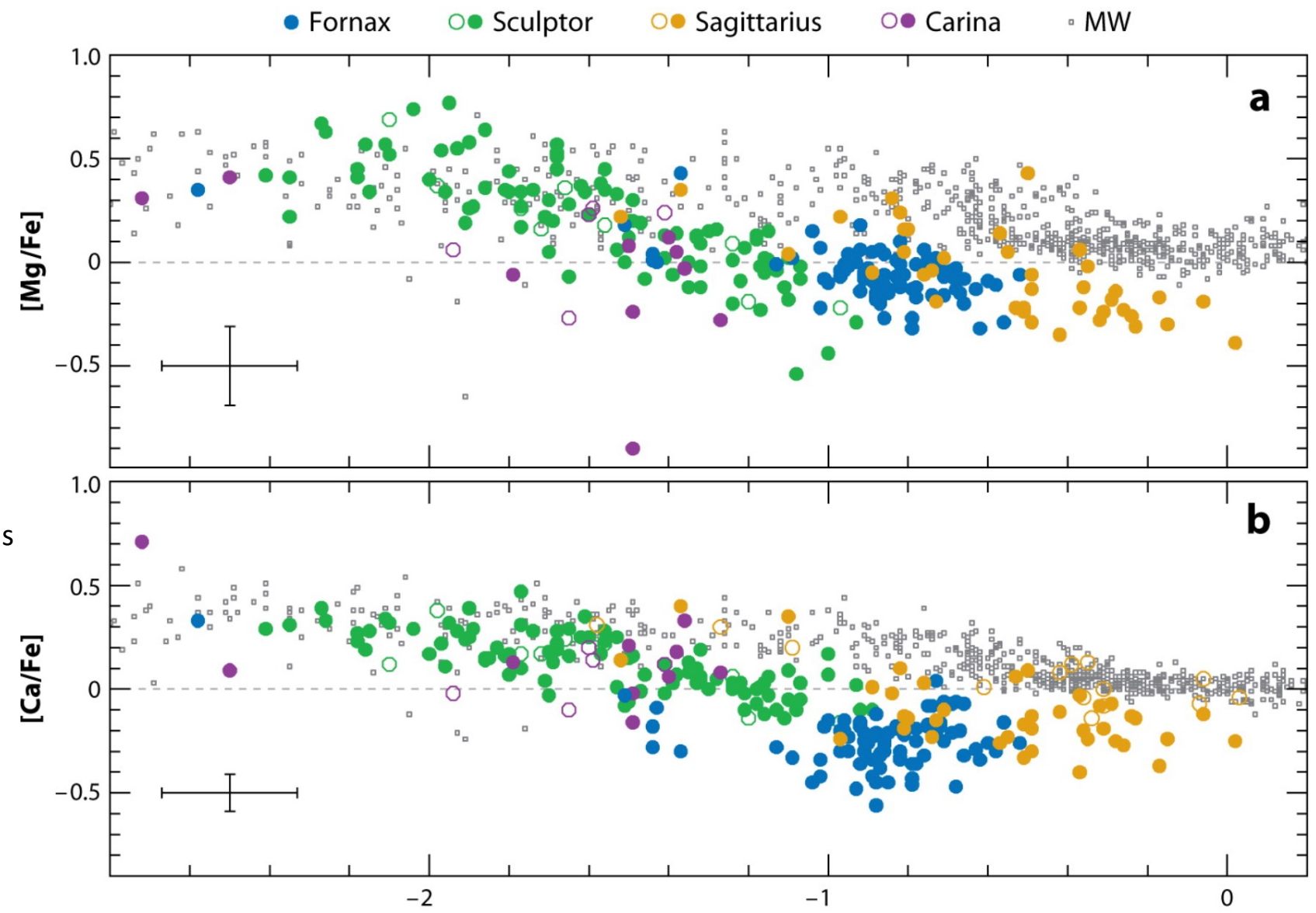
Furhmann (1998) : 270 stars

[Mg/Fe] *vs* [Fe/H] :
c-c SNe *vs* Ia SNe



Gaia-ESO (2021) : 10^5 stars

The knee position indicates the metallicity at the time SNe Ia start to contribute to the chemical evolution and the knee is expected to be different because of the wide variety of SFHs



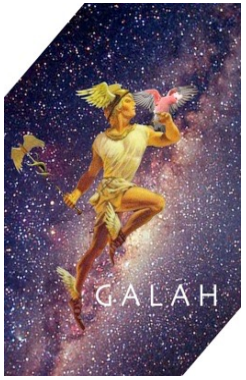
Tolstoy, Hill & Tosi 2009, ARAA, 47, 371

In the following we will see a few highlights (*very biased choice*, sorry) for four surveys (three high-res, one low/medium-res):

- **Gaia-ESO** observation finished; spectra public; final data release [soon] with 110000 stars
- **APOGEE** APOGEE-2, also South, on-going; spectra public; DR16 has 430000 stars
- **GALAH** on-going; spectra public; DR3 has 600000 stars

and

- **LAMOST** on-going; public up to DR6 with about 10 million LR and 6 MR million stars



gaia-eso.eu

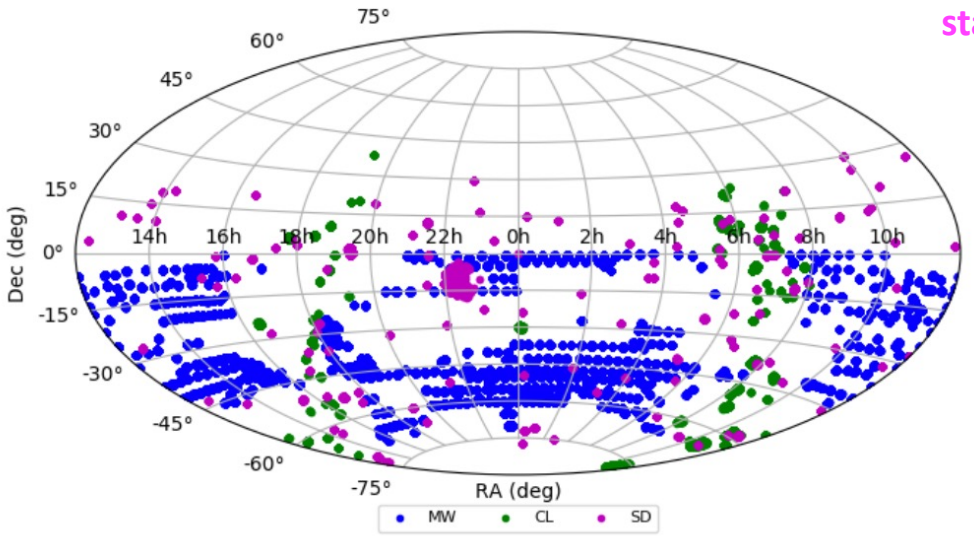
Log in

Search

Gaia-ESO Survey

Home | Consortium | Science | Observations | Data reduction | Products | News | Events | Publications

clusters
field MW
standard



reduced & stacked spectra
(final catalog due soon)

Latest news

Public data release 4

We are pleased to let you know that the Gaia-ESO data release 4 is now online. Read more

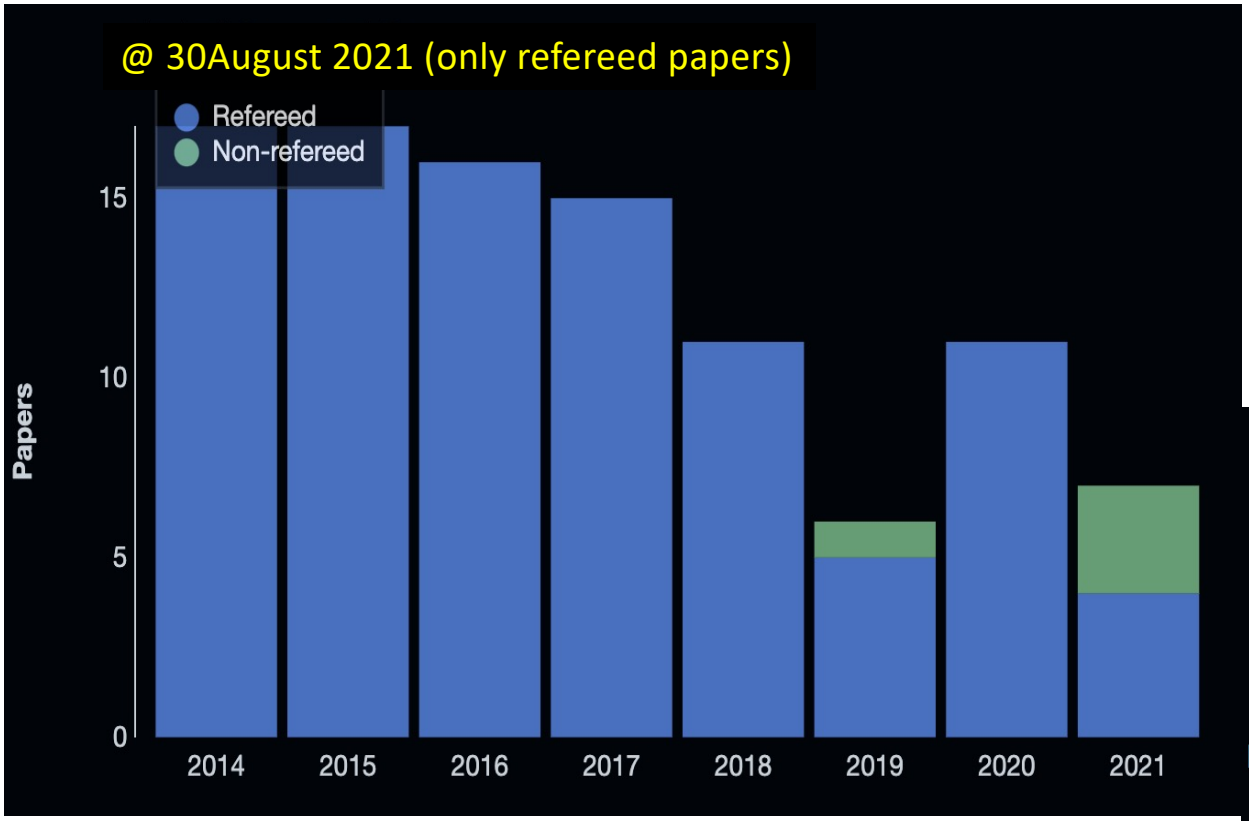
Read more news

Latest events

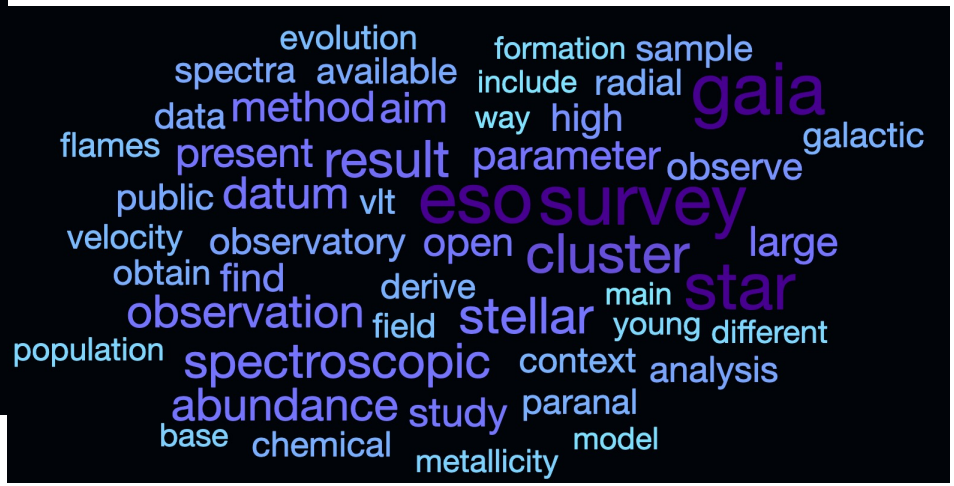
GES 2019: Gaia-ESO Survey All-Hands meeting

24 September, 2019 to 27 September, 2019, Firenze, Italy. Read more

More events



100 papers → Gaia-ESO in the title*
(only refereed papers + recent arXiv)
52 are on/rely on open clusters

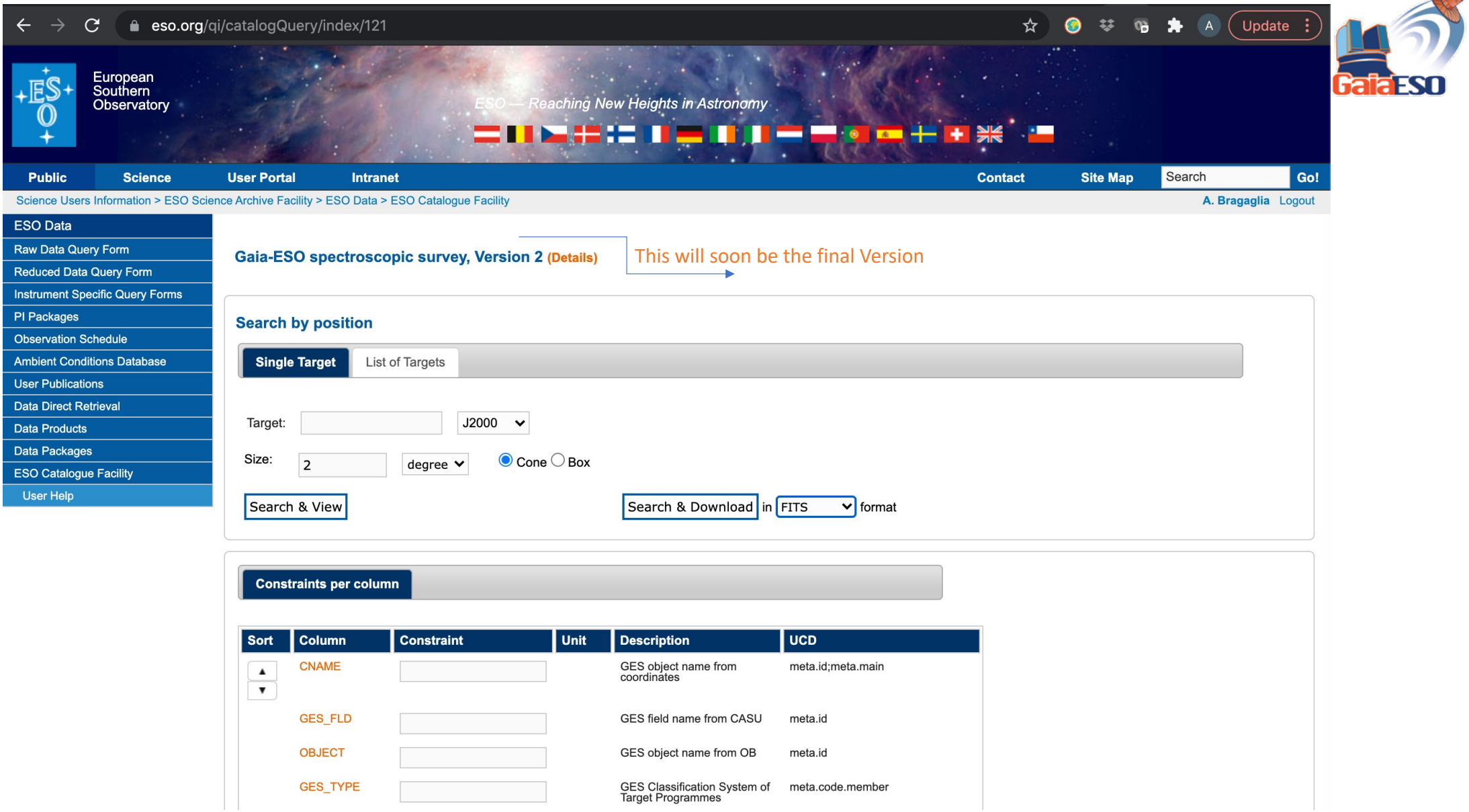


Gaia-ESO is a **public** survey so :

- Spectra (also fully reduced) are public through ESO archive (http://archive.eso.org/cms.html)
- Final catalog of RV, stellar parameters, abundances of 110000 stars is (will soon be) public at ESO website for catalogs (https://www.eso.org/qi/)

➔ **you can (and are welcome to) use spectra/catalog for your own science & publications**

*and ~50 more using Gaia-ESO data


eso.org/qi/catalogQuery/index/121
Update
European Southern Observatory
ESO — Reaching New Heights in Astronomy
Public
Science
User Portal
Intranet
Contact
Site Map
Search
Go!
Science Users Information > ESO Science Archive Facility > ESO Data > ESO Catalogue Facility
A. Bragaglia
Logout
ESO Data
Raw Data Query Form
Reduced Data Query Form
Instrument Specific Query Forms
PI Packages
Observation Schedule
Ambient Conditions Database
User Publications
Data Direct Retrieval
Data Products
Data Packages
ESO Catalogue Facility
User Help
Gaia-ESO spectroscopic survey, Version 2 (Details)
This will soon be the final Version
Search by position
Single Target
List of Targets
Target:
J2000
Size:
2
degree
Cone
Box
Search & View
Search & Download
in
FITS
format
Constraints per column
Sort
Column
Constraint
Unit
Description
UCD
CNAME
GES object name from coordinates
meta.id;meta.main
GES_FLD
GES field name from CASU
meta.id
OBJECT
GES object name from OB
meta.id
GES_TYPE
GES Classification System of Target Programmes
meta.code.member

- Instrument Specific Query Forms
- PI Packages
- Observation Schedule
- Ambient Conditions Database
- User Publications
- Data Direct Retrieval
- Data Products
- Data Packages
- ESO Catalogue Facility
- User Help

Query constraints

Input Target trumpler 20
Resolved into:
RA (J2000) 189.9 (12:39:45.120)
Dec (J2000) -60.7 (-60:38:06.00)
Cone size 2 degree

New Query | Modify Query

→ Trumpler 20 was observed in first Gaia-ESO runs + archive spectra were added

Query Results

582 records found (out of 25533) Download in FITS Format ☐ Only selected columns

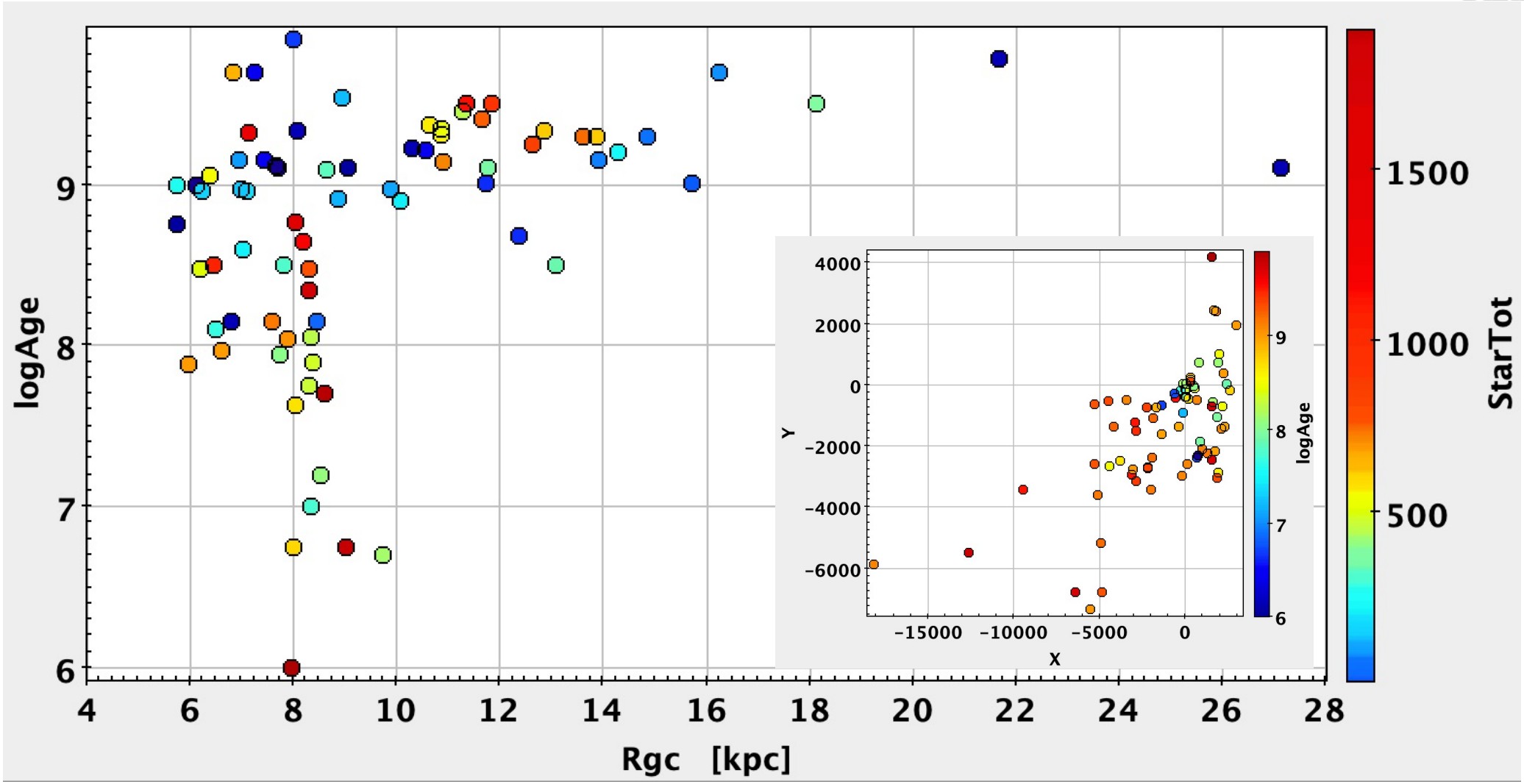
Elapsed time: 2.345 s

Results **1-10** of **582** Show 10 results per page Previous **1** 2 3 4 5 6 7 8 9 … 59 Next

Text boxes under columns select matching rows Apply Filter Clear Filter

CNAME	GES_FLD	OBJECT	GES_TYPE	SETUP	RA	DECLINATION	VRAD	E_VRAD	TEFF	E_TEFF	«	»
String	String	String	String	String	Number	Number	Number	Number	Number	Number		
12395448-6037128	Trumpler20	616	GE_CL	HR15N	189.97700	-60.62022	-41.0111	0.592317	6421.00	233.000		
12395806-6038445	Trumpler20	3279	AR_CL		189.99192	-60.64569	-19.7705	0.222350				
12395682-6031599	Trumpler20	6048	AR_CL		189.98675	-60.53331	-63.2498	0.118239				
12395021-6037168	Trumpler20	3946|621	AR_CL|GE_CL	HR15N	189.95933	-60.62133	2.42643	0.242213	6208.00	86.0000		
12392366-6041524	Trumpler20	3874	GE_CL	HR15N	189.84858	-60.69789	-22.0761	1.13316	6383.00	214.000		
12392629-6041204	Trumpler20	2180	AR_CL		189.85954	-60.68900	-46.0157	0.102399				
12393638-6035181	Trumpler20	5999	GE_CL	HR15N	189.90158	-60.58836	-39.2539	0.397890	5921.00	216.000		

- **62 Open Clusters extensively observed by Gaia-ESO** (+existing archive)
- **20+ directly retrieved from UVES-FLAMES archive**



Topics touched by Gaia-ESO papers on open clusters:

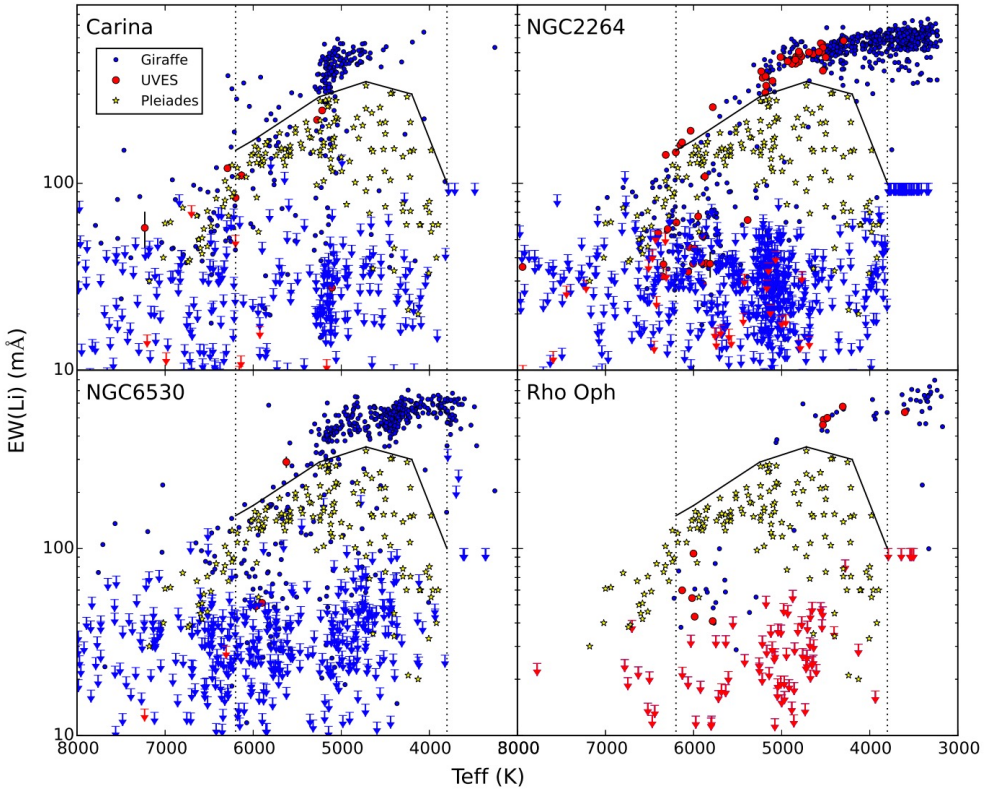
- **Properties of individual clusters and star forming regions (membership, metallicity, updated derivation of age & distance)**
- **Internal kinematics and substructures with high-precision radial velocities**
- **Pre-main sequence stars (empirical)**
- **Detailed chemical abundances and their variation with evolutionary phase (e.g. C, N, Li, Na, and others)**
- **Massive/young stars**
- **Characterisation of low-mass stars**
- **Connections rotation/chromospheric activity/accretion**
- **Distribution of metallicity and elements in the Milky Way (aka "gradient")**
- **Open clusters as calibrators (e.g. for stellar evolutionary models)**
- **Chemical clocks and their calibration and applicability (e.g. [C/N], [Y/Mg], Li)**

