Mass segregation influence on weighting young star clusters

Jean-Julien Fleck

Observatoire Astronomique de Strasbourg

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Coll. with C.Boily, A.Lançon, D.Heggie & S.Deiters

Where does it come from ?

- Observations :
  - Half-Light Radius, 1D Dispersion
  - Equilibrium ? Tides ?
- Theory :
  - Half-Mass Radius, 3D Dispersion
  - Equilibrium => Virial Theorem

$$M = \eta \frac{R_{hl}\, \sigma_{los}^2}{G}$$

Mass segregation

- Origin : Thermical equilibrium of different masses (tend to equalize Kinetic energy)
- Implications : massive particules get lower mean speed
- Astrophysic : Mean radius decreases for high masses

Implications

- Dynamical Issue : equilibrium for a multi-mass system ?
- Observationnal Issue : Massive stars dominate light flux and thus radius and dispersion estimations.

Characteristic Times

- Relaxation Time

$$\frac{t_{\mathrm{r}}}{t_{\mathrm{cr}}} \simeq 0.138 \left[\frac{r_{\mathrm{hm}}}{2r_{\mathrm{g}}}\right]^{3/2} \frac{\mathrm{N}}{\ln(0.4\,\mathrm{N})}$$

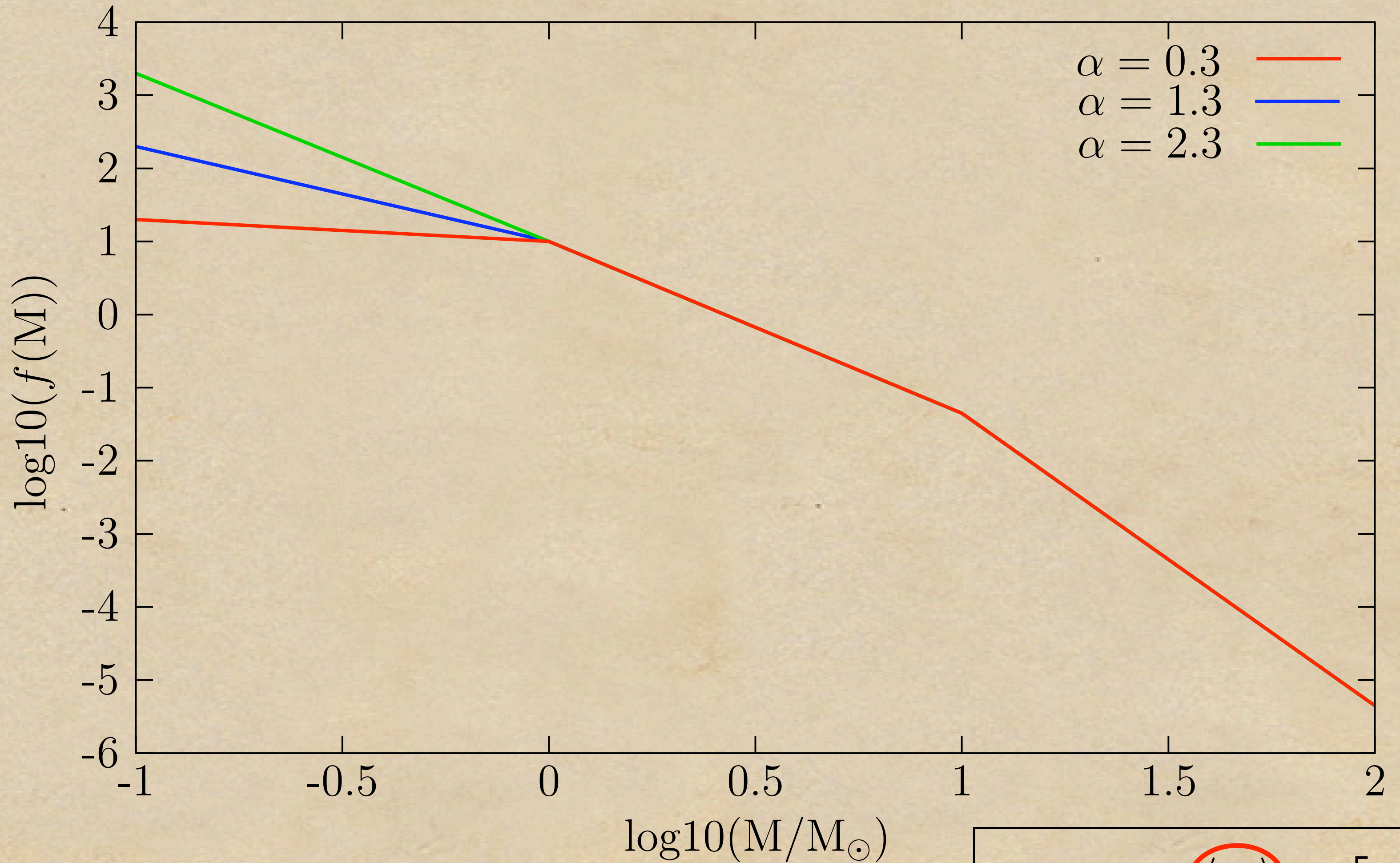
- Segregation Time

$$\frac{t_{\mathrm{ms}}}{t_{\mathrm{r}}} \simeq \frac{\pi}{3} \frac{\langle m \rangle}{m_{\mathrm{max}}} \frac{\bar{\rho}}{\rho} \left[\frac{r_{\mathrm{hm}}}{r_{\mathrm{g}}}\right]^{3/2}$$

Code & Assumptions

- Gaseous model:
    - Spedi from R. Spurzem
    - S. Deiters added stellar evolution
- Spherical and continuous
- Mass sampling: 35 components
- THE more massive group dominates
- Stellar genocide

Initial Mass Function (IMF)



