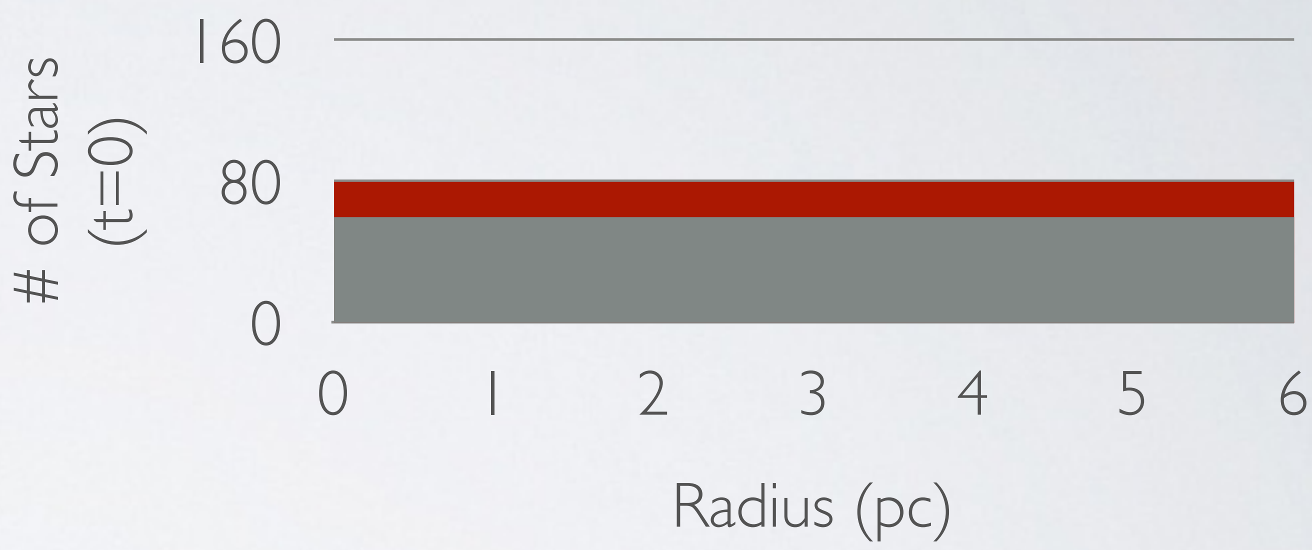
MIGRATORY PATTERNS OF WILD BINARIES

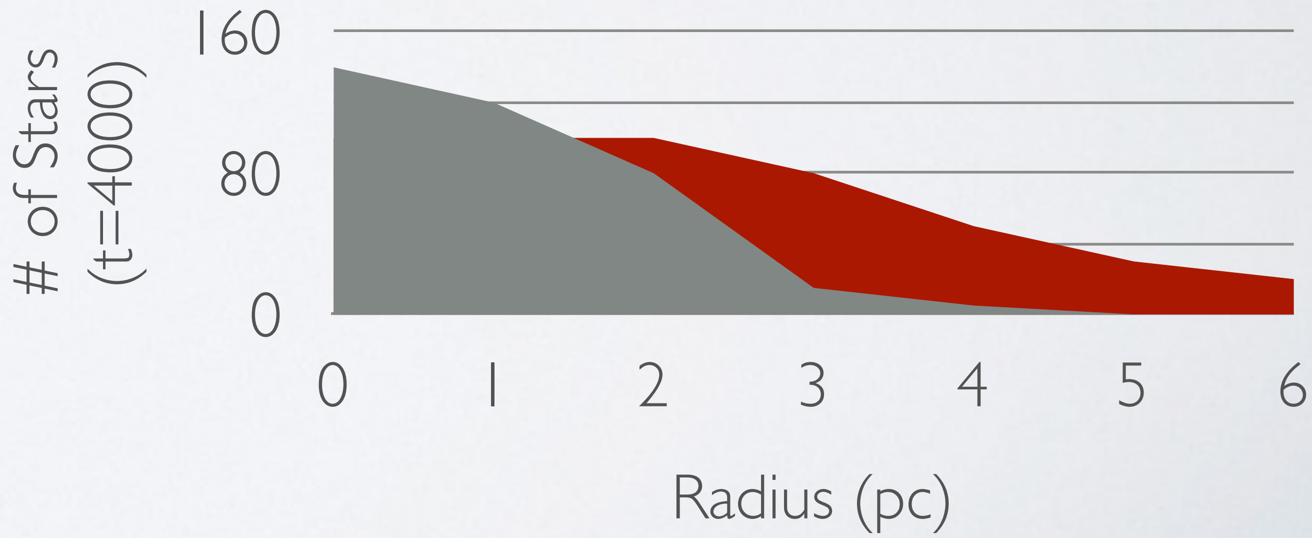
MASS SEGREGATION

- Cluster forms when large cloud of gas collapses
  - Isotropic
- Stars interact gravitationally
  - Equipartition of energy
  - $KE = 0.5mv^2$

Example Cluster:

