Dissecting iDR2 disk data by GMM cluster models

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Gaia-ESO Survey Second Science Meeting
Porto, 2014

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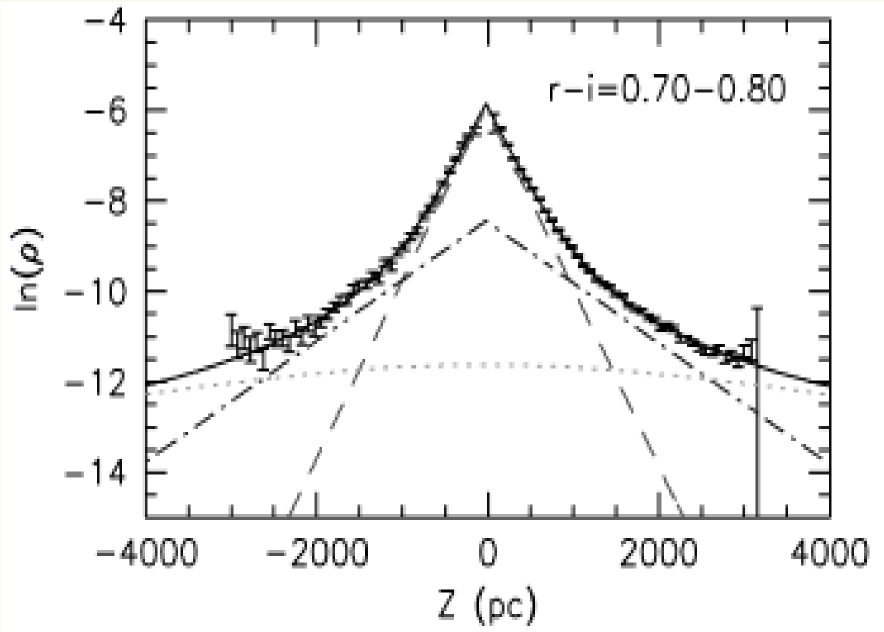
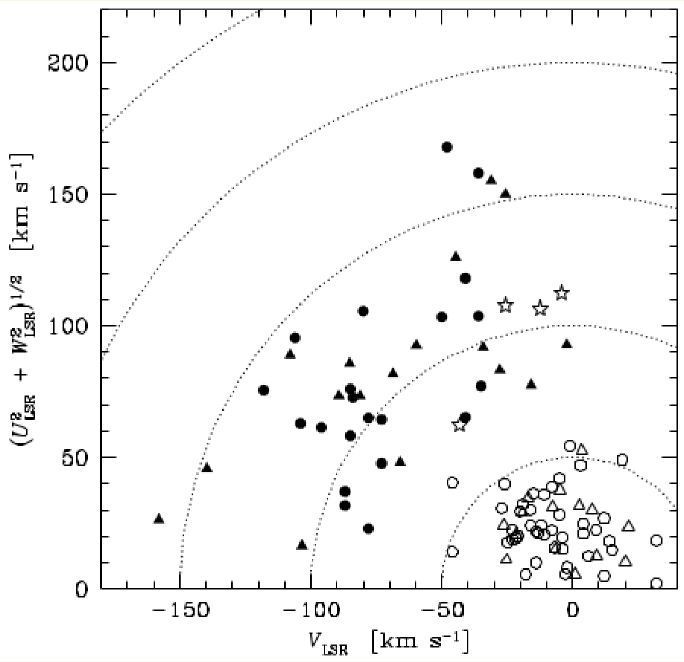
Lagrange

Thin/thick disc dichotomy

Structural → number density counts



Juric et al. 2008



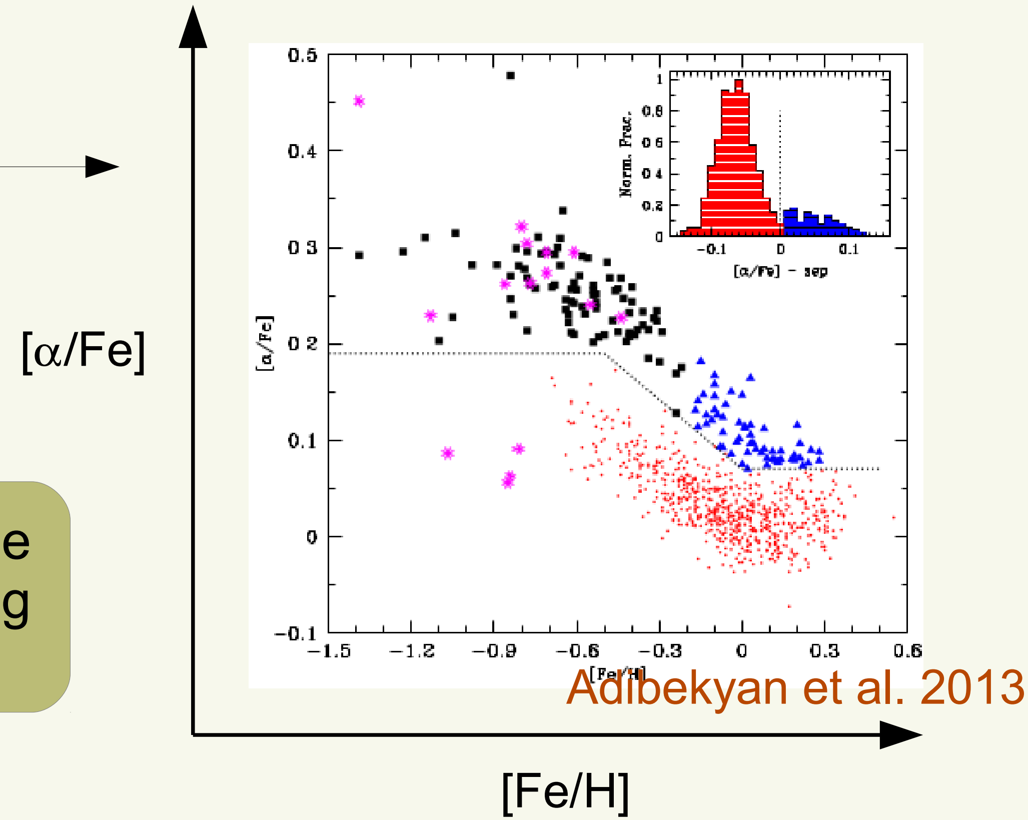
Bensby et al. 2005

Kinematically selected samples → Radial velocity + proper motions

Distribution of physical parameters overlaps in this thin/thick disc defined samples

