

Isochrone Fitting of Stellar Clusters

Astrostatistics Project

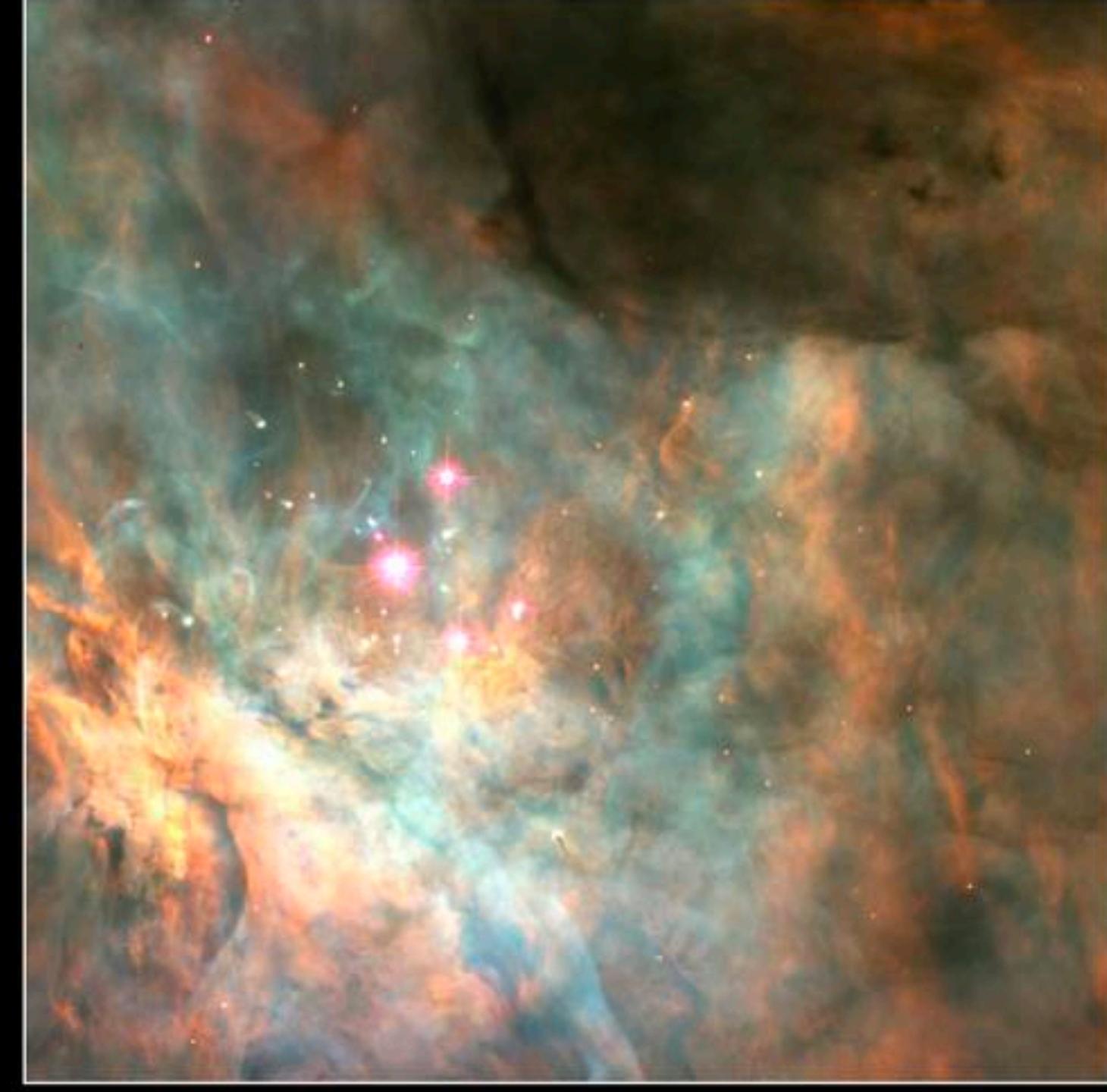
Ian Baeza

The Project

- It consists in generalize the isochrone fitting process
- First get likely members from my cluster selection
(which consisted in near stellar clusters)
- Then map the likelyhood of the models
- Finally interpolate the likelyhood and run an MCMC to get errors

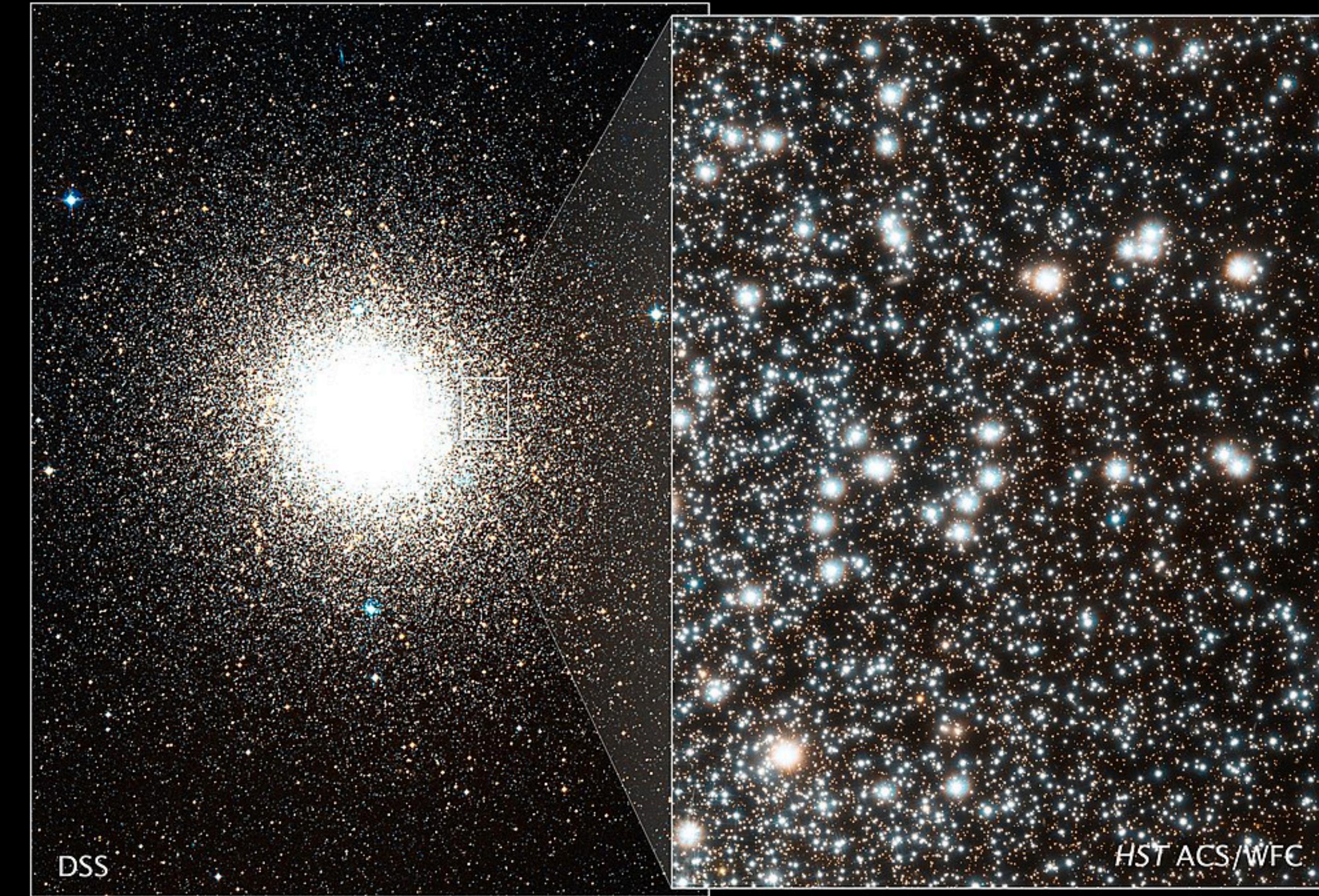
Motivation

- Stellar Clusters:
Are stars that born together
- This means that in principle they have *the same Age and Metallicity*
(Very hard properties to get from stars)
- Can be used to estimate distance and extinction in the line of sight
- They are Gravitationally Bound



<https://www.nasa.gov/content/discoveries-hubbles-star-clusters>

- There exist 2 main kinds of stellar clusters



NASA and ESA

Globular Cluster 47 Tuc
Hubble Space Telescope ■ ACS/WFC

STScI-PRC13-25a

- **Open Cluster**

- **Globular Cluster**

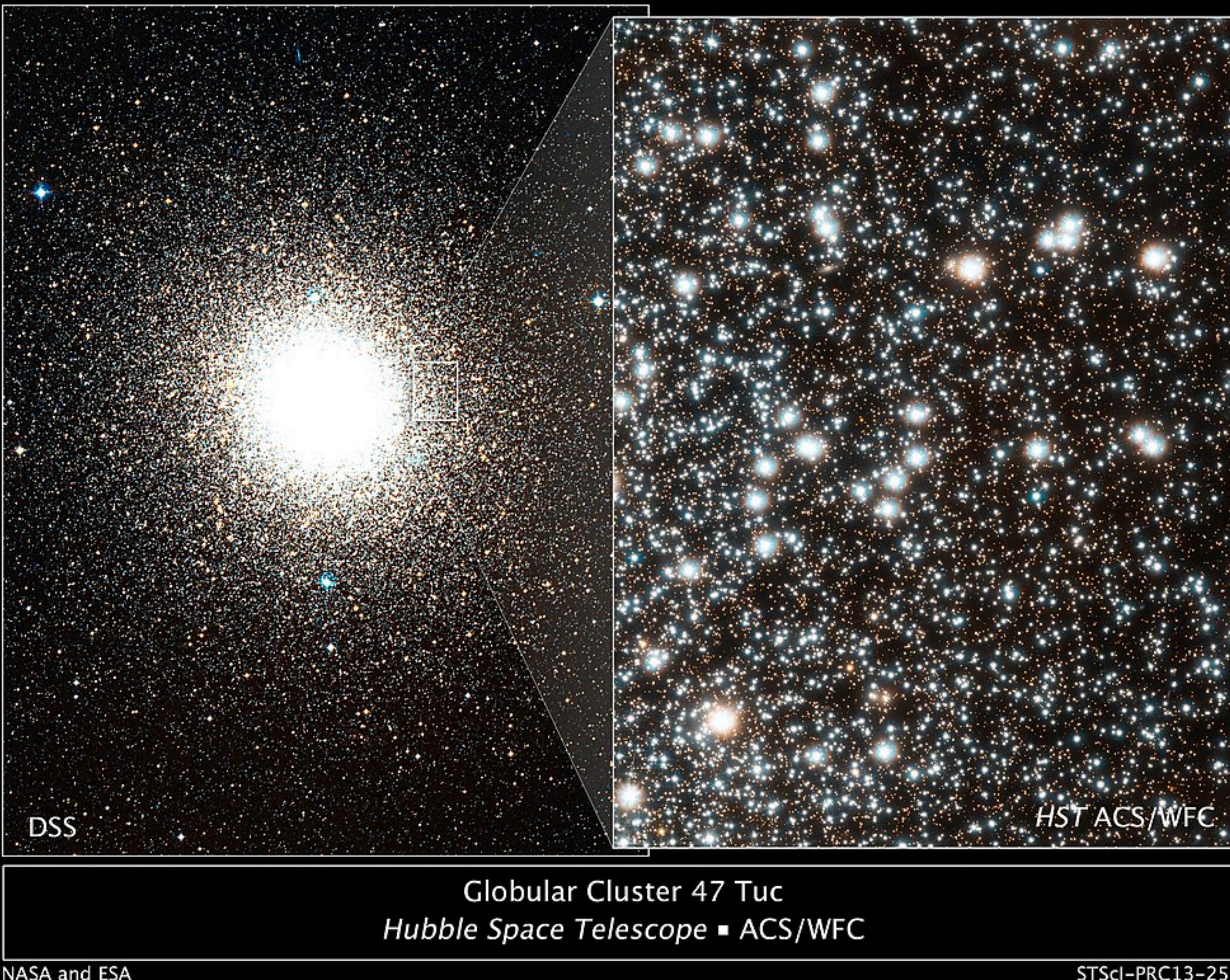
- **Open Cluster**



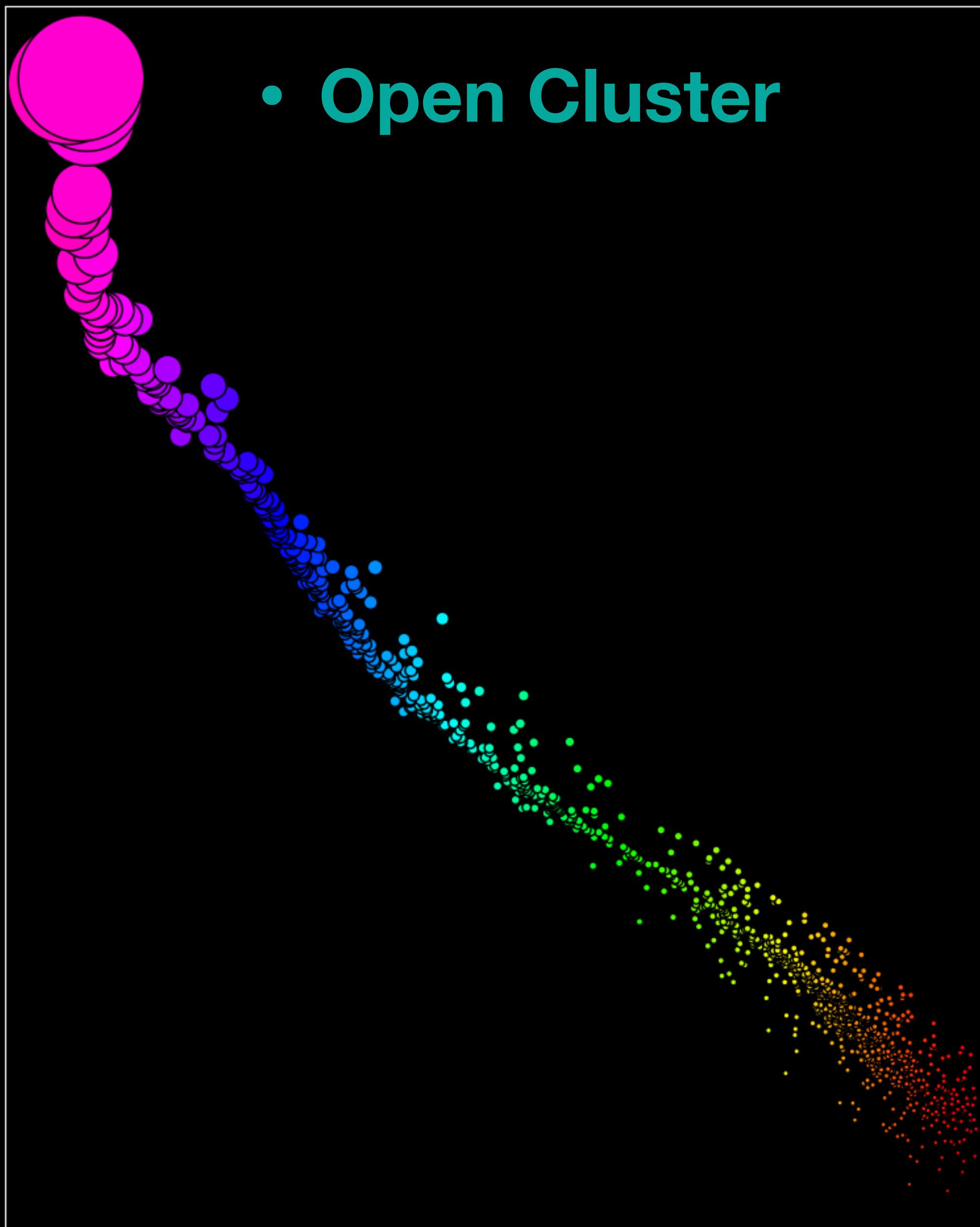
- Are young
- Near to areas of stars formation
- Have OB stars
- (Exist more sub-categories YMC, Embedded, etc.)

• Globular Cluster

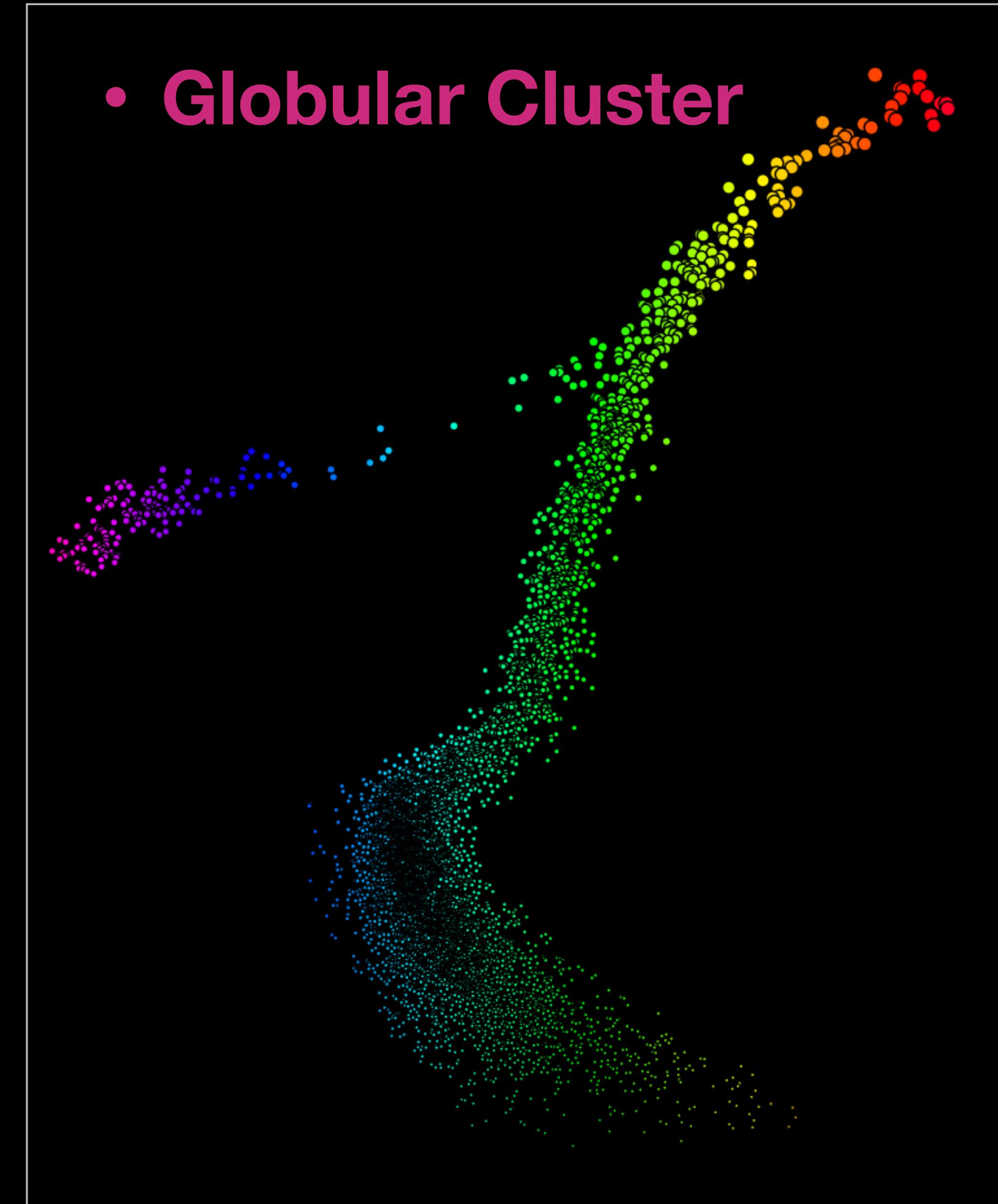
- Very old and Massive
- Can be found in the oldest structures of galaxies
- Present a unique chemical pattern (MP phenomena)
- They have all stages of stellar evolution (not very massive stars)



