

THE ORIGINAL COMPOSITION OF THE GAS FORMING FIRST-POPULATION STARS IN GLOBULAR CLUSTERS

MARIA VITTORIA LEGNARDI

Dipartimento di Fisica e Astronomia 'G. Galilei', Università Di Padova



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

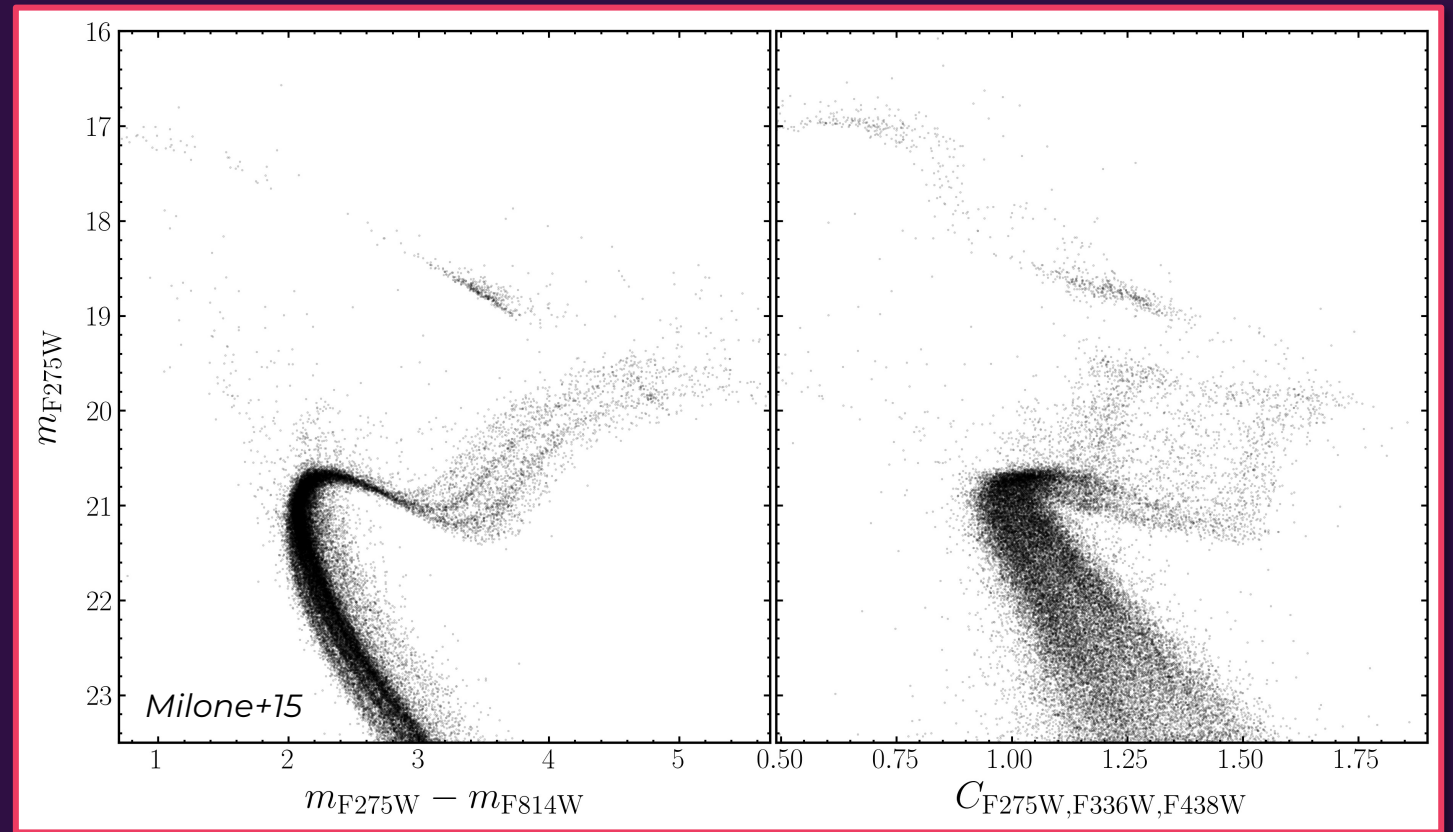
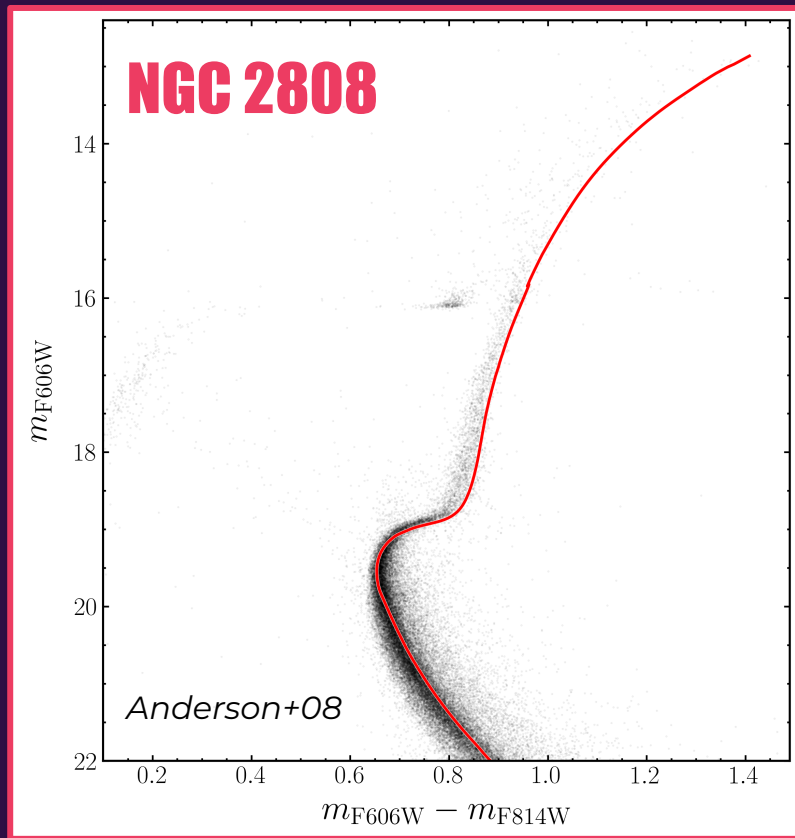
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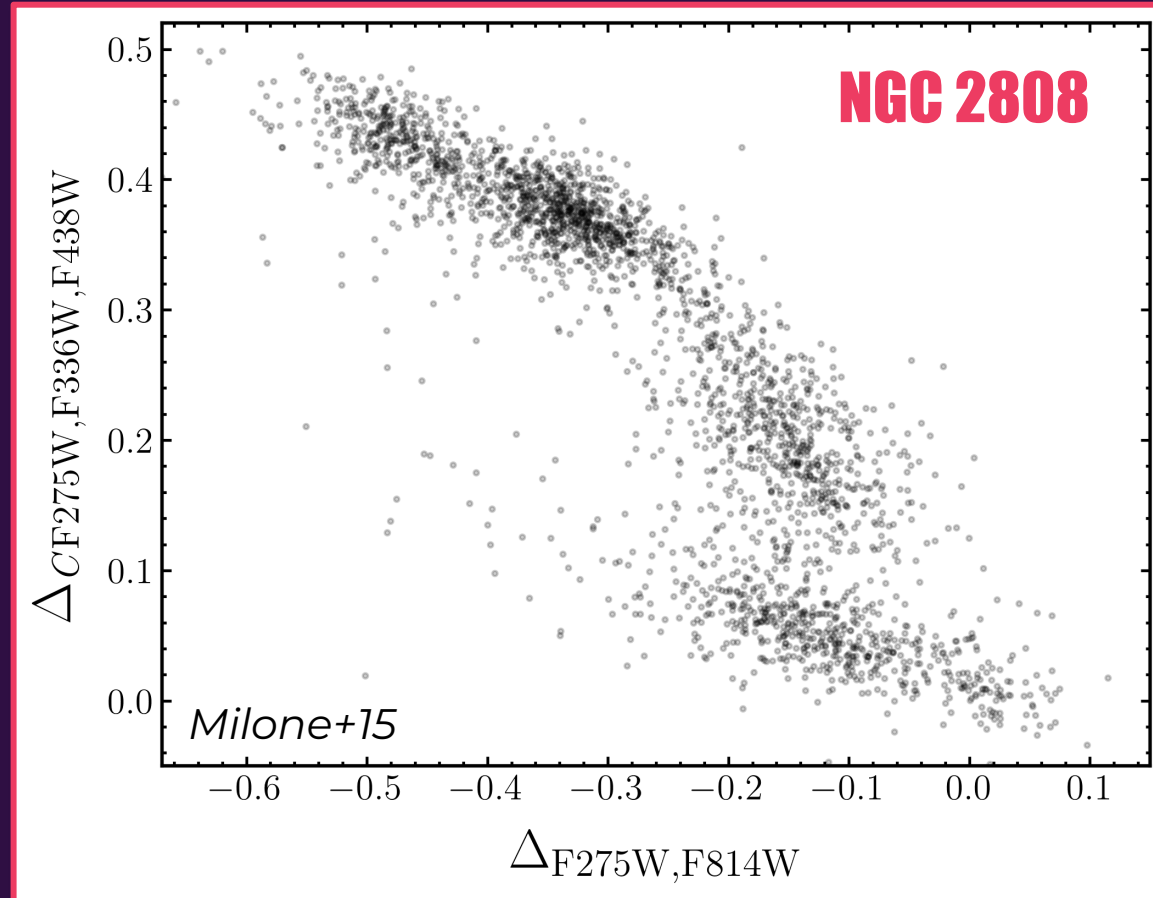
THE ORIGINAL COMPOSITION OF PRIMORDIAL CLOUDS



MULTIPLE STELLAR POPULATIONS IN GLOBULAR CLUSTERS



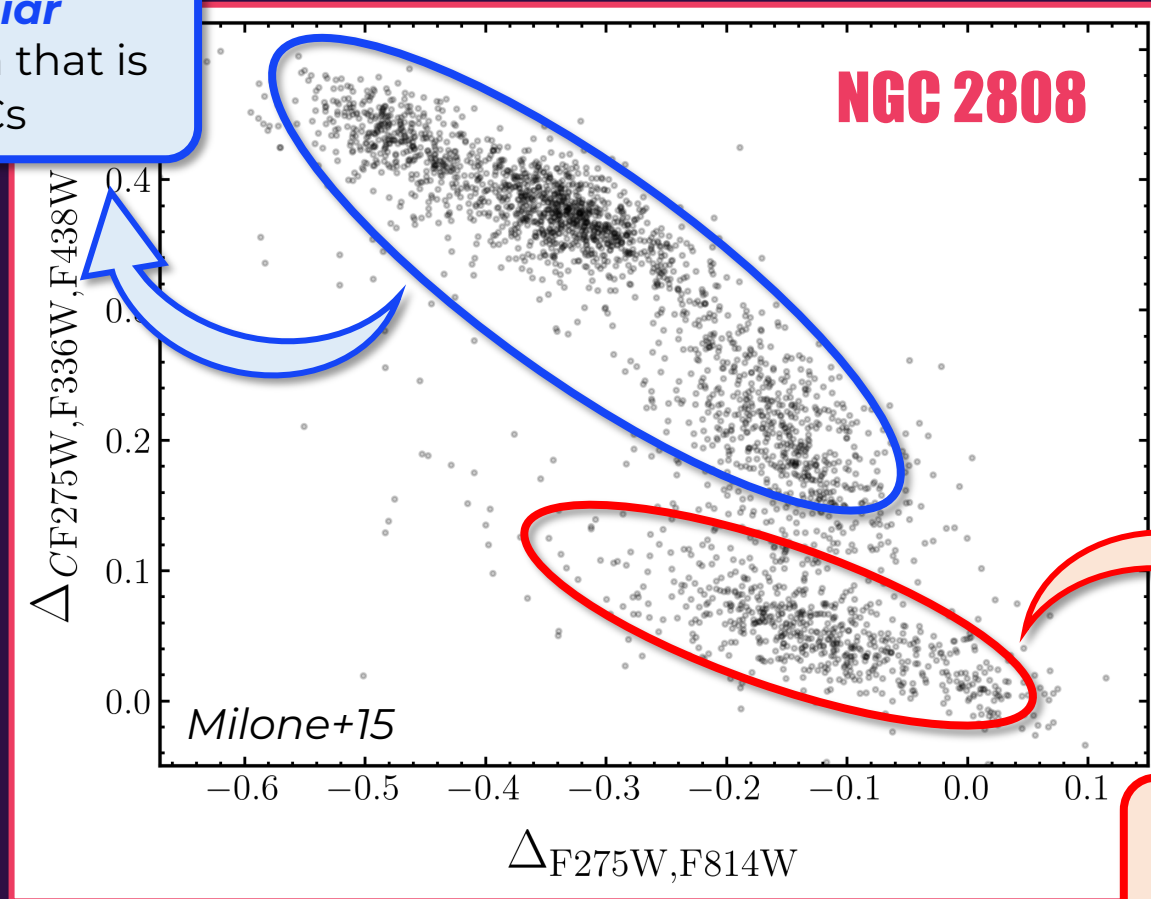
THE CHROMOSOME MAP OF GLOBULAR CLUSTERS



THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

SECOND POPULATION (2P)

