STAR CLUSTER FORMATION AND EARLY EVOLUTION

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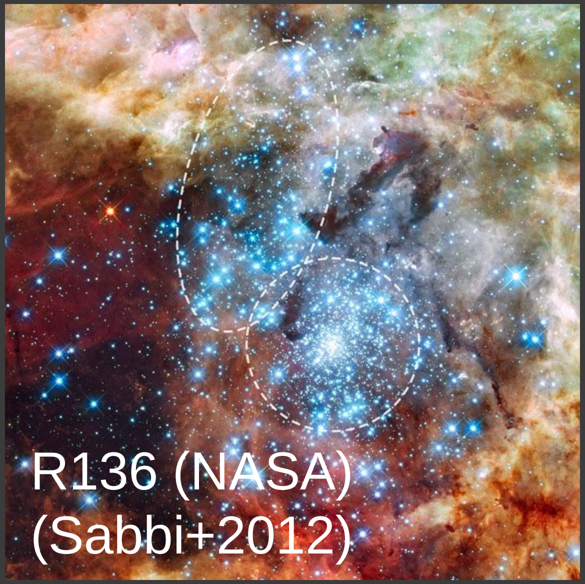
Outline

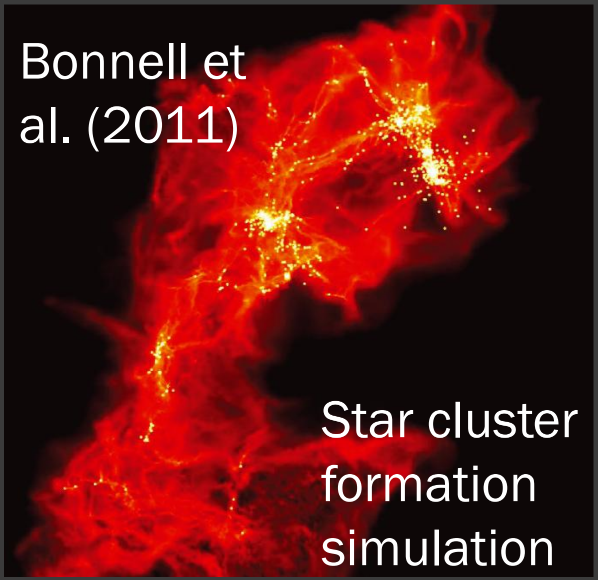
- Star cluster formation
  - Observations and simulations
- Methods
  - SPH and N-body simulations
- Results:
  - Cluster mass and size distribution
  - Cluster mass function
- Discussion
- Summary

Star cluster formation via merger

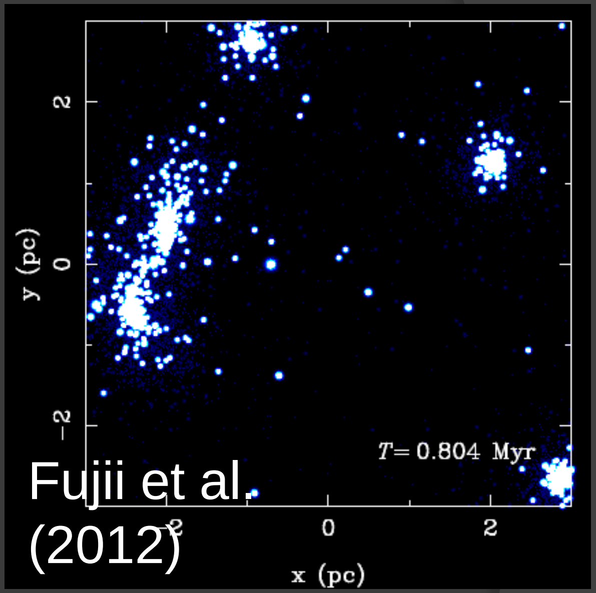
Observation



Star formation sim.



Clump merger sim.