Photometry

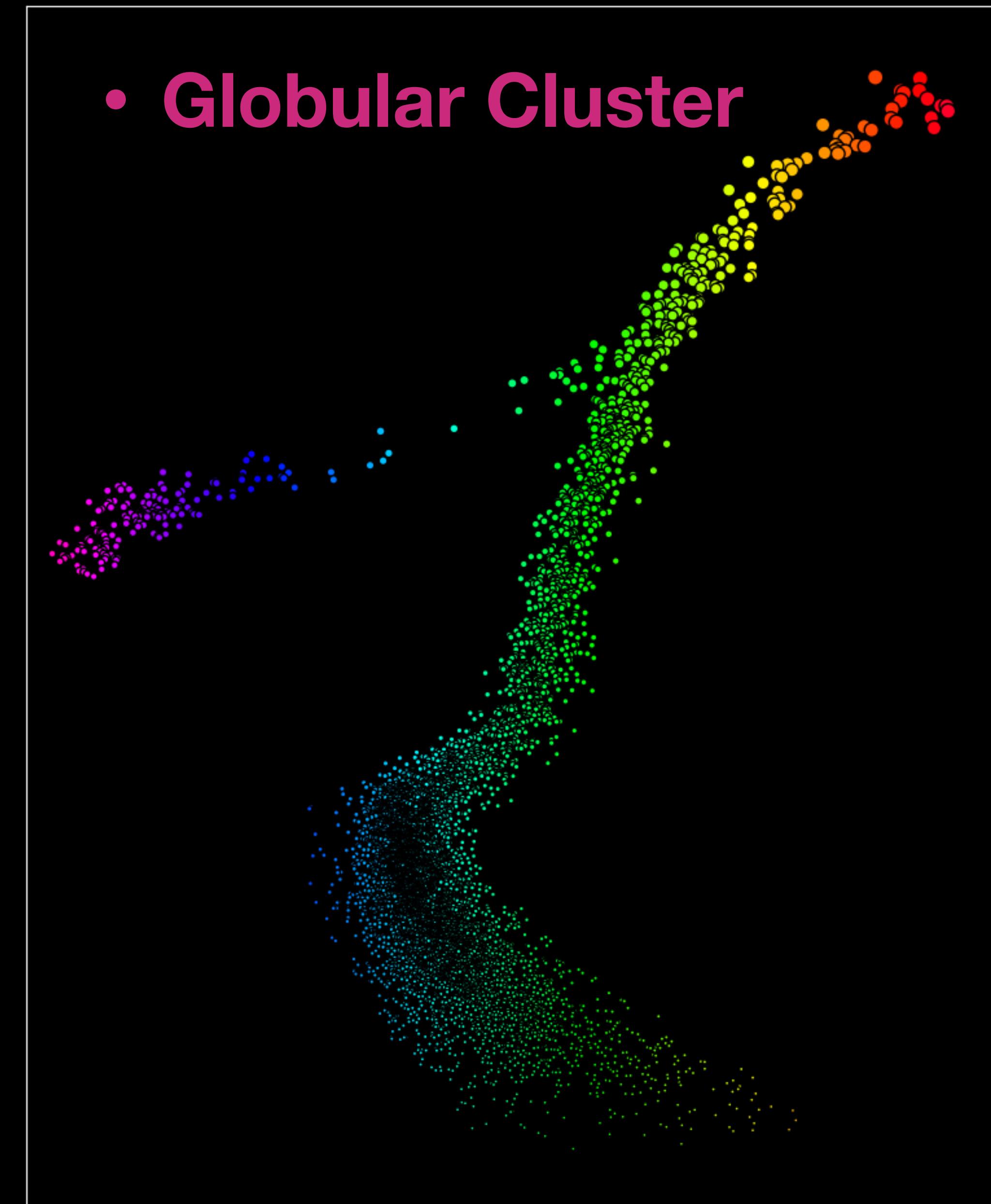
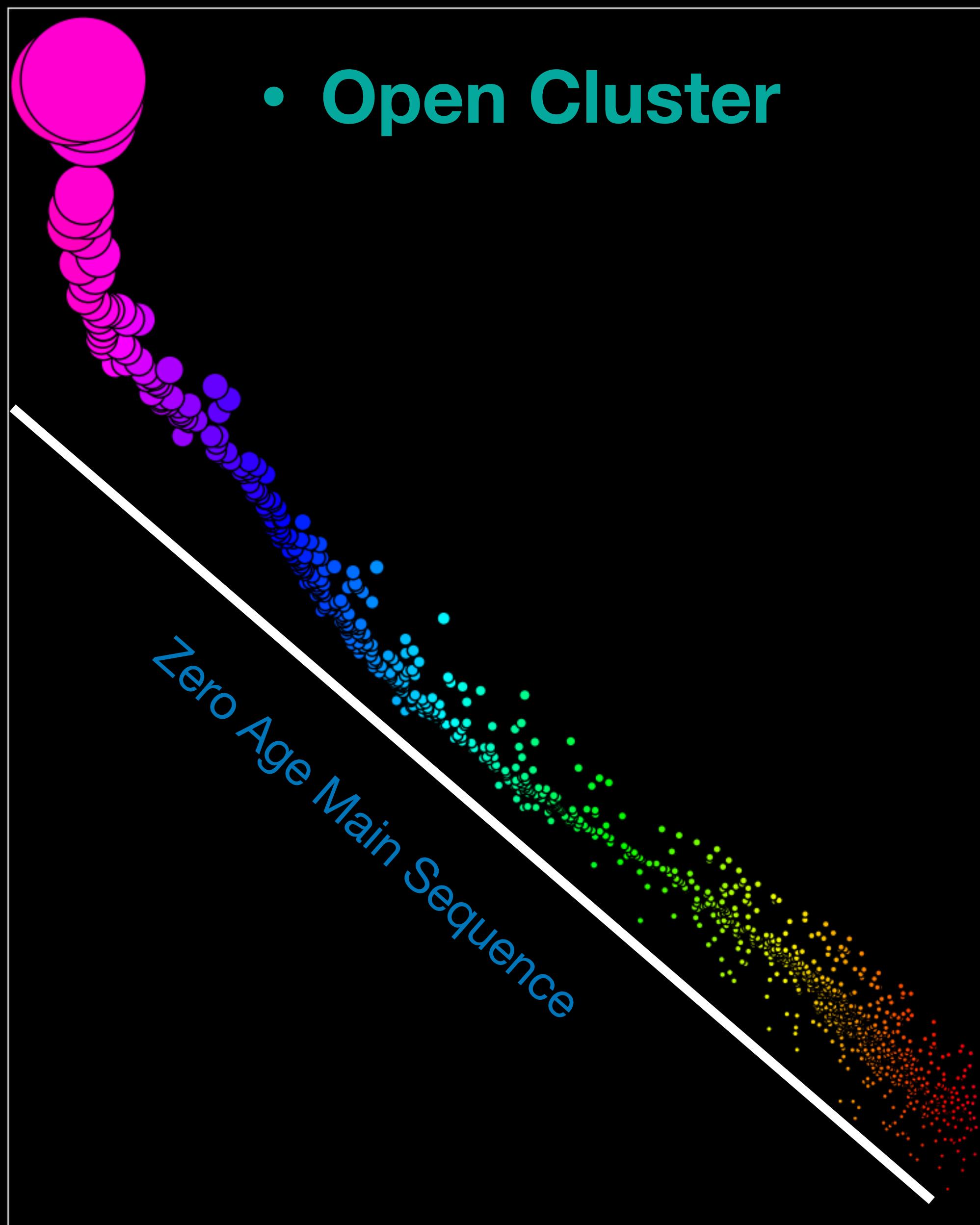


- Open Cluster

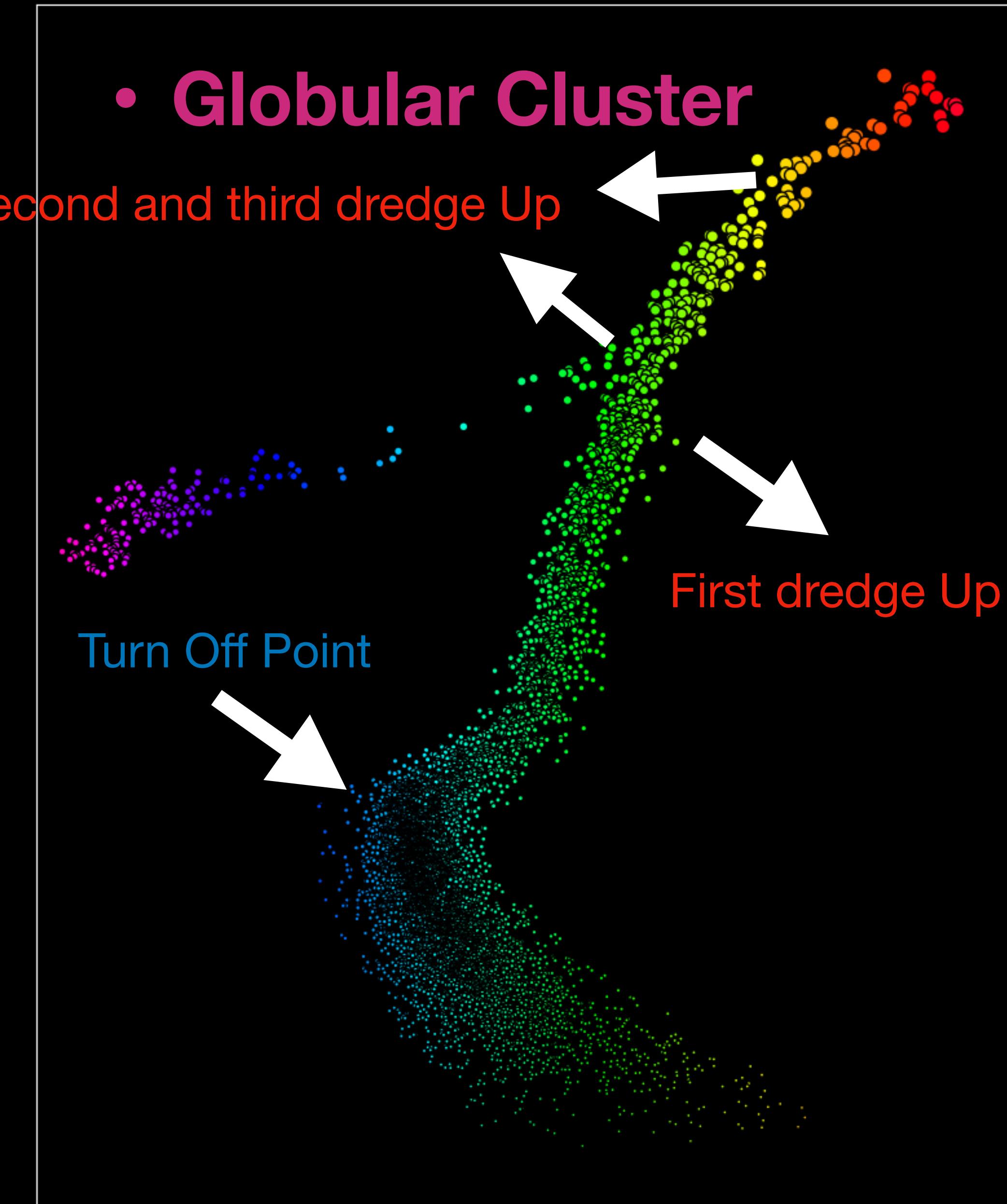
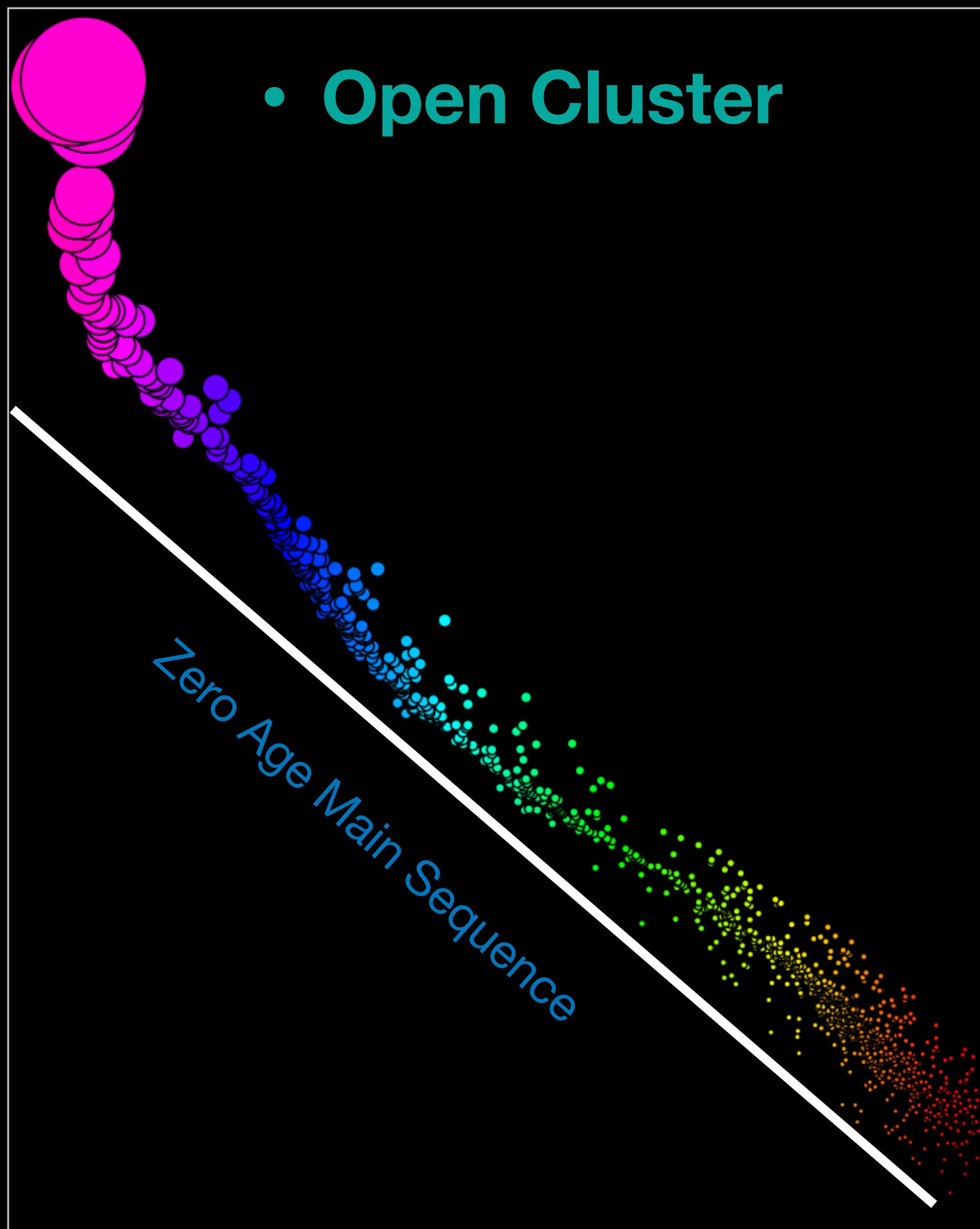


- Globular Cluster

Photometry

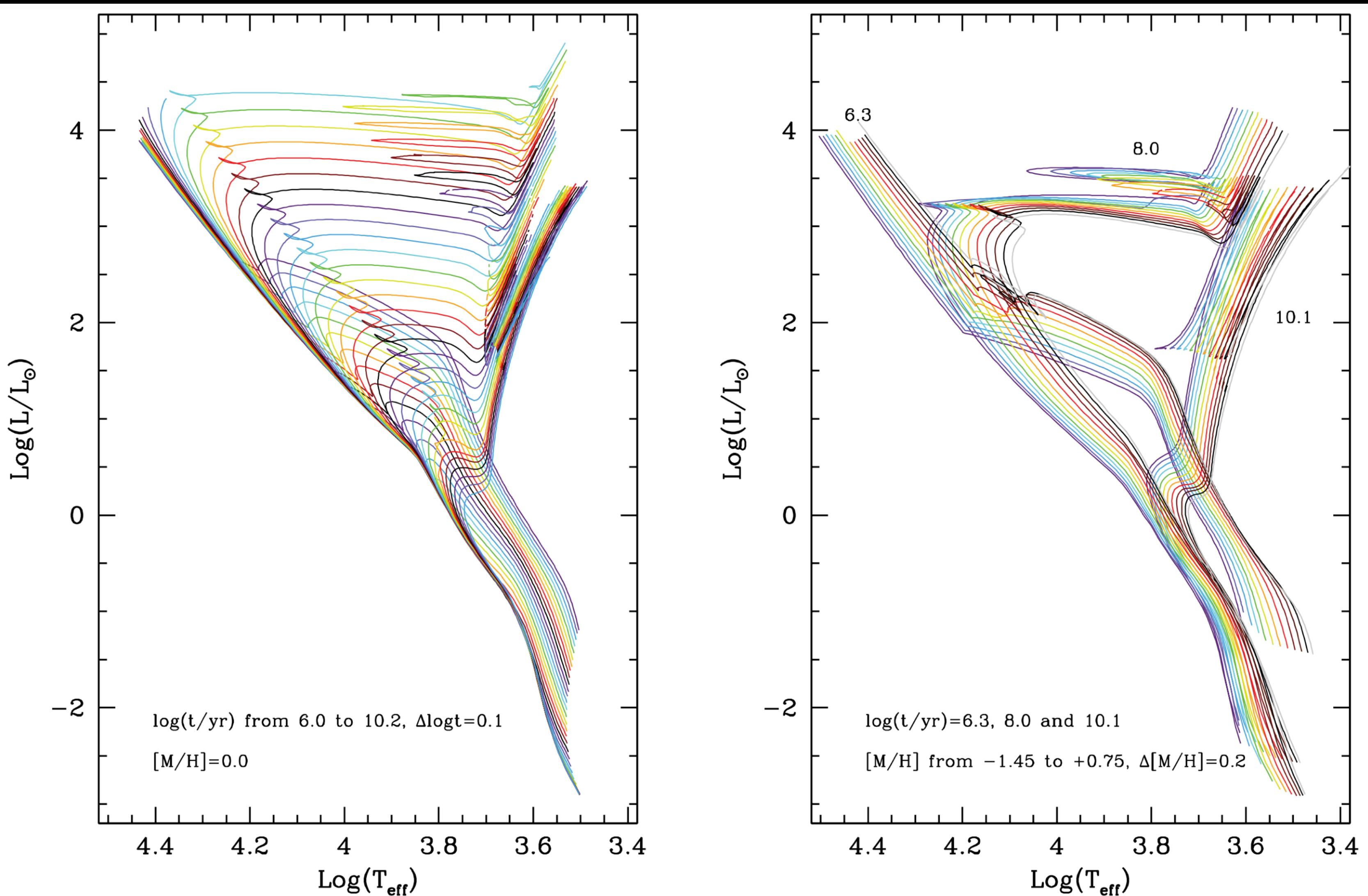


Photometry



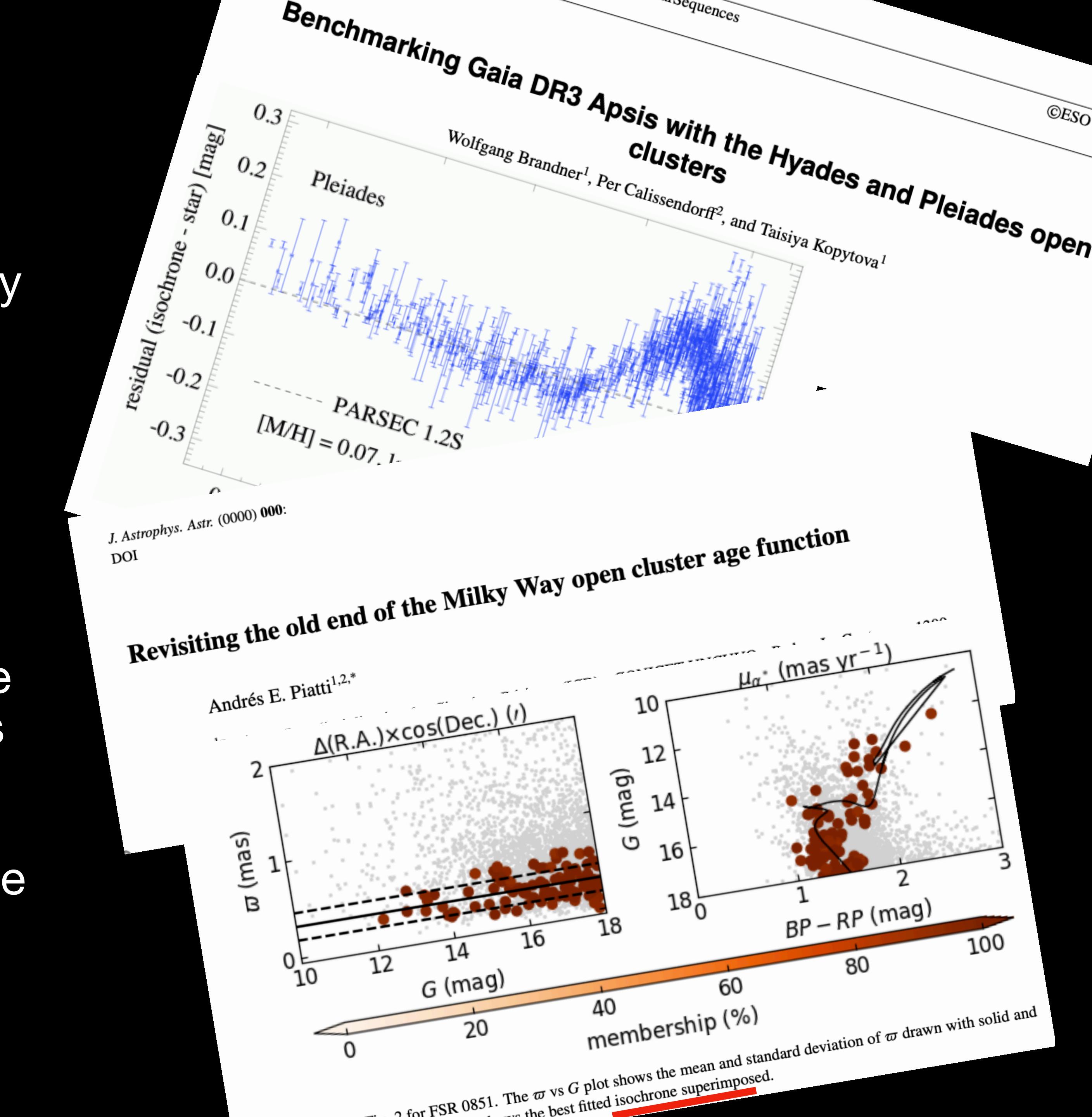
Isochrones

- Theoretical models that samples a range of masses (usually given by an IMF) with the same **AGE** and **Metallicity**



