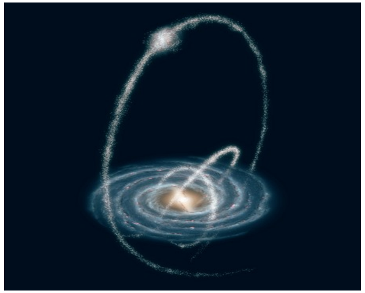
A new tool for chemical tagging based on iron-peak elements

Alice Minelli (UniBo)

Collaborators: A. Mucciarelli (UniBo), D. Massari (INAF), M. Bellazzini (INAF), D. Romano (INAF), R.F. Ferraro (UniBo)

21 October 2021

Outline

Homogeneous comparison between LMC – Sgr – MW

↓

New diagnostics

↓

Application: identification of accreted stars

Closest Milky Way satellites

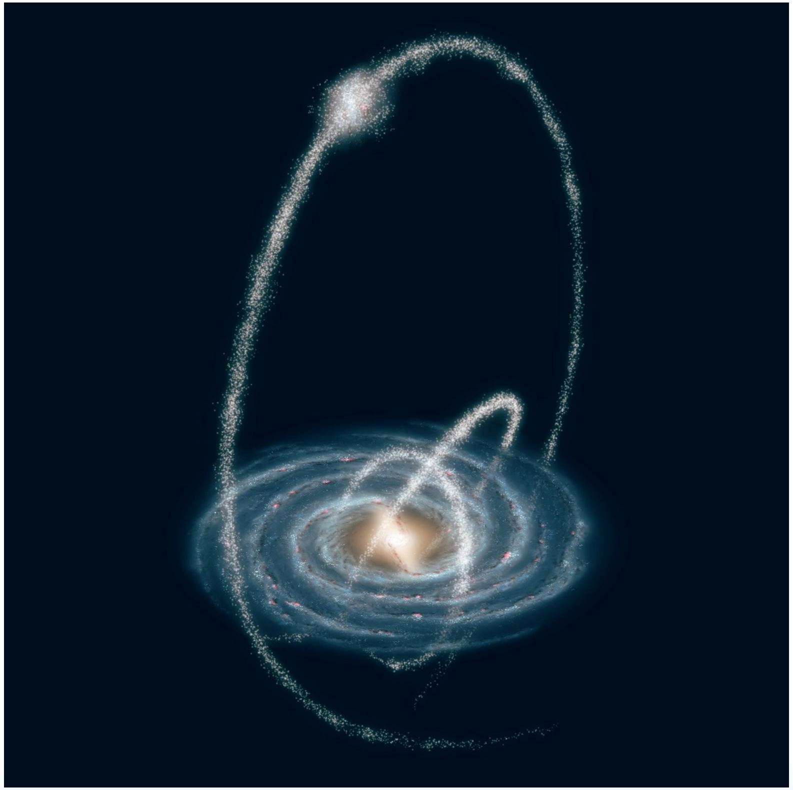
NO isolated systems

LMC

Gravitational interaction with MW
Early stage of a minor merger with SMC

Sgr

Disrupted by MW tidal field

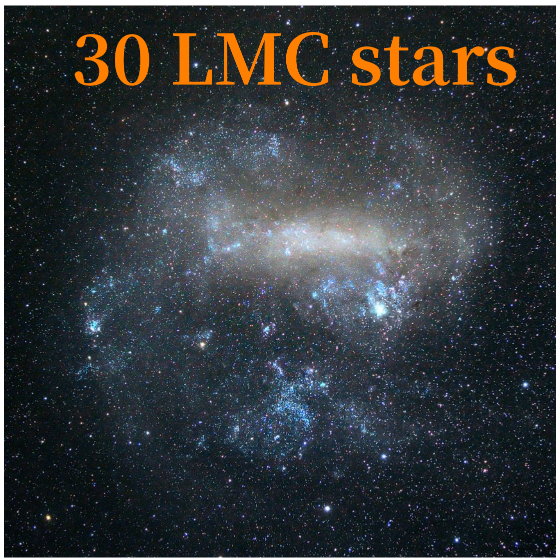


LMC vs Sgr Scientific goal

Homogeneous comparison between LMC-Sgr-MW

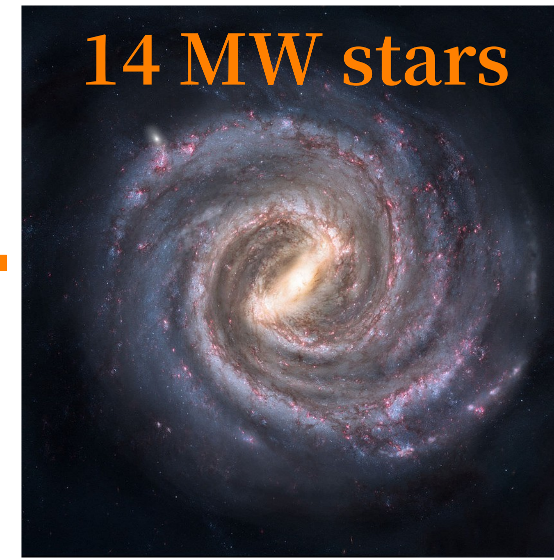
for the main groups of elements

UVES-FLAMES@VLT spectra (R ~ 45000, λ = 4800-6800 Å) of RGB stars



+

+



Abundance ratios for ~20 species

(α, light, iron peak, neutron capture elements)

