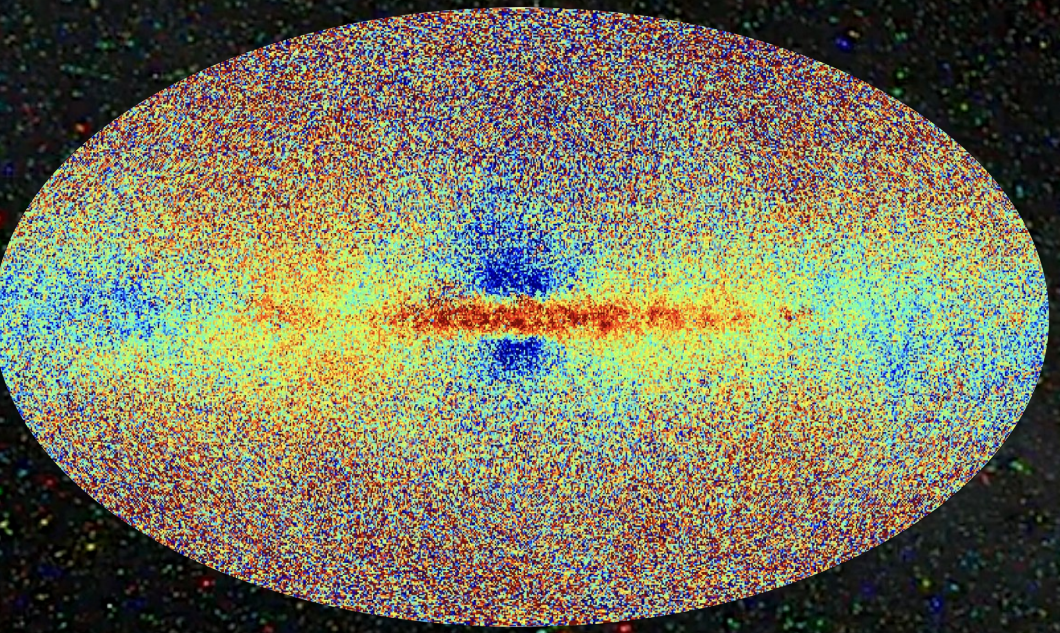
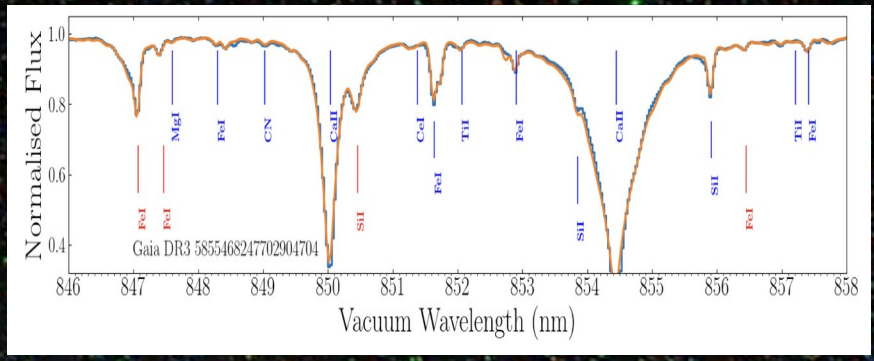
Exploring the Galactic content in *s*-process elements

High precision space spectroscopy with Gaia RVS





RVS = Radial Velocity Spectrograph

Patrick de Laverny

Observatoire de la Côte d'Azur (Lab. Lagrange)

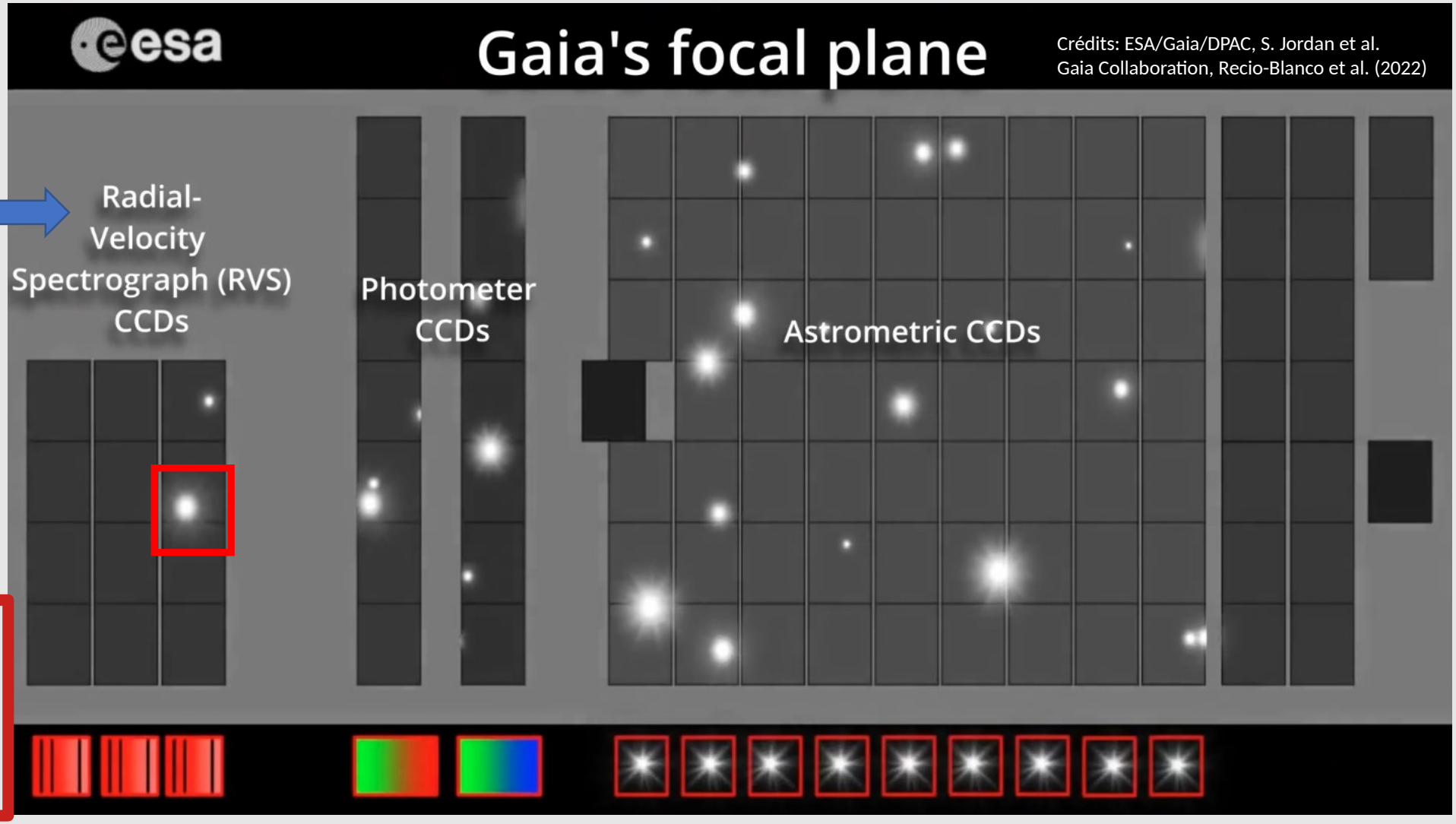
with contributions from :
A. Recio-Blanco, G. Contursi
& P.A. Palicio

I. Gaia/GSP-spec: a space spectroscopic survey

RVS

Resolving power:
11 500

Wavelength domain:
846 - 870 nm



GSP-spec: General Stellar Parametrizer– Spectroscopy

P.I : A. Recio-Blanco

I. Gaia/GSP-spec: a space spectroscopic survey

Gaia/RVS is **SPACE spectroscopy** ≠ ground-based spectroscopy

- Continuous observations for years:
  34 months for DR3 (~25 000 h of continuous observations)
  60 / 120 months for DR4 / DR5

- High number statistics : hundreds of thousands of high SNR (>150) DR3/data

- Stable conditions (no atmosphere)