➔ **In general, stellar clusters are very good particle test / calibrators / validating sets as their stars share a common origin, age, initial chemical composition**

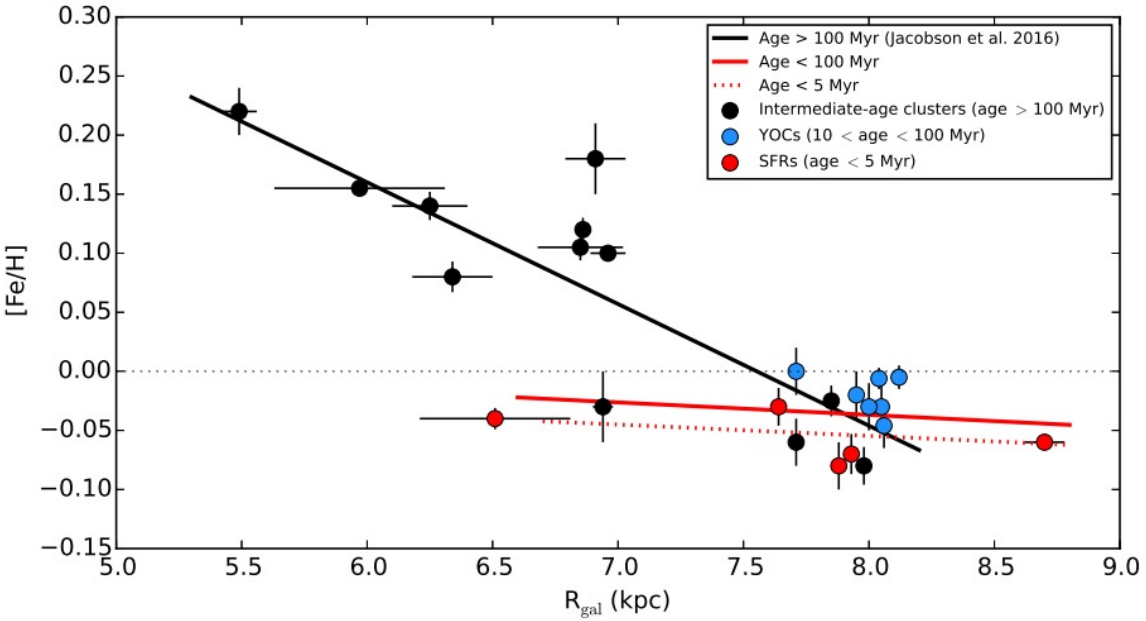
Note : Gaia-ESO observations were entirely conducted prevous to Gaia releases, but can be integrated in the "Gaia Universe", as was the original intention of this Gaia-precursor survey

The Gaia-ESO Survey: the present-day radial metallicity distribution of the Galactic disc probed by pre-main-sequence clusters

Spina+ 2017



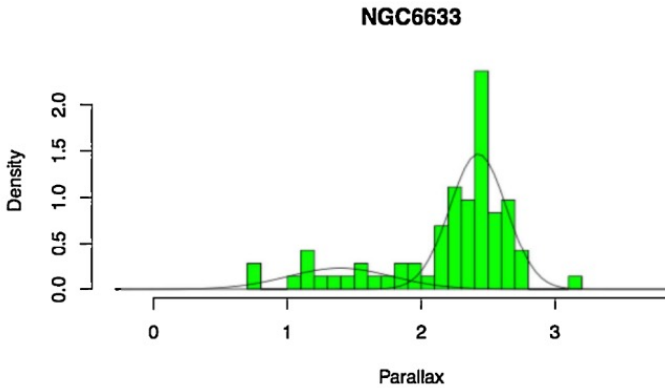
Cluster members: above the solid line



young (<100 Myr) intermediate & old (>100 Myr)

Younger clusters metal-poorer than older ones …
Chemical evolution in the disc ?
Analysis problems ? [e.g. Baratella+2020]

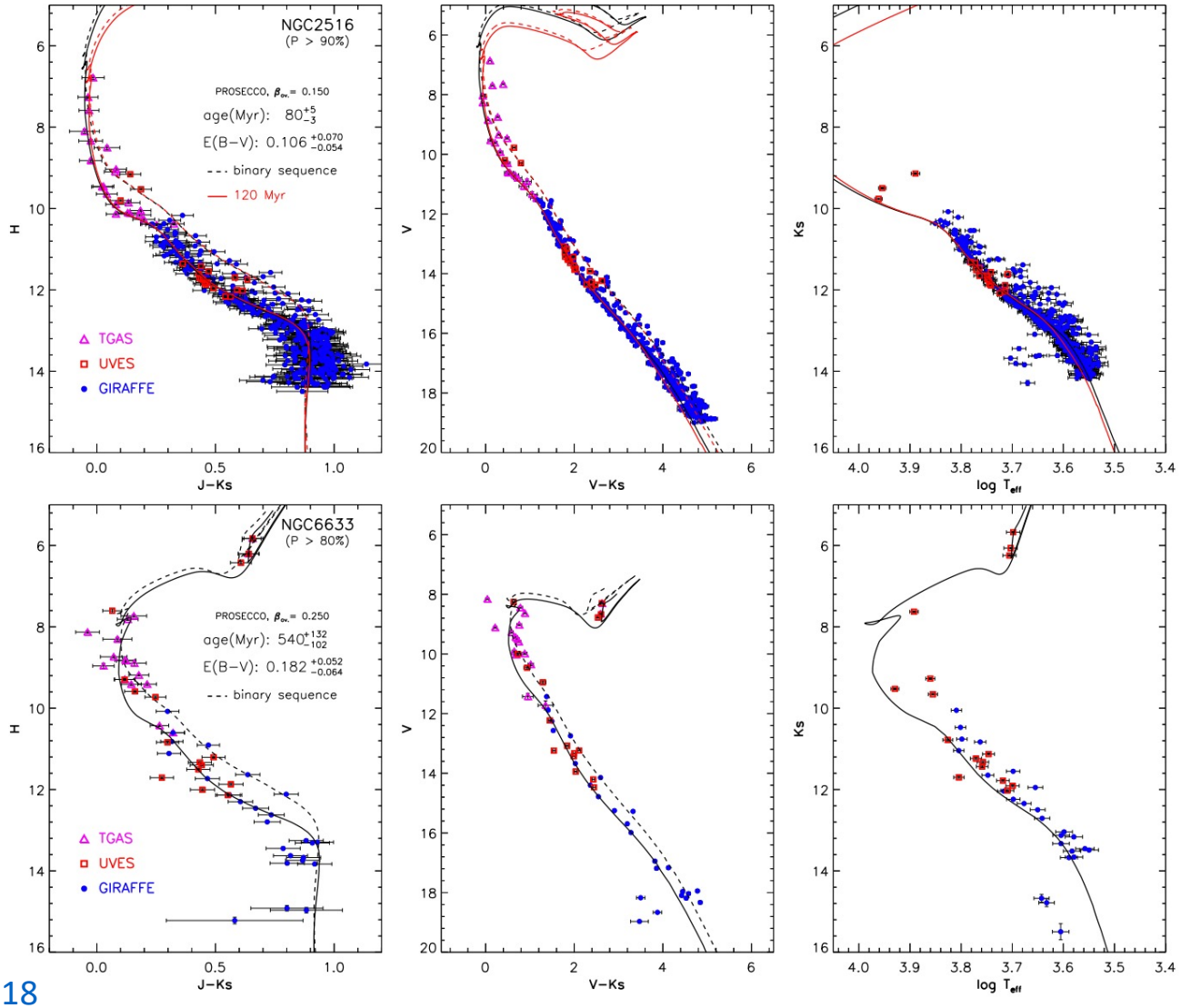
The Gaia-ESO Survey: open clusters in Gaia-DR1 . A way forward to stellar age calibration



"Demonstration" using GDR1

Gaia DR1: TGAS = Tycho-Gaia Astrometric Solution
~2.5 million stars, bright

Members:
Gaia (TGAS)
Gaia-ESO (UVES, GIRAFFE)
➔ Verify / calibrate stellar models with open clusters
➔ Ages (on same scale)

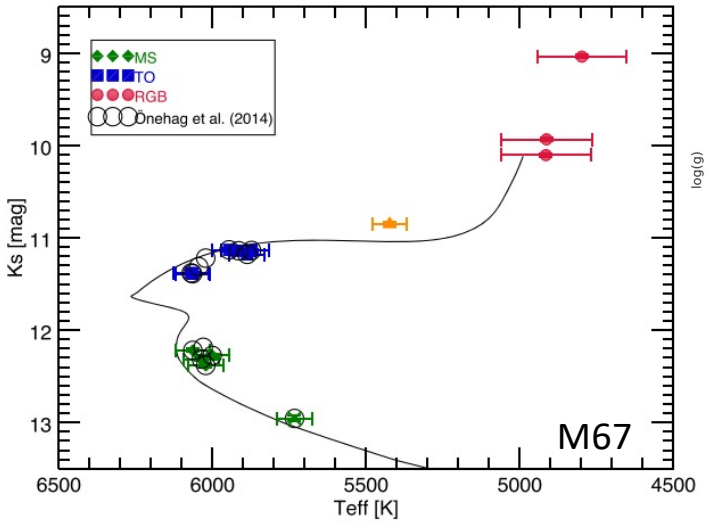


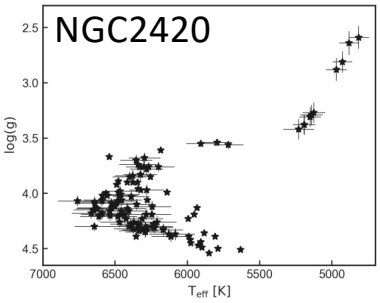
Two of the eight clusters

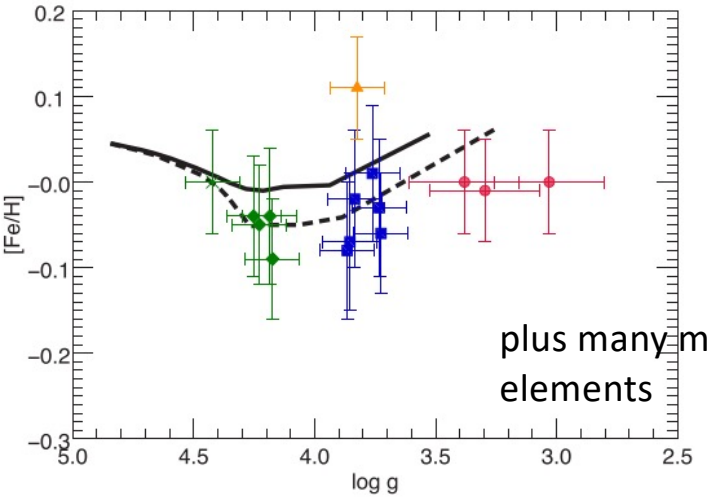
Pisa isochrones here, but also MIST, PARSEC tested

Randich+ 2018

The Gaia-ESO Survey: evidence of atomic diffusion in M67?



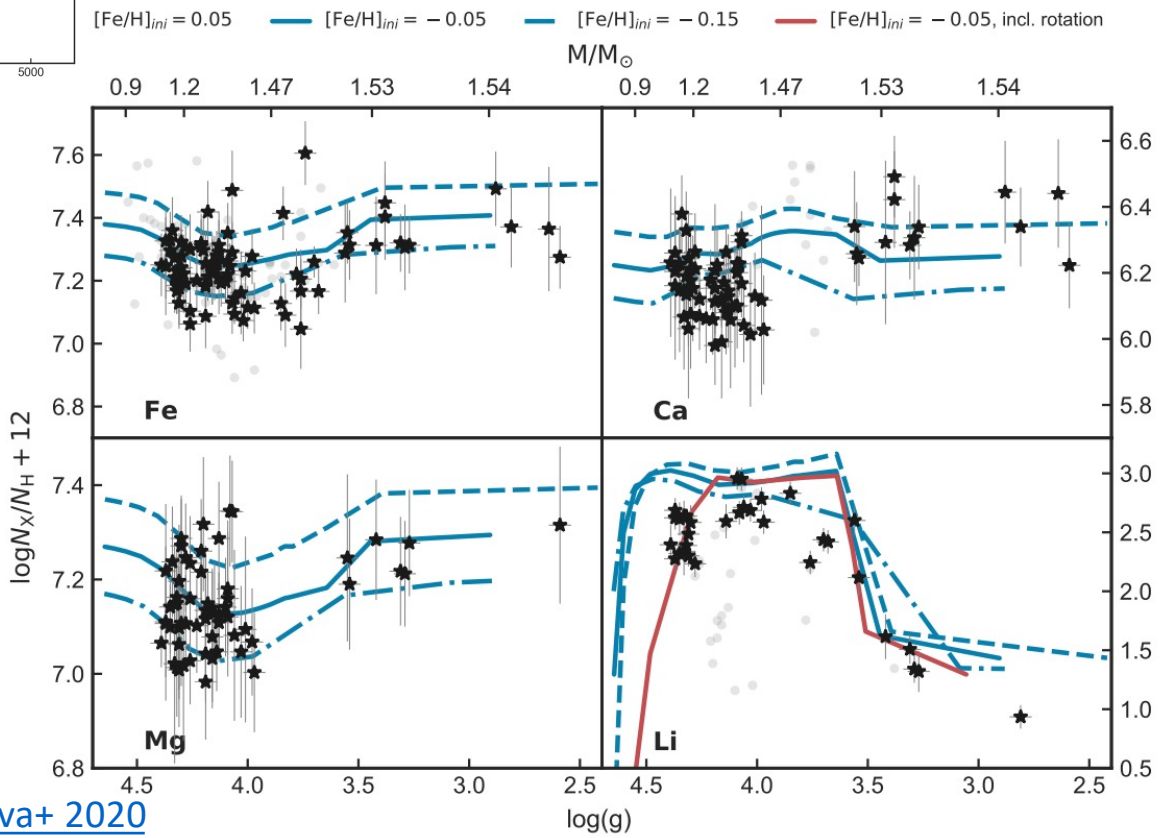




plus many more elements

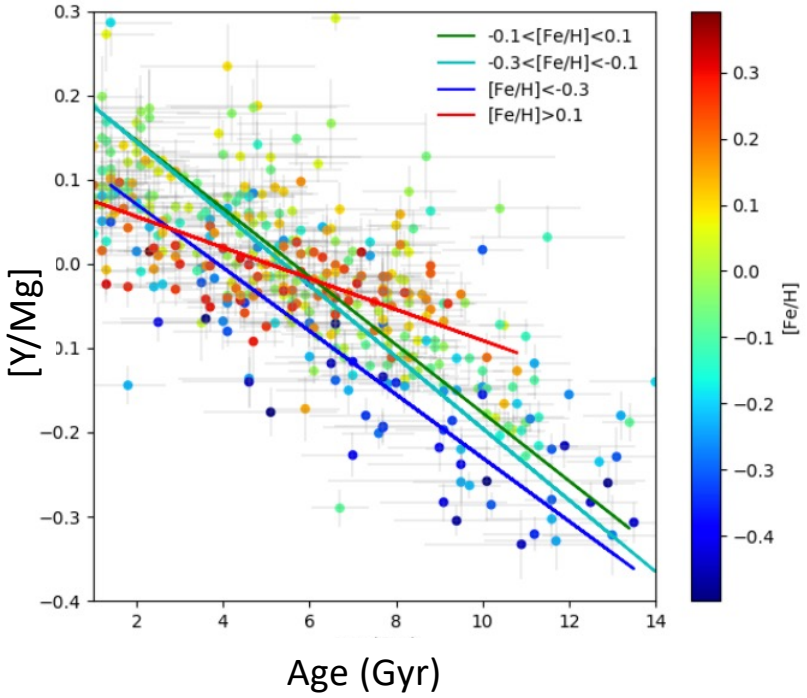
[Bertelli-Motta+ 2018]

The Gaia-ESO survey: 3D NLTE abundances in the open cluster NGC 2420 suggest atomic diffusion and turbulent mixing are at the origin of chemical abundance variations

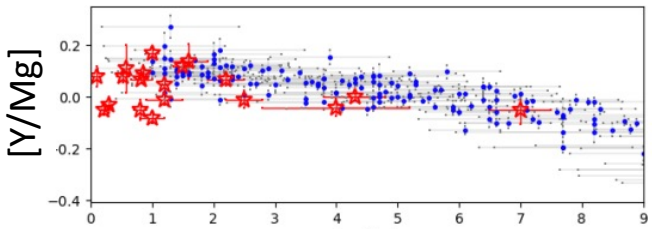


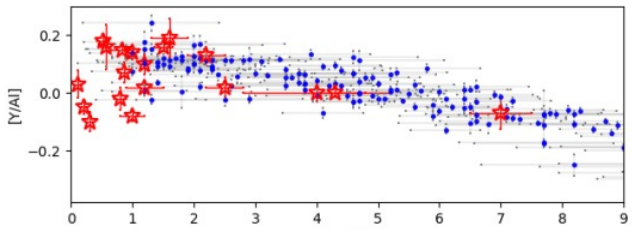
[Semenova+ 2020]

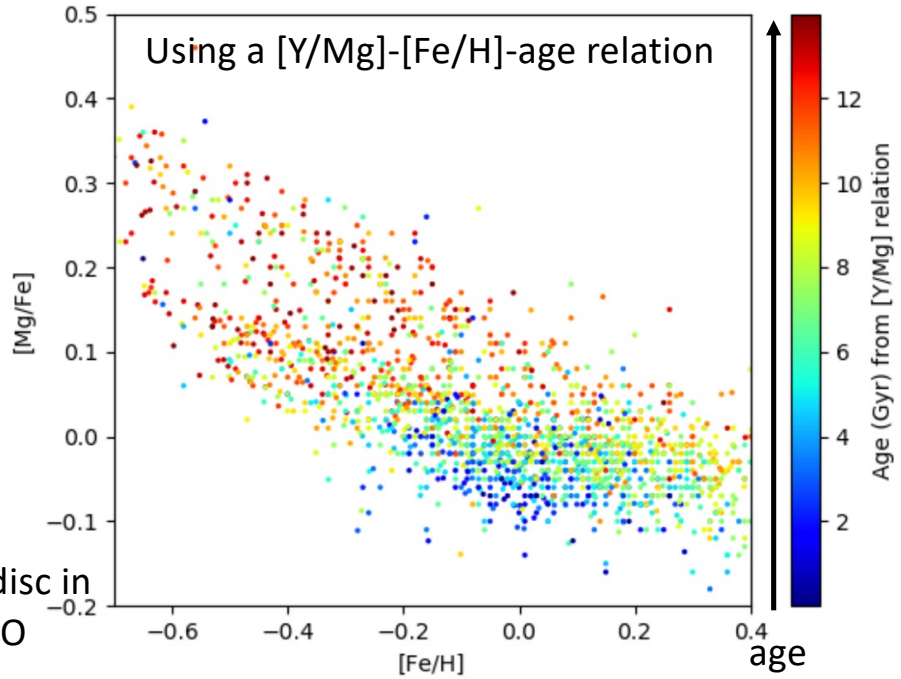
The Gaia-ESO survey: the non-universality of the age-chemical-clocks-metallicity relations in the Galactic disc



Field stars Open clusters







α-elements released on short scale (massive stars)

neutron-capture elements on long scale (intermediate/low mass)

➔ their ratio is function of age (empirical relation) : *known*

➔ but also of metallicity (i.e. star formation history) : *new here*

Age of stars in high-**α** and low-**α** disc in solar vicinity observed by Gaia-ESO

Casali+ 2020

APOGEE is part of the Sloan Digital Sky Survey

(*Apache Point Observatory Galaxy Evolution Experiment*)

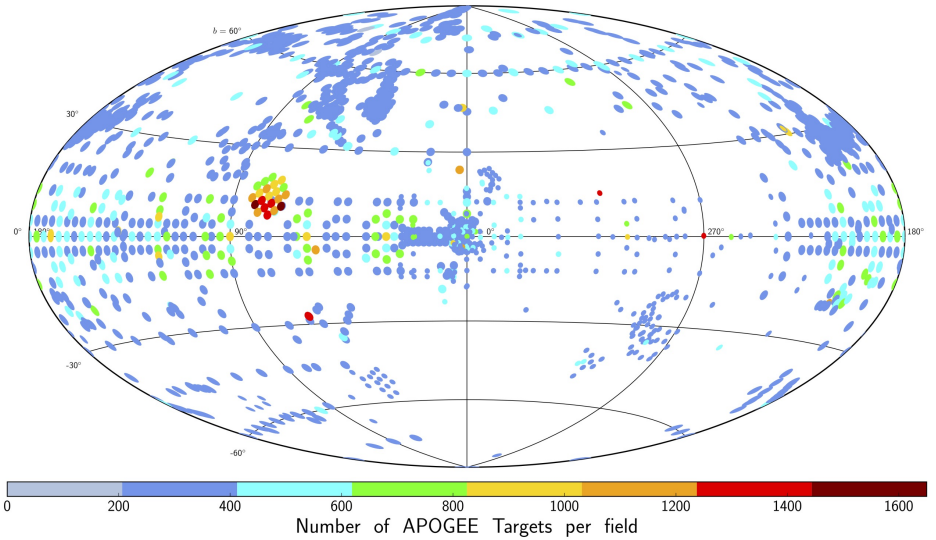
sdss.org/dr16

SDSS

This is Data Release 16.

Data Surveys Instruments

Datasets Imaging Data Optical Spectra APOGEE IR Spectra MaStar Library I



Data Release 16

(DR17 public in Dec 2021)

Data Release 16 (DR16) is the fourth data release of the fourth phase of t
Digital Sky Survey (SDSS-IV). DR16 contains SDSS observations through August 2018.

DR16 includes the following:

- ☆ The latest and final data release of optical spectra from the SDSS component extended Baryon Oscillation Spectroscopic Survey (eBOSS), including the spectra of the SPectroscopic IDentfication of ERosita Sources (SPIDERS) survey and Time Domain Spectroscopic Survey (TDSS).
- ☆ The latest infrared spectra of the SDSS component Apache Point Observatory Galaxy Evolution Experiment 2 (APOGEE-2), including the first public release of spectra taken at Las Campanas Observatory (APOGEE-2 South) as well as newly improved data tutorials

Data Access

What's New in DR16

Scope of DR16

Value Added Catalogs

sdss.org/dr16

Accessing the Data

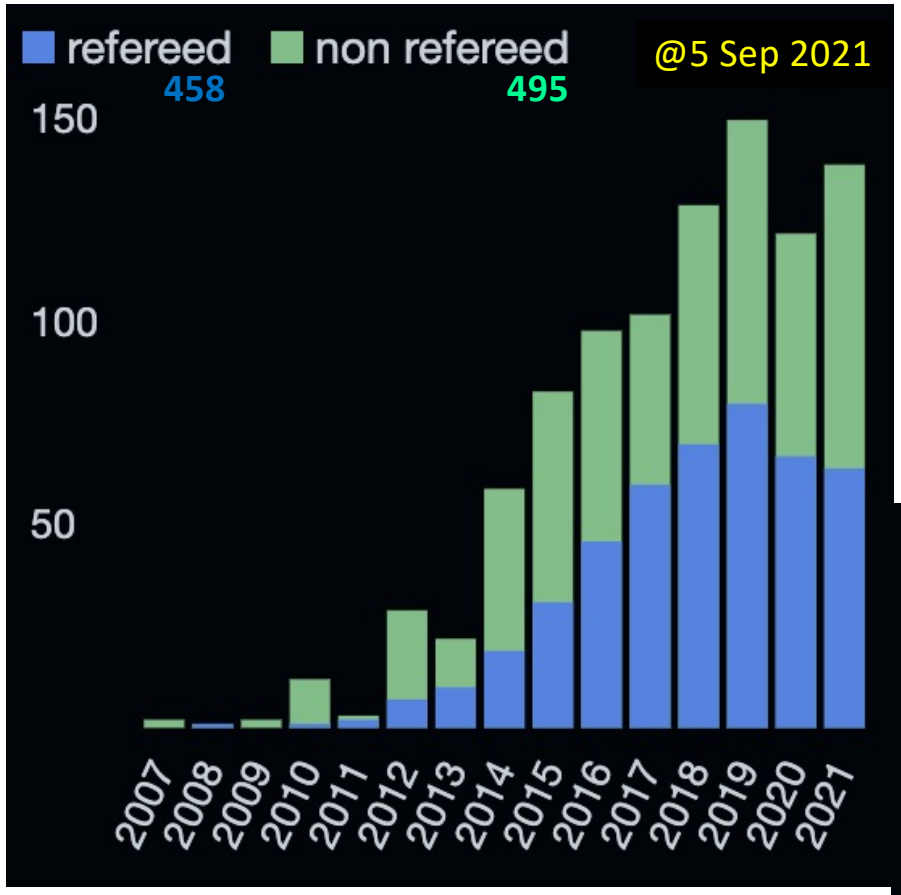
Data Release 16 includes six types of data: **images**, **optical spectra** (SDSS/SEGUE/BOSS/SEQUELS/eBOSS), **infrared spectra** (APOGEE/APOGEE-2), **IFU spectra** (MaNGA), **stellar library spectra** (MaStar), and **catalog data** (parameters measured from images and spectra, such as magnitudes and redshifts).

