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A Parametric Study on the Formation of ECs and UCDs

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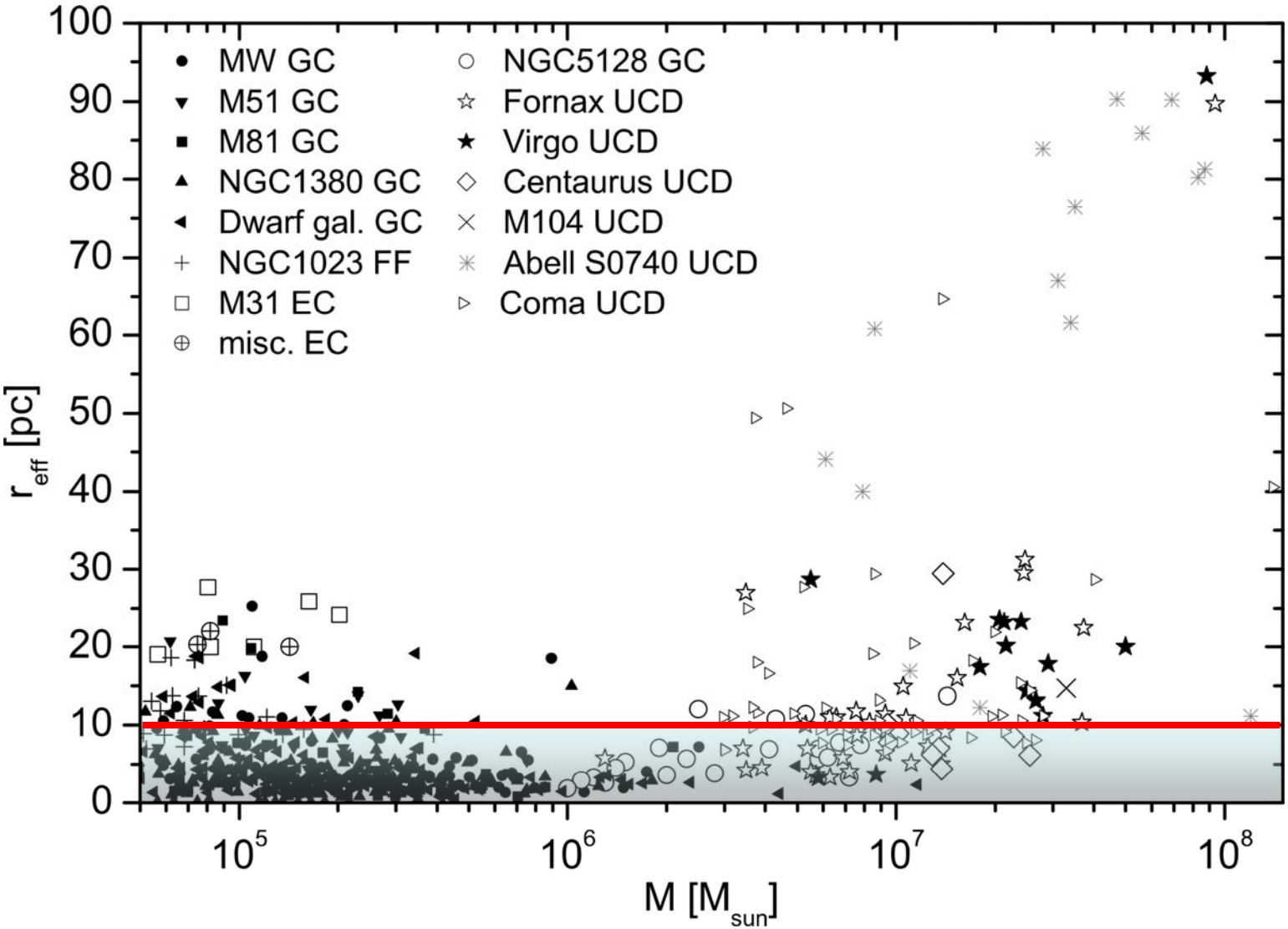
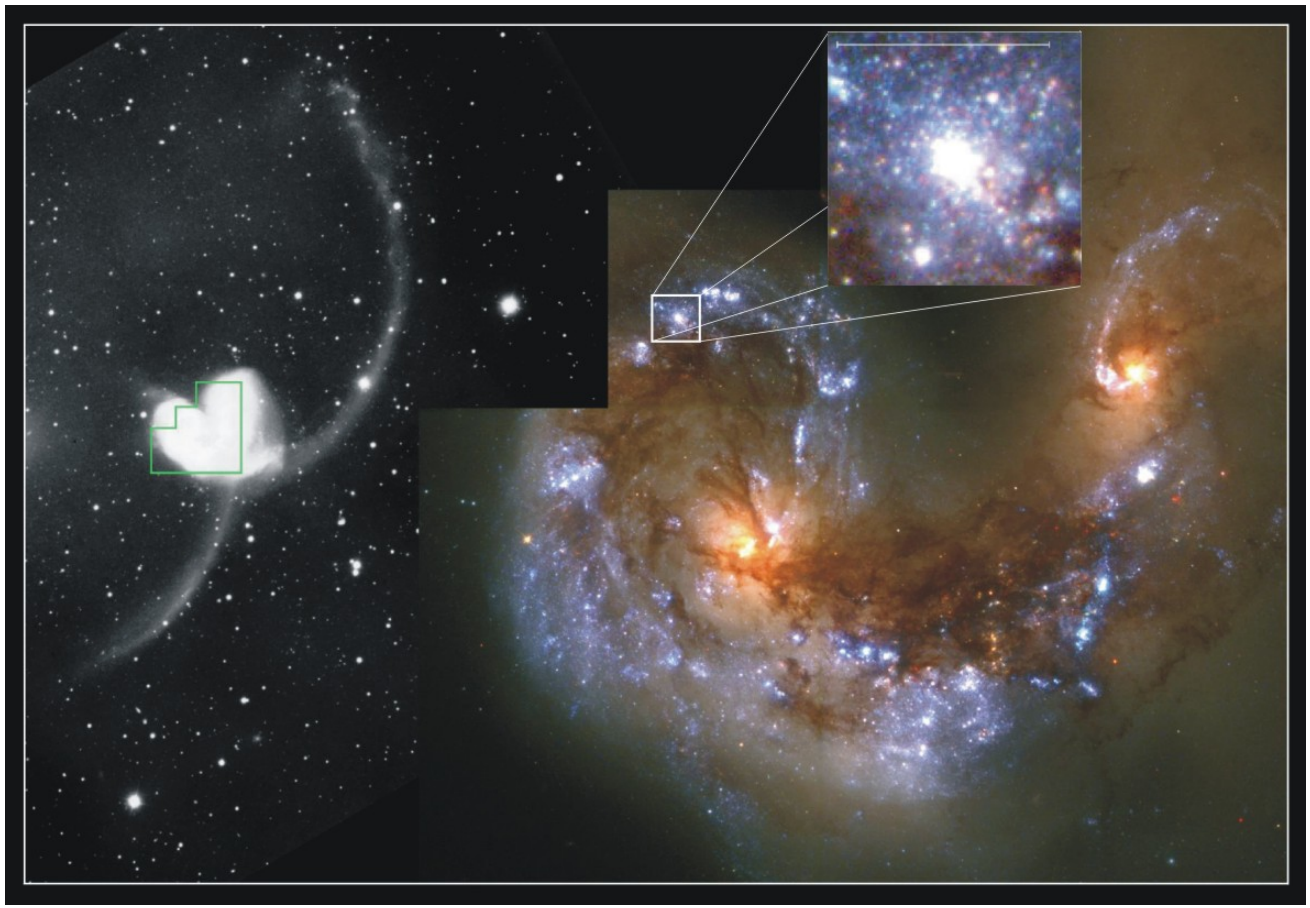
ECs and UCDs


