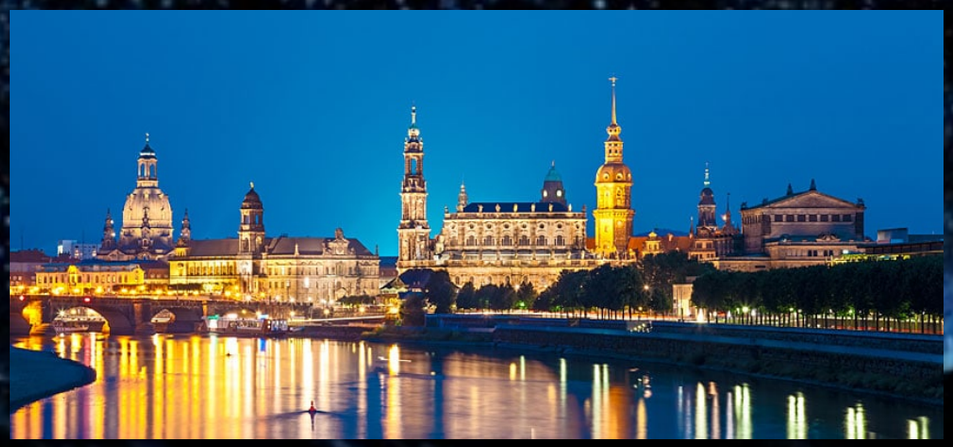
Osservatorio Astronomico di Trieste
Astronomical Observatory of Trieste

UNIVERSITÀ DEGLI STUDI DI TRIESTE

MINCE

Measuring at Intermediate Metallicity Neutron Capture Elements

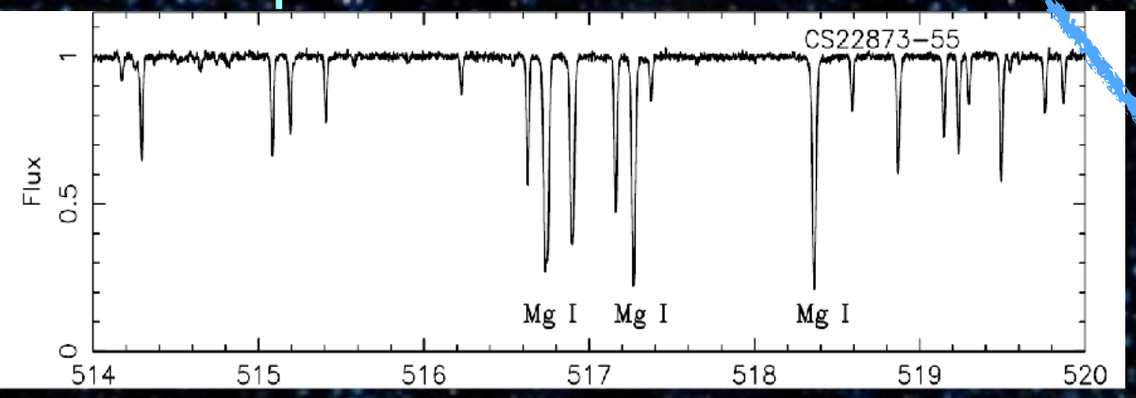
Gabriele Cescutti + all the MINCERS



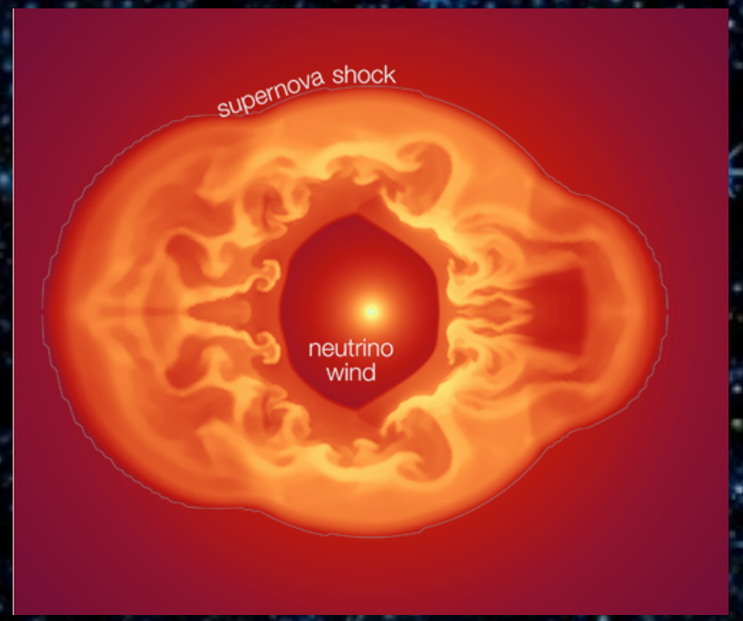
ChETEC GA 5 – Dresden, 18 September 2025

How to compare?

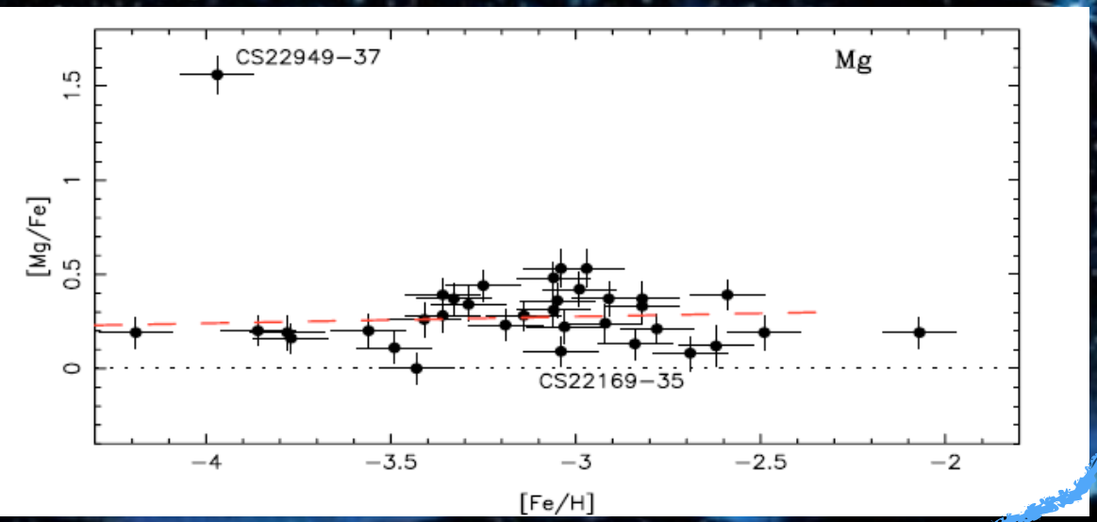
Stellar spectra



Stellar evolution

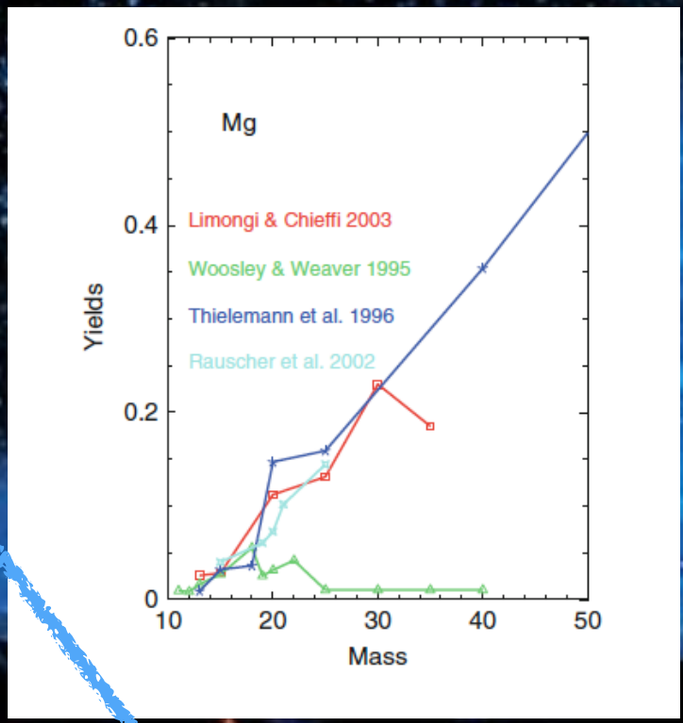


Stellar chemical abundances



Cayrel+04

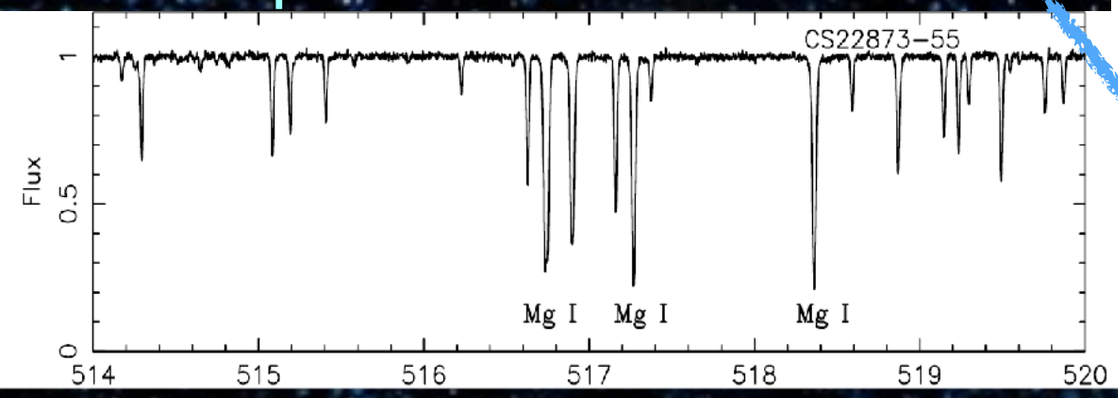
Nucleosynthesis

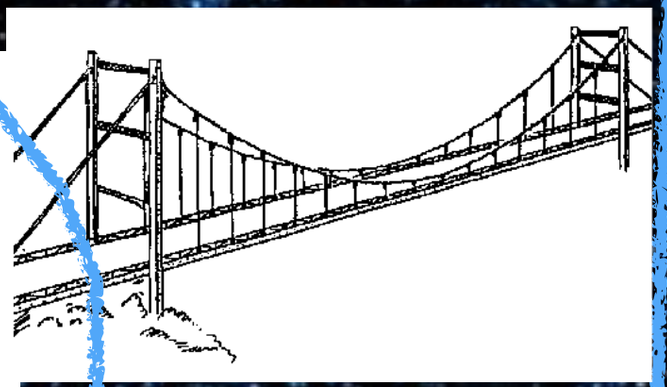


Romano+10

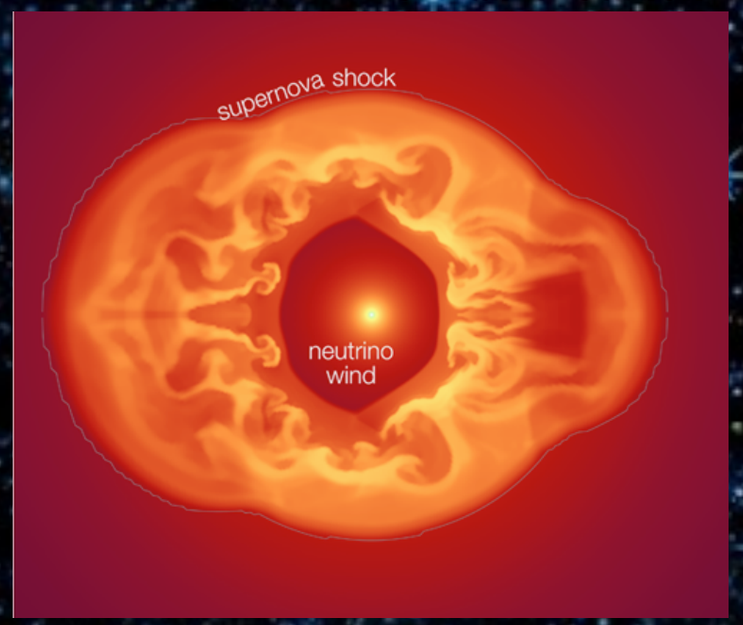
How to compare?

