Dynamical Structure of the Quintuplet Cluster

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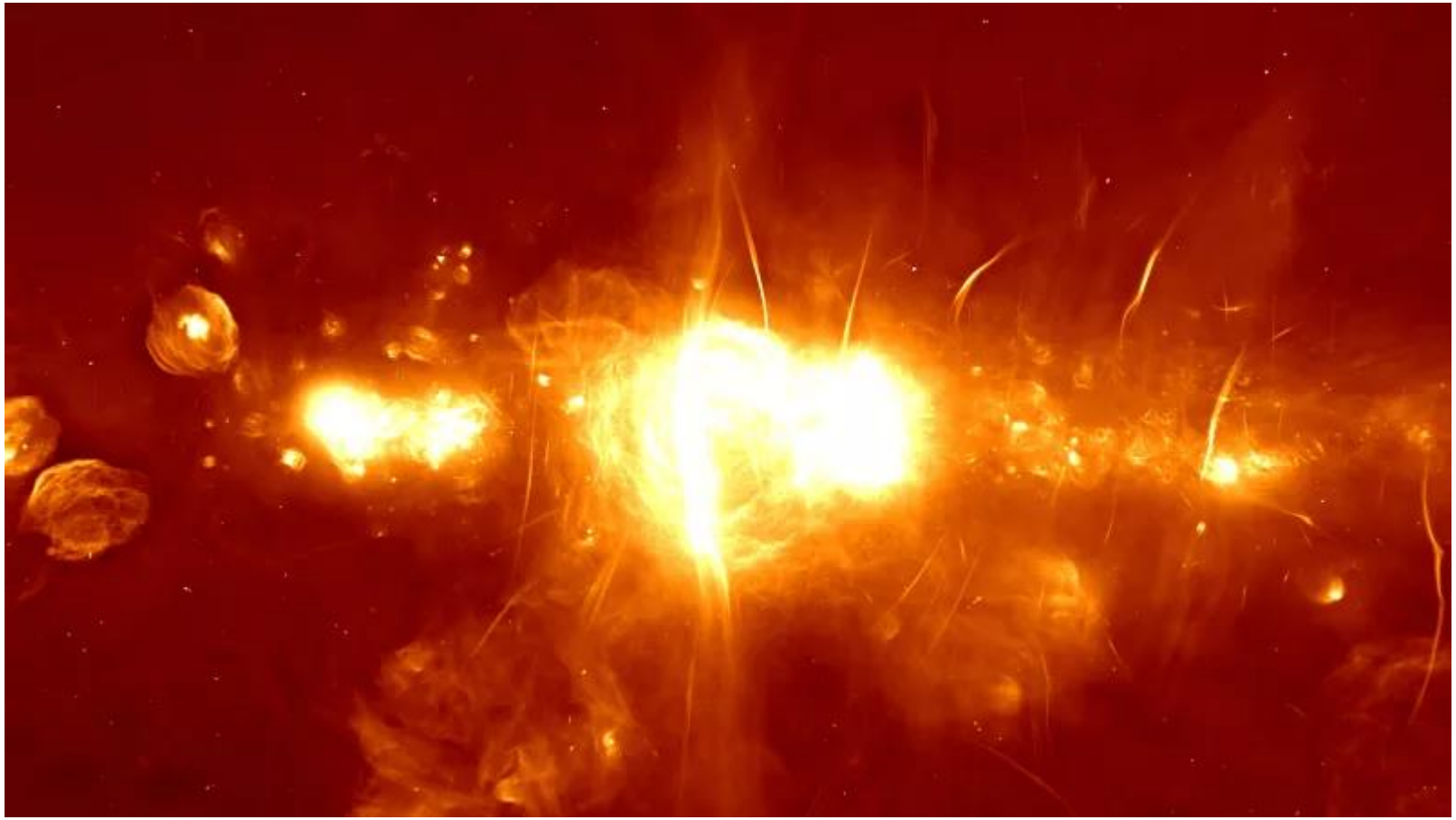
Galactic Center

About 8 kpc away

Centered around a supermassive black hole Sgr A*

Extreme environment with regards to temperatures, pressures, magnetic fields, and tidal fields



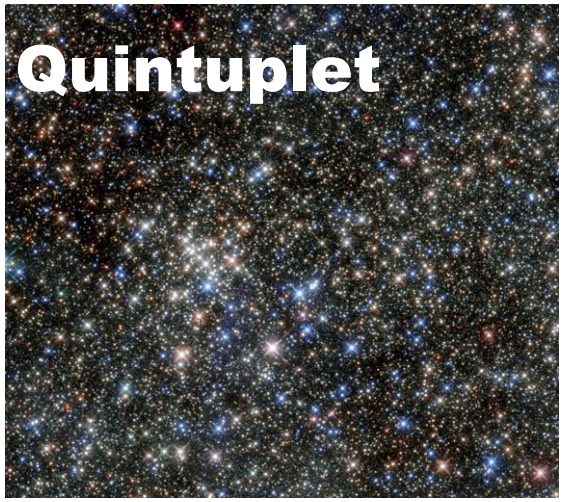
Star Clusters in the Galactic Center

Three young (~1-10 Myr), massive (~10^4 solar masses), star clusters in the Galactic Center:

Arches

Quintuplet

Young Nuclear Cluster



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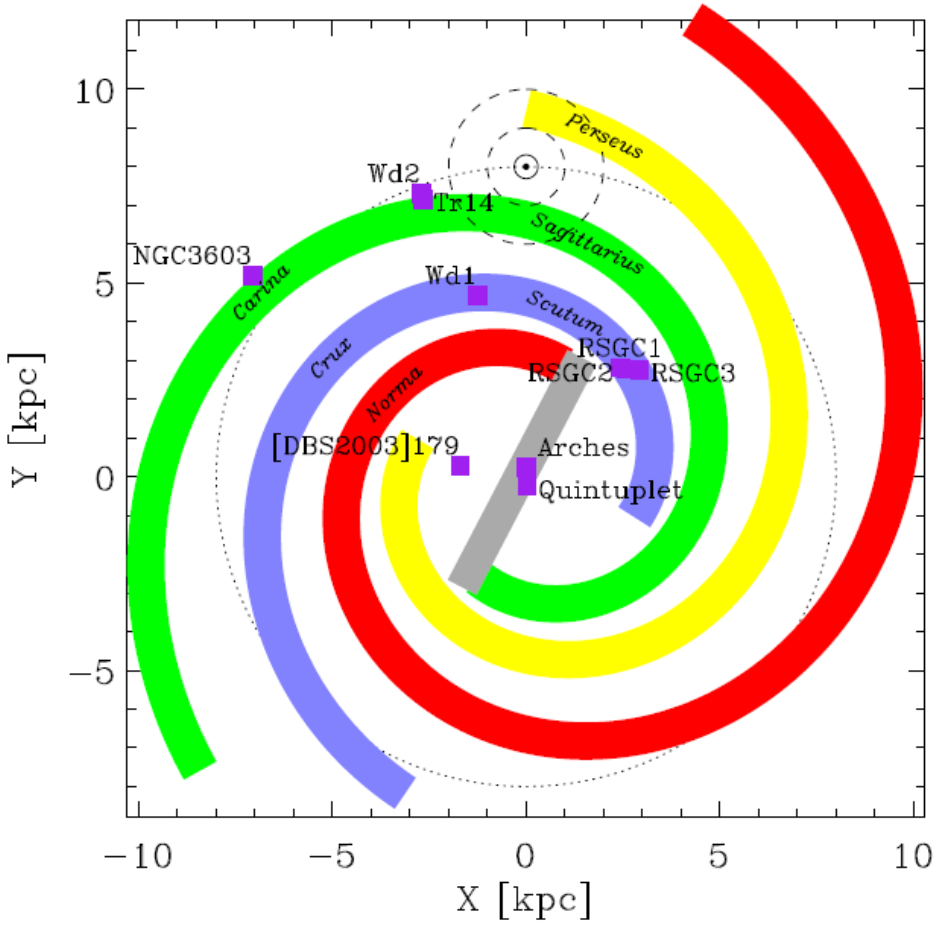


Portegies Zwart et al. 2010

The Quintuplet Cluster

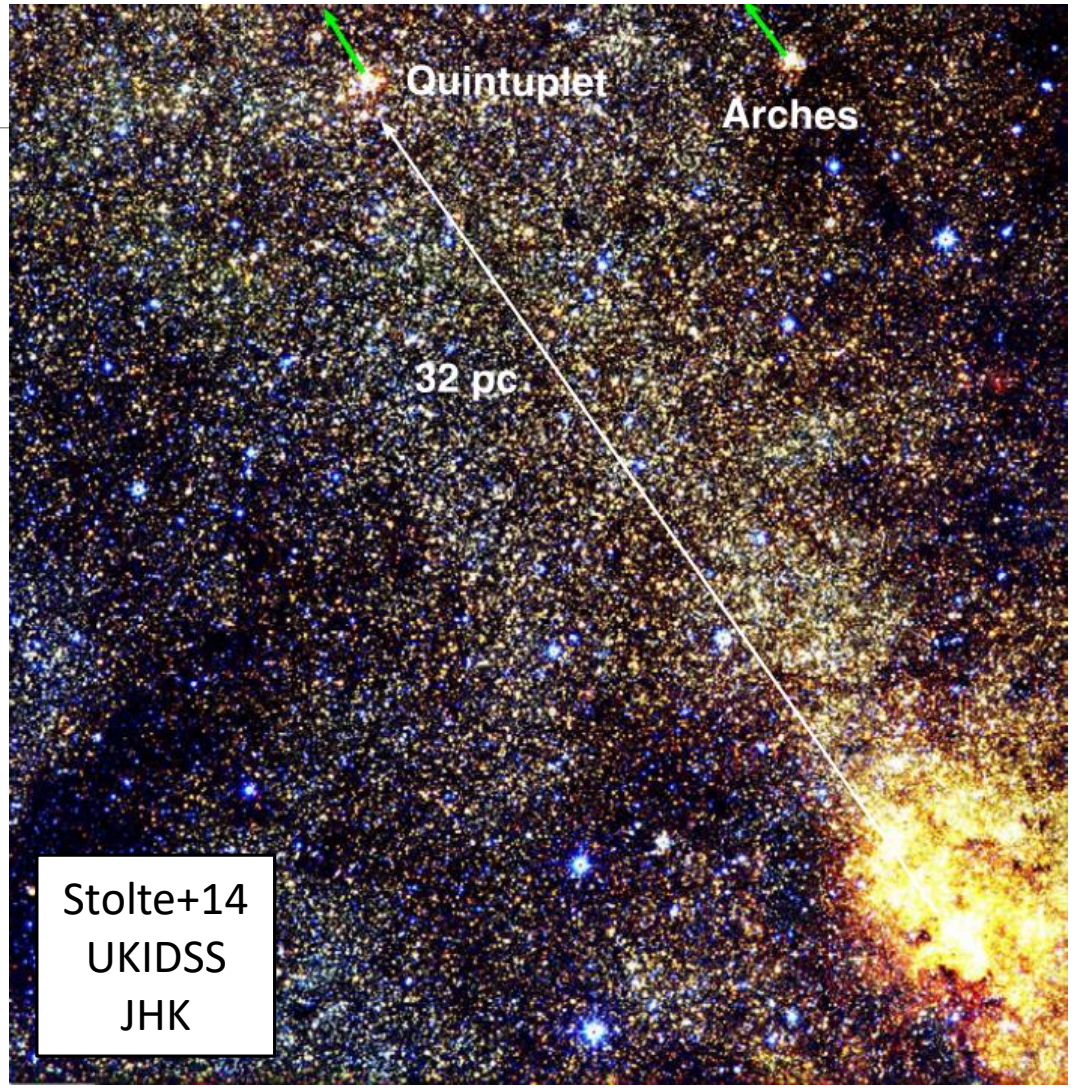
Young Massive Cluster

~30 pc from Sgr A*

~4.8 Myr

More diffuse than Arches

On disk



Why Study?