- Merger scenario can explain the early dynamical evolution (ex. mass segregation) of young massive clusters (Fujii et al. 2012)

Motivation

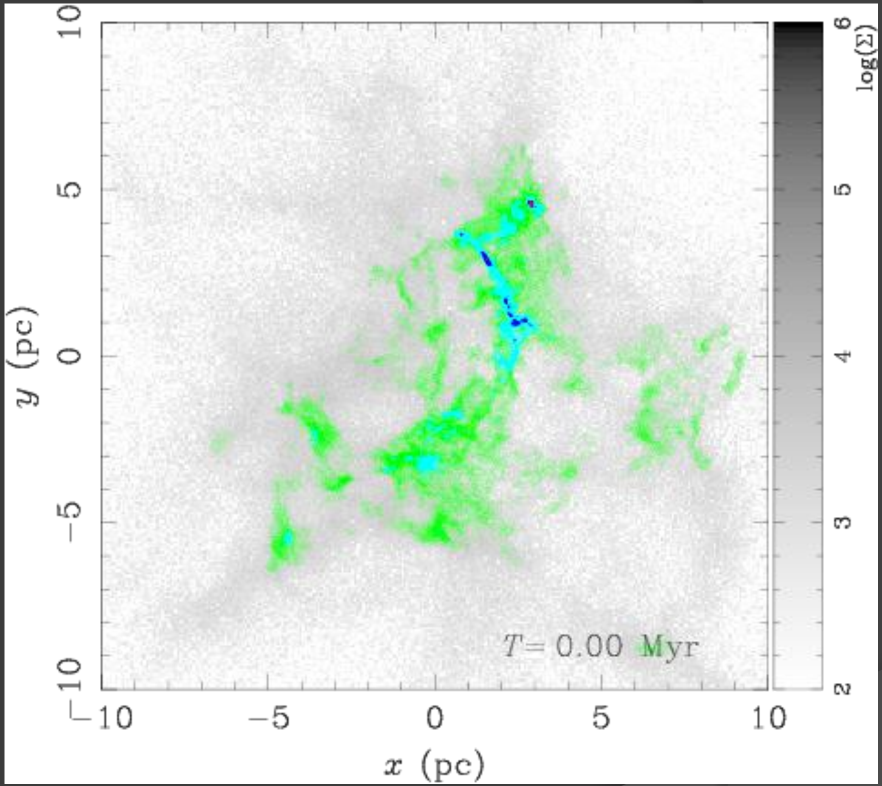
- Our previous models are too simple
  - 8 or 4 clumps
- More realistic initial condition
  - Filaments and clumps formed from turbulent molecular clouds
- Easier method compared to star formation simulations
  - We can treat larger systems

Method

- Step1: Perform SPH simulations of turbulent molecular cloud until it collapse (free-fall time)
- Step2: Convert gas particles to stars assuming a star formation efficiency depending on the local density and remove gas
- Step3: Perform N-body simulations up to 10 Myr