MW GC
M51 GC
M81 GC
NGC1380 GC
Dwarf gal. GC
NGC1023 FF
M31 EC
misc. EC
NGC5128 GC
Fornax UCD
Virgo UCD
Centaurus UCD
M104 UCD
Abell S0740 UCD
Coma UCD
r_eff [pc]
M [M_sun]
100
90
80
70
60
50
40
30
20
10
0
10^5
10^6
10^7
10^8

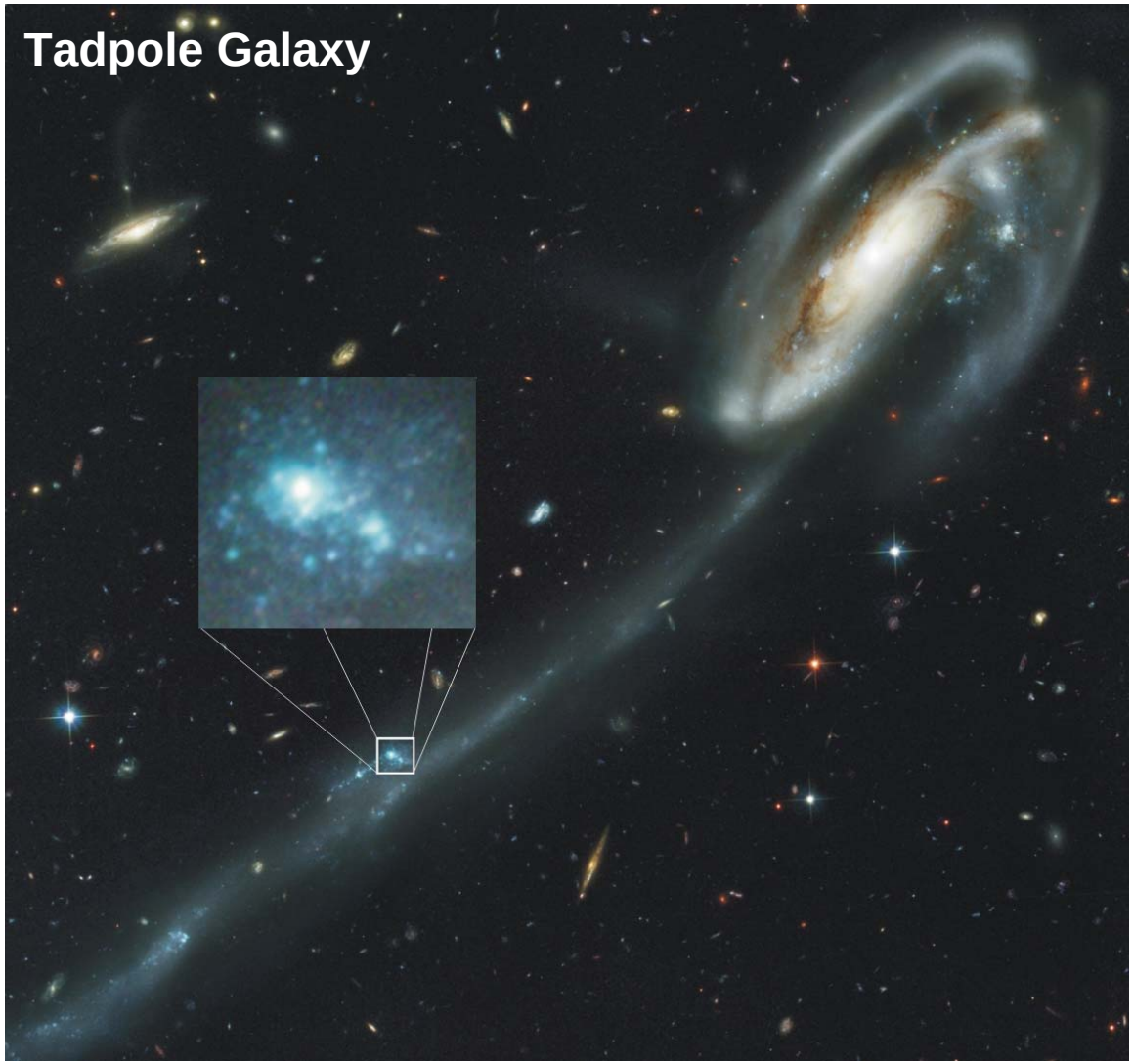
Cluster Complexes (CCs)



