Simulation of binaries properties in a fragmented cluster

Timothé Roland

PhD work with

Christian Boily & Laurent Cambresy

Observatoire astronomique de Strasbourg

Introduction

Aim of my PhD: try to simulate the complexity of star forming region (SFR):

- Multiphysical process
- Deal with large to small spatial scales

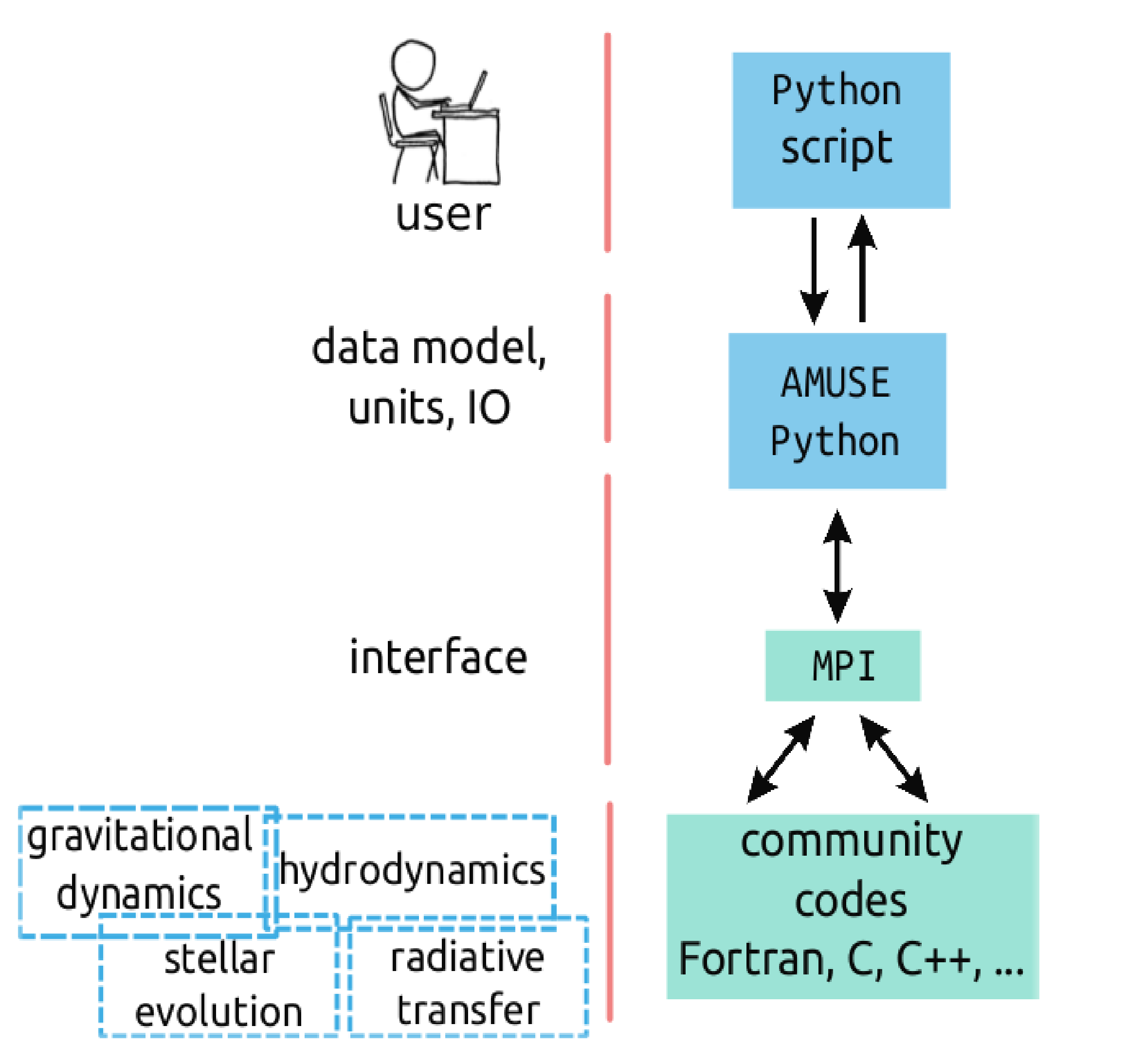
First work: made with the AMUSE platform on binaries

Question: Are stars of the field born in observed SFR ?

- Difference between the binaries in the field and in SFR:

The AMUSE code

- Same architecture and interface to use lots of different codes
- Allow to compute multiphysics with the code you want

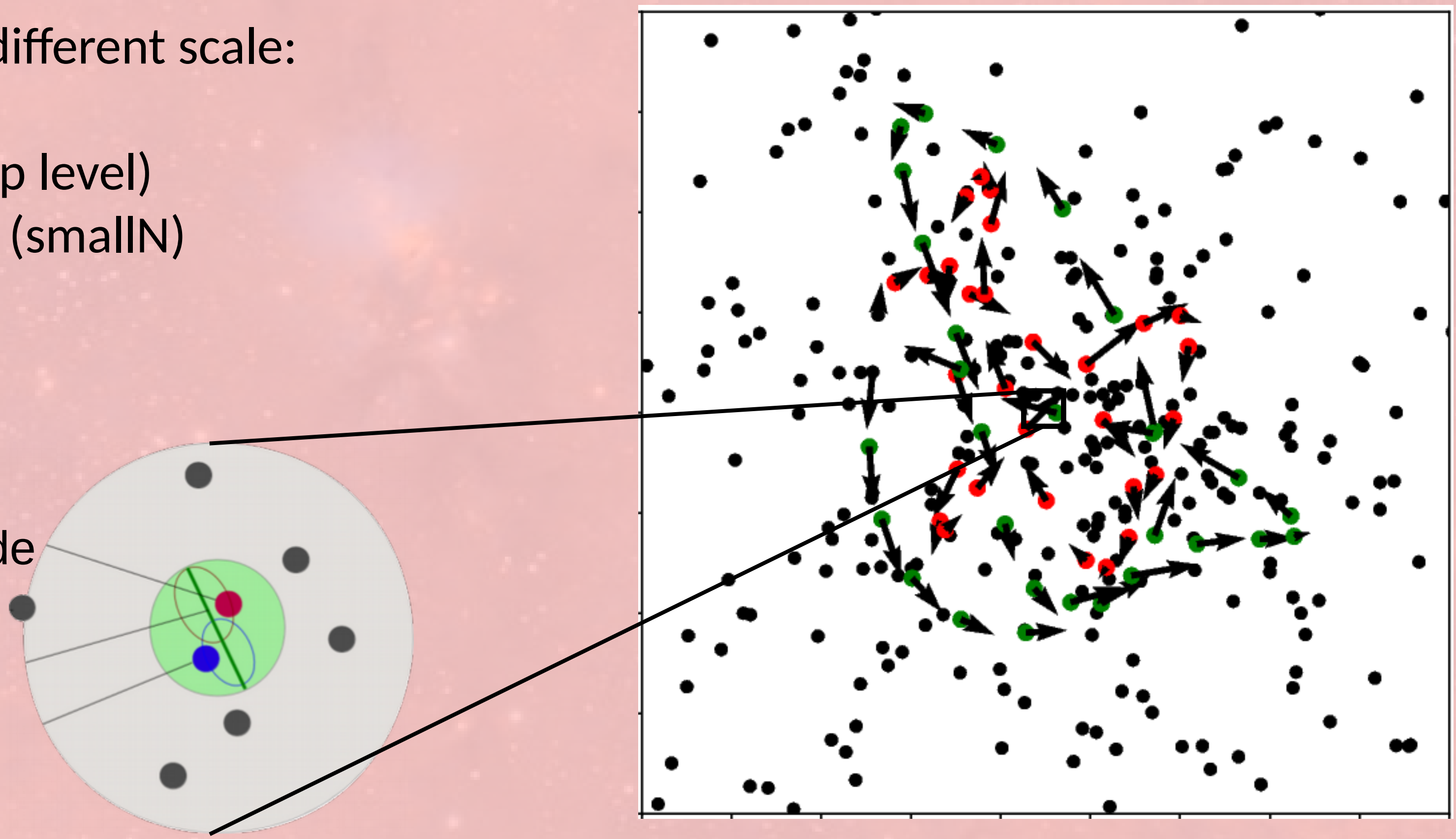


Code developed in Leiden
By Portegies Zwart et al
https://github.com/amusecode/amuse

The AMUSE multiple module

- Pure Nbody code usually numerically complex

- AMUSE Multiple module:
  uses different code to model different scale:
  (2+1 pure Nbody solver)
  - one for the whole cluster (top level)
  - two for the multiple systems (smallN)



First basic simulation

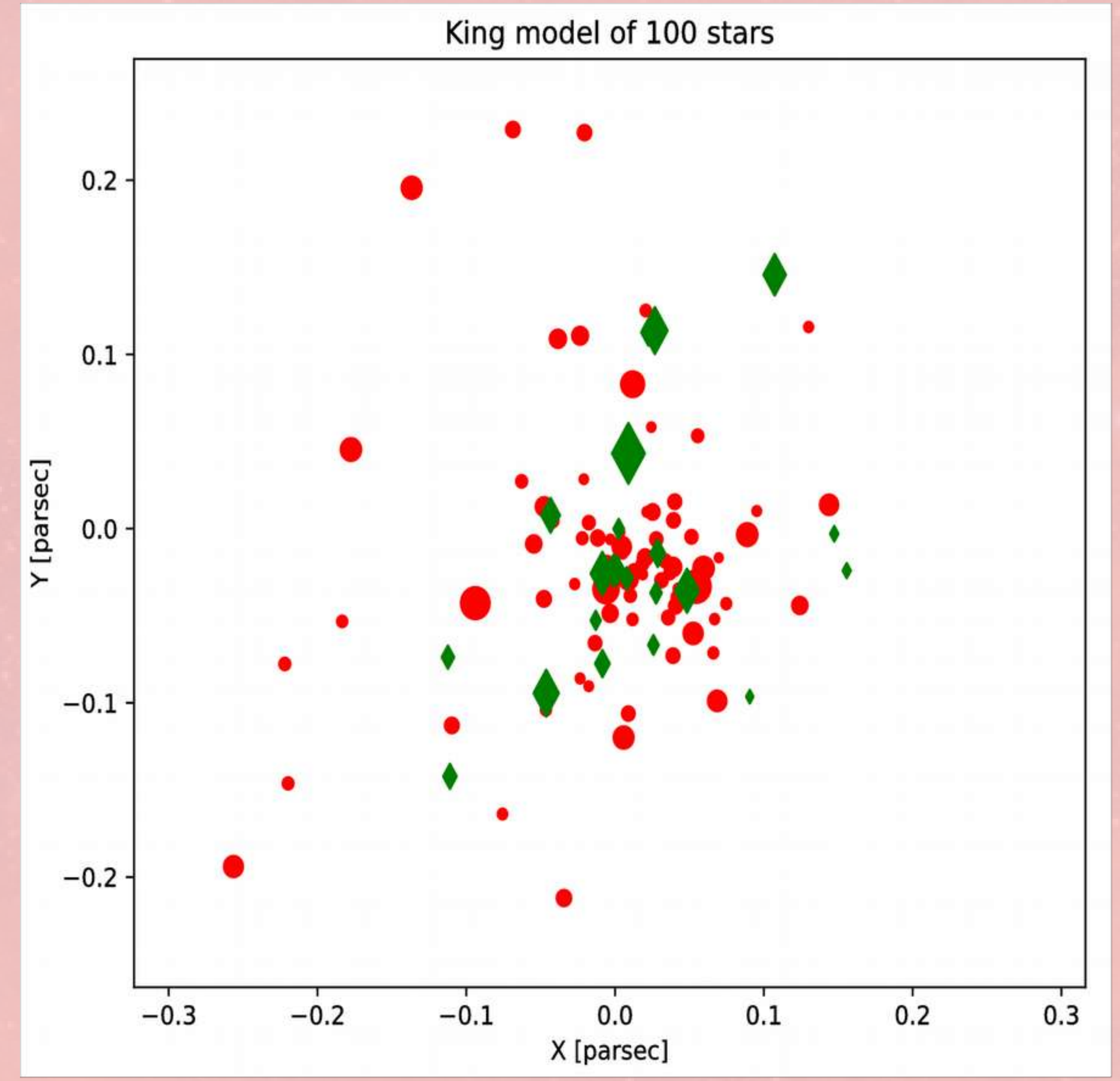
Initial conditions :

