Do Globular Clusters Share the Chemical Enrichment History of their Host Galaxy?

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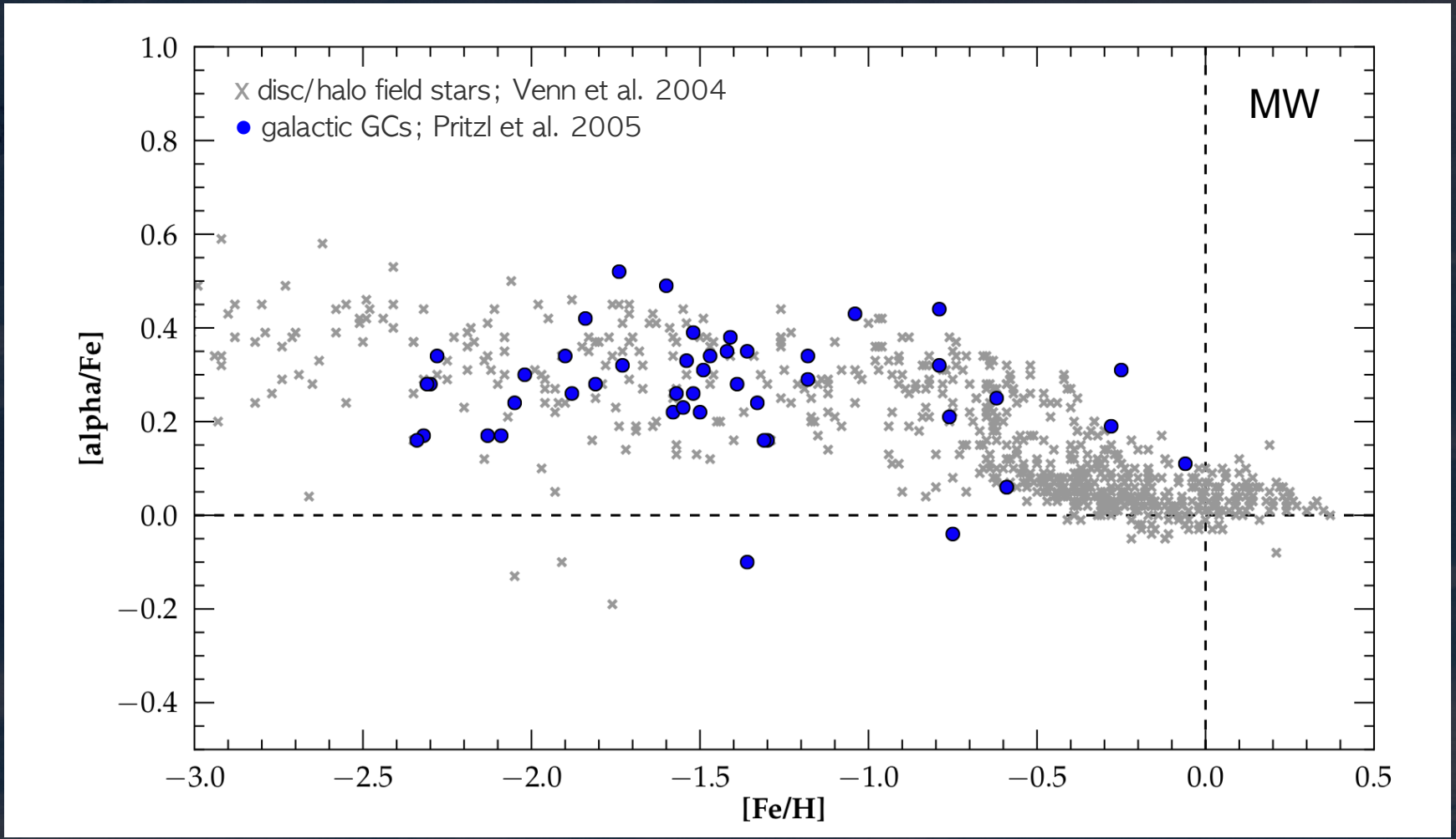
Chemical Signatures of MW Globular Clusters



- GCs in the MW have uniform, high [alpha/Fe]-ratios at all [Fe/H].
- Indication that large majority formed in an environment of rapid chemical enrichment.

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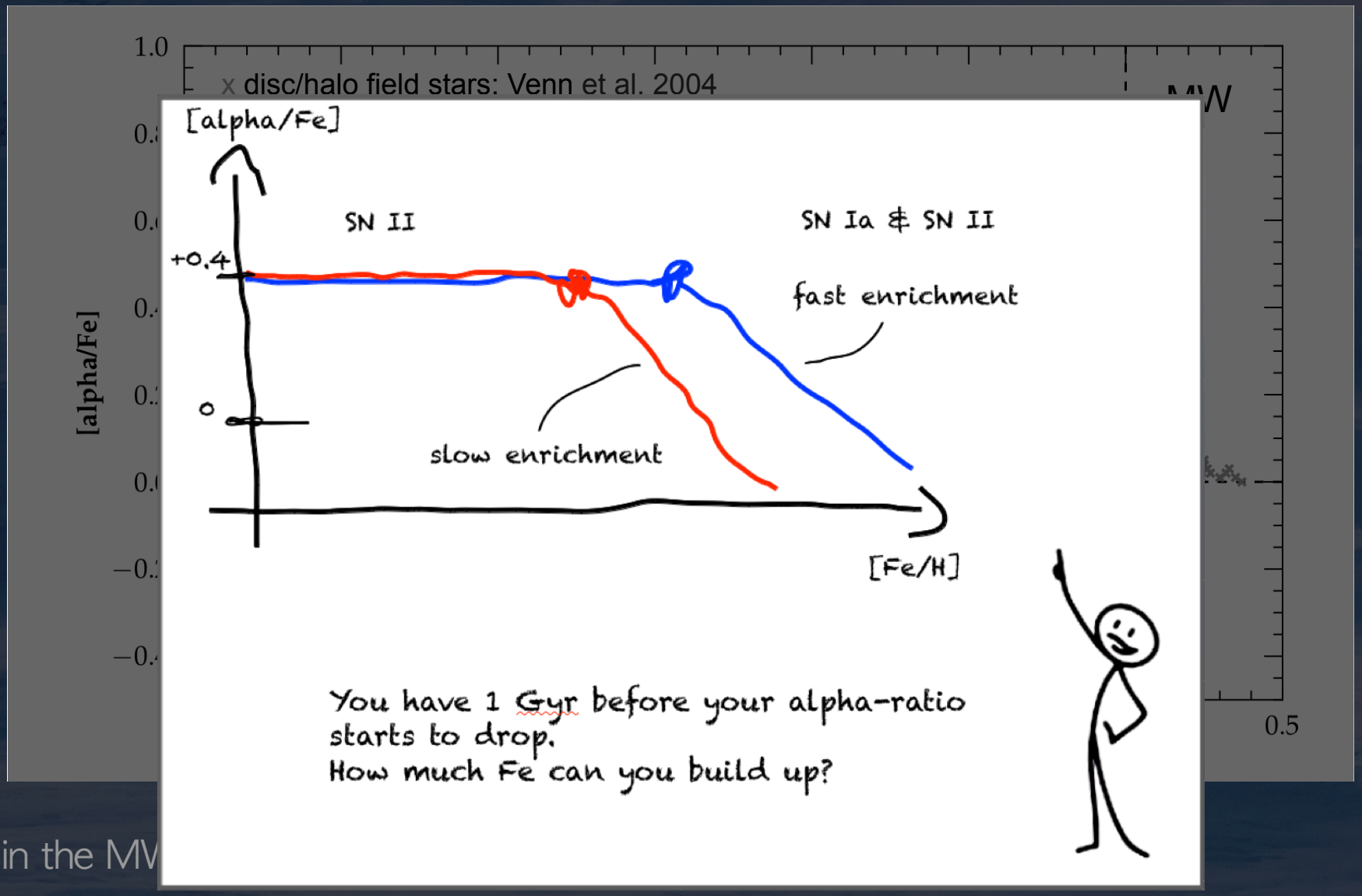

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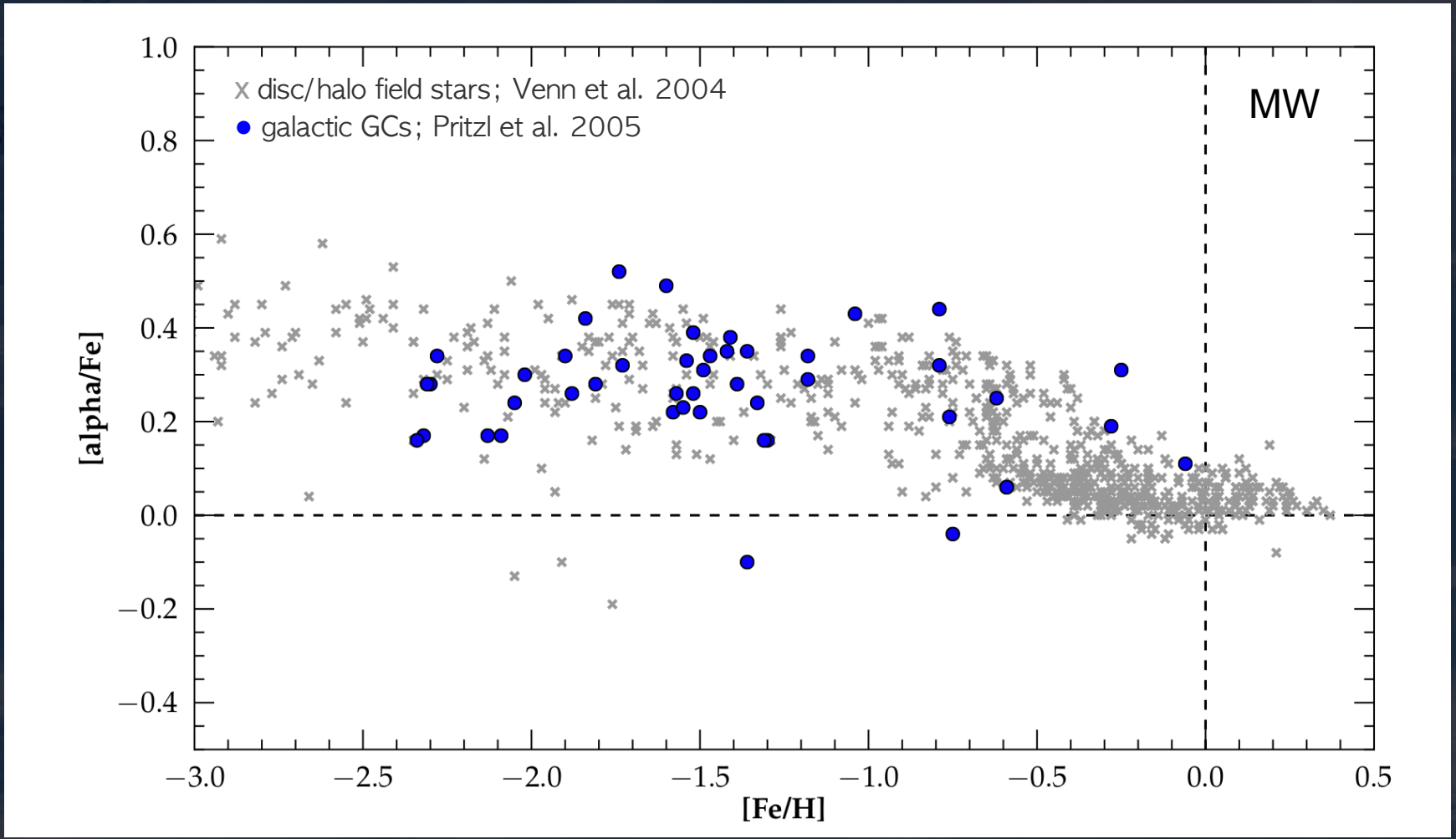

