Ricardo Schiavon

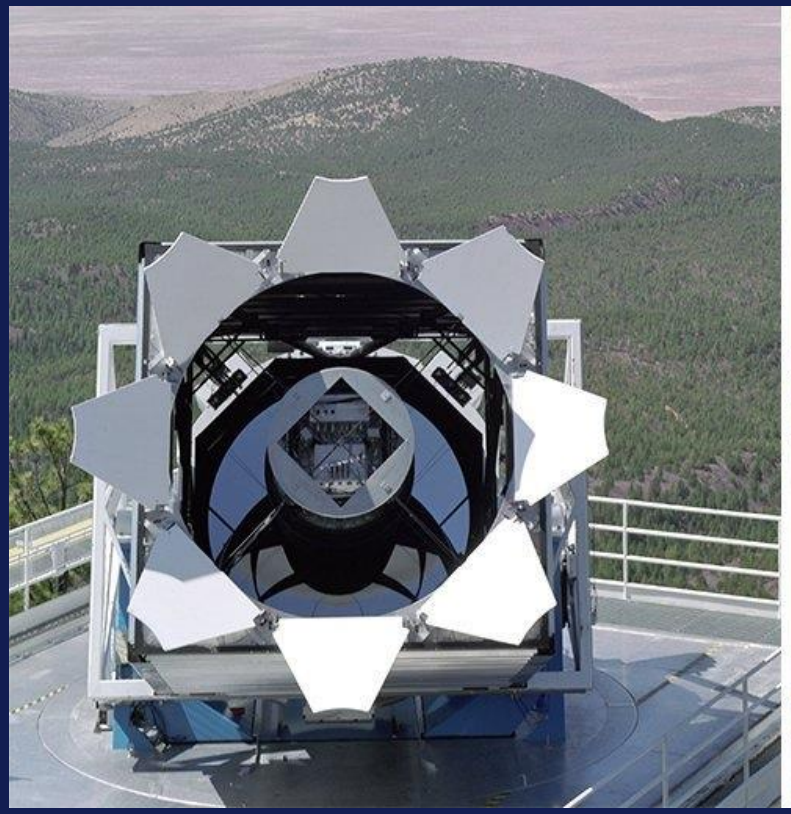
IAUS 395, Paraty, 20/11/2024

LIVERPOOL JOHN MOORES UNIVERSITY

IAU Angra dos Reis, 1991

APACHE POINT OBSERVATORY GALACTIC EVOLUTION EXPERIMENT

2.5 m SDSS telescope at Apache Point Observatory



2.5 m du Pont telescope at Las Campanas Observatory

A dual hemisphere spectroscopic survey of Milky Way stellar populations

PI: Steve Majewski

APOGEE SCIENTIFIC FOOTPRINT

- Galactic Archaeology (MW, Local Group)
- Stellar clusters (globular and open)
- Stars (single and binary)
- Interstellar medium
- Substellar components
- Spectral analysis

APOGEE SCIENTIFIC FOOTPRINT

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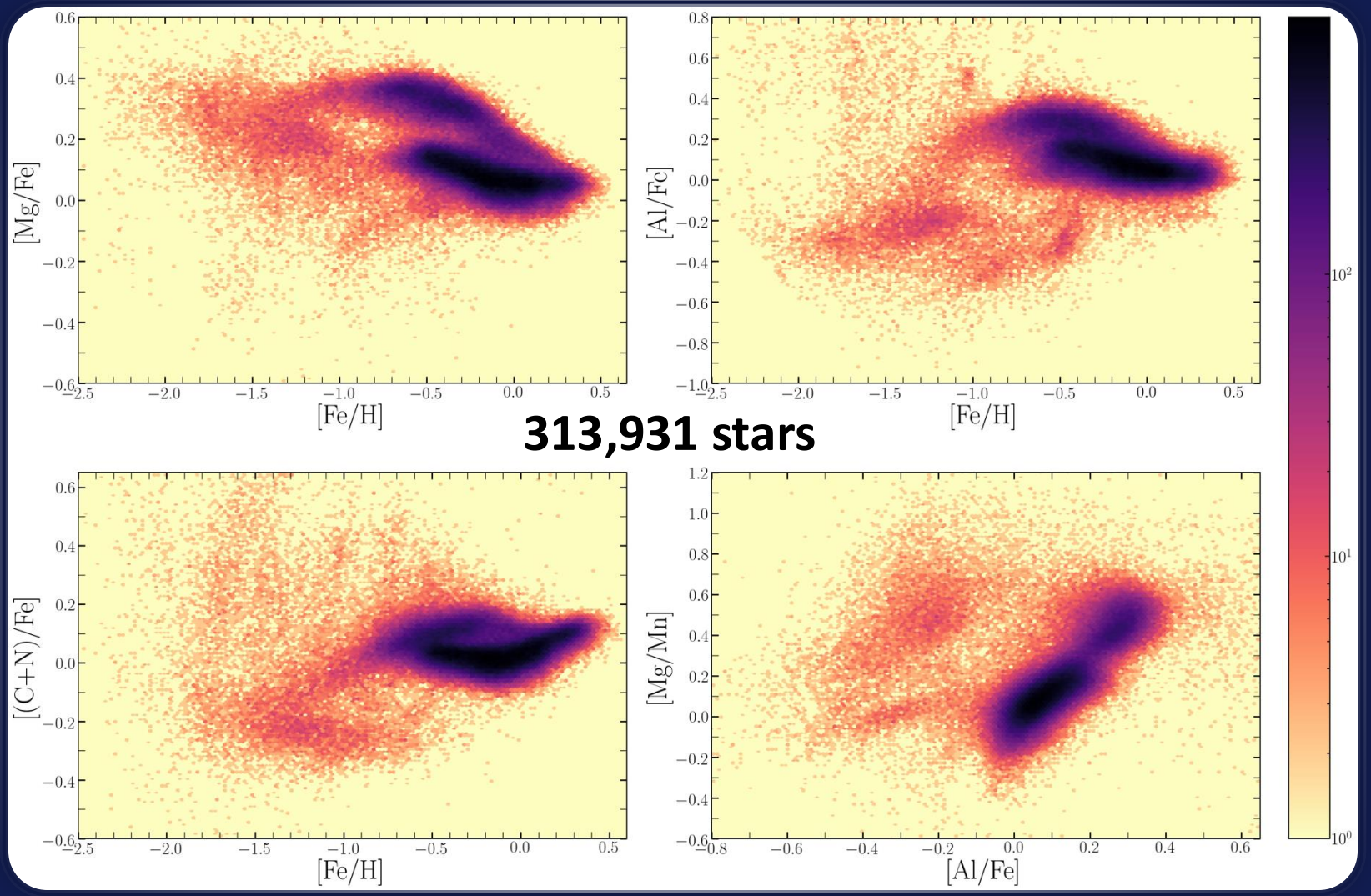
WHY APOGEE STANDS OUT

- R = 23,000, high S/N
- Near Infrared & Dual hemisphere
- 500,000 giants

PRECISION ABUNDANCES



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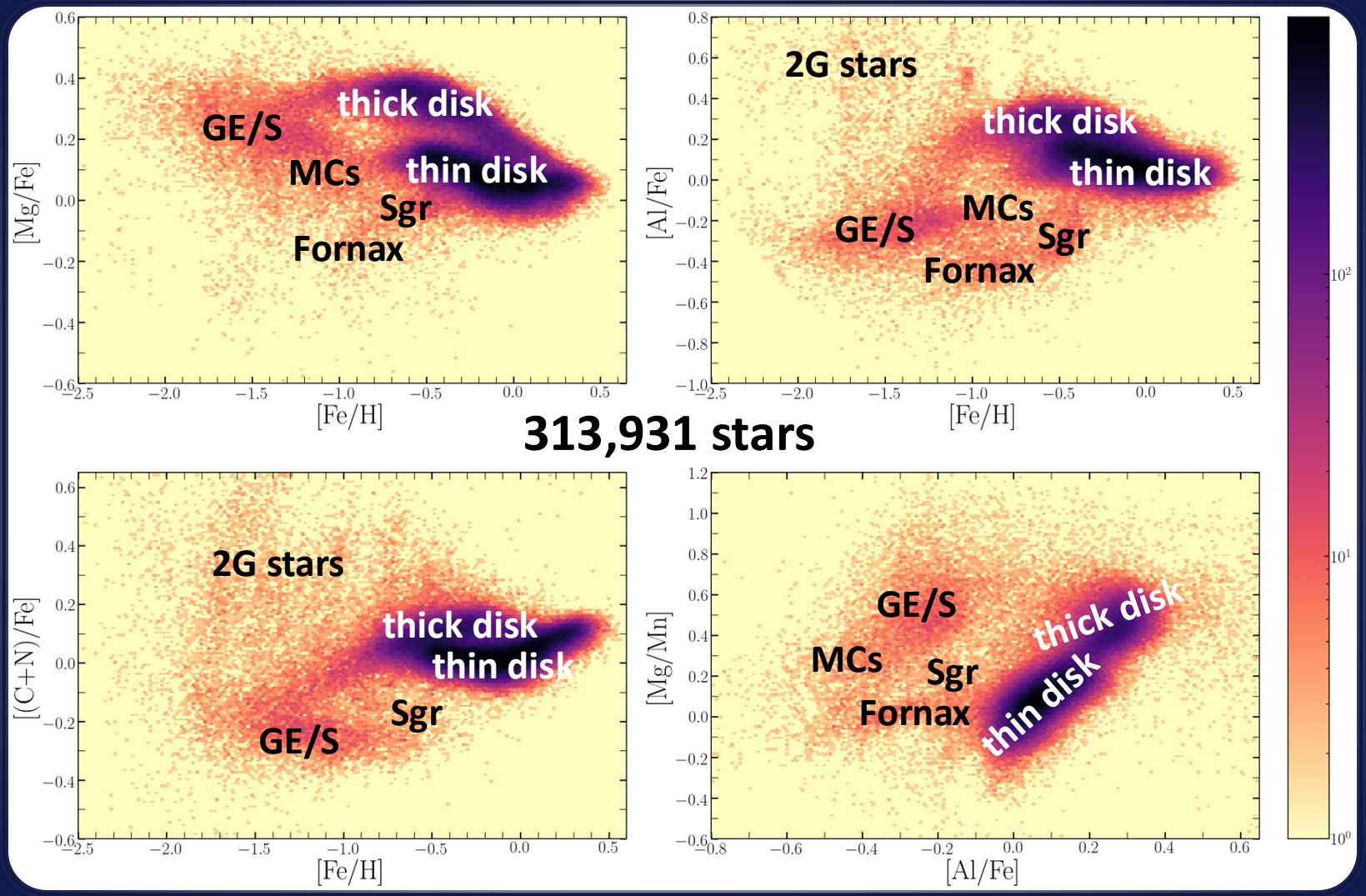

