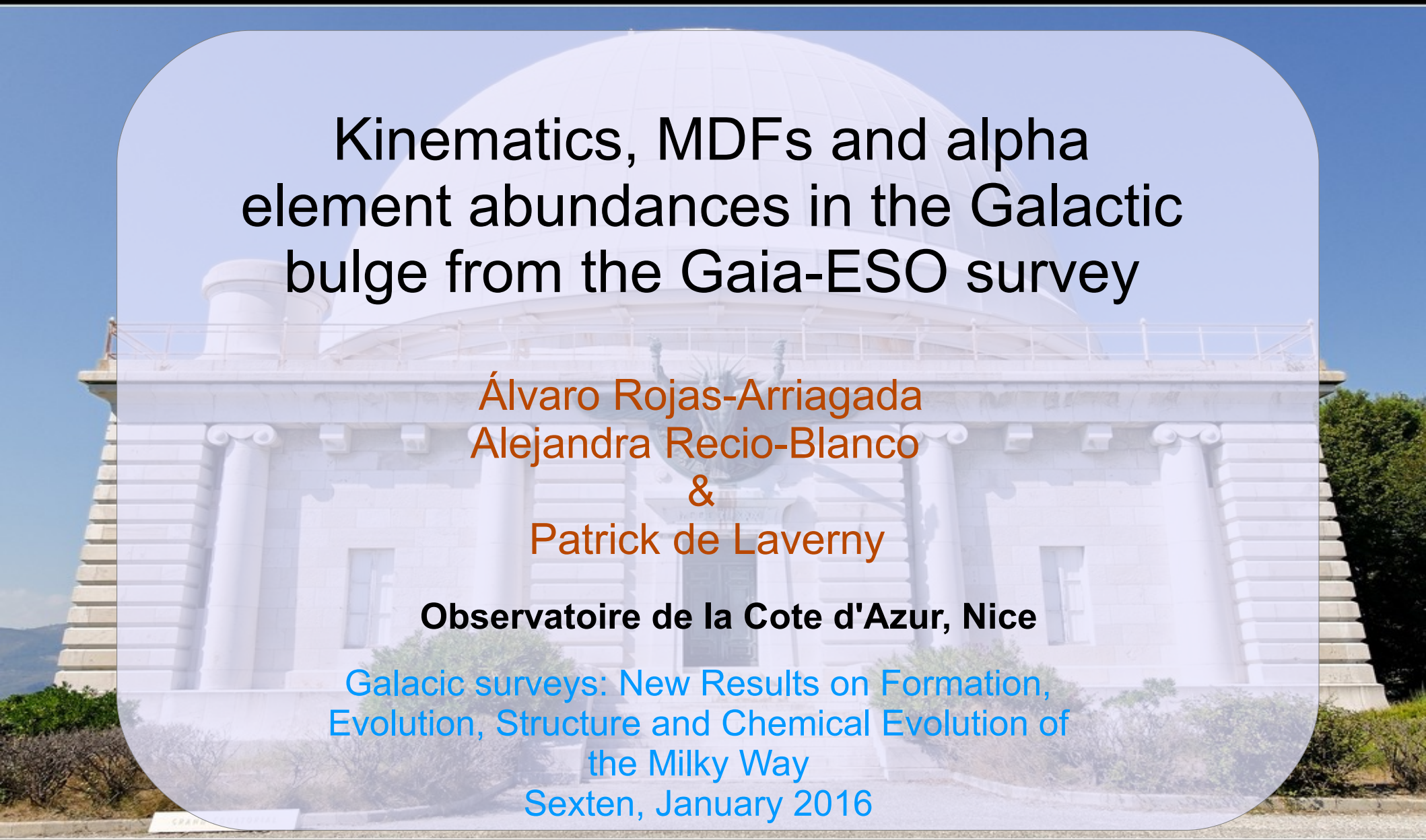

Kinematics, MDFs and alpha element abundances in the Galactic bulge from the Gaia-ESO survey

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Galacic surveys: New Results on Formation, Evolution, Structure and Chemical Evolution of the Milky Way
Sexten, January 2016

The question

How did the Milky Way form?

...but maybe, a more general one...

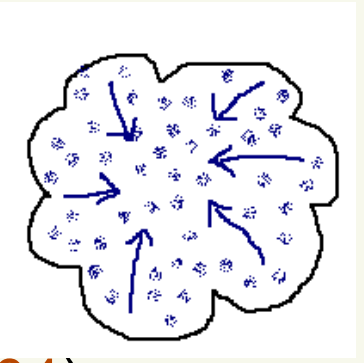
How the galaxies similar to milky way did form?

In the general context of galaxy formation the Milky Way bulge appears as an ideal laboratory

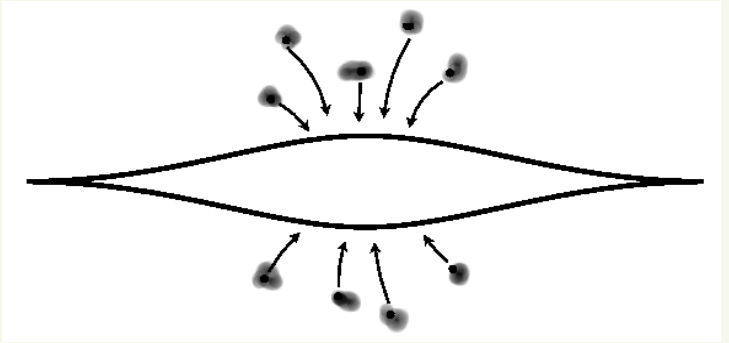
- Massive component: $M_{bulge}=1.8\cdot10^{10}\ M_{sun}$
- Closest bulge: Star-to-star based analysis of resolved stellar populations

Envisaged scenarios for bulge formation

- In-situ formation via dissipative collapse of protogalactic gas cloud in a free fall time scale (Eggen et al. 1962)



- Hierarchical merging of subclumps:
  - •Through an early disk evolution (Immeli et al. 2004)
  - •Through mergers (Scannapieco & Tissera 2004; Nakasato & Nomoto 2003)



- Secular evolution of the galactic disk:
  - Bar formation
  - Vertical instabilities
  - Buckling and fatten

Combes & Sanders 1981; Pfenniger & Norman 1990, Kormendy & Kennicutt 2004; Athanassoula 2005