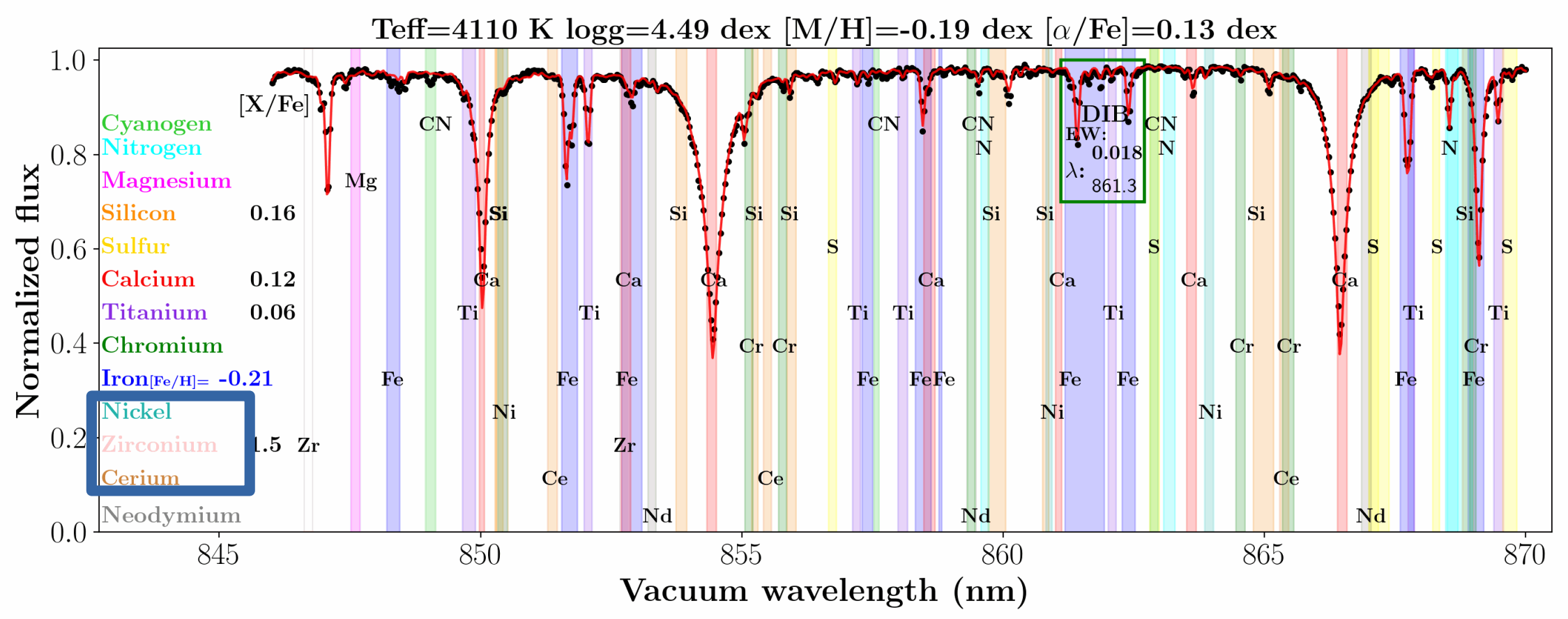
- Very good control and modeling of systematics

- Extremely homogeneous treatment

Parametrization quality comparable to ground-based surveys of higher spectral resolution and wavelength coverage.

I. Gaia/GSP-spec: a space spectroscopic survey

CU8/GSPspec: 5.6 million stars parametrized in Gaia DR3



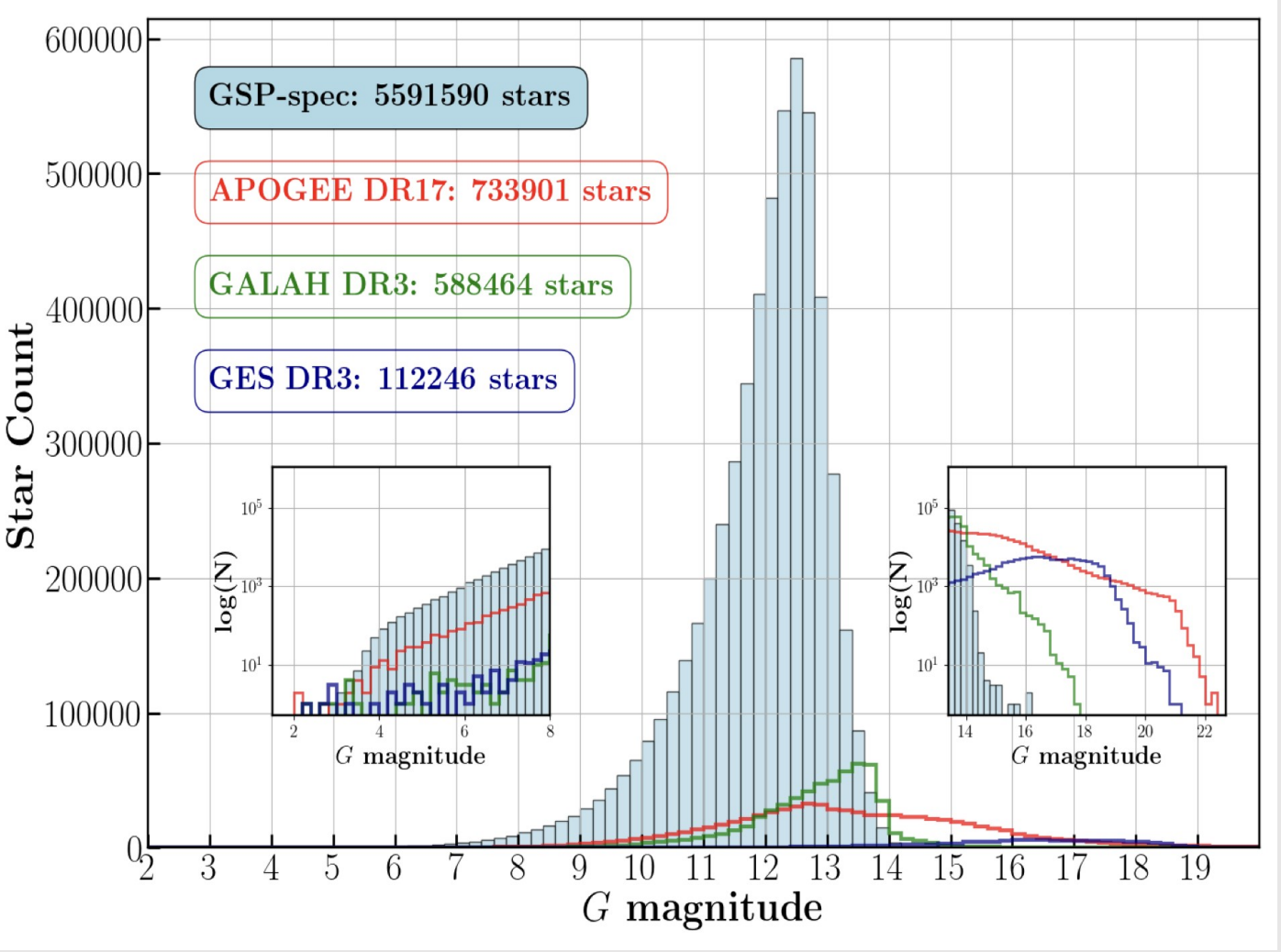
GSP-spec/DR3 articles: Recio-Blanco+2023 & Gaia Collab., Recio-Blanco+2023

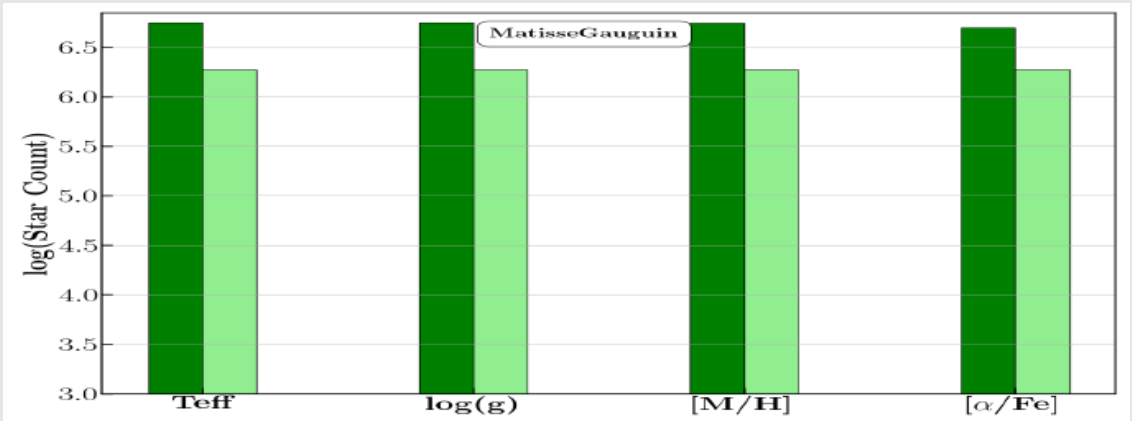
GSP-spec s-process: Contursi+2023 & 2024a

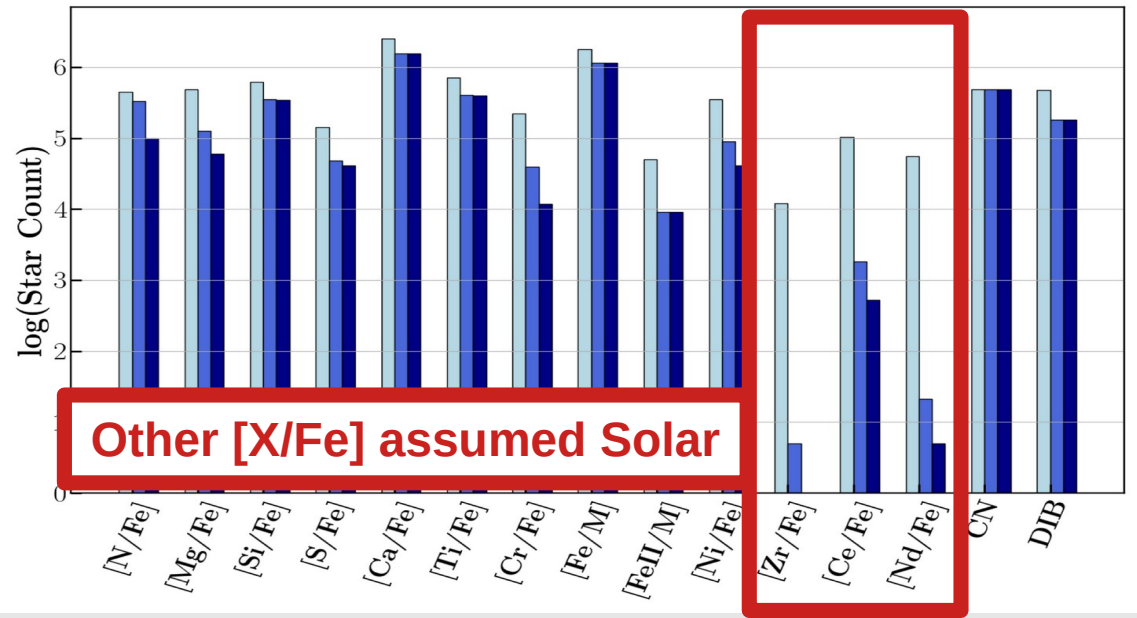
I. Gaia/GSP-spec: a space spectroscopic survey

