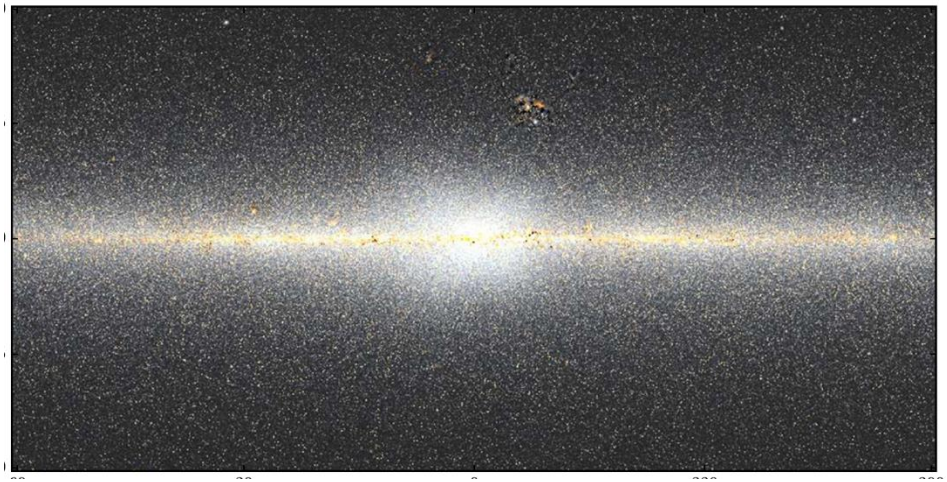
Dealing with Dust in the Galactic Plane

2026 Sagan Summer Workshop

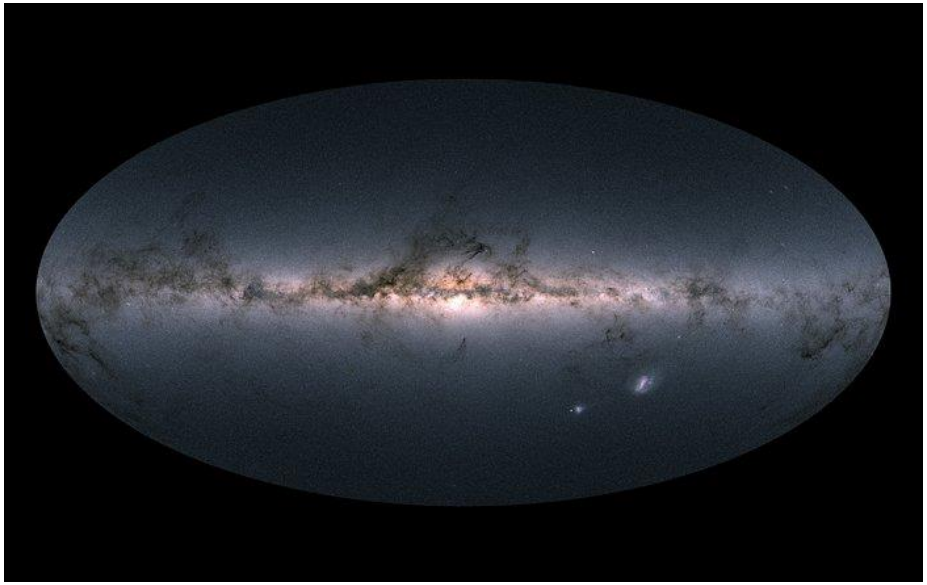
David M. Nataf, July 21st, 2026

The Milky Way in WISE and Gaia

Wavelength
~ 4000 nm



Wavelength
~ 600 nm

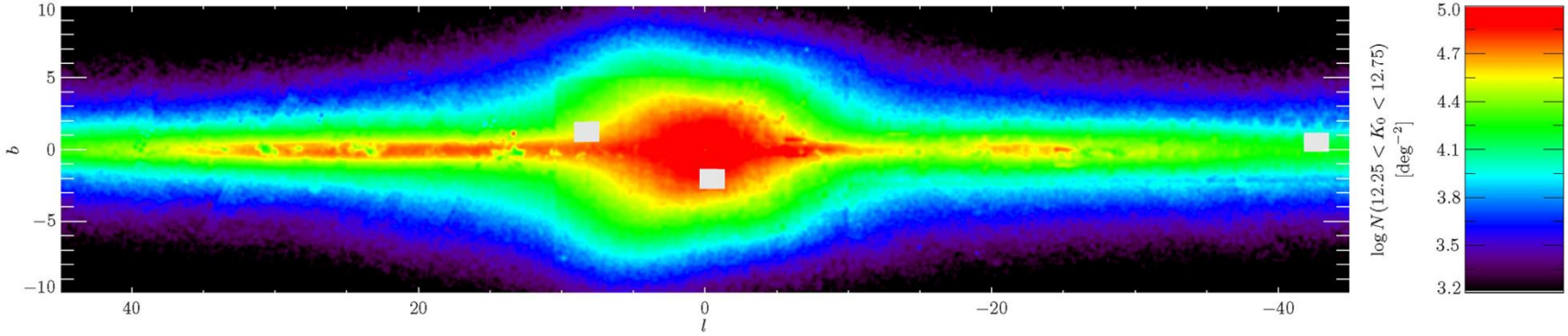


Australian Aboriginal Astronomy

Lots of Stars, and Lots of Dust Toward the Plane

Photo by Krzysztof Ulaczyk

Wegg et al.,
2015MNRAS.450.4050W

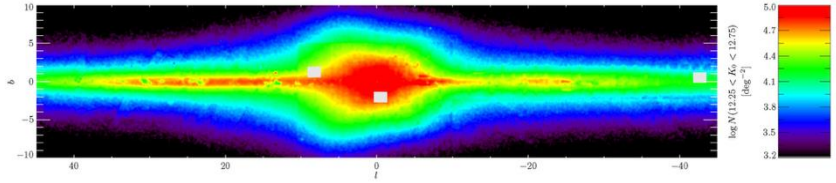


Going closer to the plane is a tradeoff

Microlensing probability goes as the square of the surface density of sources, so we get more microlensing events closer to the plane.

But crowding and extinction are also higher closer to the plane, so there's a tradeoff.