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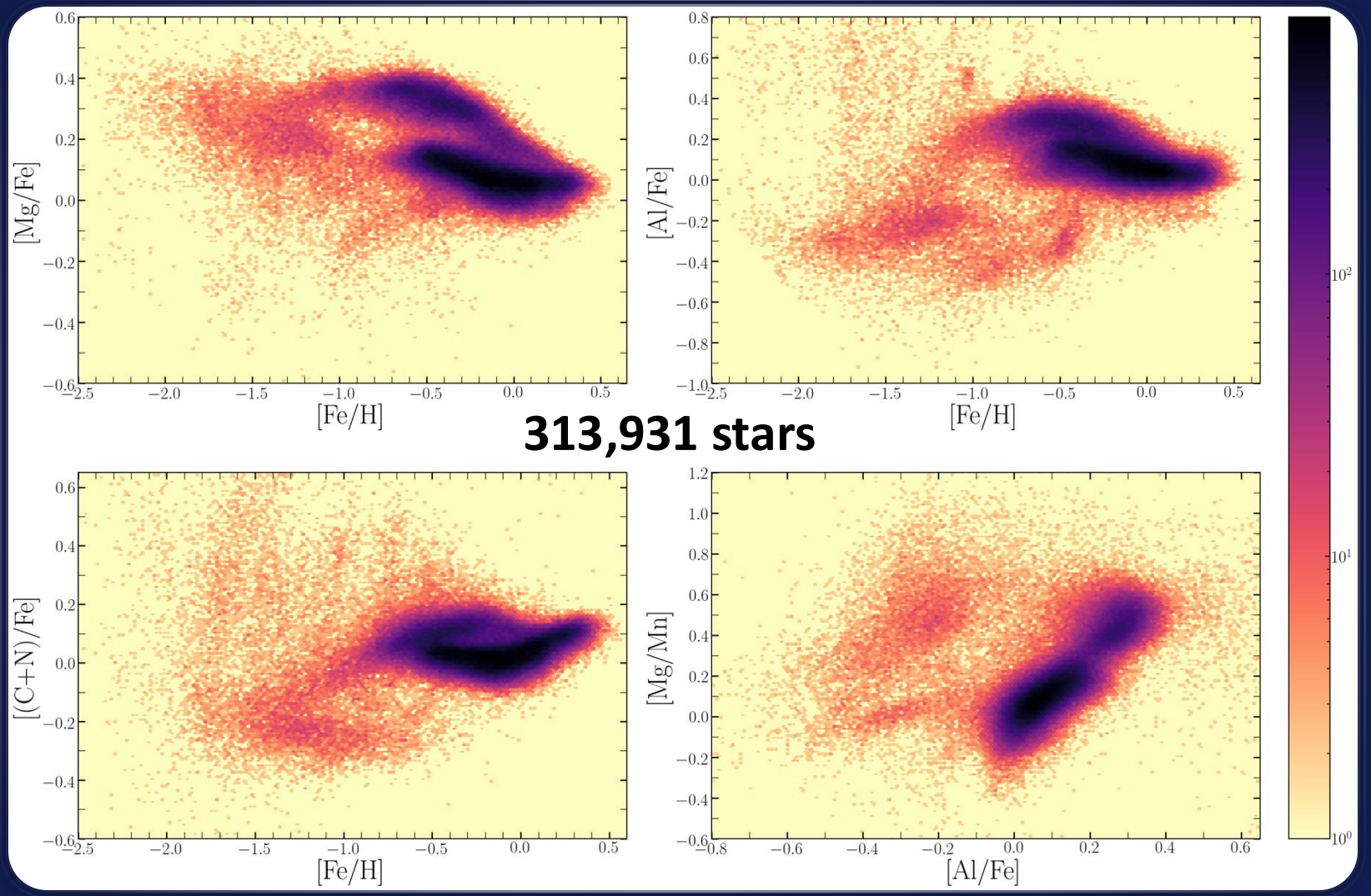

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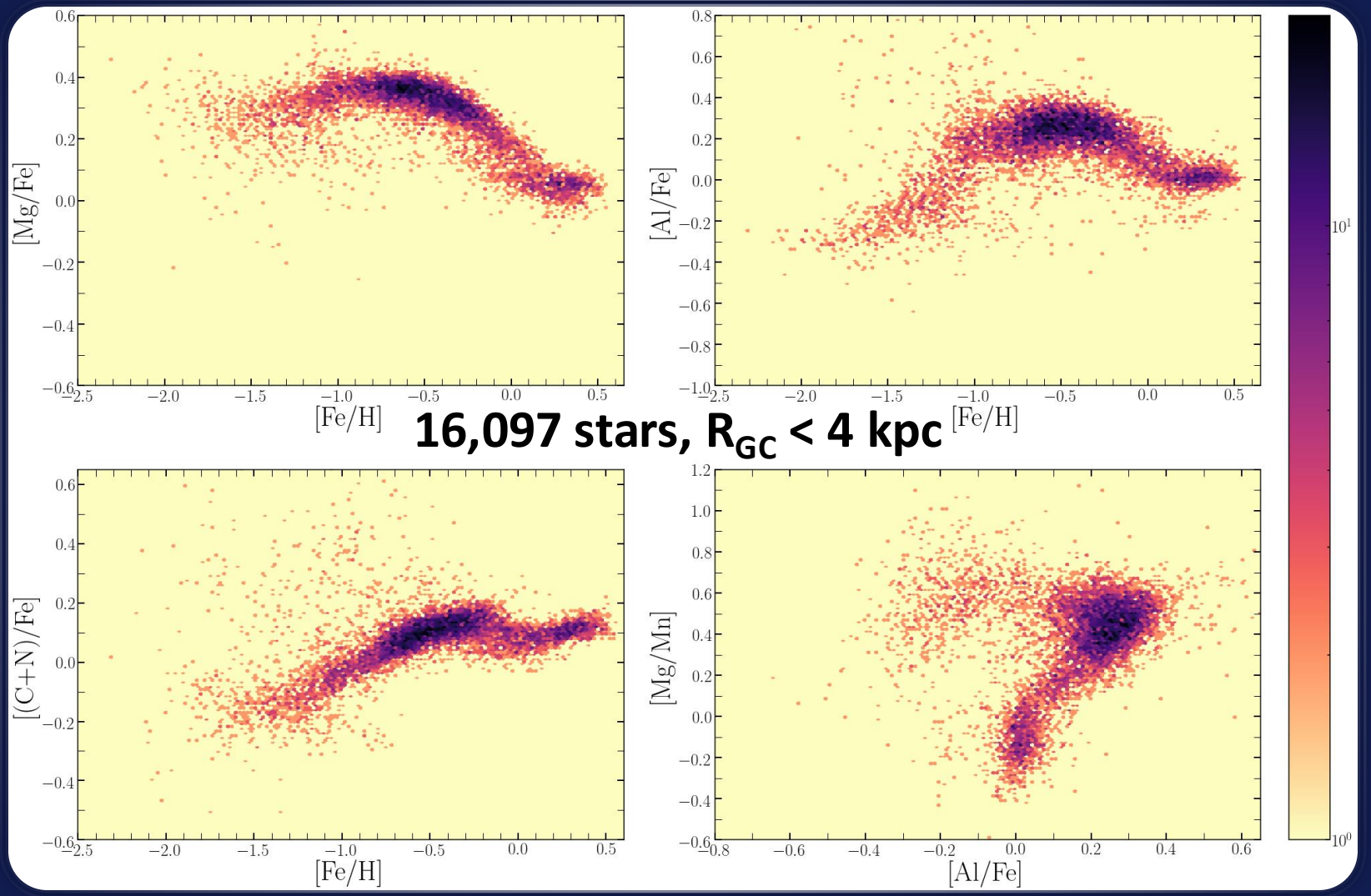
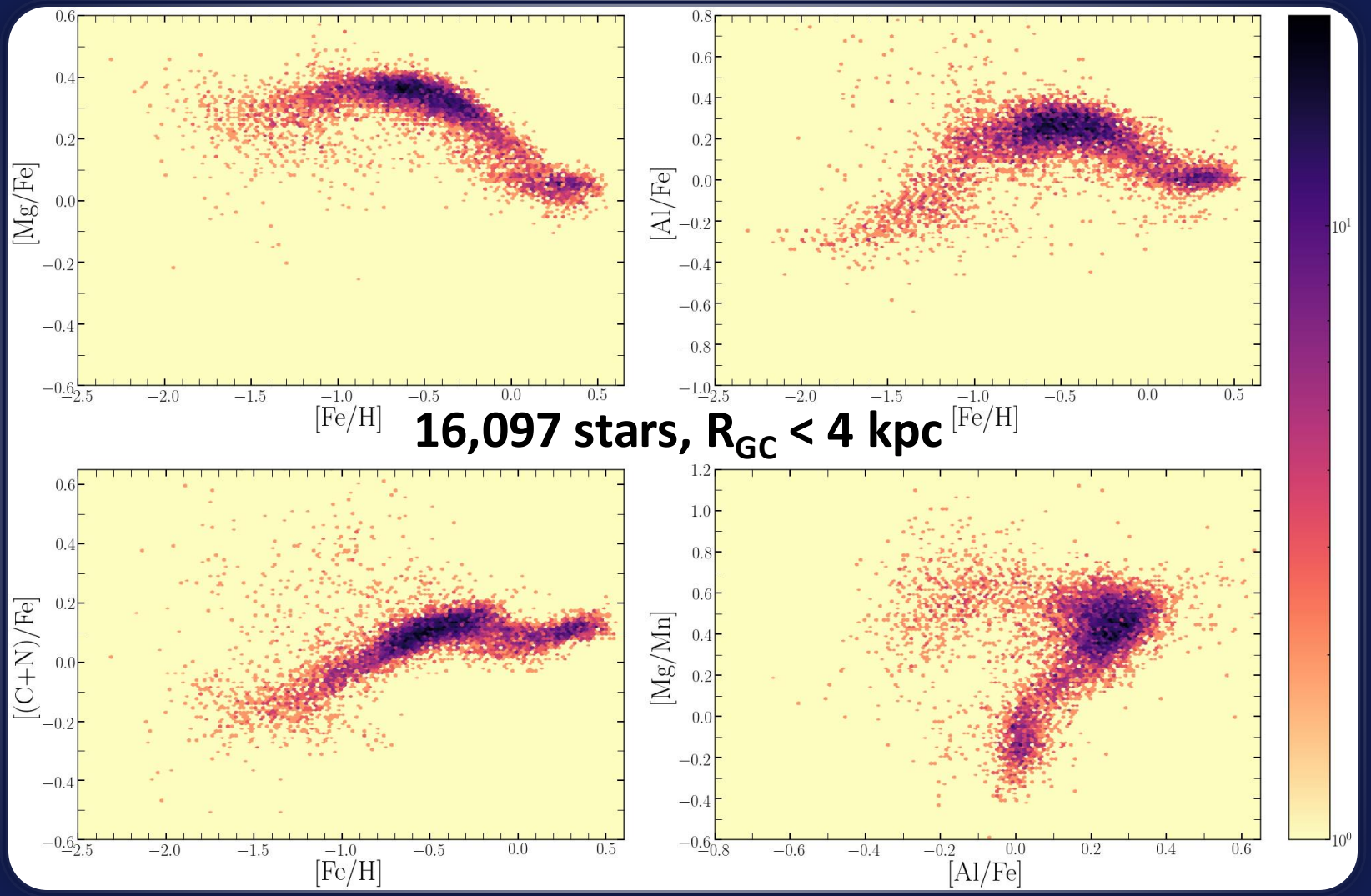


