Do planets have more time to grow than we thought?

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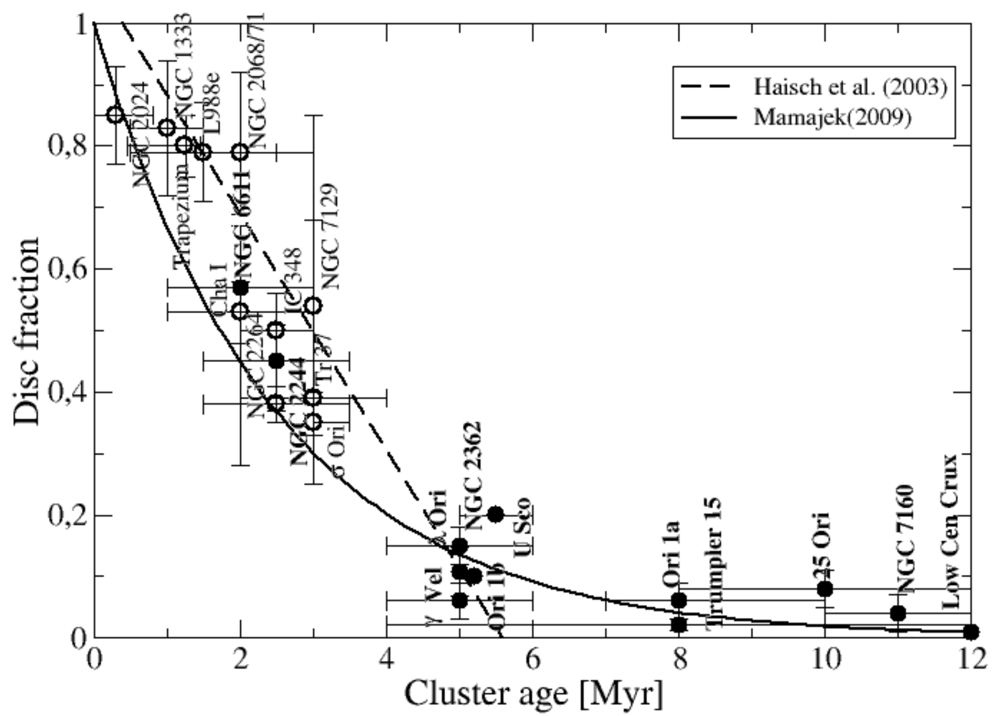
Determination of disc dispersal time

1. Use **cluster** as many stars of similar age located in small area
2. Look for **disc indicators** (infrared excess, accretion signature)
3. Determine **relative number** of stars with disc
4. Repeat for cluster of **different age**

Development of stellar properties

Disc fraction vs. cluster age



Standard interpretation:

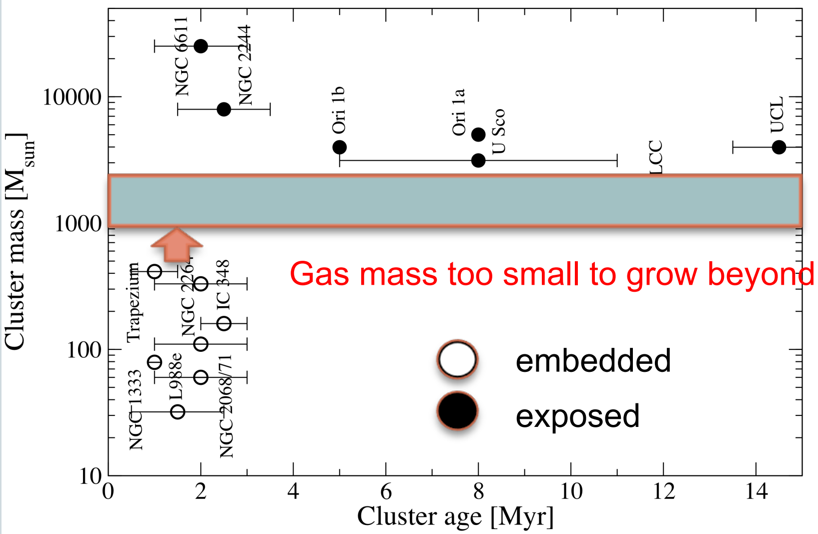
Most **disc dissipate** within **2-3 Myr**

