

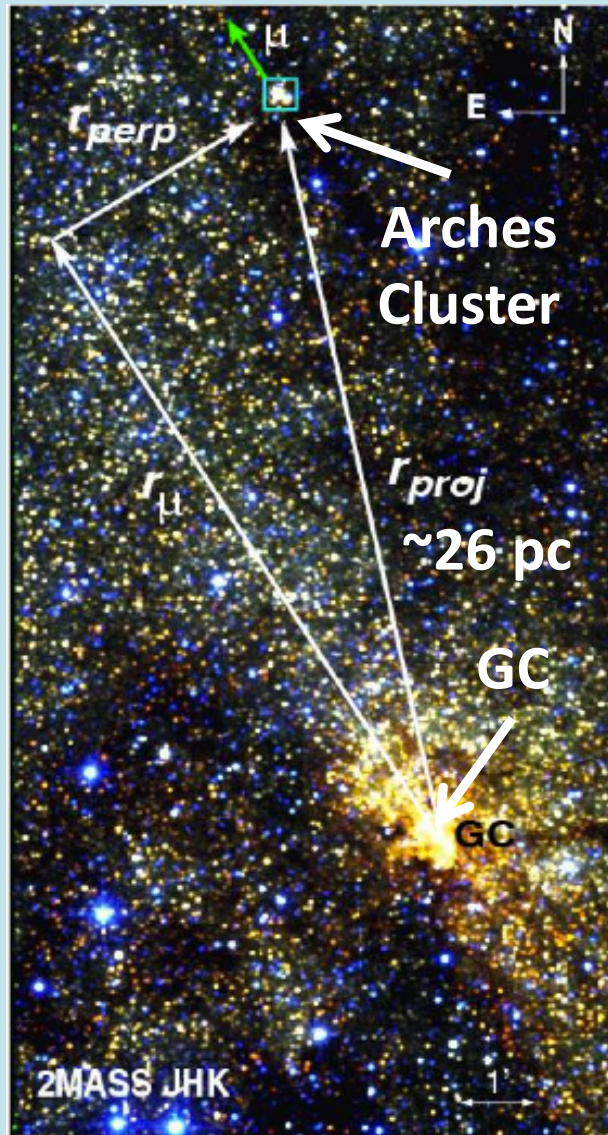
The Dynamical Structure and Initial Mass Function of the Arches Cluster



Matthew Hosek Jr.
Graduate Student, UH/IfA

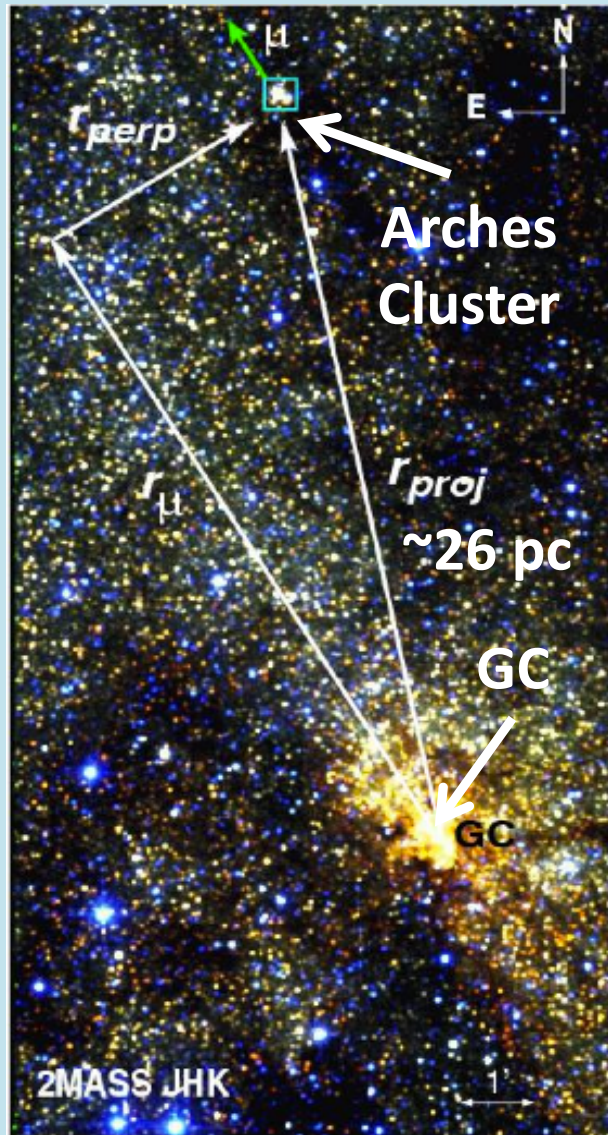
Jessica Lu (UH/IfA), Jay Anderson (StSci),
Andrea Ghez (UCLA), Mark Morris (UCLA), Will
Clarkson (UMichigan-Dearborn), Tuan Do
(UCLA)

The Arches Cluster: A Young Massive Cluster Near the Galactic Center



Stolte et al. (2008)

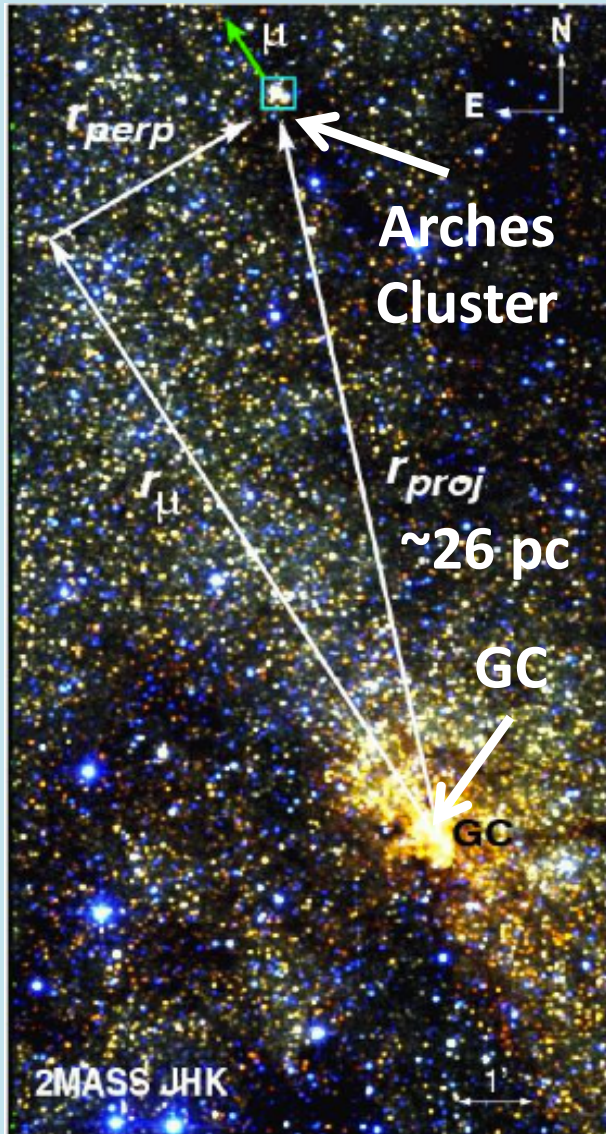
The Arches Cluster: A Young Massive Cluster Near the Galactic Center



- **What impact does the GC environment have on the dynamical structure of massive star clusters?**

Stolte et al. (2008)

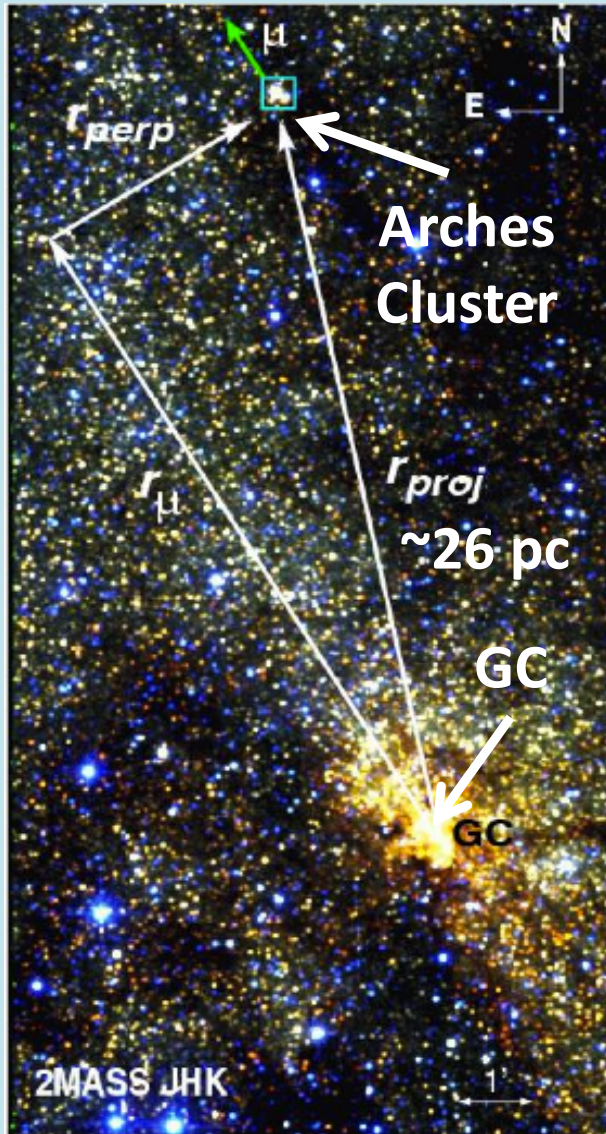
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- **How does the Initial Mass Function behave in extreme star-formation environments?**