Gaia/RVS is **SPACE spectroscopy** ≠ ground-based spectroscopy

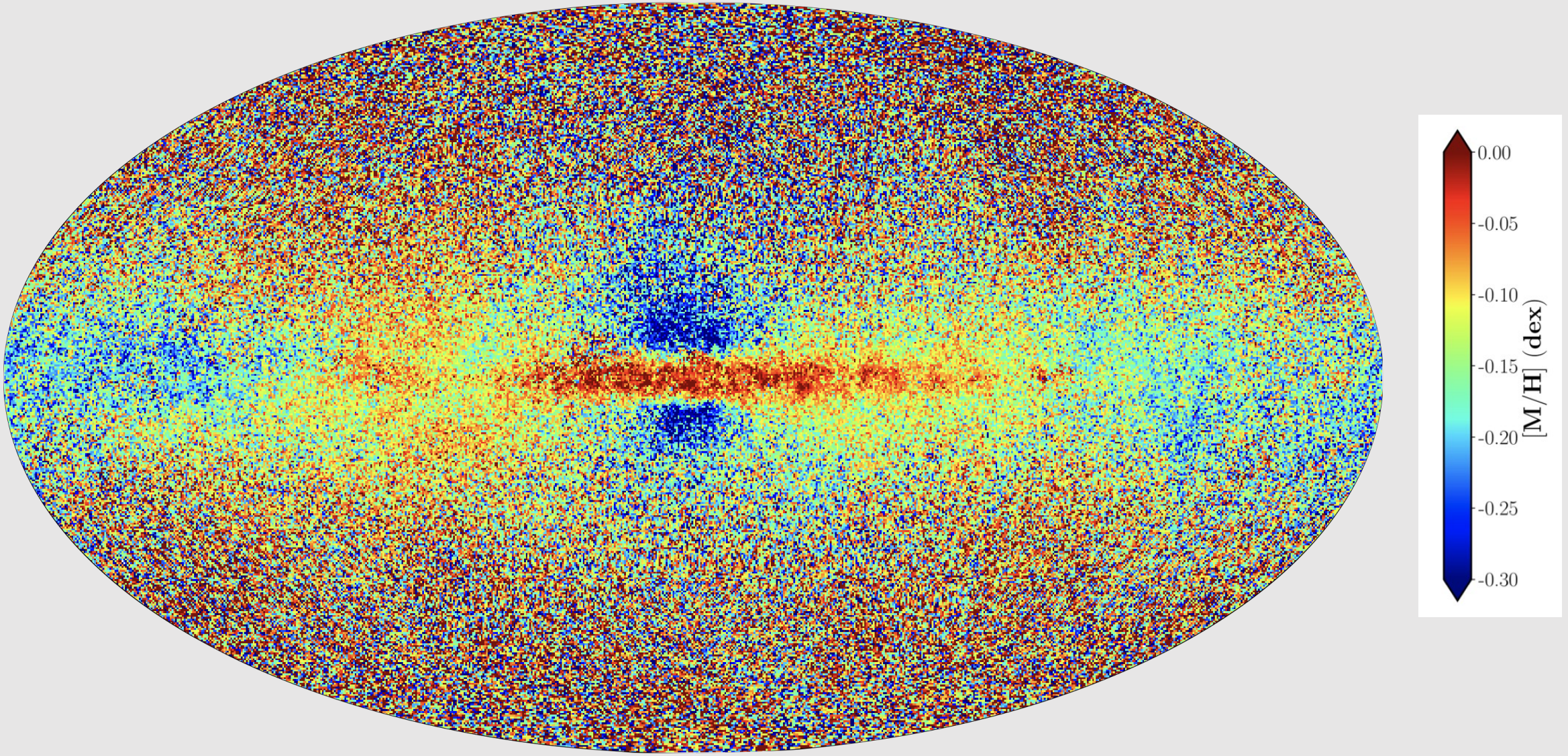
5.6 million stars with chemo-physical parameters