Planets form very fast

< 5Myr

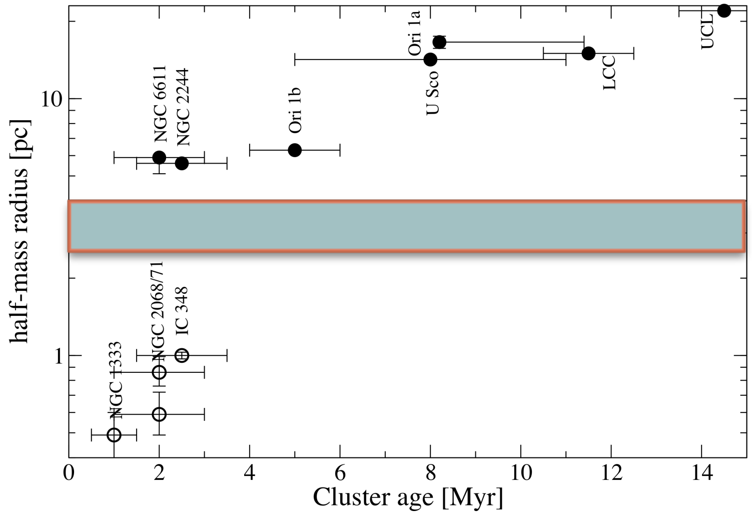
Selection effect I:

Mass



Pfalzner et al. (subm.)

Radius



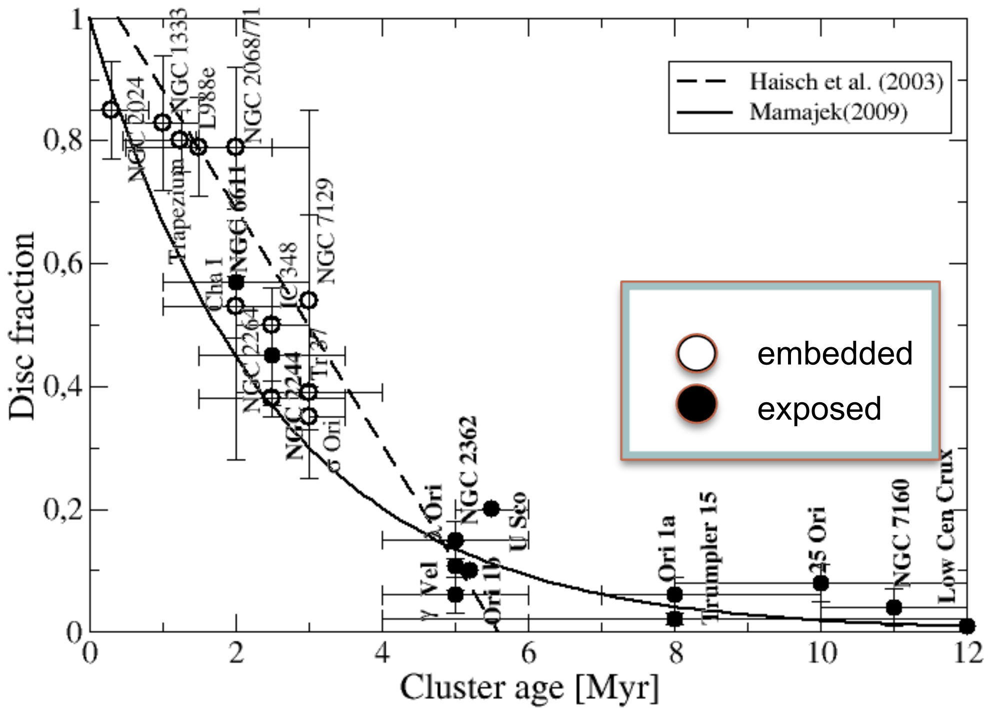
Older clusters all much

Inhomogenous sample

- **more massive**
- **more extended**

Development of stellar properties

Disc fraction vs. cluster age

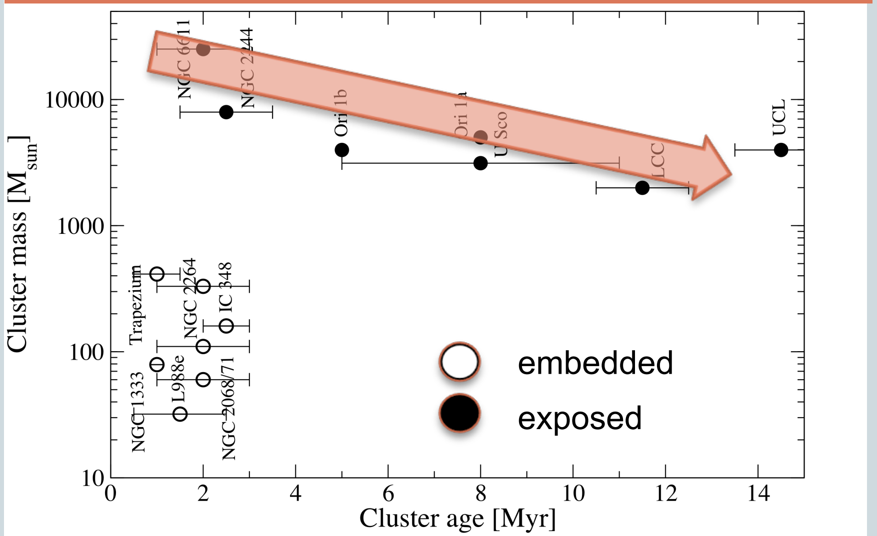


Disc lifetime of stars:

of massive cluster

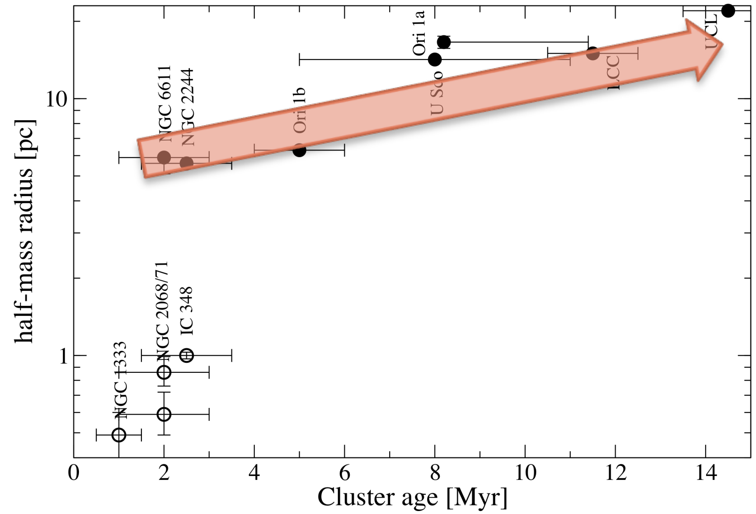
Selection effect I

Loose 80-90% of their mass



Pfalzner et al. (subm.)

Clusters expand by factor 5-10



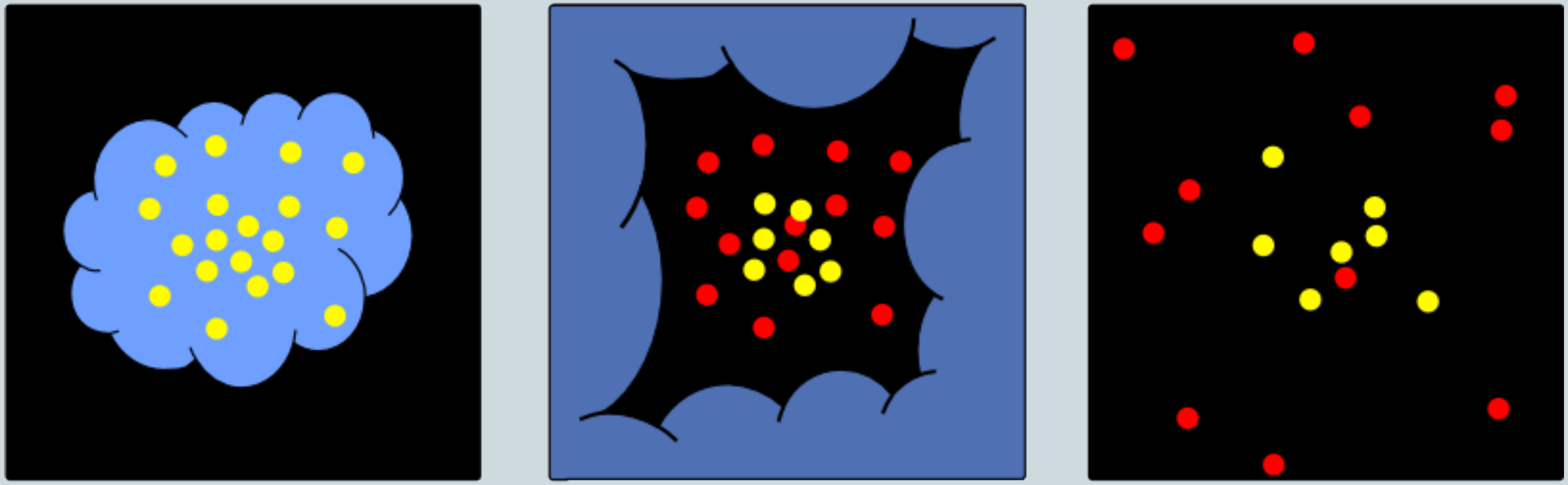
Older clusters all much

Why?

