MORPHOLOGICAL PROPERTIES OF YOUNG CLUSTERS

The case of Gamma Velorum

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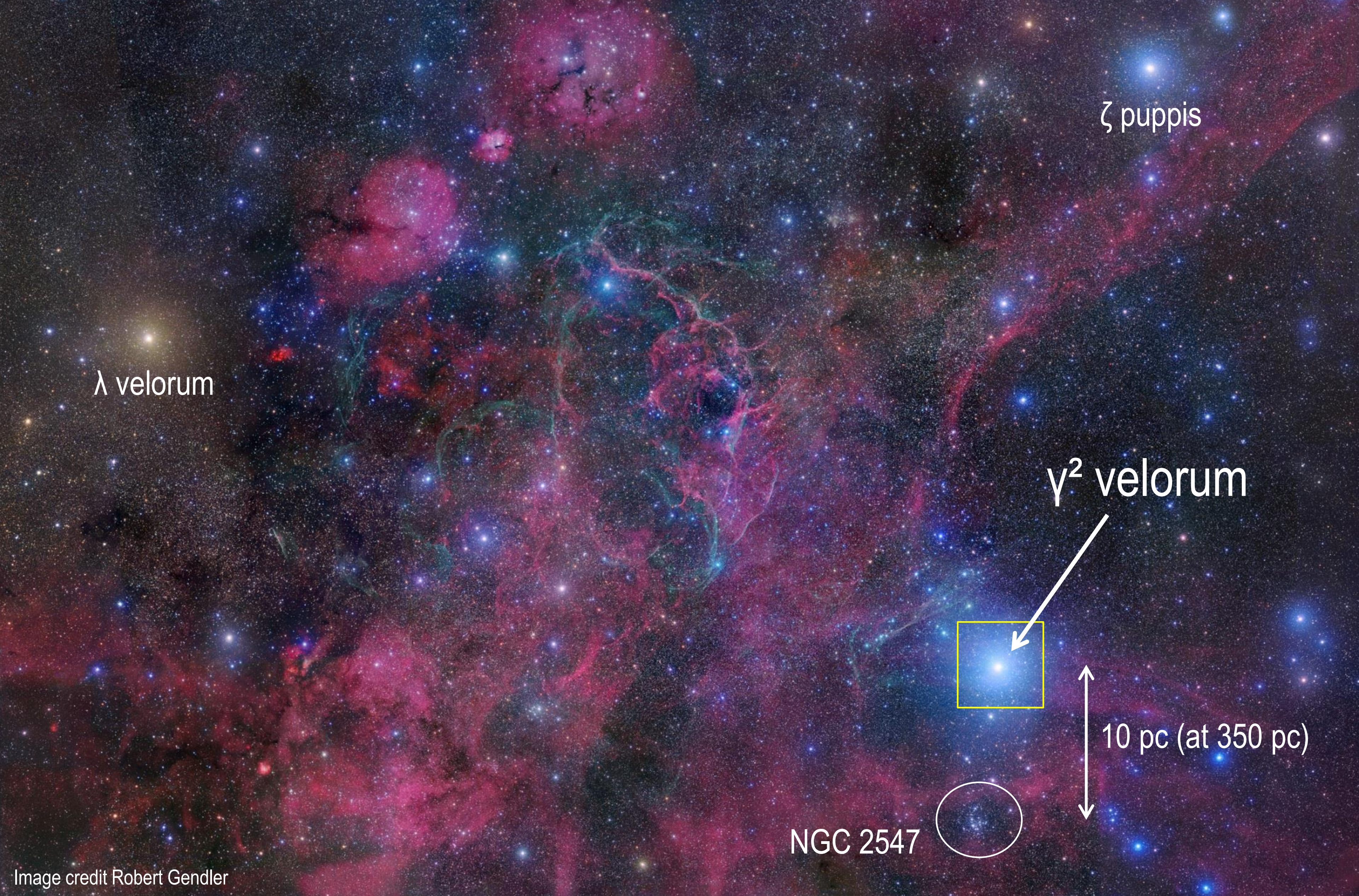
INTRODUCTION

- Young clusters may retain some of the primordial properties of the molecular cloud they originate from and tell us how they assembled: multiple vs single cluster formation events?
- Different scenarios predict a variety of forms for young clusters, e.g. quiescent star formation with age spread among the same cloud (Krumholz & Tan 2007) or competitive accretion on short timescales (Clark et al. 2007).