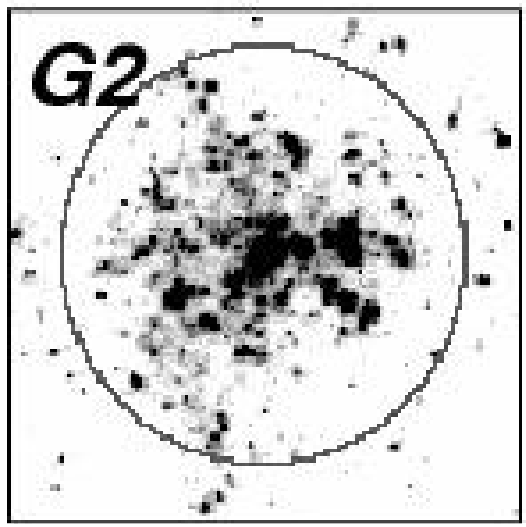
Cluster Complex = cluster of young star clusters

Properties of CCs: diameter: 100 – 1200 pc; mass: 10^5 – 10^8 M_{sun}

Cluster Complexes (CCs)



CC in the disk of M51



Bastian et al. 2005, A&A 443, 79

Outline of Parameter Study

- **Hypothesis:**

  ECs and extended UCDs are the remnants of Cluster Complexes.

- **Method:**
  - Setup of CC models covering a suitable parameter space
  - Placing CC models in the gravitational field of a Milky Way like galaxy
  - Numerical simulations of the evolution of CCs with the particle-mesh Code SUPERBOX++
  - Comparison of structural parameters of evolved CCs with observed ECs and extended UCDs

Initial Setup (1)

Cluster Complex:

N_{CC} = 32 star clusters

$M_{CC} = 10^{5.5}$ to 10^{8} M_{sun}

$R_{pl,CC}$ = 10 to 160 pc

Plummer distribution

Virial equilibrium

Star Cluster:

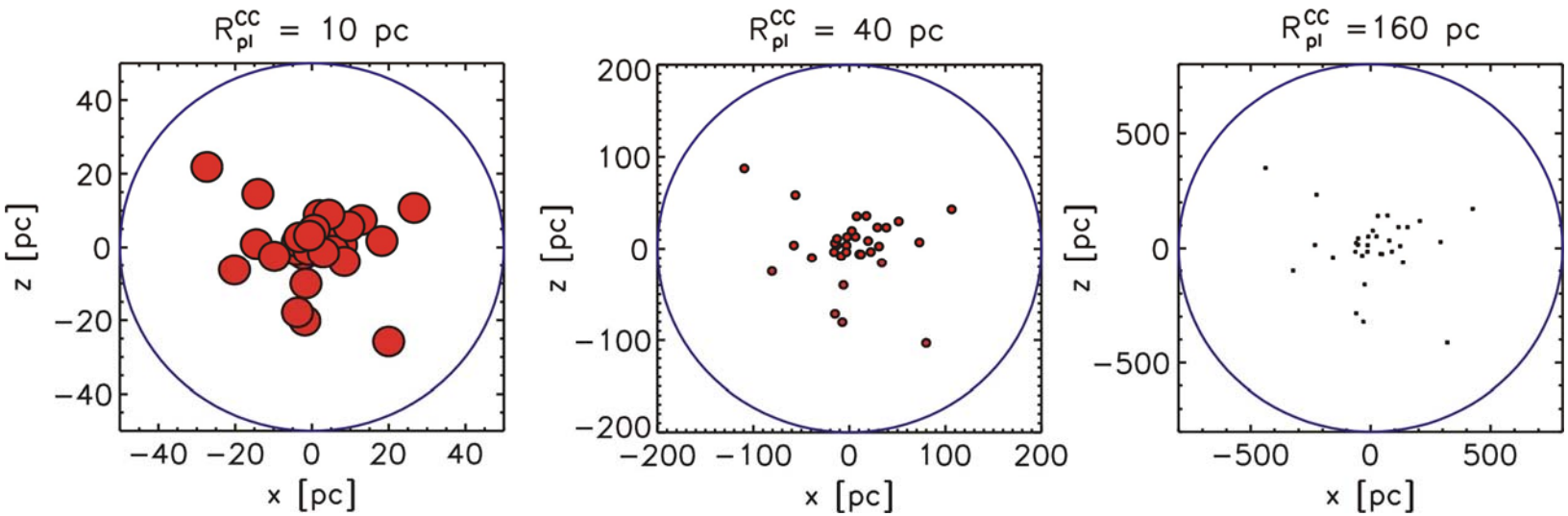
N_{SC} = 100,000 particles

M_{SC} = 1/32 M_{CC}

$R_{pl,SC}$ = 4 pc

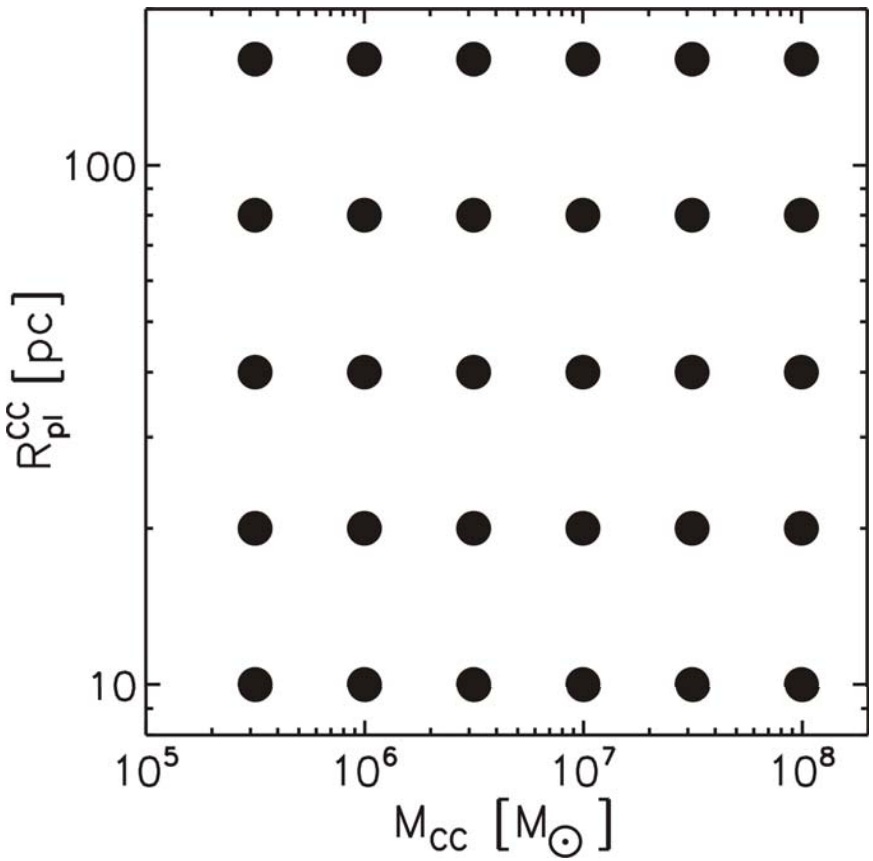
Plummer distribution

Virial equilibrium

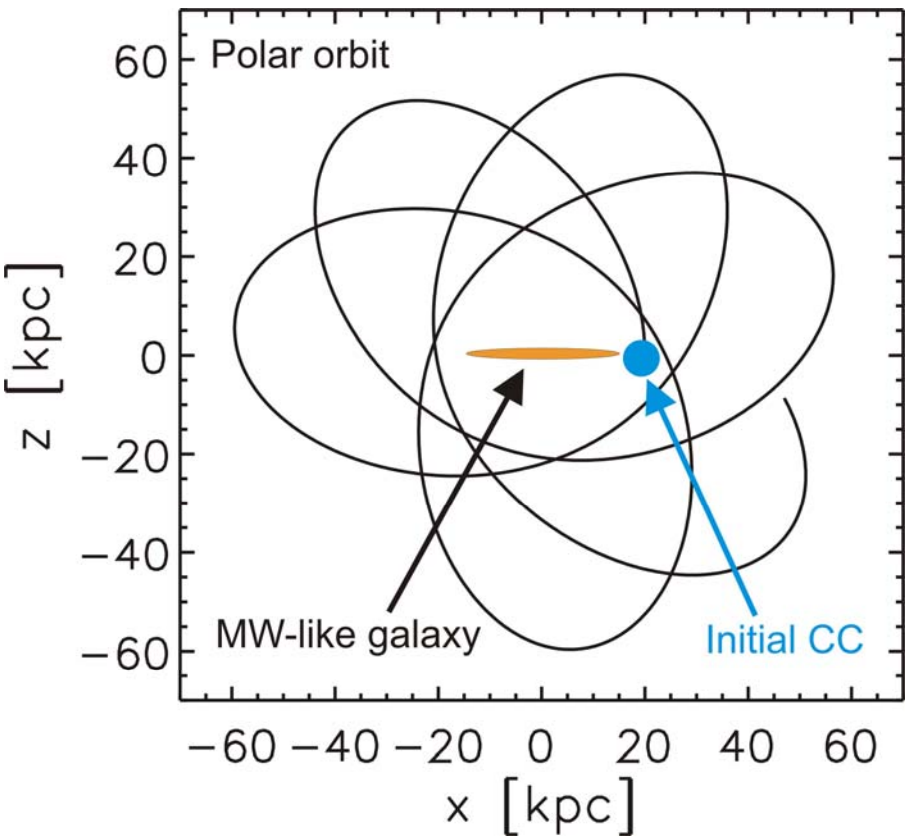


Initial Setup (2)