LMC vs Sgr — Scientific goal

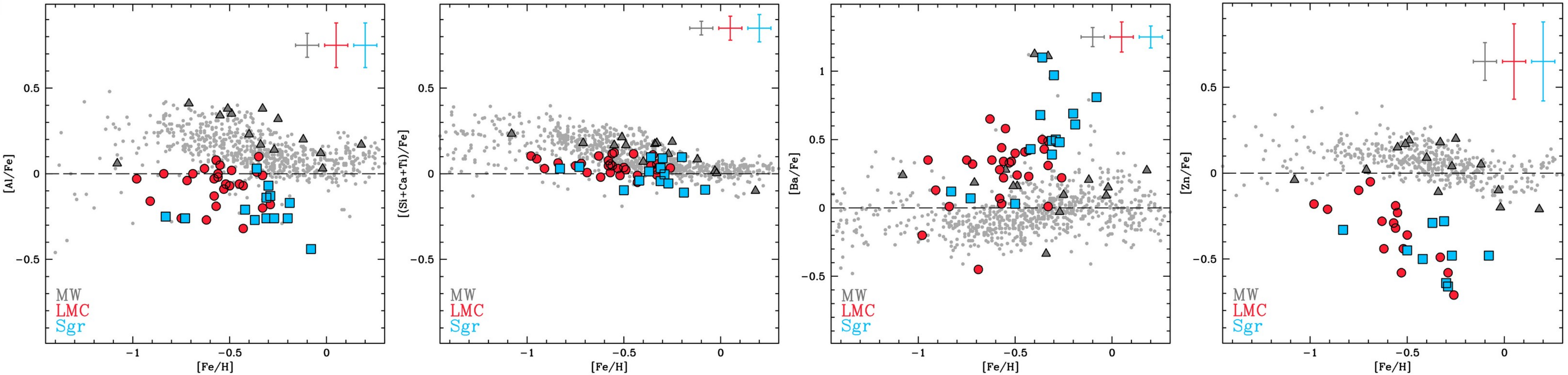
<u>Homogeneous analysis</u>:

Same:

- **atomic data**
- **model atmosphere/code**
- **solar values**
- **approch to derive Teff/log g**

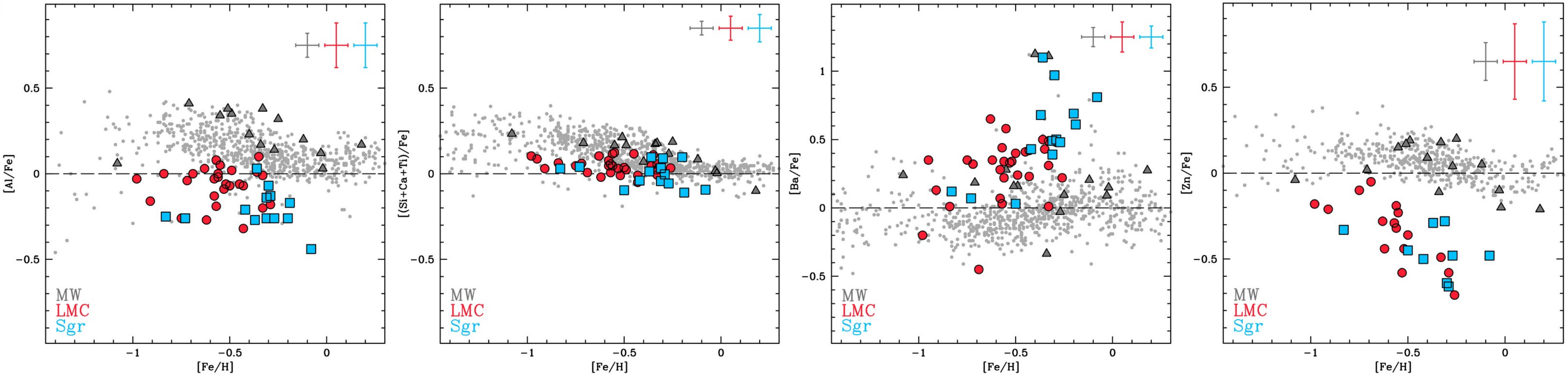
~~Systematics in the analyses~~

LMC vs Sgr Results



Minelli et al. 2021a

LMC vs Sgr Results

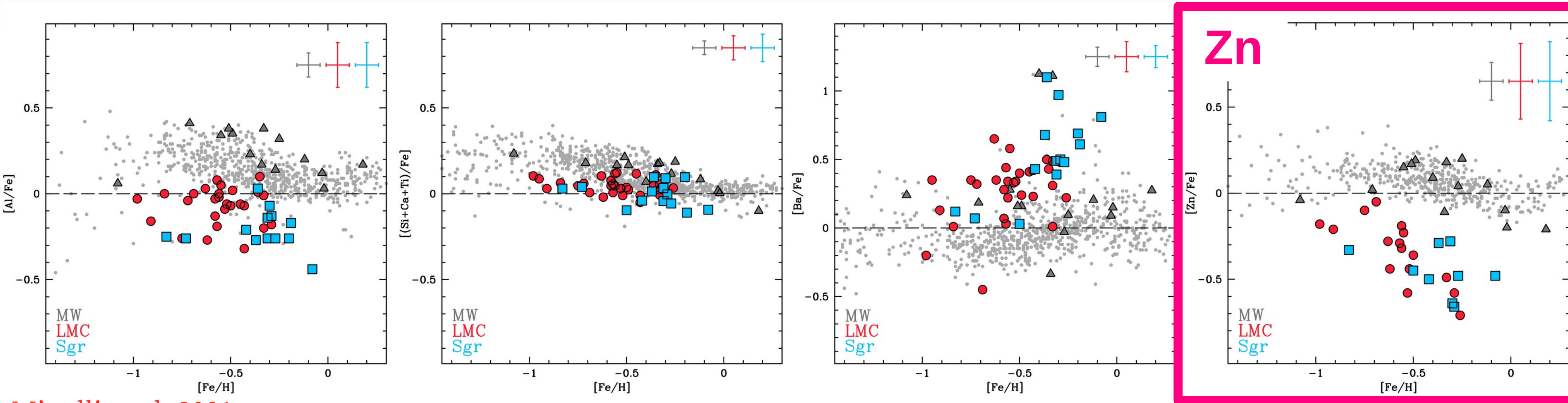


Minelli et al. 2021a

LMC vs Sgr → Similar chemical abundance ratios for all the elements
Similar chemical enrichment history