Bulge fields in the GES iDR4

11 fields

~200 stars per field

GIRAFFE HR21 data

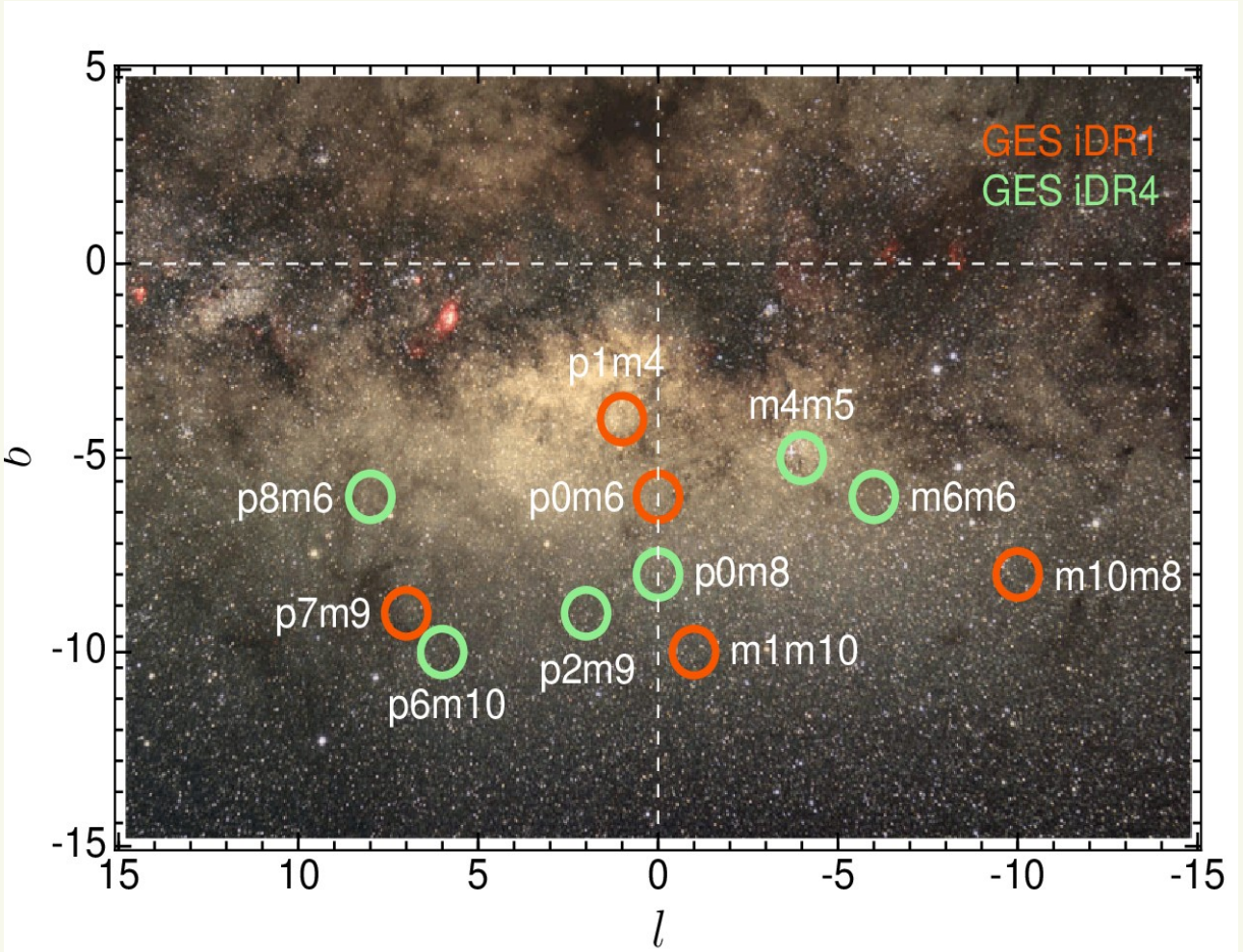
8484-9001 A

R~16200

Sample size
2548 stars:

GE_MW_BL: 2320

AR_MW_BL: 228

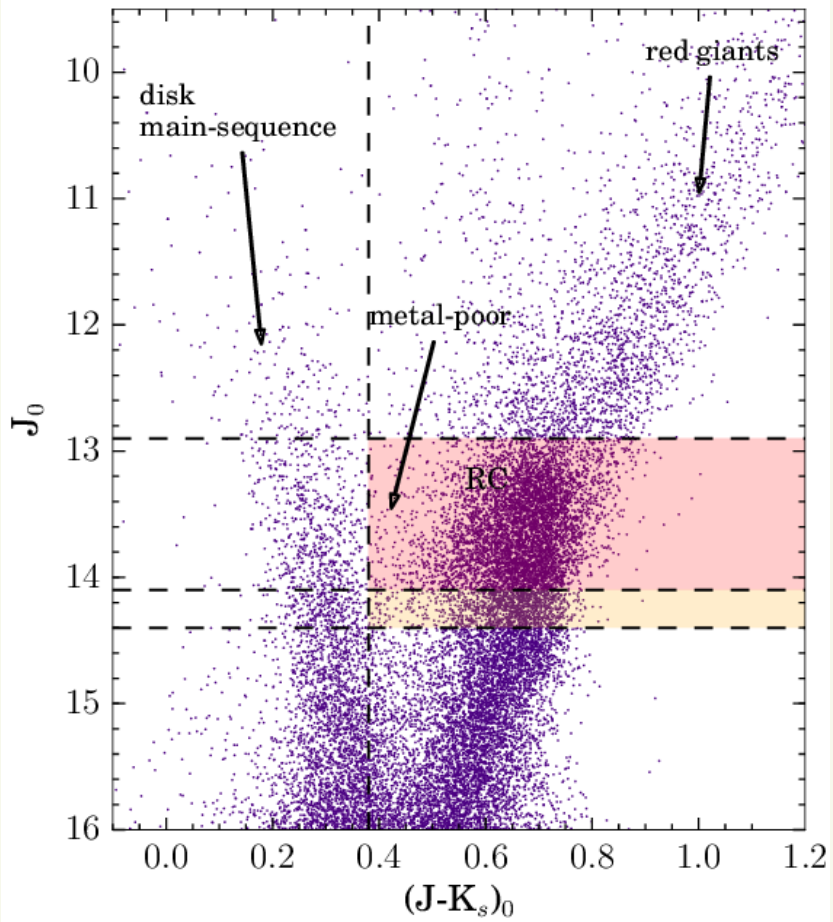


Target selection

From VVV photometry

Color → $(J\text{-}K_s)_0 > 0.38$

Magnitude → $(14.1\text{-}1.2) < J_0 < 14.1$



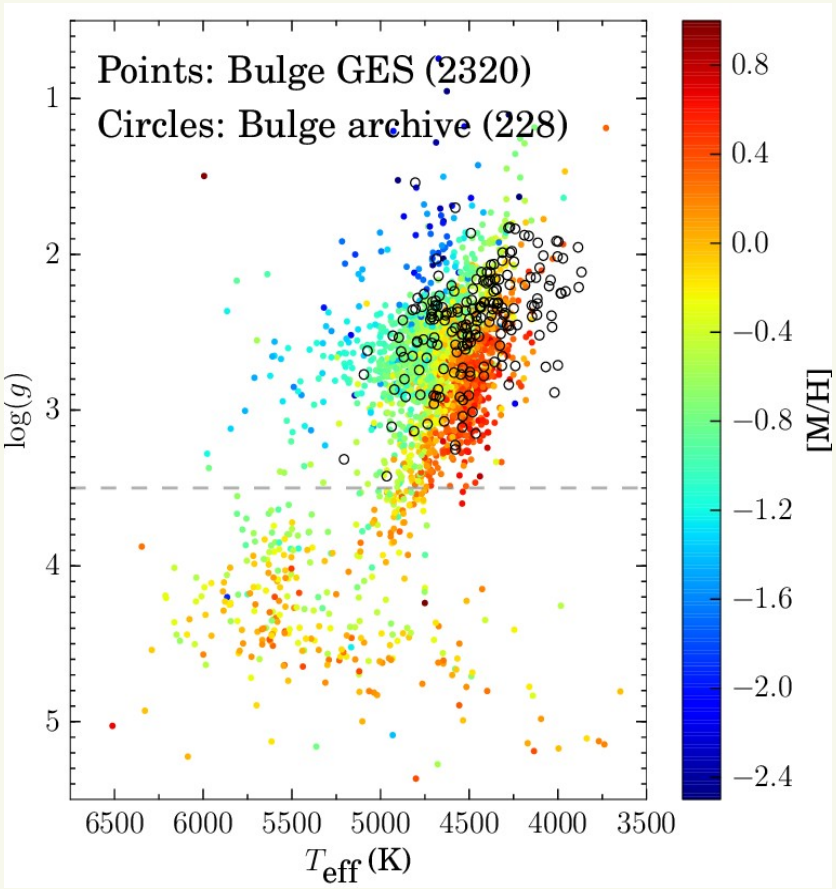
If double RC include up to 30% more targets in another 0.3 mag below nominal cut

Fundamental parameters

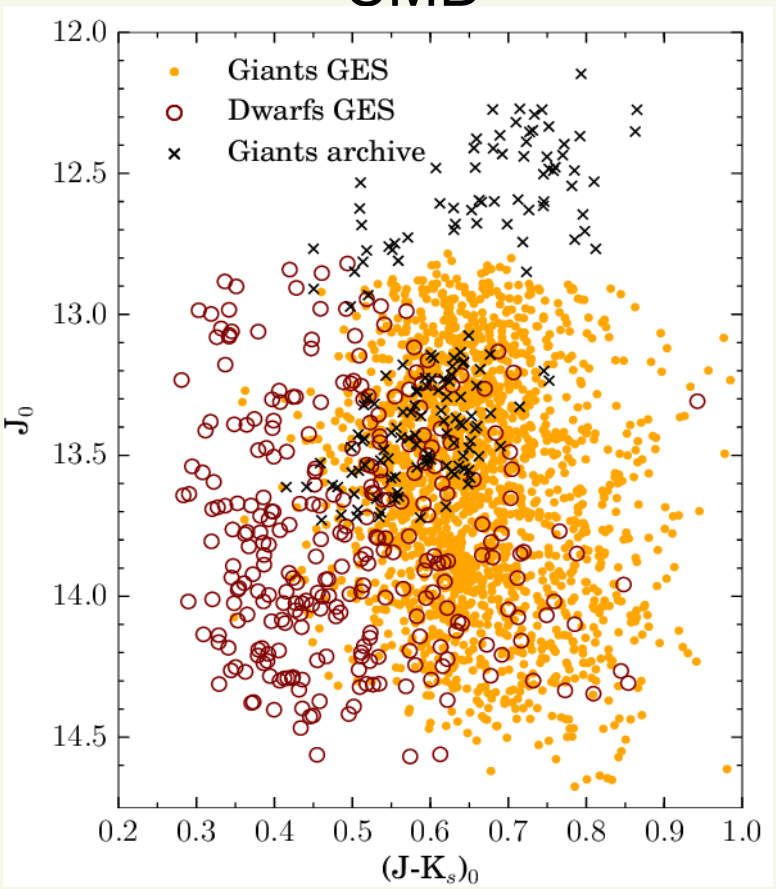
Homogenization of results from 3 codes:
FERRE, MATISSE and SME

T_{eff}, log(g), [M/H] and [α/Fe]