Motivation

- In general this fitting process is widely fitted by eye
(superposing the isochrone or not explicit said how the fit was done)
- And even if they talk about a fitting usually is done with a Chi2 assuming an horizontal projection which could be a good approximation but not always will describe the nature of the cluster
(But they don't talk about the distance modulus or reddening adjustment)



Of Course there exist some papers that address this problem , but I wanted to try my own approach considering the 4 main variables

A&A 516, A2 (2010)
DOI: [10.1051/0004-6361/200913677](https://doi.org/10.1051/0004-6361/200913677)
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**Astronomy
&
Astrophysics**

Fitting isochrones to open cluster photometric data

A new global optimization tool

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Received 16 November 2009 / Accepted 17 March 2010

(modulus or reddening adjustment)

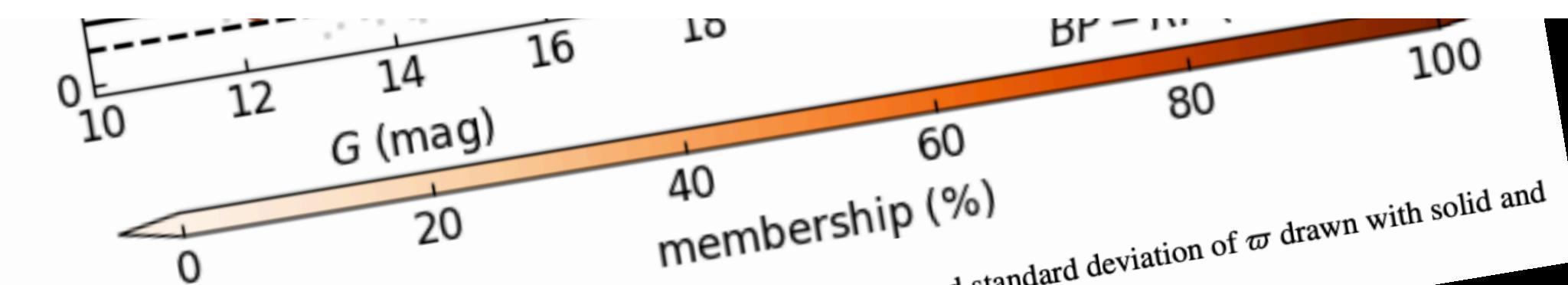


Fig. 2 for FSR 0851. The ϖ vs G plot shows the mean and standard deviation of ϖ drawn with solid and dashed lines. The horizontal red line shows the best fitted isochrone superimposed.

My project : Candidates

Close Star Clusters

- 47 Tucanae
- Second Brightest GCs in the sky
- $[Fe/H]=-0,78$ dex
- Age= 13.06 Gyr
- Distance 4.45 kpc (UM=13.29)
- $E(B-V)=0.04$ (Av approx 0.12)



NASA and ESA

Globular Cluster 47 Tuc
Hubble Space Telescope ■ ACS/WFC

STScI-PRC13-25a

My project : Candidates Close Star Clusters

- M4
- The closest GCs
- $[\text{Fe}/\text{H}] = -1.07$
- Age = 11.5 Gyr
- Distance = 1850 pc (UM: 11.33)
- $E(B-V) = 0.35$ (Av approx 1.07)



My project : Candidates

Close Star Clusters

- M 22
- One of the first discovered GCs
- $[\text{Fe}/\text{H}] = -1.49$
- Age = 12 Gyr
- Distance = 3300 pc (UM: 12.6)
- $E(B-V) = 0.34$ (Av approx 1.04)



My project : Candidates

Close Star Clusters

- Melotte 22
- Among the nearest Star Clusters
- $[Fe/H] = 0.07$
- Age = 115 Myr
- Distance = 136 pc (UM: 5.68)
- $E(B-V) = 0.03-0.4$ Av approx 0.09-1.23

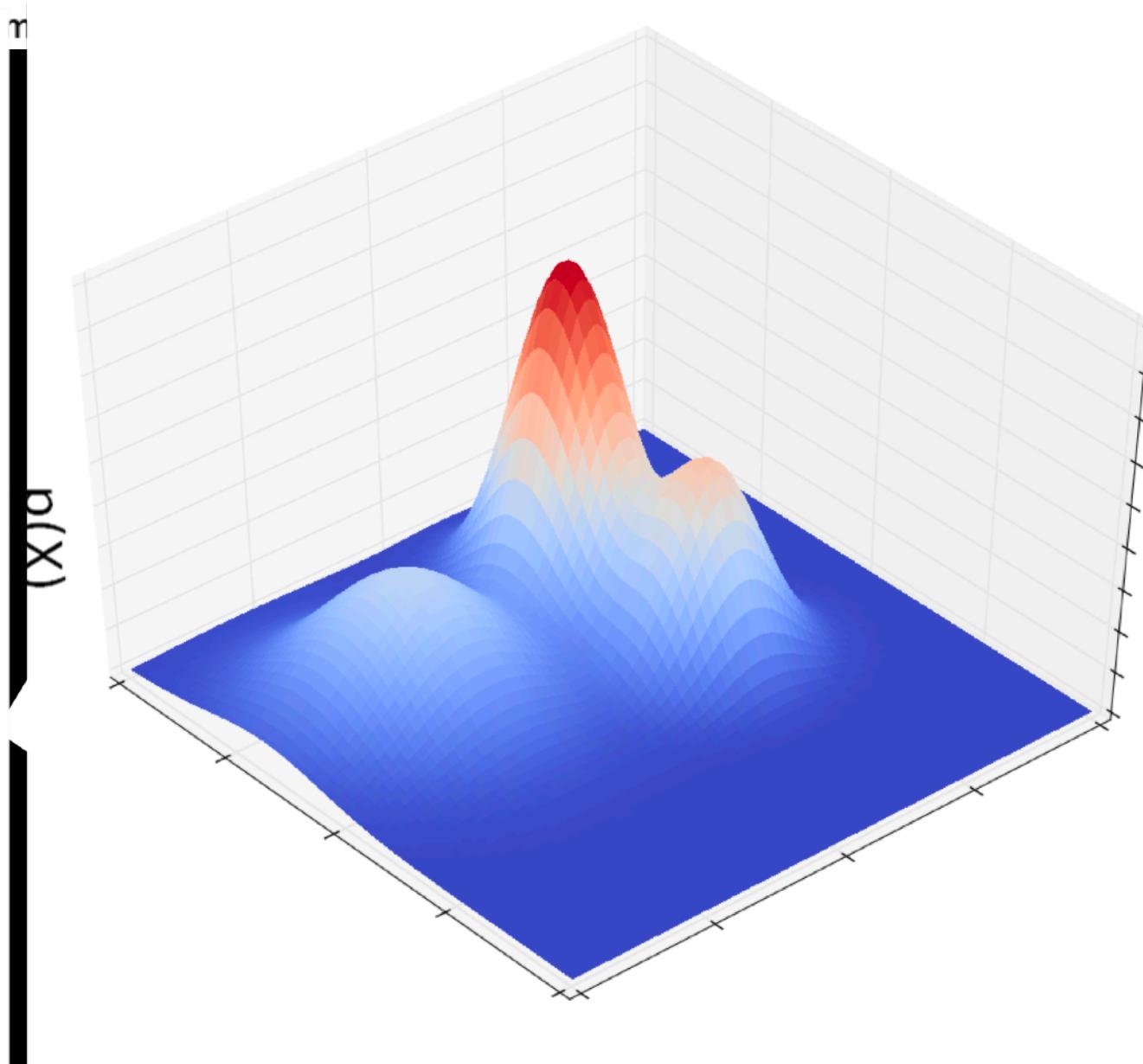
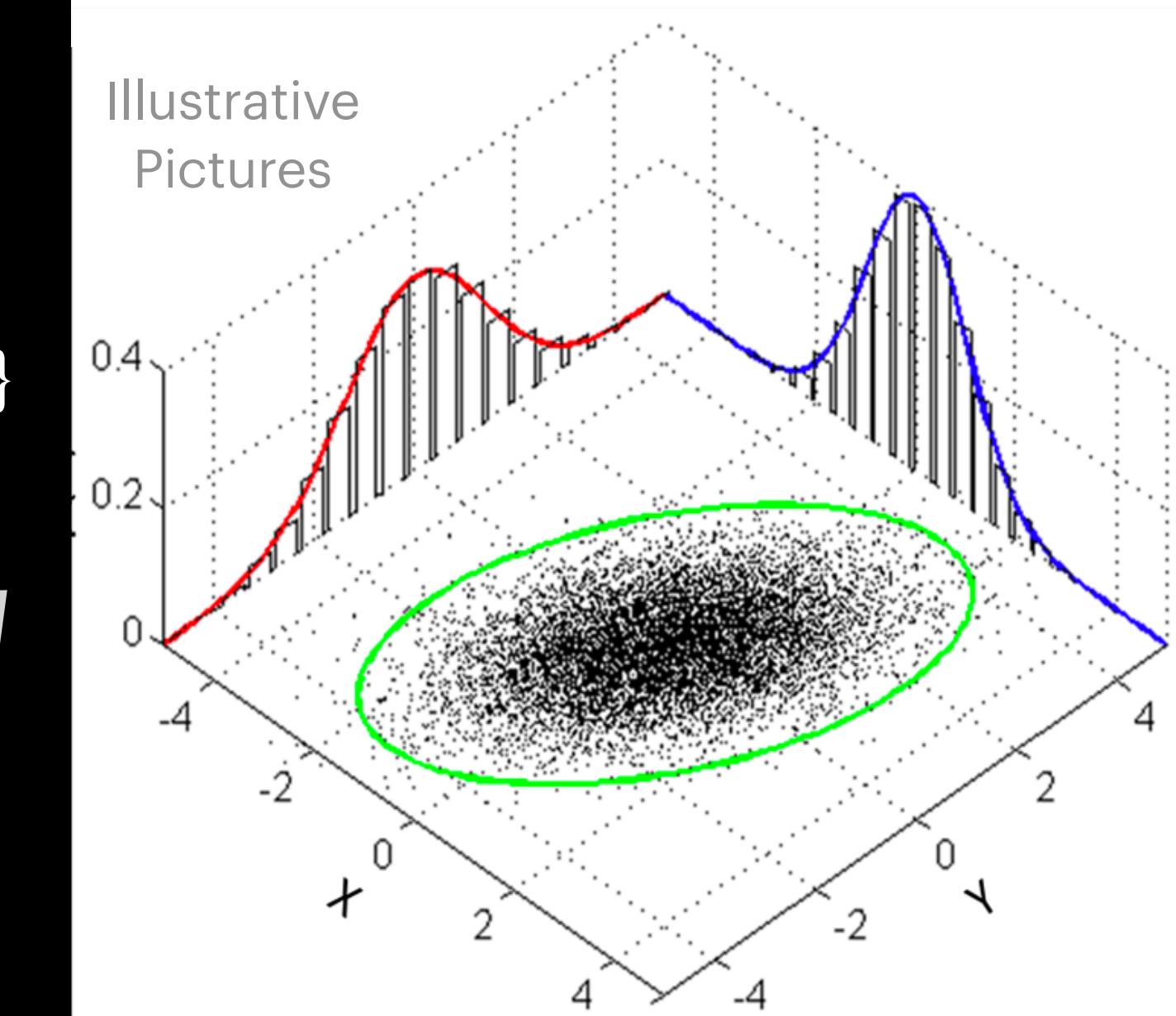
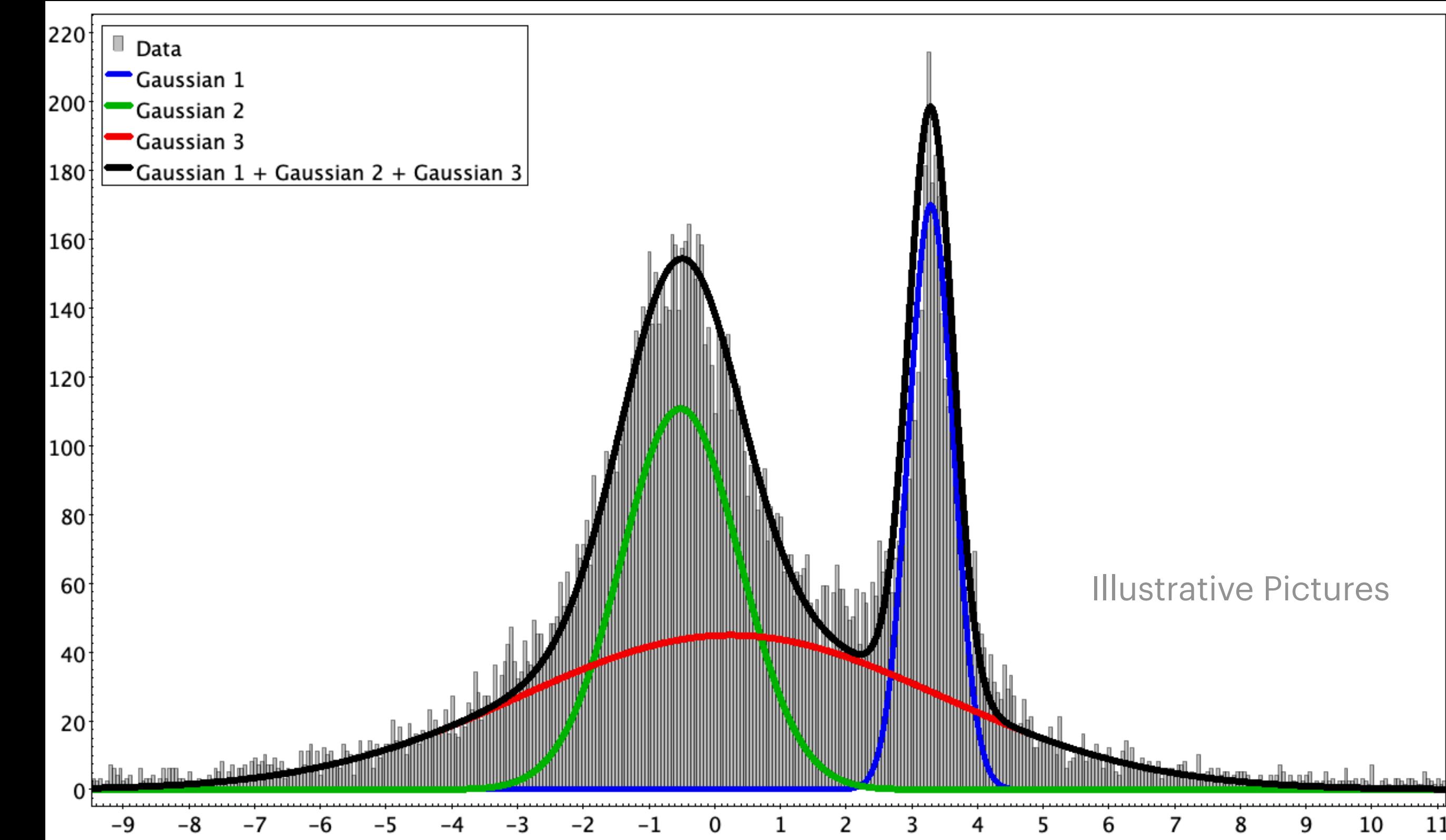