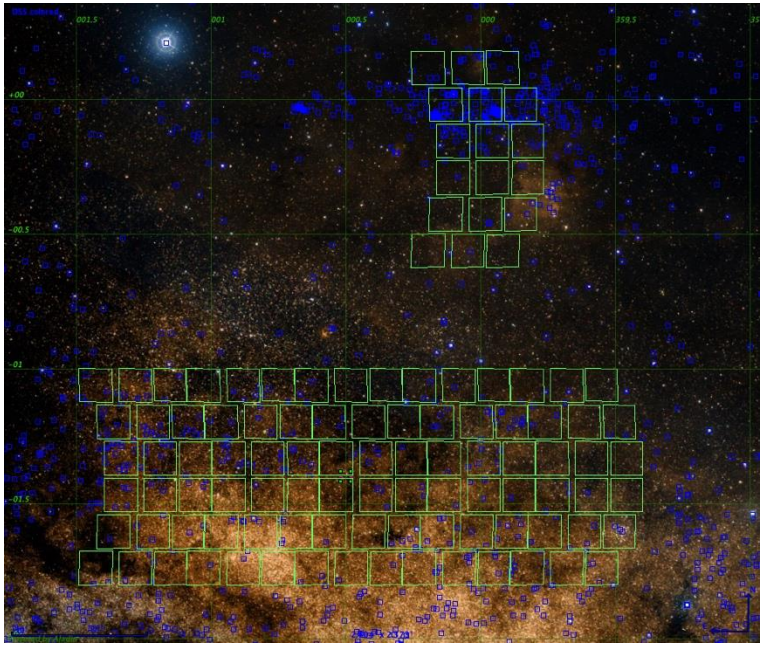
Roman shifts the balance point closer to the plane. PSF FWHM will be one third the diameter the best ground-based sights, and extinction is a little lower in the infrared.



The Extinction Toward the GBTDS

The estimated extinction toward the GBTDS field is $\langle A_H \rangle \approx 0.60$ for the main field, and $\langle A_H \rangle \approx 3.0$ for the Galactic center field.

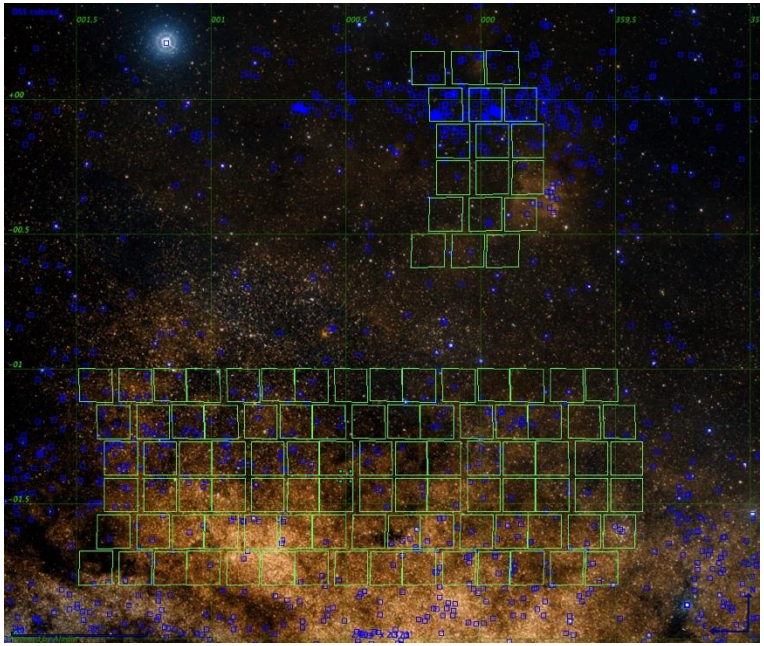
Contrasts to $\langle A_H \rangle \approx 0.03$ and $\langle A_V \rangle \approx 0.30$ for the Kepler field.



Effects of High Extinction

It will be harder to get follow-up, u-band and sometimes g-band from Rubin/LSST just won't be available. It will be harder to determine the metallicities, etc of many host stars.

It will be harder to estimate the masses of lenses. For sources with finite source effects, the angular size of the lens can be estimated from its dereddened color. A 1% error in extinction propagates as a 1% error in the host mass.



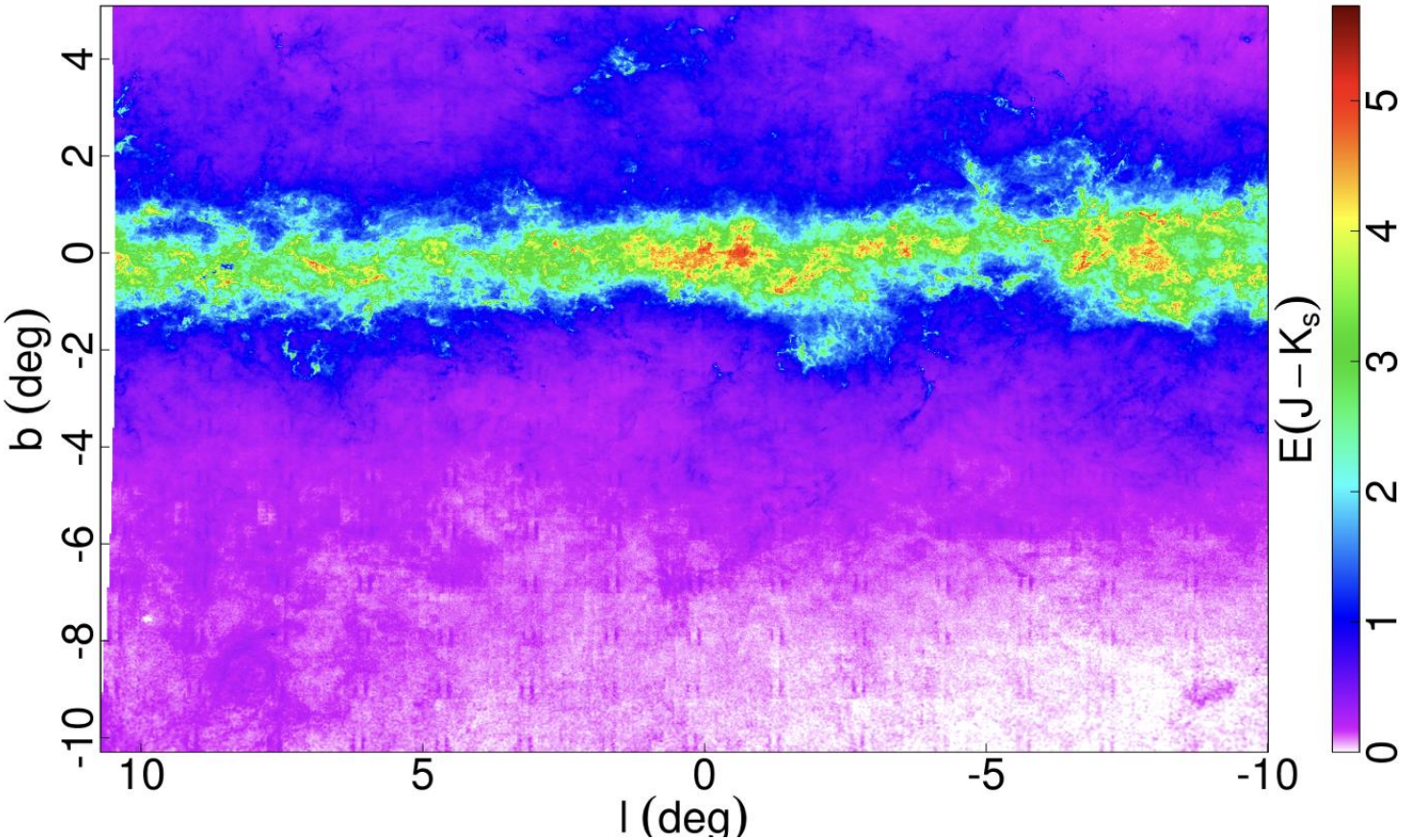
Available Means of Correcting for Extinction