Star formation near GC (IMF)

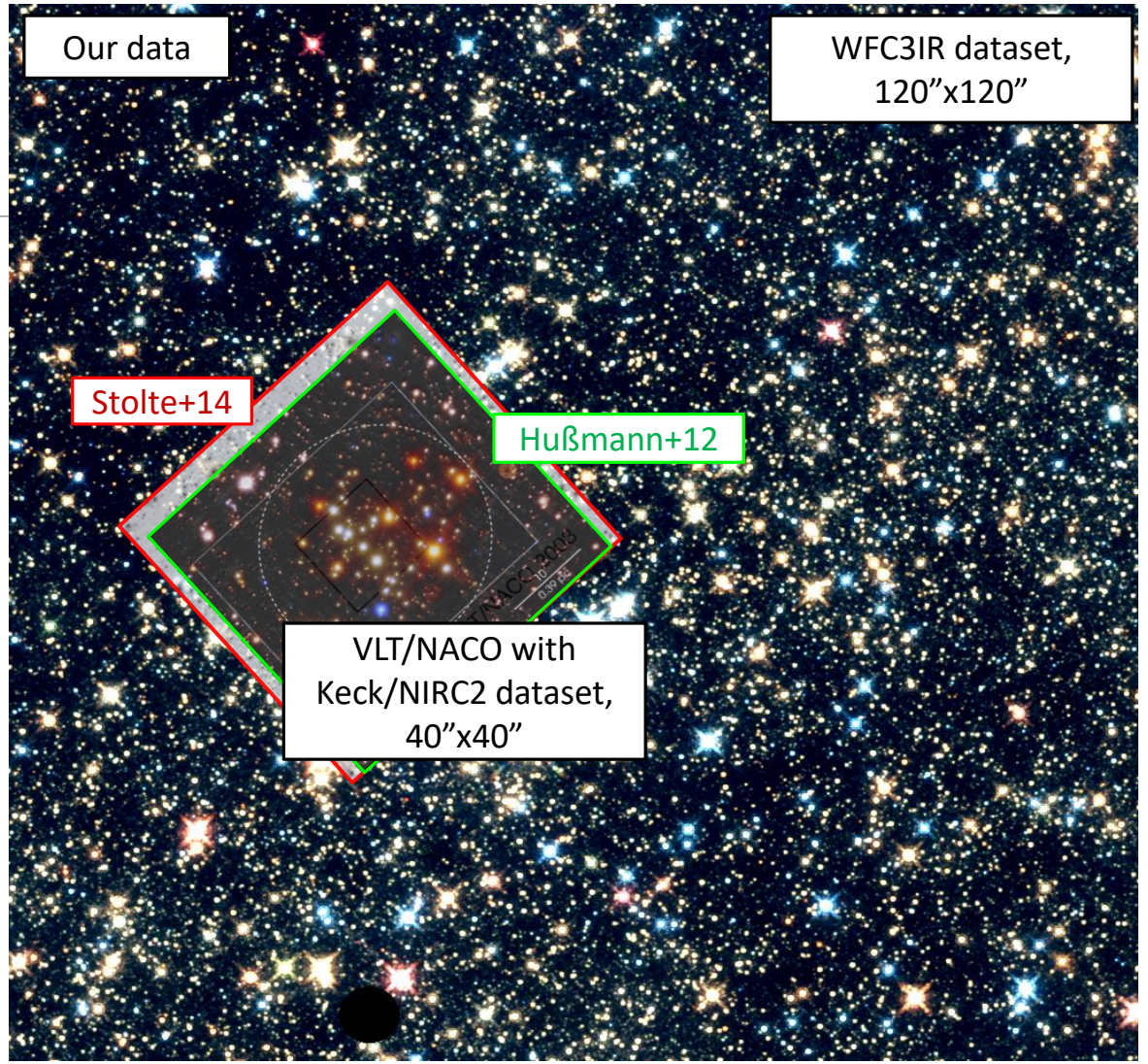
- Universal IMF?

Structure

- GC's effect on clusters
- Comparison to Arches cluster

Orbital history

- More comprehensive PM study can better constrain Quintuplet orbit
- Birthplace?