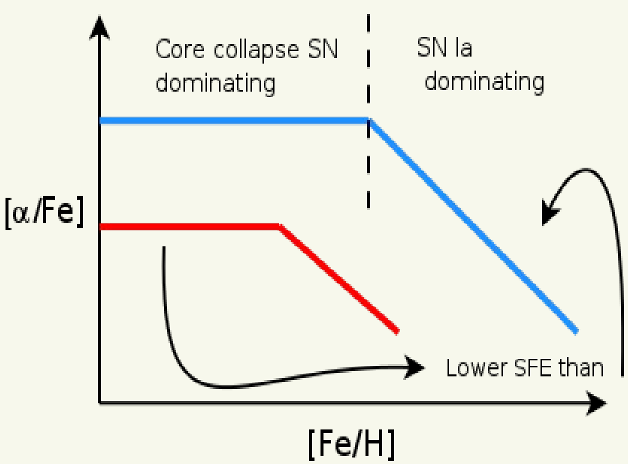
Chemical separation → chemical tagging of stars based in one or more elements

Solar neighborhood →



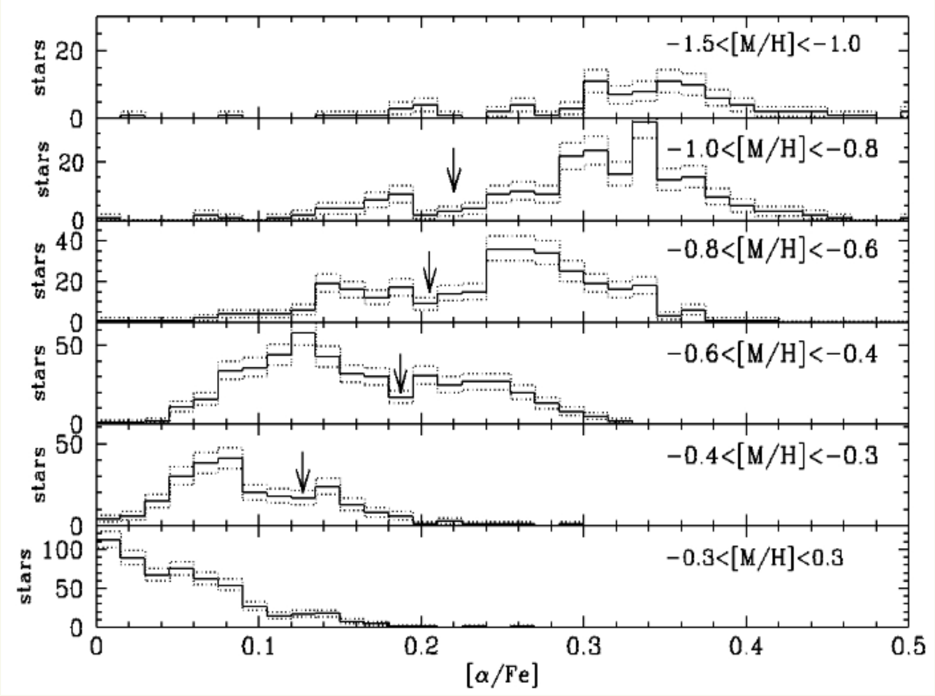
Adibekyan et al. 2013

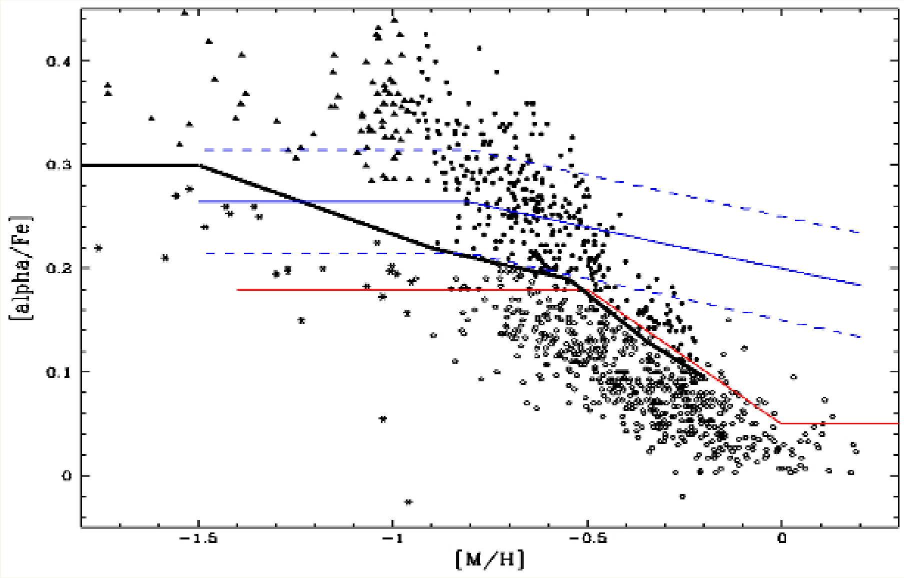
Chemical composition is more stable property than kinematic or position during stellar system evolution



→ Chemical enrichment history

Good quality data → follow number density gap in the [α/Fe] vs. [Fe/H] plane





Recio-Blanco et al. 2014

GES iDR1

We propose a different approach to split data in the abundance-metallicity plane

- Clustering formalism
- To find substructure supported by data
- Mathematically rigorous procedure

GMM in 2D (Gaussian Mixture Models)

GMM defined as a weighted sum of bivariate normal distributions

$$M(z|\mu,\Sigma) = \sum_{i=1}^{k} w_i N(z|\mu_i,\Sigma_i)$$

- With means μ and covariance matrix Σ
- Mixture with specific set of parameters μ_i, σ_i is an attempt to fit data set z composed by N observations

Given a GMM → best set of parameters → maximum likelihood

$$L(z|\mu,\Sigma) = \prod_{j=1}^{N} M(z_j|\mu,\Sigma).$$

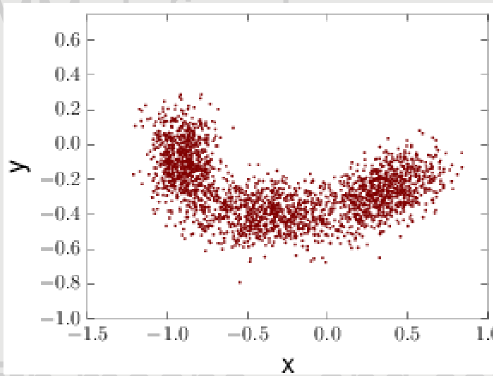
EM algorithm

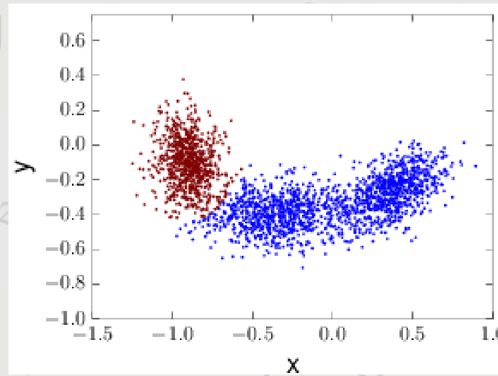
Given several maximum likelihood GMM models → complexity supported by data → AIC