HR



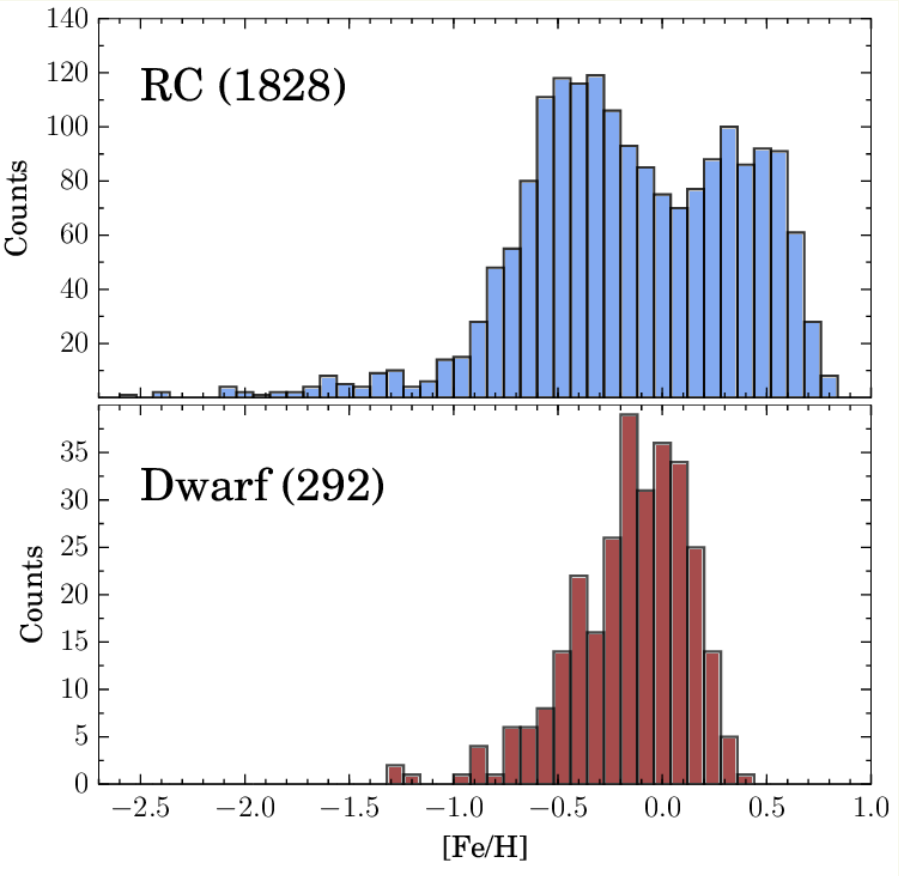
CMD



Bulge MDF and kinematics

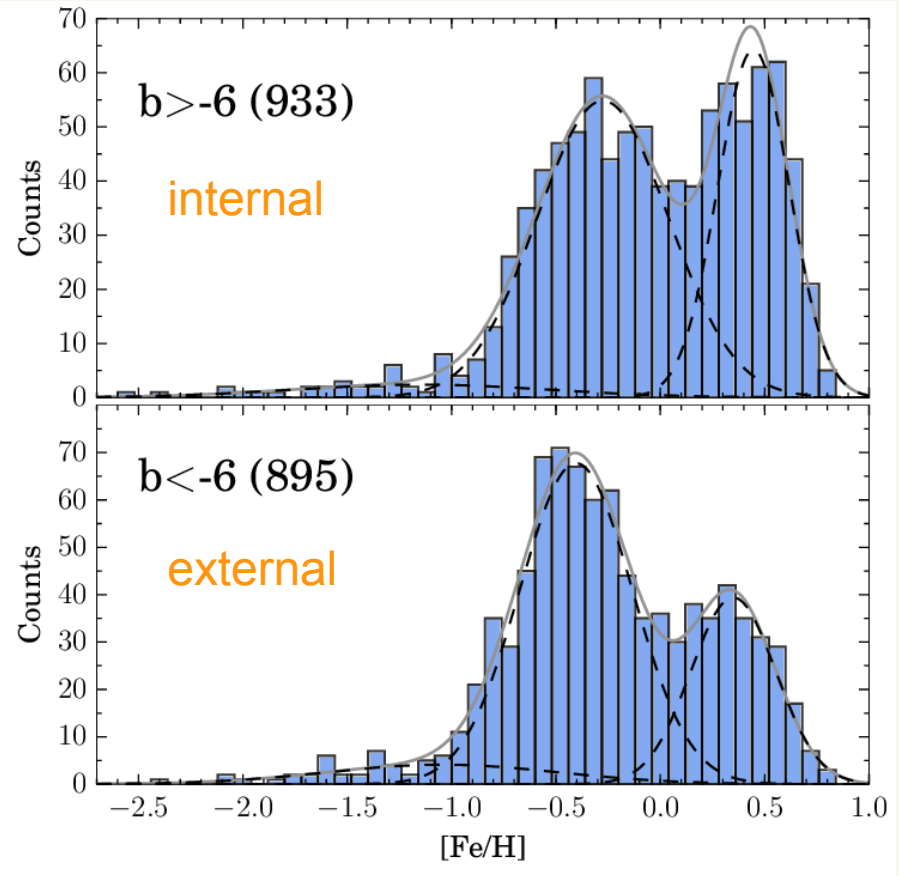
MDFs

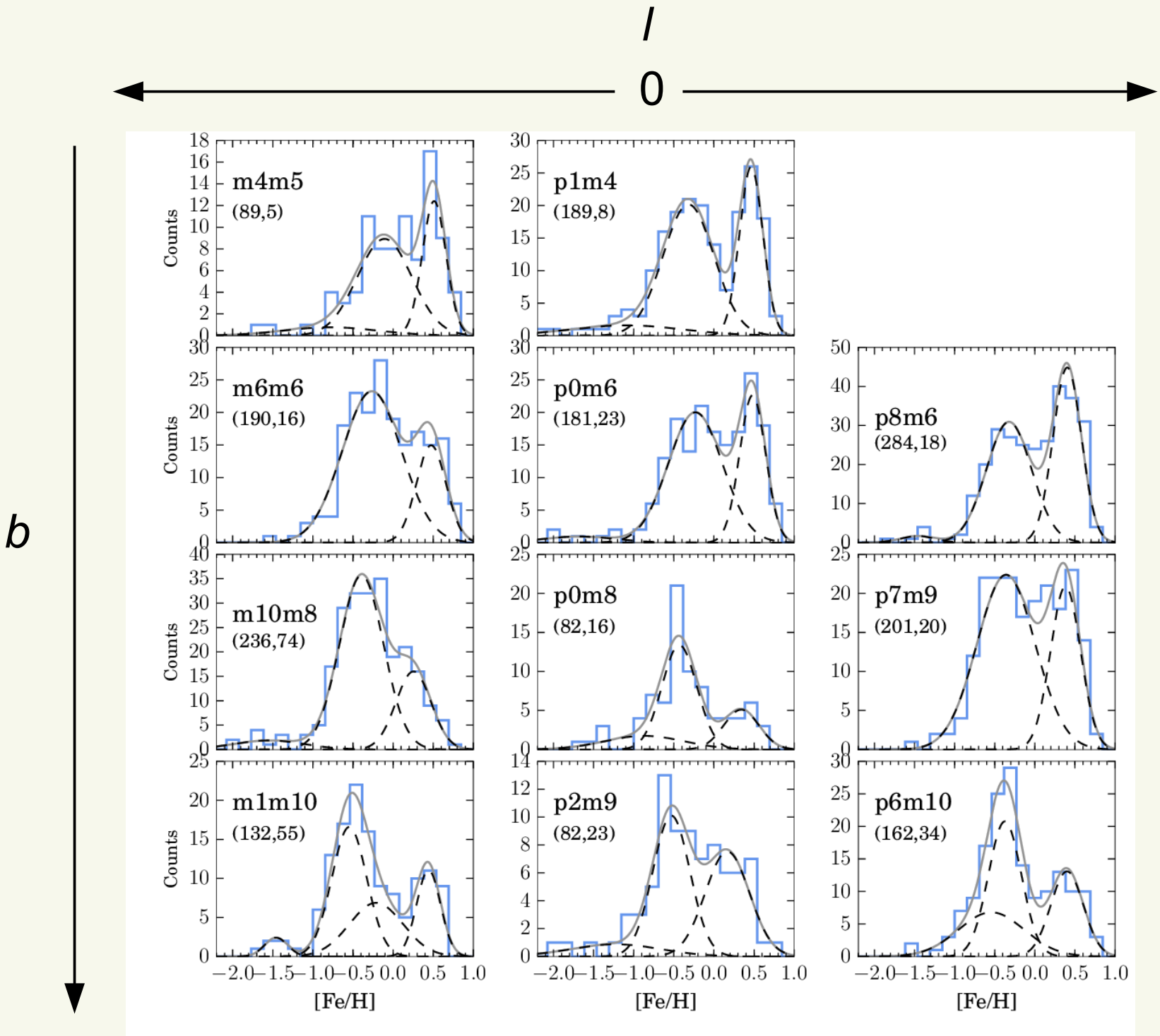
$\log(g)_{crit}$=3.5 dex



GMM

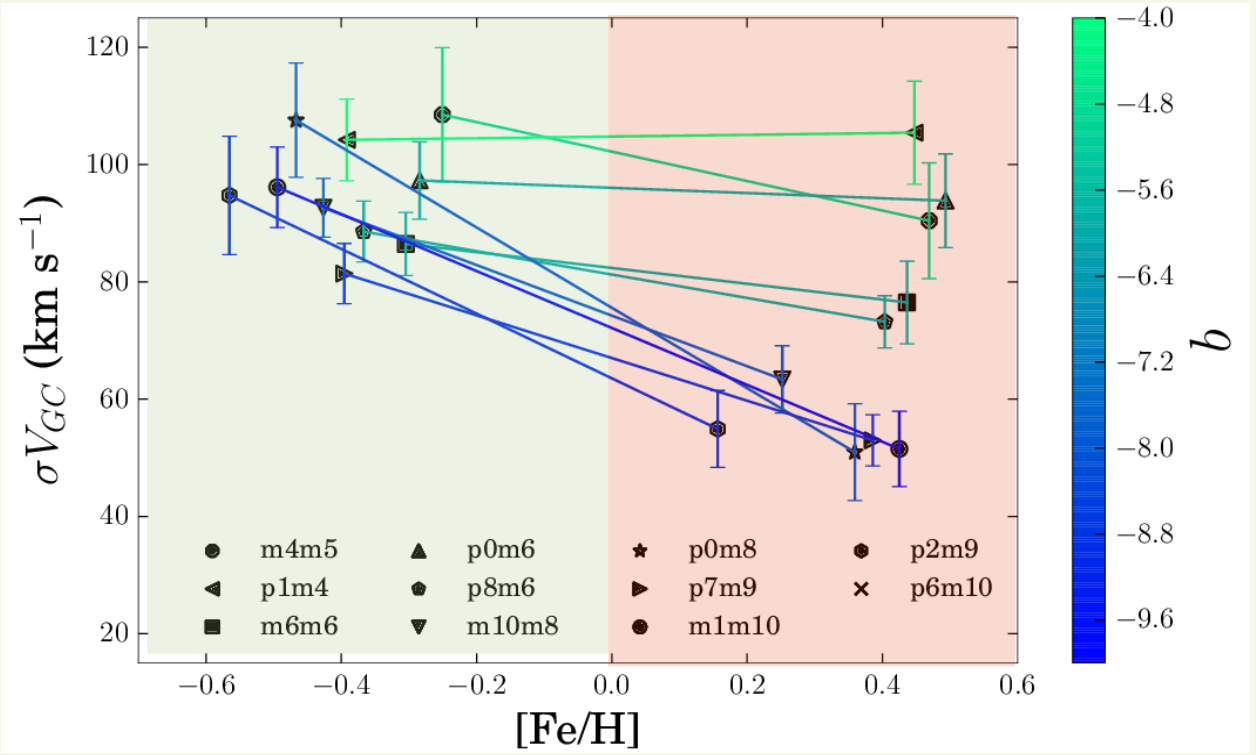
ii) i)




l
0
b
m4m5
(89,5)
p1m4
(189,8)
m6m6
(190,16)
p0m6
(181,23)
p8m6
(284,18)
m10m8
(236,74)
p0m8
(82,16)
p7m9
(201,20)
m1m10
(132,55)
p2m9
(82,23)
p6m10
(162,34)
Counts
[Fe/H]

Kinematics of components