- cluster of 100 stars in a virialized king model
- with canonical IMF
- ~30% of binaries randomly positionned following observationnal parameters (review of Duchêne and Kraus 2013)

Mass range	Multiplicity fraction	Mass fraction	Semimajor axis [AU]
VLM type [0.01MΘ; 0.1MΘ]	0.22 ± 0.05	$q^{4.2}$	logNormal (μ=4.5, logσ = 0.5)
M type [0.1MΘ; 0.7MΘ]	0.26 ± 0.03	$q^{0.4}$	logNormal (μ = 5.3, logσ = 1.3)
Solar type [0.7MΘ; 1.5MΘ]	0.44 ± 0.02	$q^{0.3}$	logNormal (μ = 45, logσ = 2.3)
A type [1.5MΘ; 5MΘ]	[0.5; 0.7]	$q^{-0.5}$	logNormal (μ = 350, logσ = 3)
B type [5MΘ; 16MΘ]	[0.6; 0.7]	$q^{-0.5}$	Uniform(0.15, 15)
O type > 16MΘ	[0.8, 1]	$q^{-0.5}$	Uniform(0.15, 15)

First basic simulation

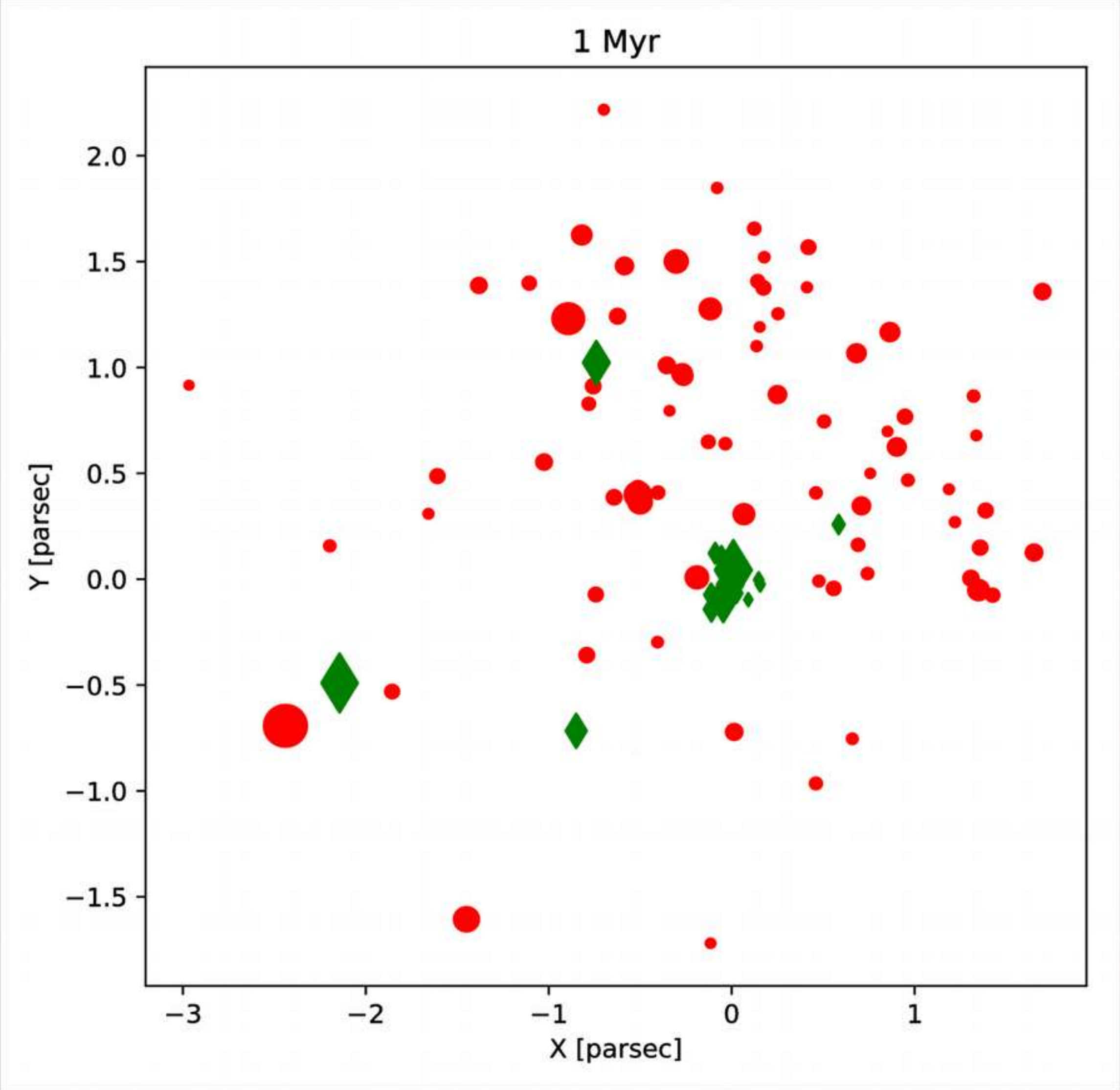
Evolution during 20 Myr :
- ➢Unstable system
- ➢Lots of collisions in the first Myr: leads to mass segregation



First basic simulation

Evolution during 20 Myr :

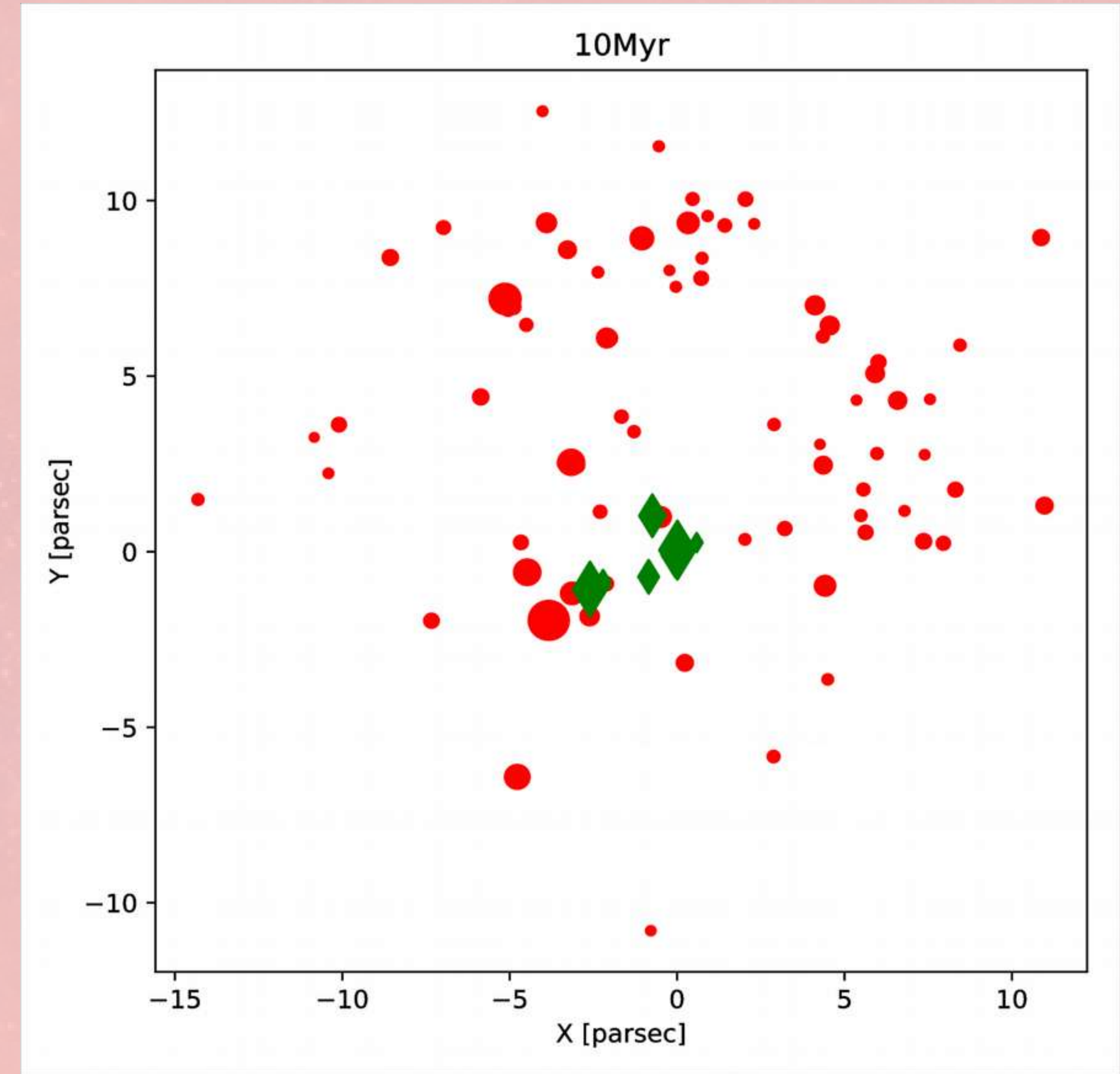
- ➢Unstable system
- ➢Lots of collisions in the first Myr: leads to mass segregation



First basic simulation

Evolution during 20 Myr :

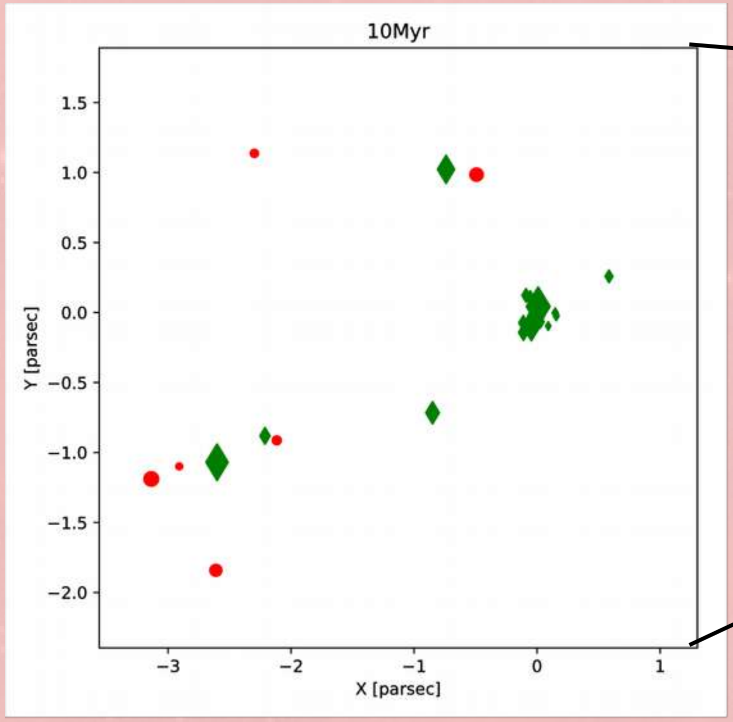
- ➢Unstable system
- ➢Lots of collisions in the first Myr: leads to mass segregation