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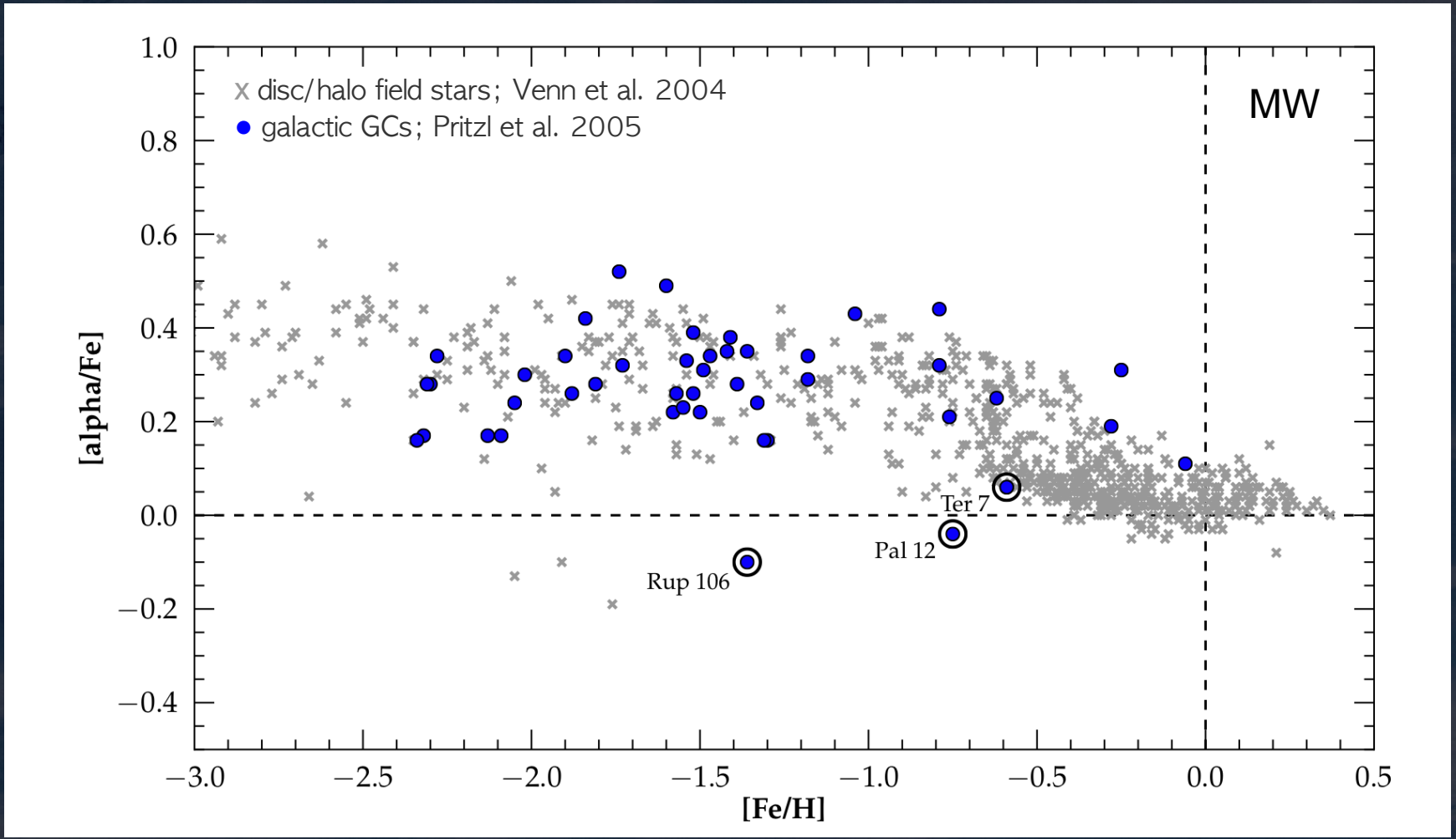
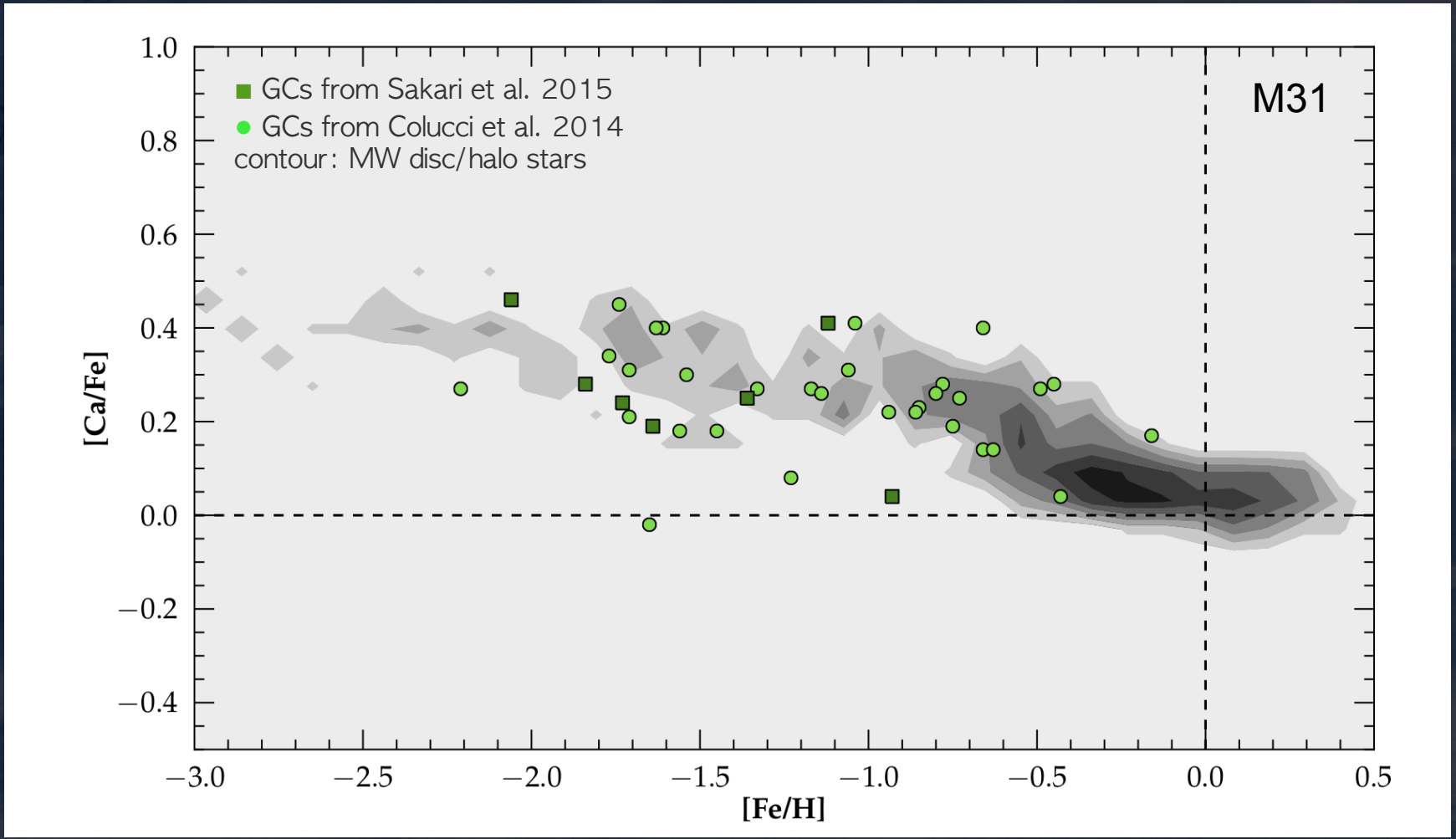


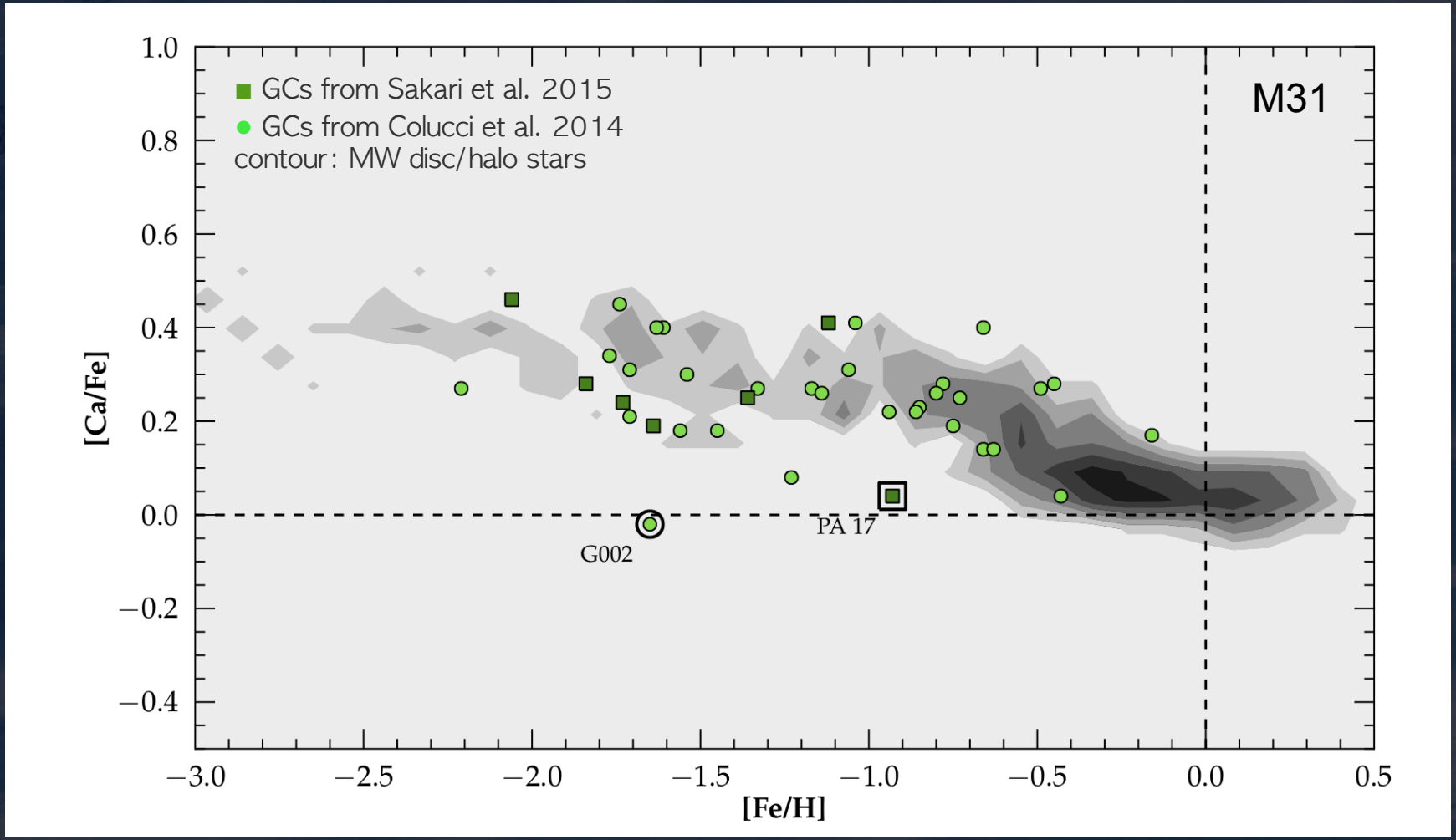
- Few outliers with low [alpha/Fe]: accreted from other (dwarf) galaxies?