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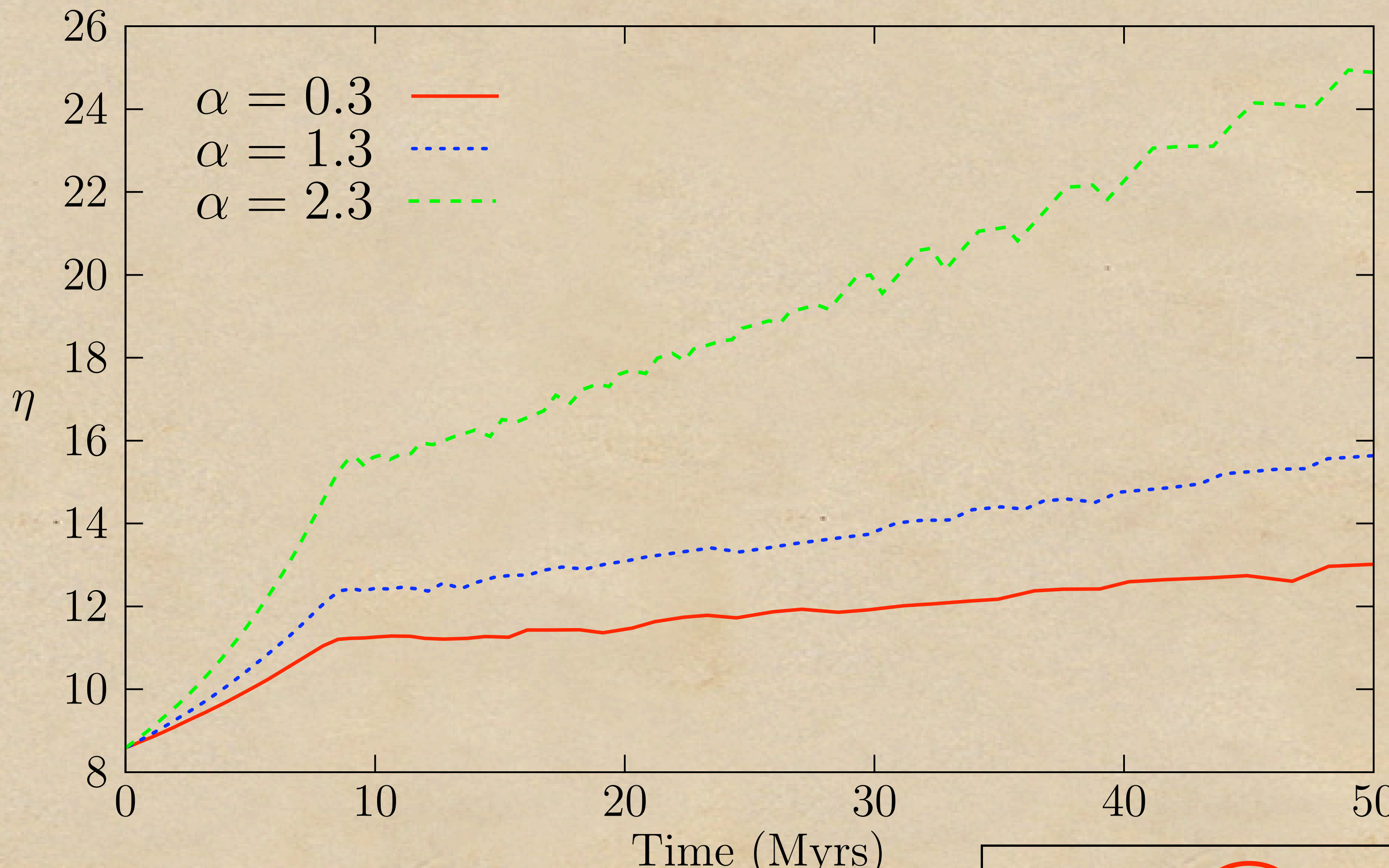

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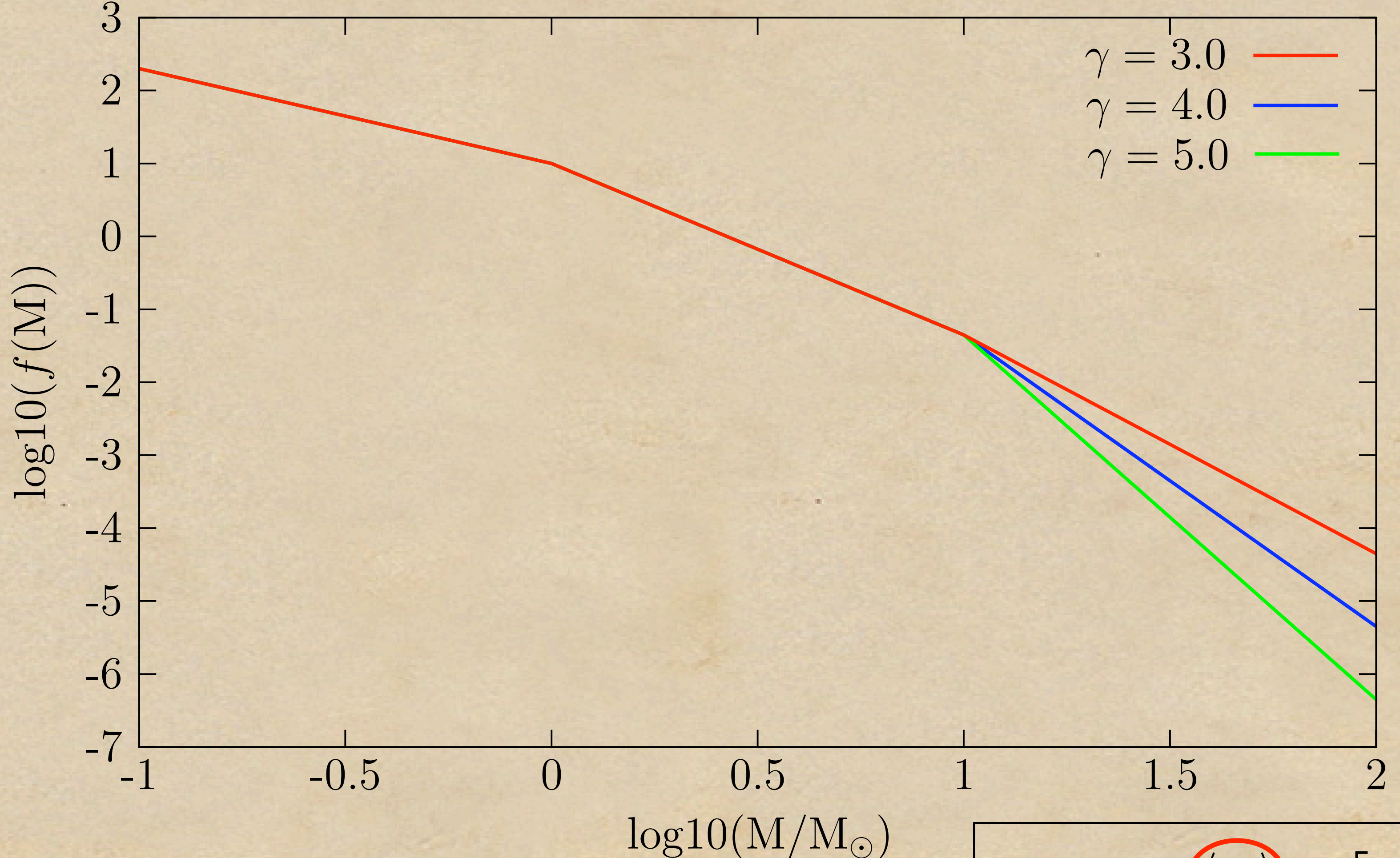