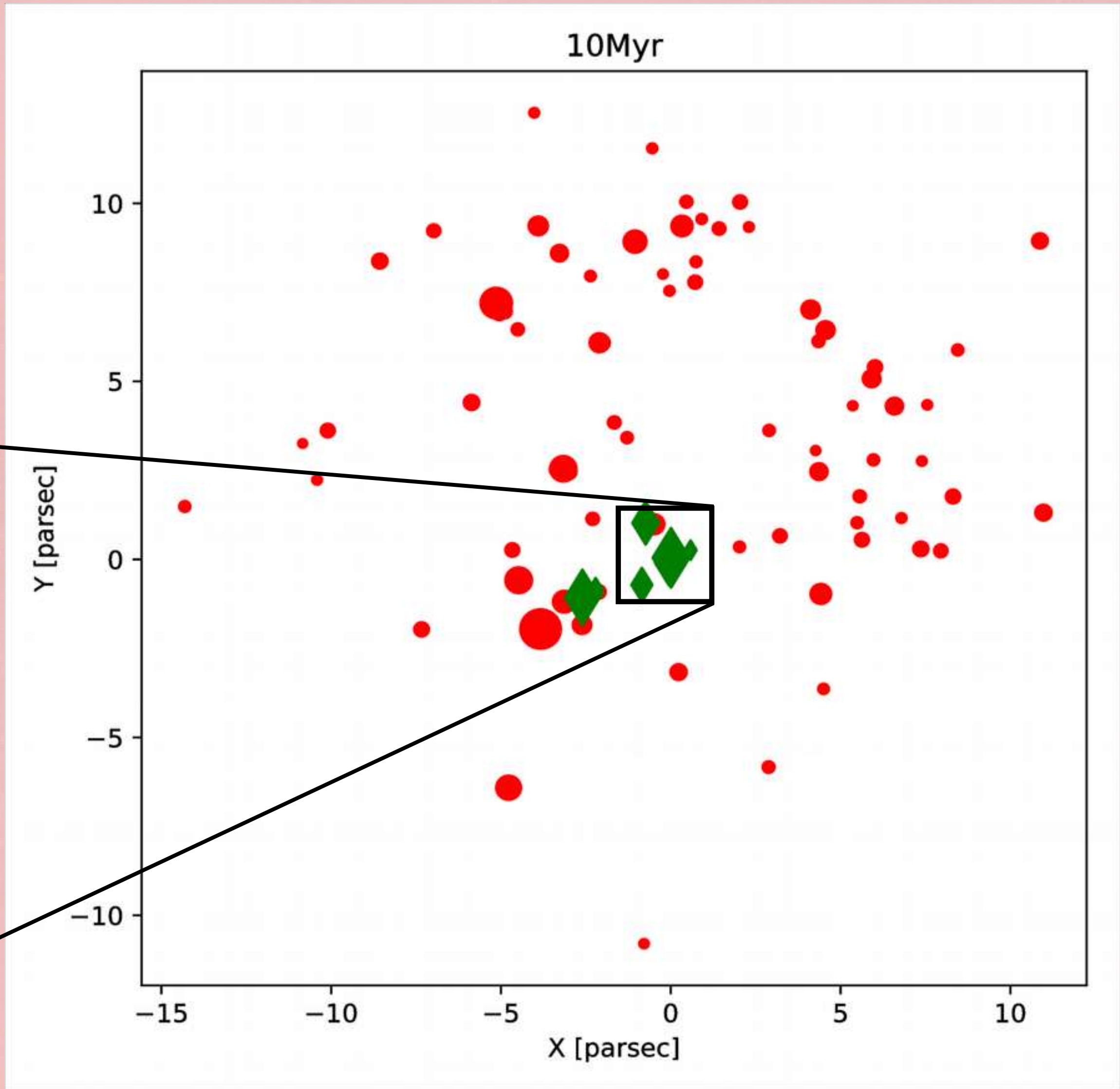


First basic simulation

Evolution during 20 Myr :

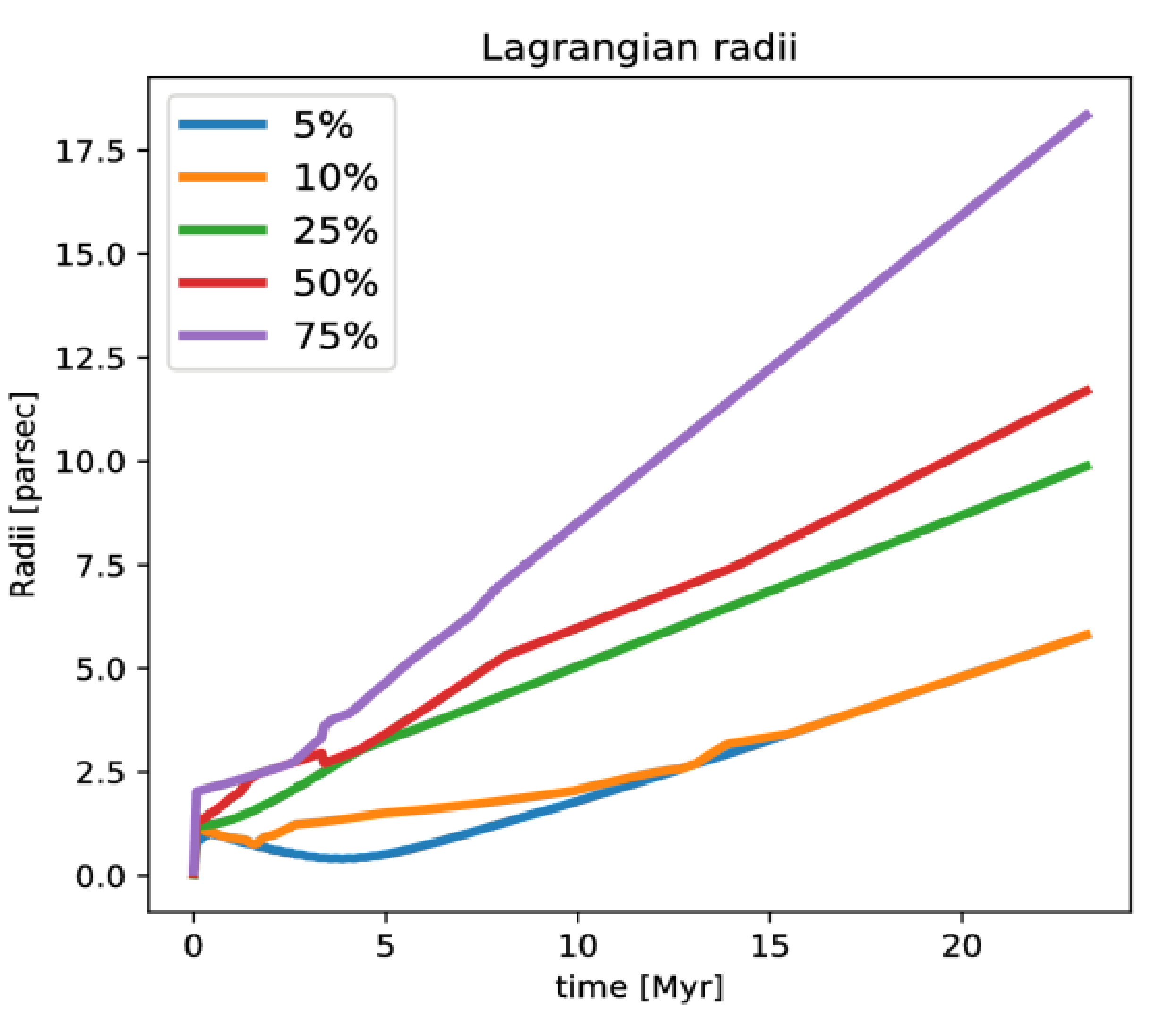
- ➢Unstable system
- ➢Lots of collisions in the first Myr: leads to mass segregation





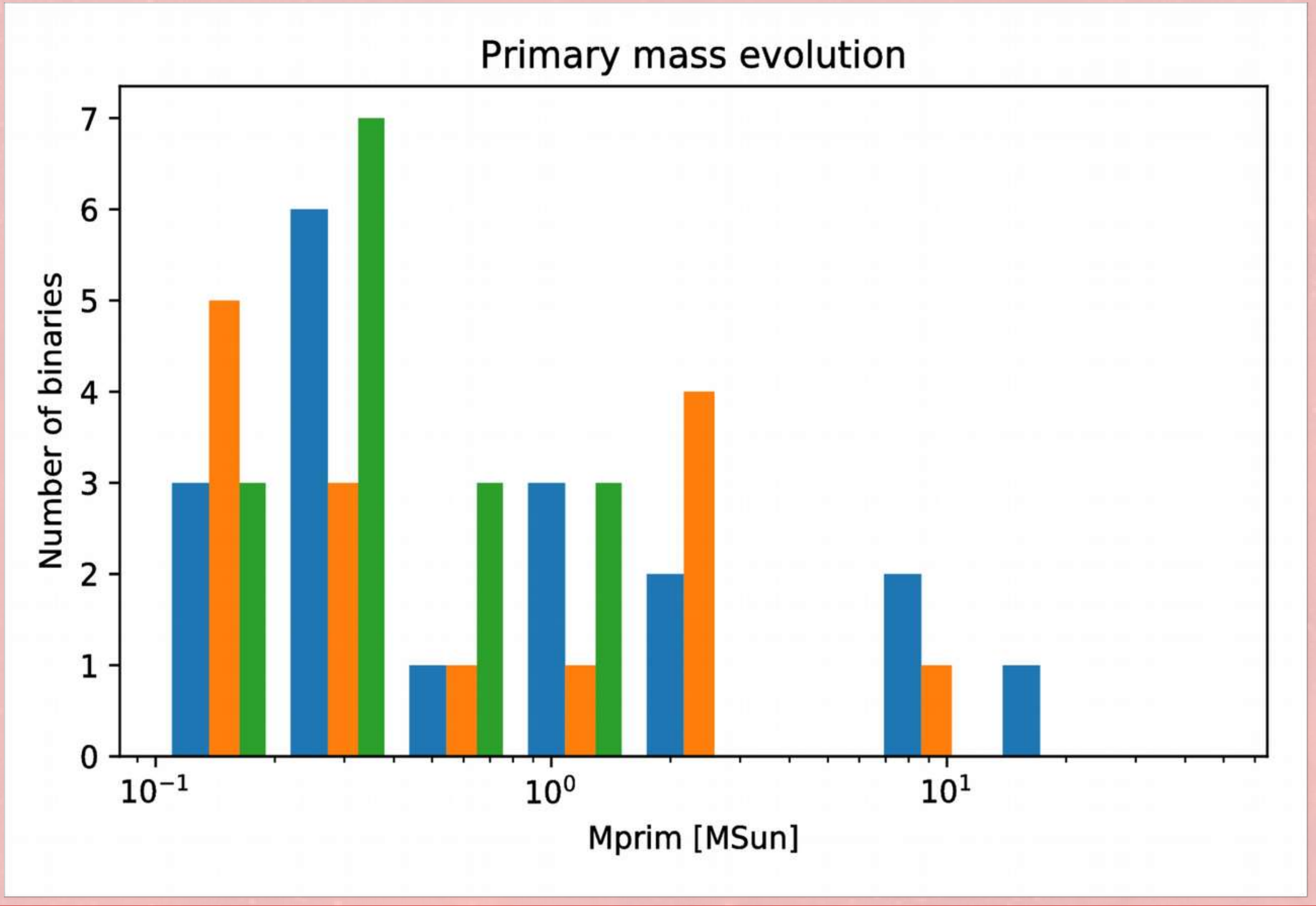
First basic simulation

Evolution during 20 Myr :
- ➢Unstable system
- ➢Lots of collisions in the first Myr:
  - leads to mass segregation
  - Modifies the binaries properties