- Applying priors from extinction maps, 2D (**Surot** et al., 2020A%26A...644A.140S; **Zelakiewicz** et al. 2025AJ....170..328Z, and 3D (**Zucker** et al. 2025ApJ...992...39Z).

A 2D map gives you the estimated extinction at the distance to the Bulge, whereas a 3D reddening map attempts to correct for extinction as a function of distance along the line of sight.

- Correcting for extinction on a star-by-star basis.

Current gold standard for the extinction to the Bulge, Surot et al. 2020A%26A...644A.140S



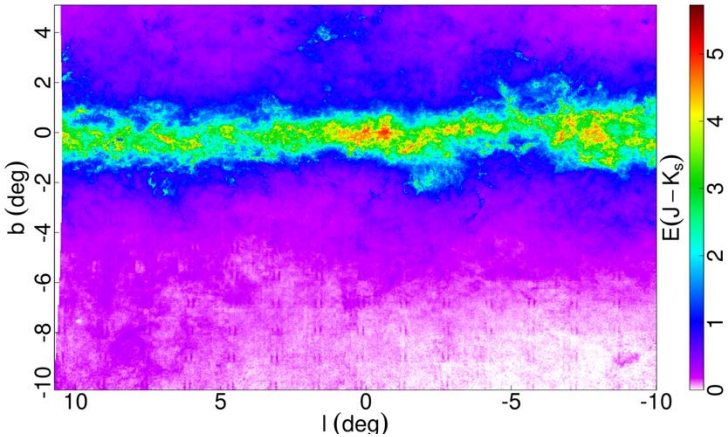
Current gold standard for the extinction to the Bulge, Surot et al. 2020A%26A...644A.140S

Covers the entire Bulge, including regions of interest beyond the GBTDS FoV.

You can find the entire map here (easy to use):

https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/644/A140

High-resolution, but what is measured is 2D, and only E(J-Ks). Conversion to extinction in other filters not given.



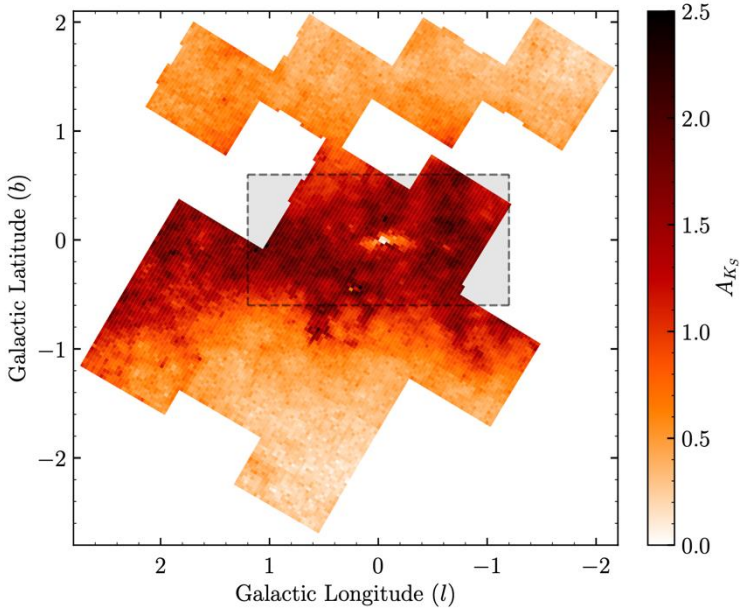
Perhaps the best 2D extinction map for the sightlines of interest, Zelakiewicz et al. 2025AJ....170..328Z

Map is easy to access, gives E(H-Ks) and A_{Ks}:

https://zenodo.org/records/14919461

Slightly better imaging than the VVV survey that Surot's map is based on.

Does not cover the entire Roman GBTDS field, but does cover most of it.

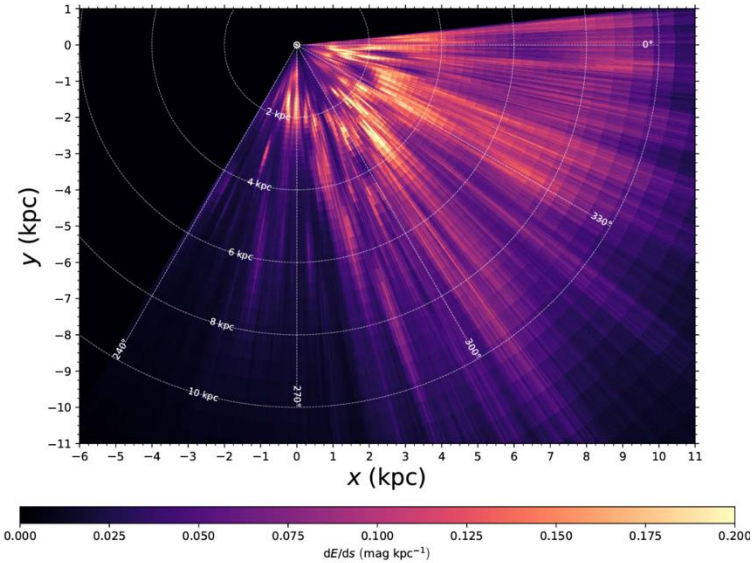


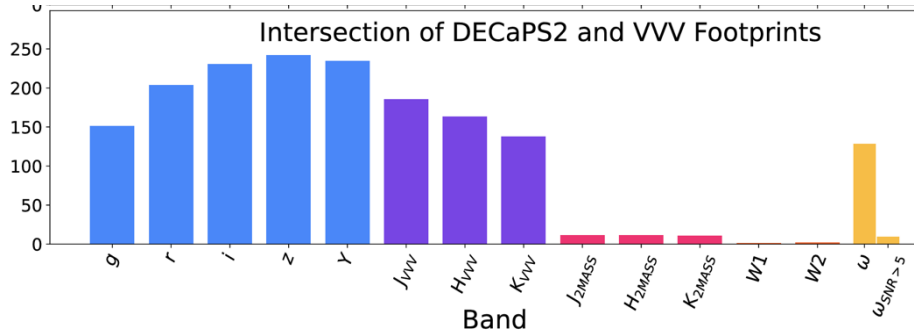
Perhaps the best available 3D extinction map, Zucker et al 2025ApJ...992...39Z