We want to study the star formation process in the Gamma Velorum region

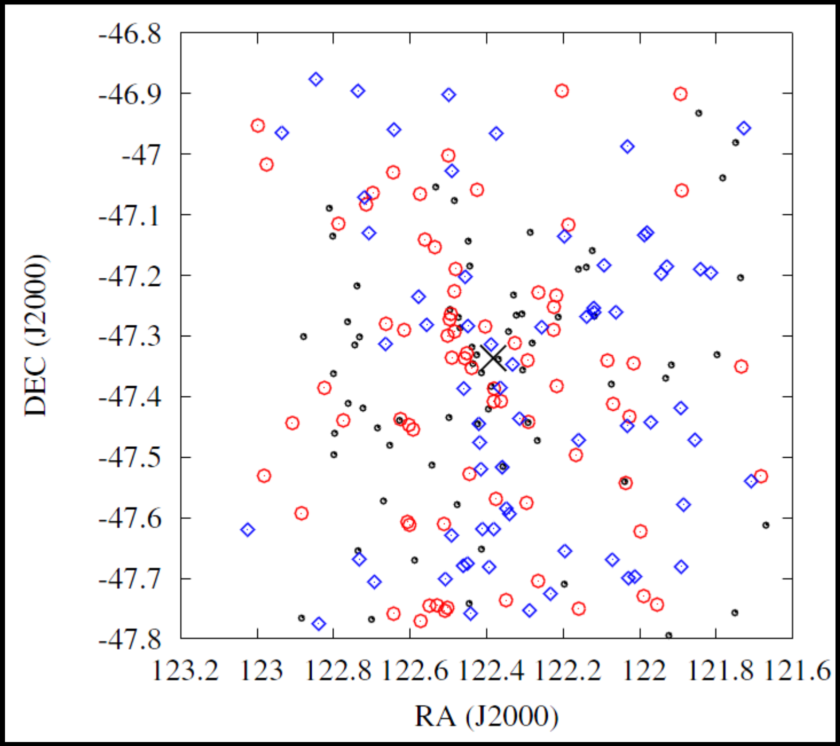
Image credit Robert Gendler

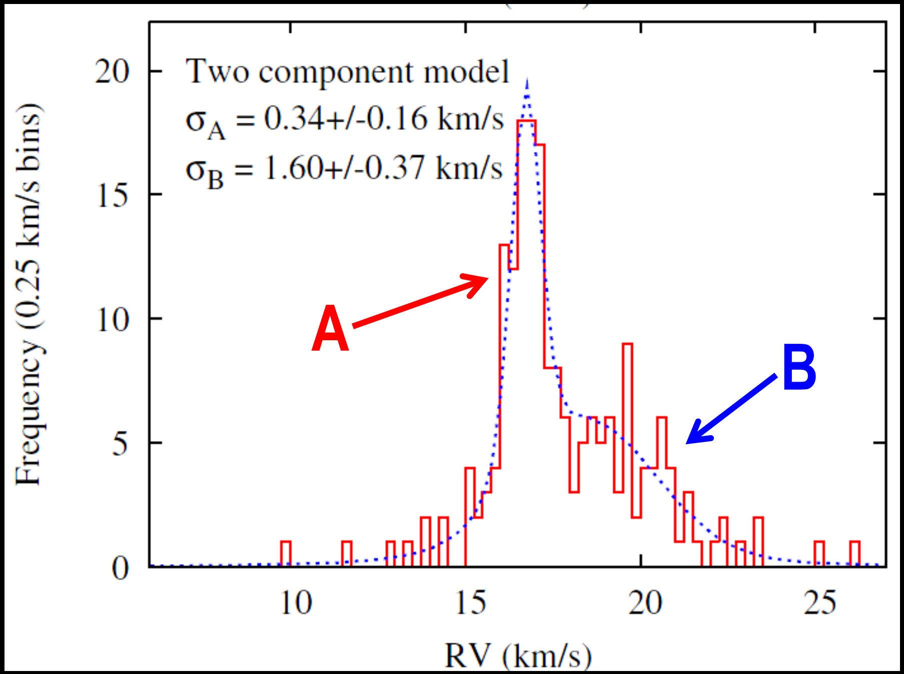
VELA-PUPPIS STAR-FORMING REGION



GAMMA 2 VELORUM CLUSTER – OBSERVATIONAL SITUATION

- Distance 350-400pc
- Made up of two populations (A and B) with 2 km/s radial velocity offset
- A is richer and more concentrated than B
- Age difference/different distance along the line of sight?
- Offset between two population centroids





[Jeffries et al. 2014]

N-BODY SIMULATIONS

Observational properties best reproduced when pop. B is very supervirial ($Q>4.5$).

Mapelli et al. (in prep. GES manuscript #31 and poster)