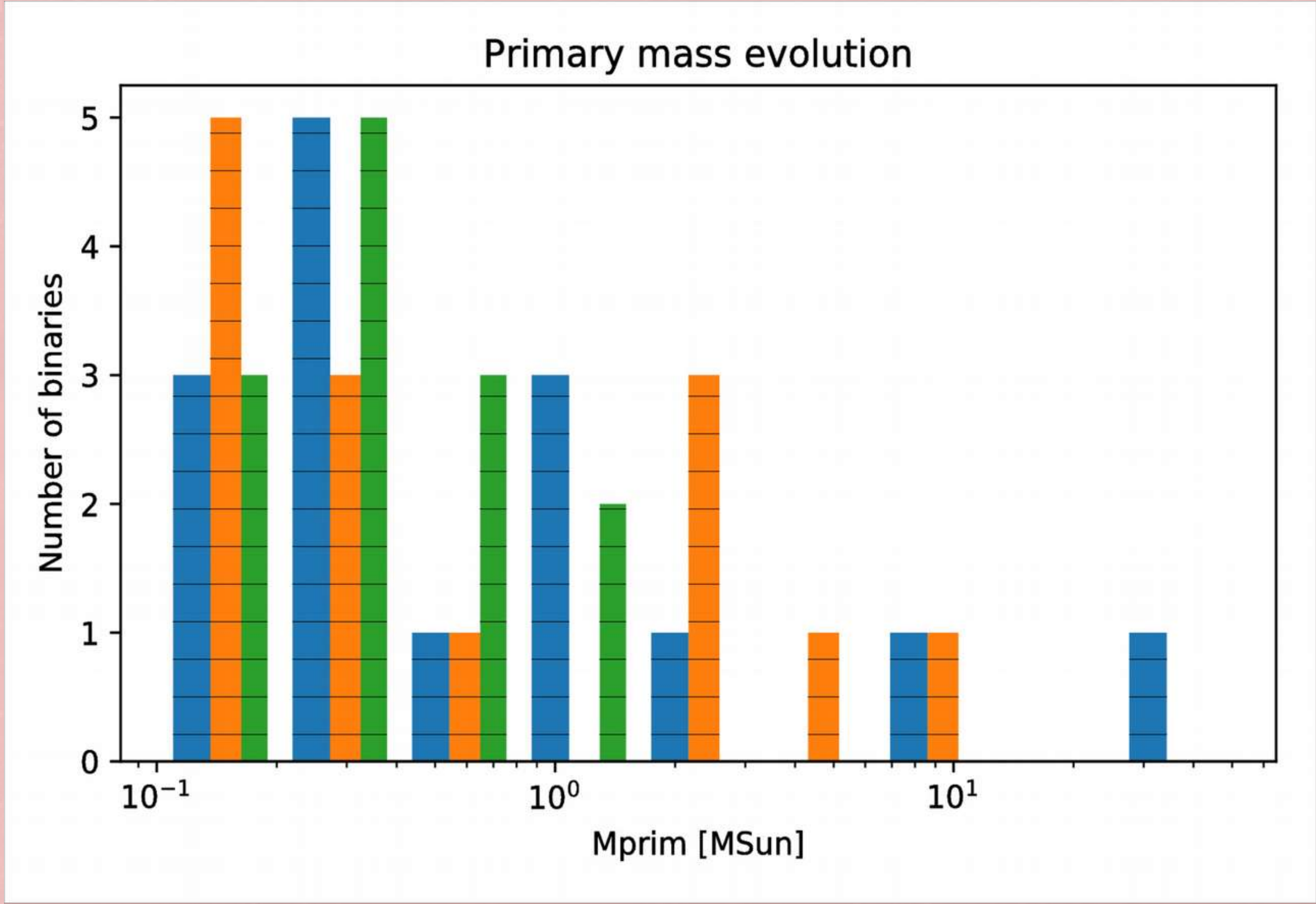
Binaries properties

Initial conditions



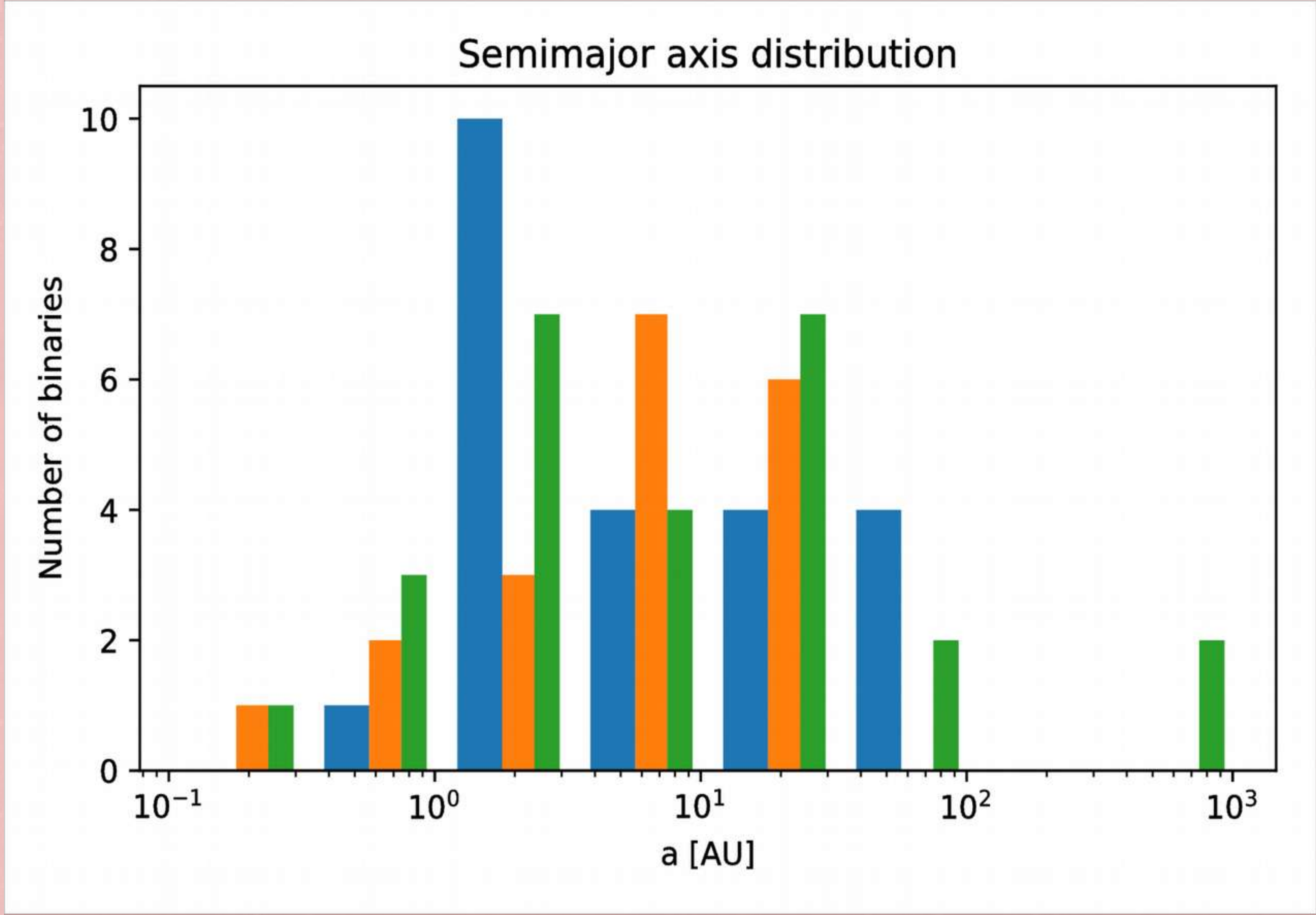
Binaries properties

After 10 Myr



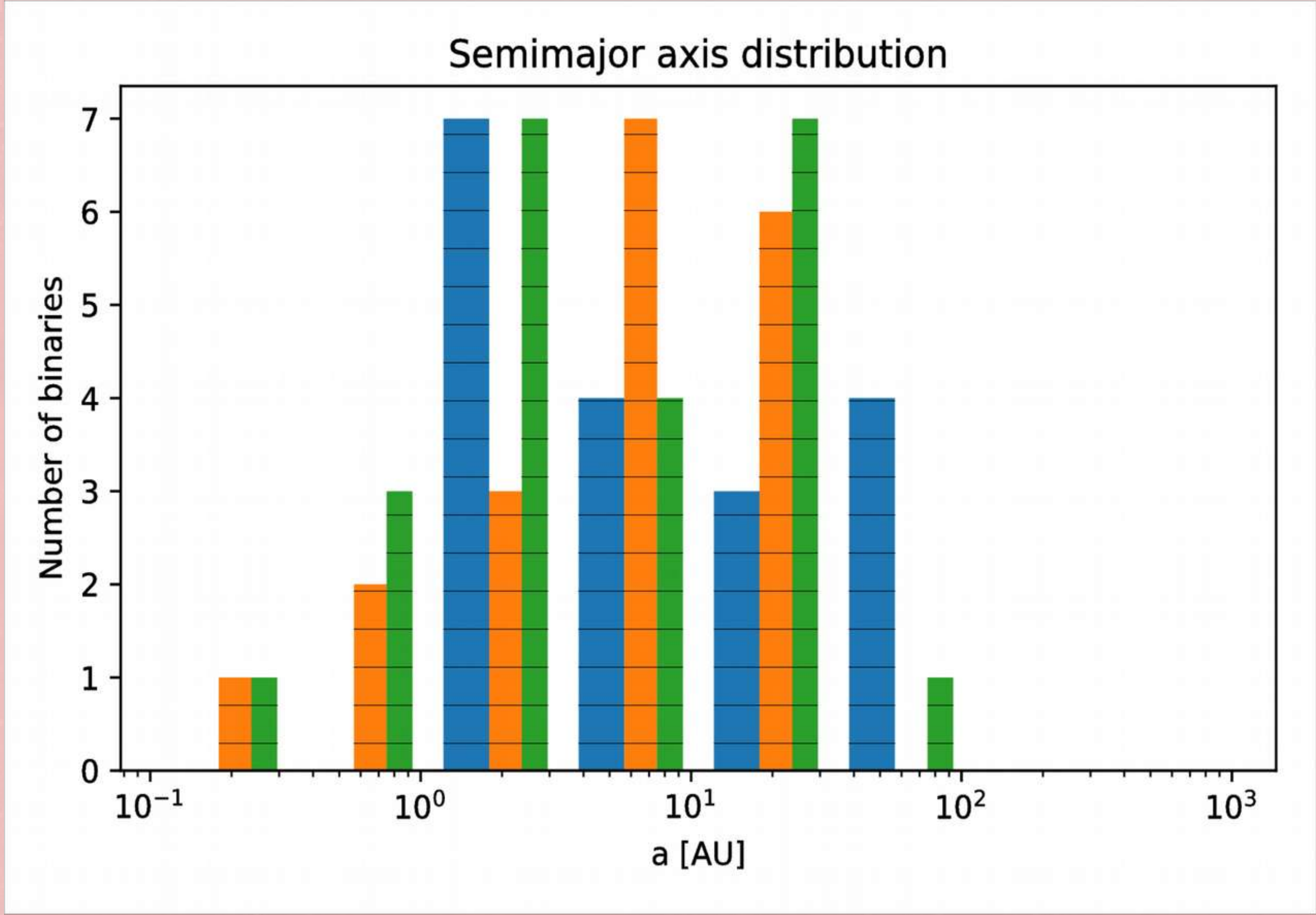
Binaries properties

Initial conditions