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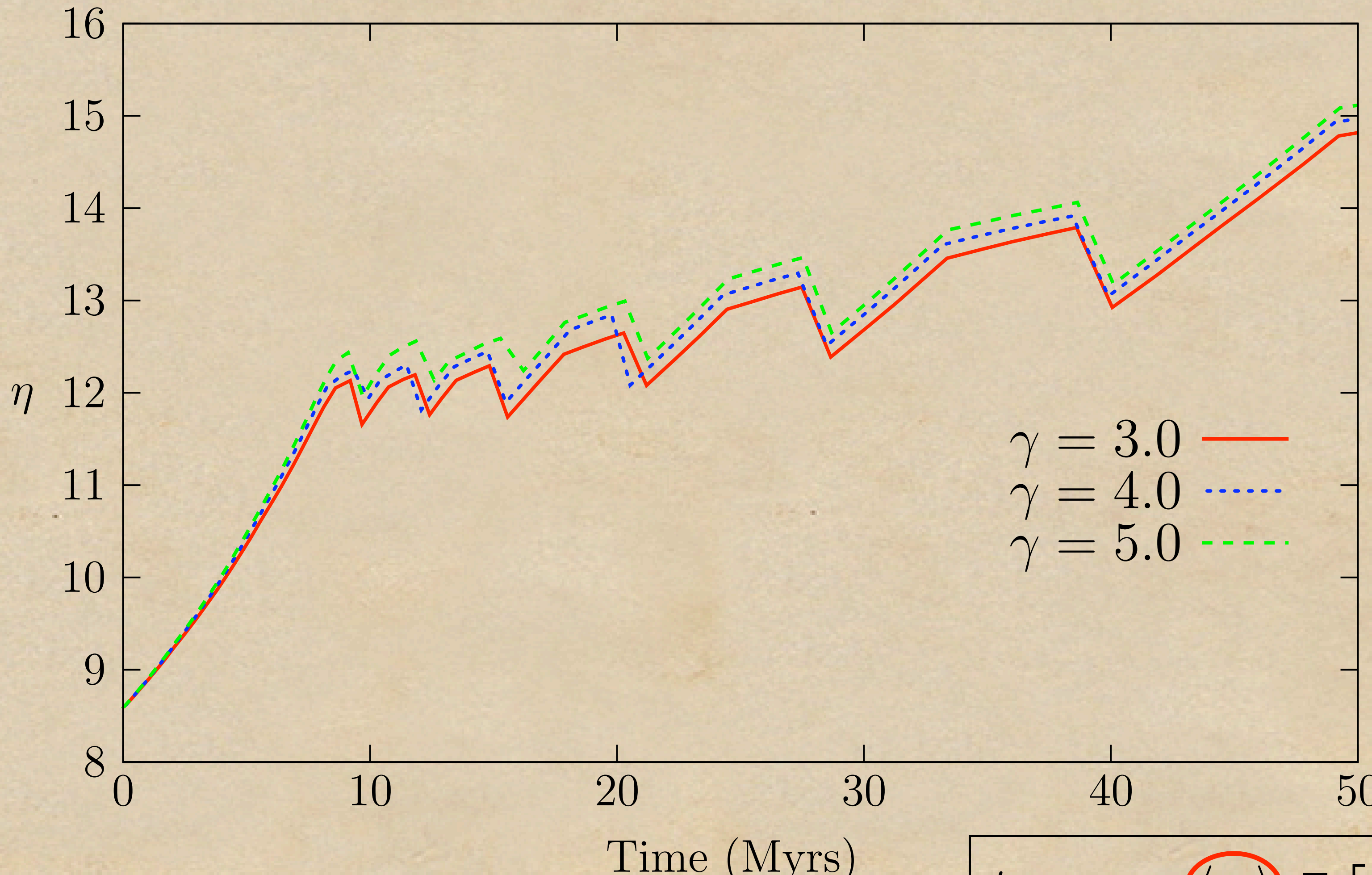

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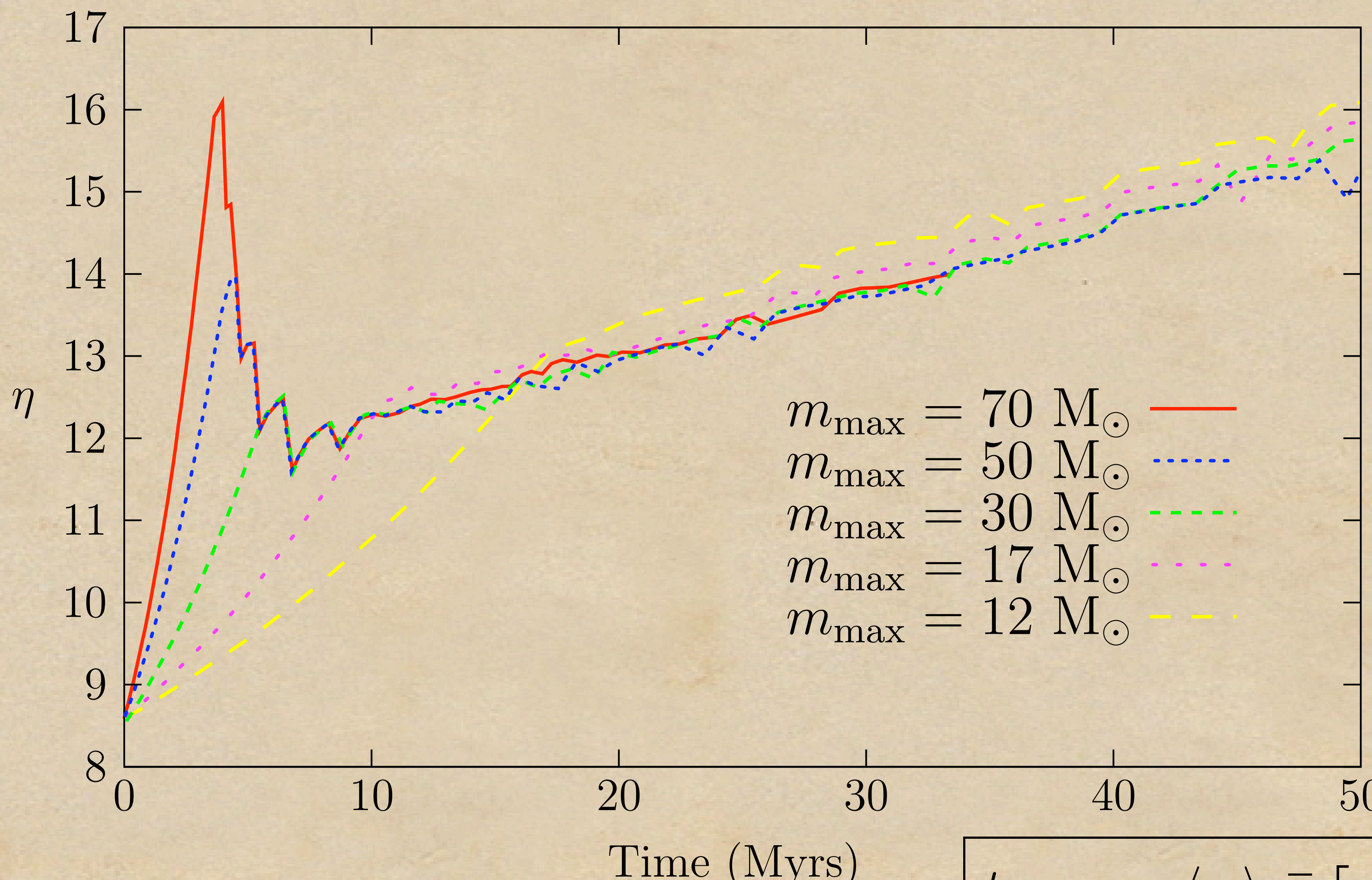
Mass extension