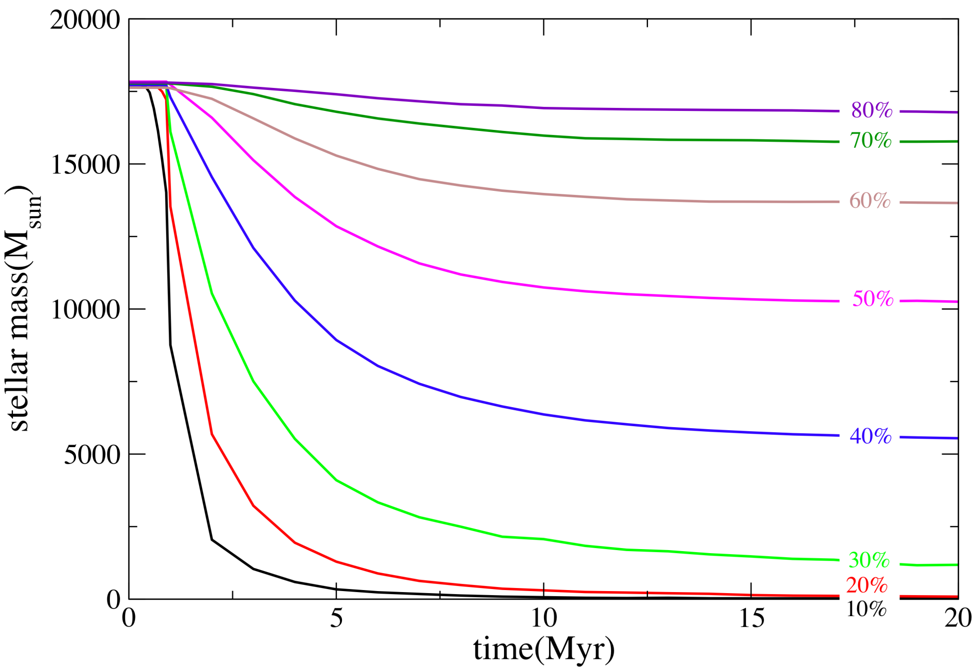
- **more massive**
- **more extended**

Models of massive cluster formation

- **Distribution of subclusters that merge**
  Increasing size with age not straightforward
- **Formation as single massive entity**
  Gas expulsion: explanation for cluster growth



Result of gas expulsion depends on ....



Highly deterministic

- **Star formation efficiency**

  Tutukov 1978, Hills 1980, Mathieu 1980, Adams 2000,Geyer & Burkert 2001, Kroupa et al. 2001, Boily &Kroupa 2003, Bastian & Goodwin 2006, Converse & Stahler 2011 ... many more

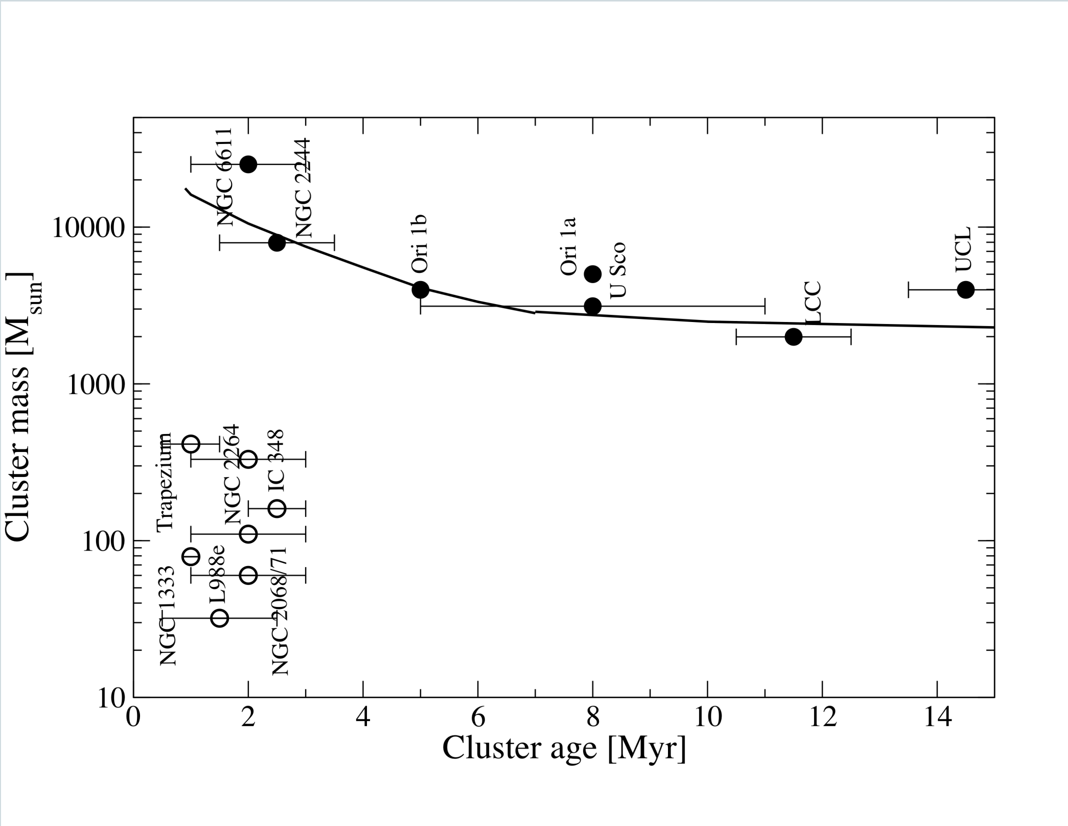
- **Duration of gas expulsion phase (rapid vs. slow)** Lada et al. 1984

