

The Dynamical Structure and Initial Mass Function of the Arches Cluster

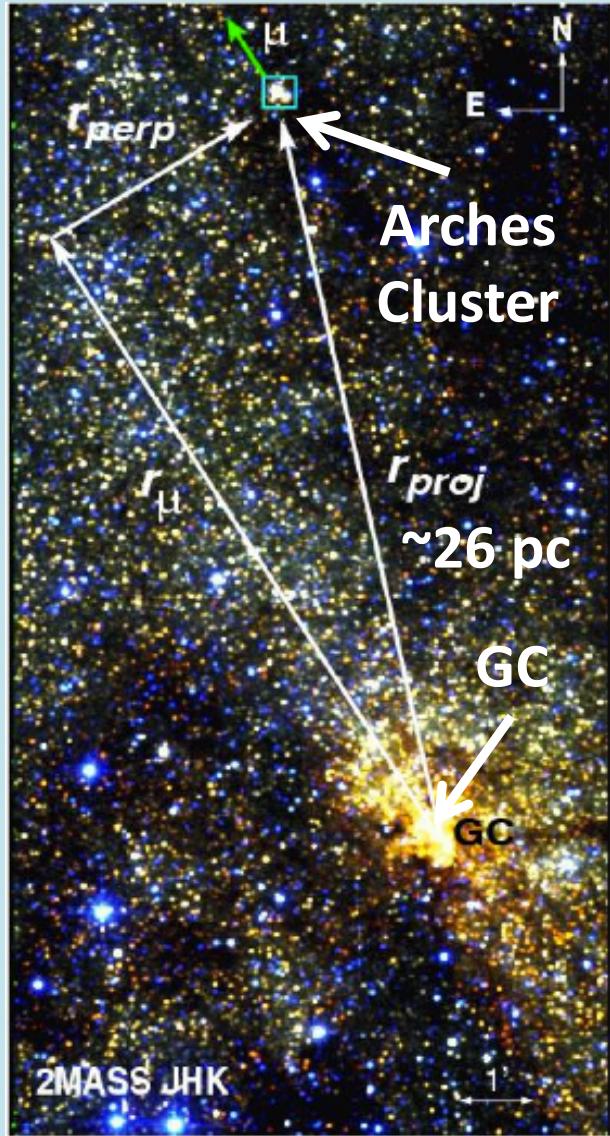


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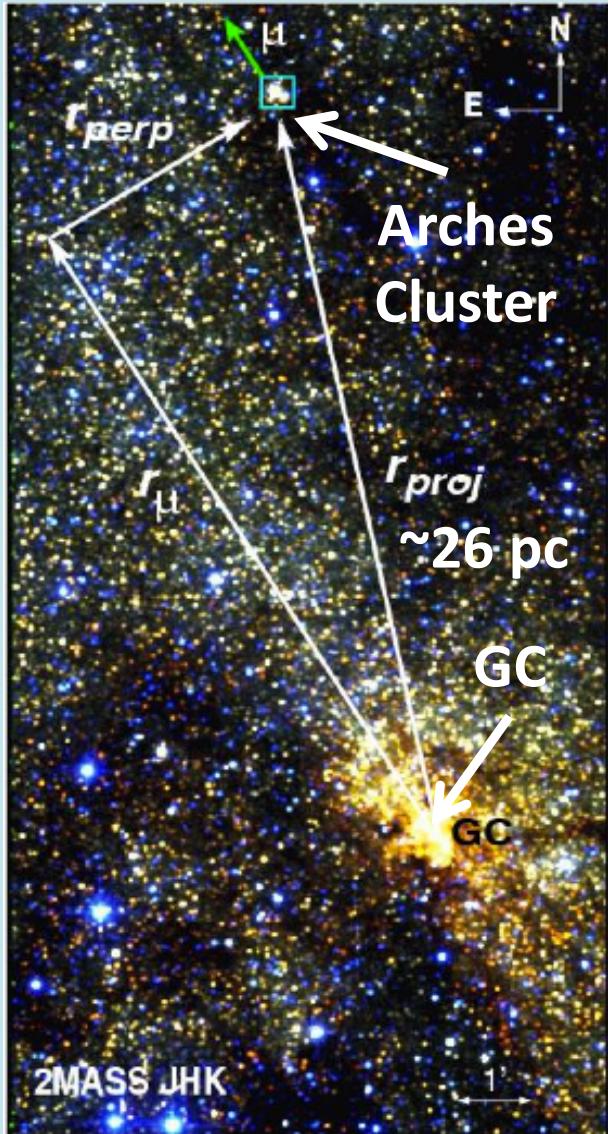
Jessica Lu (UH/IfA), Jay Anderson (StSci),
Andrea Ghez (UCLA), Mark Morris (UCLA), Will
Clarkson (UMichigan-Dearborn), Tuan Do
(UCLA)

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



Stolte et al. (2008)

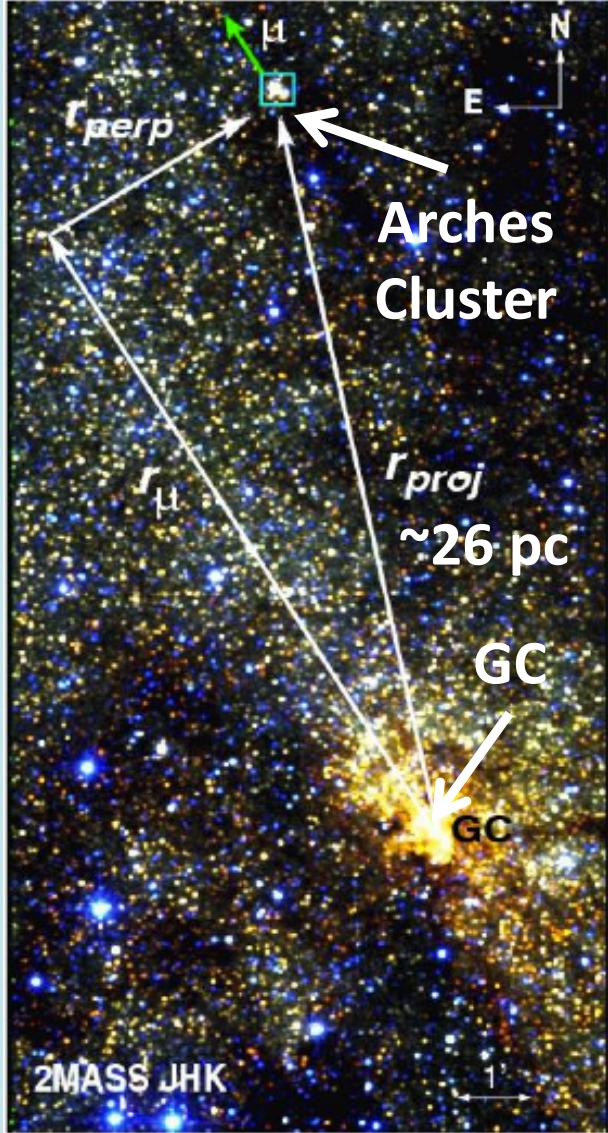
The Arches Cluster: A Young Massive Cluster Near the Galactic Center



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

Stolte et al. (2008)

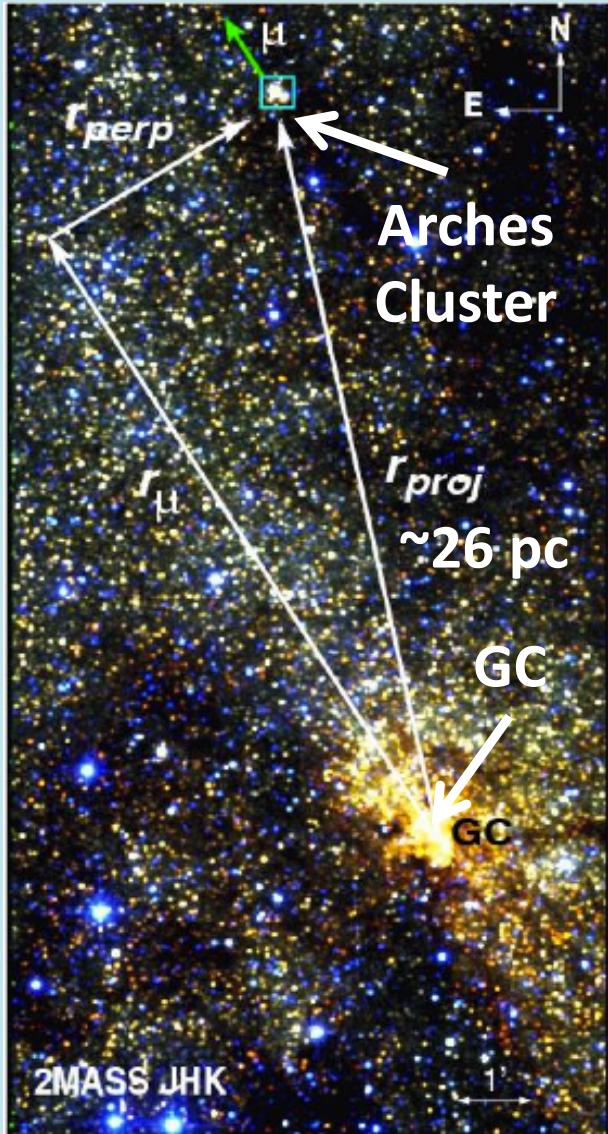
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- How does the Initial Mass Function behave in extreme star-formation environments?