of $3M_{sun}$ and $2M_{sun}$ vs Radius

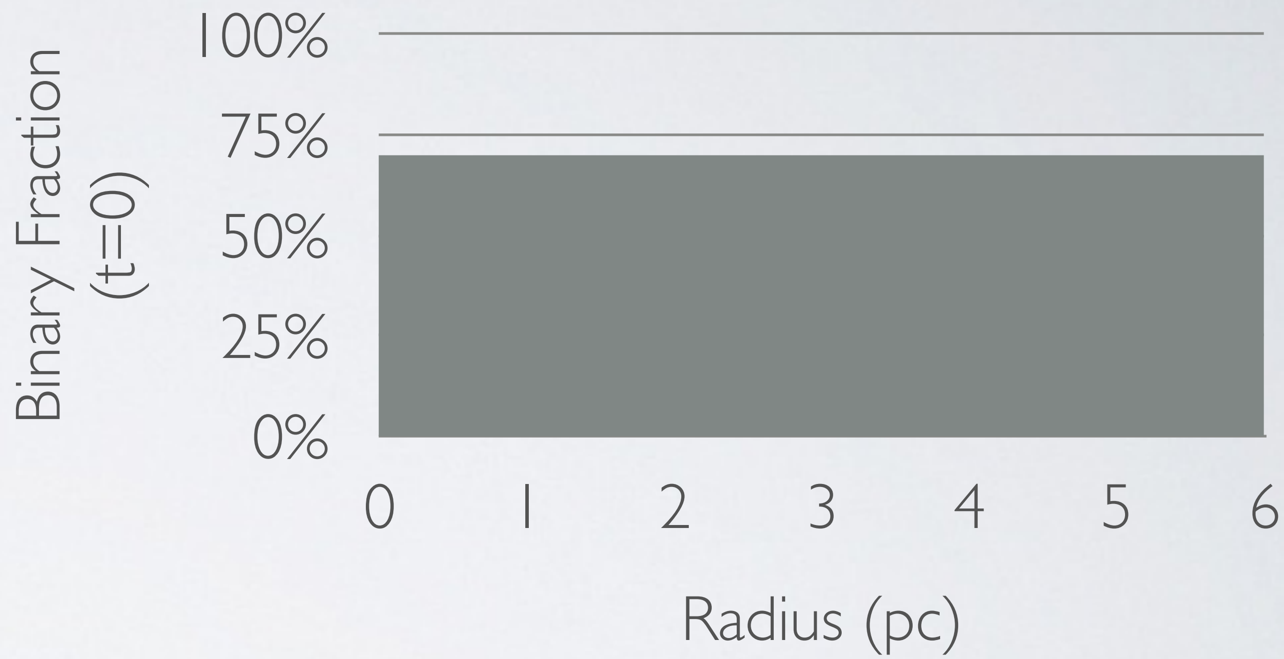




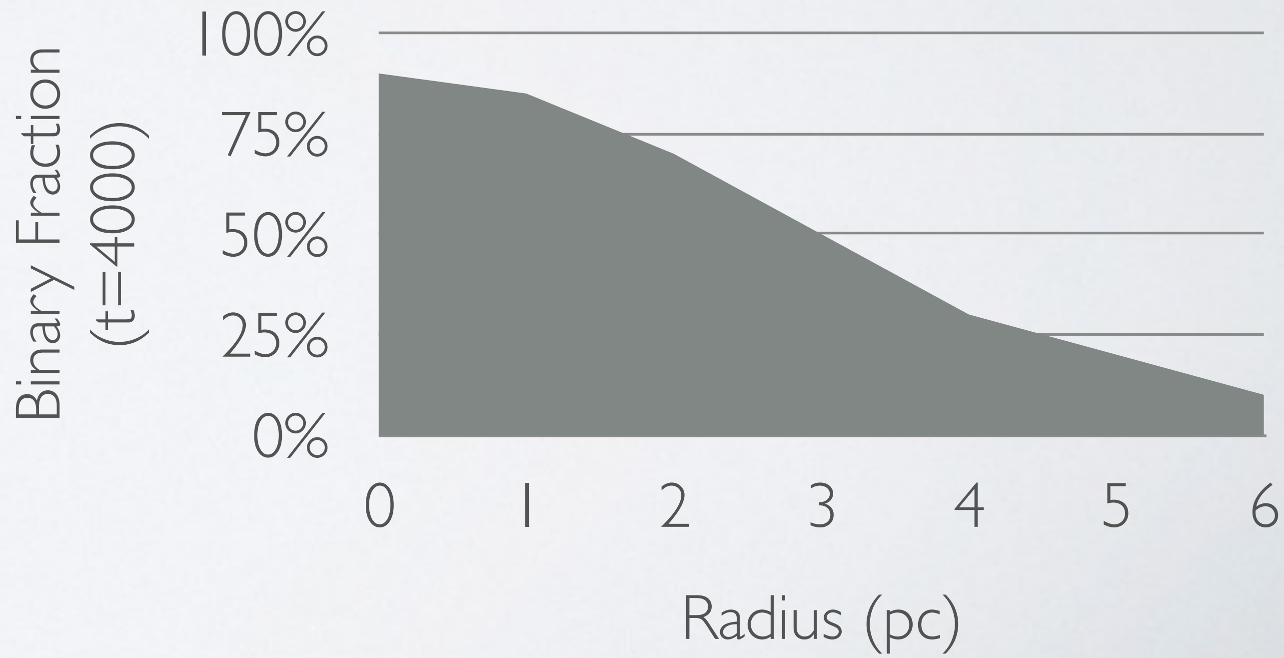
BINARY SEGREGATION

Example Cluster:

- Binary formation is similar
  - Initially isotropic

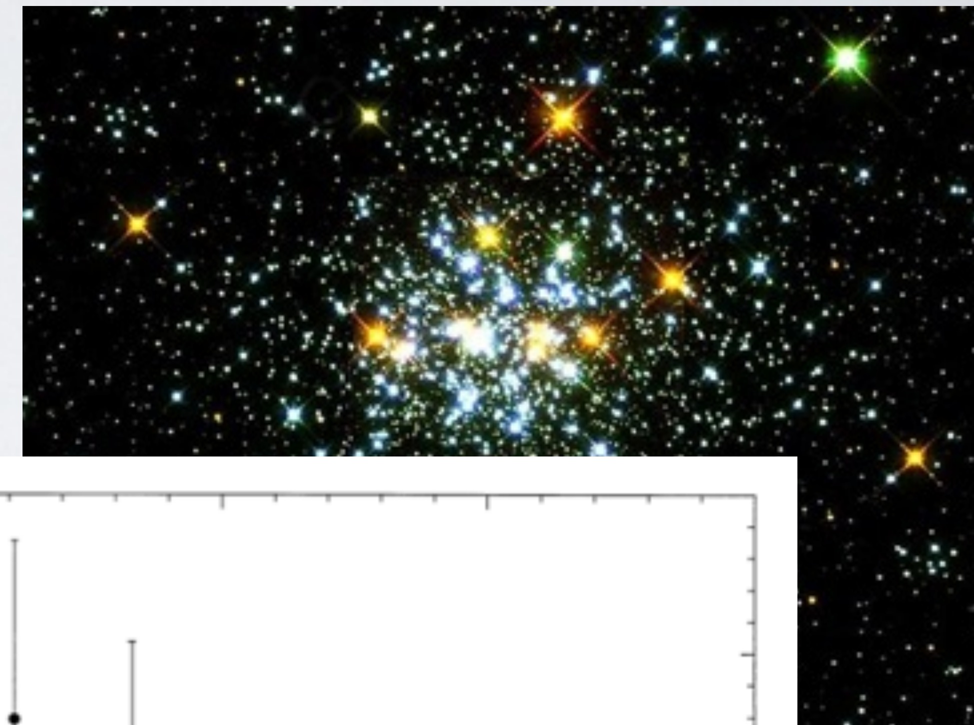


- Binaries are more massive than singles
  - Should become more centrally concentrated



