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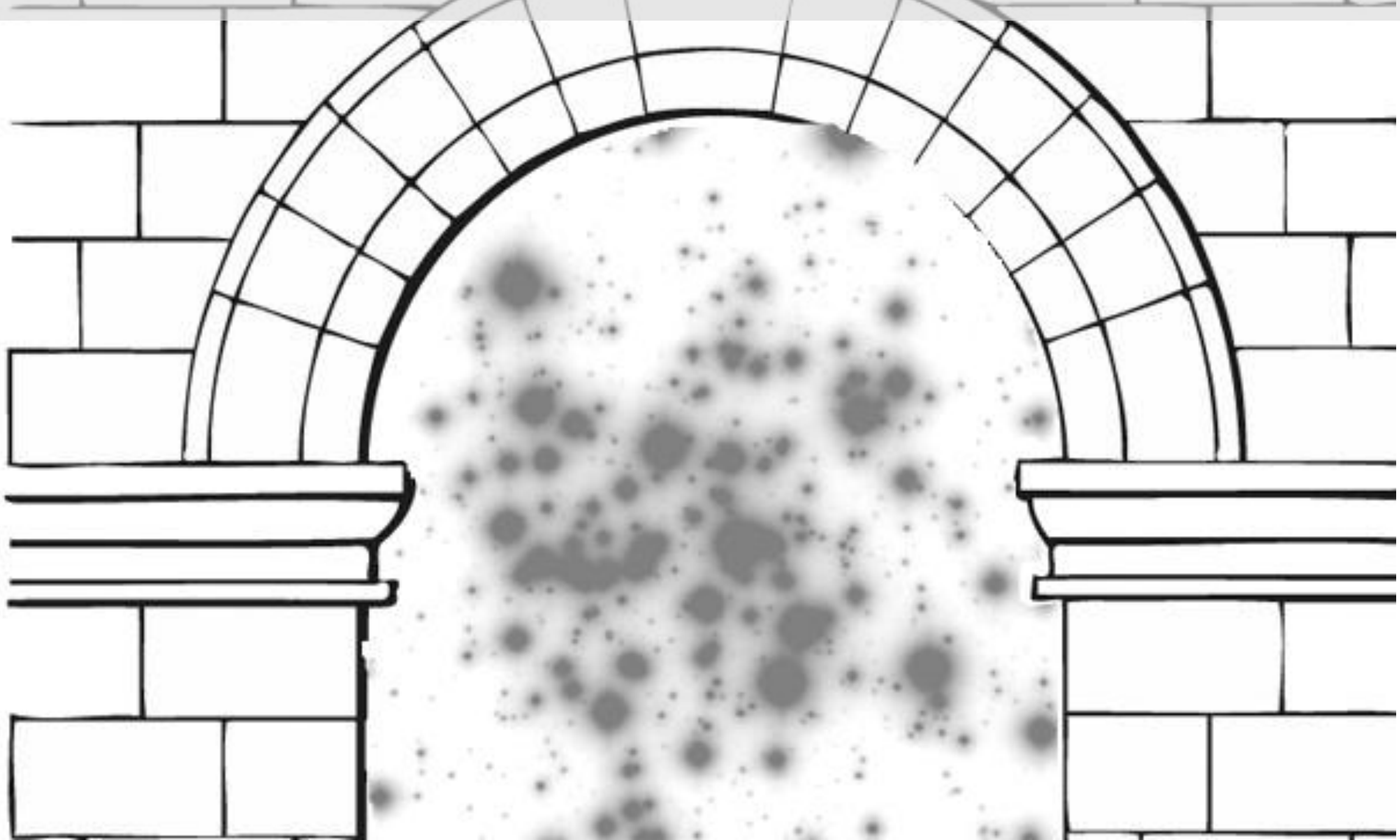
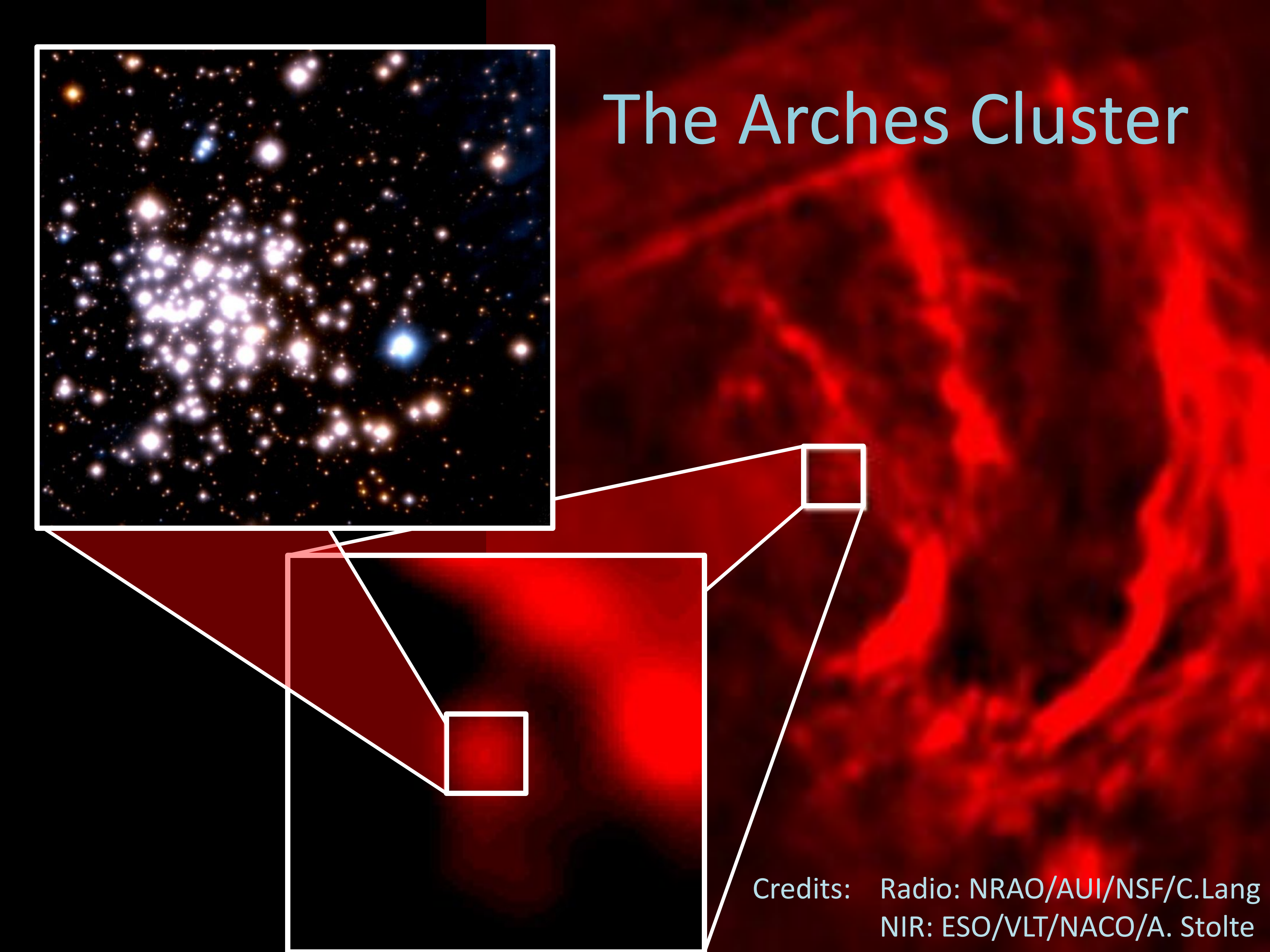
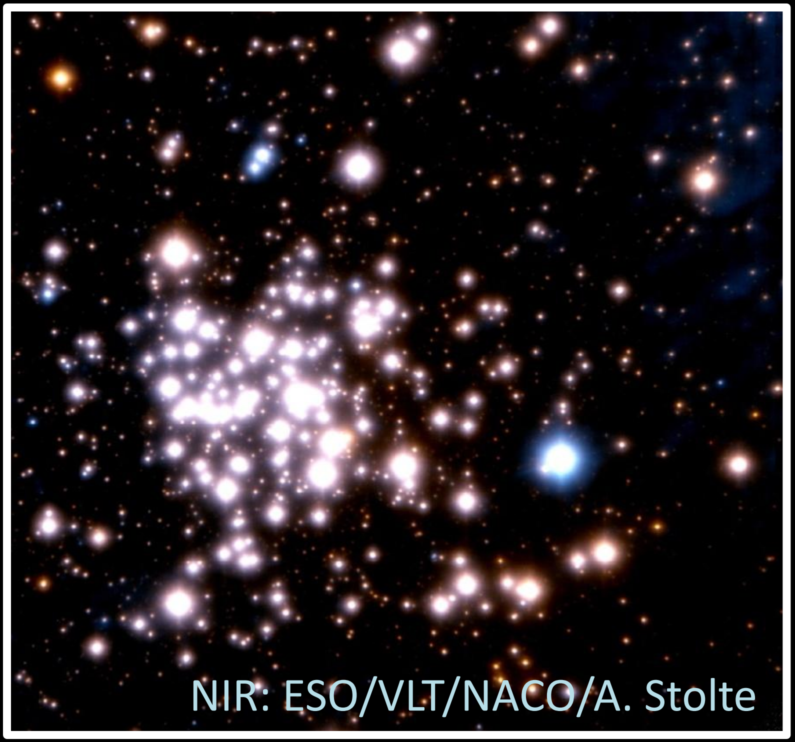
The Past and the Future of the Arches Cluster