LMC/Sgr vs MW → Different chemical abundances ratios

LMC vs Sgr Results



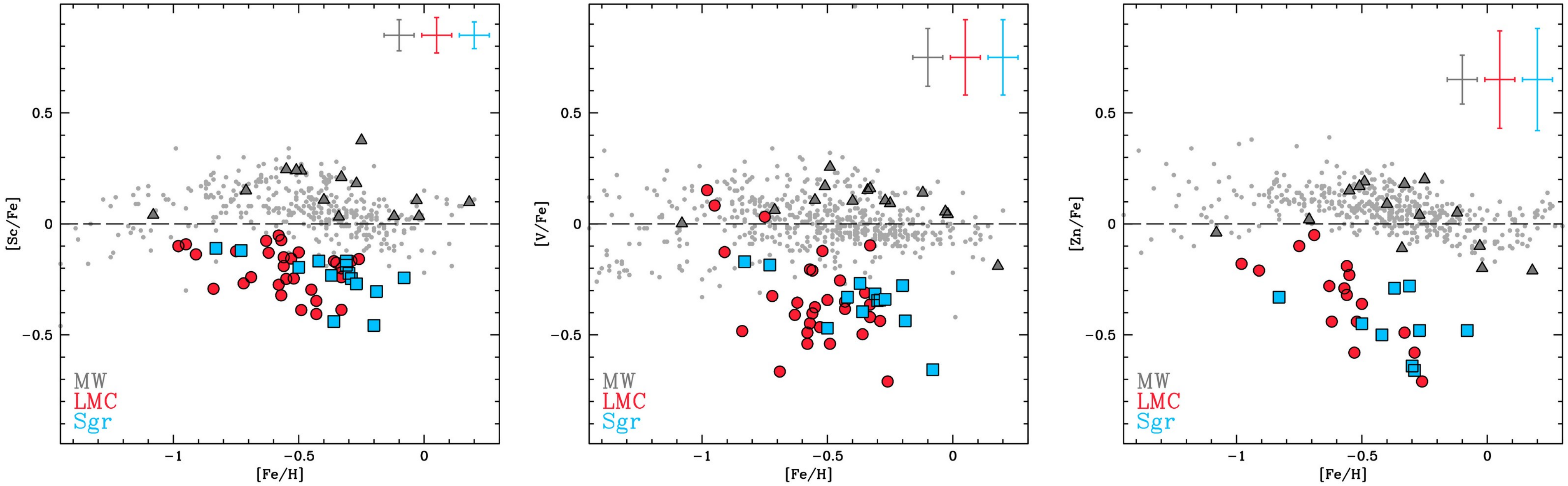
Minelli et al. 2021a

LMC vs Sgr → Similar chemical abundance ratios for all the elements
Similar chemical enrichment history