Stellar spectra

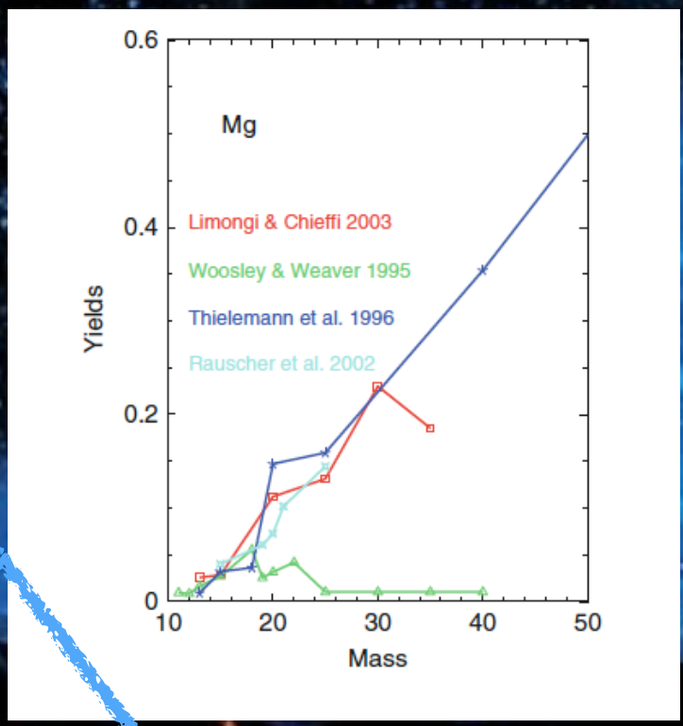




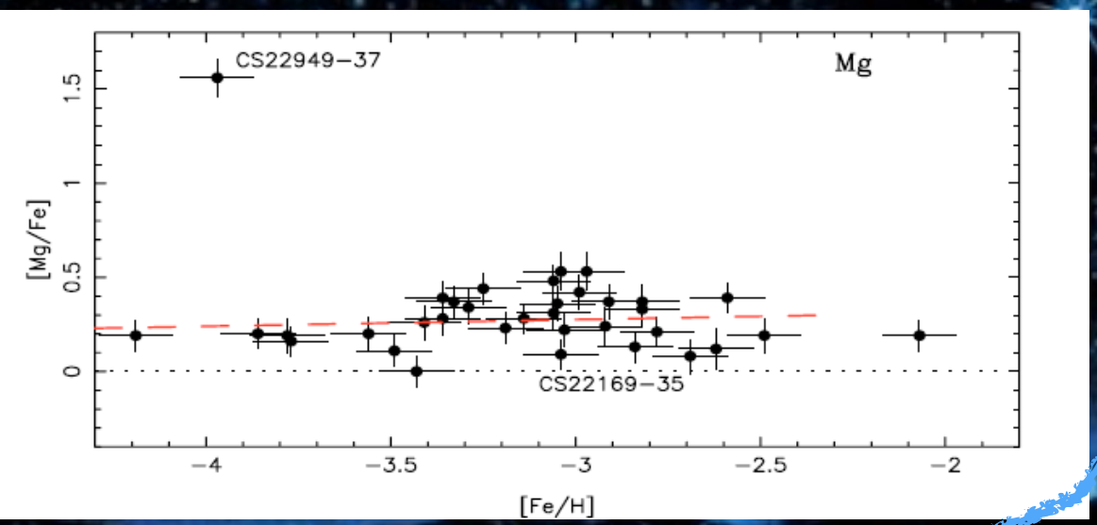
Stellar evolution



Nucleosynthesis



Stellar chemical abundances

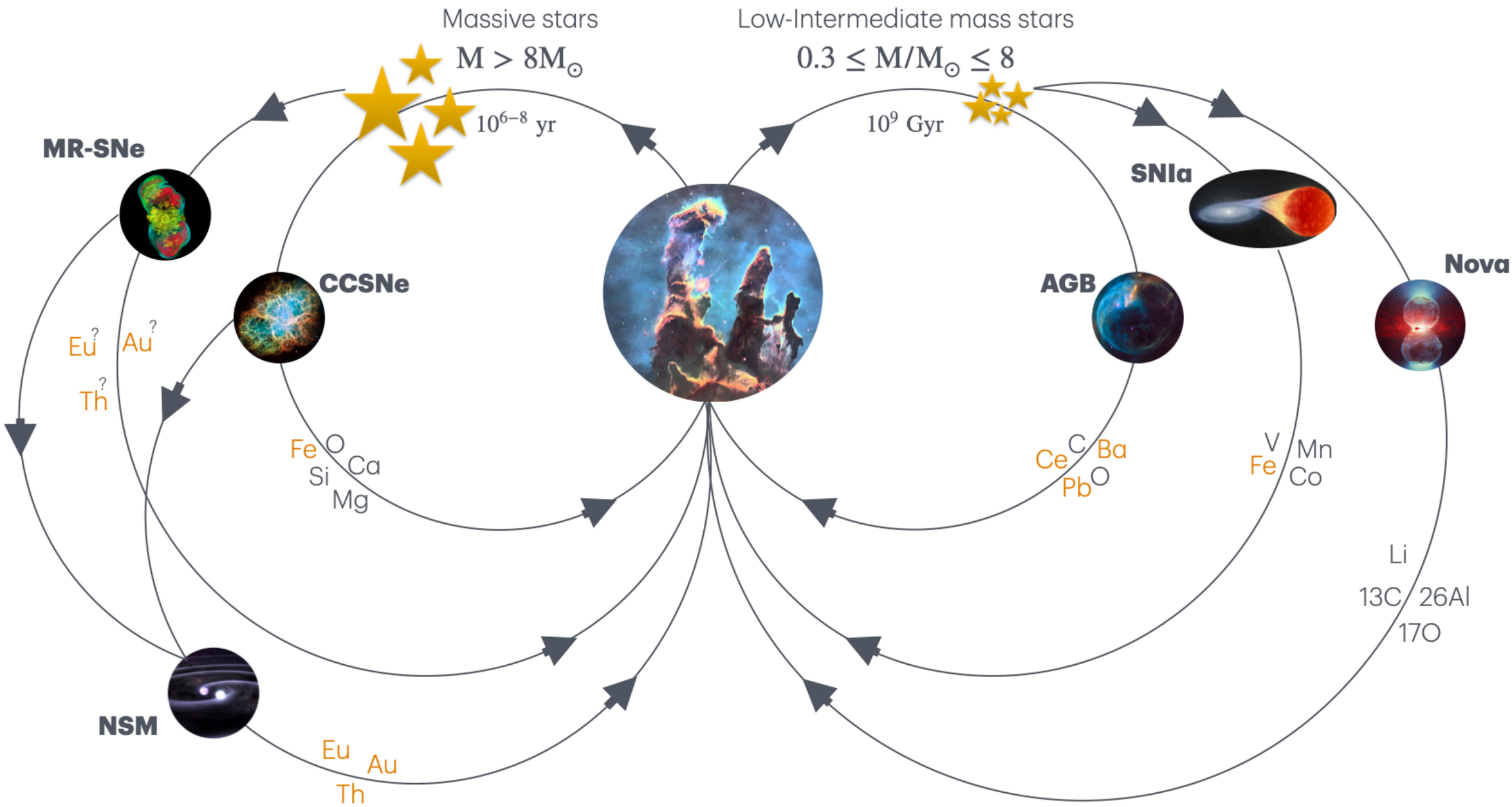


Cayrel+04

Romano+10

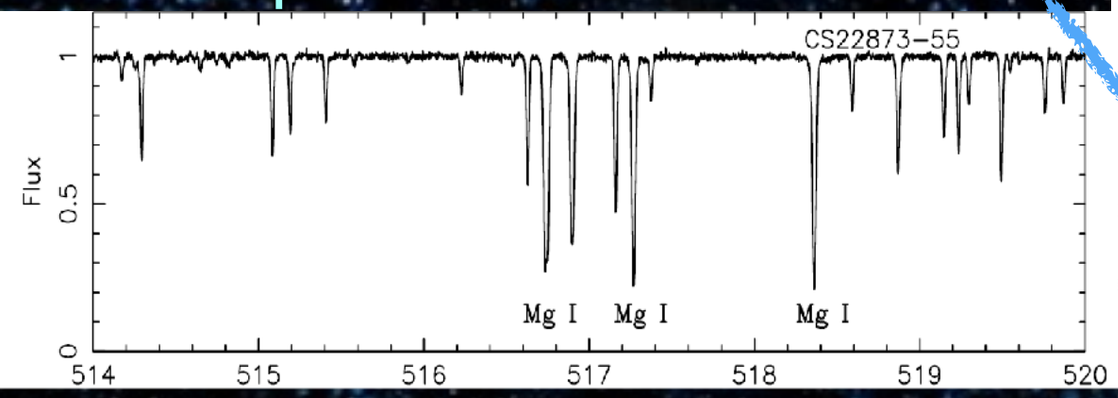
Chemical evolution

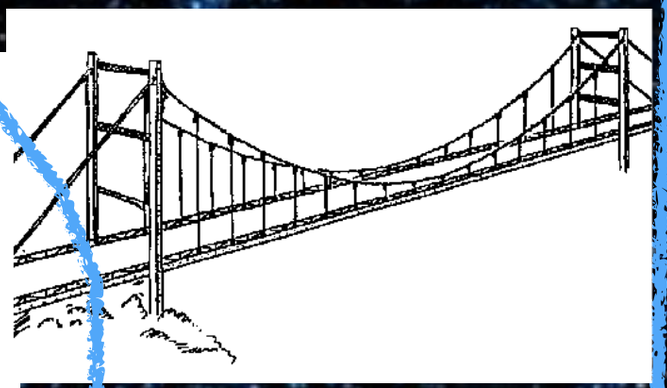
Credits: Marta Molero



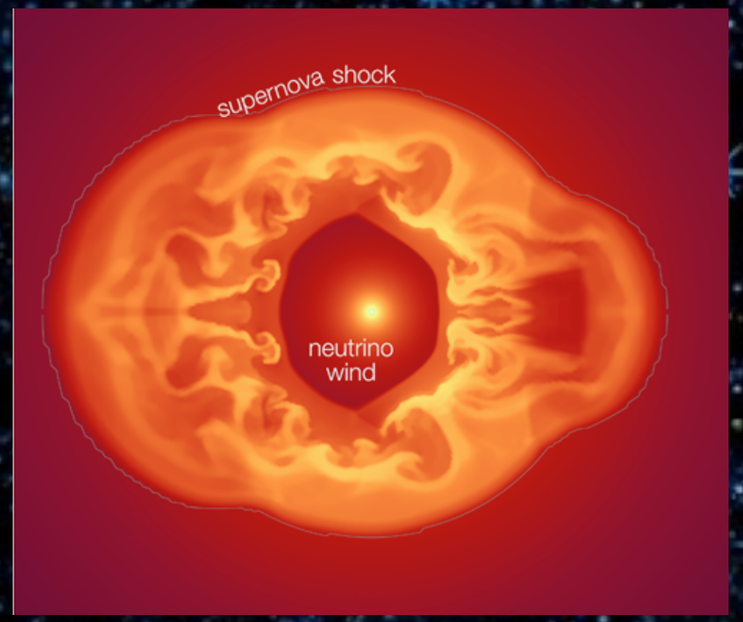
Chemical evolution models

Stellar spectra



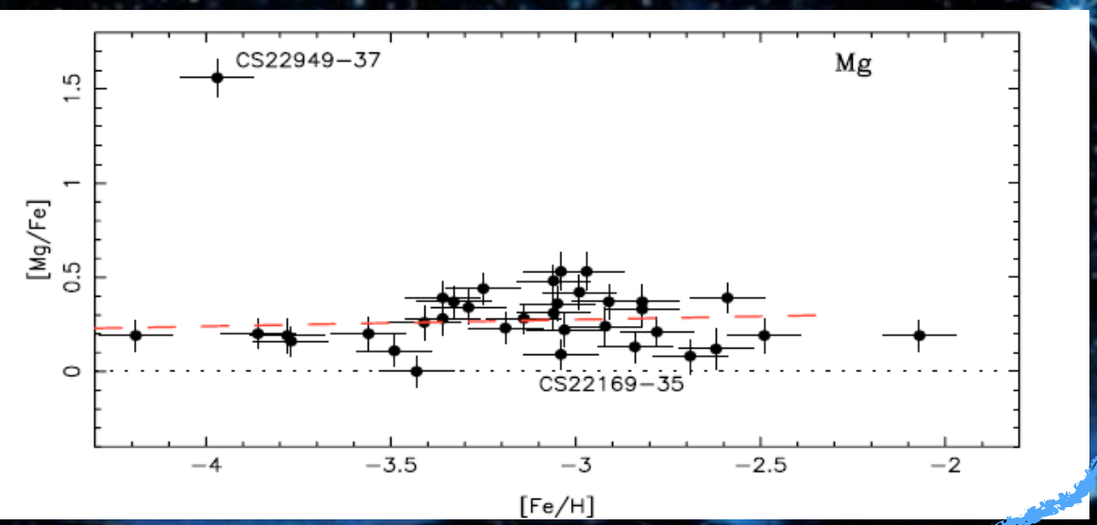


Stellar evolution

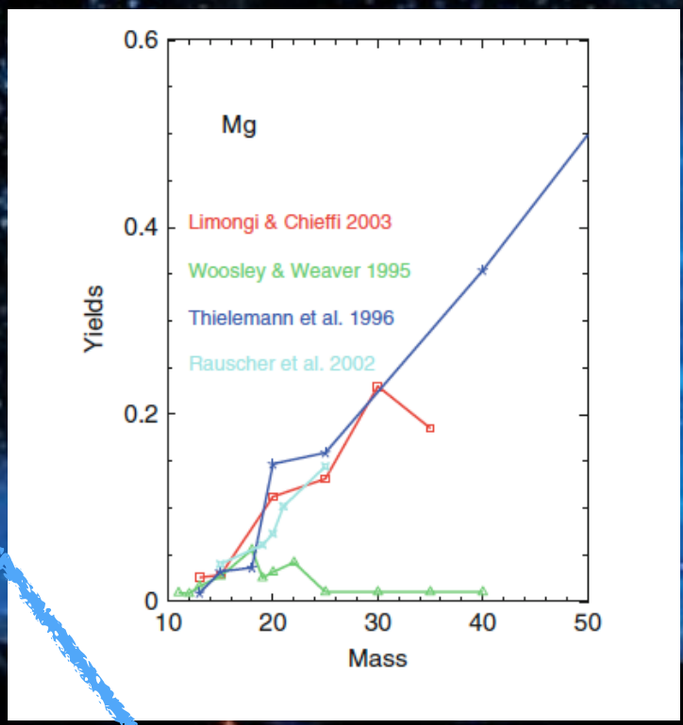


Nucleosynthesis

Stellar chemical abundances



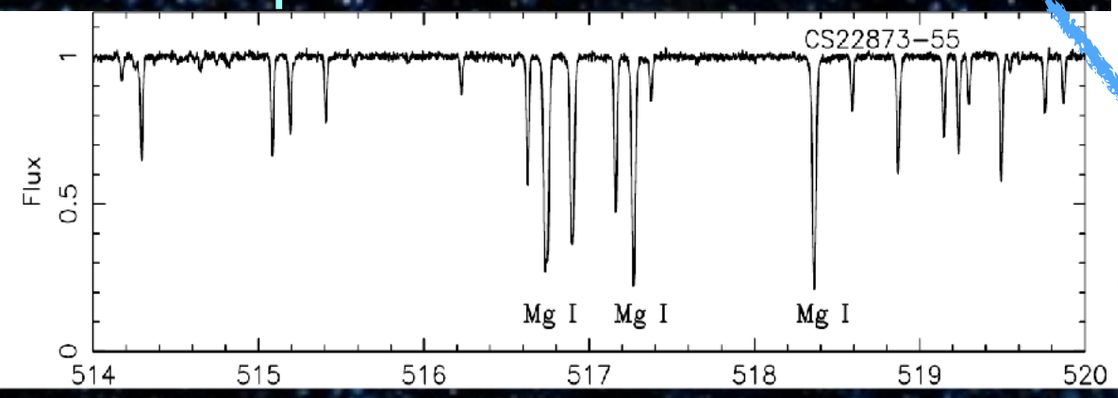
Cayrel+04

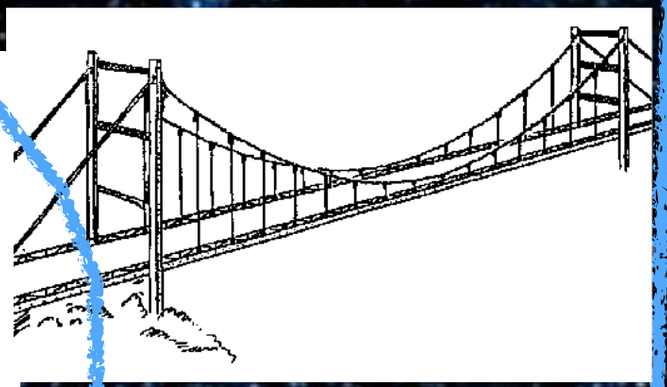


Romano+10

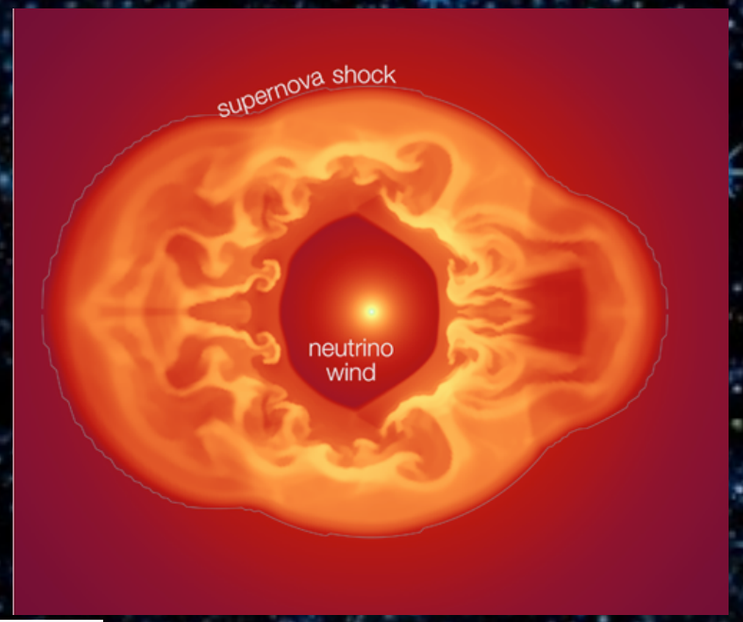
Chemical evolution models

Stellar spectra





Stellar evolution



Nucleosynthesis

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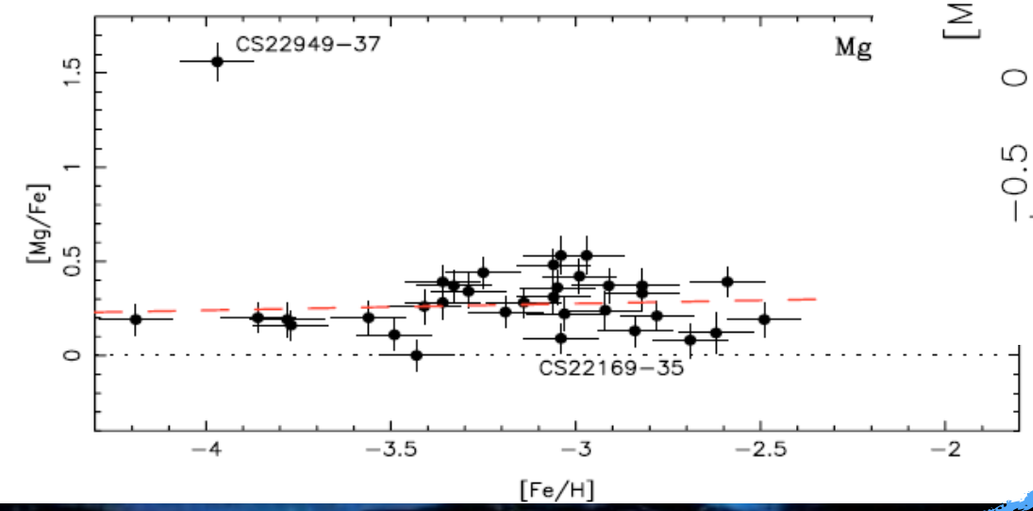
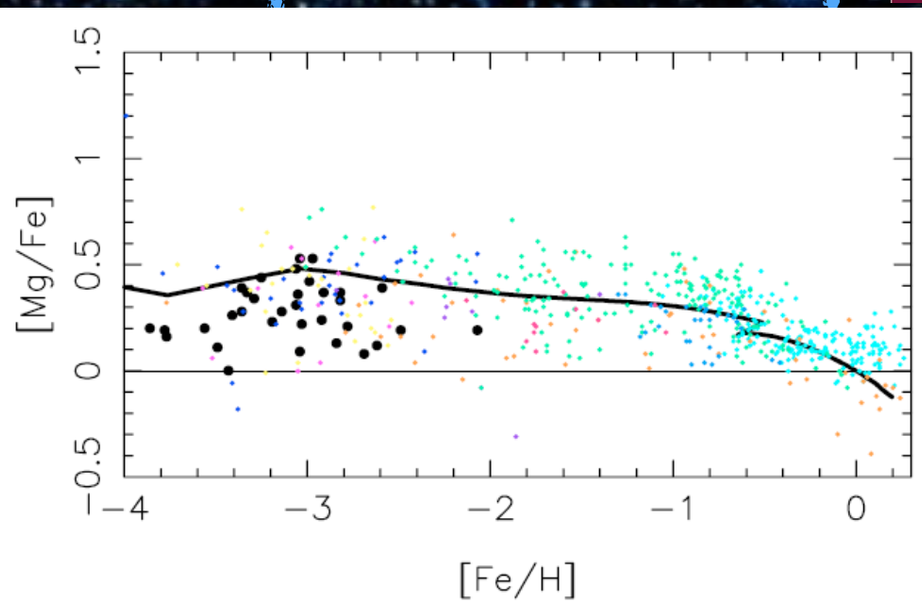
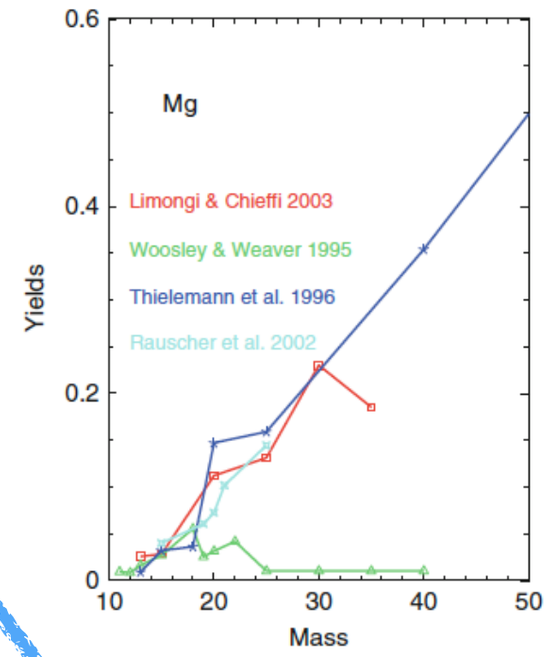