The Arches Cluster
Credits: Radio: NRAO/AUI/NSF/C.Lang
NIR: ESO/VLT/NACO/A. Stolte



The Arches Cluster

- densest cluster in the MW
  - >100 O-Stars within 1pc
- only ~2.5Myr old
- one of only a few star burst clusters in the MW
- nearby the Galactic center
  - projected distance ~30pc

The Arches cluster is a unique object to study star formation and the dynamical evolution of dense stellar systems in a strong tidal field !

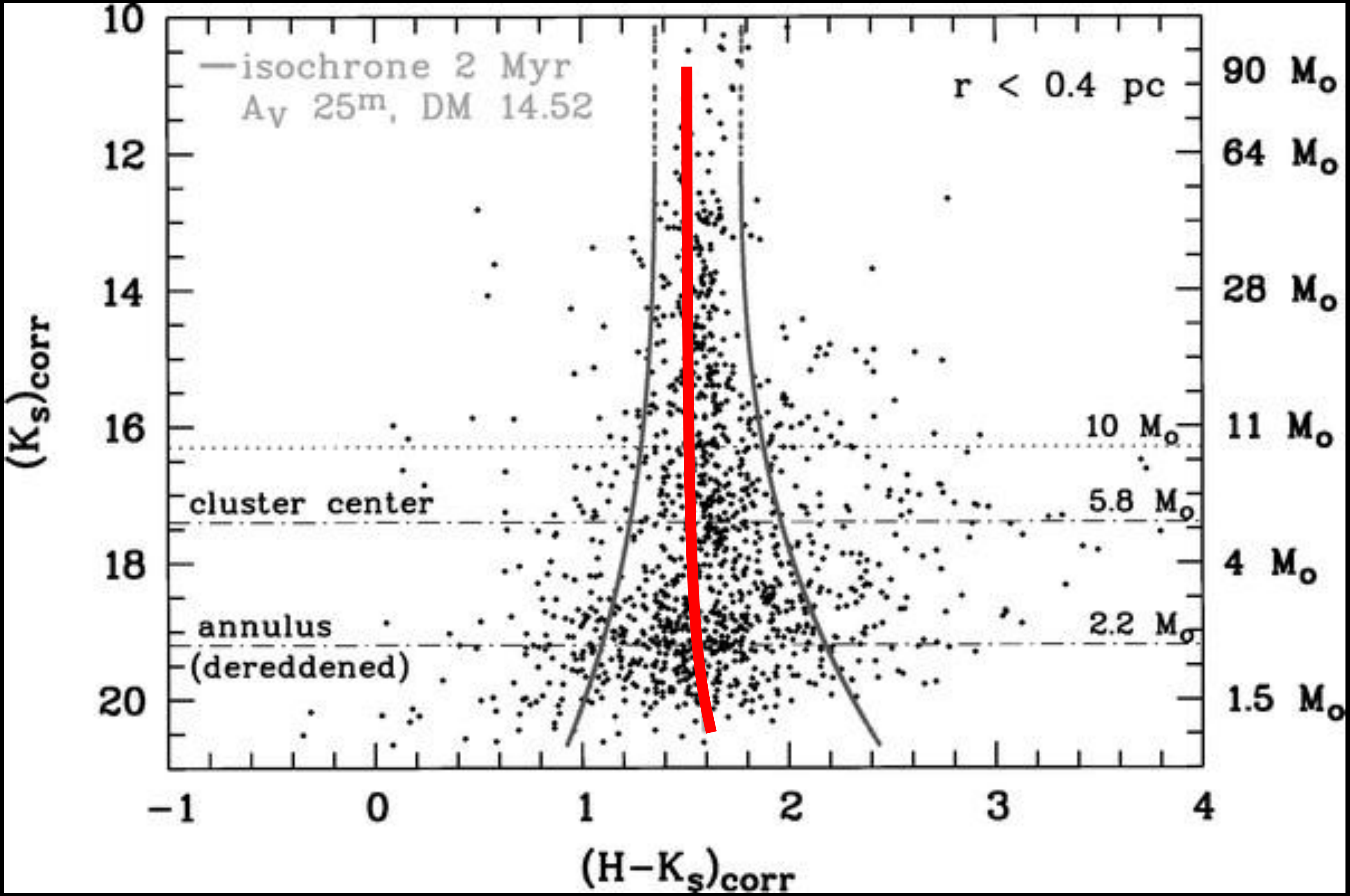
Motivation: what can we learn from N-body models about the past and the future of the Arches cluster

The Present

Observational Data

- data from VLT/NACO
  - AO NIR photometry
  - two wave-bands (H and K)

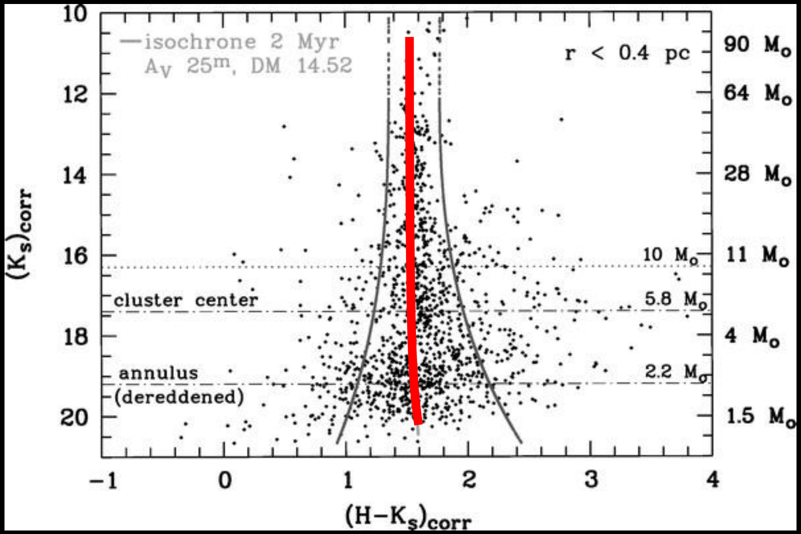
Cluster Membership



(Stolte et al., 2005)

Observational Data

(Stolte et al., 2005)