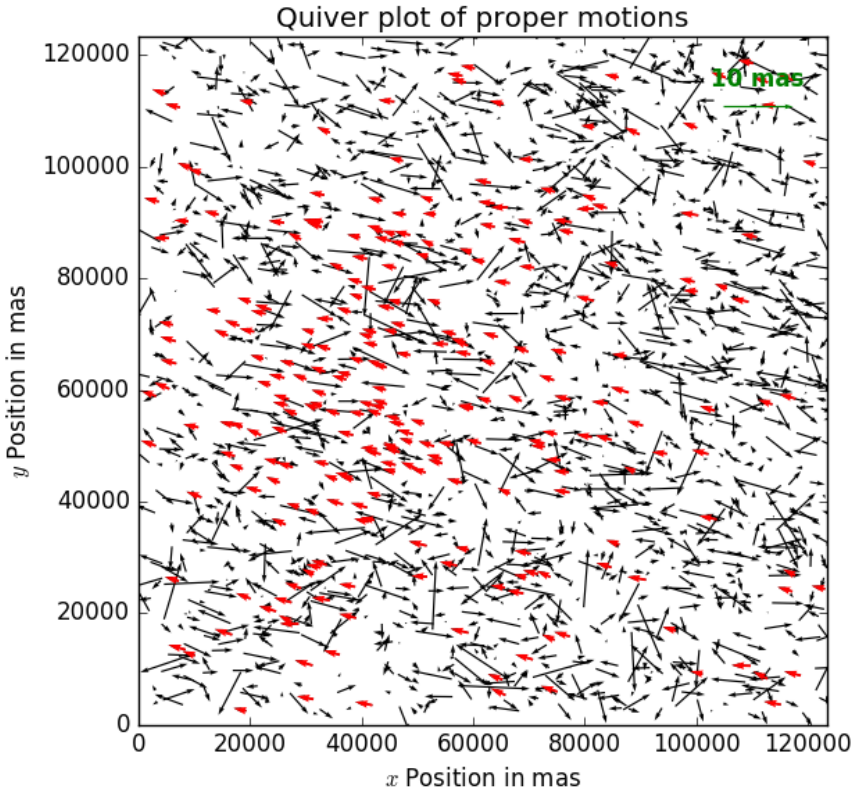


Proper Motions and Membership

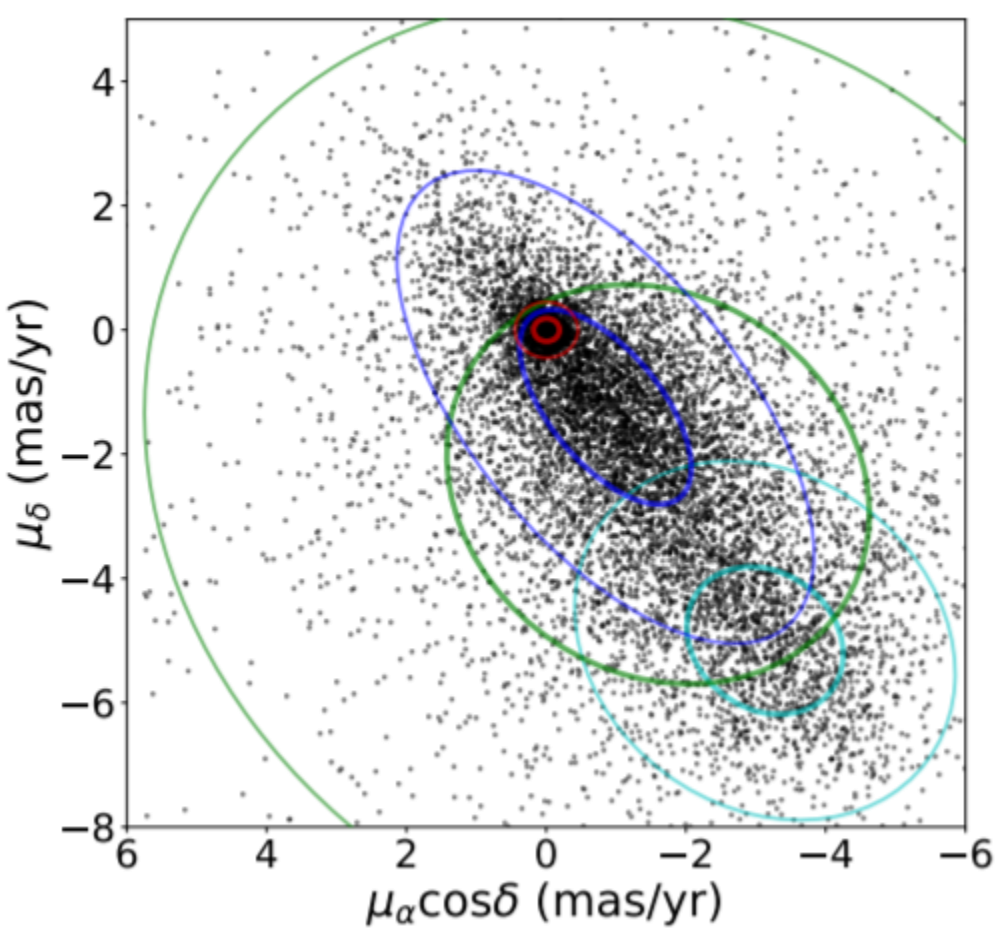
We observe the Quintuplet with WFC3-IR on Hubble for six years (2010-2016)

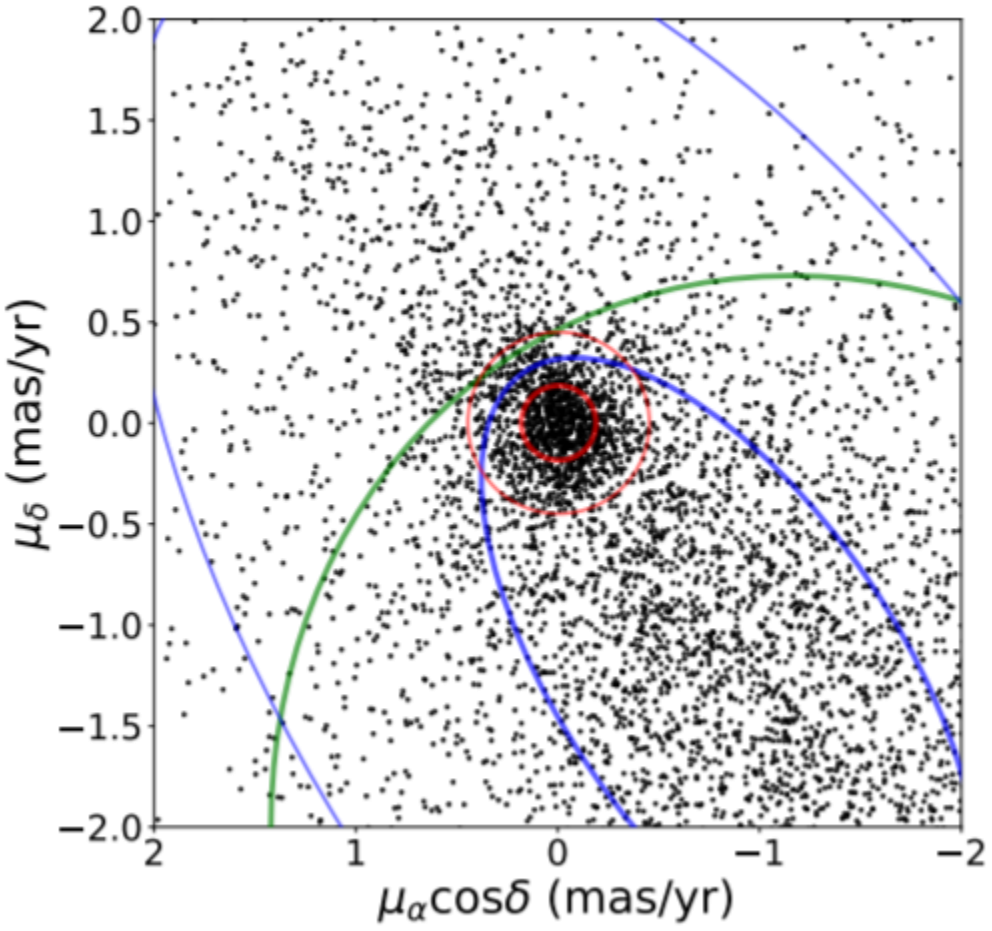
Stars which co-move with the star cluster can be considered to be gravitationally bound

Fit the field to a four-Gaussian mixture model using multi-modal nested sampling to maximize likelihood