Stars with a **peculiar** chemical composition that is found only in GCs



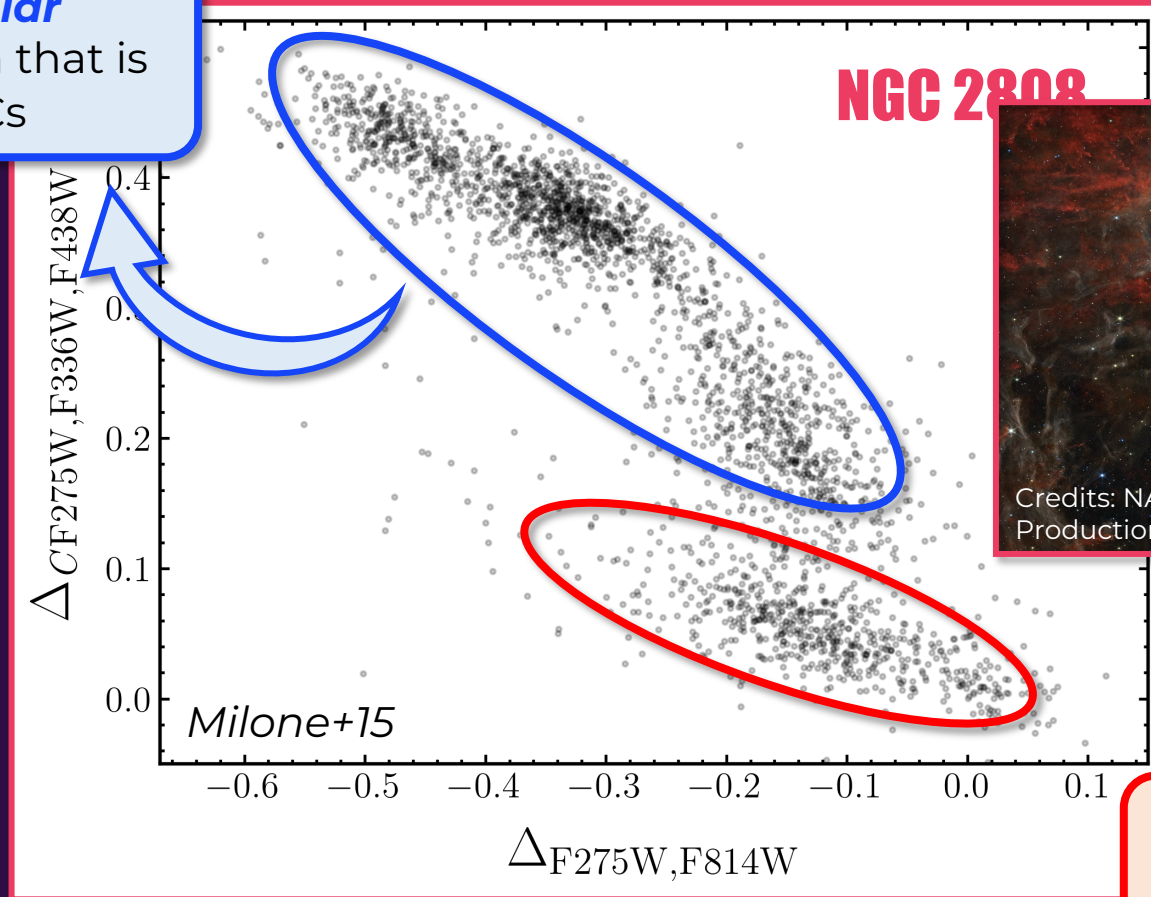
FIRST POPULATION (1P)

Stars with the **'original'** chemical composition of the GC natal cloud

THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

SECOND POPULATION (2P)

Stars with a **peculiar** chemical composition that is found only in GCs



FIRST POPULATION (1P)

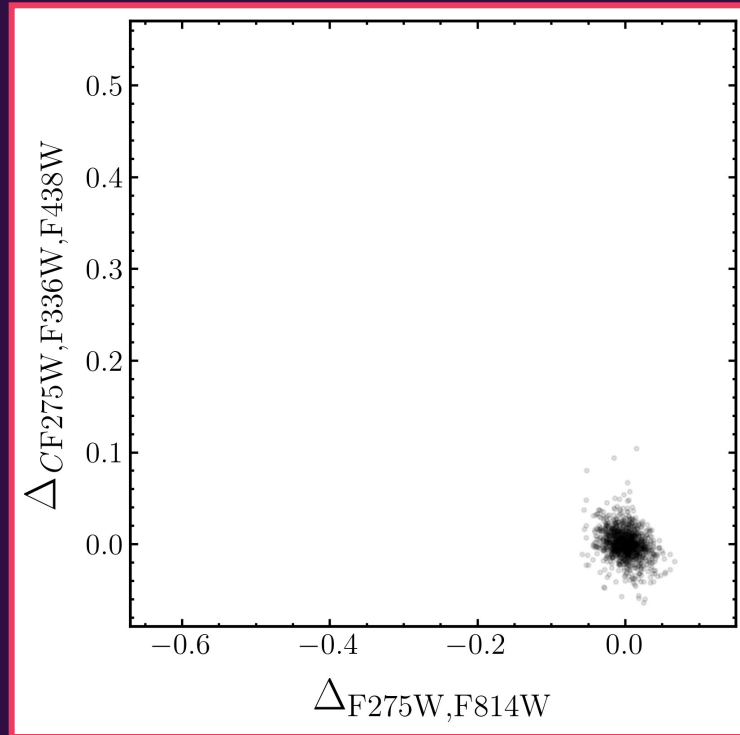
Stars with the **'original'** chemical composition of the GC natal cloud

THE EXTENDED 1P SEQUENCE

1P stars are **not** consistent with a **simple stellar population** as they exhibit extended or bimodal sequences in the ChM

THE EXTENDED 1P SEQUENCE

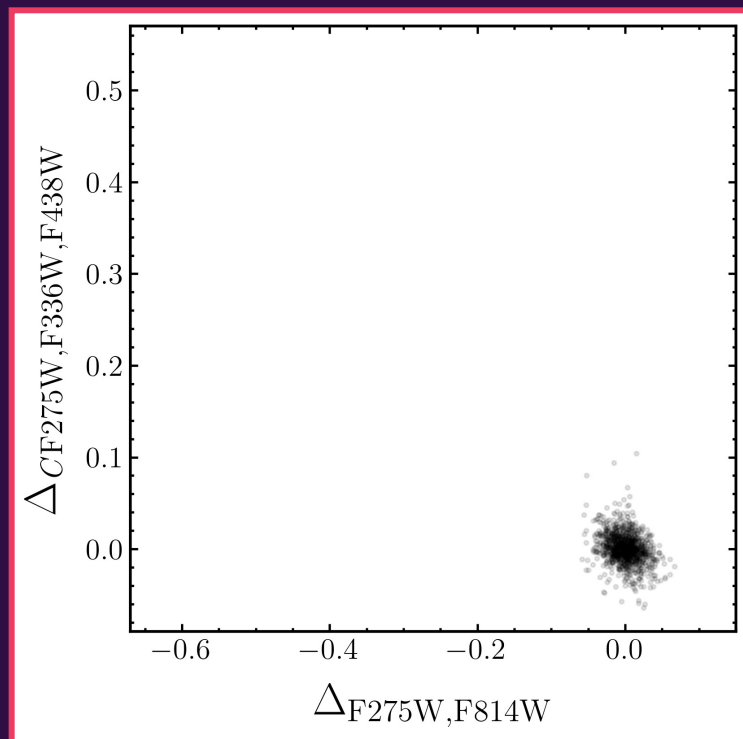
EXPECTATIONS...



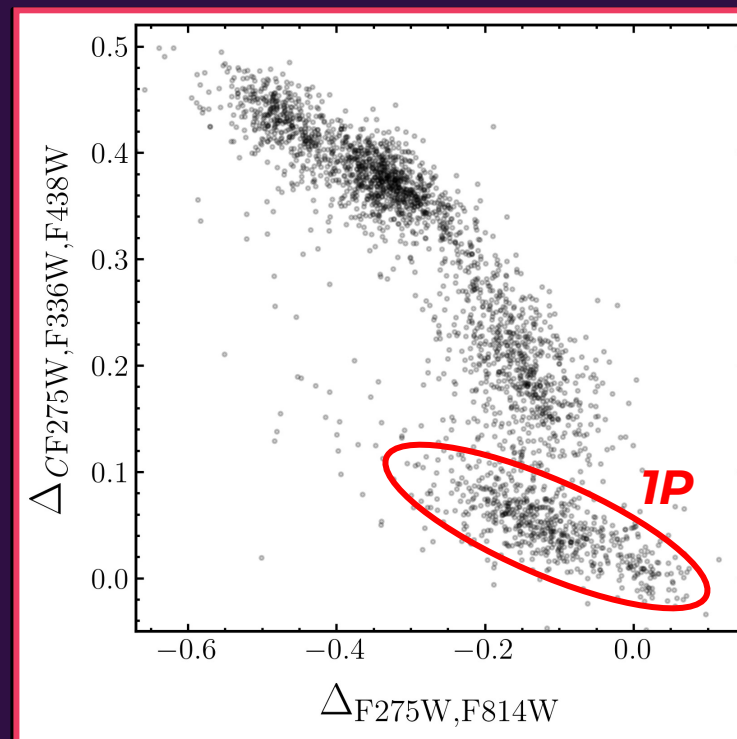
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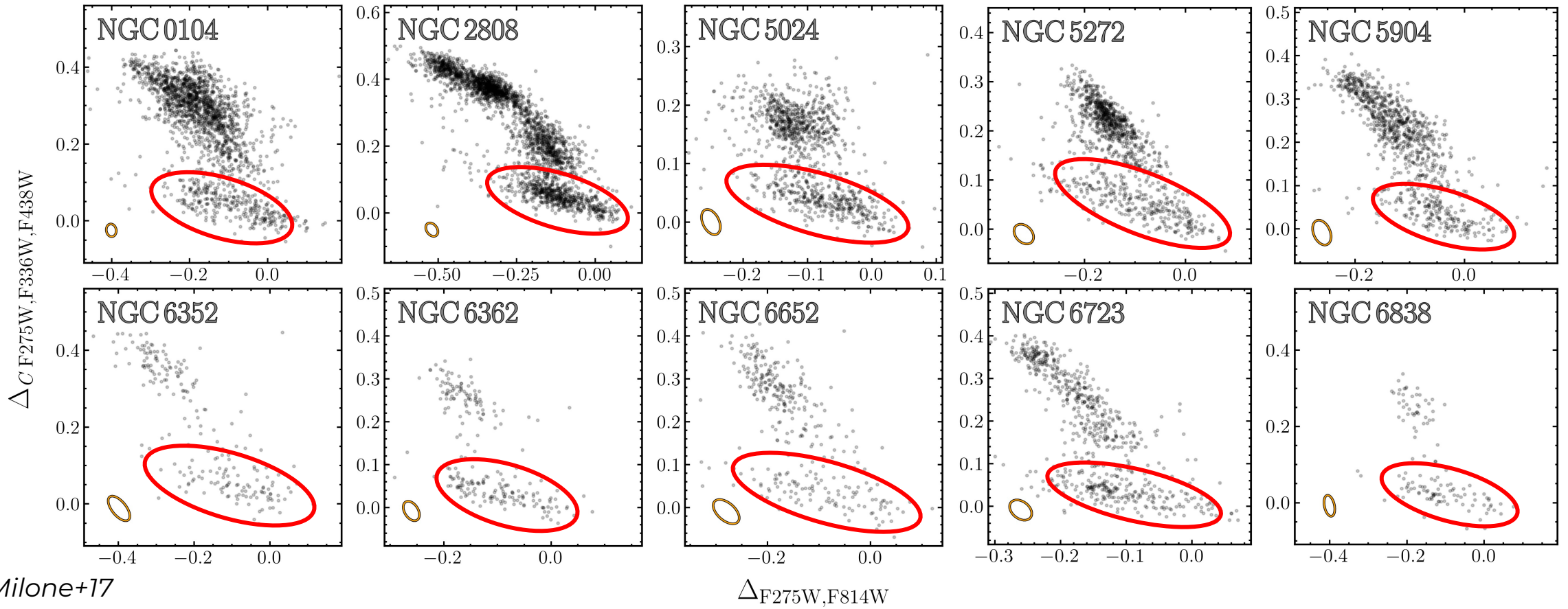


...REALITY!