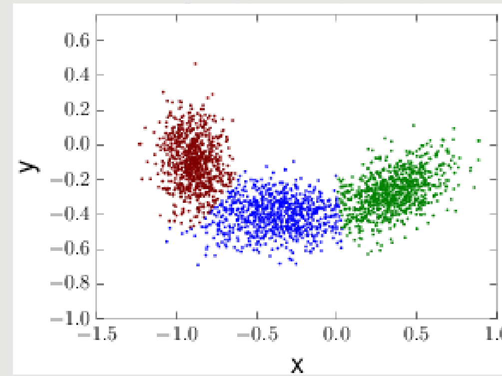
Best generating model

$$AIC = 2N_p - 2\ln(L_{max})$$

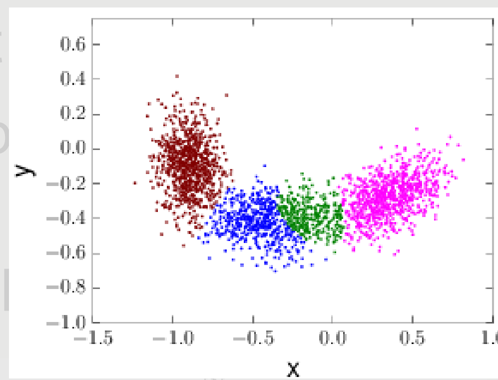
GMM in 2D

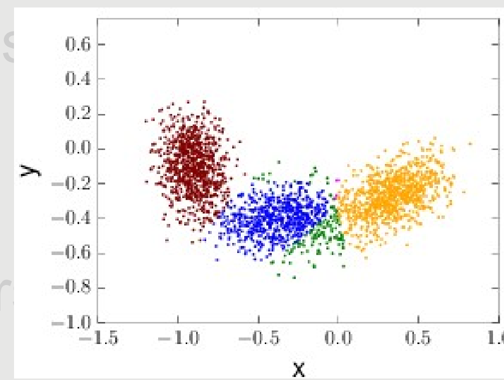






- With means μ and covariance matrix Σ
- Mixture with specific set … is … data set z composed by N ob…





Given a GMM (fixed k) → … ihood

$$L(z|\mu,\Sigma) = \prod_{j=1}^{N} M(z_j|\mu,\Sigma).$$

EM algorithm

Max. likelihood solutions

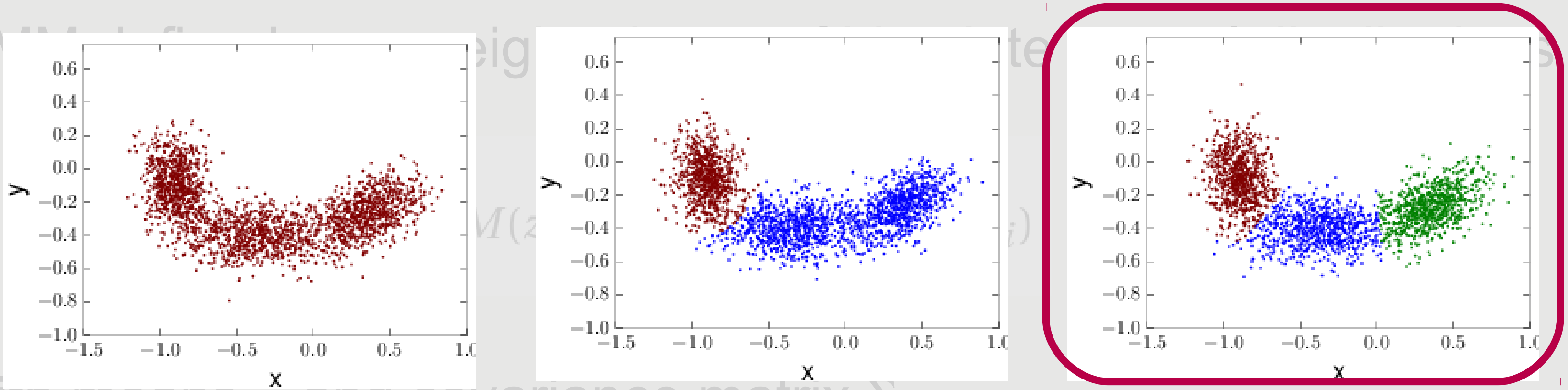
Given several maximum likelihood GMM models → complexity supported by data → AIC

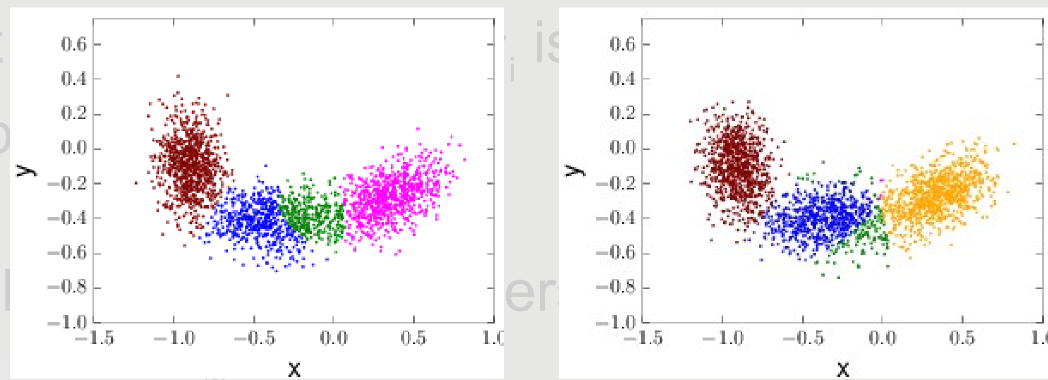
Which is the “best” one??