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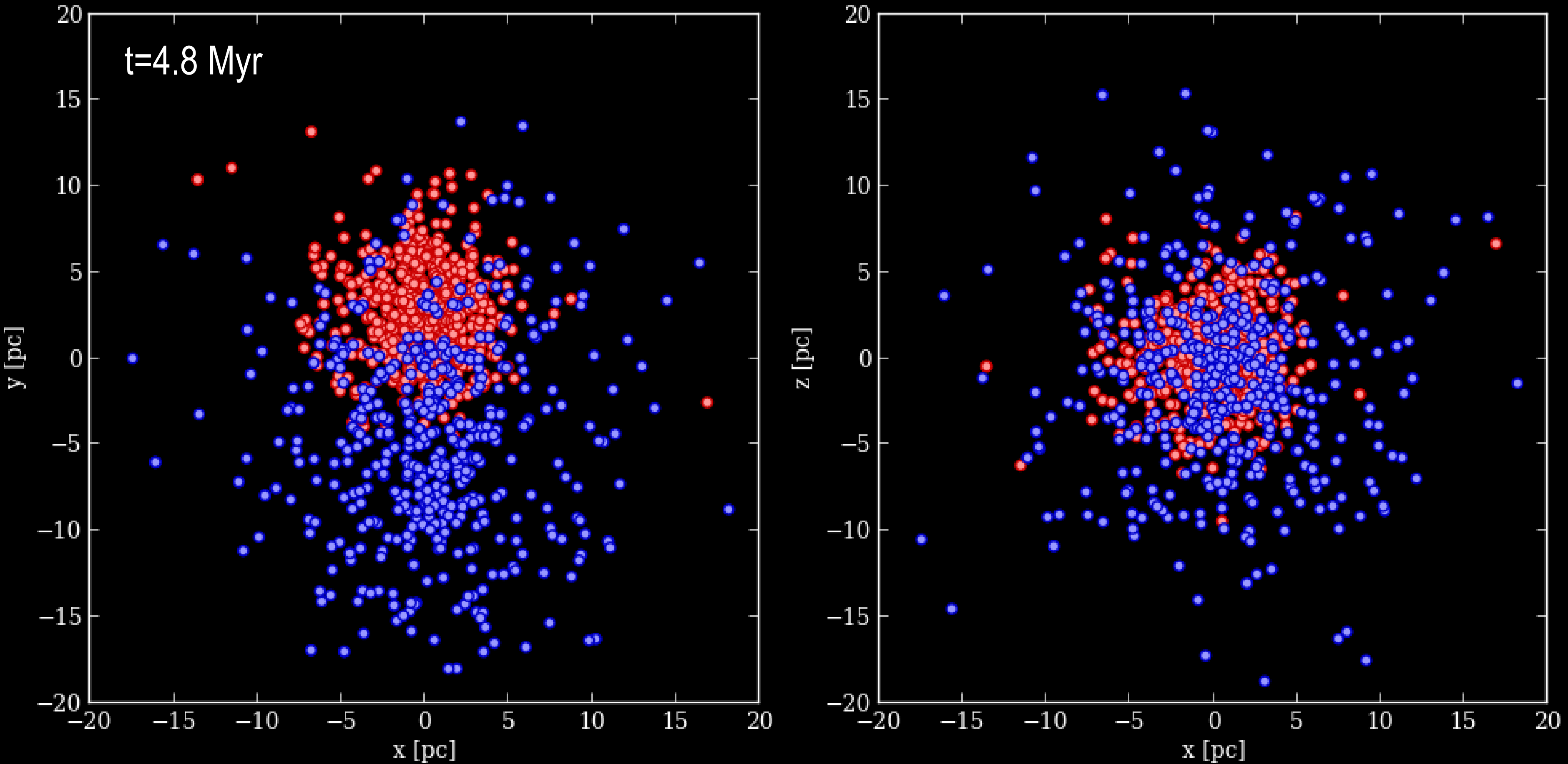
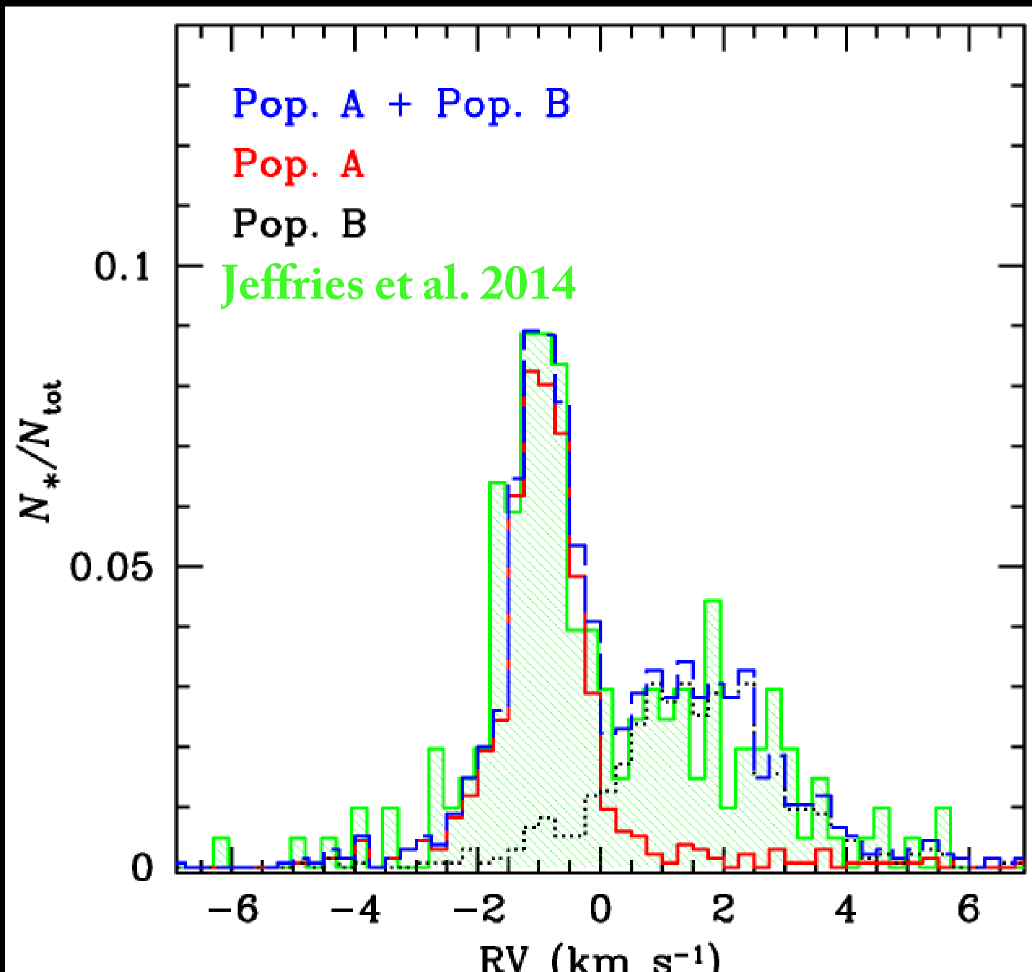
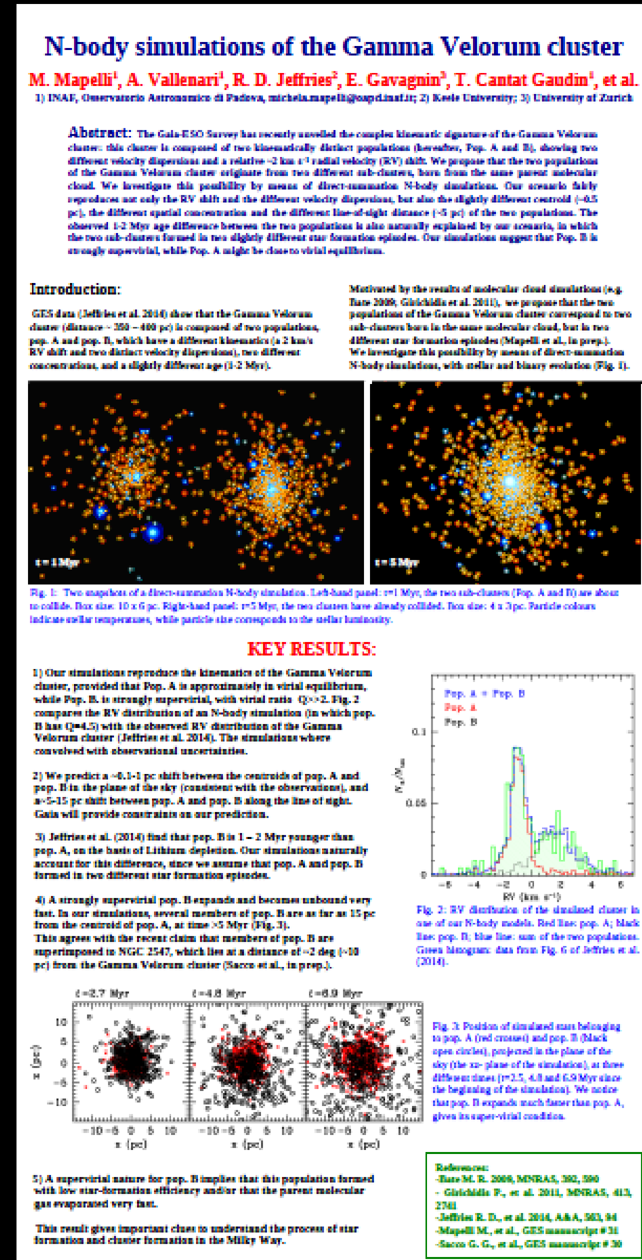