My project : First Step

Estimation of Likely members

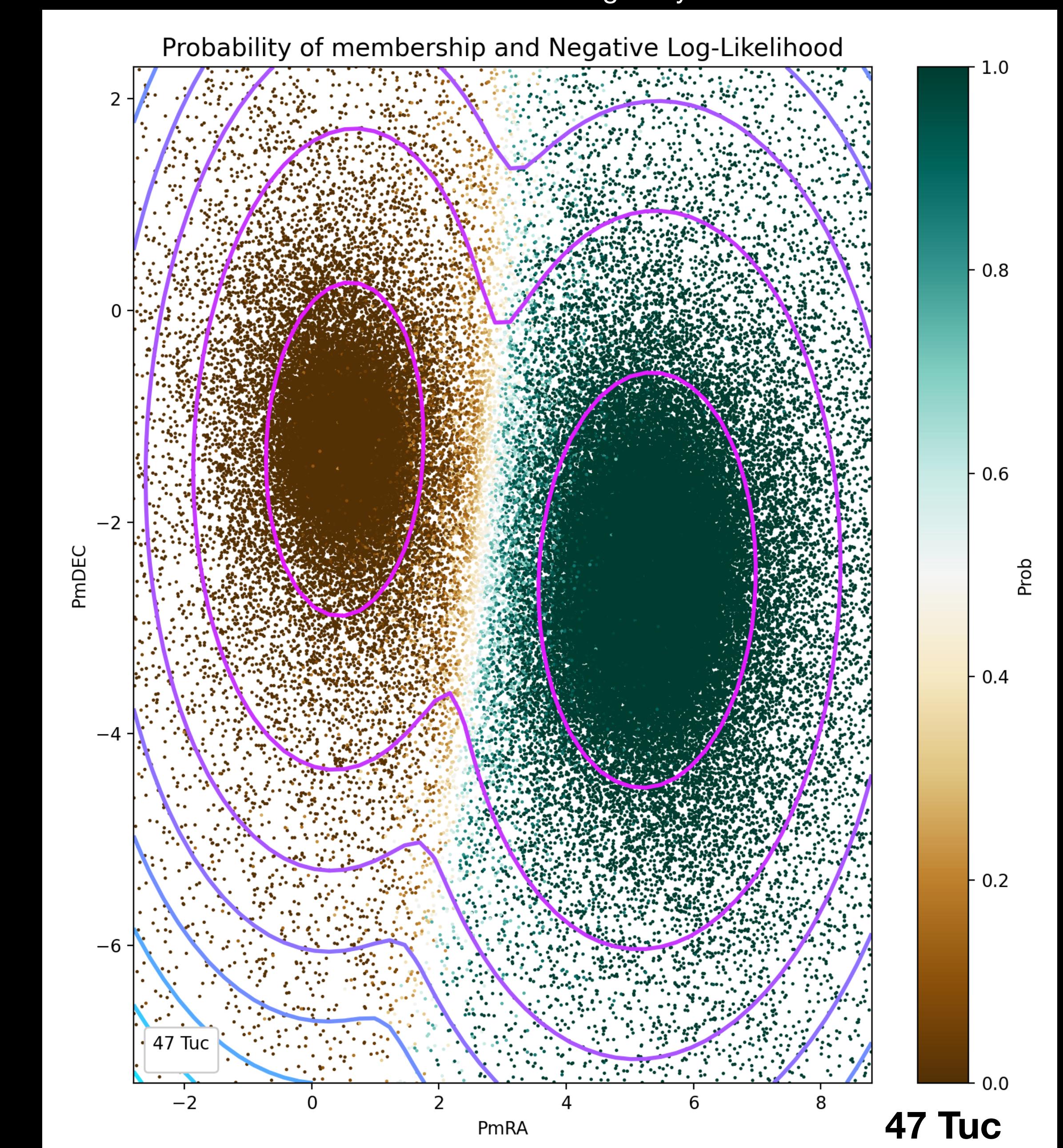
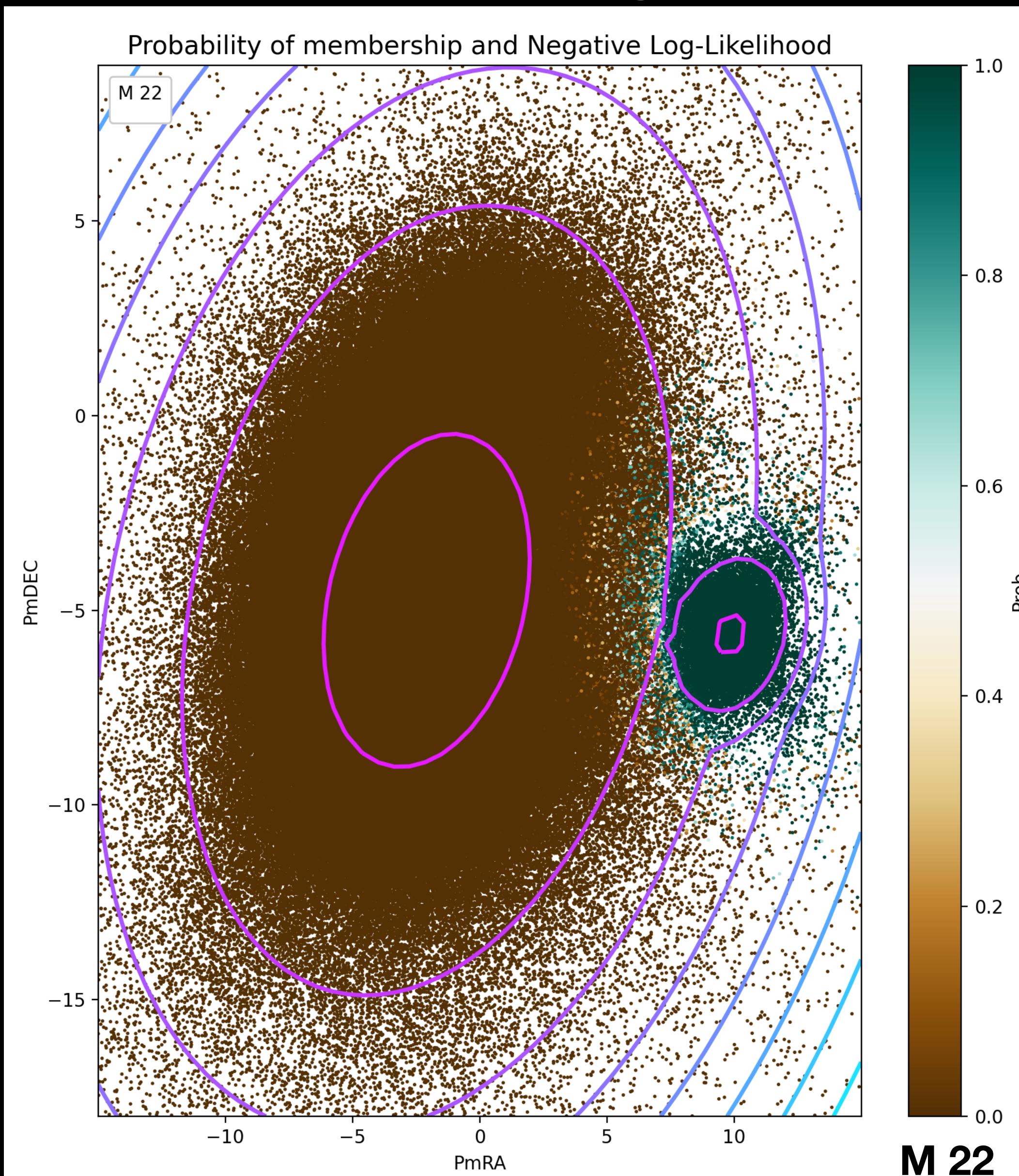
$$Prob_C(i) = \frac{\Phi_C(i)}{\Phi(i)} ; \quad \Phi = \Phi_C + \Phi_F$$

$$\mathcal{N}(\vec{X} | \vec{\mu}, \Sigma) = \frac{1}{(2\pi)^{1/2}} \frac{1}{|\Sigma|^{1/2}} \exp\left\{-\frac{1}{2}(\vec{X} - \vec{\mu})^T \Sigma^{-1} (\vec{X} - \vec{\mu})\right\}$$



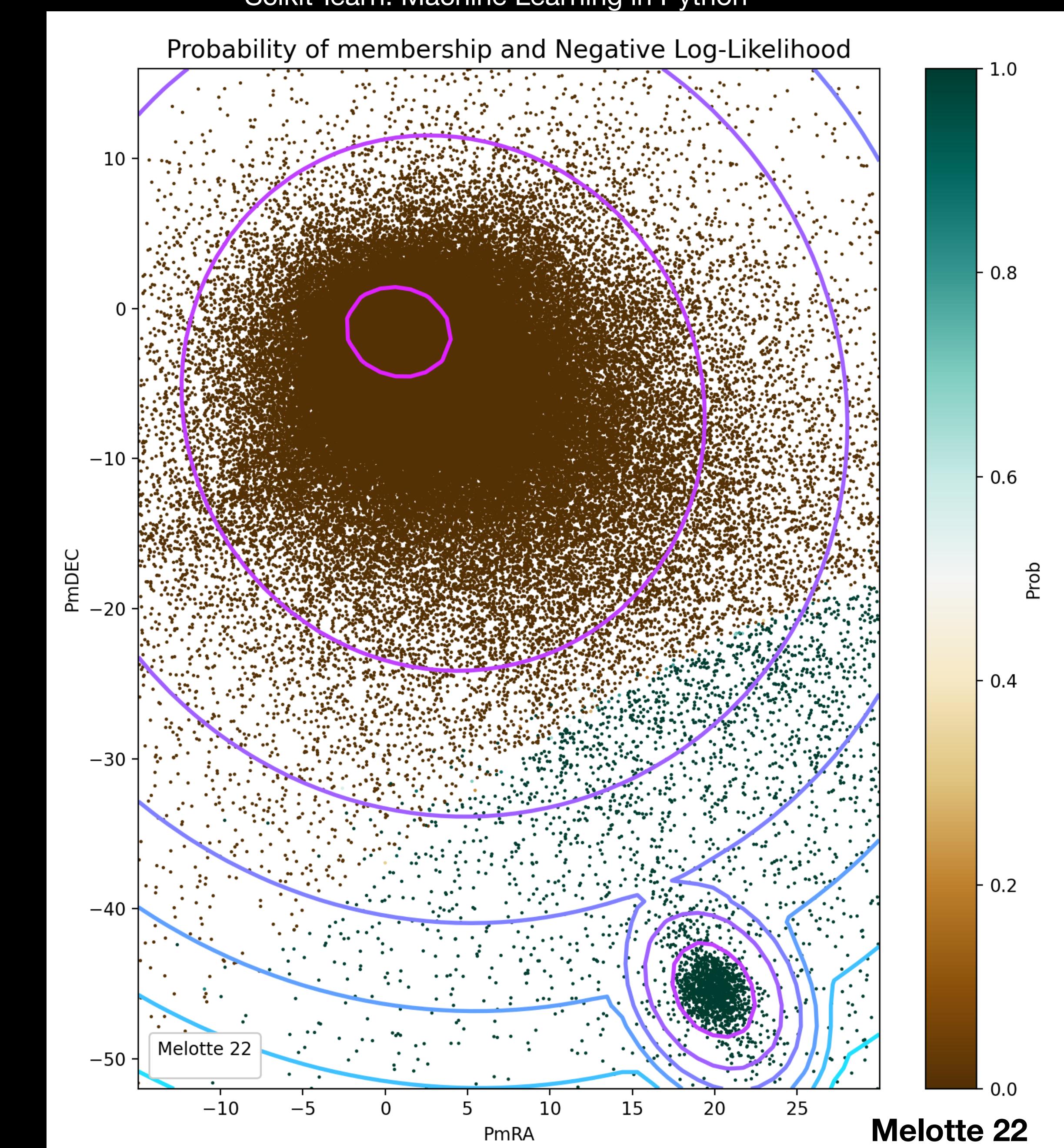
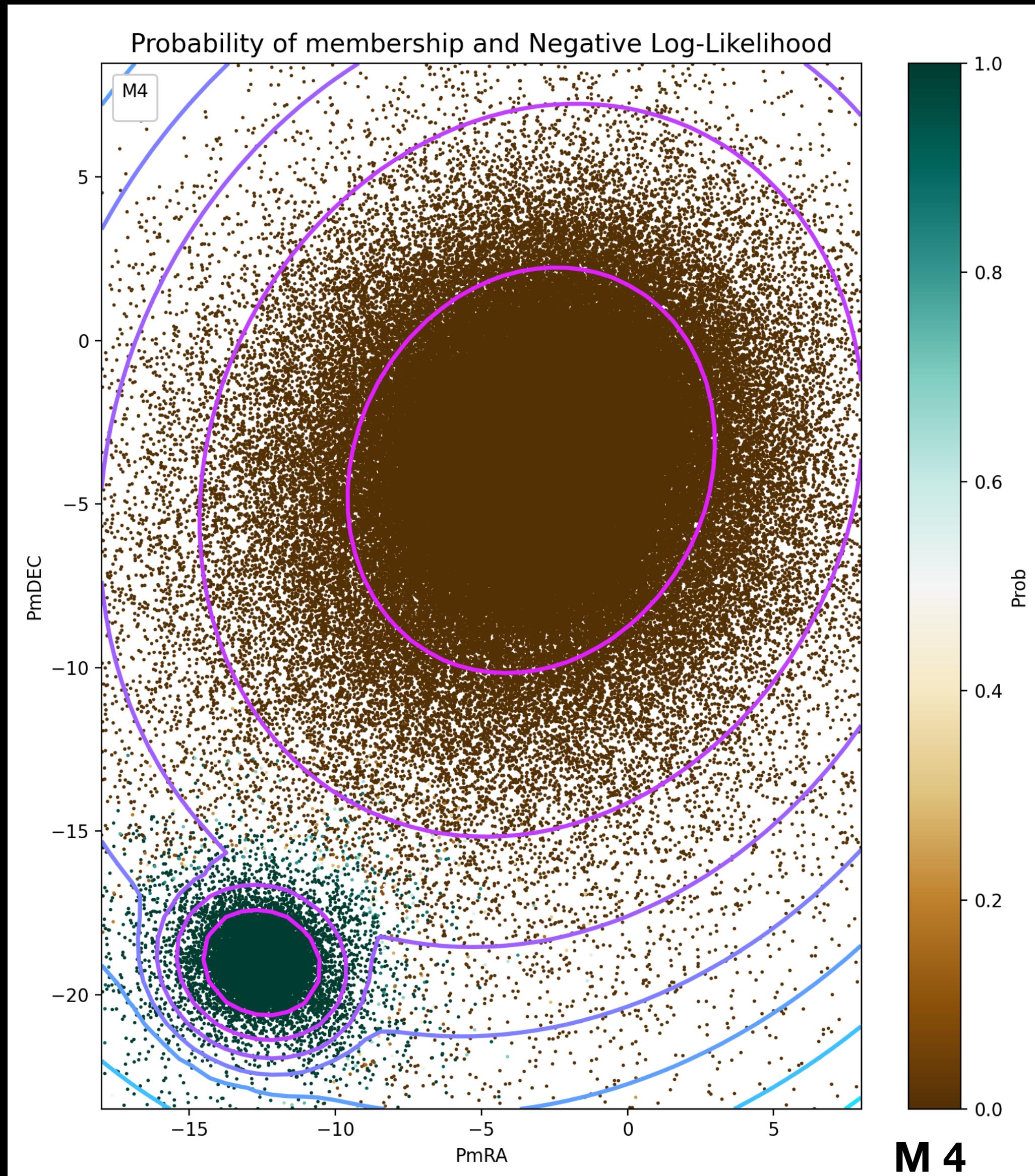
My project : First Step

Estimation of Likely members



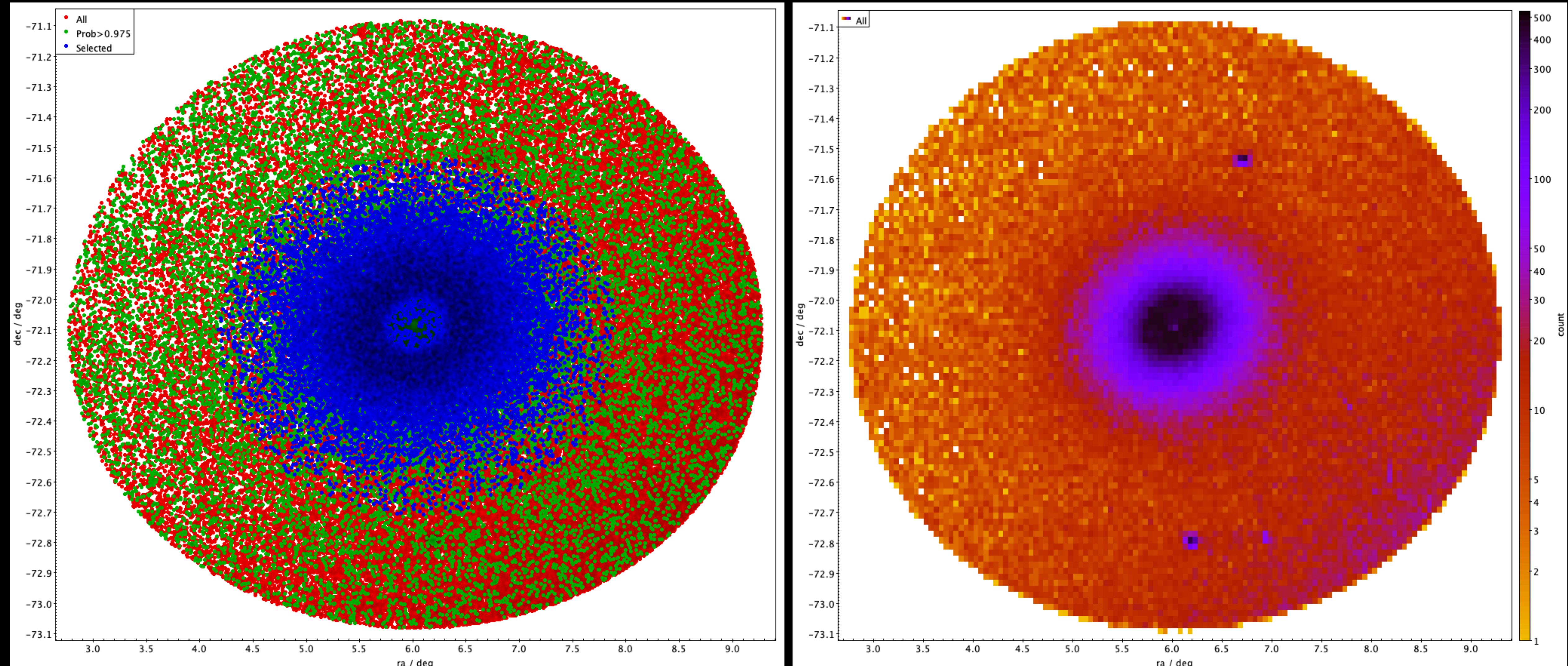
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Estimation of Likely members



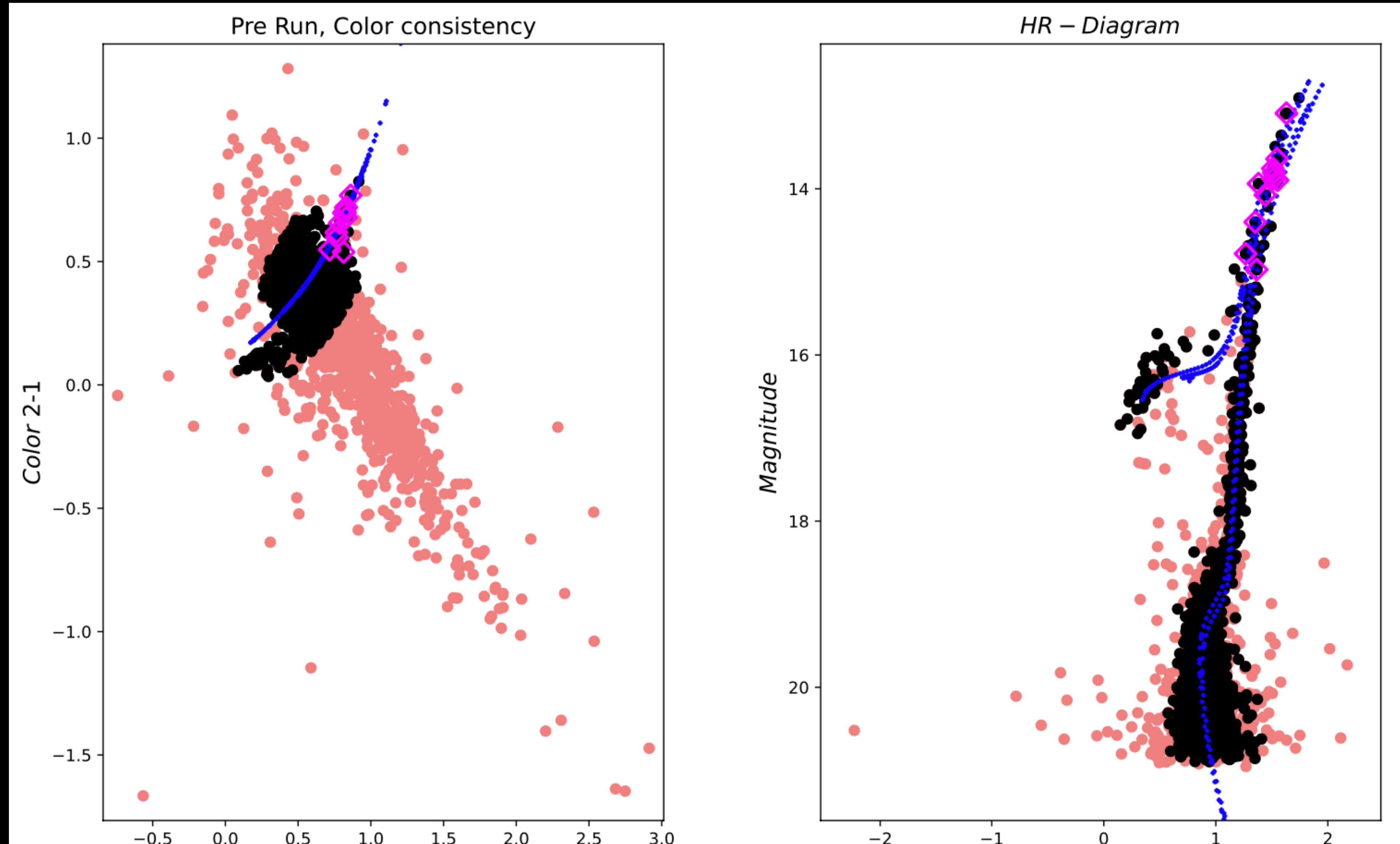
My project : First Step

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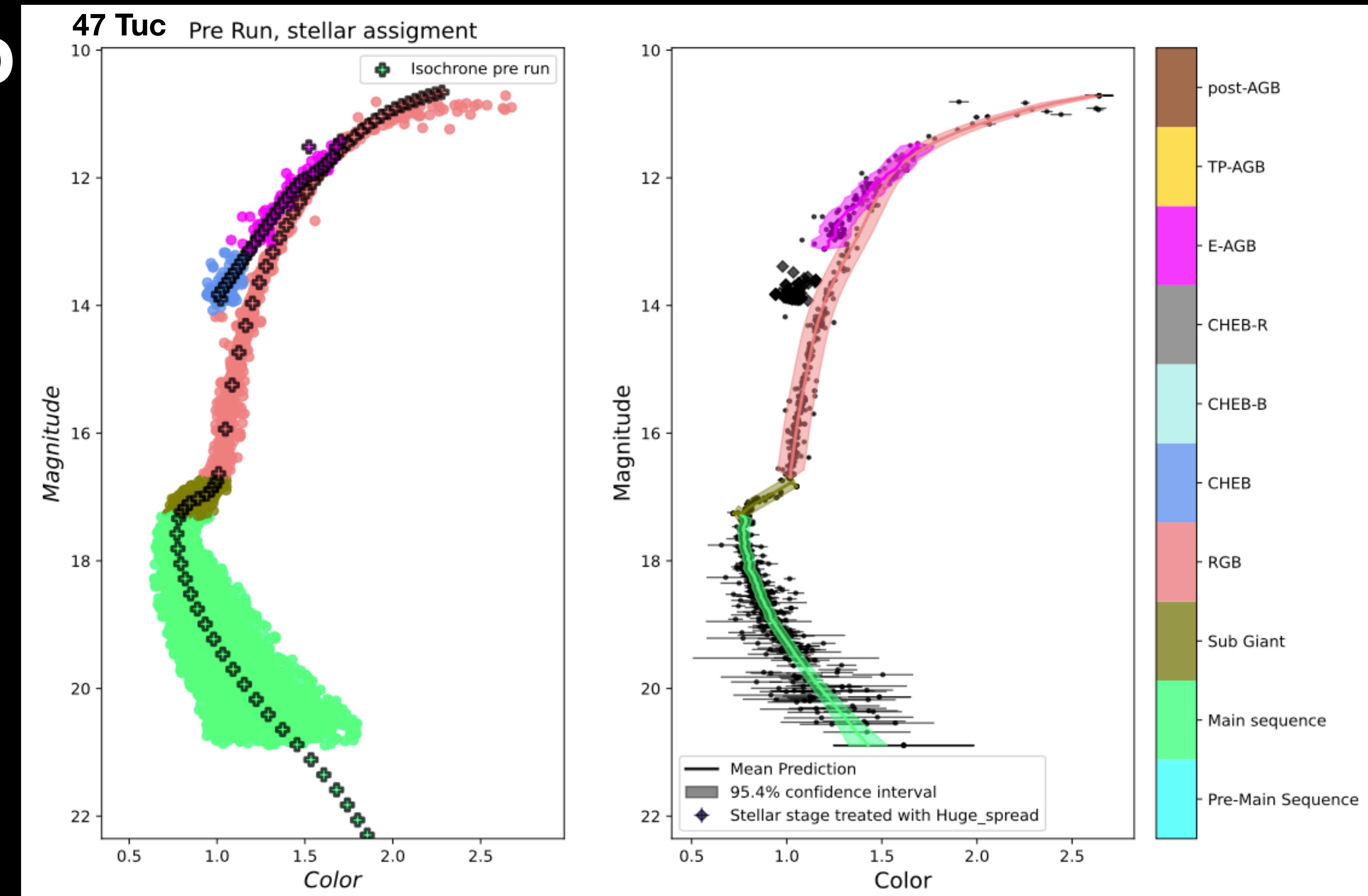
My project : First Step