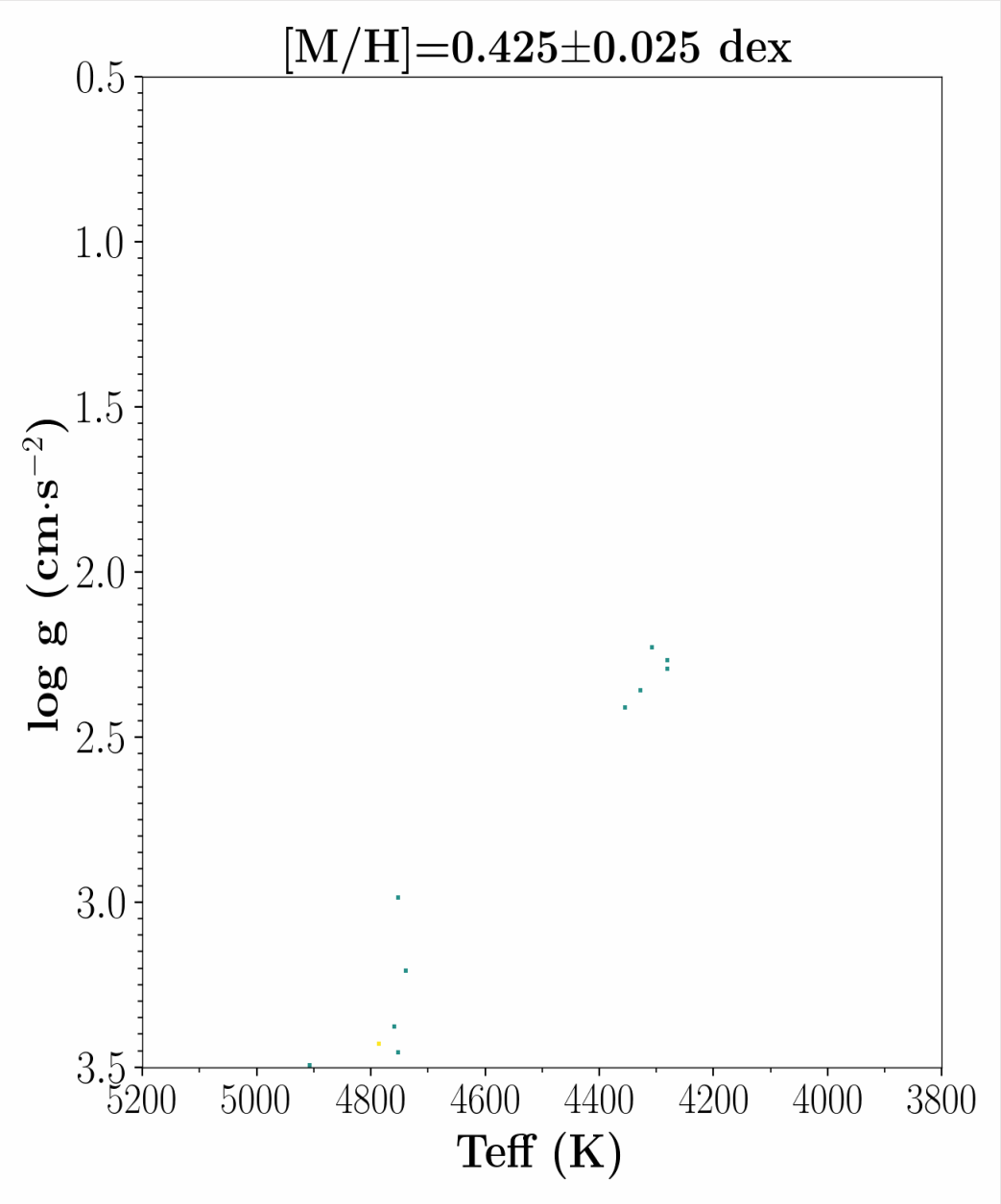


I. Gaia/GSP-spec: a space spectroscopic survey



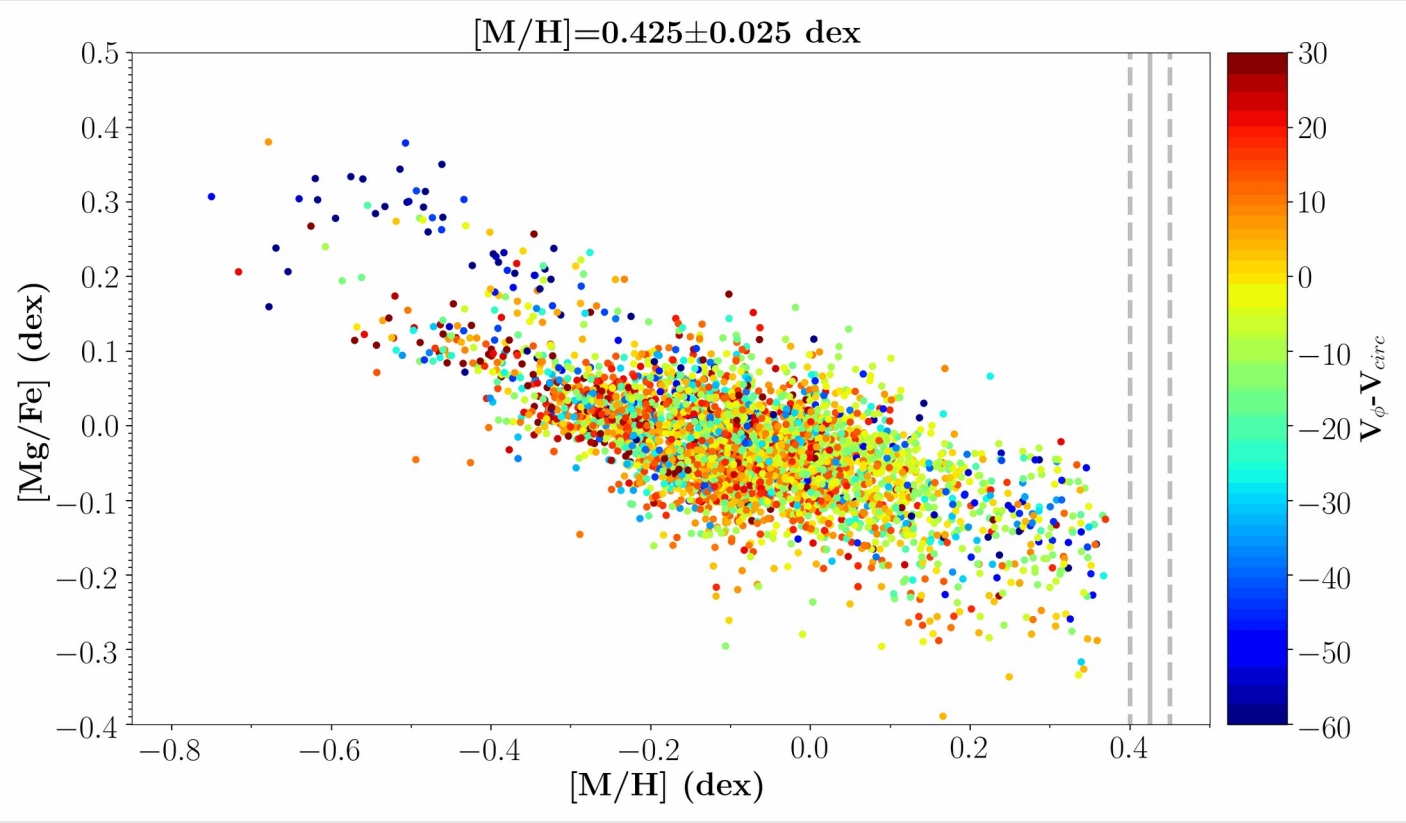
Chemical cartography of the Milky Way

I. Gaia/GSP-spec: a space spectroscopic survey



⇒ RGB & RC with high-precision

Gaia GSPspec : mono-abundance disc populations

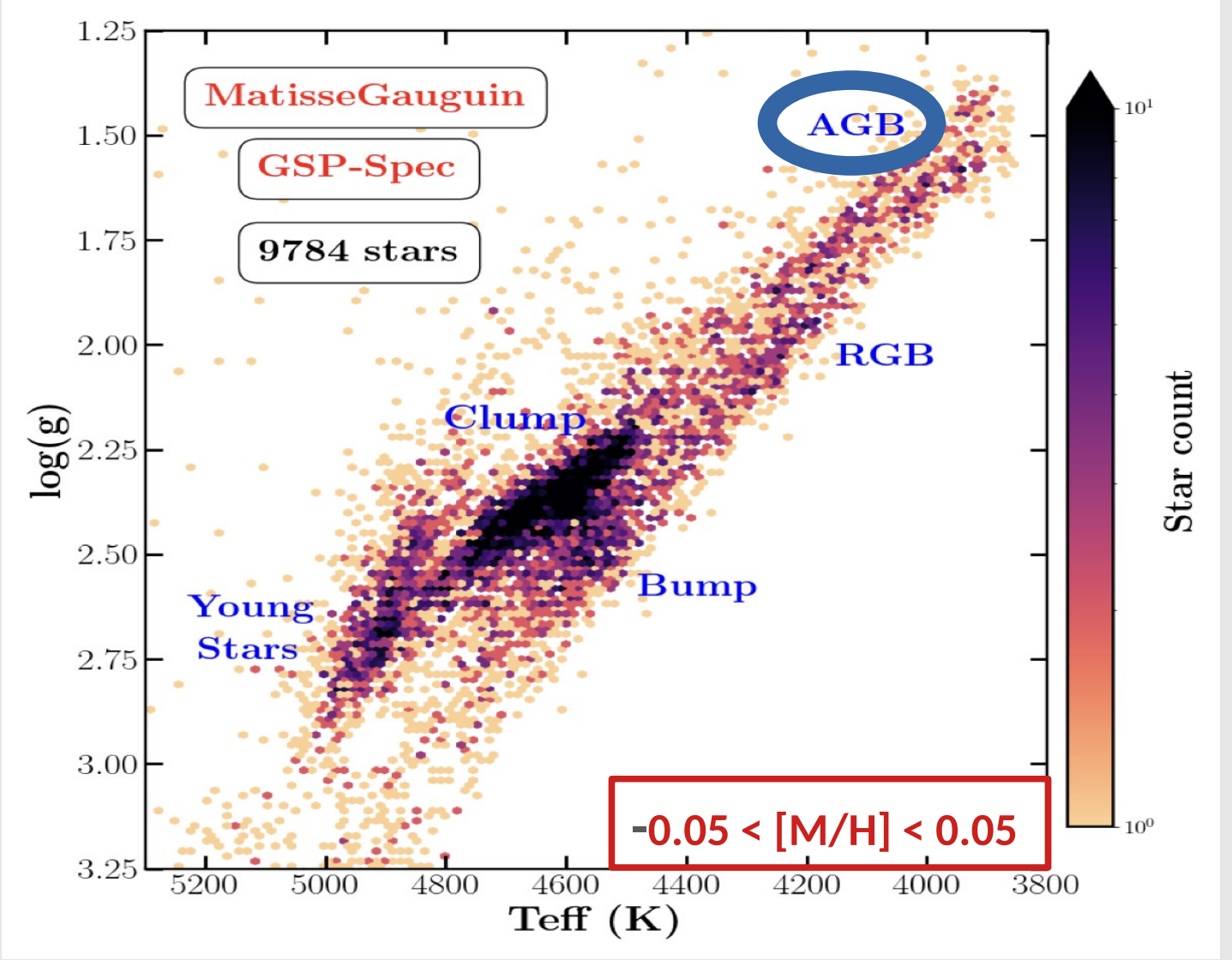


Recio-Blanco et al. 2024

II. GSP-spec: AGB stars & *s*-elements

→ **AGB Stars in GSP-spec/DR3**

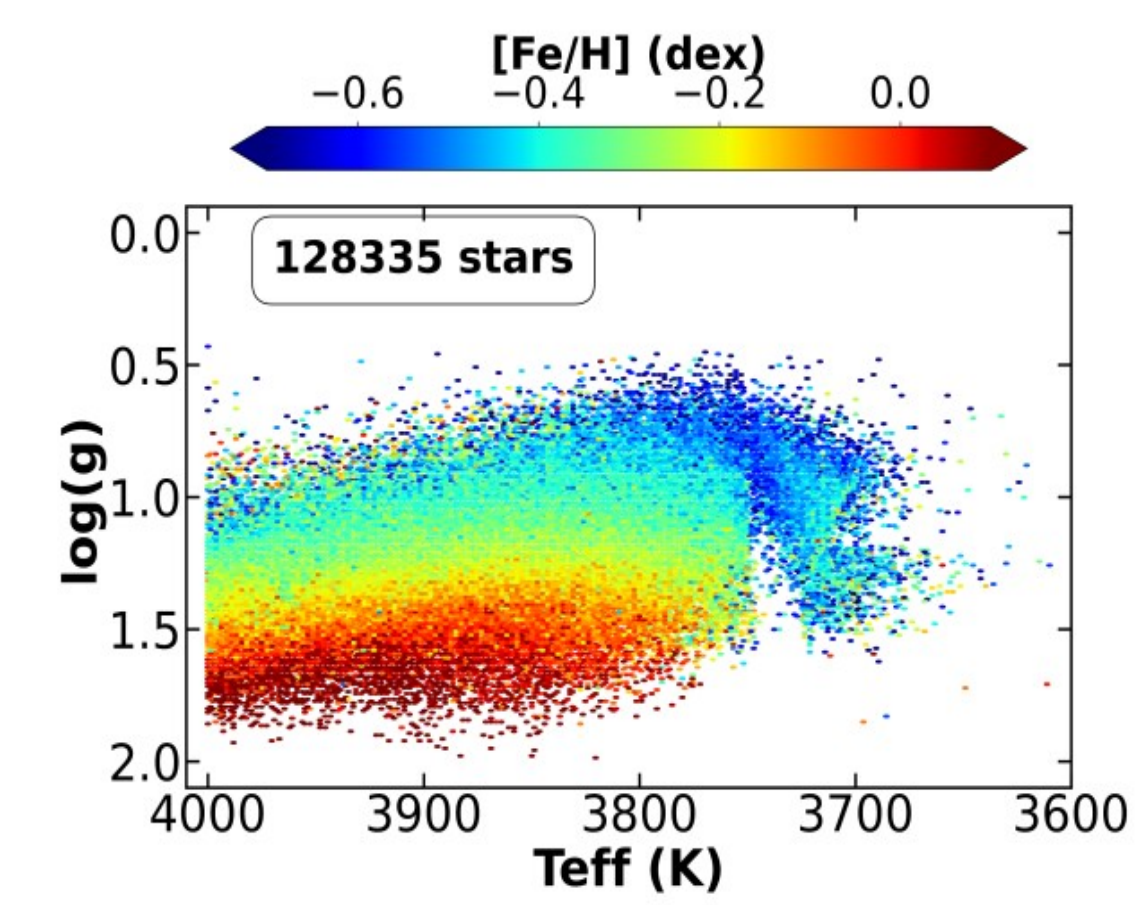
~130,000 AGB with High-Quality atm. parameters