Available via an easy-to-use code: https://dustmaps.readthedocs.io/en/latest/modules.html

Pros: This is probably the extinction prior of choice for *e.g.* transiting planet host stars between us and the Bulge.

Cons: inherits the systematics of both the DeCaPs and VVV surveys, and doesn't reach the Bulge itself.

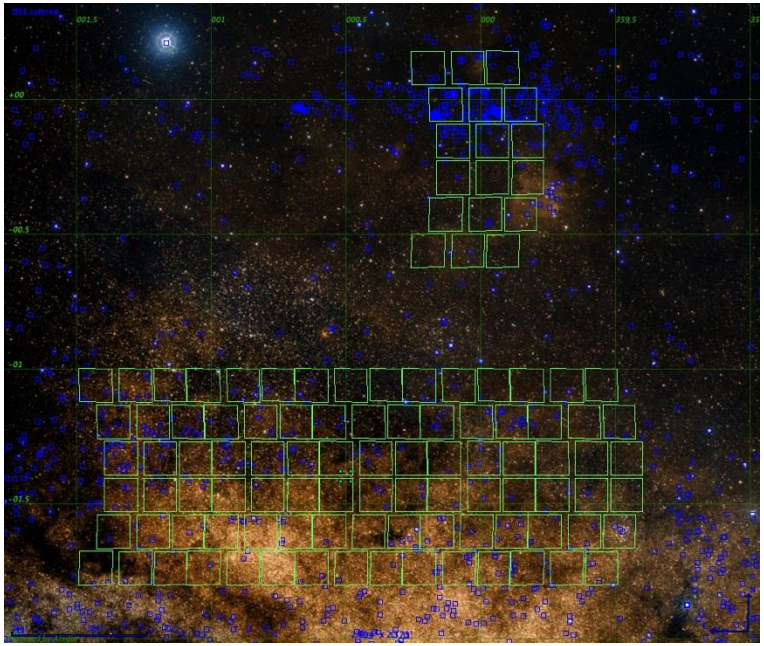




On the extinction maps

The maps of Surot, Zelakiewicz, and Zucker should be quite helpful for the main field of the GBTDS.

There is currently no adequate map fot eh Galactic center field.



Correcting for Extinction on a Star-by-Star Basis – how about the star in the black circle? (4056465395590999808)