CURIOUS CASE OF NGC 1818

- NGC 1818 is a young, massive cluster in the Large Magellanic Cloud



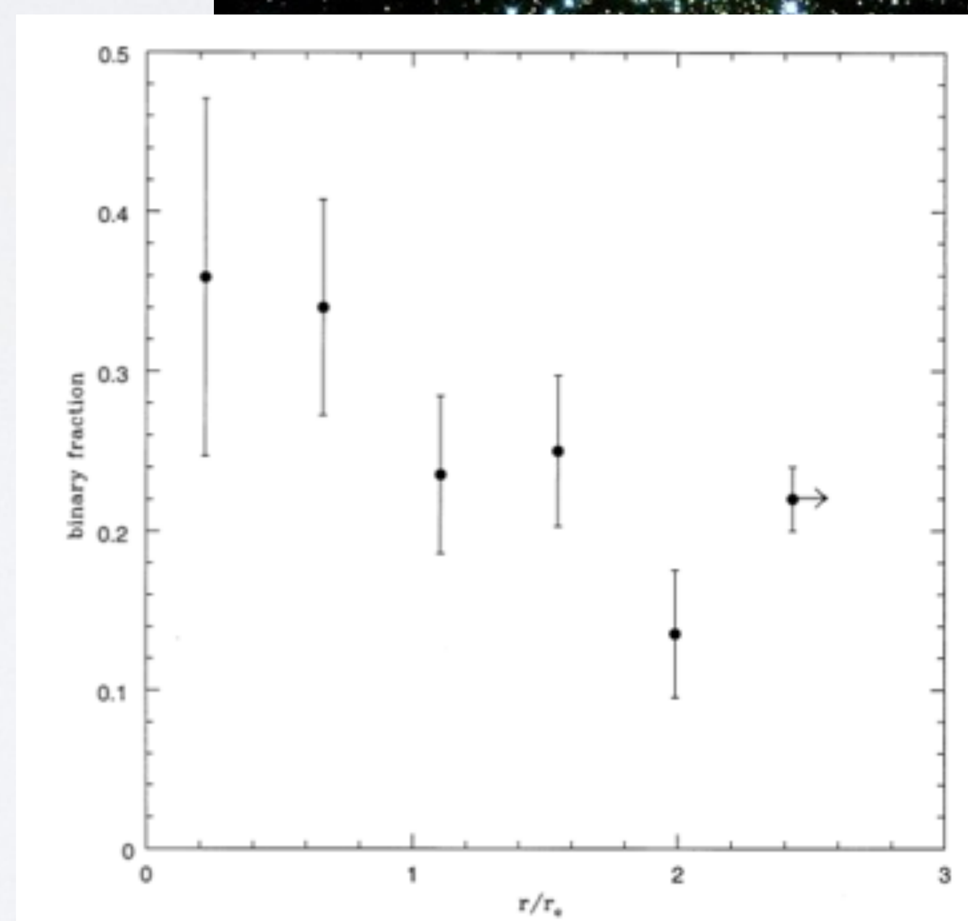


Figure reproduced from Elson et al. 1998

- Elson et al. 1998 studied binary % vs radius for 2 - 5.5 M_{sun}
  - Binaries are mass segregated

CURIOUS CASE OF NGC 1818

- NGC 1818's binary % was studied again in 2013 by de Grijs et al.
  - Binary % for stars with 1.3 - 1.6 M_{sun}
  - $m_2/m_1 > 0.55$ (mass ratio)
- This plot is cumulative! Ugh.
  - Binary % *increasing* with radius
  - Anti-mass segregation?

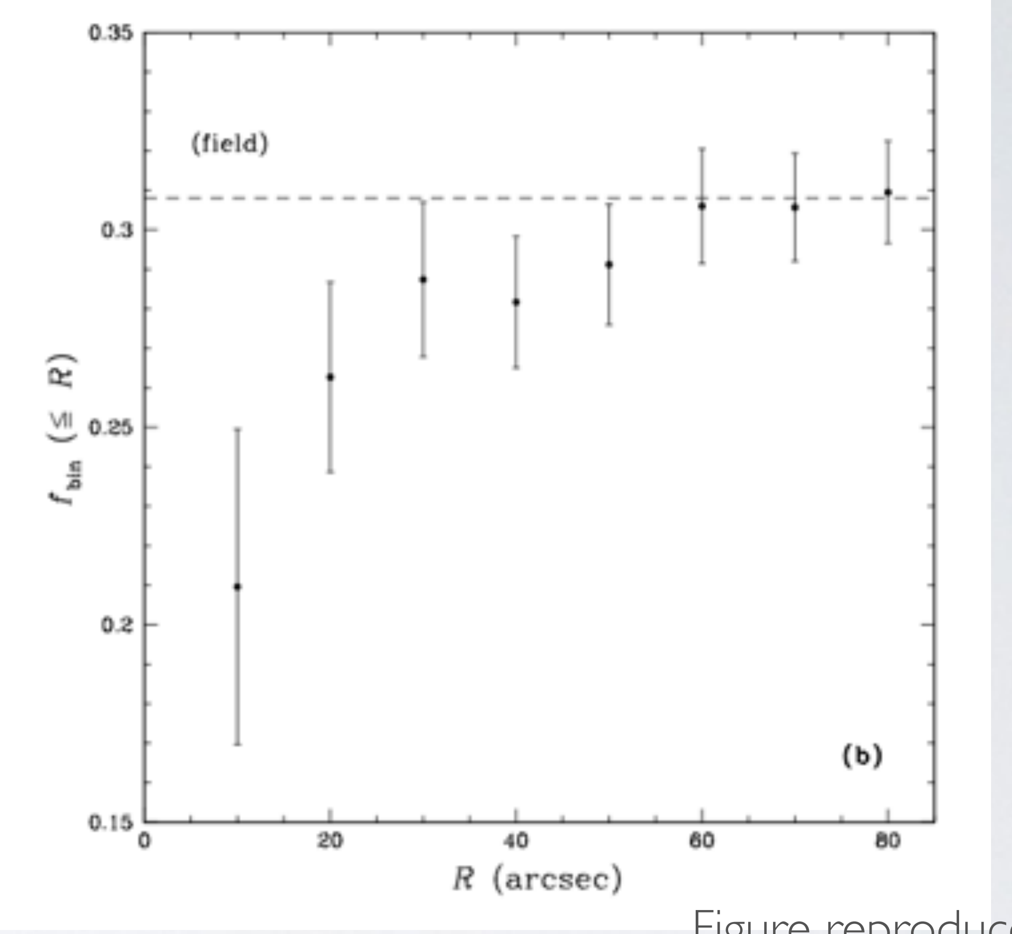


Figure reproduced from de Grijs et al. 2013

COMPUTERS!