Chemical Signatures in M 31 Globular Clusters



- metal-poor GCs are alpha-rich
- interestingly: metal-rich GCs seem to show a 'knee'
- similar to MW scenario: alpha-depleted outliers.

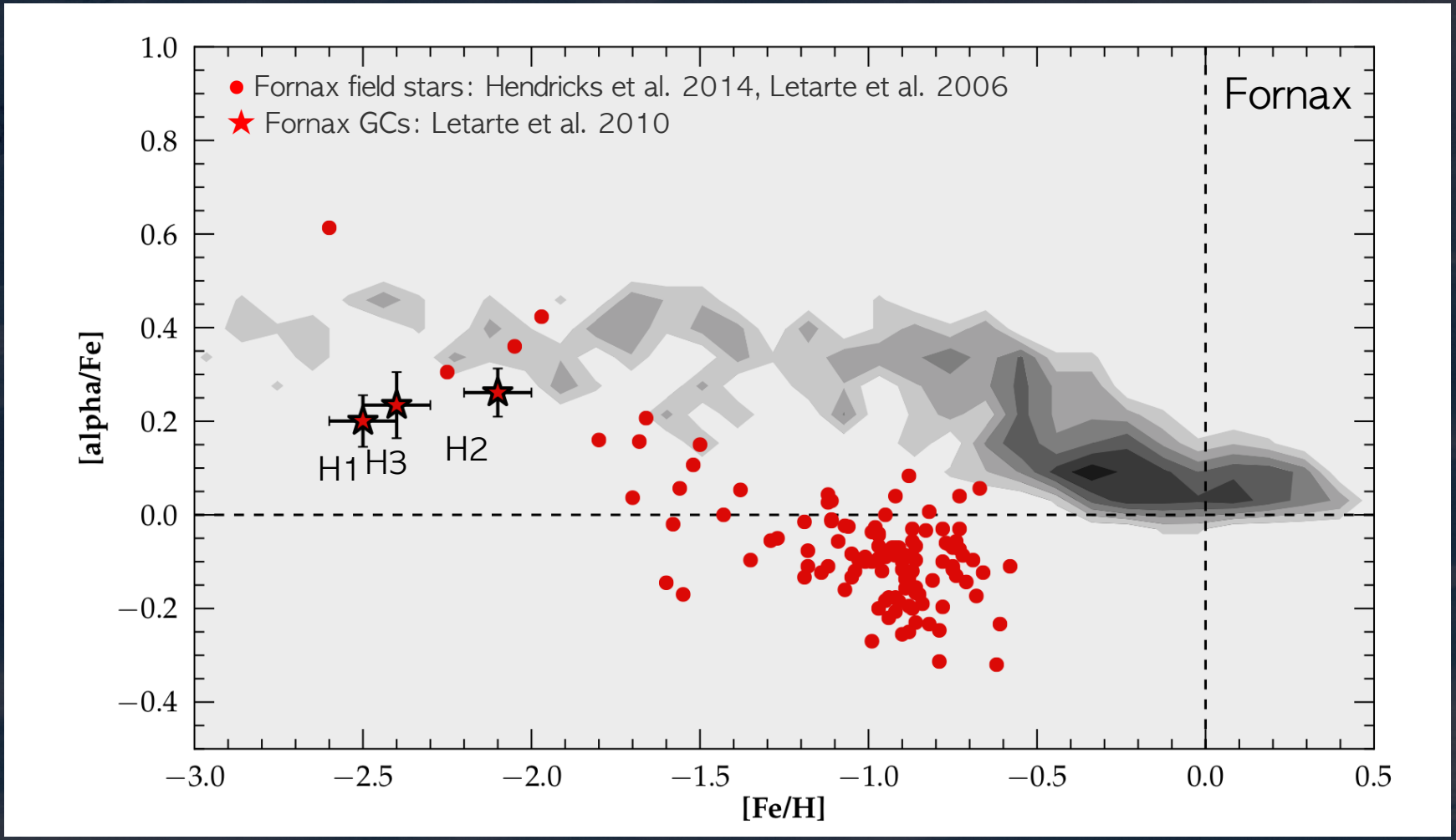
Chemical Signatures in M 31 Globular Clusters



Do GCs follow the chemical evolution of the field stars?

Low [alpha/Fe] in GCs: A chemical fingerprint for accretion?

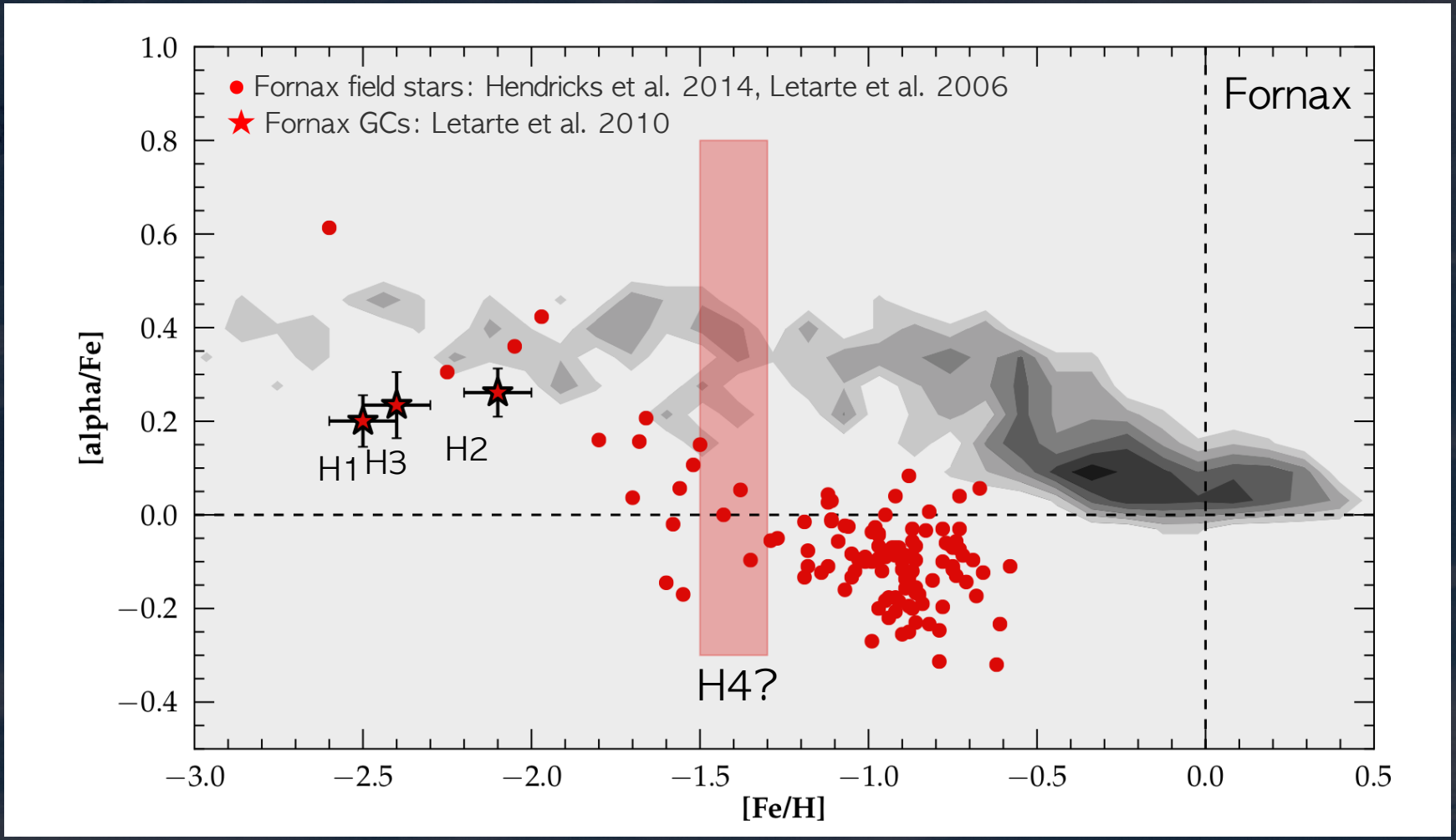
Fornax: A Key Galaxy to understand GC enrichment



- Hendricks et al. 2014: Fornax shows early depletion of alpha-elements;
  〉 low chemical enrichment efficiency

- Fornax hosts own GC population:
  3 metal-poor (old) clusters are alpha-enhanced (Letarte et al. 2010) …

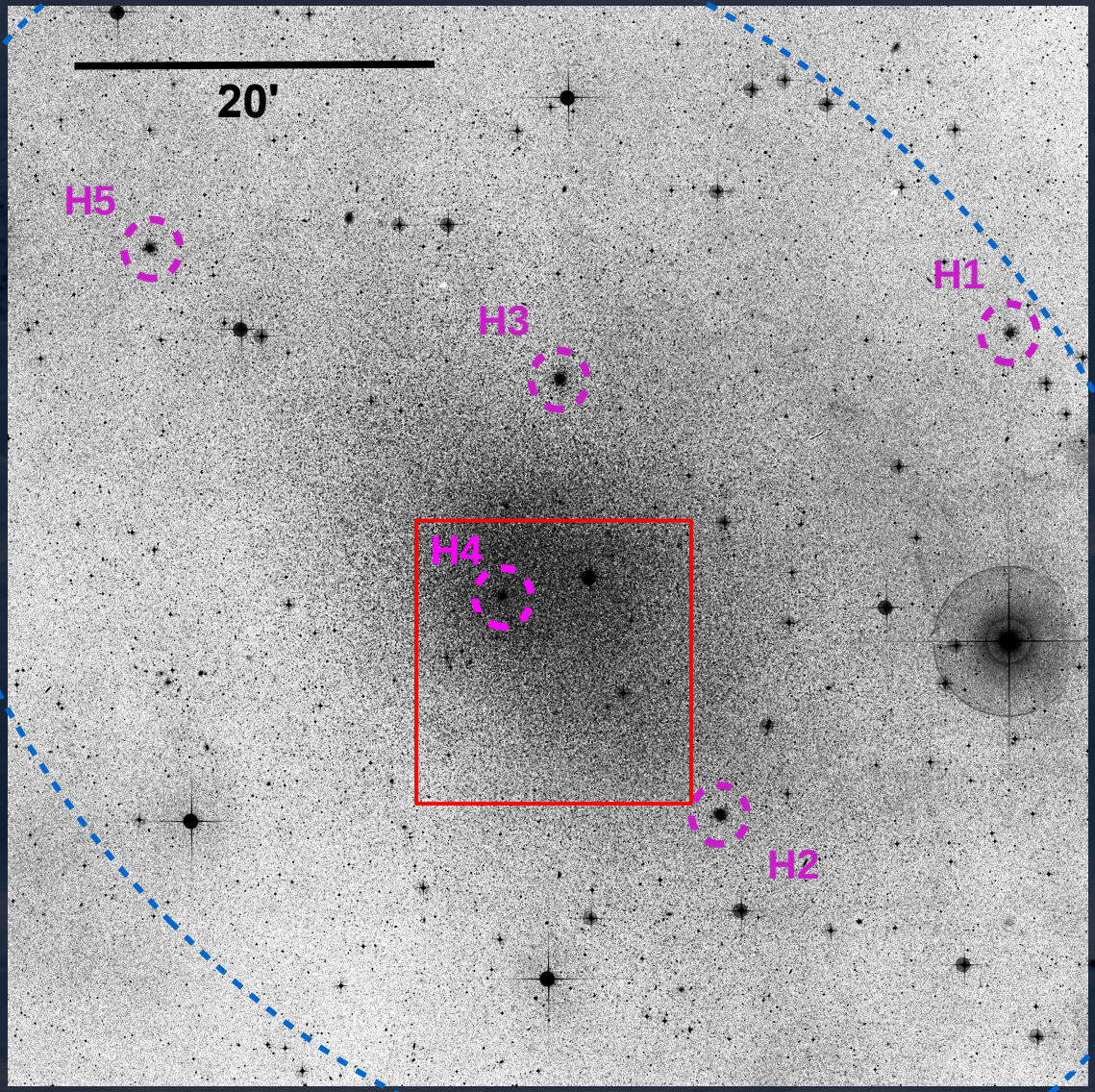
Fornax: A Key Galaxy to understand GC enrichment



- … one globular cluster (H4) is more metal-rich but its 〔alpha/Fe〕-ratio is unknown.