Mapelli et al. (in prep. GES manuscript #31 and poster)

N-BODY SIMULATIONS

Simulated radial velocity distribution:





See M. Mapelli's poster.

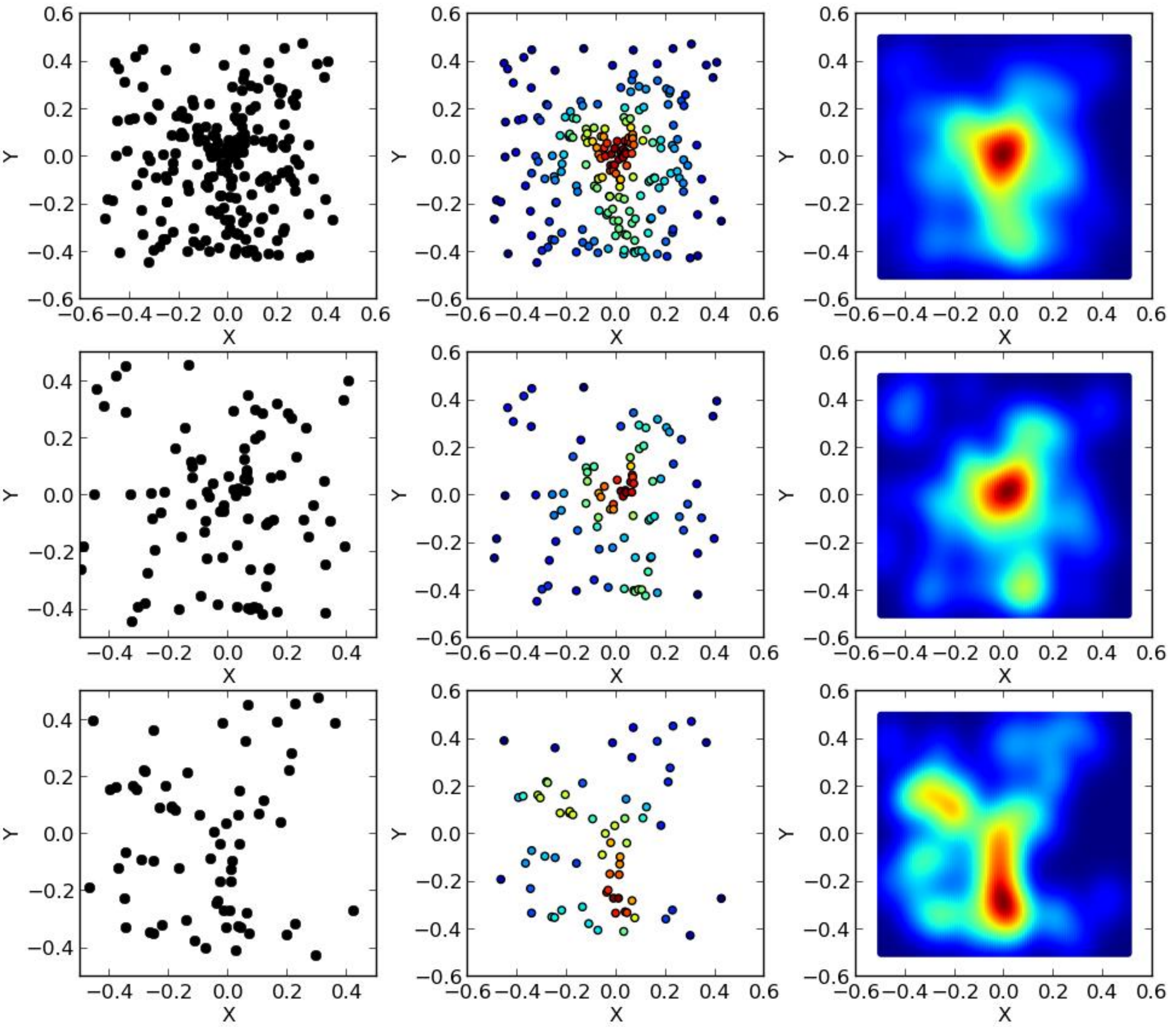
WORKING ON OBSERVATIONAL DATA: THE DIFFERENT MORPHOLOGY OF A AND B

If A and B are in two different dynamical states, it must impact the spatial distribution of their stars.