- The best way to figure anything out in astronomy is on a computer
- Things evolve over a **long** time
- Geller et al. 2013 simulated cluster, checked binary % at various ages

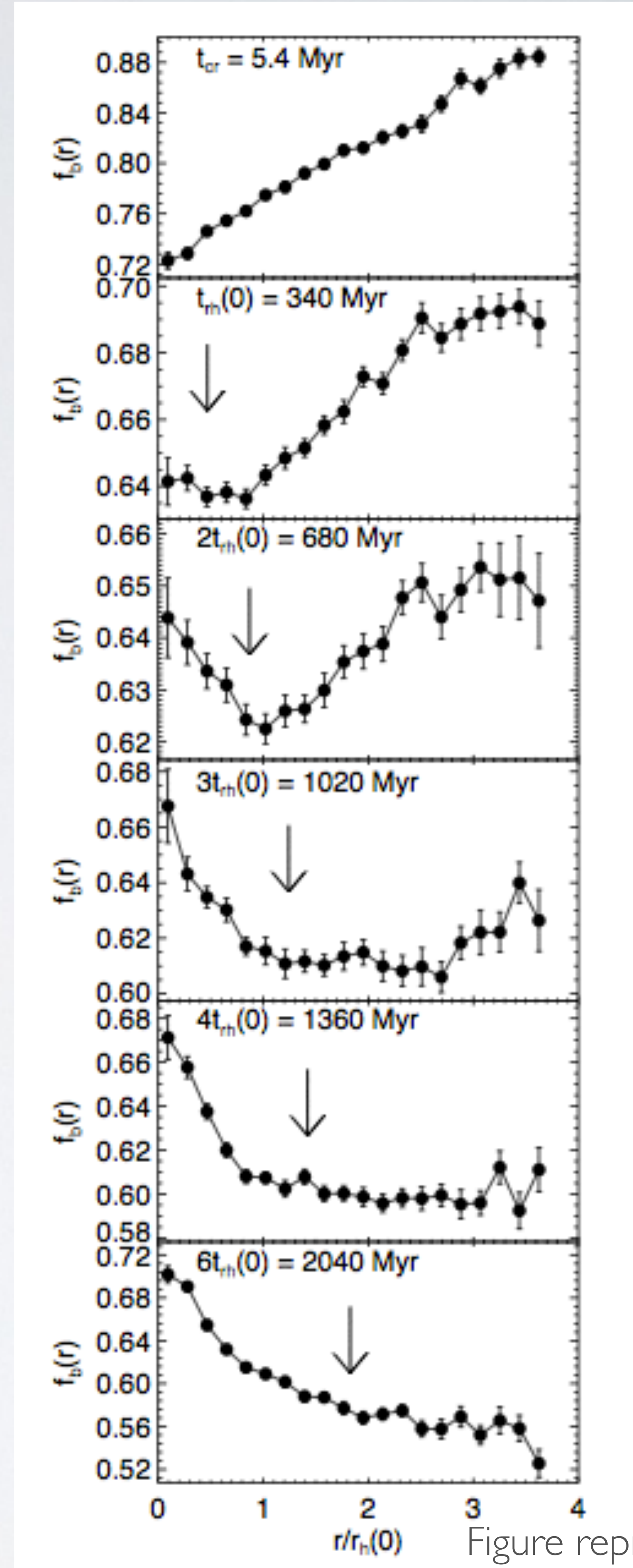
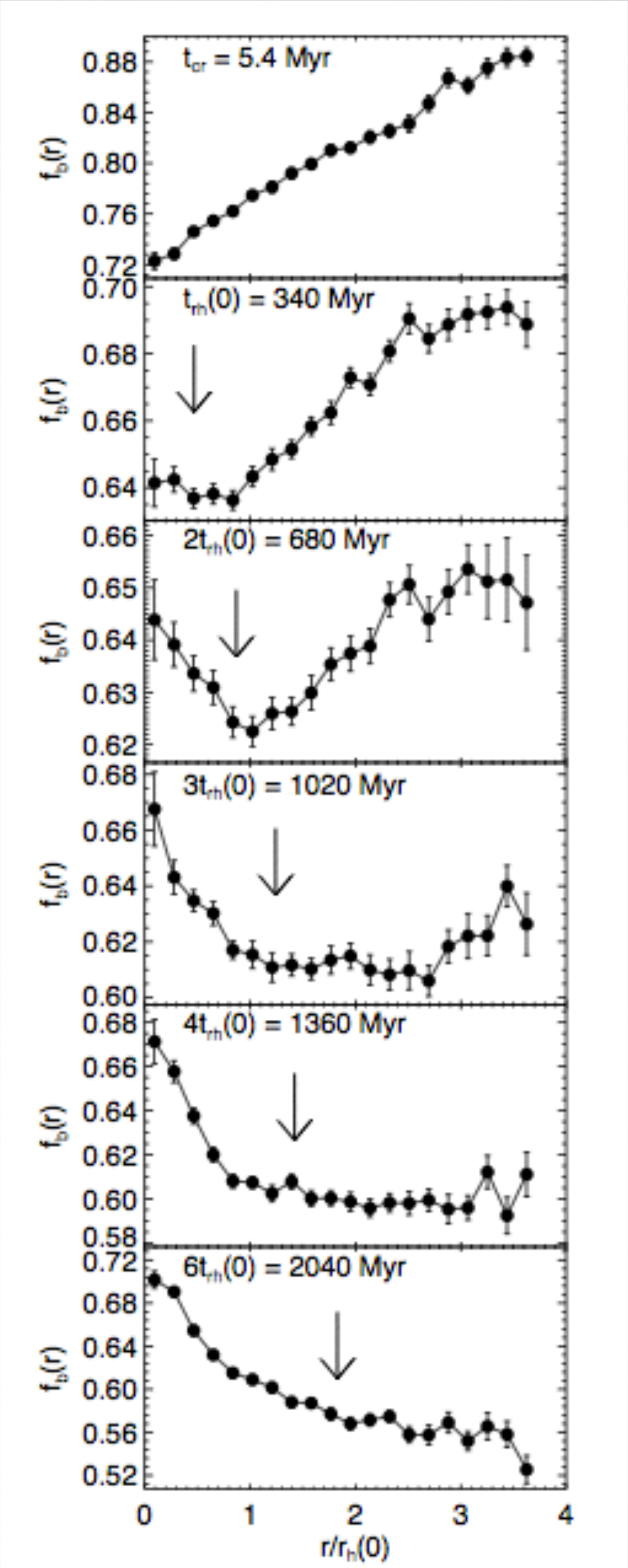


Figure reproduced from Geller et al. 2013

COMPUTERS!

- What's going on here?
  - Binary % distribution is initially flat
  - "Weak" binaries disrupted easily
  - More interactions in core = more binaries disrupted
  - Evolution is interplay between disruption + mass segregation
- NGC 1818 is young: supports de Grijs. What did Elson et al. see?



WHAT IS GOING ON?