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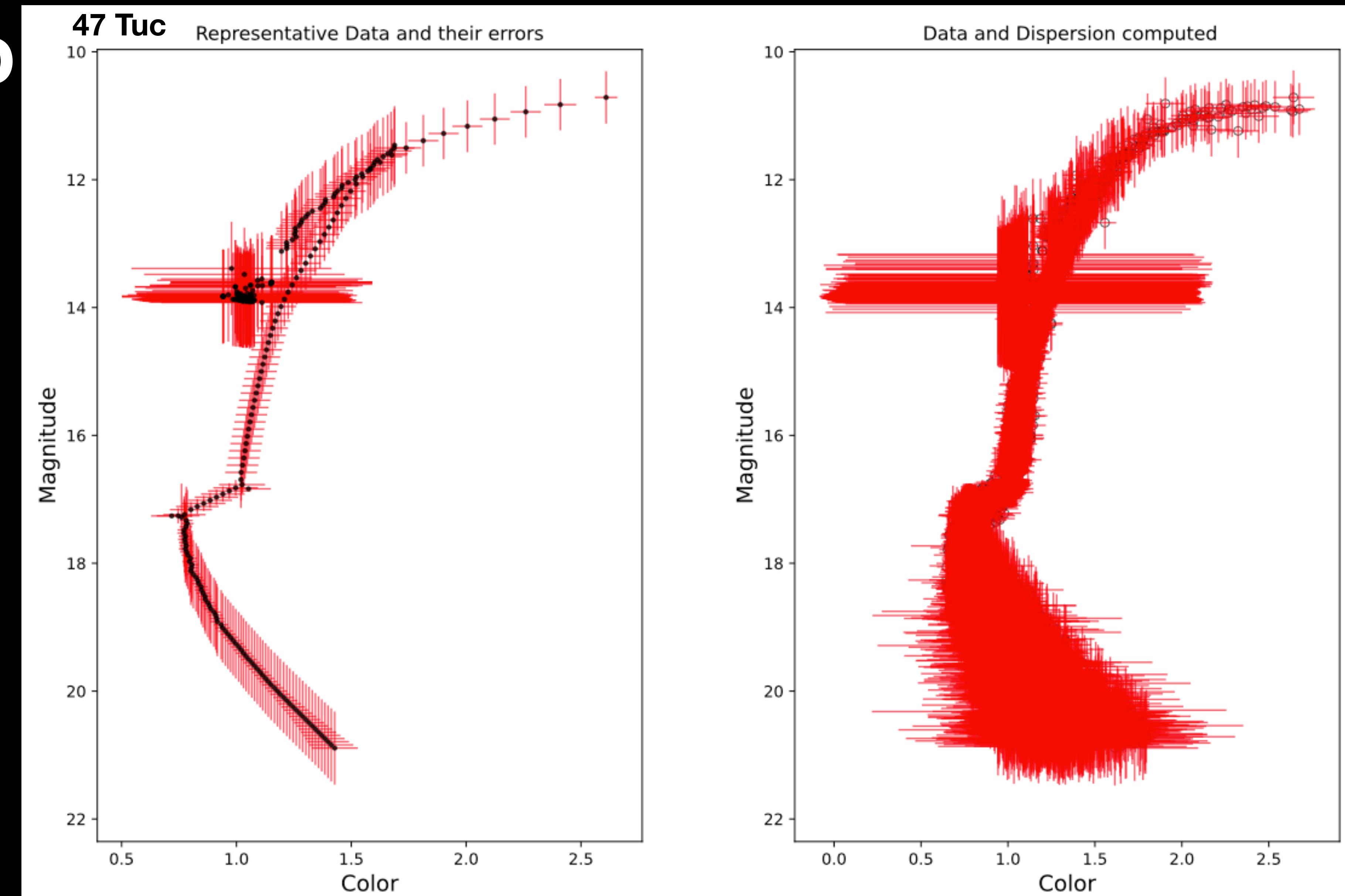
My project : Second Step

Inference of
intrinsic dispersion
of the stellar stage



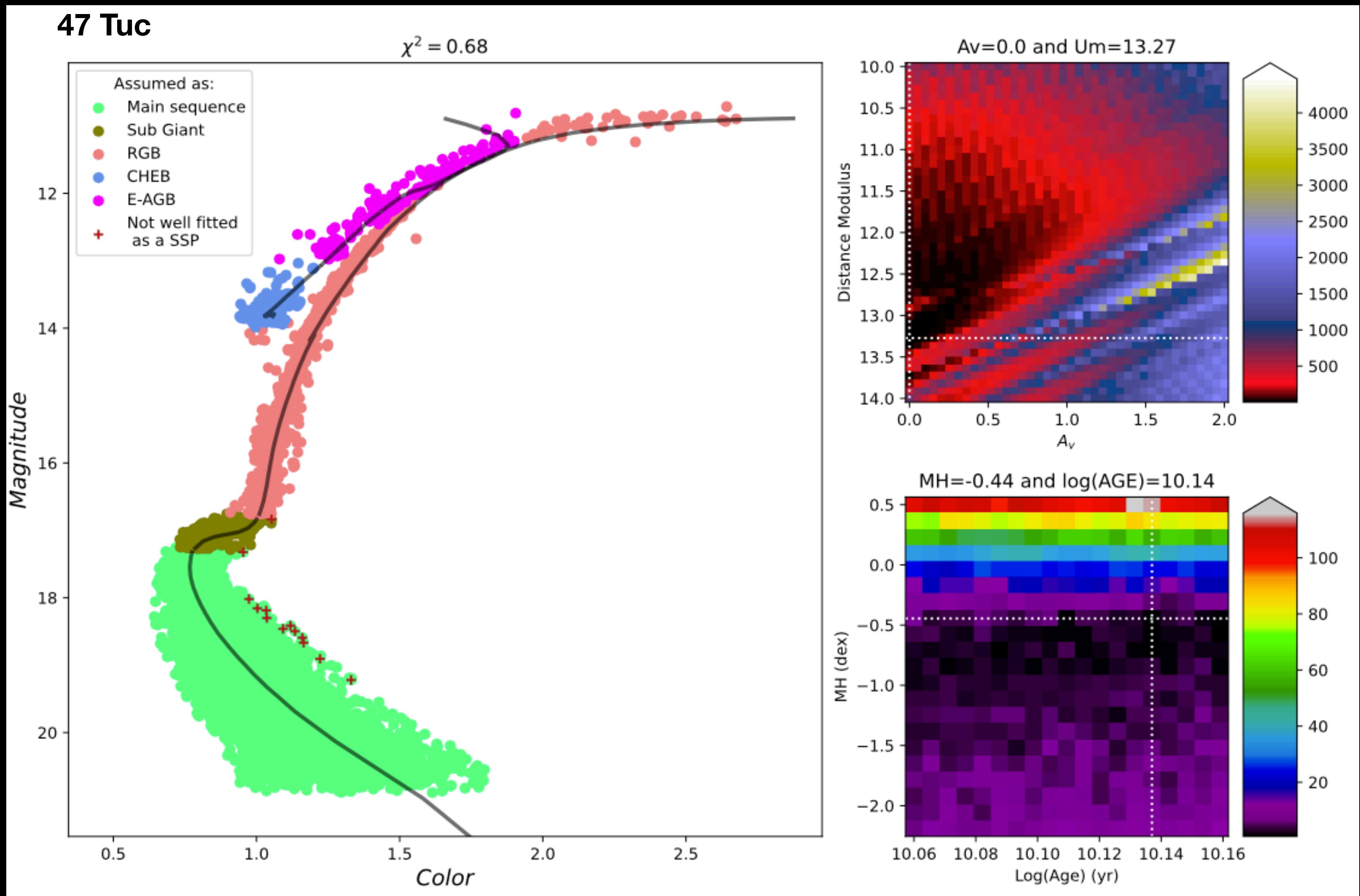
My project : Second Step

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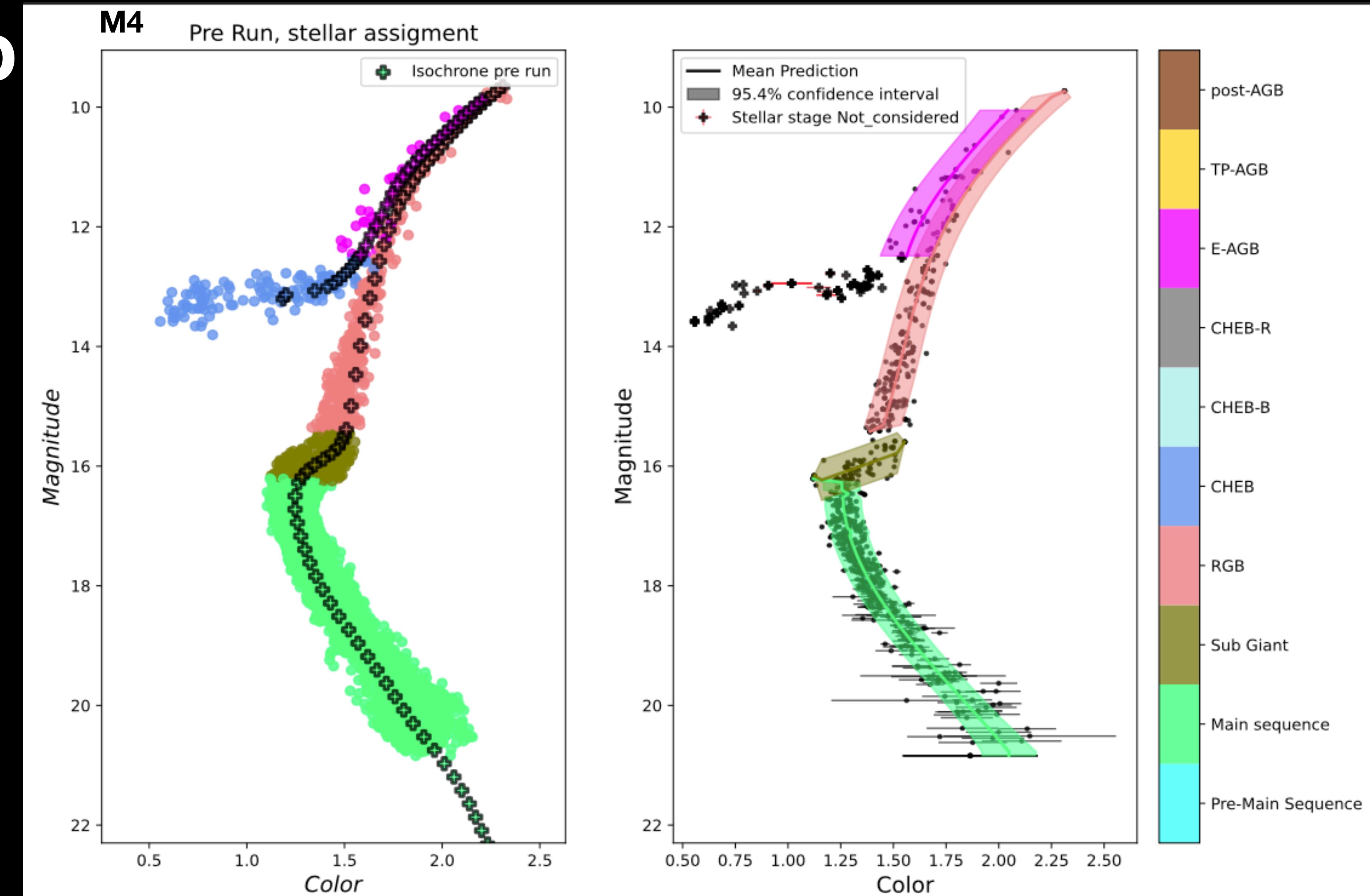
My project : Third Step