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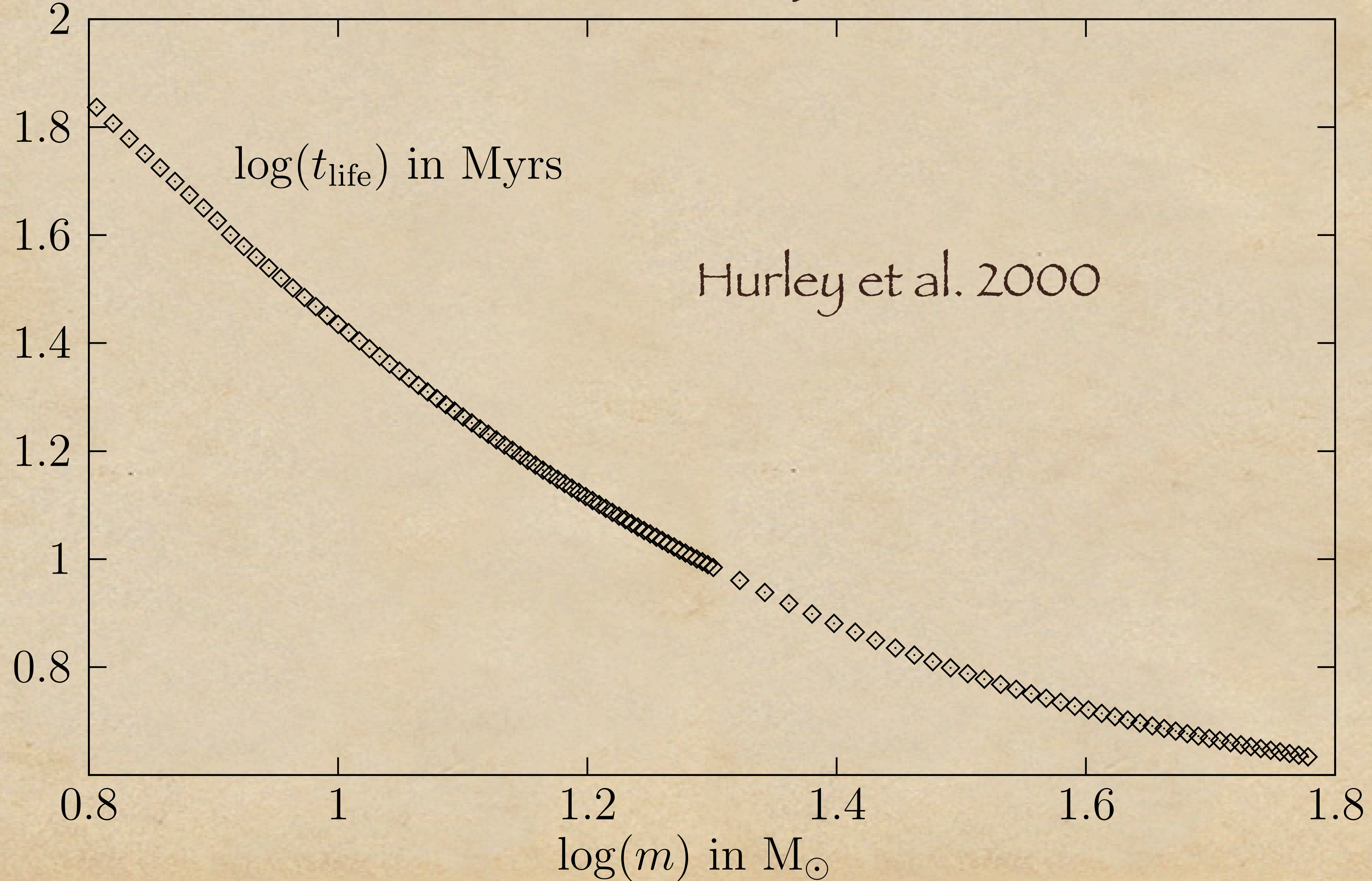
Theoretical expectation