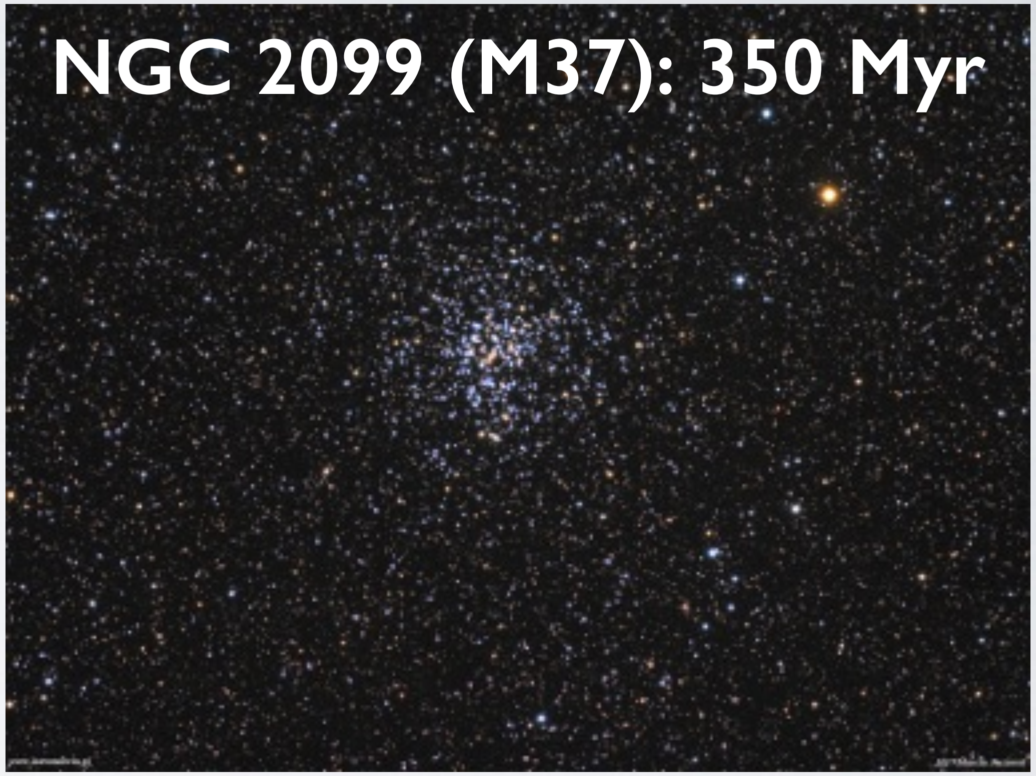
- de Grijs et al. state that their binary detection method (also used by Elson et al.) cannot work outside 1.3 - 1.6 M_{sun} range.
  - Elson et al. results likely due to contamination
- Both studies don't overlap the same mass region. Can they both be right?
  - Let's find out!

BINOCS

- NGC 1818 has observed stars between 0.6 - 6 $M_{sun.}$ Why can we only use 0.3?
  - Method used by de Grijs + Elson is quite susceptible to errors.
  - Can only detect binaries with mass ratio > 0.55!
- My research involves a new method of detecting binaries: BINOCS
  - **B**inary **IN**formation on **O**pen **C**lusters using **S**EDs
  - Everything in astronomy must have a clever acronym
- Vast improvement over previous methods:
  - Can use entire mass range (0.6 - 6 M_{sun} for NGC 1818)
  - Minimum mass ratios ~ 0.3

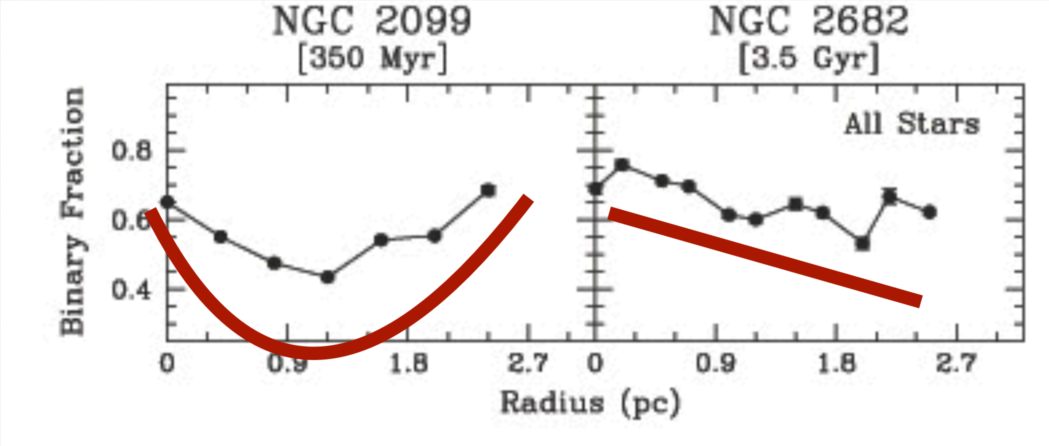
OPEN CLUSTERS

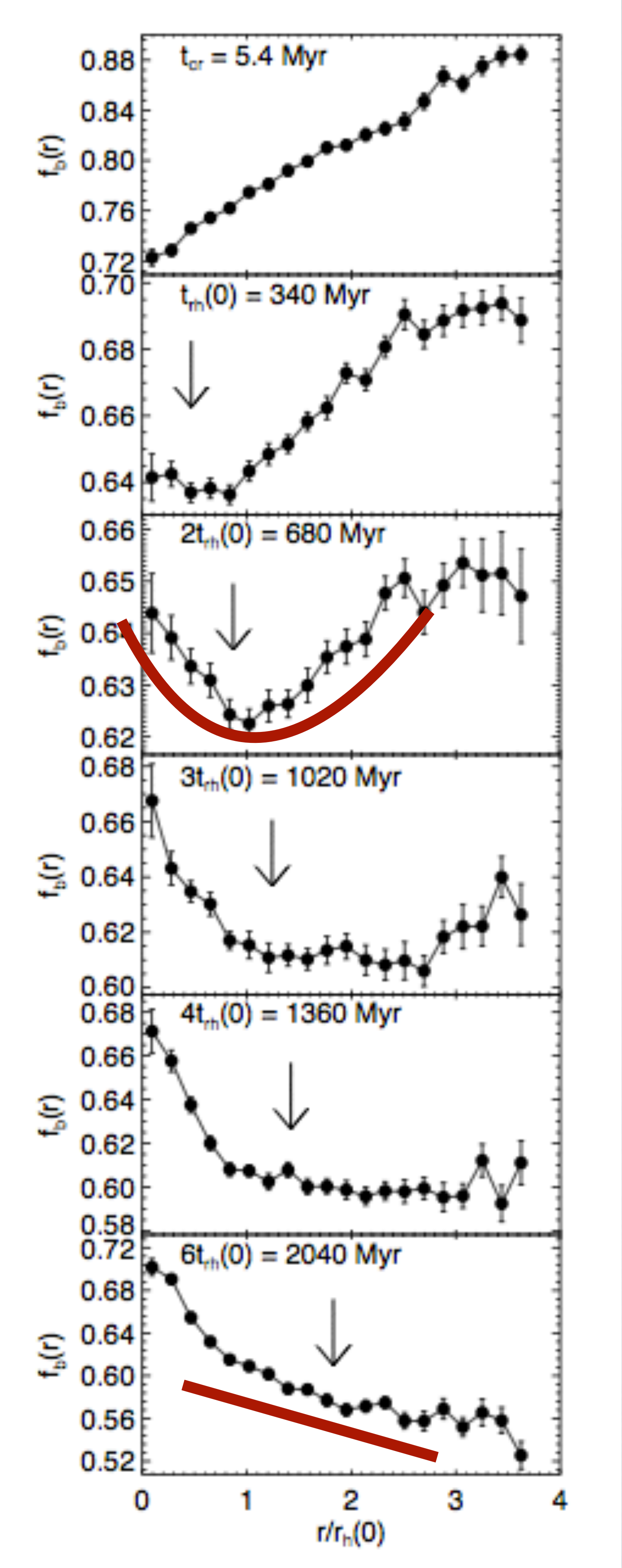
- We want to look at how binary % evolves
  - Do we see the same thing as simulations?
  - Take 2 clusters with vastly different ages