Best generating model

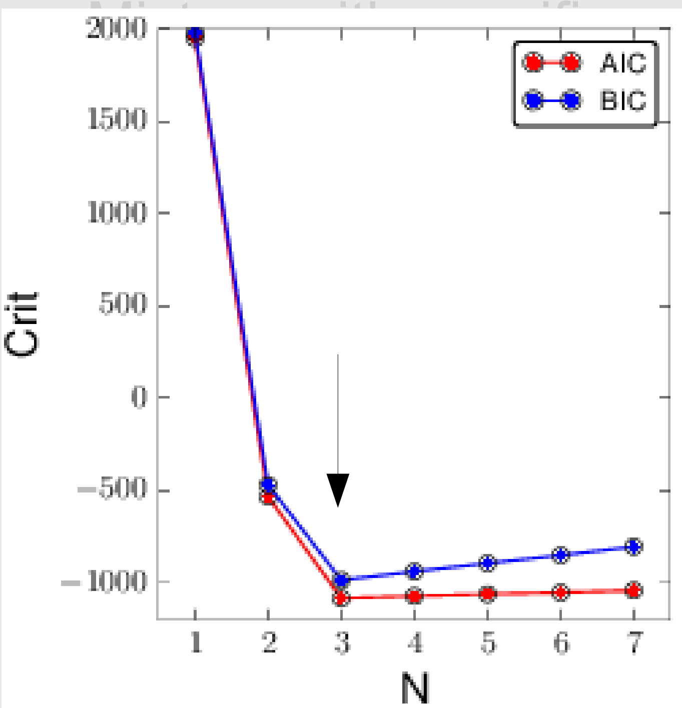
$$AIC = 2N_p - 2\ln(L_{max})$$

GMM in 2D





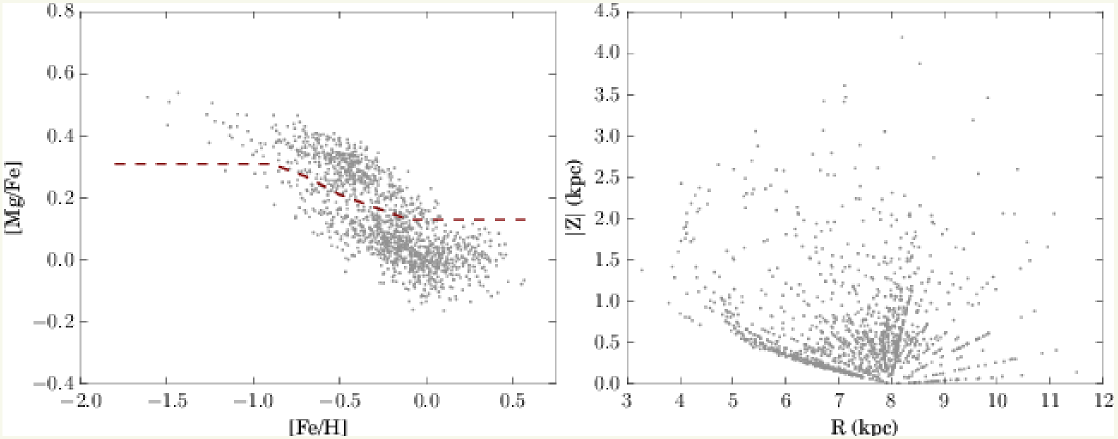
Max. likelihood solutions



Which is the “best” one??

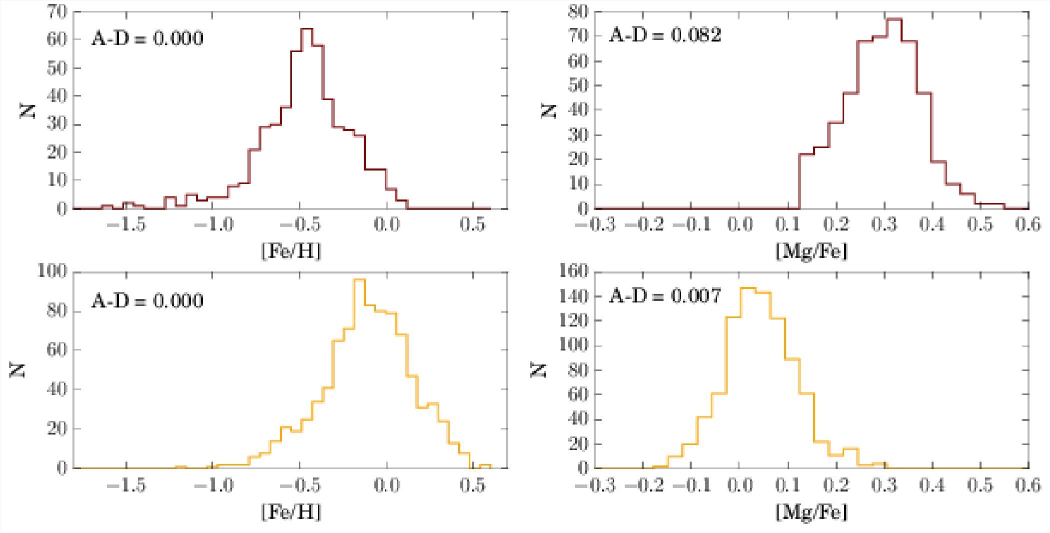
Application to disc GES iDR2 data

Stellar parameters, metallicity and abundances derived from H10 + HR21setups → clean sample of 1375 stars