Let's say we have a lot of data …

From HST

F606W = 20.00 ± 0.01

F814W = 18.42 ± 0.01

F098M = 17.38 ± 0.01

F127M = 16.56 ± 0.01

F139M = 16.34 ± 0.01

F153M = 16.14 ± 0.01

F167N = 15.98 ± 0.01

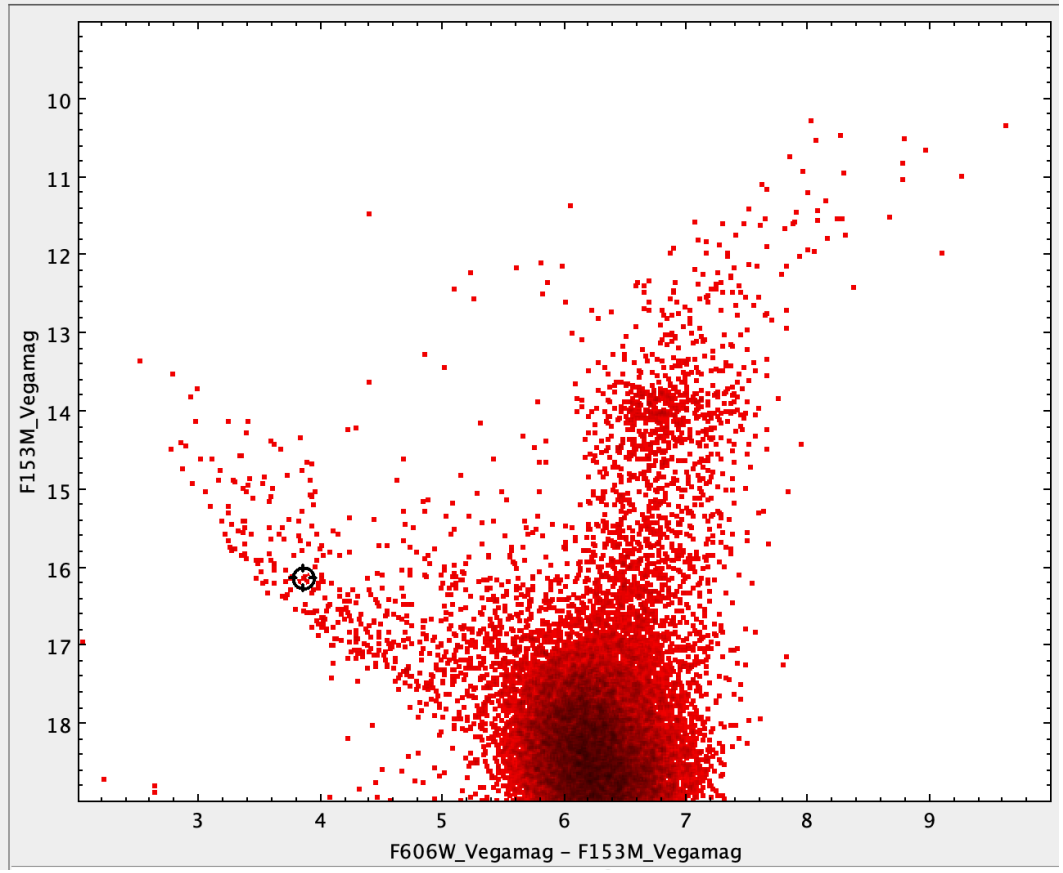
From Gaia

Parallax = 1.646 ± 0.439

G = 19.45 ± 0.01

BP = 20.34 ± 0.17

RP = 18.20 ± 0.13

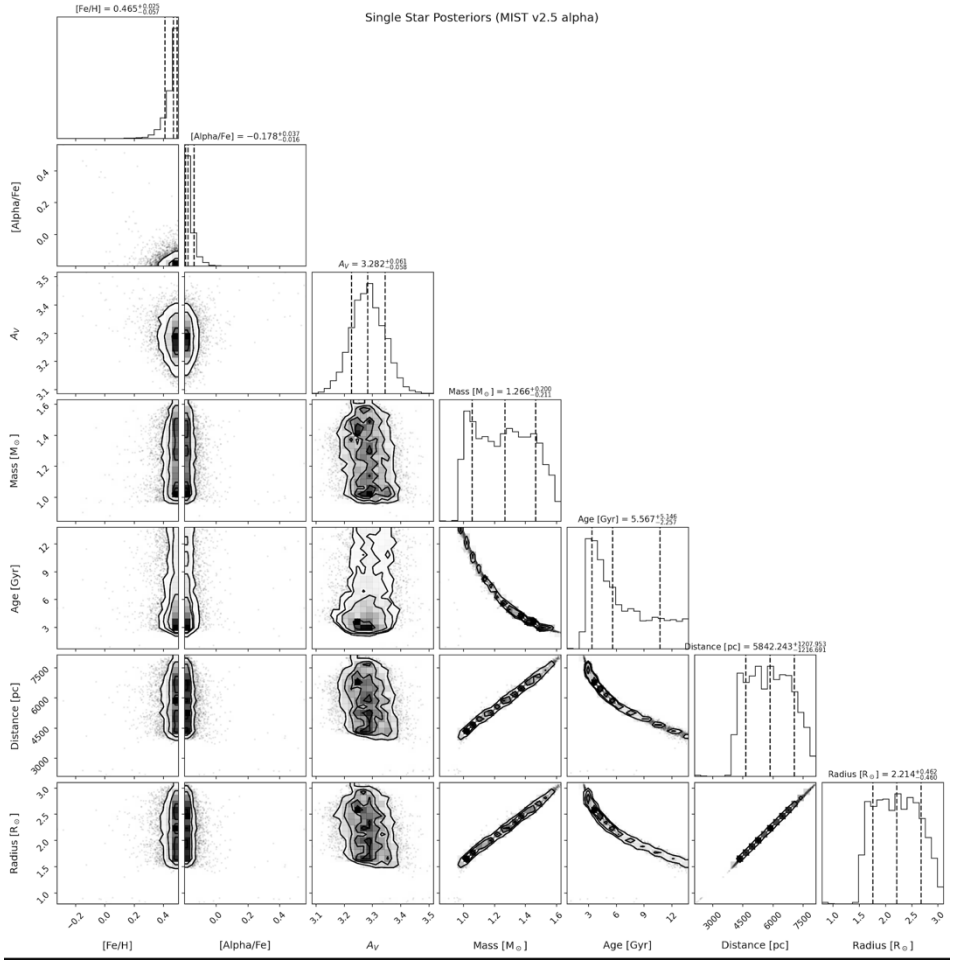


Correcting for Extinction on a Star-by-Star Basis – it didn't work

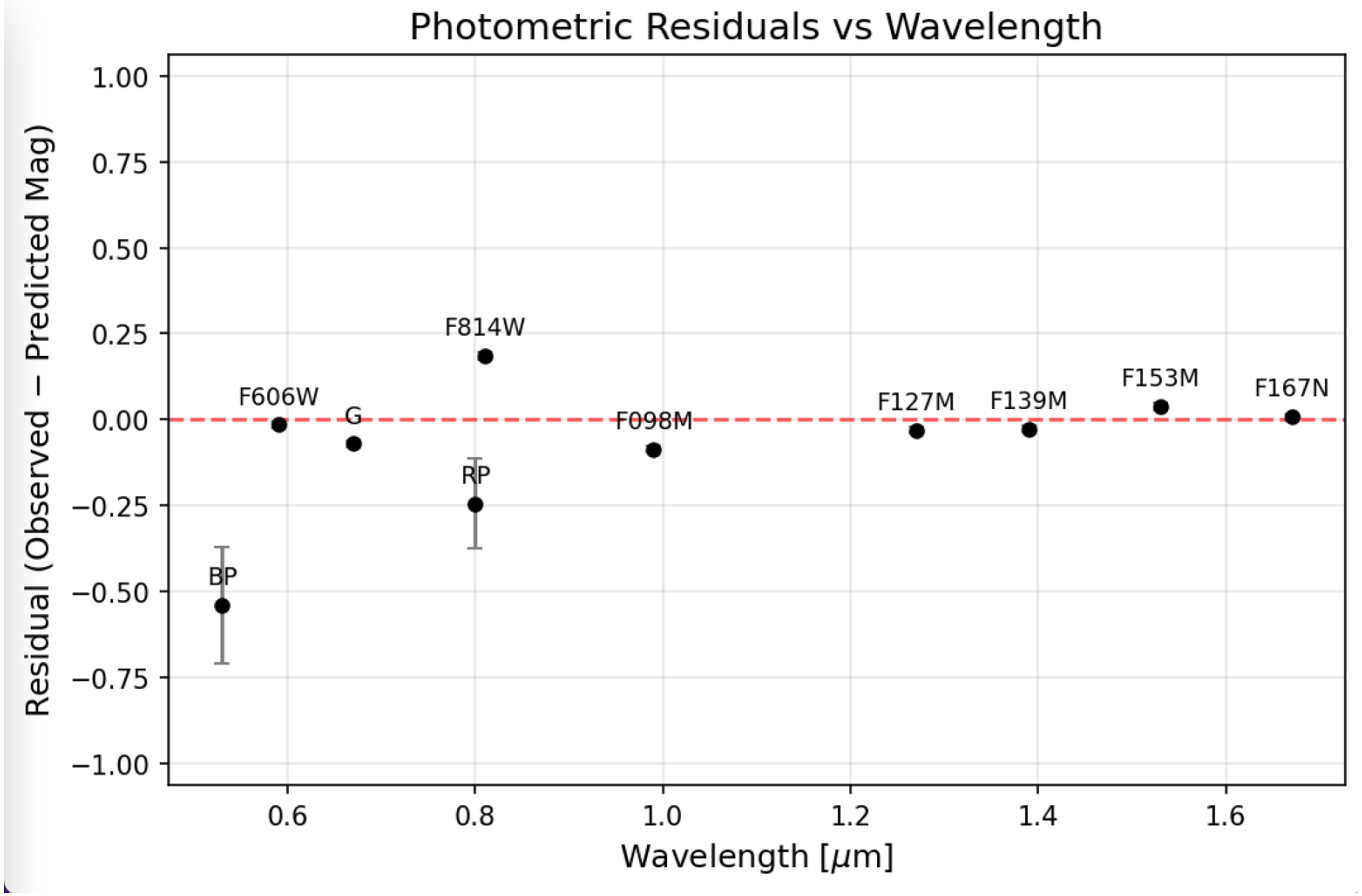
In spite of 10 photometric measurements and a 25% parallax, we got a lot of nonsense.