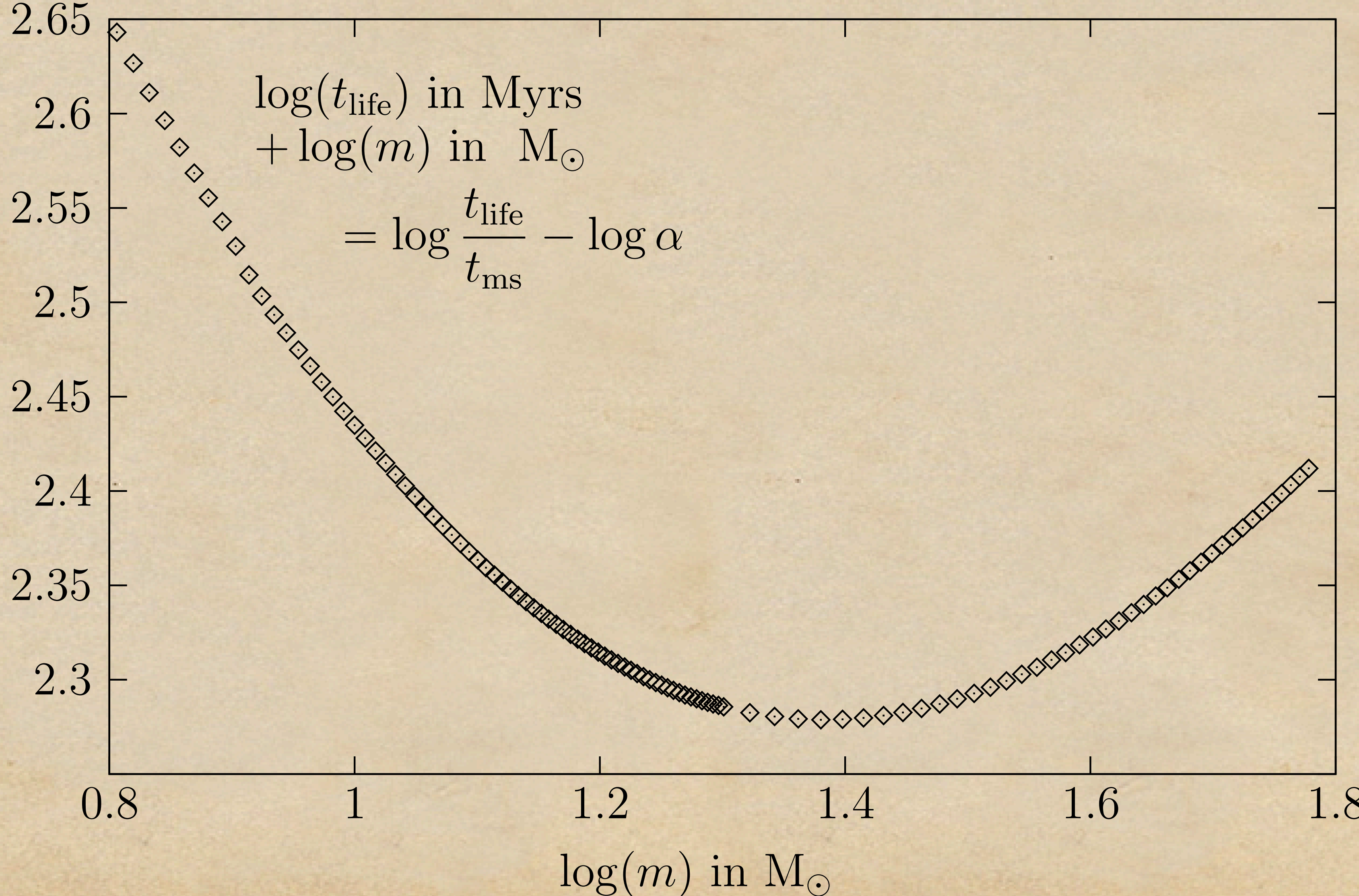
Theoretical expectation

Exponential growth on timescale $t_{\rm ms} = \dfrac{\alpha}{m}$

Comparison life-time vs segregation time

$\Rightarrow$ Compare $\exp\left[\dfrac{t_{\rm life}}{t_{\rm ms}}\right]$

