The Trials and Tribulations of Chemodynamical Tagging Star Clusters

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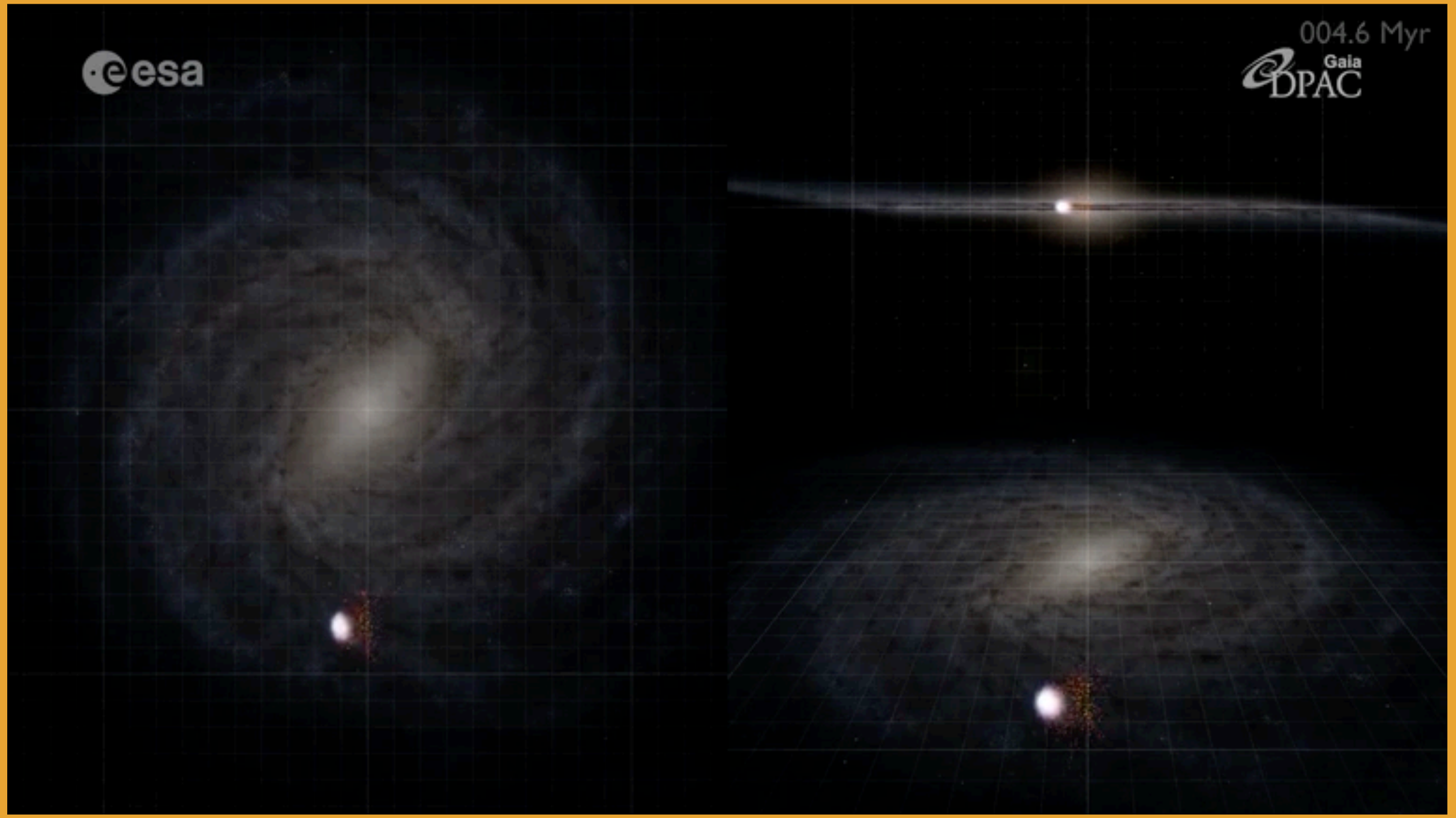
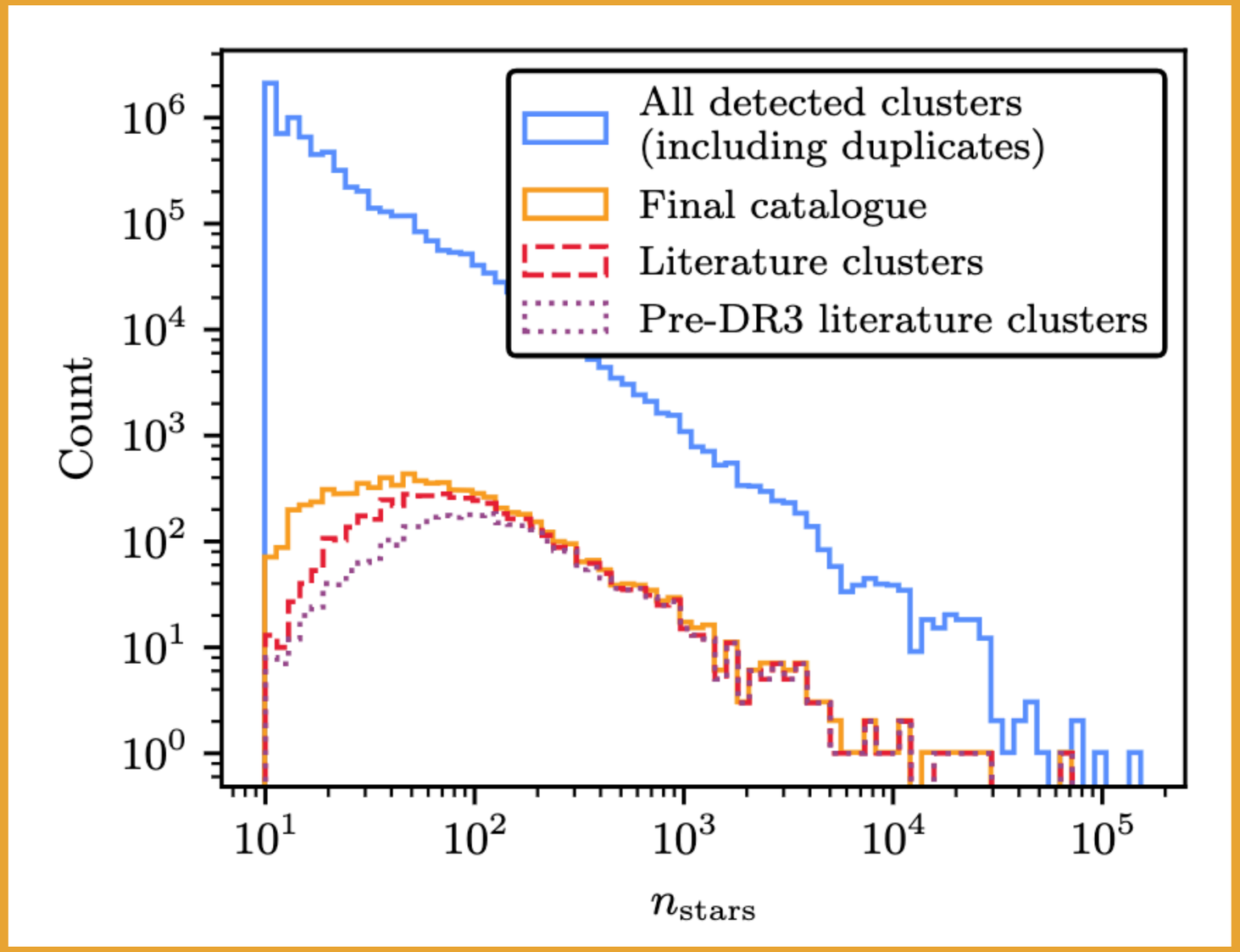
The Fate of Star Clusters in the Milky Way



S. Payne-Wardenaar, S. Jordan, C. Reylé and Smart et al. (2020)

Gaia and Milky Way Open Clusters

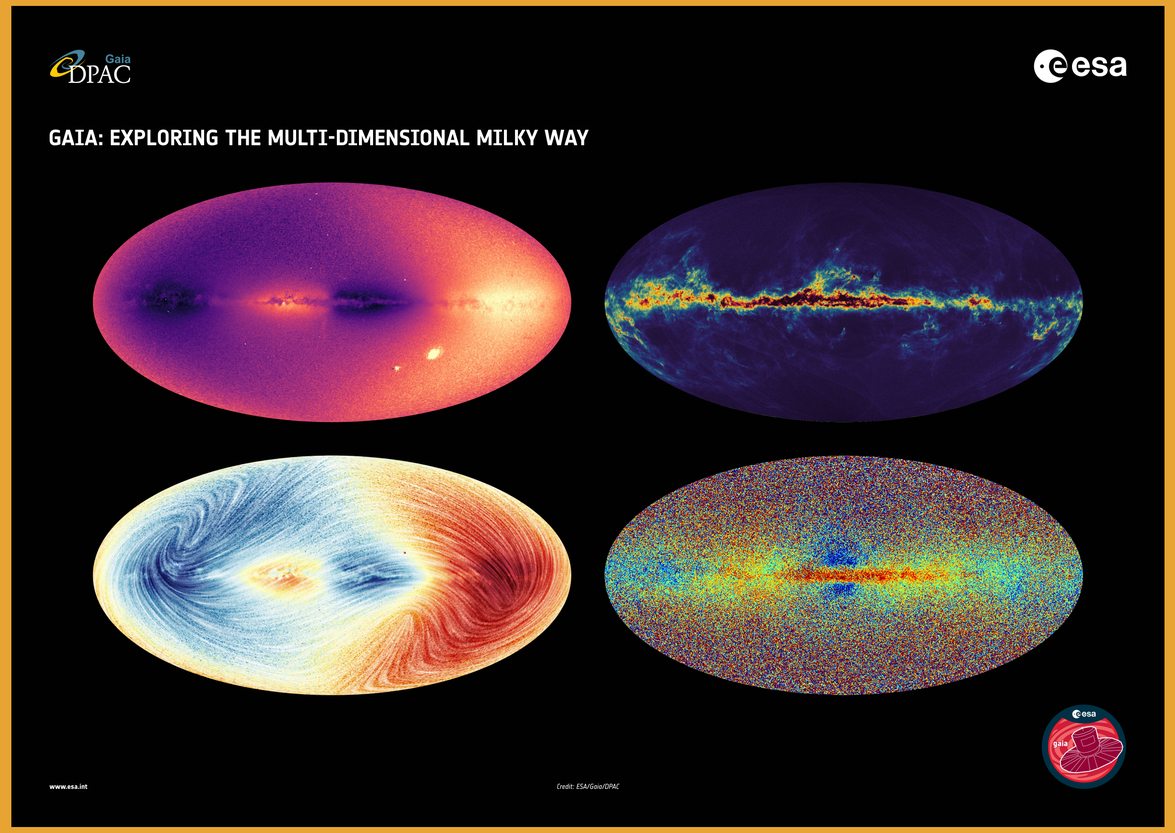


Hunt et al. 2023

Using Gaia positional data and HBDScan, Hunt et al. 2023 were able to detect and catalog 7000+ Milky Way Open Clusters!