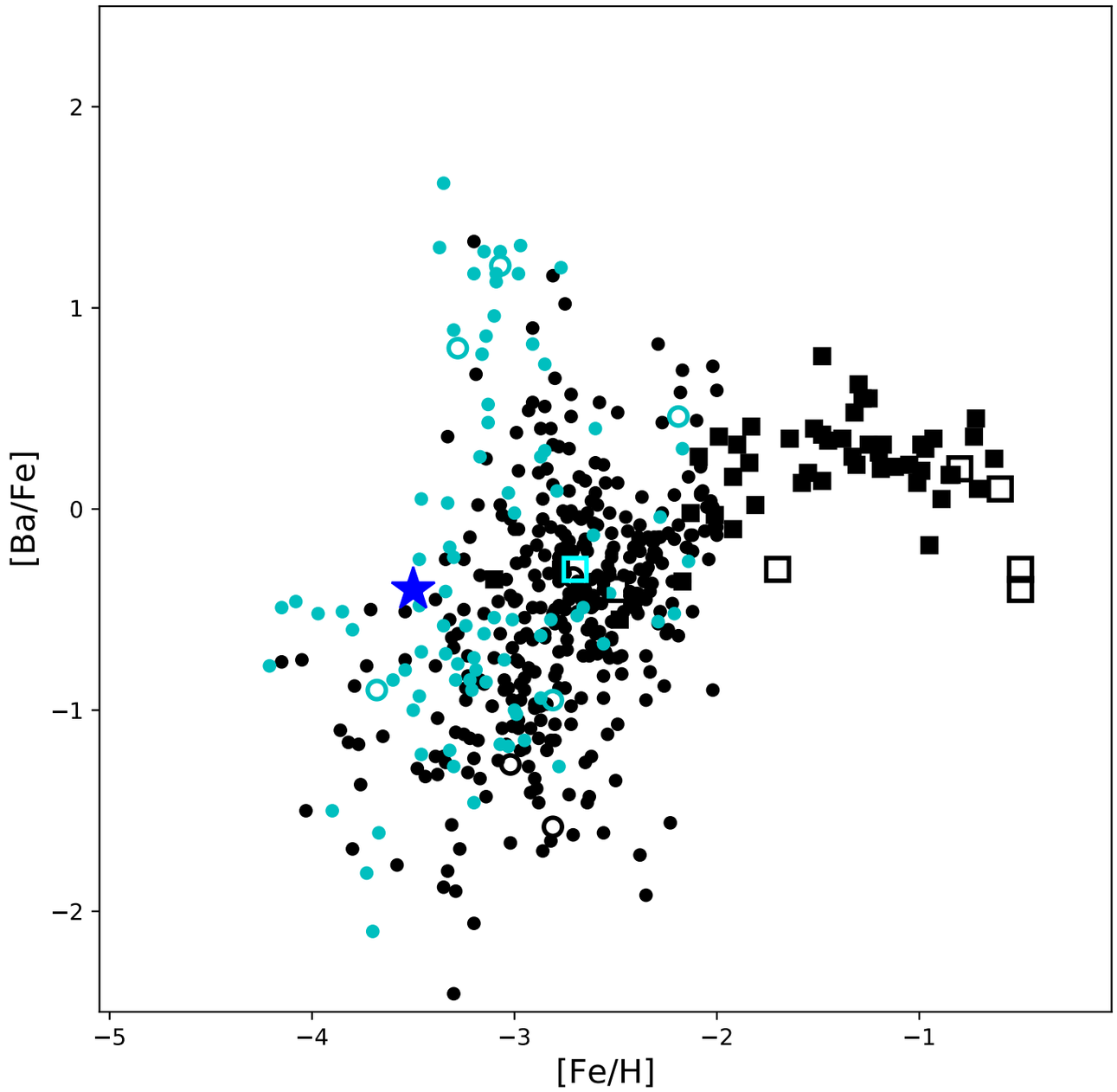


Cayrel+04

Francois+04

Romano+10

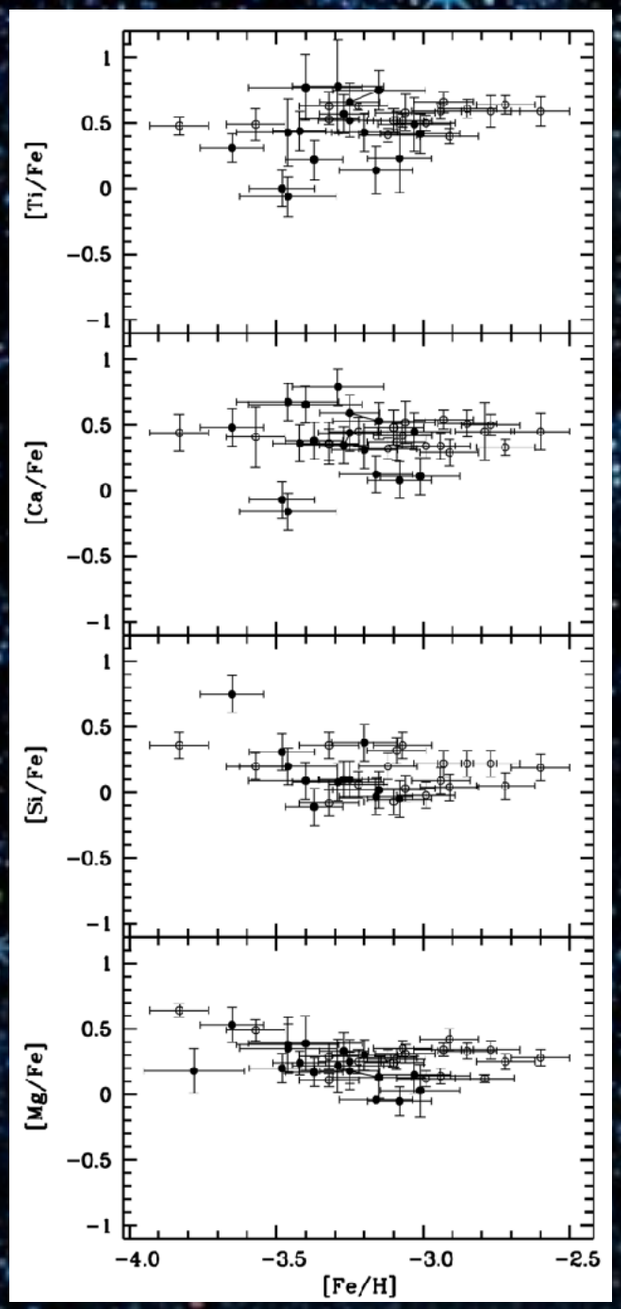
What about neutron capture elements?

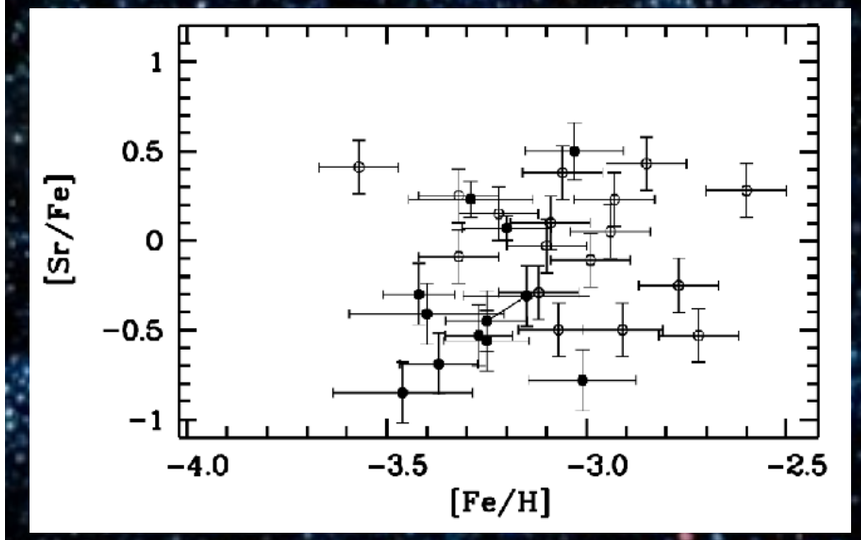


data from in
Placco+14
Hansen+12
Hansen+16
Cescutti+16

Galaxy Evolution via Montecarlo Sampling

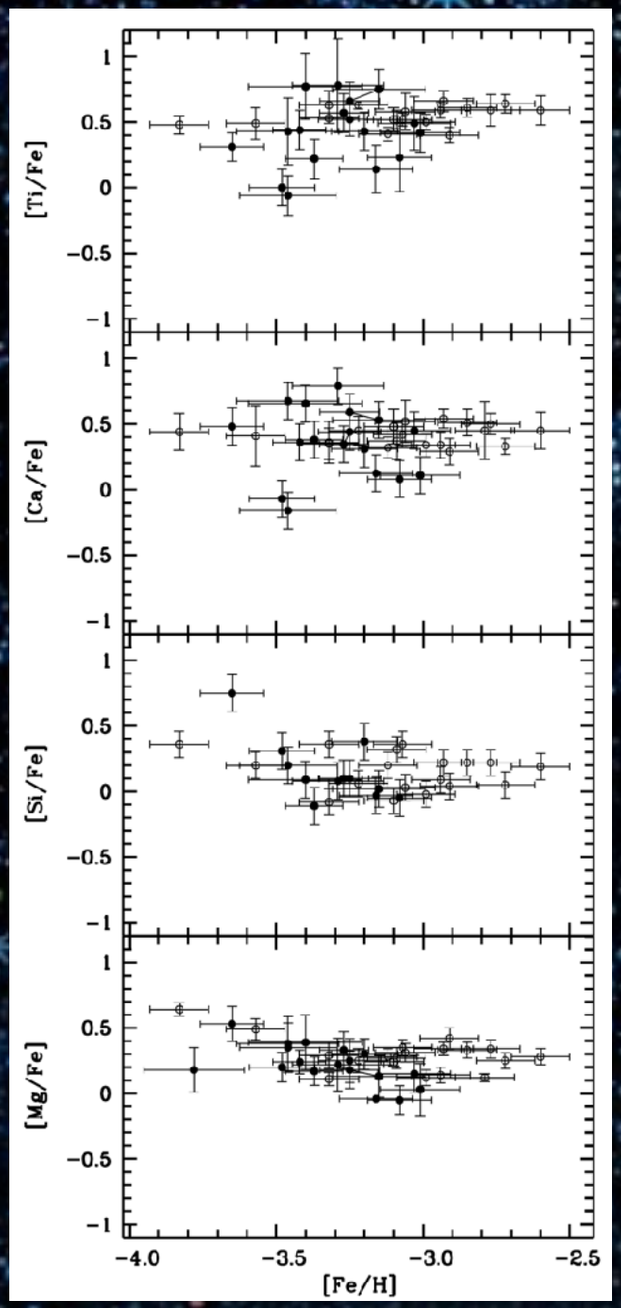
Problem:
Neutron capture elements present
a spread alpha elements do not





Bonifacio+12

Galaxy Evolution via Montecarlo Sampling



Bonifacio+12

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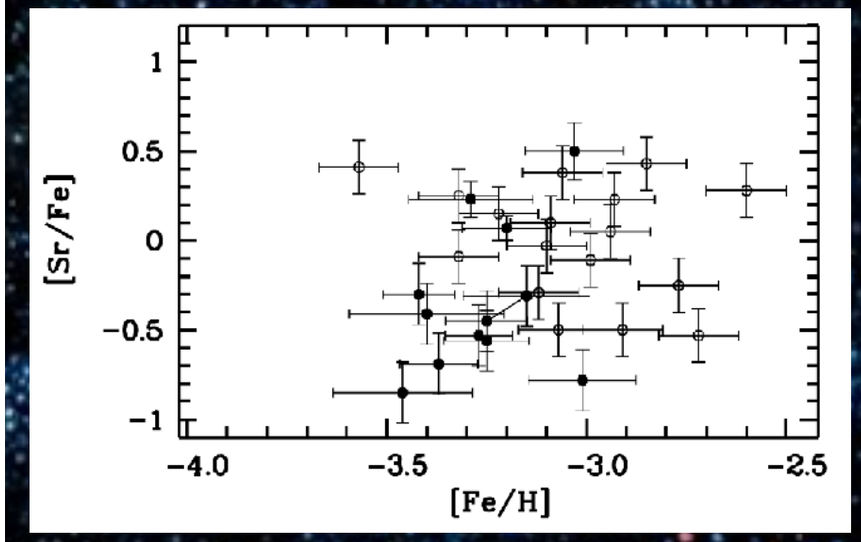
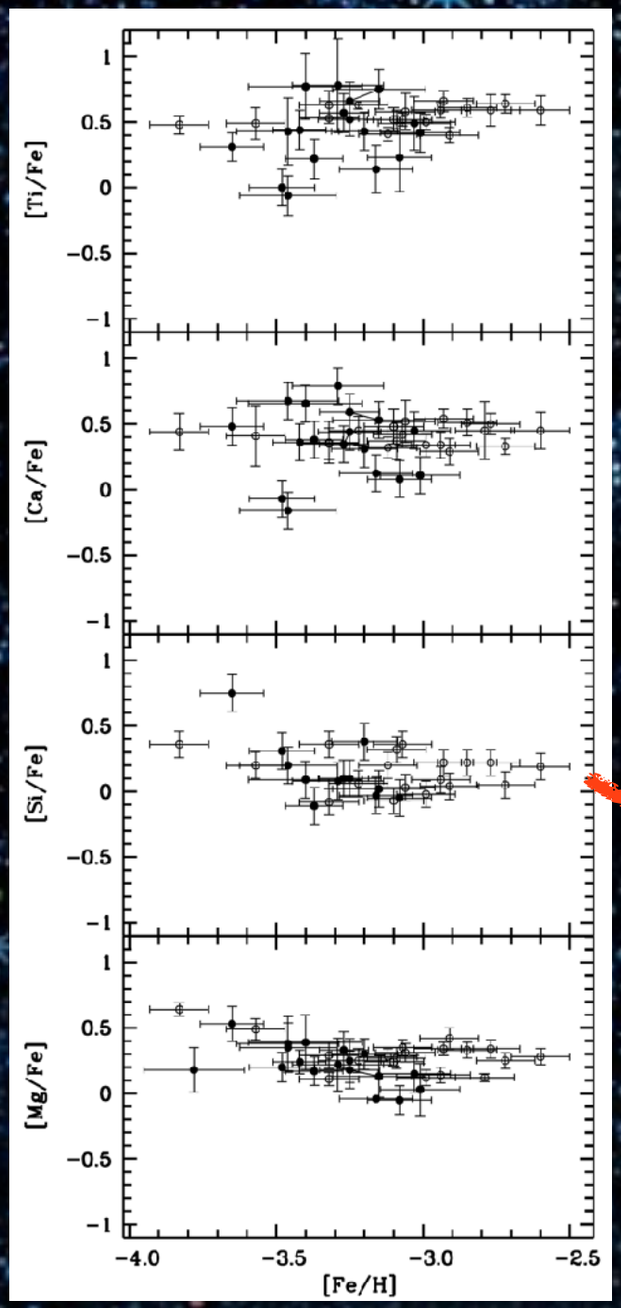


Solution:
The volumes in which the ISM is well mixed are discrete. Assuming a SNe bubble as typical volume with a low regime of star formation the IMF is not fully sampled.
This promotes spread among different volumes if nucleosynthesis of the element is is different among different SNe,

Galaxy Evolution via Montecarlo Sampling



Bonifacio+12

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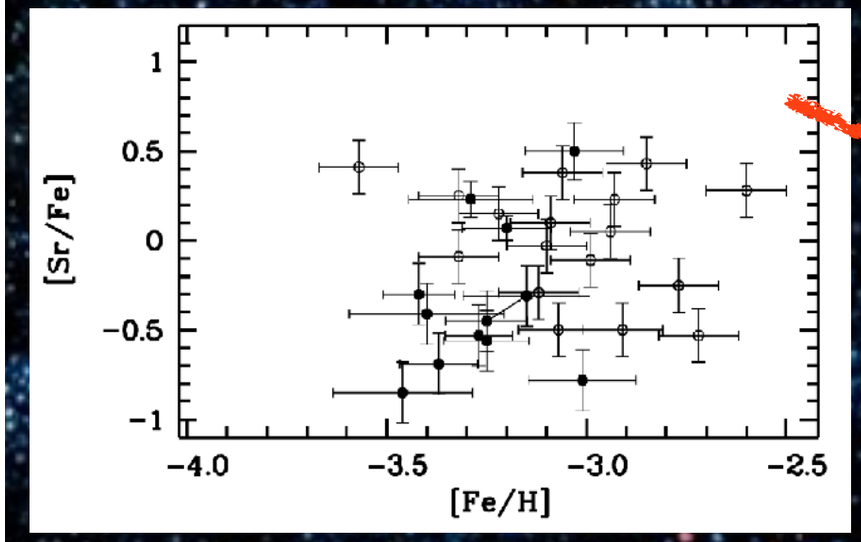