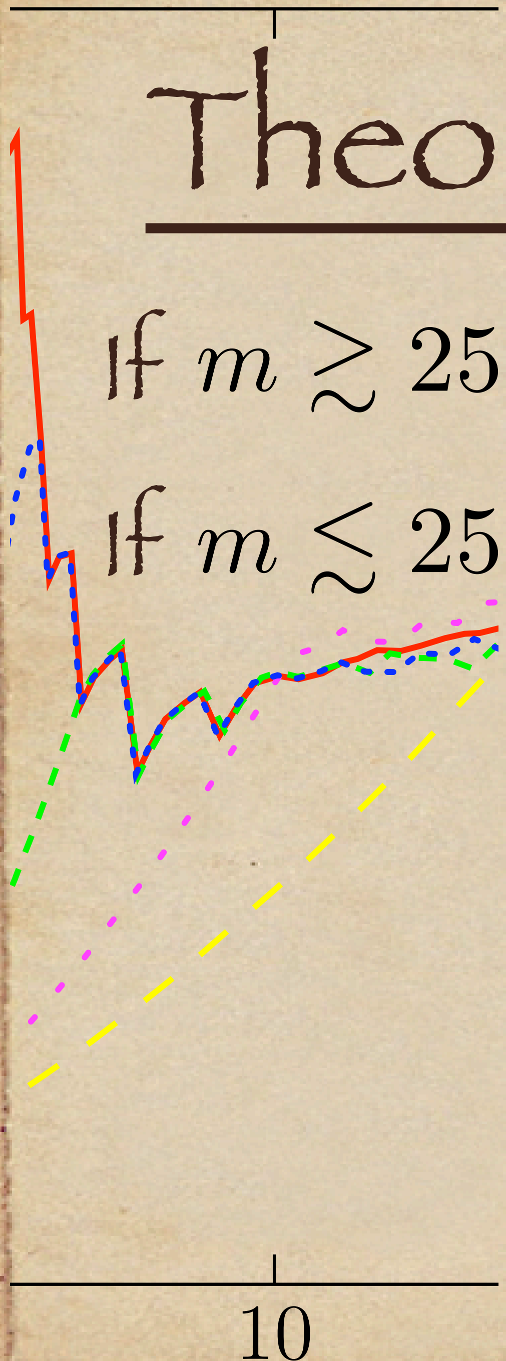
Theoretical expectation



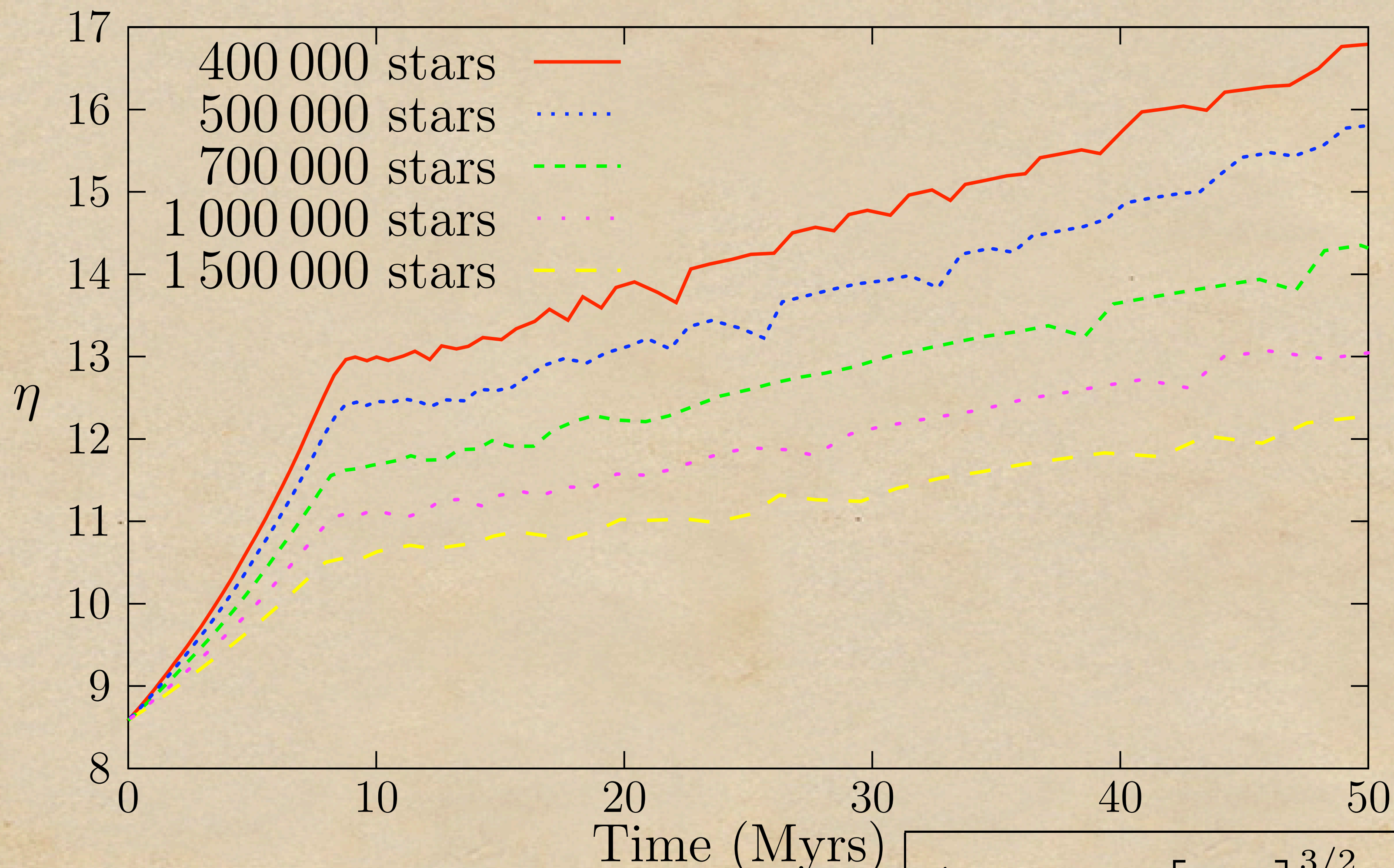
Theoretical expectation

If $m \gtrsim 25\ \mathrm{M}_\odot$ Then η decreases in mean

If $m \lesssim 25\ \mathrm{M}_\odot$ Then η increases in mean