CC Parameter Space

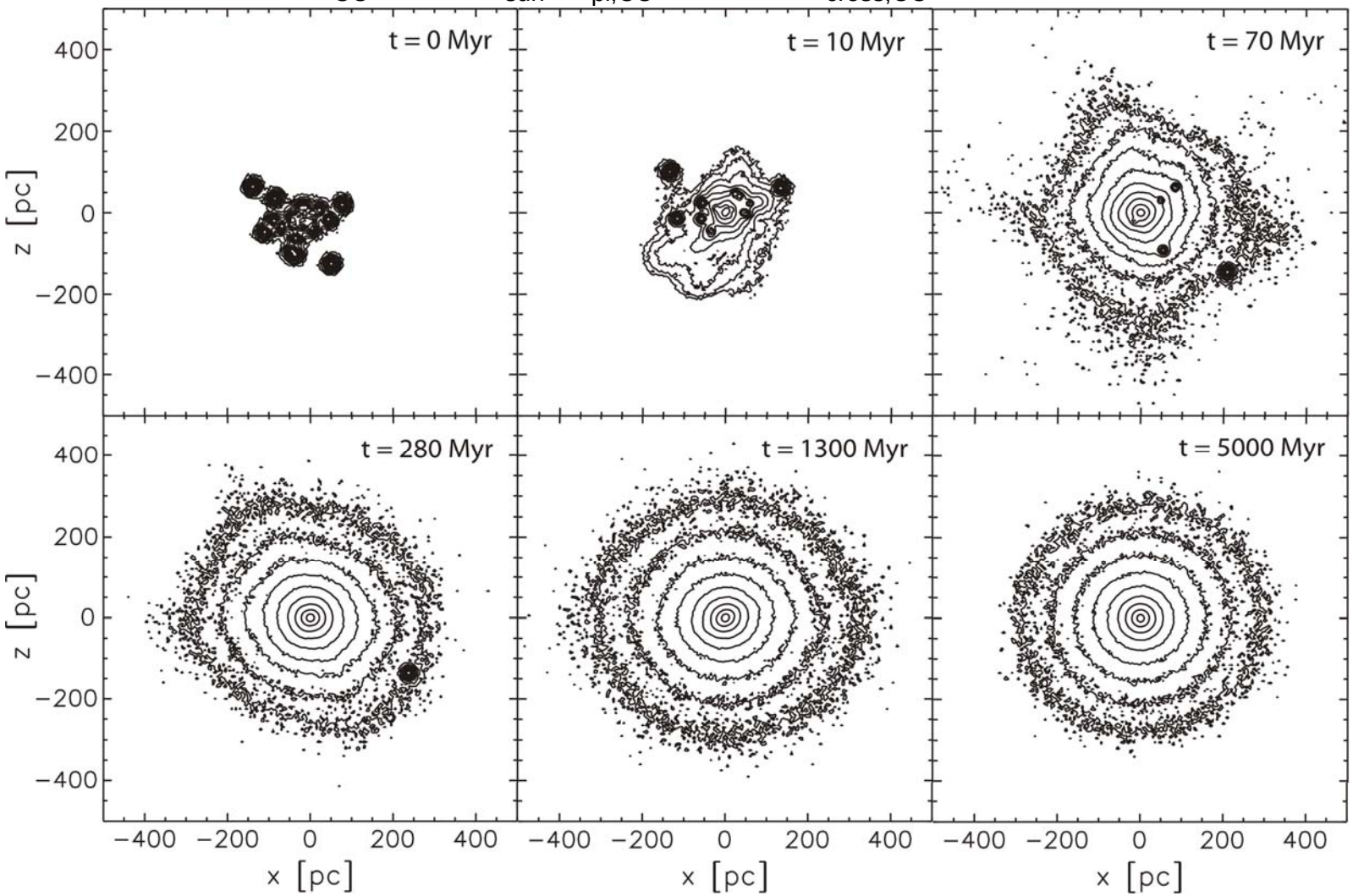


Orbit



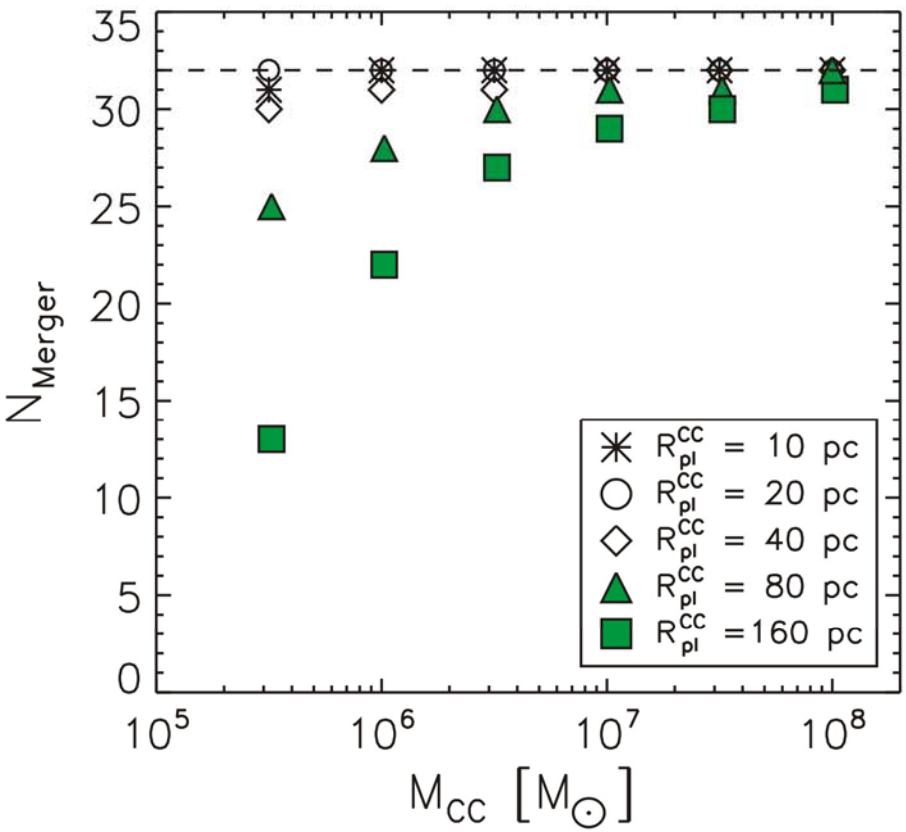
Time Evolution

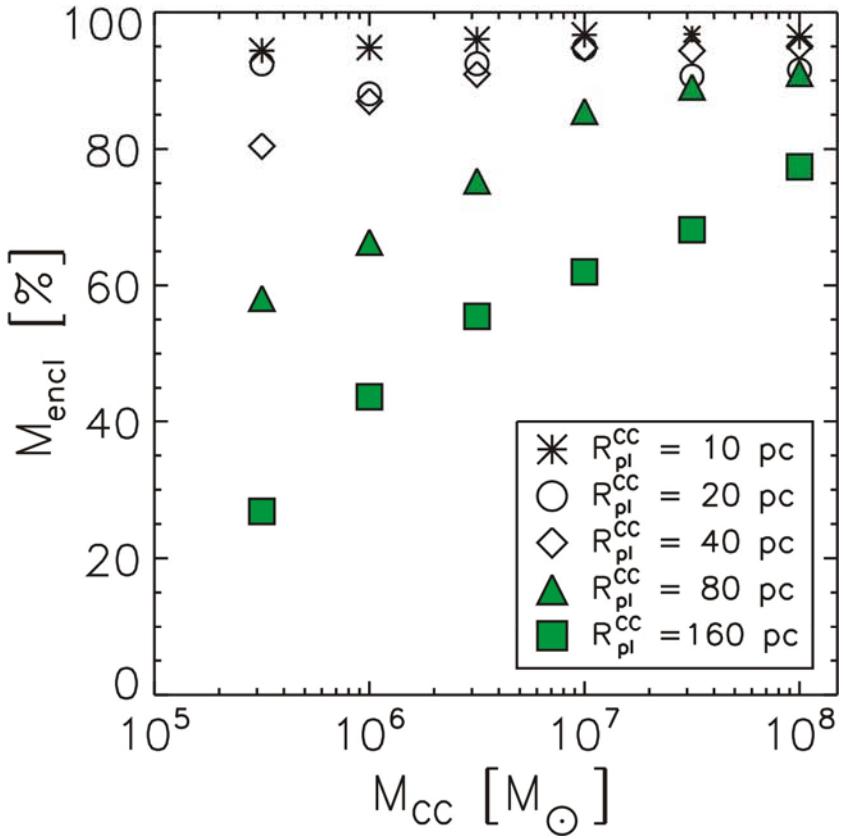
$M_{CC} = 10^7\ M_{sun}$, $R_{pl,CC} = 40$ pc, $T_{cross,CC} = 7.5$ Myr