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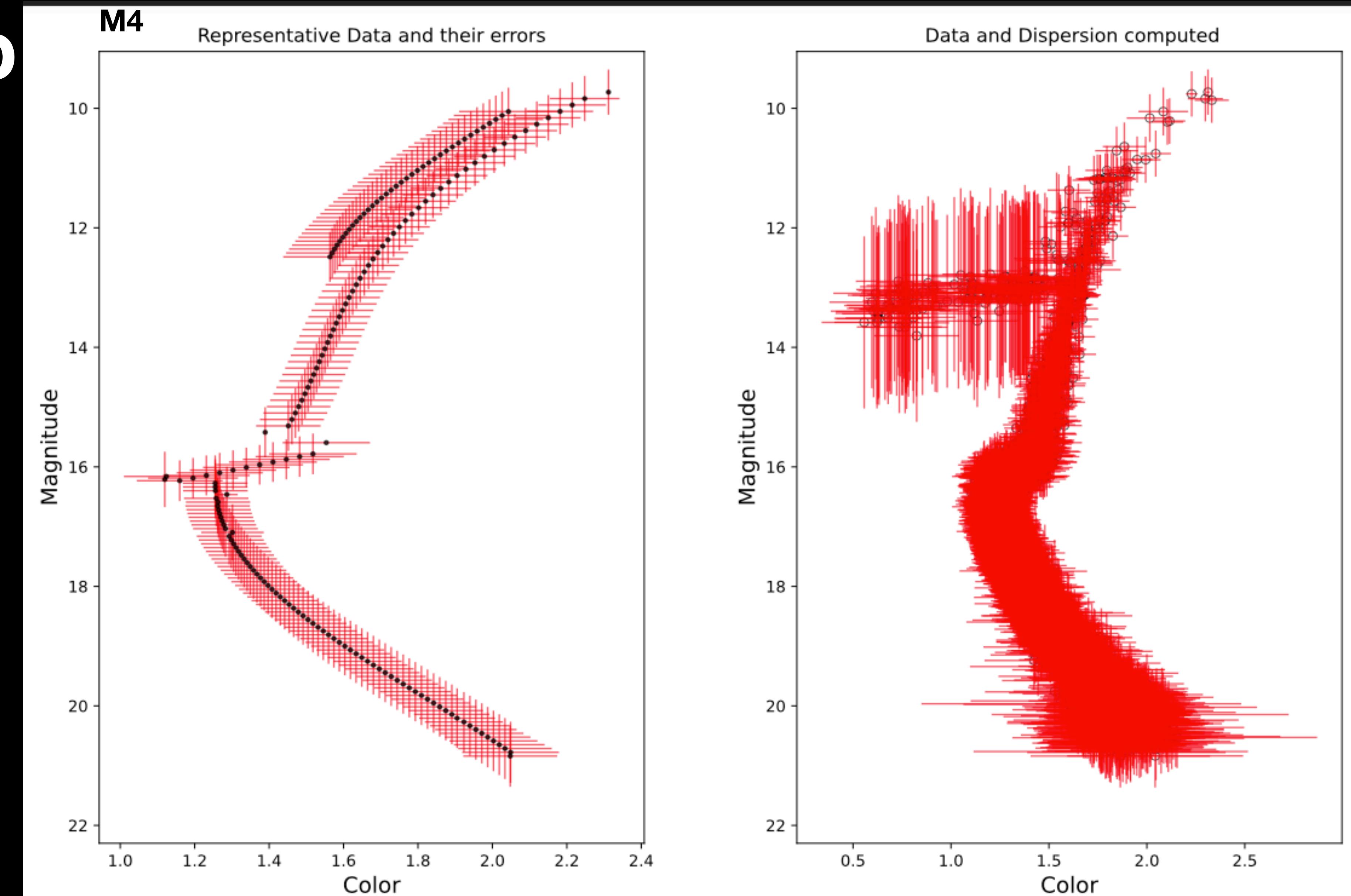
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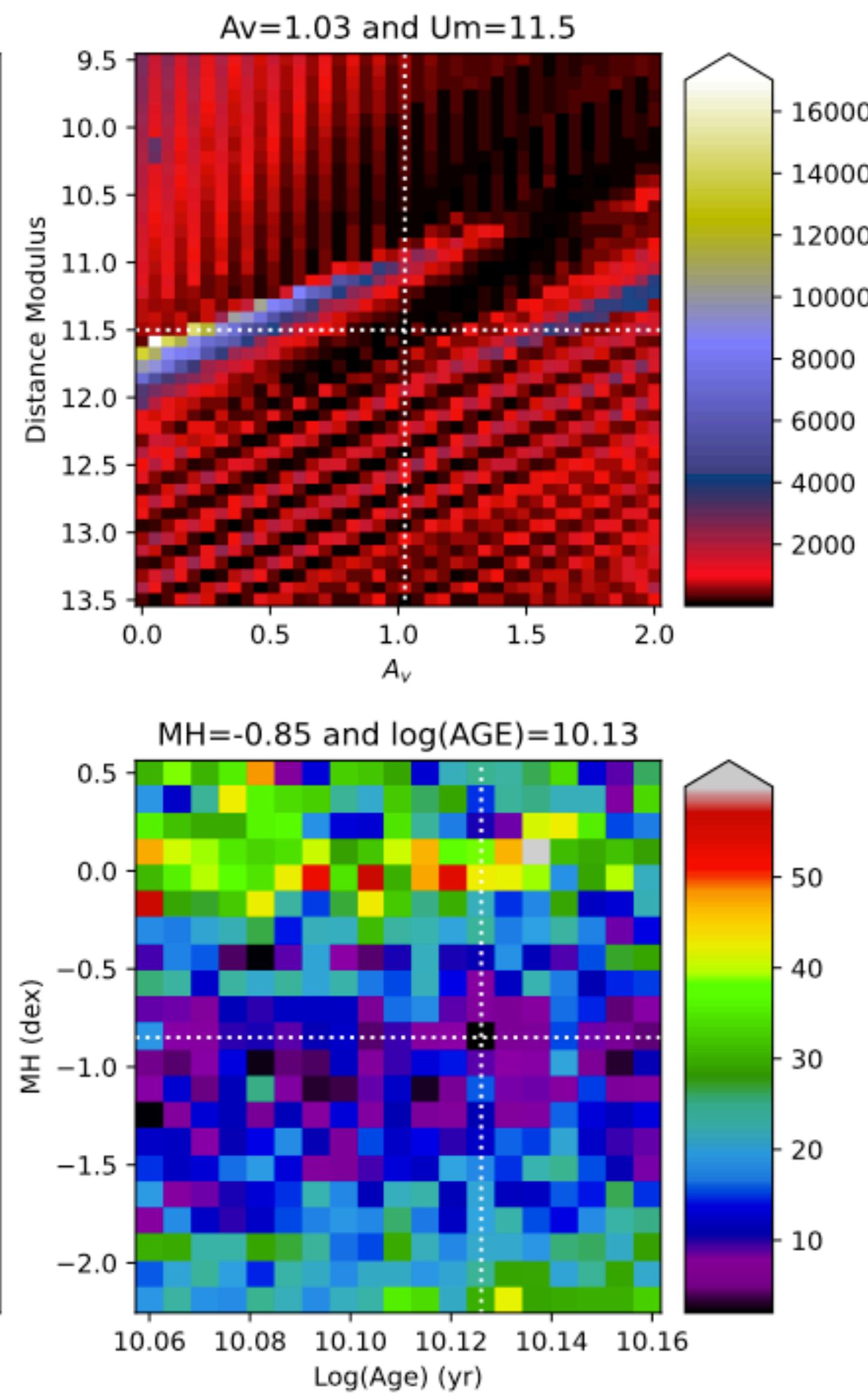
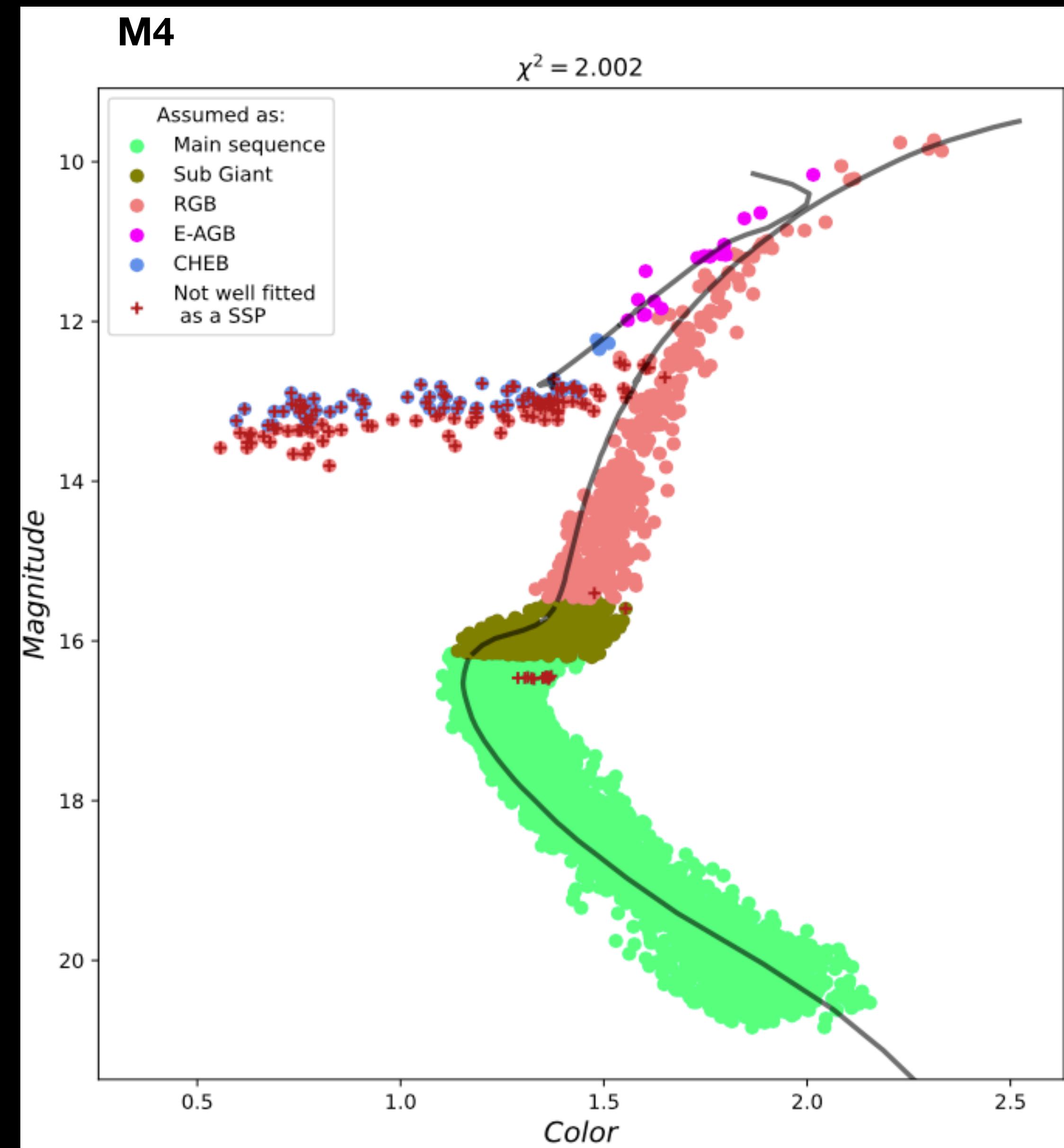
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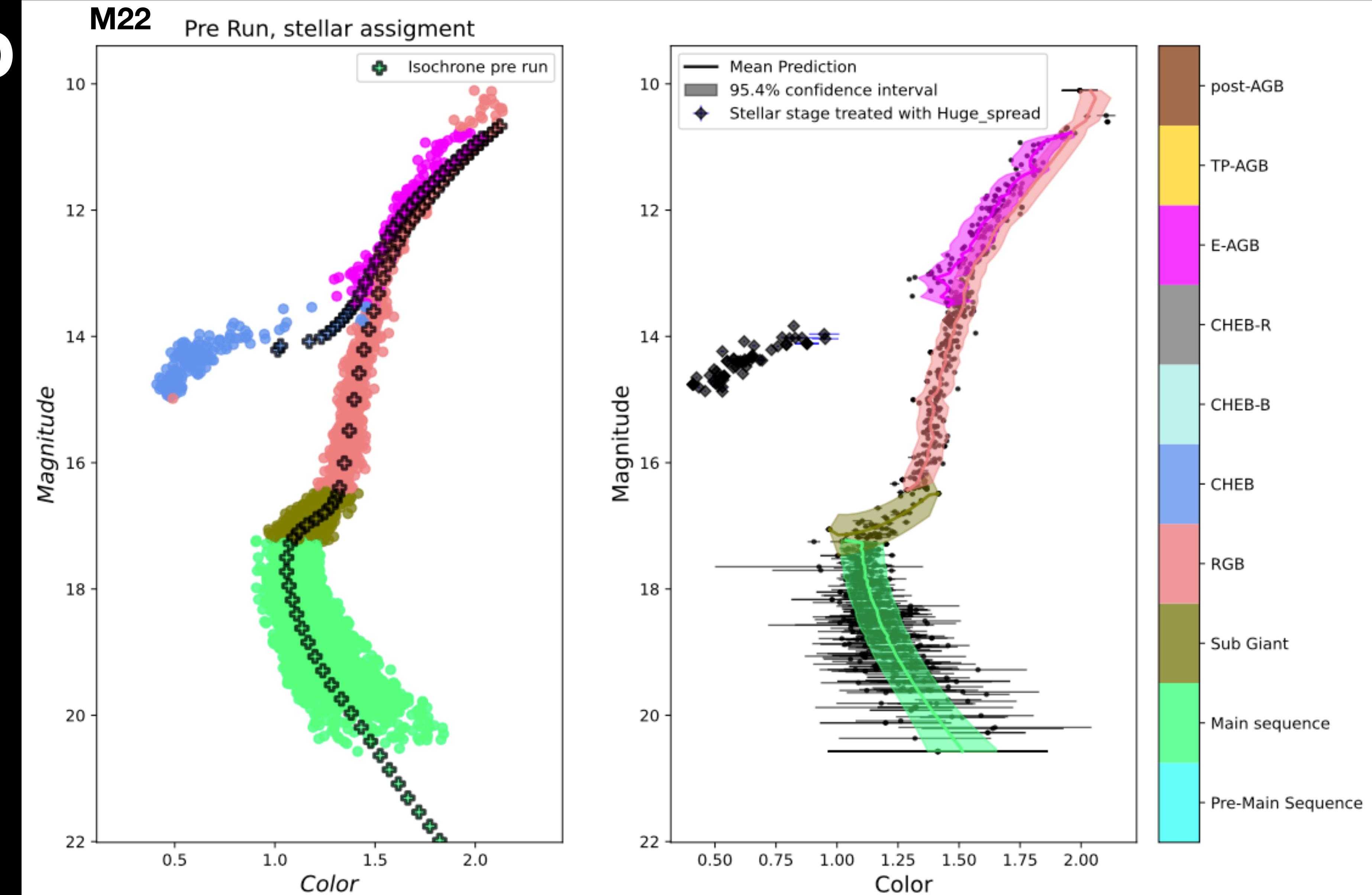
My project : Third Step