[Fe/H]=+0.50, [Alpha/Fe]=-0.20, mass/age/distance/radius totally degenerate.

Is the situation hopeless? Because this data is as good as we're ever going to get.



Correcting for Extinction on a Star-by-Star Basis – residuals are a function of wavelength, likely due to extinction model



Extinction has at least two parameters: A_V and R_V

- A_V is the magnitude of extinction in the V-band, describes the **quantity** of extinction.
- $R_V = A_V/E(B-V)$ is the total-to-selective extinction ratio, typically 3.1 in the solar neighborhood, describes the **quality** of extinction.

Walter Baade on the Properties of Dust

Walter Baade (1893–1960) was once asked if he would choose to be an astronomer again in another life. He jokingly replied that he would do it **only if the ratio of total to selective absorption is everywhere the same**.

$$R_V = \frac{A_V}{E(B-V)}$$

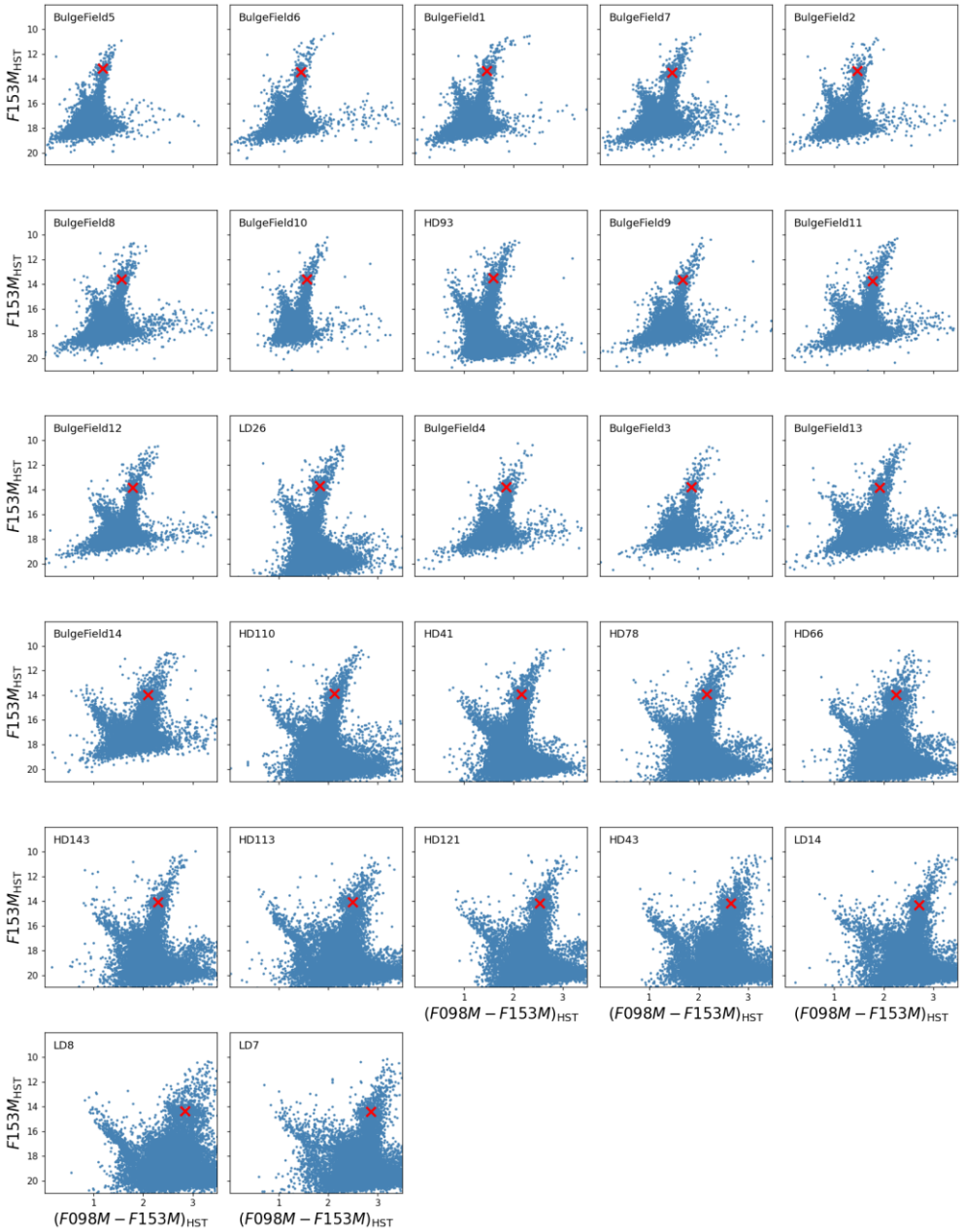
Enter HST Programs 17173 + 17923

27 Bulge fields observed with up to 5 WFC3/IR bandpasses, like the one we just saw.

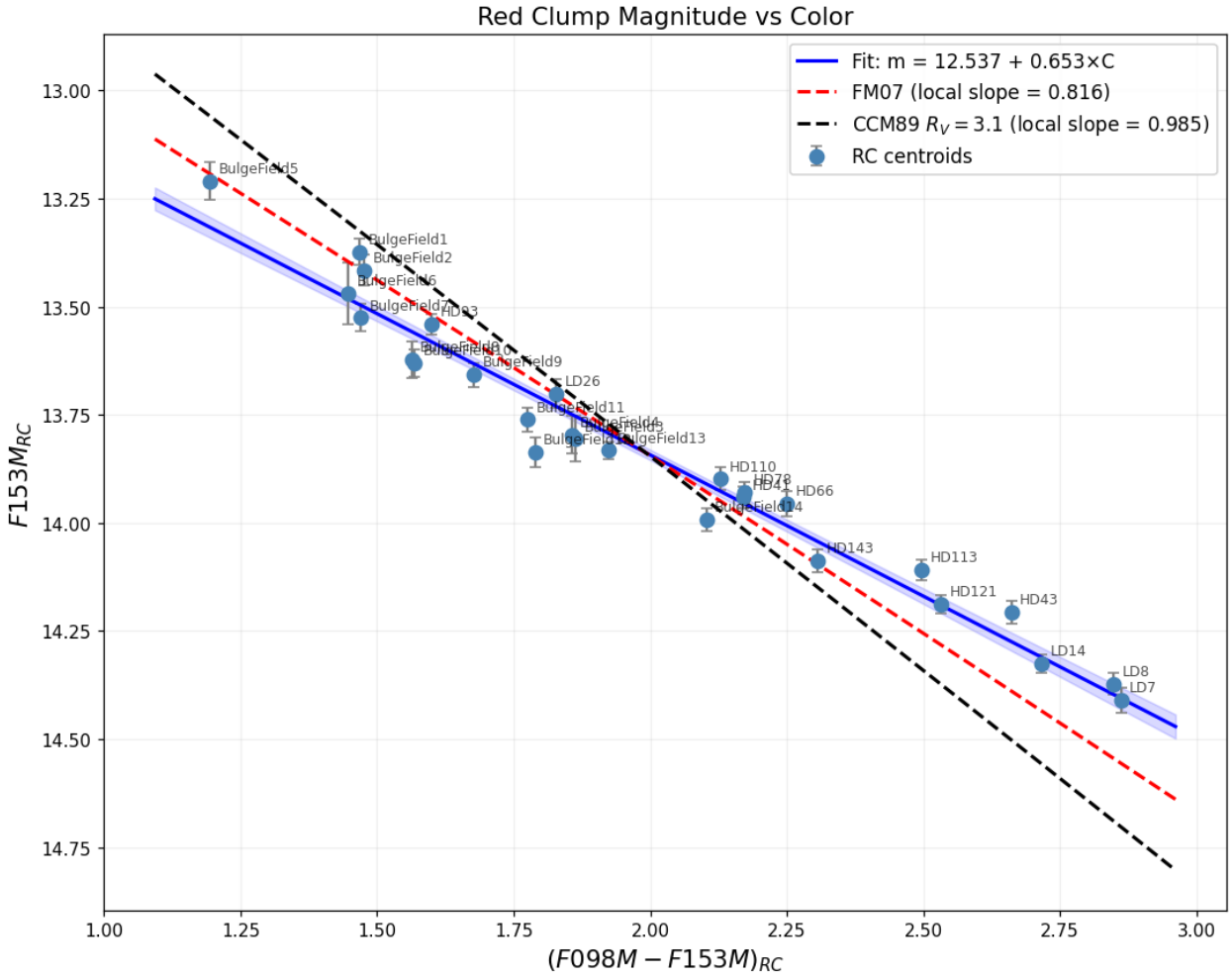
Aim is to study the extinction curve and its variations. Substantial (15 of 27 fields) overlap with the program of Sean Terry (GO-17776), which obtained photometry in F606W and F814W.

Data reduced by IPAC staff scientist Jacob Jencson.

Red clump method is used to trace reddening in 27 fields and multiple colors



Reddening curve is indeed non-standard



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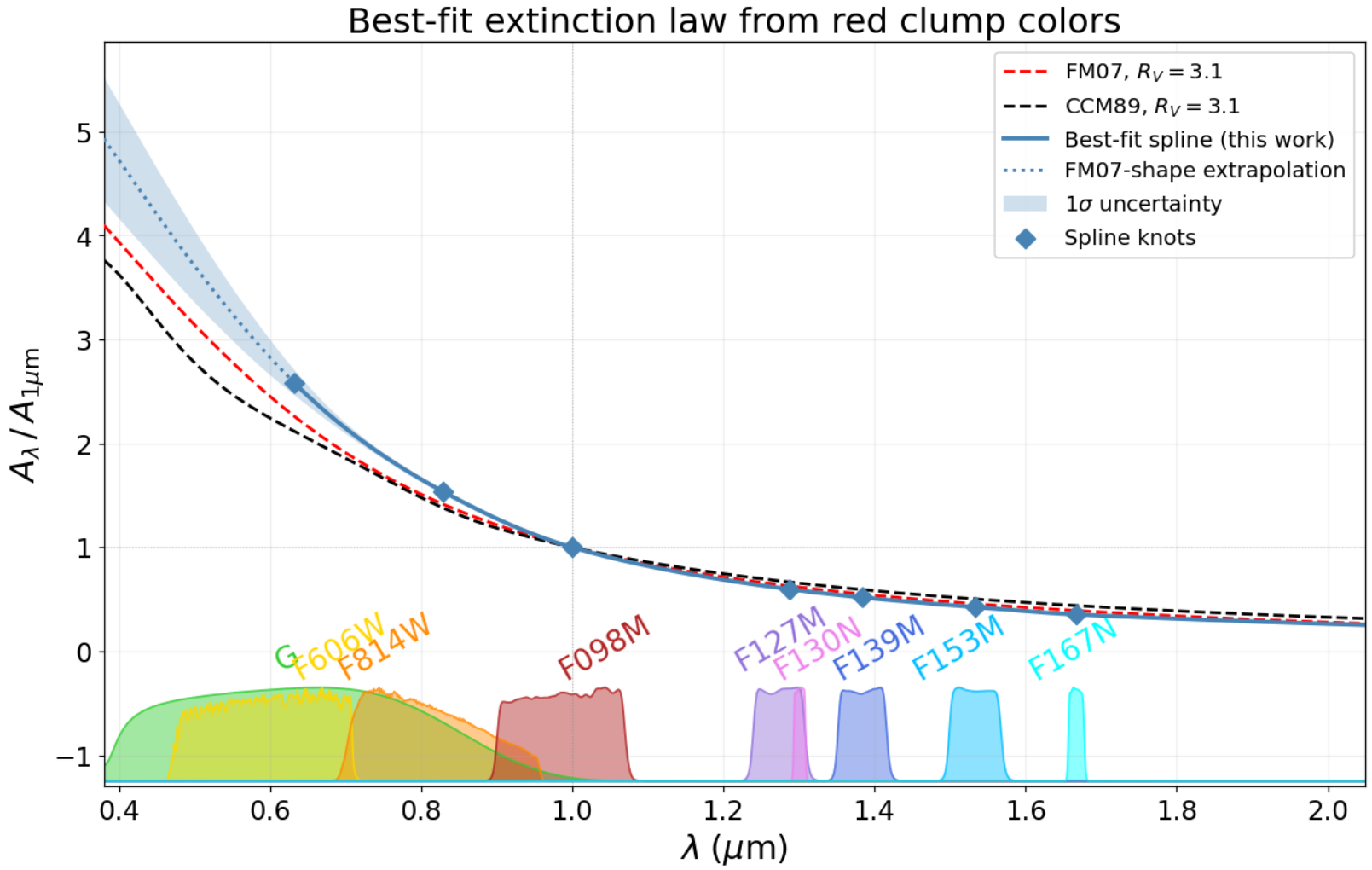
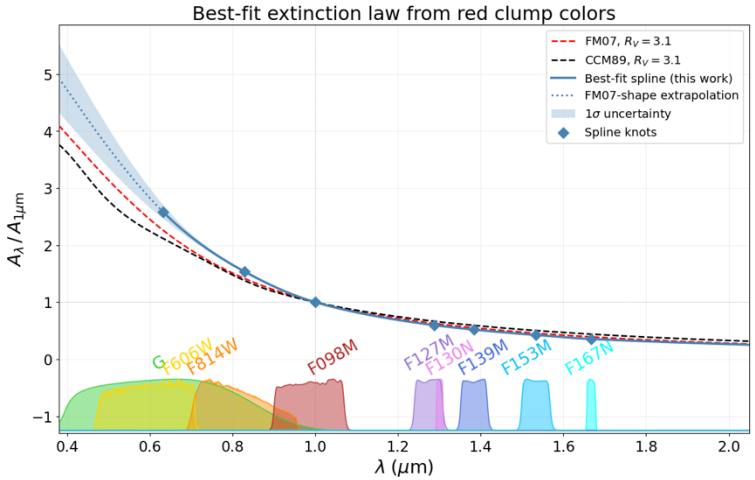