The SDSS offers several different online data access tools, each suited to a particular need:

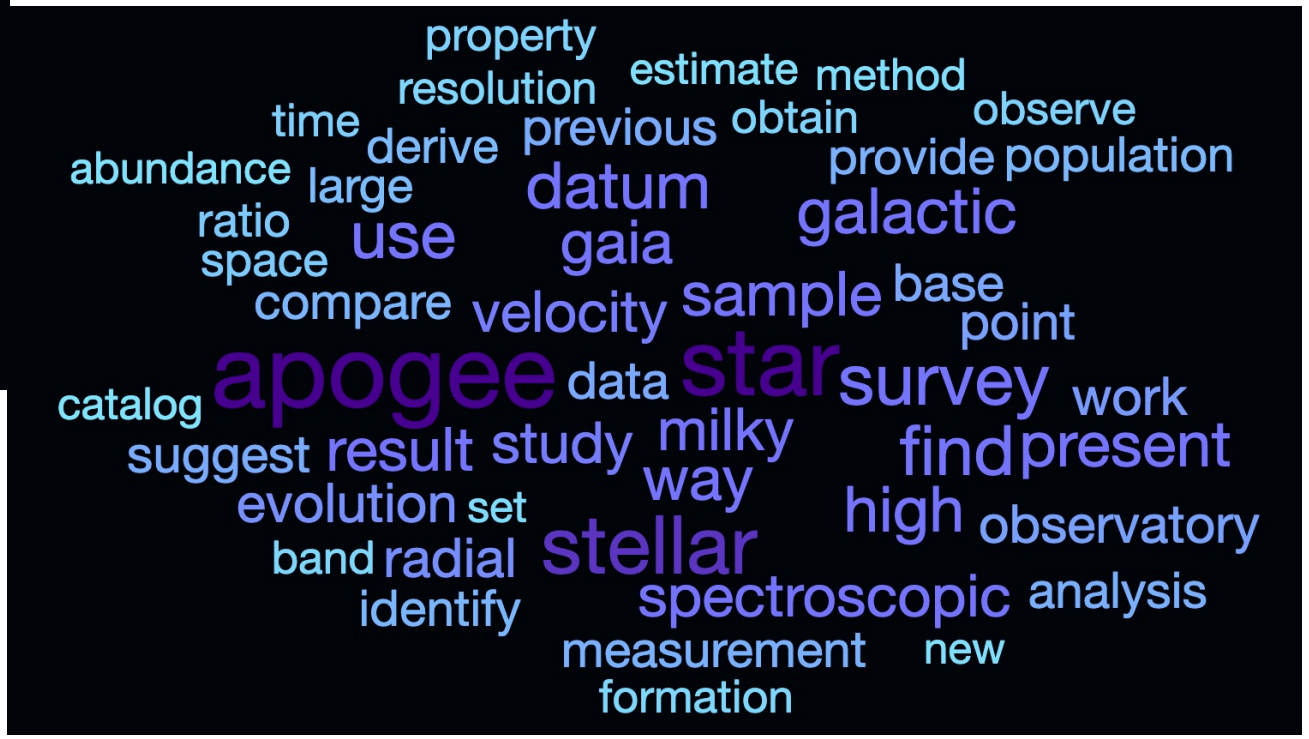
Website	Purpose
DR16 Science Archive Server	Interactive spectra and image mosaics
Marvin	Visualisation and analysis tool for MaNGA data cubes and maps
DR16 SkyServer	Browser-based access to the Catalog Archive Server (CAS) database, with resources for learning SQL and projects to teach science
CasJobs	Flexible advanced SQL-based interface to the CAS, for all data releases (quick registration required). To select data from DR16, choose **DR16** as the query context.
DR16 FITS	Direct download access to DR16 FITS data files for experts
Data Model	Details of the Science Archive Server (SAS) directory structure, file formats, and the contents of each file

Index of /sas/dr16/apogee/spectro/aspcap/r12/l33/

File Name ↓	File Size ↓
Parent directory/	-
allCal/	-
allStar-r12-l33/	-
apo1m/	-
apo25m/	-
cal/	-
config/	-
html/	-
lco25m/	-
allCal-r12-l33.fits	358695360
allCal-r12-l33.html	4667
allPlates-r12-l33.fits	1463040
allStar-r12-l33.fits	3229427520
allStar-r12-l33.html	6503
allStarLite-r12-l33.fits	987831360
allVisit-r12-l33.fits	1720120320
spectro_aspcap_r12_l33.sha1sum	446

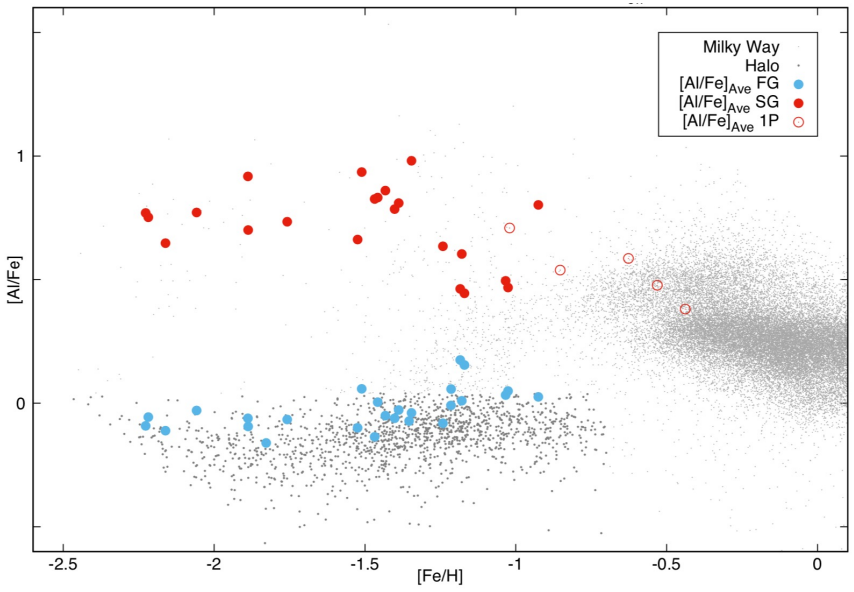


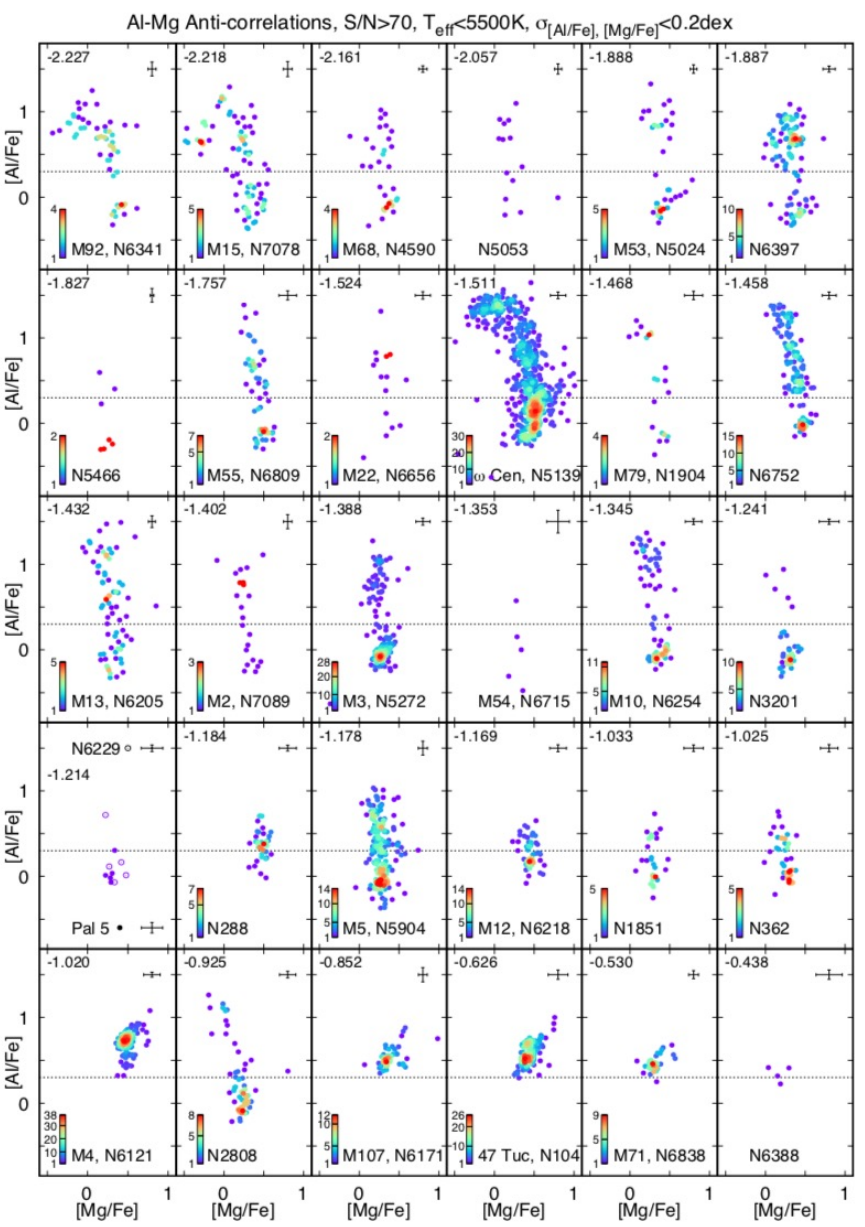
Papers with “APOGEE” in abstract



Homogeneous analysis of globular clusters from the APOGEE survey with the BACCHUS code – II. The Southern clusters and overview

- ~2300 stars in 31 GCs (of the 40+ observed)*
- Fe, C, N, O, Mg, Al, Si, K, Ca, Ce, and Nd
- Intrinsic Fe spread; shape and statistics of **Al-Mg** and **N-C anti-correlations** as a function of cluster mass, luminosity, age, and metallicity
- No metallicity spread in M22, NGC1851 (at odds with previous works)
- Al enrichment ∝ GC mass





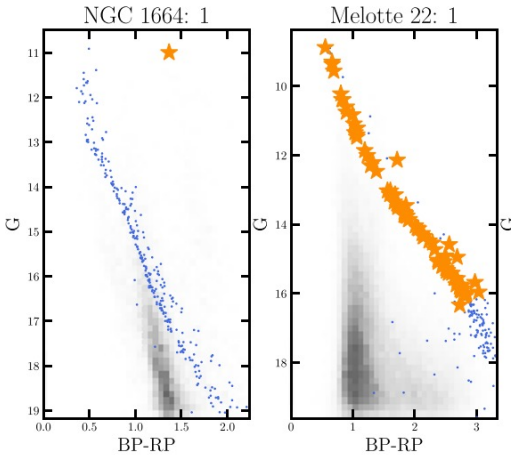
**Carretta & Co have a sample of same size in optical, using FLAMES@VLT*

See also GCs in Gaia-ESO

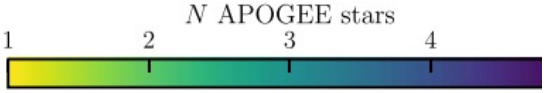
Plus more…

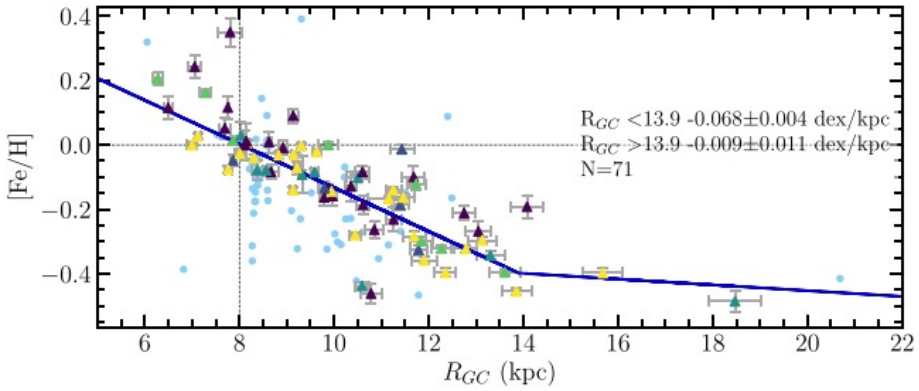
Mészáros+ 2020

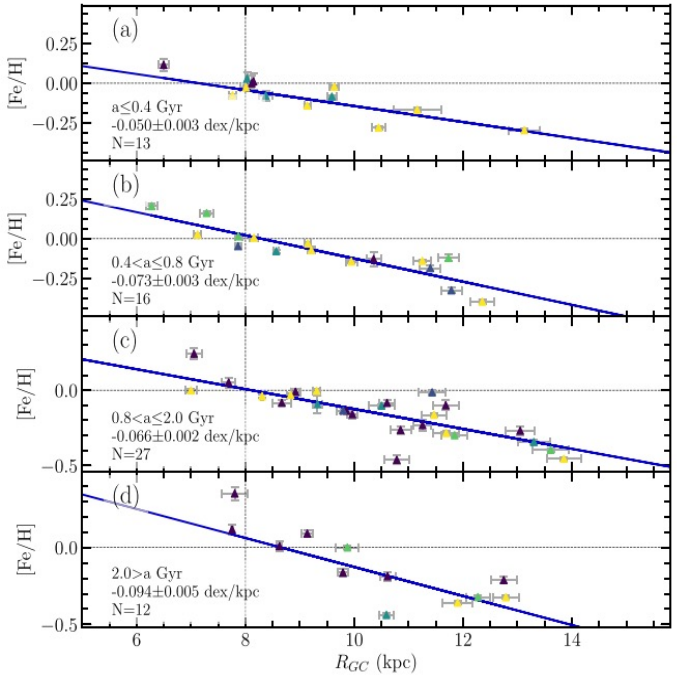
The Open Cluster Chemical Abundances and Mapping Survey. IV. Abundances for 128 Open Clusters Using SDSS/APOGEE DR16 Donor+ 2020



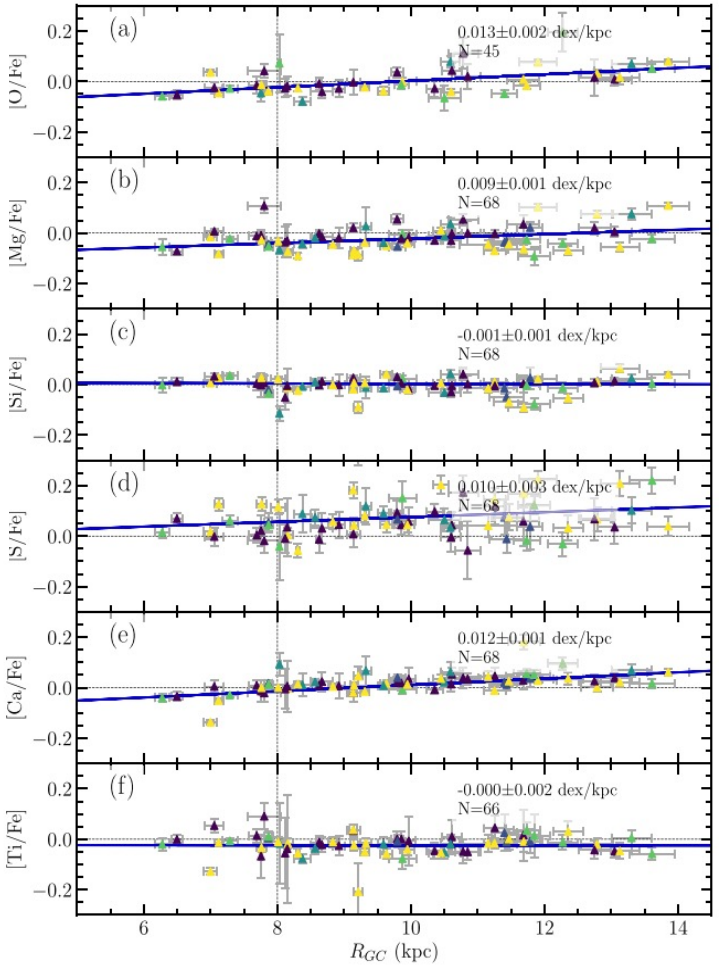
Nr stars: 1 (for half of the sample) to 83, average 7 stars (s.d. 13)







- Gradient in metallicity radial (Rgc) and height (z)
- Separation in age and height bins
- Gradient for 16 elements



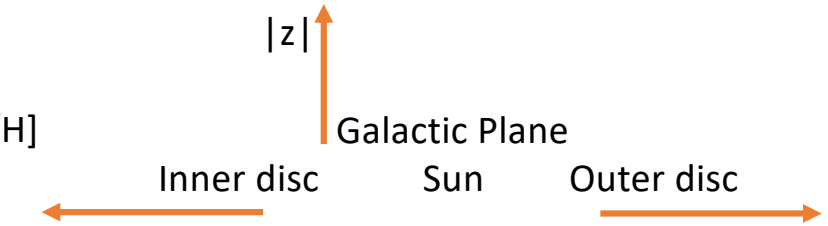
Chemical Cartography with APOGEE: Metallicity Distribution Functions and the Chemical Structure of the Milky Way Disk

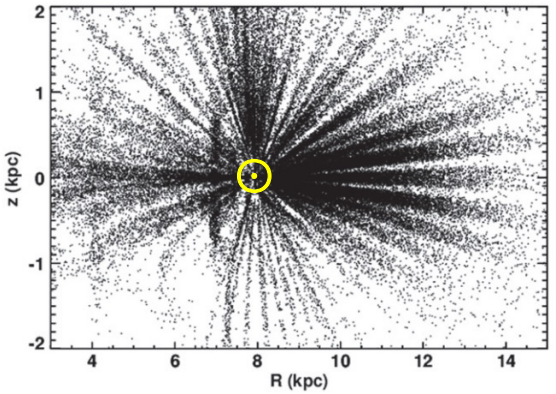
Hayden+ 2015

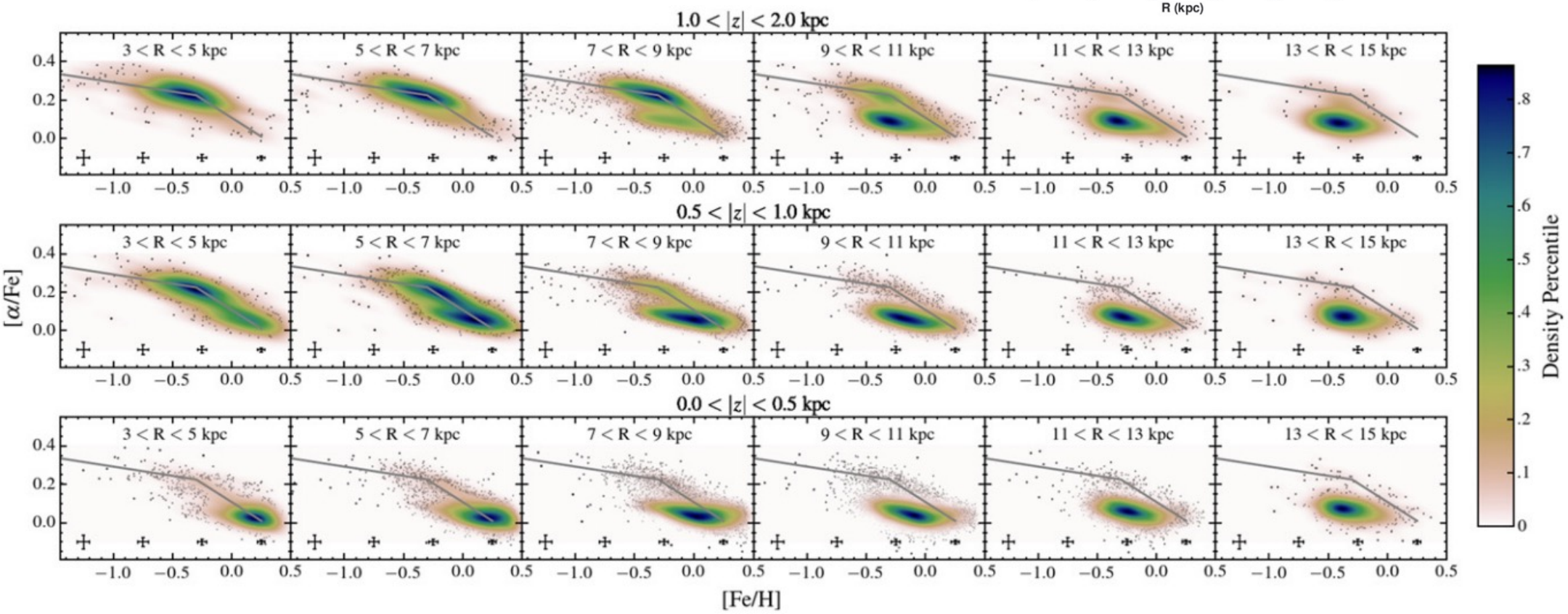
70k stars, DR12

Rgc=3-15 kpc, |z|<2 kpc

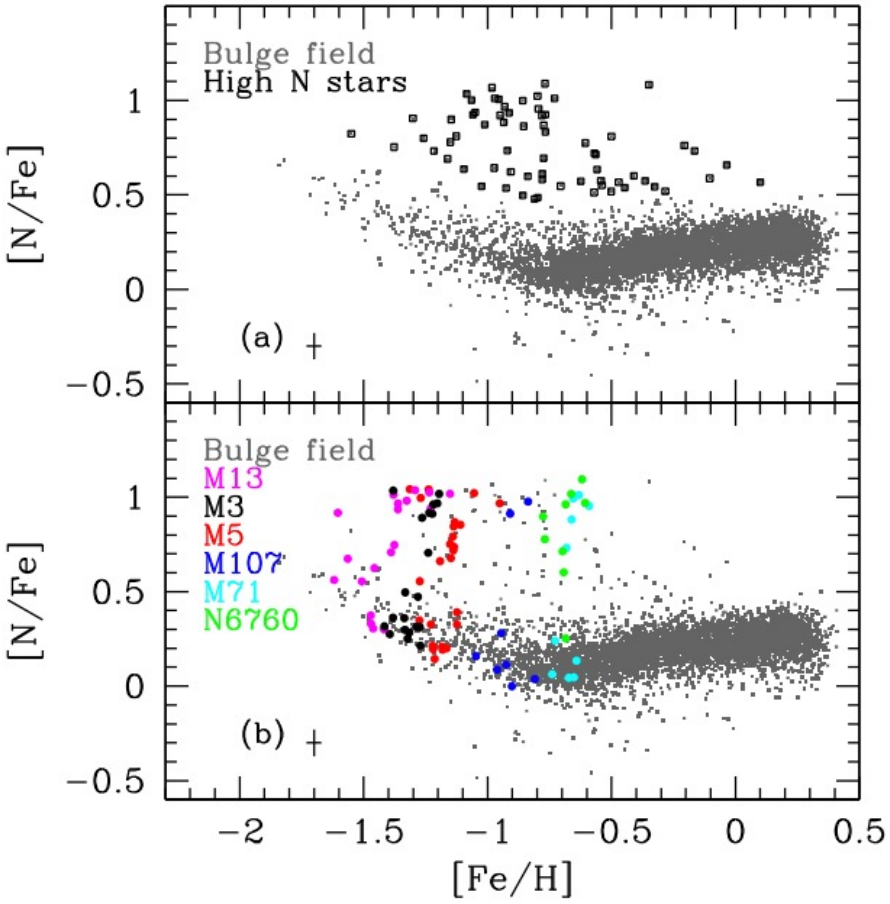
→ Different [α/Fe] vs [Fe/H] sequences with Rgc

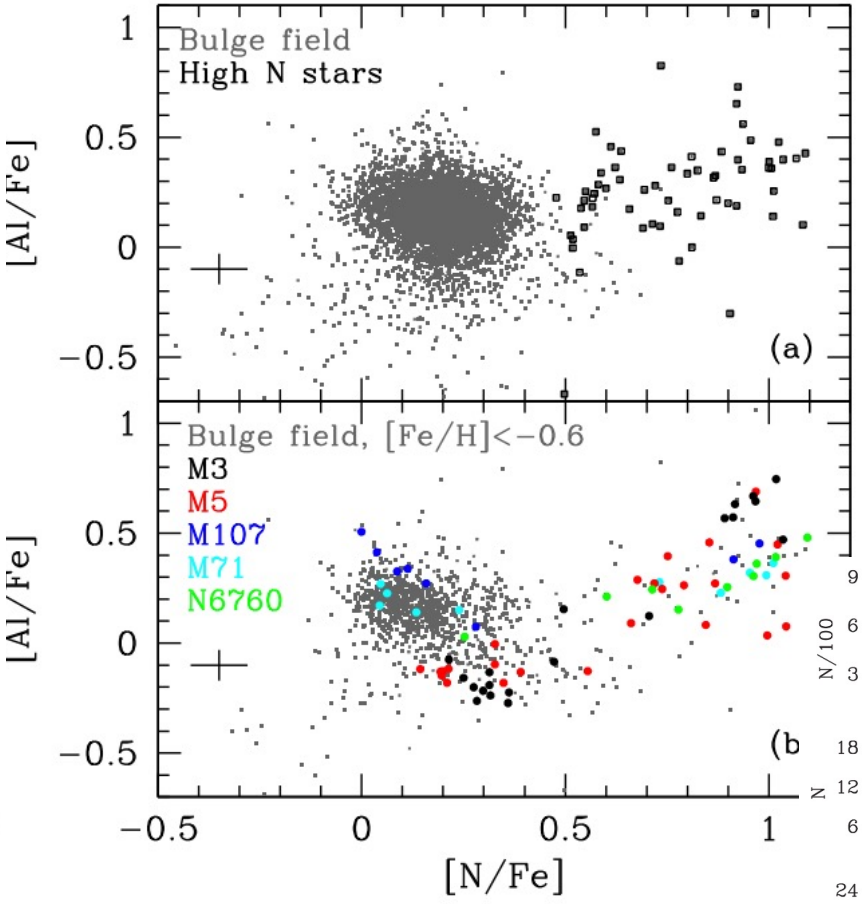


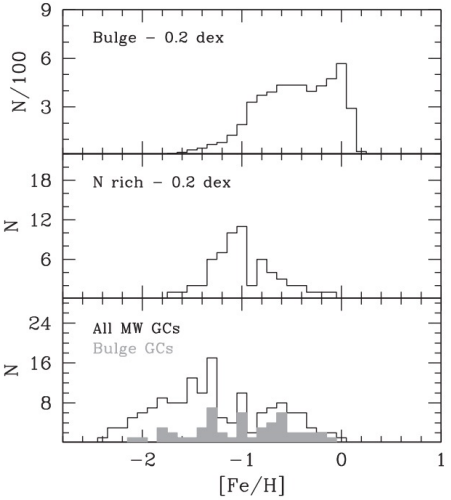




Chemical tagging with APOGEE: discovery of a large population of N-rich stars in the inner Galaxy