RESULTS I

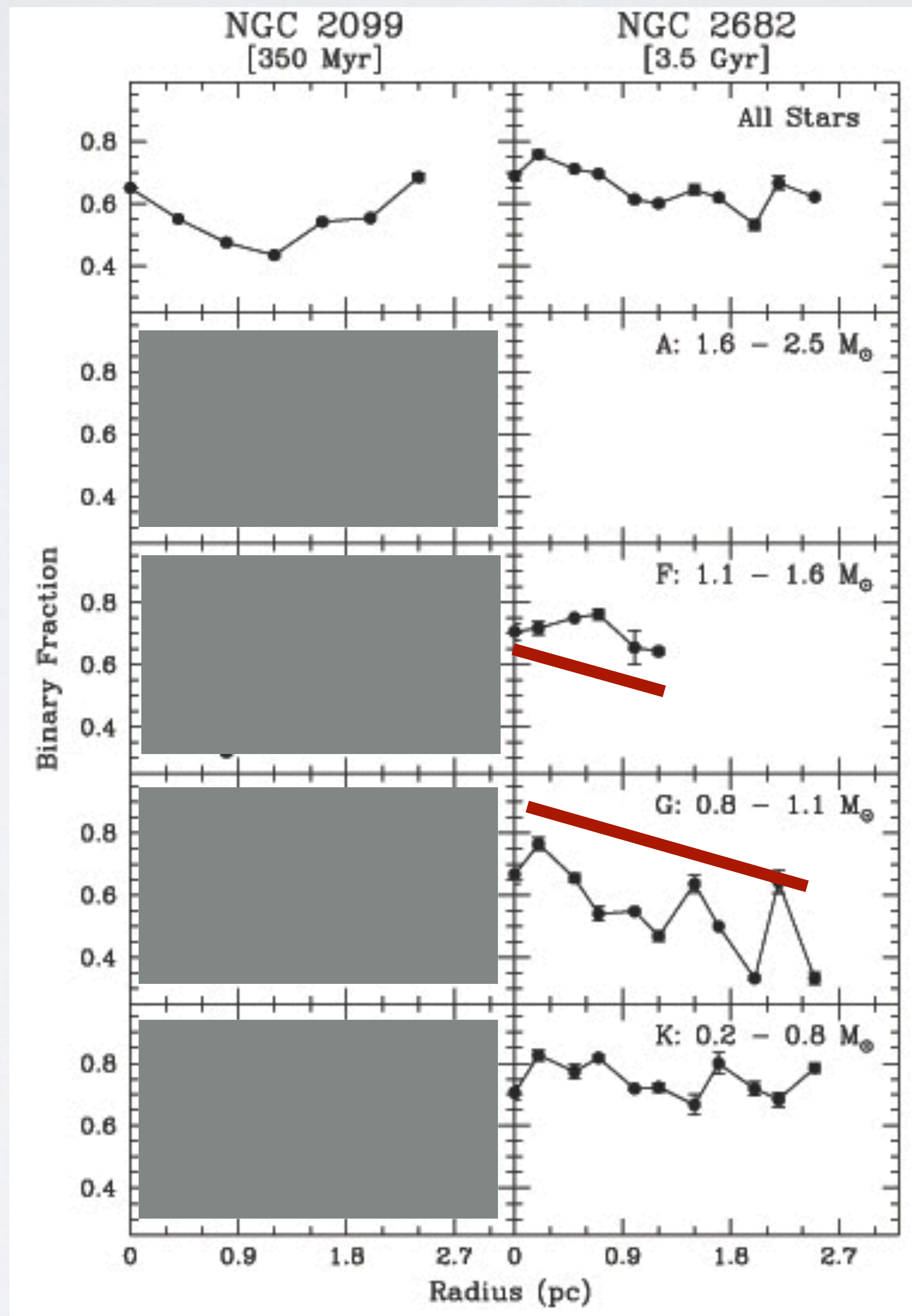
- Computed binary % as a function of radius for both clusters:

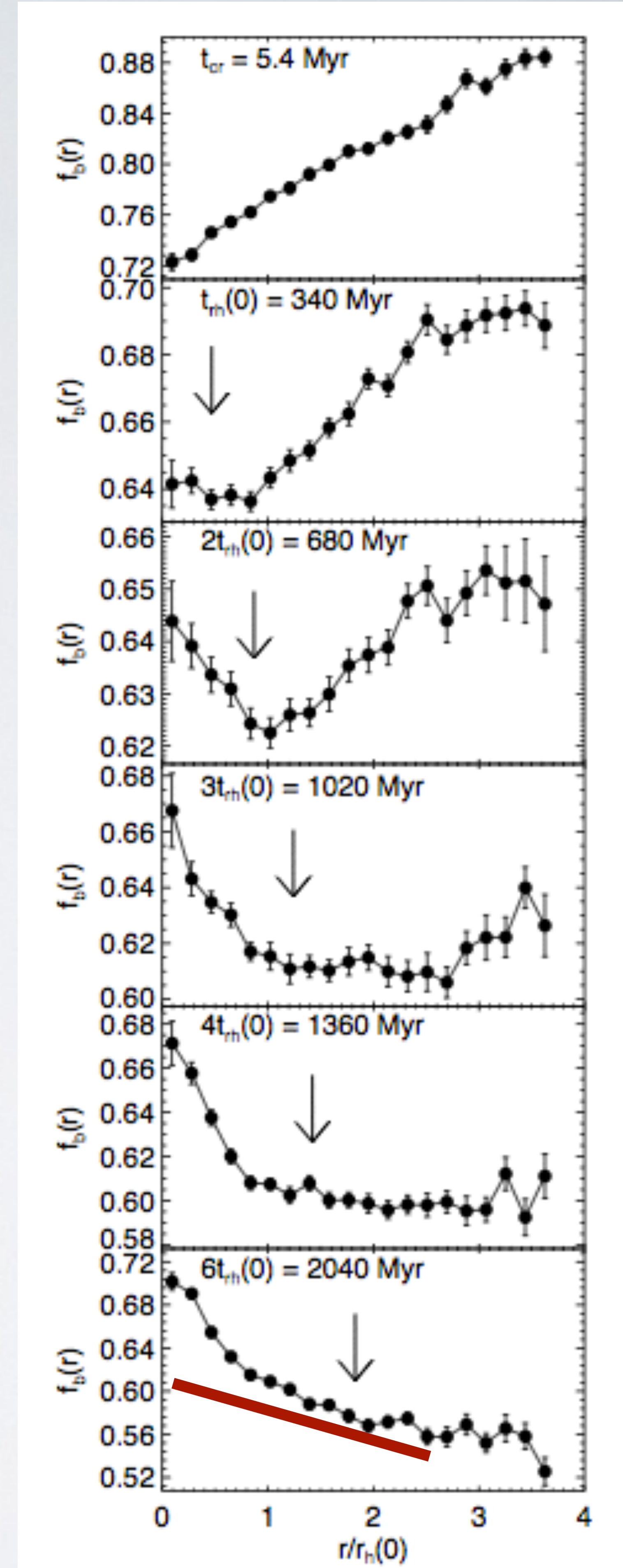




RESULTS II

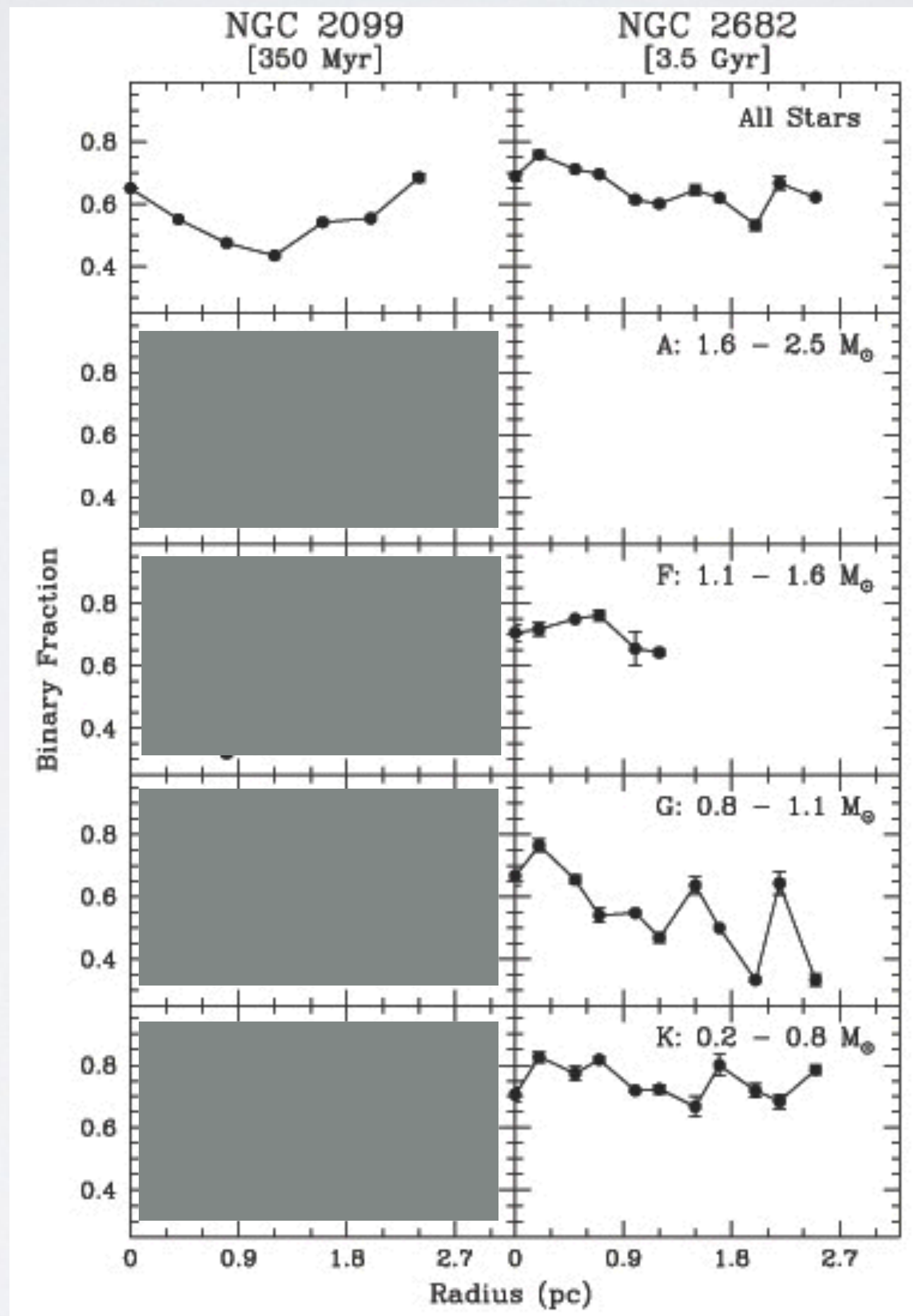
- BINOCS can work for a large range of masses.
- How does radial trend change with mass?
- M67: all mass ranges segregated