LMC/Sgr vs MW → Different chemical abundances ratios

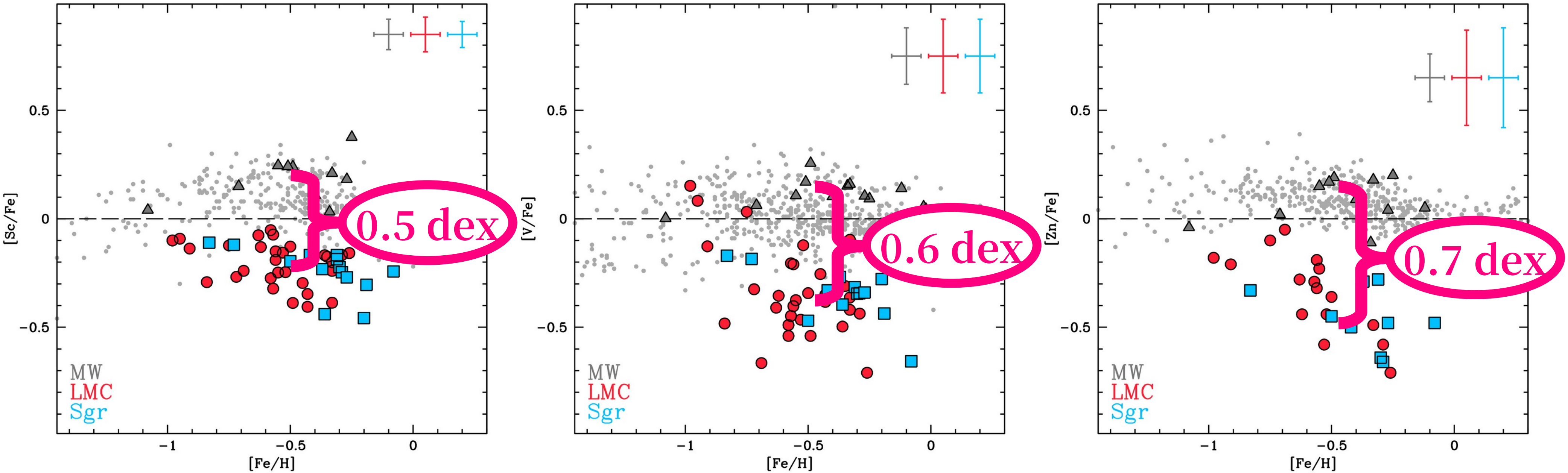
LMC vs Sgr Results

Minelli et al. 2021a



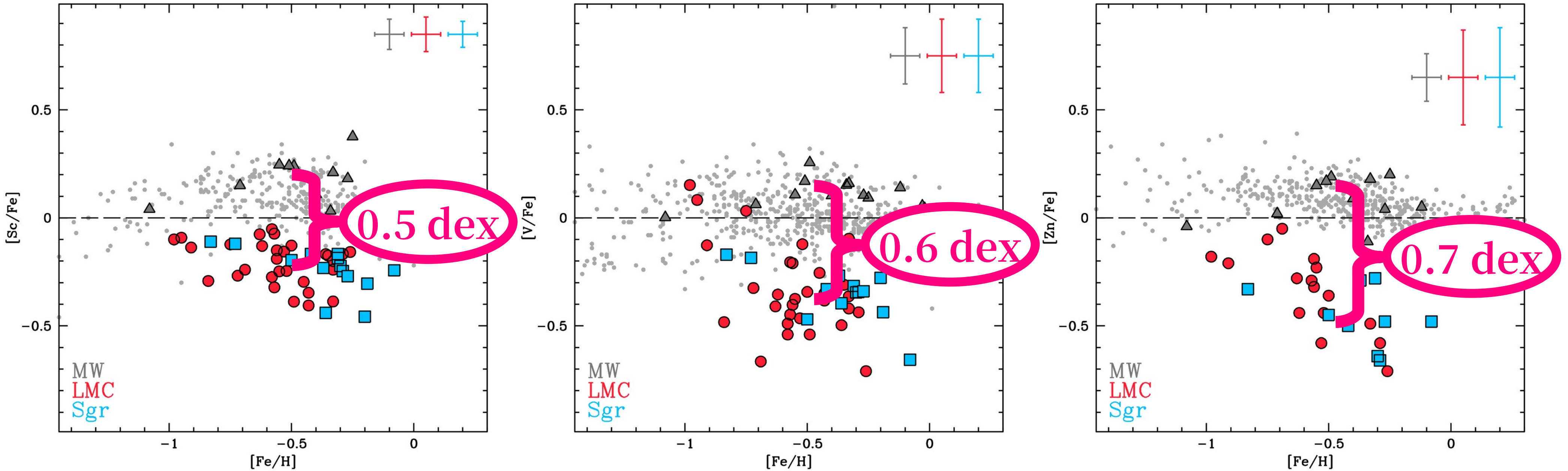
LMC vs Sgr Results

Minelli et al. 2021a



LMC vs Sgr Results

Minelli et al. 2021a



Sc, V, Zn → **NEW DIAGNOSTICS** to distinguish metal-rich stars formed outside the MW

Analysed targets

Check the origin of **MW** clusters

Accreted or in-situ origin of the GCs can be assess using their dynamical properties.

But sometimes do not allow a clear-cut classification.

Analysed targets

MW GCs

NGC 5927

[Fe/H] = – 0.46 $\pm$ 0.03 dex

M = 2.75 $\pm$ 0.02 $\times$ 10^5 $M_\odot$ [1]

NGC 6388

[Fe/H] = – 0.49 $\pm$ 0.02 dex

M = 1.25 $\pm$ 0.01 $\times$ 10^6 $M_\odot$ [1]

NGC 6496

[Fe/H] = – 0.64 $\pm$ 0.03 dex

M = 6.89 $\pm$ 0.73 $\times$ 10^4 $M_\odot$ [1]

NGC 6441

[Fe/H] = – 0.54 $\pm$ 0.08 dex

M = 1.32 $\pm$ 0.01 $\times$ 10^6 $M_\odot$ [1]

[1] Baumgardt 2017; Baumgardt & Hilker 2018

Analysed targets

MW GCs

NGC 5927

[Fe/H] = – 0.46 ± 0.03 dex

M = 2.75 ± 0.02 × 10^5 $M_\odot$ [1]

NGC 6388

[Fe/H] = – 0.49 ± 0.02 dex

M = 1.25 ± 0.01 × 10^6 $M_\odot$ [1]

IN SITU GCs [2]

ACCRETED GCs [2] **??**

NGC 6496

[Fe/H] = – 0.64 ± 0.03 dex

M = 6.89 ± 0.73 × 10^4 $M_\odot$ [1]

NGC 6441

[Fe/H] = – 0.54 ± 0.08 dex

M = 1.32 ± 0.01 × 10^6 $M_\odot$ [1]

[1] Baumgardt 2017; Baumgardt & Hilker 2018

[2] (Massari et al. 2019)

Analysed targets

MW GCs

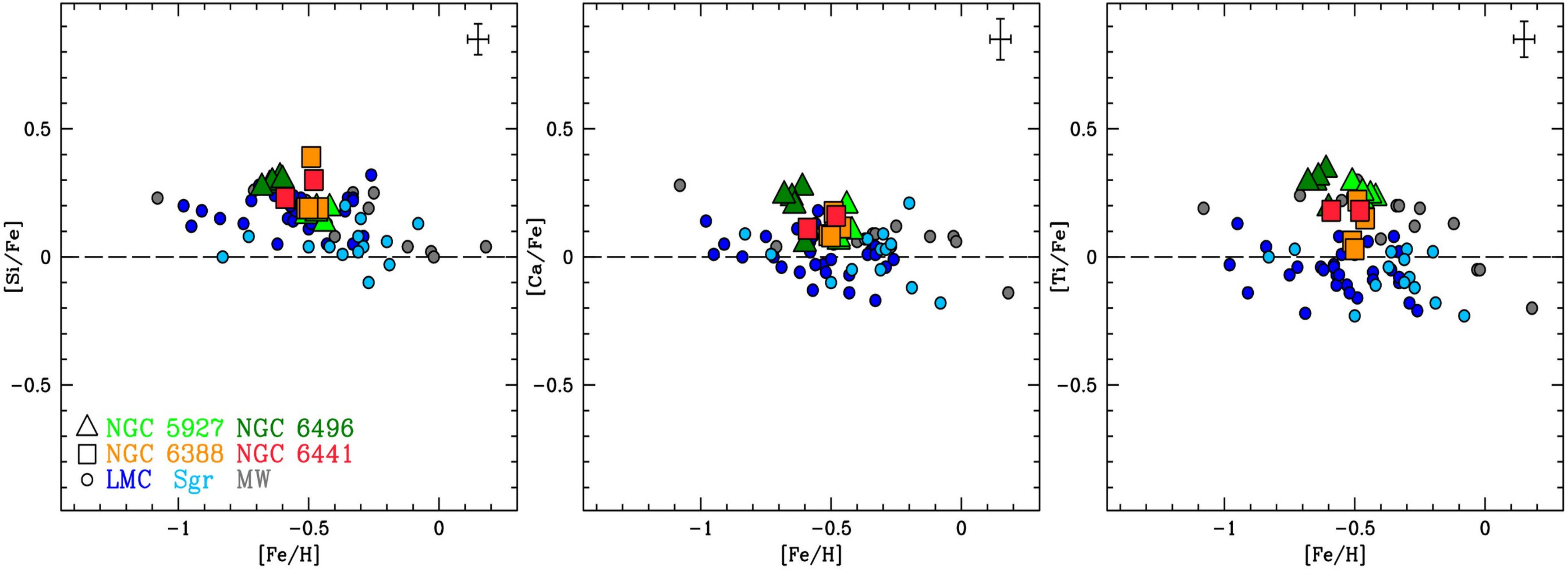
NGC 5927 **NGC 6496** **NGC 6388** **NGC 6441**