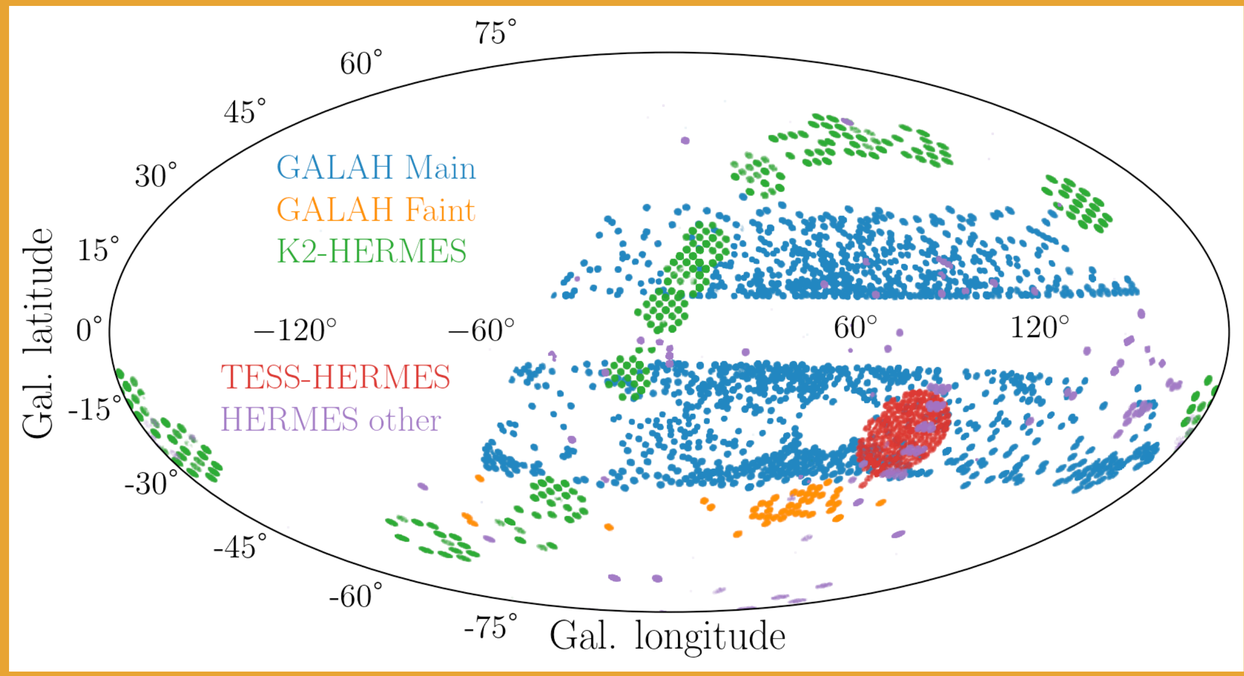
Era of Big Surveys

Gaia



Precise positions and velocities of ~2 billion Milky Way Stars

GALAH



Stellar Parameters and individual chemical abundances for 588,571 stars

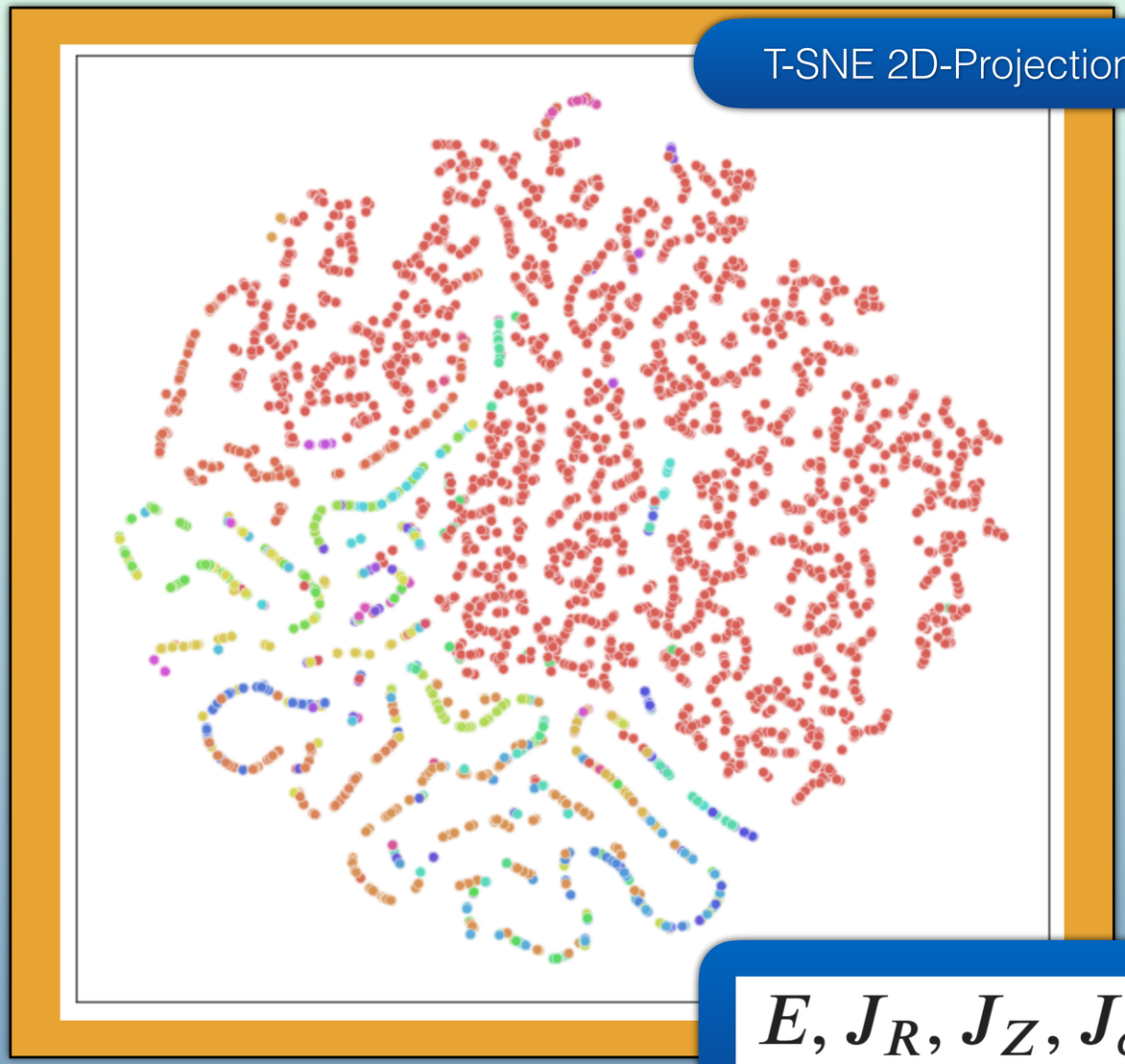
Our Method
Dataset and Parameters

Open Clusters

33 open clusters with 10+ stars with Gaia and GALAH data

Parameters

Orbital parameters (Gaia): E, J_Z, J_R, J_ϕ
Metallicity (GALAH): [Fe/H]
Abundances - [X/Fe]: O, Na, Mg, Al, Si, K, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Ba, Y

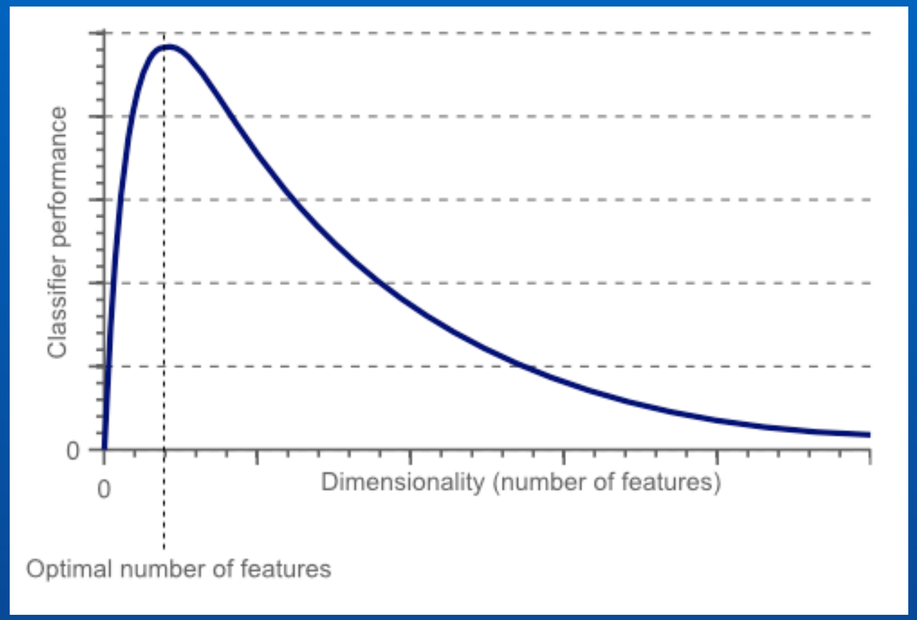


T-SNE 2D-Projection

$$E, J_R, J_Z, J_\phi$$

The Curse of Dimensionality!