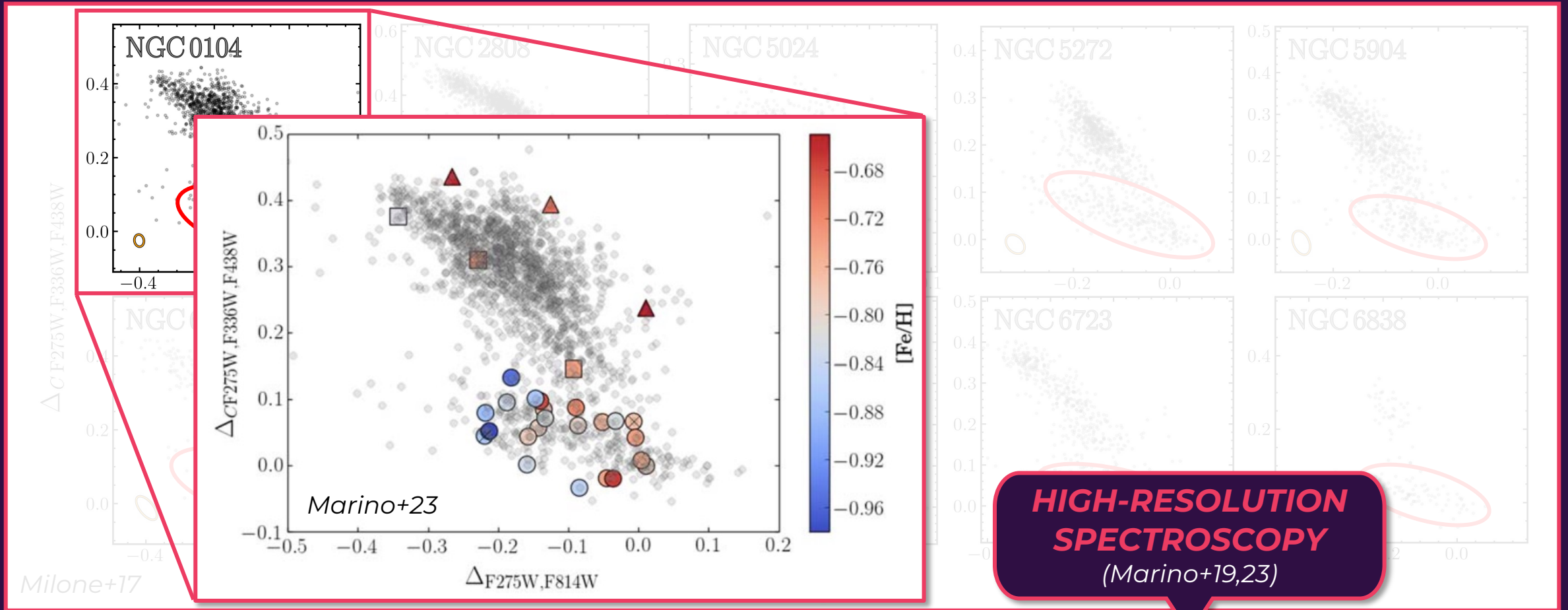
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THE EXTENDED 1P SEQUENCE



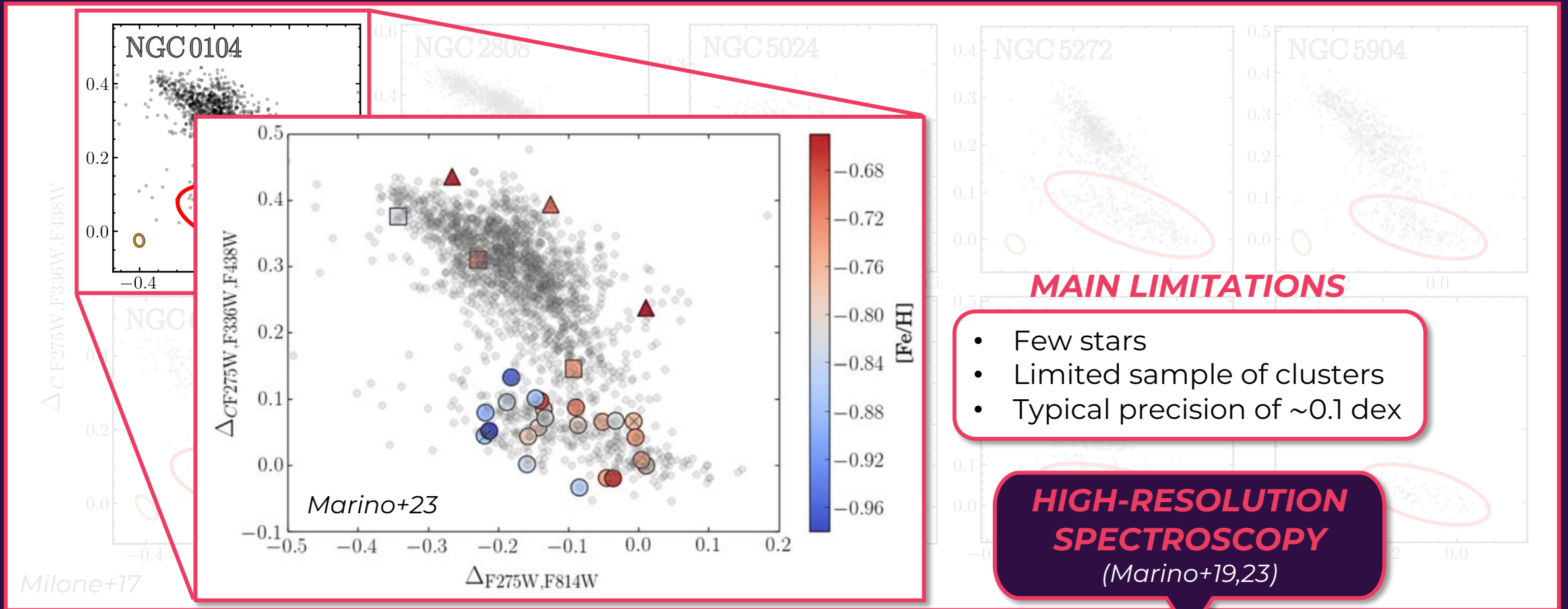
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THE EXTENDED 1P SEQUENCE



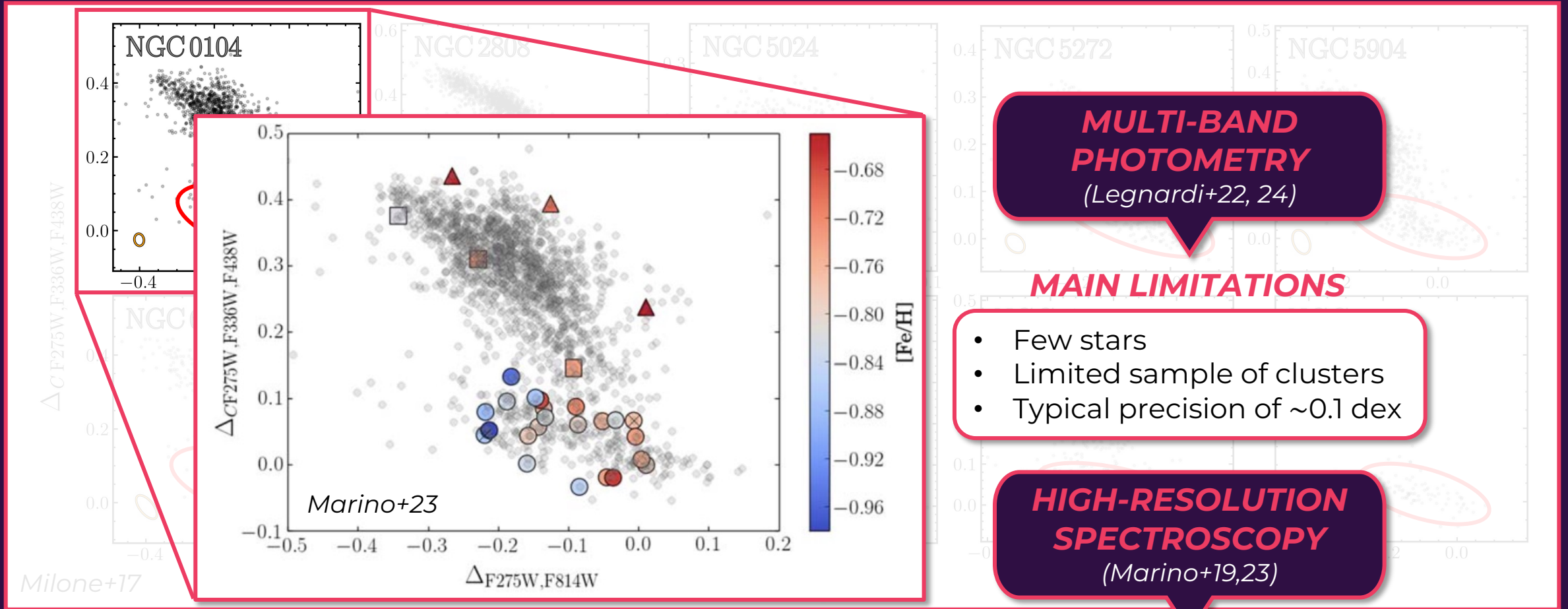
The extended 1P sequence is associated with **metallicity variations** inherited from the pristine material out of which they formed

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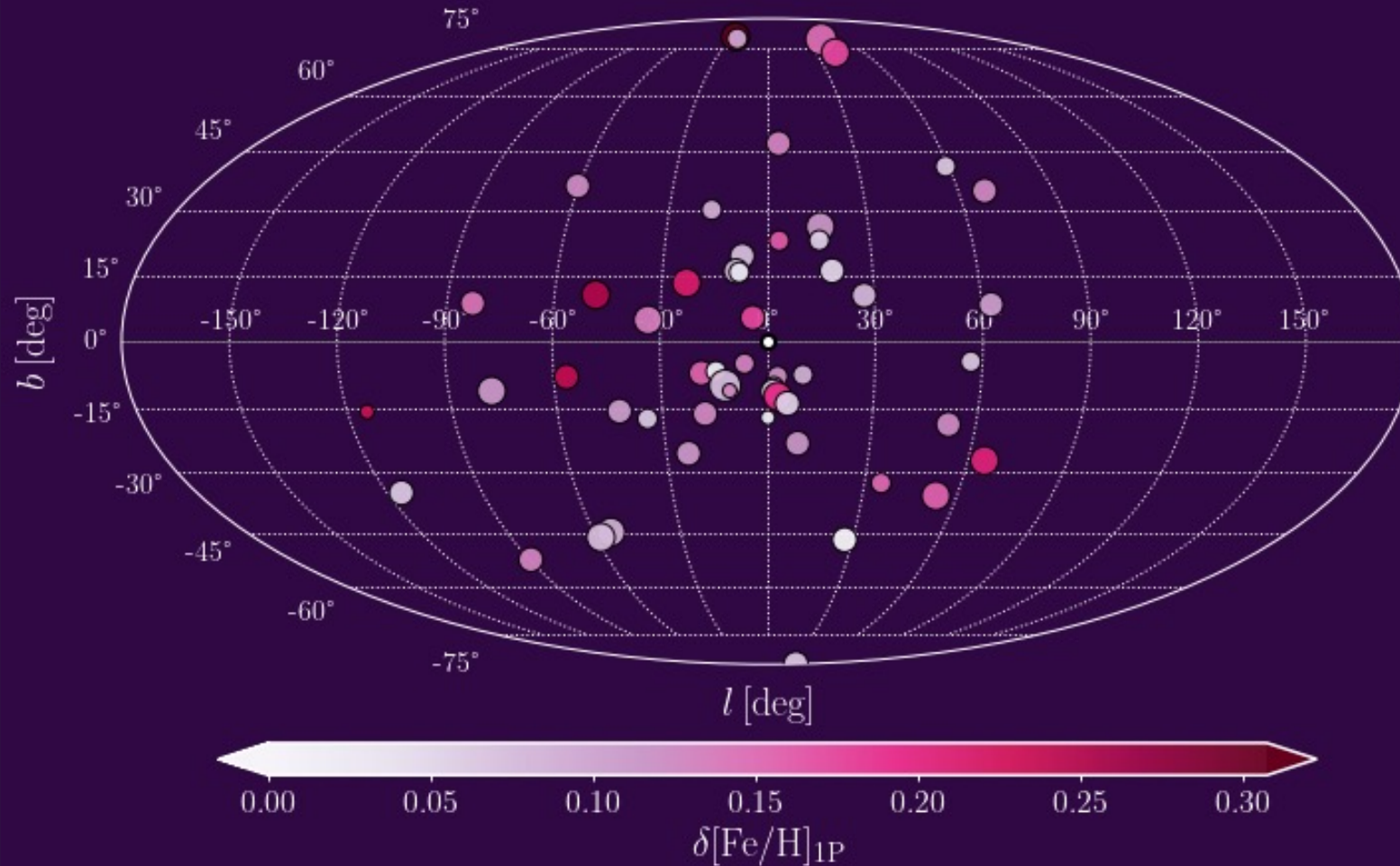