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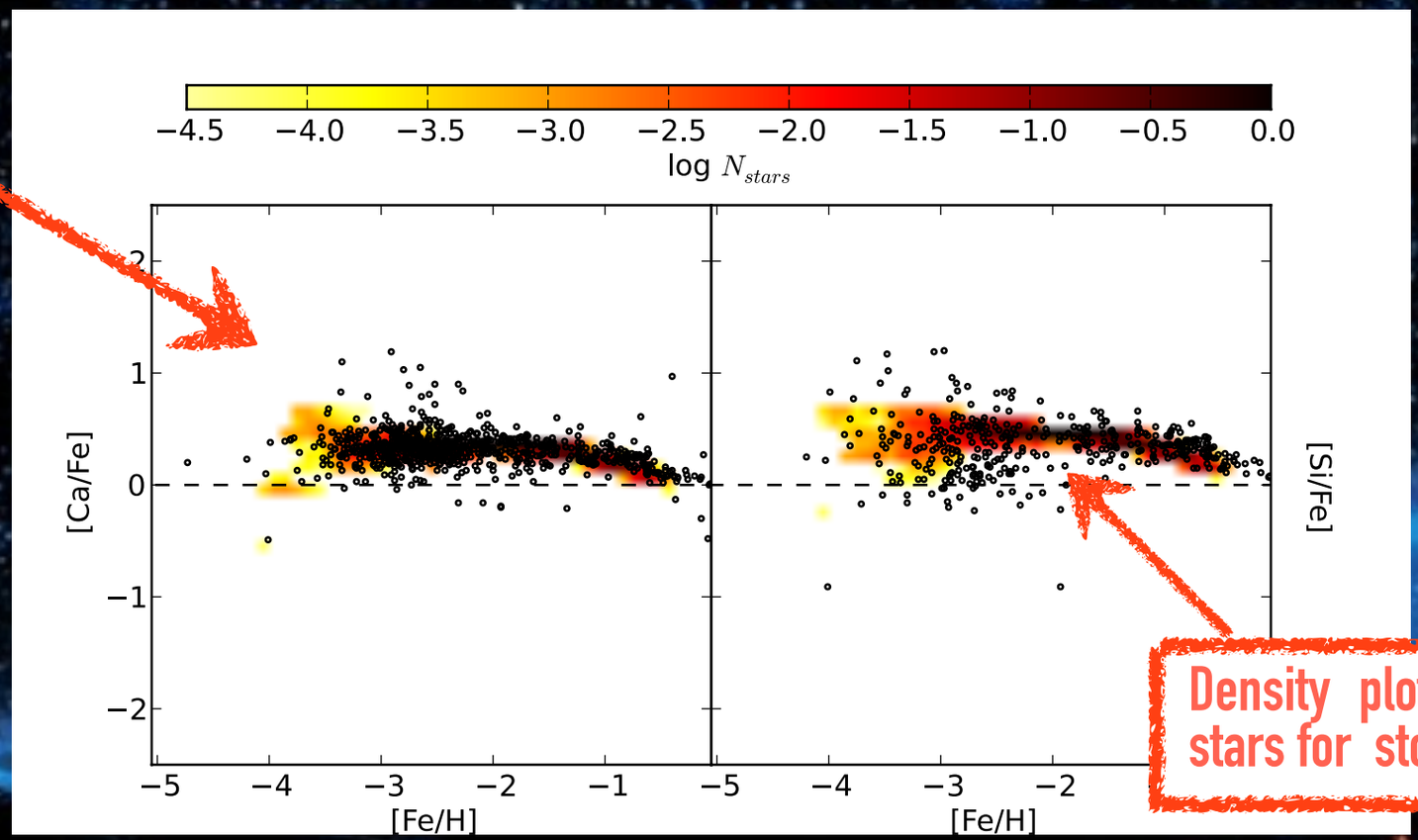


Density plot of long living stars for stochastic model

Cescutti 2008
Cescutti et al. 2013

data collected in Frebel 2010

Galaxy Evolution via Montecarlo Sampling

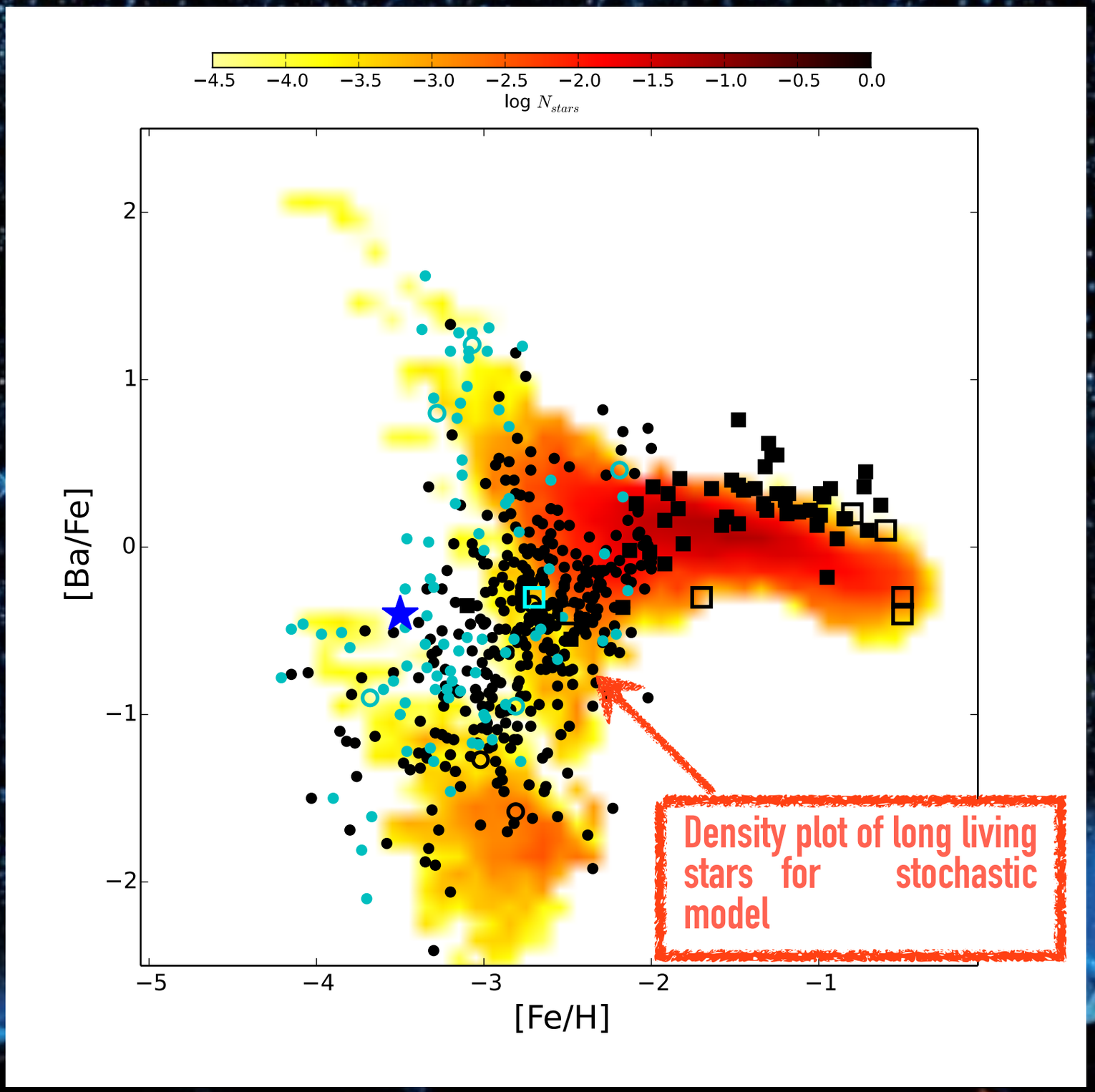
We run the stochastic model (based on Cescutti '08) with these yields for the Ba production:

r-process

10% of all the massive stars produce

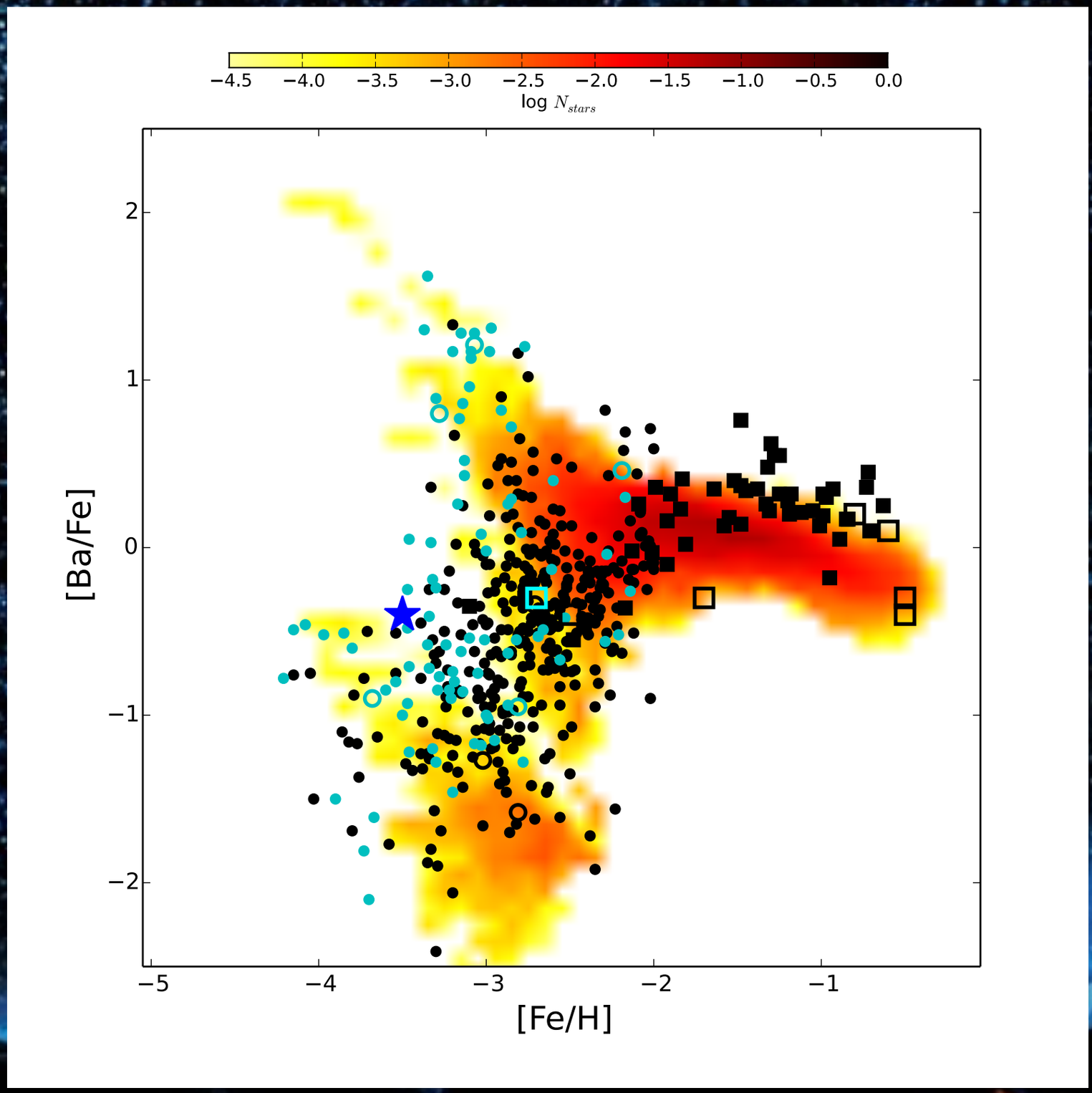
s-process

- rotating massive stars
- AGB

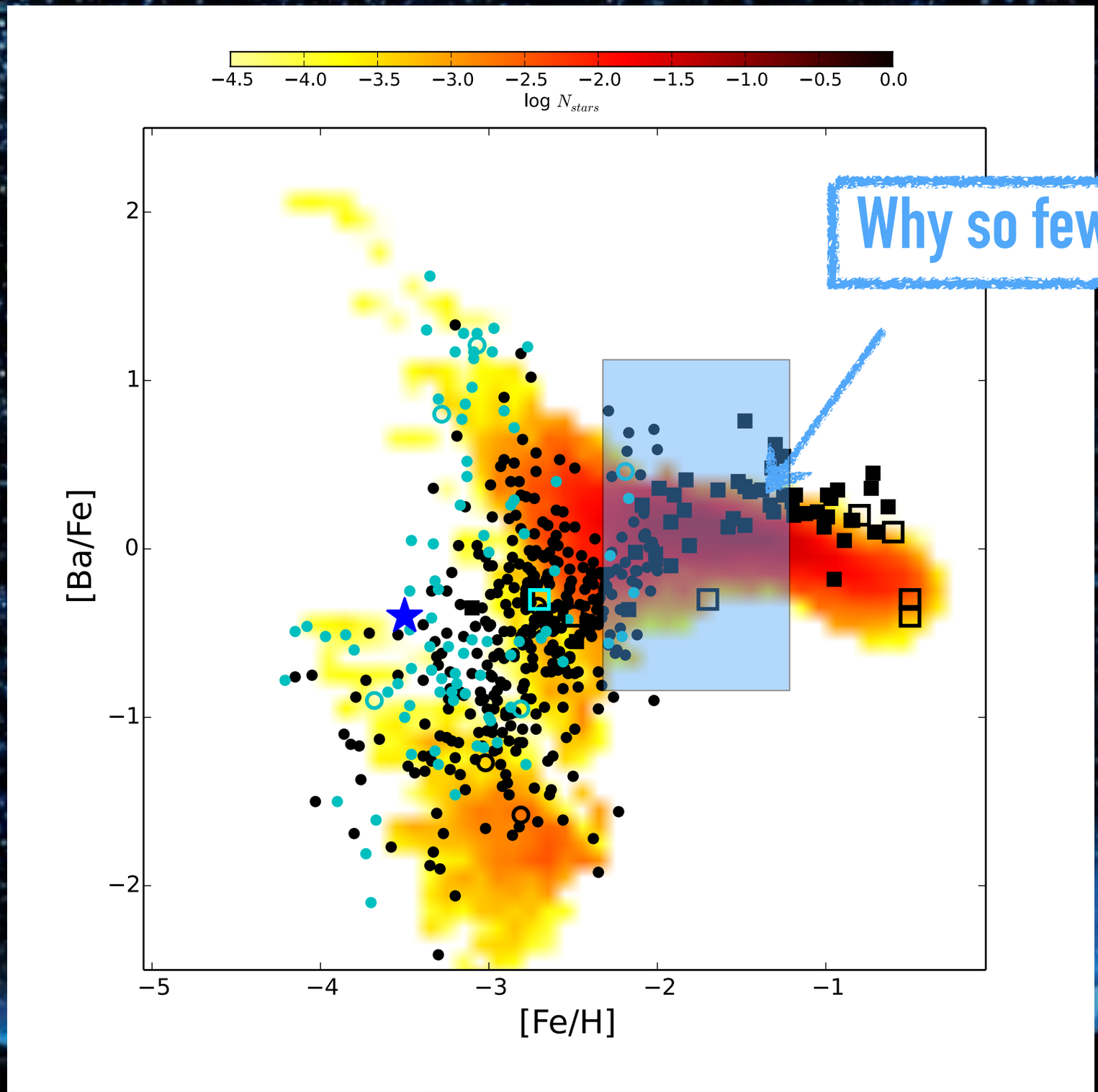


We can reproduce the [Ba/Fe] spread

Galaxy Evolution via Montecarlo Sampling



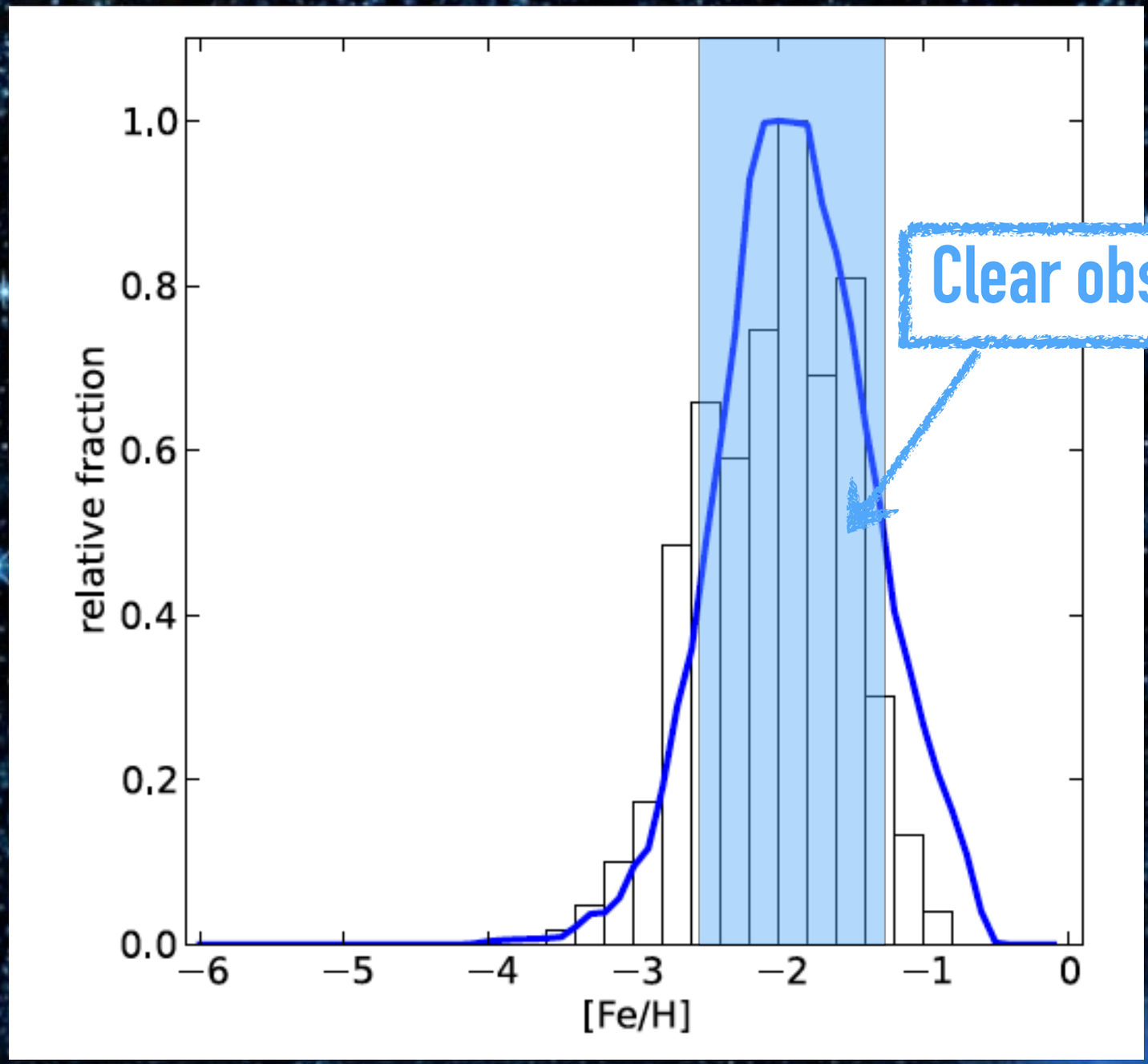
Galaxy Evolution via Montecarlo Sampling