IN THE INNER GALAXY

- *For the first time*: precision detailed chemistry for 10^4 stars

PRECISION ABUNDANCES



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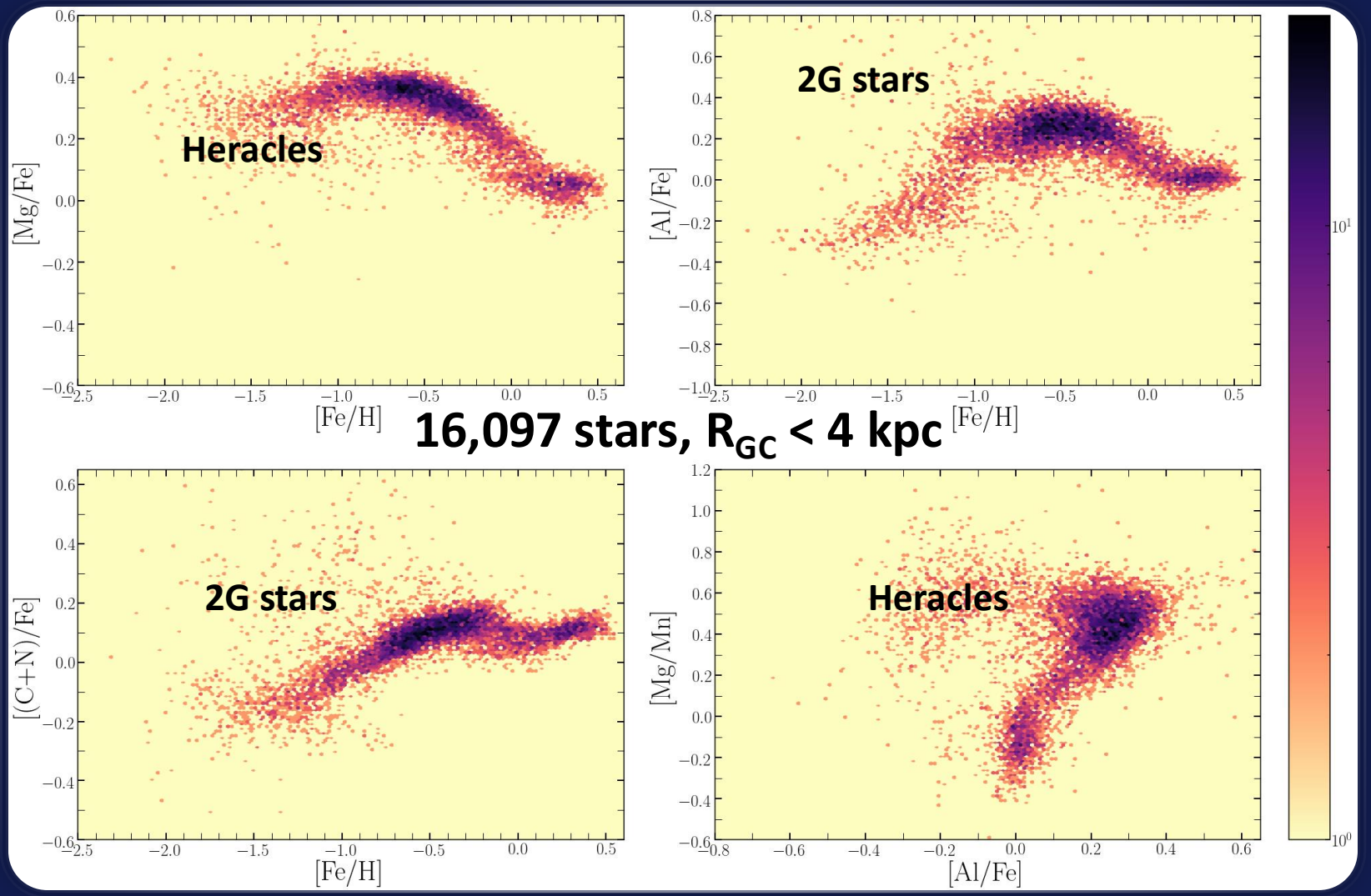
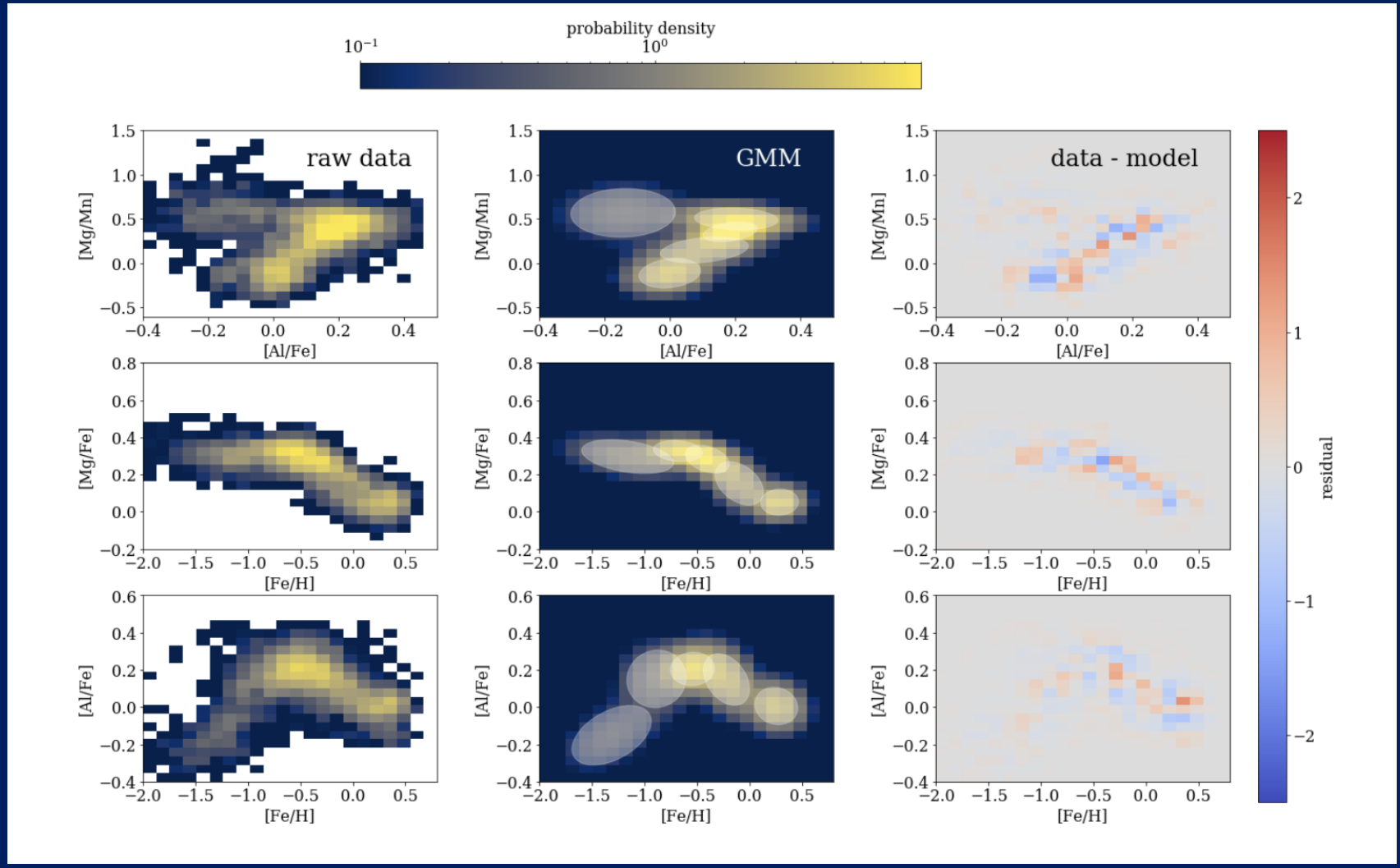


GALACTIC BULGE

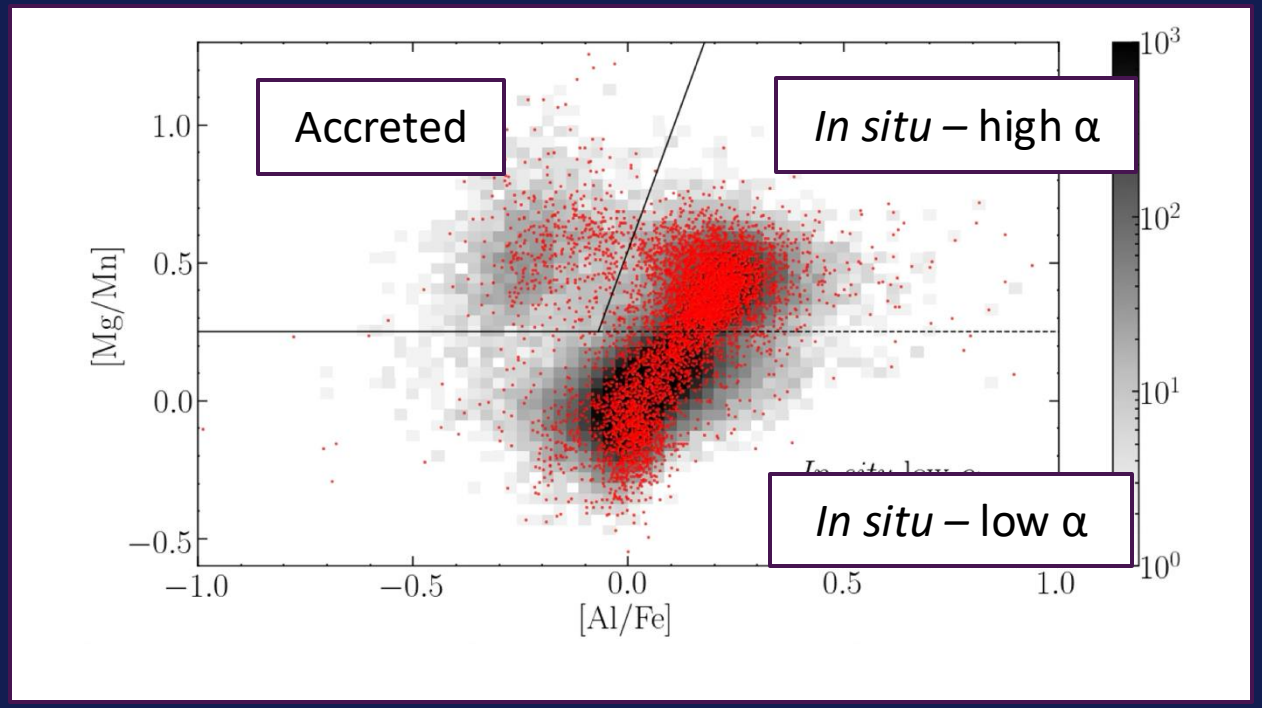
See talk by Anna Queiroz

- Going beyond metallicity and α/Fe
- Going beyond MDFs
- Breaking degeneracies brings multiple components to sharp relief



Horta+2021

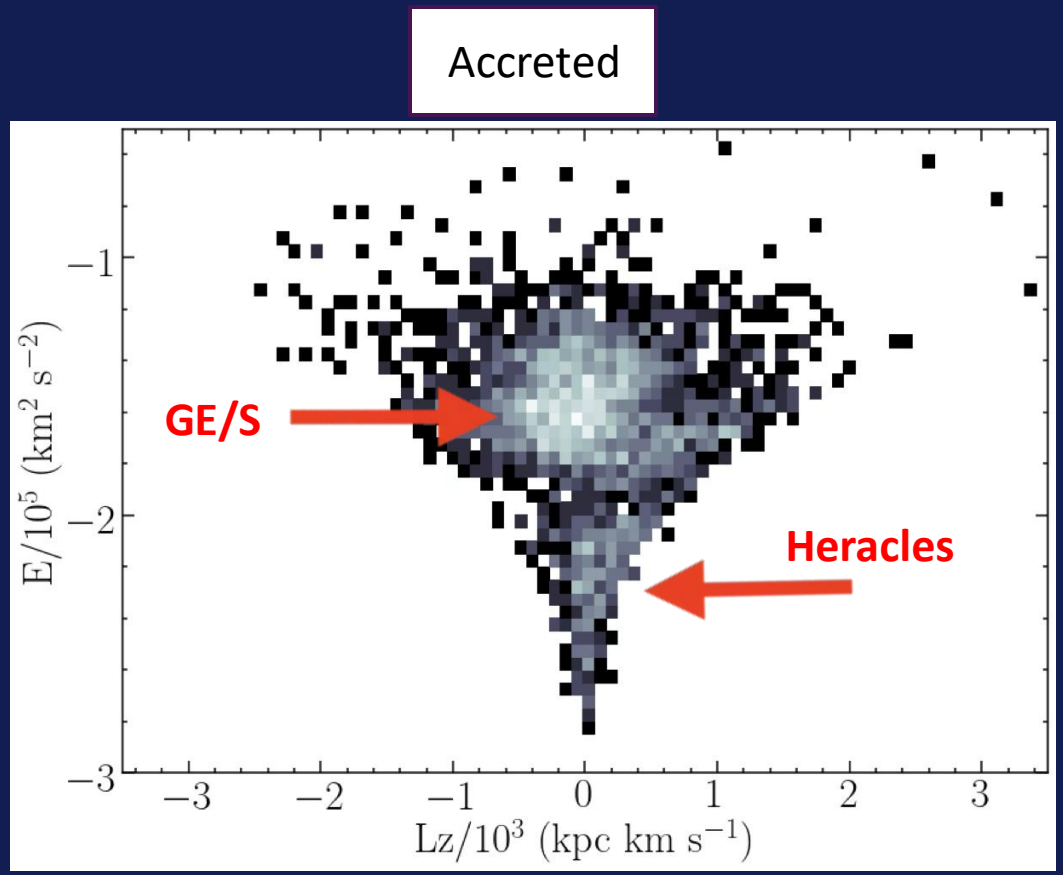
THE MILKY WAY ACCRETION HISTORY



- Massive accretion event ($M_* \approx$ 5x10^8 $M_\odot$)
- Maybe associated with the Kraken (Kruijssen+2020)
- Higher [α/Fe]