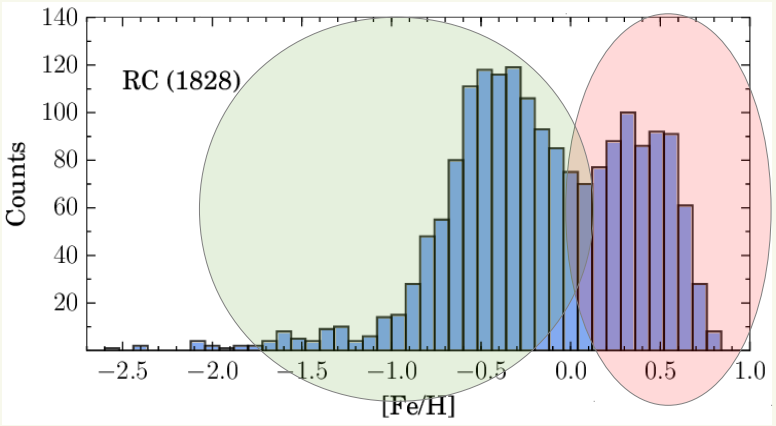
Field samples separated according to GMM components



Velocity dispersion:

- High for component (ii)
- Low and variable with (*l*,*b*) for (i)

… X-shaped orbital structure



Summarizing

	Metallicity	Breadth	Velocity dispersion	Double RC
i)	Metal-rich [Fe/H]=0.3/0.4 dex	Narrow	Decrease with *b*	Yes
ii)	Metal-poor [Fe/H]= -0.3/-0.4 dex	Broad	Constant	No

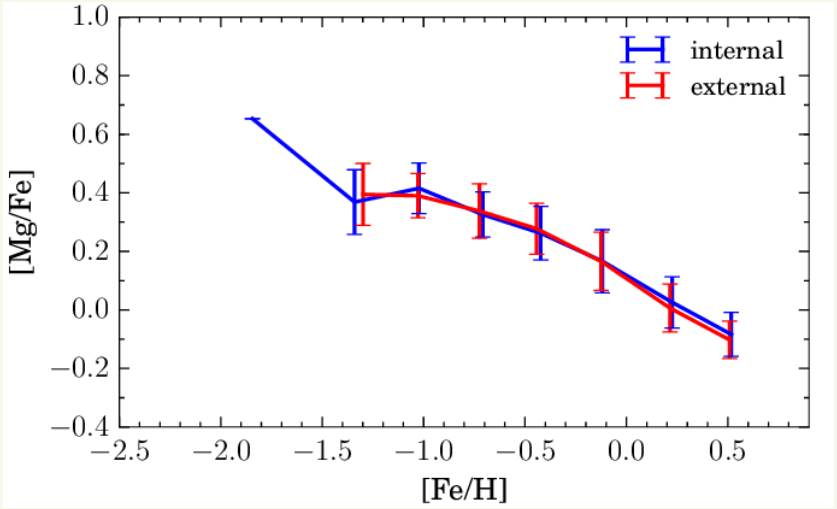
I): [-0.1:0.5] dex: X-shaped boxy/peanut