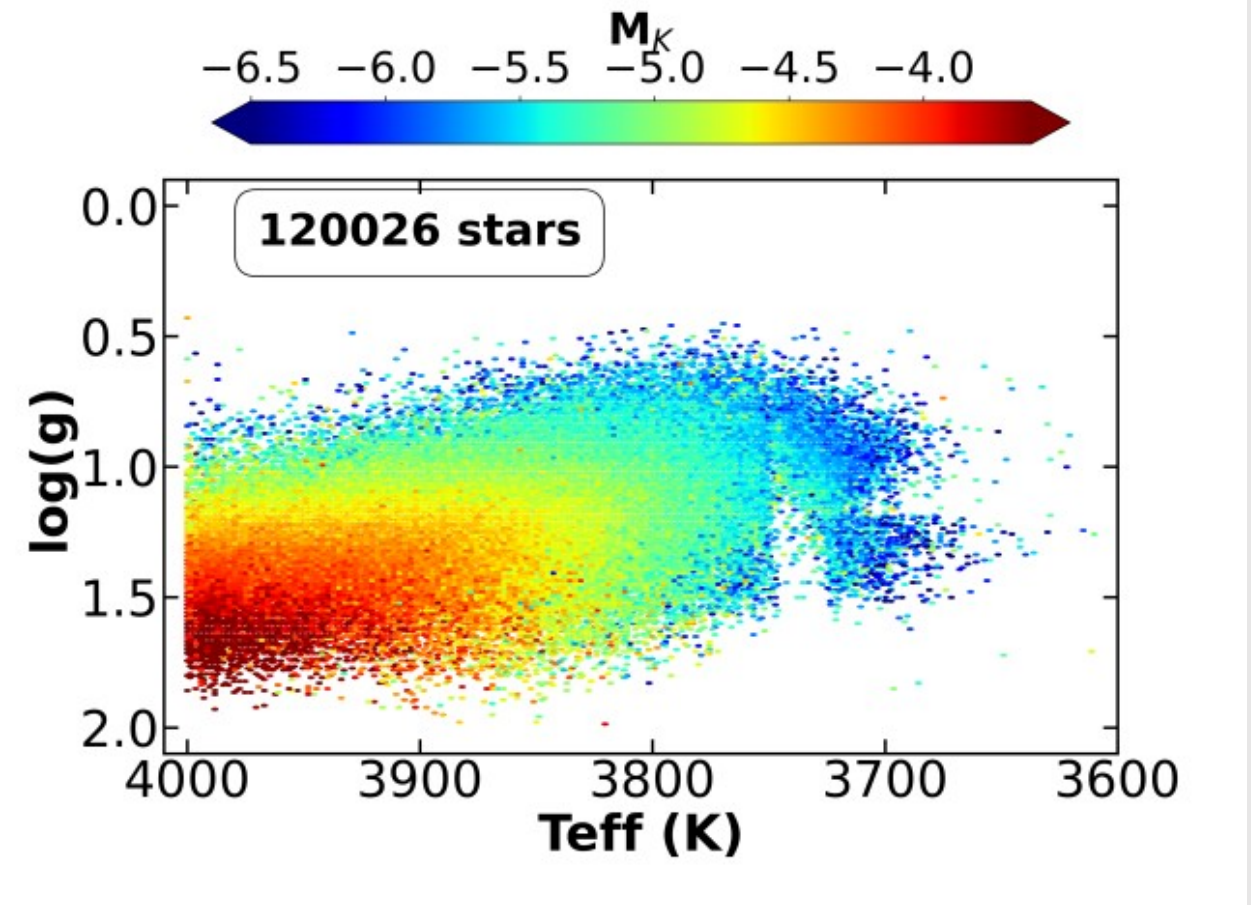


II. GSP-spec: AGB stars & *s*-elements

→ AGB Stars in GSP-spec/DR3

~130,000 AGB with High-Quality atm. parameters





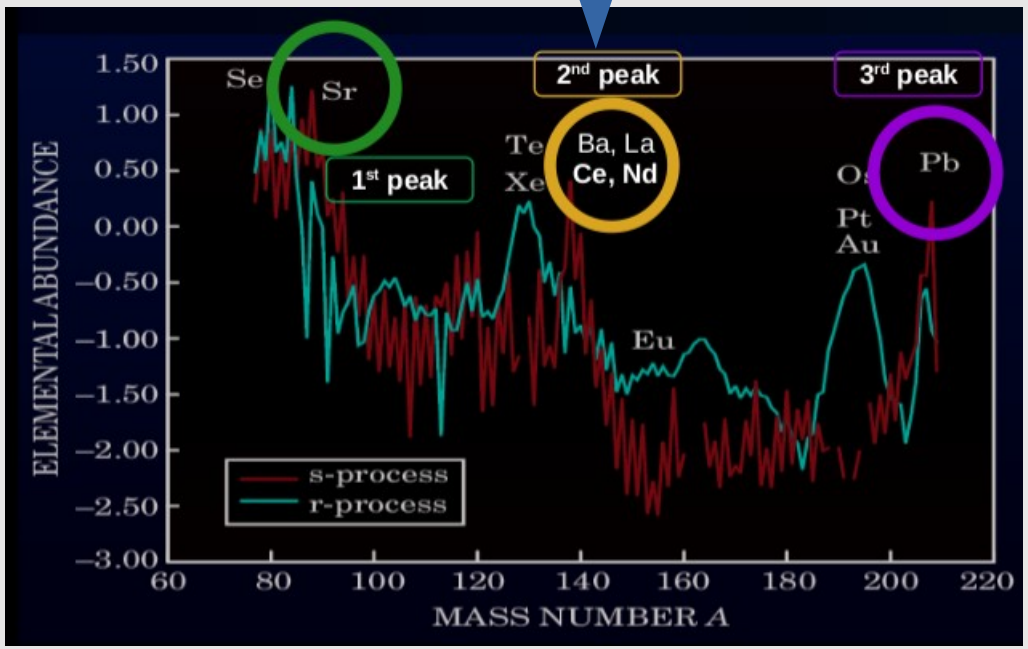
II. GSP-spec: AGB stars & *s*-elements

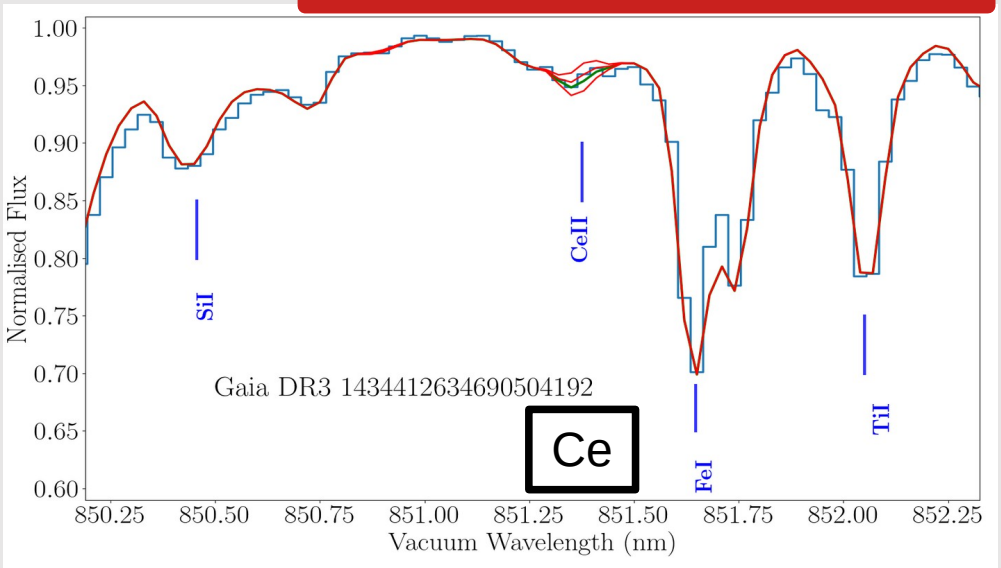
Other [X/Fe] assumed Solar

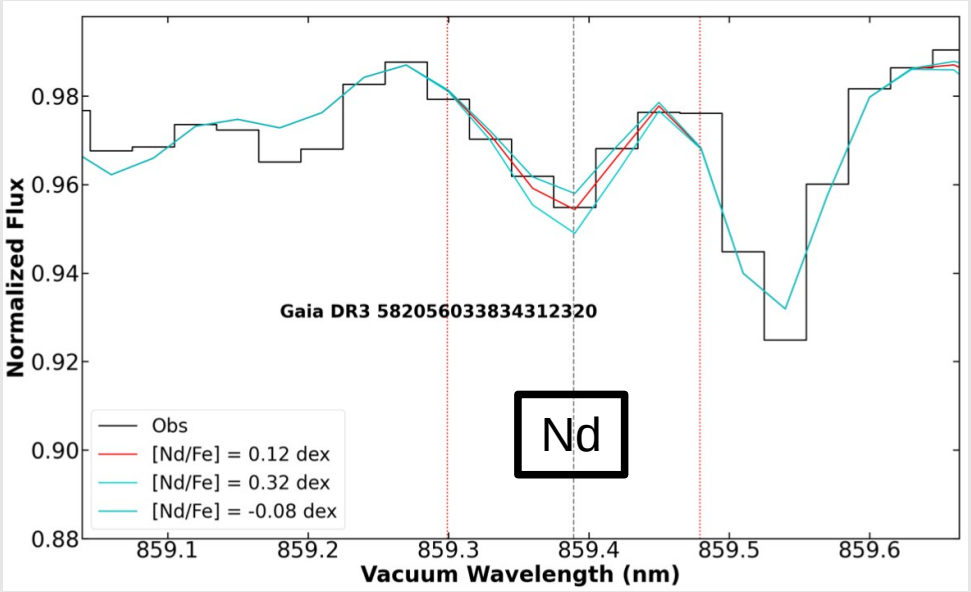
→ AGB Stars in GSP-spec/DR3