Heracles

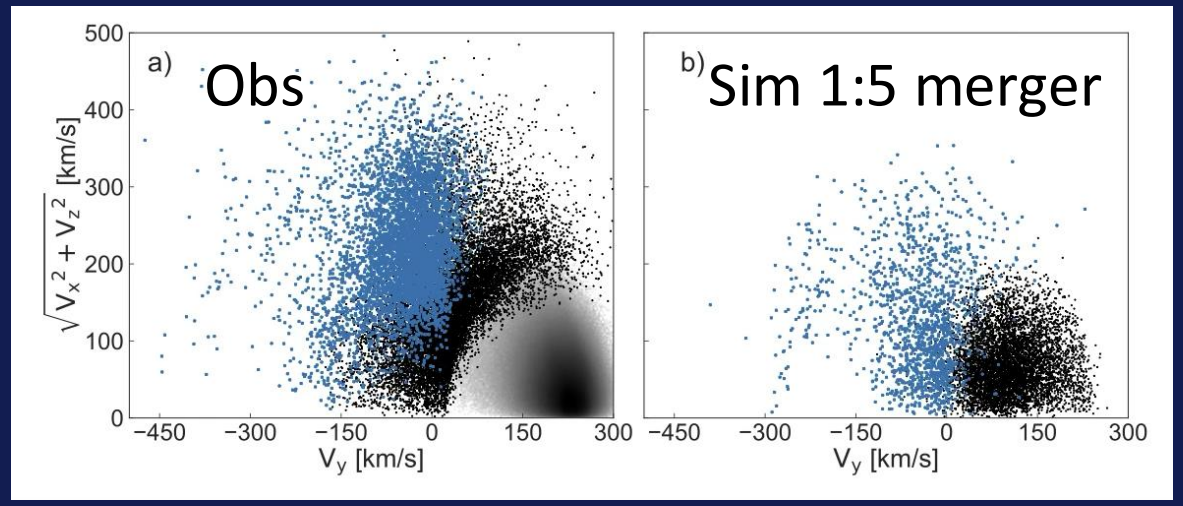
Horta+2021, Horta & RPS 2024



THE MILKY WAY ACCRETION HISTORY

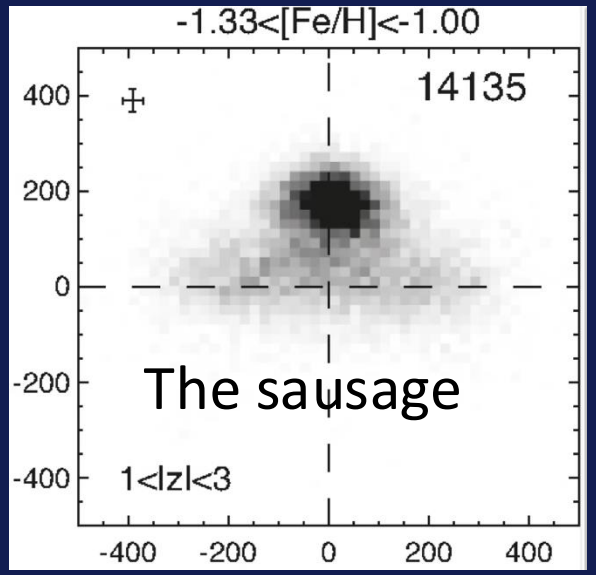
Gaia Enceladus / Sausage

Helmi+2018, Belokurov+2018, Haywood+2018,
Gaia Collab+Babusiaux+2018, Mackereth+2019

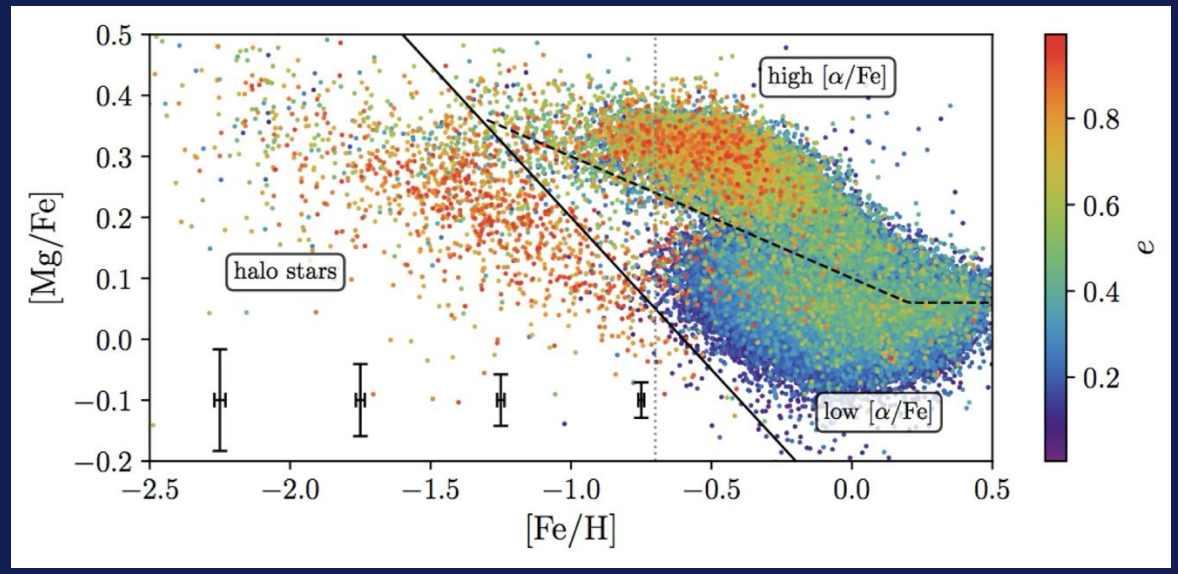


Helmi+2018

Massive accretion event ($M_* \approx 3x10^8 M_\odot$)
Approximately 9 Gyr ago
Low [α/Fe]



Belokurov+2018

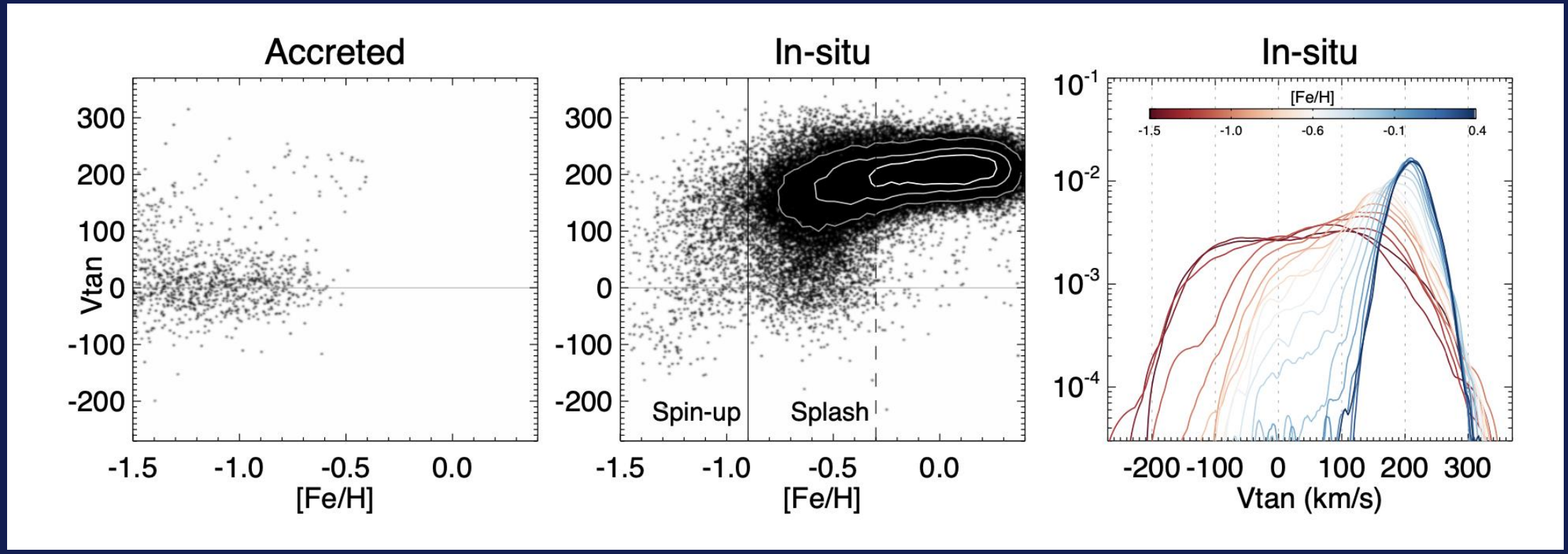


Mackereth+2019

THE EARLY MILKY WAY HALO

Aurora & MW Poor Old Heart

Belokurov & Kravtsov 2022, Rix+2022

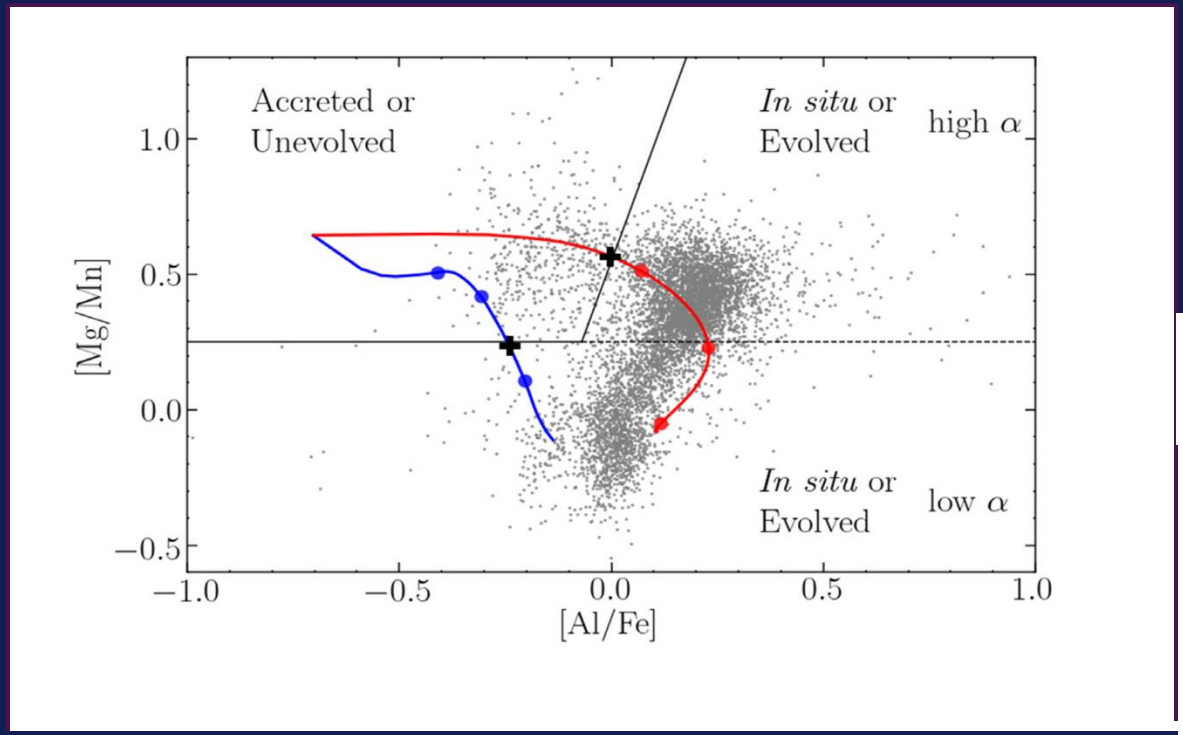


- Detection of the early in situ Milky Way population
- Turbulent, kinematically hot, pre formation of the disk (Spin up phase)
- No need for an accreted component in the inner Galaxy