- **Virial state before expulsion** Aarseth 1972,...Allison & Goodwin 2011

- **Spatial distribution before expulsion (clumping, central concentration)** Fellhauer & Kroupa 2005

- **Strength of tidal field** Goodwin 1997, Baumgardt & Kroupa 2007

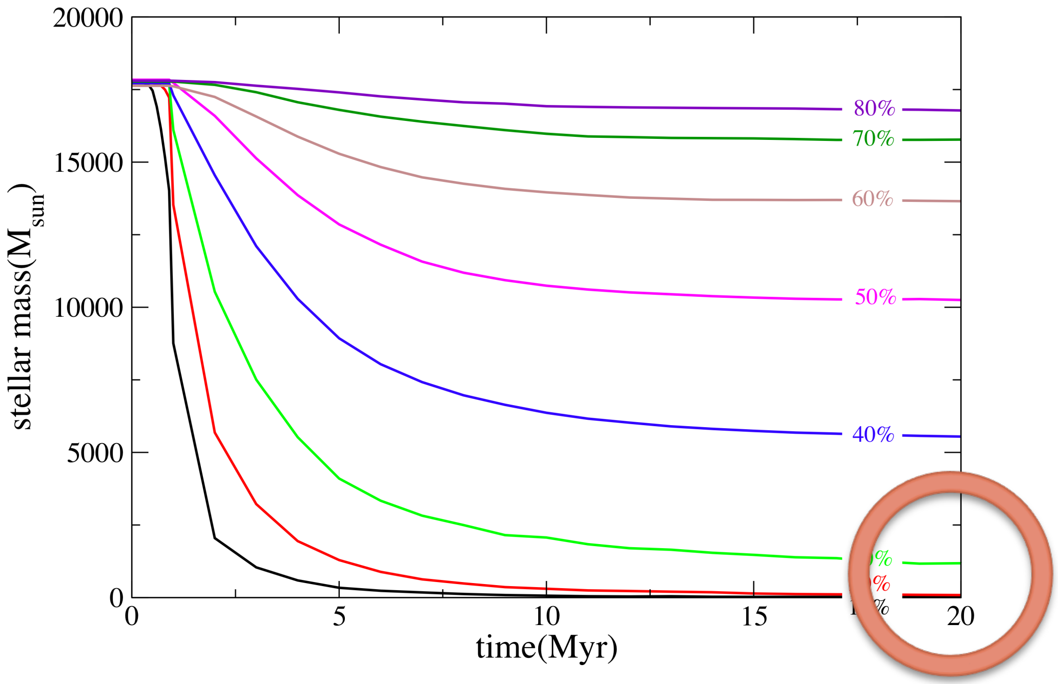
Associations/Extended clusters



Sequence corresponds to **30% SFE**

Corresponds to maximum observed SFE in solar neighbourhood

Consequences of 30% SFE



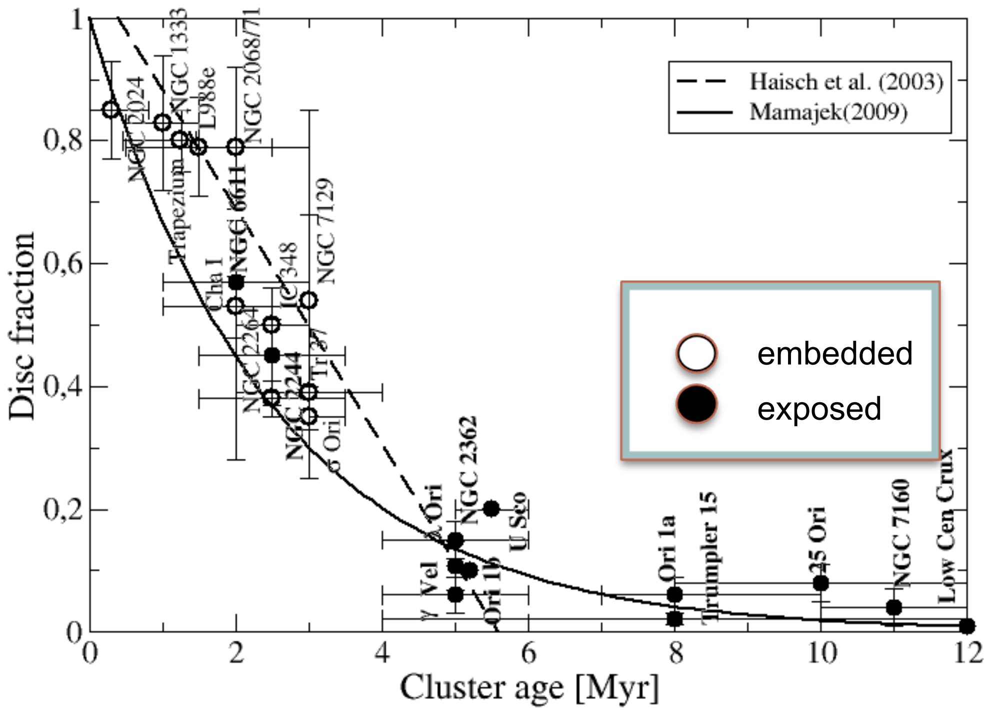
Remnant cluster contains

- 10% of initial cluster stars
- spread out FOV of ~50x50pc at 10 Myr

- Lower mass clusters fall below detection limit
- We look at small fraction of cluster stars

Development of stellar properties

Disc fraction vs. cluster age