Proper Motions and Membership



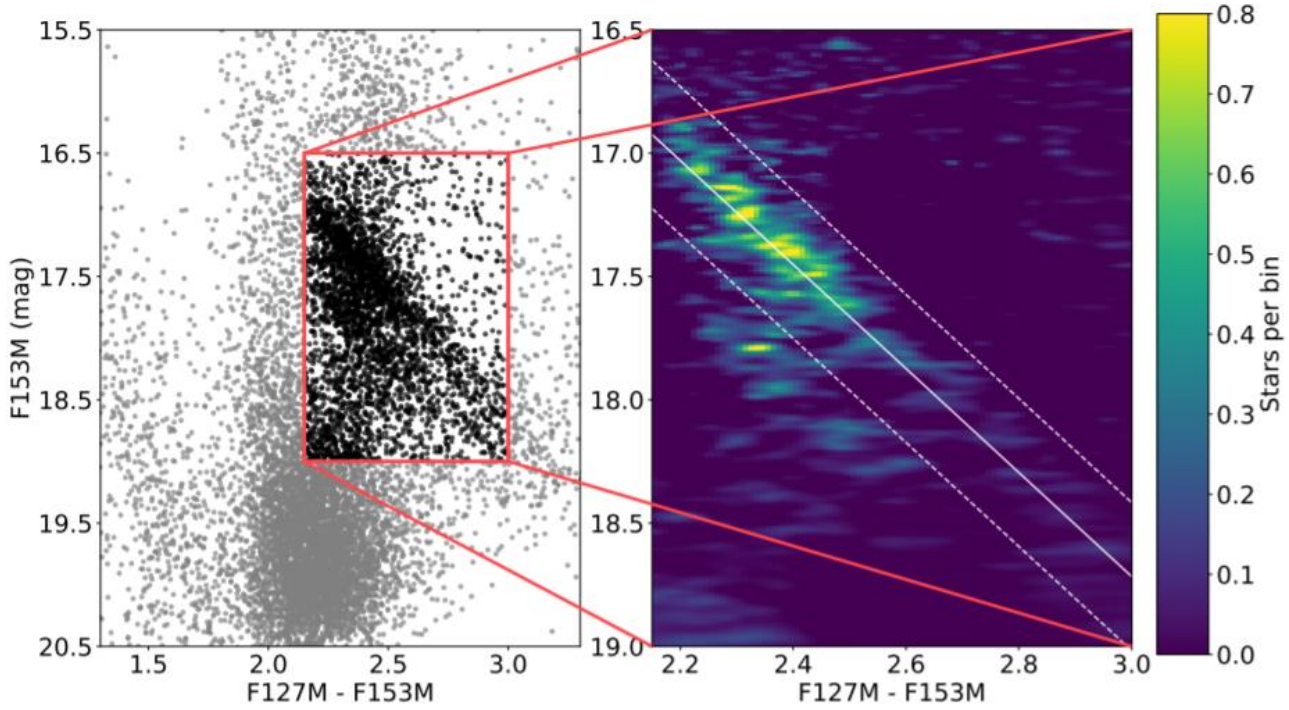


Extinction Correction

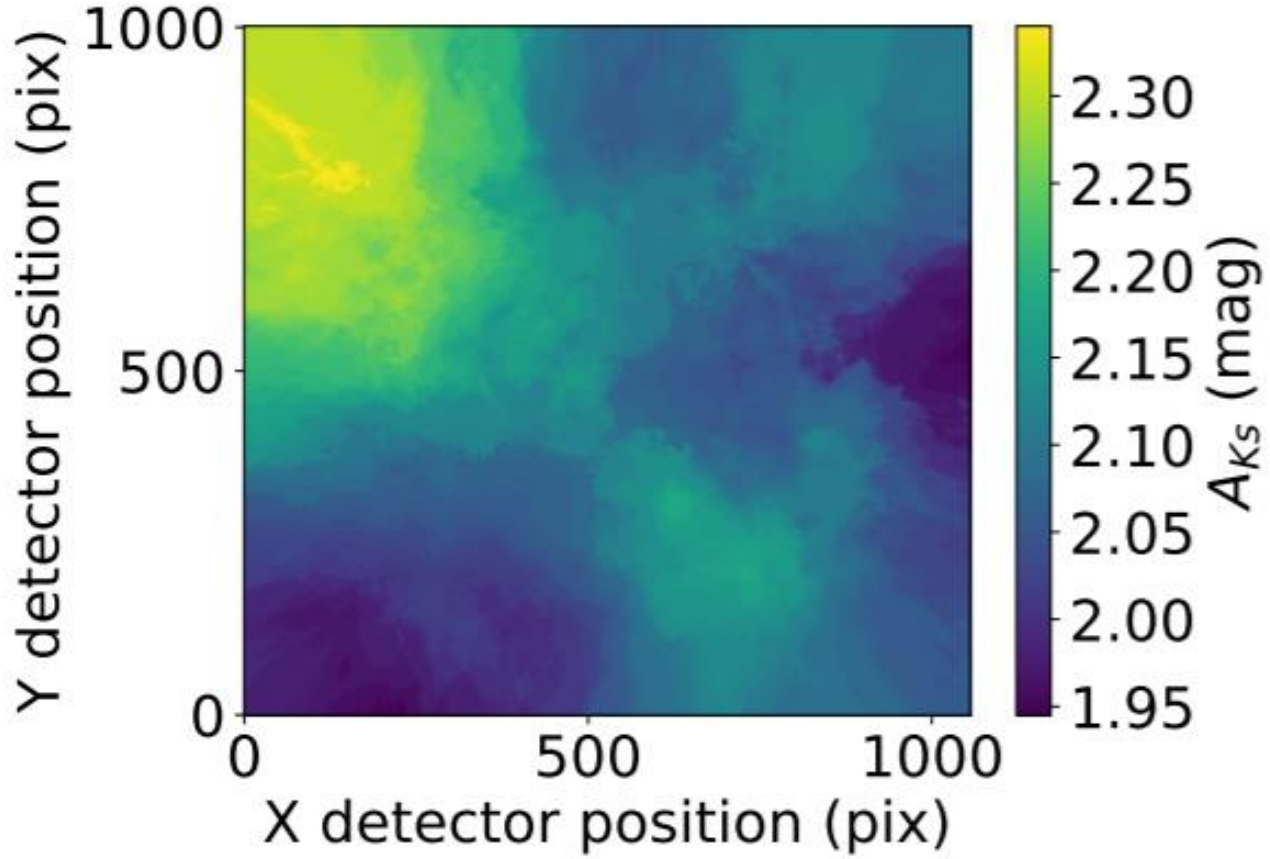
Quintuplet is about ~8 kpc in-disk, so wavelength-dependent light scattering reddens stars

Use the RC, a consistent population of stars in the bulge, to create a map of foreground extinction

Deredden stars, make a further membership cut, and get more accurate masses via star population modeling