UVES-FLAMES@VLT spectra
(R ~ 45000, λ = 4800-6800 Å)
RGB stars

Abundance ratios for
α, iron peak & neutron capture elements

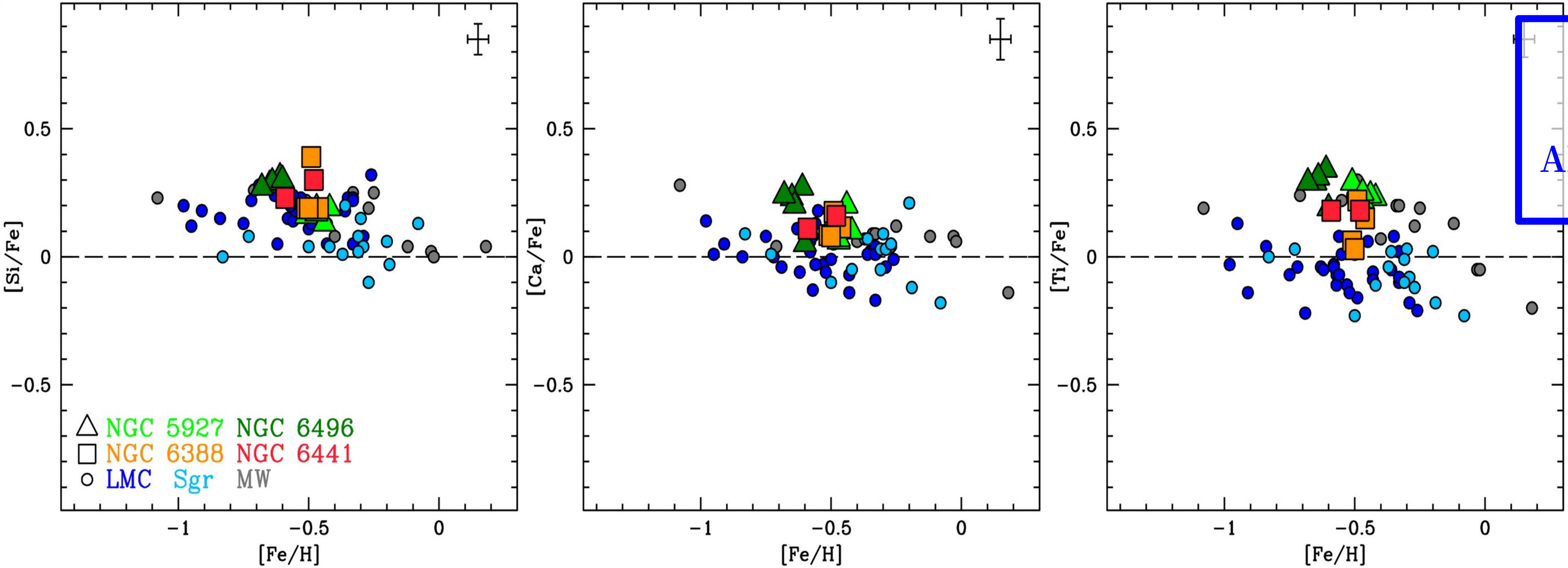
Results

Minelli et al. 2021b



Results

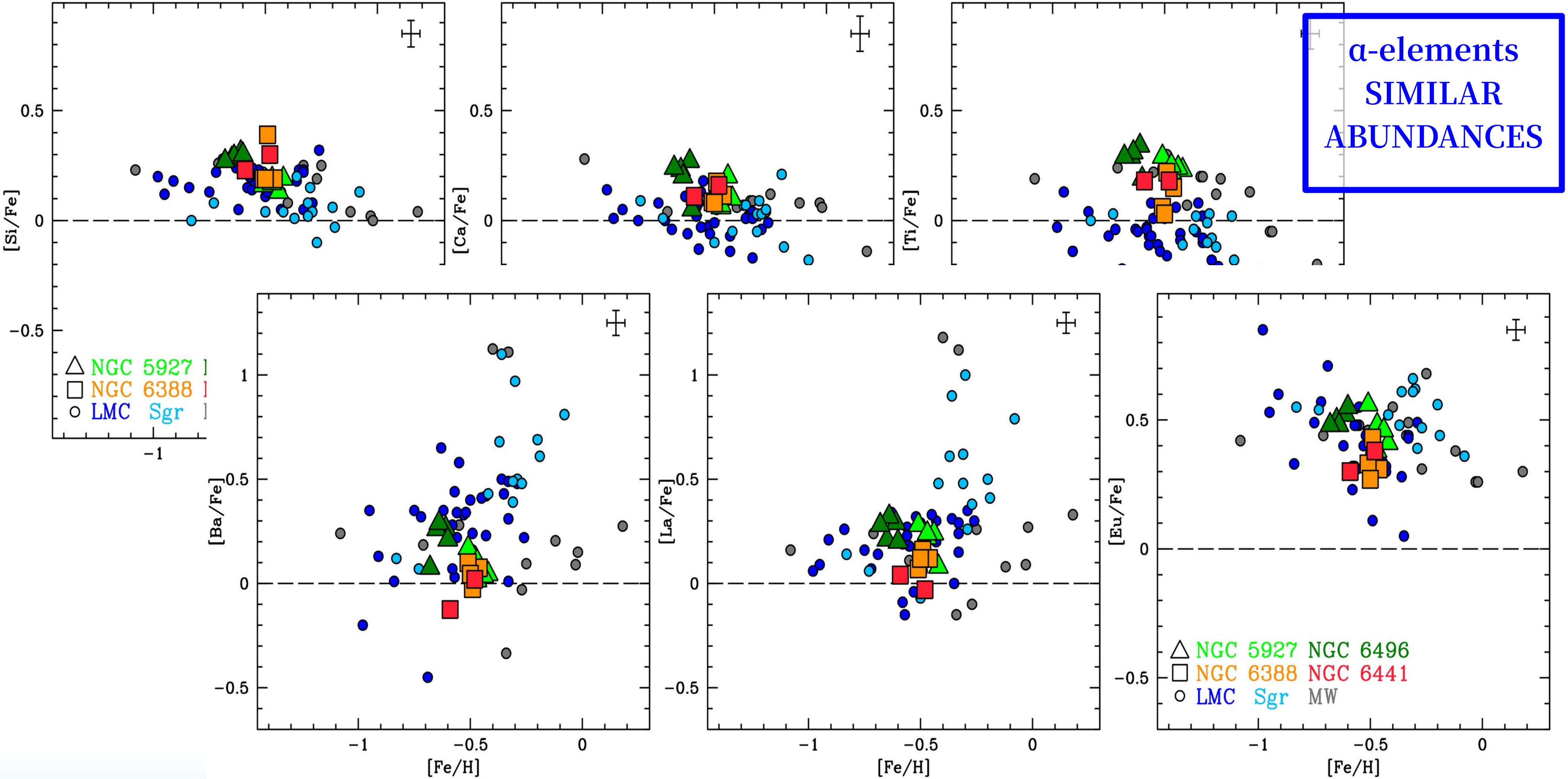
Minelli et al. 2021b



α-elements
SIMILAR
ABUNDANCES

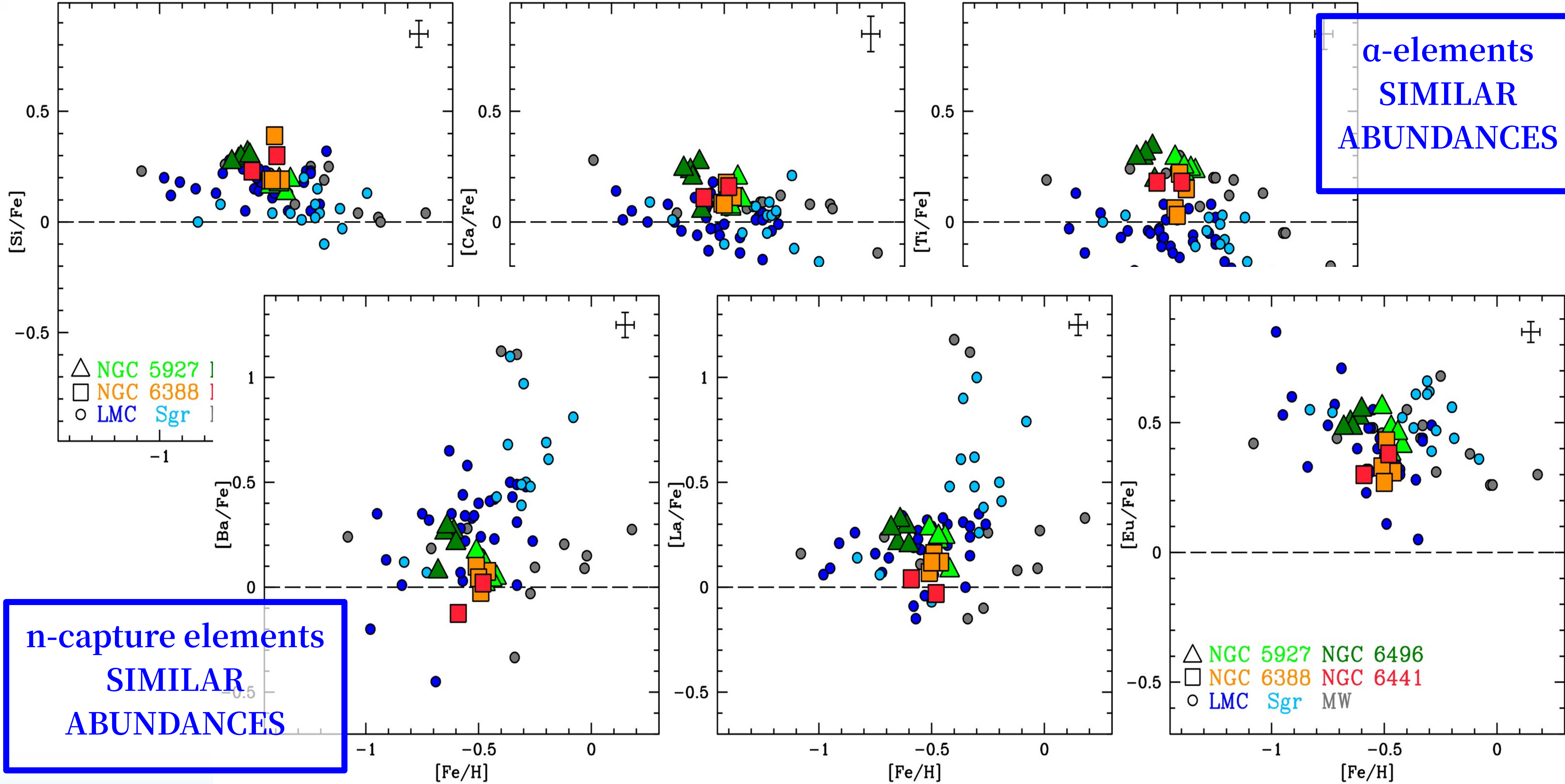
Results

Minelli et al. 2021b



Results

Minelli et al. 2021b

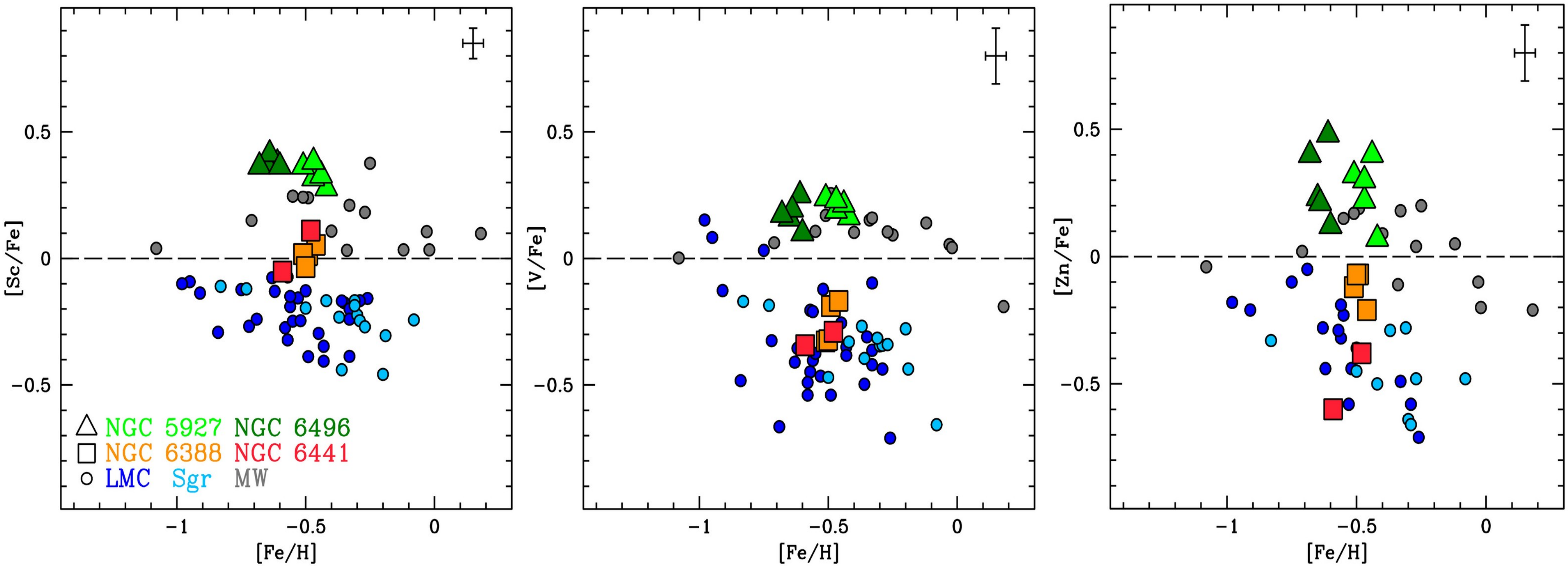


α-elements SIMILAR ABUNDANCES