Nearly 5 million unique parameter combinations!



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Thus we can consider combinations of 1-5 parameters

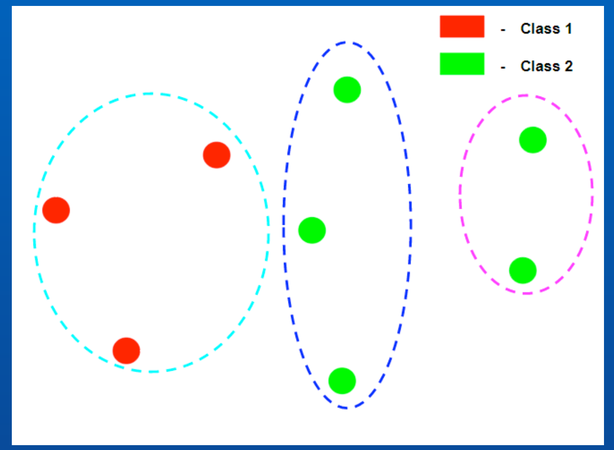
What's the Best Parameter Combination?

V-Measure Score

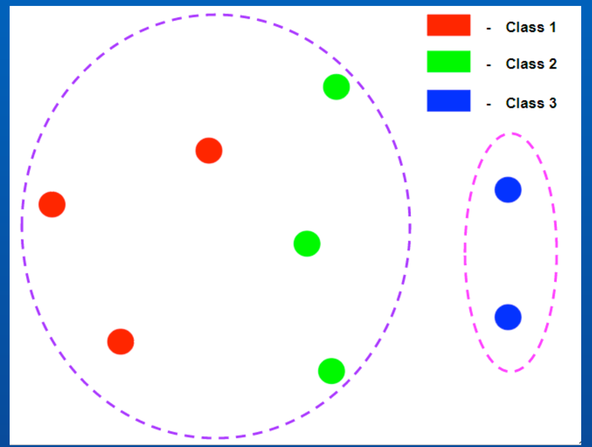
$$v = \frac{(1+\beta) \times \text{homogeneity} \times \text{completeness}}{(\beta \times \text{homogeneity} + \text{completeness})}$$