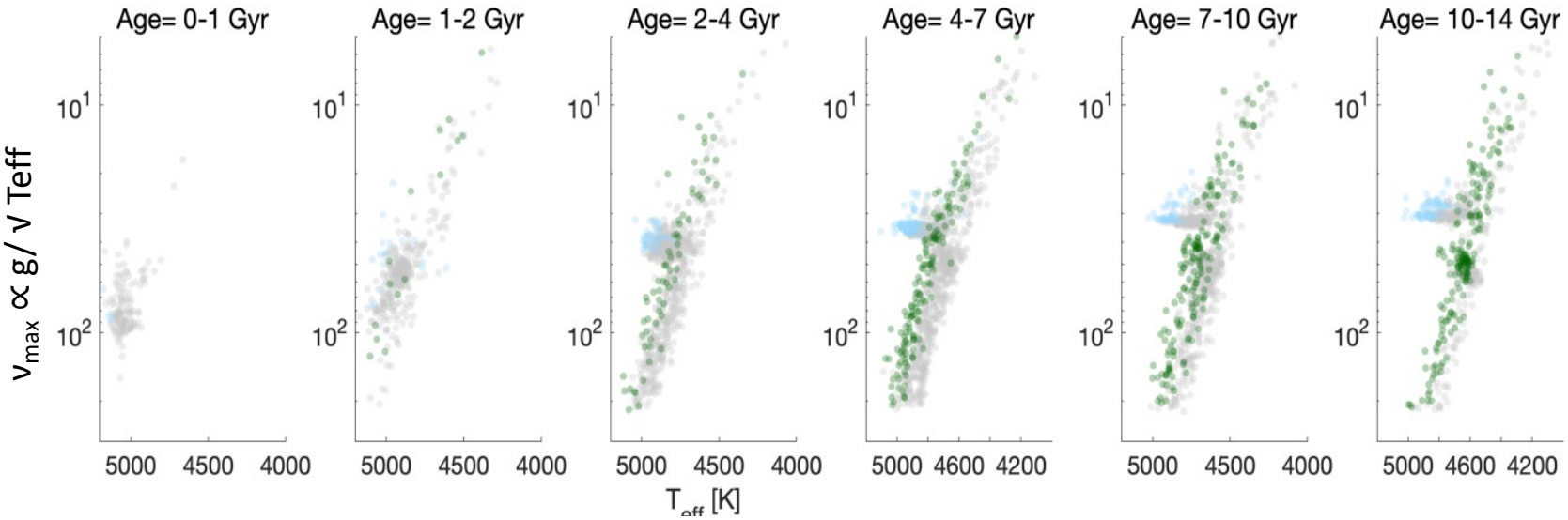
N-rich (& Al-rich, C-poor) stars = second generation stars in GCs ? Too many…

Schiavon+ 2017

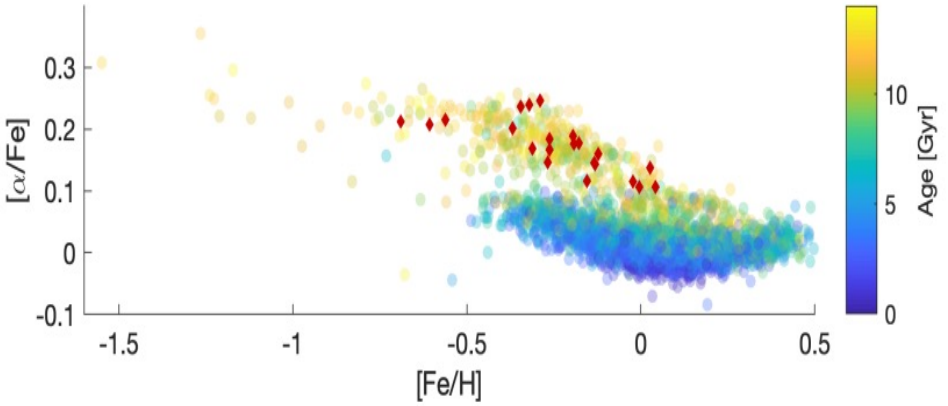
Age dissection of the Milky Way discs: Red giants in the Kepler field

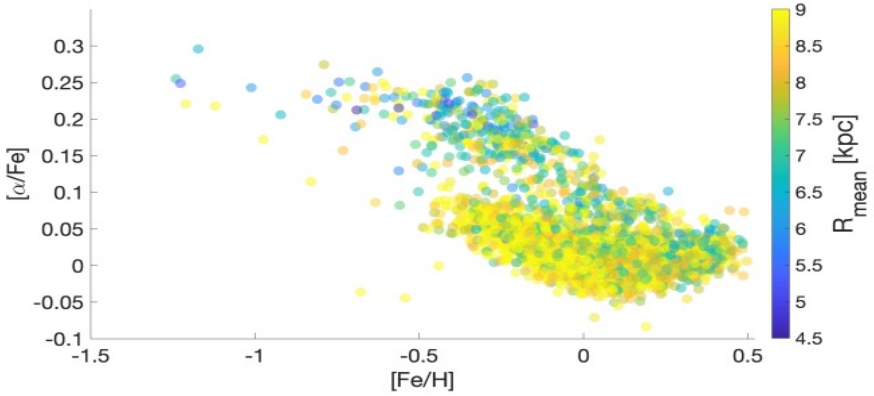
Miglio+ 2021

Solar-like oscillating giants: **APOGEE** Teff, [Fe/H], [α/M] + ***Kepler*** ν_{max} , Δν + RV + **Gaia** + evolutionary models
➔ mass ➔ age

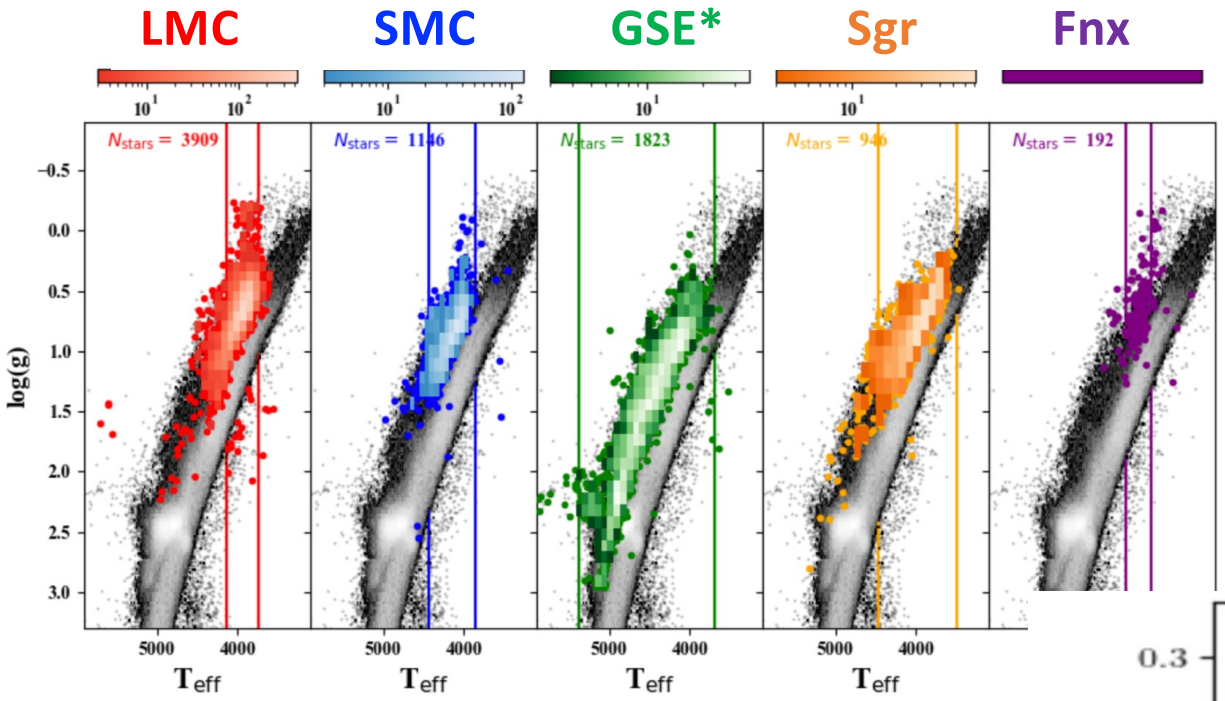


-0.5 ≤[Fe/H]≤-0.2 RGB / RC
-0.15 ≤[Fe/H]≤+0.2 RGB / RC
➔ Young metal-poor stars are rare

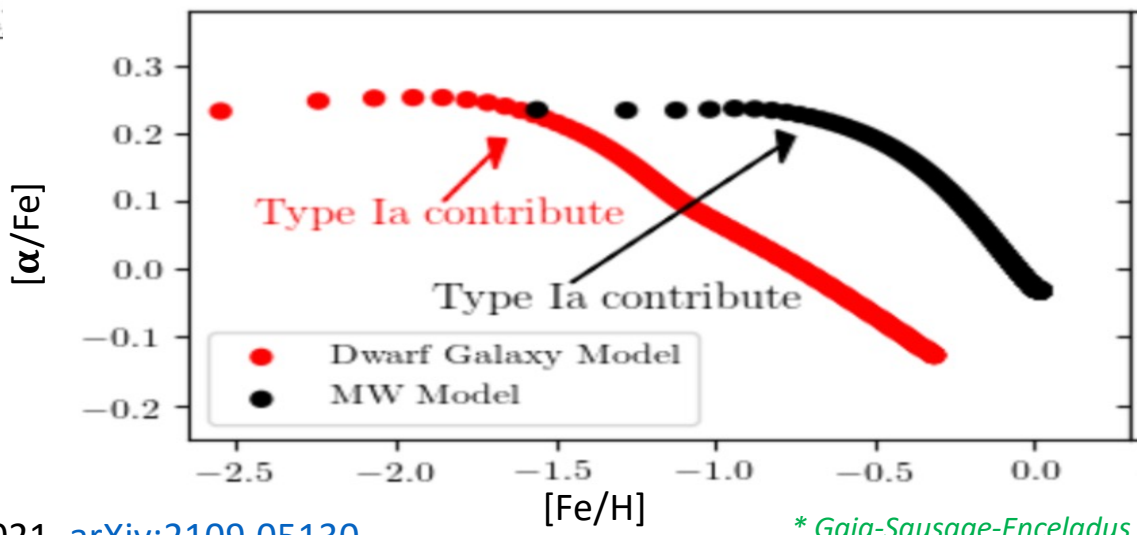




Abundance pattern of MW satellites



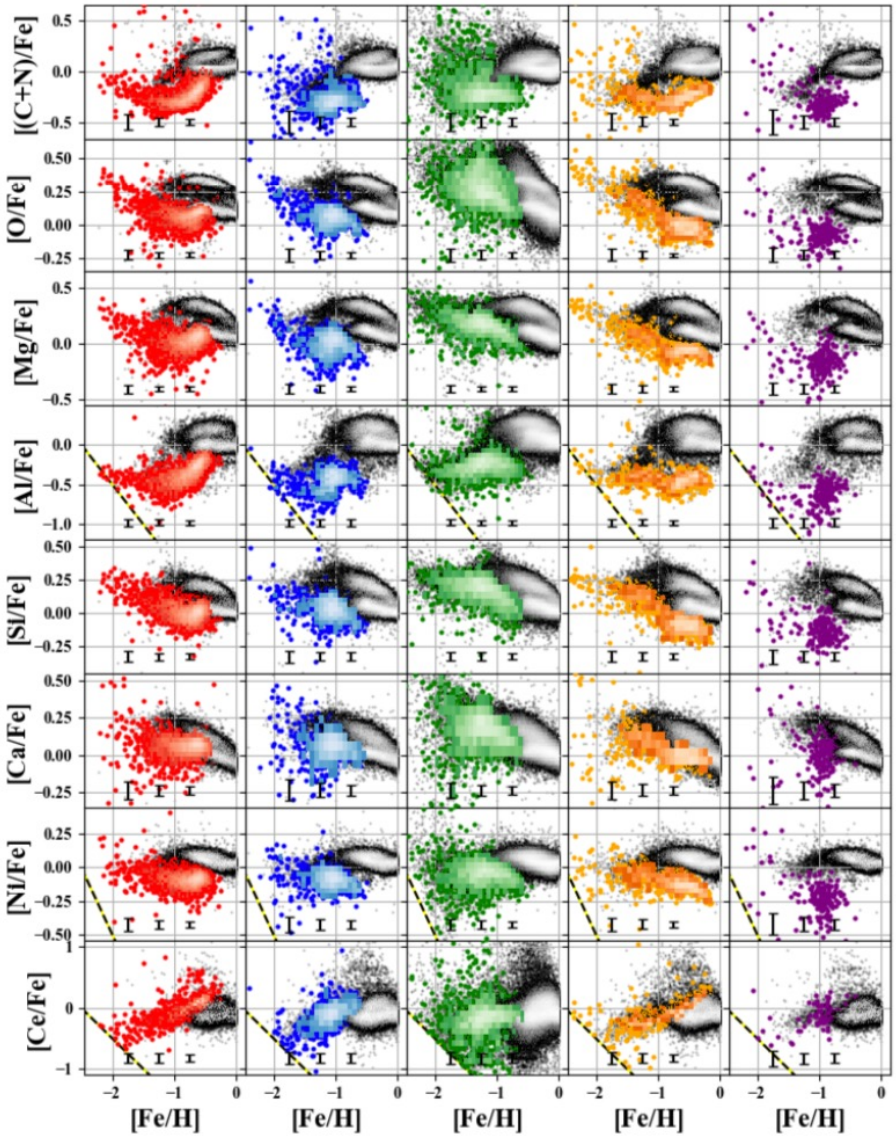
From **APOGEE DR17** (internal release):
-relative abundance trends of multiple elements
(C, N, O, Mg, Al, Si, Ca, Fe, Ni, and Ce)
-fitting chemical evolution models to the [α/Fe]-[Fe/H]
abundance plane for each galaxy

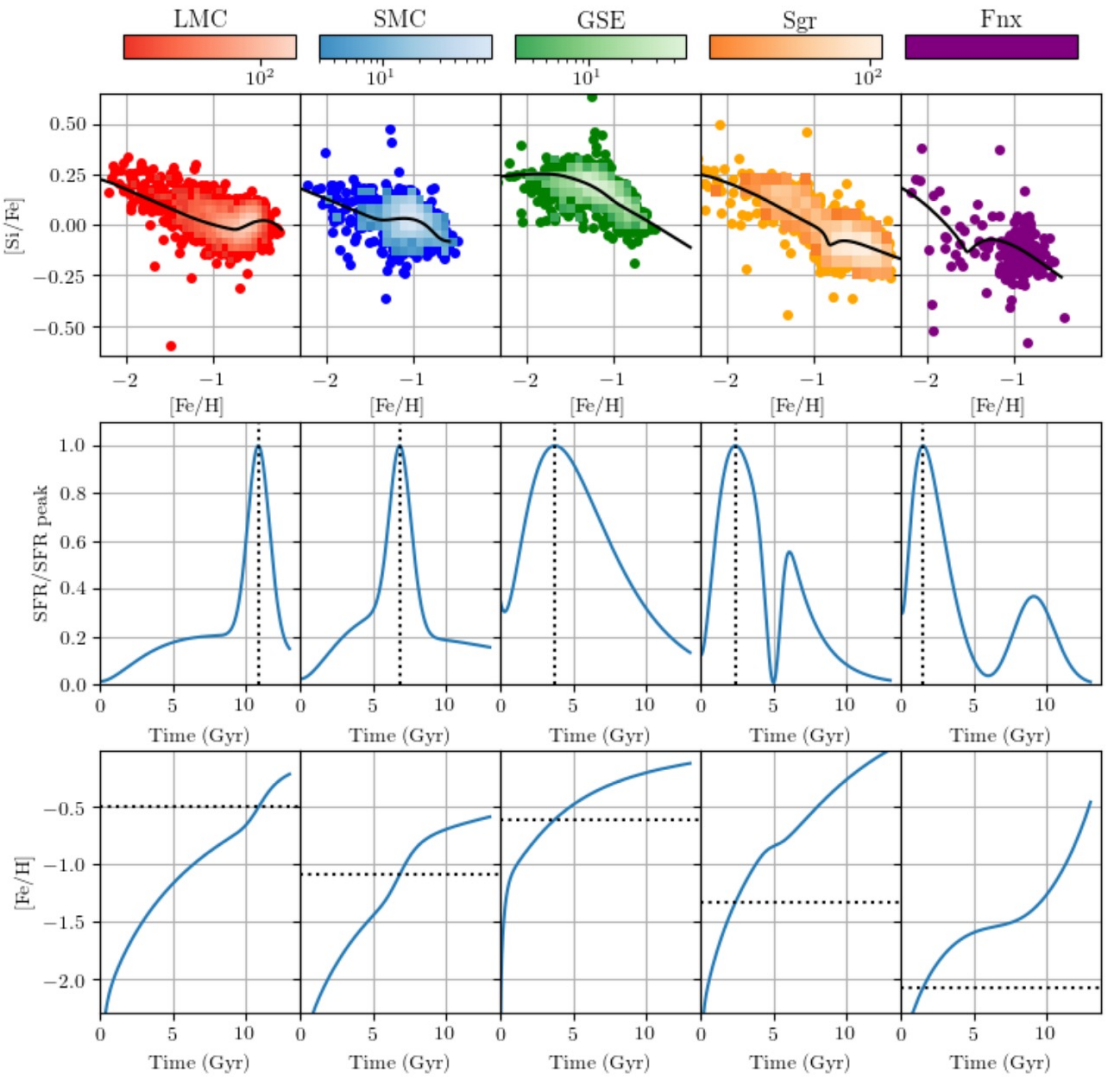


Hasselquist+2021, arXiv:2109.05130

** Gaia-Sausage-Enceladus*

Abundance pattern of MW satellites: LMC SMC GSE* Sgr Fnx





[Si/Fe] *vs* [Fe/H]

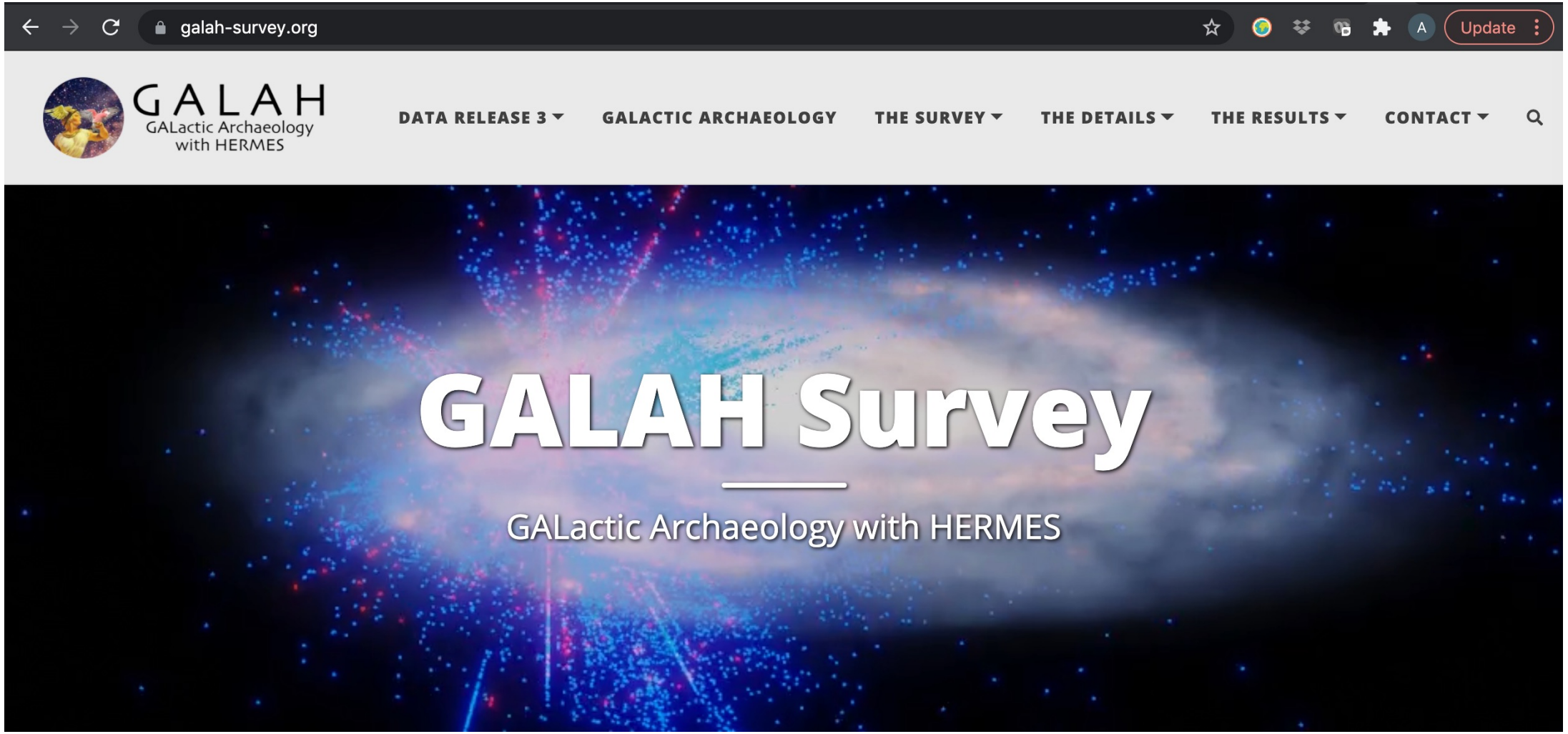
SFH

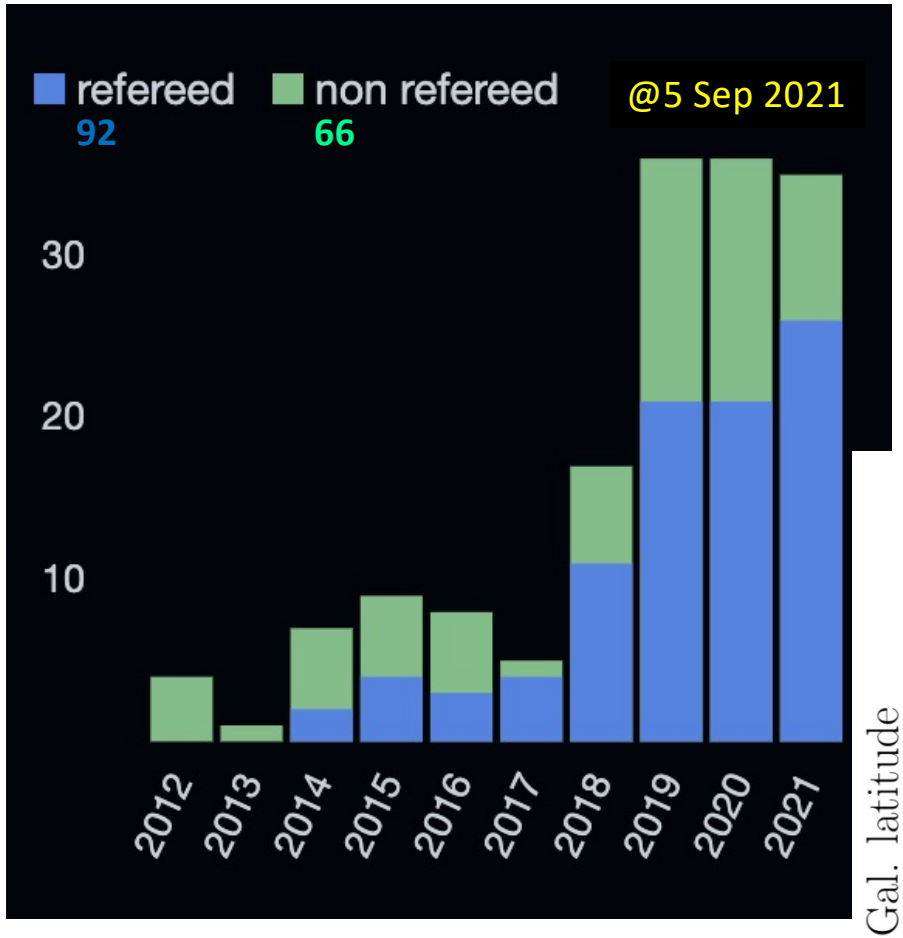
[Fe/H] time evolut.