Stolte et al. (2008)

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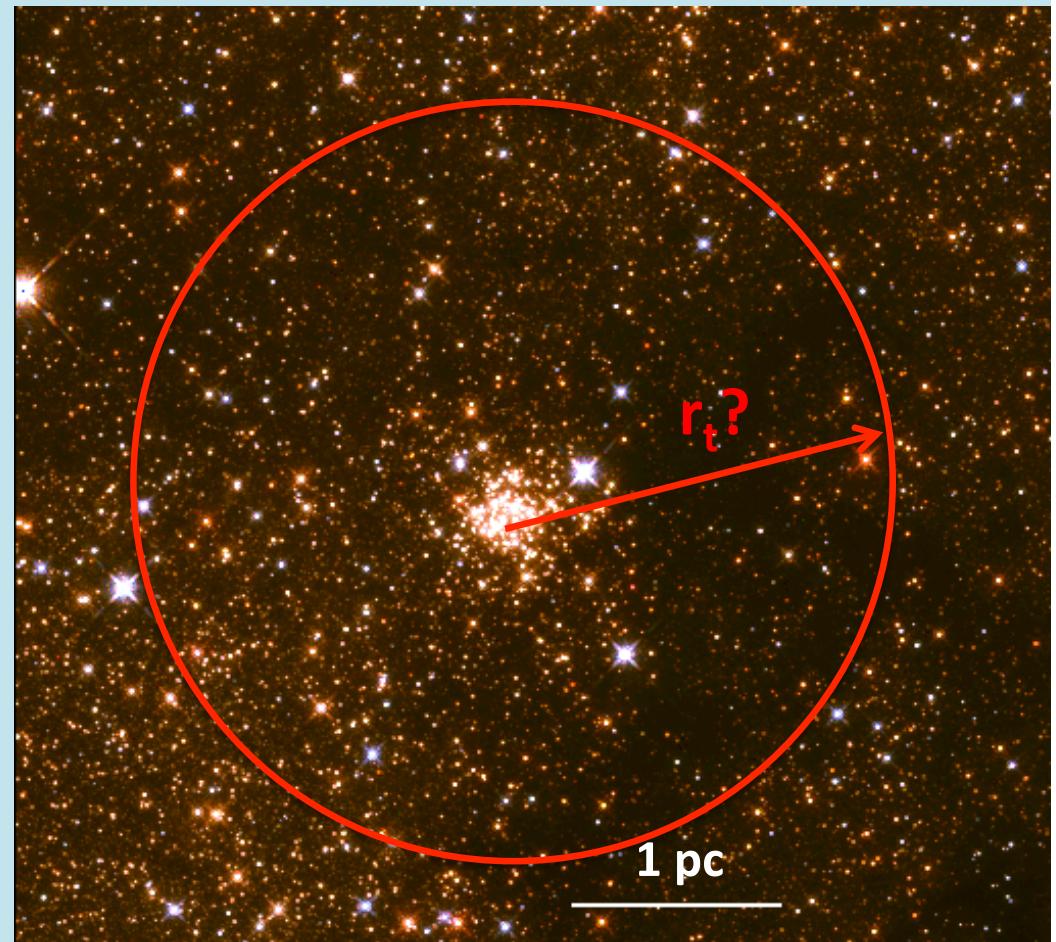


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Stolte et al. (2008)

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

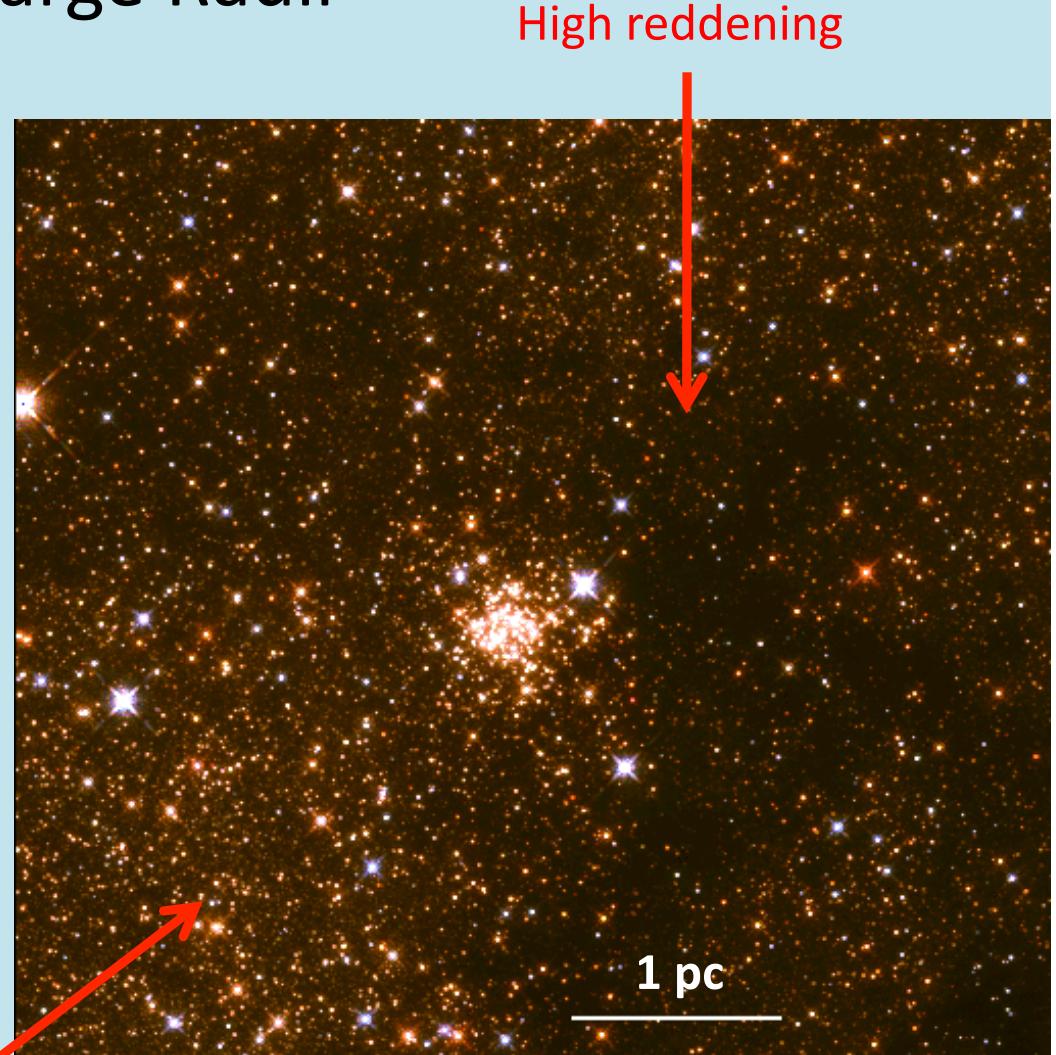
- Unknown tidal radius, profile only measured to $R = 0.4$ pc (Espinoza+09)
 - Extra-tidal stars?



HST WFC3IR image of the
Arches Cluster

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

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- **Challenge:** Significant differential reddening
 - $\Delta A_V \sim 10\text{-}15$ 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

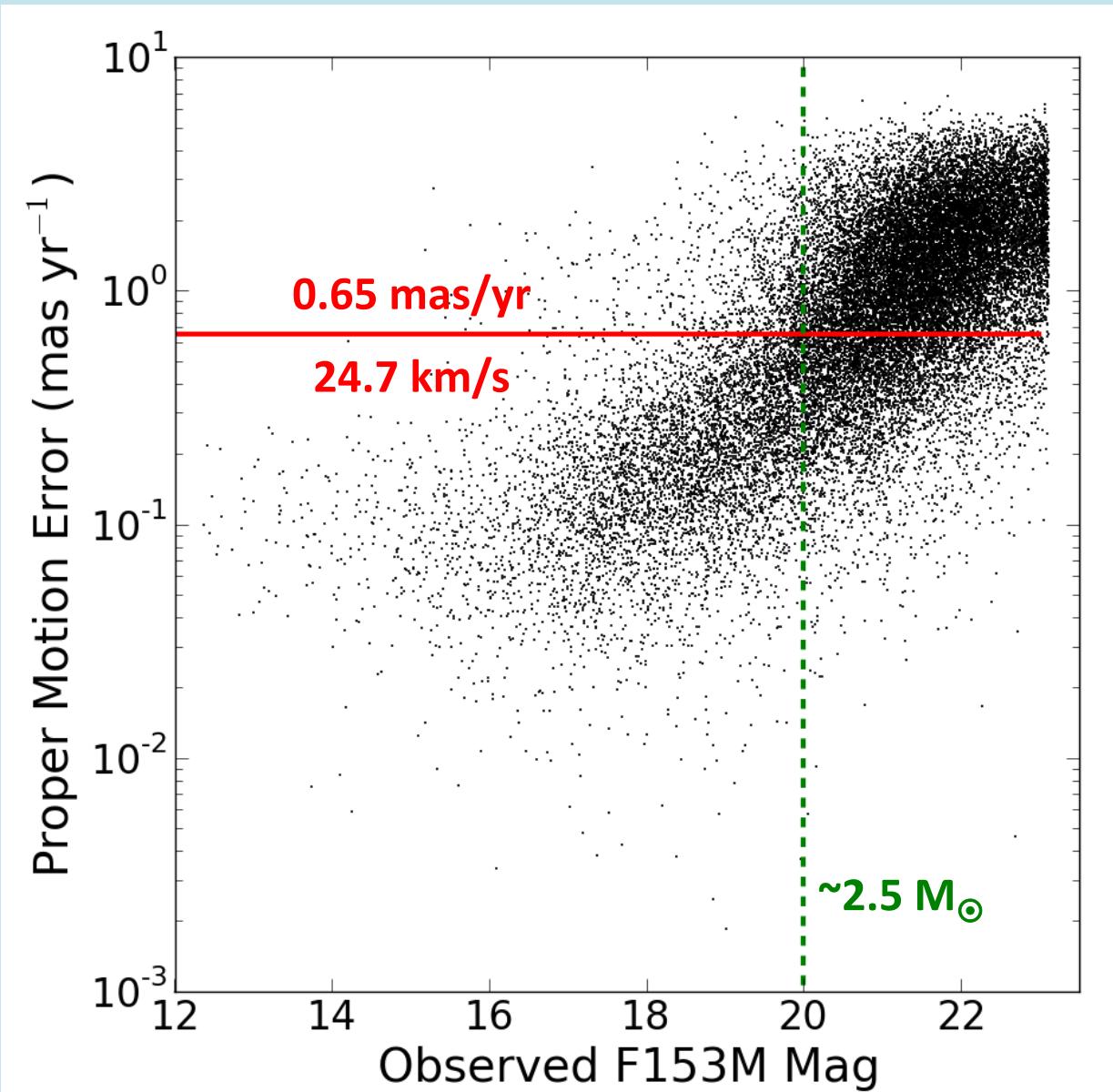


<http://www.spacetelescope.org/>

Advantages:

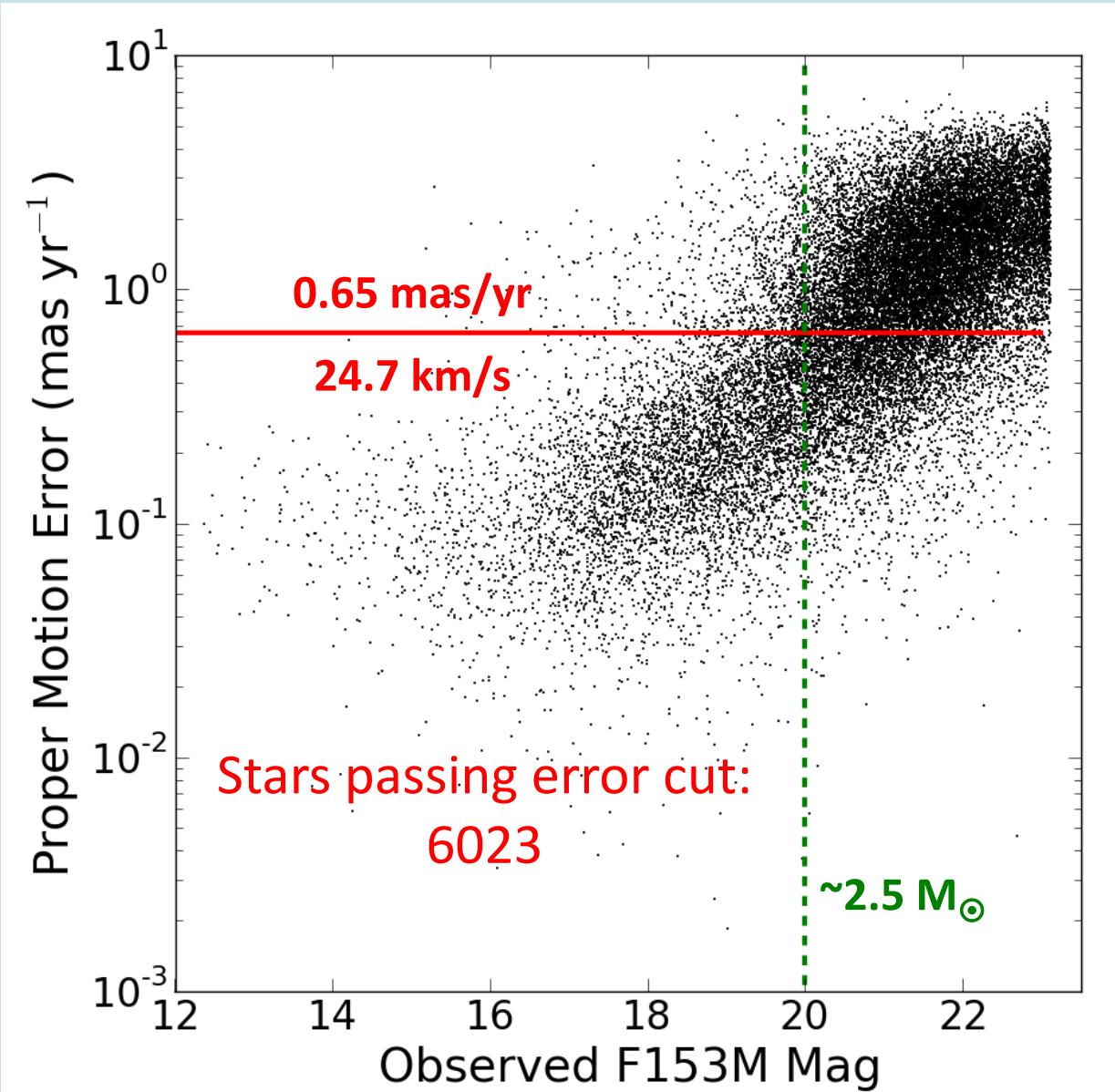
- (1) Proper motions for improved cluster membership
- (2) Wide field of view:
120x120'' (4.8 pc x 4.8 pc)
- (3) Deep: $\sim 2.5 M_{\odot}$