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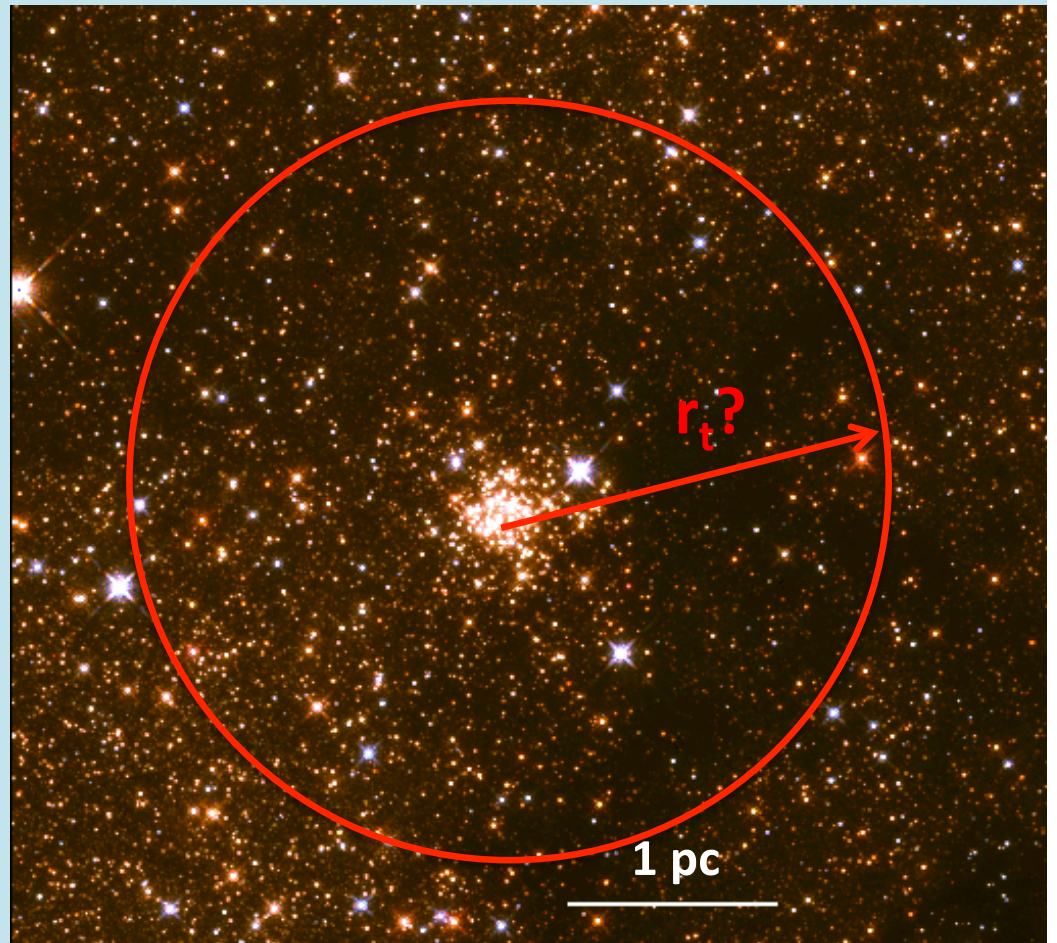


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Hosek et al. (2015): Measure the Radial Profile to Large Radii

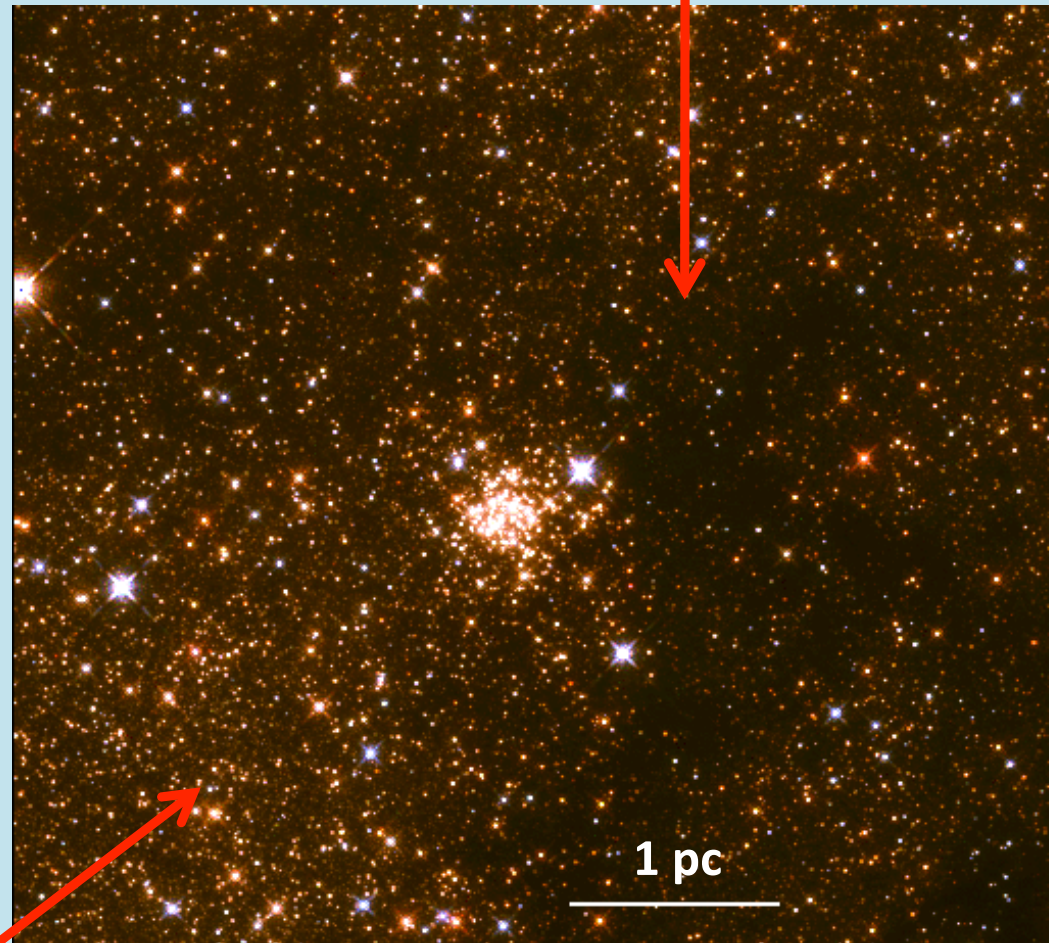
- Unknown tidal radius, profile only measured to $R = 0.4$ pc (Espinoza+09)
 - Extra-tidal stars?



HST WFC3IR image of the Arches Cluster

Hosek et al. (2015): Measure the Radial Profile to Large Radii

- Unknown tidal radius, profile only measured to $R = 0.4$ pc (Espinoza+09)
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- **Challenge:** Significant differential reddening
 - $\Delta A_V \sim 10$ -15 mag (Habibi+13)
 - Cluster membership tricky!