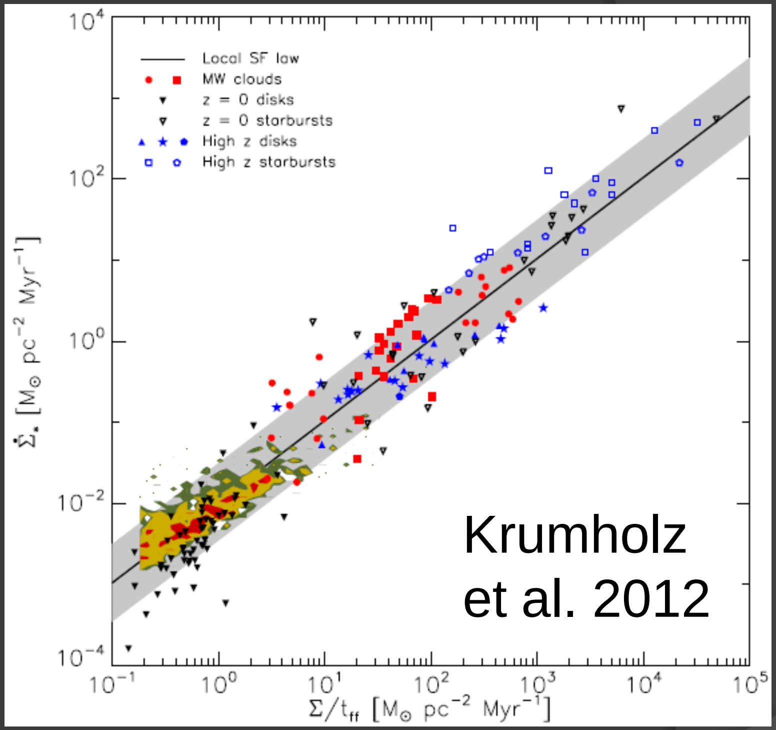
SPH simulation

- Code: Fi in AMUSE
  - Isothermal
  - $m_{gas} = 1M_{sun}$
  - eps = 0.1 pc
- Homogeneous sphere
  - Turbulence k=-3
  - Density 100 M_{sun} pc^{-3}
  - $M_{cloud} = 4x10^5, 10^6, 5x10^6$ M_{sun}



From Gas particles to star particles

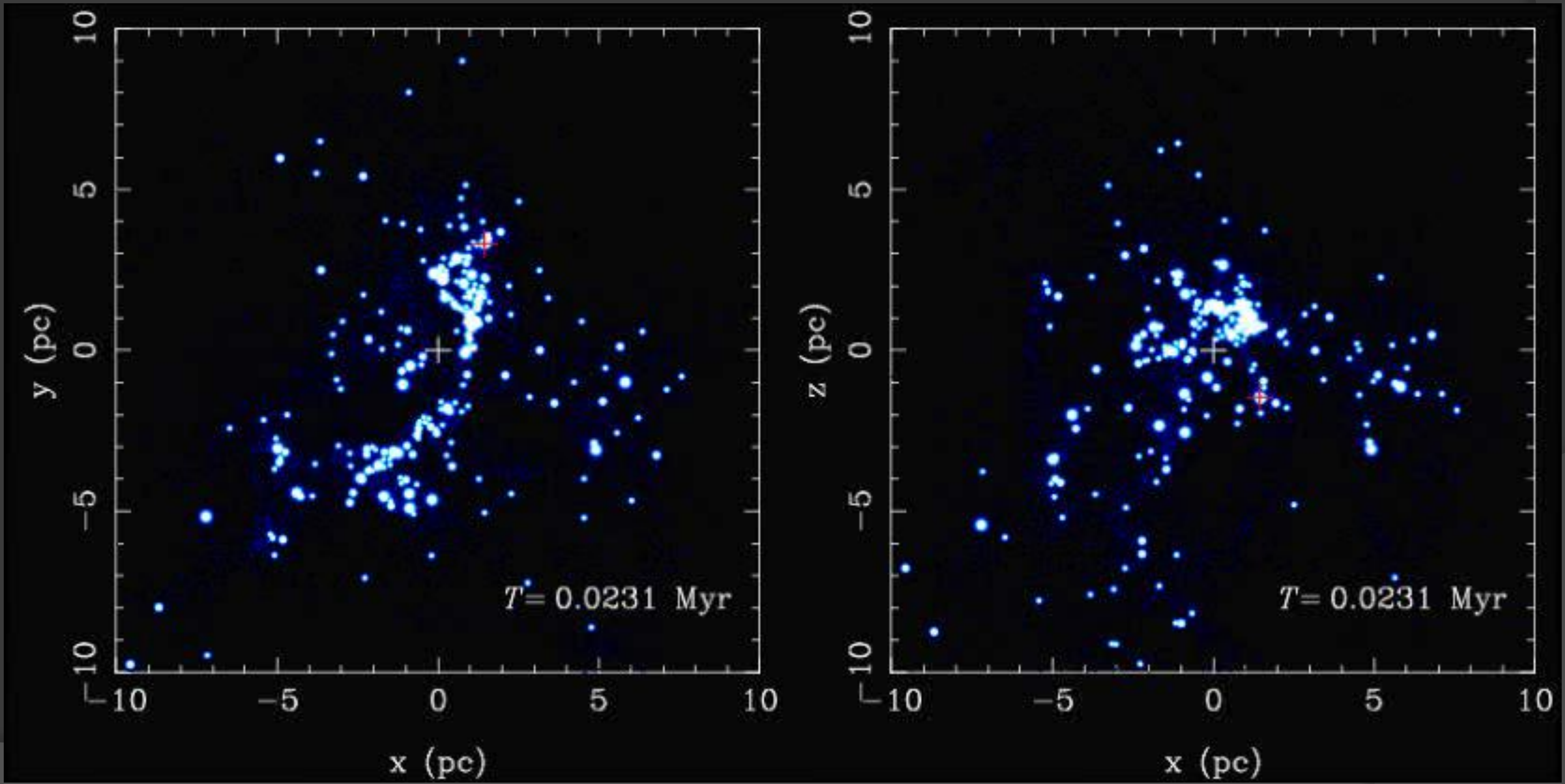
- Star formation efficiency
  - Star formation efficiency per free-fall time is constant (Krumholz et al. 2012)
  - We assume a star formation efficiency correlated to √ρ
  - SFE~0.05—0.1 (total) ~0.3 for dense region