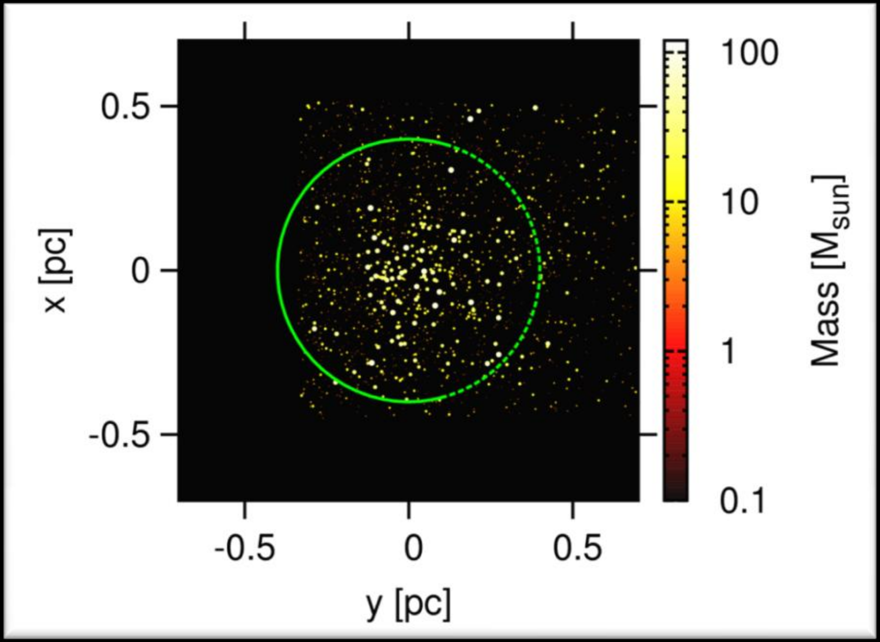


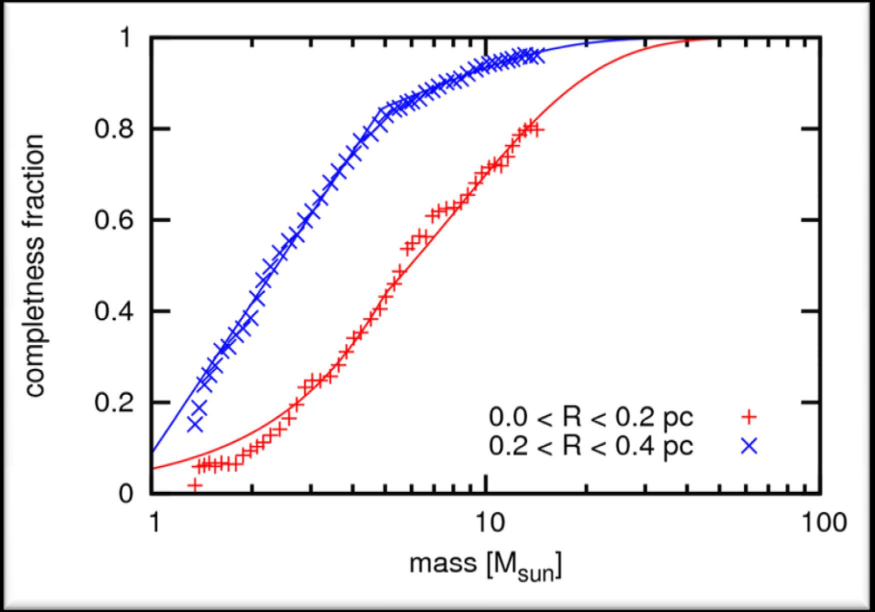
- data from VLT/NACO
  - AO NIR photometry
  - two wave-bands (H and K)
- cluster membership by color selection
  - approximately 1500 stars
- stellar masses from Geneva tracks (Lejeune & Schaerer, 2001)
  - assumed age 2.5Myr
  - solar metallicity

Observational Limits

- field of view
  - only stars within 0.4pc are completely covered by FOV
- crowding effects
  - resolution of 0.84”
  - artificial star simulations give completeness fraction

(Stolte et al., 2005)

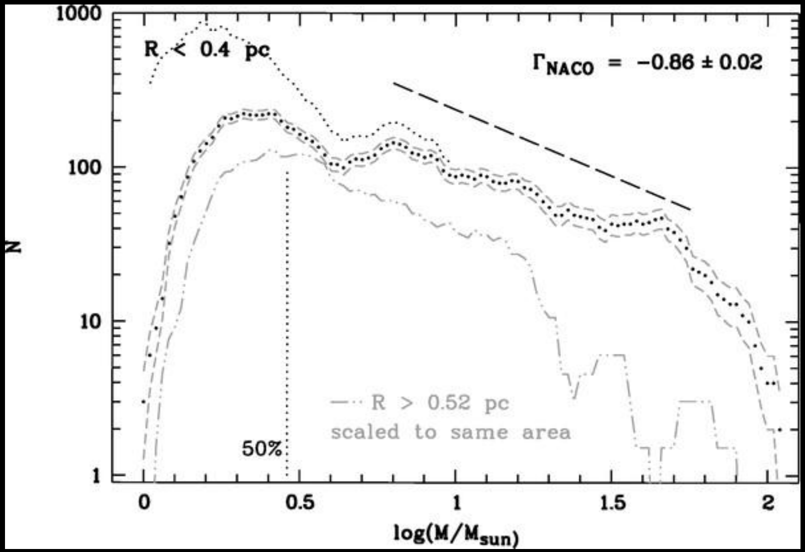


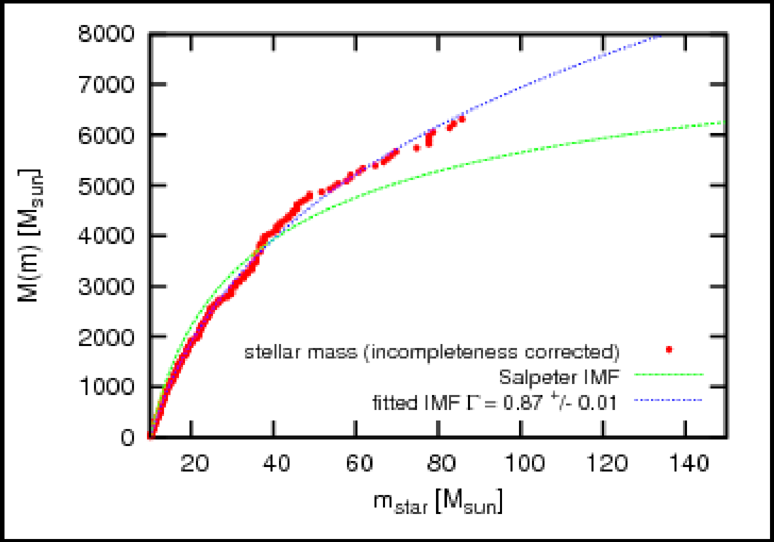


Arches Initial Mass Function

(Stolte et al., 2005)

- Is the IMF of Arches standard?
  - has formed in extreme environment
  - observed MF shallower than Salpeter (however, latest result is consistent with Salpeter)
  - depleted at low masses with turn-over at 6-7$M_\odot$
- is the observed MF also the IMF?
  - dynamical effects are not taken into account