- unique test case to understand coupling of chemical evolution between field stars and GCs in a shared environment.

H4: Target Selection



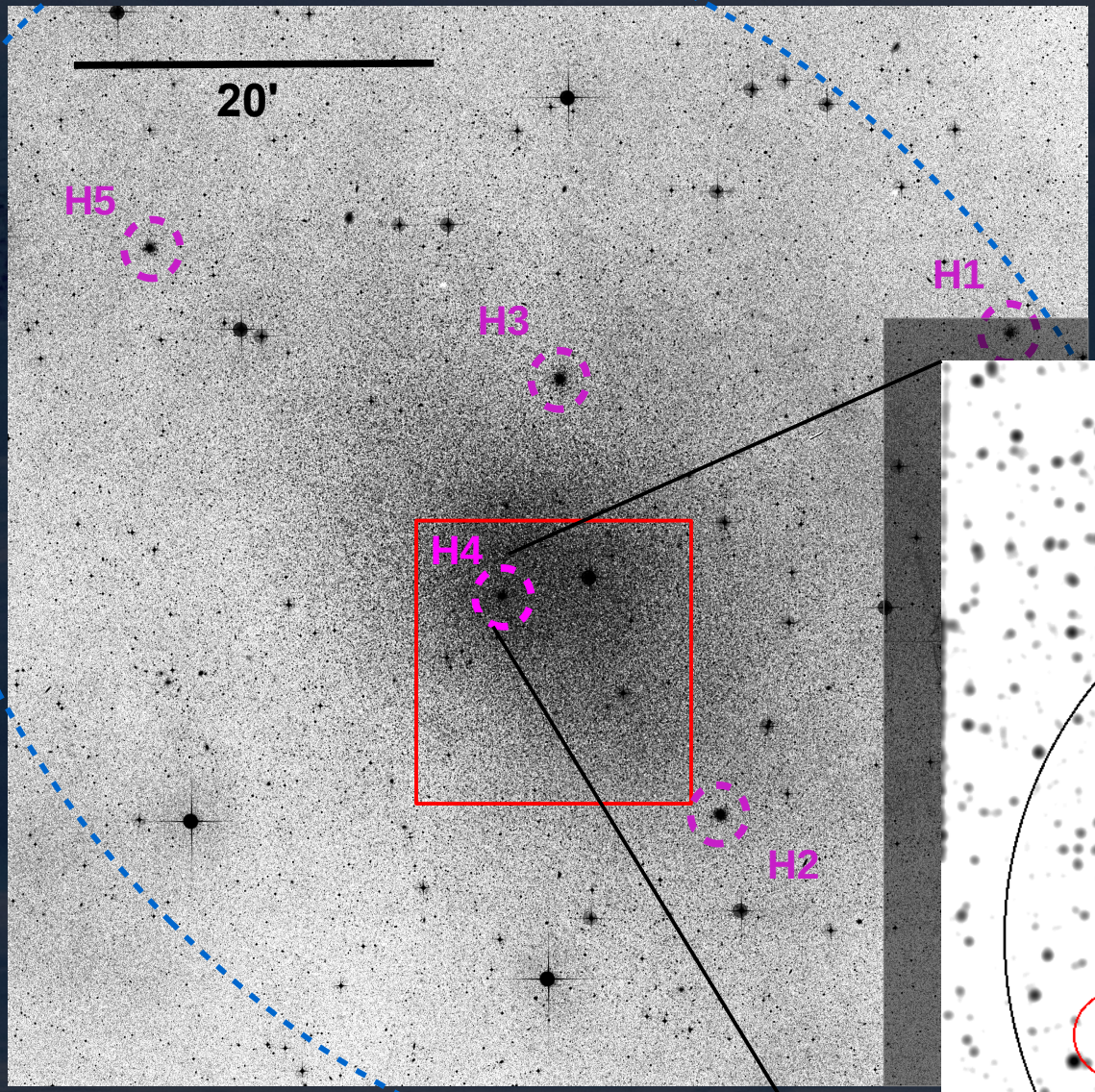
Fornax dSph with GCs
(ESO DSS image)

red: M2FS FoV
blue: tidal radius

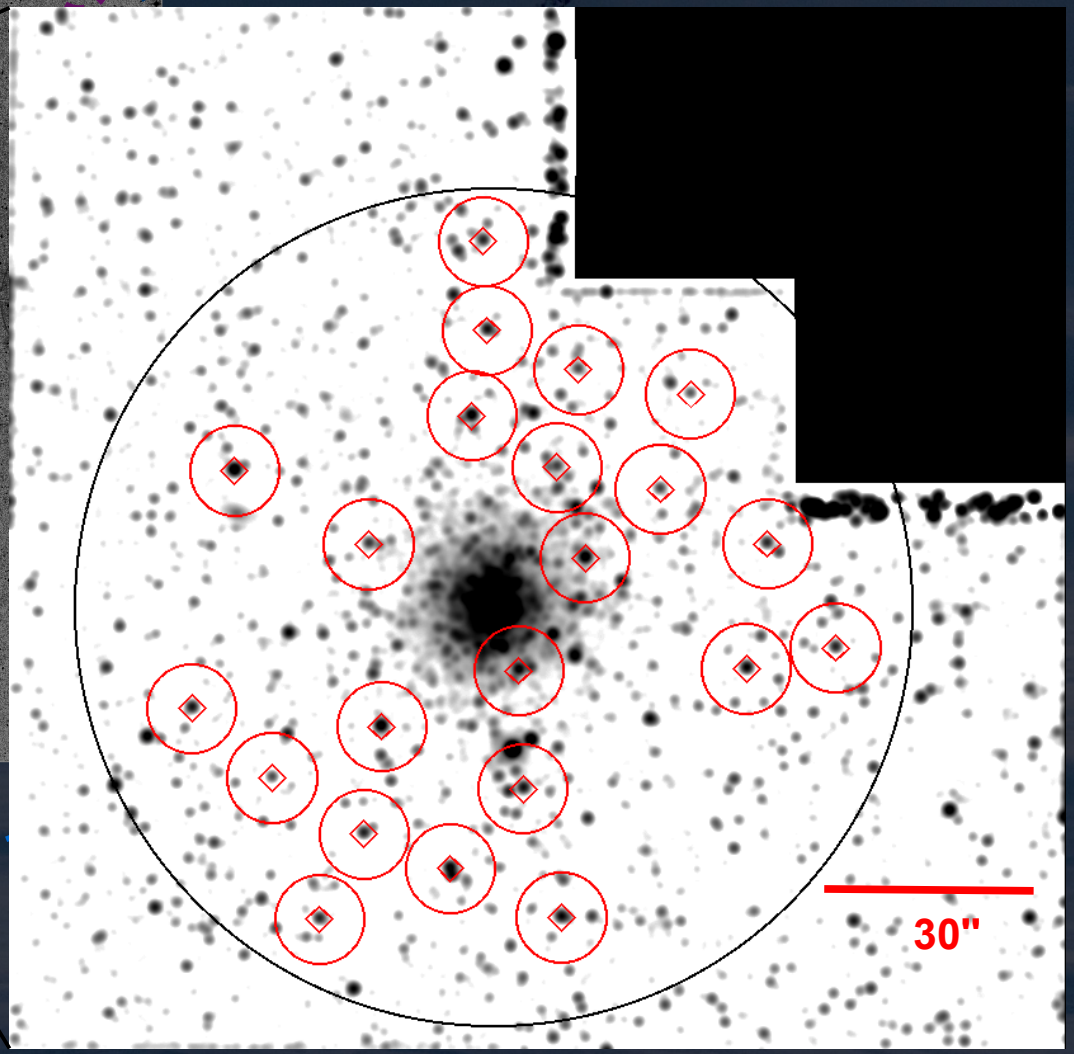
Our Program:
7 hours with M2FS @ Magellan Telescope
42 Objects @ R=28,000
S/N ~ 30/res.el.

range: 6150 - 6720 Å

H4: Target Selection

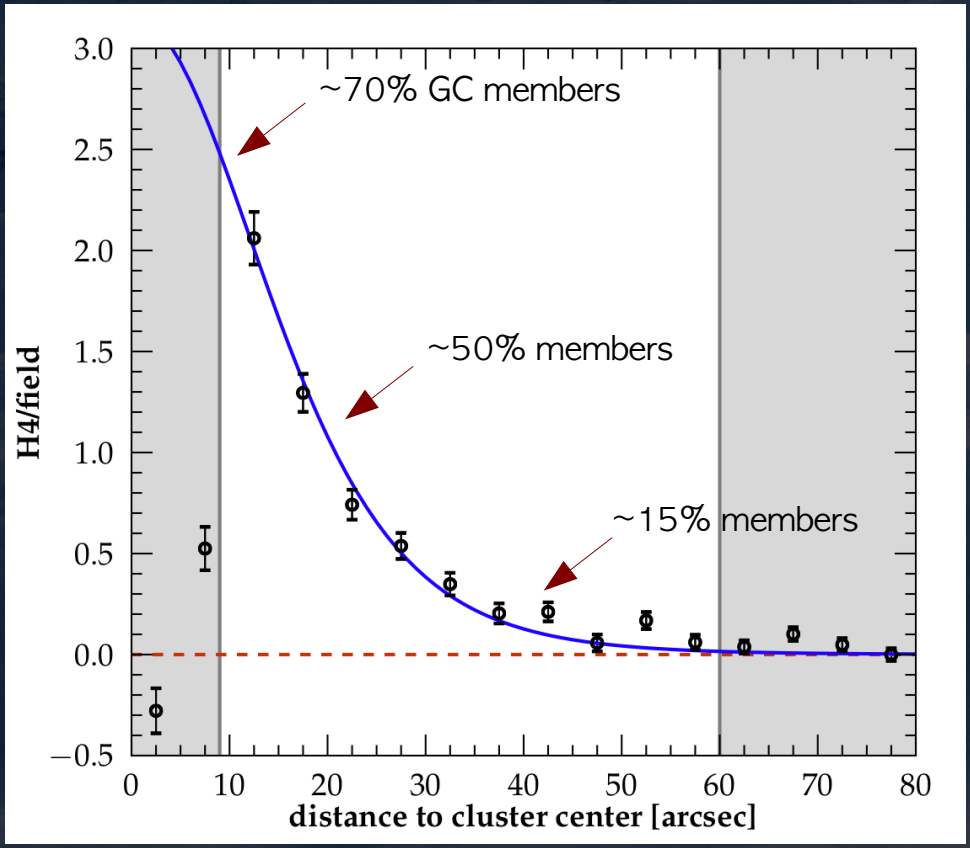


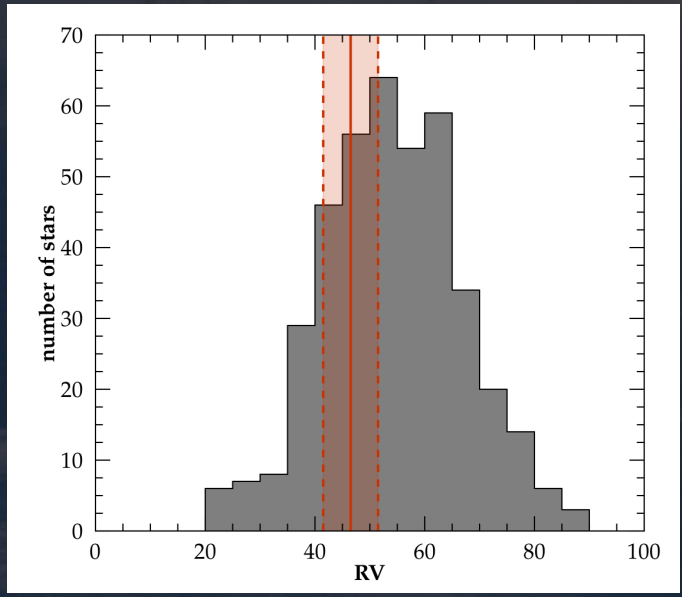
HST image of H4, degraded to 1" seeing:
black: cluster tidal radius
red: observed targets



Main difficulty:
H4 is heavily crowded in the center, and severely contaminated at larger radii.