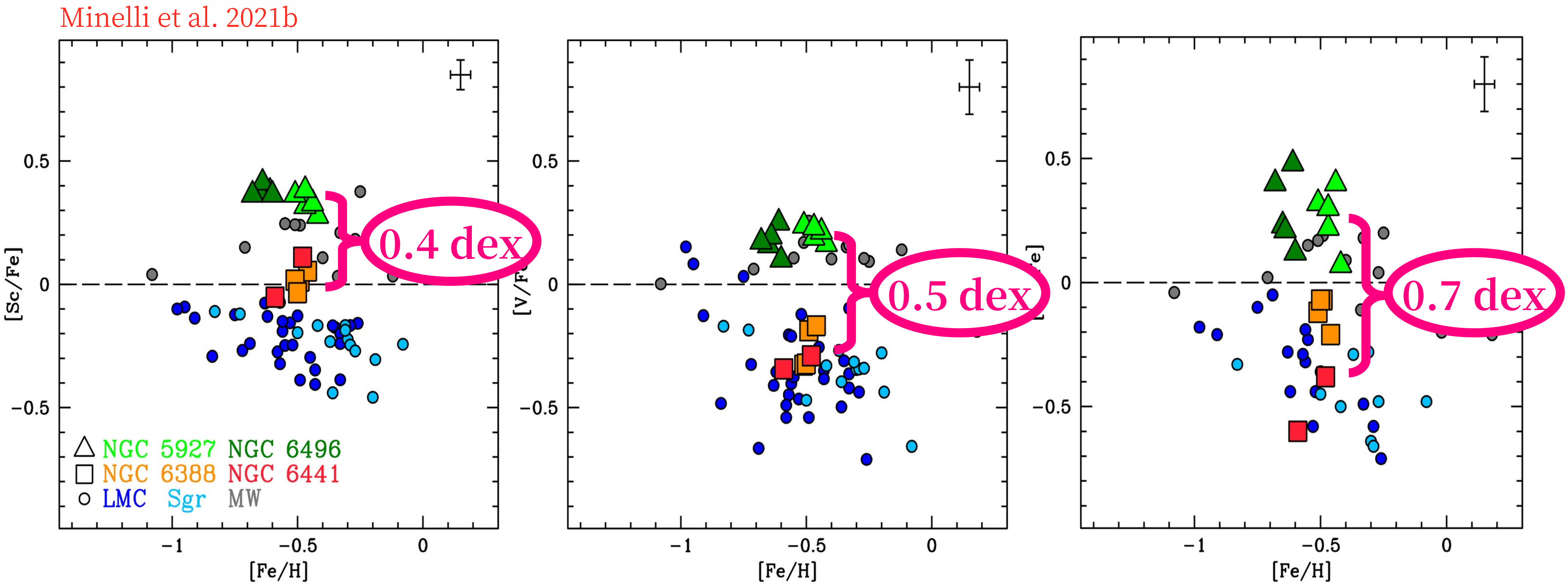
n-capture elements SIMILAR ABUNDANCES

Results

Minelli et al. 2021b



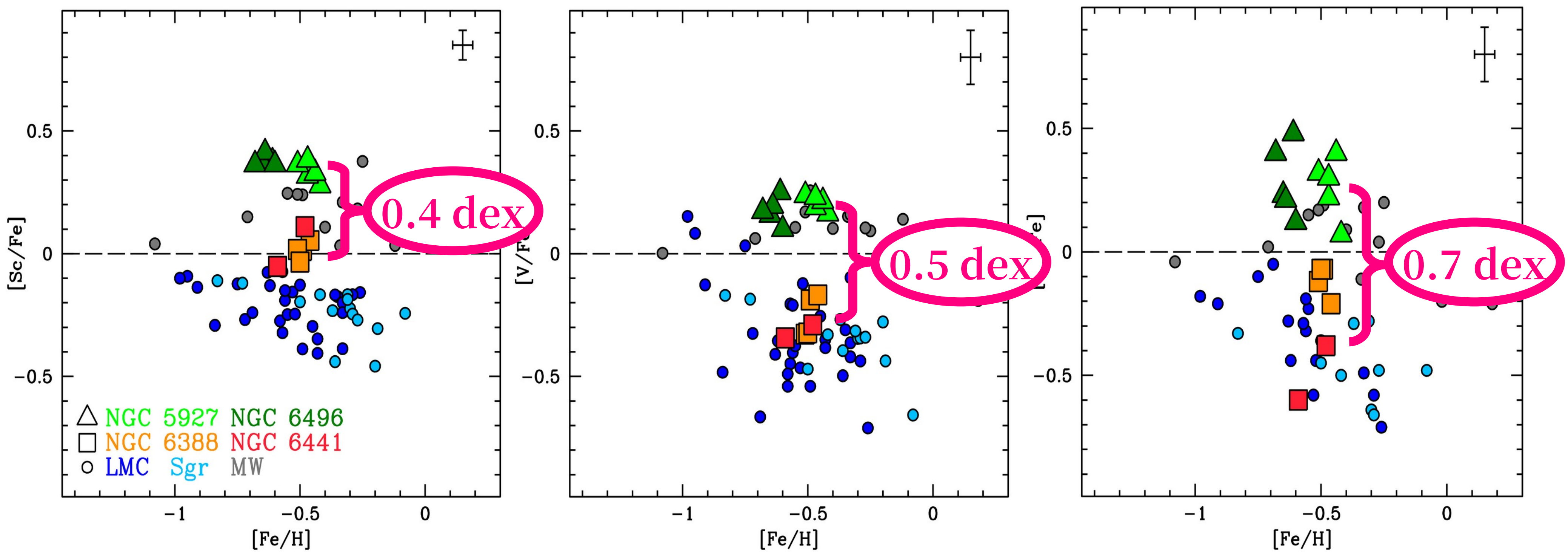
Results



Fe-peak elements
LARGE DIFFERENCE IN ABUNDANCES

Results

Minelli et al. 2021b

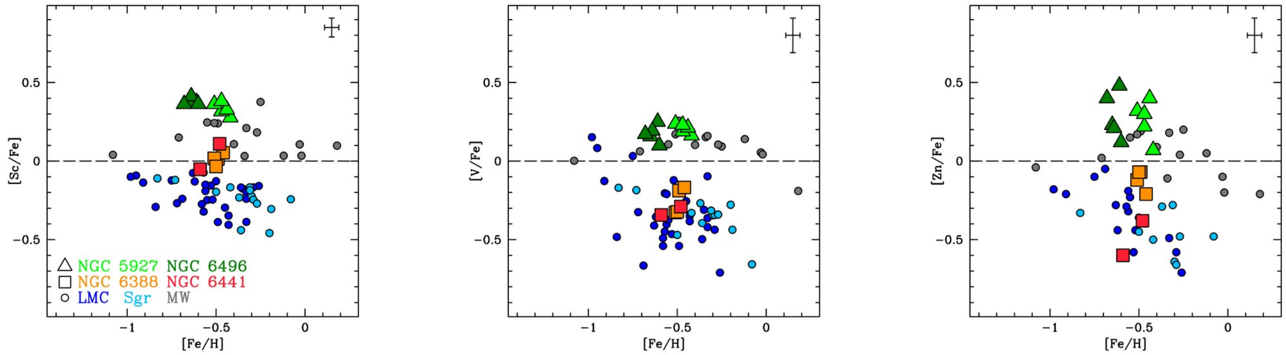


From Fe-peak element abundances:
NGC 5927 - NGC 6496 → confirmation of their in-situ origin
NGC 6388 - NGC 6441 → accreted origin

Take home message

Chemical tagging is a powerful tool to disentangle between the origin of astronomical object