- Density maps
- Density profiles
- Two-point separation function
- Mass segregation: Λ parameter
- Fractality: Q parameter

KDE

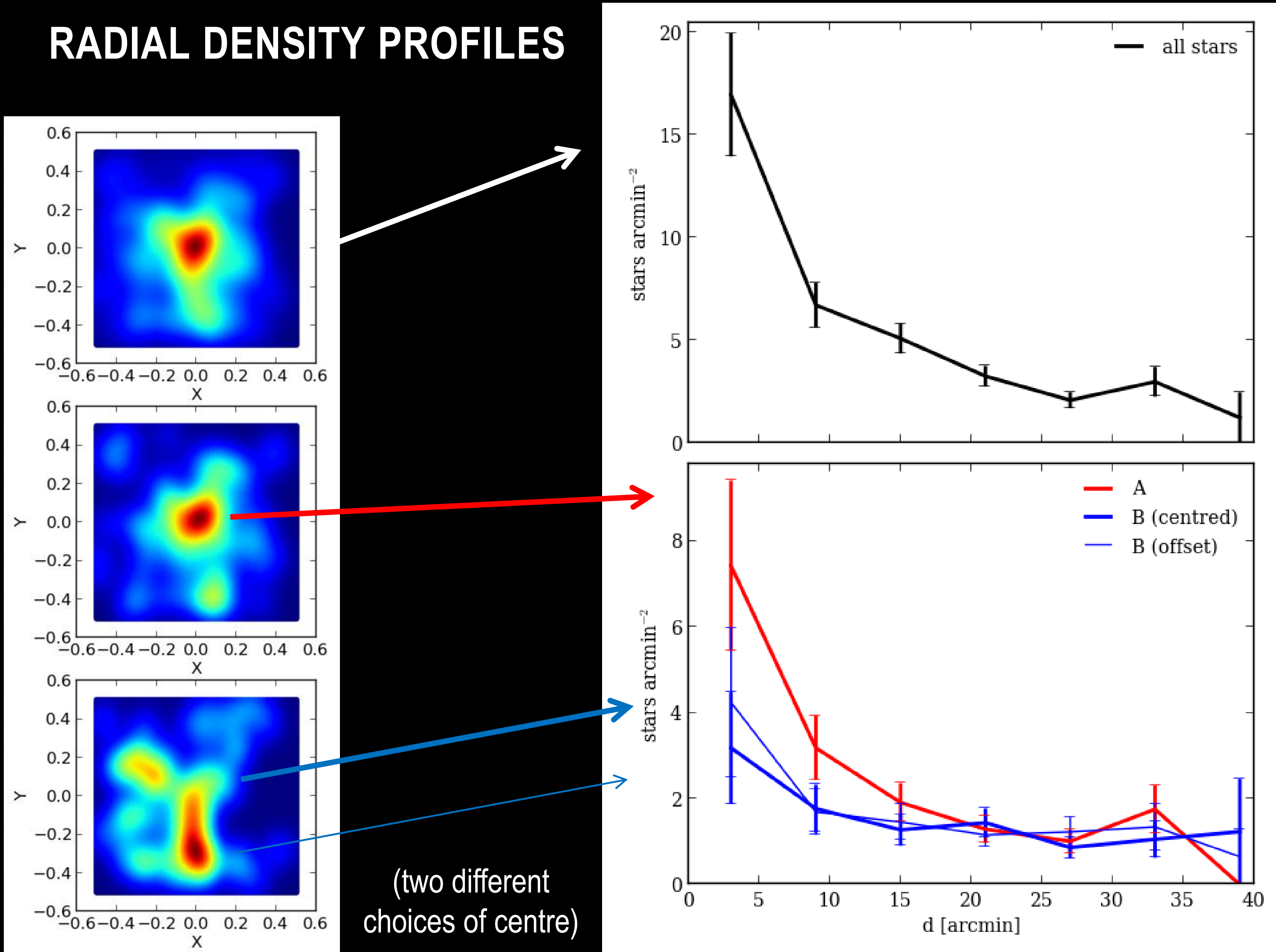
208 cluster members



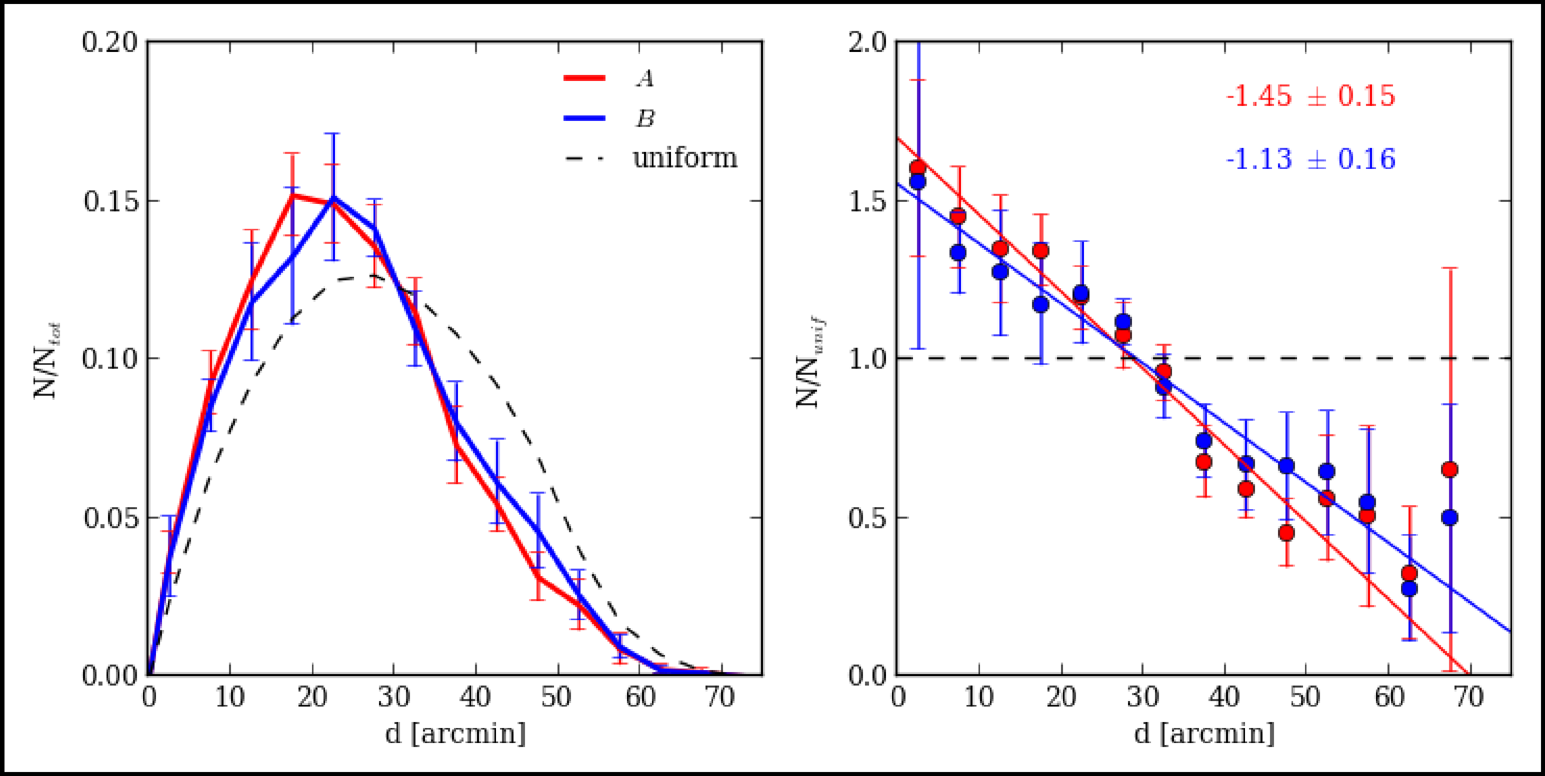
Pop. A
(p_A>75%)