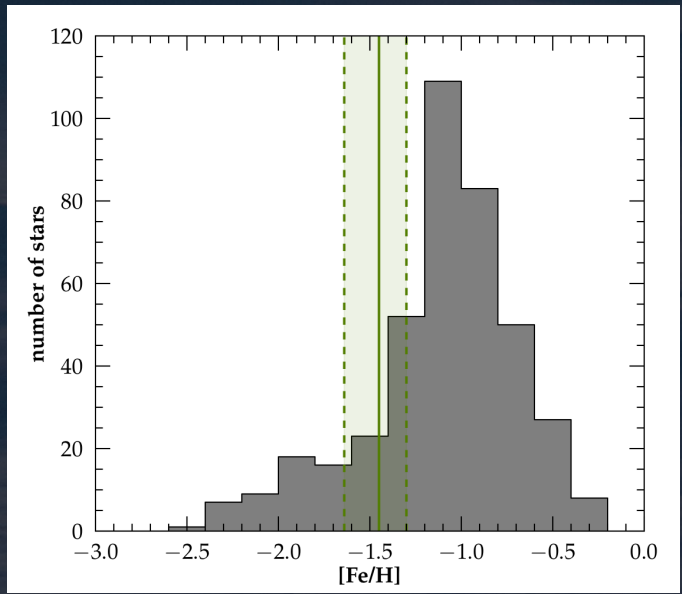
H4: Membership likelihood





- [Fe/H], RV, RV_disp from Larsen et al. 2012, Strader et al. 2003, Dubath et al. 1992

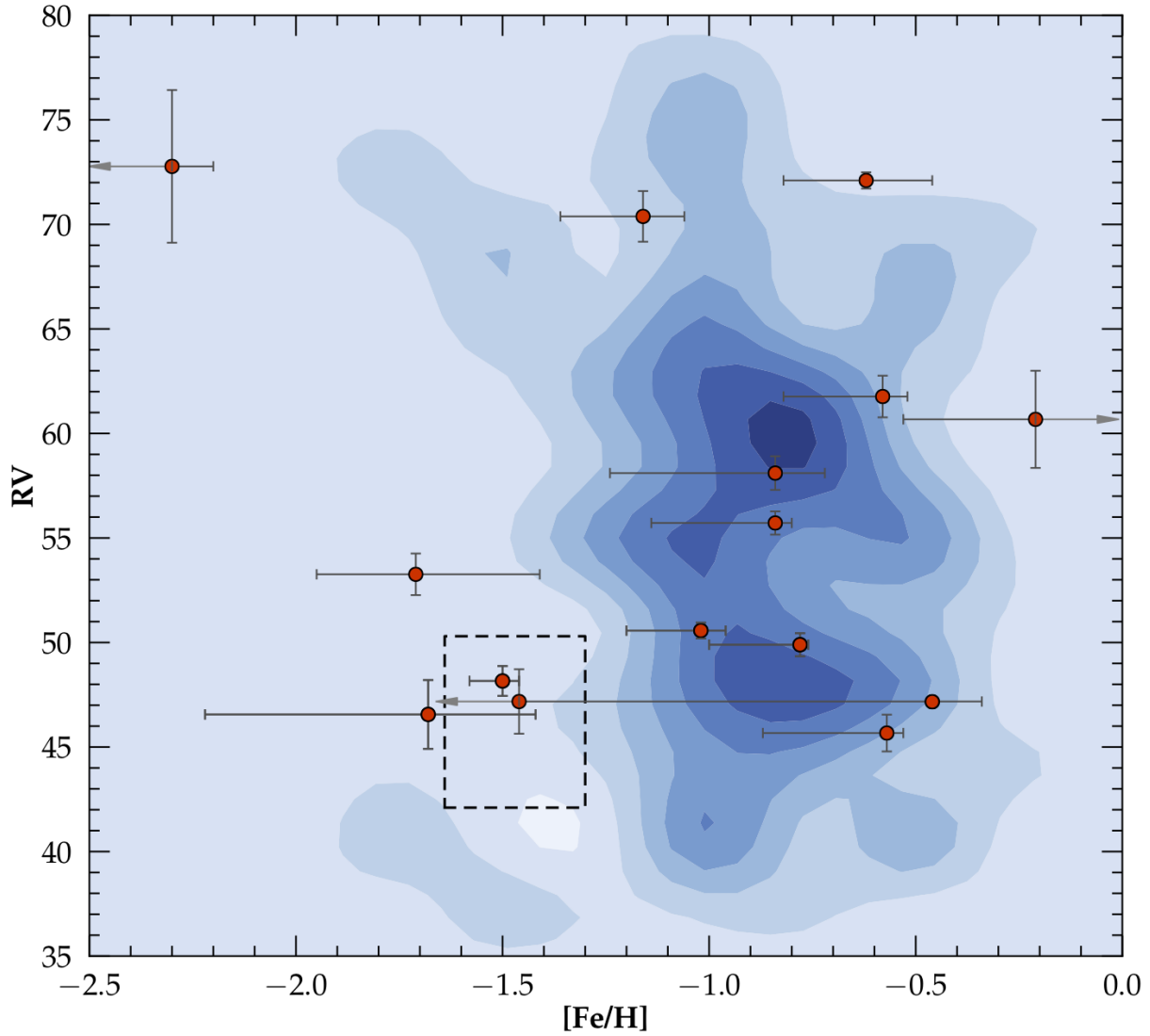
- local field star distributions from Battaglia et al. 2009



■ Membership likelihood estimation from
- simple star count over-density (a),
- known metallicity (b), and
- radial velocity (c) of H4.

■ GC properties from IL; systematic bias possible.
Therefore: flat probability distribution within 'box'.

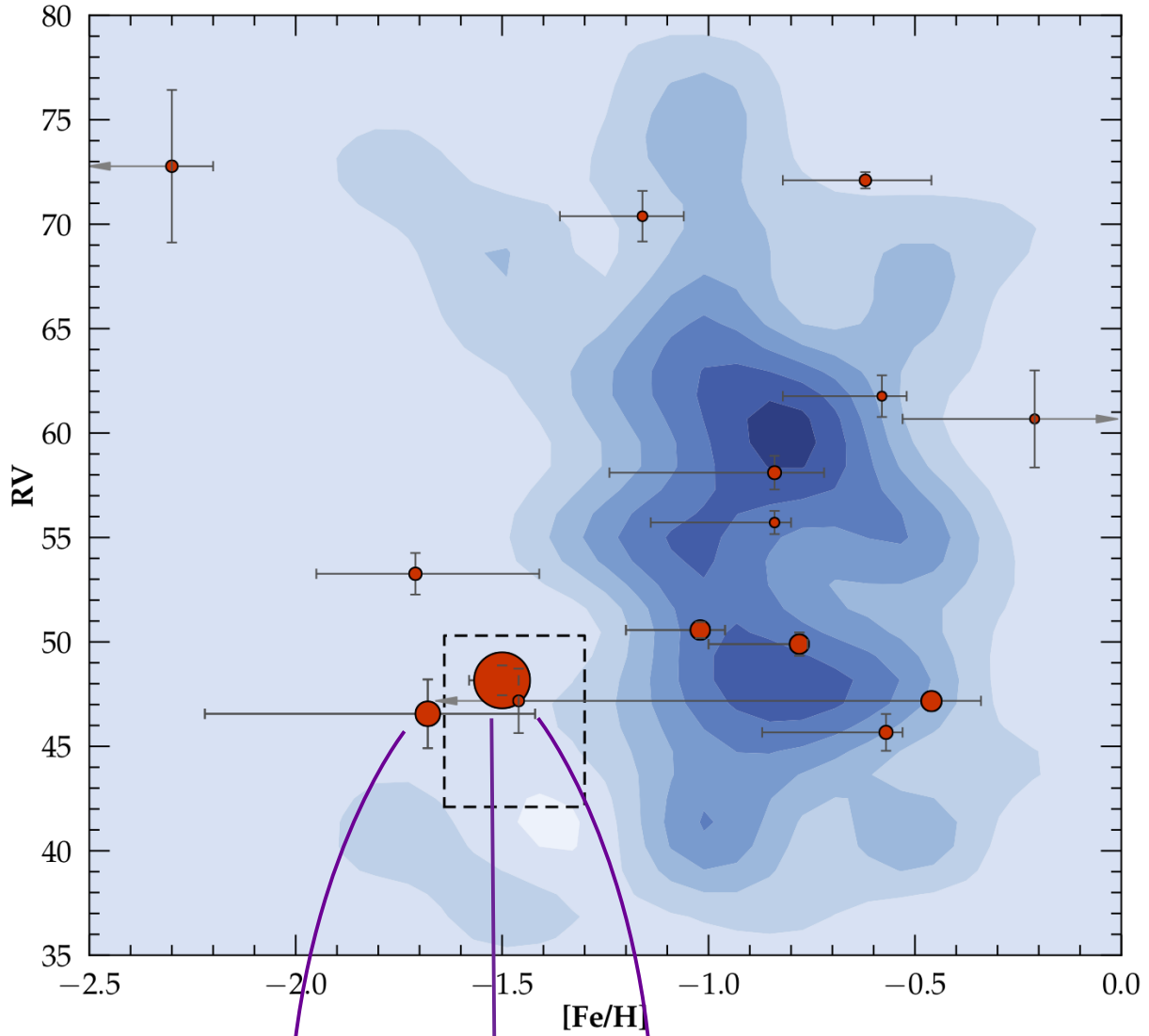
Results: RV and [Fe/H]



blue contours: 2d field star distribution
red: our measurements of bona-fide H4 candidates
black box: allowed parameter space for H4 members

- Majority of targets are consistent with Fornax field stars.
- 2-3 targets fall within the selection box
- 1 target with high S/N, full chemical analysis possible.