Low reddening

HST WFC3IR image of the Arches Cluster

Solution: HST Astrometry

- HST WFC3IR: 3 epochs / 2 years in F153M, 1 epoch in F127M

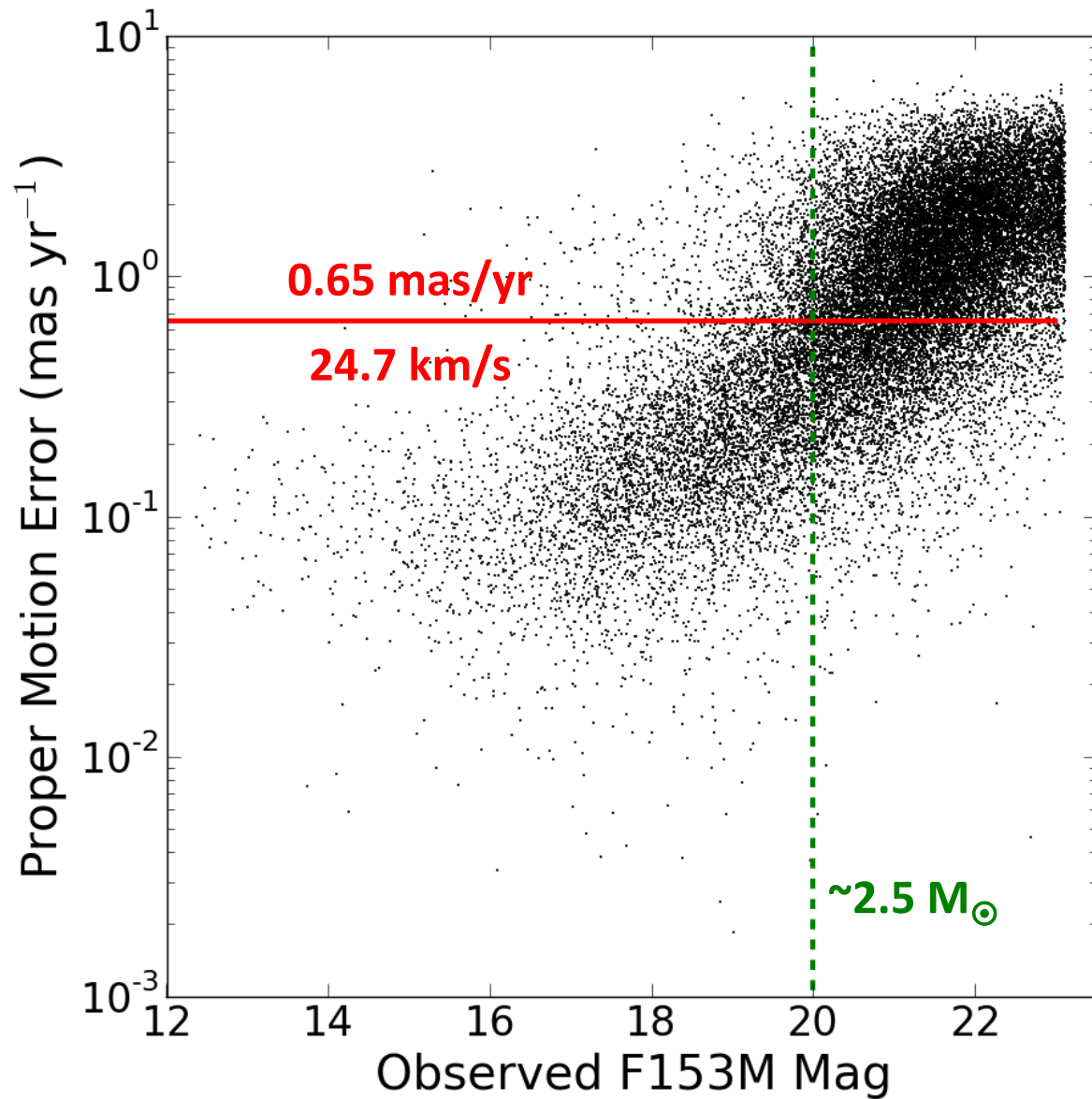


<http://www.spacetelescope.org/>

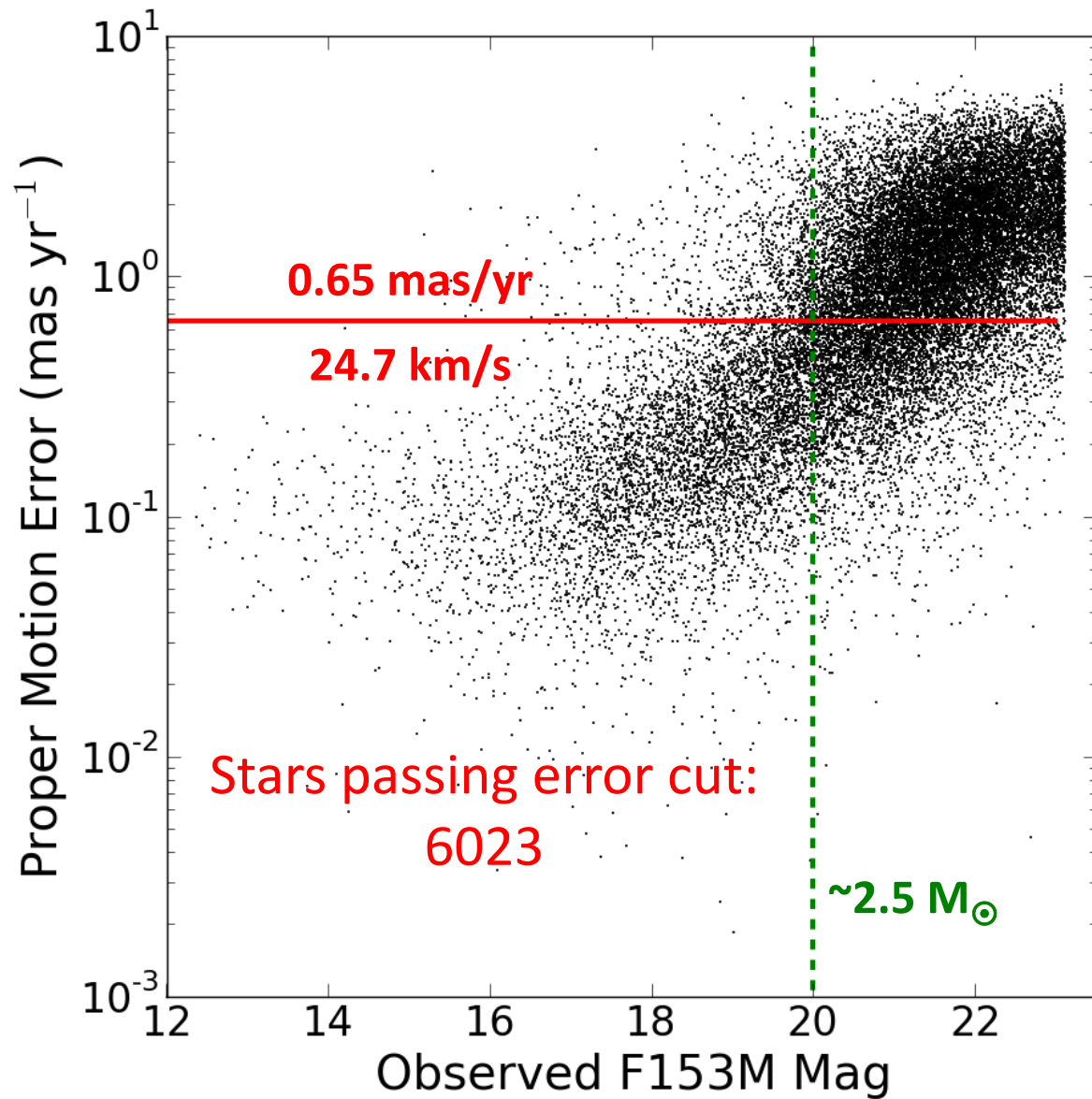
Advantages:

- (1) Proper motions for improved cluster membership
- (2) Wide field of view: 120x120'' (4.8 pc x 4.8 pc)
- (3) Deep: $\sim 2.5 M_{\odot}$

High-Precision Proper Motions

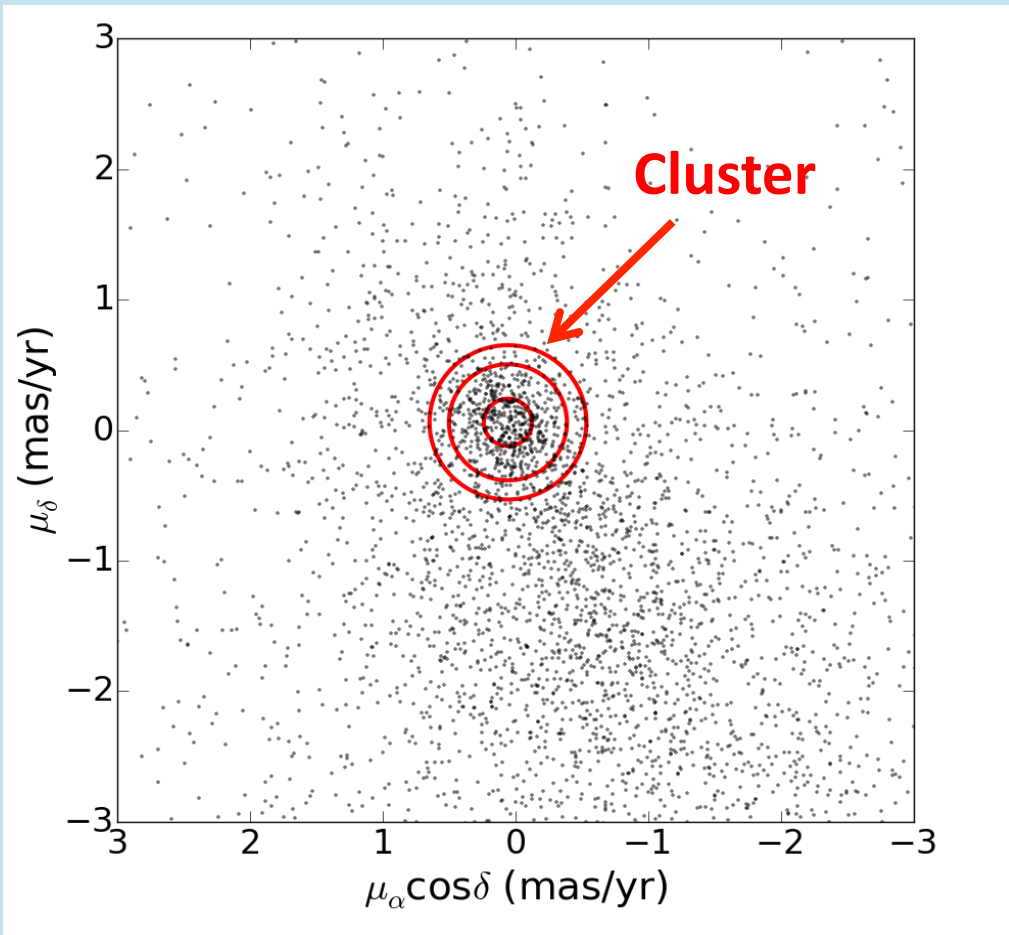


High-Precision Proper Motions



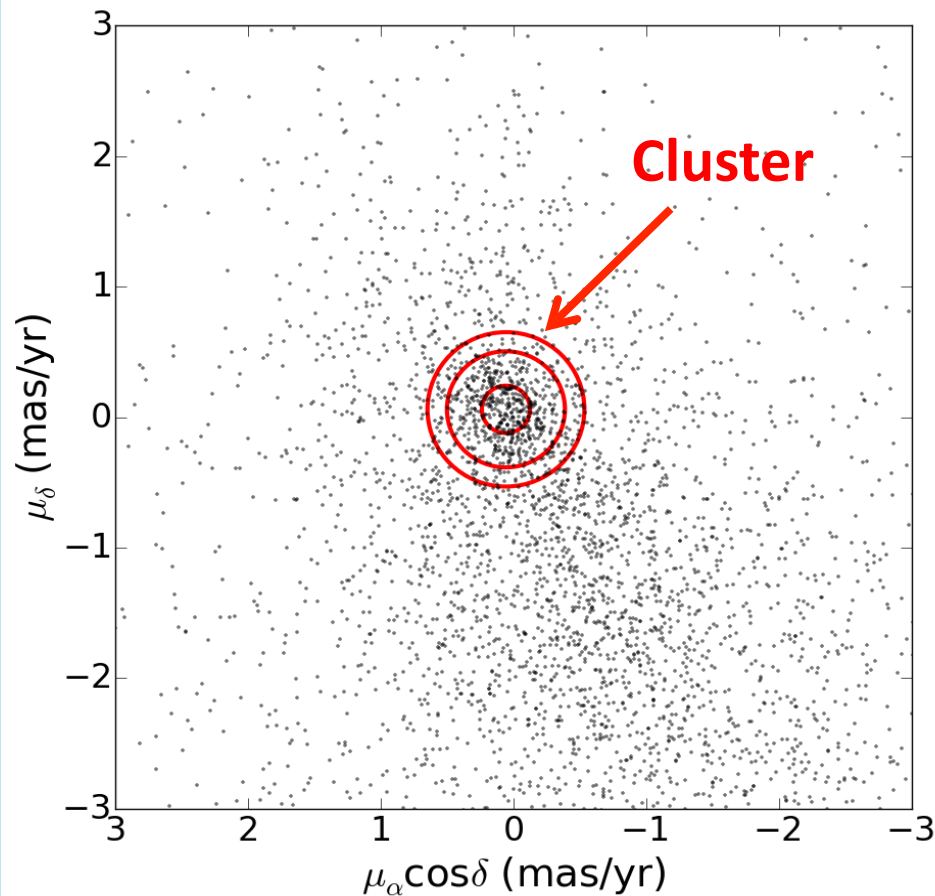
Modeling Cluster and Field Kinematics: Gaussian Mixture Model