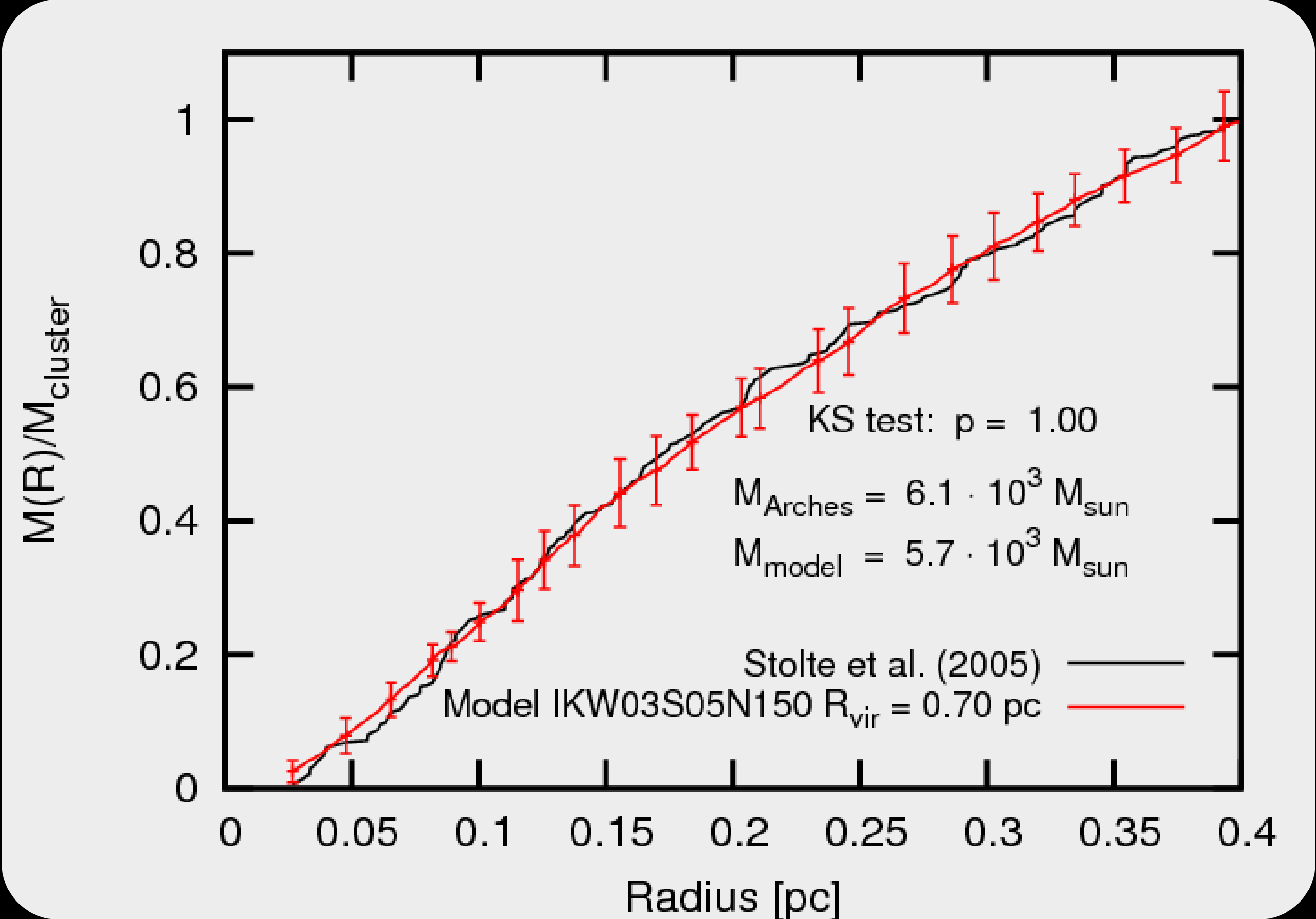
The Past

Fitting a model to observations

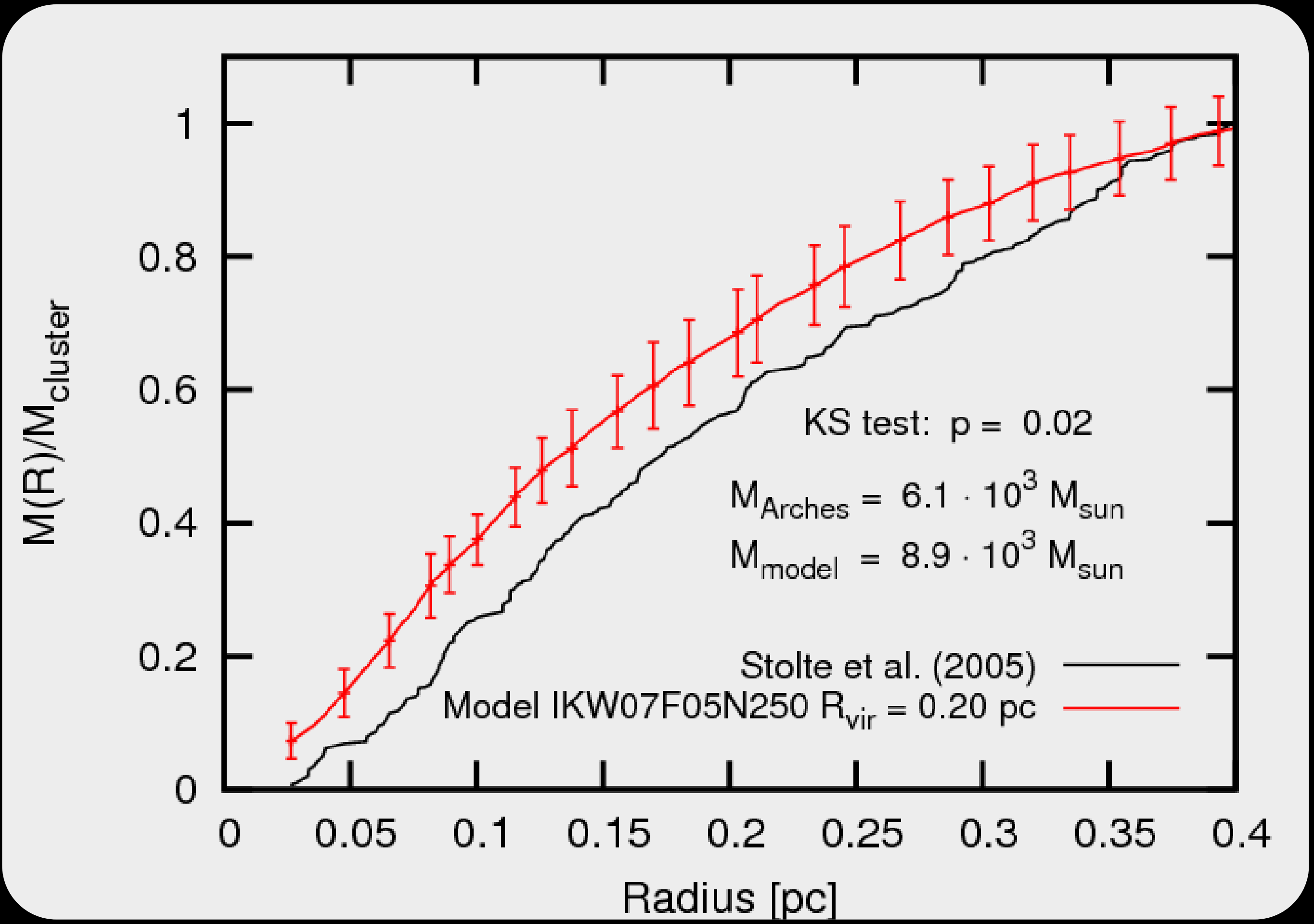
- find the best model
  - constrain cluster properties such as IMF, total mass, ...
- model parameter
  - King model with three different concentration parameters W_0
  - initial cluster mass given by number of massive stars
  - initial virial radius
  - Salpeter IMF and flat IMF,
    both with different lower mass limit

- N-body simulations with Starlab
  - neglecting stellar evolution and tidal field
  - 10 simulations per 65 models
  - total of 1235 averaged snapshots
  - comparing stars with $R<0.4$pc and $m>10M_{\odot}$ (>80% complete)