~18,000 stars with [Ce/Fe] **AND** High-Quality parameters + Abund.

~ 3,500 stars with [Nd/Fe] **AND** High-Quality parameters + Abund.

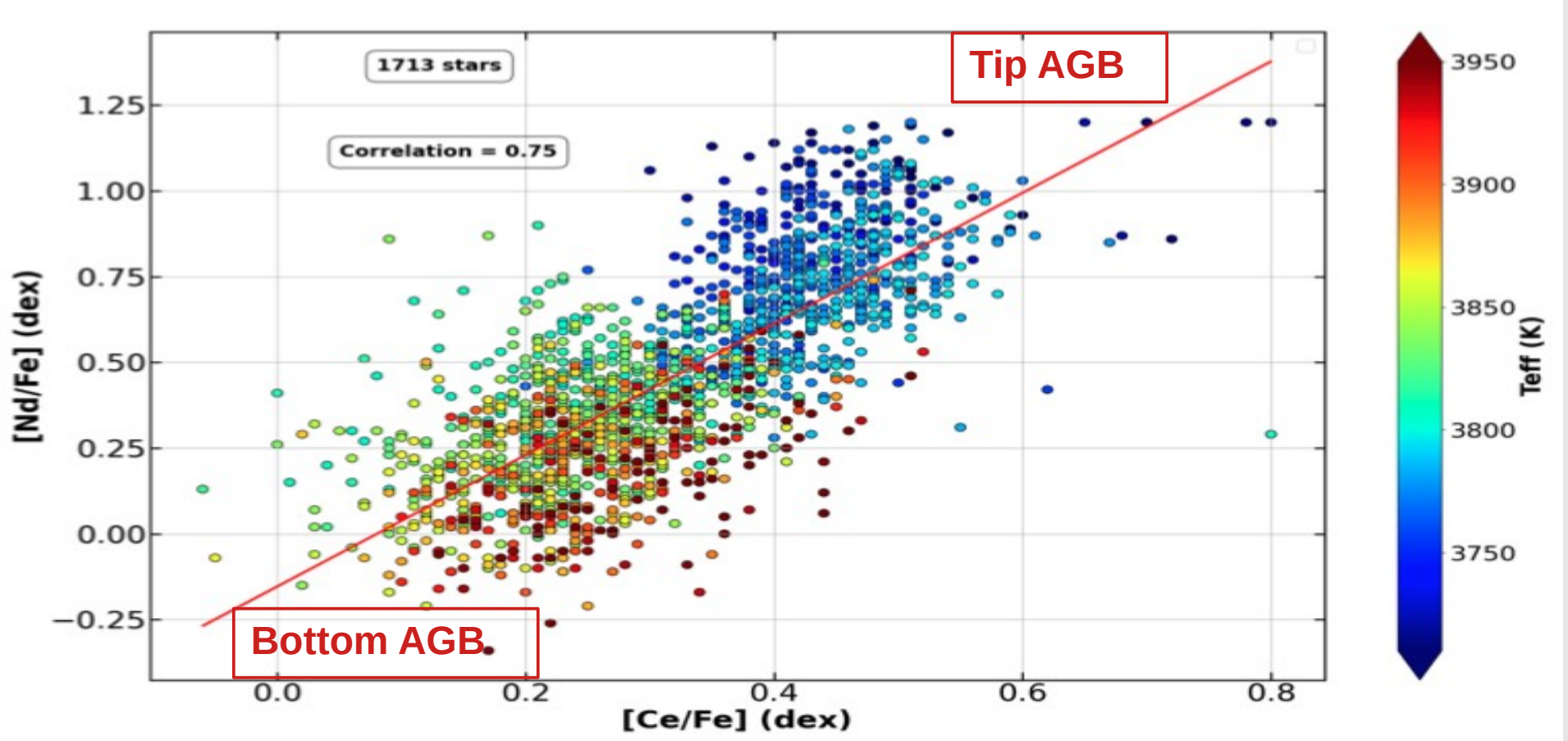






II. GSP-spec: AGB stars & *s*-elements

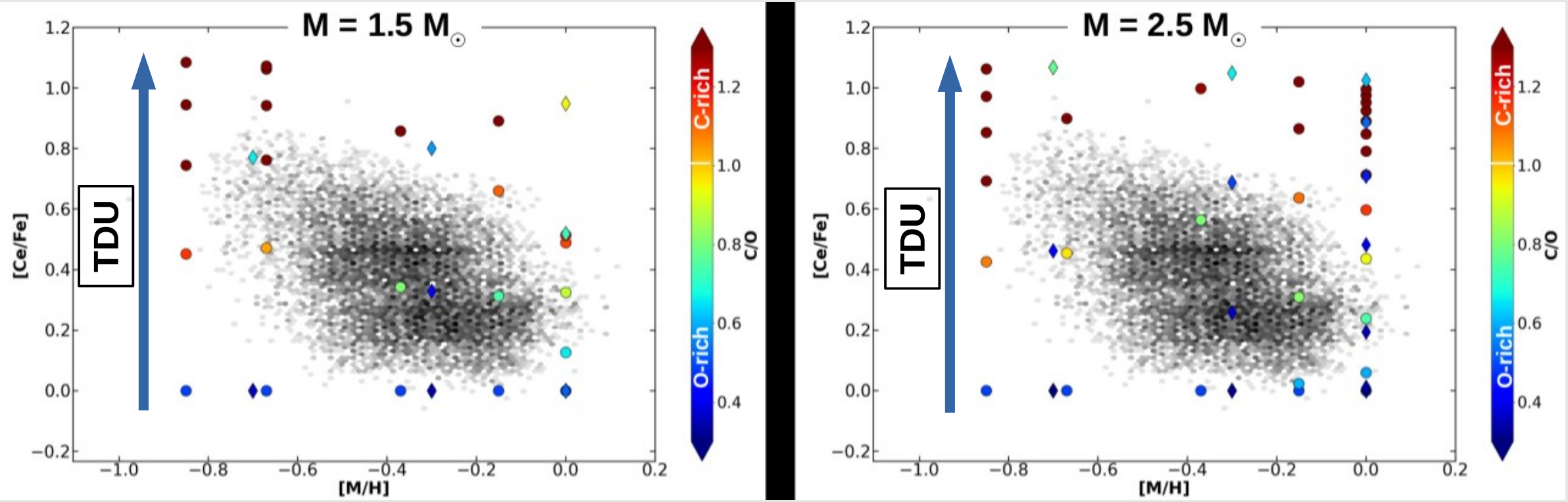
→ **AGB production of s-process elements**
Higher Ce and Nd abundances for more evolved AGB stars of similar metallicity.