Results: RV and [Fe/H]



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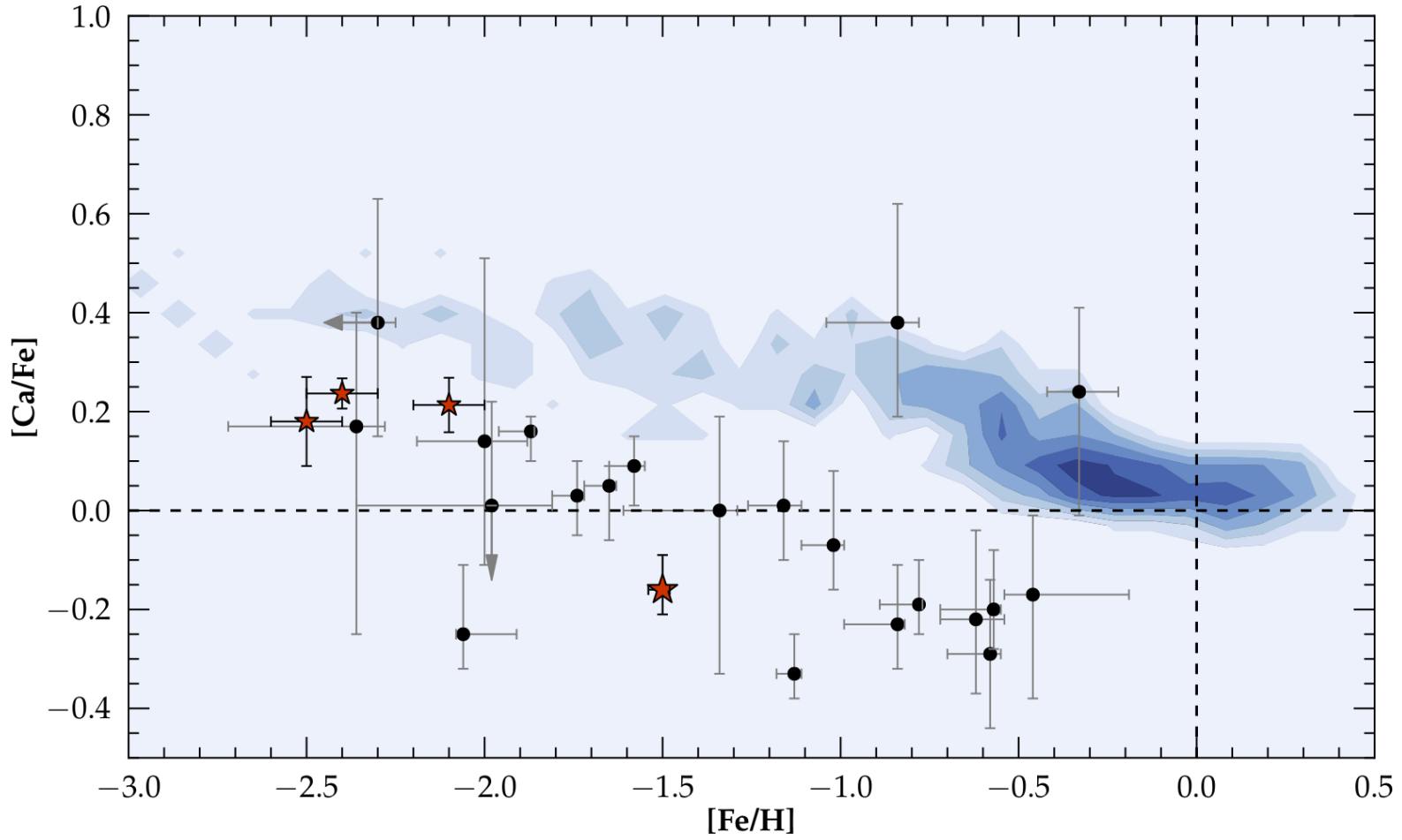
Results: Alpha-Abundances



- Clear trend of 〔Ca/Fe〕 with 〔Fe/H〕; depleted 〔Ca/Fe〕 ratio at low metallicity indicates slow chemical enrichment in the center of Fornax.

- The H4 member star is alpha-depleted, following the field evolution.

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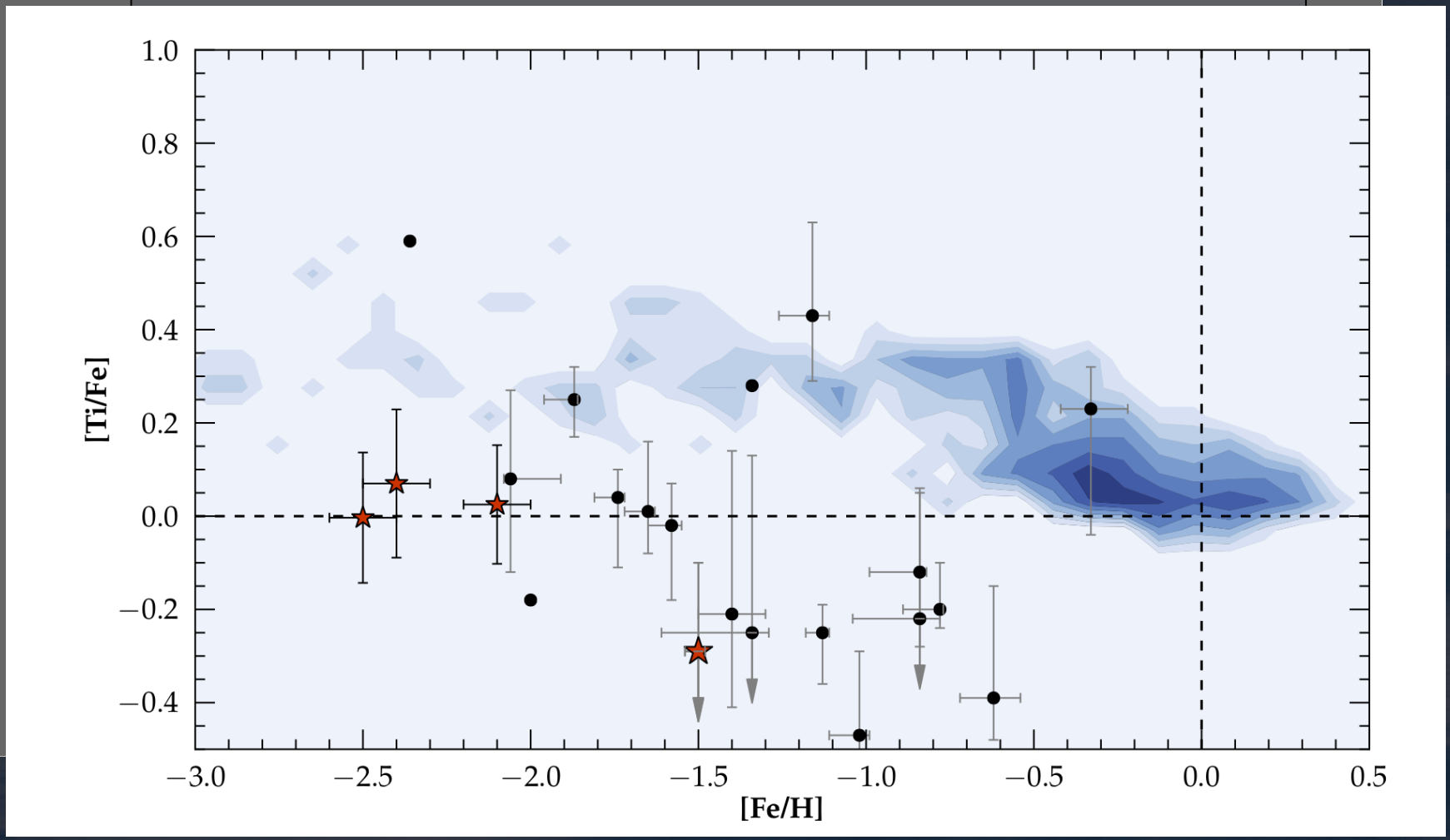
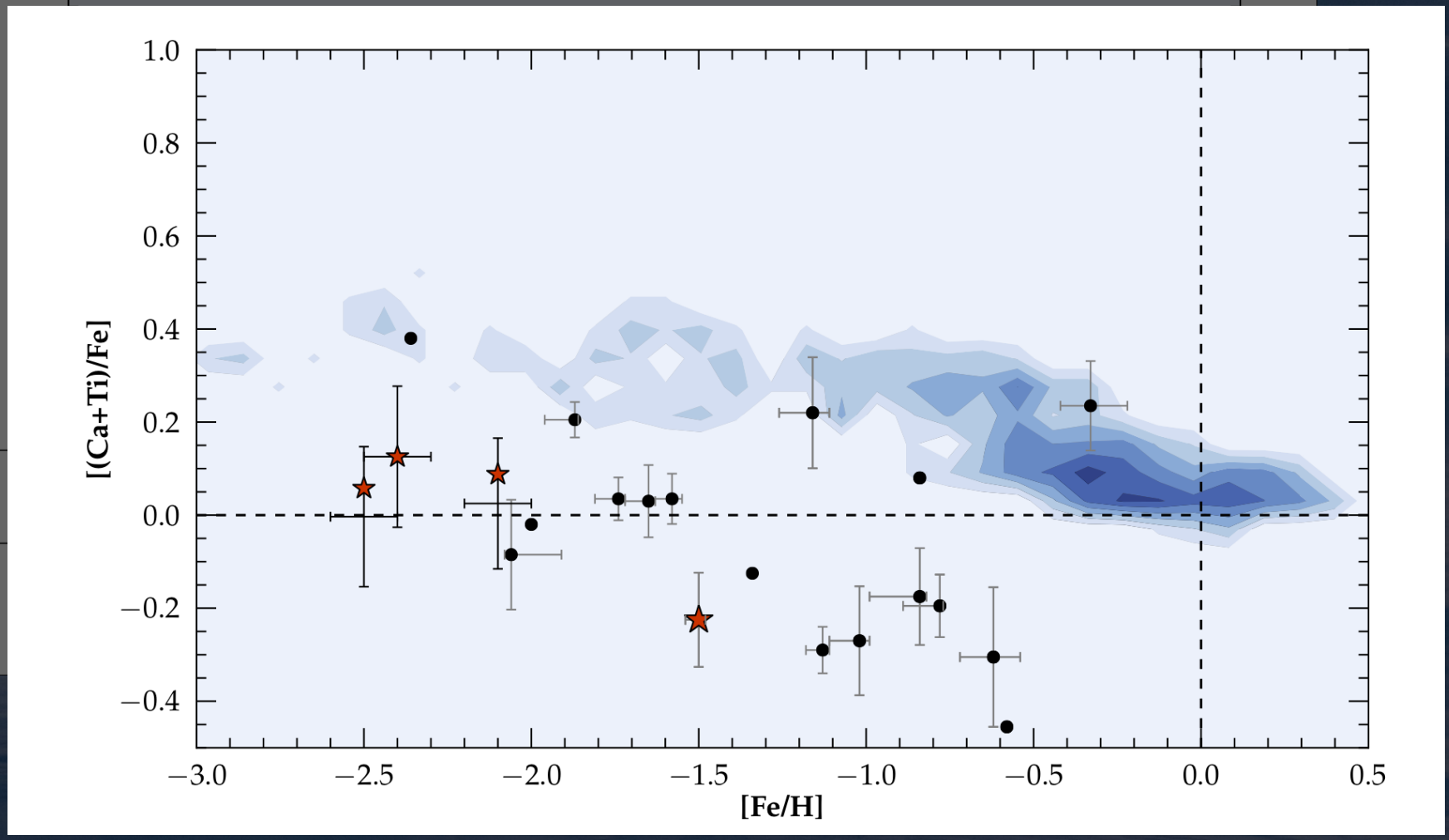


- Similar pattern, with larger uncertainties, observed in [Ti/Fe] and [Si/Fe].
- H4 member star with sub-solar [alpha/Fe] for all three species.