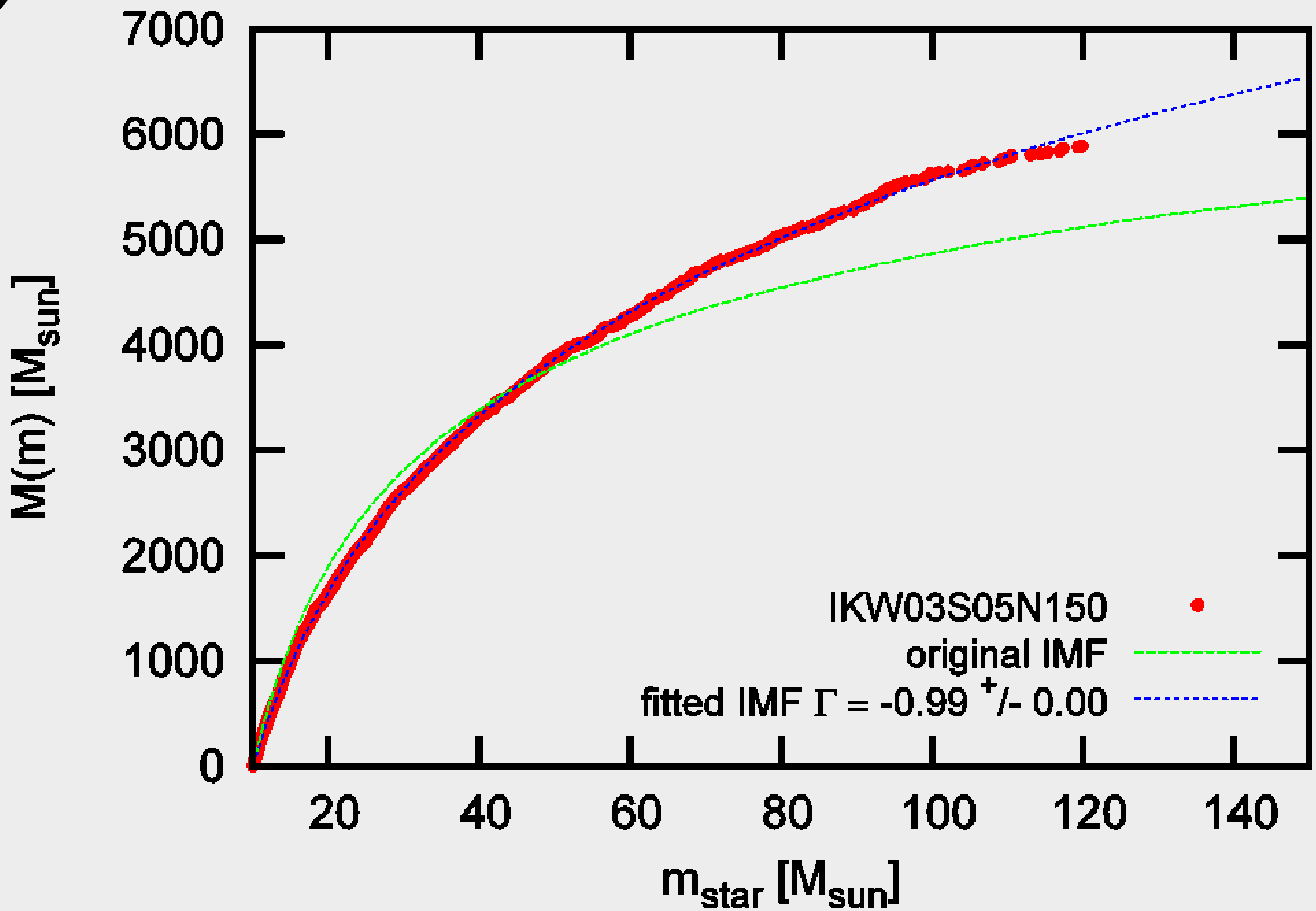
Comparing Cumulative Mass Profile



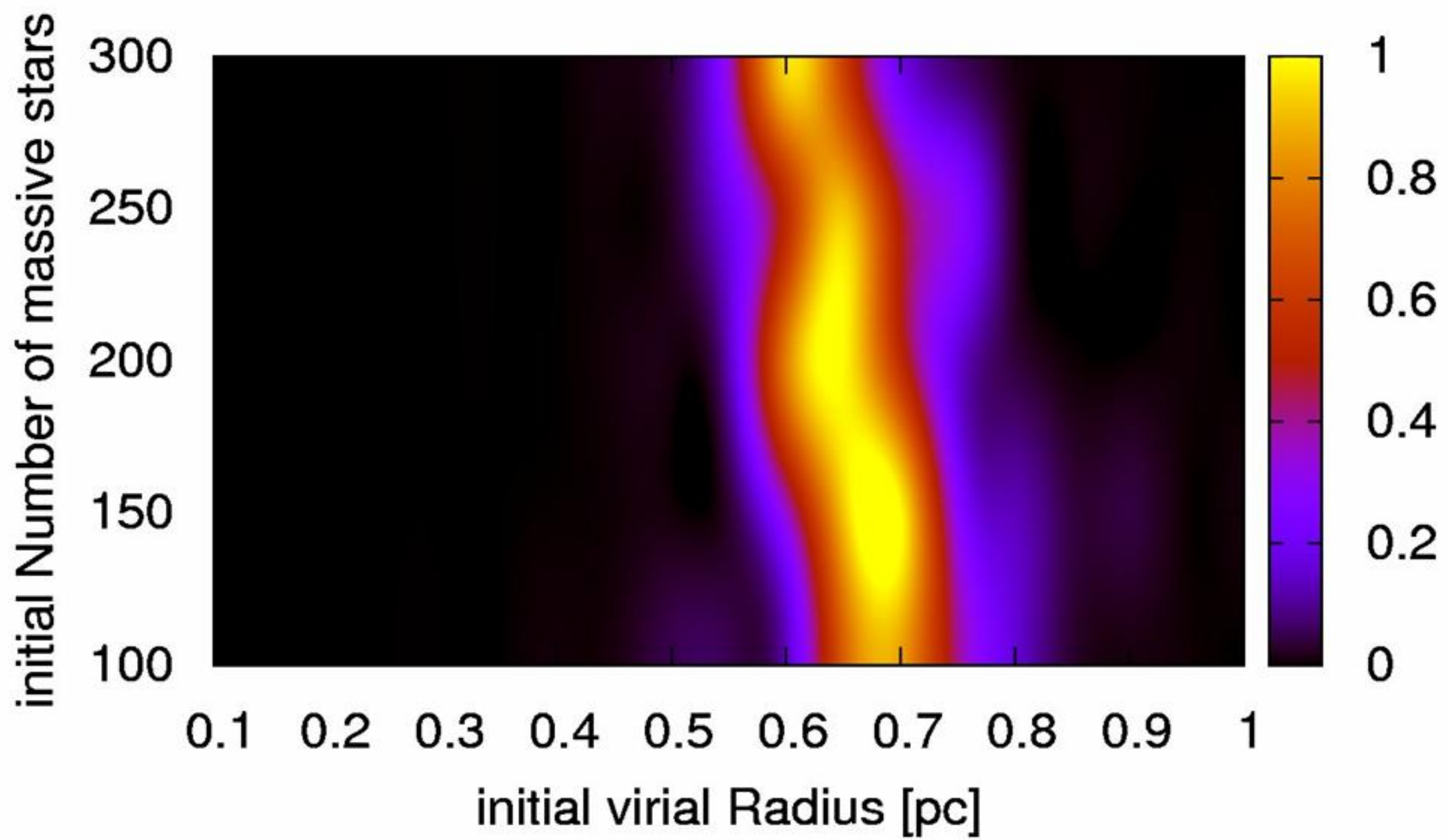
Comparing Cumulative Mass Profile



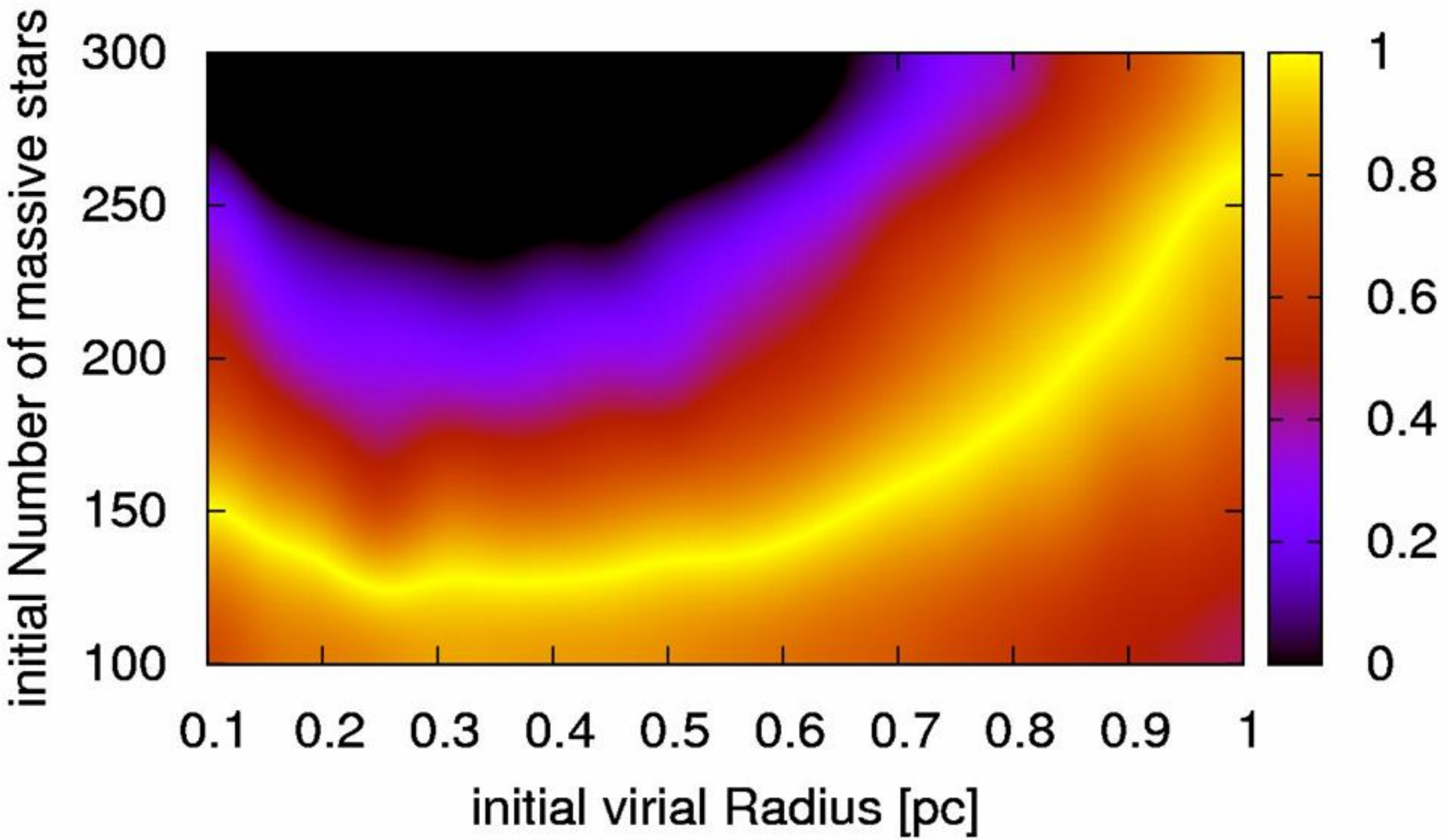
Comparing Observed Mass Function



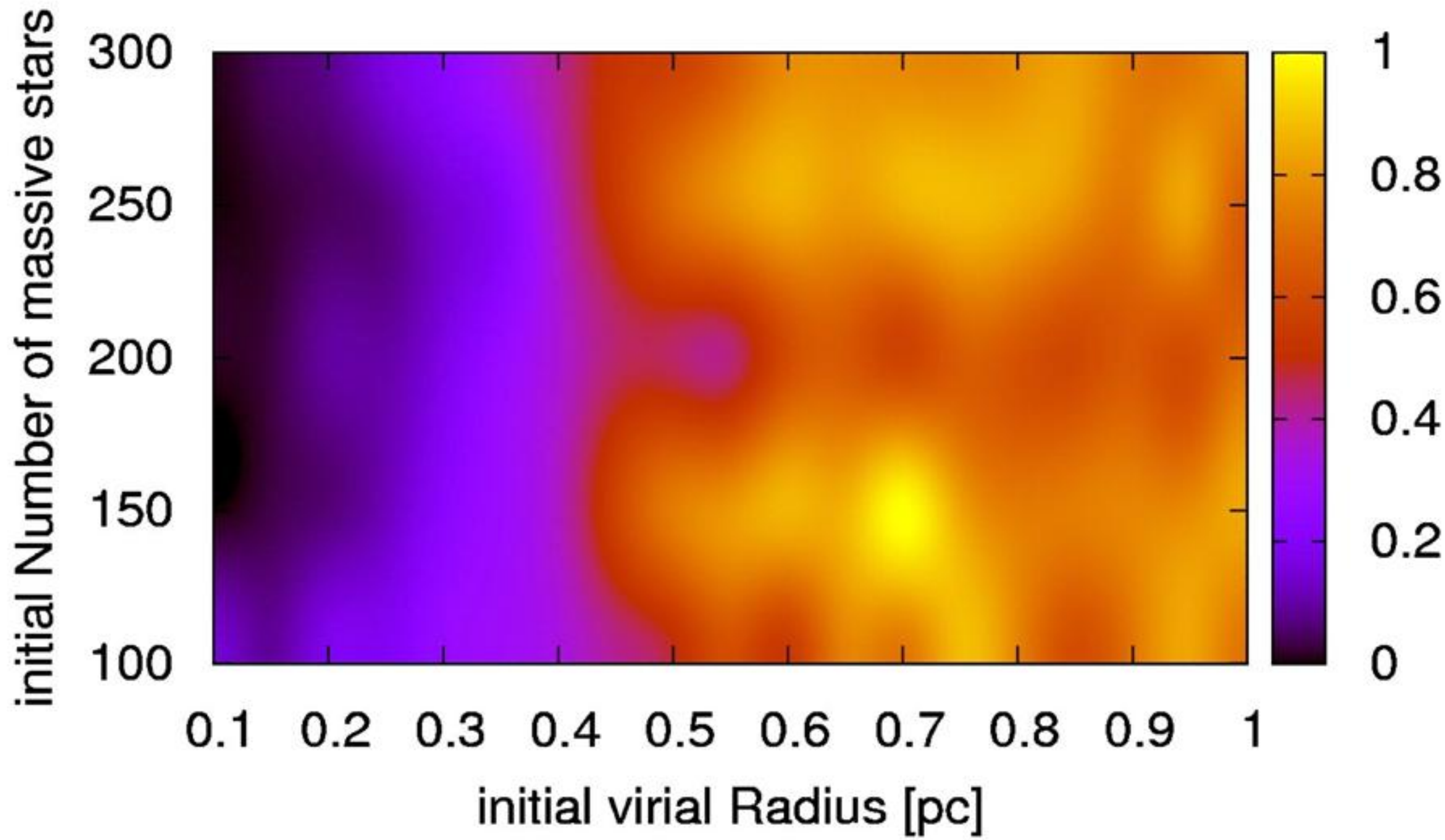
Comparing Cumulative Mass Profile



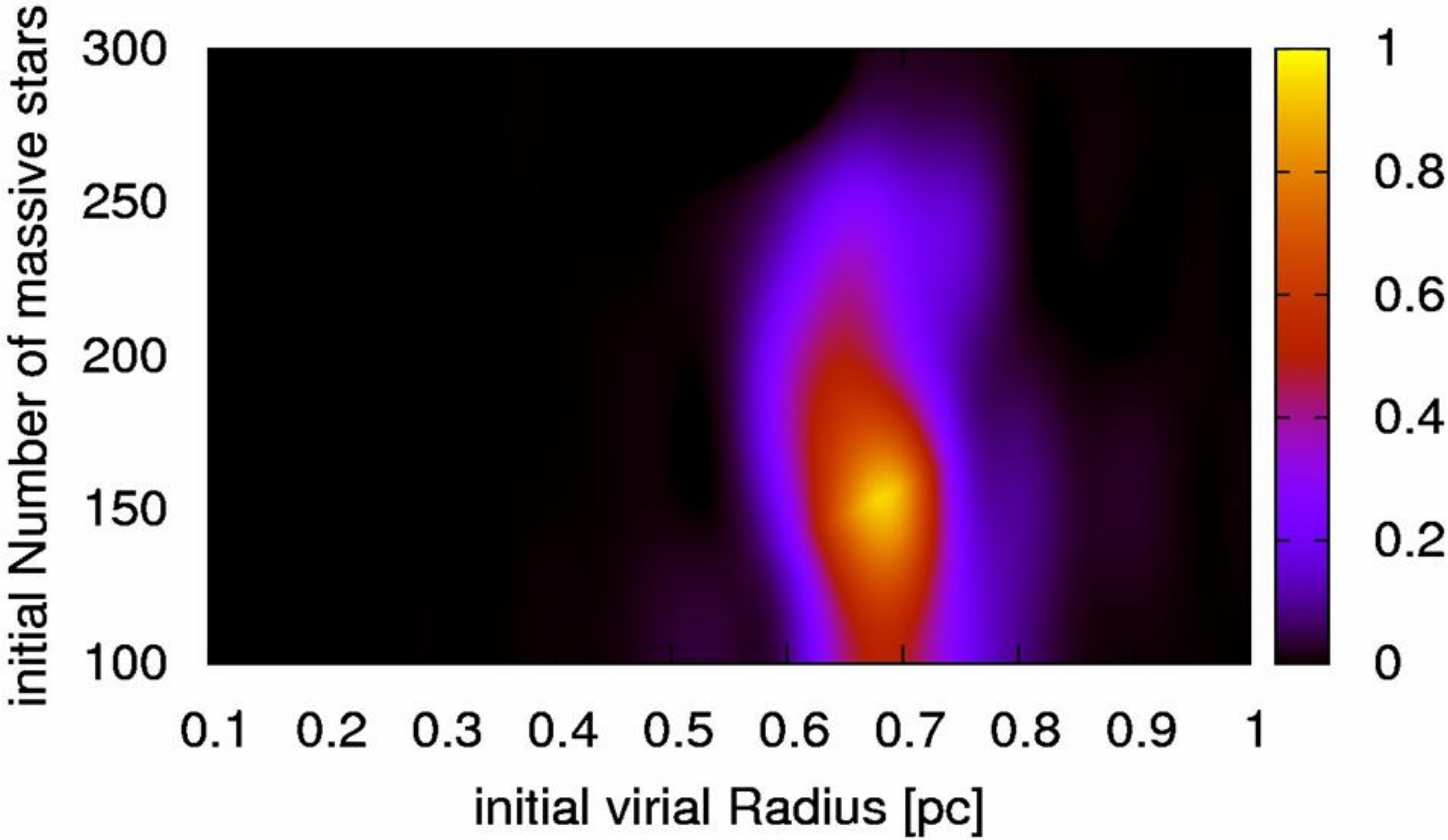