Disc lifetime of stars:

of massive cluster that remain bound

Representative for the field population ?

Disc destruction processes

internal processes

Weidenschilling 1997, Hueso & Guillot 2005,Williams & Cieza 2011, Wolf et al. 2012

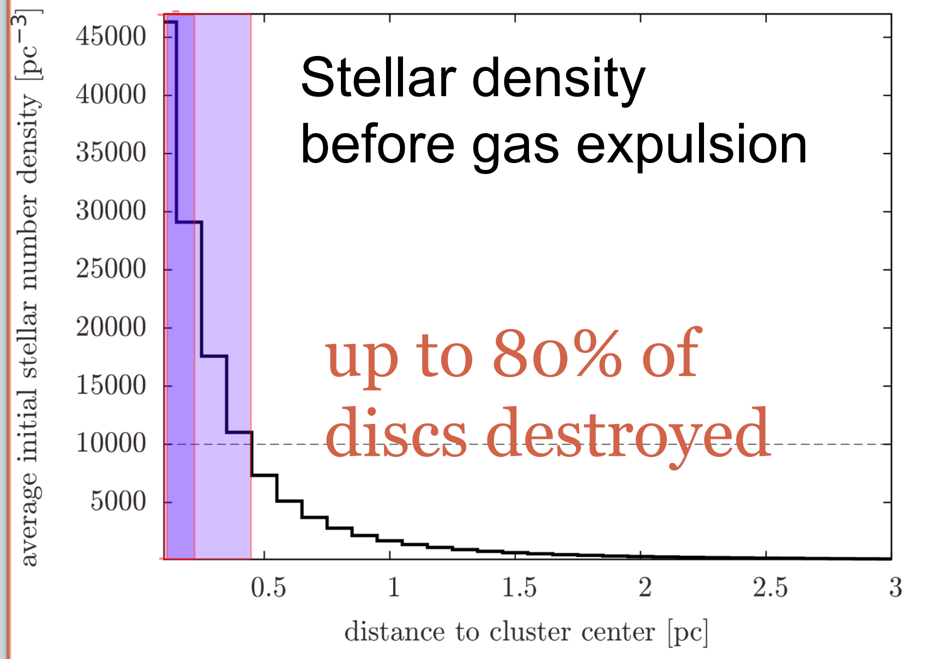
- dust growth
- viscous spreading
- internal photo evaporation

external processes

- external photo-evaporation by the massive stars
  Richling & Yorke 1998, Alexander 2008, Anderson et al. 2013
- tidal stripping
  gravitational interactions with other cluster members

Heller 1995, Pfalzner et al. 2006, Olczak et al. 2010

External disc destruction processes



Observations: Gutermuth et al. 2009)
important when volume density exceeds 10^4 stars/pc^3.