Results: Alpha-Abundances



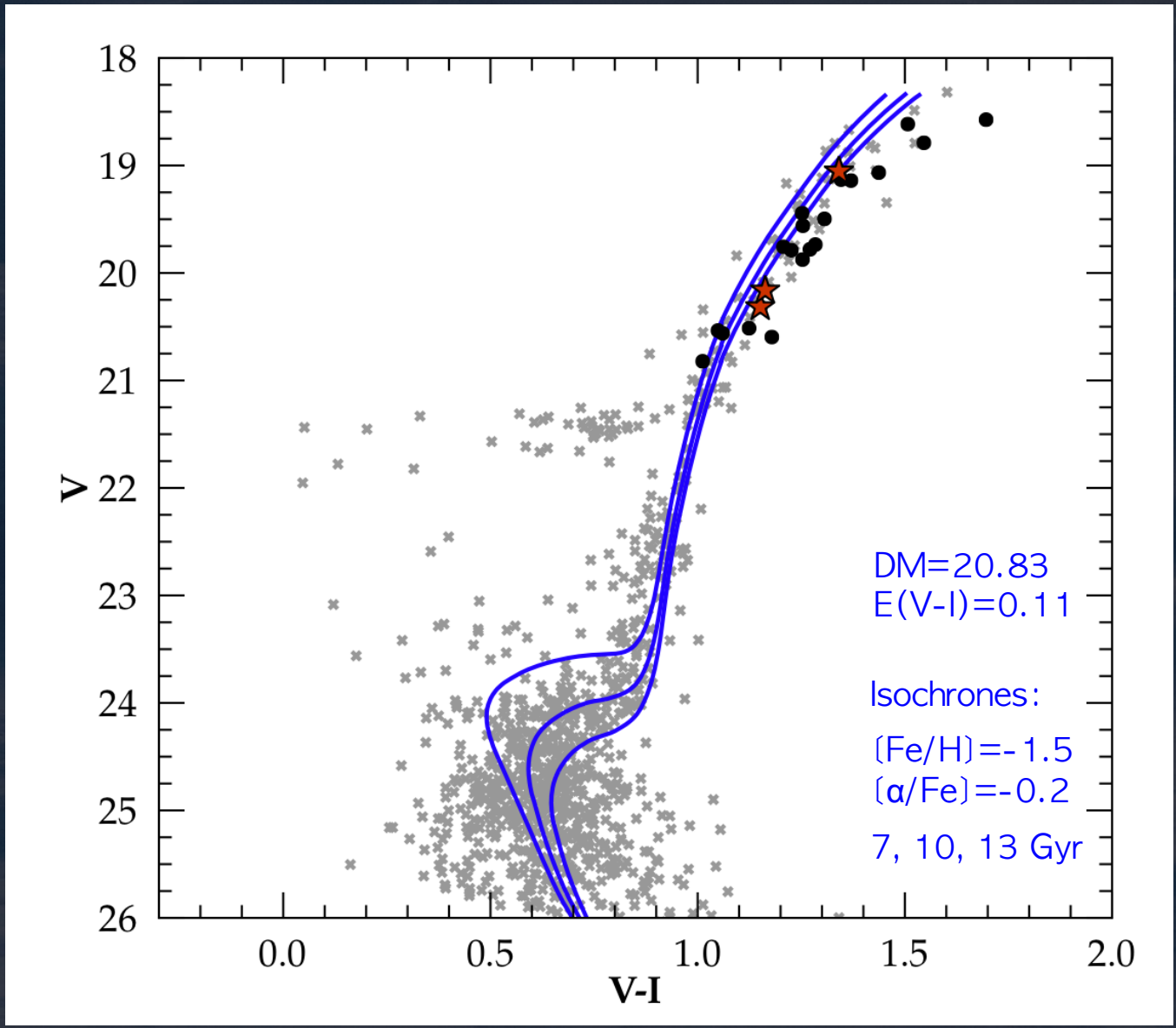
H4: New Constraints on its Age

- Precise alpha-abundance necessary for age estimation

- but: uncertainties in distance and reddening (still) do not allow a tight constraint

- age of the cluster: 9 - 12 Gyr

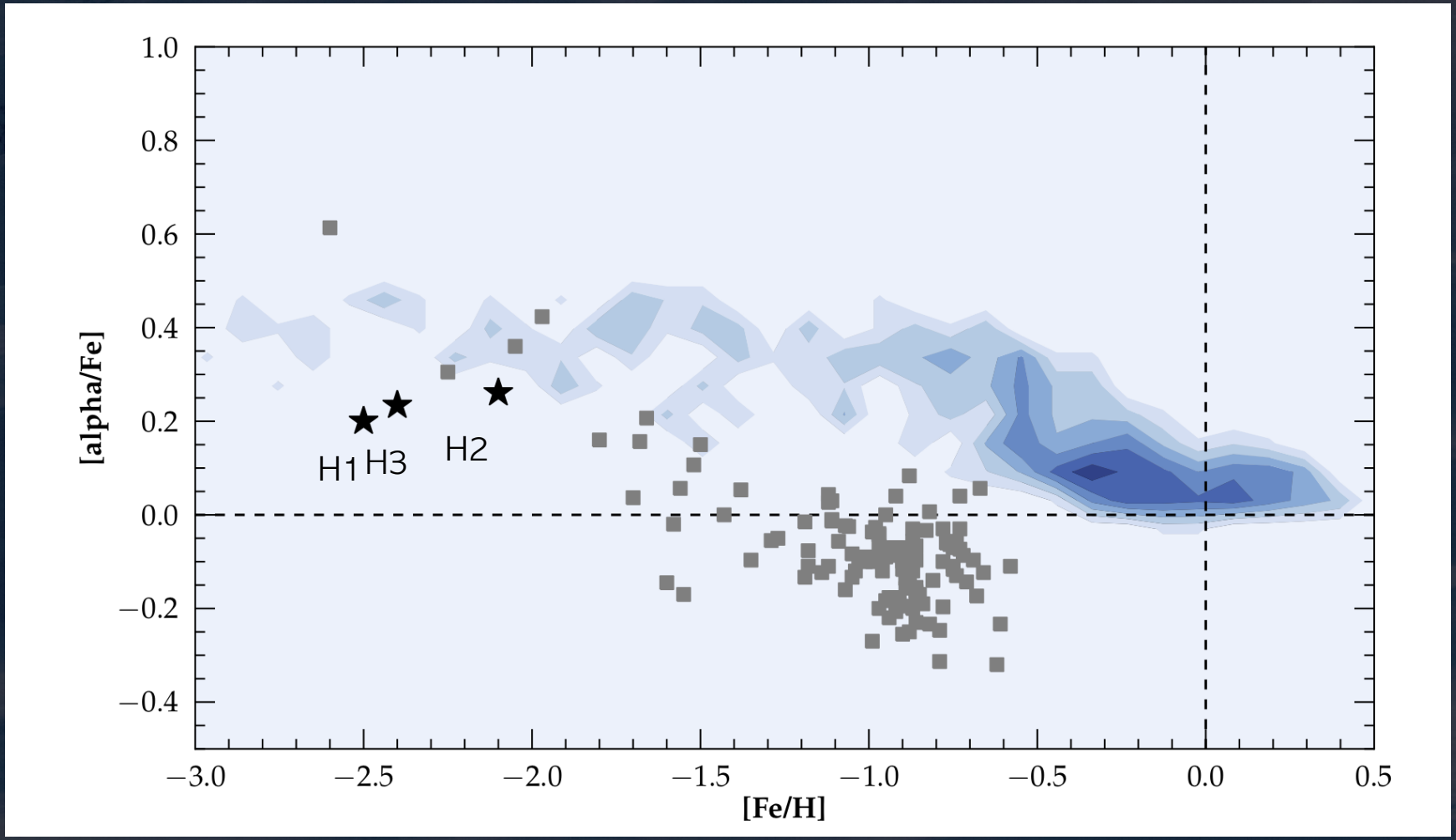
▶ H4 is an old GC, but possibly younger than the rest of the GC population in Fornax.



isochrones: Dotter et al. 2009

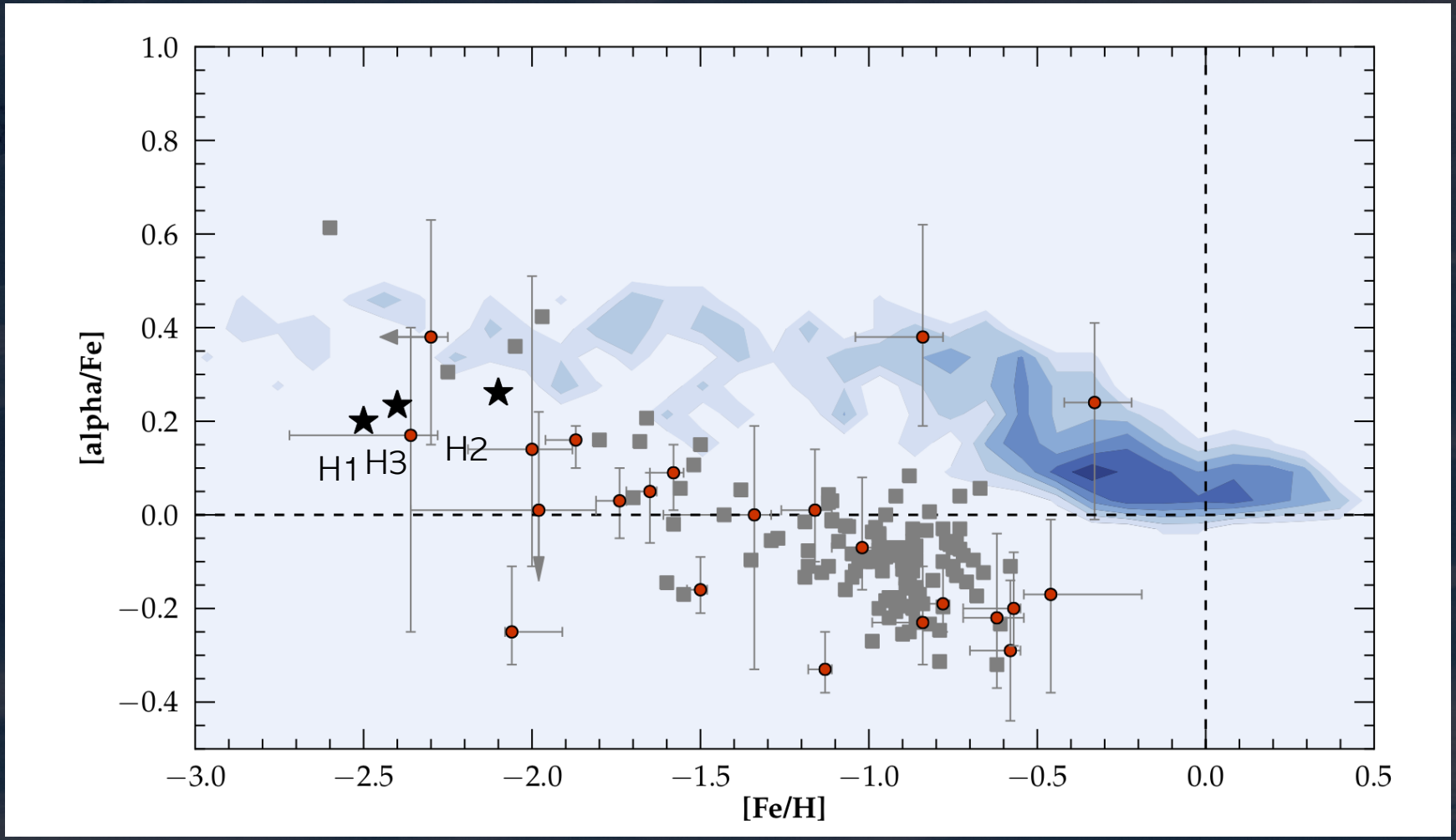
photometry: M. Frank (priv. comm.)