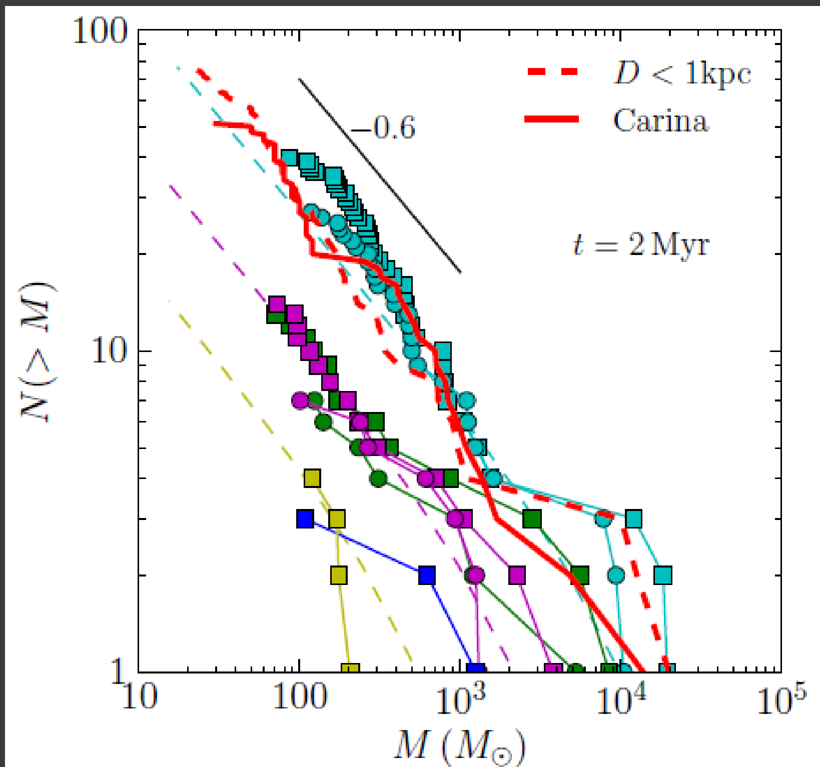
- Stellar mass function: Salpeter MF
  - Mass is independent from the local density