Pop. B
(p_A<25%)

RADIAL DENSITY PROFILES



FOR NON-CENTRALLY CONCENTRADED DISTRIBUTIONS, TWO-POINT SEPARATION FUNCTION BETTER THAN RADIAL DENSITY PROFILE

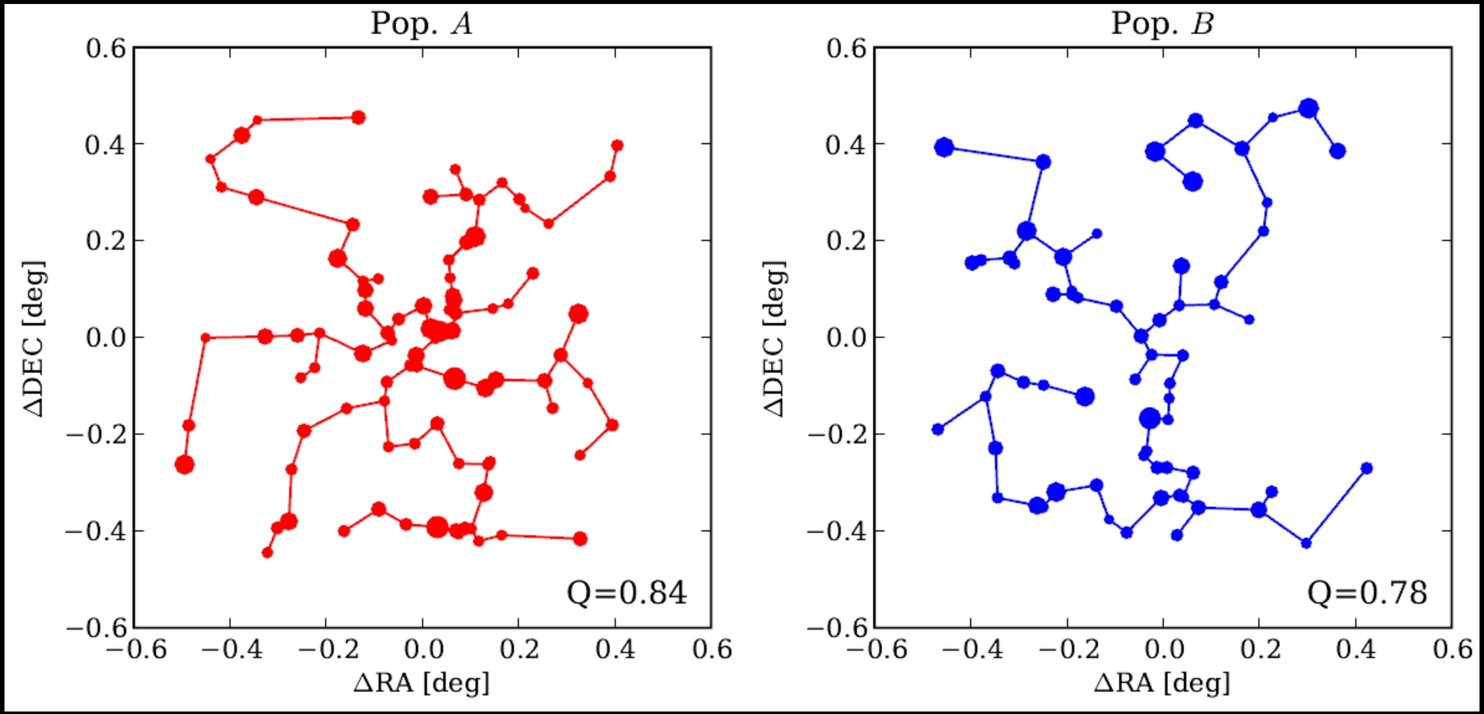


Ratio between two-point separation of population and a uniform distribution: steeper slope for population A.

A is not just denser, it is also more concentrated.