Mapping the
likelihood



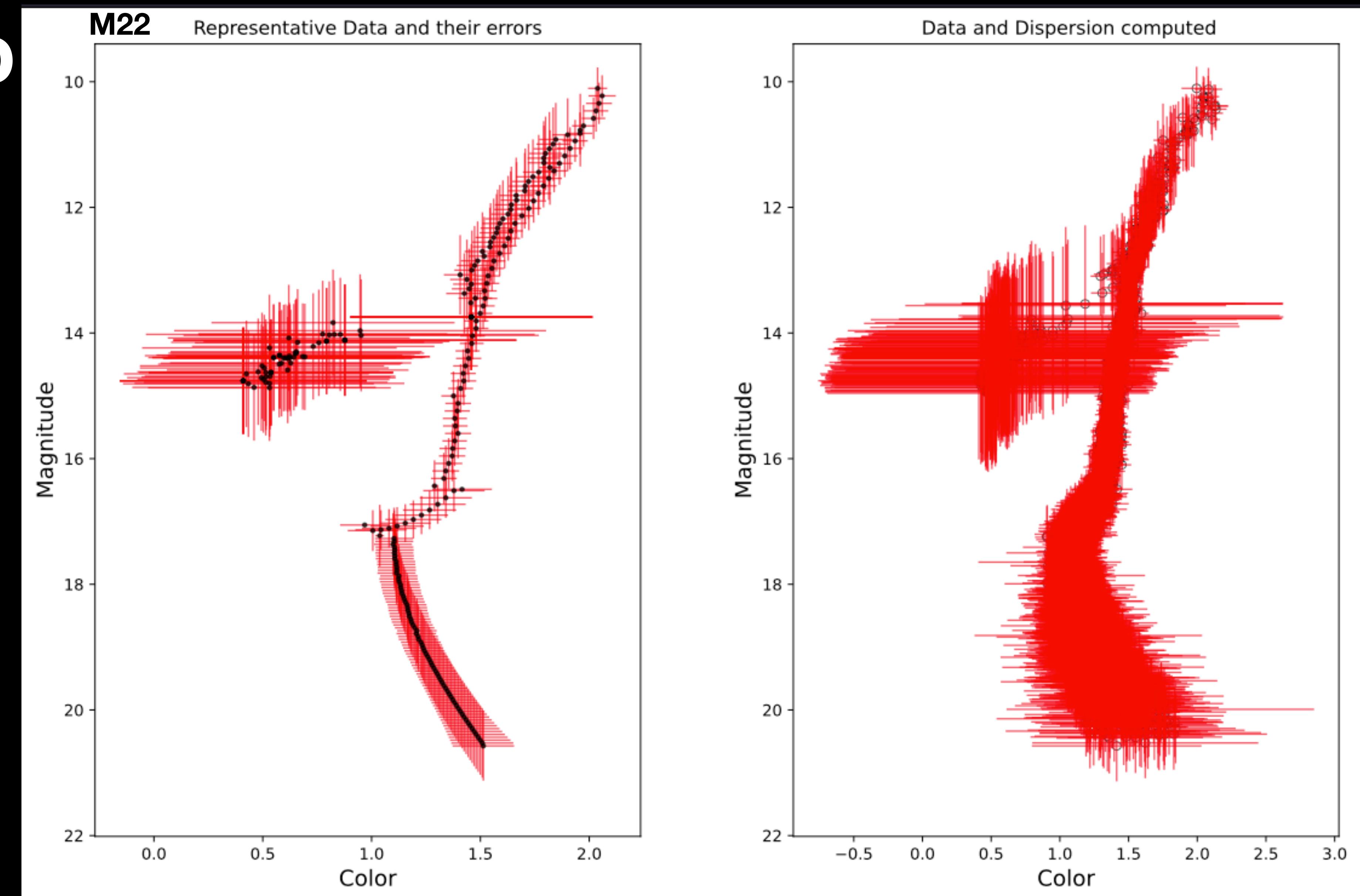
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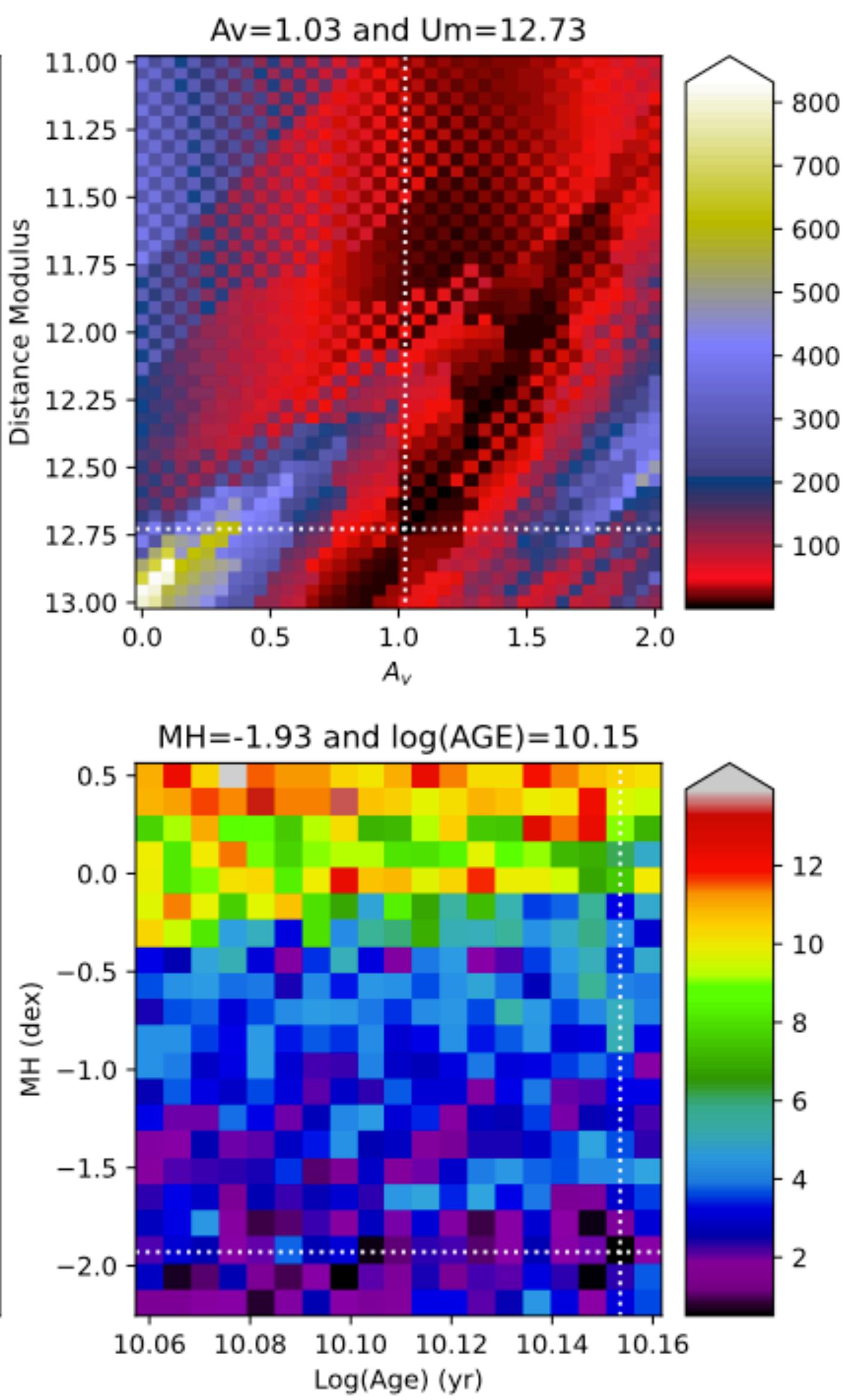
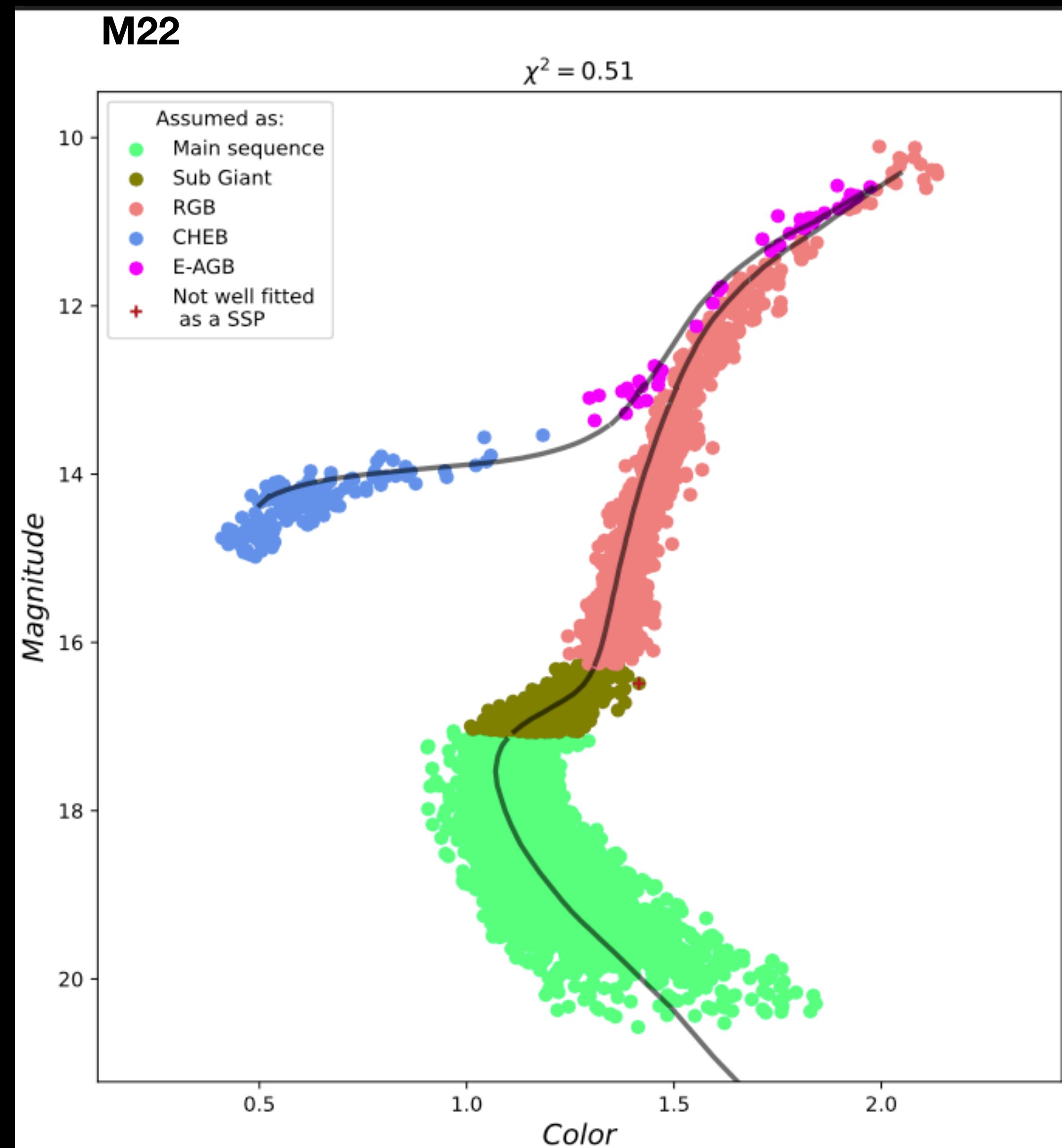
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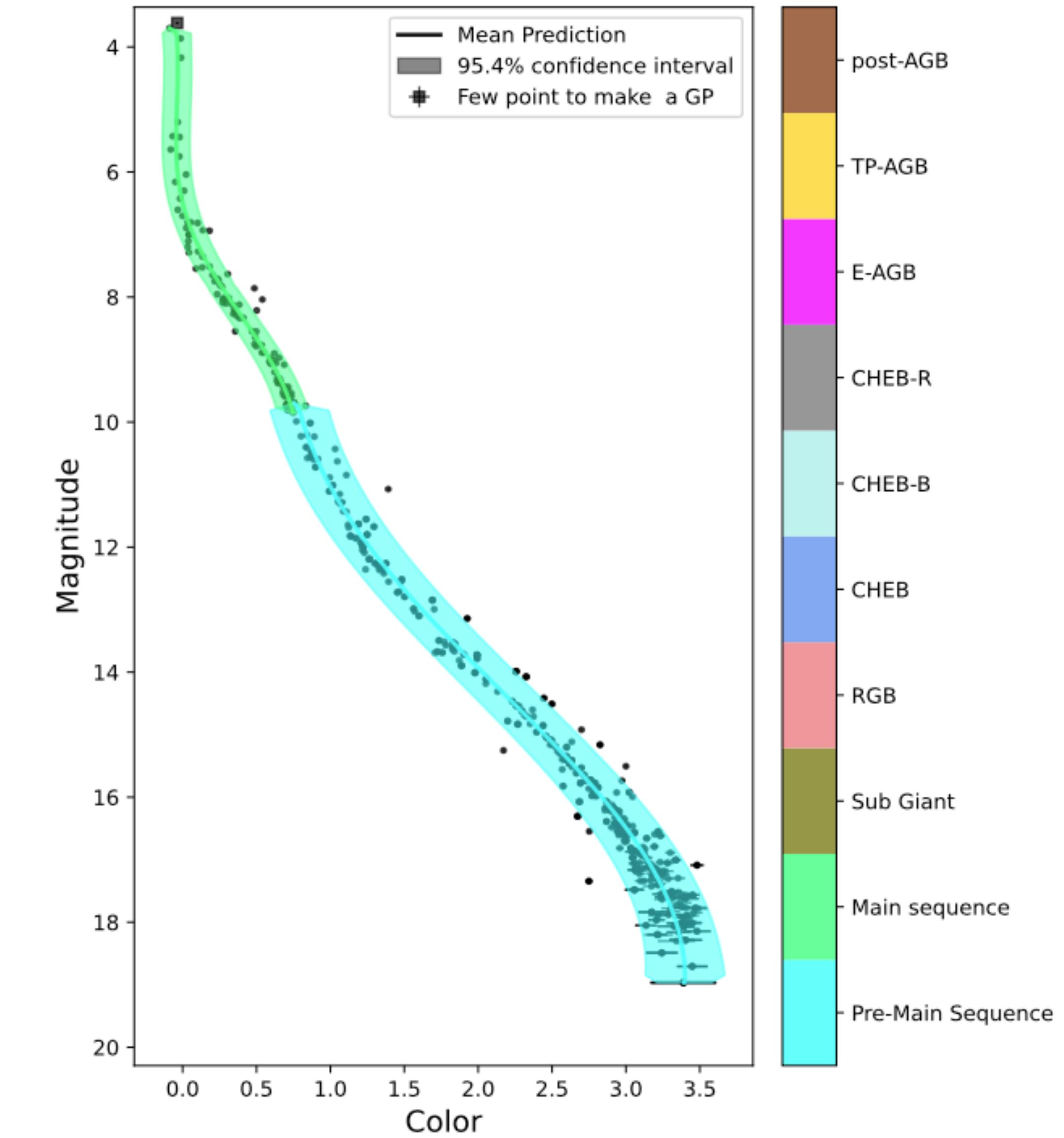
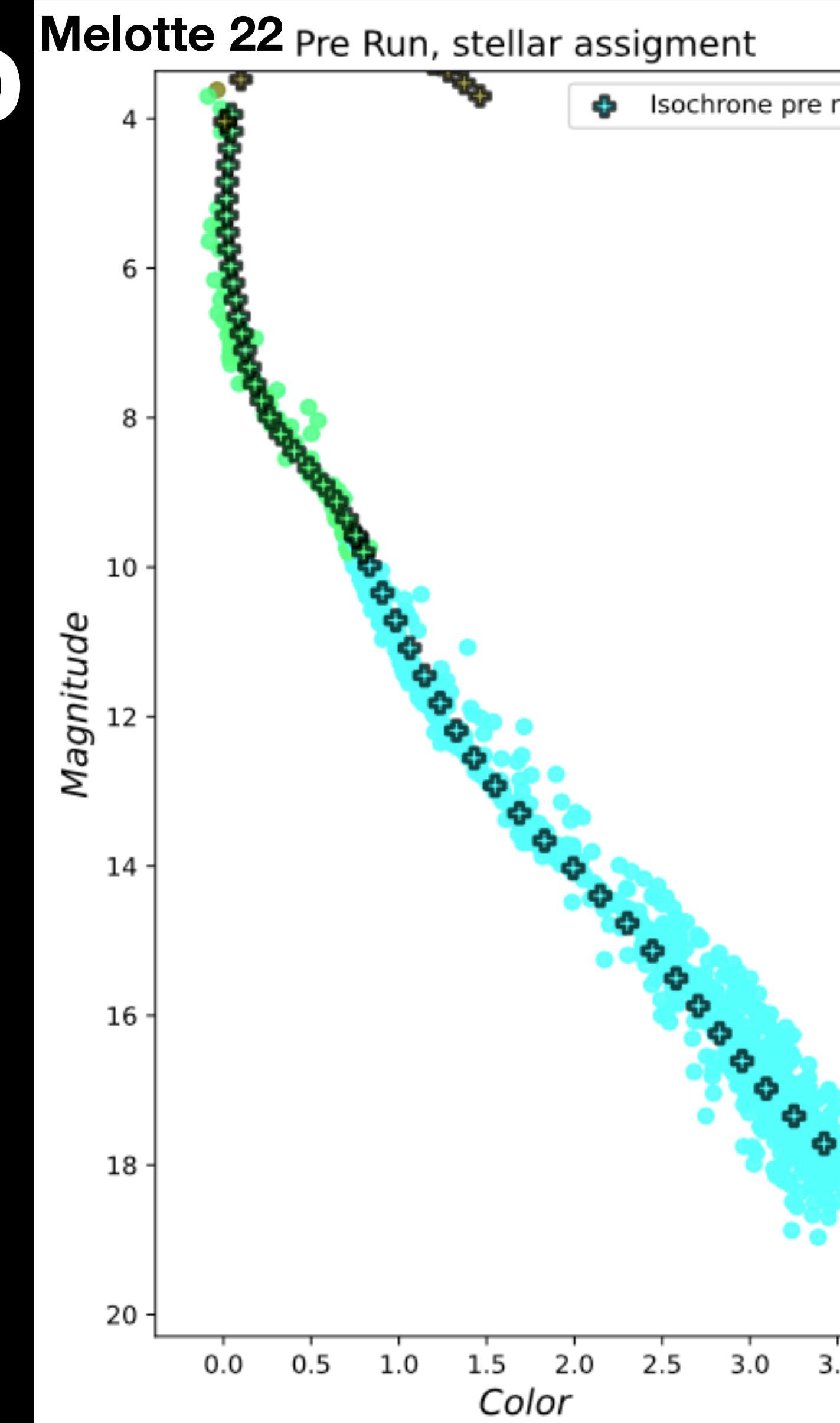
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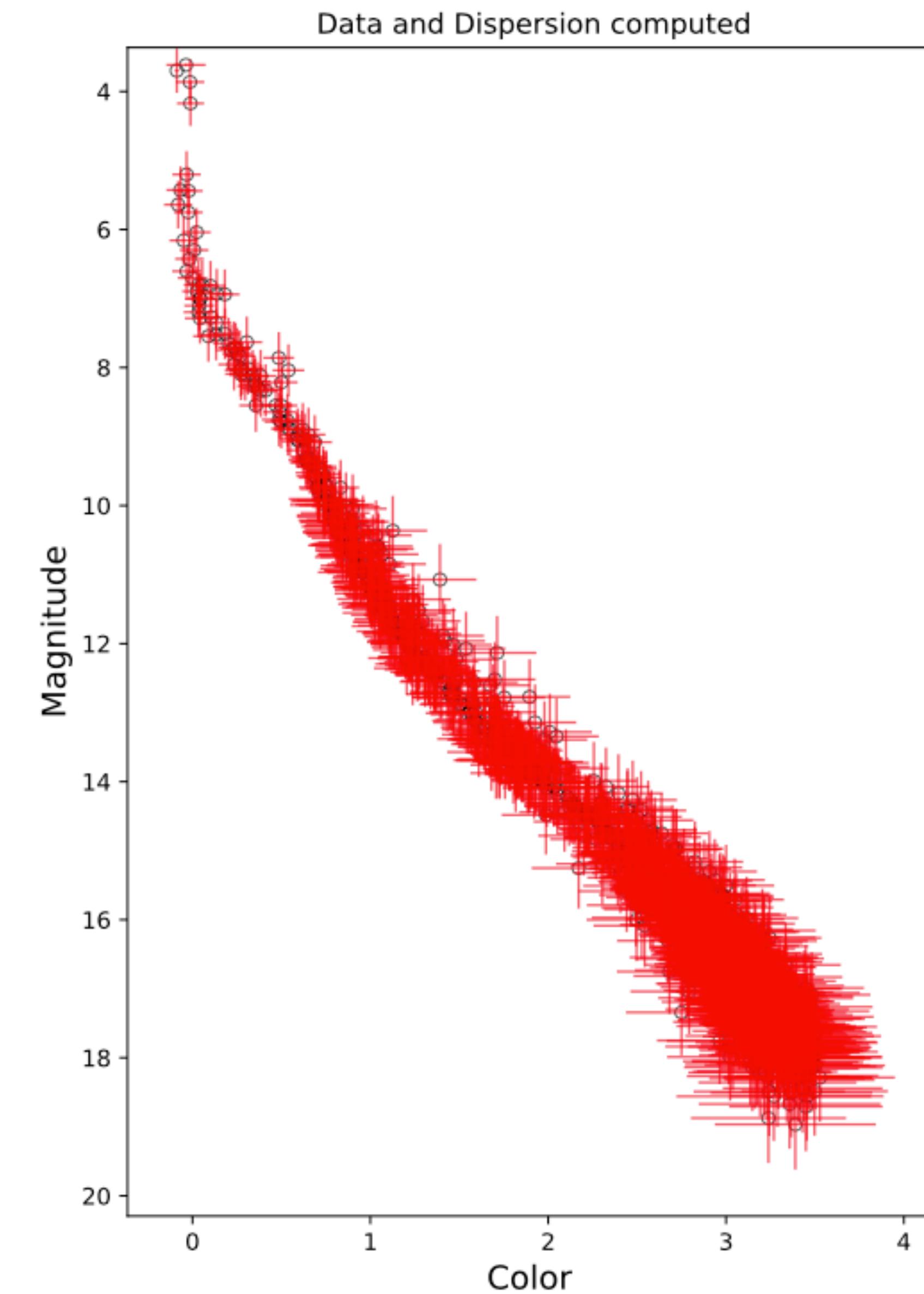
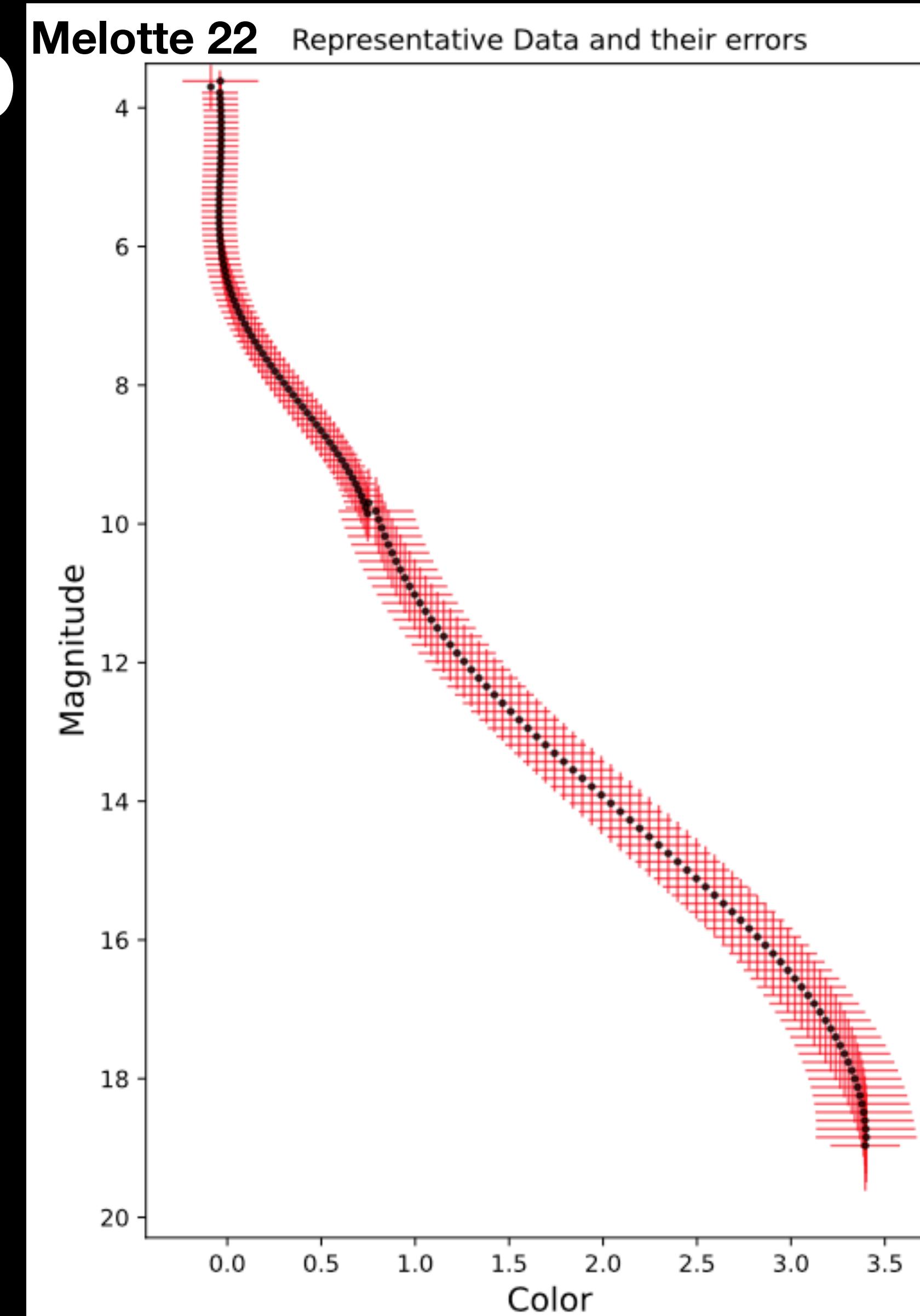
My project : Second Step

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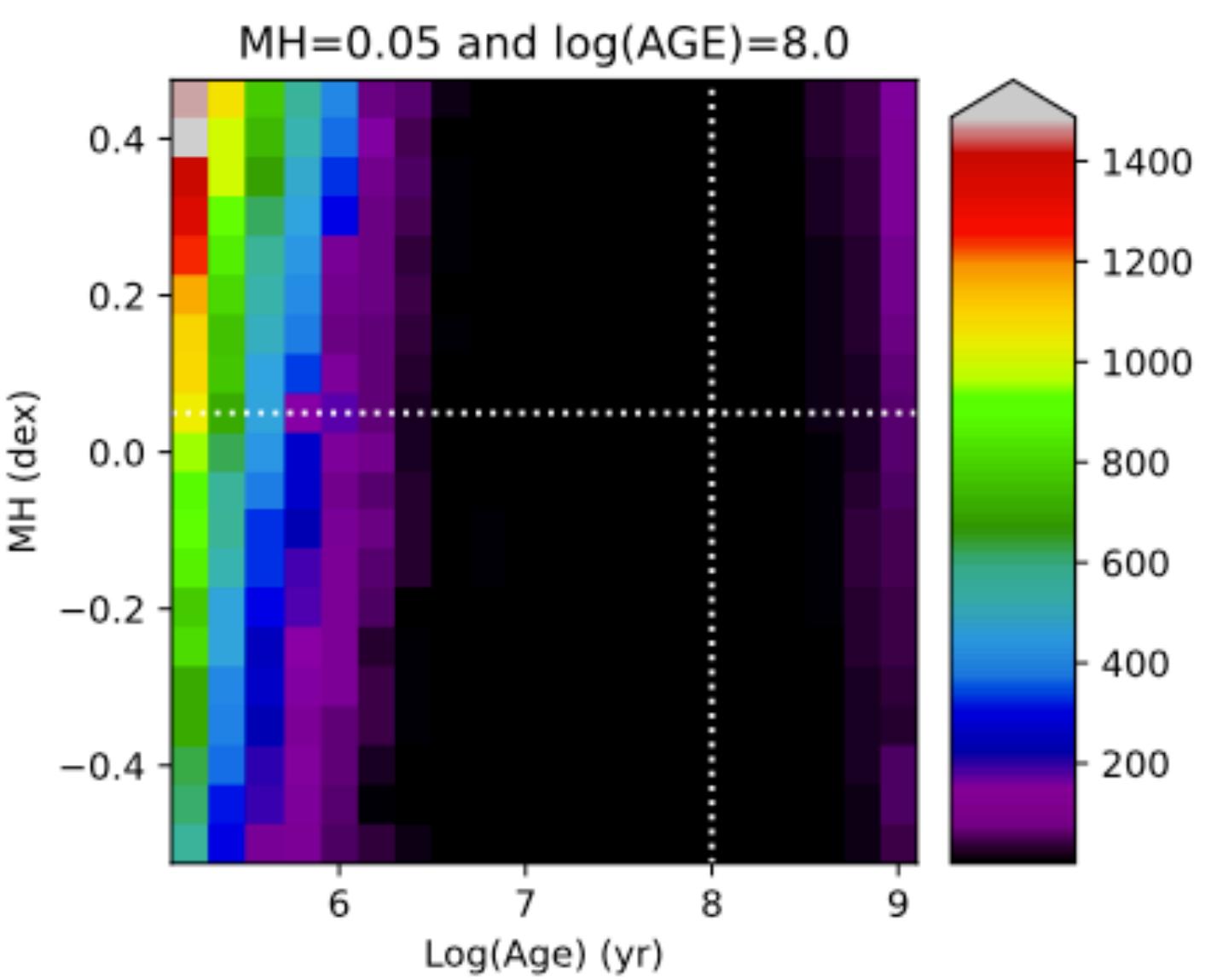
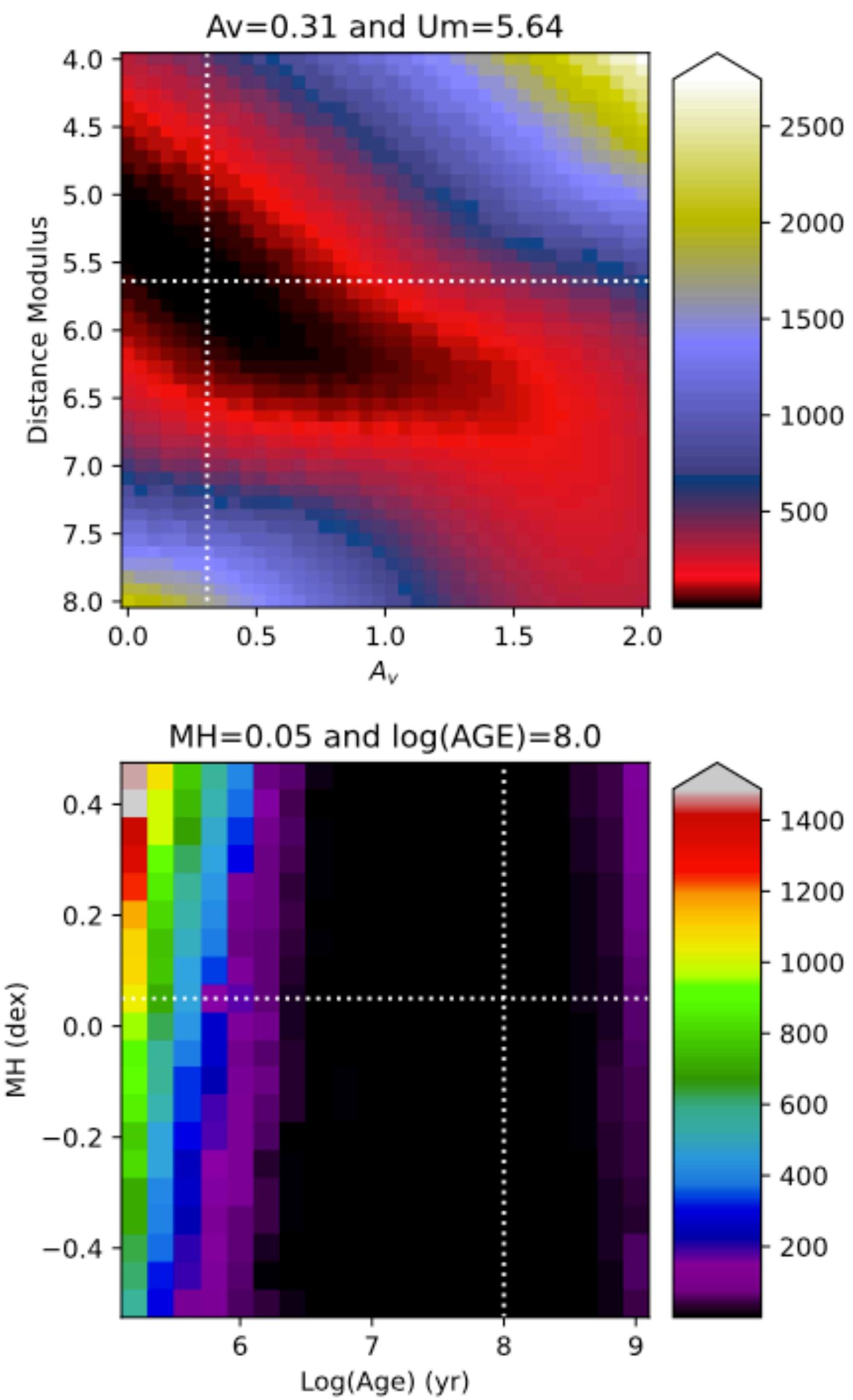
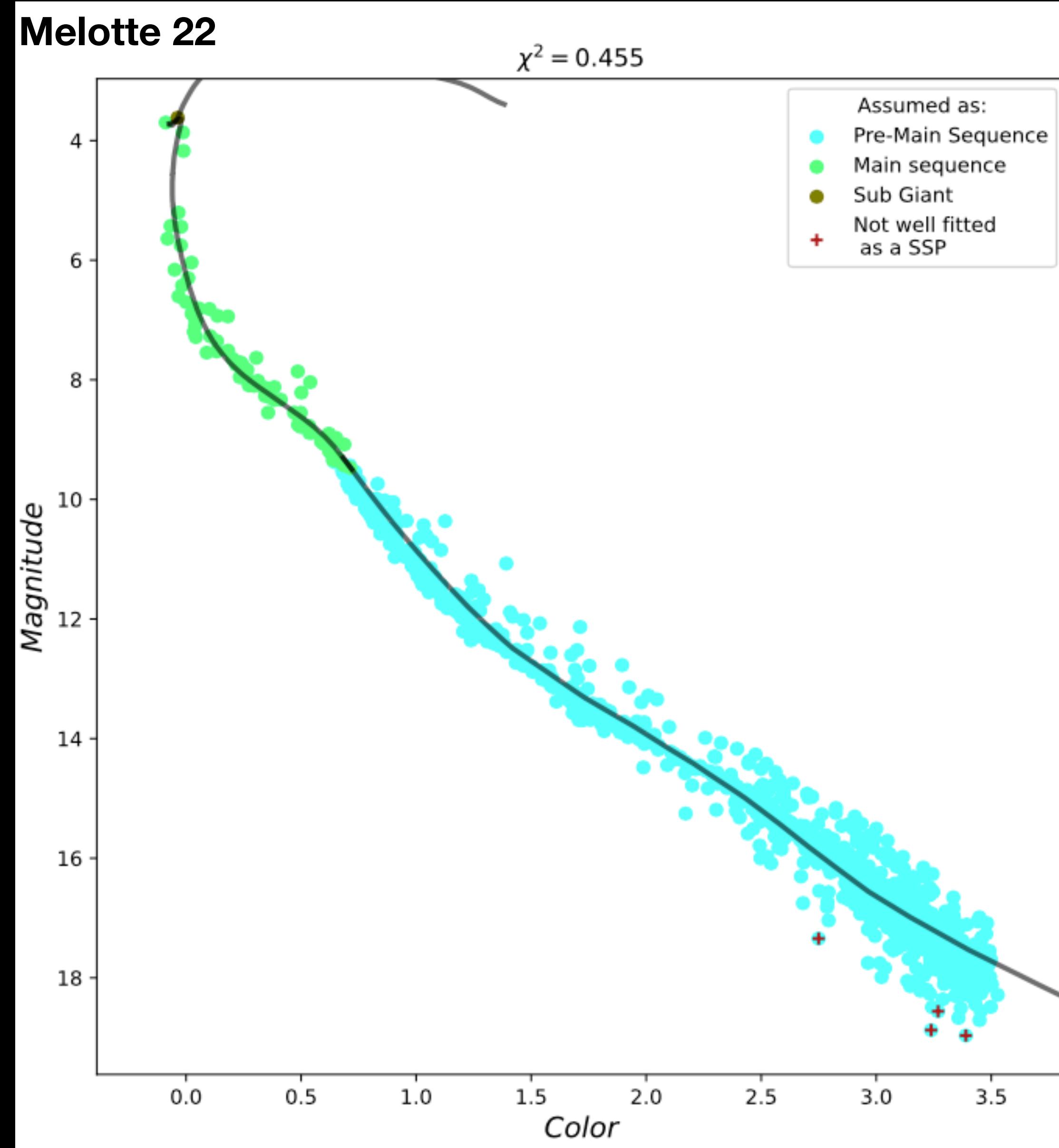
My project : Second Step