Extinction Correction



Extinction Correction

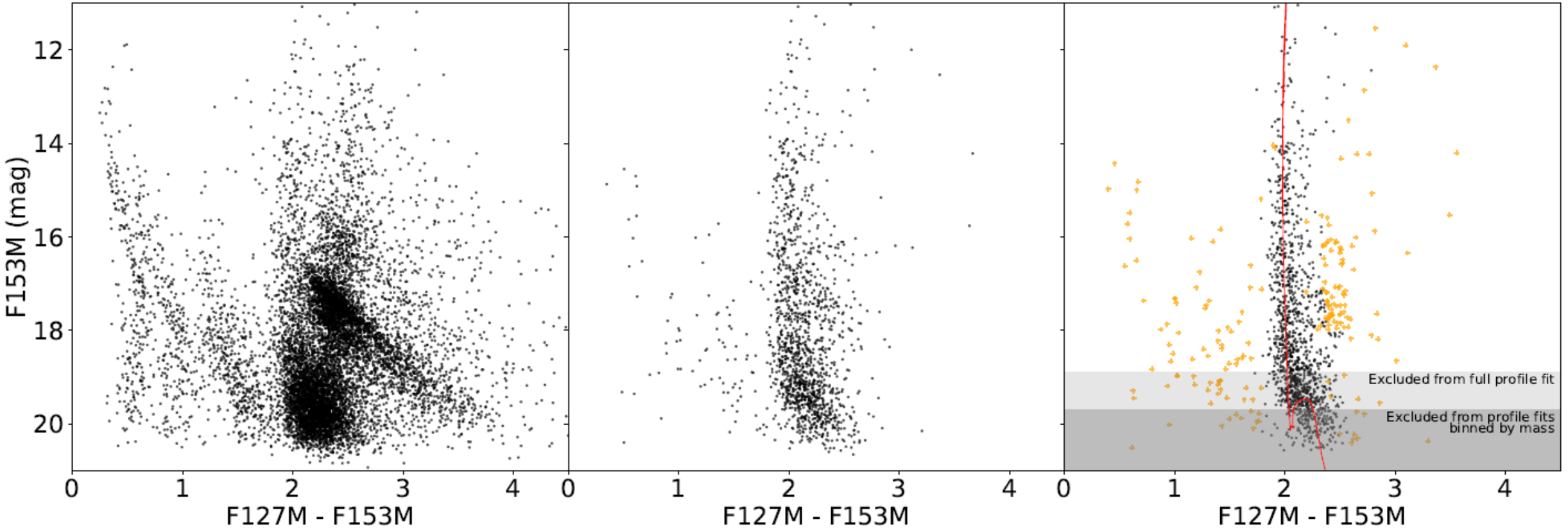
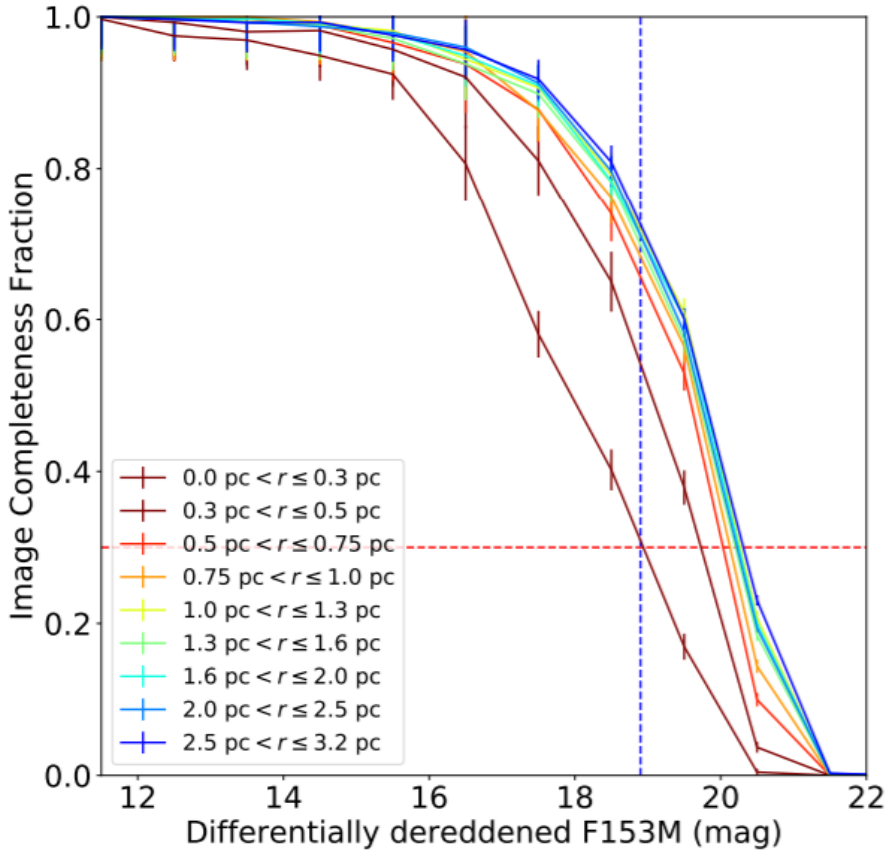