Hasselquist+2021, arXiv:2109.05130

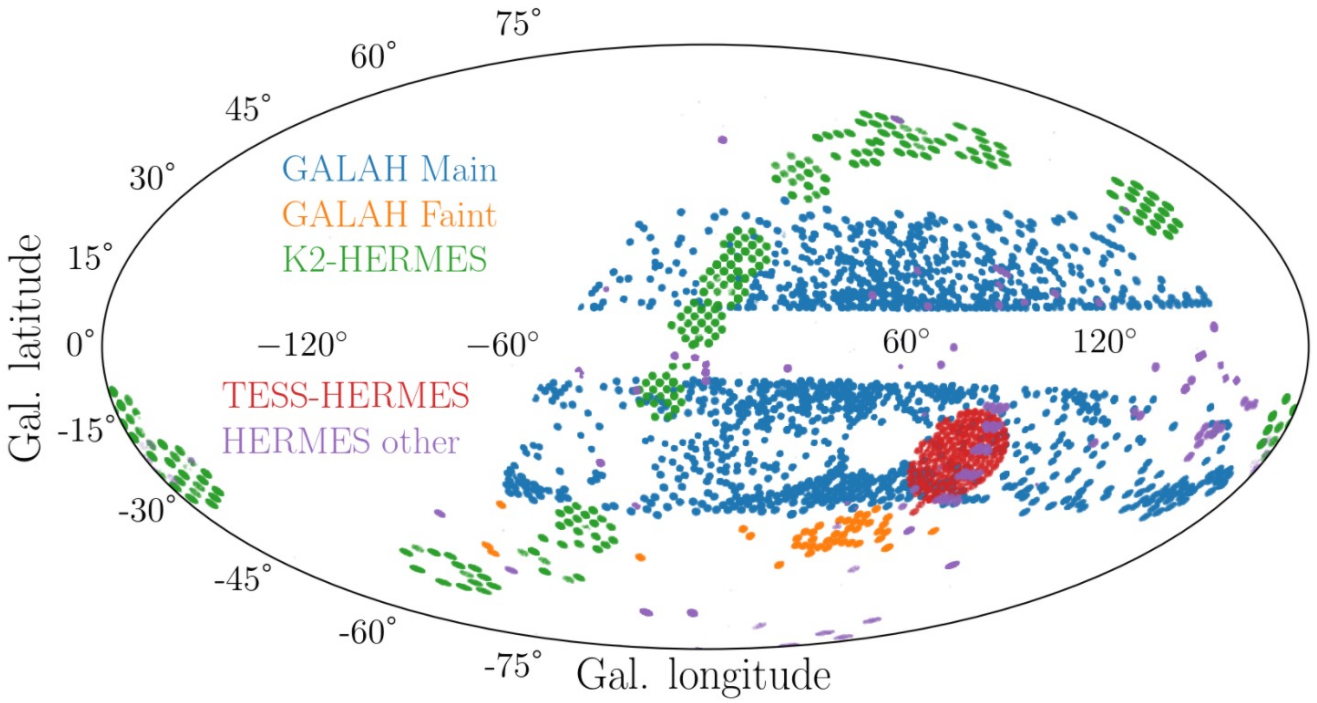
** Gaia-Sausage-Enceladus*

GALAH

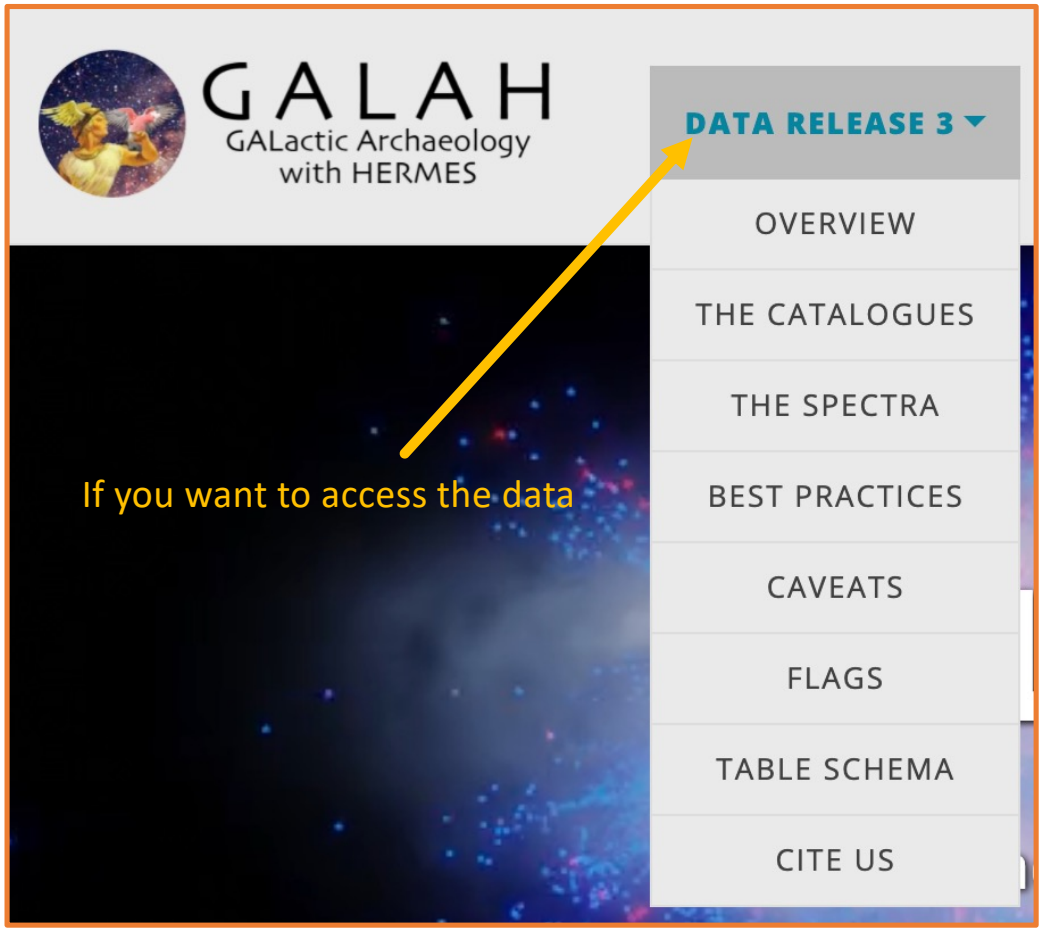

galah-survey.org
Update
GALAH
GALactic Archaeology with HERMES
DATA RELEASE 3
GALACTIC ARCHAEOLOGY
THE SURVEY
THE DETAILS
THE RESULTS
CONTACT
GALAH Survey
GALactic Archaeology with HERMES



Papers with “GALAH” in abstract



*This picture shows spatial coverage of stars observed with HERMES Image credit: Buder *et al.*, 2021*



Want to start working right now with GALAH DR3?

The GALAH survey published our third data release on 6 November 2020. For almost 600,000 stars, we provide reduced spectra, stellar parameters and up to 30 elemental abundances.

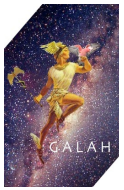
If you want our best effort stellar parameters and elemental abundances, we recommend the `GALAH_DR3_main_allstar_v2.fits` catalogue.

Get GALAH DR3 catalogues

Get GALAH DR3 spectra

Read the DR3 documentation

https://www.galah-survey.org/

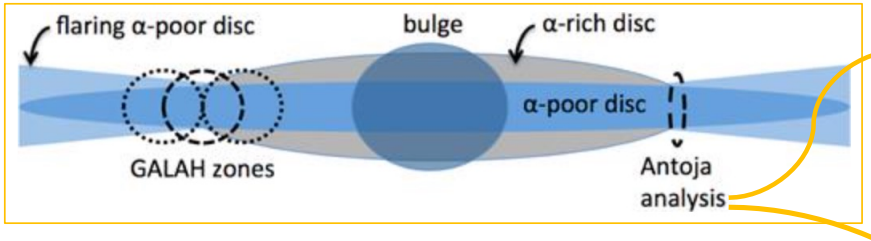


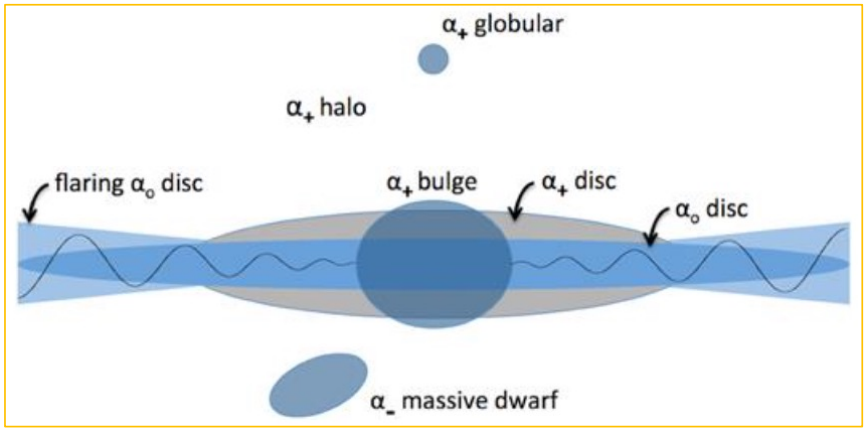
Key results (as from GALAH Survey webpage)

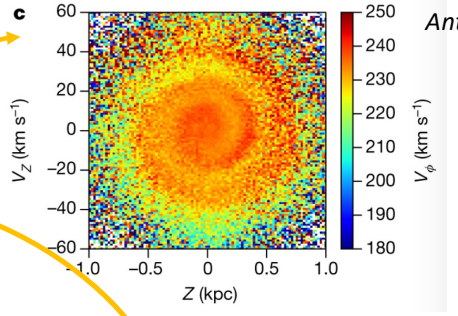
- Dissection of the stellar disks
- The accreted halo
- Chemical tagging
- Lithium*
- Calibrating other surveys

- Dissection of the stellar disks in terms of age, velocity, action, and location + chemistry
- First follow-up of Gaia's discovery of the "phase spiral" perturbation in the local disc
- Differing abundance trends between the thin and thick disk as well as with metallicity and age
- Nearly 40% of stars in the solar vicinity have metallicities higher than the local ISM
- Radial migration is an important process in the evolution of disk galaxies

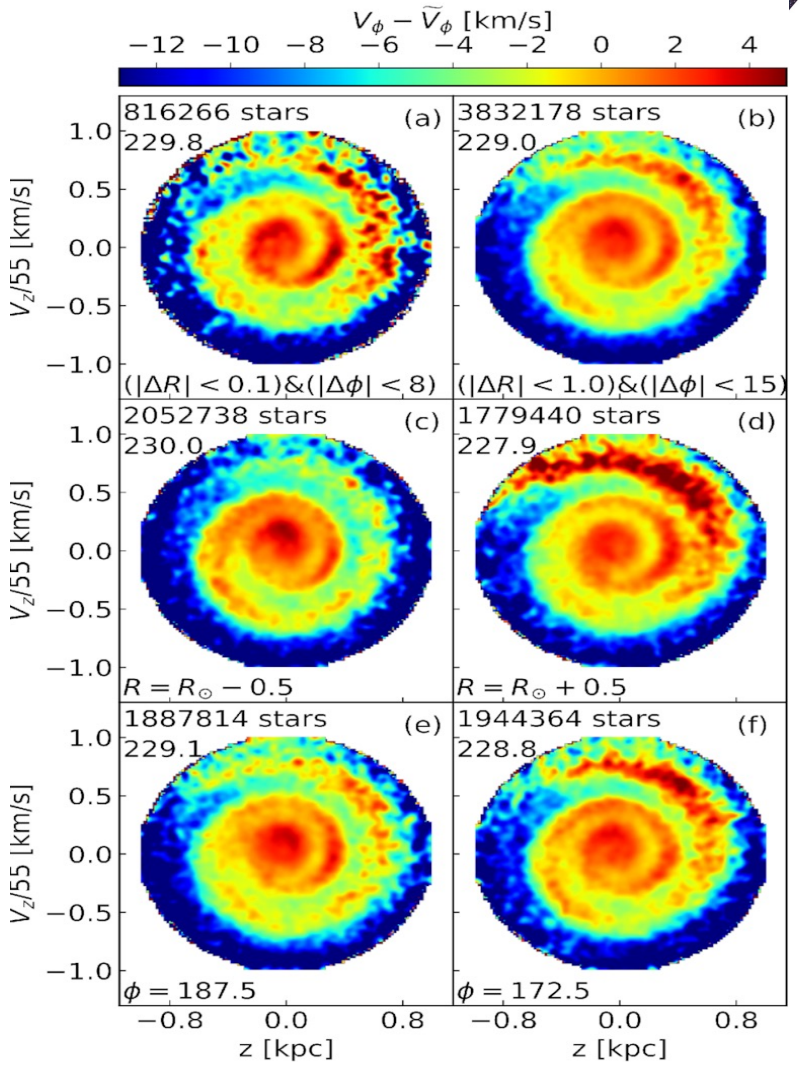
** Lithium (^{7}Li) measured from 6708 Å line → optical spectra, medium-to-high resolution works better*



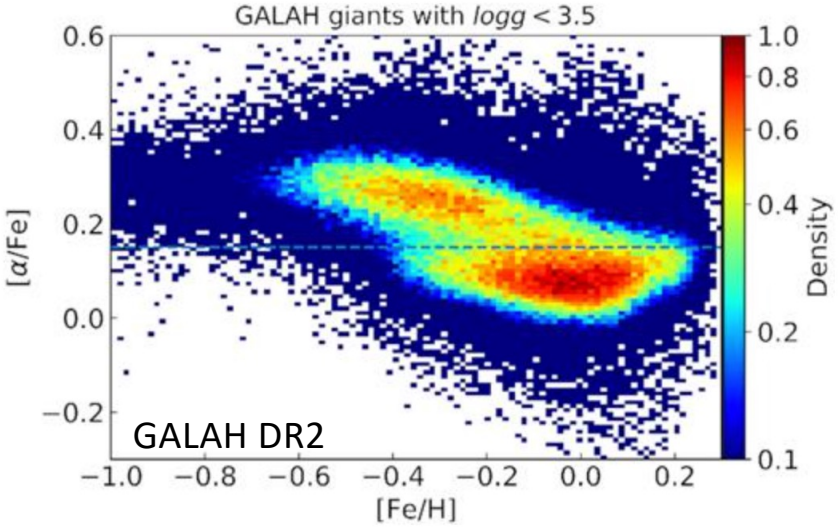




Antoja+2018, Nature, 561, 360 : A dynamically young and perturbed Milky Way disc



Traditional (top) and new (bottom) view of MW disks



α-rich and **α**-poor disks

Bland-Hawthorn+ 2019

Key results (as from GALAH Survey webpage)

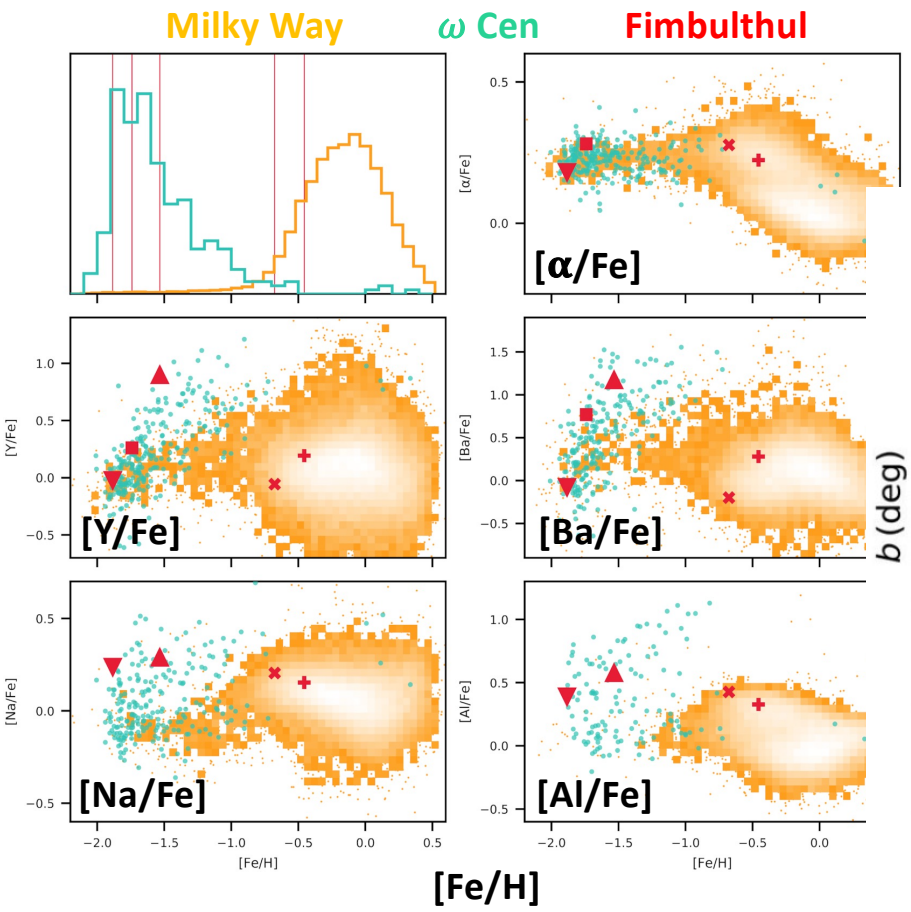
- Dissection of the stellar disks
- The accreted halo
- Chemical tagging
- Lithium*
- Calibrating other surveys

- RVs and abundances used to untangle kinematical halo signatures
- Chemical tagging of the Fimbulthul stellar stream to ω Centauri
- Orbital & abundance properties of the Helmi streams
- r-process in accreted Gaia-Enceladus show higher ratios of [Eu/Mg] than *in-situ*

** Lithium (^{7}Li) measured from 6708 Å line → optical spectra, medium-to-high resolution works better*

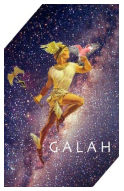
The GALAH Survey: Chemically tagging the Fimbulthul stream to the globular cluster ω Centauri

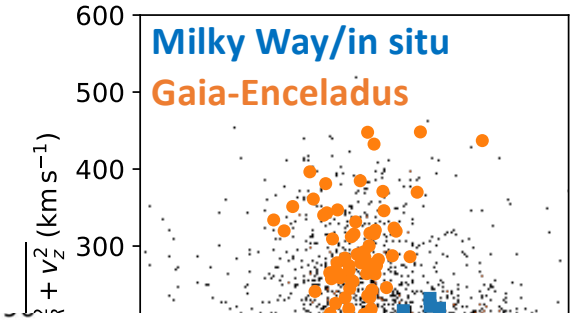
5 candidates, 2-3 good ones



[Simpson+ 2020]

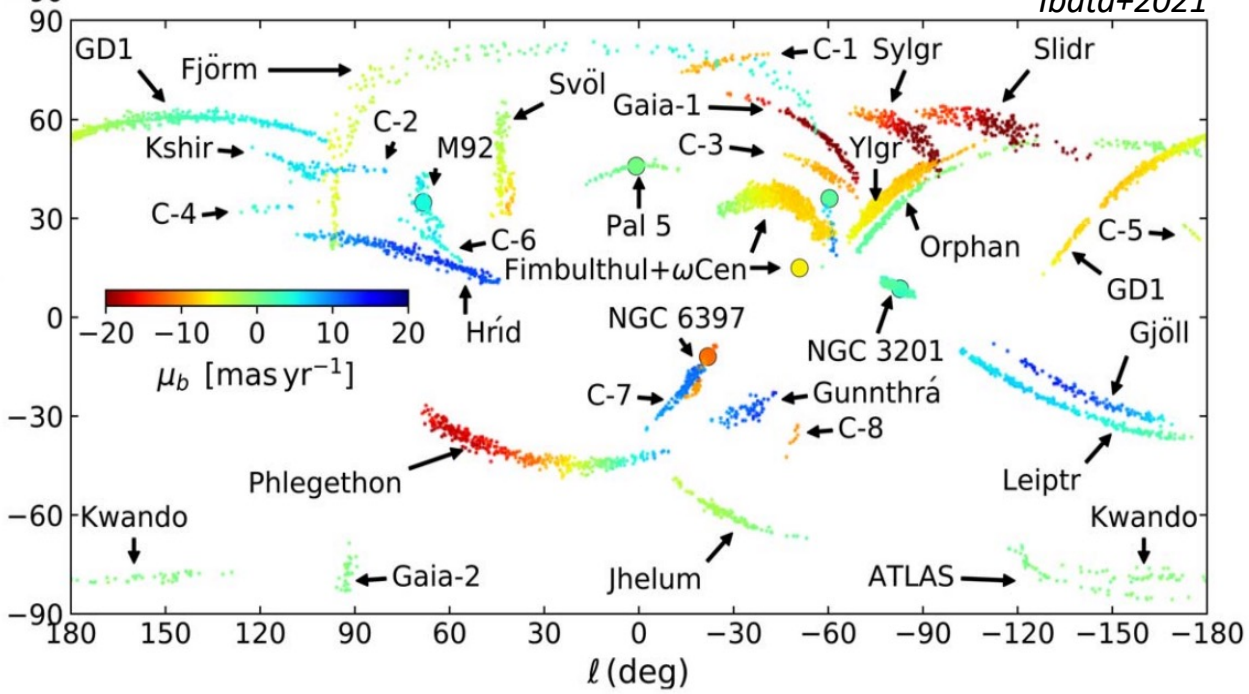
R-process enhancements of Gaia-Enceladus in GALAH DR3





dominant site of production of *r*-process elements unclear
→ Need to compare *r*-process abu in different environments

Ibata+2021

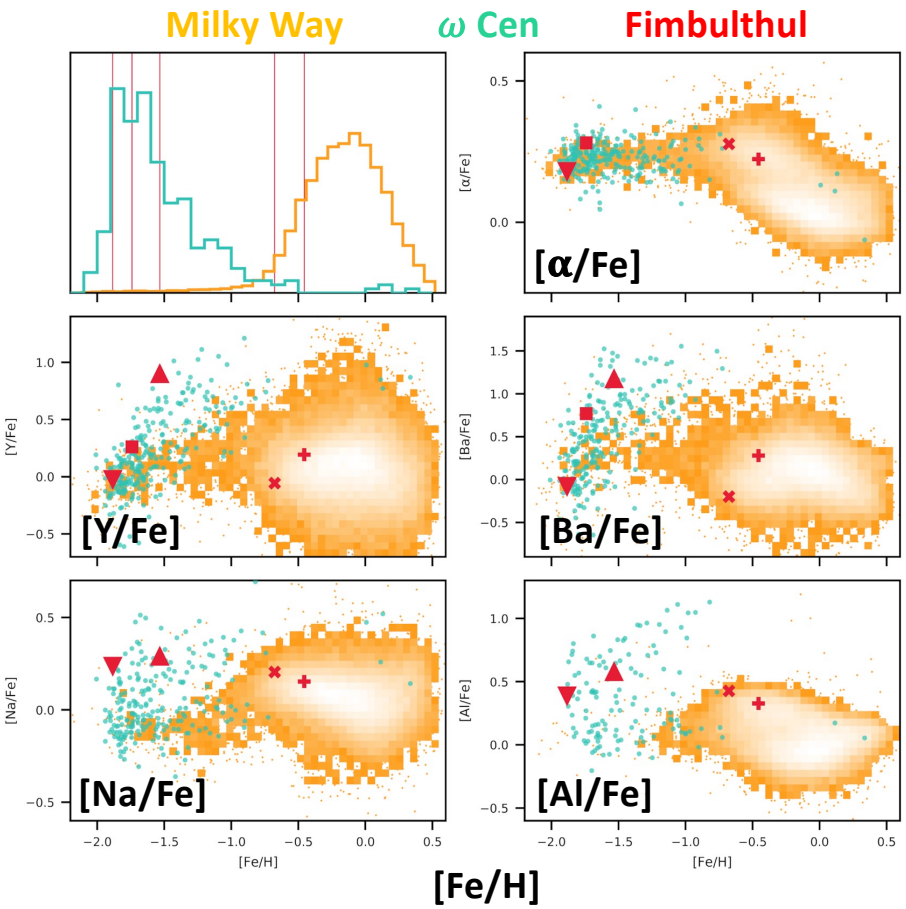


high [Eu/Mg] of Gaia-Enceladus explained by *r*-process enrichment by neutron-star merger

[Matsuno+ 2021]

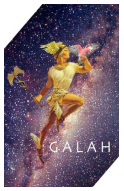
The GALAH Survey: Chemically tagging the Fimbulthul stream to the globular cluster ω Centauri

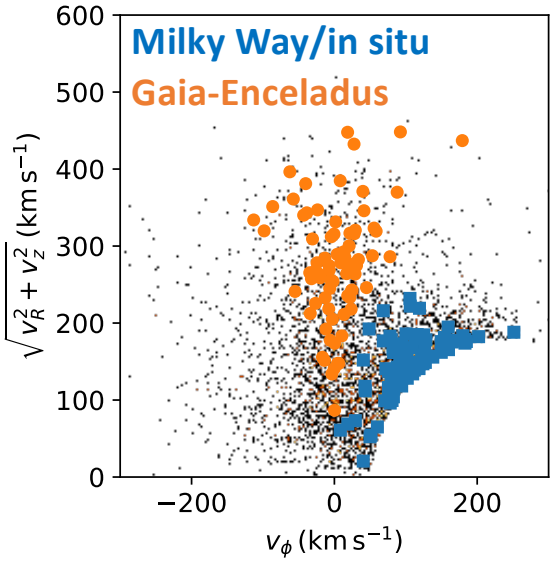
5 candidates, 2-3 good ones



Simpson+ 2020

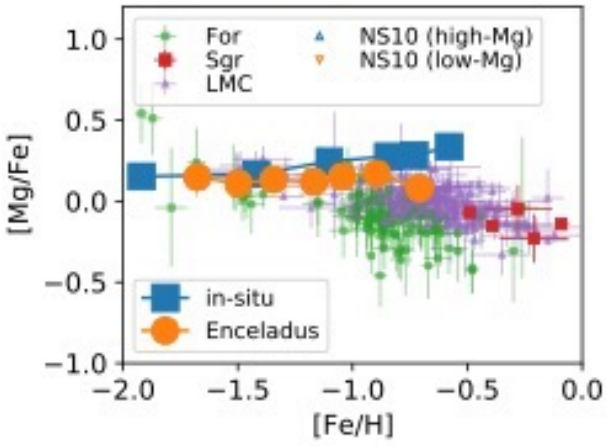
R-process enhancements of Gaia-Enceladus in GALAH DR3