Contours: Surface density, lowest level 0.625 M_{sun} pc^{-2}, increasing by factors of 3

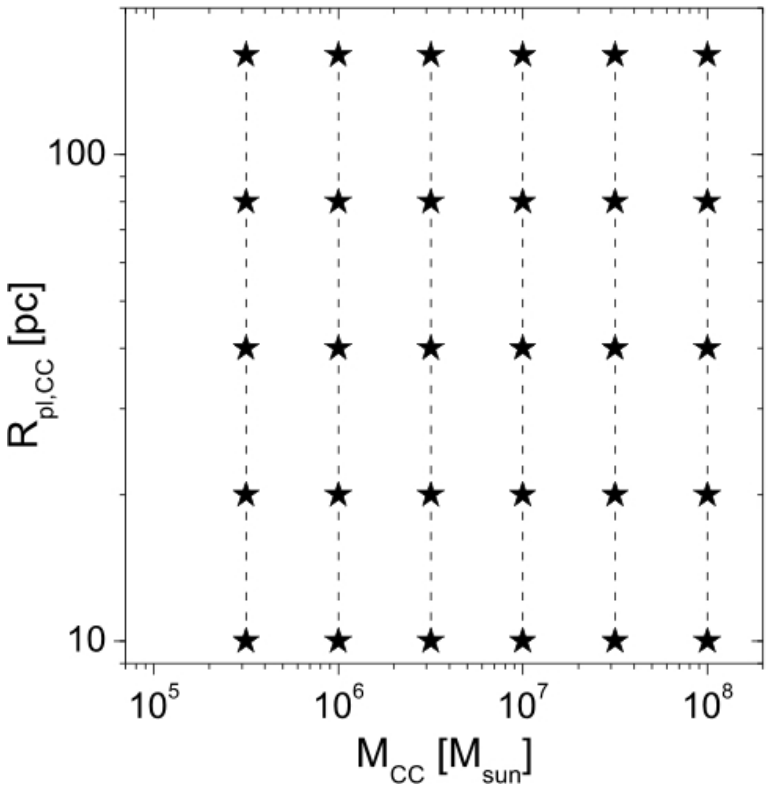
Number of Mergers and Final Mass



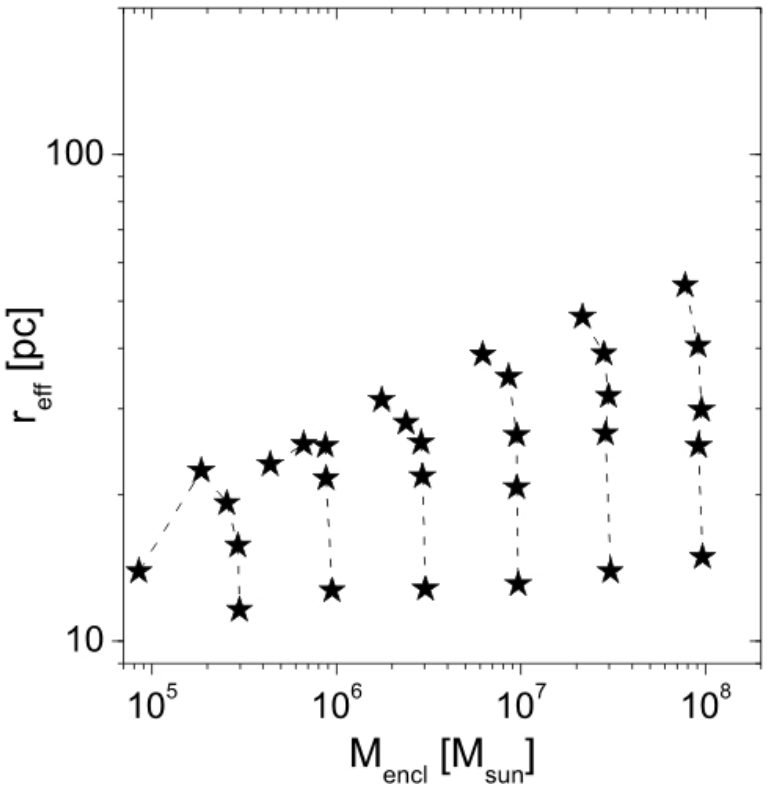


Input versus Output Parameters

Input CC Parameter Space

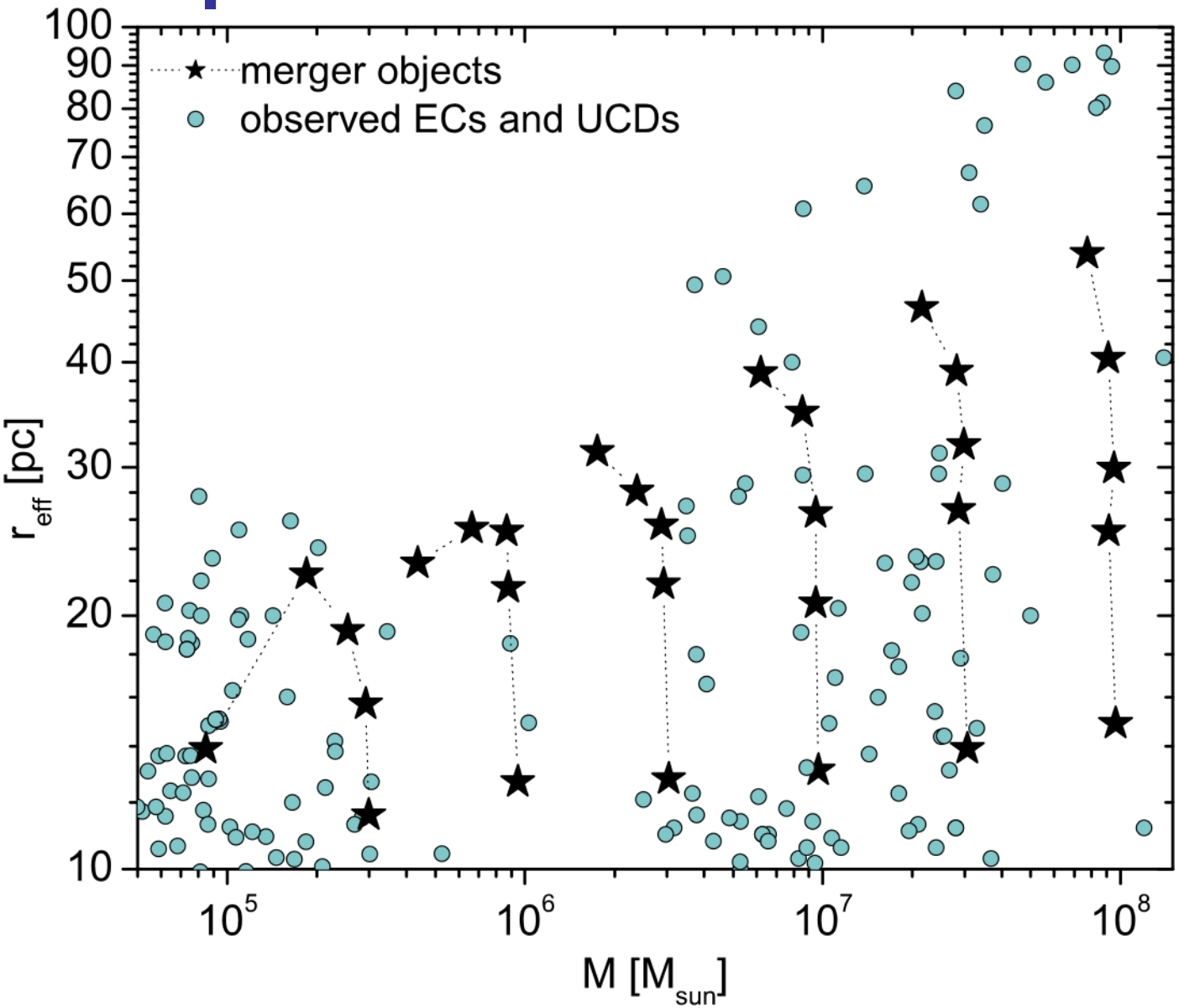


Merger Objects

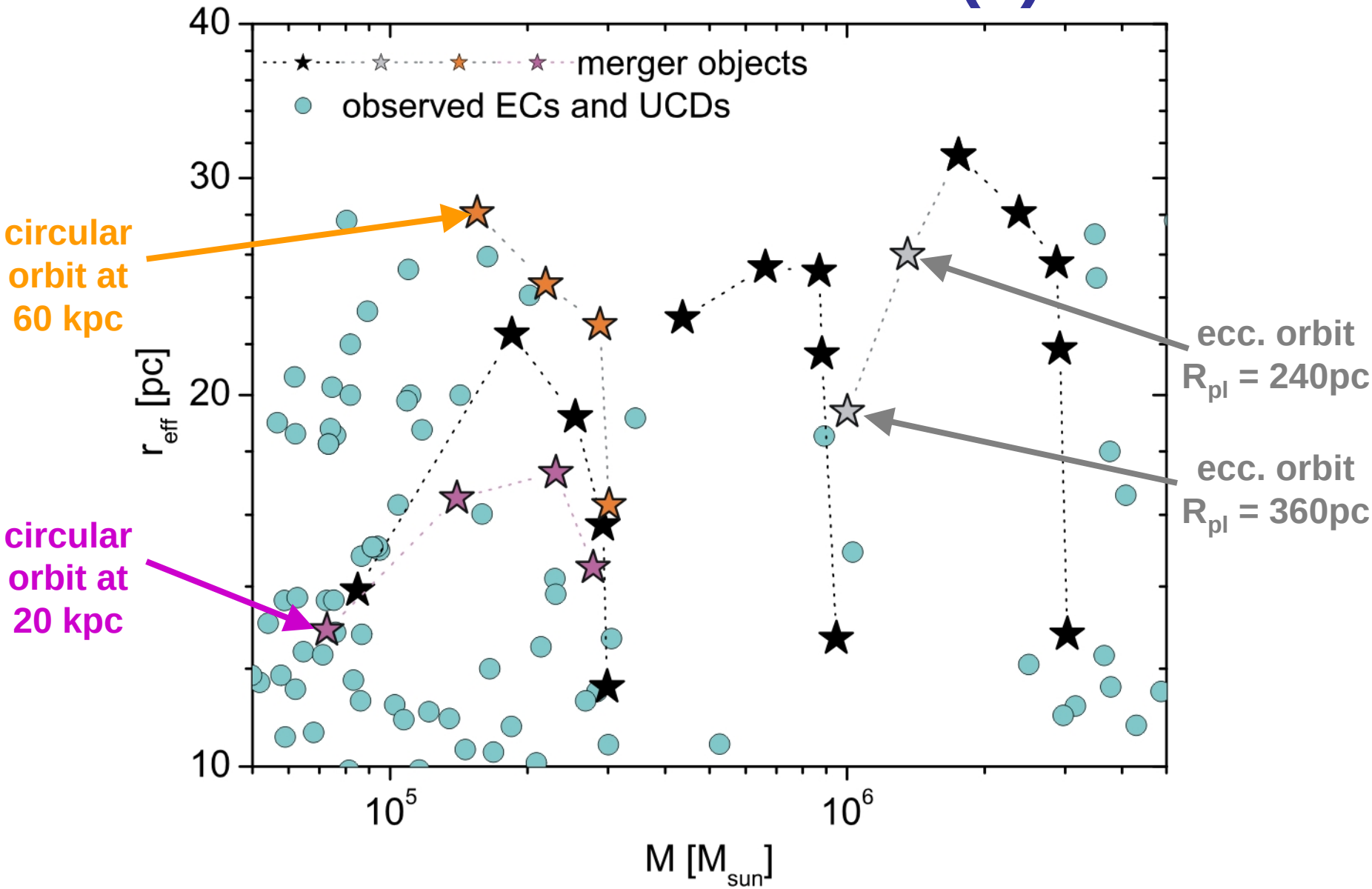


The merger objects cover a significantly smaller parameter space than the input CC models

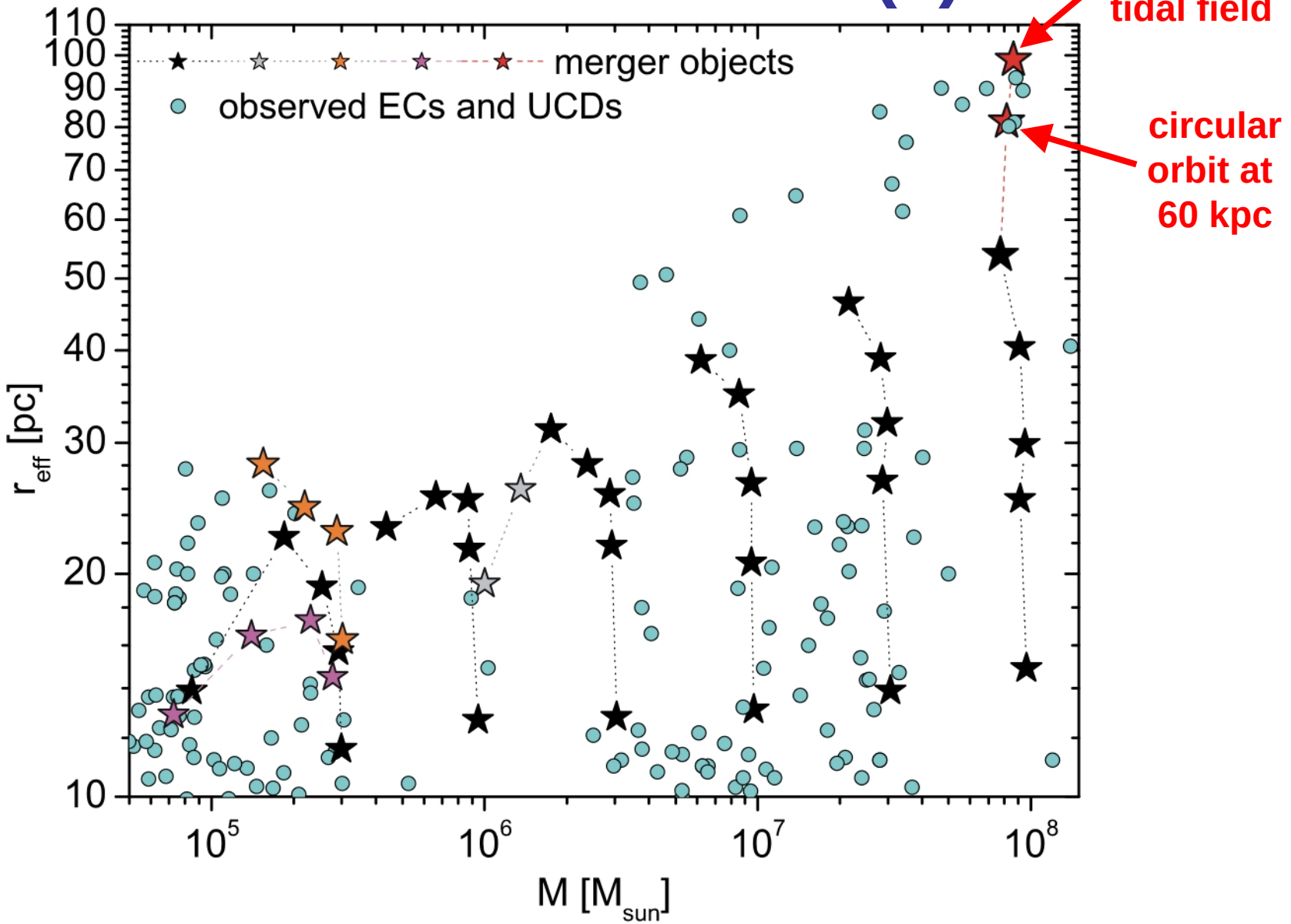
Comparison with Observations



Additional Models (1)



Additional Models (2)



Summary

We performed numerical simulations of CC models.

The applied CC parameter space is fully consistent with the range of observed CCs.

The parameter space of the merger objects agrees well with that of observed ECs and extended UCDs

The merged CC scenario is a likely formation scenario for ECs and extended UCDs

see Bruens et al. 2011, A&A, 529, 138

Wish List to Observers

Young massive star cluster complexes

- What is the detailed structure of CCs (e.g. density profile)?
- What is the dynamical state of CCs?
- Is there a general size-mass relation of CCs as found by Bastian et al. 2005 in the disk of M51?

Databases on ECs and UCDs are incomplete

- HST surveys cover only a very small fraction of the galactic halo.
- ECs are often excluded from GC catalogs to minimize the contamination with background objects (size limits of <10 pc).
- The luminosity limits of UCD surveys should be adapted to cover medium-mass halo objects like NGC 2419.