Each cluster only contains members of a single class

Homogeneity



Completeness

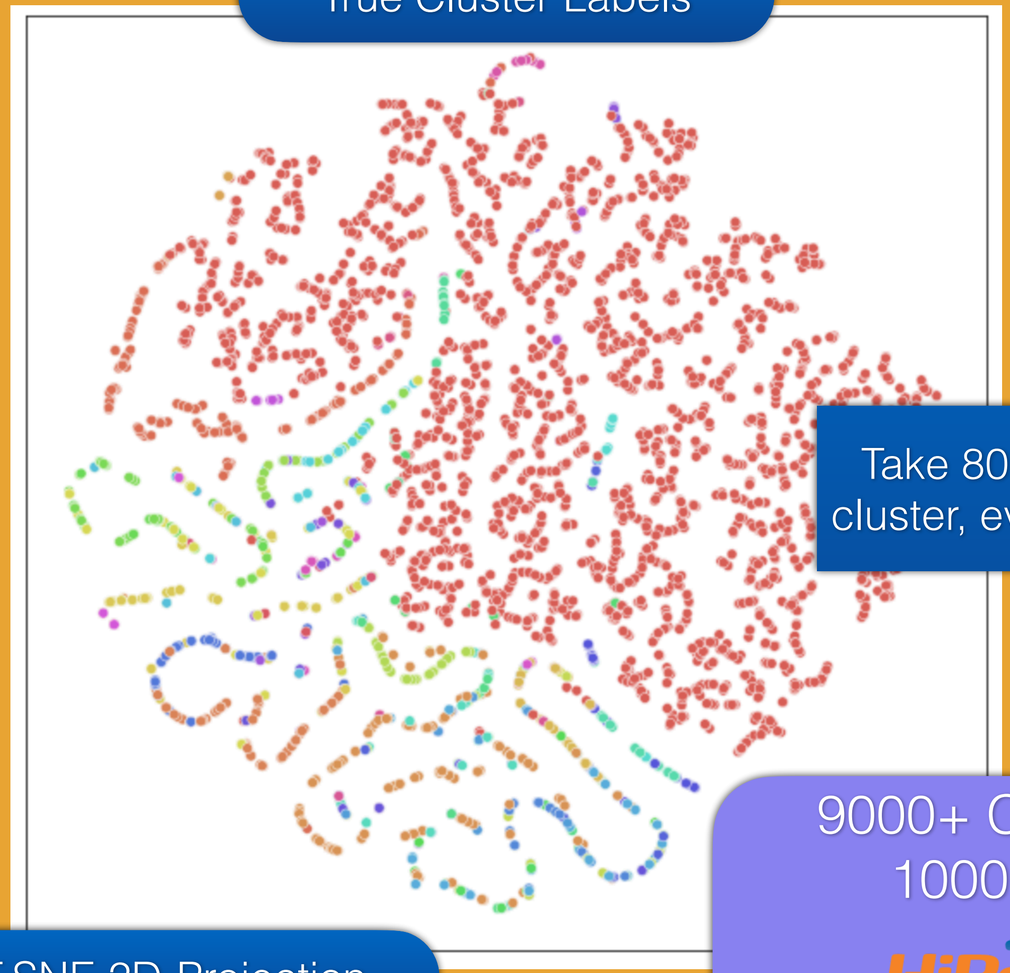


geeksforgeeks.org

All members of a given class are assigned to the same cluster

Bootstrap Analysis

True Cluster Labels



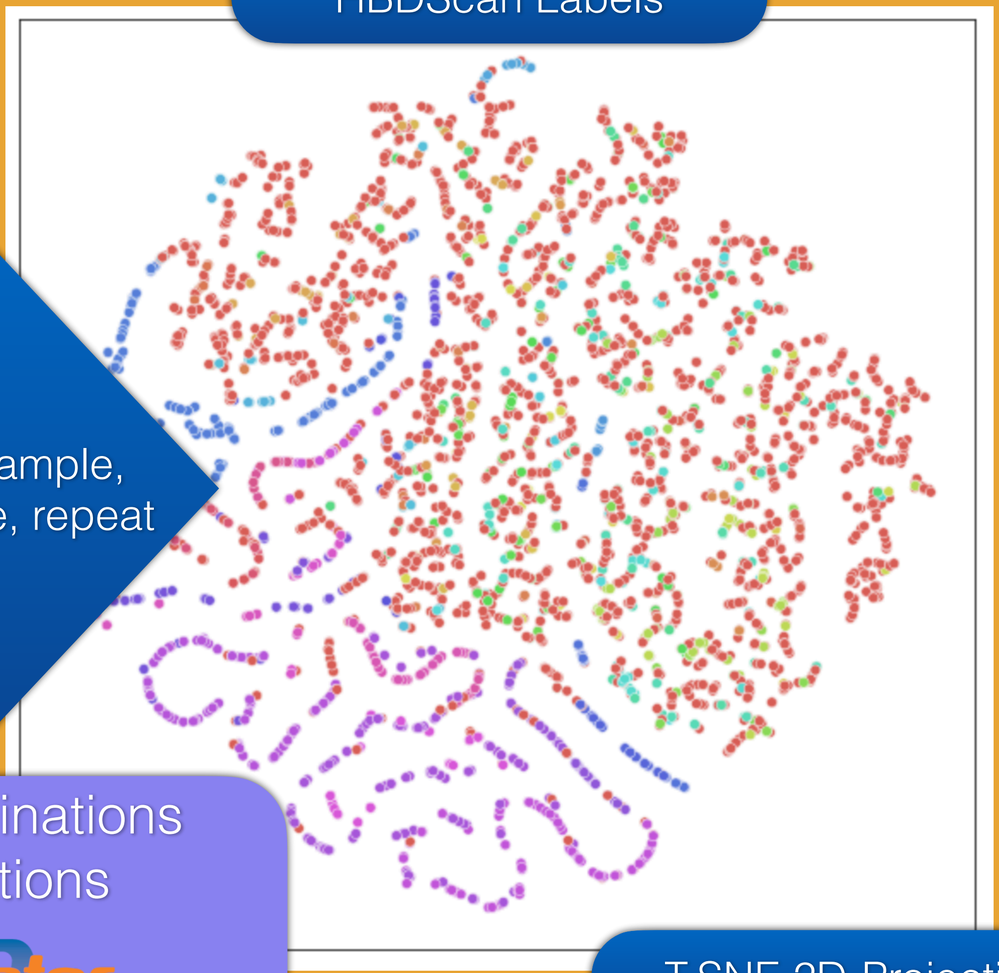
T-SNE 2D-Projection

Take 80% of sample,
cluster, evaluate, repeat

9000+ Combinations
1000 Iterations

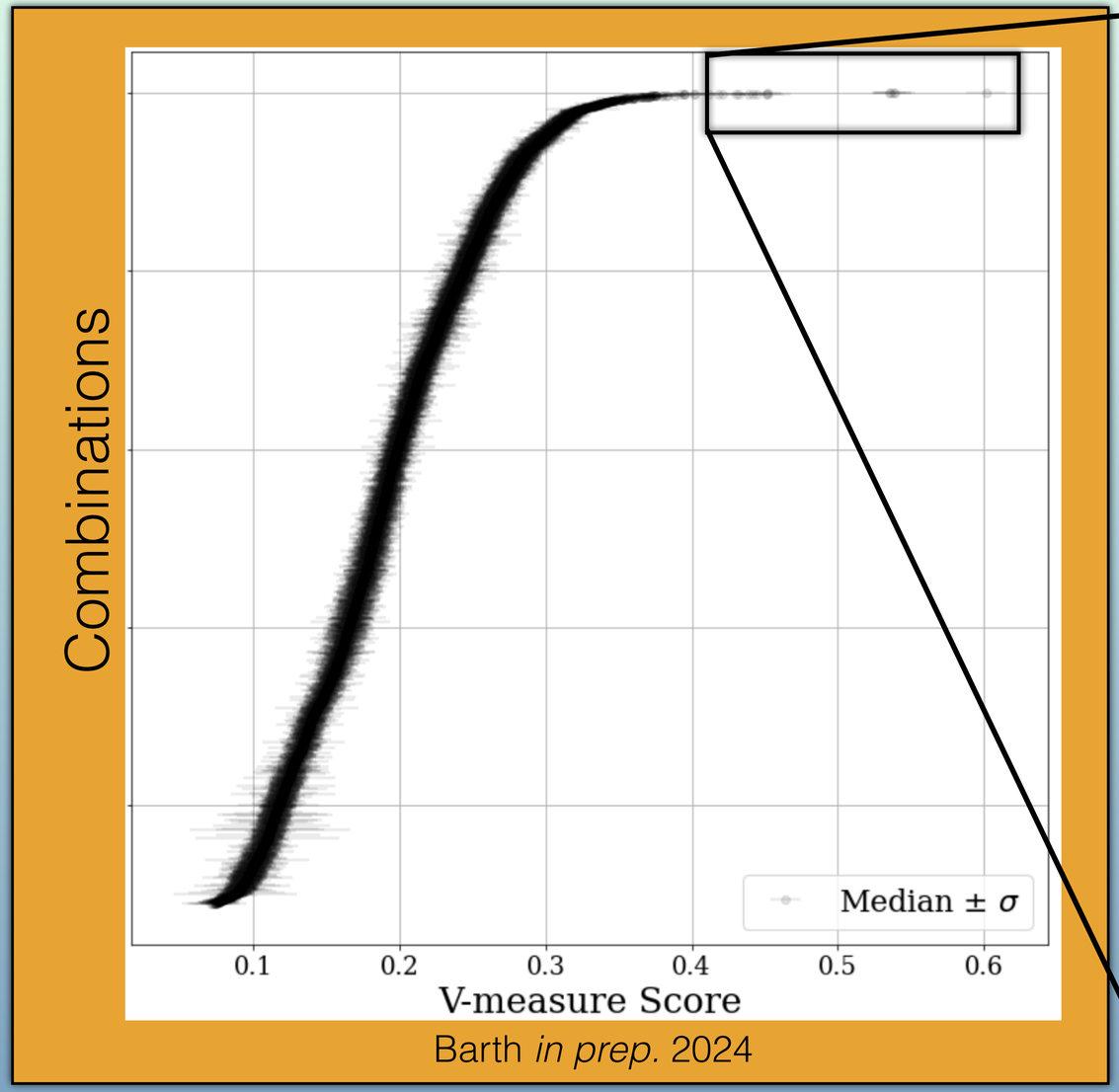
HiPerGator

HBDScan Labels



T-SNE 2D-Projection

Combination Average Scores



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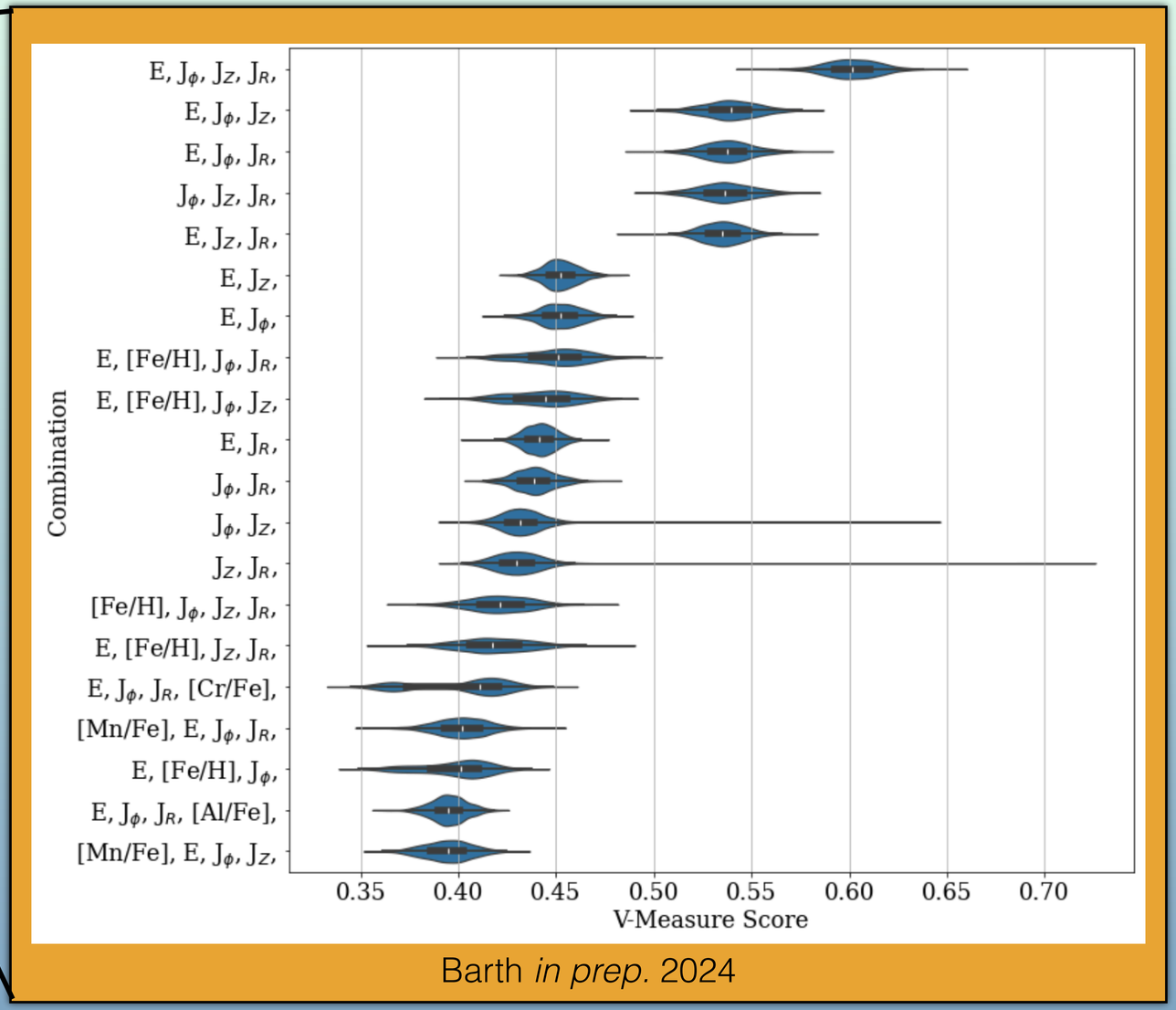

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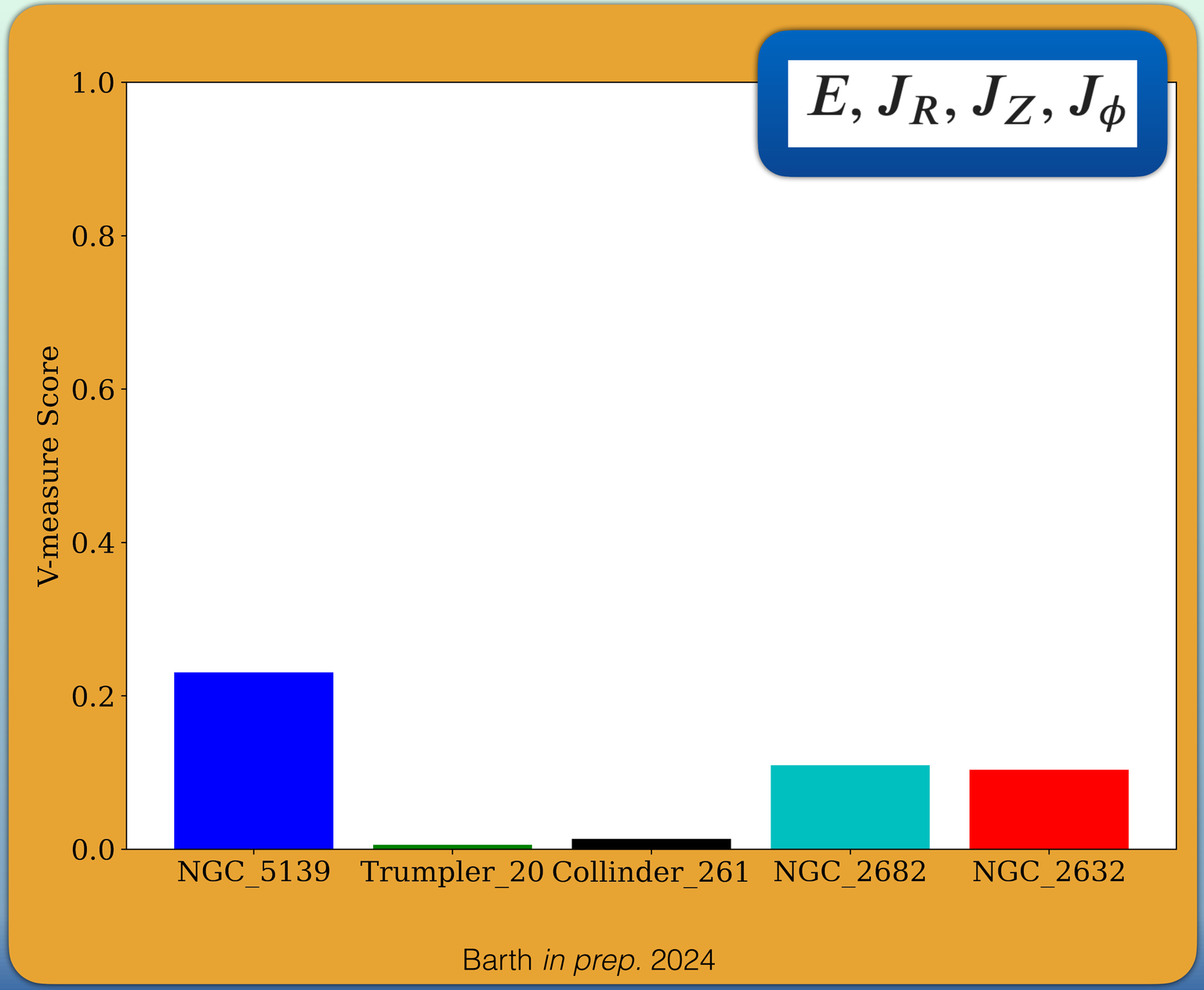
How does this do with the full Gaia and GALAH dataset