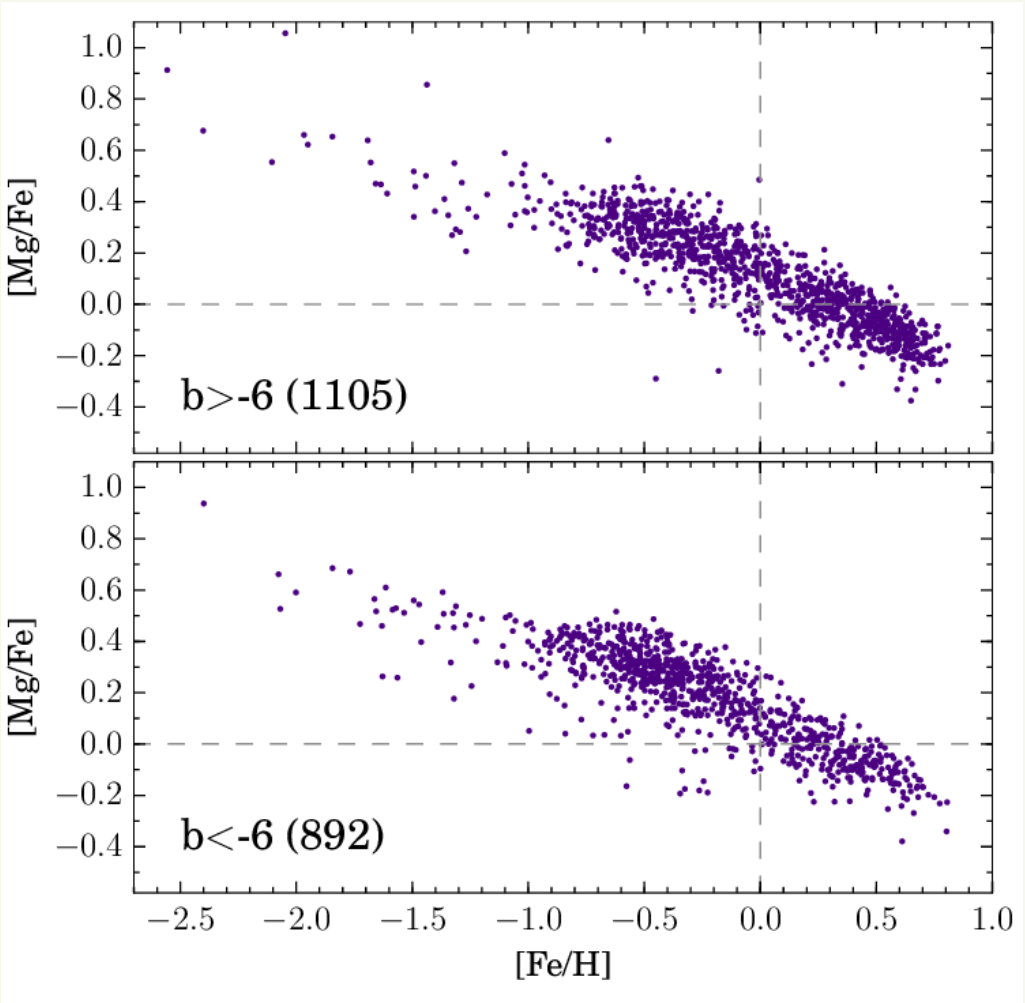
ii): [-1.5:-0.1] dex: spheroidal? Classical? thick disk?

Detailed abundances

The bulge in the [Mg/Fe] vs. [Fe/H] plane

Detailed abundances measured from spectral lines using recommended fundamental parameters





Comparing the bulge with the disk(s)

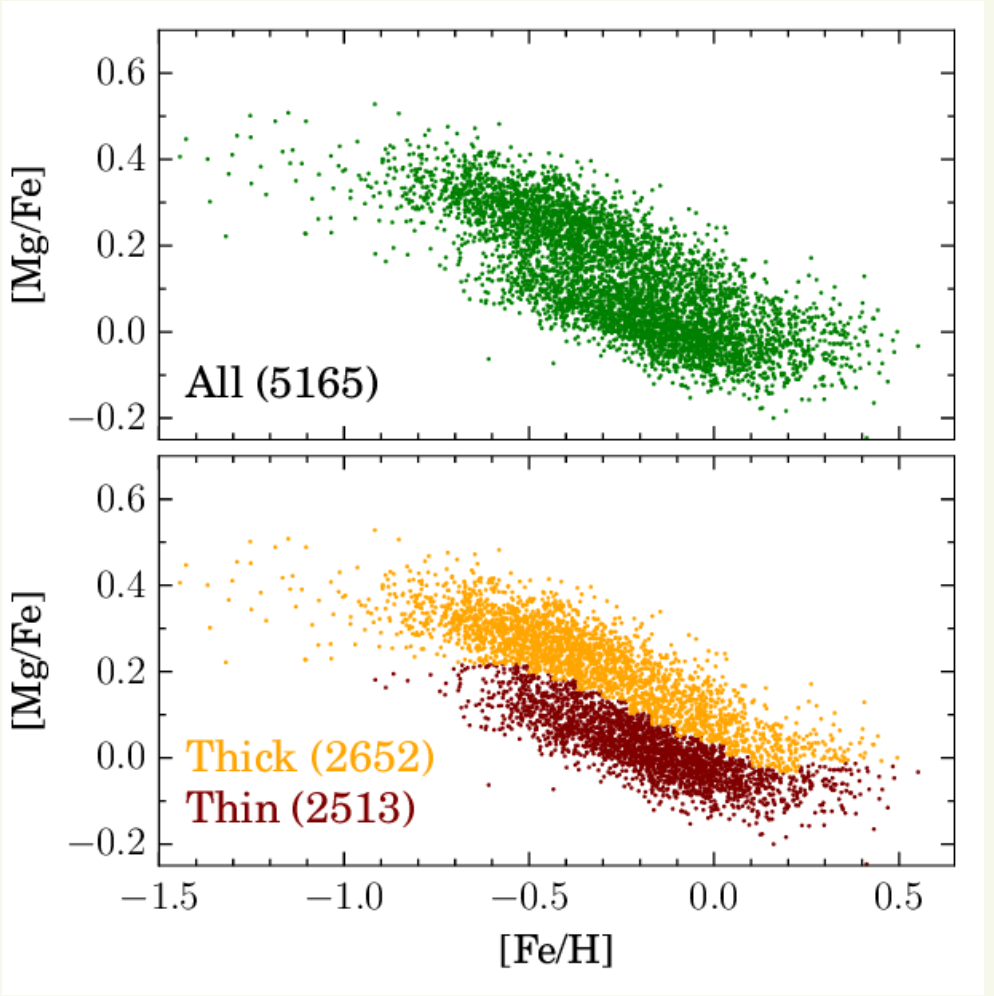
From the HR10|HR21 portion of iDR4

Field stars (GE_MW)

Cuts in 80th percentile; errors in T_{eff}, log(g), [M/H], A(FeI) and A(MgI)