II. GSP-spec: AGB stars & *s*-elements

→ AGB production of s-process elements

- Comparison with FRUITY & Monash models : C/O<1 confirmed
- These stars have M<~3Msun
- Too large Ce & Nd enhancements predicted by Monash



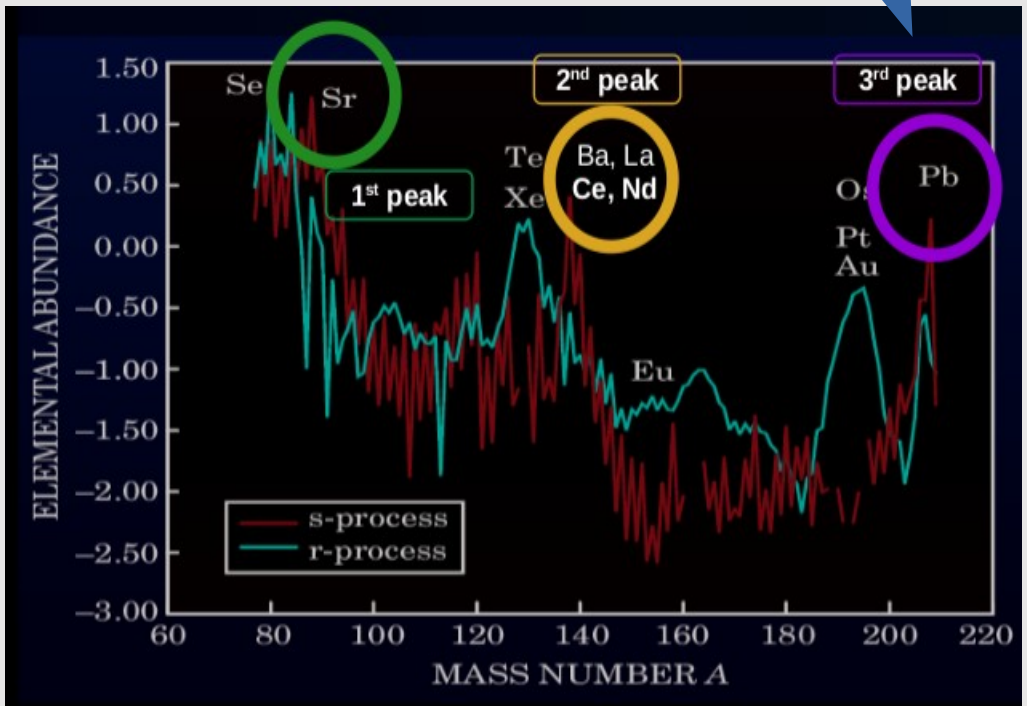
Circles: FRUITY models Diamonds: Monash

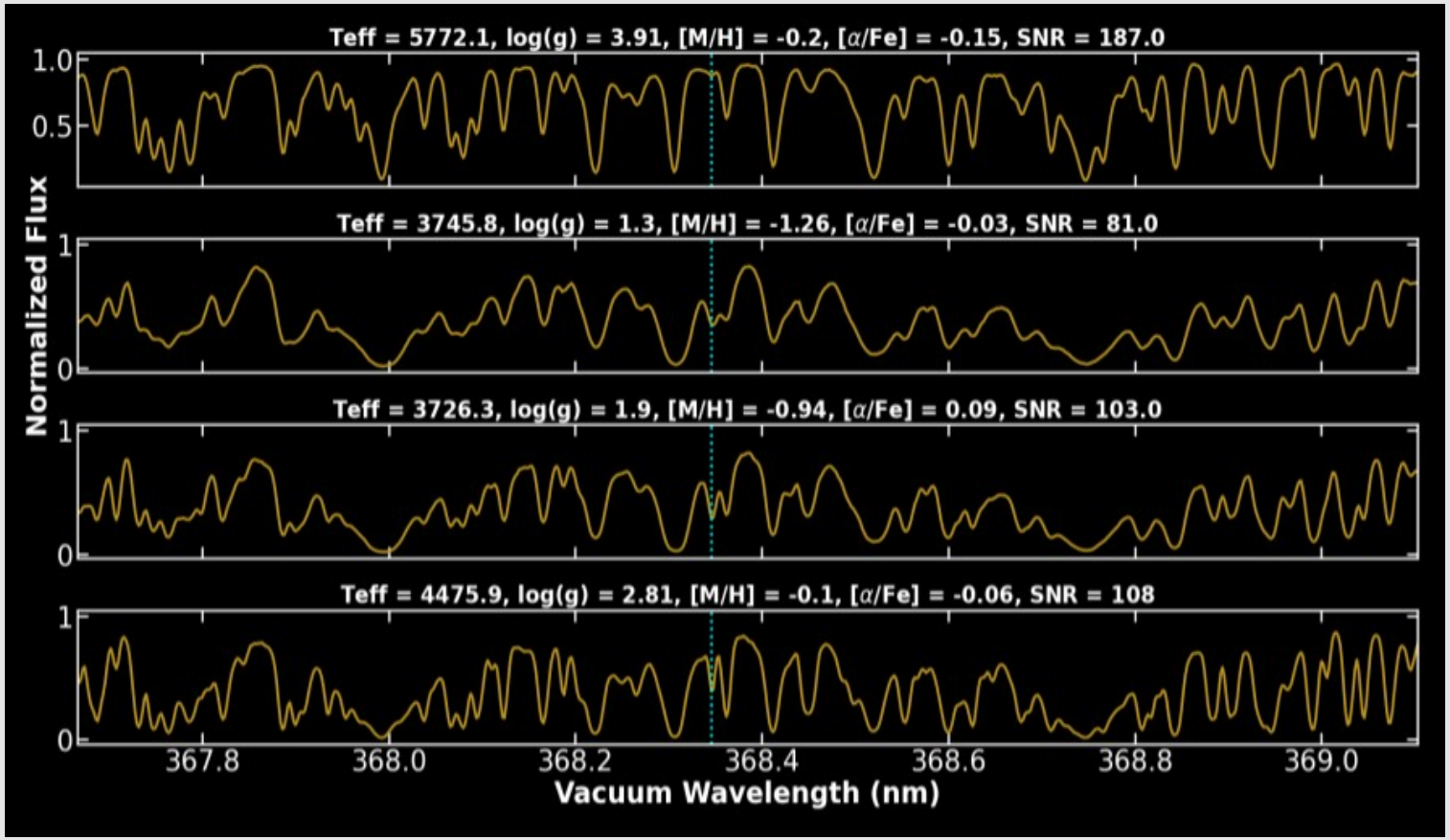
III. AMBRE Project: Lead abundances in the Galactic disc

→ **AMBRE Project** (de Laverny+14, Worley+12,...)

- Automatic parameterisation of ESO archived spectra

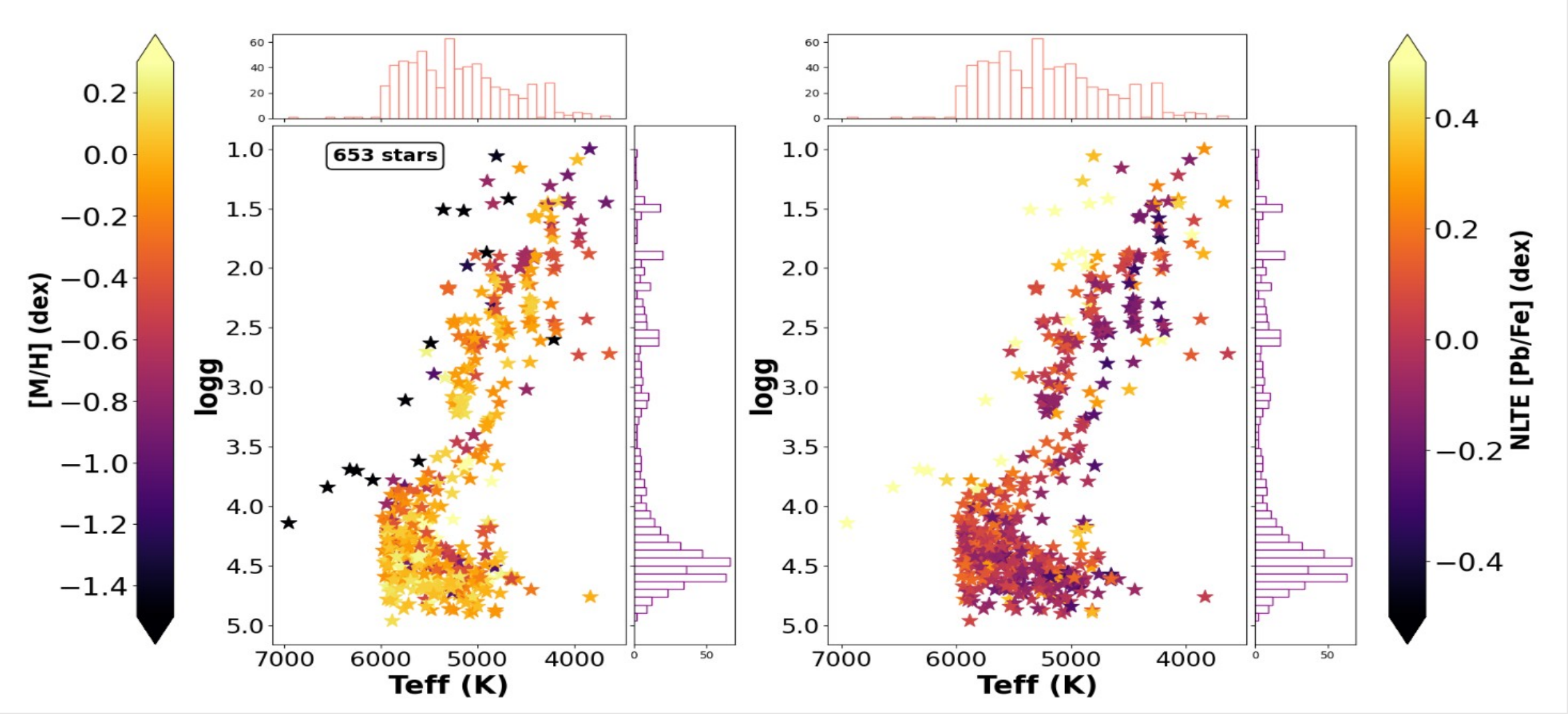
- ~8700 UVES and FEROS spectra of MS → AGB stars
  PbI line @368.35nm
  (Contursi+24b)