Why so few stars here?

data from in
Placco+14
Hansen+12
Hansen+16
Cescutti+16

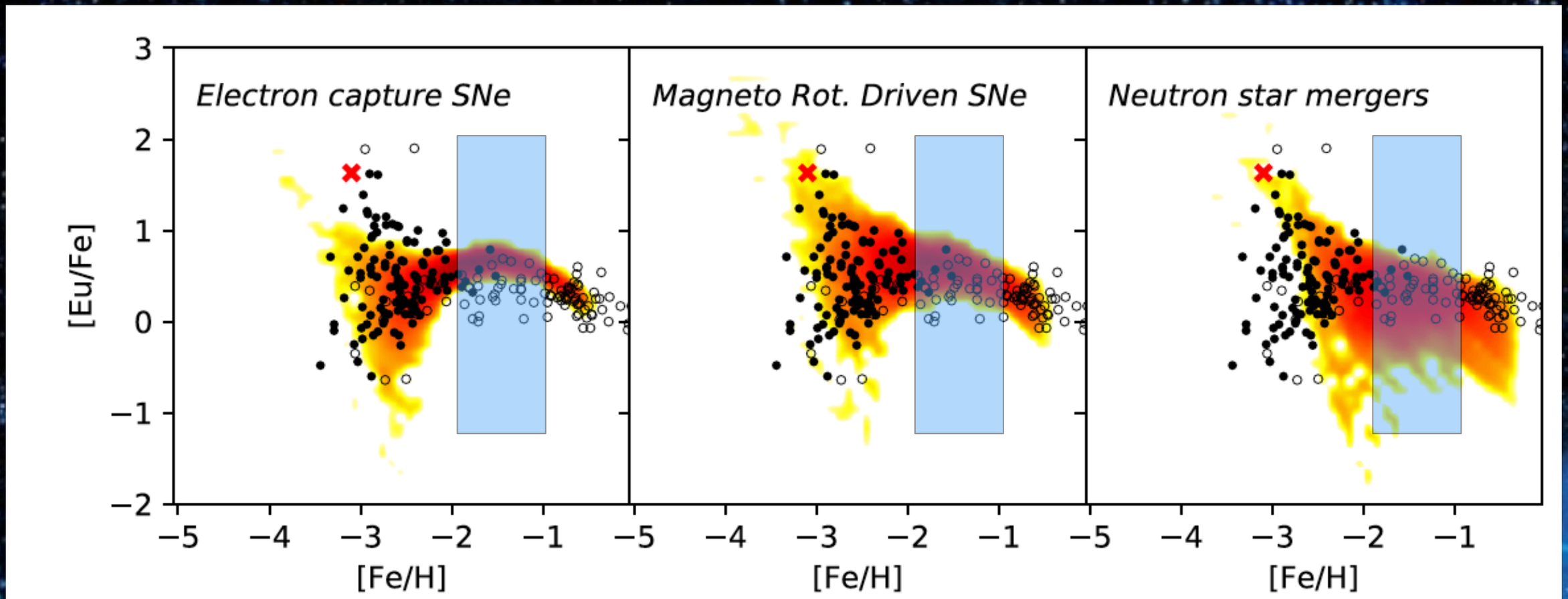
Metallicity distribution function of the Galactic halo



Clear observational bias

Li et al. (2010): main-sequence turnoff stars in the HESS (Hamburg ESO)

Important region to study!



Cavallo+21

What can we do?

Measuring nc elements is demanding!

—> High Resolution spectroscopy

—> high S/N

However . . .

we are not looking for the most metal poor stars,

just honest halo giants . . .

(giants better suited for measuring the nc elements lines)

Nature is generous:

it provides a lot of them in our Galaxy, and

some (>1000) are close enough to be measured

with 2-4m telescopes (V<10-11)

MINCE

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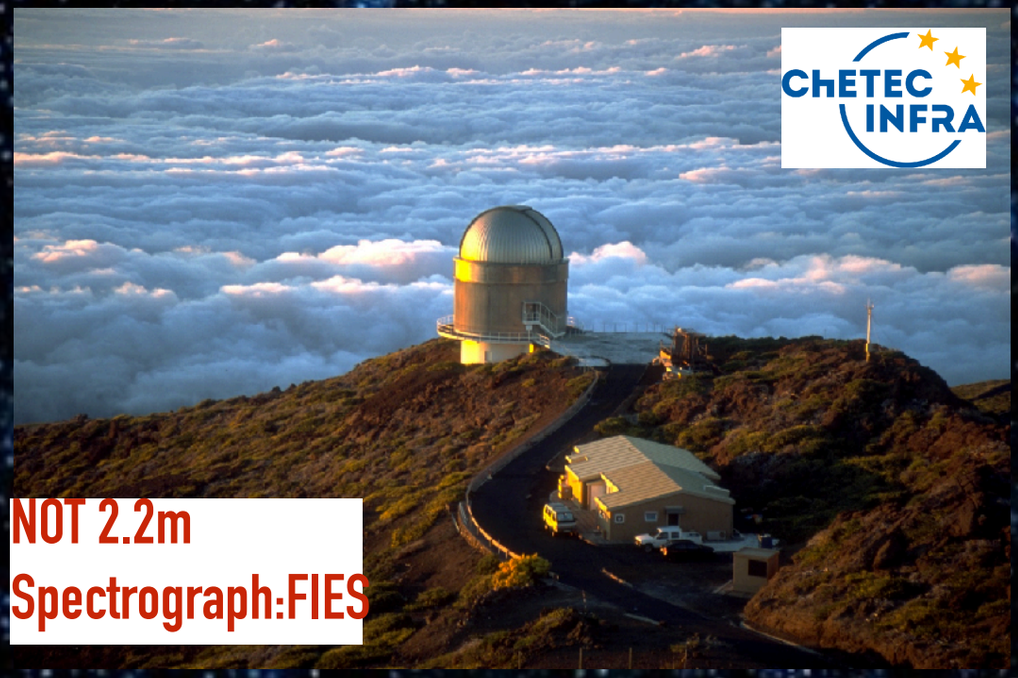
MINCE

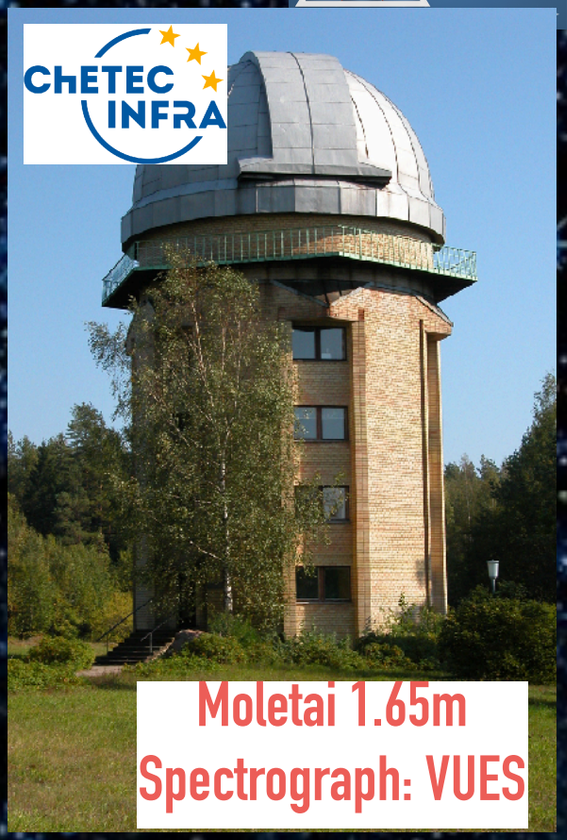
9 Facilities used
2 from ChETEC-INFRA

TNG 3.58m
Spectrograph HARPS-N

VLT 8.2m
Spectrograph: UVES



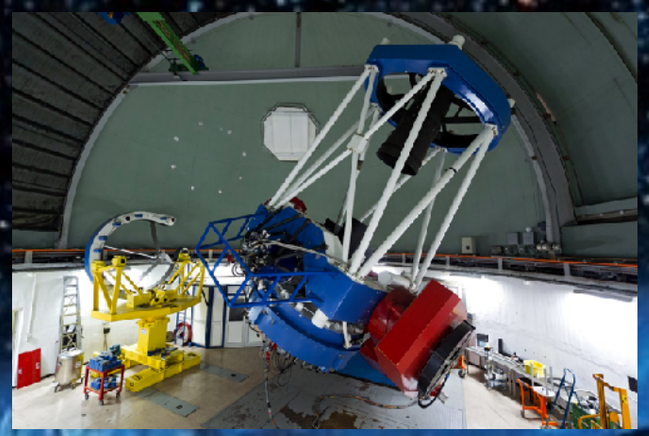
NOT 2.2m
Spectrograph:FIES



Moletai 1.65m
Spectrograph: VUES

OHP 1.93m
Spectrograph SOPHIE

CFHT: 3.58m
Spectrograph ESPaDOnS



MPG/ESO 2.2-metre
FEROS

Magellan 6.5m
Spectrograph: MIKE

Observation summary before ChETEC INFRA

Awarded time by MINCE project

telescope	instrument	time	targets	status
A40-41 TNG	HARPS-N	21 h	31	observed
A42 TNG	HARPS-N	1n	12	observed
A43 TNG	HARPS-N	1n	16	observed
CFHT 2019B+20A	ESPaDOnS	30h	12	observed
CFHT 2020B	ESPaDOnS	24.5h	6	observed
OHP 2019B+20A	Sophie	6n	42	observed
TBL 2020A	NeoNArval	13h	12	observed (reduction problematic)
2019B 2.2m	FEROS	4n	65(72)	observed (2n cancelled)
2020B 2.2m	FEROS	2n	65	observed
Magellan	MIKE	2n	14 (20)	observed (1 night cancelled)
VLT ESO period 106-107	UVES	100h	100	observed
period 61, NOT	FIES	3n	16	observed
period 62, NOT	FIES	8h	8	observed
Moletai 1.65m	VUES	38n	24	observed

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 1: September 2021

Observer: Aroa del Mar Matas Pinto (Obs. de Paris)

PI Bonifacio

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 1: September 2021

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ChETEC-INFRA 1: September 2021

Observer: Aroa del Mar Matas Pinto (Obs. de Paris)

PI Bonifacio

Ashes and dust. No Observations taken

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 3: April 2022

Observer & PI: Andreas Korn (Uppsala University)

PI Korn

"Given the poor seeing/transparency/high winds throughout, we probably managed to get ~30% of what we had planned. So 5 stars out of 16."

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 5: October 2022

Patrick Francois (Obs. de Paris)

PI Korn

I had some pointing constraints on night #1 and #2 due to rather strong wind . . .

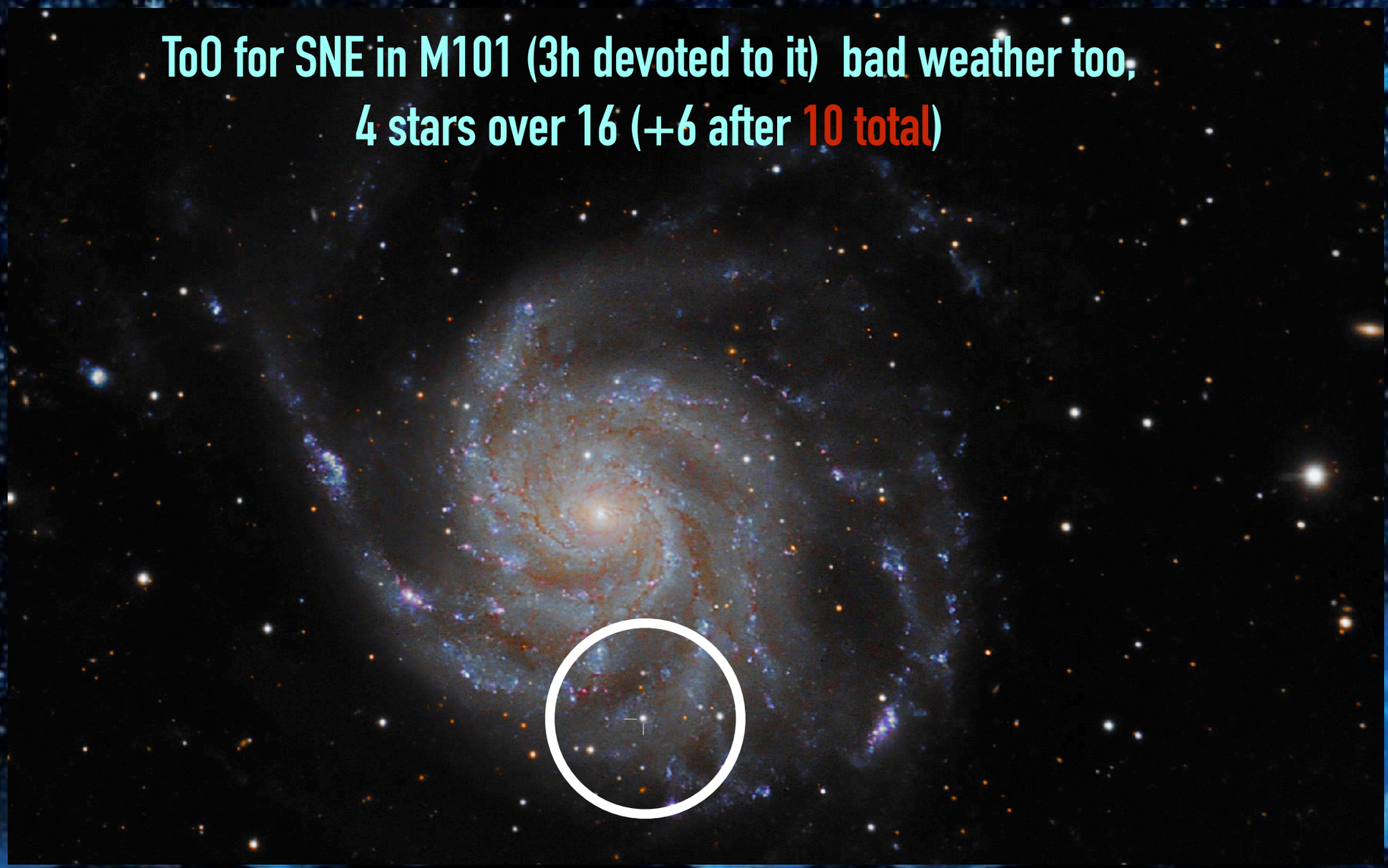
The last night was perfect. 16 stars

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 7: May 2023

Observer: Marica Valentini (AIP)

ToO for SNE in M101 (3h devoted to it) bad weather too,
4 stars over 16 (+6 after 10 total)



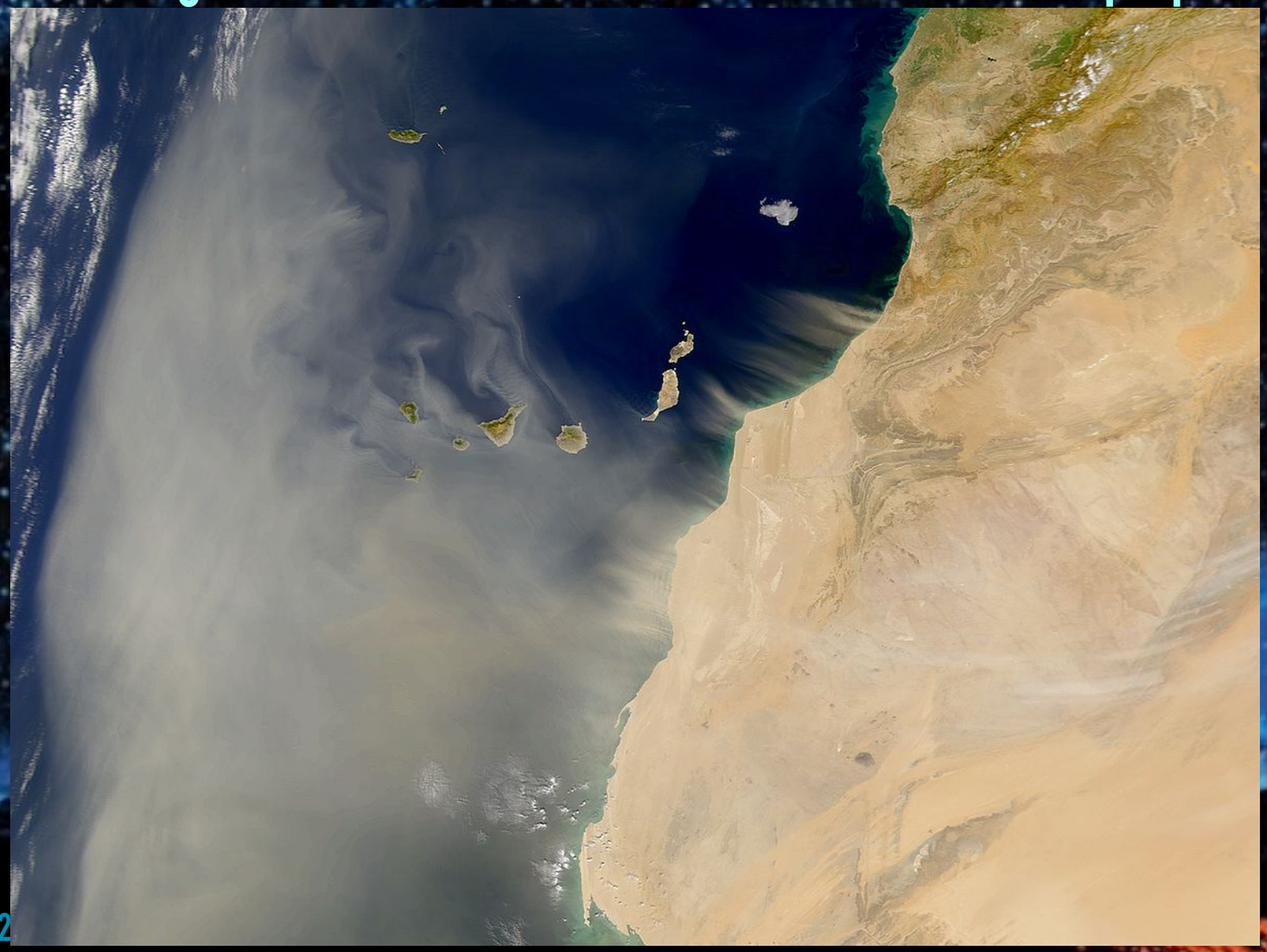
PI Korn

Observations thanks to ChETEC-INFRA

ChETEC-INFRA 11: August 2024

Observer: Johannes Puschnig (Uppsala University)