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In the larger dataset of 500,000+ stars, the V-measure score is low for even the best combinations

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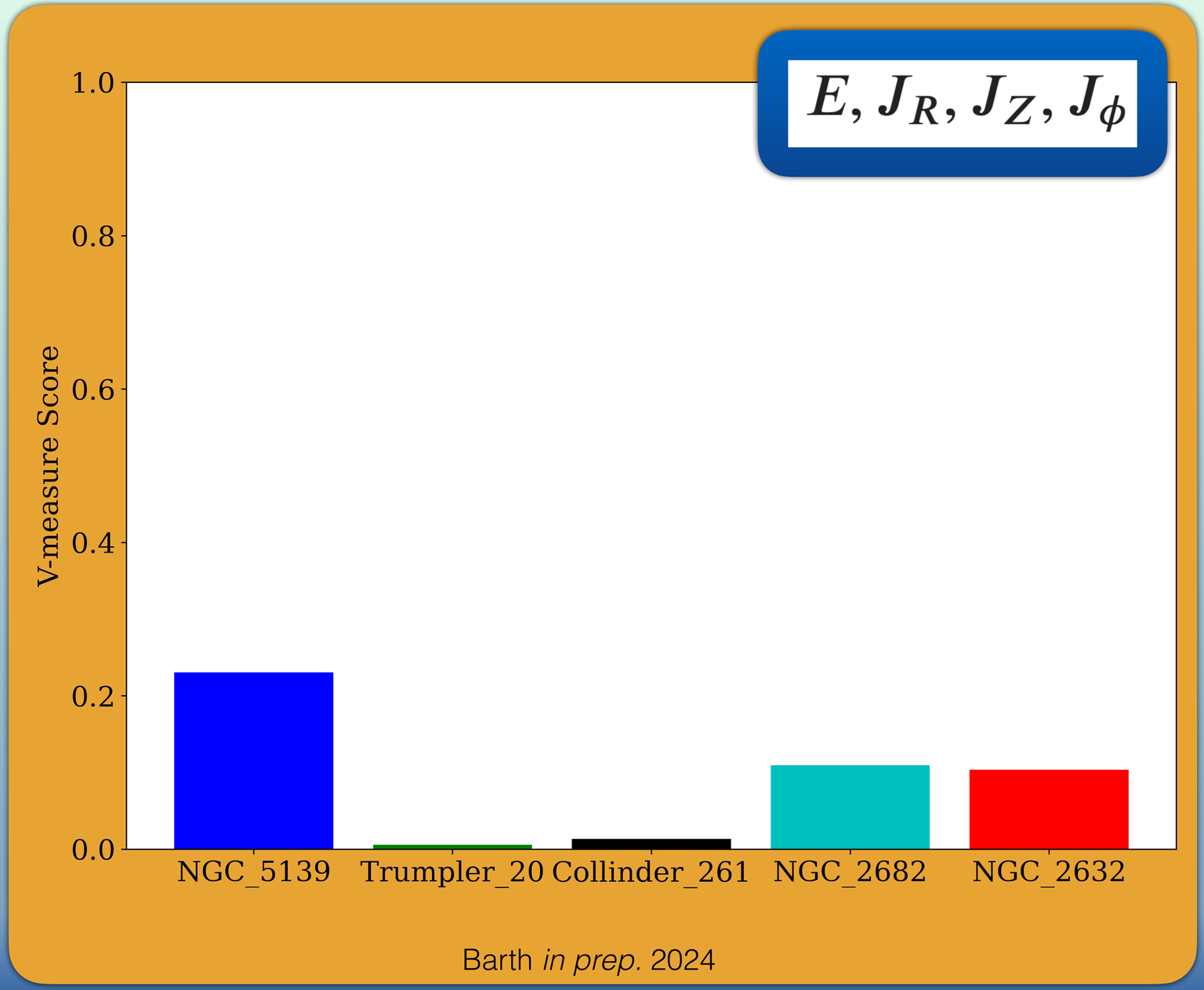

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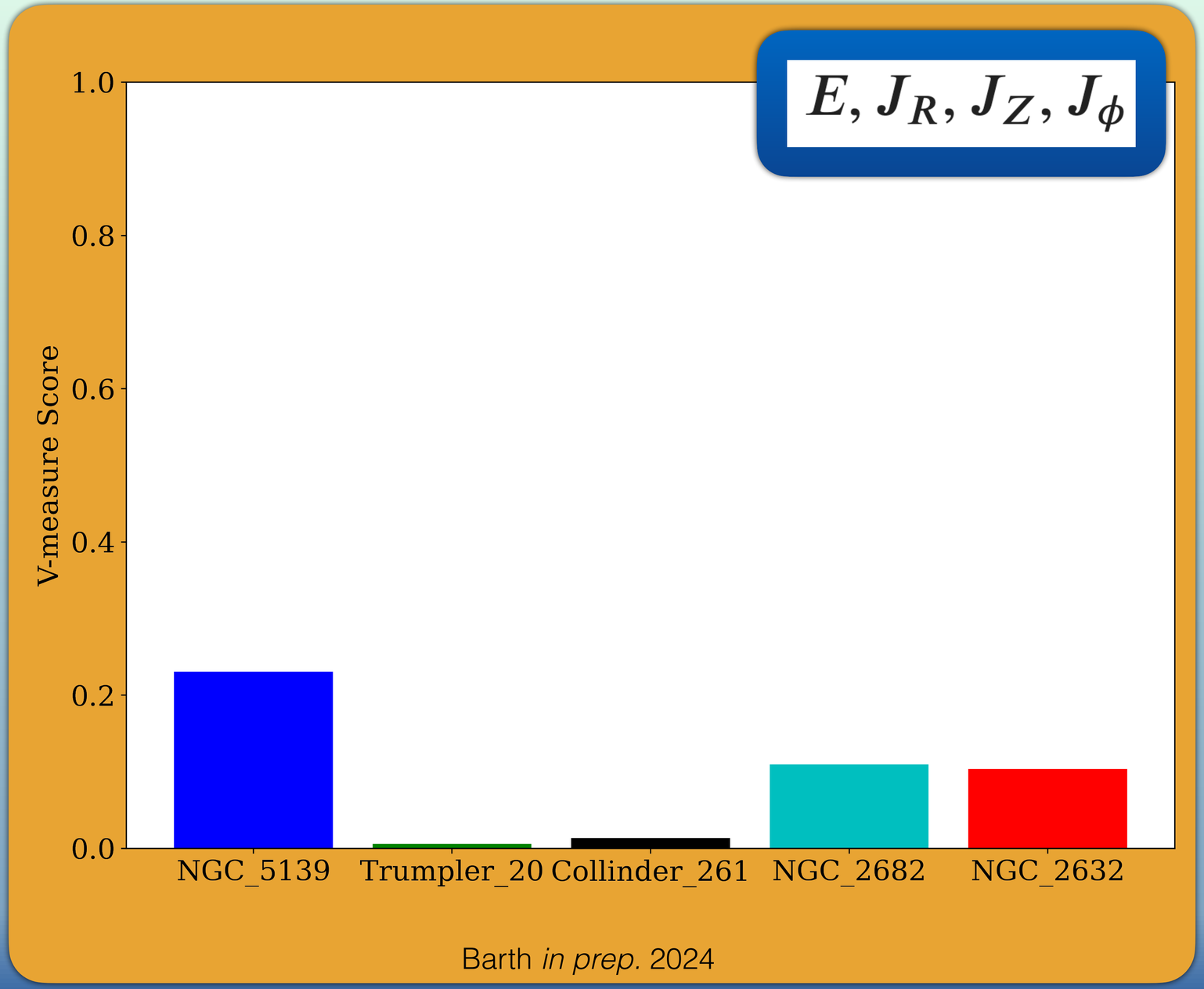

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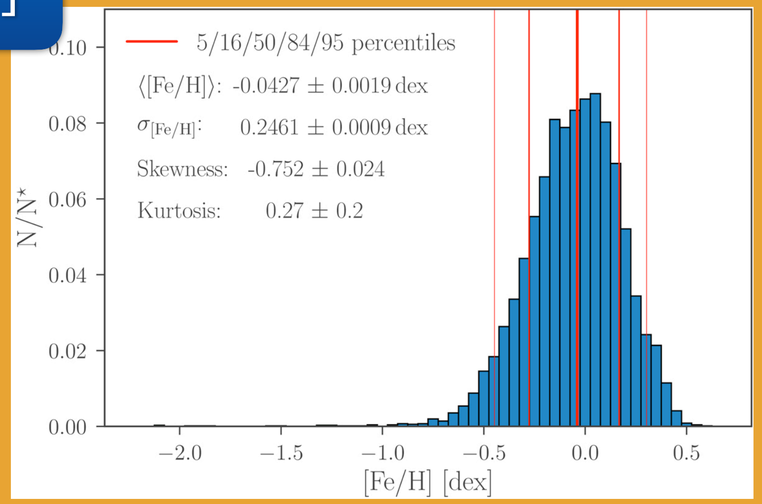
In the larger dataset of 500,000+ stars, the V-measure score is low for even the best combinations

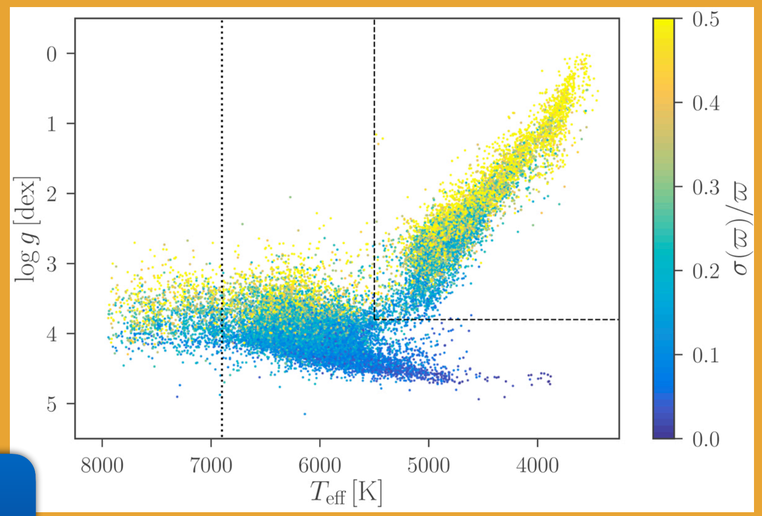
If we can limit the size of data set with a priori information, we might be able to improve our recovery