Comparing Cluster Mass



Comparing Cluster MF



Comparing Everything

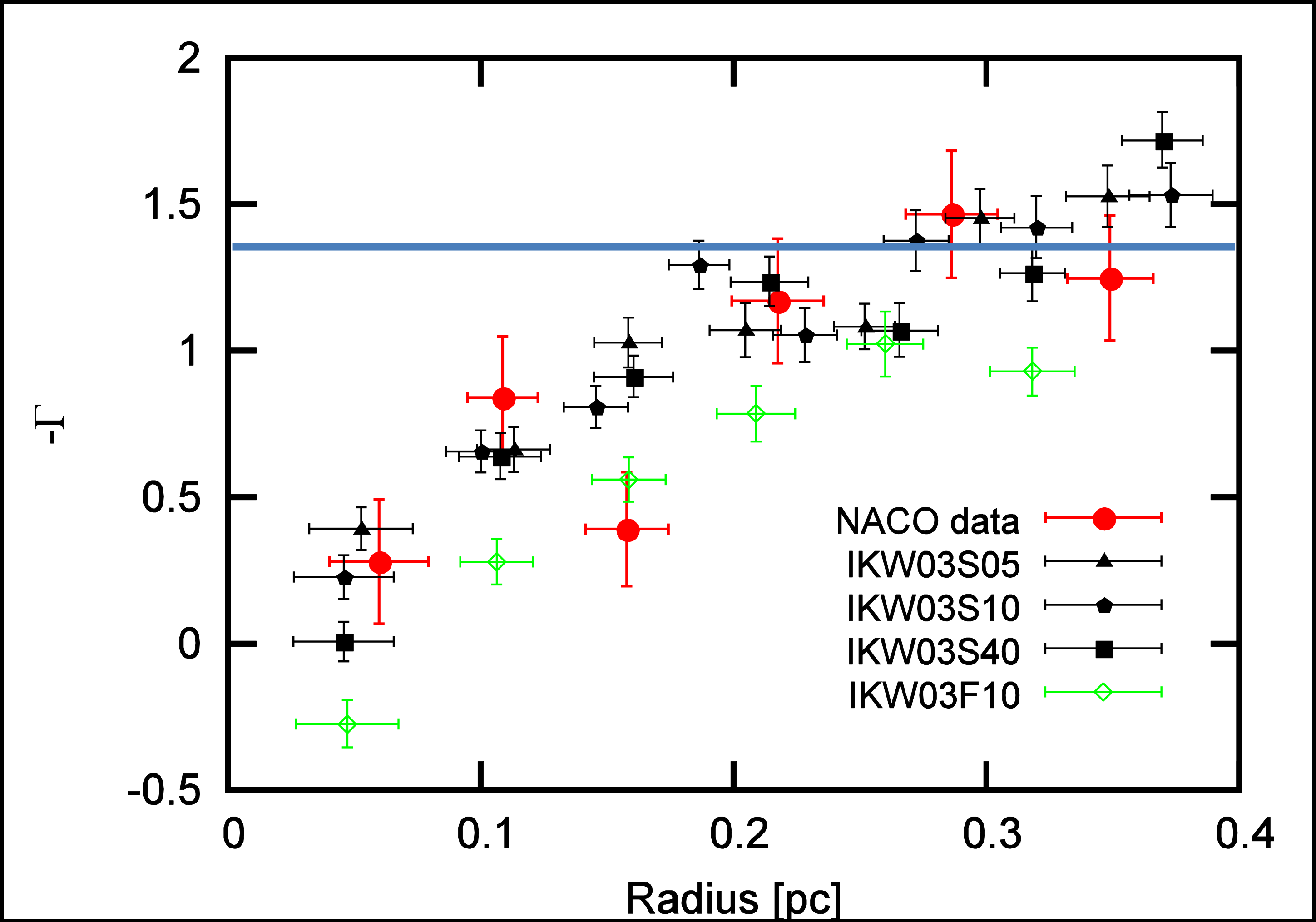


Results – Best Fit Model

- found best fit model with
  - Salpeter IMF
  - virial radius 0.7pc
  - total initial mass $4x10^4 M_\odot$
  - lower mass limit IMF $0.5M_\odot$
  - initial concentration $W_0=3$

Model	Parameters		f_{all}
	N_{MS}	r_{vir}	
IKW03F05	200	0.65	0.333389
IKW03F10	200	0.70	0.389688
IKW03S05	150	0.70	0.928229
IKW03S10	150	0.65	0.891674
IKW03S40	200	0.60	0.72182
IKW05F05	200	0.85	0.411755
IKW05F10	250	0.90	0.427615
IKW05S10	200	0.80	0.791796
IKW05S40	200	0.75	0.872719
IKW07F05	200	0.75	0.468826
IKW07F10	250	0.85	0.554017
IKW07S10	200	1.00	0.751365
IKW07S40	200	0.70	0.861753