SNR>50

~5200 disk stars



Radial limited samples

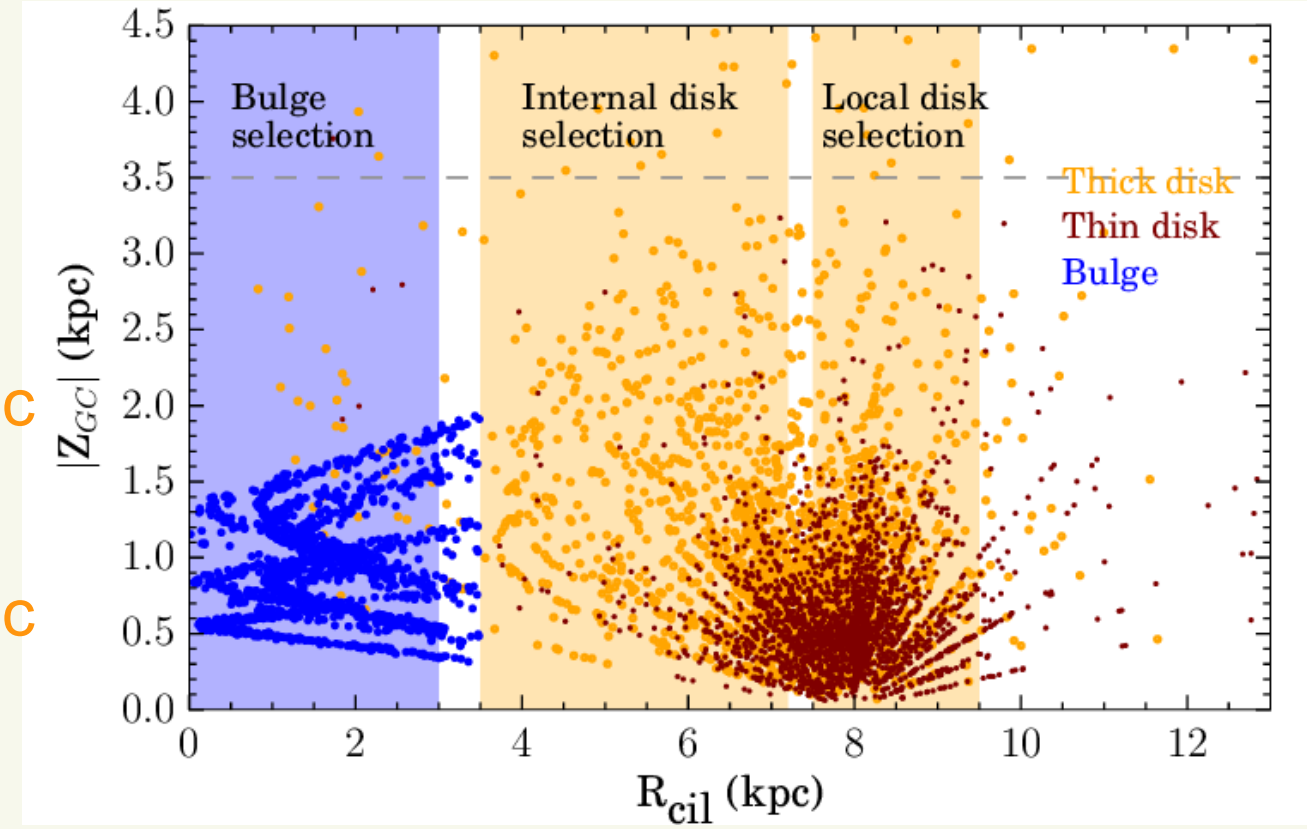
Distances computed via isochrone fitting (PARSEC)

For all stars with |Z|<3.5 kpc

Bulge: R<3.5 kpc

Disk (internal):
3.5<R<7.2 kpc

Disk (external):
7.5<R<9.5 kpc



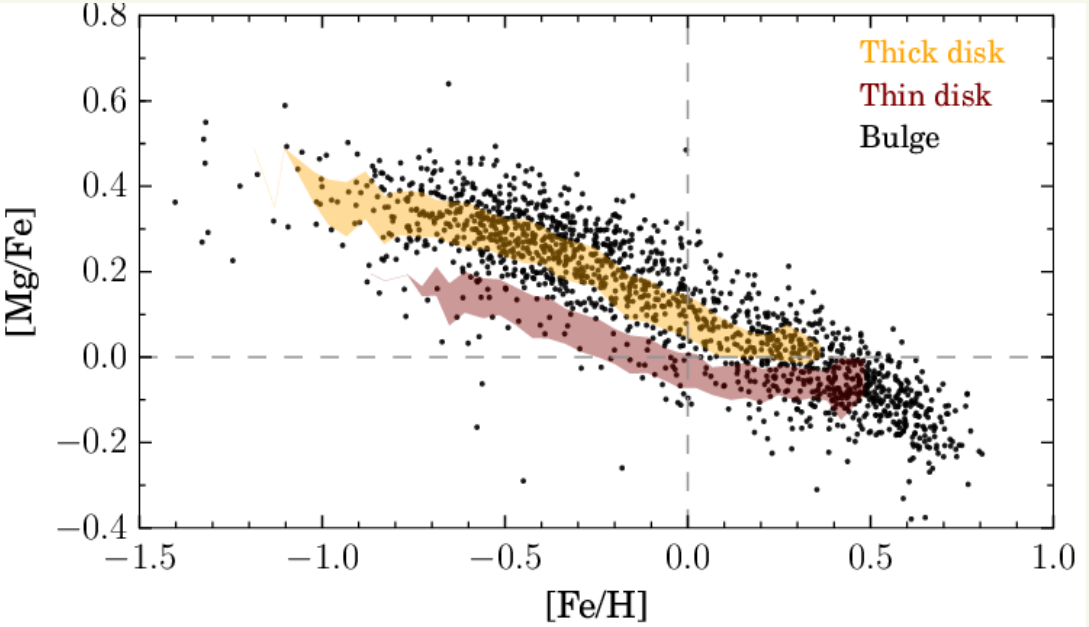
A qualitative comparison

Thin+thick disk (R>3.5 kpc) vs. Bulge (R<3.5 kpc)