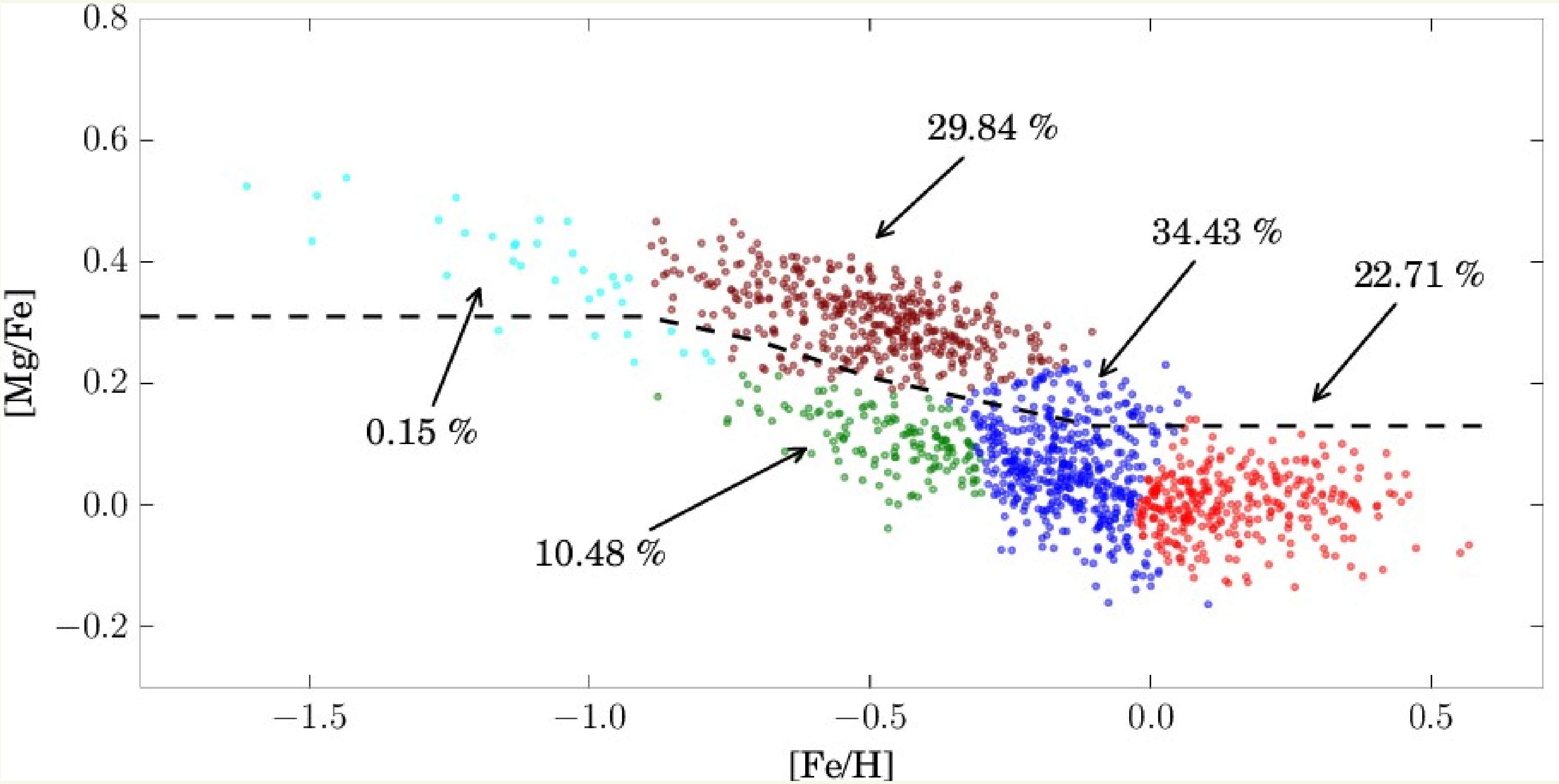
Thick-disc →

Thin-disc →



Best GMM model solution

- 5 components
- Thin/thick separation in good agreement with “follow-gap” procedure

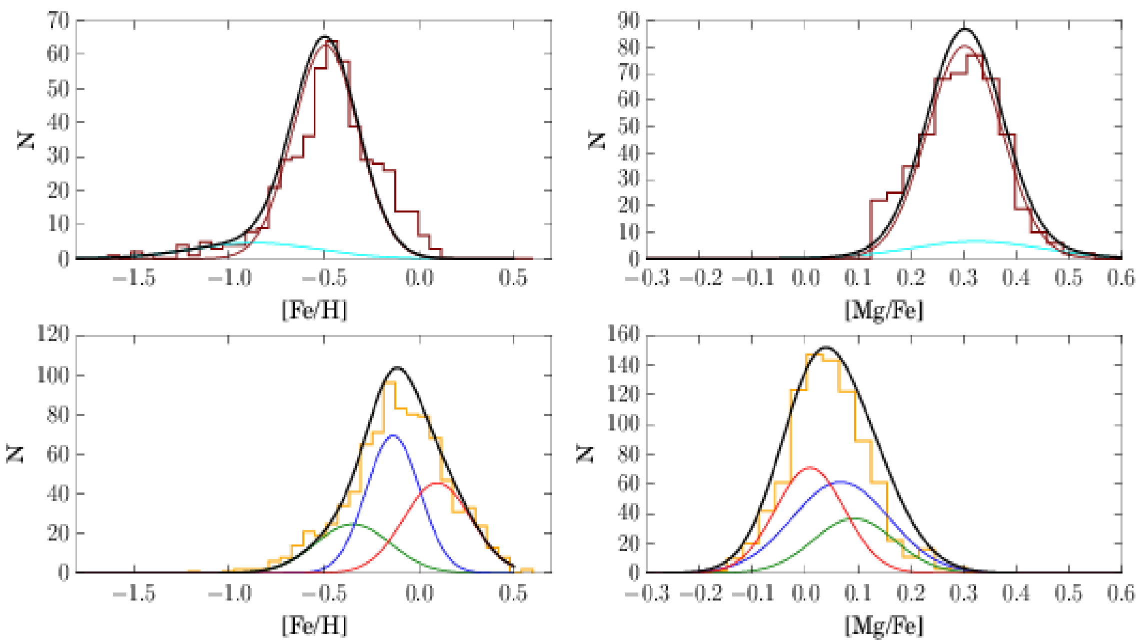


Best GMM model solution

- 5 components
- Thin/thick separation in good agreement with “follow-gap” procedure