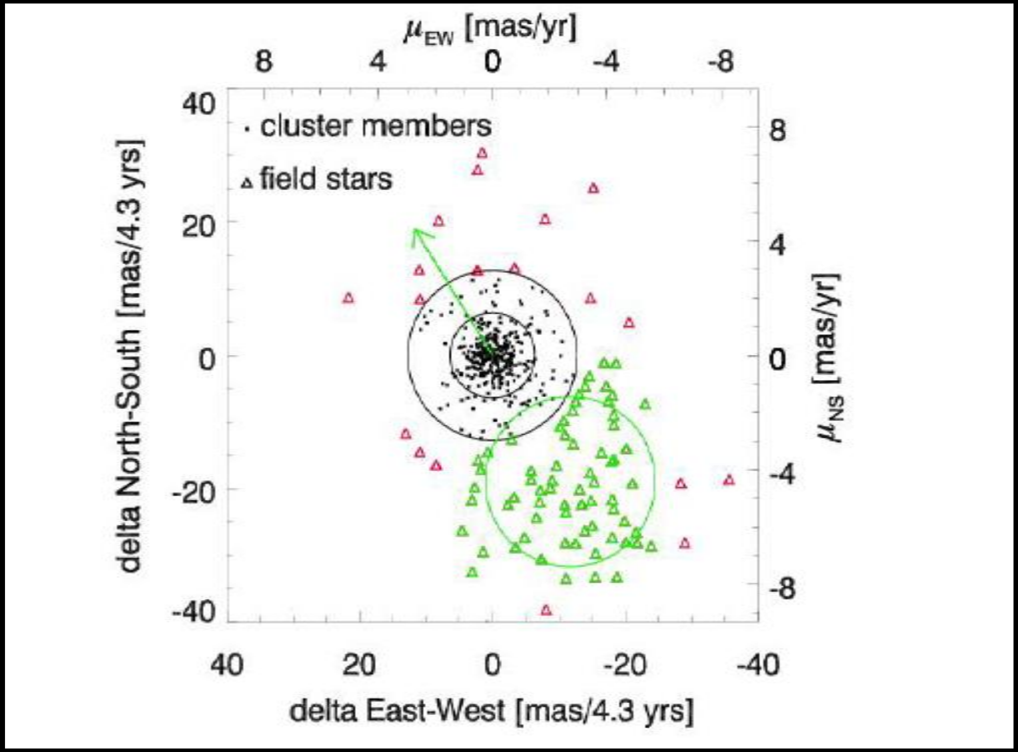
Radial MF variations



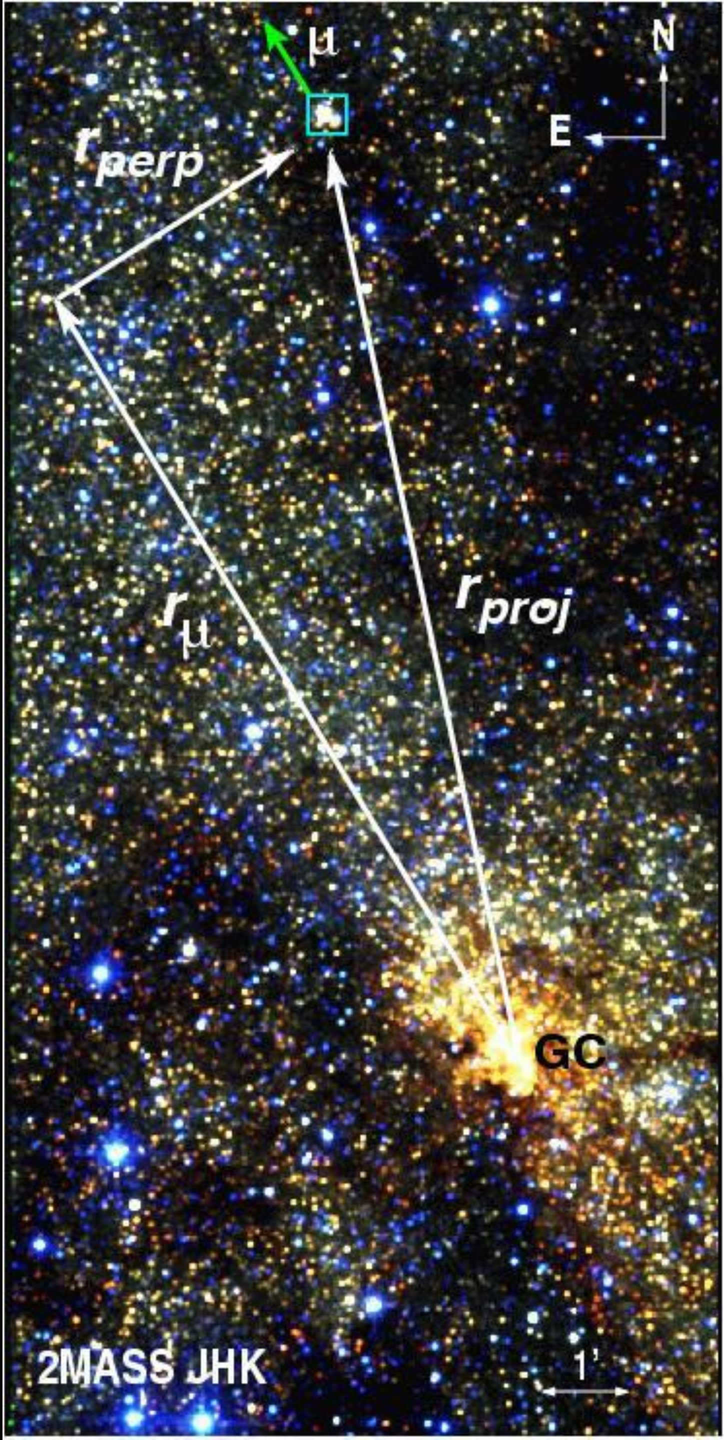
The Future

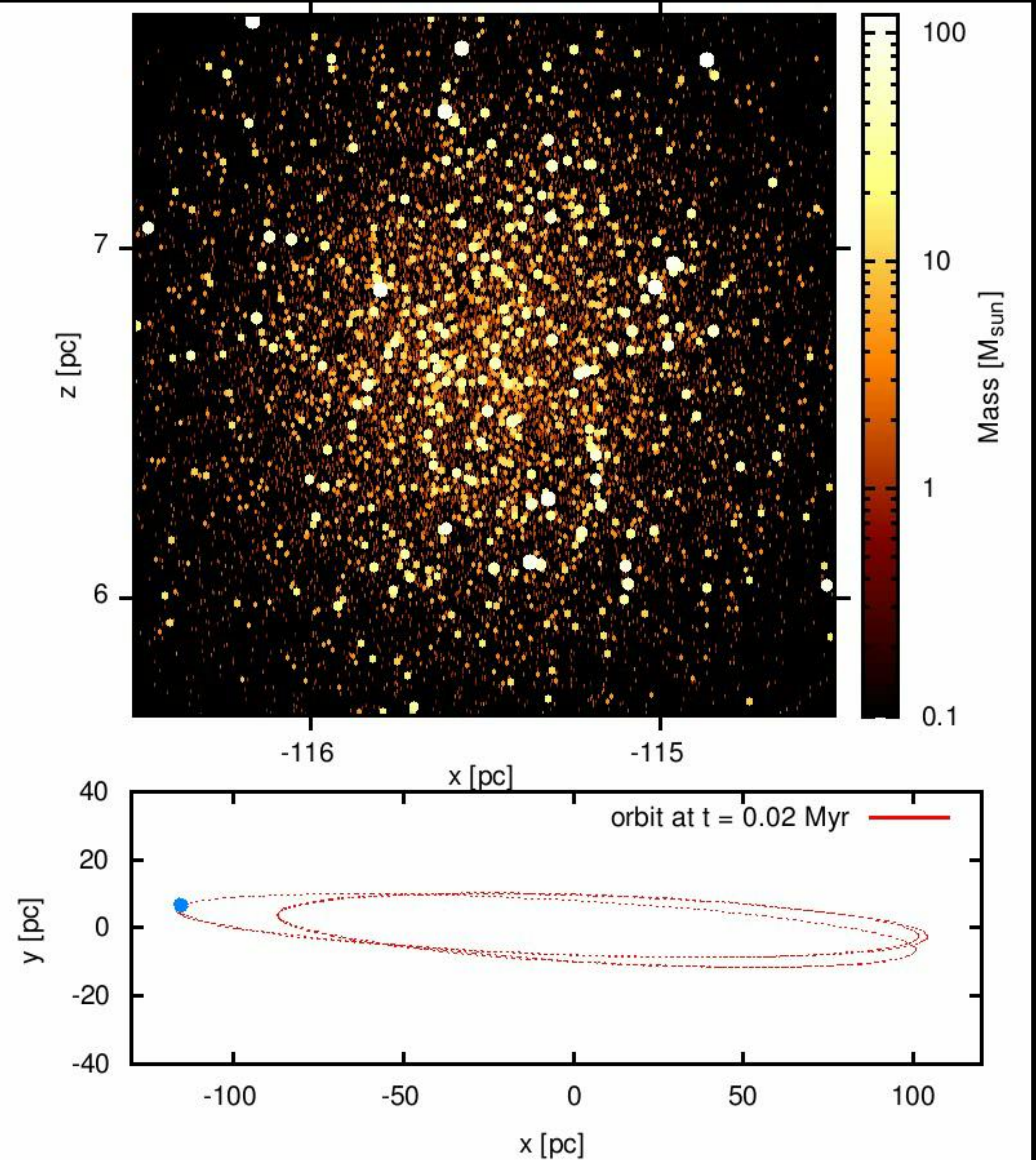
Cluster orbit

- known proper motion of the cluster
  - line-of-sight distance can be varied



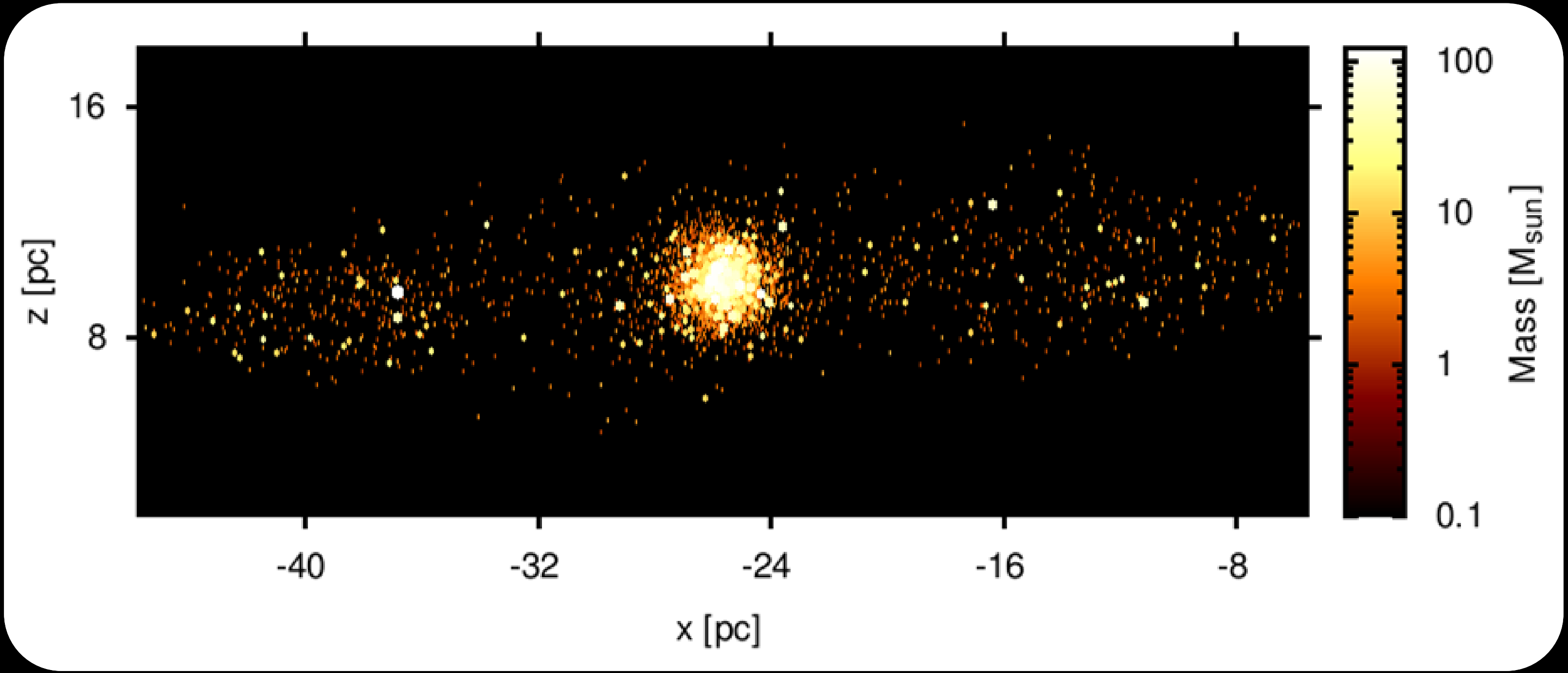
(Stolte et al., 2008)





7
6
z [pc]
-116
-115
x [pc]
100
10
1
0.1
Mass [M_sun]
40
20
0
-20
-40
y [pc]
orbit at t = 0.02 Myr
-100
-50
0
50
100
x [pc]

Orbit Evolution



- most of the cluster mass is still bound at 2.5Myr
- tidal tails form (parallel to Galactic plane)
- cluster dissolves on a time scale of several tens of Myr

Summary

(Harfst, Portegies Zwart, & Stolte, 2010, astro-ph/0911.3058)

Past
– Salpeter slope of IMF down to 1(?) $M_\odot$
– initial mass $4\text{x}10^4 M_\odot$

Present
– cluster is close to core-collapse
– radial variations in slope of MF due to dynamical mass segregation

Future
– cluster forms tidal tails