Thick disk sequence on the bulge locus up to [Fe/H]=0.15 dex

Thin disk runs under bulge sequence

Thin disk metal-rich end match bulge sequence at [Fe/H]>0.15 dex

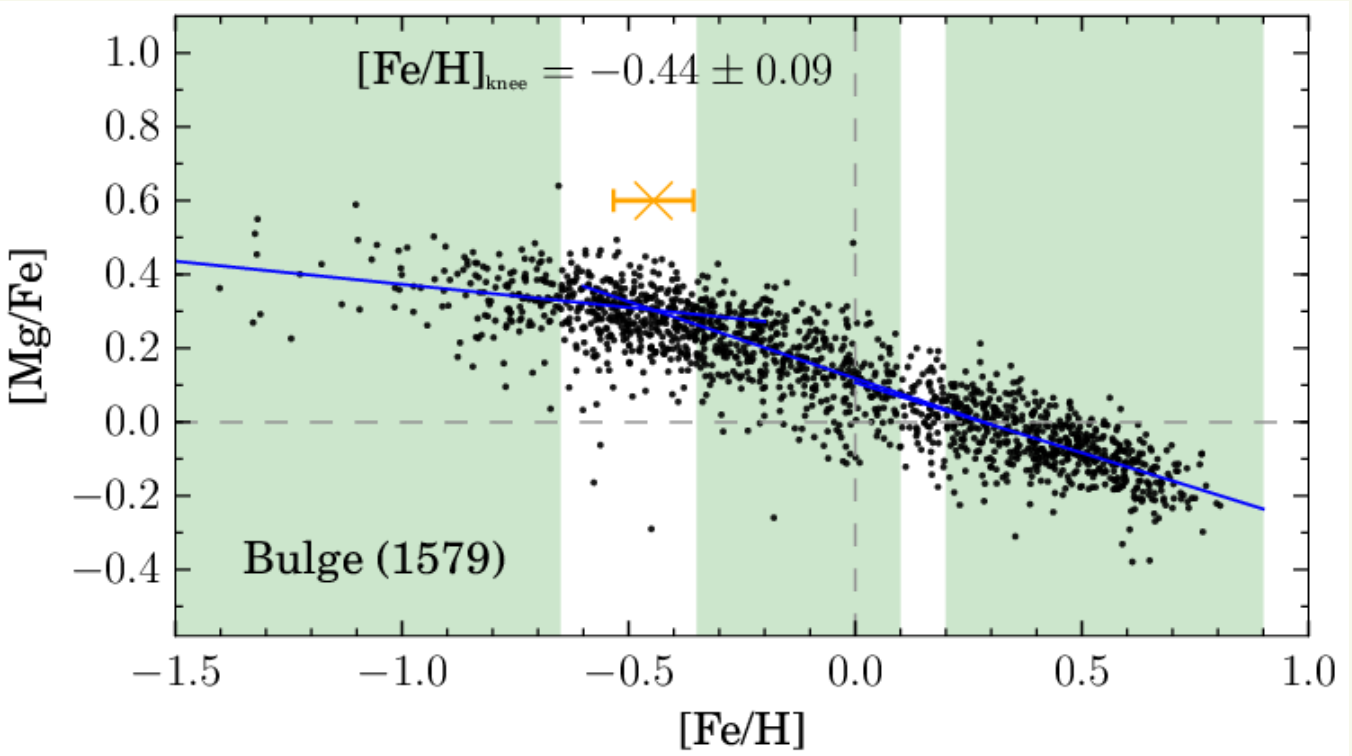


Chemical similarity between metal-poor bulge and thick disk

The “knee” position (bulge)

Central tendency fit using stars in selected regions

“knee” position errorbar computed with Monte Carlo resamplings

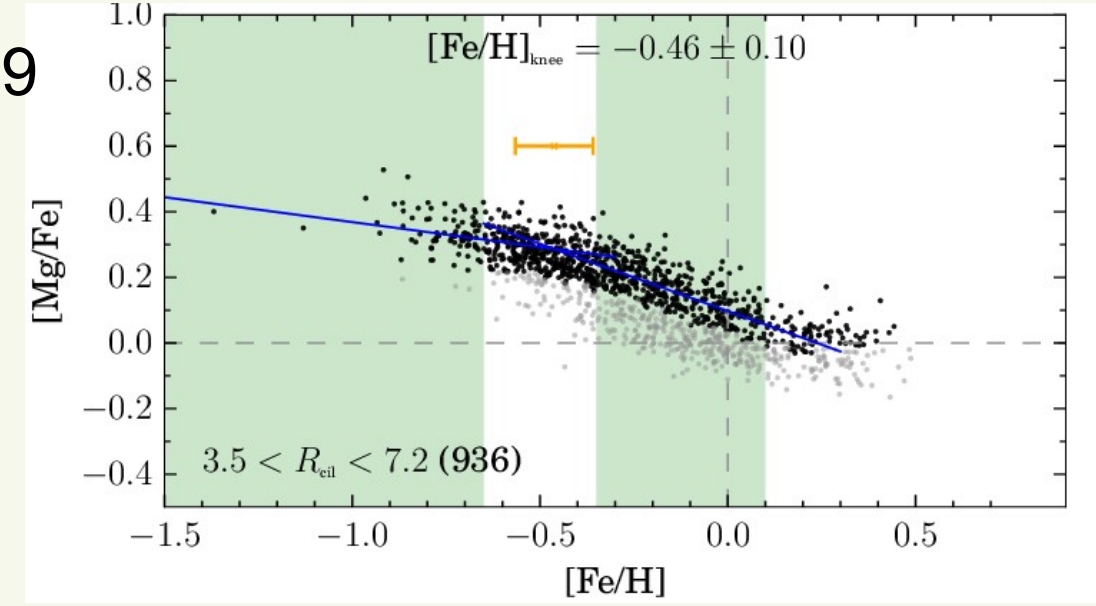


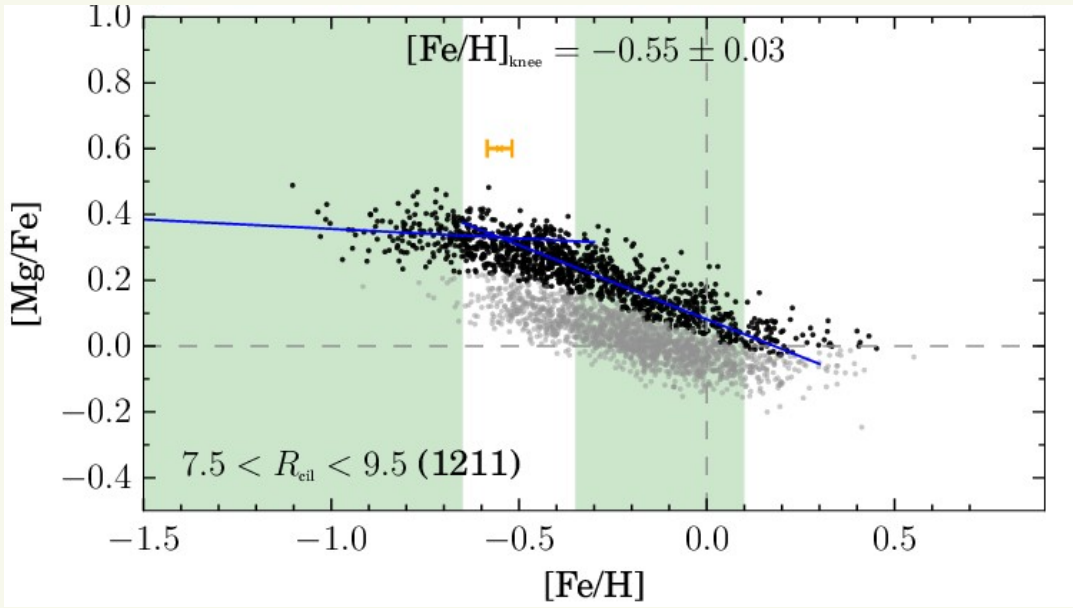
The “knee” position (disk samples)

Bulge: $[Fe/H]_{knee}$ = -0.44+/-0.09

Inner disk sample:
“knee” position comparable with that of the bulge

Outer disk sample:
“knee” position ~0.1 dex more metal-poor than the one of bulge





To summarize

- The Gaia-ESO survey provide fundamental parameters, metallicity and abundance measurements for a large sample of bulge and disk stars
- We confirmed presence of at least 2 components in the bulge MDF across the bulge region
- Velocity dispersion behavior with *b* different for metal-rich and metal-poor portions of the MDF

To summarize, cont

- In the abundance-metallicity plane:
  - Indication for a metal-rich bulge sequence; [Fe/H] >0.10 dex
  - Qualitative chemical similarities between the bulge and the thick disk up to [Fe/H]=0.1 dex
  - Position of the thick disk“knee” change with radial distance: comparable to that of the bulge for a inner sample
  - Metal-rich bulge: thin disk origin

    Metal-poor bulge: thick disk? Need to conciliate with kinematic evidence

Thank you!