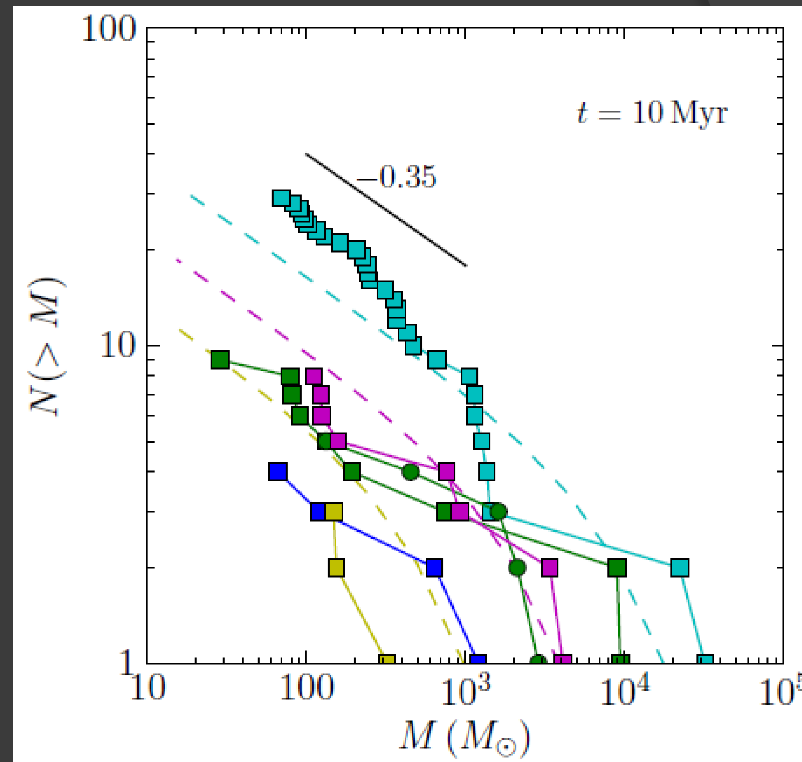
N-body simulation

- 6th-order Hermite scheme
- XC30 at CfCA



Cluster mass function





- Schechter function

$$N(>M) \propto M^{\beta+1} \exp\left(-\frac{M}{M_{\rm cut}}\right)$$

$$M_{\rm c,max} = 1.7 M_{\rm g}^{0.6}$$

$$\beta = -1.55 \pm 0.11$$

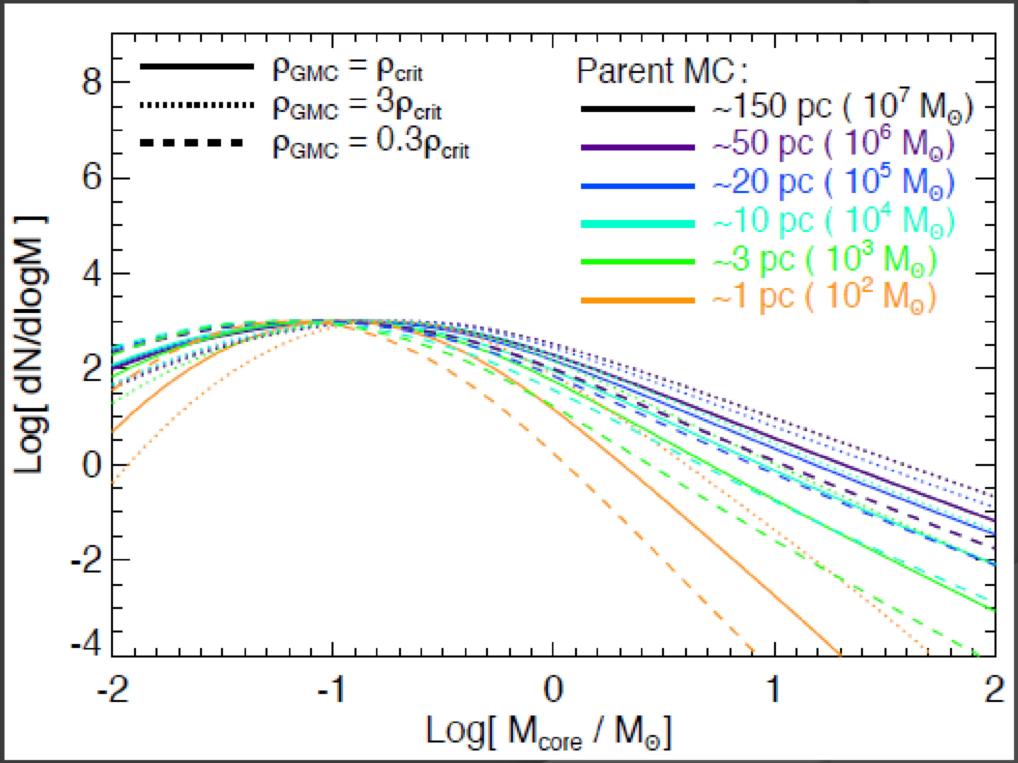
Self-similar structure?

- Stellar MF

  $$m_{\max} \simeq 0.4 m^{0.67} M_c$$

  - Pflamm-Altenburg et al. 2007
  - Similar to cluster MF
- Scale free?

Analytic core mass function
(Hopkins 2013)



Summary

- We performed SPH simulations of turbulent molecular clouds
- From the SPH simulations, we construct initial conditions of N-body simulations
- We performed N-body simulations of star cluster formations
- Both open clusters and young massive clusters form from turbulent clouds
  - YMCs form via mergers
- Cluster MF is similar to stellar MF