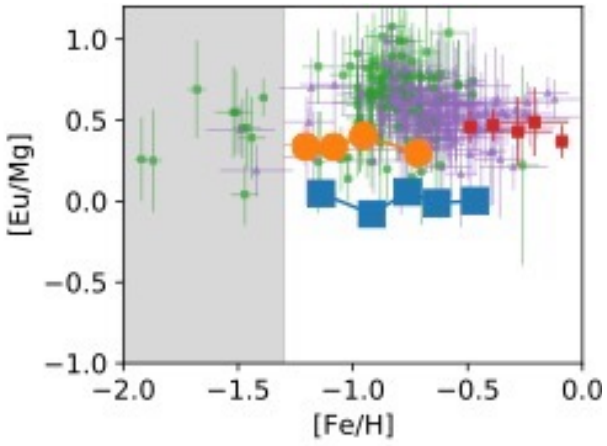




dominant site of production of *r*-process elements unclear

→ Need to compare *r*-process abu in different environments





high [Eu/Mg] of Gaia-Enceladus explained by *r*-process enrichment by neutron-star merger

Matsuno+ 2021

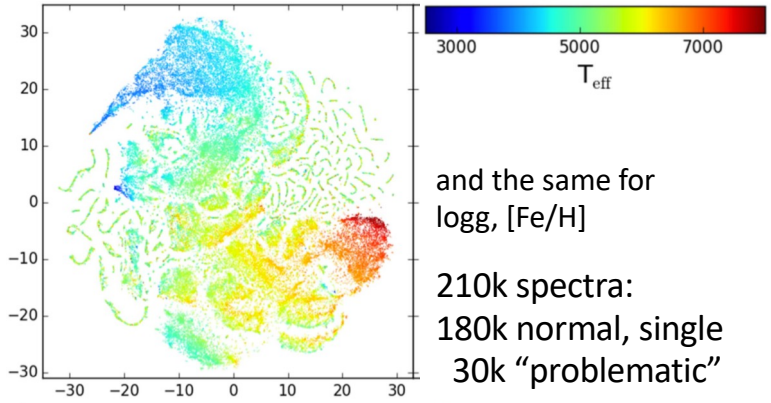
Key results (as from GALAH Survey webpage)

- Dissection of the stellar disks
- The accreted halo
- Chemical tagging
- Lithium*
- Calibrating other surveys

- Blind chemical tagging
- Unsupervised classification with t-SNE to detect peculiar objects using stellar spectra
- Recovering Gaia-Enceladus stars with chemistry and dynamics

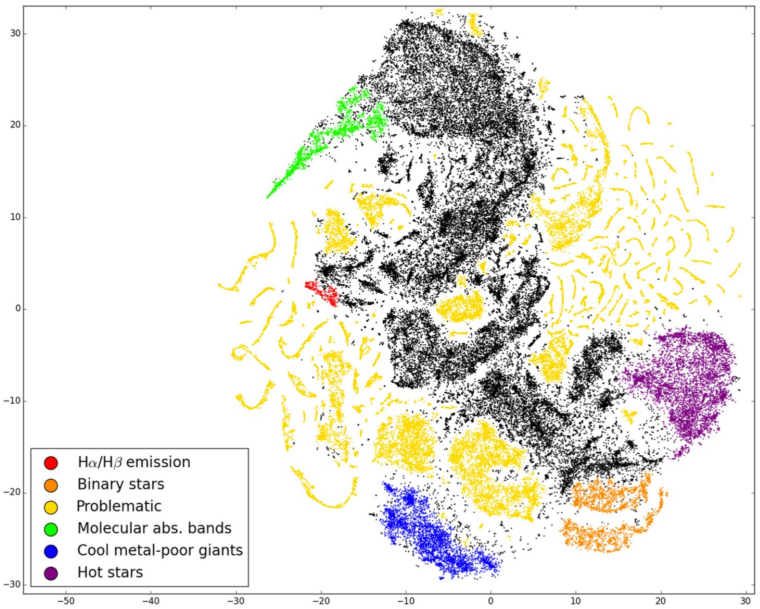
** Lithium (^{7}Li) measured from 6708 Å line → optical spectra, medium-to-high resolution works better*

The GALAH Survey: Classification and Diagnostics with t-SNE Reduction of Spectral Information



and the same for logg, [Fe/H]

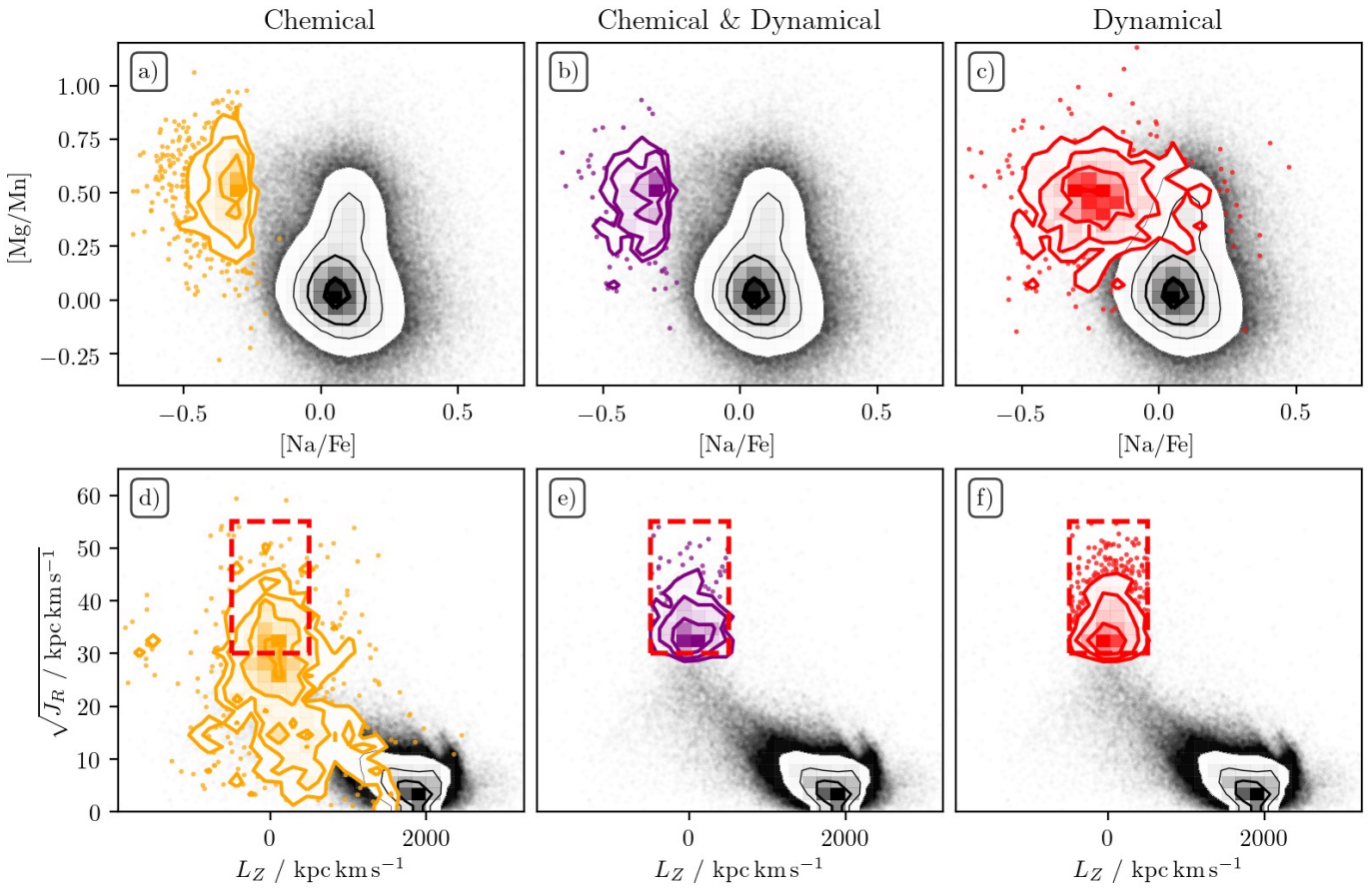
210k spectra:
180k normal, single
30k "problematic"



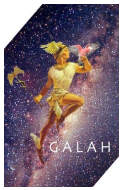
t-SNE (t-distributed stochastic neighbor embedding)

Traven+ 2017

The GALAH Survey: Chemical tagging and chrono-chemodynamics of accreted halo stars with GALAH+ DR3 and Gaia eDR3



Buder+ 2021



Key results (as from GALAH Survey webpage)

- Dissection of the stellar disks
- The accreted halo
- Chemical tagging
- Lithium*
- Calibrating other surveys

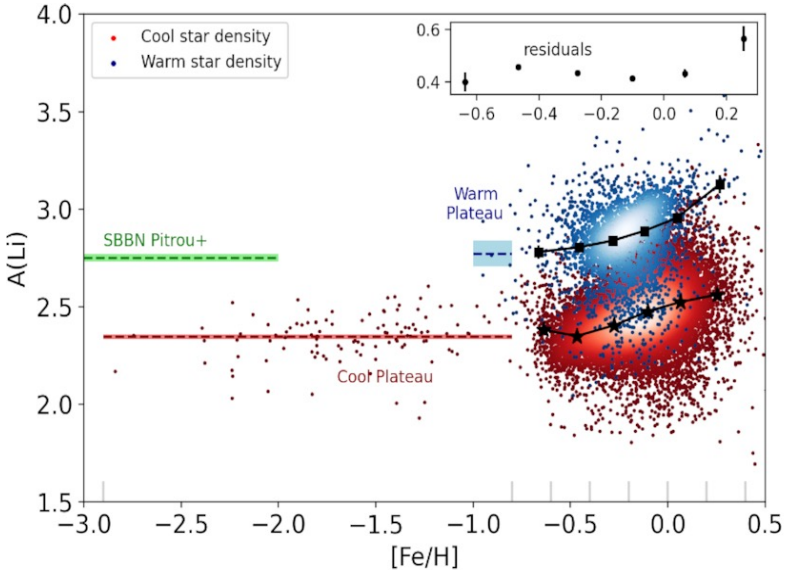
- 100000 stars with Li: investigate why dwarfs show too little lithium and some giants too much
- Accreted stars show same Spite plateau of in-situ stars (cosmological Li problem not due to MW)
- Red clump stars more probably Li-rich than RGB (but Li production general)

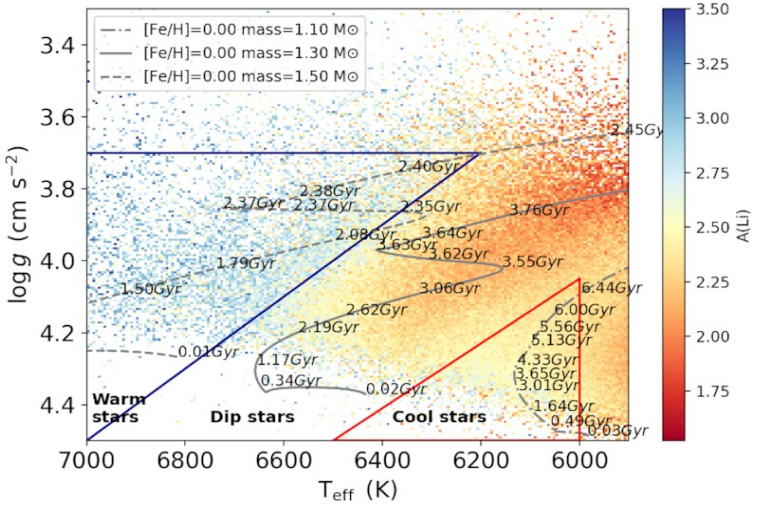
** Lithium (^{7}Li) measured from 6708 Å line → optical spectra, medium-to-high resolution works better*

Lithium & GALAH

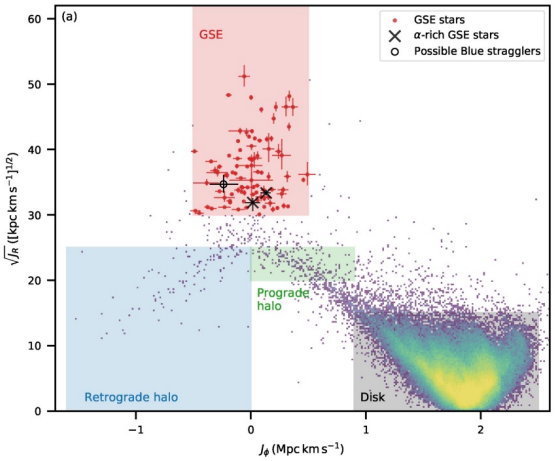
Warmer stars show a Li abundance consistent with the primordial value given by standard SBBN (Standard Big Bang Nucleosynthesis)

Accreted stars (here GES, Gaia-Sausage-Enceladus) also inhabit the Spite Li plateau

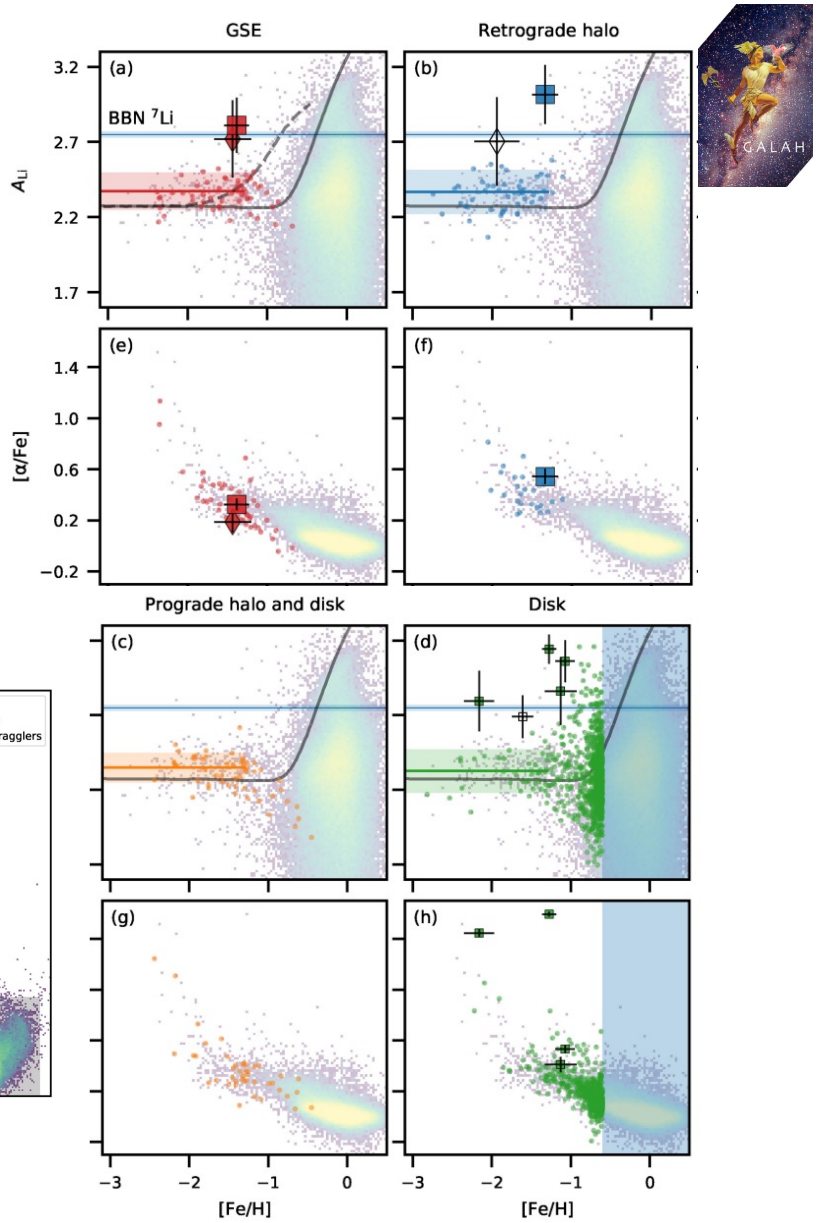




Gao+ 2020



Simpson+ 2021



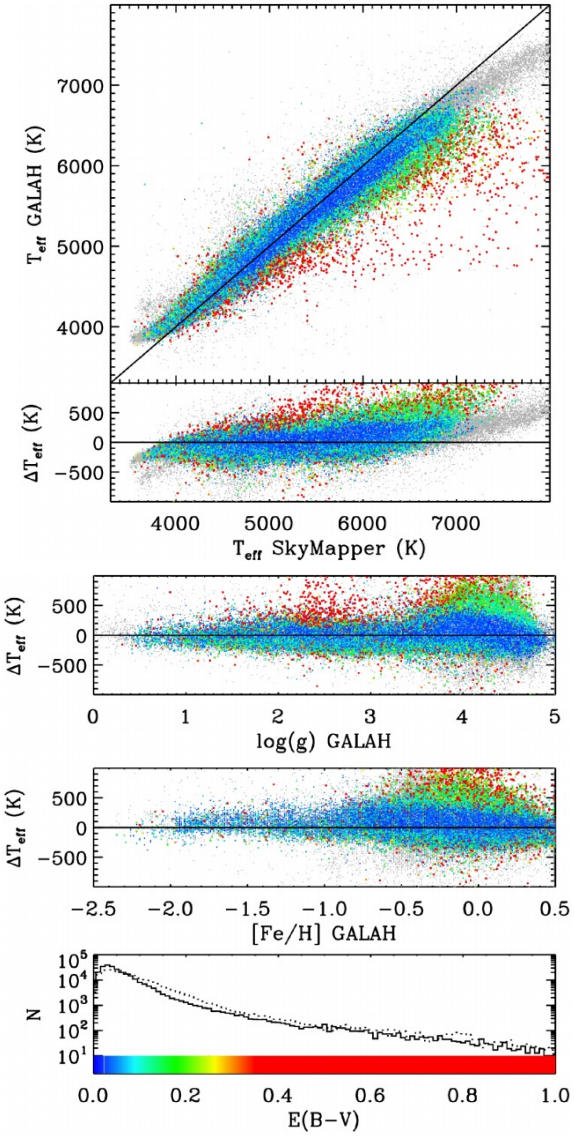
Key results (as from GALAH Survey webpage)

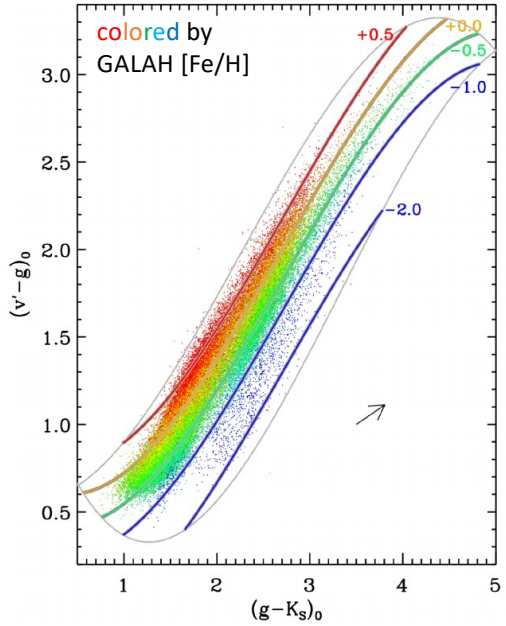
- Dissection of the stellar disks
- The accreted halo
- Chemical tagging
- Lithium*
- Calibrating other surveys

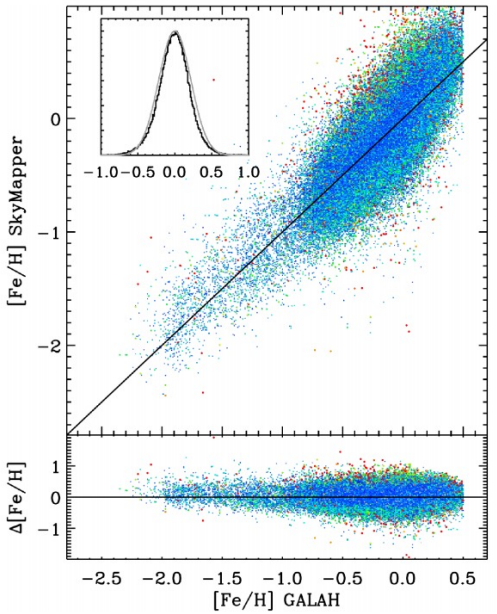
- Crucial as a cross-check and calibration of other large surveys
- Largest, very precise RV (0.1 km/s) catalog
- TESS input catalog
- Used by RAVE, GALAH, Skymapper, LAMOST, etc to validate/calibrate

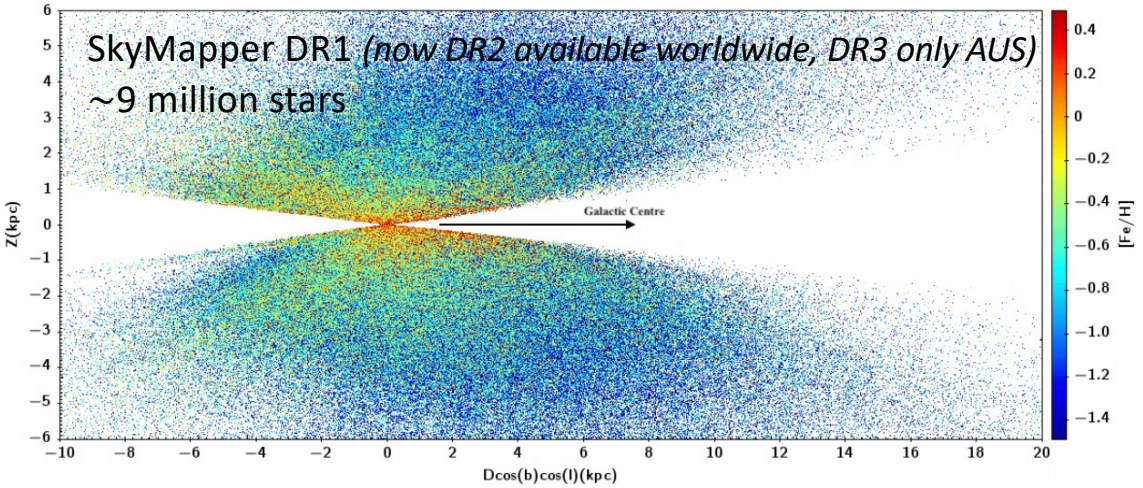
** Lithium (^{7}Li) measured from 6708 Å line → optical spectra, medium-to-high resolution works better*

SkyMapper stellar parameters for Galactic Archaeology on a grand-scale









SkyMapper:
ANU project, 1.3m tel, uvgriz

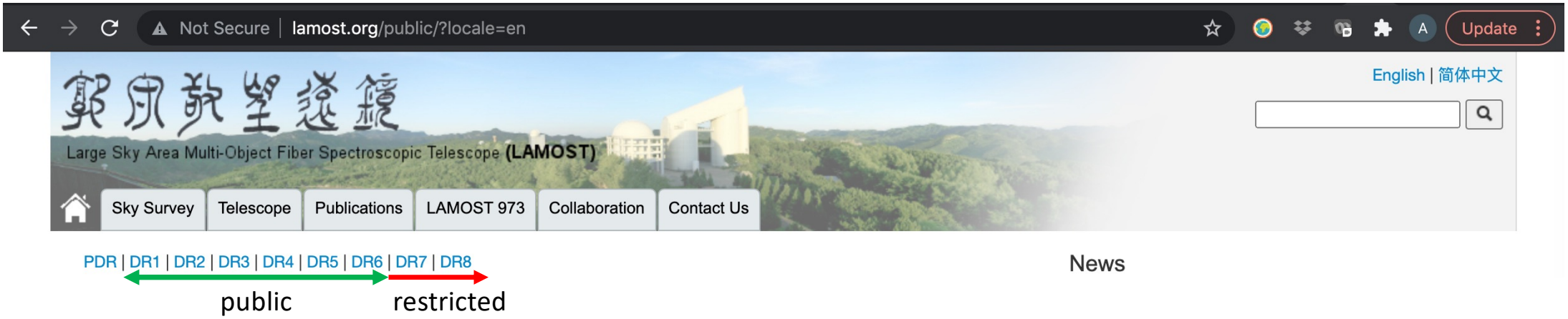
➔ Teff at better than 100K
➔ [Fe/H] at 0.2 dex

Casagrande+ 2019

Suggested watching if you want to see/know more on GALAH

Talk videos *All talks were broadcast and recorded via Zoom. When available each talk title is linked to recording to the talk on YouTube. There is also a playlist for Day 1, Day 2, Day 3*

LAMOST



LAMOST survey contains two main parts:
the LAMOST ExtraGAlactic Survey (LEGAS), and the **LAMOST Experiment for Galactic Understanding and Exploration (LEGUE) survey of Milky Way stellar structure**.