Vector Point Diagram

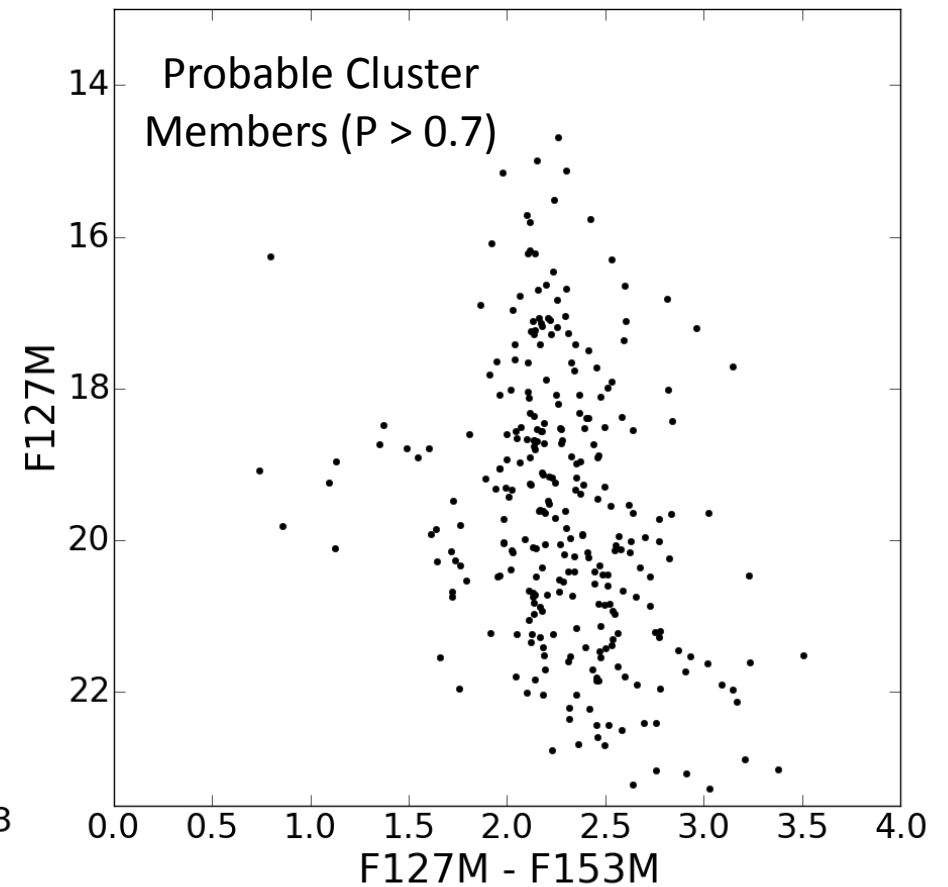


Modeling Cluster and Field Kinematics: Gaussian Mixture Model

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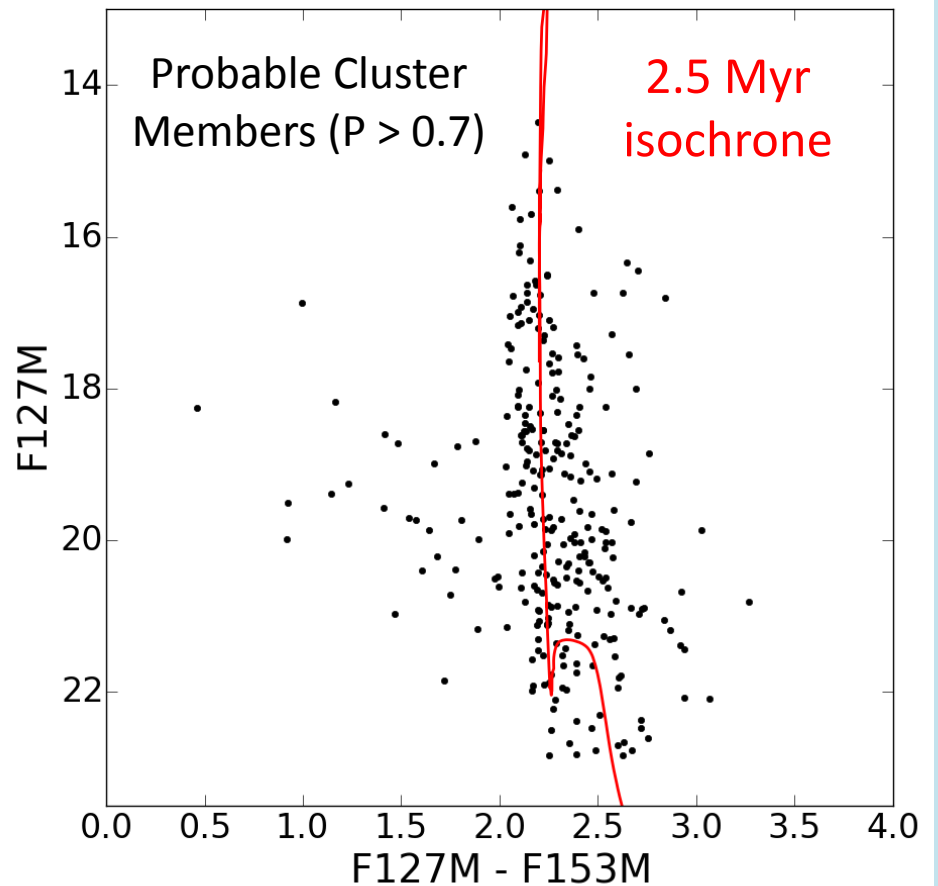
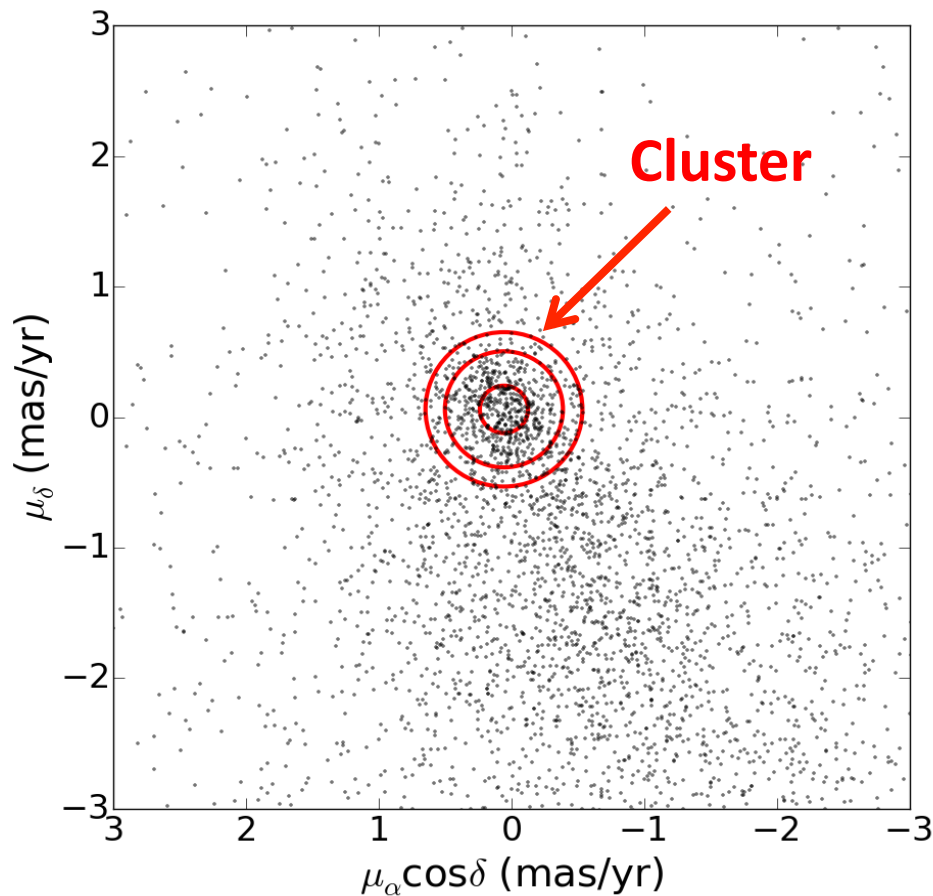
Observed CMD



Modeling Cluster and Field Kinematics: Gaussian Mixture Model

Vector Point Diagram

Diff. De-reddened CMD



The Extended Radial Profile of the Arches Cluster

Model:

Power-Law + Constant

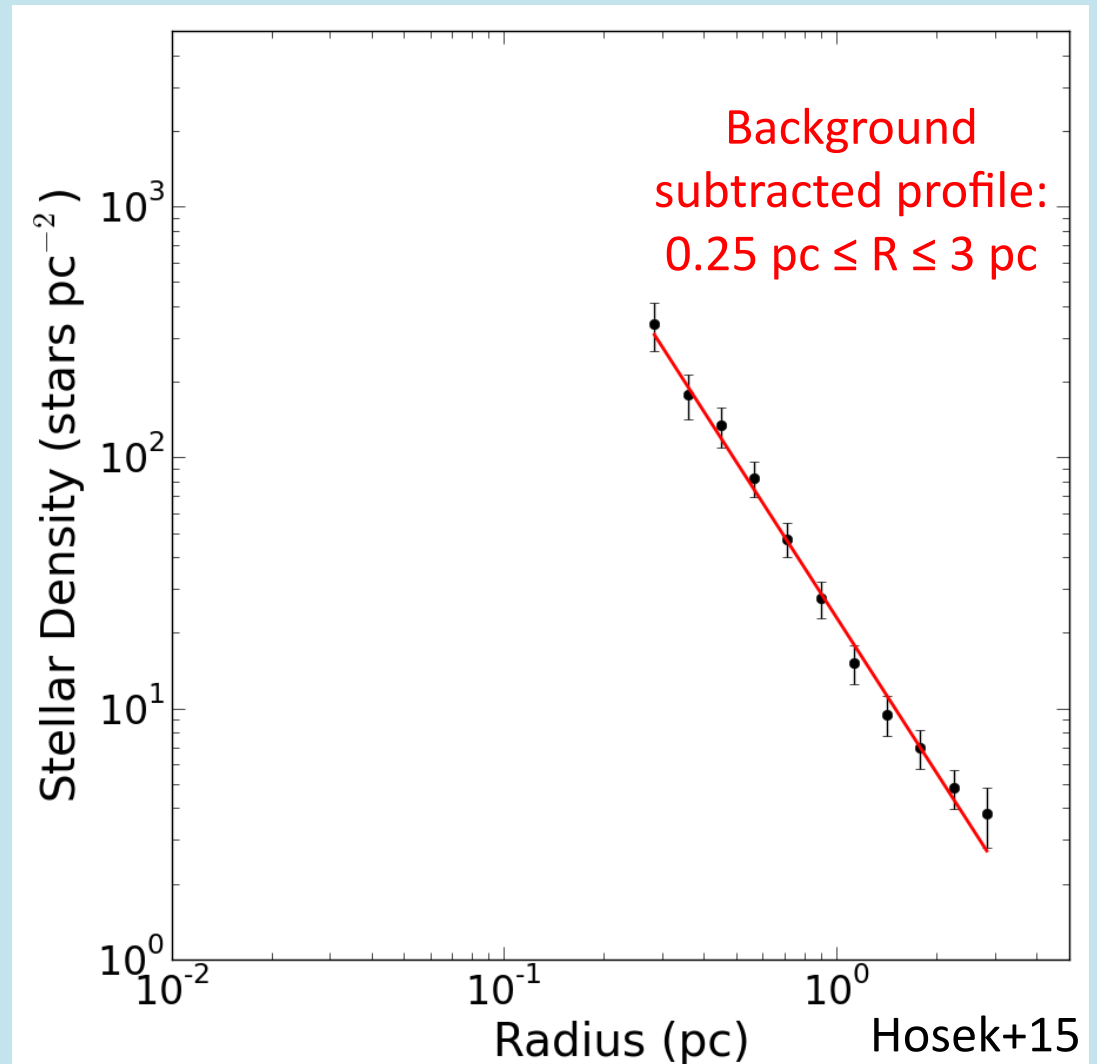
$$L_i(r, \Gamma, b) = A_0 r_i^{-\Gamma} + b$$

Best-Fit Params:

$$\Gamma = 2.06 \pm 0.17$$

$$b = 2.52 \pm 1.32 \text{ stars/pc}^2$$

$$A_0 = 23.09 \pm 3.5 \text{ stars}$$



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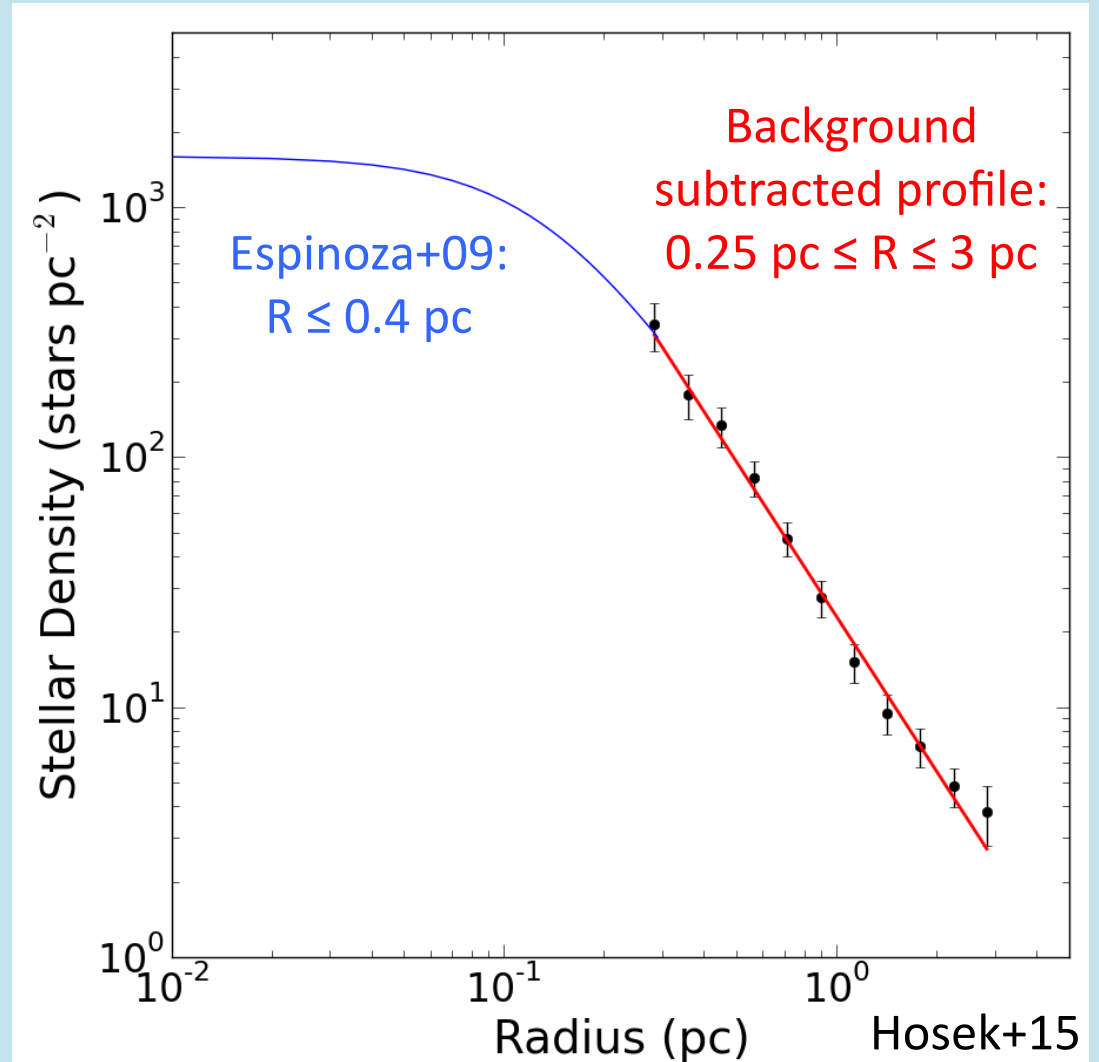