THE MILKY WAY ACCRETION HISTORY

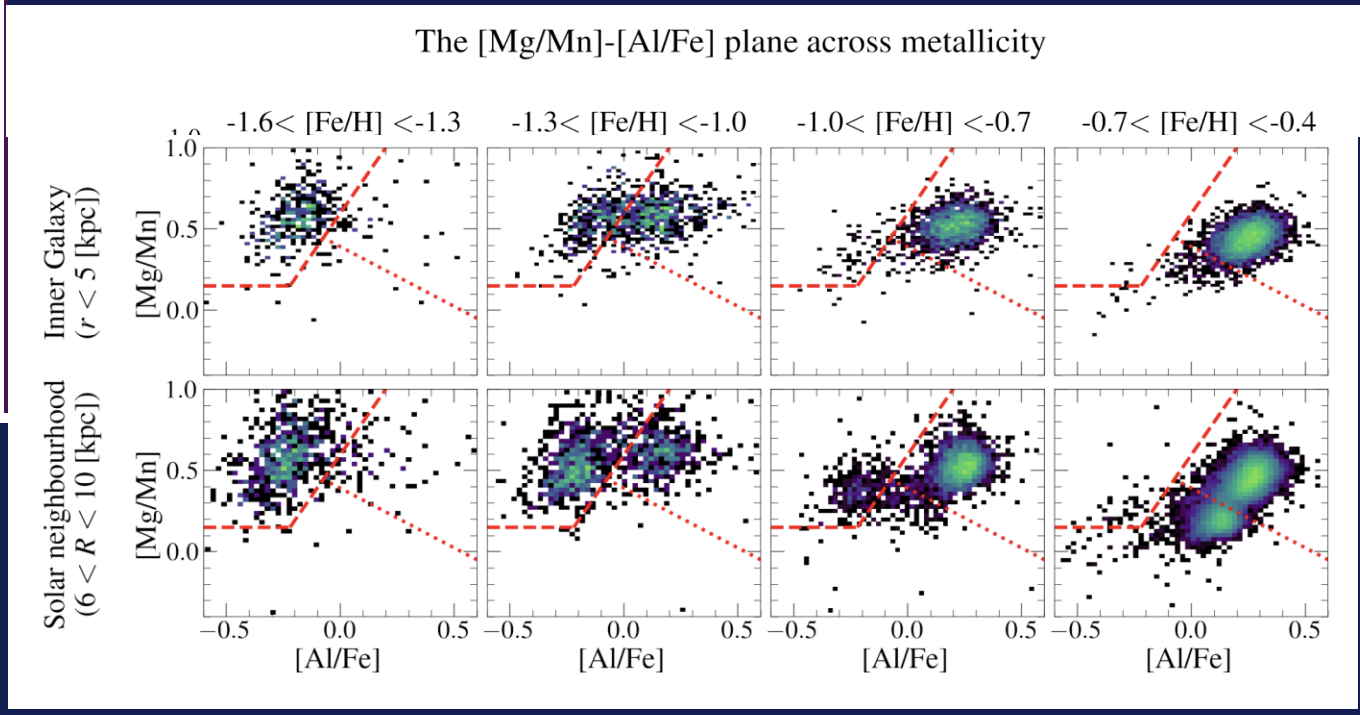
Heracles

Horta+2021, Horta & RPS 2024



Horta+2021

- Star formation efficiency can help distinguish in situ (Aurora) from accreted (Heracles) populations

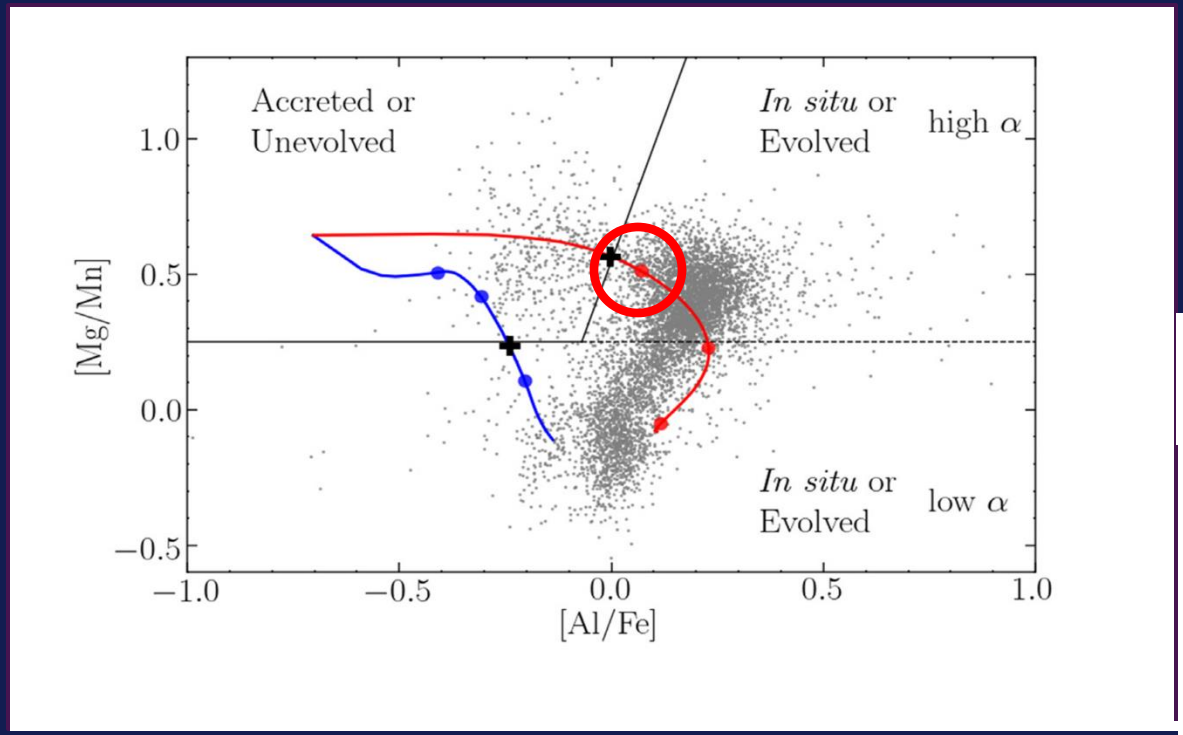


Horta & RPS 2024

THE MILKY WAY ACCRETION HISTORY

Heracles

Horta+2021, Horta & RPS 2024



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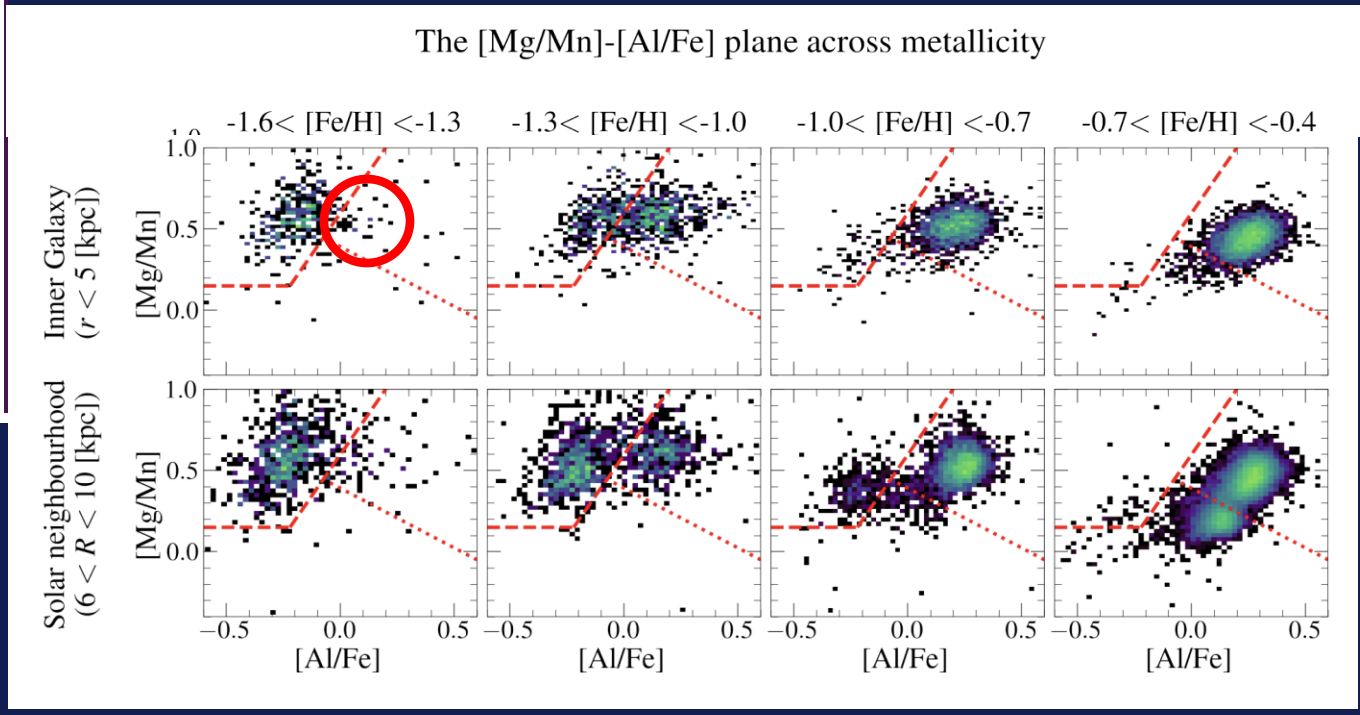
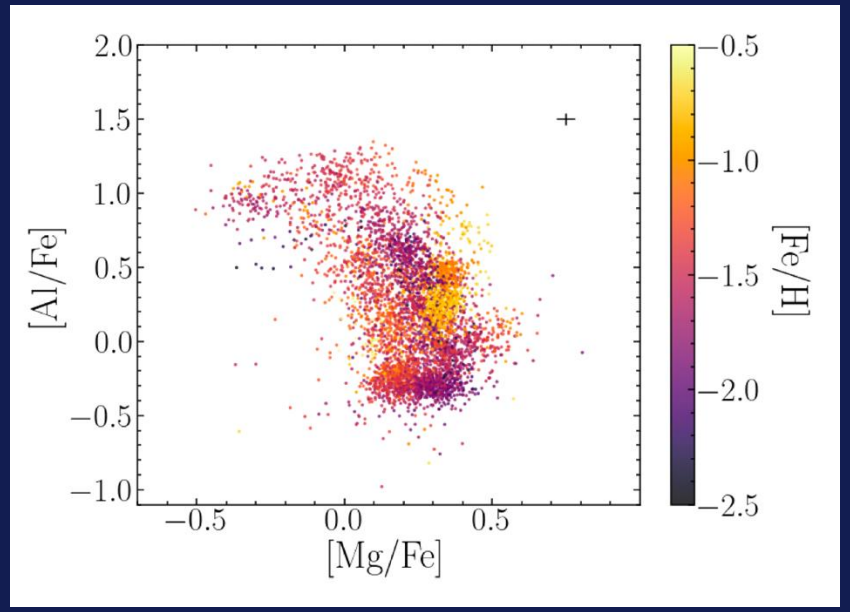