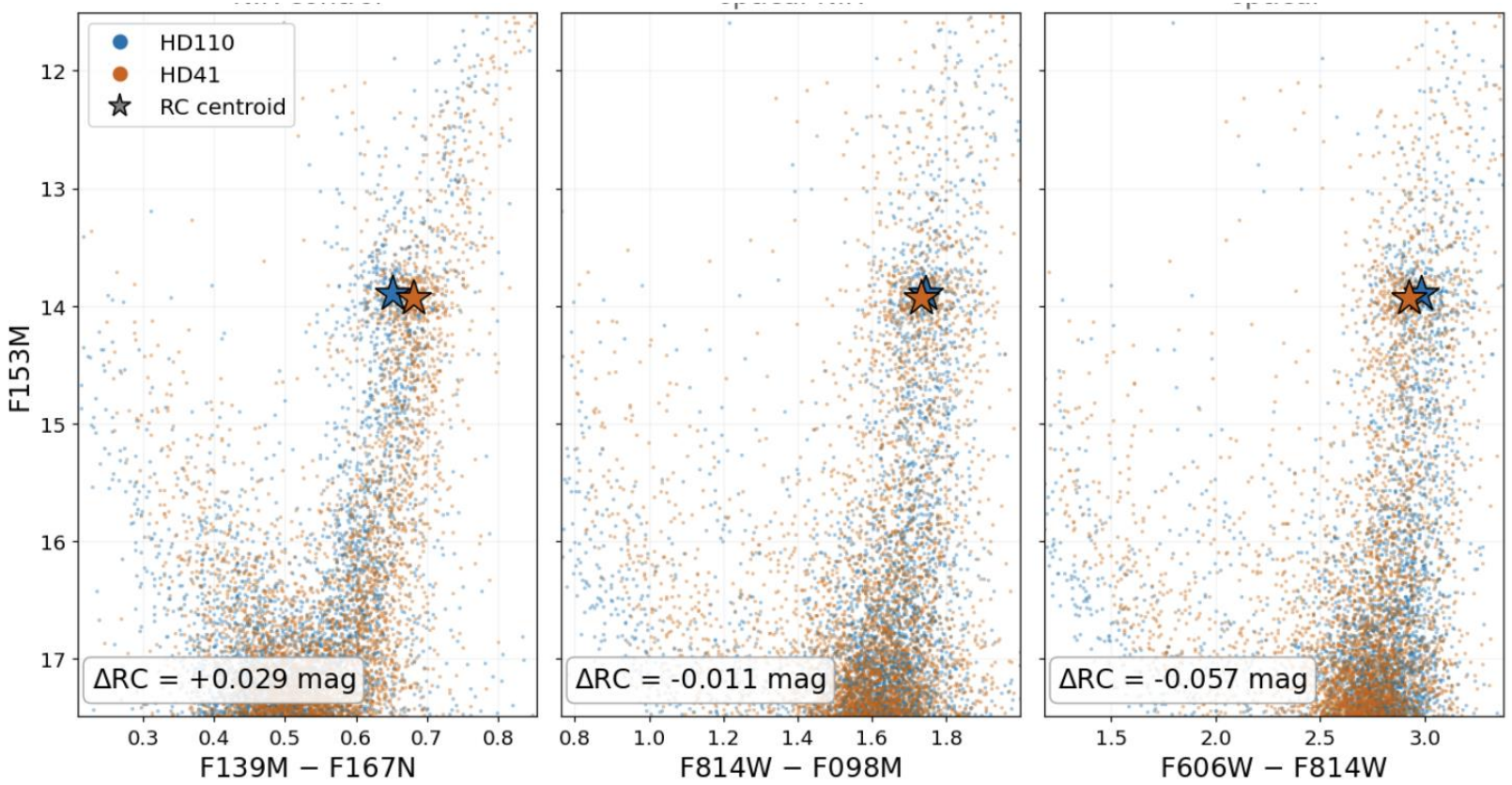
Reddening curve is indeed non-standard

I have a few more consistency checks that I want to implement.

The mean extinction curve will be available by itself, as a table of prediction for the Roman filters, and as a patch for the **Isochrones v2p5** and **Starlord** stellar parameter fitting codes.



A wrinkle: Reddening Curve is non-standard and variable



Summary -- Dealing with Dust in the Galactic Plane

- Extinction is an important consideration in evaluating planet-host stars.
- The maps of Surot, Zelakiewicz, and Zucker should provide useful priors for stars in and toward the main GBTDS field, but not the GC field.
- A variable reddening curve will converge stellar parameters to incorrect determinations when extinction is high, but a better extinction curve is on the way (Nataf et al., late 2026).

Questions?
Thank you