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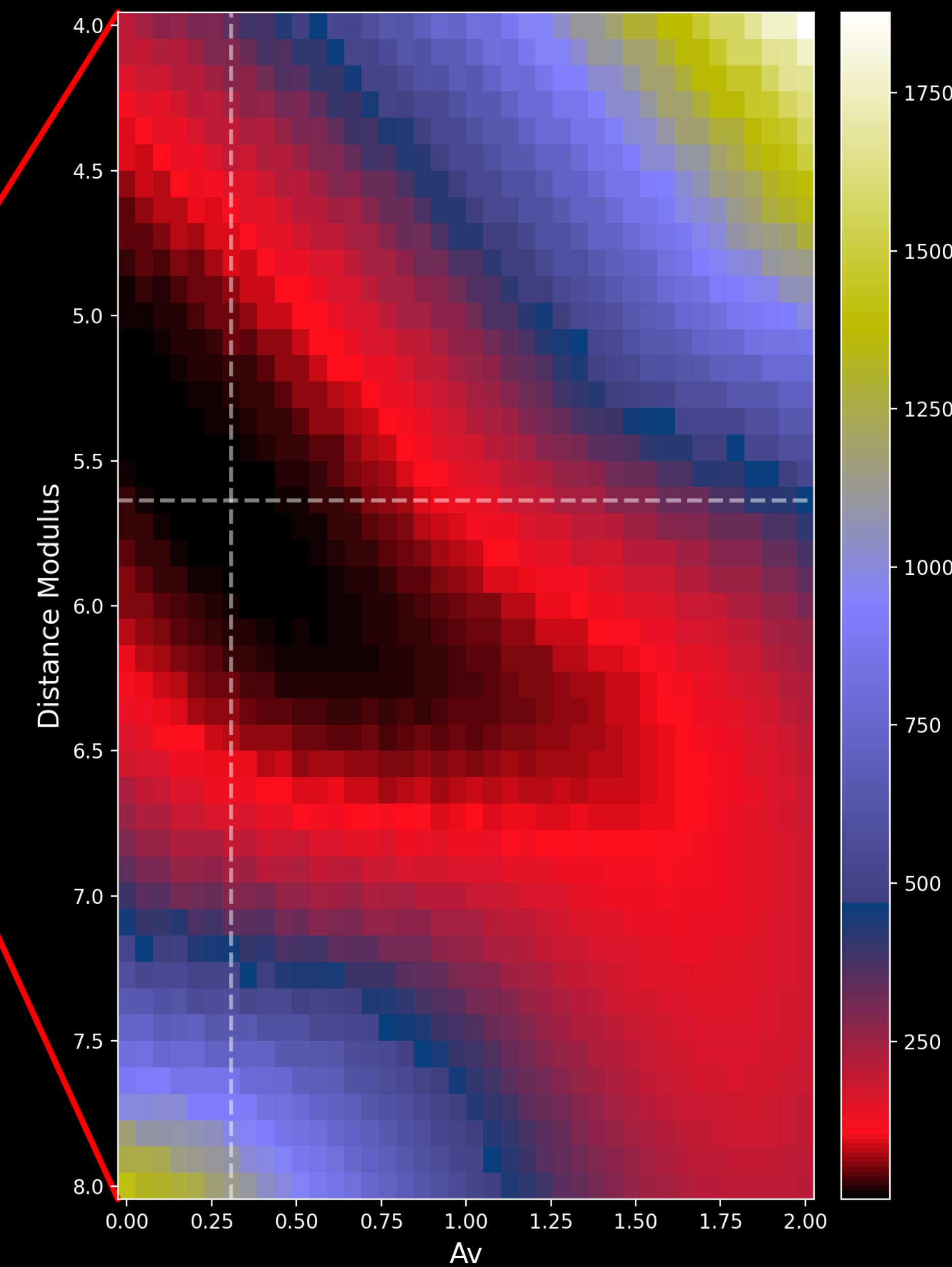
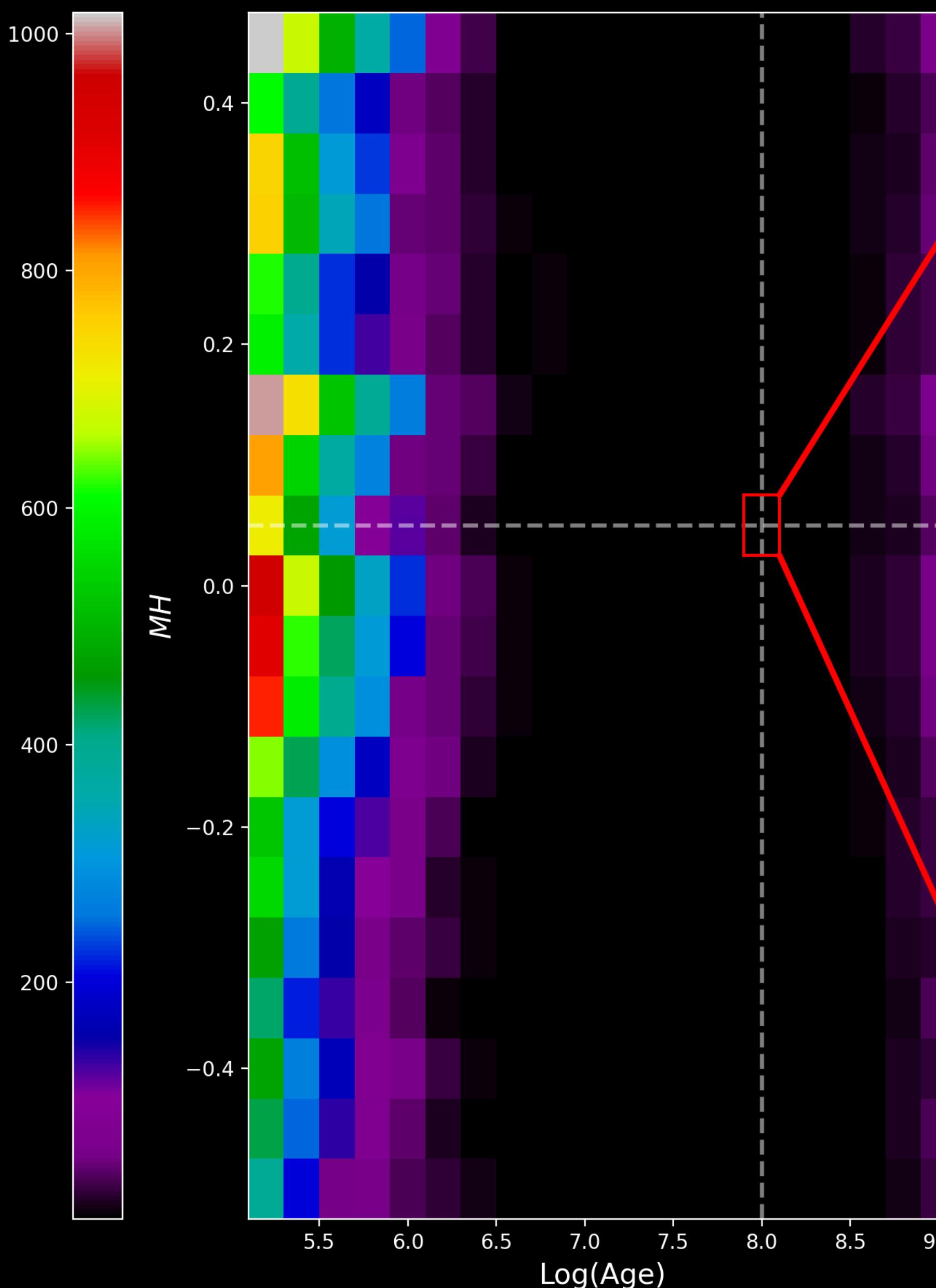
My project : Third Step

Mapping the
likelihood



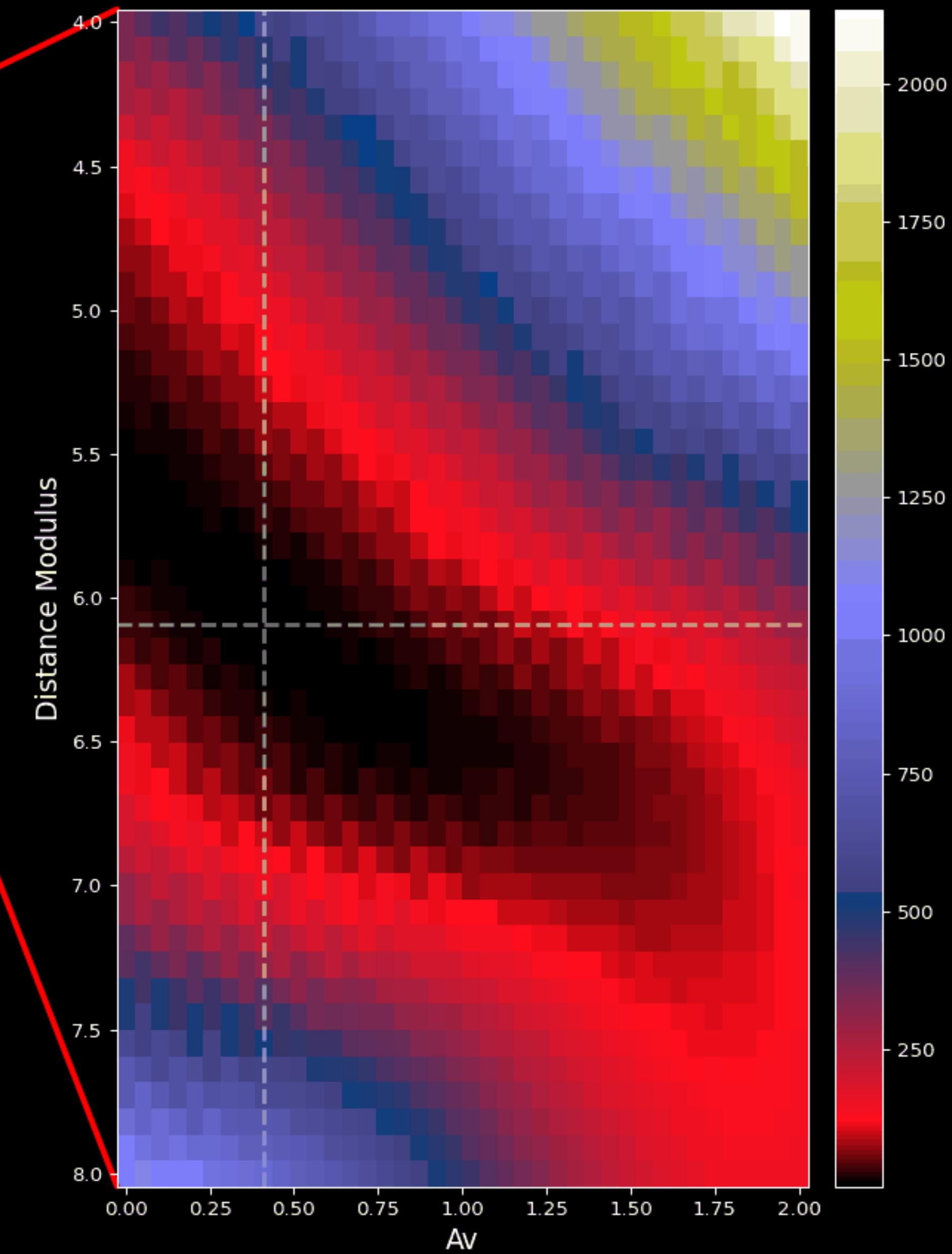
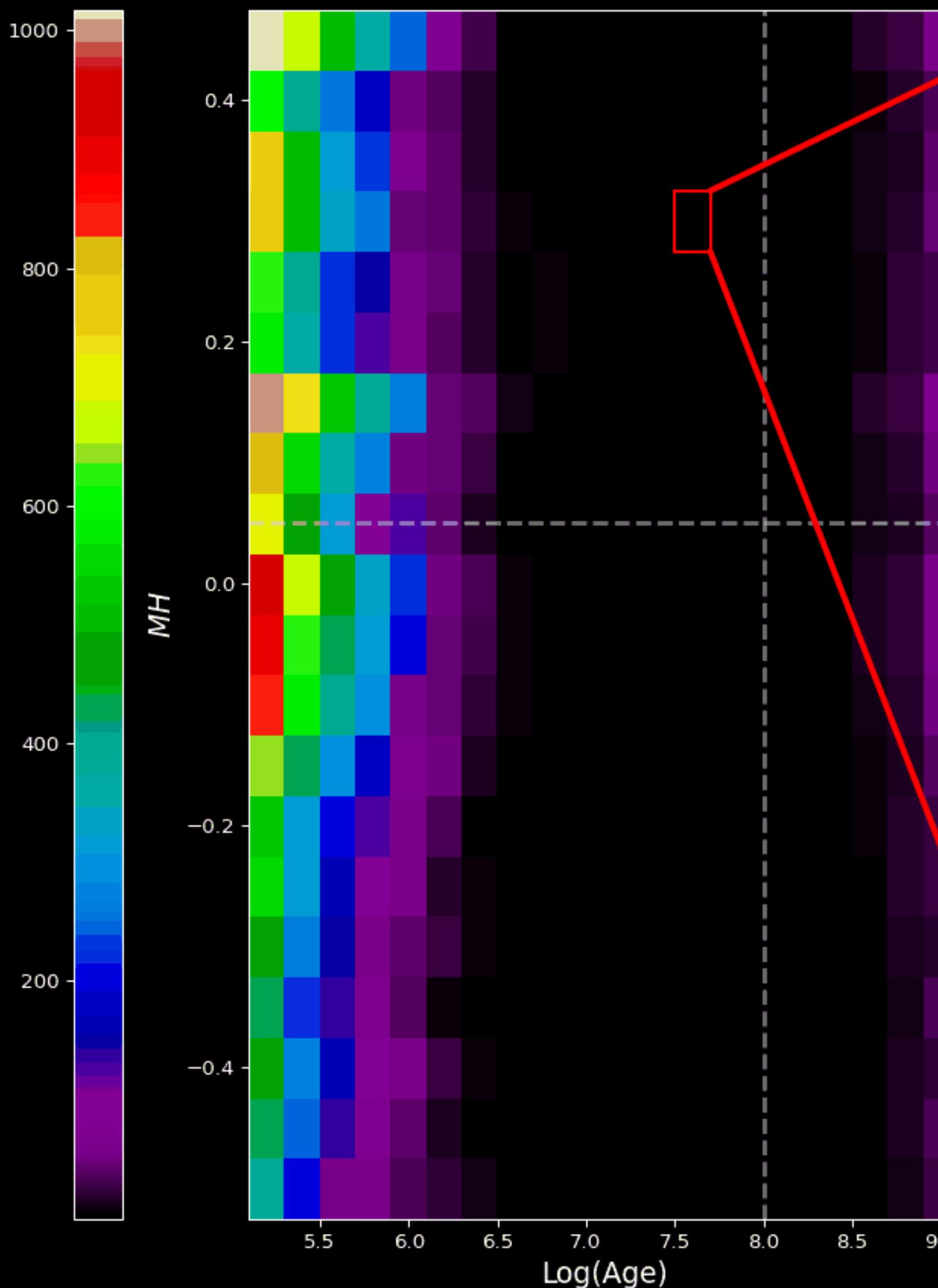
My project : Last Step

Getting errors
(at least how it would be)



My project : Last Step

Getting errors
(at least how it would be)



**Thanks for your
attention**

Questions?