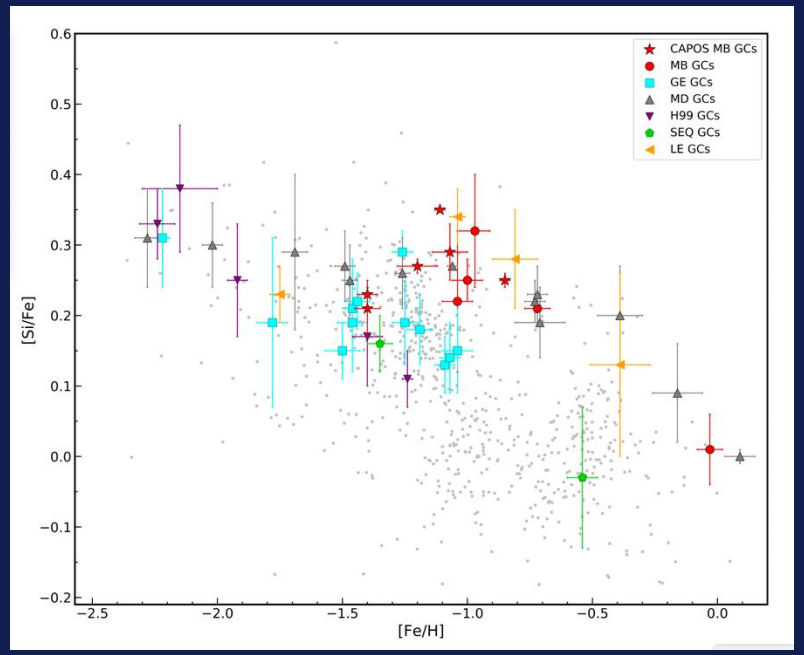
Horta & RPS 2024

GLOBULAR CLUSTERS

Mészáros+2015,2020,2021, Schiavon+2017, Masseron+2019, Nataf+2019, Horta+2021, Geisler+2024, Schiavon+2024



Schiavon+2024

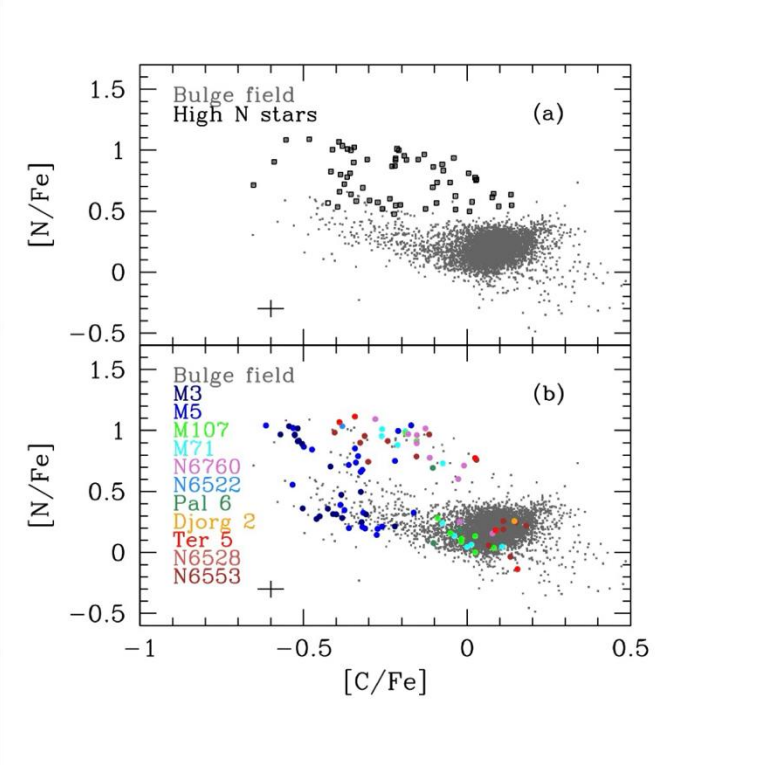


Geisler+2024

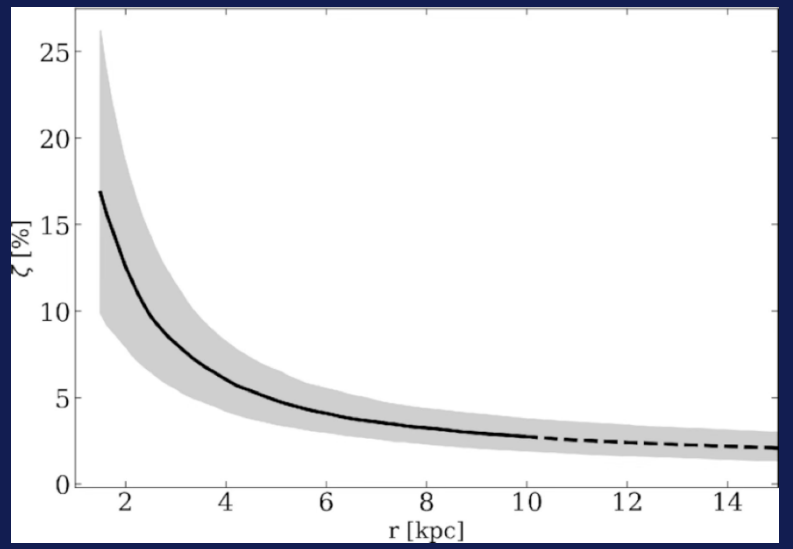
- Value Added Catalog of GC member stars (6400+ stars, 72 GCs), including data from the CAPOS project (Geisler+2024)
- Multiple populations phenomenon
- Accretion history of the MW halo

GLOBULAR CLUSTER DESTRUCTION

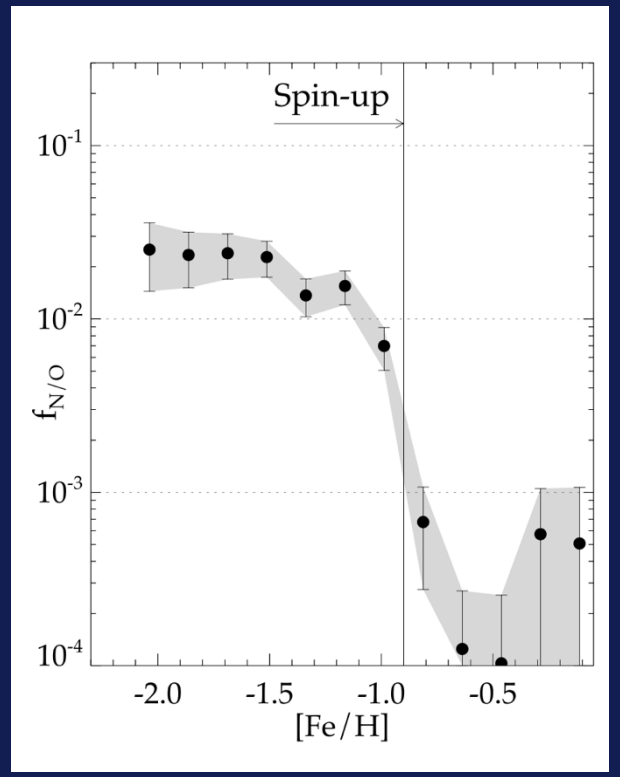
Schiavon+2017, Martell+2016, Fernández-Trincado+2017,2022, Kisku+2021, Horta+2021, Belokurov & Kravtsov 2023



Schiavon+2017



Horta+2021b



Belokurov+Kravtsov 2022

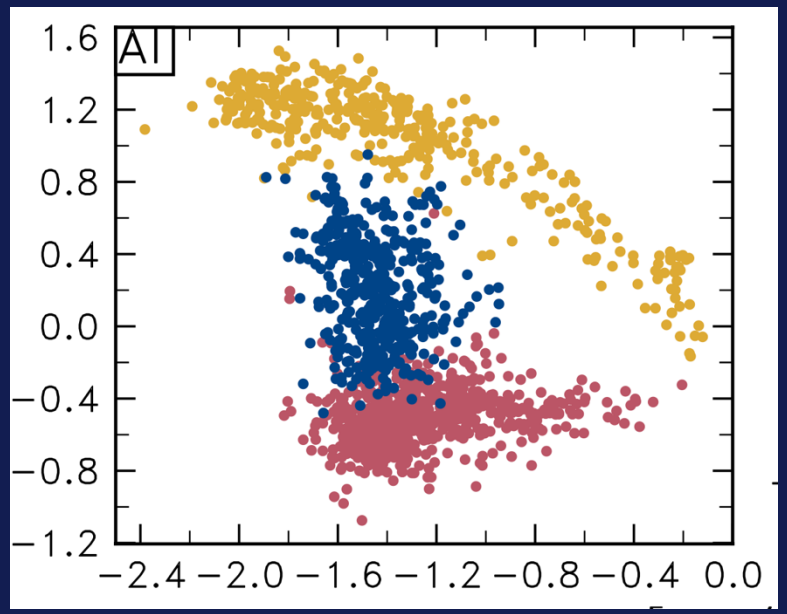
- Approx 10^8 $M_\odot$ in destroyed GCs within few kpc of MW centre
- Strongly concentrated
- Accreted or in situ?