external processes

- external photo-evaporation by the massive stars
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- tidal stripping
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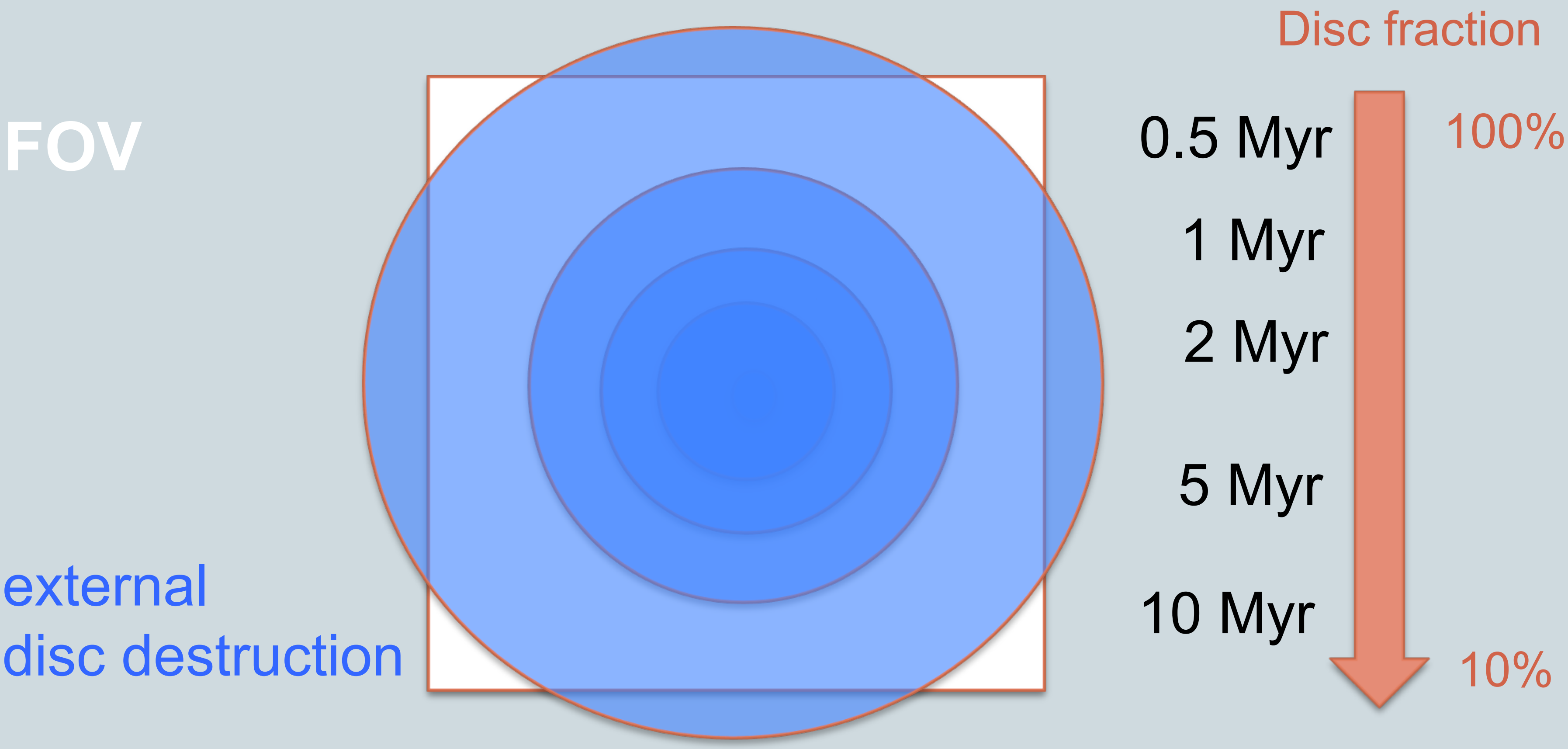
Only in inner 0.2-0.4 pc

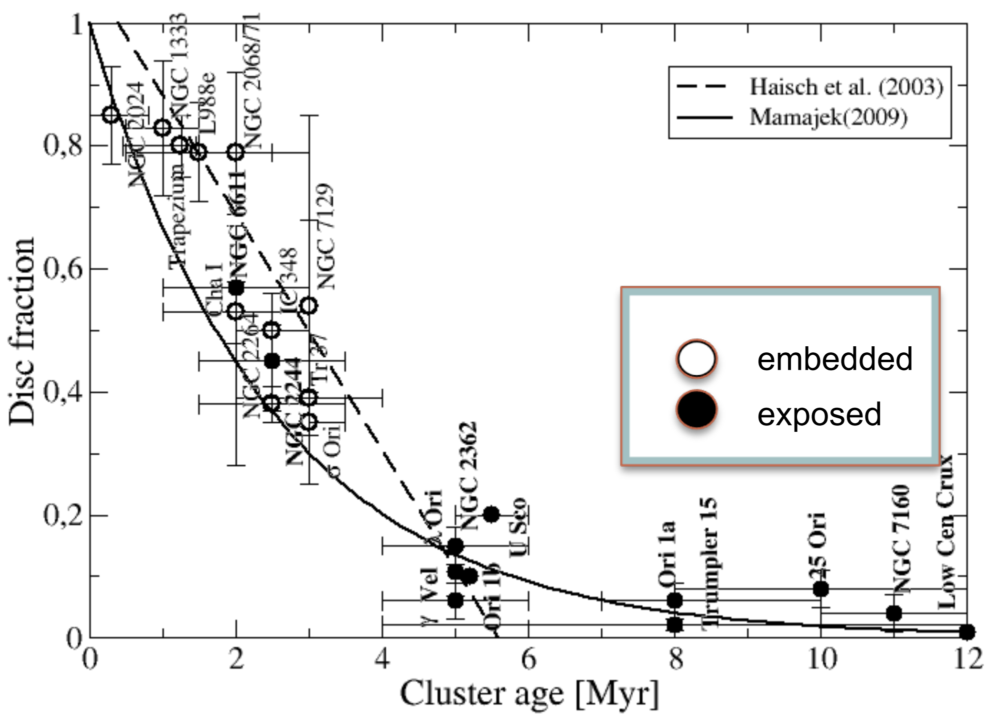
Cluster expansion determines disc fraction