Image Completeness

Dimmer stars are less likely to be detected than brighter stars

In order to take this into account, plant artificial stars across the field

See how many artificial stars our software can extract

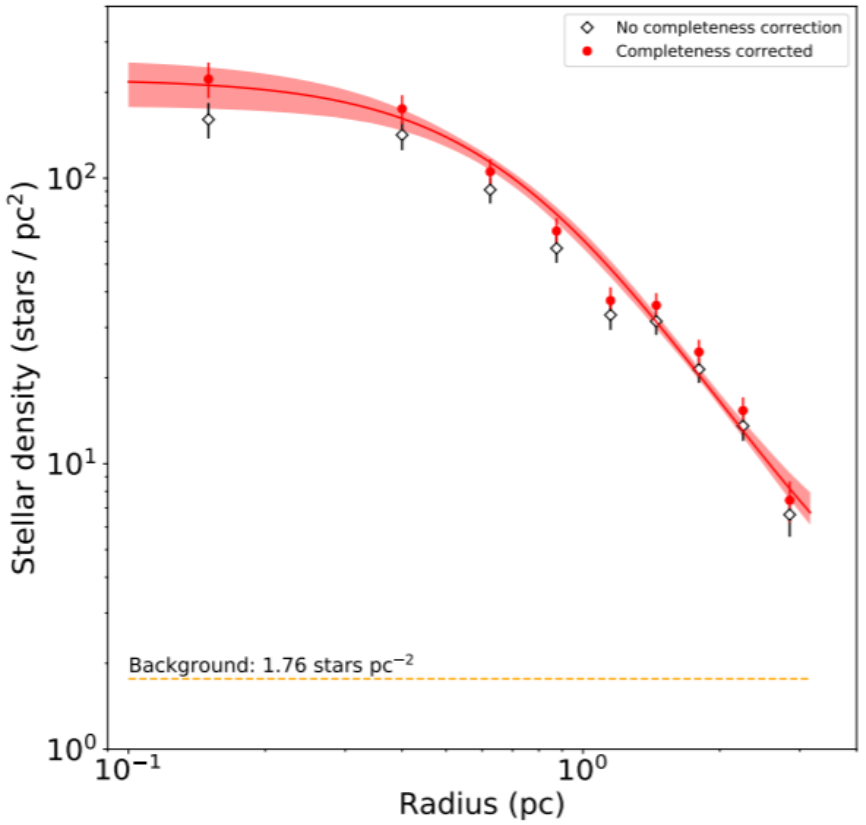


Radial density profile

Use Bayesian framework to fit a radial density profile

Take into account area and image completeness

Can start to make structural statements



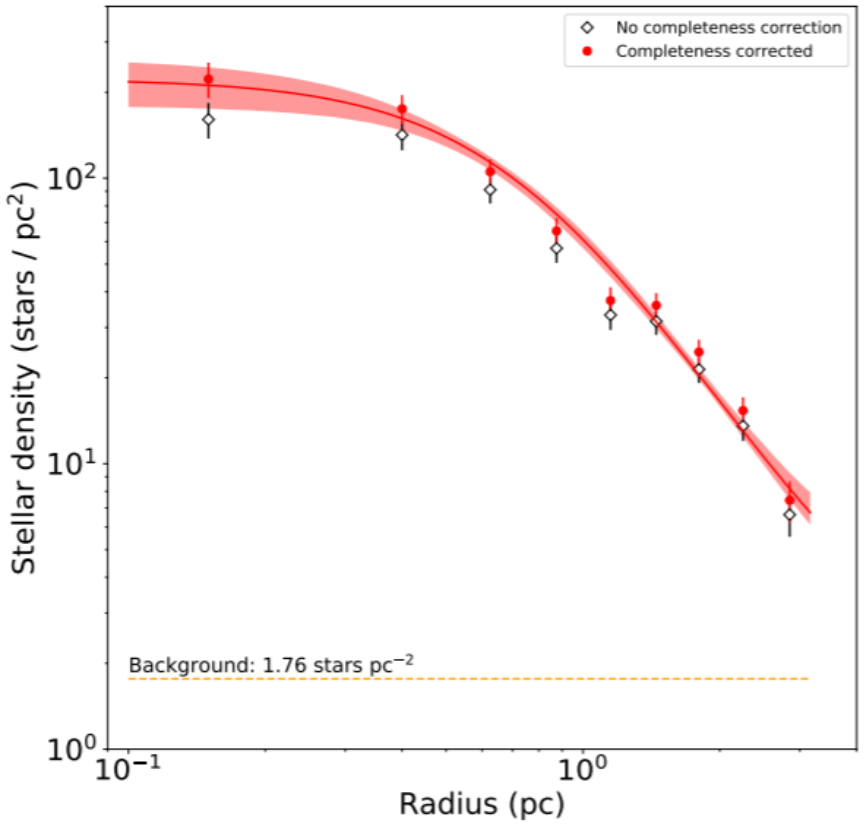
Fitting the Profile

We fit to King (truncated) and Elson (not truncated) profiles

We put a 3σ lower limit on the tidal radius at 3.8 using fitting with King

Core radius ~ 0.6-0.7 pc

We observe power law behavior, rather than a truncation



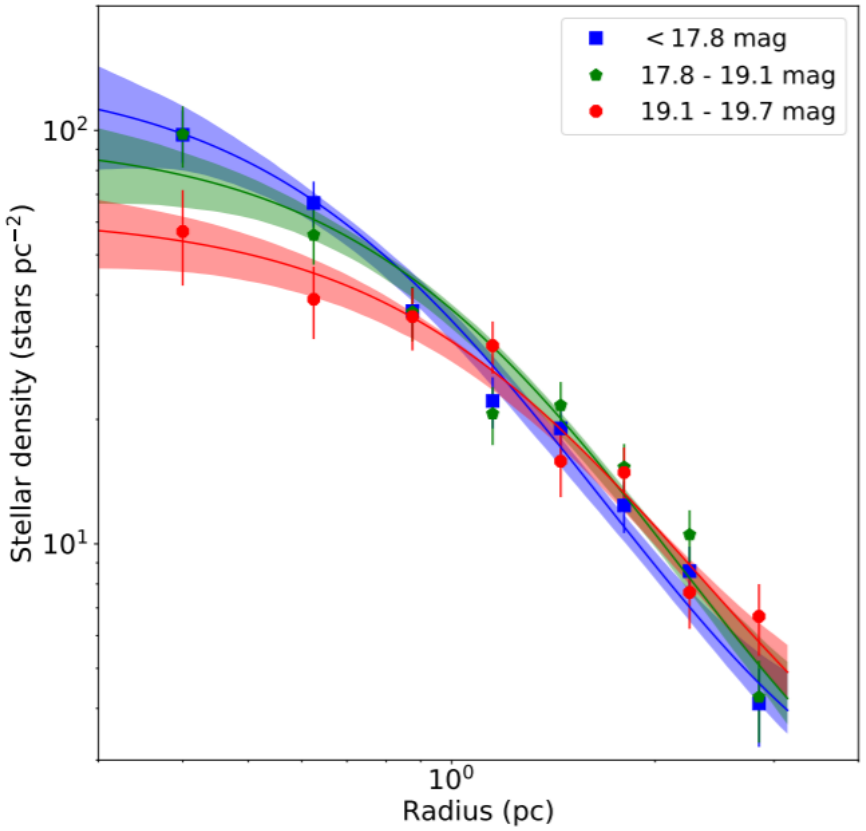
Mass Segregation

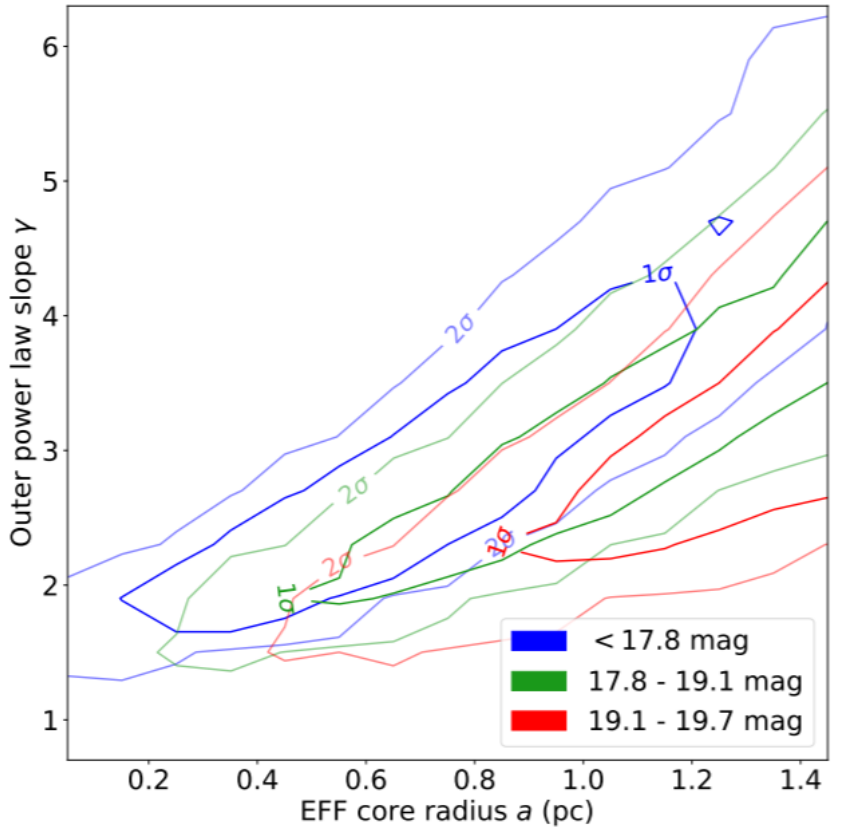
We find marginal, but not conclusive, evidence of mass segregation

Signal is weaker than that of the Arches, which is weird since mass segregation occurs over time