Calima (dust) and scattered cloud during the first two nights, PI Cescutti
final night offered good conditions. 9 of the 16 stars listed in the proposal;



Observations thanks to ChETEC-INFRA

ChETEC-INFRA 13: January 2025

Observer: Lapo Sgatti (Trieste University)

PI Cescutti

2 ToO + the last night lost for bad weather 19 stars taken

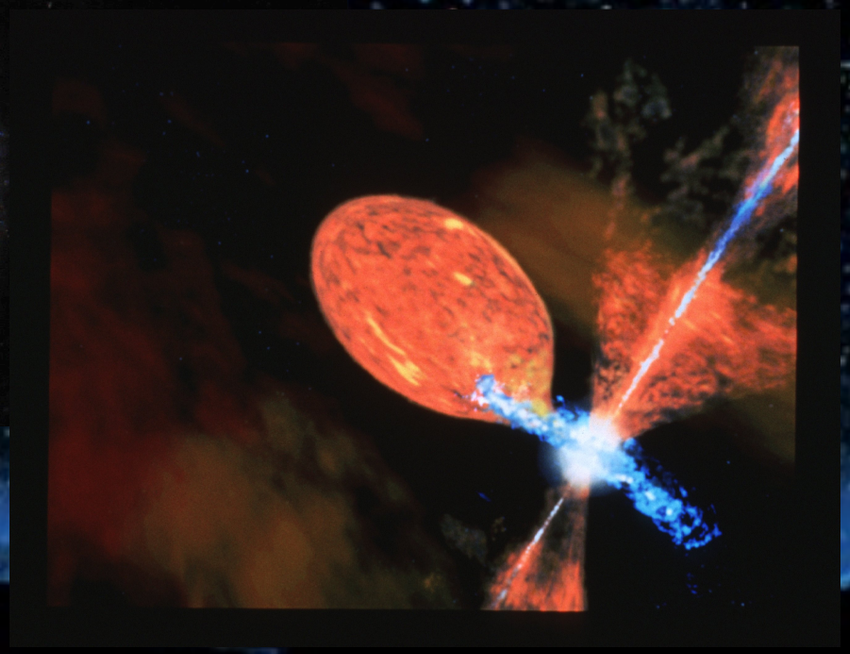
Observations thanks to ChETEC-INFRA

ChETEC-INFRA 15: August 2025

Observer: Lapo Sgatti (Trieste University)

16 stars a ToO was accepted and carried out +
a photometric observation of the symbiotic stars R Aquarii was done +
mechanical problems (2h last night)

PI Cescutti



Who is Lapo Sgatti?
PhD at Trieste University . . .

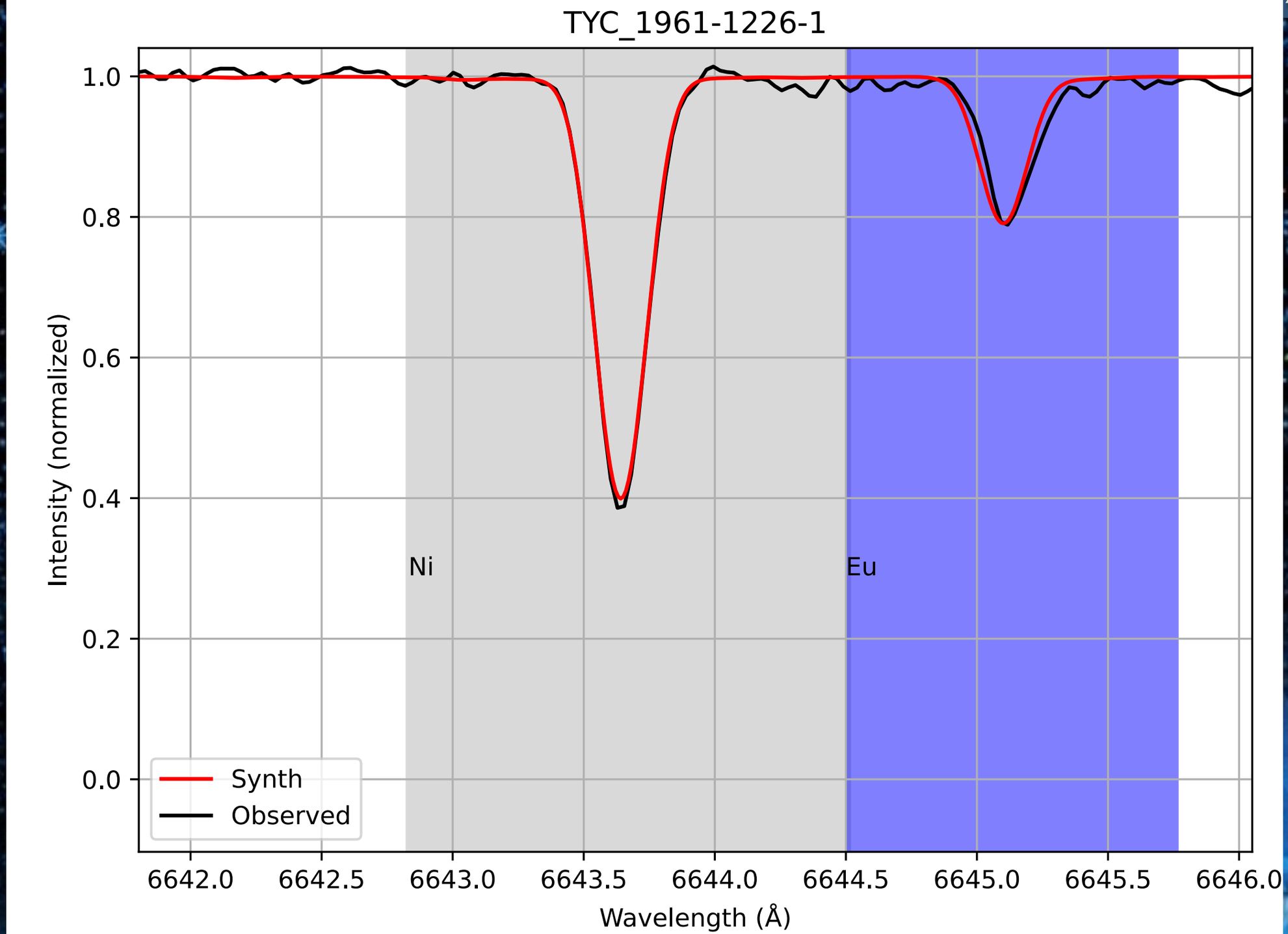
ChETEC INFRA Observational School (ChINOS)

student!

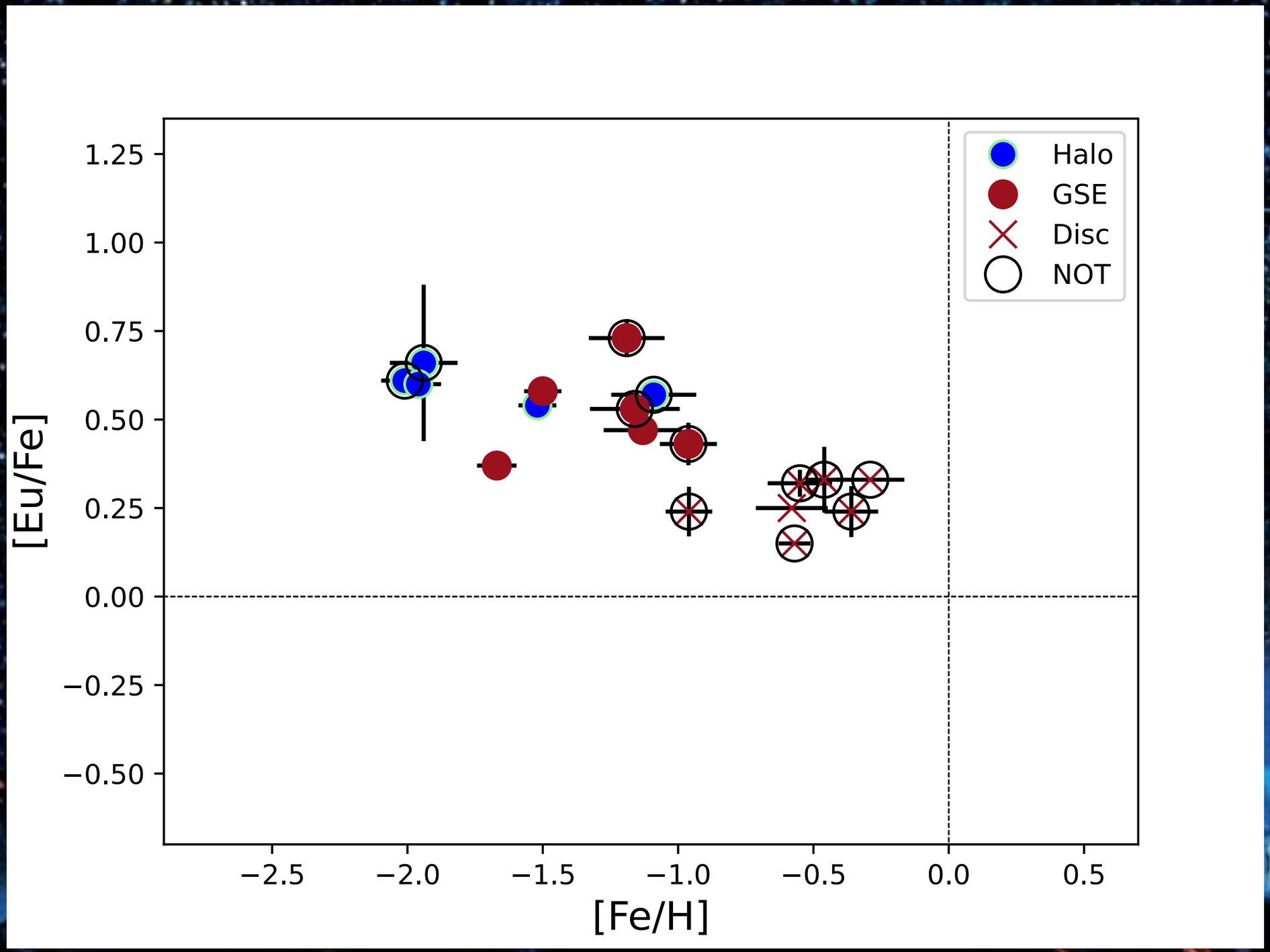
Annika Schichtel

Lapo Sgatti

Example of stellar spectrum



New results by Lapo (analysis ongoing)



~400 stellar spectra before ChETEC INFRA
with high S/N and Resolution

75 stellar spectra from ChETEC INFRA

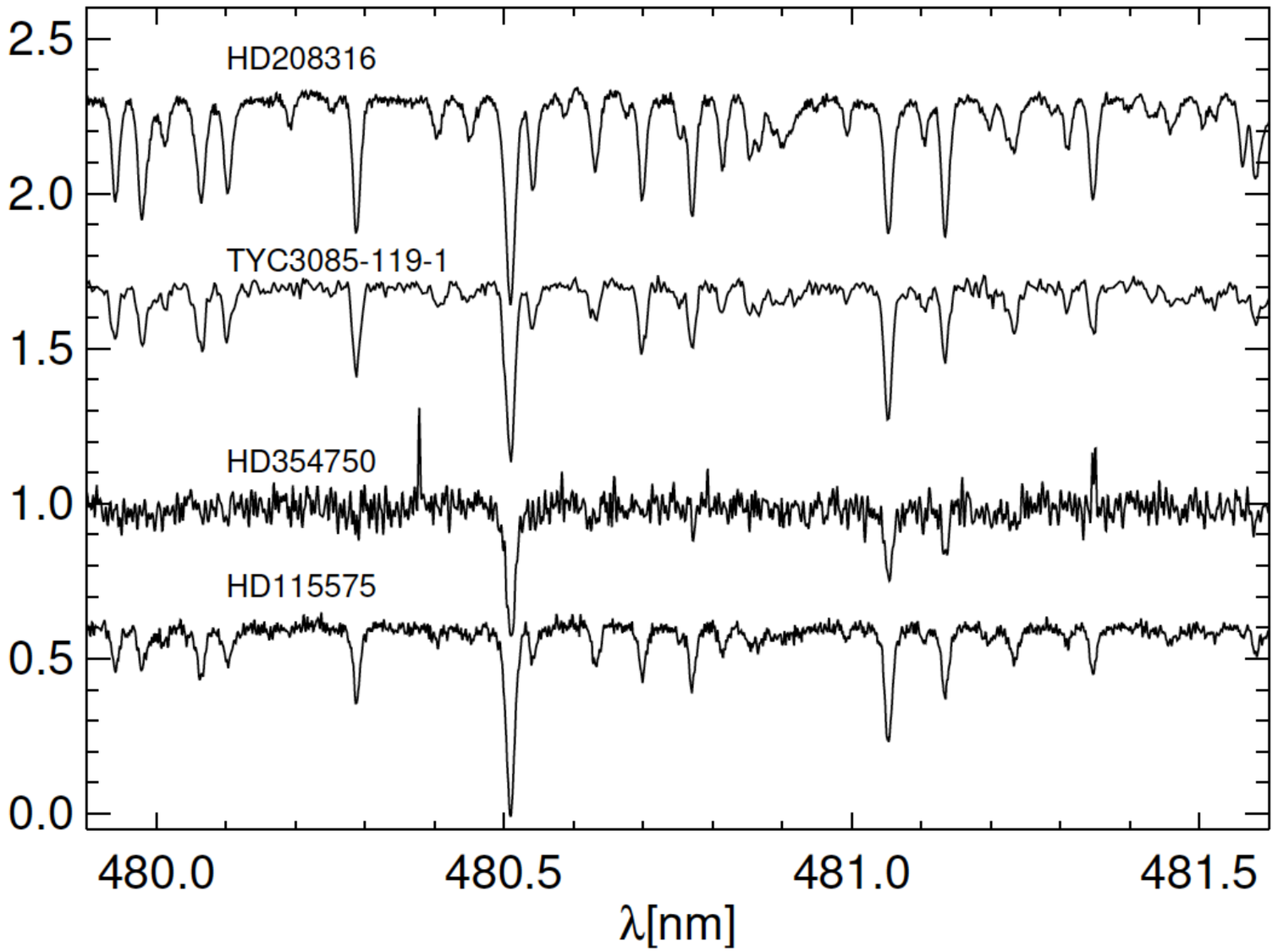
Around 20% of stellar spectra are now
from ChETEC-INFRA

Astronomy & Astrophysics manuscript no. MINCEI.01
November 14, 2022

MINCE I. Presentation of the project and of the first year sample⋆,⋆⋆

G. Cescutti[1,2,3], P. Bonifacio[4], E. Caffau[4], L. Monaco[5], M. Franchini[2], L. Lombardo[4], A.M. Matas Pinto[4]
F. Lucertini[5,6], P. François[4,7], E. Spitoni[8,9], R. Lallement[4], L. Sbordone[6], A. Mucciarelli[10,11], M. Spite[4],
C.J. Hansen[12], P. Di Marcantonio[2], A. Kučinskas[13], V. Dobrovolskas[13], A.J. Korn[14], M. Valentini[15], L. Magrini[16],
S. Cristallo[17,18], and F. Matteucci[1,2,3]

(Affiliations can be found after the references)