Thick →

Thin →



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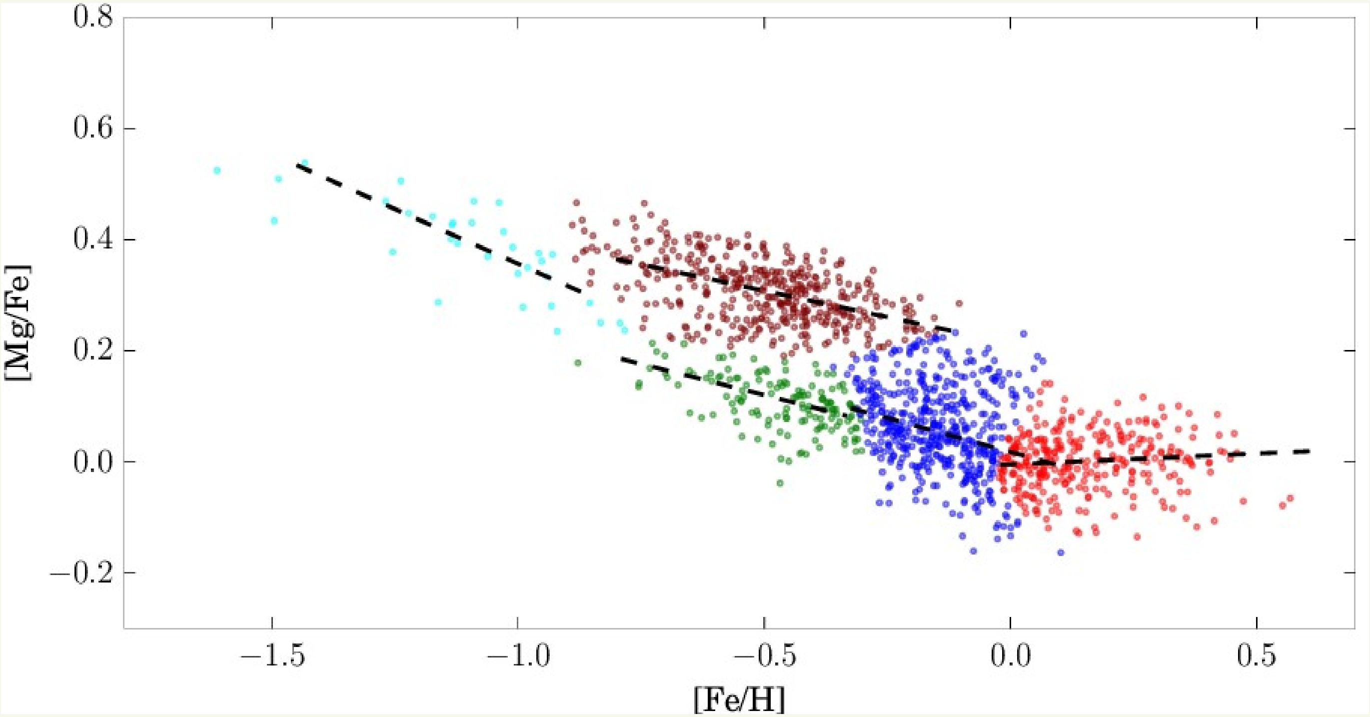
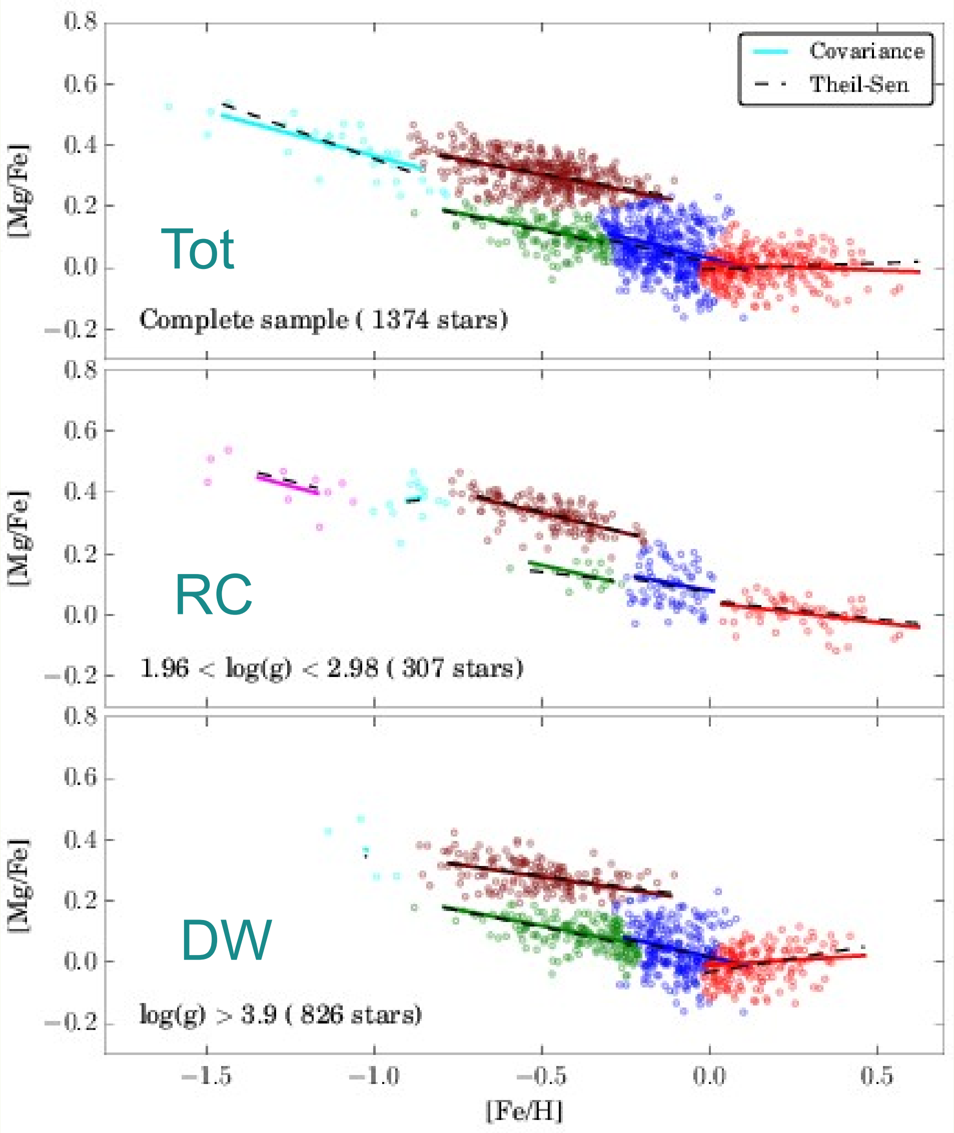


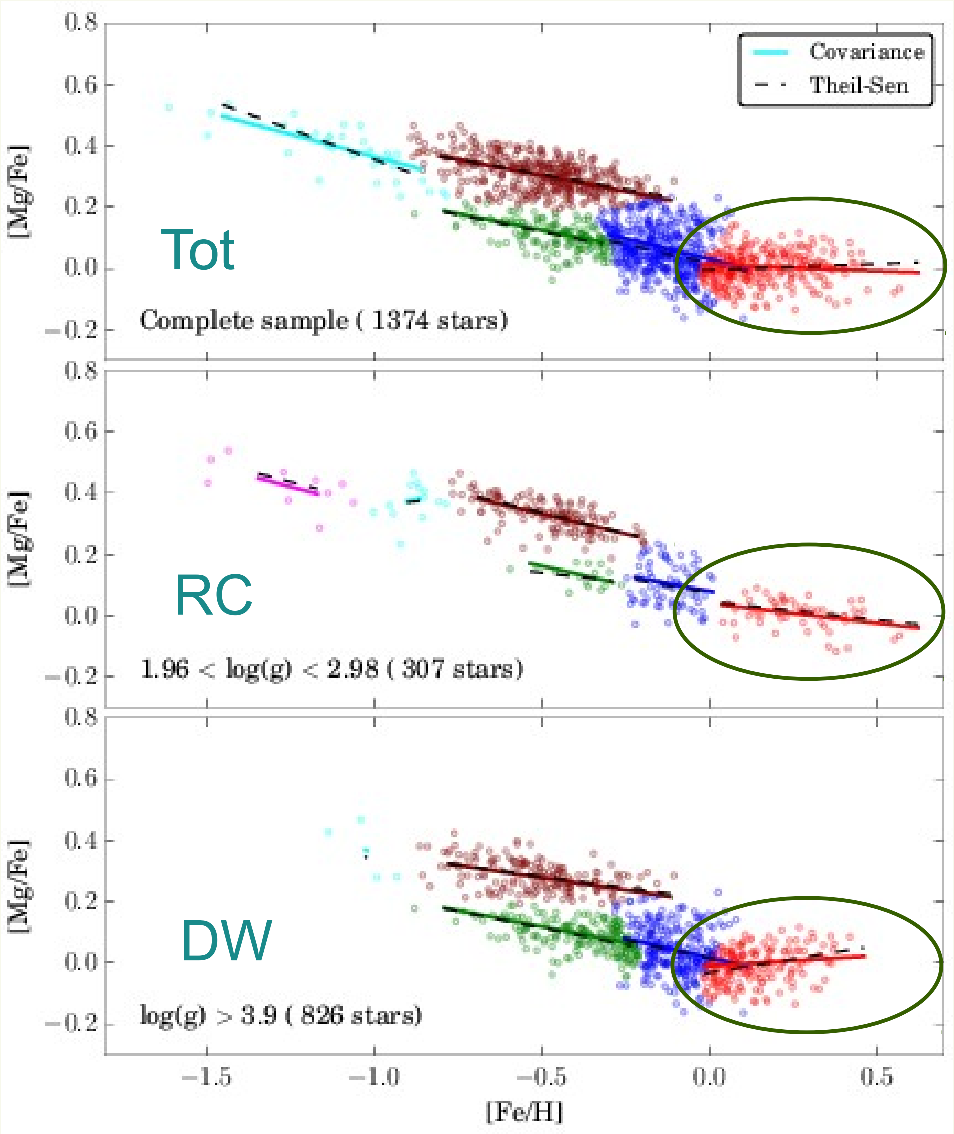
Statistically significant difference in slope for red and blue groups
No significant slope difference for blue and green groups