Summary



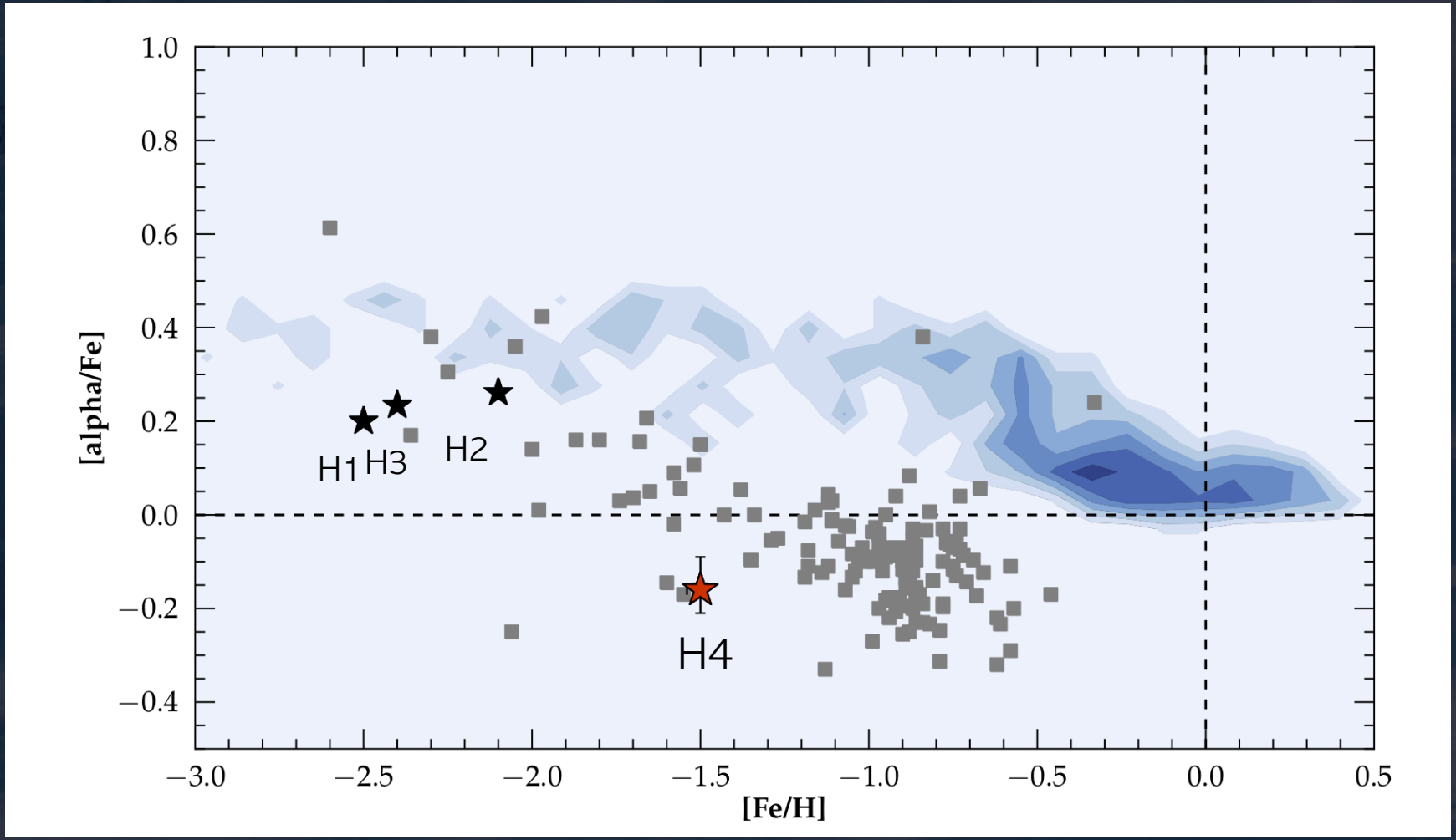
- The field stars in Fornax show an early (metal-poor) depletion in alpha-elements. Therefore, its GC population falls on both sides of the 'knee'.

Summary



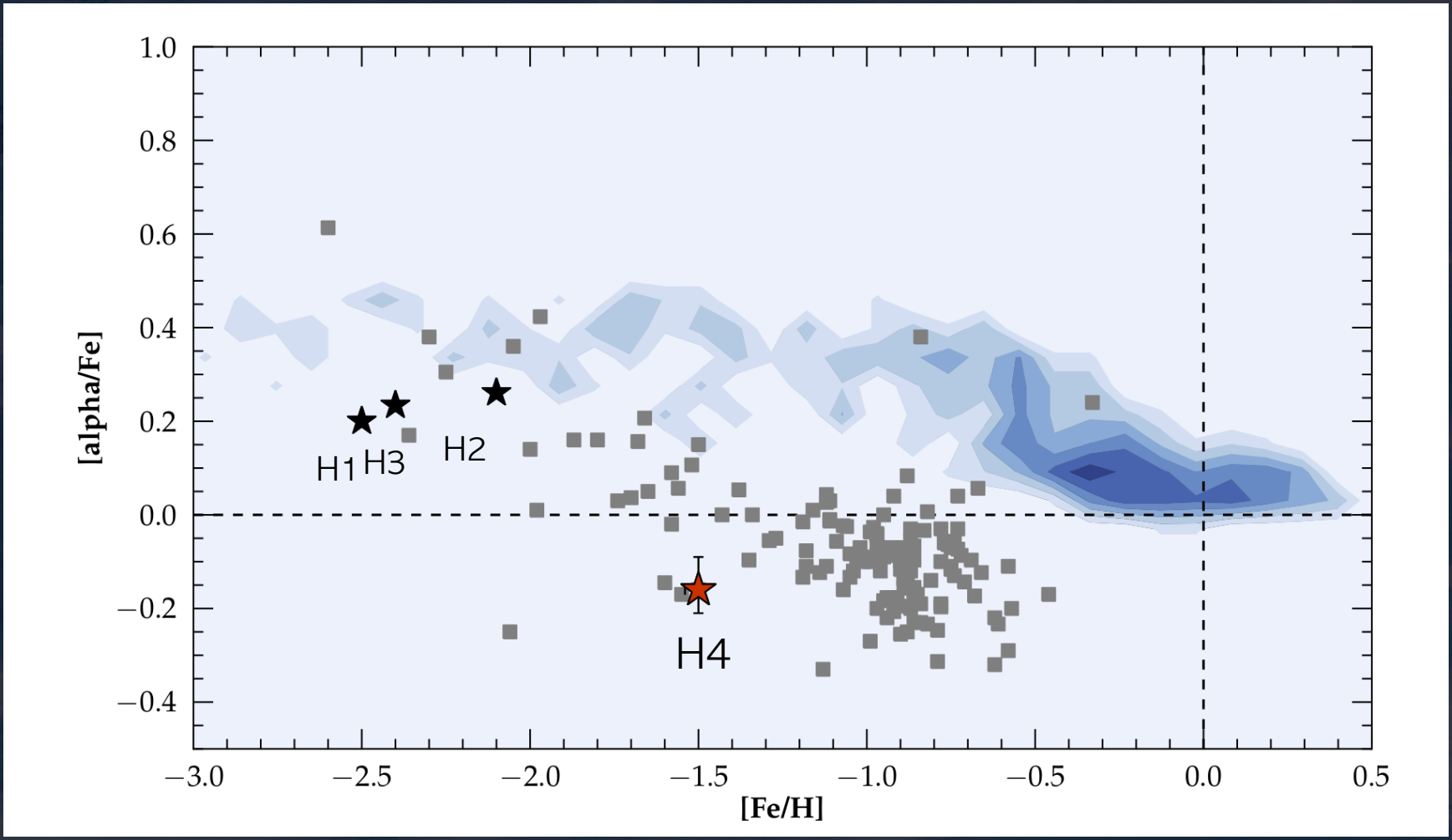
■ Here, we measure alpha-abundances (Ca, Ti) for field stars in the central part of the Fornax dSph, over a large range in 〔Fe/H〕. The observed alpha-evolution agrees well with that of previously studied stars in the outer field, indicating no significant difference in the chemical enrichment as a function of radius.

Summary

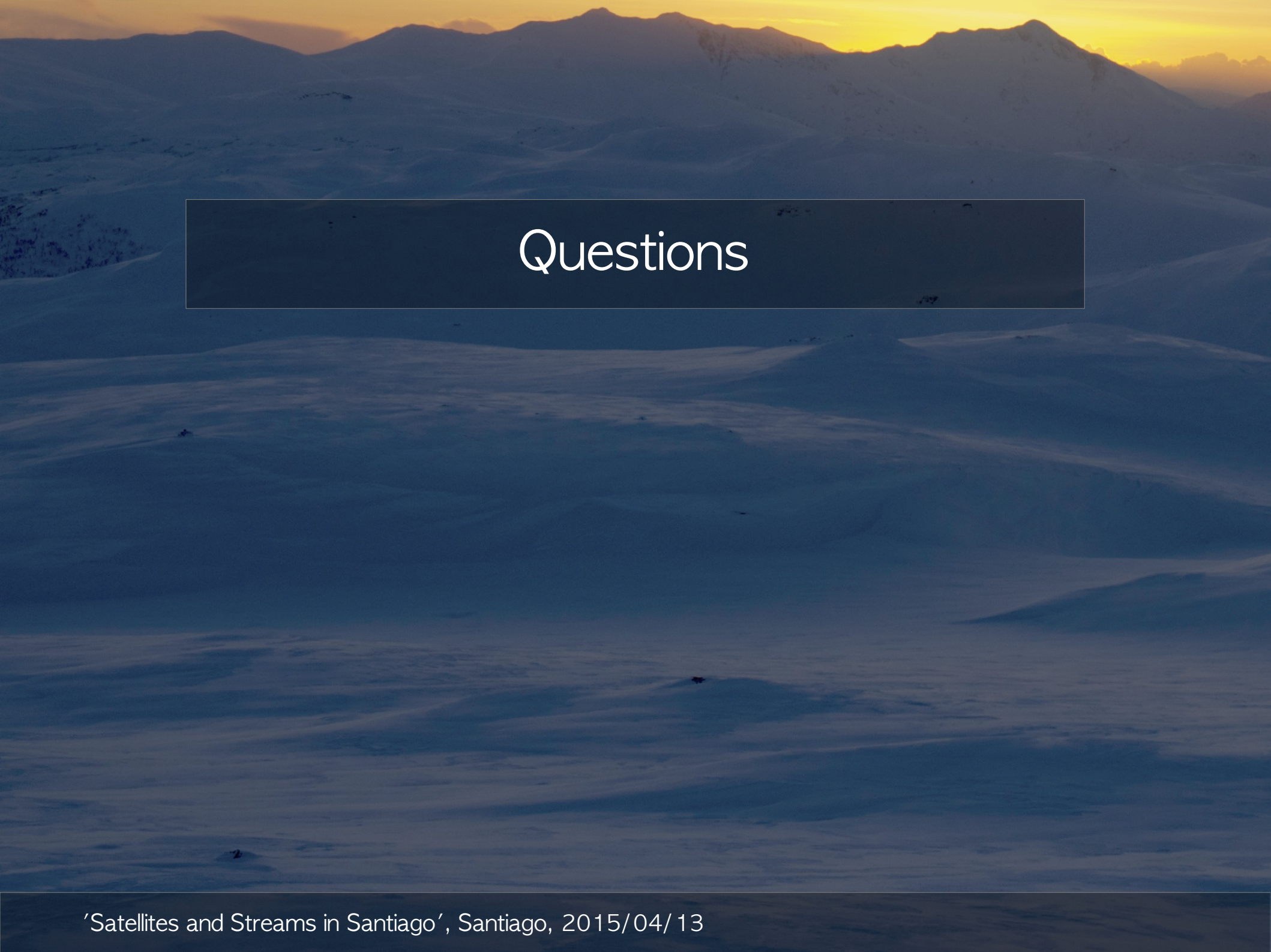


■ We isolate one individual star with a 3-sigma membership likelihood to the metal-rich GC H4. For this star, we find depleted, sub-solar abundances for Ca, Si, and Ti.

Summary



■ Our results give strong evidence for a **coupled alpha-evolution between field- and GC stars** in a common environment. If our result can be confirmed with more stars, we find in Fornax the first observed birthplace for old, alpha-depleted GCs and a possible origin for similarly alpha-depleted GCs in the Halos of larger galaxies.


Questions