High-Precision Proper Motions



Hosek+15

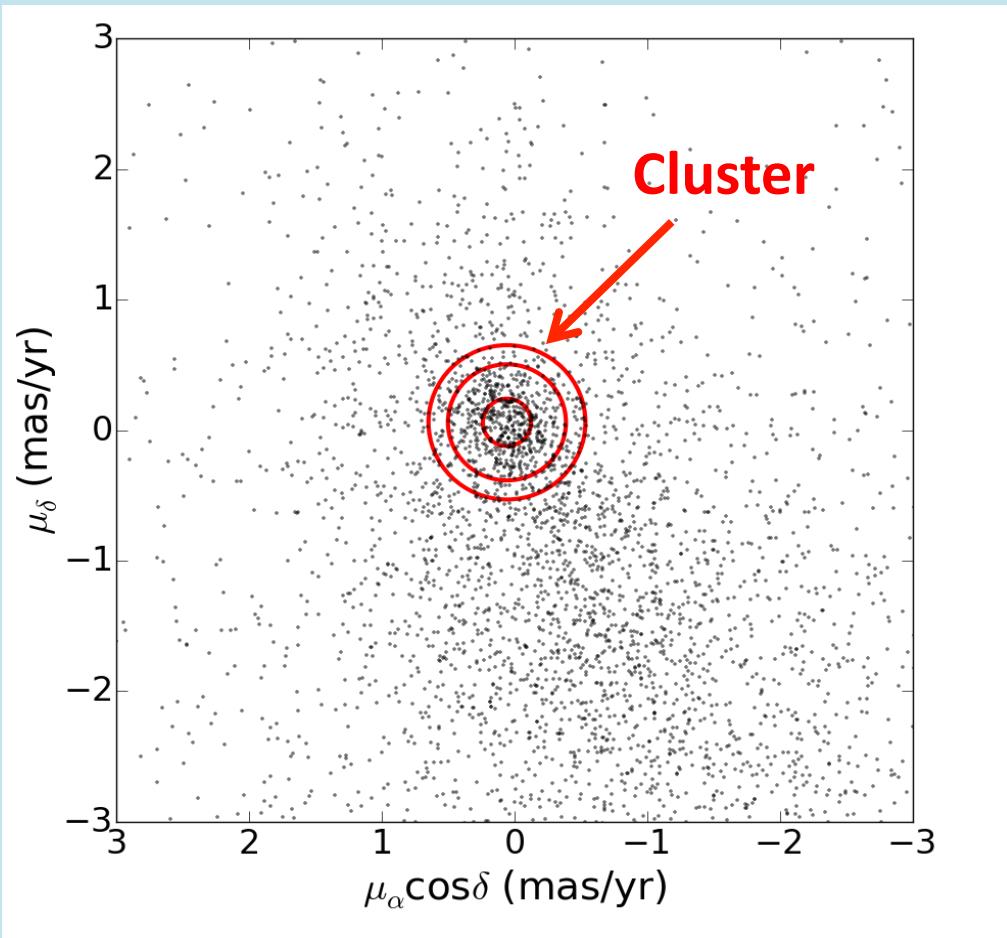
High-Precision Proper Motions



Hosek+15

Modeling Cluster and Field Kinematics: Gaussian Mixture Model

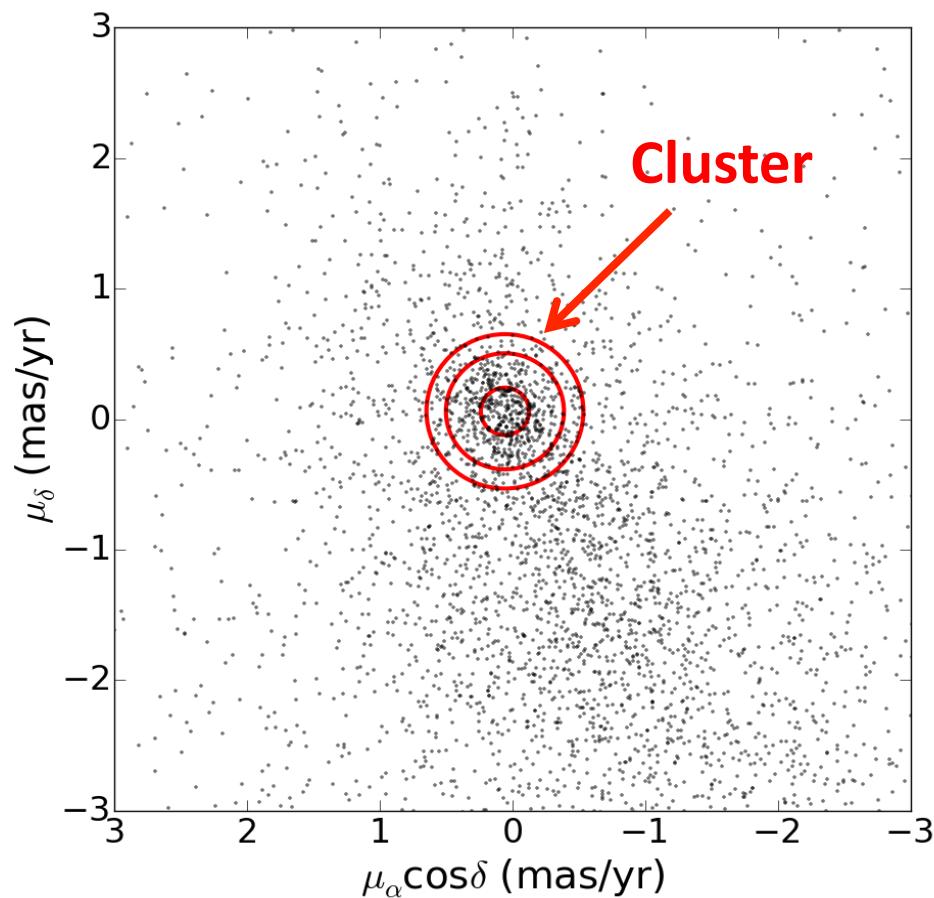
Vector Point Diagram



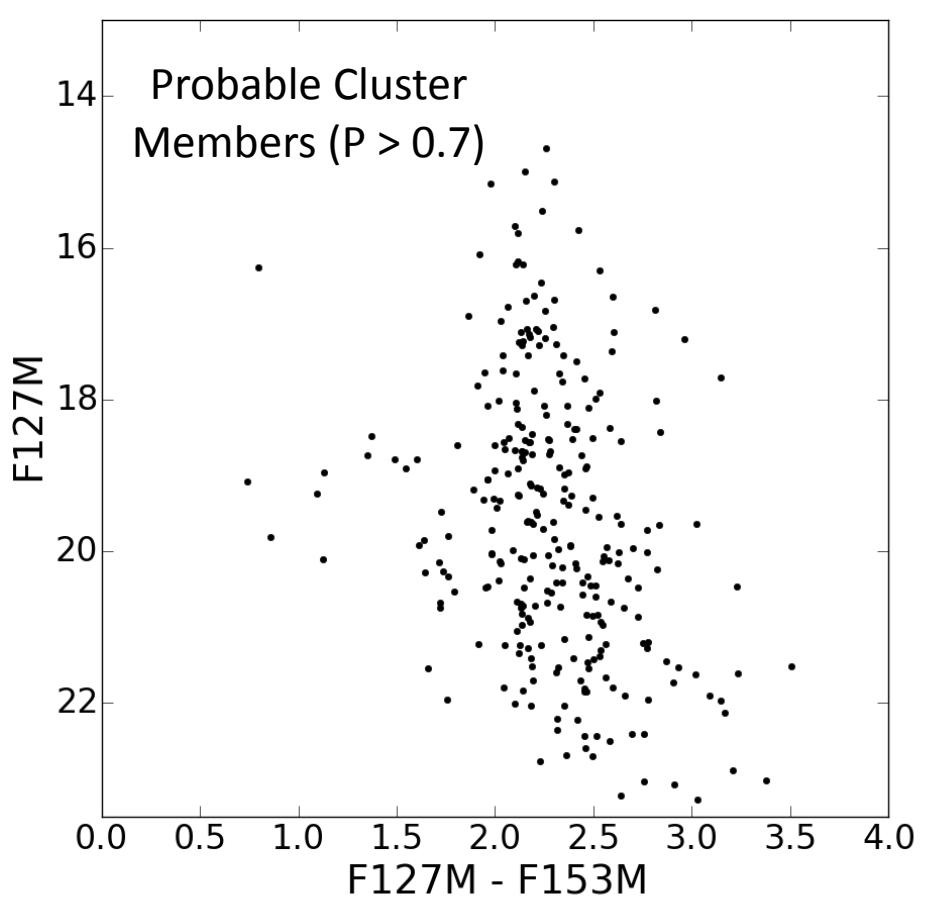
Hosek+15

Modeling Cluster and Field Kinematics: Gaussian Mixture Model

Vector Point Diagram

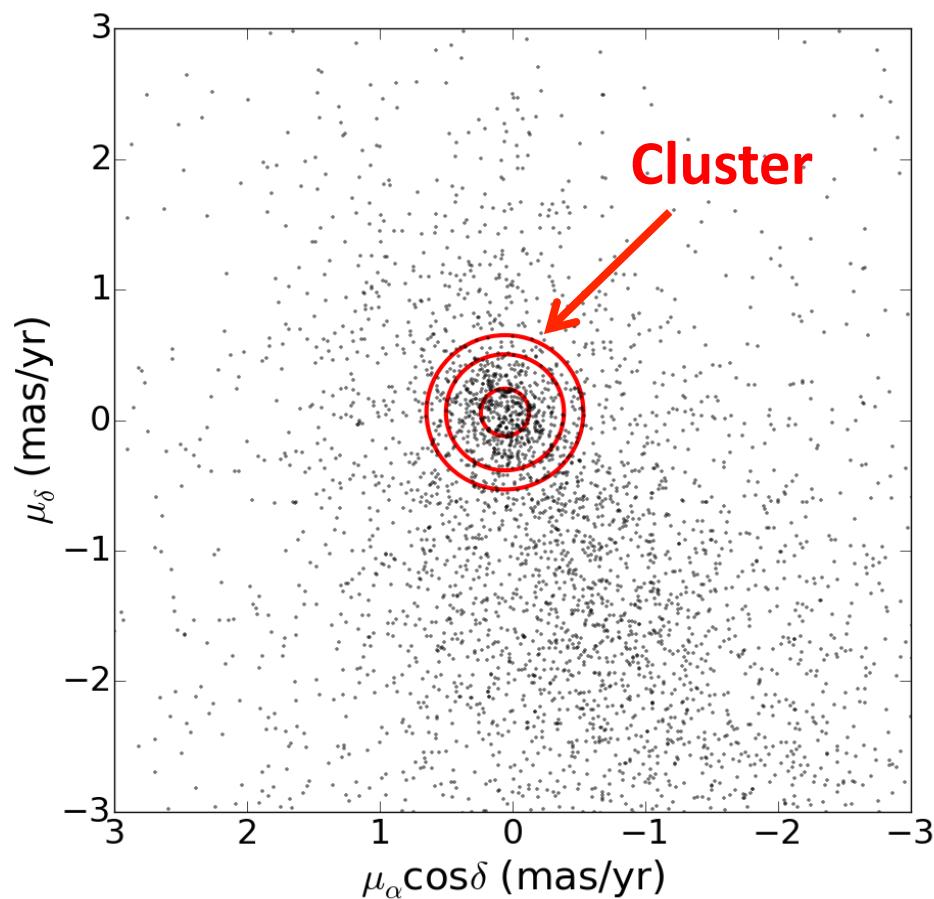


Observed CMD

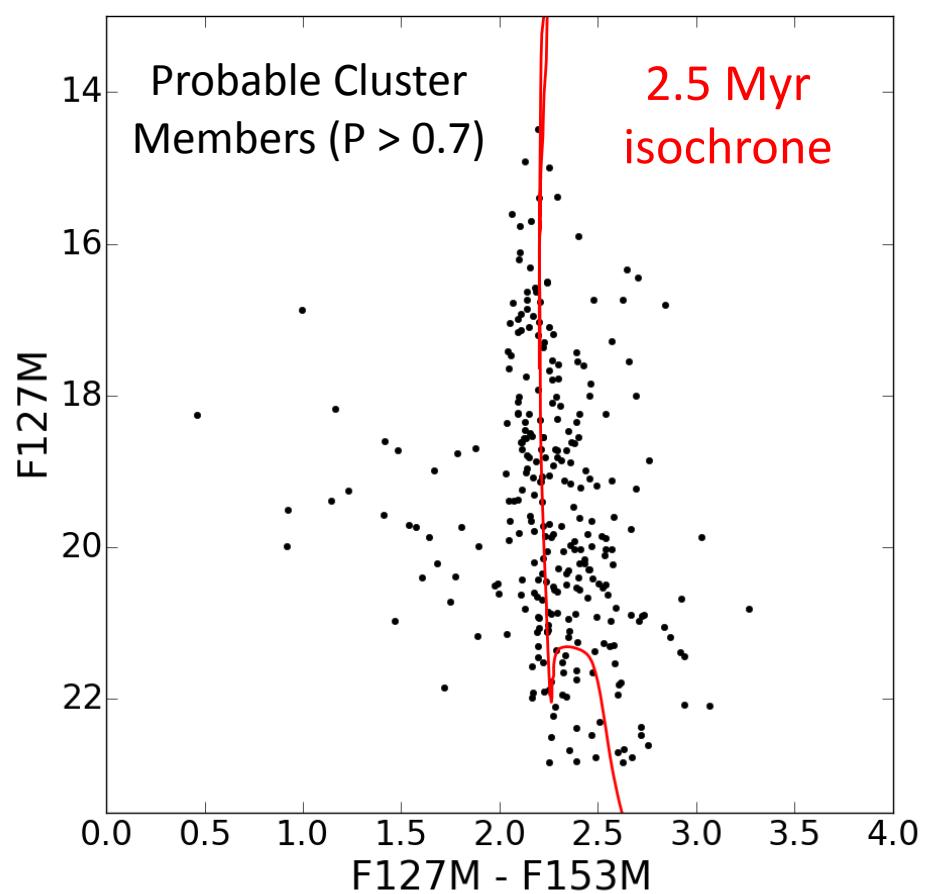


Modeling Cluster and Field Kinematics: Gaussian Mixture Model

Vector Point Diagram



Diff. De-reddened CMD



Hosek+15

The Extended Radial Profile of the Arches Cluster

Model:

Power-Law + Constant

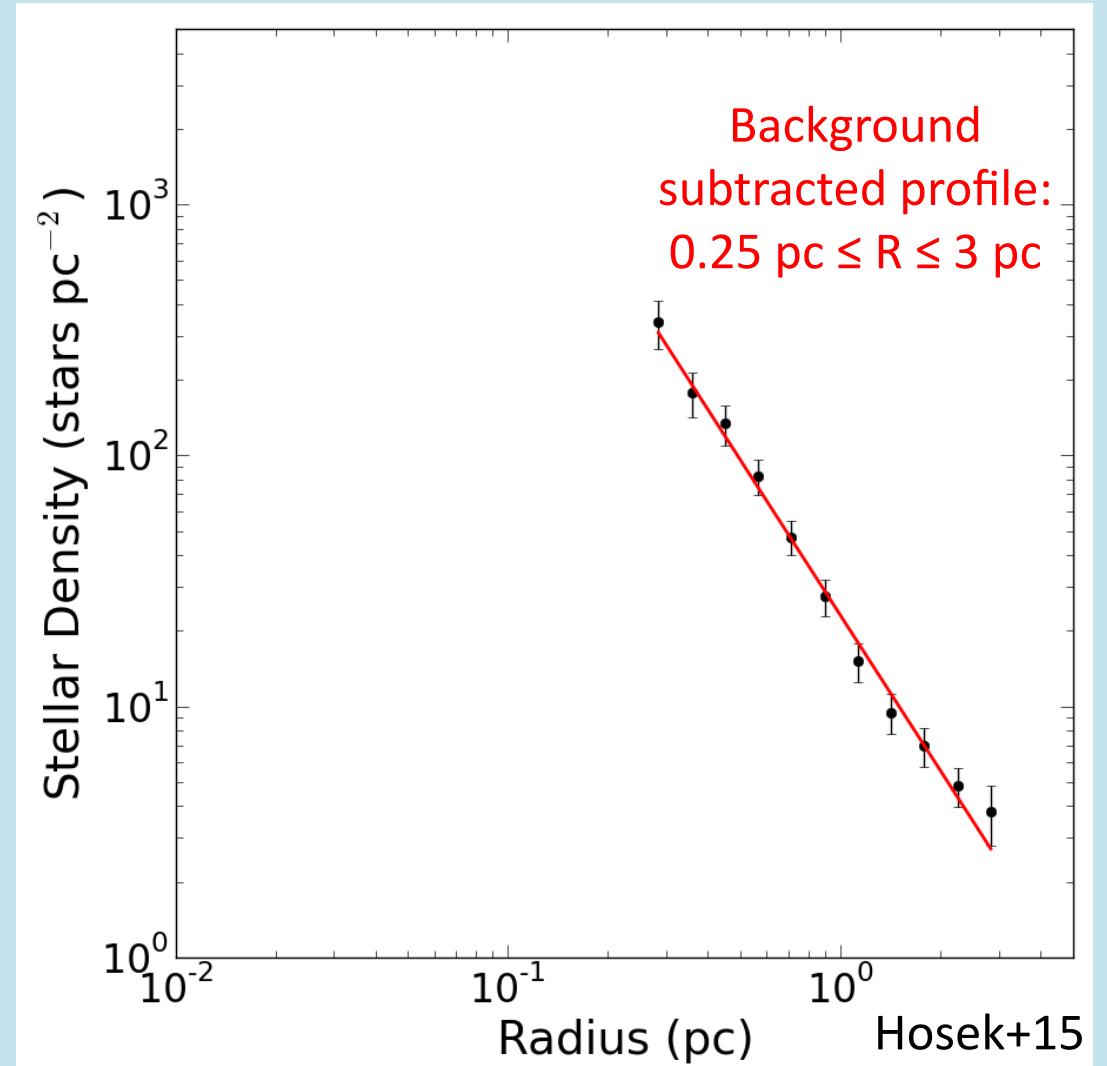
$$L_i(r, \Gamma, b) = A_0 r_i^{-\Gamma} + b$$

Best-Fit Params:

$$\Gamma = 2.06 \pm 0.17$$

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

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



The Extended Radial Profile of the Arches Cluster

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Power-Law + Constant

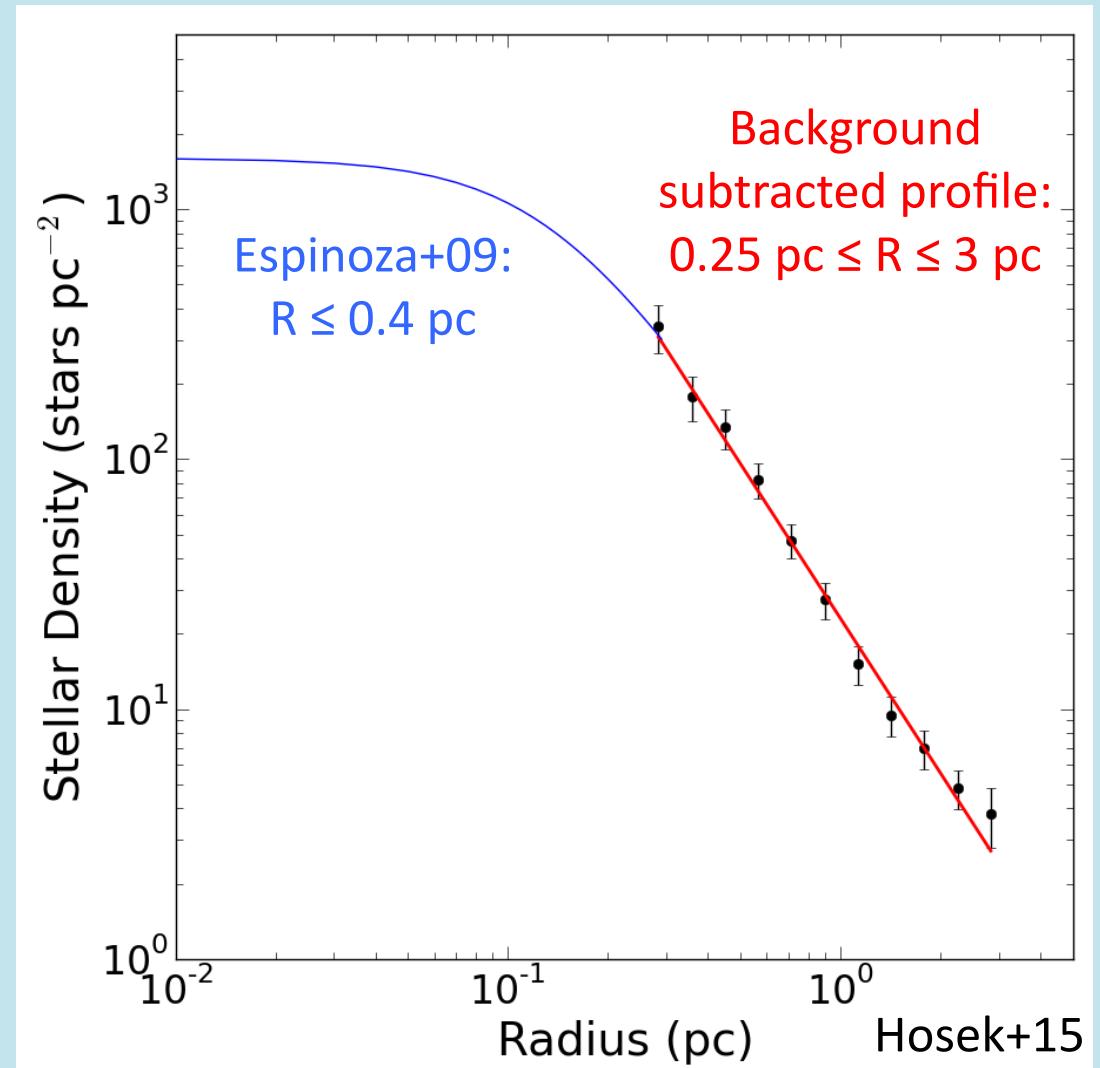
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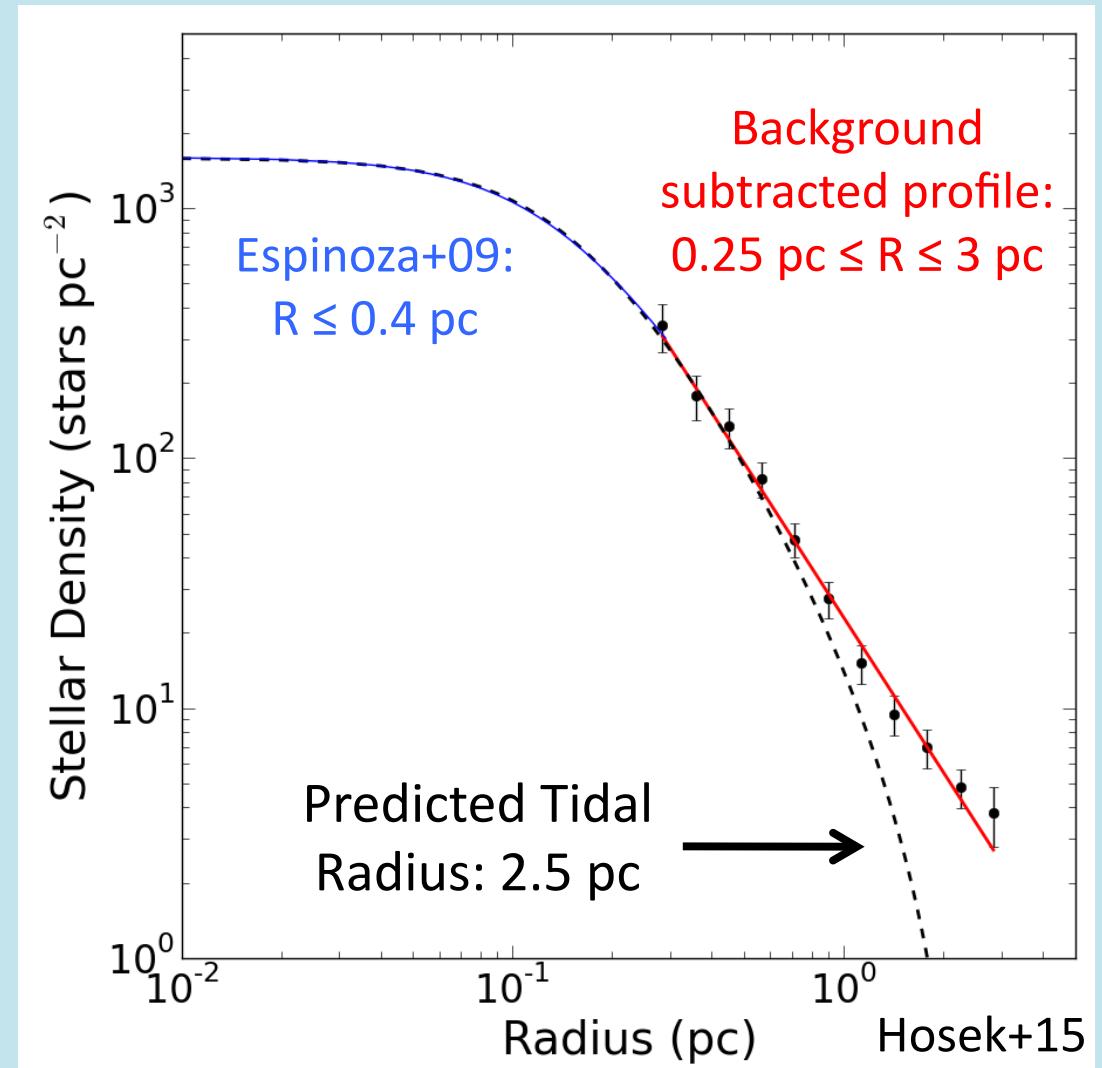
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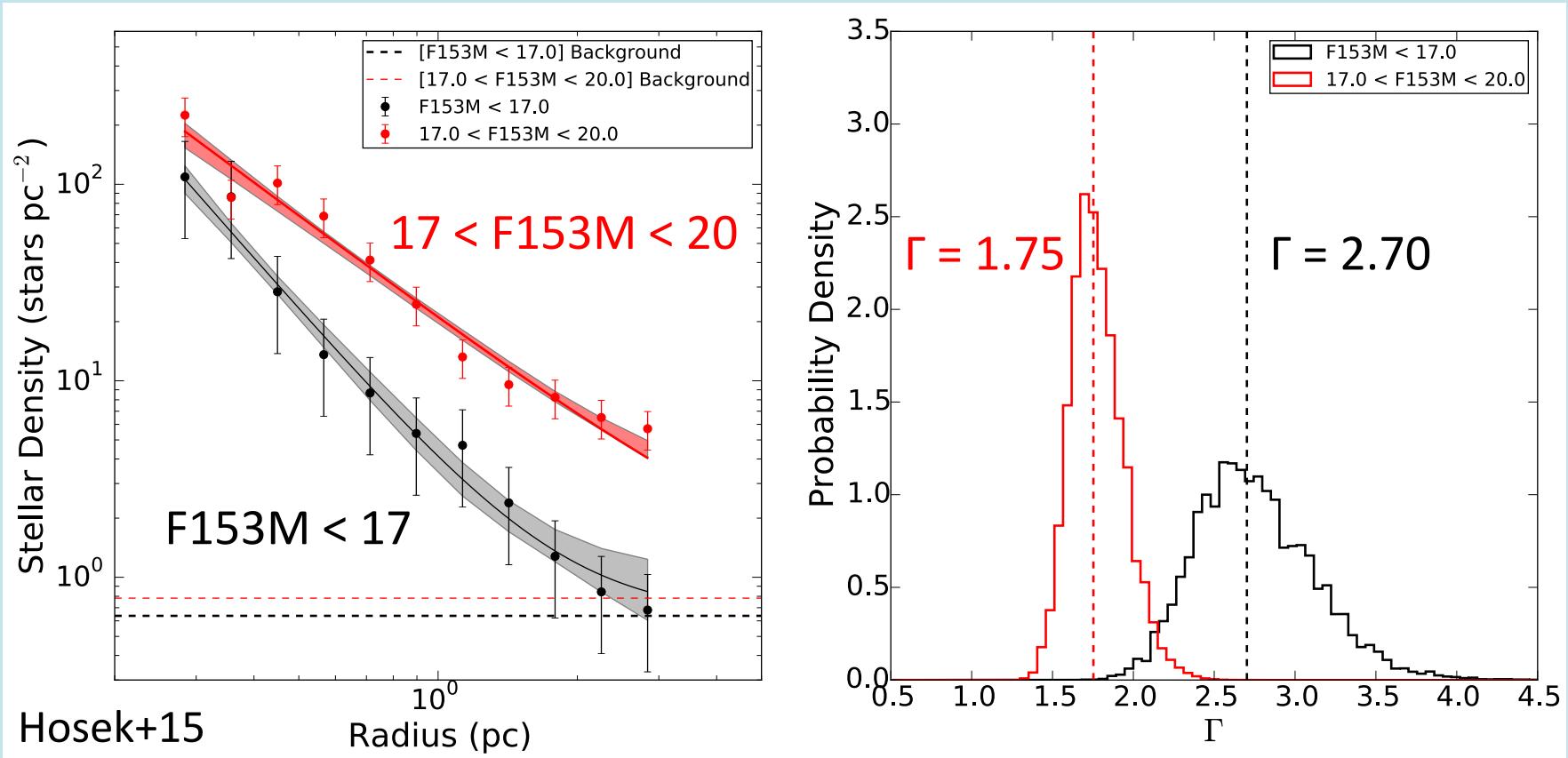
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**3 σ lower limit on
tidal radius: 2.8 pc**