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THE ORIGINAL COMPOSITION OF GC NATAL CLOUDS



Results based on Legnardi+22

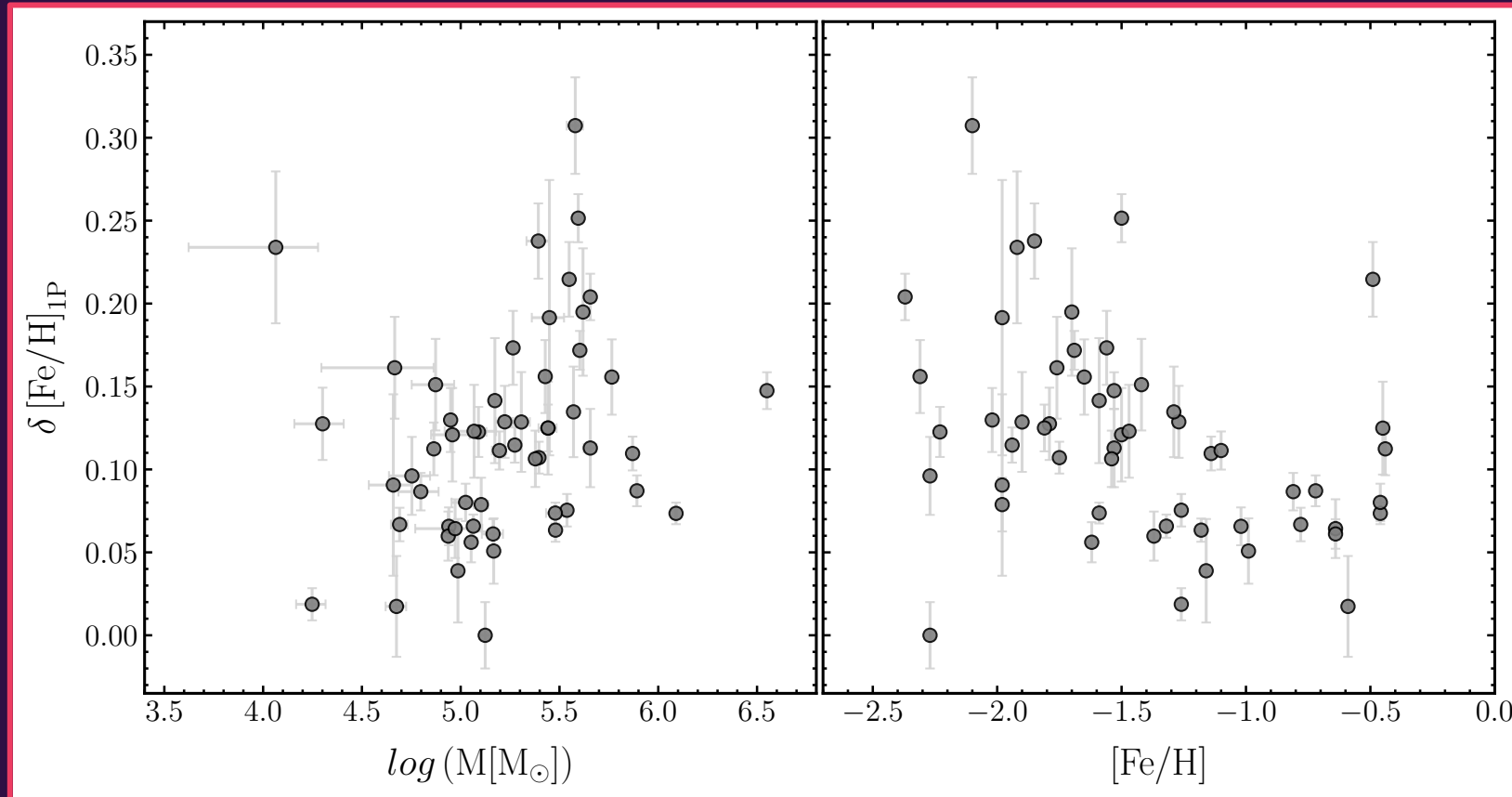


The analysis of ChMs in a large sample of **55 Galactic GCs** demonstrates that $[\text{Fe}/\text{H}]$ variations exhibit a **high level of variability** within the Galaxy

THE ORIGINAL COMPOSITION OF GC NATAL CLOUDS



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The analysis of ChMs in a large sample of **55 Galactic GCs** demonstrates that $[\text{Fe}/\text{H}]$ variations correlate with **cluster mass** and **metallicity**

THE ORIGINAL COMPOSITION OF GC NATAL CLOUDS

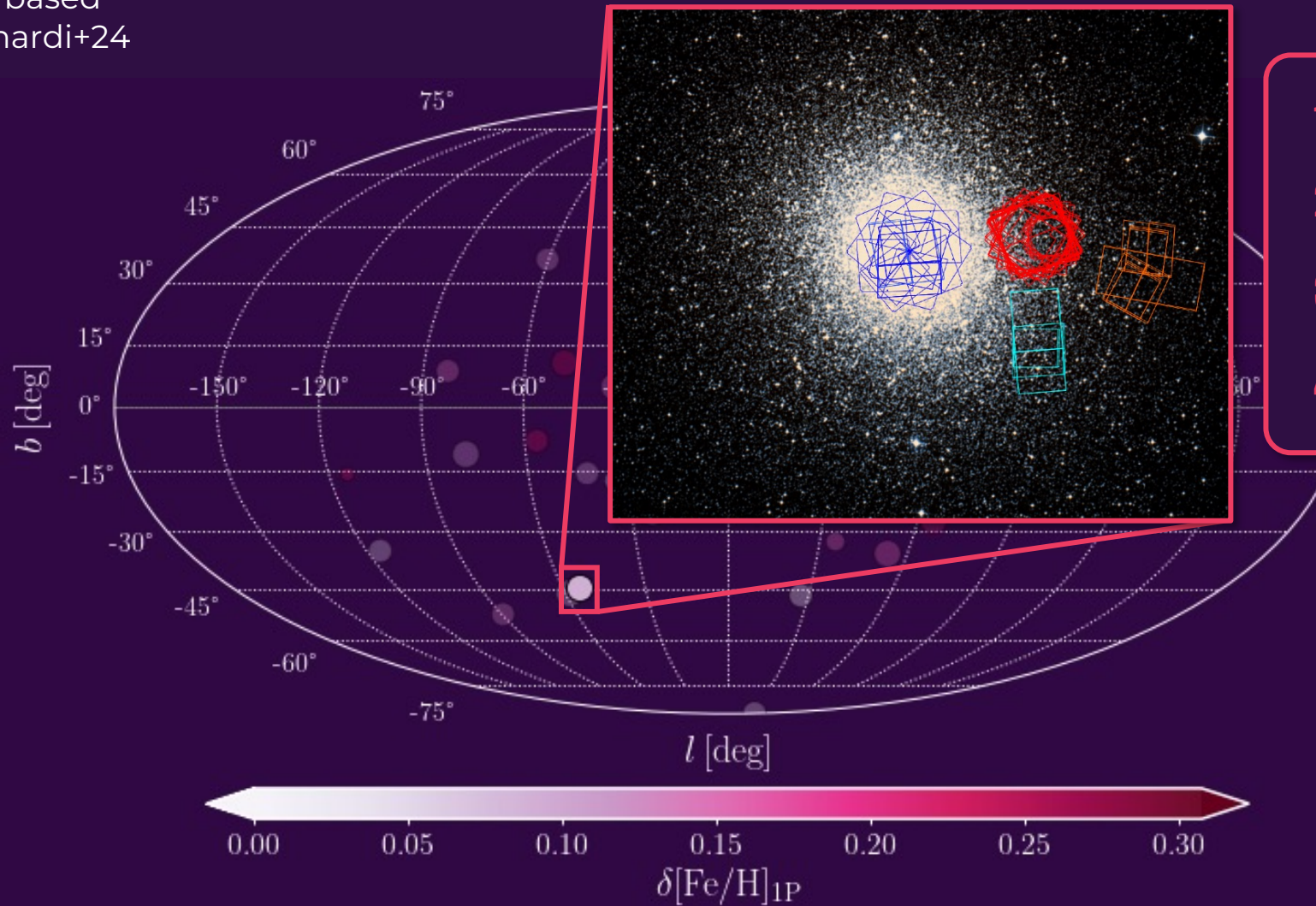


**WHAT ABOUT 1G METALLICITY
VARIATIONS IN THE OUTSKIRTS OF GCs?**

The metal content of 1G stars has been examined in the **central regions** of **old** Galactic GCs with **multiple stellar populations**

AN IN-DEPTH ANALYSIS OF 1P STARS IN 47 TUCANAE

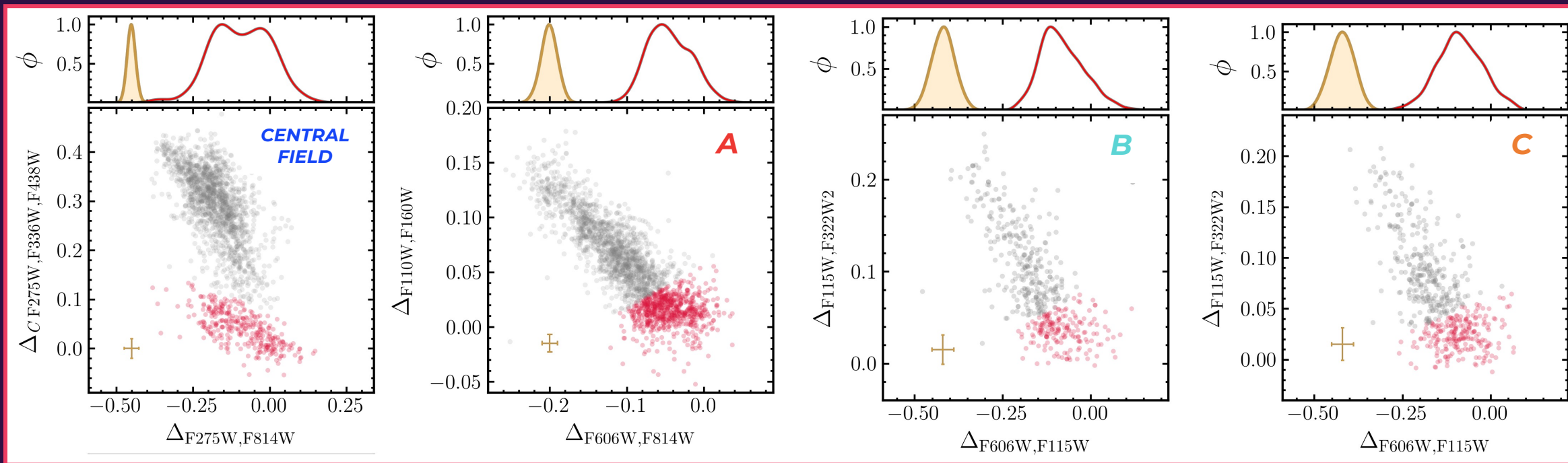
Results based
on Legnardi+24



- 1. CENTRAL FIELD**
- 2. FIELD A** (~ 7 arcmin)
- 3. FIELD B** (~ 8.5 arcmin)
- 4. FIELD C** (~ 11 arcmin)