Sc, V and Zn are ideal diagnostics to identify stars formed in galaxies with a low star formation efficiency, especially in metal-rich regime
(but also for metal-poor stars, see Mucciarelli et al. 2021, Nature Astronomy)

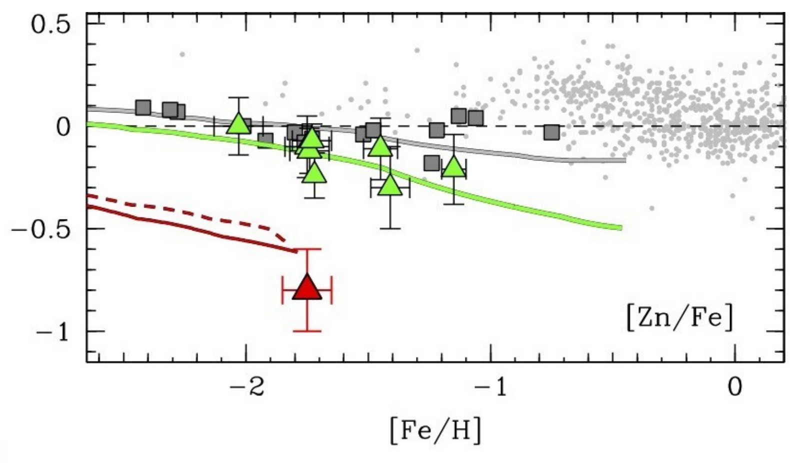


Minelli et al. 2021b

Take home message

Chemical tagging is a powerful tool to disentagle between the origin of astronomical object

Sc, V and Zn are ideal diagnostics to identify stars formed in galaxies with a low star formation efficiency, especially in metal-rich regime (but also for metal-poor stars, see Mucciarelli et al. 2021, Nature Astronomy)



Minelli et al. 2021b

Science case for HRMOS

Identification of accreted stars

Fe-peak elements abundances are needed

Main optical lines:

Sc: 5318 Å - 5526 Å - 5641 Å - 5657 Å - 5667 Å - 5684 Å - 6279 Å

V: 5670 Å - 5727 Å - 6150 Å - 6224 Å - 6285 Å - 6292 Å

Zn: 4810 Å

Top level requirements for HRMOS:

define the spectral coverage in order to include also these lines