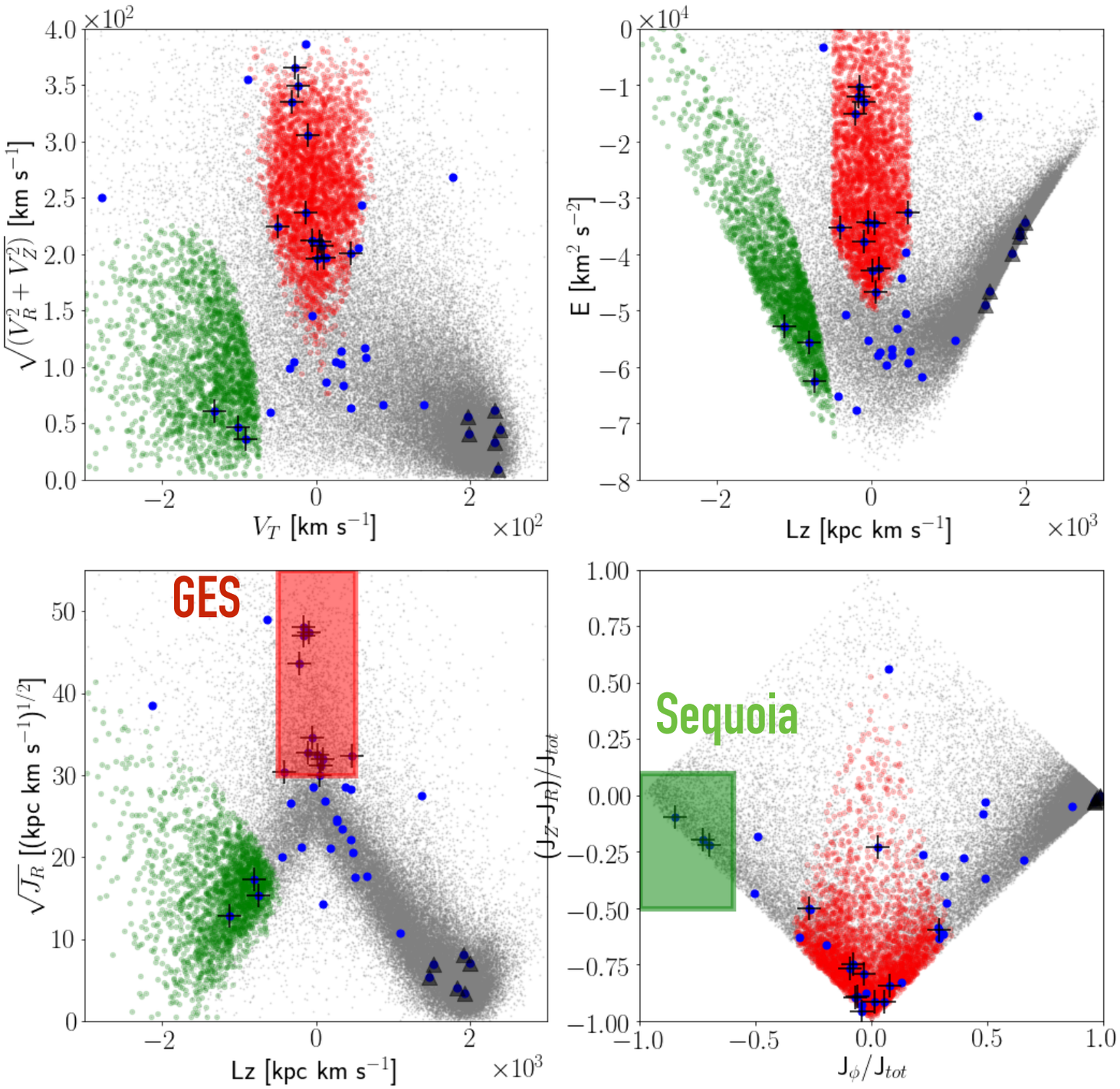


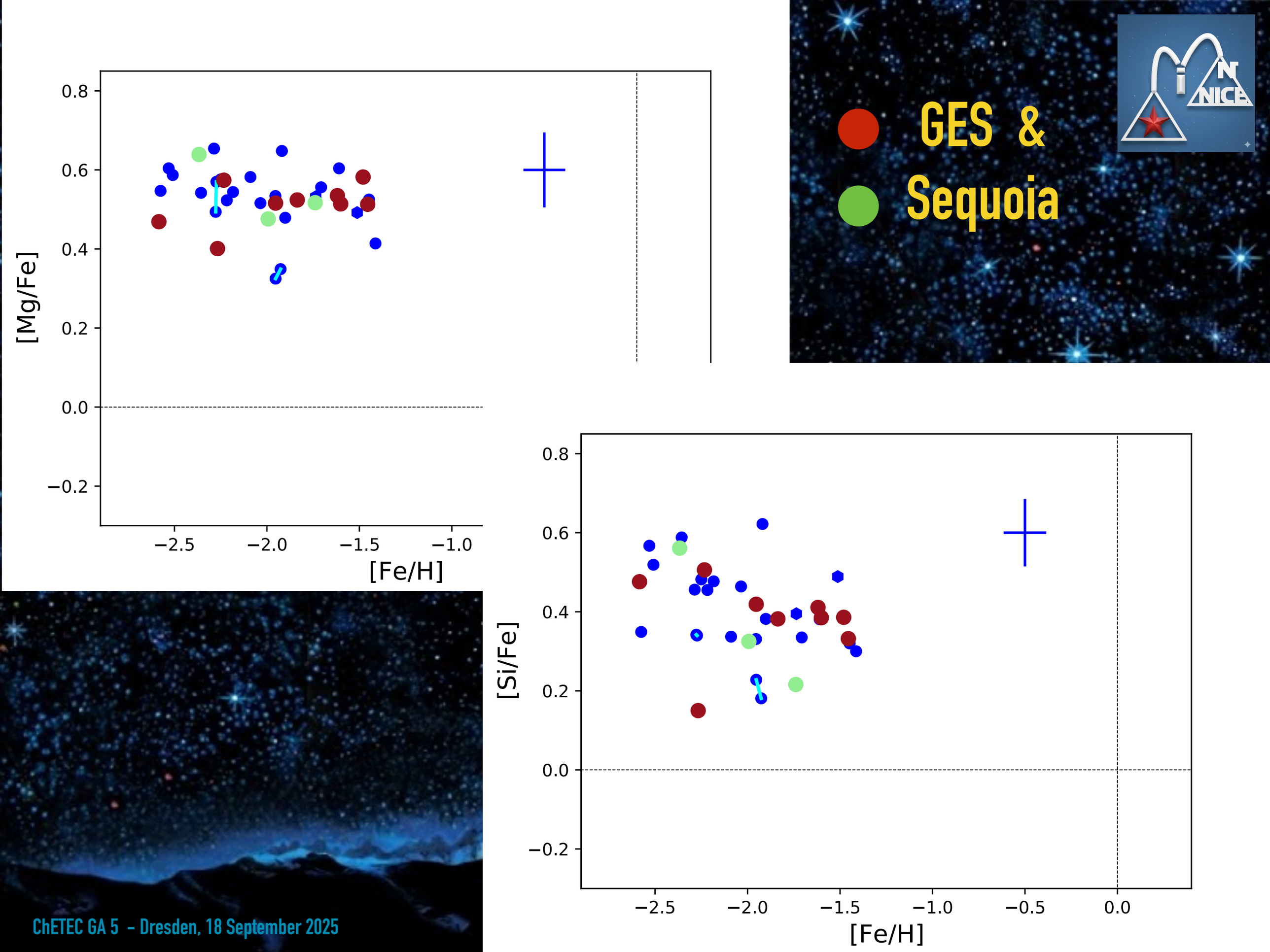
42 stars

16 elements

Tracing the substructures

Sequoia & GES as defined in Feuillet+21




GES &
Sequoia
iN NICE
[Mg/Fe]
[Fe/H]
[Si/Fe]
[Fe/H]
ChETEC GA 5 – Dresden, 18 September 2025

Astronomy & Astrophysics manuscript no. output
February 1, 2024

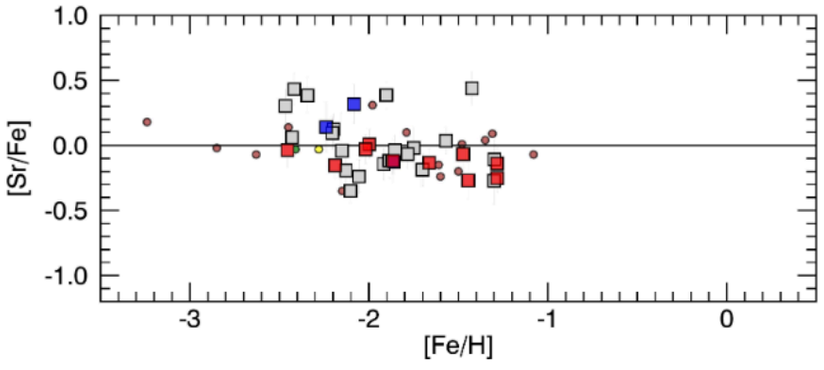
MINCE II. Neutron capture elements ⋆

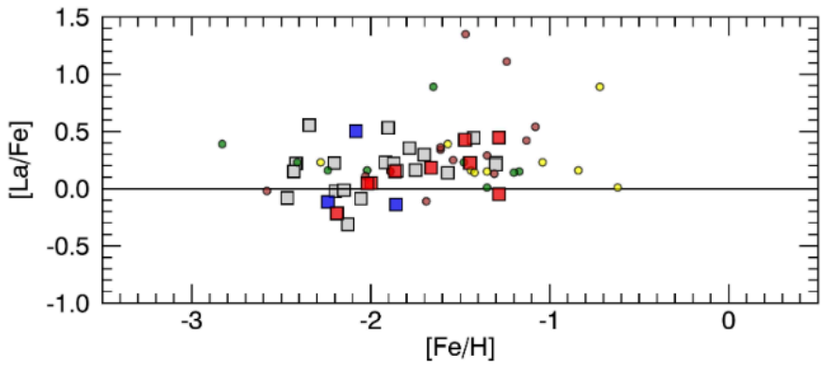
P. François[1,2], G. Cescutti[3,4,5], P. Bonifacio[1], E. Caffau[1], L. Monaco[6], M. Steffen[7], J. Puschnig[8], F. Calura[9], S. Cristallo[10,11], P. Di Marcantonio[4], V. Dobrovolskas[12], M. Franchini[4], A. J. Gallagher[7], C. J. Hansen[13], A. Korn[8], A. Kučinskas[12], R. Lallement[4], L. Lombardo[13], F. Lucertini[14], L. Magrini[15], A.M. Matas Pinto[1], F. Matteucci[3,4,5], A. Mucciarelli[16,9], L. Sbordone[14], M. Spite[1], E. Spitoni[4], and M. Valentini[7]

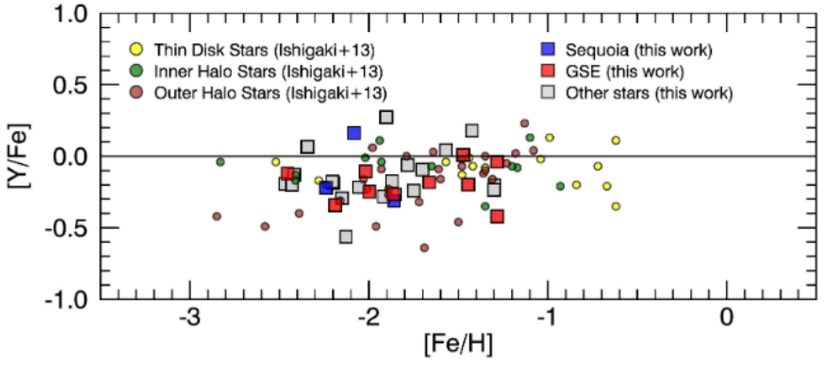
[1] GEPI, Observatoire de Paris, Université PSL, CNRS, 5 Place Jules Janssen, 92190 Meudon, France
[2] UPJV, Université de Picardie Jules Verne, Pôle Scientifique, 33 rue St Leu, 80039, Amiens, France
[3] Dipartimento di Fisica, Sezione di Astronomia, Università di Trieste, Via G. B. Tiepolo 11, 34143 Trieste, Italy

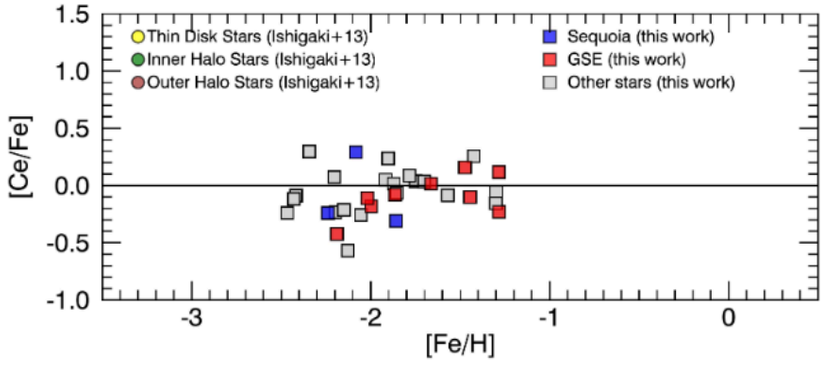
detailed analysis of the nc elements!
40% women

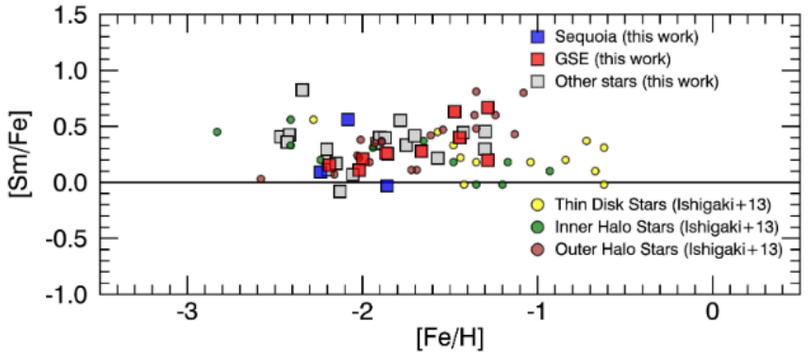
10 elements

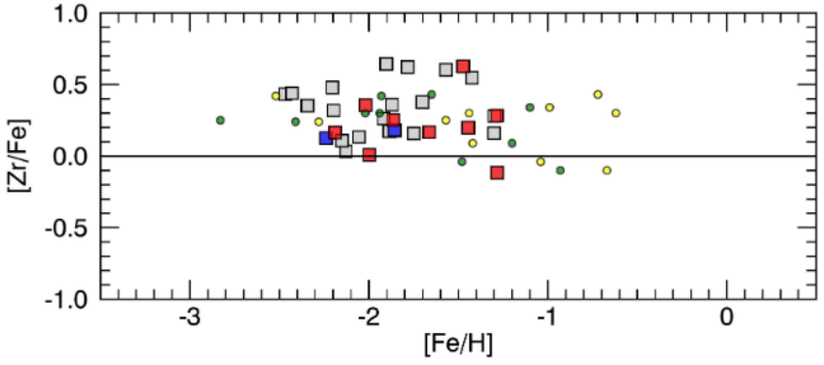

[Sr/Fe]
[Fe/H]


[La/Fe]
[Fe/H]


Thin Disk Stars (Ishigaki+13)
Inner Halo Stars (Ishigaki+13)
Outer Halo Stars (Ishigaki+13)
Sequoia (this work)
GSE (this work)
Other stars (this work)
[Y/Fe]
[Fe/H]


Thin Disk Stars (Ishigaki+13)
Inner Halo Stars (Ishigaki+13)
Outer Halo Stars (Ishigaki+13)
Sequoia (this work)
GSE (this work)
Other stars (this work)
[Ce/Fe]
[Fe/H]