We can achieve this with cuts to the dataset relating to age, metallicity, and birth radii

Age, Metallicity, and Birth Radii

[Fe/H]

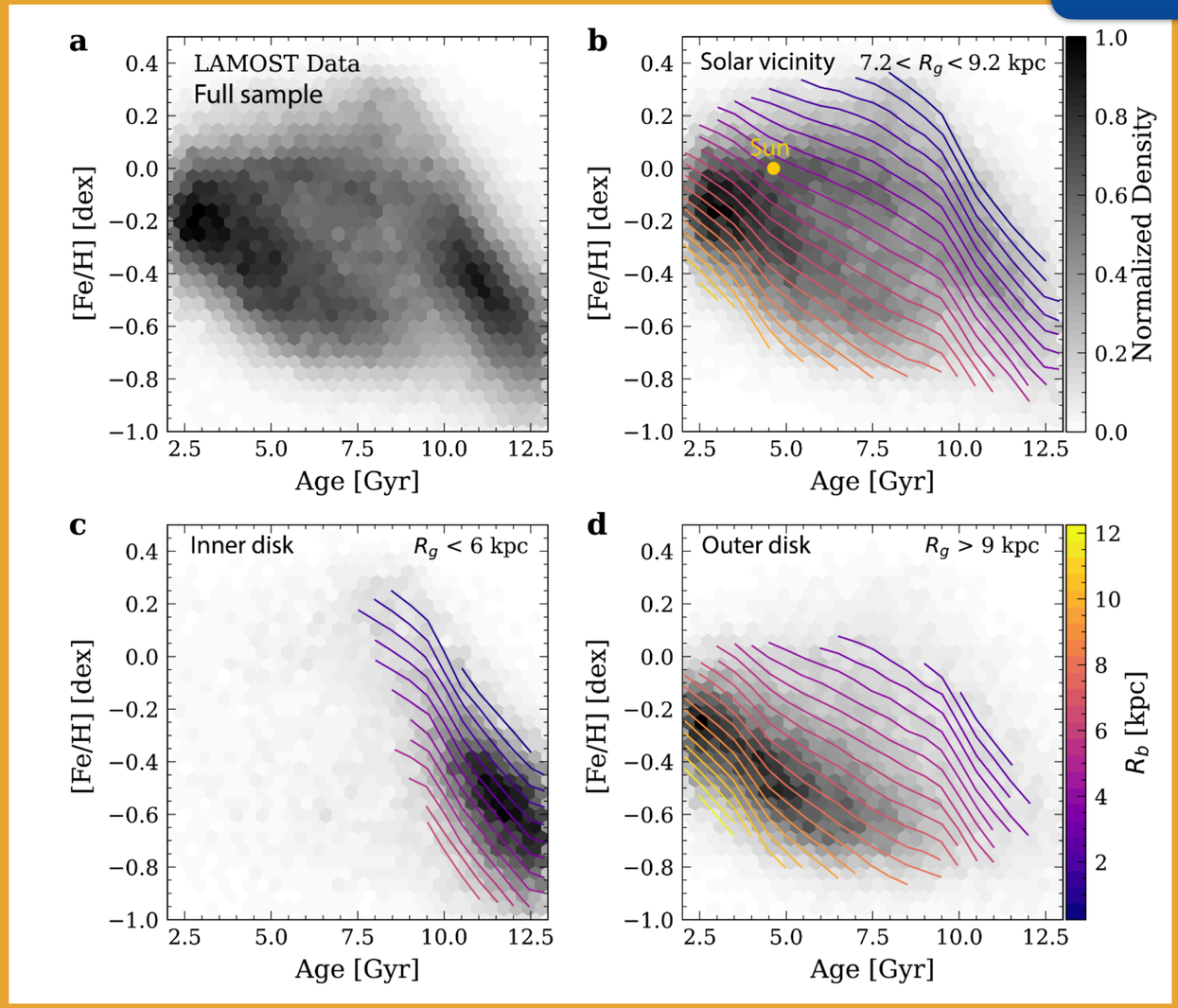




Age

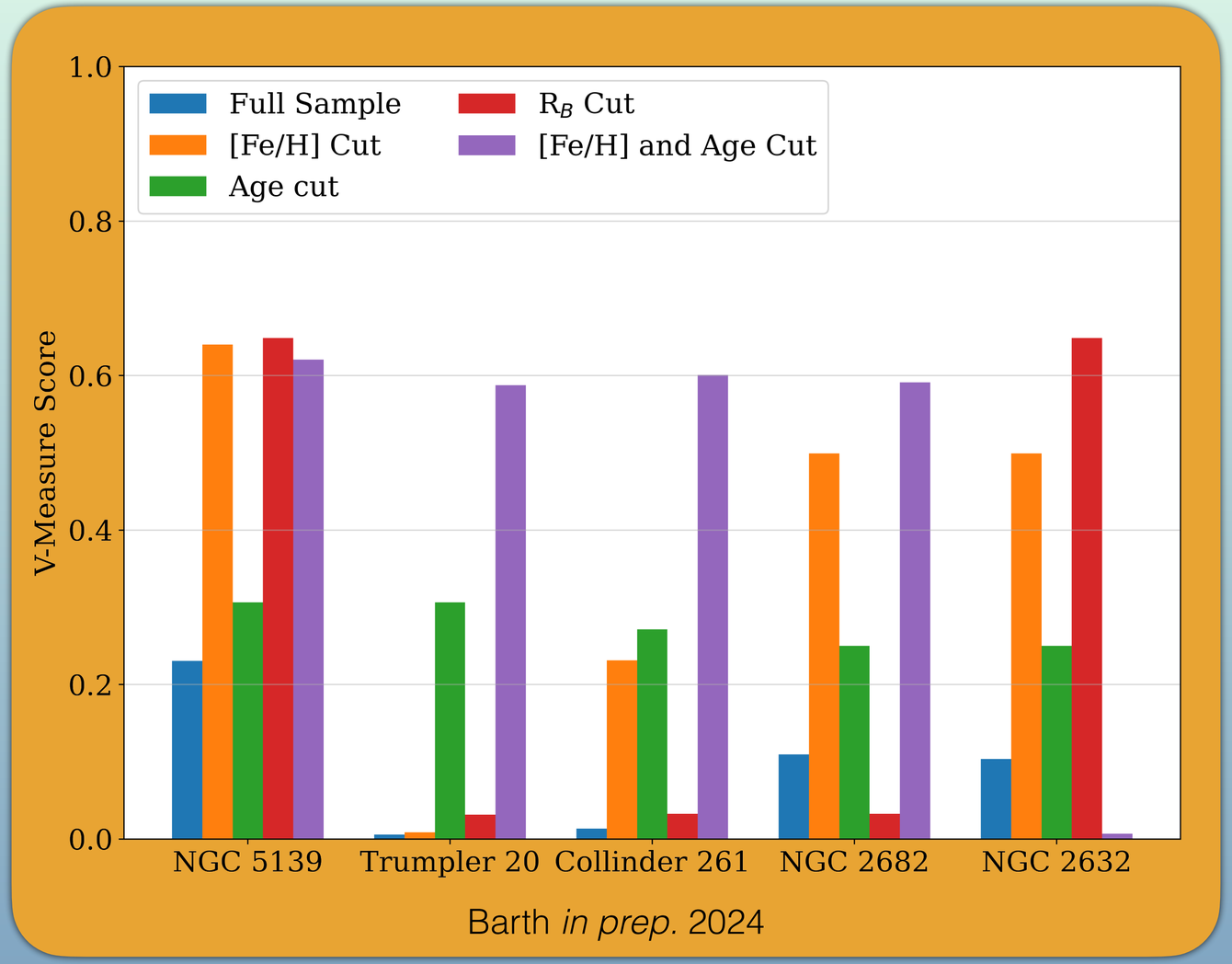
Buder et al. 2018

R_B



Lu et al. 2023

Results of Metallicity, Age, and Birth Radii Cuts



Take Aways

The Milky Way has had many clusters that have been dispersed over time

Using Open Clusters as a laboratory for testing which combinations of observable parameters has shown orbital actions and metallicity as key clustering parameters

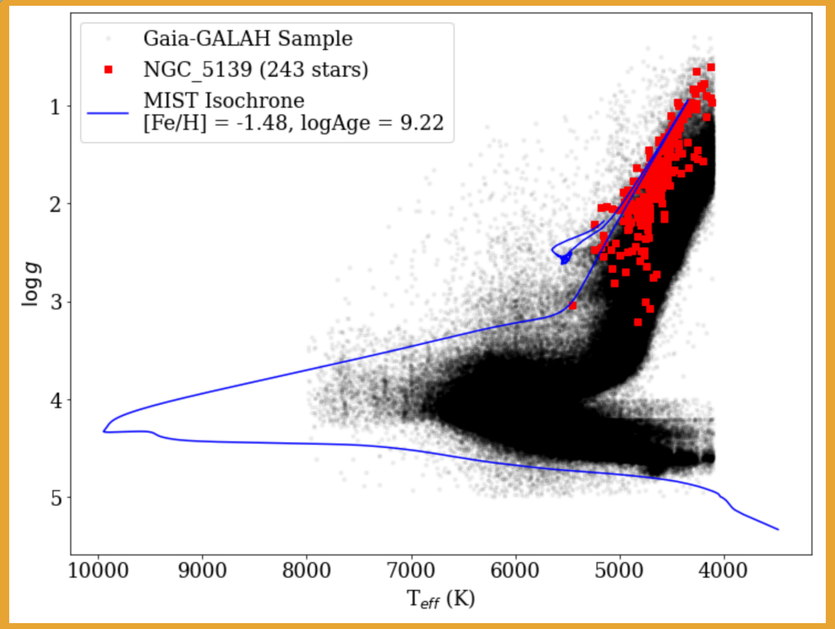
Identifying clusters in large datasets can be difficult, but using cuts based on age, metallicity, and birth radii can improve recovery rates