FRACTALITY AND MASS SEGREGATION

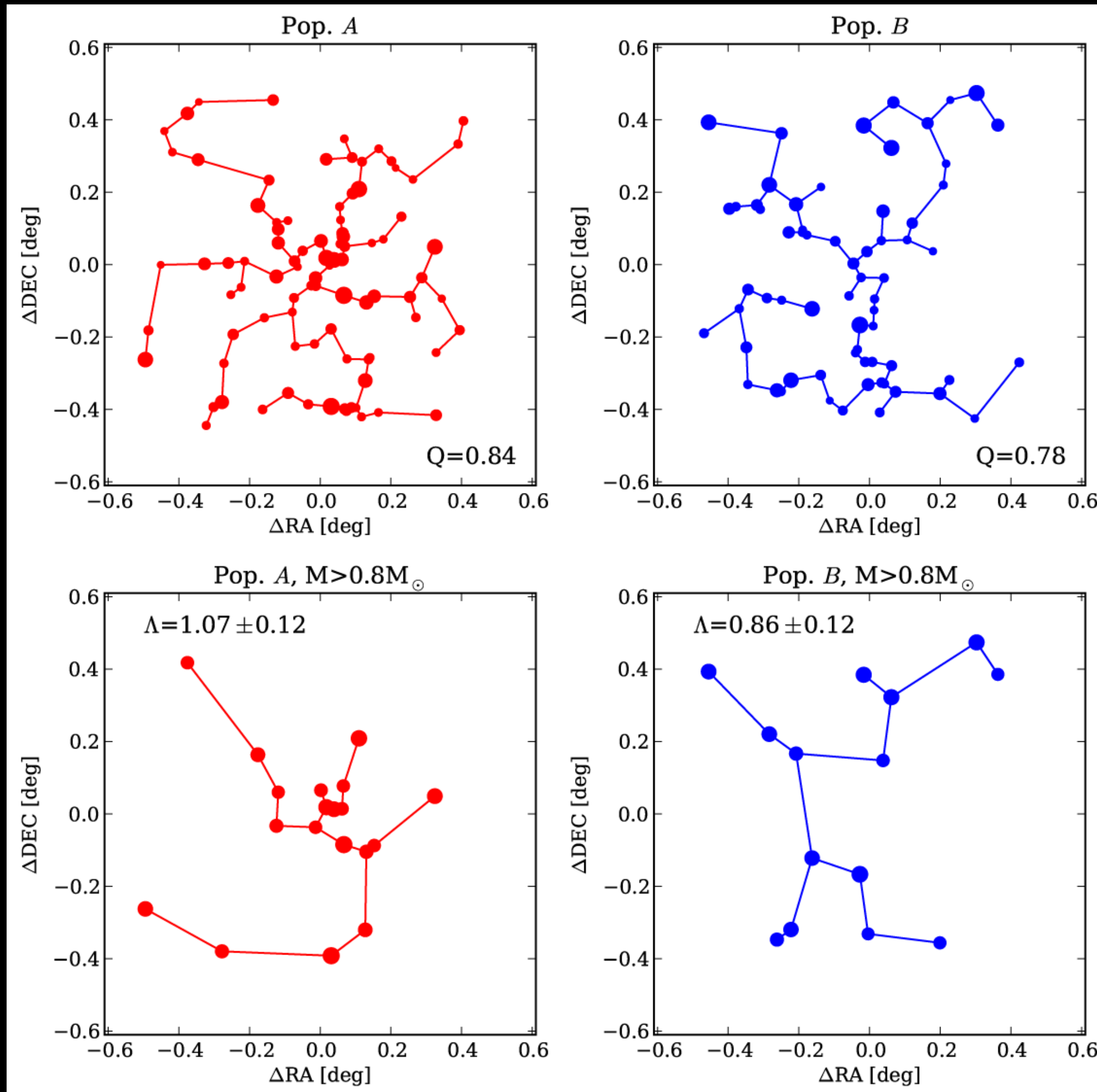
- Clusters evolve from a primordial fractal structure to a radial one (Klessen 2011, Maschberger & Clarke 2011).
- A supervirial cluster undergoes a **warm collapse** (Parker & Meyer 2012) and retains some of its primordial substructure for a longer time (5-10 Myr).
- Fractality can be quantified through parameter Q (Cartwright & Whitworth 2004):
  Q>0.8: centrally distributed **Q<0.8: fractally distributed**
- Mass segregation can be either primordial or appear dynamically.
  segregation + high Q = cold collapse (Delgado et al. 2013)



FRACTALITY AND MASS SEGREGATION

A

Mass-segregated and less fractal?