Sequoia (this work)
GSE (this work)
Other stars (this work)
Thin Disk Stars (Ishigaki+13)
Inner Halo Stars (Ishigaki+13)
Outer Halo Stars (Ishigaki+13)
[Sm/Fe]
[Fe/H]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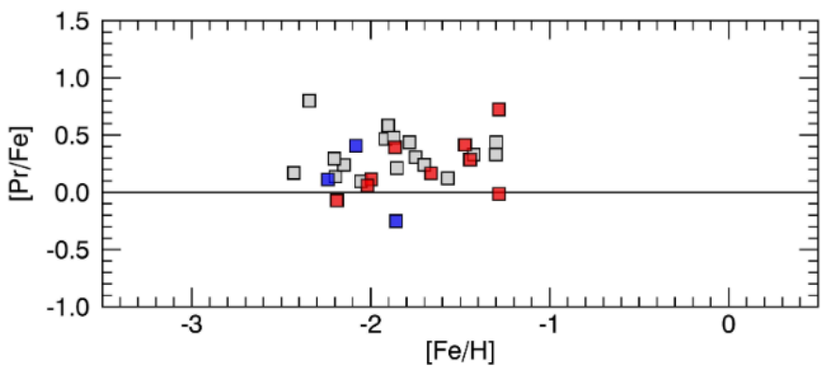
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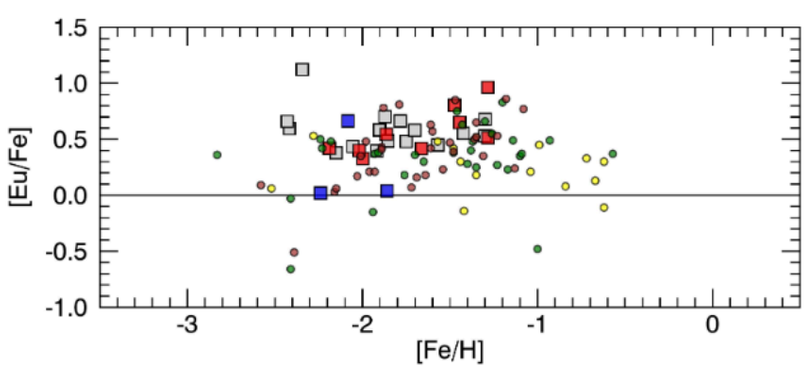
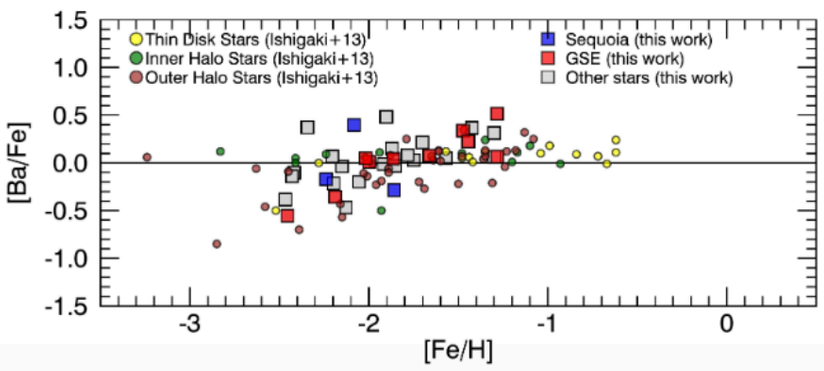
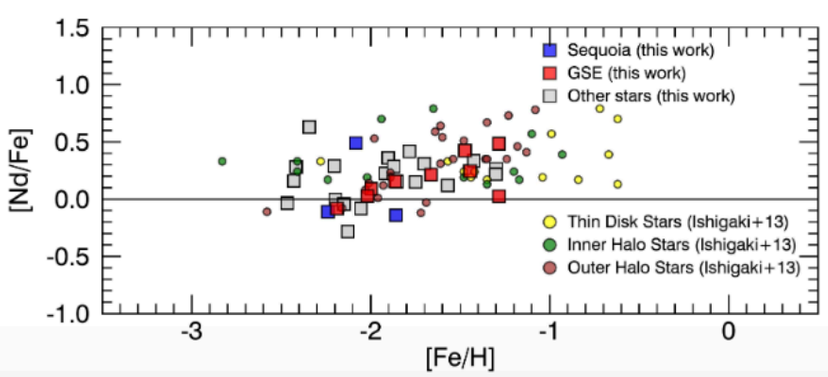
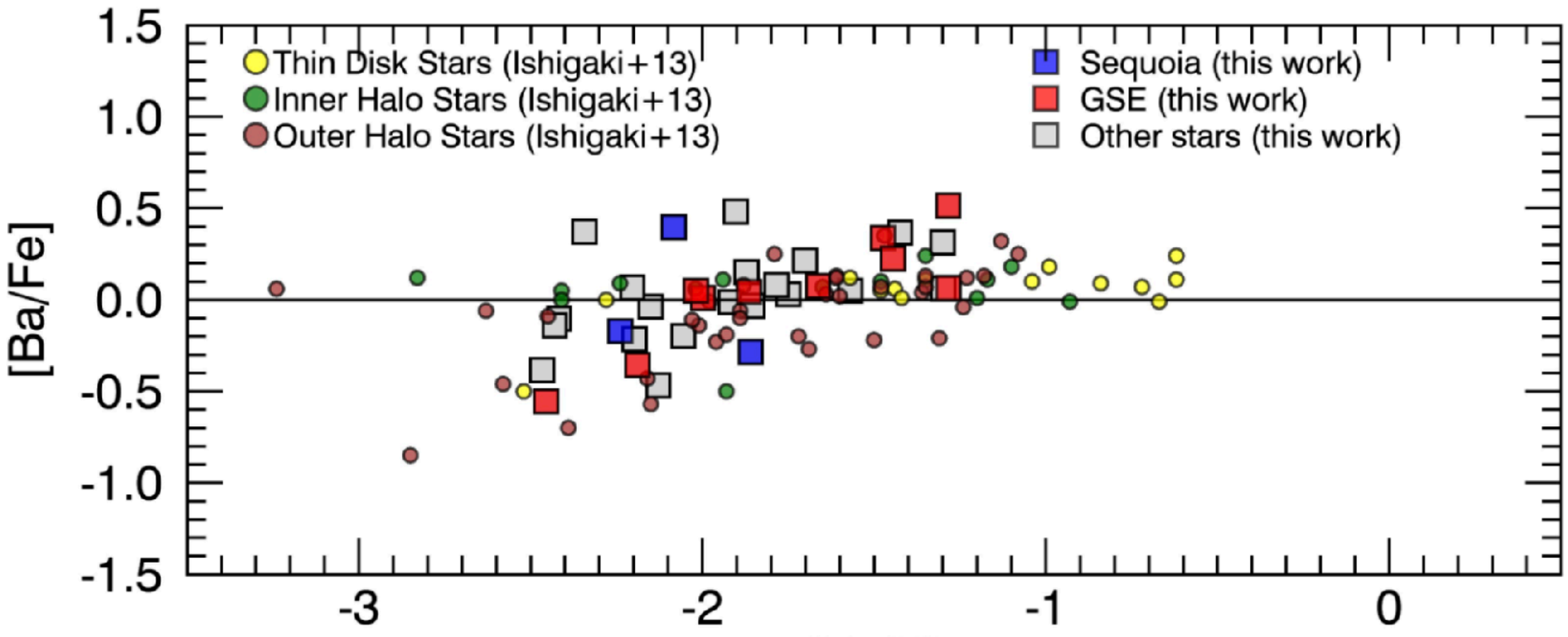
[Fe/H]

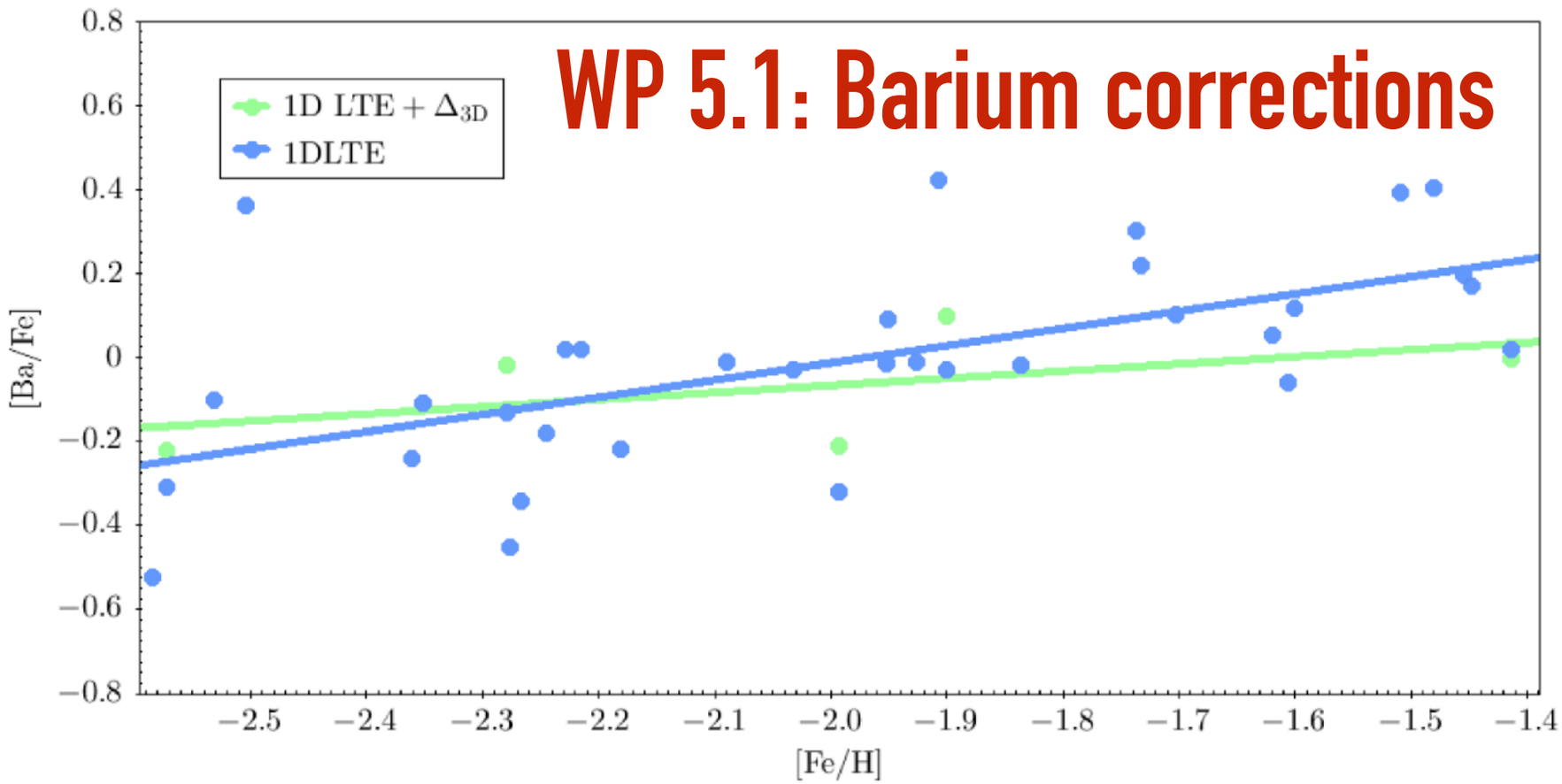

[Eu/Fe]
[Fe/H]


Thin Disk Stars (Ishigaki+13)
Inner Halo Stars (Ishigaki+13)
Outer Halo Stars (Ishigaki+13)
Sequoia (this work)
GSE (this work)
Other stars (this work)
[Ba/Fe]
[Fe/H]


Sequoia (this work)
GSE (this work)
Other stars (this work)
Thin Disk Stars (Ishigaki+13)
Inner Halo Stars (Ishigaki+13)
Outer Halo Stars (Ishigaki+13)
[Nd/Fe]
[Fe/H]



WP 5.1: Barium corrections



A&A, 695, A36 (2025)
https://doi.org/10.1051/0004-6361/202452964

Astronomy & Astrophysics

MINCE

III. Detailed chemical analysis of the UVES sample★

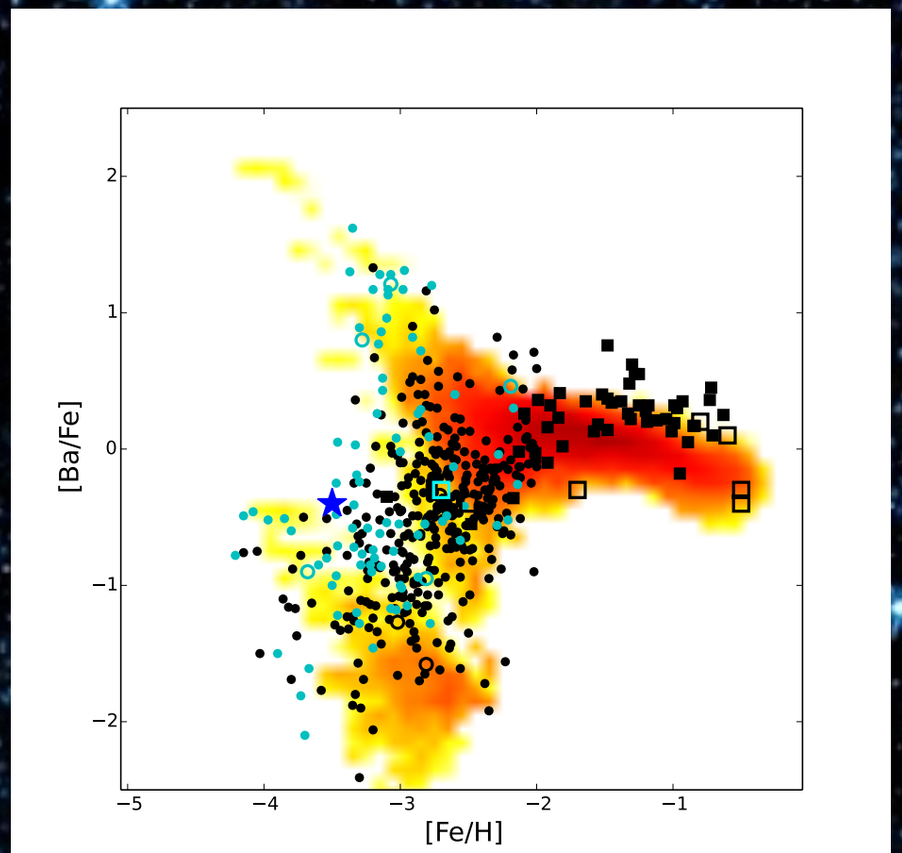
F. Lucertini[1,★★], L. Sbordone[1], E. Caffau[2,3], P. Bonifacio[2,3], L. Monaco[4,3], G. Cescutti[5,3,6], R. Lallement[2], P. François[2,7], E. Spitoni[3], C. J. Hansen[8], A. J. Korn[9], A. Kučinskas[10], A. Mucciarelli[11,12], L. Magrini[13], L. Lombardo[8], M. Franchini[3], and R. F. de Melo[8]

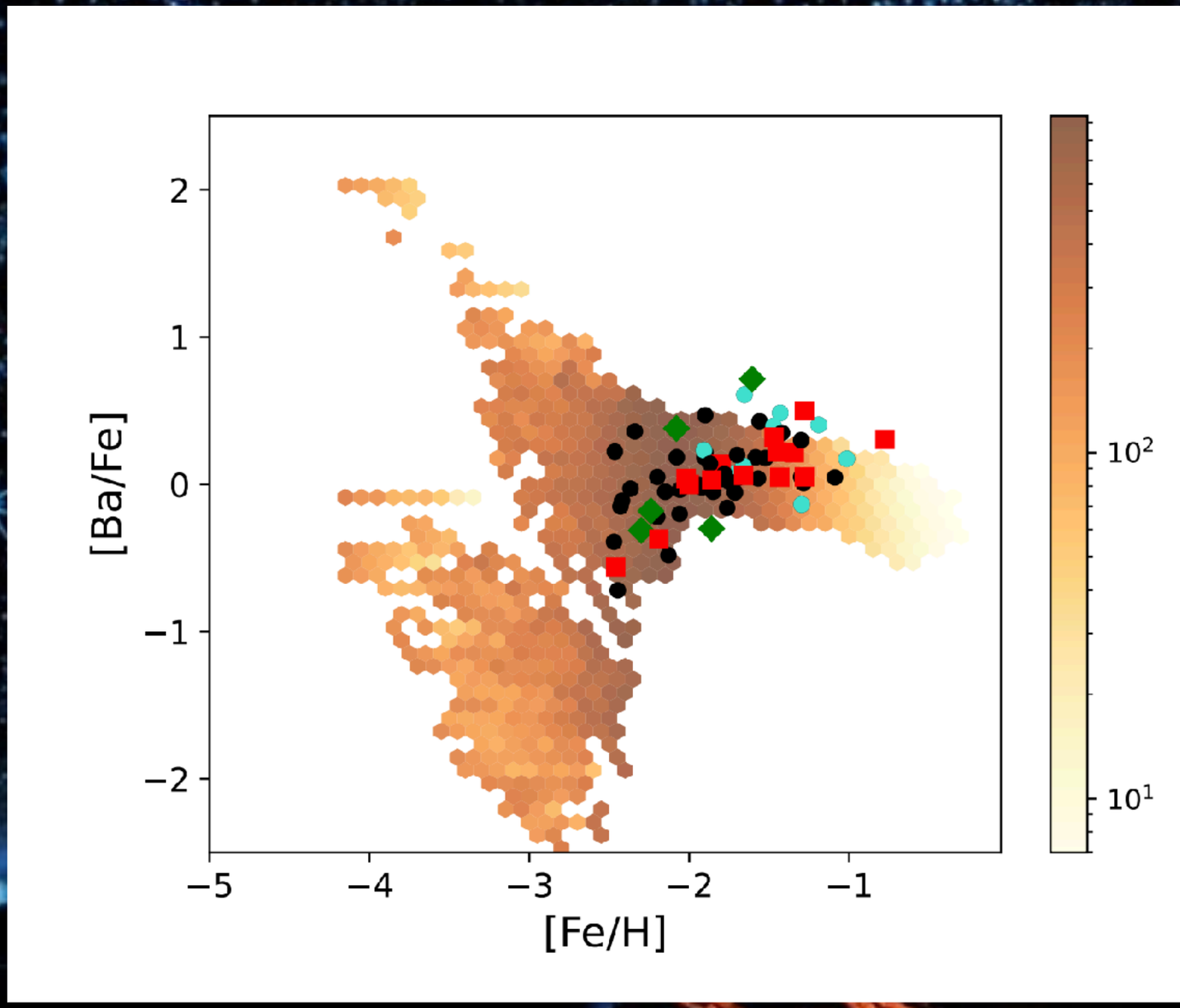
with 27 elements!

47% women

and the IV and V are coming . . .

And we have already almost double the number of stellar abundances!





The final goal of MINCE
is to publish
all results & spectra
in a public database

http://archives.ia2.inaf.it/mince/

IA2 Italian Center for Astronomical Archives
Centro Italiano Archivi Astronomici

ChETEC INFRA

Help

Your files 0

MINCE

Name resolver: Object name | Resolve

RA hh:mm:ss.ss **Dec** dd:mm:ss.ss **Radius (arcmin)** 10

Object

Instrument All

T_{eff} Min Max

log g Min Max

[Fe/H] Min Max

Chemical Abundance Select Element Min Max

Download | Edit query

Rows displayed: 20

R.A.	Dec	Object	Instrument	Teff	log g	[Fe I/H]	[O I/H]	[Na I/H]	[Mg I/H]	[A
249.13796823401	20.42953452623	BD+20 3298	Espadons	4154	0.57	-1.95	-1.08	-2.06	-1.44	-1.
157.07175275159	30.44126036941	BD+31 2143	Espadons	4565	1.15	-2.37	-1.27	-2.5	-1.73	-9
217.91228168557	31.98280165634	BD+32 2483	Espadons	4516	1.17	-2.25	-99	-2.44	-1.67	-9
270.94723989385	39.54211562921	BD+39 3309	Espadons	4909	1.73	-2.58	-99	-99	-2.12	-9
209.83221897743	48.0931106353	BD+48 2167	Espadons	4468	1	-2.29	-1.23	-2.4	-1.63	-9

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008324 (ChETEC-INFRA).