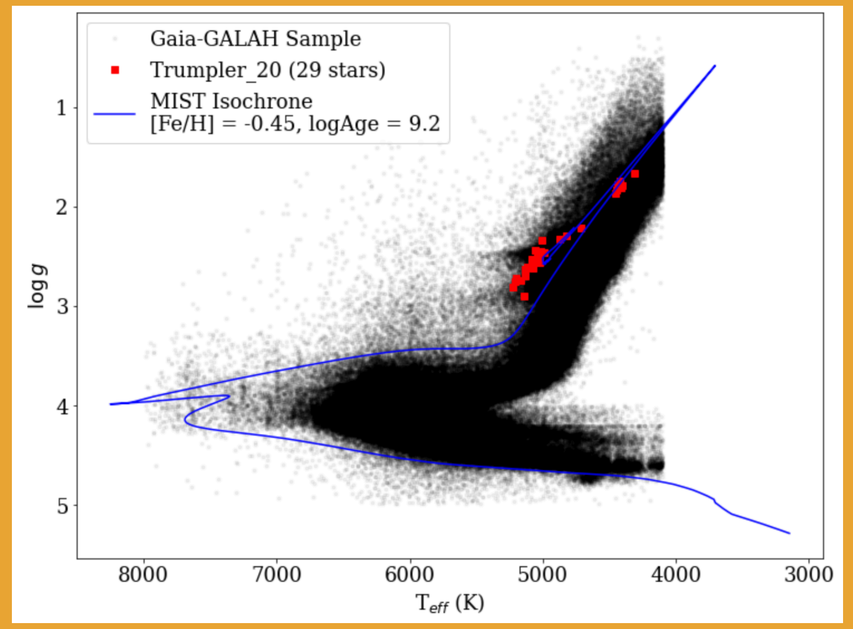
Future Work

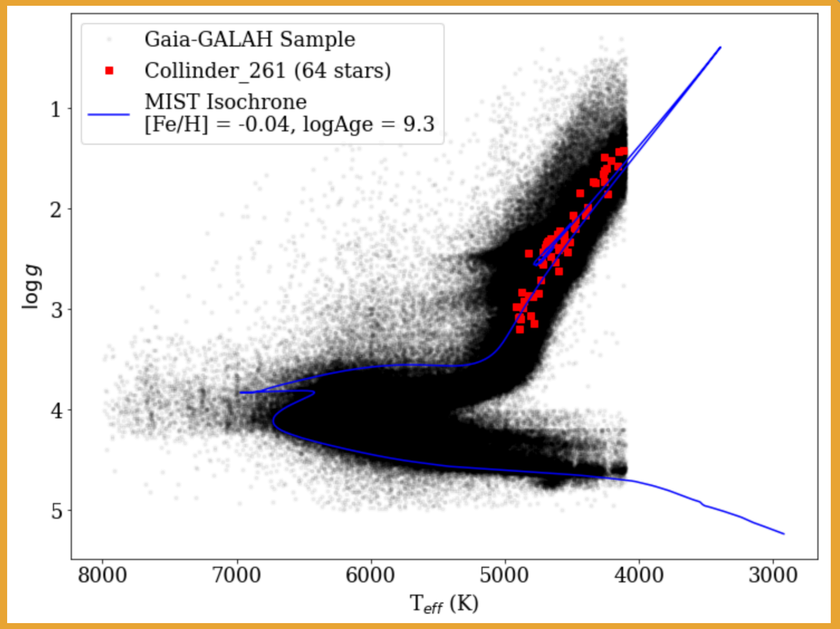
Using our knowledge of the Sun, we hope to find solar siblings scattered across the Milky Way

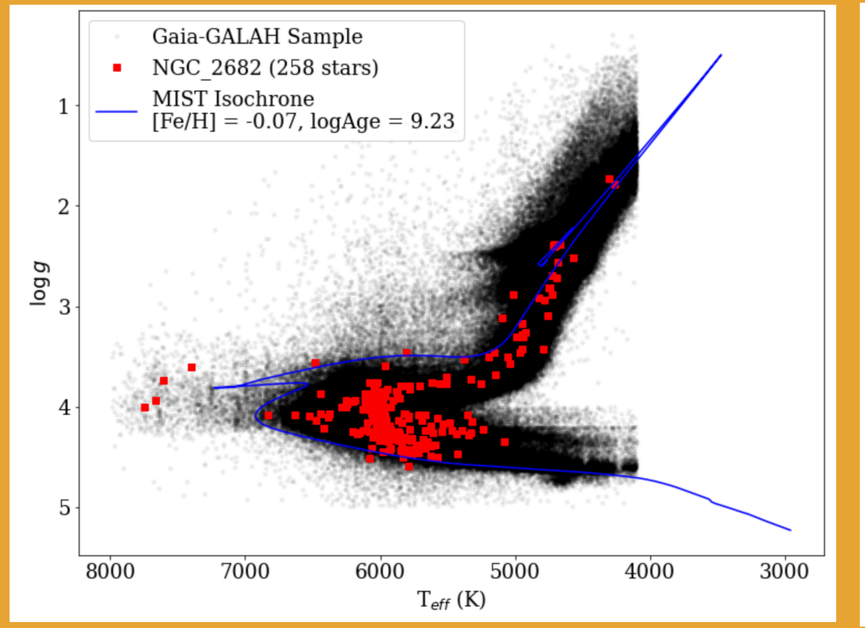
We can then perform high resolution, spectroscopic followup to compare the chemistry of possible siblings to assess their likelihood of being a true solar sibling

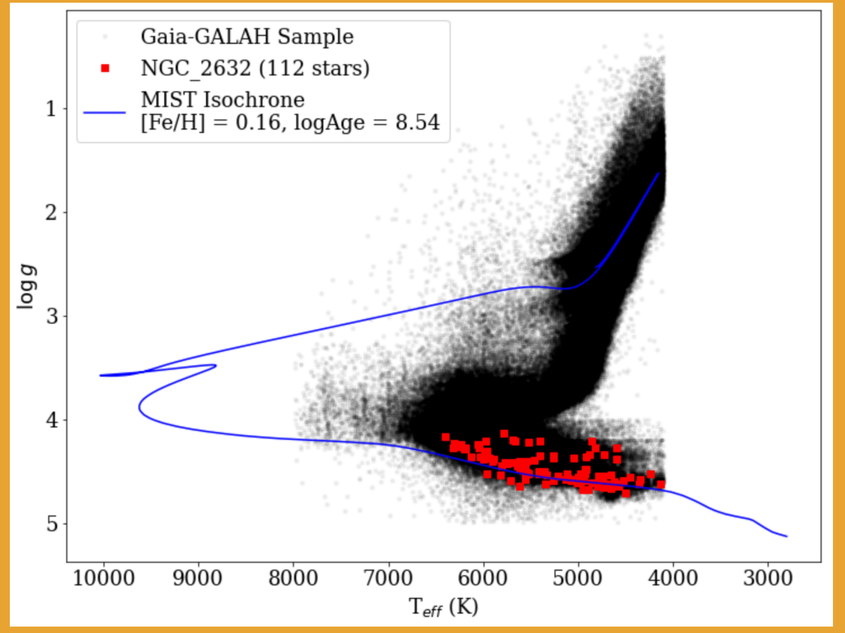
Testing Metallicity, Age, and Birth Radii Cuts











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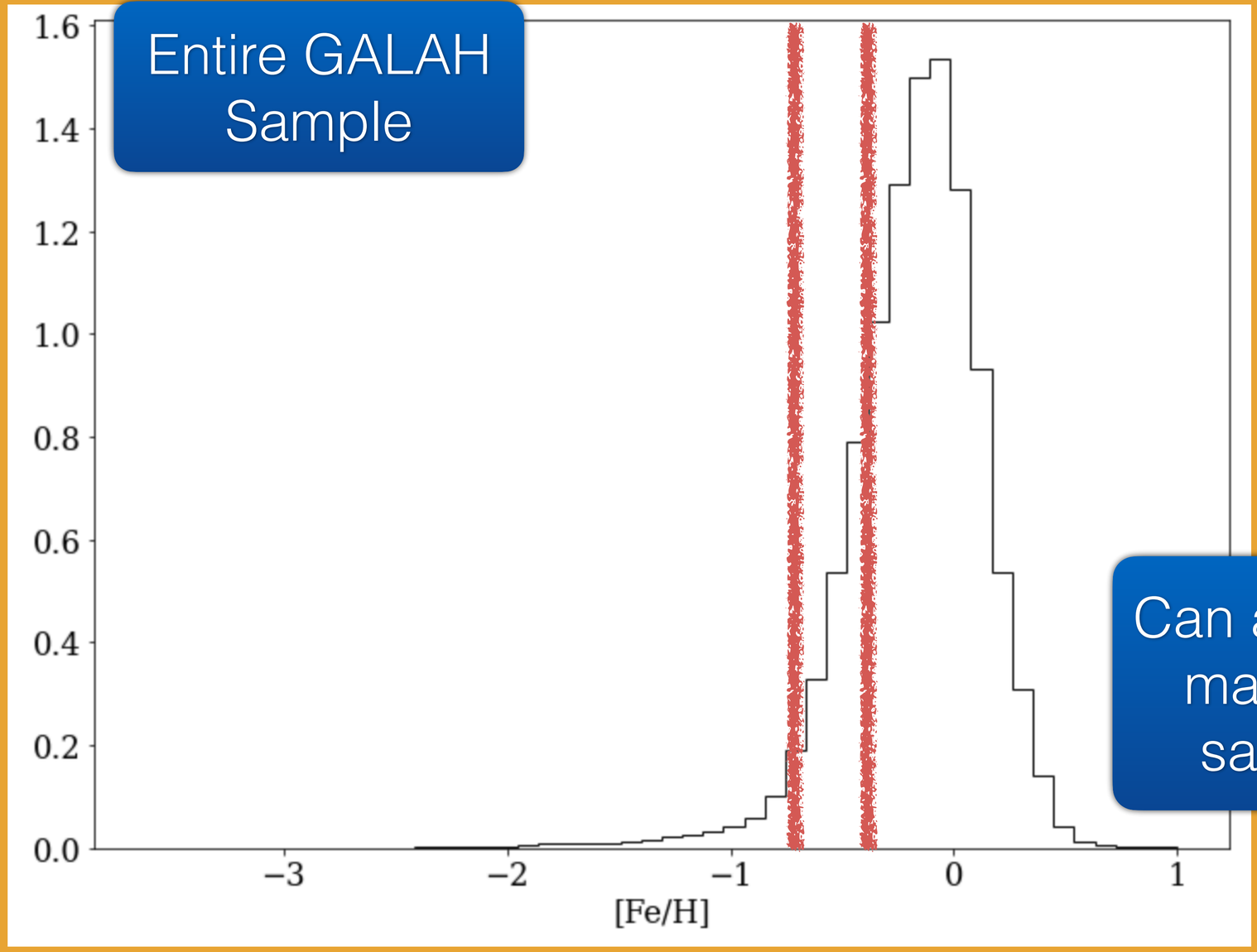
Using prior information to improve results