AN IN-DEPTH ANALYSIS OF 1P STARS IN 47 TUCANAE

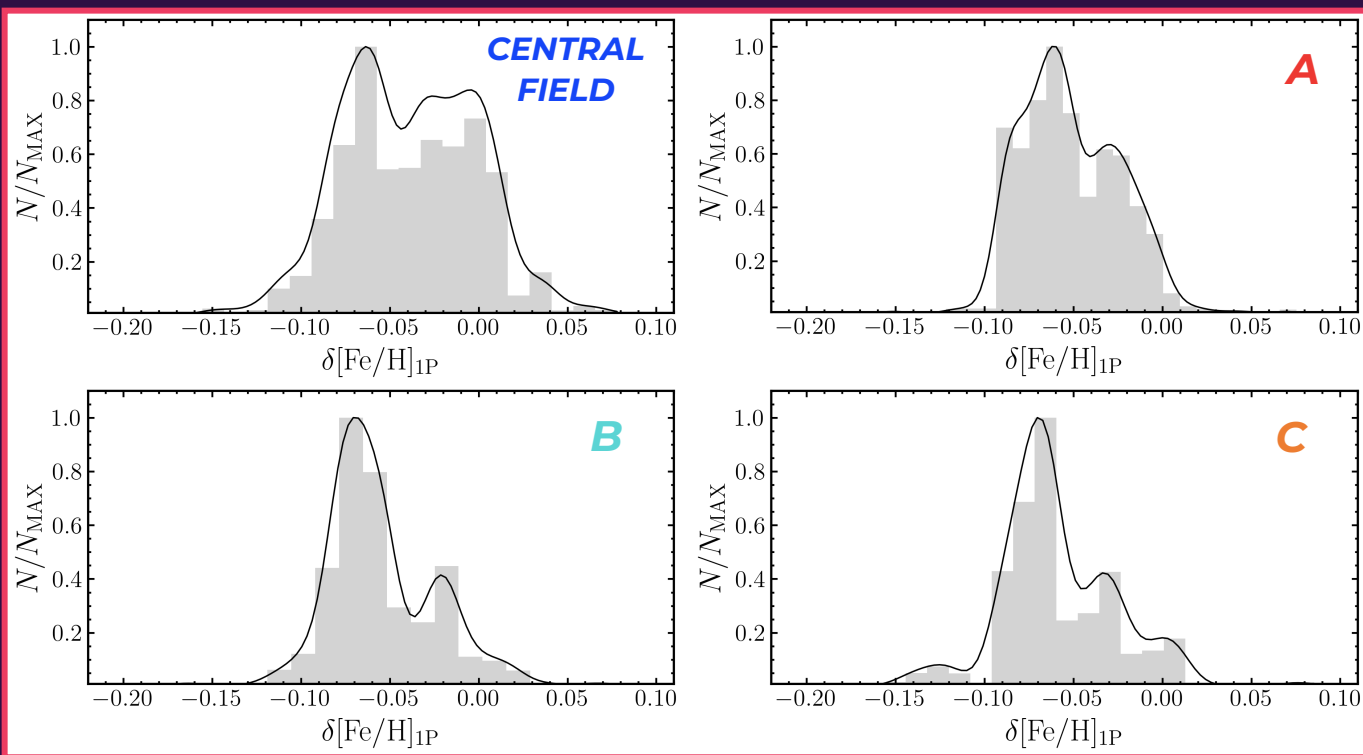
Results based
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In all ChMs, 1P stars define an **extended** sequence in the direction of the x-axis, which is associated with **metallicity variations** within the primordial cloud

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Metallicity distributions

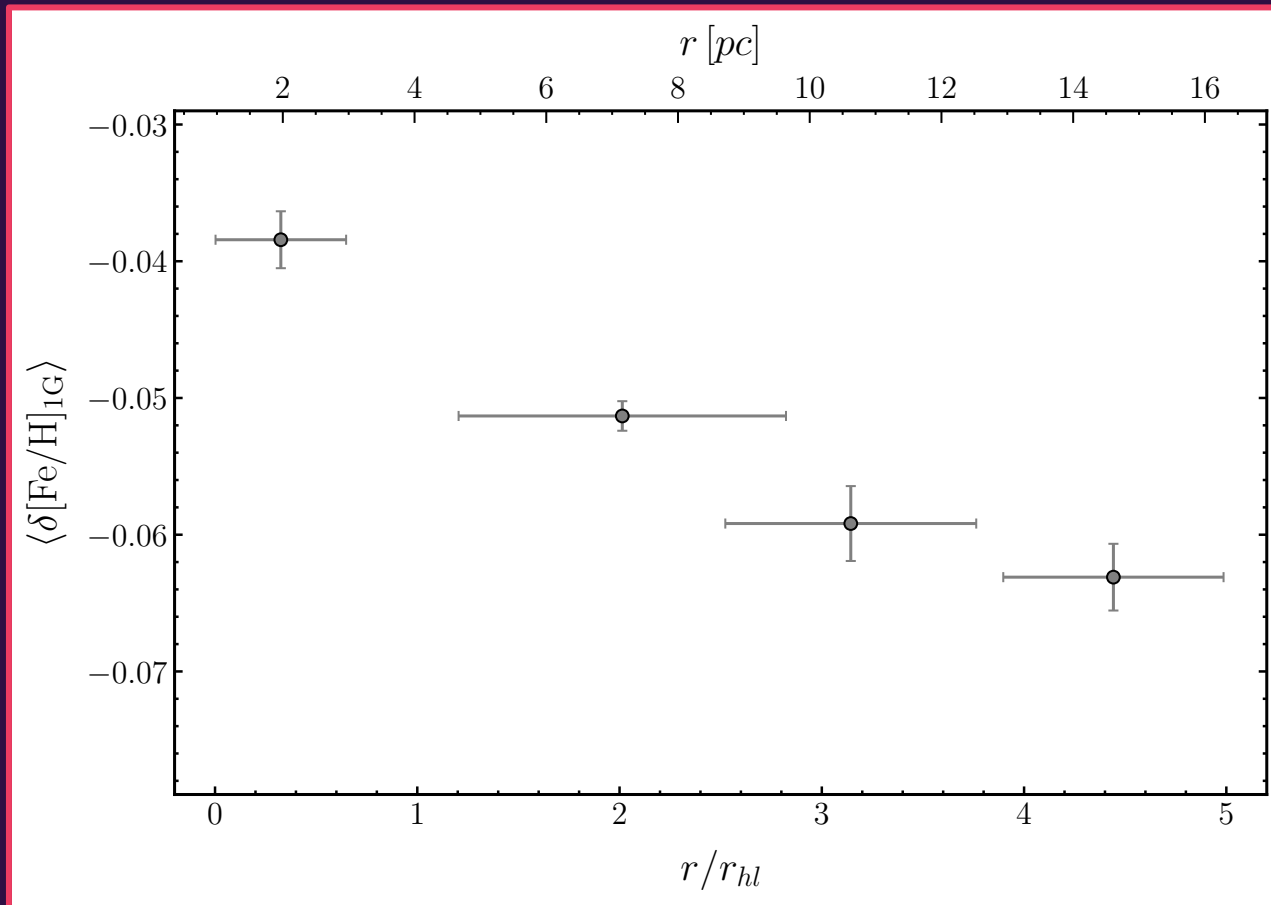
The $[\text{Fe}/\text{H}]$ distributions span similar intervals of ~ 0.1 dex, ranging from ~ -0.15 to ~ 0.05

Radial distribution

The innermost cluster regions show higher spreads in metallicity than the outer fields

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*ARE THE 1G METALLICITY SPREADS
EXCLUSIVE TO OLD GALACTIC GCs WITH
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The metal content of 1G stars has been examined in the **central regions** of **old** Galactic GCs with **multiple stellar populations**

THE ORIGINAL COMPOSITION OF GC NATAL CLOUDS



**ARE THE 1G METALLICITY SPREADS
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NGC 6791



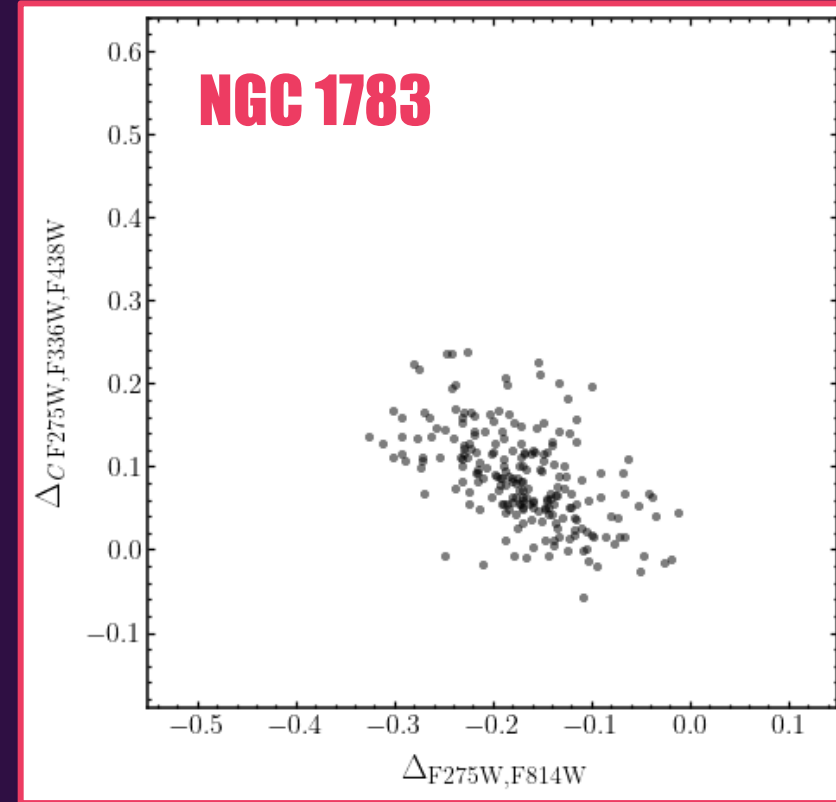
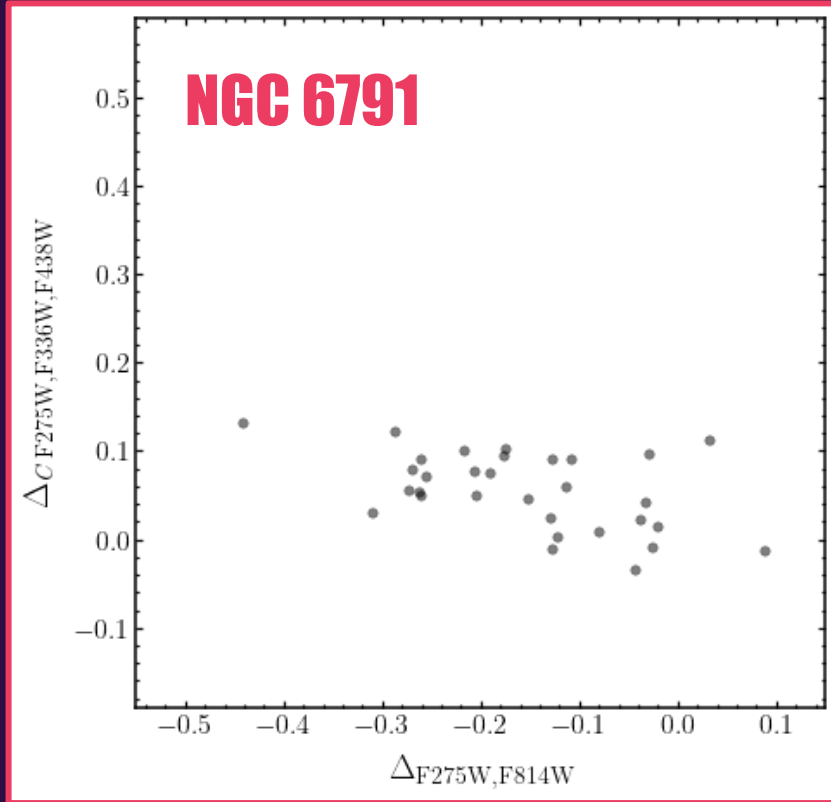
NGC 1783

The metal content of 1G stars has been examined in the **central regions** of **old** Galactic GCs with **multiple stellar populations**