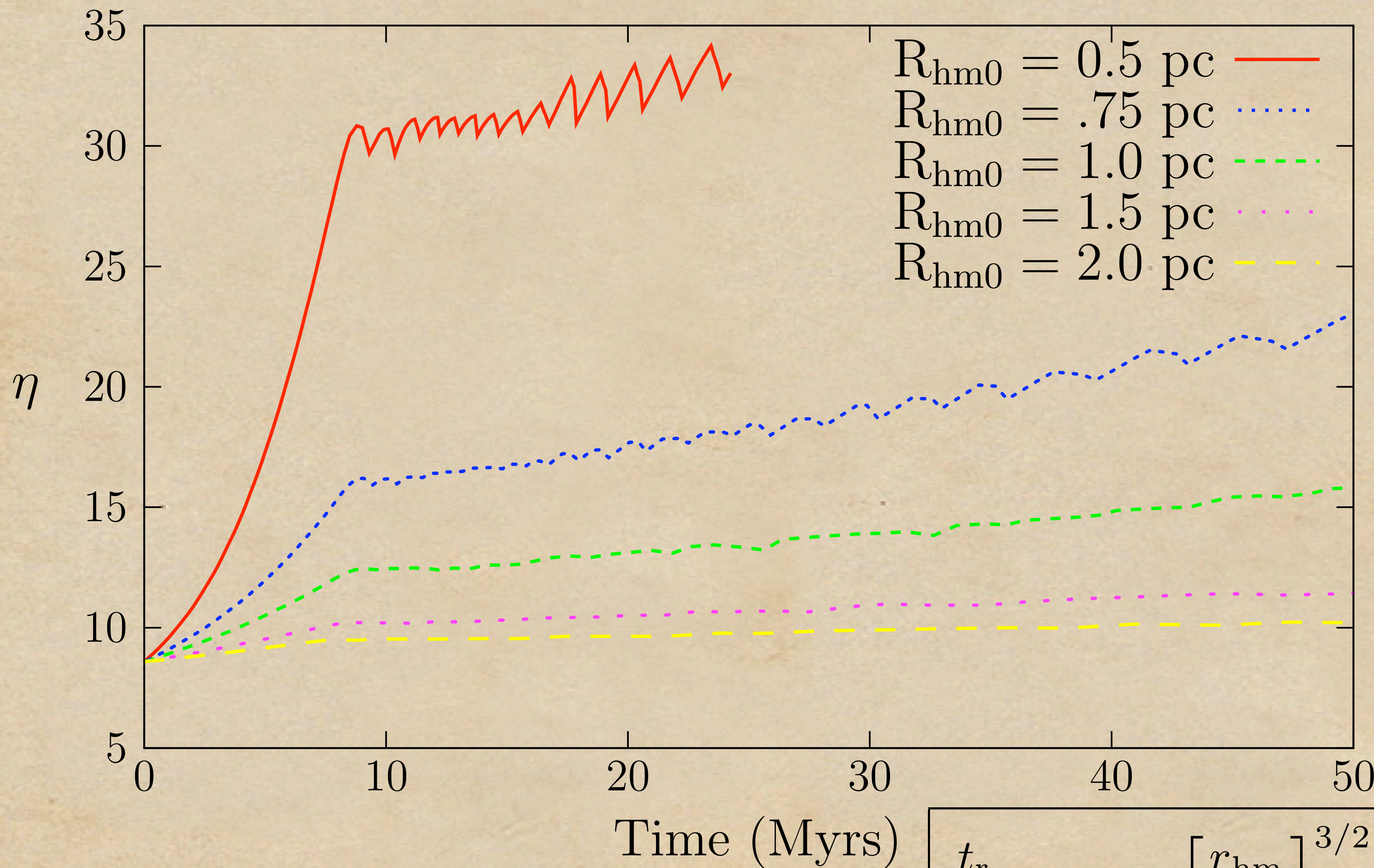


Star number



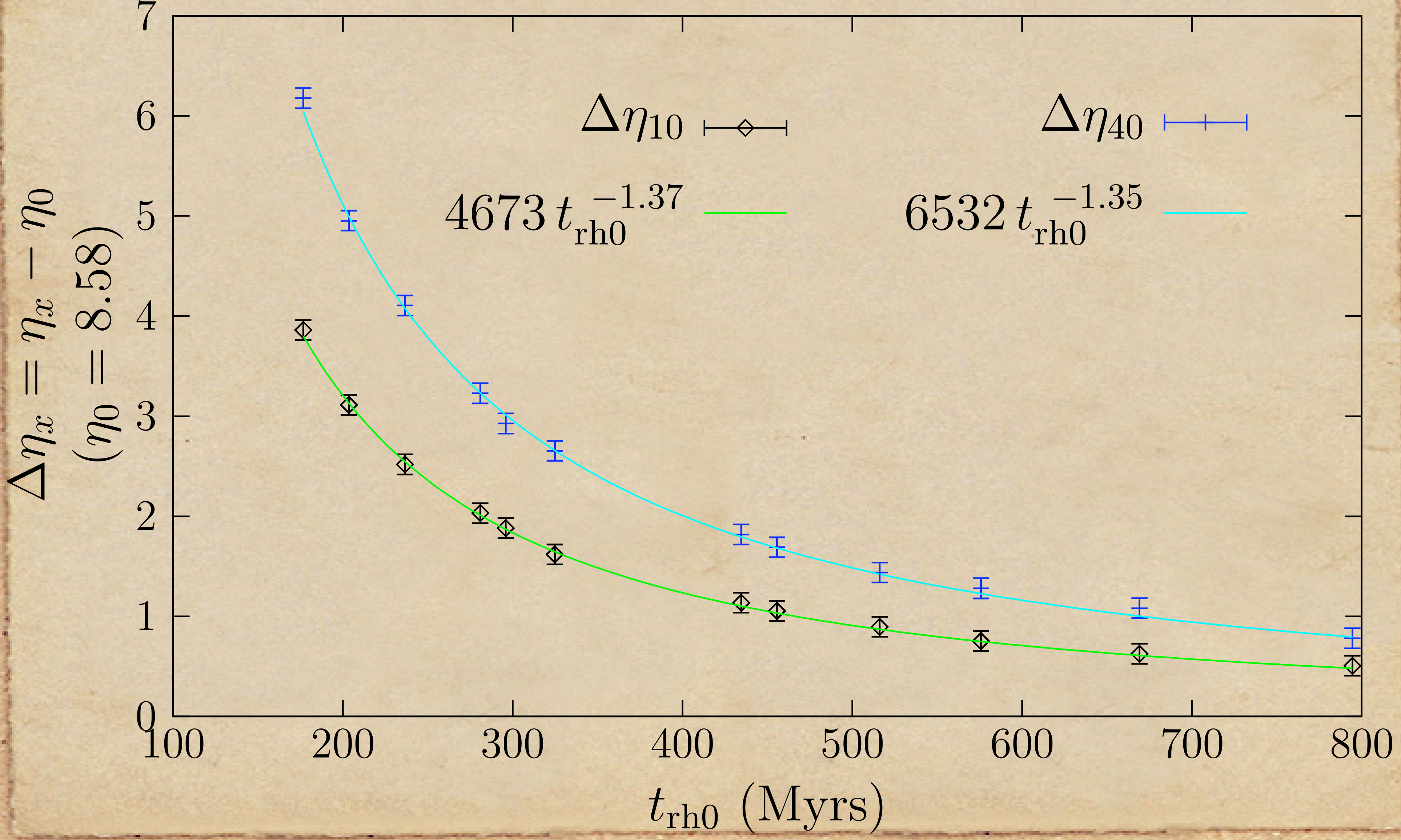
$$\frac{t_{\mathrm{r}}}{t_{\mathrm{cr}}} \simeq 0.138 \left[\frac{r_{\mathrm{hm}}}{2r_{\mathrm{g}}}\right]^{3/2} \frac{\mathrm{N}}{\ln(0.4\,\mathrm{N})}$$