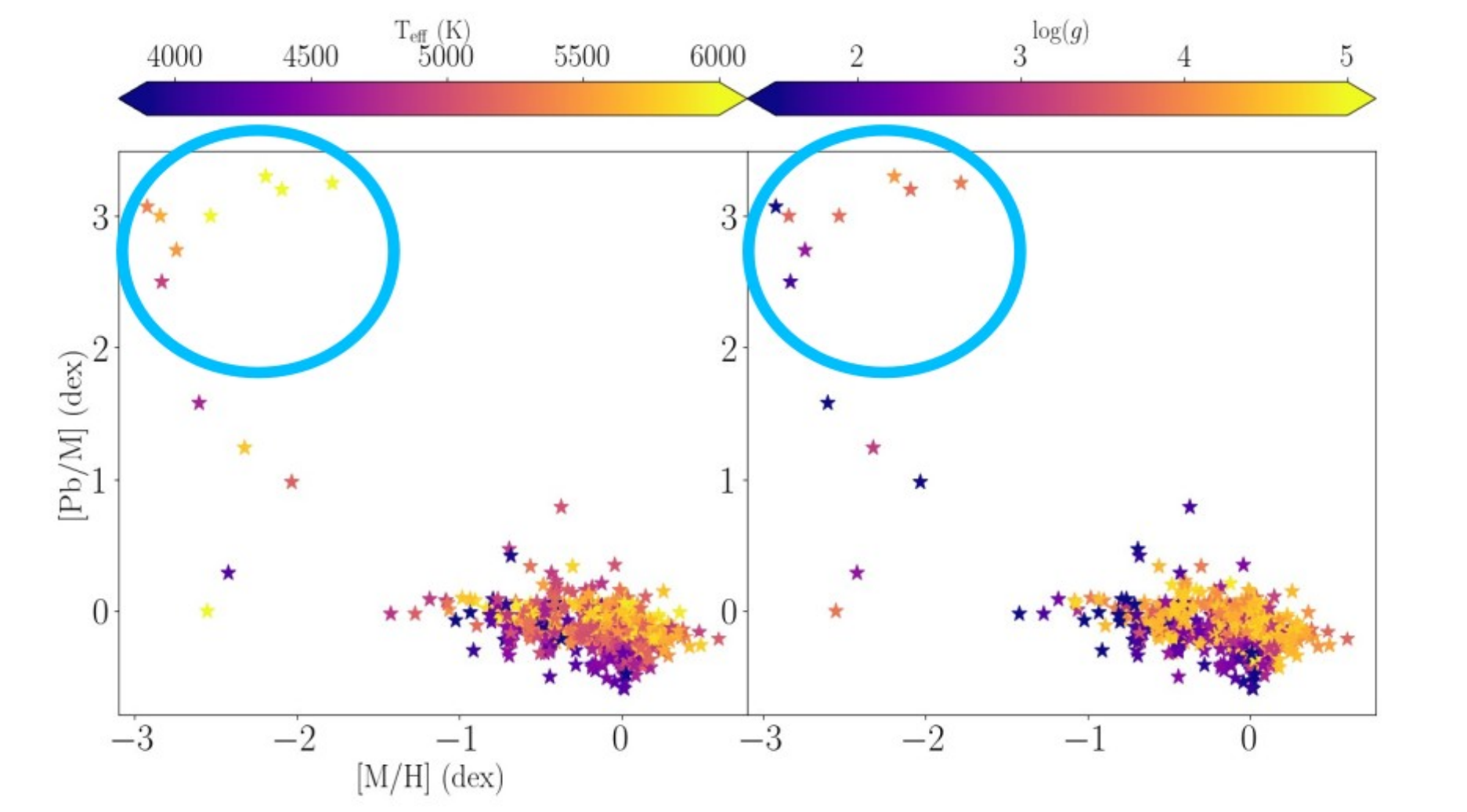
III. AMBRE Project: Lead abundances in the Galactic disc

→ **~700 stars with Pb abundances:** ~35 % giants but **No AGB Pb-rich**



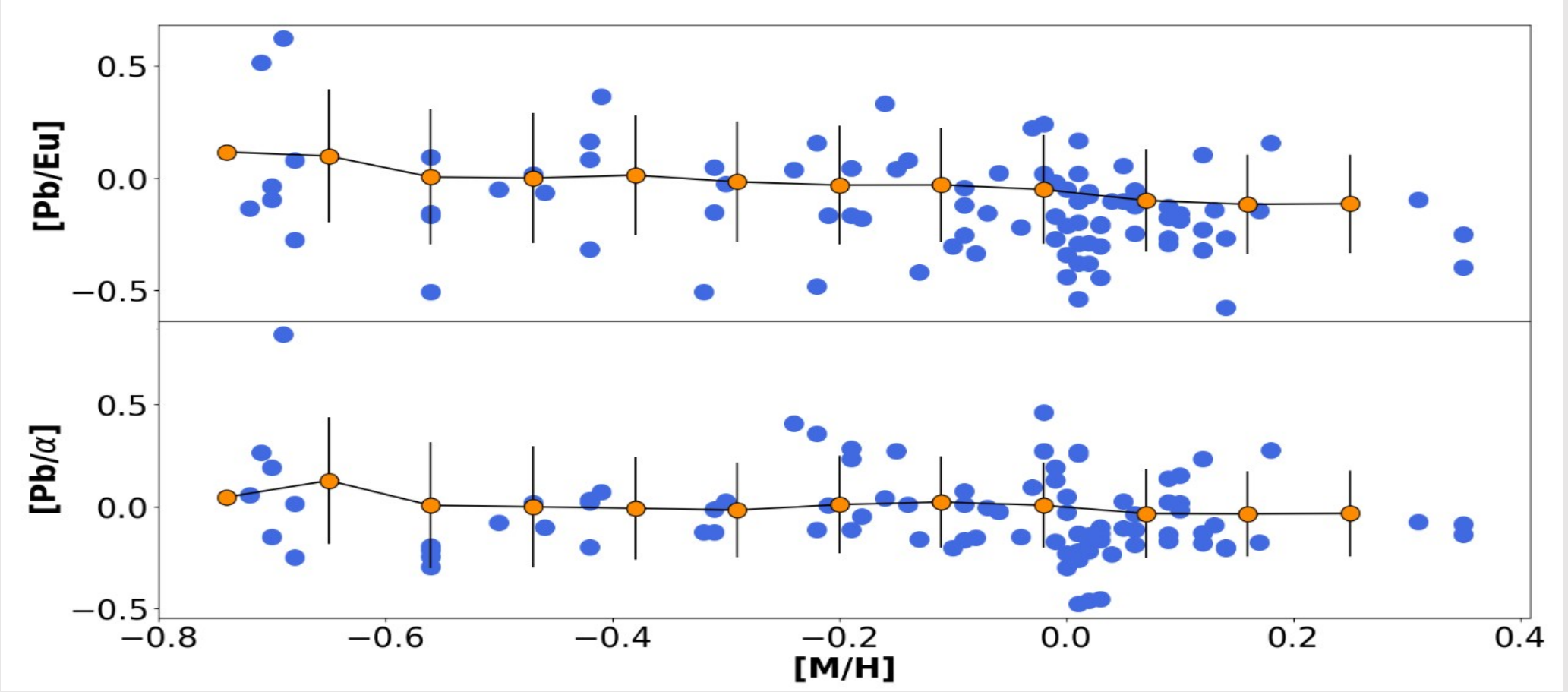
III. AMBRE Project: Lead abundances in the Galactic disc

→ **Some Pb-enriched stars:** Already known CEMP stars + new candidates



III. AMBRE Project: Lead abundances in the Galactic disc

→ **[Pb/Eu] and [Pb/alpha] trends with metallicity:** ~ flat
Galactic Chemical Models (Trieste): lower Pb production in metal-poor AGB
+ important contribution from high-rotating massive stars



Ce, Nd & Pb abundances in Galactic AGB

SUMMARY

- **Large sample of AGB parameterised thanks to Gaia/GSP-spec**

- **2nd peak *s*-elements: Ce & Nd abundances from Gaia/RVS**
  - [Ce/Fe] & [Nd/Fe] very well correlated with AGB evolutionary stage
  - Stars are more enriched in Ce & Nd when more advanced on the AGB
  - Favoured production site : low-mass AGB
  - Good agreement with FRUITY predictons
- **3rd peak *s*-element: Pb abundances from the AMBRE Project**
  - ~700 Galactic stars with Pb abundances
  - Galactic chemical models: lower AGB production at low [M/H]?

Spectroscopic analysis of Gaia spectra

SUMMARY

- **The Gaia future is bright:**
  - only ¼ of the data analysed in DR3!
  - RVS data SNR increasing with time : Better-quality parameters + Abund.
- **Much larger chemo-dynamical catalogues to come:**
  - 5.6 million stars with chemo-physical parameters in DR3 (2022)
  - ~8 / ~20 times more stars in DR4 / DR5
  - New chemical species to come

Gaia/GSP-spec offers high-precision parametrization with unprecedented **high number statistics**

Gaia/GSP-spec Frequently Asked (and not-Asked) Questions

- **When I query the Gaia catalogue, my sources do not have GSPspec parameters.**
  - Please check that you query the right table: AstophysicalParameters

- **When I plot GSPspec parameters, there is a cloud of points…**
  - Please check the quality flag chain (including atm. param AND abundances)
  - Filter out results with quality lower than desired
  - Check also the published uncertainties and the SNR (rv_expected_sig_to_noise)

- **GSPspec parameters have to be calibrated**
  - See recommendations in Recio-Blanco et al. 2023 & 2024
  - For a given species with published abund., others have assumed [X/Fe]=0