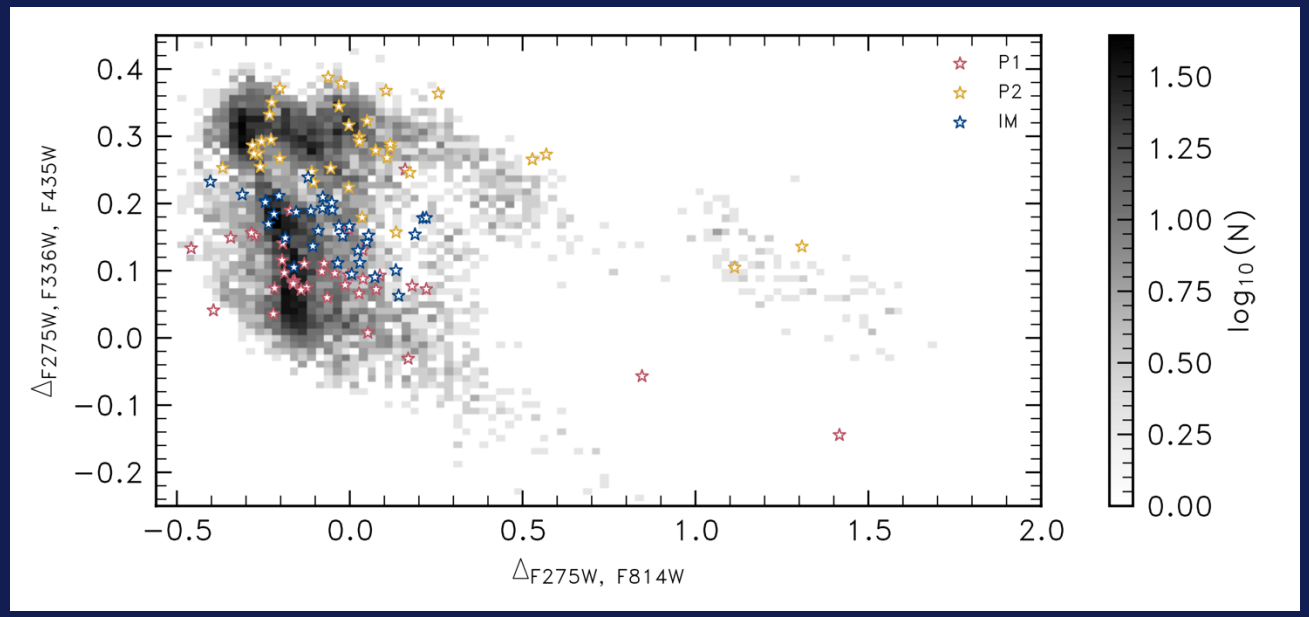
NUCLEAR STAR CLUSTERS

Mészáros+2021, Álvarez Garay+2024, Mason+2024

Mason+2024

APOGEE DR17



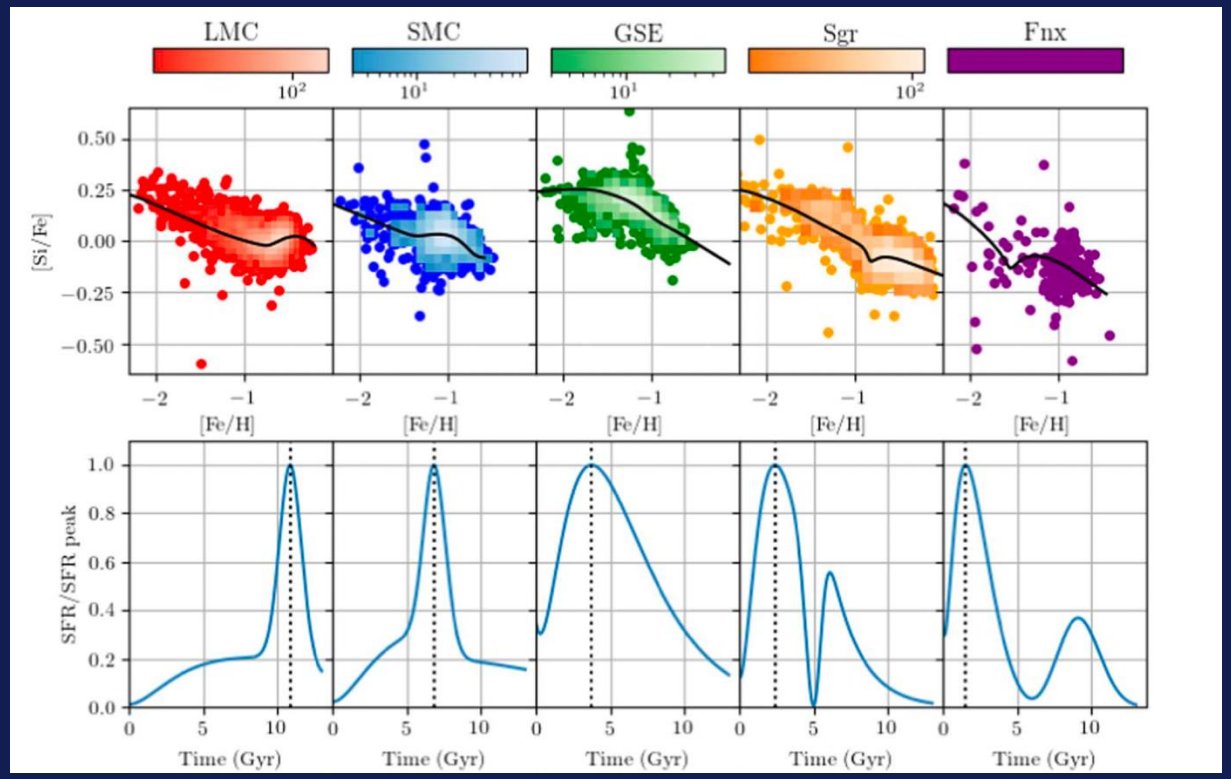


Cross-match with OmegaCAT (Nitschai+2023,Häberle+2024)

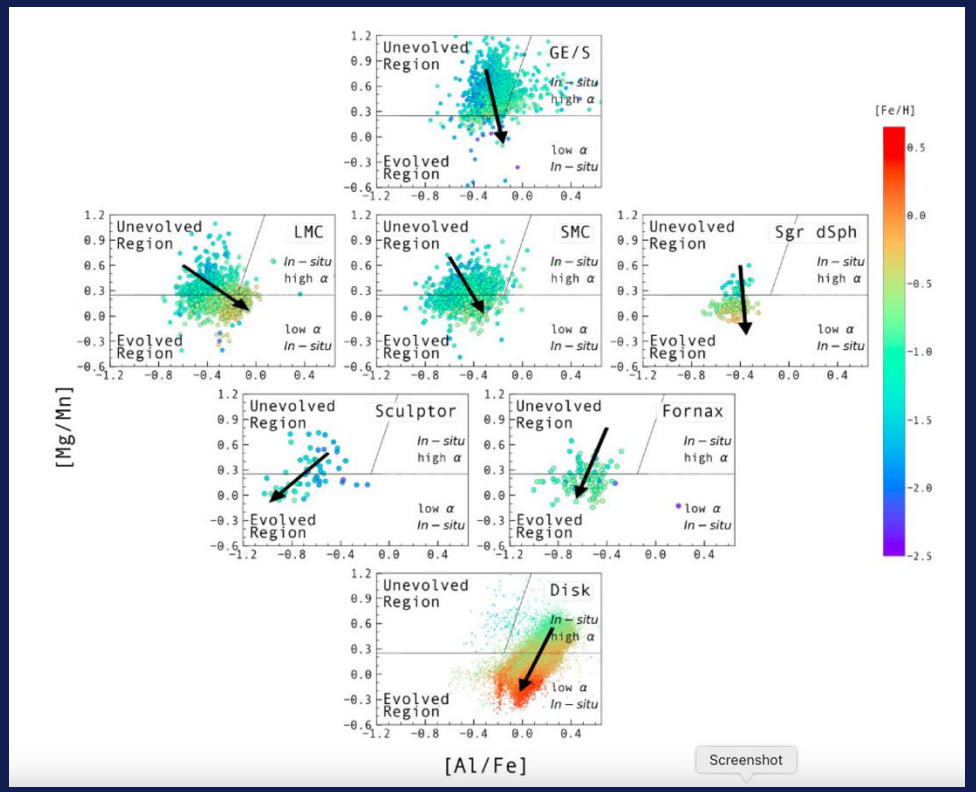
- History of star formation and chemical enrichment of NSCs
- Constraints on the MP phenomenon
- See also Michael O'Connor's poster on M54 (P48)

MILKY WAY SATELLITES

Hayes+2018,2020, Hasselquist+2021,2024,
Nidever+2020, Fernandes+2023



Hasselquist+2021

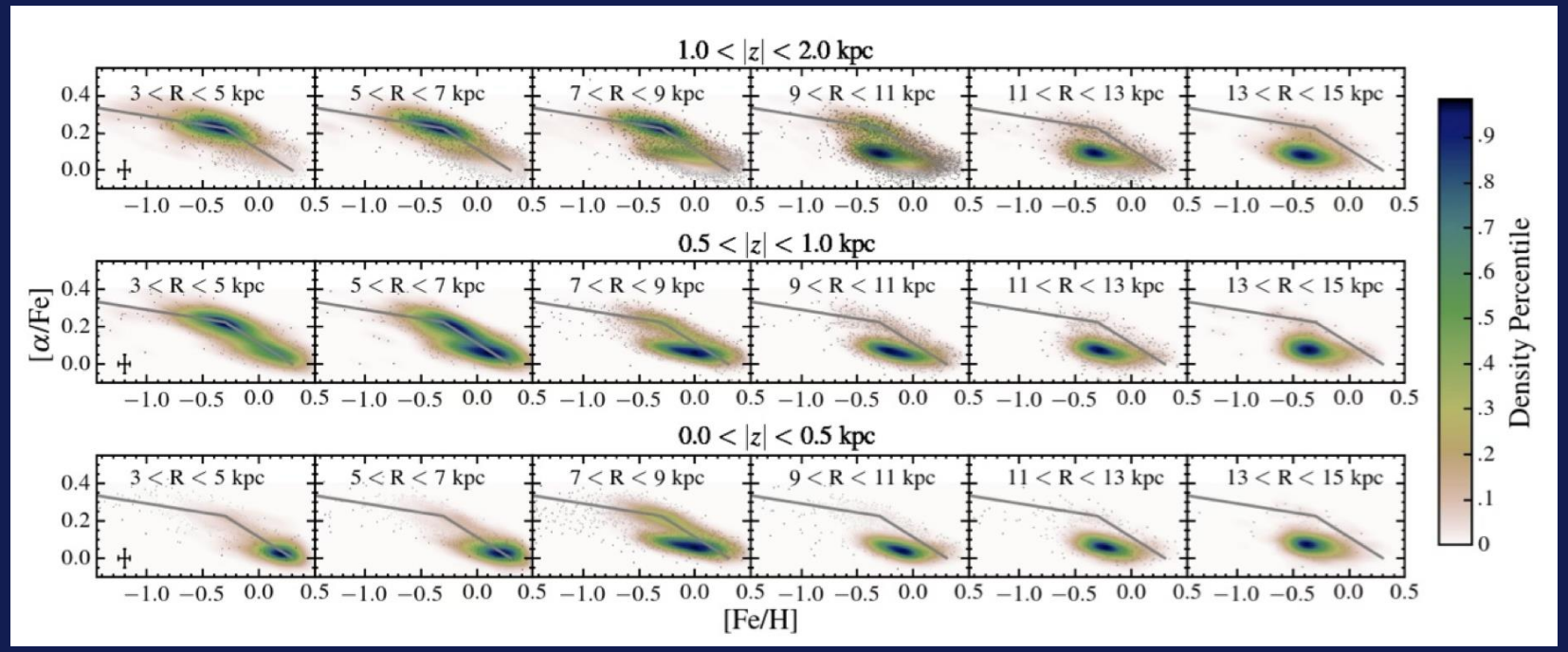


Fernandes+2023

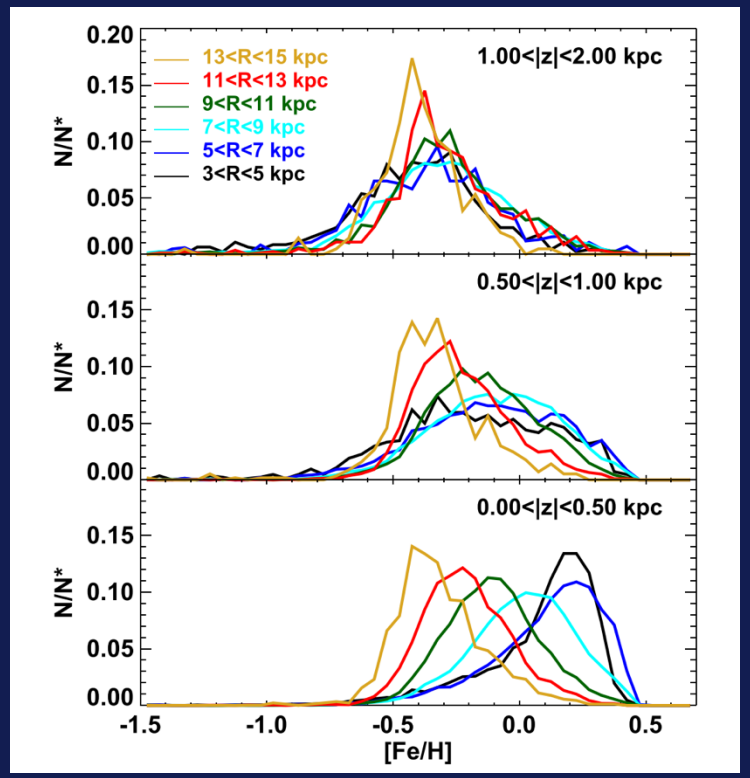
- Star formation histories of Milky Way satellites of all masses
- Dependence on mass and (possibly) environment