Cluster expansion mimicks decrease in disc fraction

Three selection effects for disc lifetimes

Disc fraction vs. cluster age



Disc lifetime of stars:

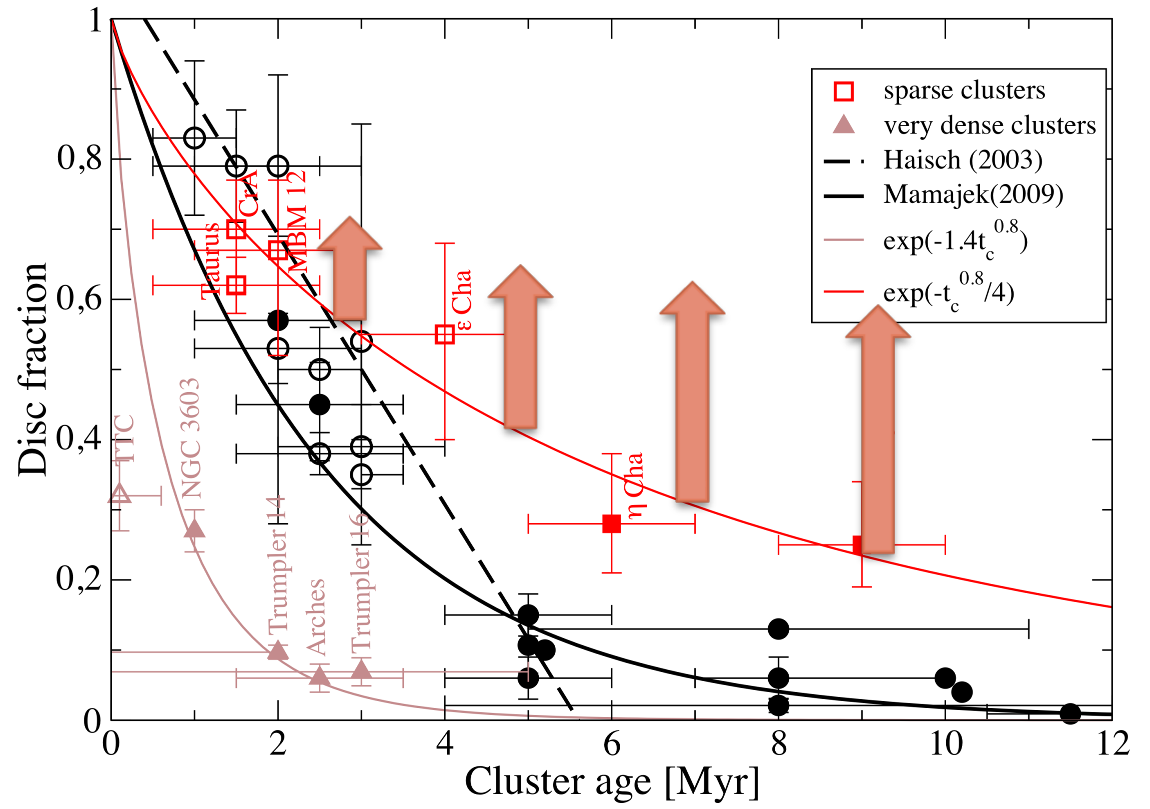
in the centre of of massive cluster that remain bound

No info for stars that

- **reside not at centre**
- **become unbound**
- **in low-mass clusters**

Disc lifetime of field population?

Fraction of long-lived discs up to 30-60%



Disc fraction in sparse co-moving groups **higher**

Summary

Disc fraction determination possibly biased towards

1. Massive clusters
2. Bound fraction (central 10%)
3. Expanding highest density areas

Probably not representative for field population

Consequence:

- **Disc life time uncertain**
- **30-60% of stars could have long-lived discs**