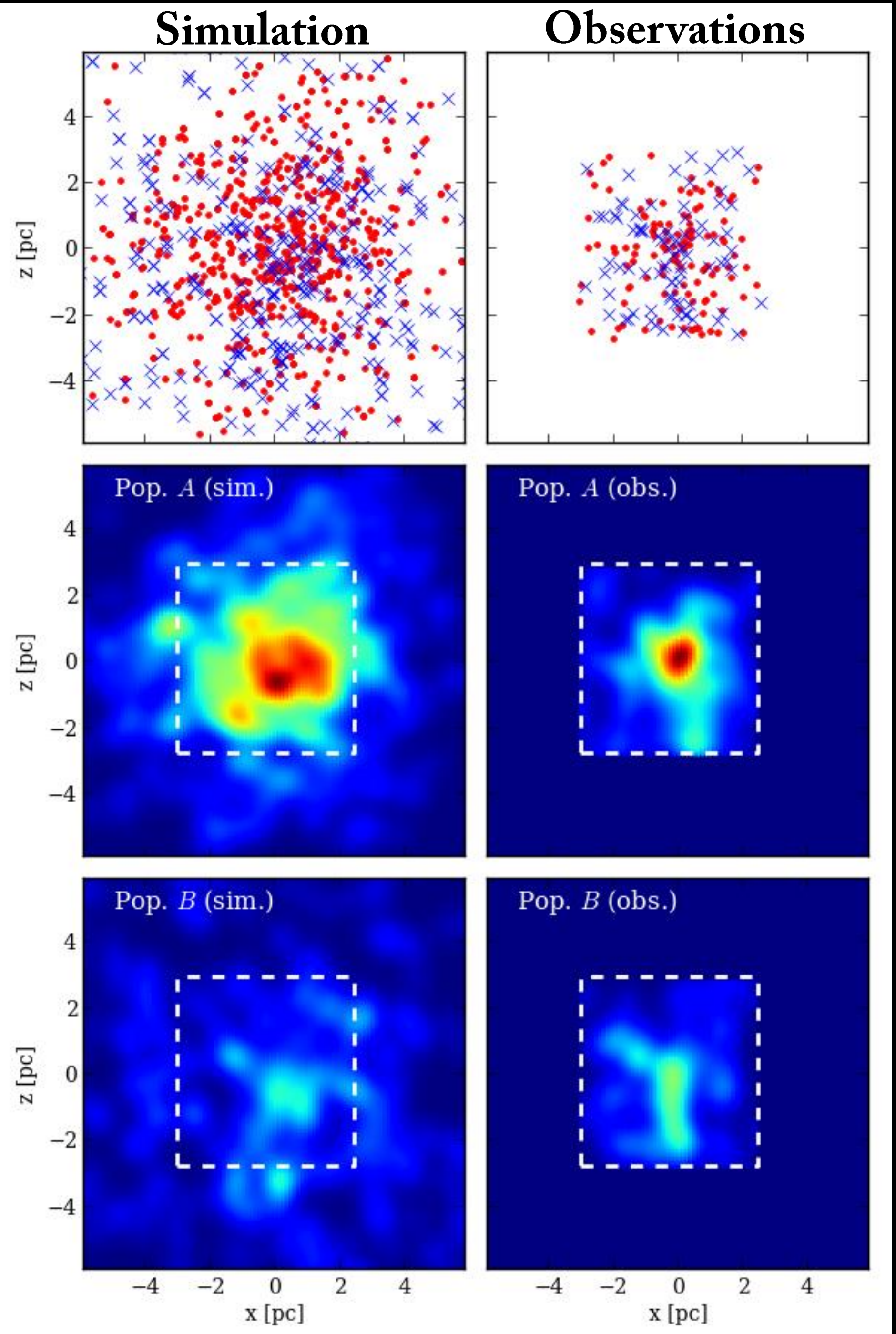
B

Not segregated and more fractal?

WE ONLY COVER THE INNER REGIONOF THE CLUSTER

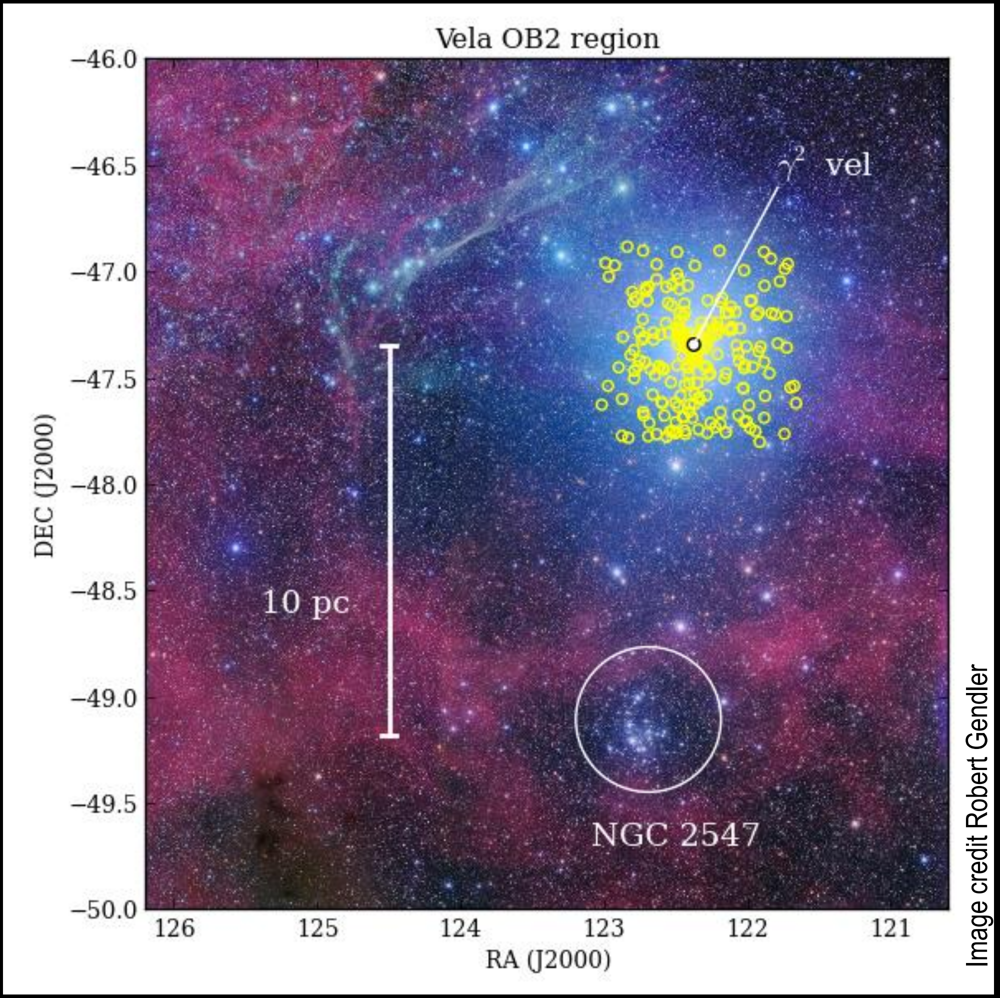
We expect B to be sparser, less concentrated, less mass-segregated, and more fractal.

Observations seem to point in that direction, but characterising the morphology of populations A and B would require studying them on a larger scale because we only see the core of the system.



THE BRIDGE TO NGC 2547

In the simulations, subcluster B expands rapidly to distances of **15 pc**.



This expansion can explain the peculiar dynamical structure observed by Sacco et al. (GES manuscript #30) in **NGC 2547**.

SUMMARY

- A and B present a different dynamical state, radial velocity distribution, density profile, and spatial distribution.
- They might have been formed in two different episodes/environments (multiple clustering has been observed in the MW e.g. Megeath et al. 2012, Feigelson et al. 2011).
- B is sparser than A due to its supervirial state: formed in a less dense environment, or lost more gas?

- This scenario naturally explains the kinematic signature of B in the NGC 2547 region.

PROSPECTS

- Spectroscopy on a larger field would improve our characterisation of the morphology of A and B.
- Line-of-sight distribution from Gaia parallaxes can solve the question of the physical link between subclusters A and B.
- The massive, young binary system **γ^2 Vel** needs to be inserted in the puzzle.