CHEMICAL CARTOGRAPHY OF THE DISK

Nidever+2014, Hayden+2015, Mackereth+2017, Weinberg+2019,2022



Hayden+2015

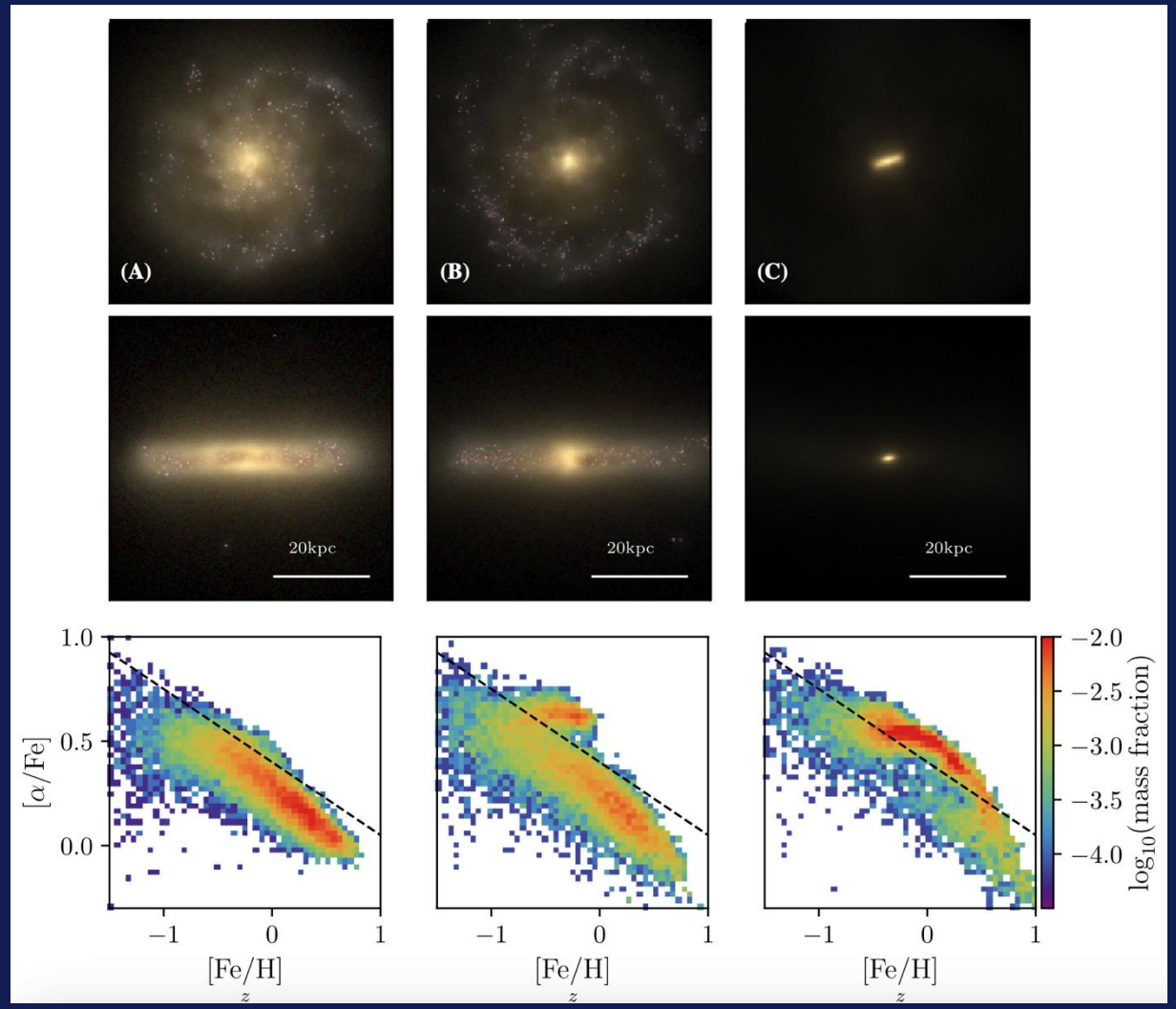


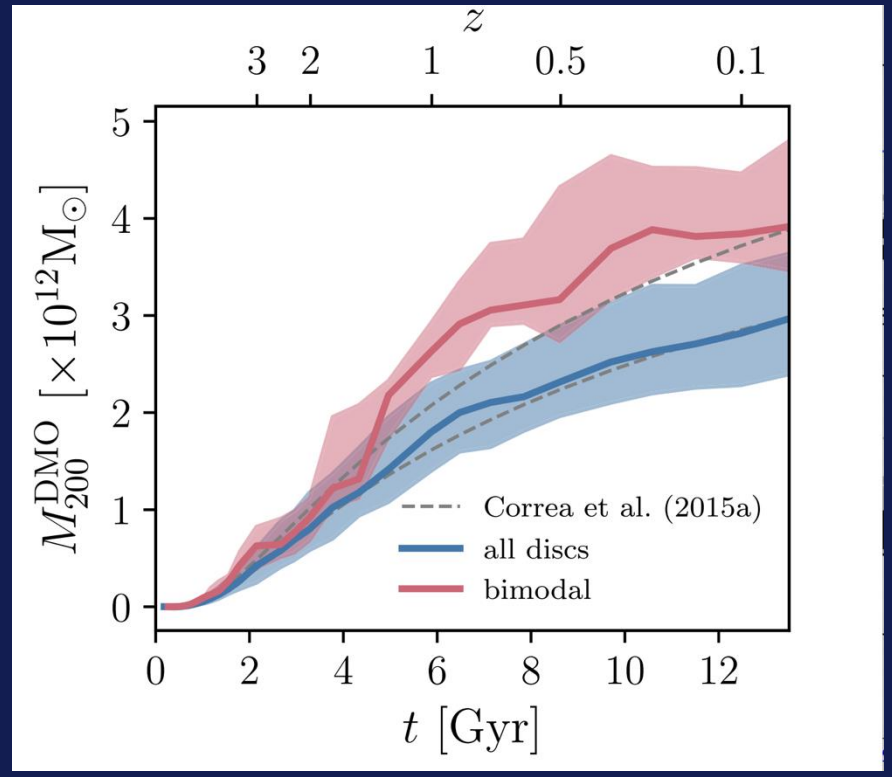
Hayden+2015

- The first large scale assessment of the detailed chemistry of the disk
- Radial mixing spotted?
- Is the Galaxy a common galaxy? (Mackereth+2018, Grand+2018, Clarke+2019, Buck+2021)

THE DISK ALPHA BIMODALITY IN COSMOLOGICAL SIMULATIONS

Mackereth+2018

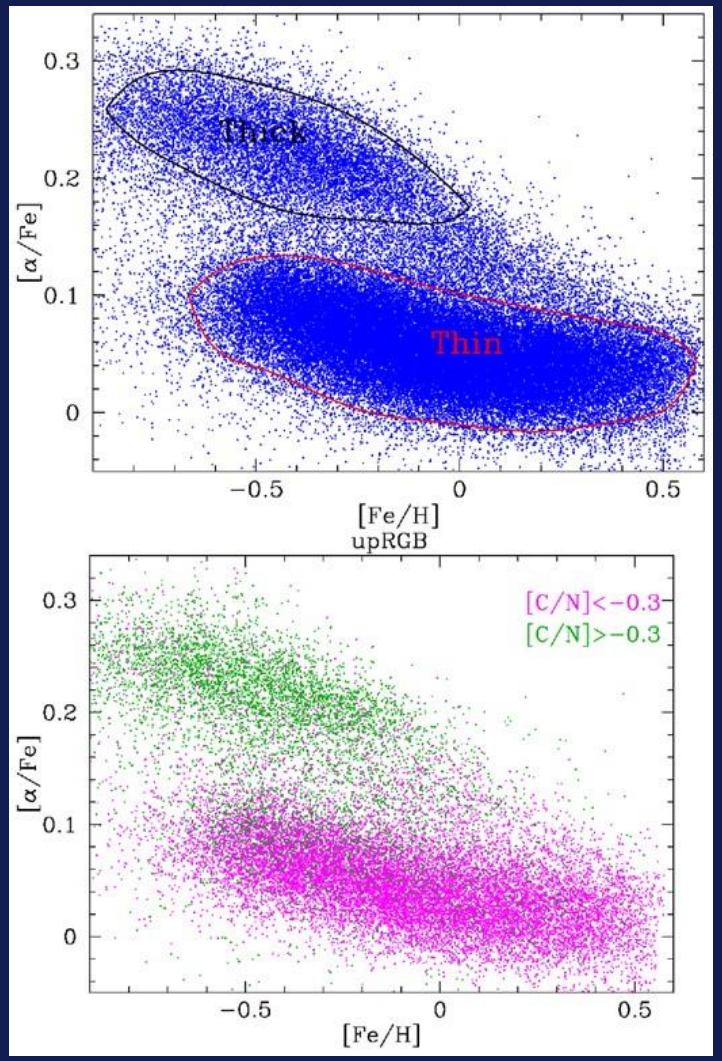




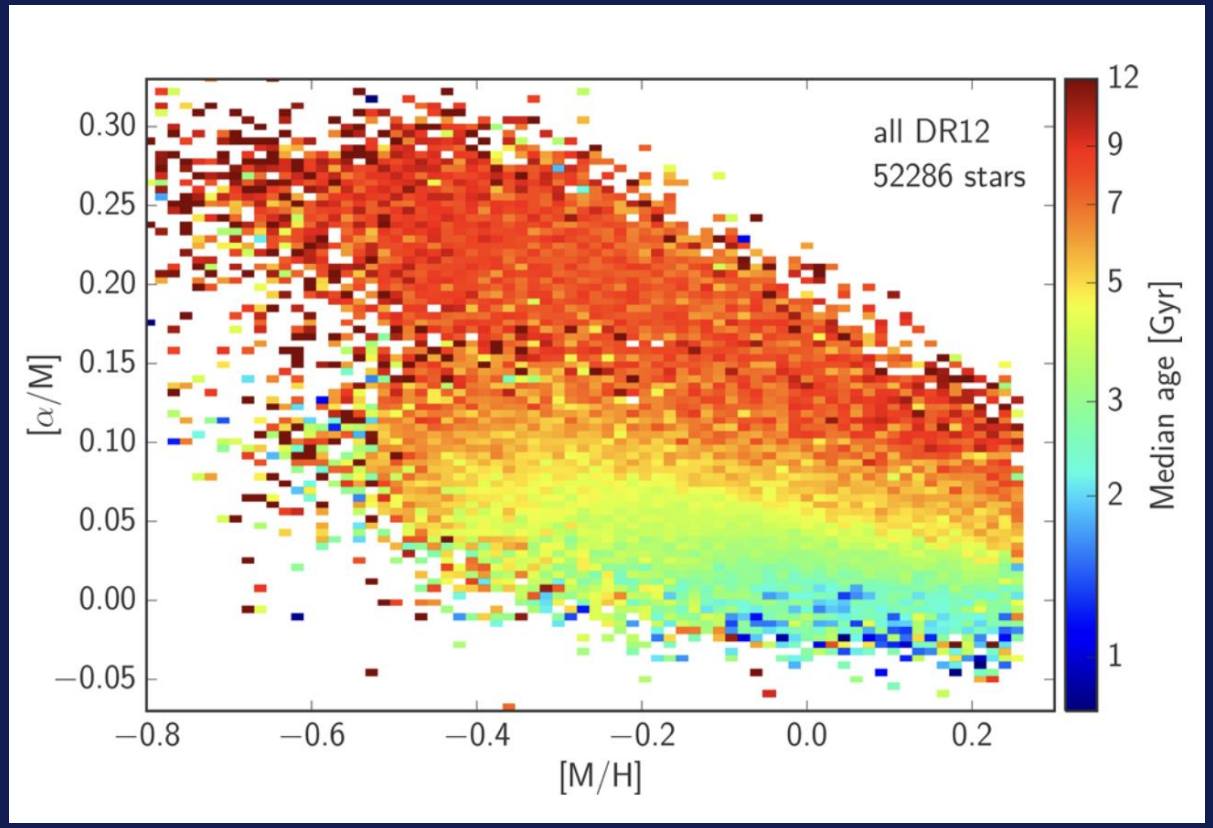
- Only 5% of MW-like galaxies have bimodality in EAGLE universe
- Bulk of accretion occurred early

STELLAR AGES

Masseron+Gilmore 2015 , Feuillet+2015, Martig+2016, Ness+2016, Schultheis+2017



Masseron+Gilmore 2015



Martig+2016

- Dependence of C/N on giant star mass
- Calibrated against Kepler/Corot asteroseismology

APOGEE SCIENCE IMPACT

From ADS, including only refereed articles

BARBUY SCIENCE IMPACT

Beatriz beats us!

LESSONS LEARNED

- Push the envelope: the NIR frontier, automatic abundance analysis
- "Simple Instrument": stable, single mode, no moving parts, made engineering, calibration, data reduction, simpler
- Target selection: focus on giants. Abundance pipeline simpler, results more homogeneous, higher precision
- Legacy nature: high S/N, high resolution spectra have lots of information. Can be extracted with improved future tools
- Always ask: do I need this much data? Are the data good enough?
- Empower the young: ECRs in leading roles, both technical and scientific