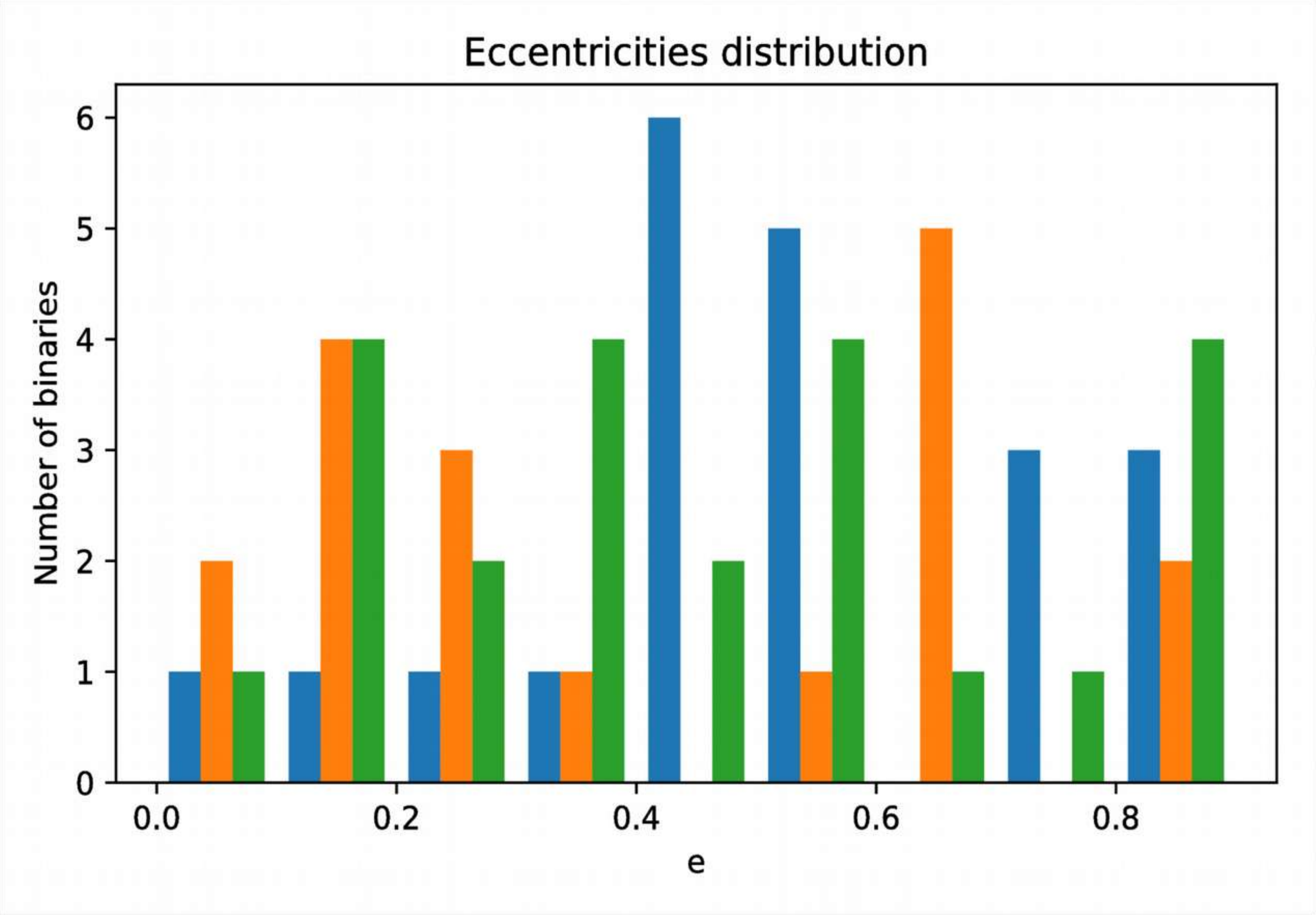
Binaries properties

After 10 Myr



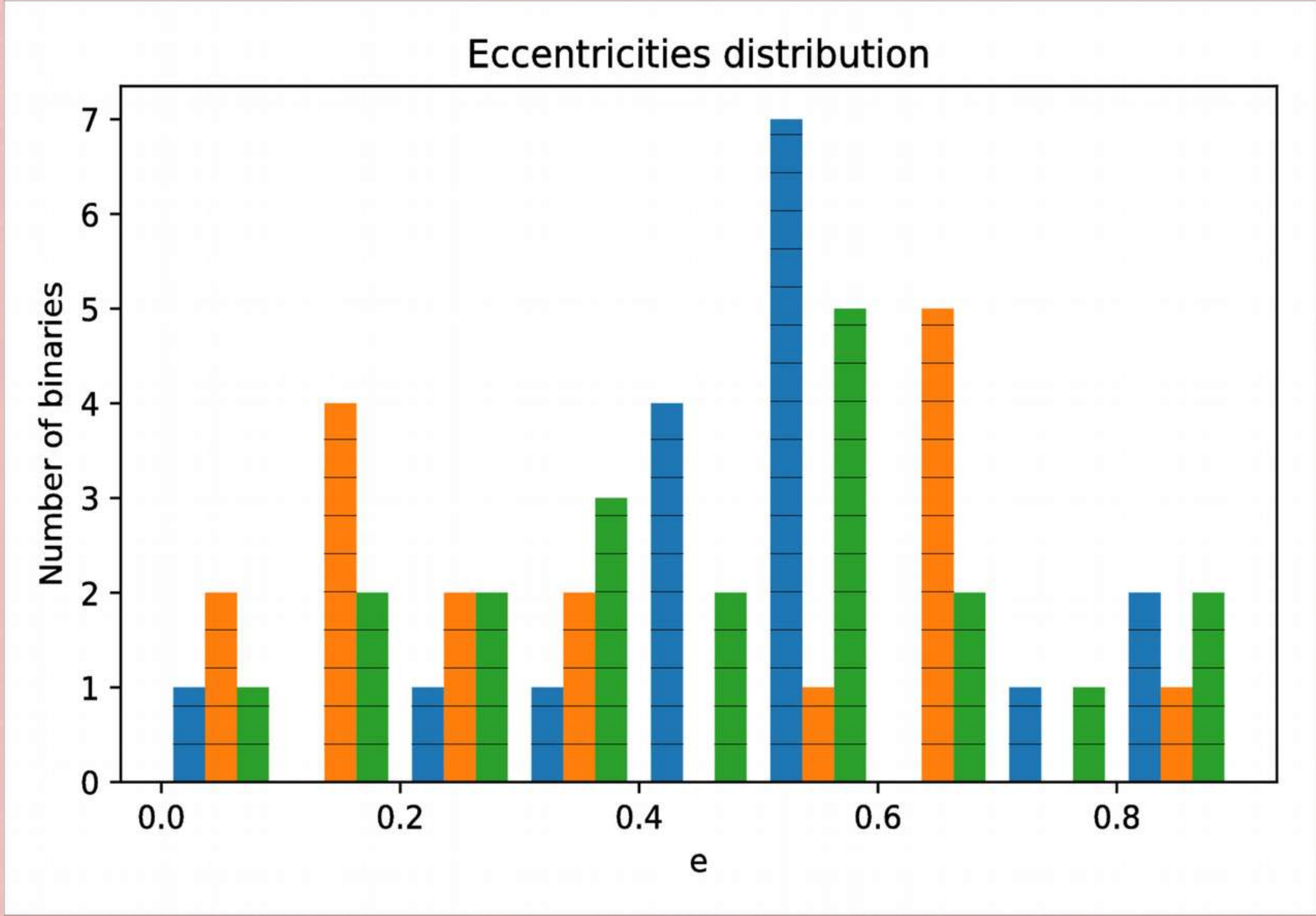
Binaries properties

Initial conditions



Binaries properties

After 10 Myr

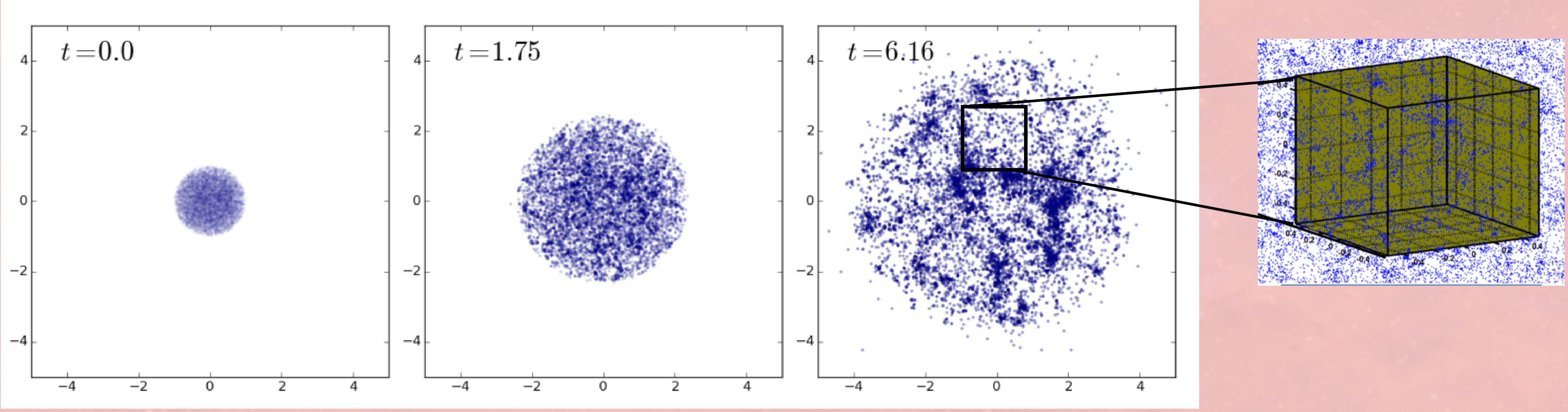


Fragmented cluster

Julien Dorval PhD work:

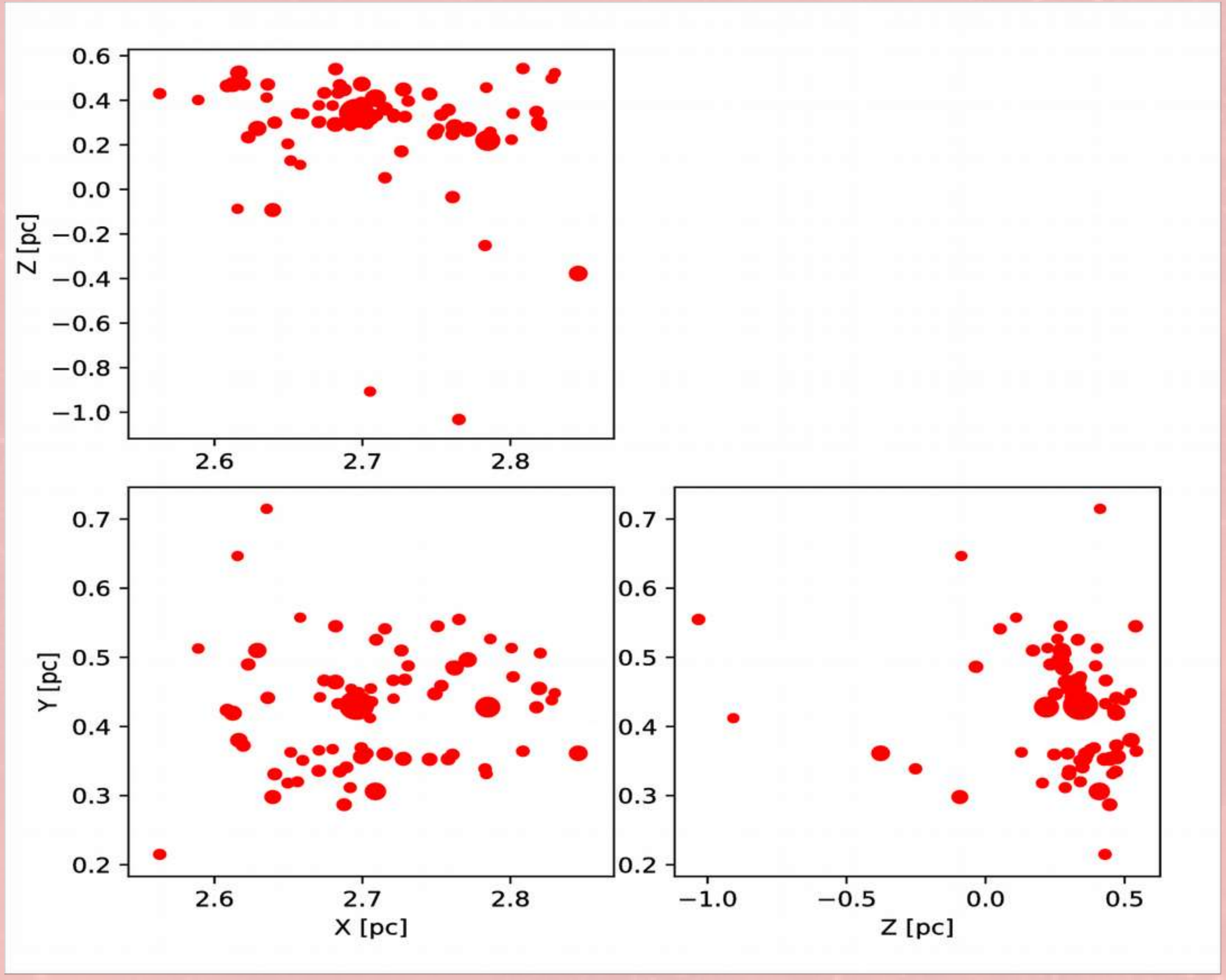
- Adiabatic expansion of a 100k stars cluster (no hydro)
- leads to fragmentation

Extract cubes of 3-5k stars and select subgroups with MST method of ~100 stars.



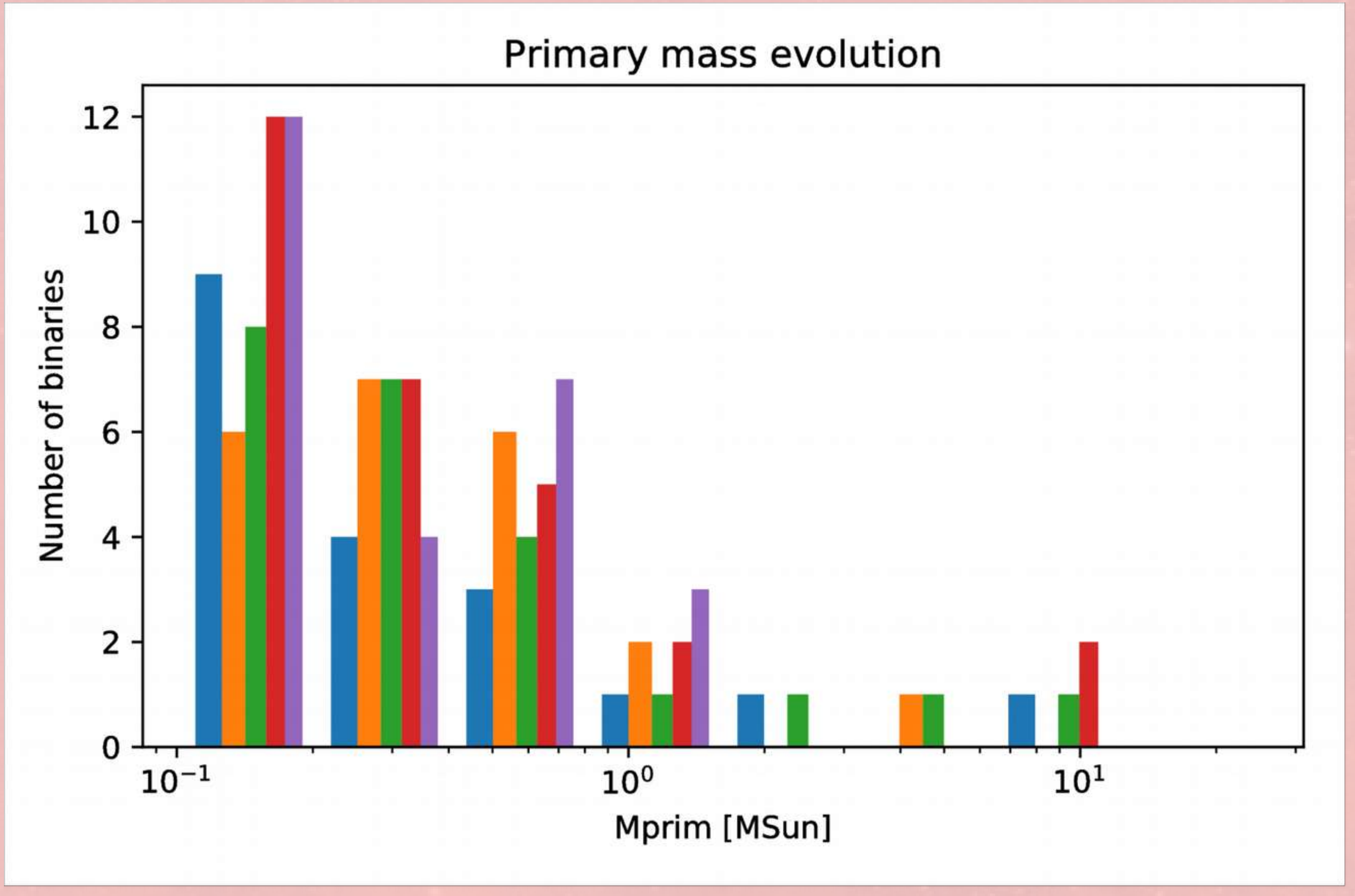
Fragmented cluster

- Auto-coherent method to generate initial conditions
- Mass segregated
- Multiplicity rate ~30%