SIMPLE POPULATION CLUSTERS: NGC 6791 AND NGC 1783

Results based
on Legnardi+24

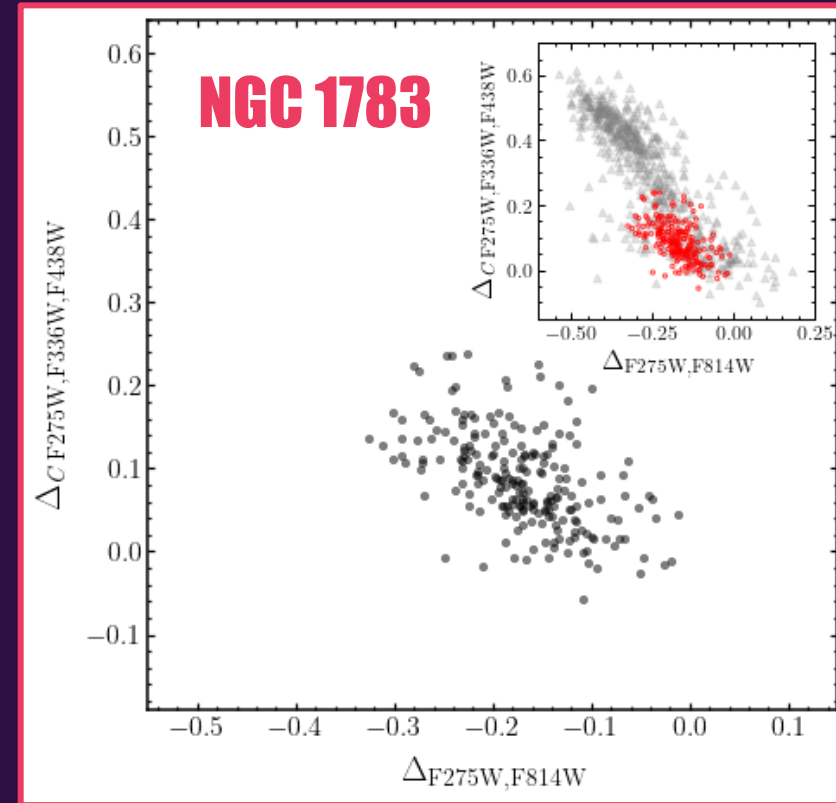
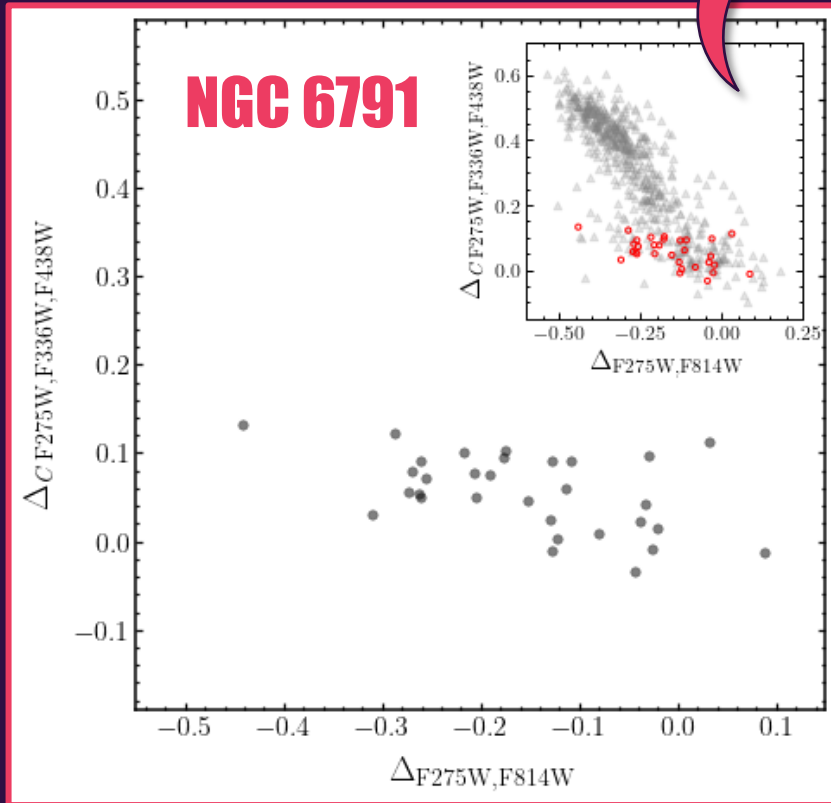


The ChMs of both clusters display **one sequence** of stars, resembling the 1G sequence of GCs with multiple populations

SIMPLE POPULATION CLUSTERS: NGC 6791 AND NGC 1783

Results based
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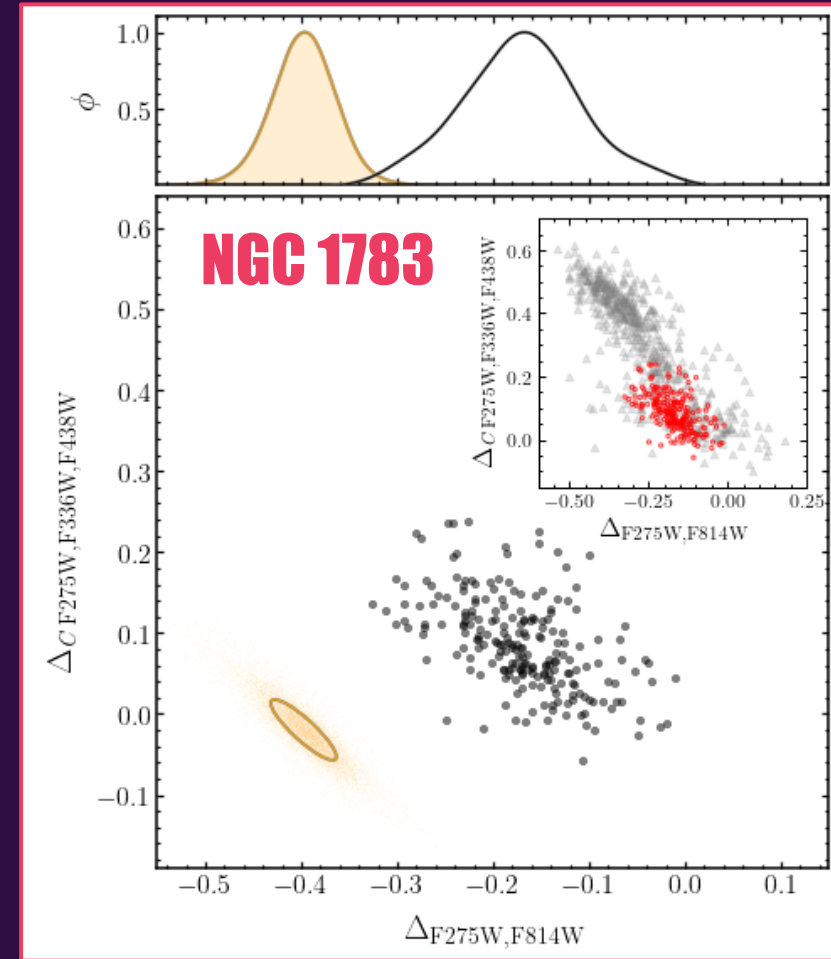
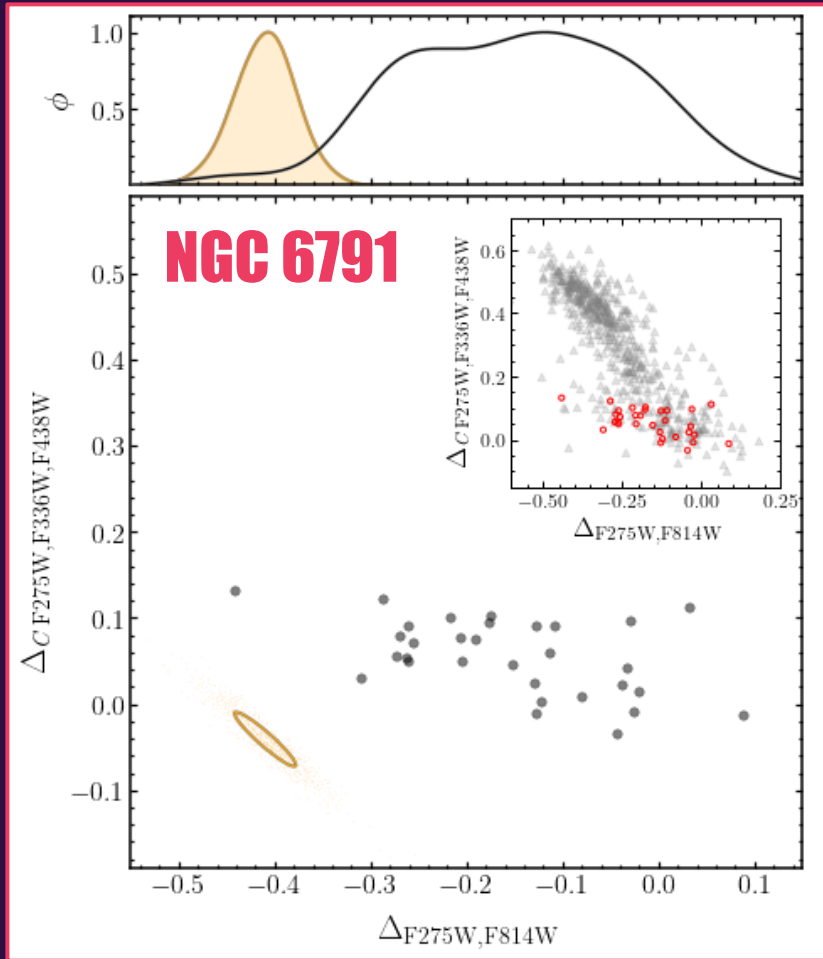
NGC 6624: GC with \sim [Fe/H]



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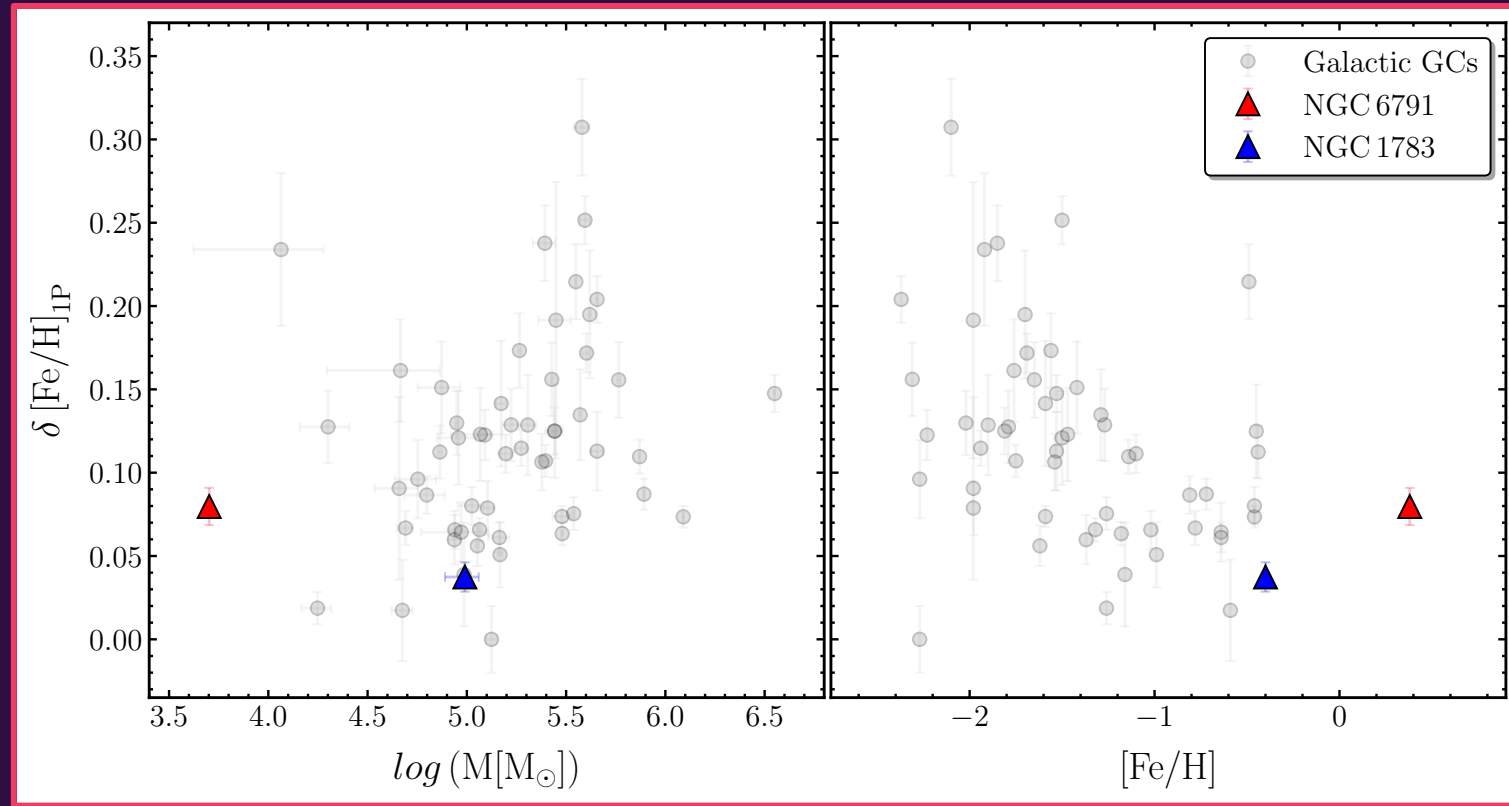
SIMPLE POPULATION CLUSTERS: NGC 6791 AND NGC 1783

Results based
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SIMPLE POPULATION CLUSTERS: NGC 6791 AND NGC 1783

Results based
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Metallicity variations of NGC 6791 and NGC 1783
are **comparable** to those observed in **metal-rich GCs** with **similar masses**

GALACTIC GCs

- The ChM analysis of **55 Galactic GCs** revealed **metallicity spreads** in the formation gas of TP stars.
- Metallicity variations are **highly variable** within the Galaxy, ranging from ~ 0.00 to ~ 0.30 dex.
- Metallicity variations correlate with cluster **mass** and **metallicity**.