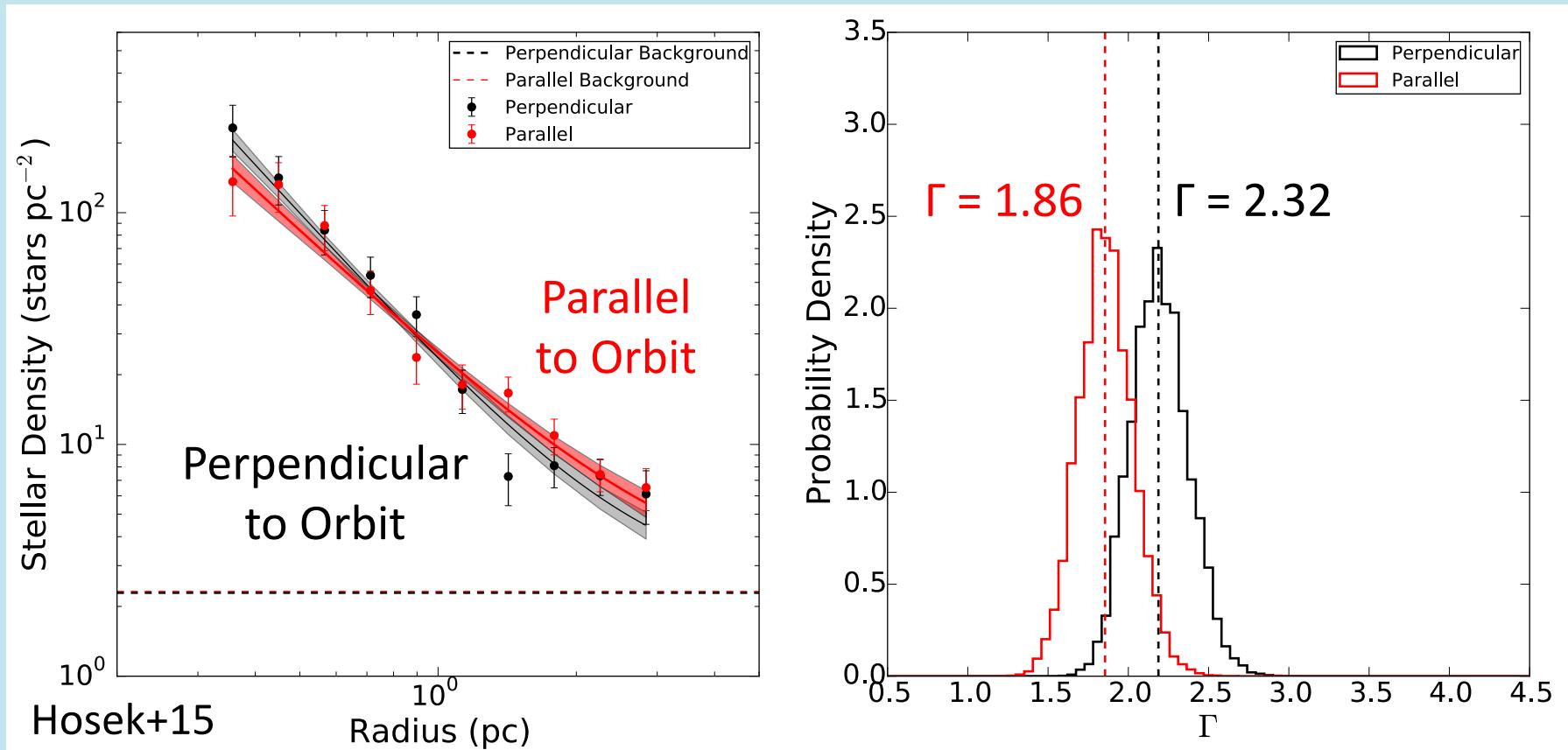


Mass Segregation Throughout Cluster



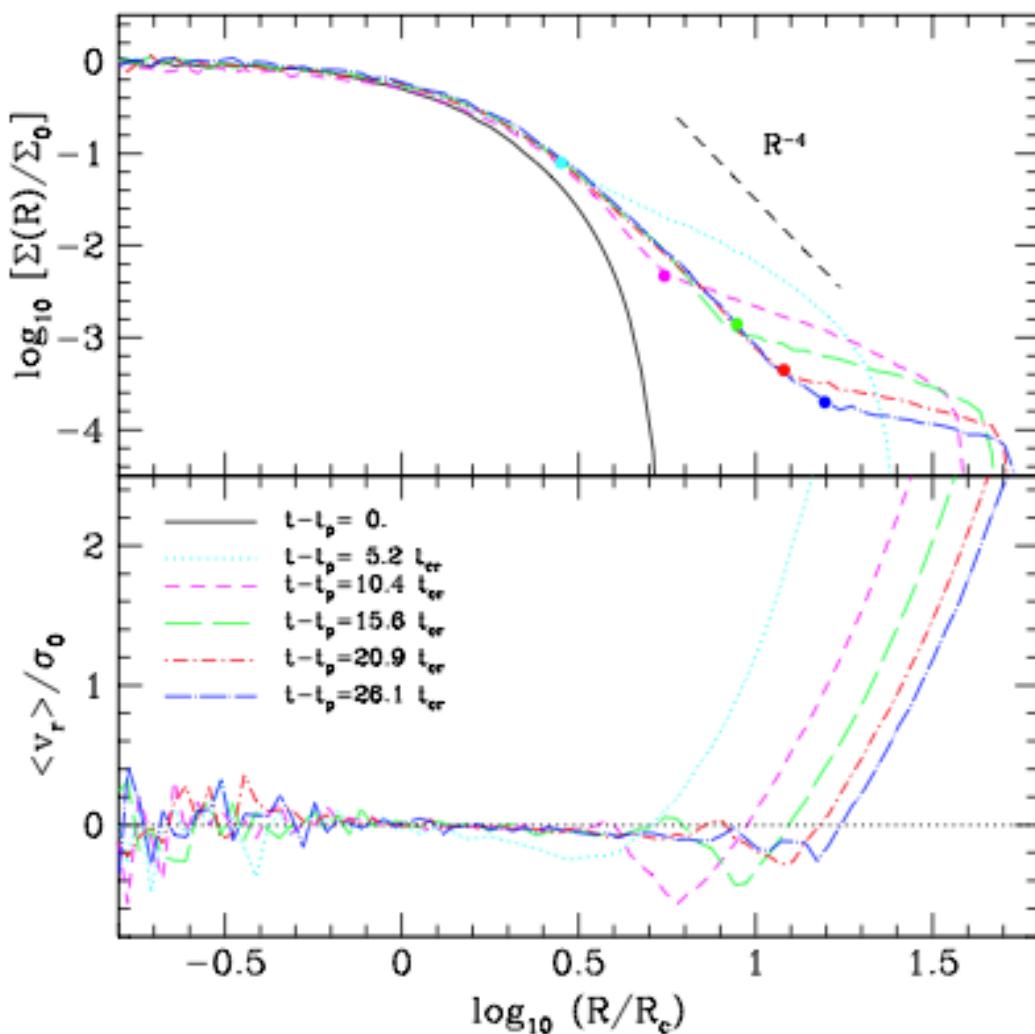
- KS test: not drawn from same parent population
 - Stolte+05, Espinoza+09, Habibi+13

No Evidence of Tidal Tails



- KS test: cannot discount same parent population

Unbroken Profile: Implications for Orbital History?



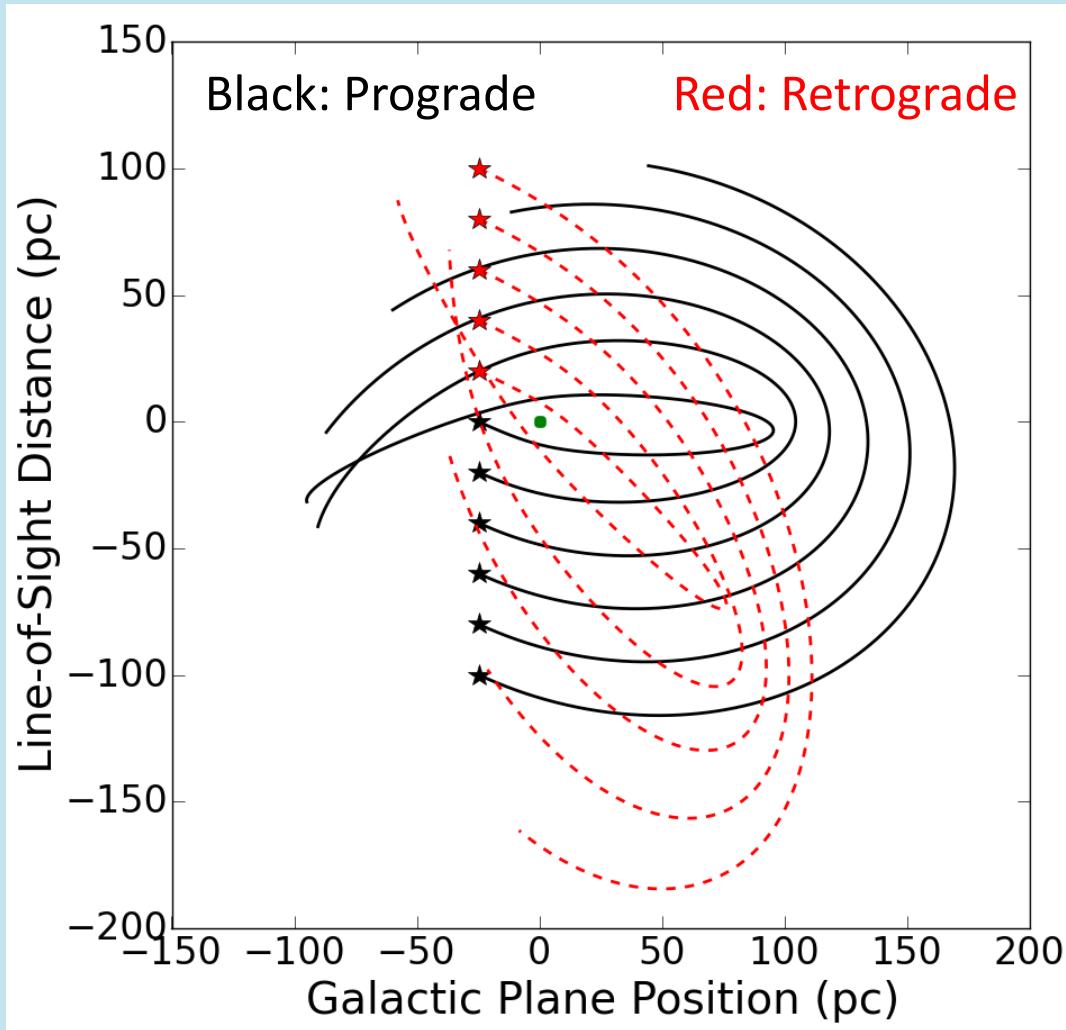
Peñarrubia+09, Lokas+13:
Simulations of dwarf galaxies on elliptical orbits show break in profile after pericenter