Entire GALAH Sample



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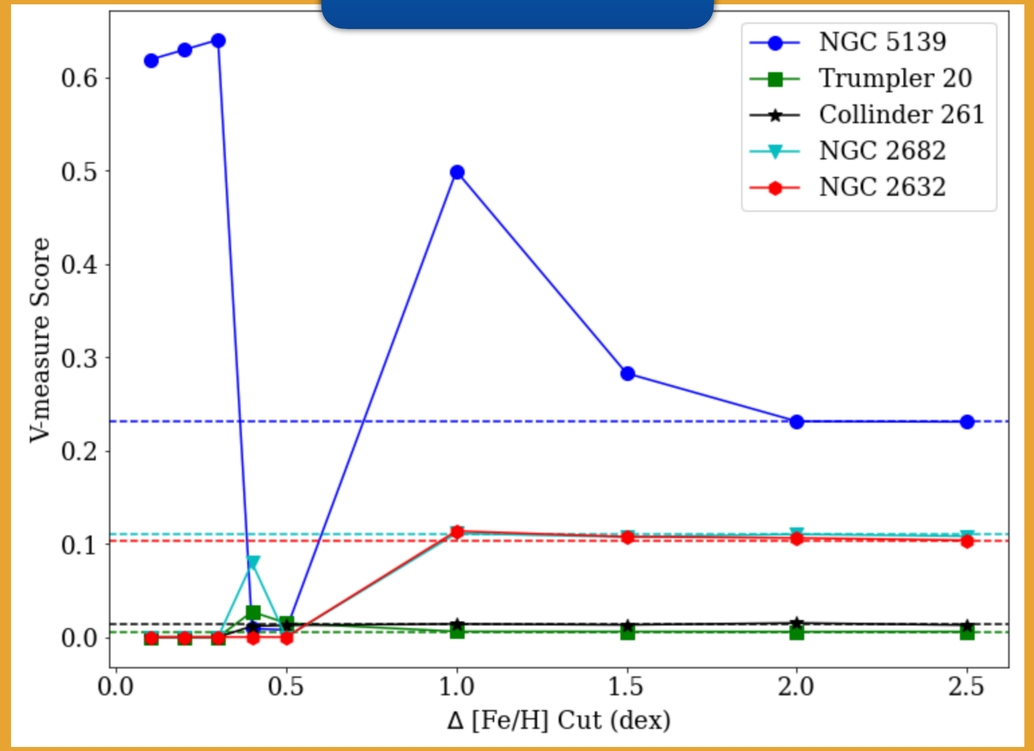
Can avoid using a majority of the sample stars

Results of Metallicity, Age, and Birth Radii Cuts

[Fe/H] Cut



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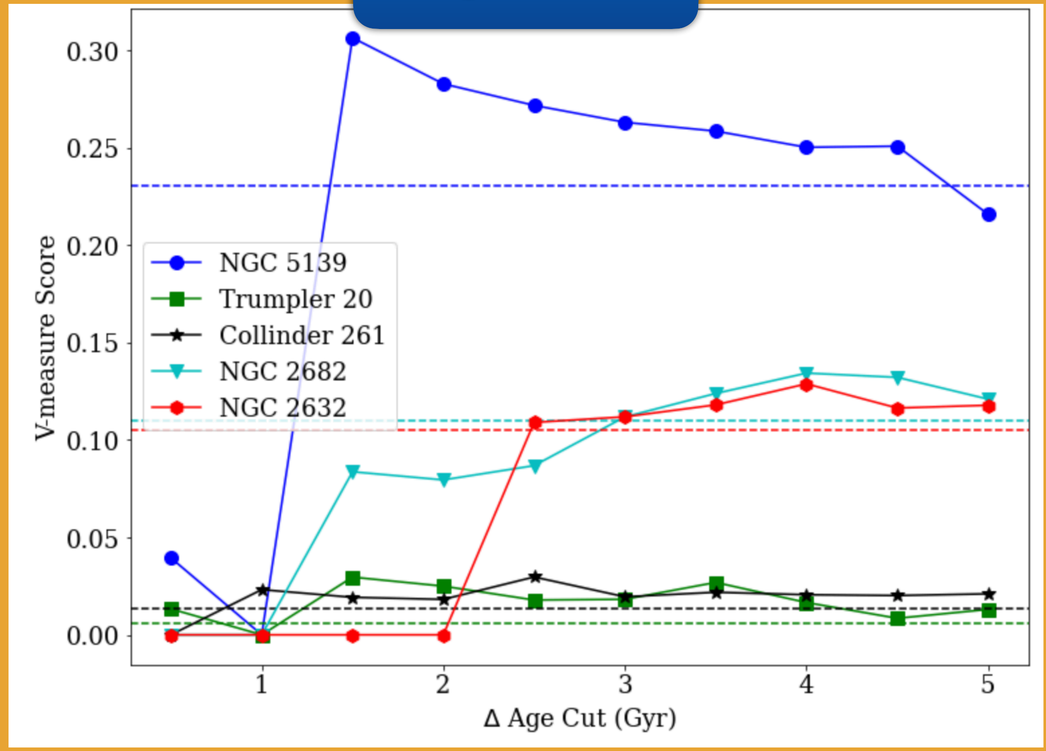
Age Cut



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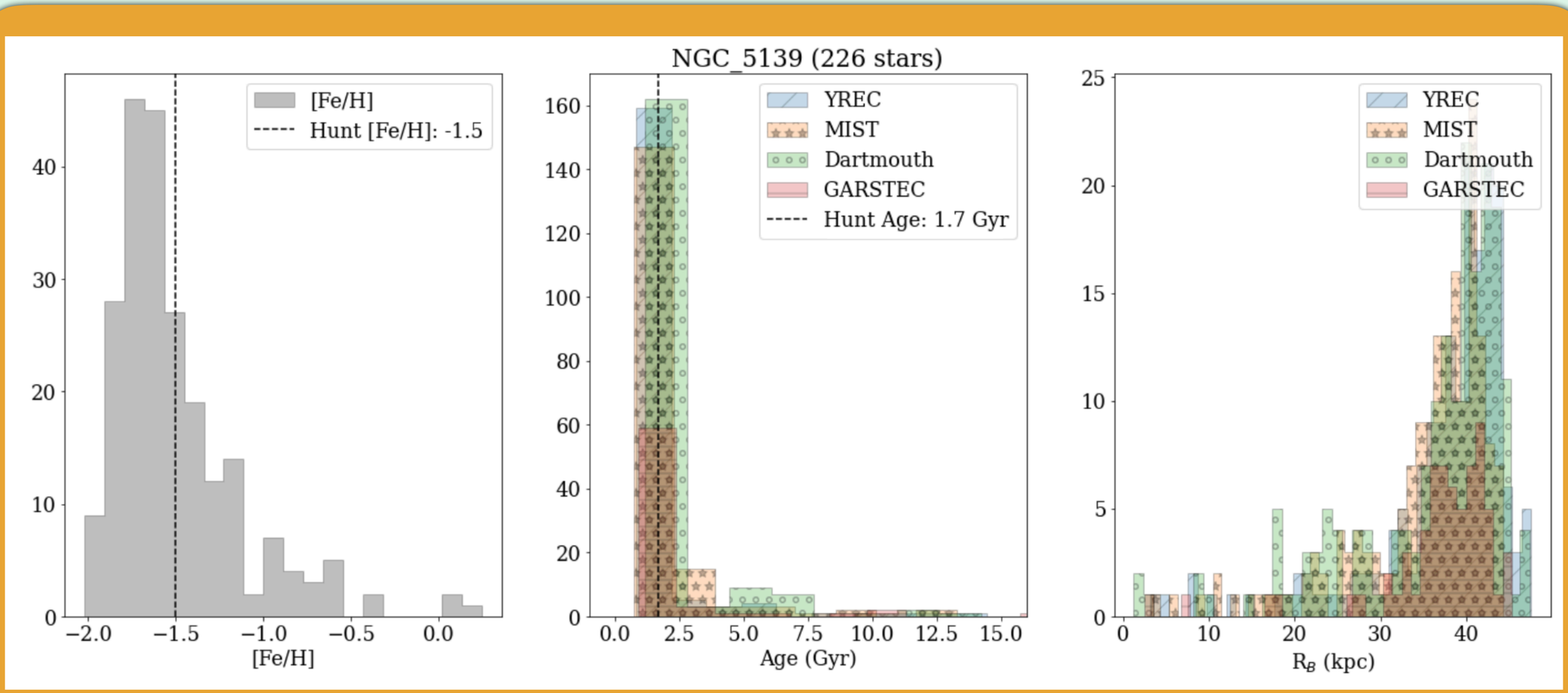

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