Results for different stellar types



- Gap thick-disc/*hαmr* stars more pronounced in RC
- Thin-disc overdensity at [Fe/H]~0.1 dex due to dwarfs
- Sequences in RC sample less dispersed than in dwarfs

Results for different stellar types

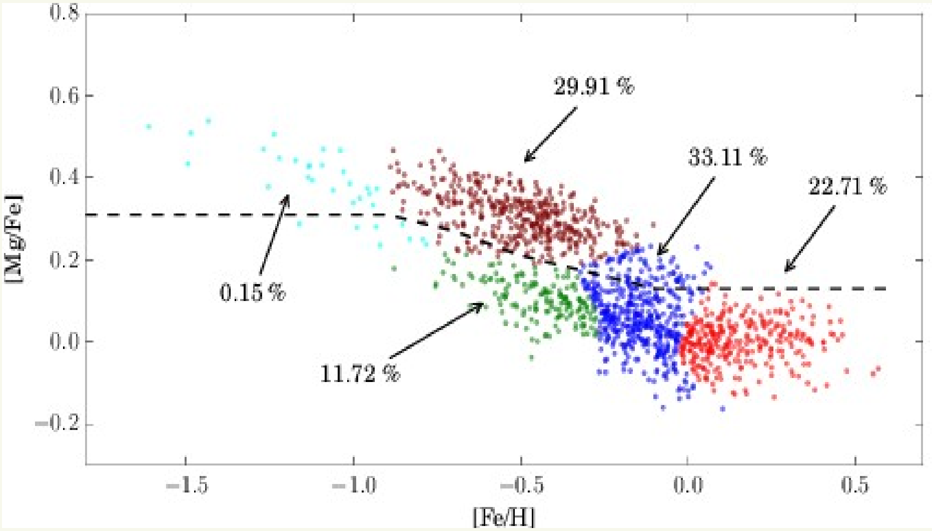


Group slopes with homogeneous trends in the three samples

Red group

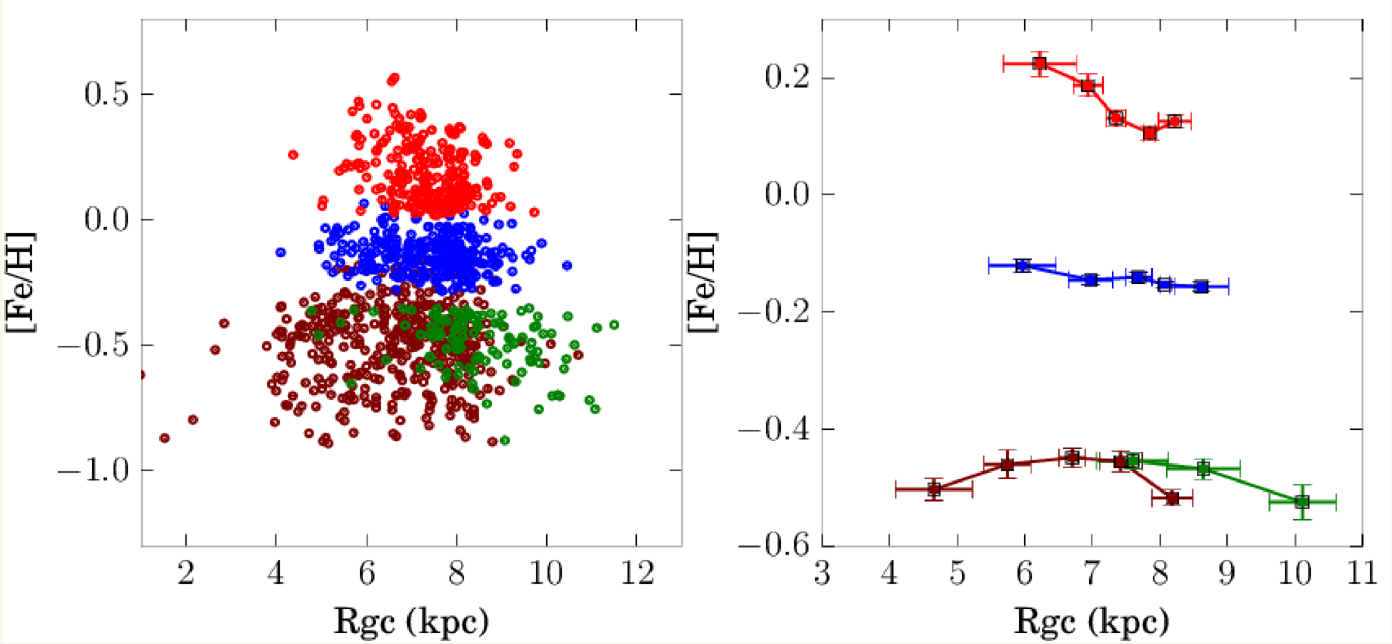
- Different trend for RC and dwarf sample
- RC red group split because subdensity
- No T_{eff} correlation with [Fe/H] to explain discrepancy