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47 TUCANAE

- **Full characterization** of metallicity spreads within the original **star-forming cloud**.
- The cluster center shows **higher** metallicity spreads than the outer regions.
- Self-enrichment?

SIMPLE-POPULATION CLUSTERS

- Extended sequences in the ChM are **not prerogatives** of Galactic GCs with multiple populations.
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47 TUCANAE

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MORE DETAILS

1. **Legnardi et al. 2022**, MNRAS, 513, 735
2. **Legnardi et al. 2024**, A&A, 687, A160

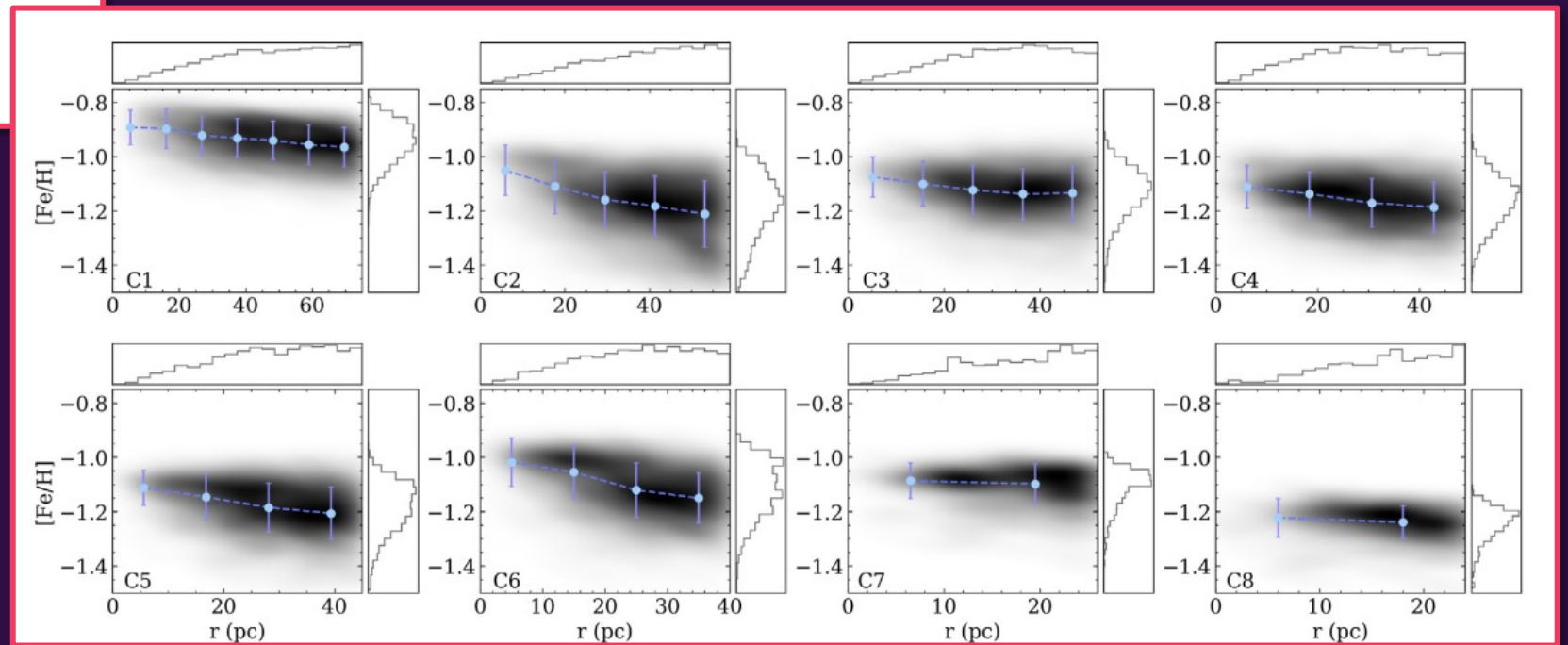
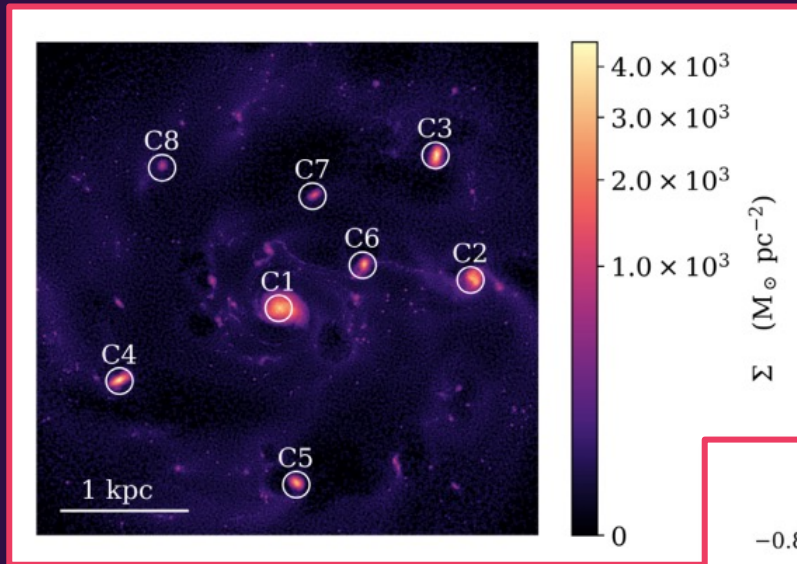


<http://progetti.dfa.unipd.it/GALFOR>

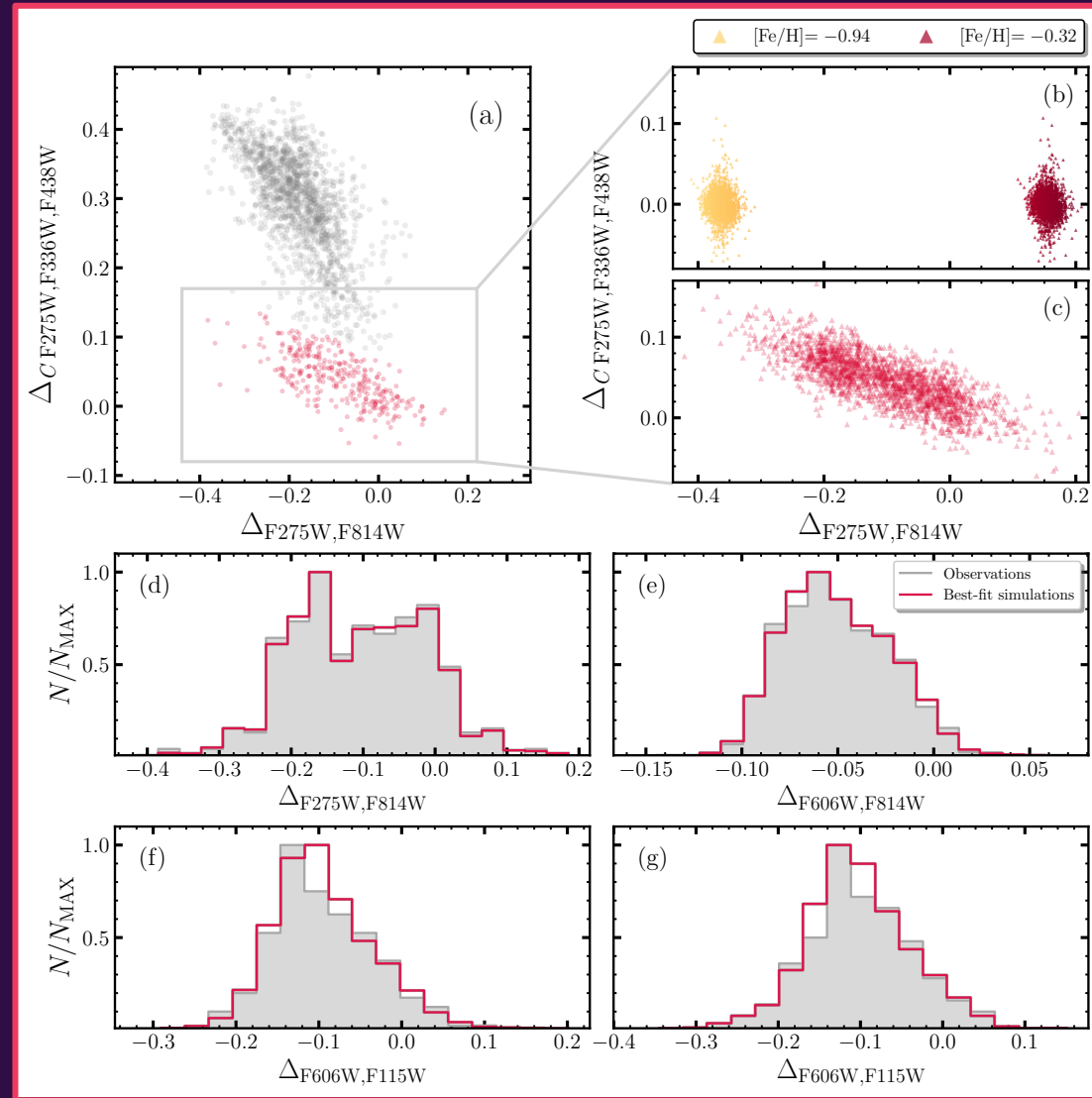
METALLICITY VARIATIONS IN GALACTIC GCs

Cluster ID	$\delta[\text{Fe}/\text{H}]_{1\text{G}}$	Cluster ID	$\delta[\text{Fe}/\text{H}]_{1\text{G}}$
NGC 0104	0.087 ± 0.009	NGC 6304	0.125 ± 0.028
NGC 0288	0.066 ± 0.007	NGC 6341	0.156 ± 0.022
NGC 0362	0.075 ± 0.010	NGC 6352	0.064 ± 0.018
NGC 1261	0.129 ± 0.022	NGC 6362	0.051 ± 0.020
NGC 1851	0.063 ± 0.007	NGC 6366	0.017 ± 0.030
NGC 2298	0.234 ± 0.046	NGC 6397	0.130 ± 0.019
NGC 2808	0.110 ± 0.010	NGC 6441	0.074 ± 0.007
NGC 3201	0.142 ± 0.038	NGC 6496	0.080 ± 0.011
NGC 4590	0.123 ± 0.015	NGC 6535	0.128 ± 0.022
NGC 4833	0.238 ± 0.023	NGC 6541	0.125 ± 0.014
NGC 5024	0.307 ± 0.029	NGC 6584	0.121 ± 0.028
NGC 5053	0.096 ± 0.024	NGC 6624	0.112 ± 0.016
NGC 5139	0.148 ± 0.011	NGC 6637	0.061 ± 0.009
NGC 5272	0.252 ± 0.015	NGC 6652	0.087 ± 0.011
NGC 5286	0.172 ± 0.012	NGC 6656	0.195 ± 0.038
NGC 5466	0.091 ± 0.055	NGC 6681	0.056 ± 0.012
NGC 5897	0.129 ± 0.030	NGC 6717	0.019 ± 0.010
NGC 5904	0.135 ± 0.027	NGC 6723	0.111 ± 0.011
NGC 5927	0.215 ± 0.023	NGC 6752	0.106 ± 0.017
NGC 5986	0.074 ± 0.006	NGC 6779	0.192 ± 0.083
NGC 6093	0.107 ± 0.010	NGC 6809	0.115 ± 0.011
NGC 6101	0.079 ± 0.016	NGC 6838	0.067 ± 0.010
NGC 6121	0.039 ± 0.031	NGC 6934	0.123 ± 0.028
NGC 6144	0.161 ± 0.031	NGC 6981	0.151 ± 0.028
NGC 6171	0.066 ± 0.011	NGC 7078	0.204 ± 0.014
NGC 6205	0.113 ± 0.024	NGC 7089	0.156 ± 0.023
NGC 6218	0.060 ± 0.015	NGC 7099	0.000 ± 0.020
NGC 6254	0.173 ± 0.022		