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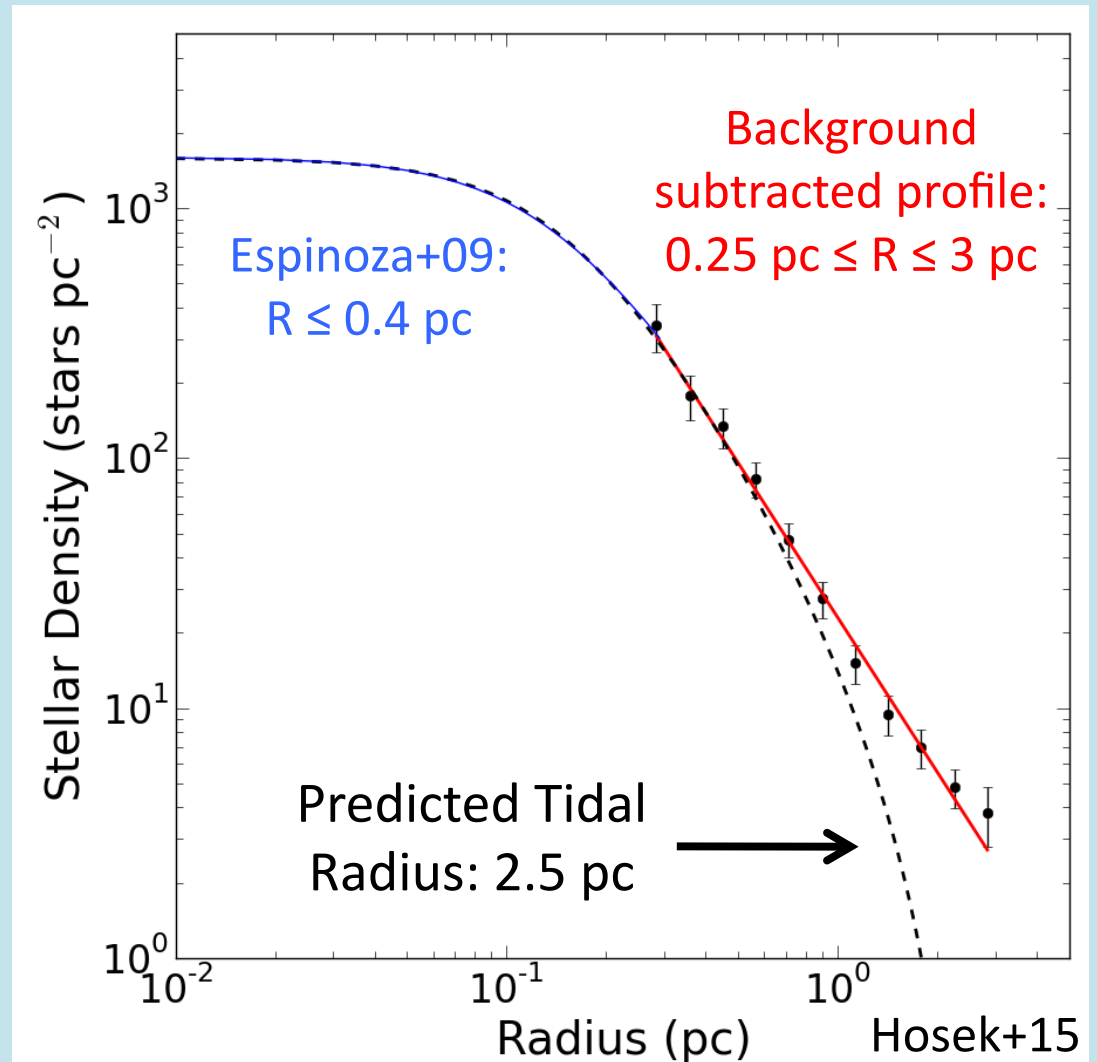
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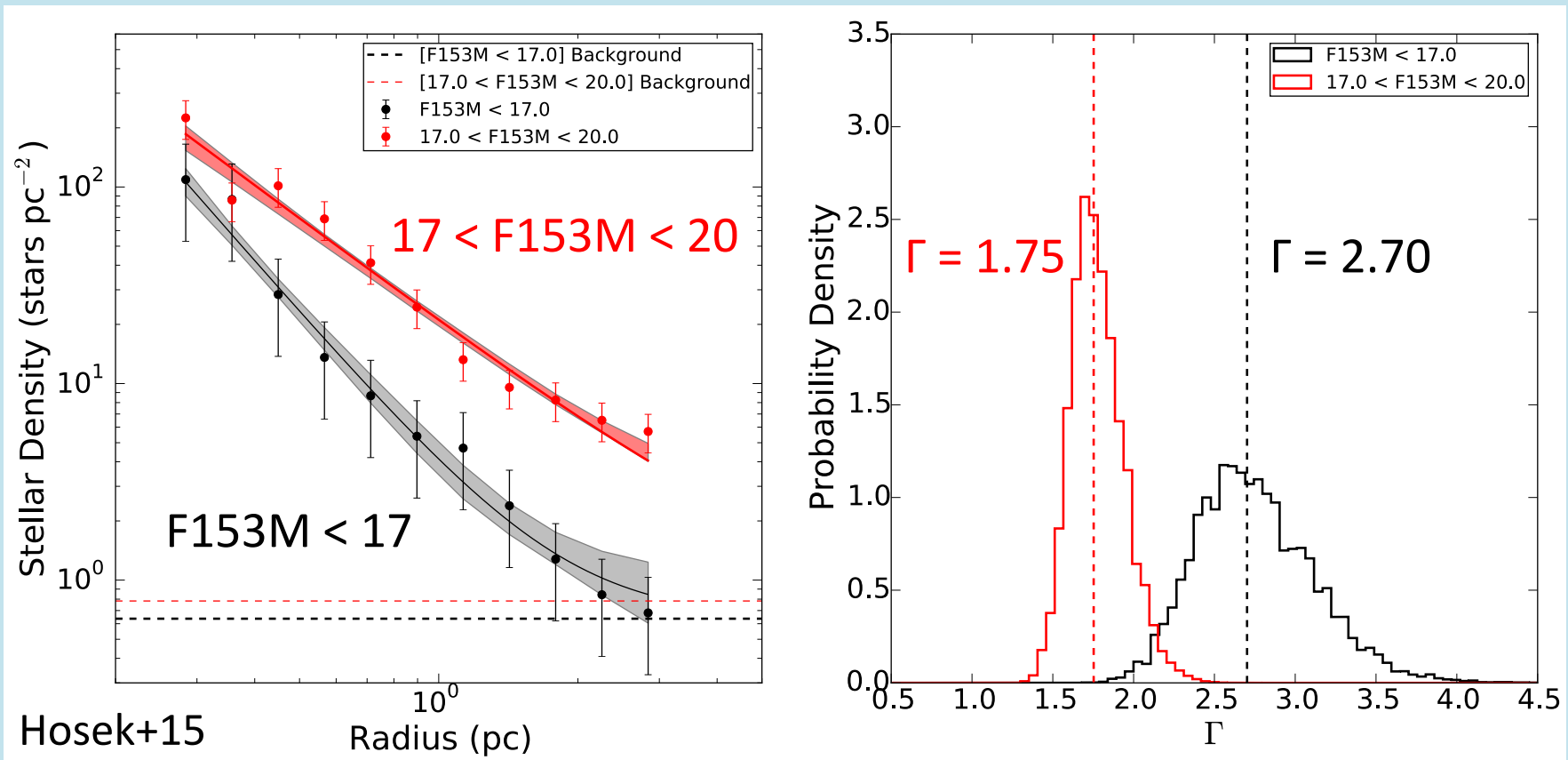
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**3 σ lower limit on
tidal radius: 2.8 pc**