Some mechanisms: different primordial segregation, tidal stripping, or dynamical timescale

Mass Segregation





Tidal Tail

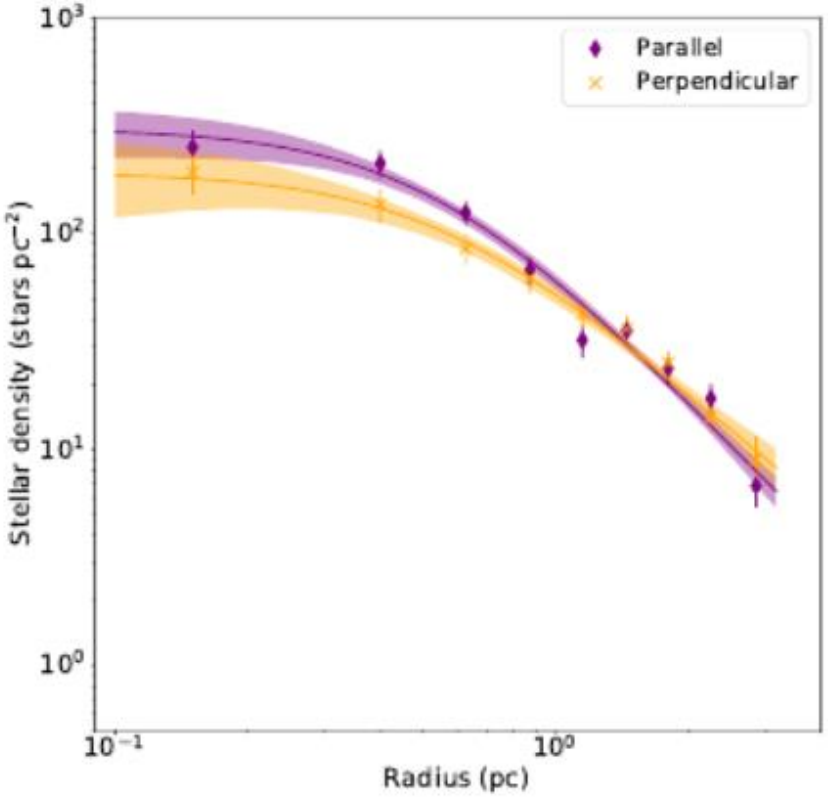
We do not observe significant evidence of a tidal tail

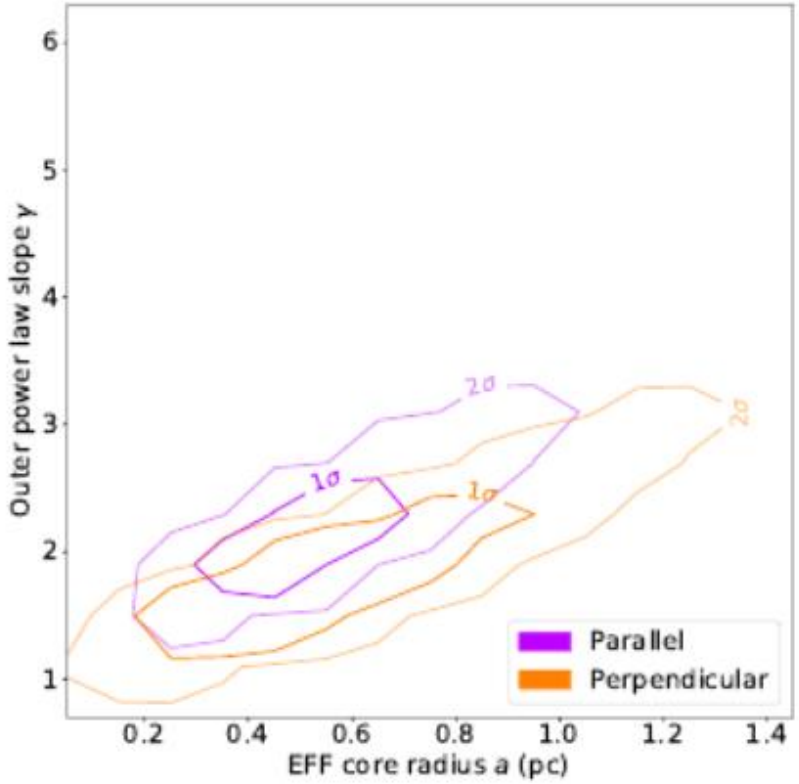
Tidal tails are expected for things undergoing large tidal perturbation

This is a mystery, but Park+2018's N-body simulations say this may be observational

Also did not show up in Arches data, challenges tidal stripping as a mechanism for lower mass segregation in the Quintuplet

Tidal Tail


Parallel
Perpendicular
Stellar density (stars pc^{-2})
Radius (pc)
10^3
10^2
10^1
10^0
10^{-1}
10^0


Outer power law slope γ
EFF core radius a (pc)
1σ
2σ
1σ
2σ
Parallel
Perpendicular
1
2
3
4
5
6
0.2
0.4
0.6
0.8
1.0
1.2
1.4

Looking Ahead

Perform an updated orbital simulation

Get a better constraint on the velocity dispersion

Get the velocity dispersion profile

Use WFIRST (in an upcoming decade) for wider field observation

Get the IMF of the star cluster

Science, science, and more science