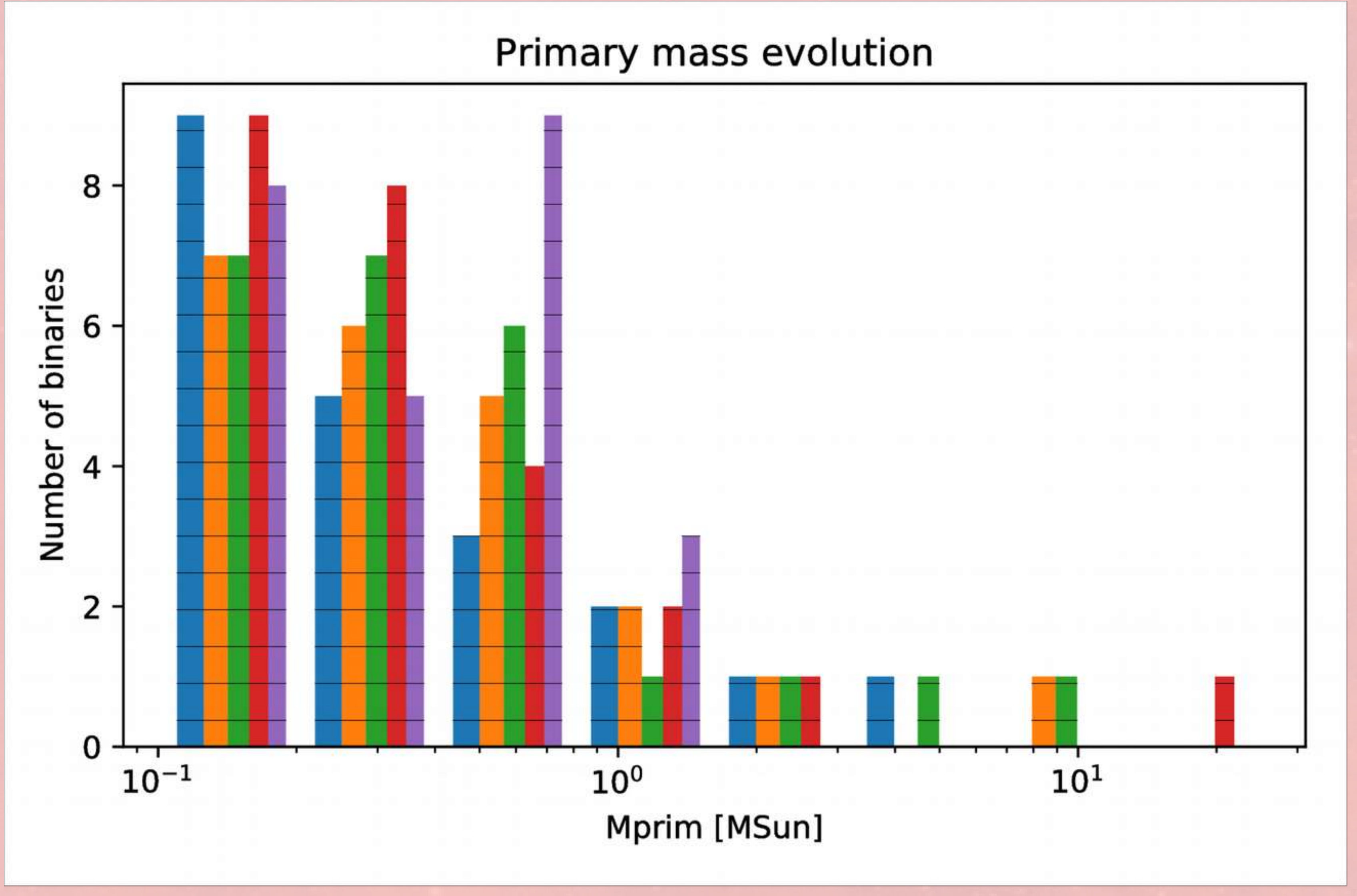
Fragmented cluster

Initial conditions



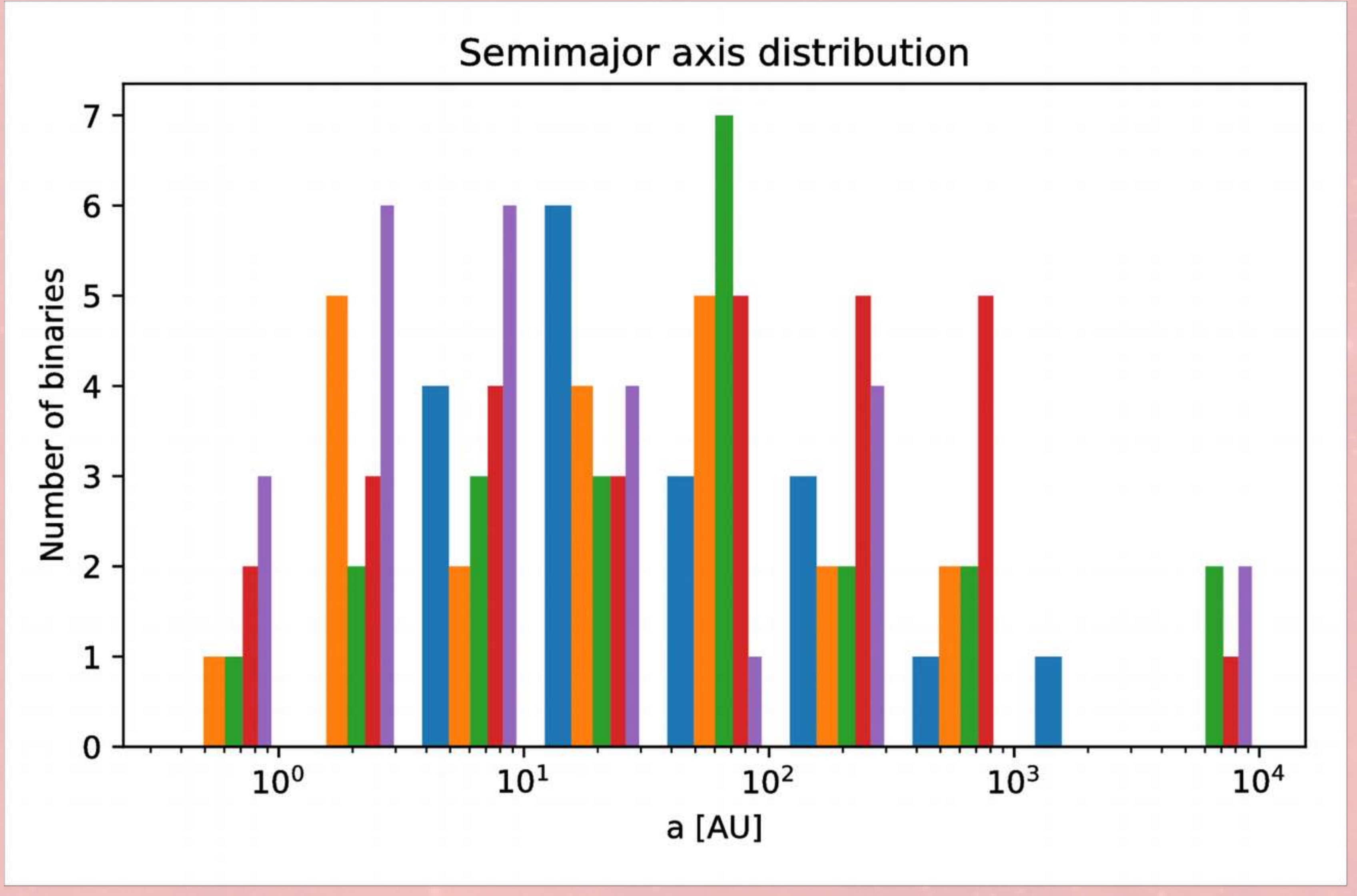
Fragmented cluster

After 10 Myr



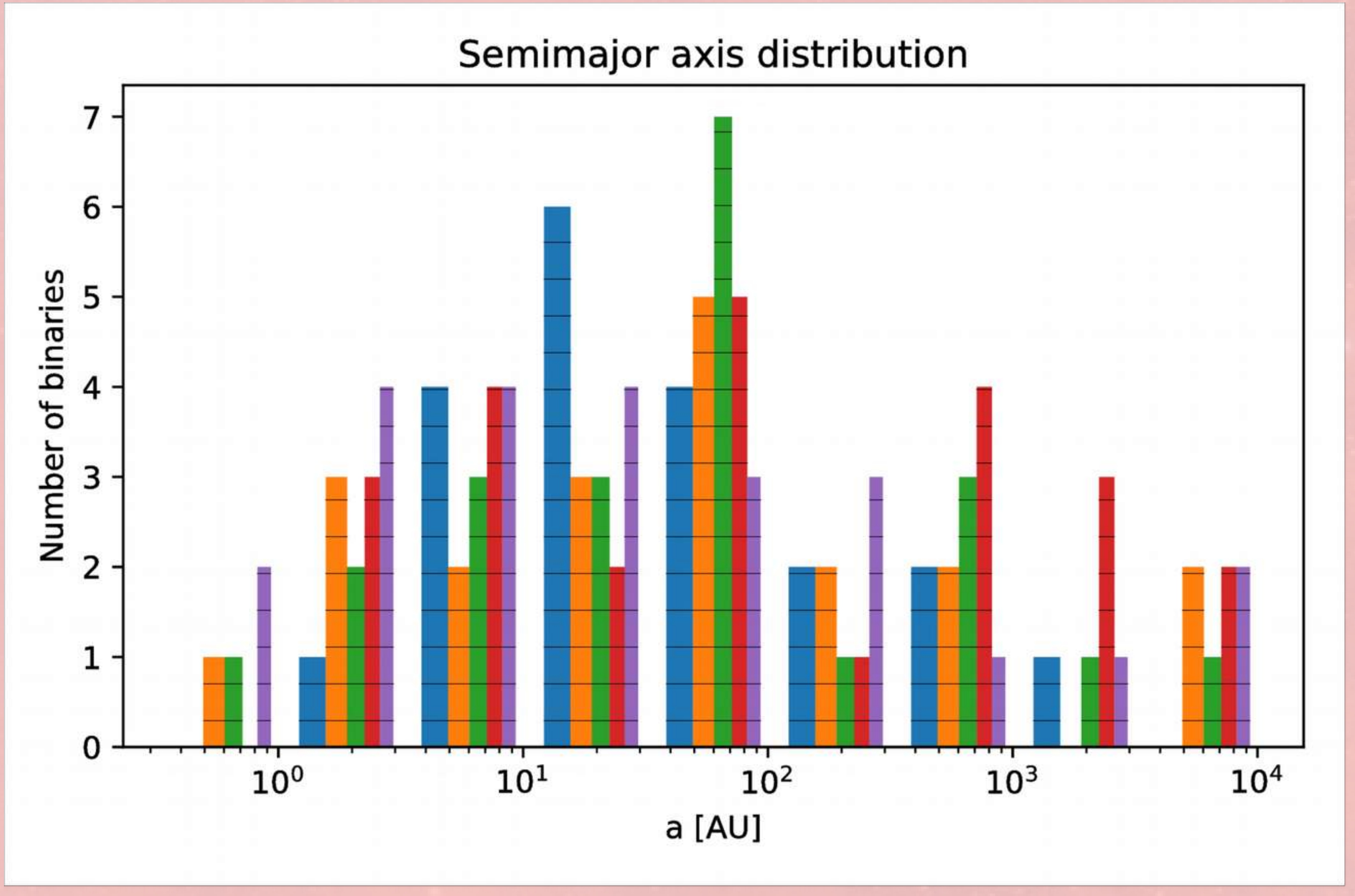
Fragmented cluster

Initial conditions



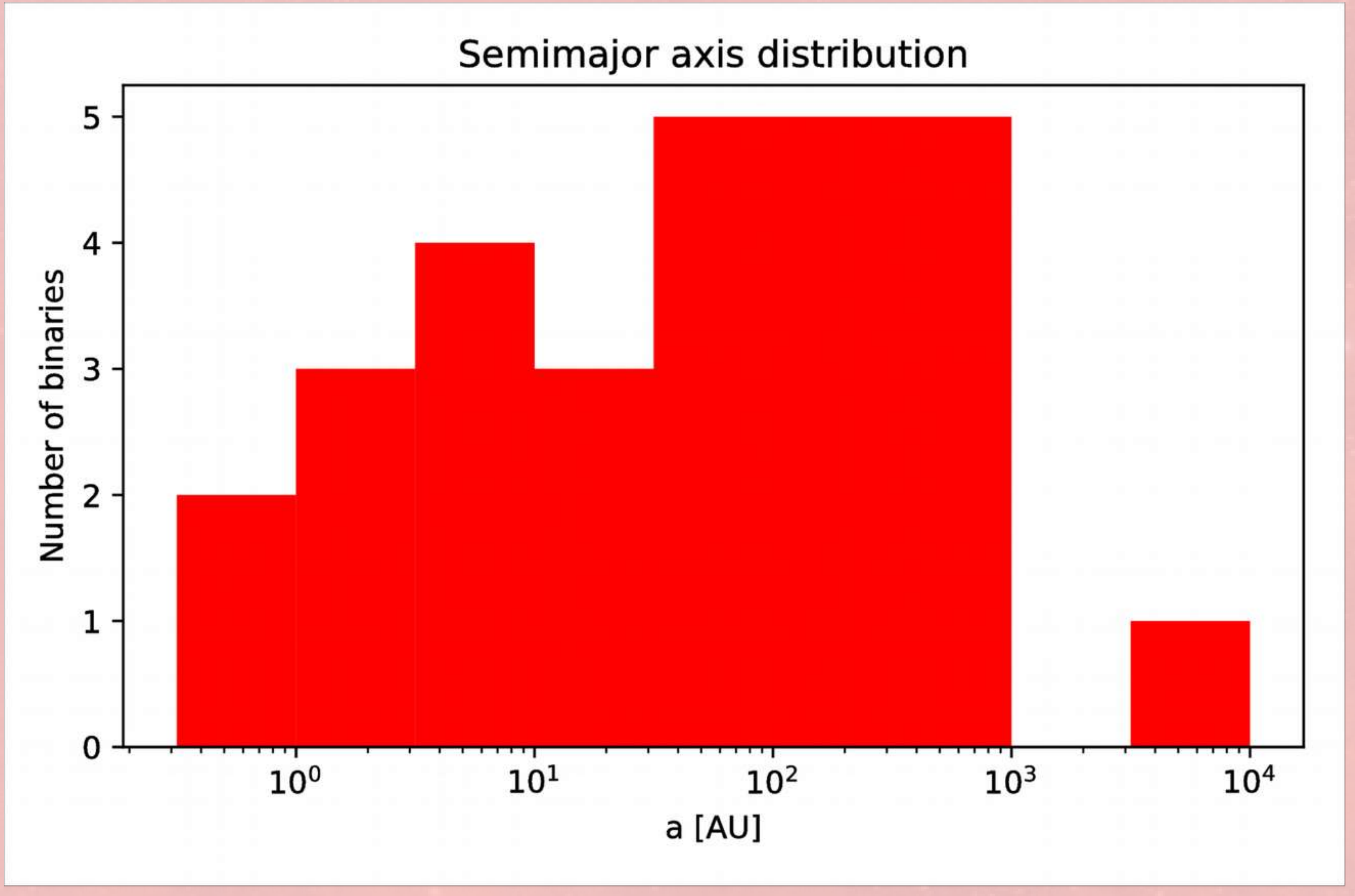
Fragmented cluster

After 10 Myr



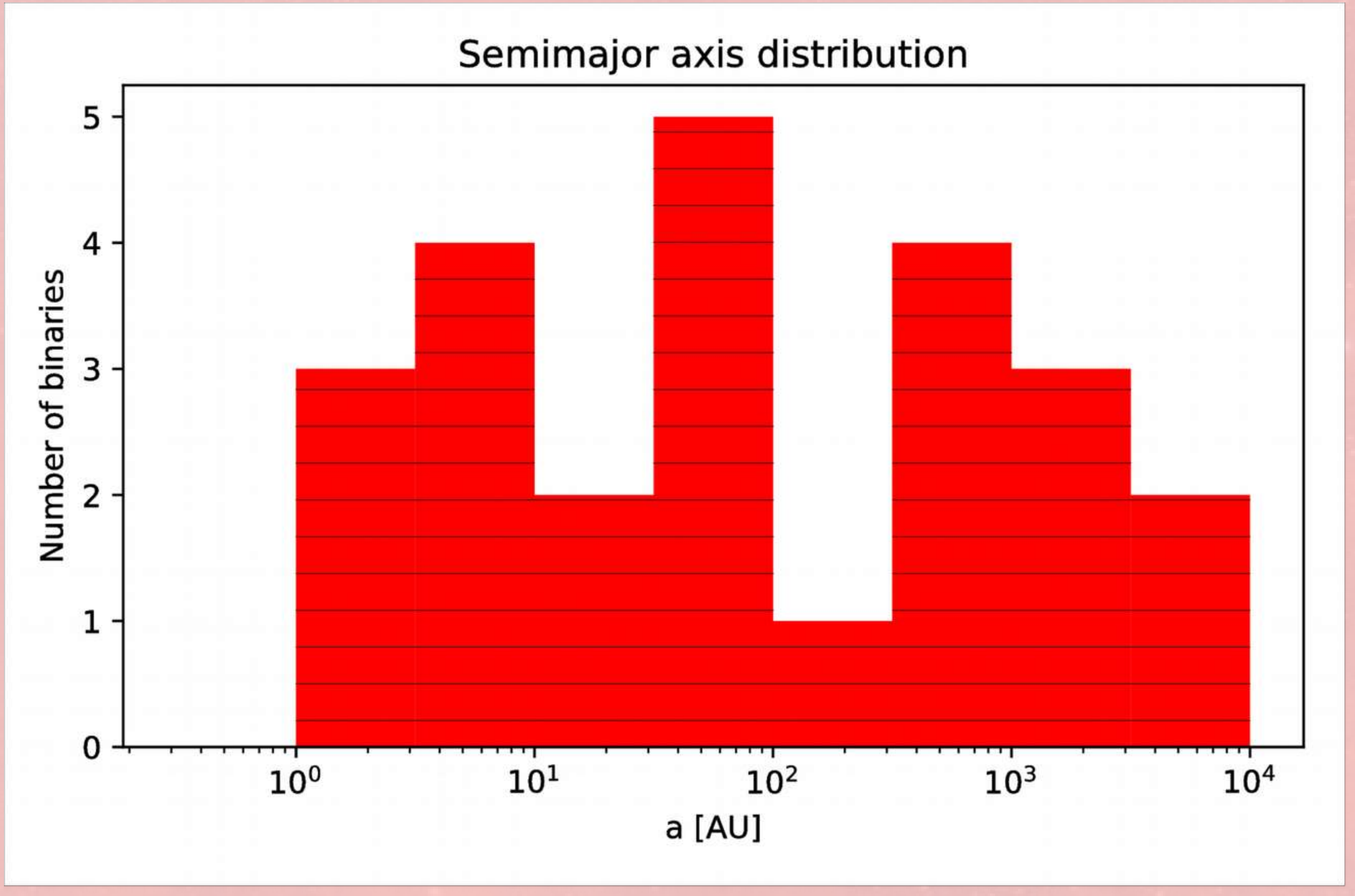
Fragmented cluster

Initial conditions



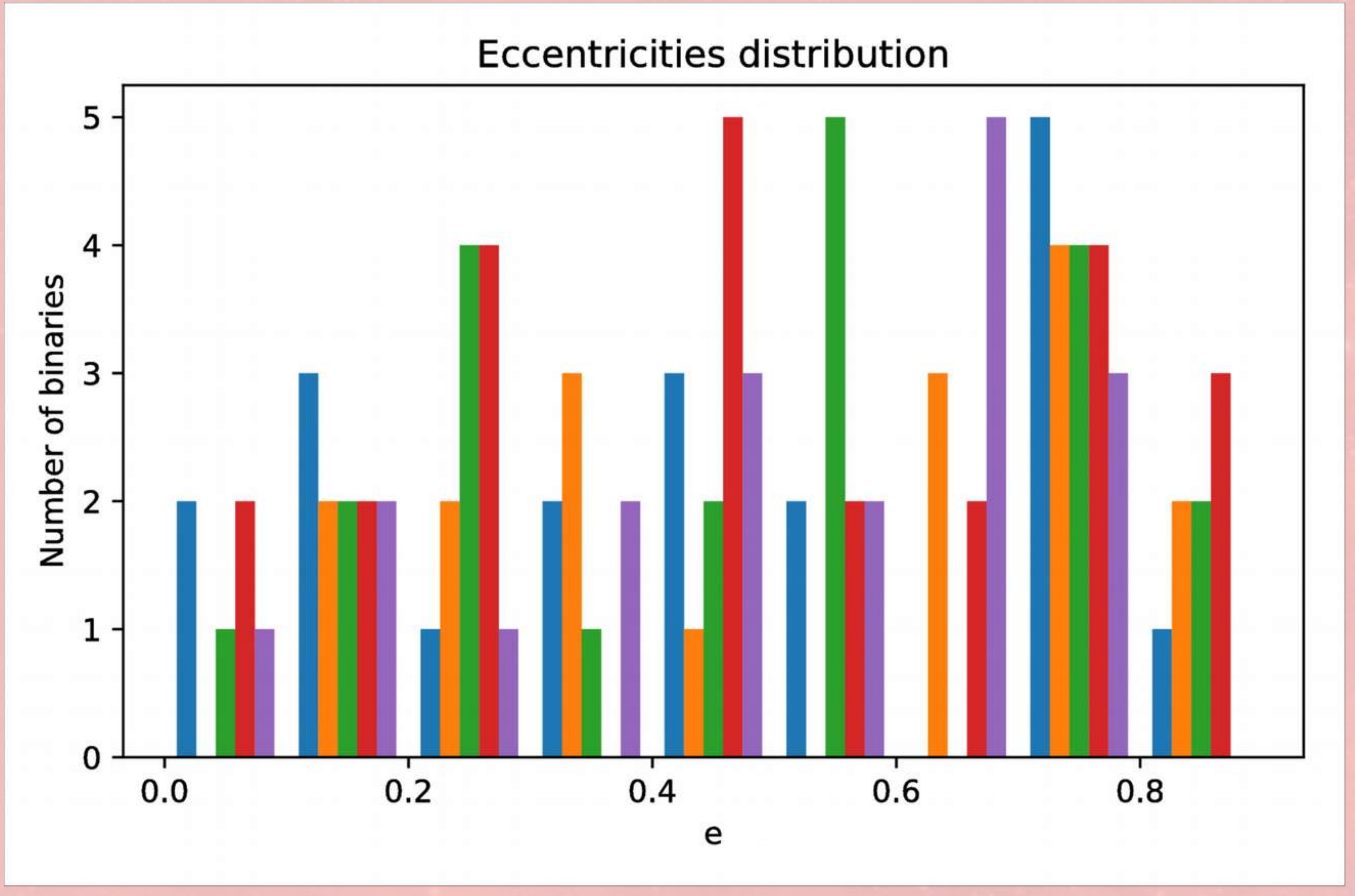