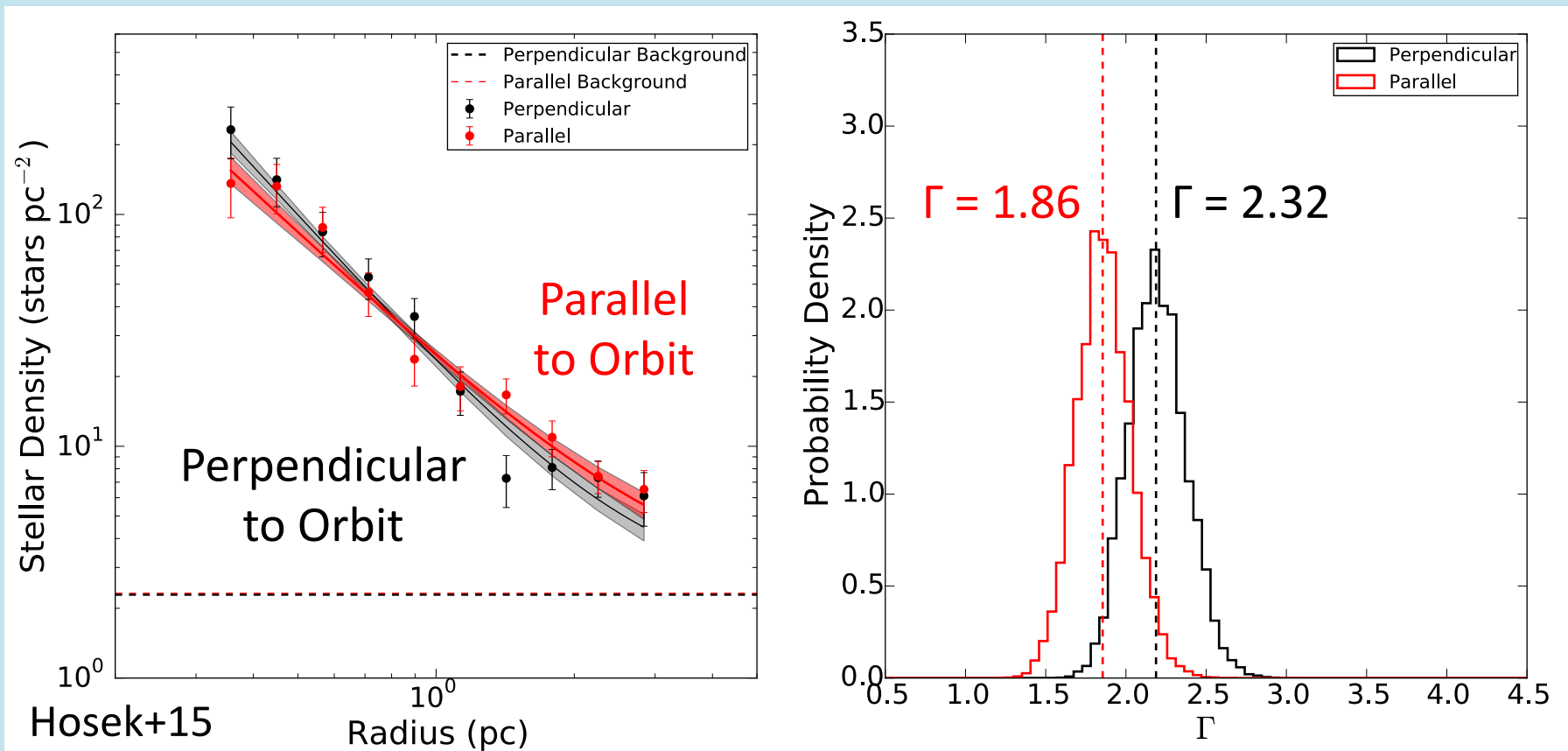


Mass Segregation Throughout Cluster



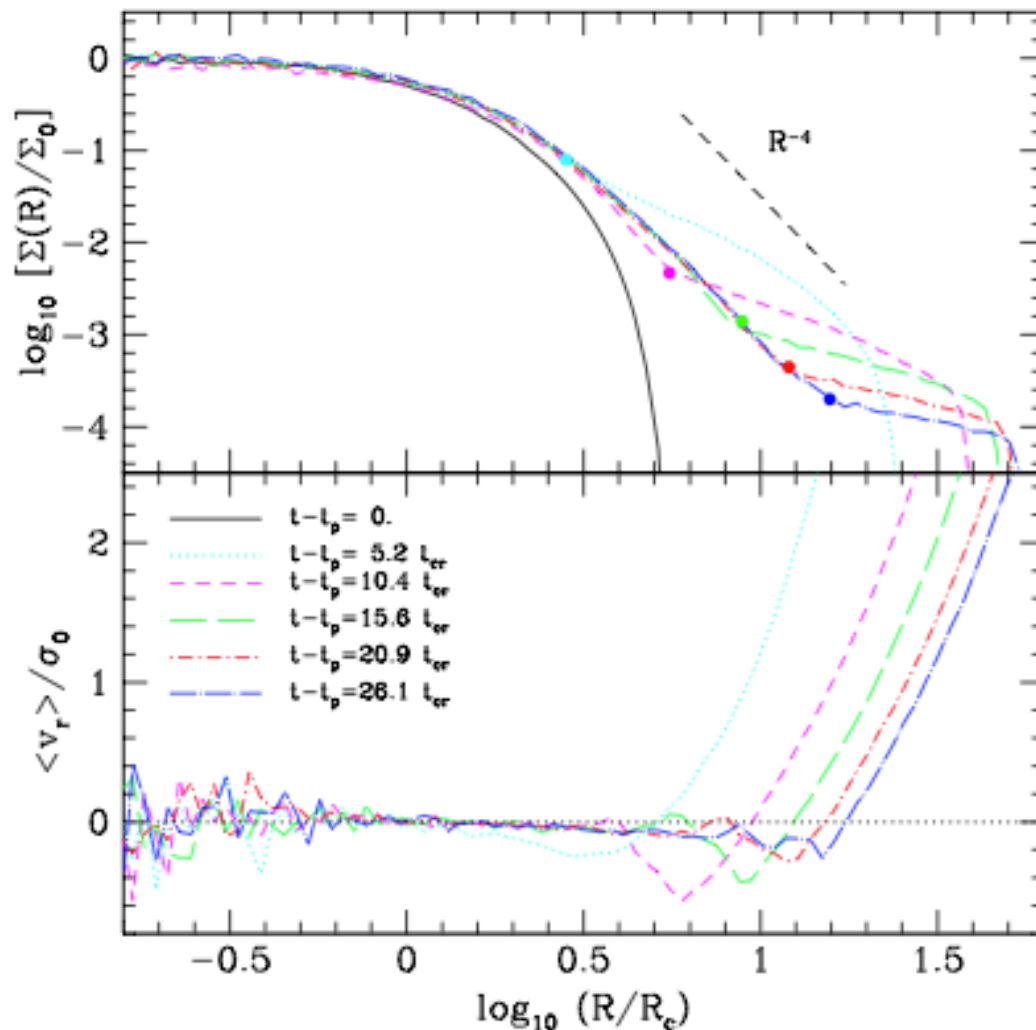
- KS test: not drawn from same parent population
 - Stolte+05, Espinoza+09, Habibi+13

No Evidence of Tidal Tails



- KS test: cannot discount same parent population

Unbroken Profile: Implications for Orbital History?



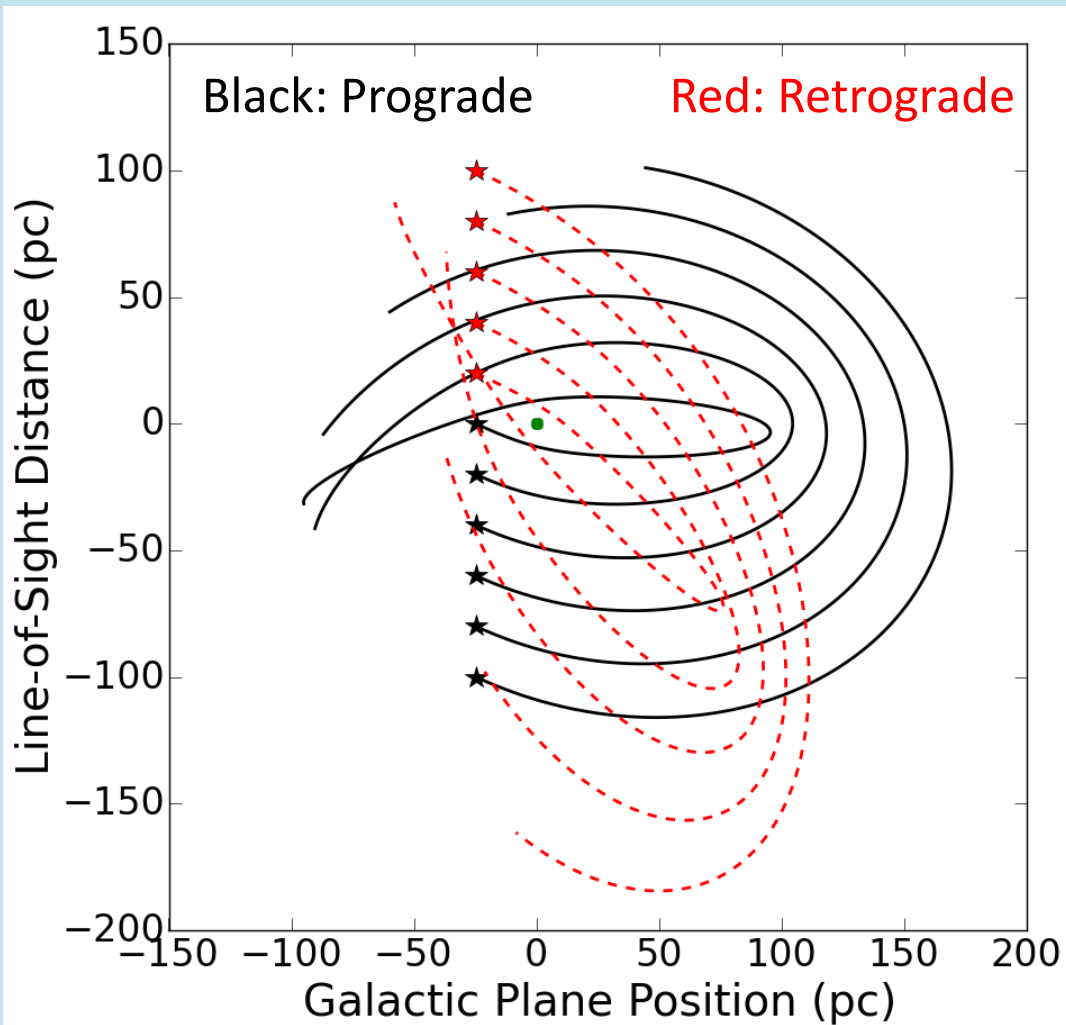
Peñarrubia+09, Lokas+13:
Simulations of dwarf galaxies on elliptical orbits show break in profile after pericenter

- Position of break related to time since pericenter passage

Fig. 2 of Peñarrubia+09

If Applicable to Arches...

- No pericenter passage between $\sim 0.2 - 1$ Myr ago



Possible Arches Orbits (Stolte+08)