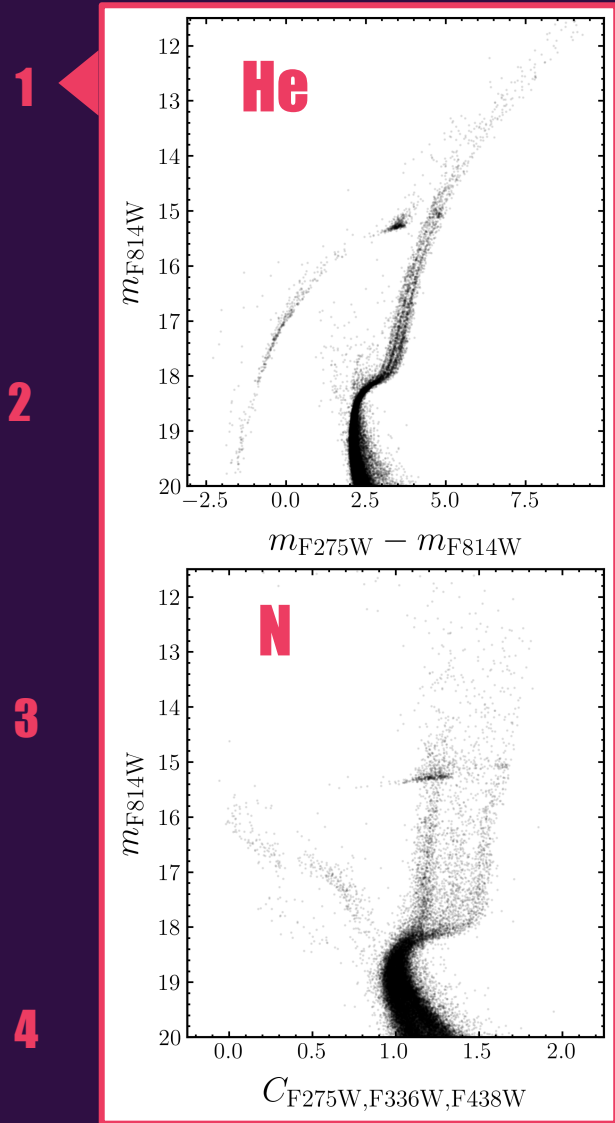
METALLICITY VARIATIONS IN GALACTIC GCs



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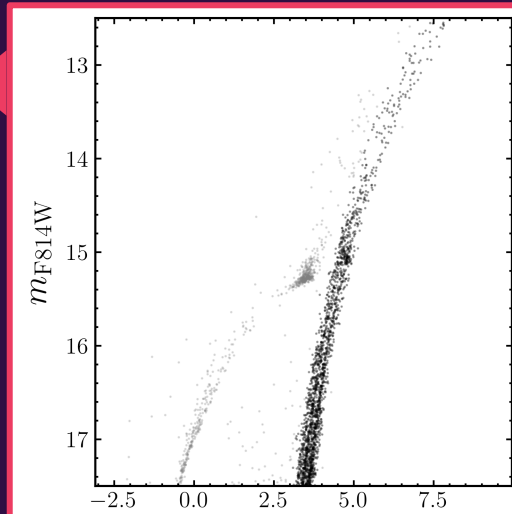
THE CHROMOSOME MAP OF GLOBULAR CLUSTERS



THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

SELECT RGB STARS

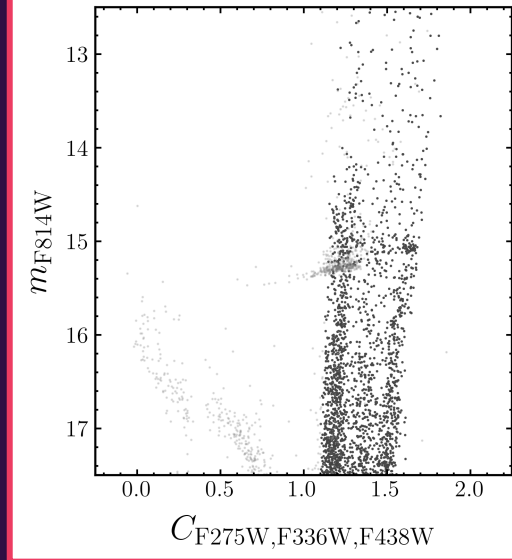
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2

3

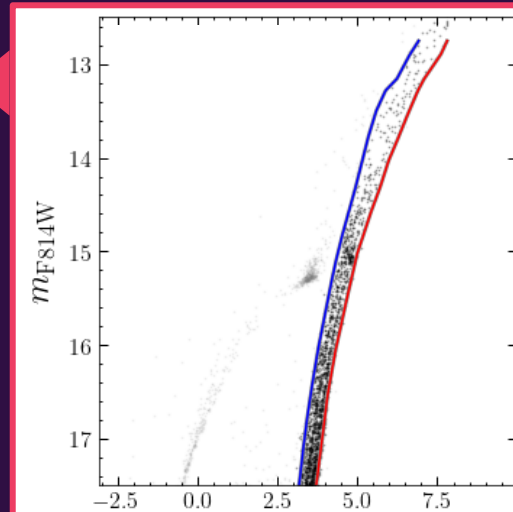
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THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

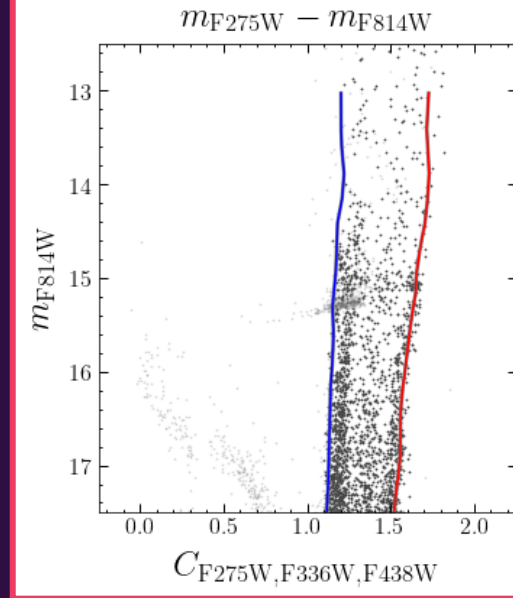
SELECT RGB STARS

1



DETERMINE RGB BOUNDARIES

2



3

4

THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

SELECT RGB STARS

1

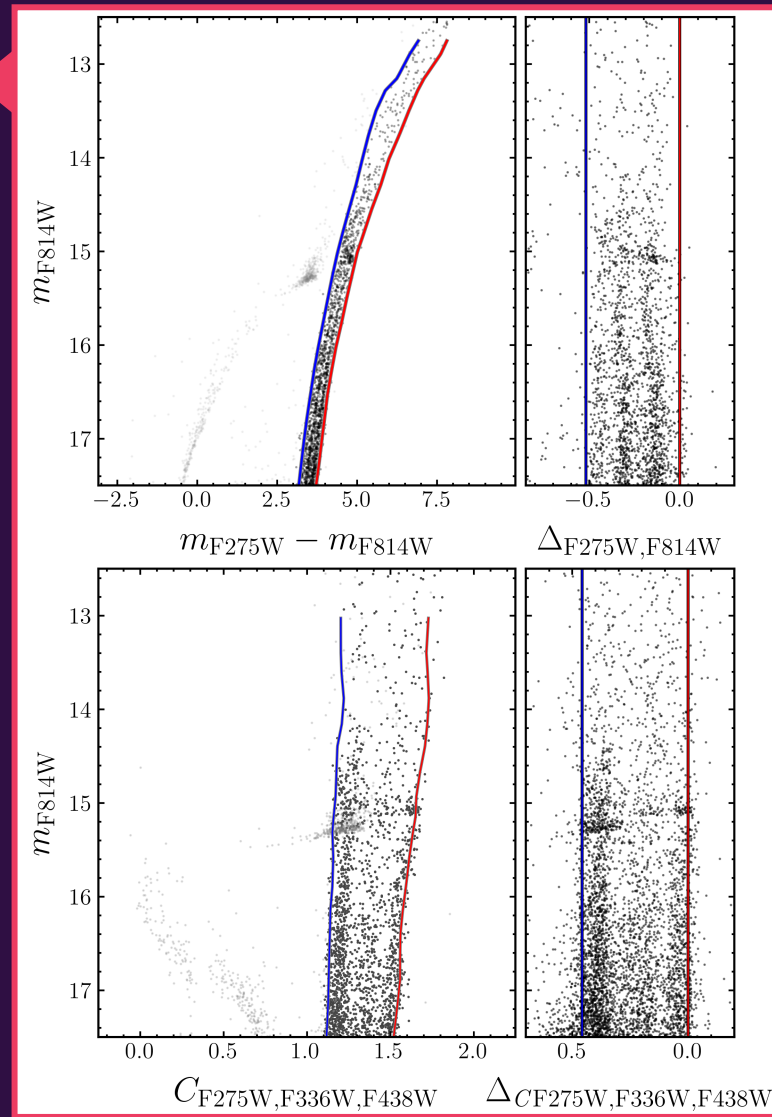
DETERMINE RGB BOUNDARIES

2

VERTICALIZE RGBs

3

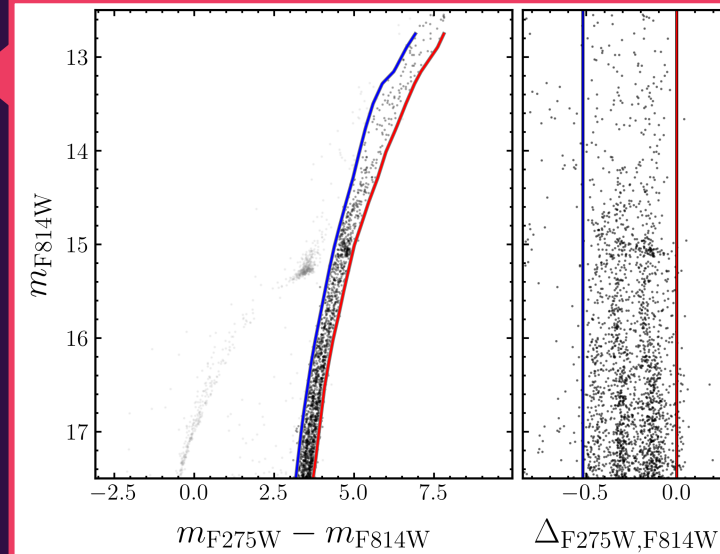
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THE CHROMOSOME MAP OF GLOBULAR CLUSTERS

SELECT RGB STARS

1

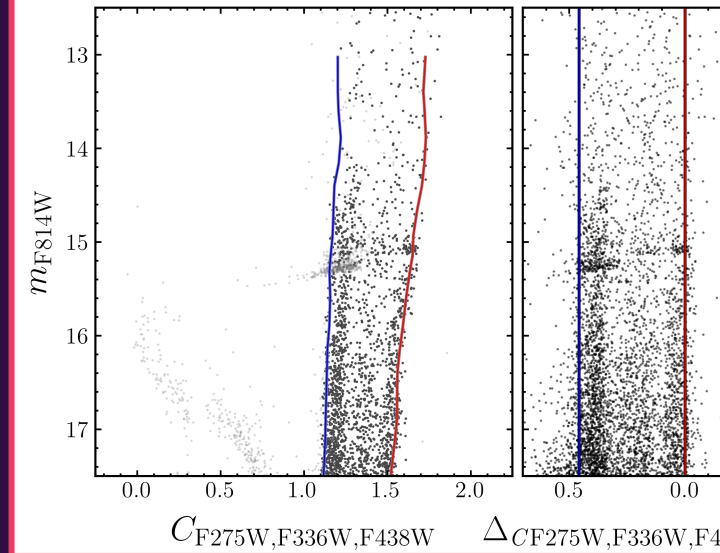


DETERMINE RGB BOUNDARIES

2

VERTICALIZE RGBs

3



PLOT THE ChM

4