The unique design of LAMOST enables it to take 4000 spectra in a single exposure to a limiting magnitude as faint as r=19 at the resolution R=1800.

LAMOST is a reflecting Schmidt telescope with its optical axis fixed along the north-south meridian. Both the Schmidt mirror (MA) and the primary mirror (MB) are segmented. The focal surface is circular with a diameter of 1.75 meters (~5°), the 4000 fibers are almost evenly distributed over it.

Not Secure | dr6.lamost.org/v2/catalogue

Home Data Access Documents Help CONTACT US

LAMOST DR6 v2

Low Resolution Catalog

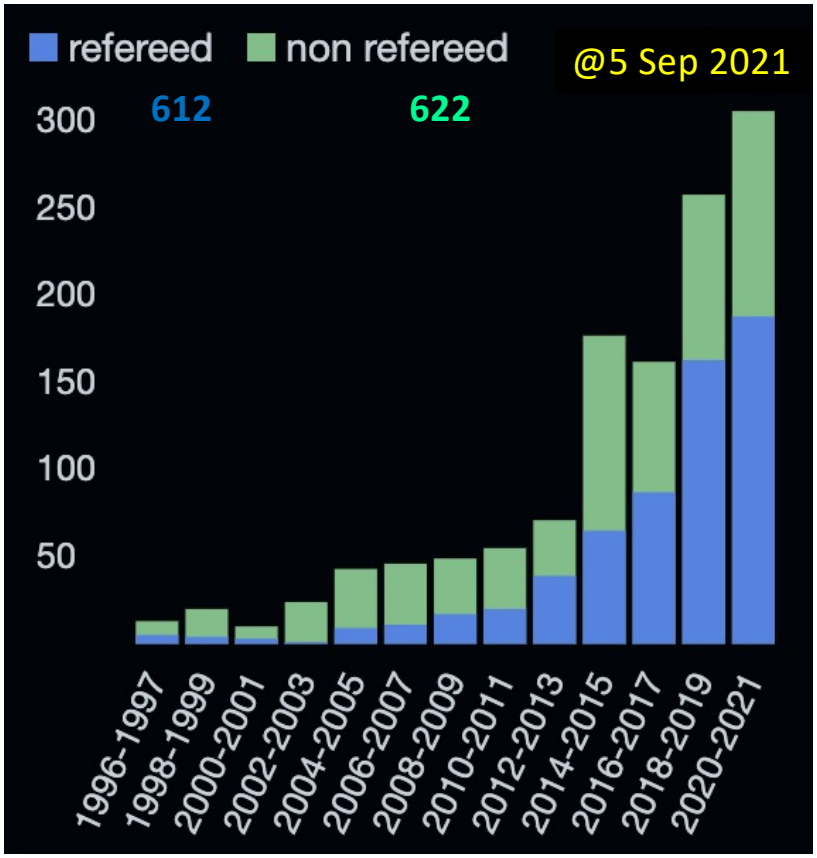
Catalog	All	Document
LAMOST LRS General Catalog	FITS CSV	Description
LAMOST LRS A, F, G and K Star Catalog	FITS CSV	Description
LAMOST LRS A Star Catalog	FITS CSV	Description
LAMOST LRS M Star Catalog	FITS CSV	Description
LAMOST LRS Observed Plate Information Catalog	CSV	Description
LAMOST LRS Input Catalog	TXT	Description

9,911,337 flux(relatively)- and wavelength-calibrated spectra
9,231,057 stellar spectra,
177,270 galaxy spectra,
62,168 quasar spectra,
and 440,842 unknown
Coverage:
3690-9100 Å at R = 1800

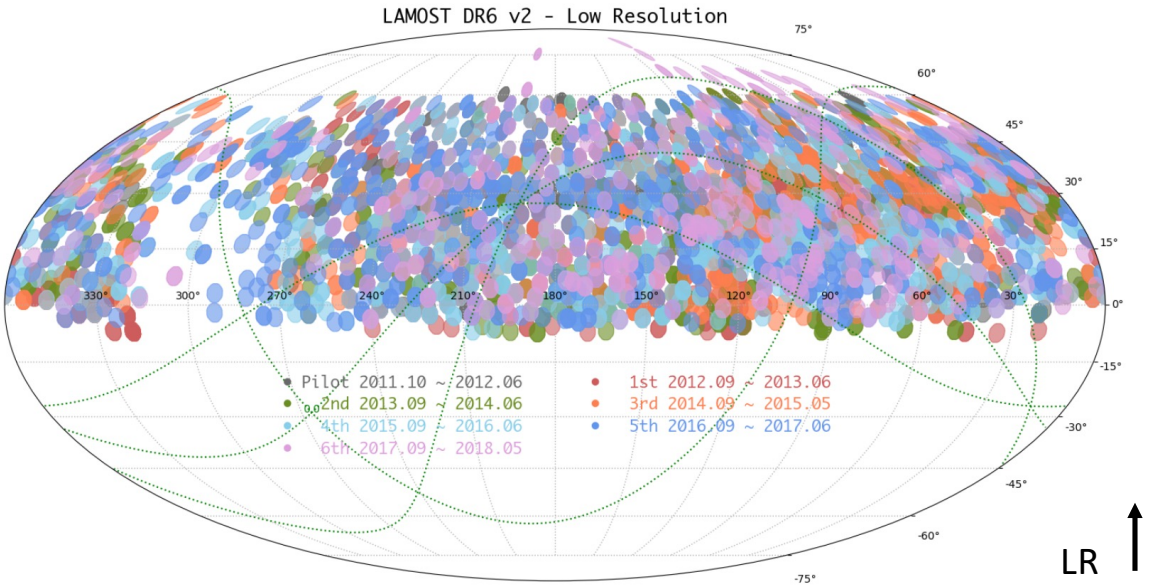
Medium Resolution Catalog

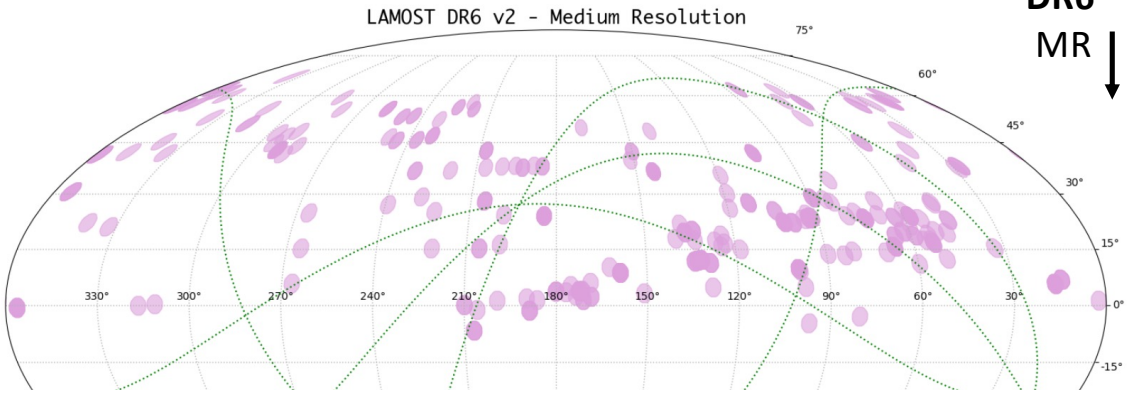
Catalog	All	Document
LAMOST MRS General Catalog	FITS CSV	Description
LAMOST MRS Parameter Catalog	FITS CSV	Description
LAMOST MRS Observed Plate Information Catalog	CSV	Description
LAMOST MRS Input Catalog	TXT	Description

MRS includes the time-domain & the non time-domain surveys
Coverage:
4950-5350 and 6300-6800 Å at R=7000



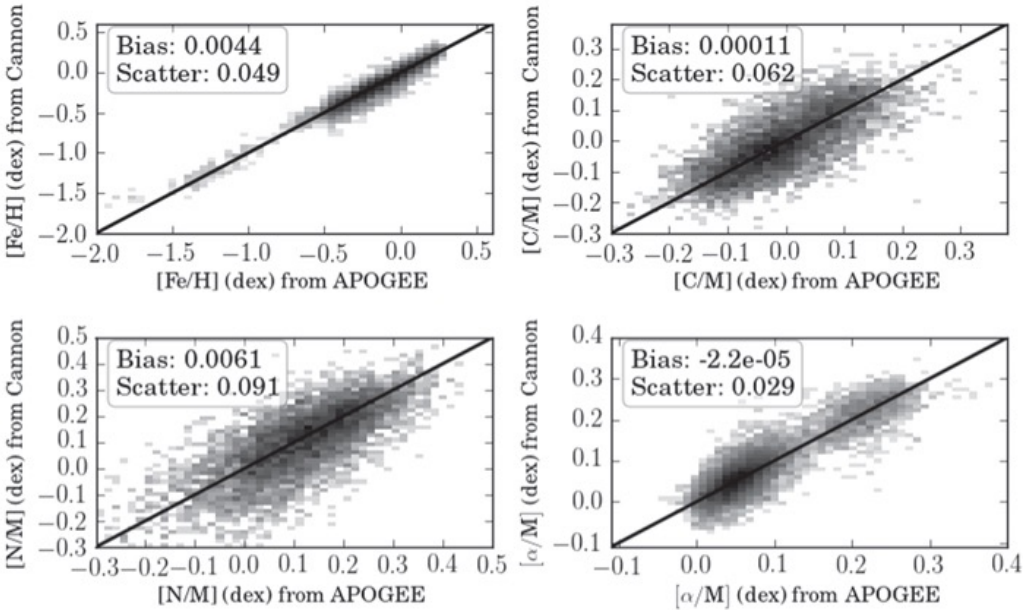
Papers with “LAMOST” in abstract

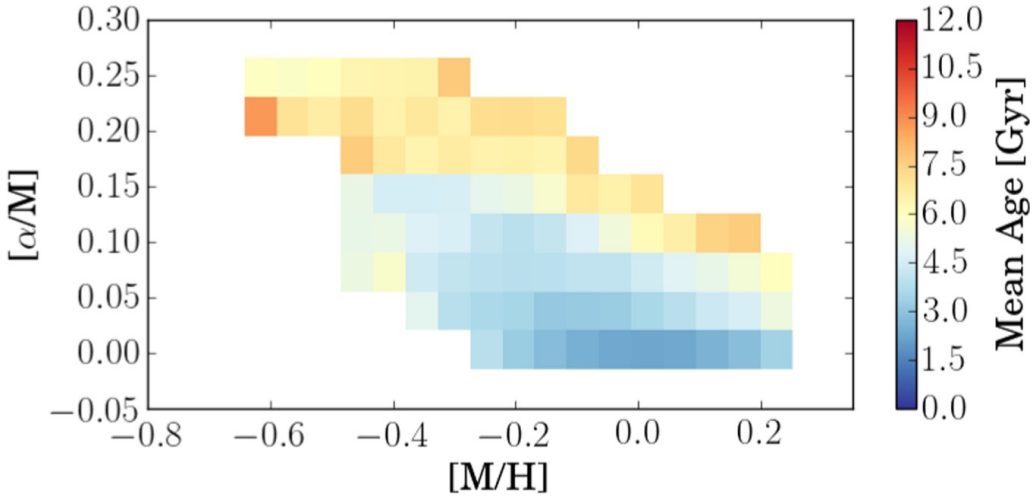




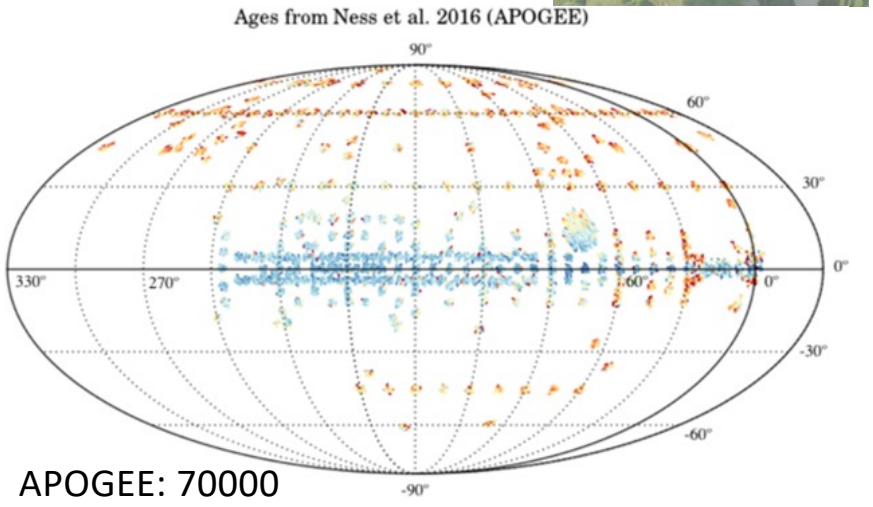
LR
DR6
MR

Masses and Ages for 230,000 LAMOST Giants, via Their Carbon and Nitrogen Abundances

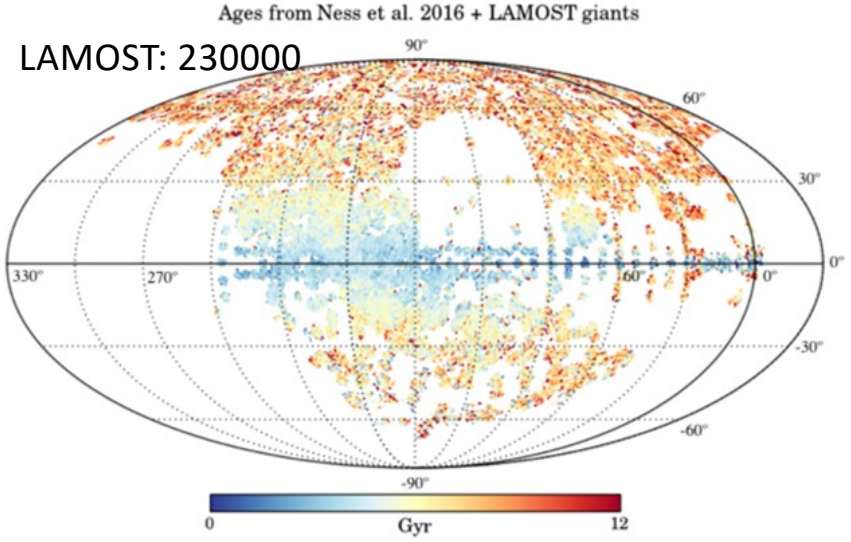




[Ho+ 2017](#)

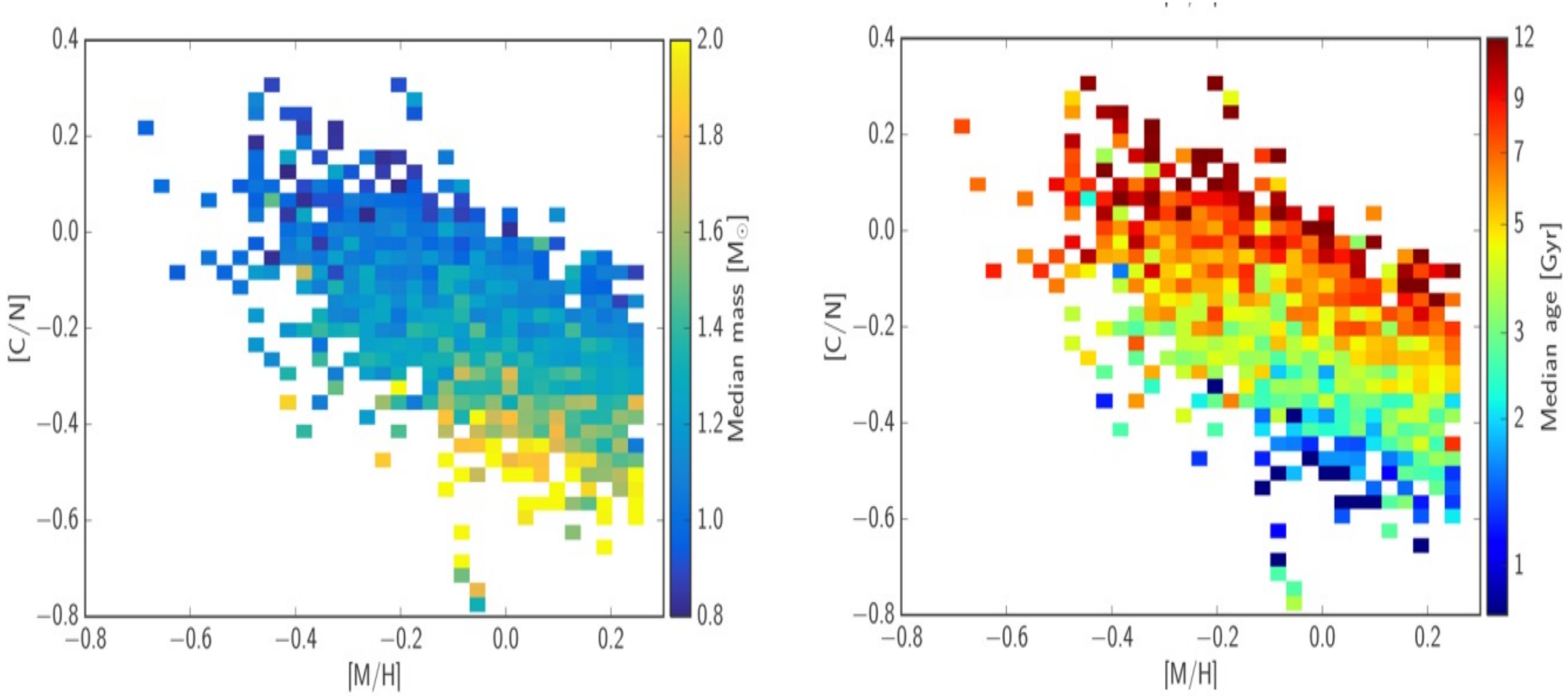


APOGEE: 70000



LAMOST: 230000

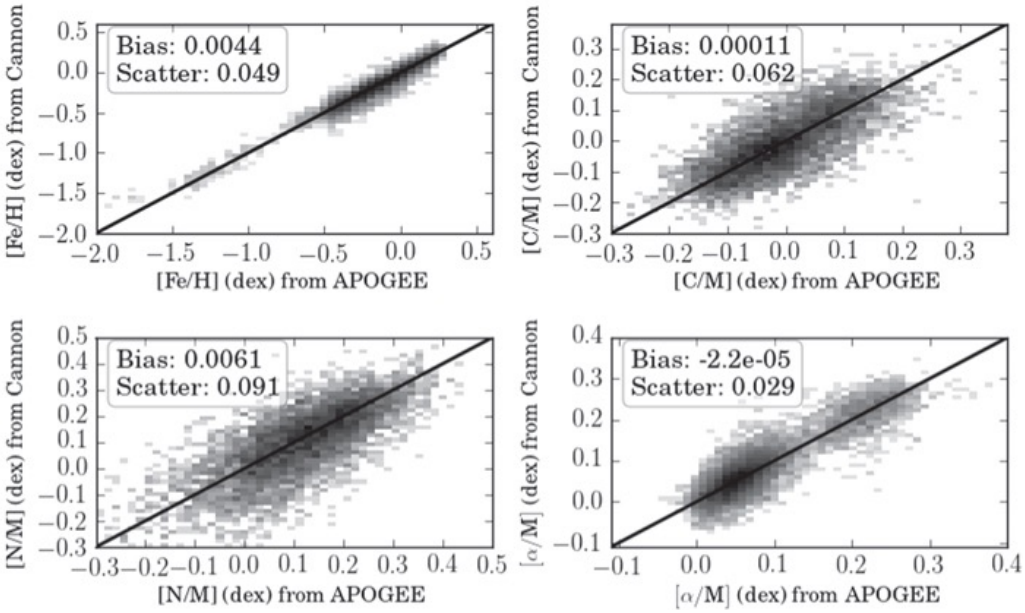
Masses and Ages for 230,000 LAMOST Giants, via Their Carbon and Nitrogen Abundances

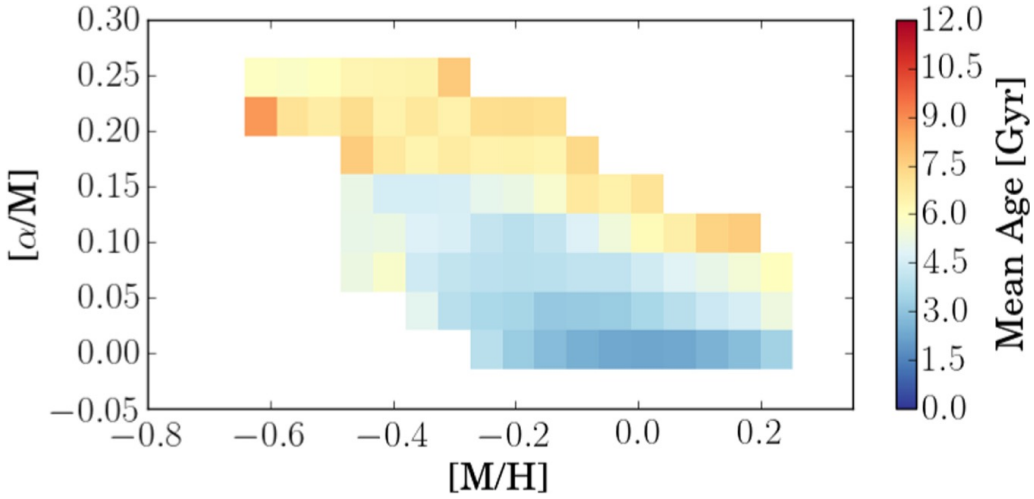


Martig+2015 : Red giant masses and ages derived from carbon and nitrogen abundances (APOGEE + Kepler)
use C,N + log g, Teff, [Fe/H] → mass (calibrated with asterosismology) → age

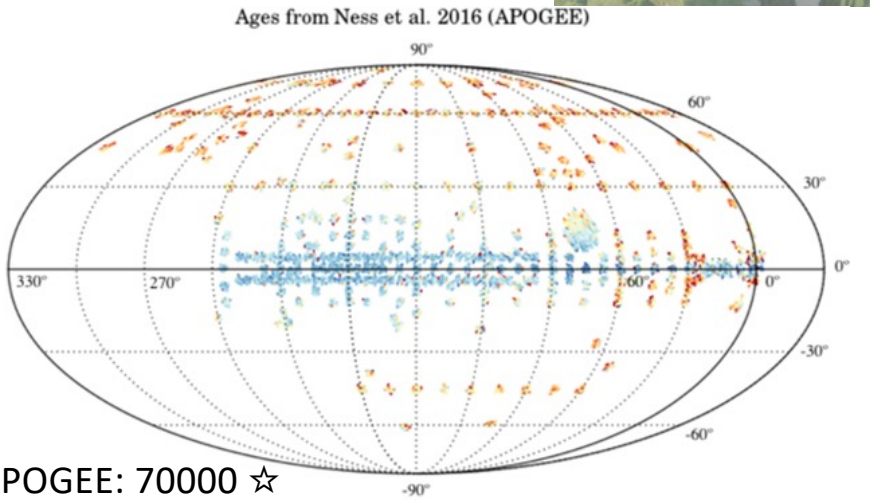
Ho+ 2017

Masses and Ages for 230,000 LAMOST Giants, via Their Carbon and Nitrogen Abundances

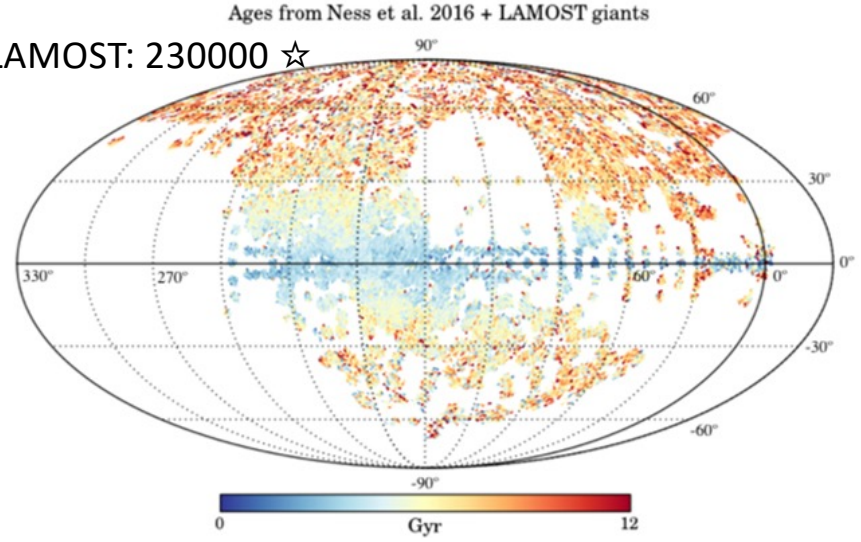




[Ho+ 2017](#)