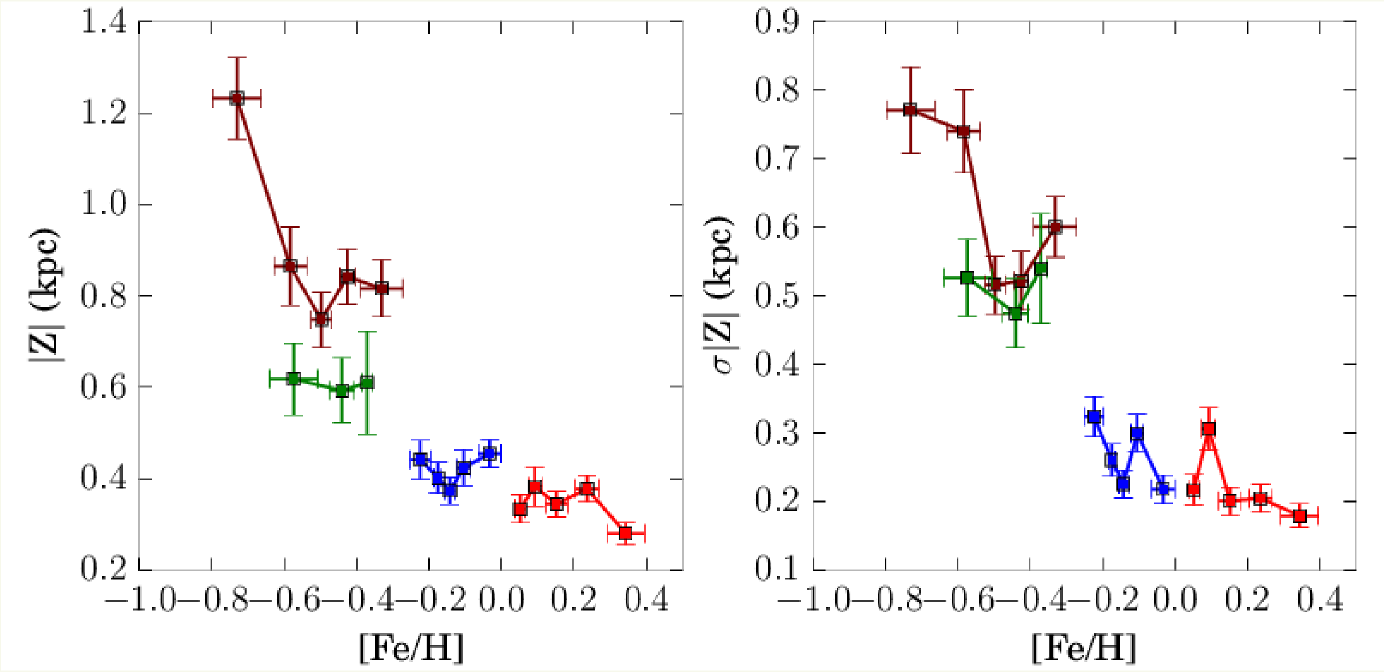
The metal-poor thin disk “green group”



No statistically significant slope difference respect to “blue” group

The “outer thin disc”?? of Haywood et al (2013)

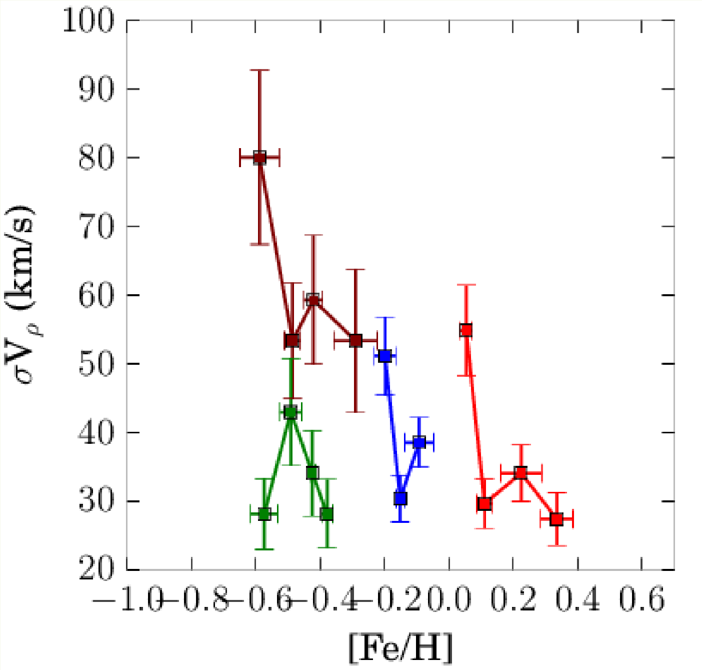




Intermediate scale height

Low radial cylindrical velocity dispersion

Radial migration??
Formation in-situ??



Summary

➡ We propose a clustering approach to examine data structure

Metallicity-abundance plane ⟷ Chemical tagging

Data structure ⟷ Gaussian formalism

➡ We found five mean components:

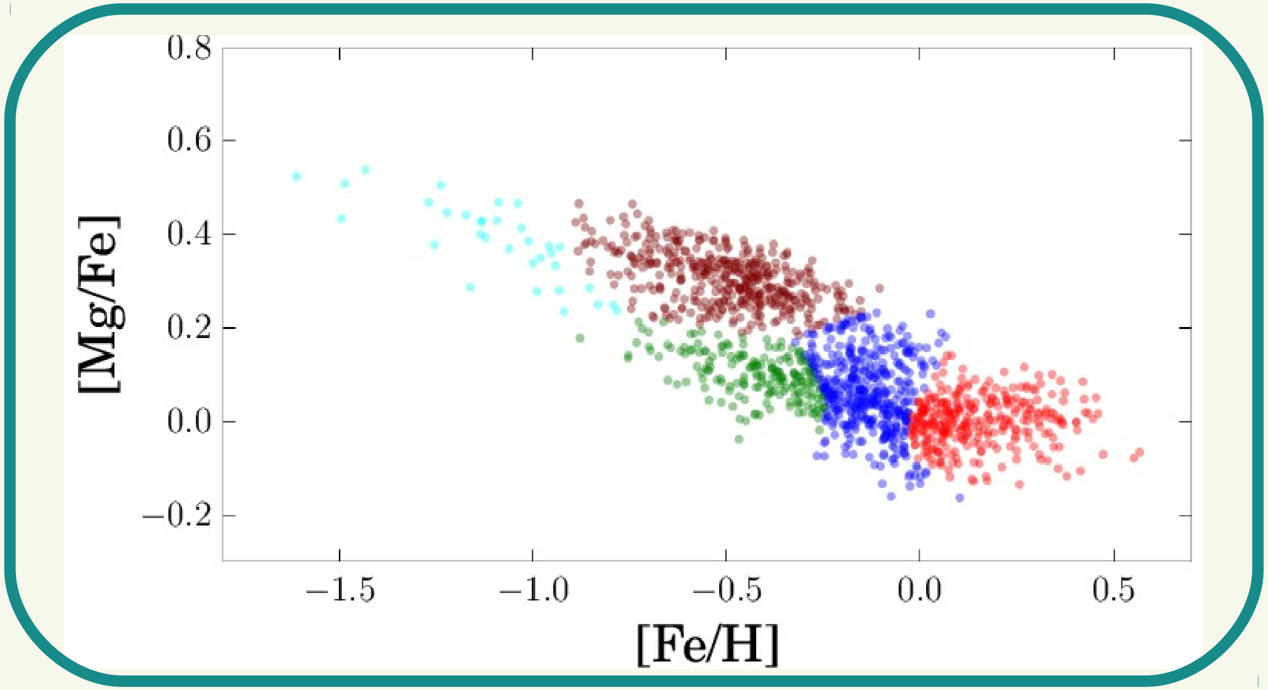
- Halo
- Thick disc
- Thin disc in three components

↓

Changes in slope + local number overdensities

Metal-rich "red" thin disc group:
Different slope for dwarf and RC stars

Metal-poor end "green" thin disc group:
Some characteristics different respect to more metal-rich thin disc stars



Thank you!