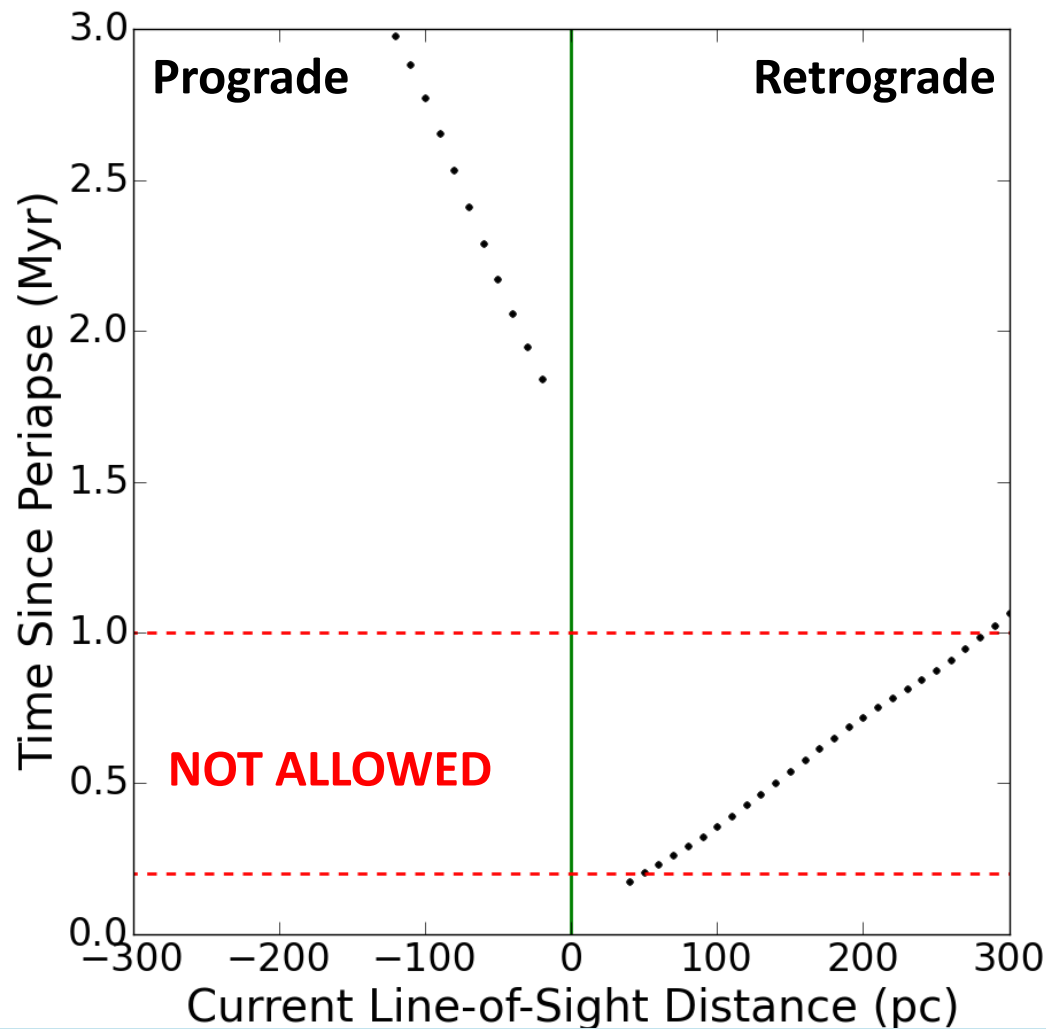
Data courtesy of Andrea Stolte

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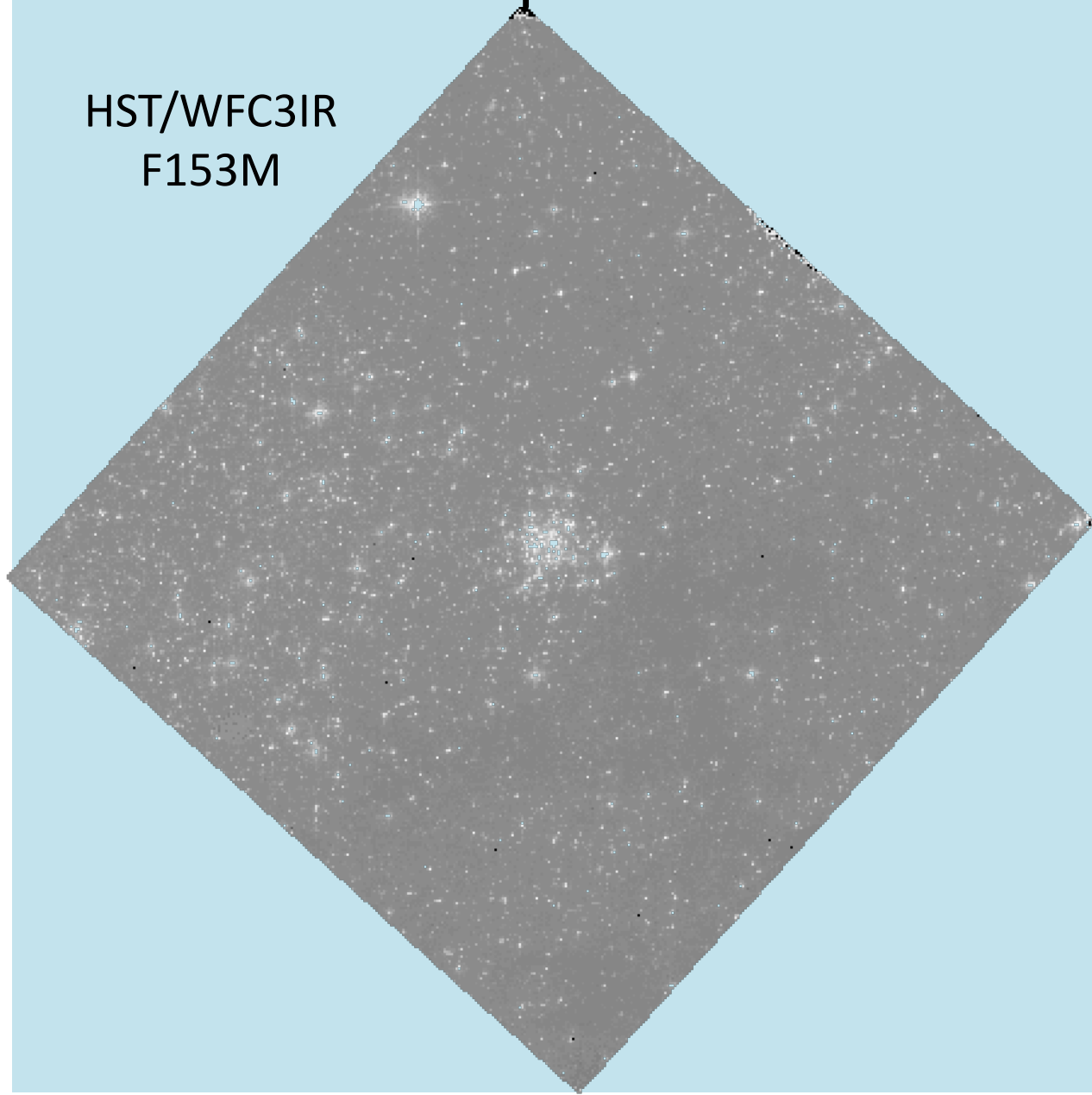
- Retrograde orbits excluded
- Arches located in front of GC sky plane



Data courtesy of Andrea Stolte

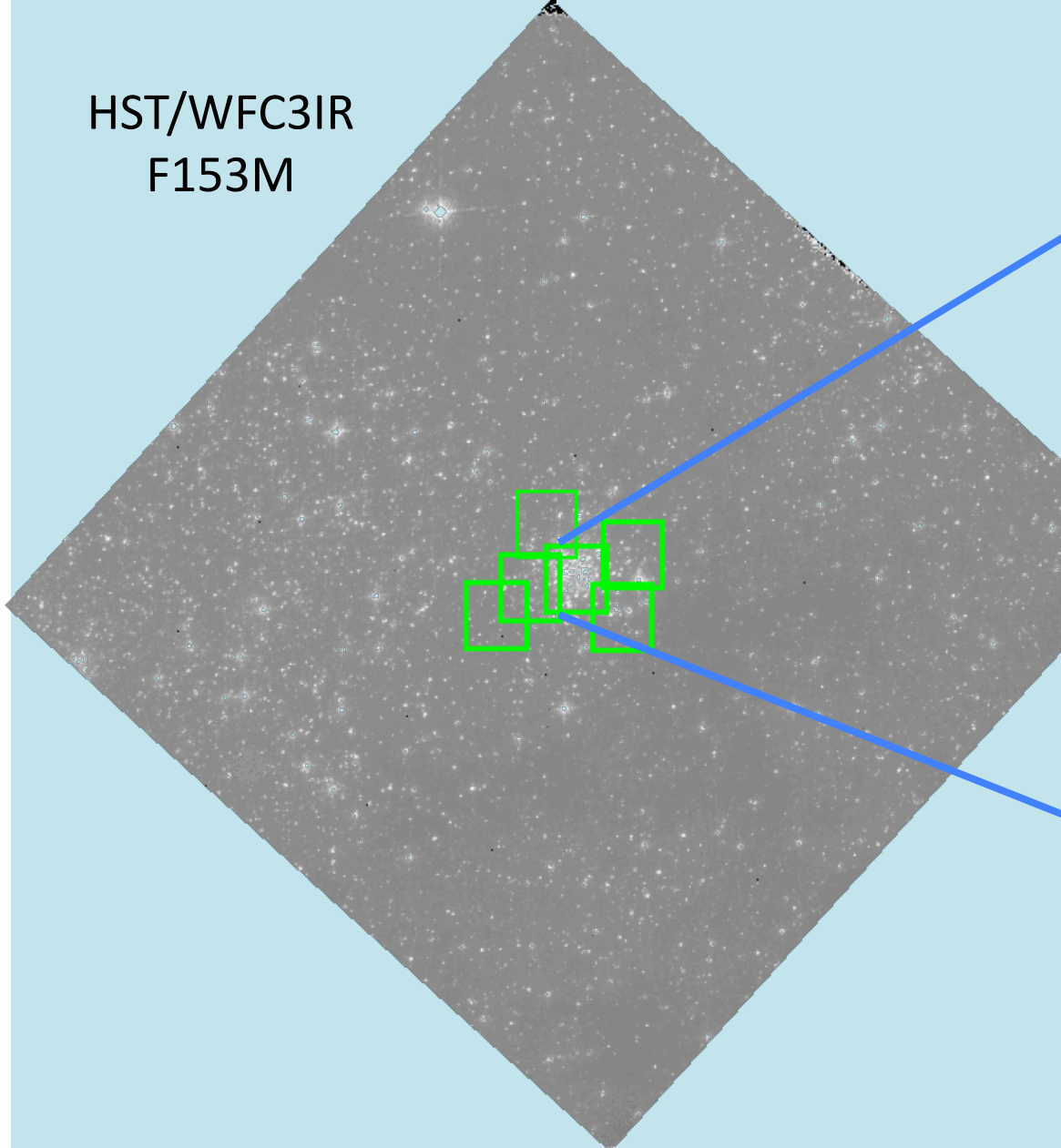
Next Step: Combine HST with AO Data

HST/WFC3IR
F153M

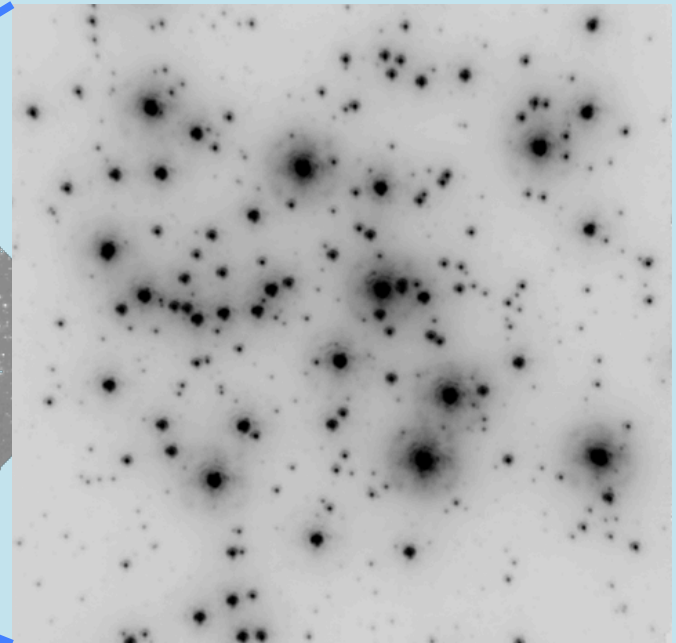


Next Step: Combine HST with AO Data

HST/WFC3IR
F153M



Keck/NIRC2 AO
K'-band



Start of Keck/NIRC2 JHK'
observing campaign:
2006

Conclusions

- HST WFC3IR study of Arches cluster
 - Proper motions to identify cluster members
 - Large FOV to measure radial profile to 3 pc
 - Depth: $2.5 M_{\odot}$
- **Unbroken power-law profile**
 - 3σ limit on King-like tidal radius: 2.8 pc
 - Constrains orbit to prograde solutions?
- No evidence for tidal tails
- Next step: Combine HST with AO imaging of cluster core