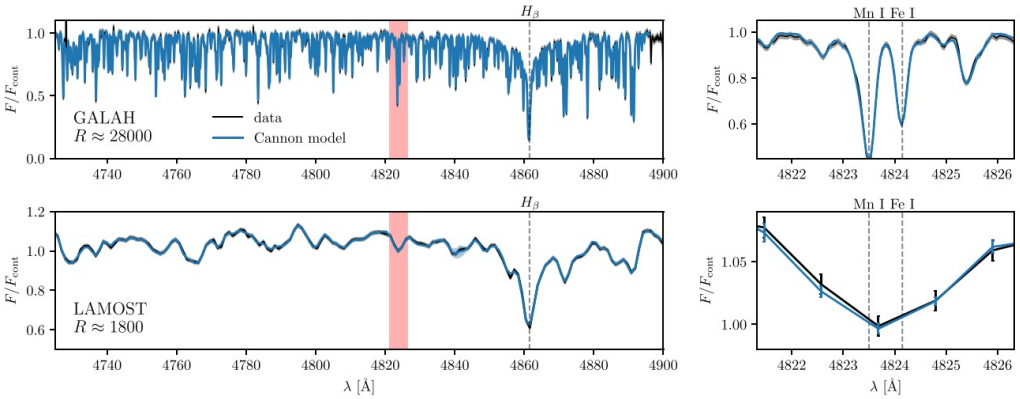
APOGEE: 70000 ☆



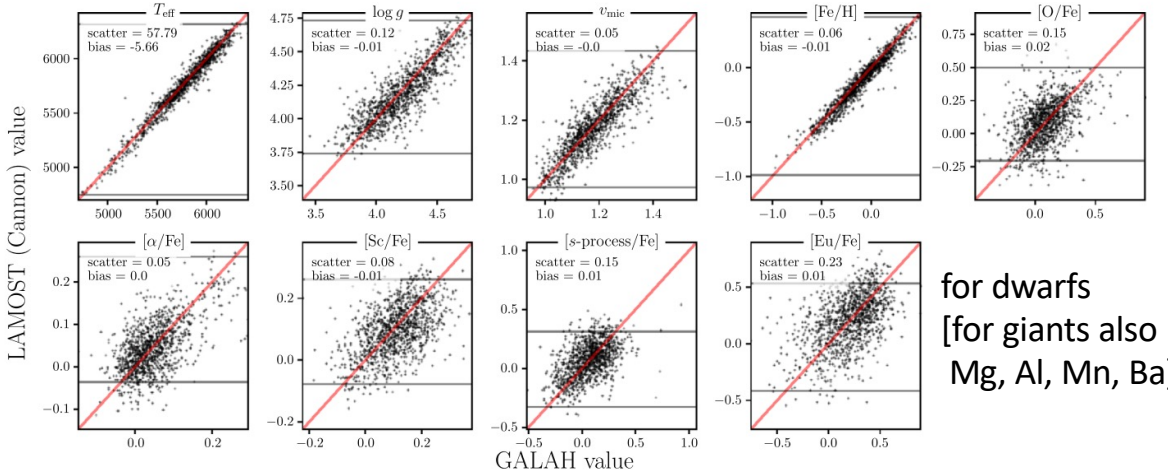
LAMOST: 230000 ☆

Abundances in the Milky Way across Five Nucleosynthetic Channels from 4 Million LAMOST Stars

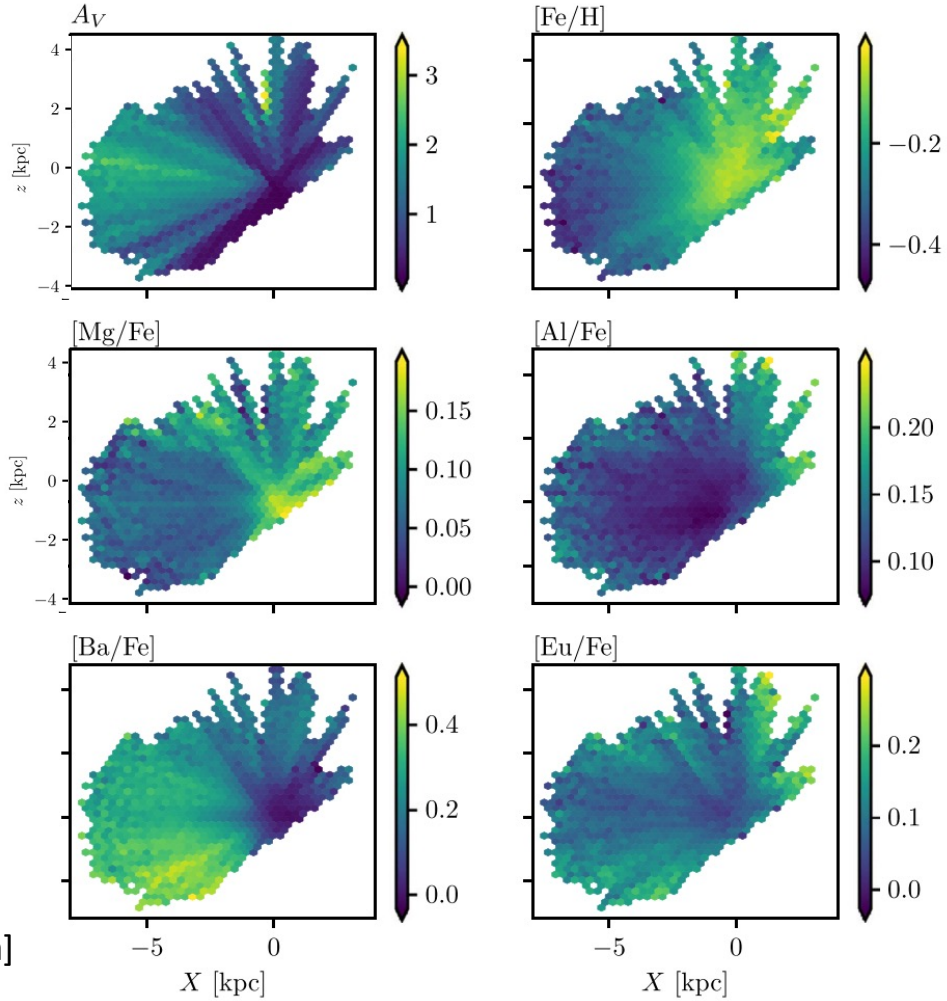
Uses: DR4 LAMOST R=1800 + GALAH DR2 R=28000 spectra + GALAH stellar parameter and abundances + Gaia proper-motion and parallax measurements



➔ *The Cannon* *[see L. Spina talk on Day 3]*

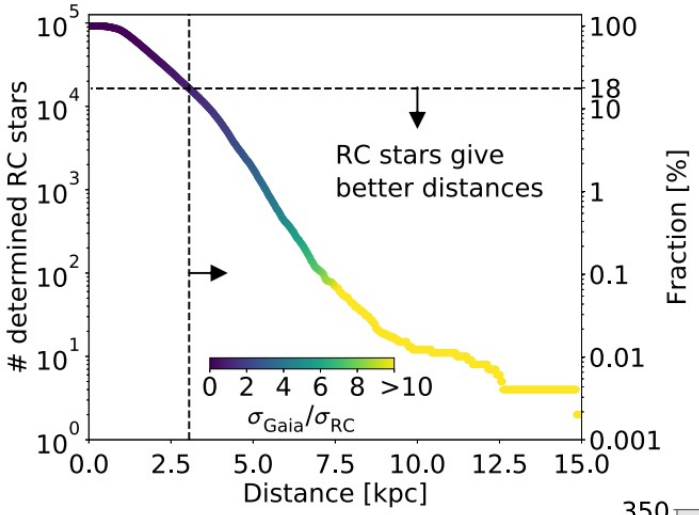


for dwarfs
[for giants also Mg, Al, Mn, Ba]

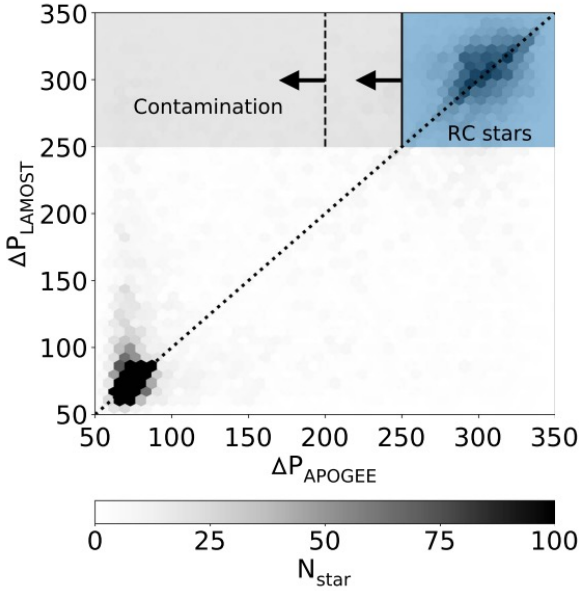


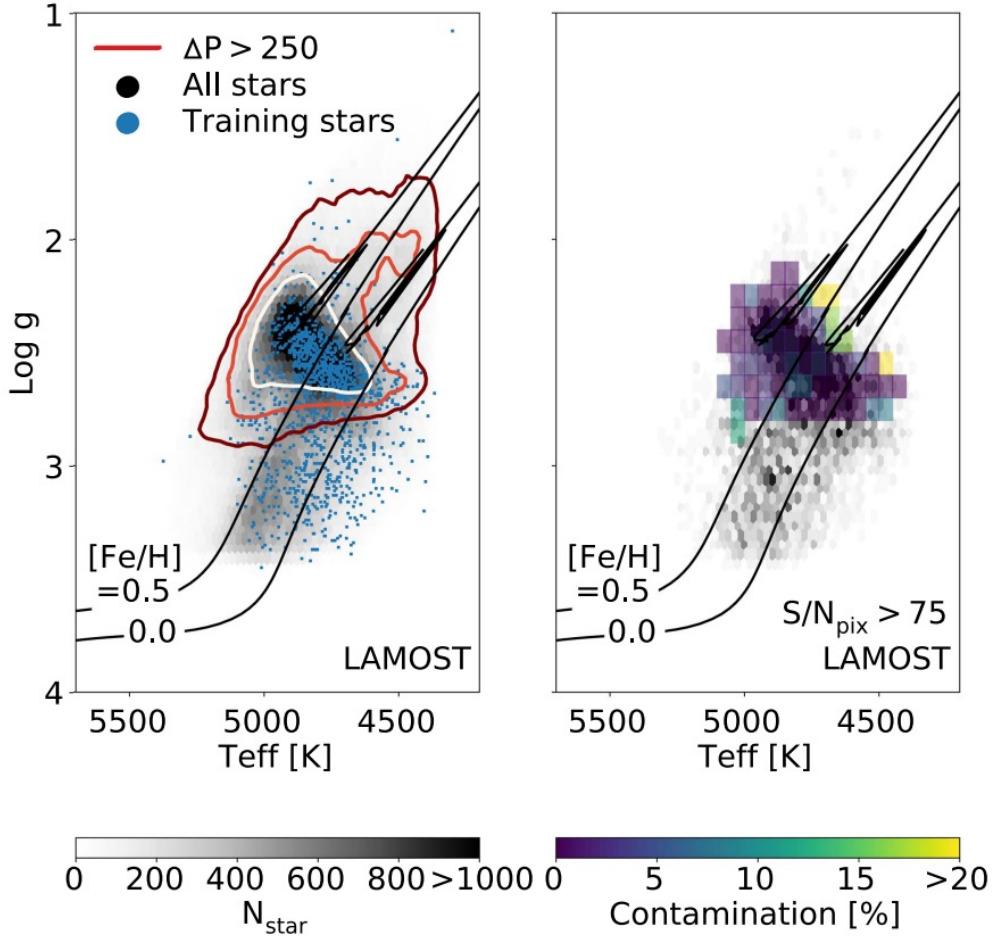
Wheeler+ 2020

A Large and Pristine Sample of Standard Candles across the Milky Way: ~100,000 Red Clump Stars with 3% Contamination *(and 9% contamination level for ~210,000 – compare to 20%)*



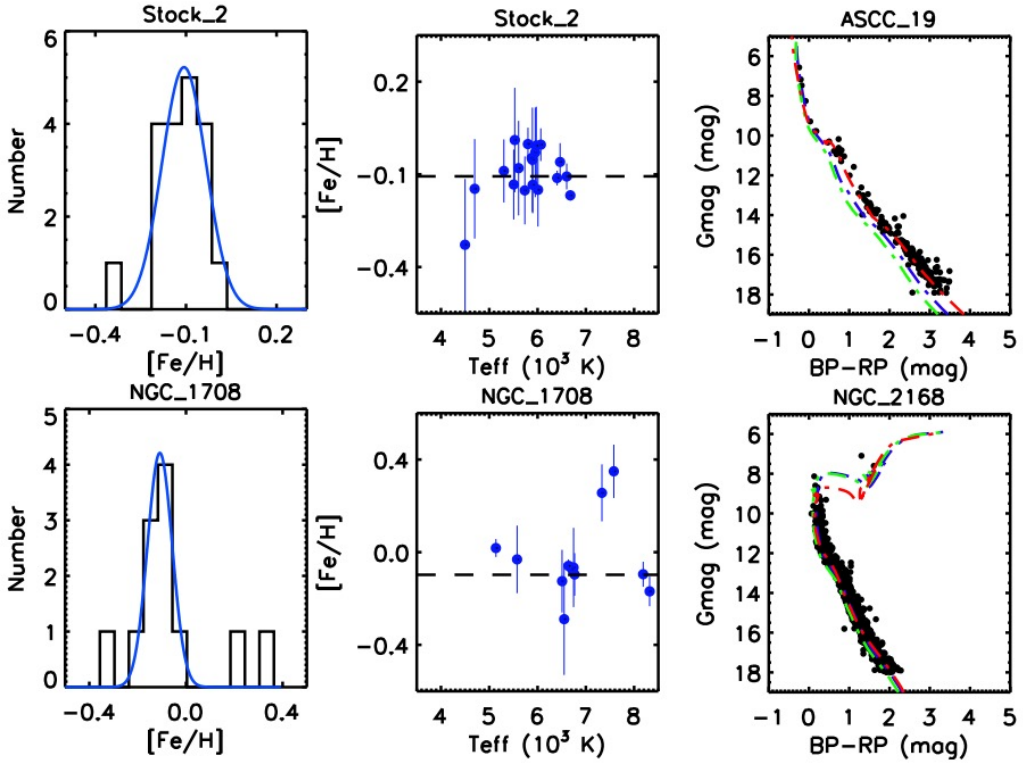
RC stars very good distance indicators [better than Gaia at large distance]



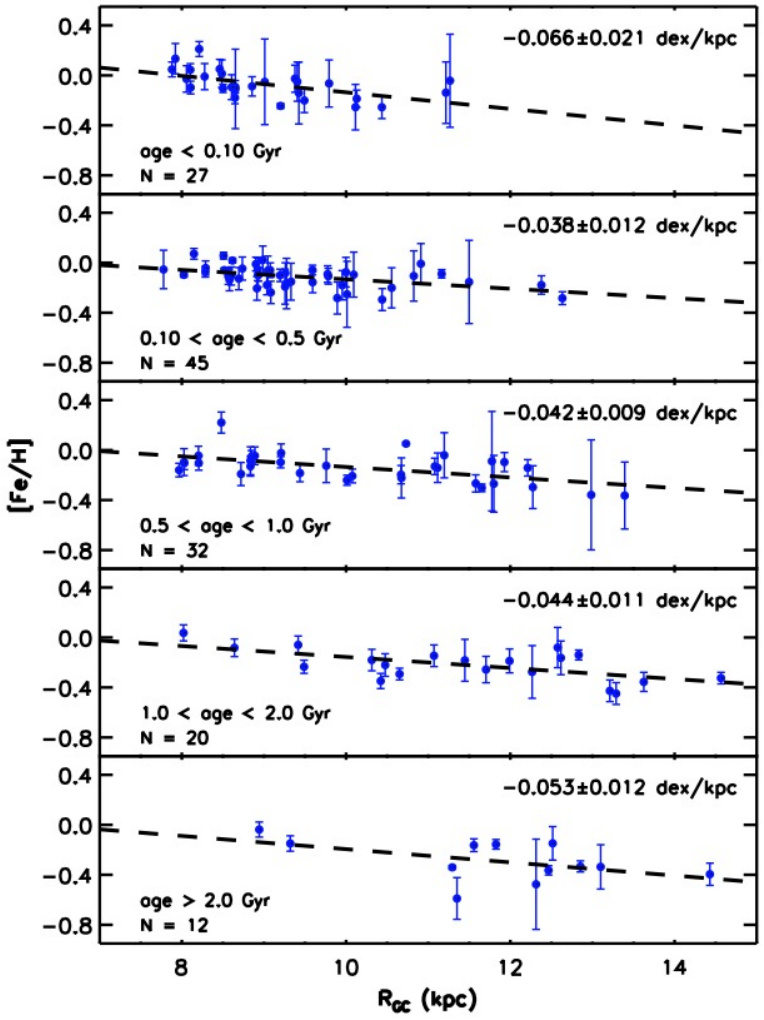


[Ting Y-S+ 2018]

Exploring open cluster properties with Gaia and LAMOST



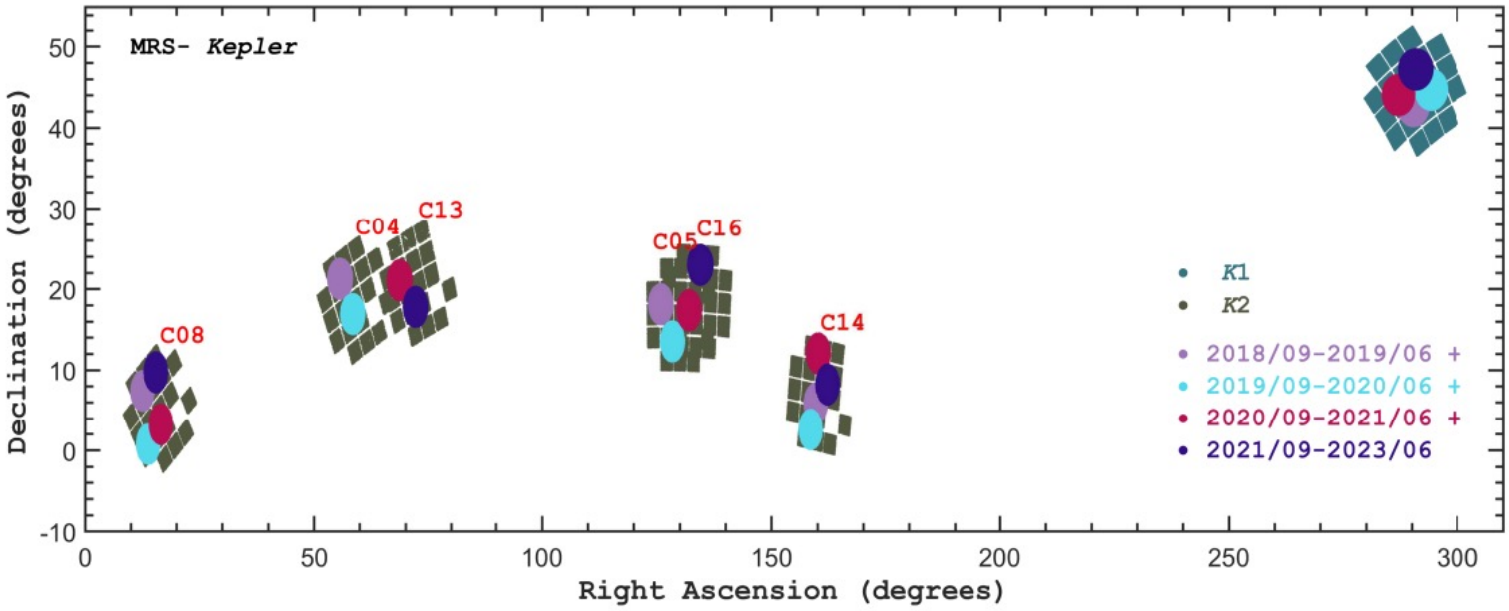
A few examples of the 295 clusters (and 8800 stars)



Zhong J+ 2020

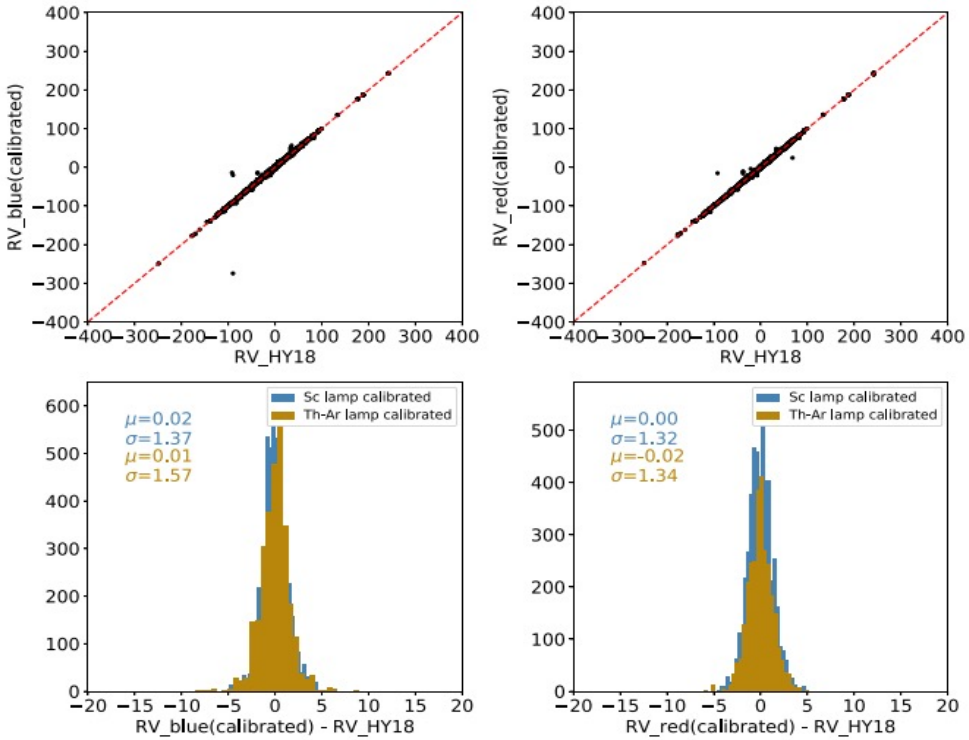
LAMOST-MRS : million of stars at R=7500 to study:

- Binarity/Multiplicity
- Stellar pulsation
- Star formation
- Emission nebulae
- Galactic archaeology
- Host stars of exoplanets
- Open clusters



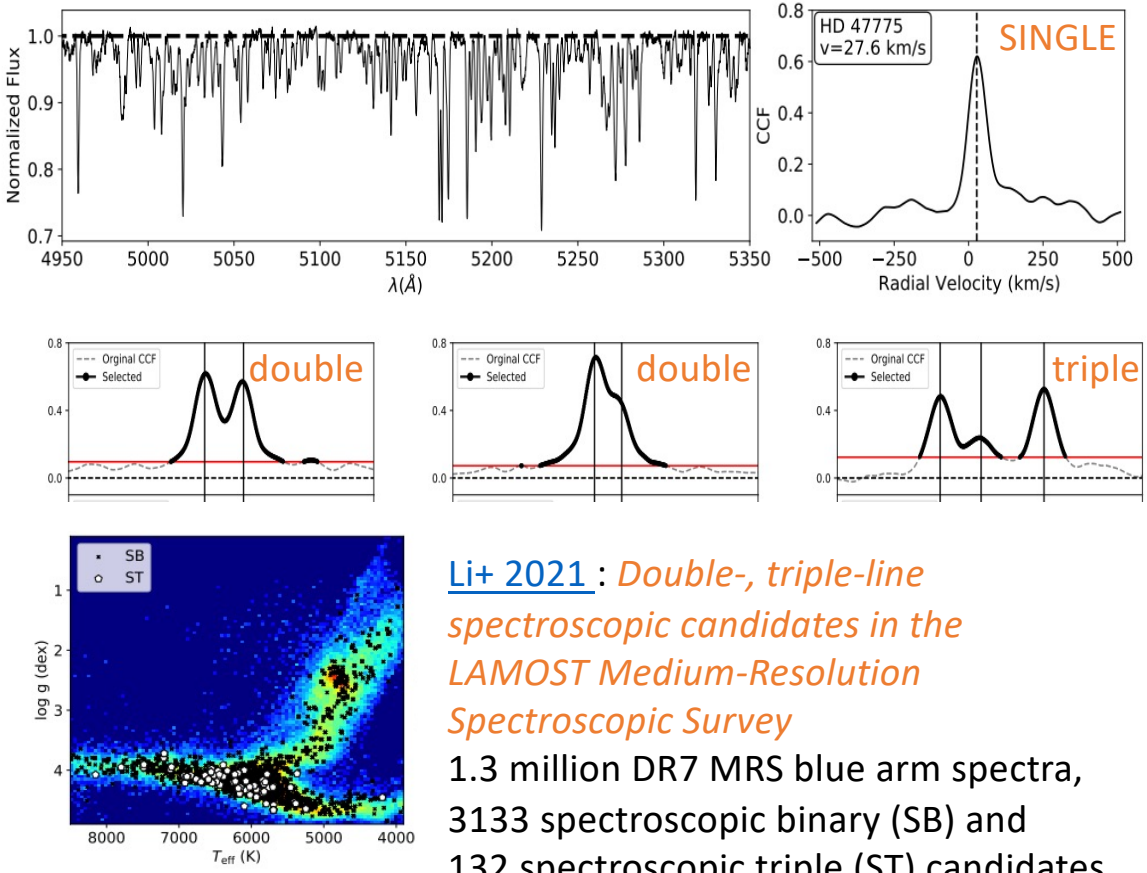
Liu+ 2020

LAMOST Medium-Resolution Spectroscopic Survey



Wang+ 2019 : *Properties of Radial Velocities Measurement Based on LAMOST-II Medium-resolution Spectroscopic Observations*

RVs with precision ≈ 1 km/s for million of stars to G ≈ 15 and very accurate (z.p. ≈ 0 wrt std stars)



Li+ 2021 : *Double-, triple-line spectroscopic candidates in the LAMOST Medium-Resolution Spectroscopic Survey*

1.3 million DR7 MRS blue arm spectra,
3133 spectroscopic binary (SB) and
132 spectroscopic triple (ST) candidates
i.e. 1.2% of the LAMOST-MRS stars.
95% of candidates are new discoveries


WE
NEED
YOU