Fragmented cluster

After 10 Myr



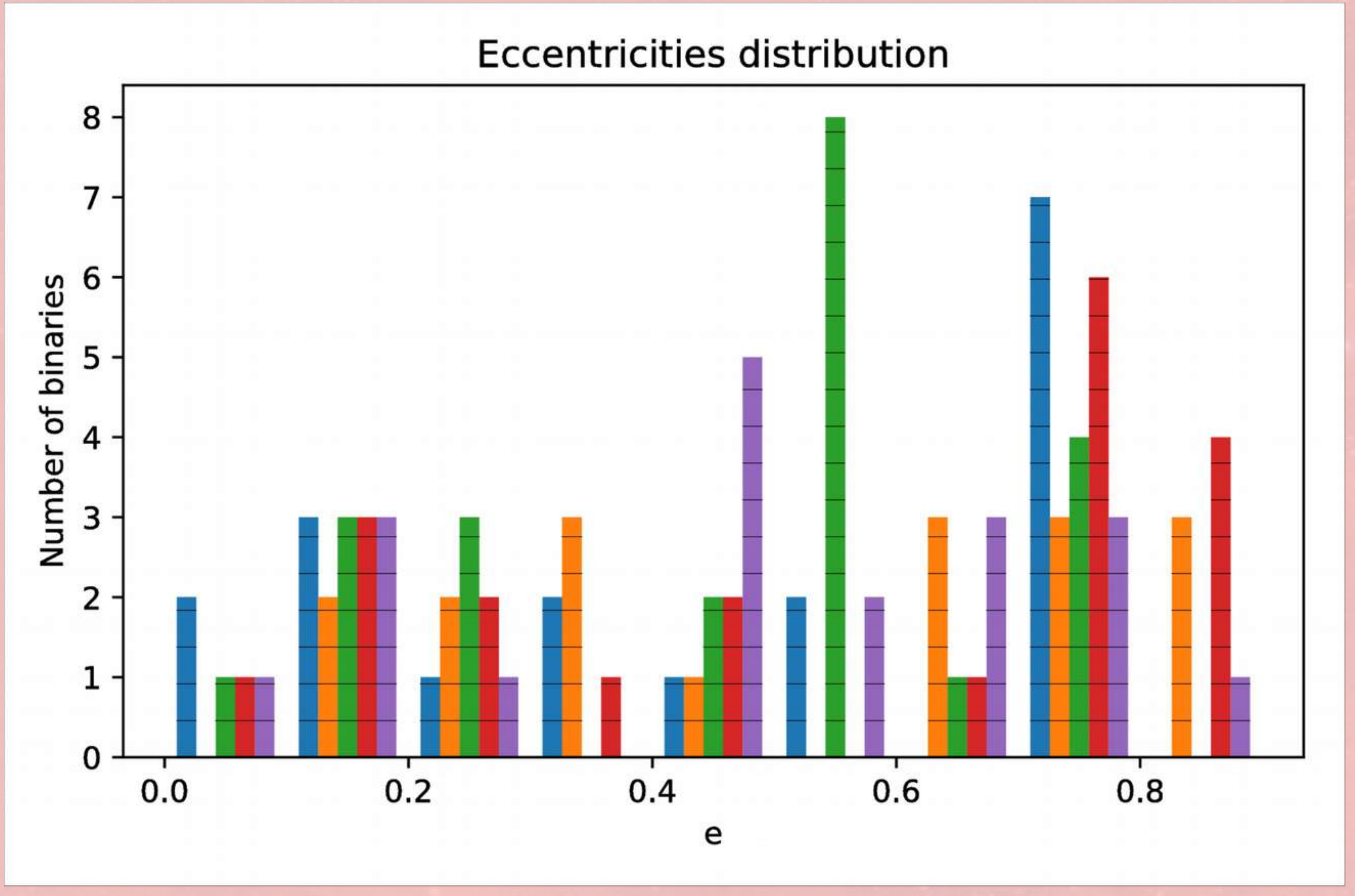
Fragmented cluster

Initial conditions



Fragmented cluster

After 10 Myr



Conclusion

Summary:

- Binary evolution very sensitive in star formation environment
- How precise the observed binary properties distribution are ?

Perspective:

- Add stellar evolution to compute the stars luminosity and extract luminosity maps
- Add gas