- 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

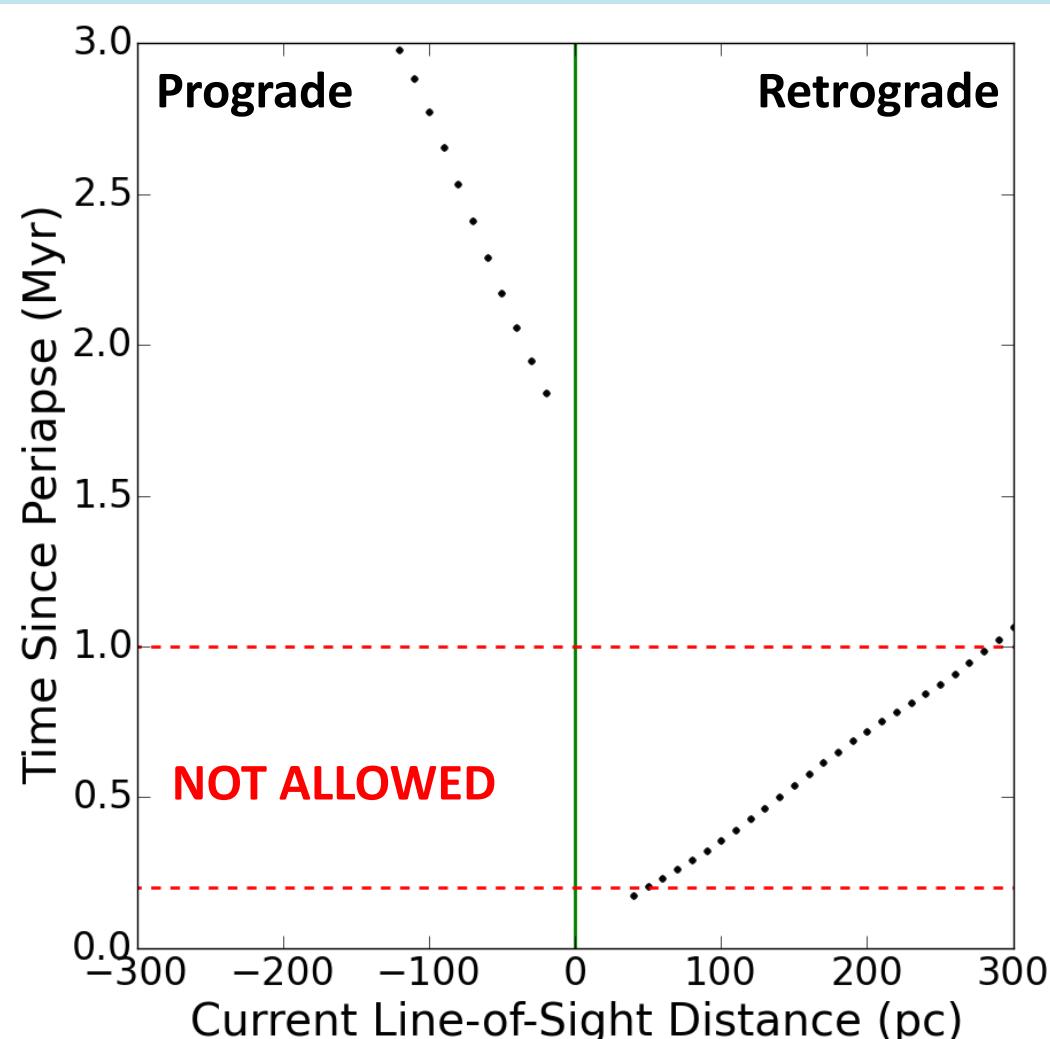


Possible Arches Orbits
(Stolte+08)

Data courtesy of Andrea Stolte

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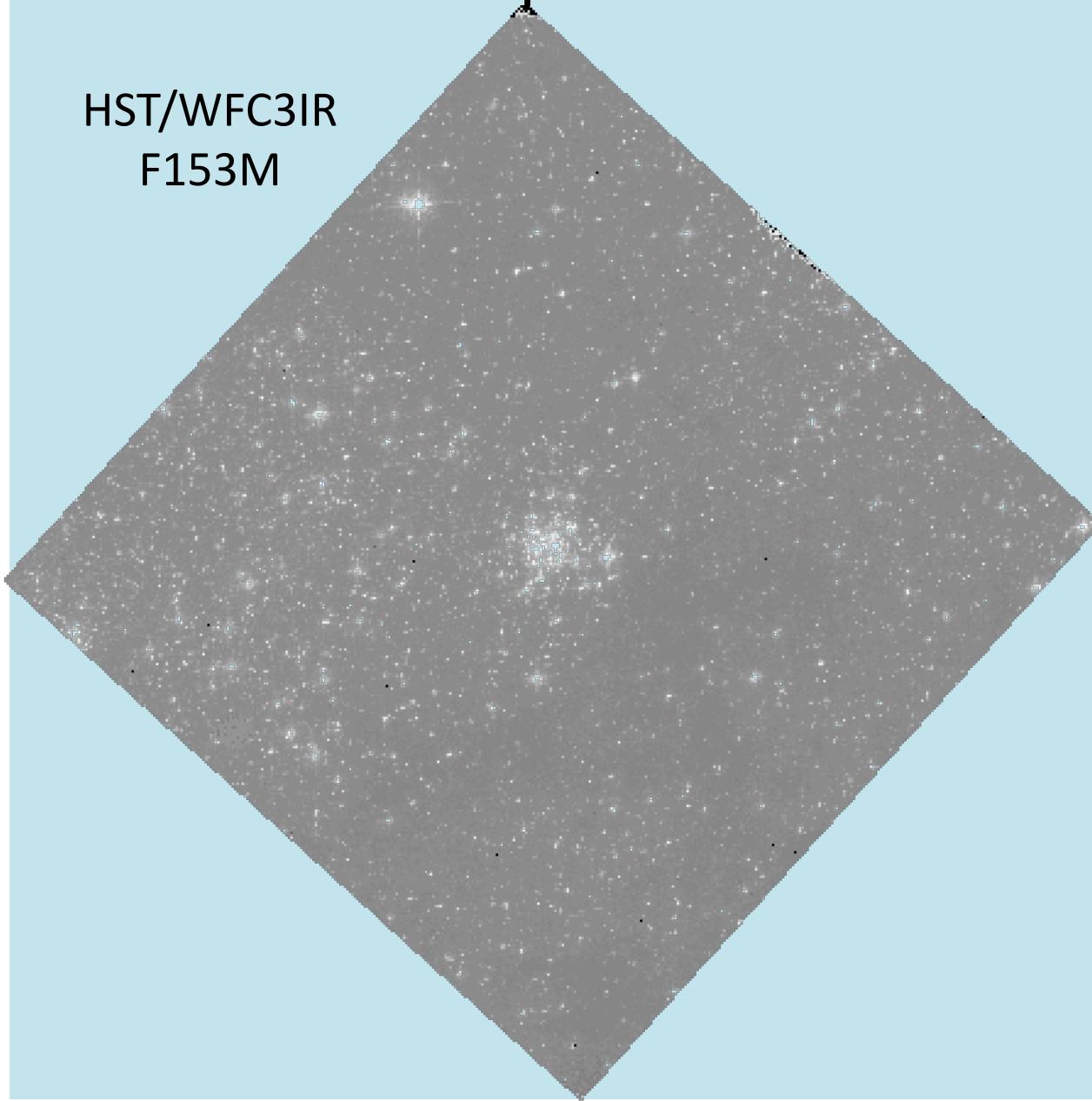
Possible Arches Orbits (Stolte+08)

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

Data courtesy of Andrea Stolte

Next Step: Combine HST with AO Data

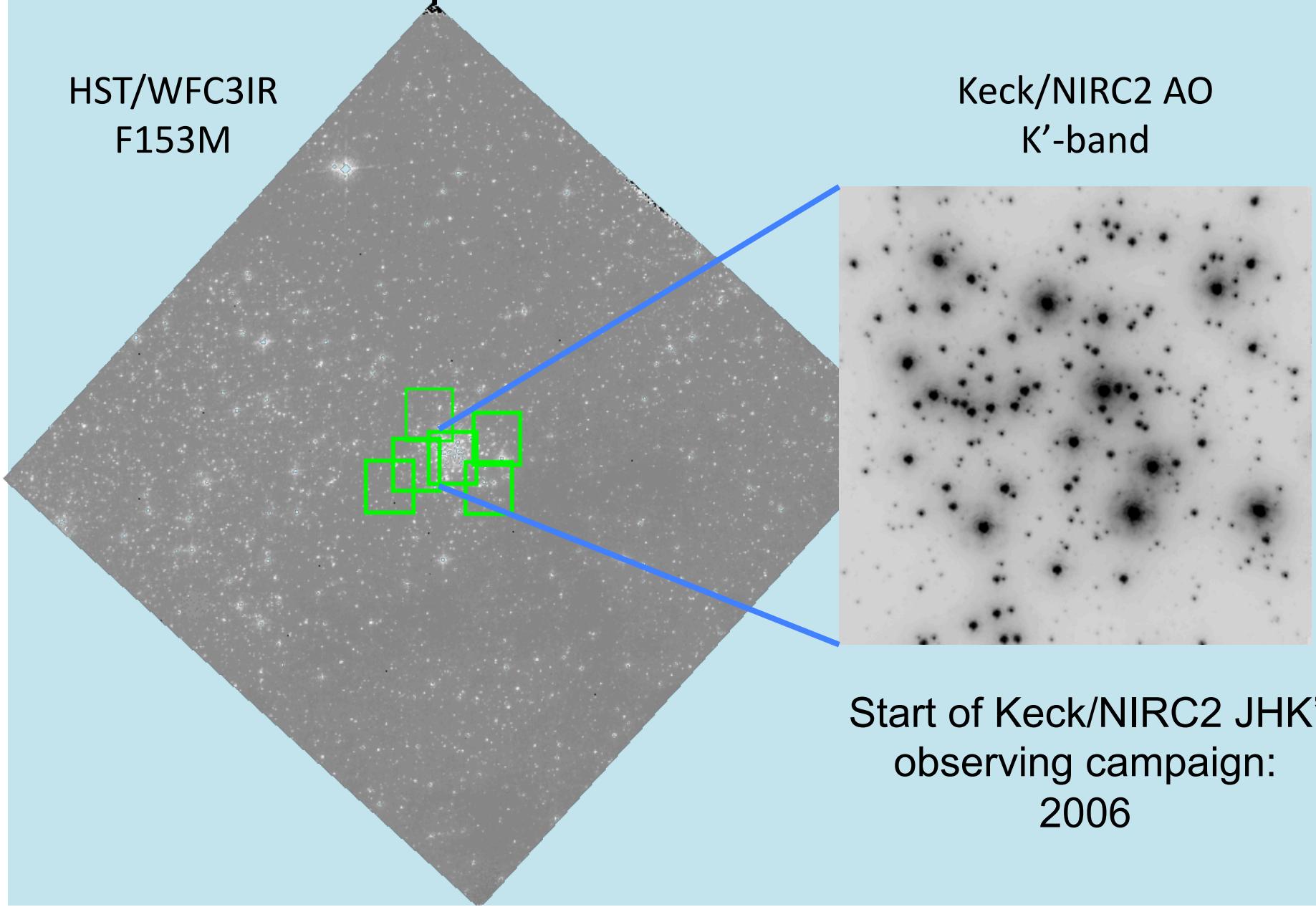
HST/WFC3IR
F153M



Next Step: Combine HST with AO Data

HST/WFC3IR
F153M

Keck/NIRC2 AO
K'-band



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