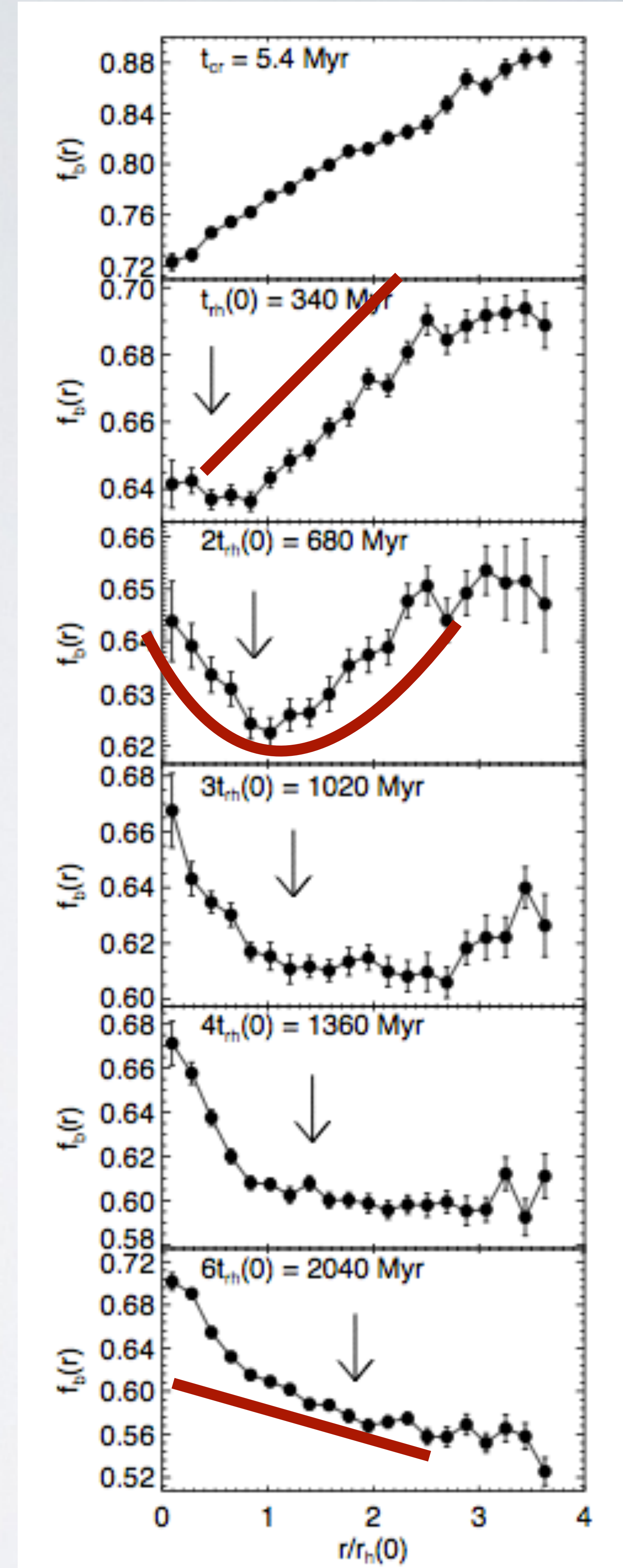




RESULTS II

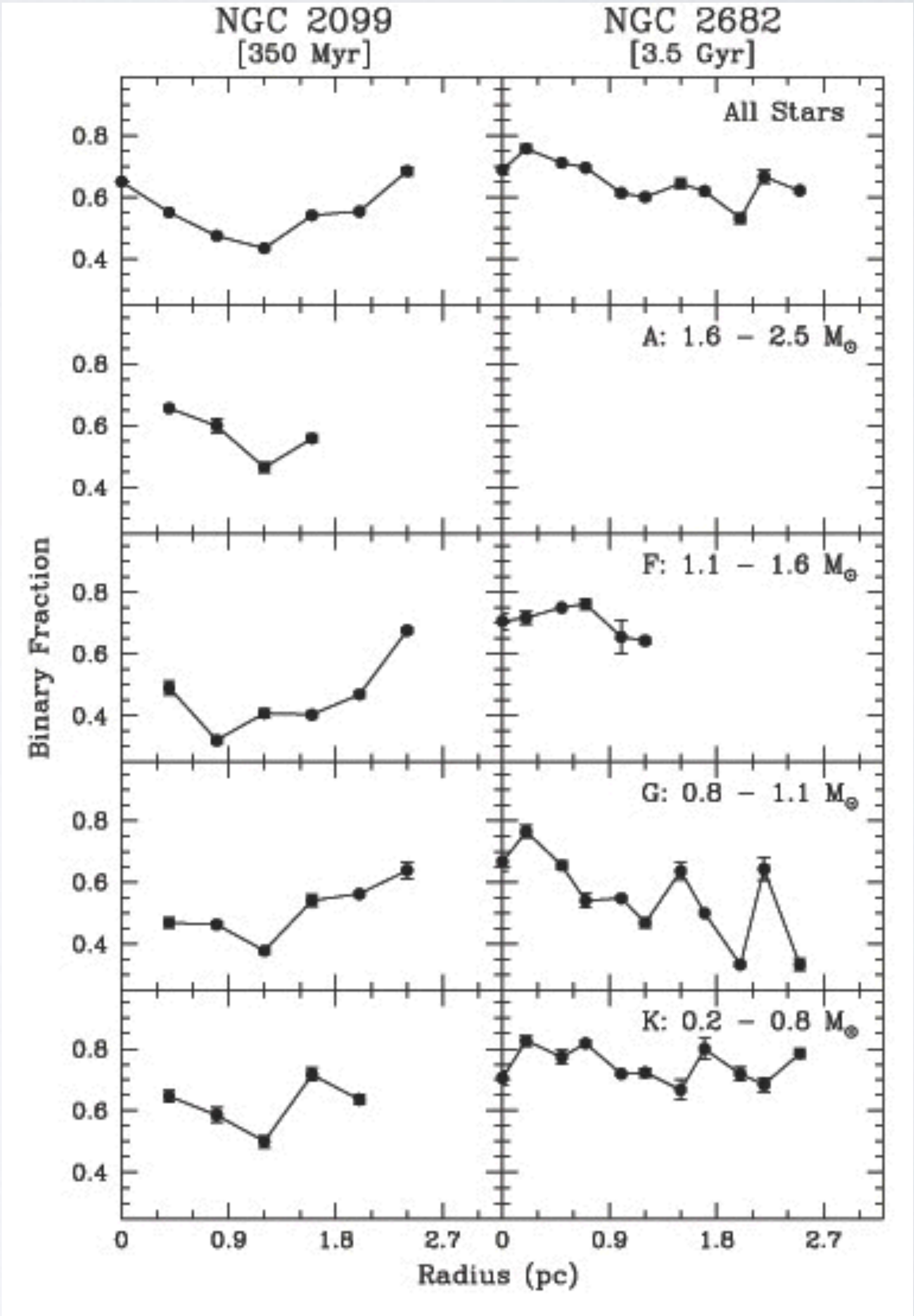
- M37:
  - A Stars: segregated
  - F Stars: In-Between
  - G Stars: anti-segregated
- Vastly different results for different mass ranges!





DOES THIS MAKE SENSE?

- It appears that different mass stars evolve with different timescales
  - Same *chronological age*, different *dynamical age*
- This makes sense:
  - Larger stars have larger "gravitational cross-sections"
  - Higher cross-section ➤ higher # of interactions
  - Higher # of interactions ➤ quicker equipartition of energy



NGC 1818 REVISITED

- de Grijs et al. brings up a good point about Elson et al.'s results being contaminated
    - This does not mean Elson et al.'s observations are wrong
- Does not mean 2 results are incompatible
    - 2 - 5.5 M_{sun} stars may be *dynamically old*
    - 1.3 - 1.6 M_{sun} stars may be *dynamically young*

SUMMARY

- BINOCS method was able to determine binary fractions for a large range of masses
- Using 2 open clusters, we were able to “solve” the problem of NGC 1818
  - Chronological age $\neq$ dynamical age

QUESTIONS?