Size -> crossing Time

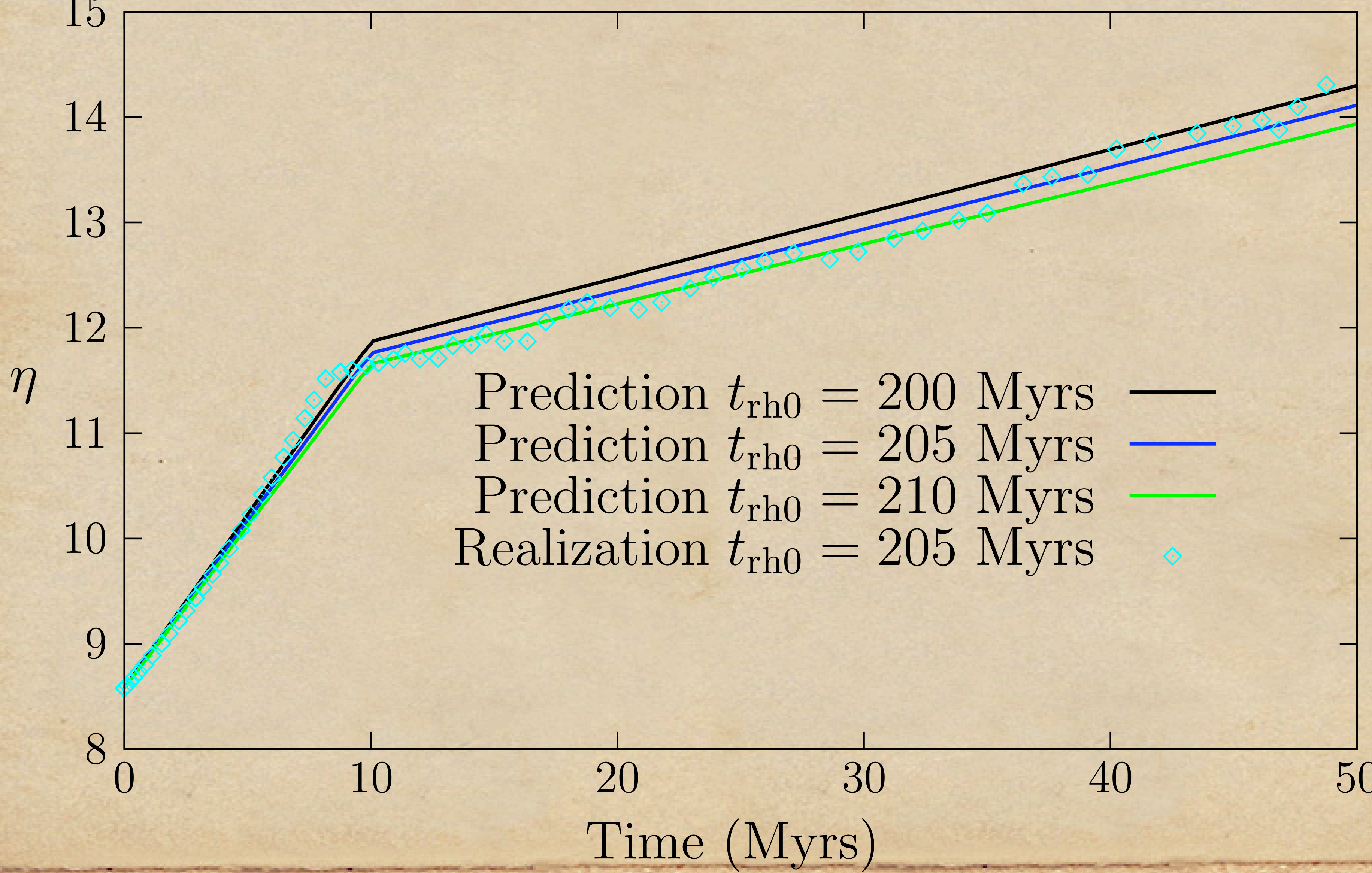


$$\frac{t_{\rm r}}{t_{\rm cr}} \simeq 0.138 \left[\frac{r_{\rm hm}}{2r_{\rm g}}\right]^{3/2} \frac{\rm N}{\ln(0.4\,{\rm N})}$$

Initial relaxation time

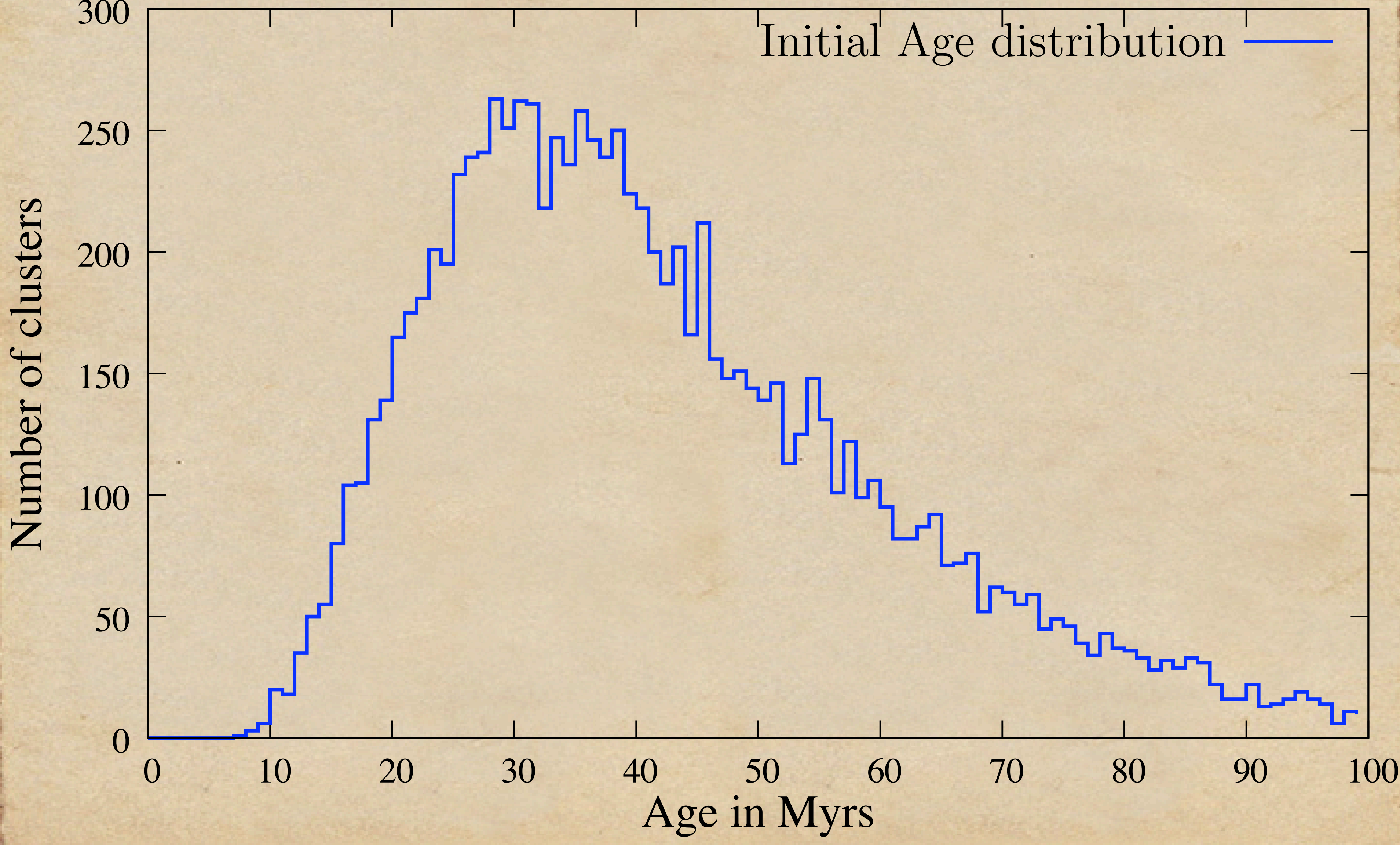


Prediction



15
14
13
12
11
10
9
8
η
0
10
20
30
40
50
Time (Myrs)
Prediction $t_{rh0} = 200$ Myrs
Prediction $t_{rh0} = 205$ Myrs
Prediction $t_{rh0} = 210$ Myrs
Realization $t_{rh0} = 205$ Myrs

Cluster mass function



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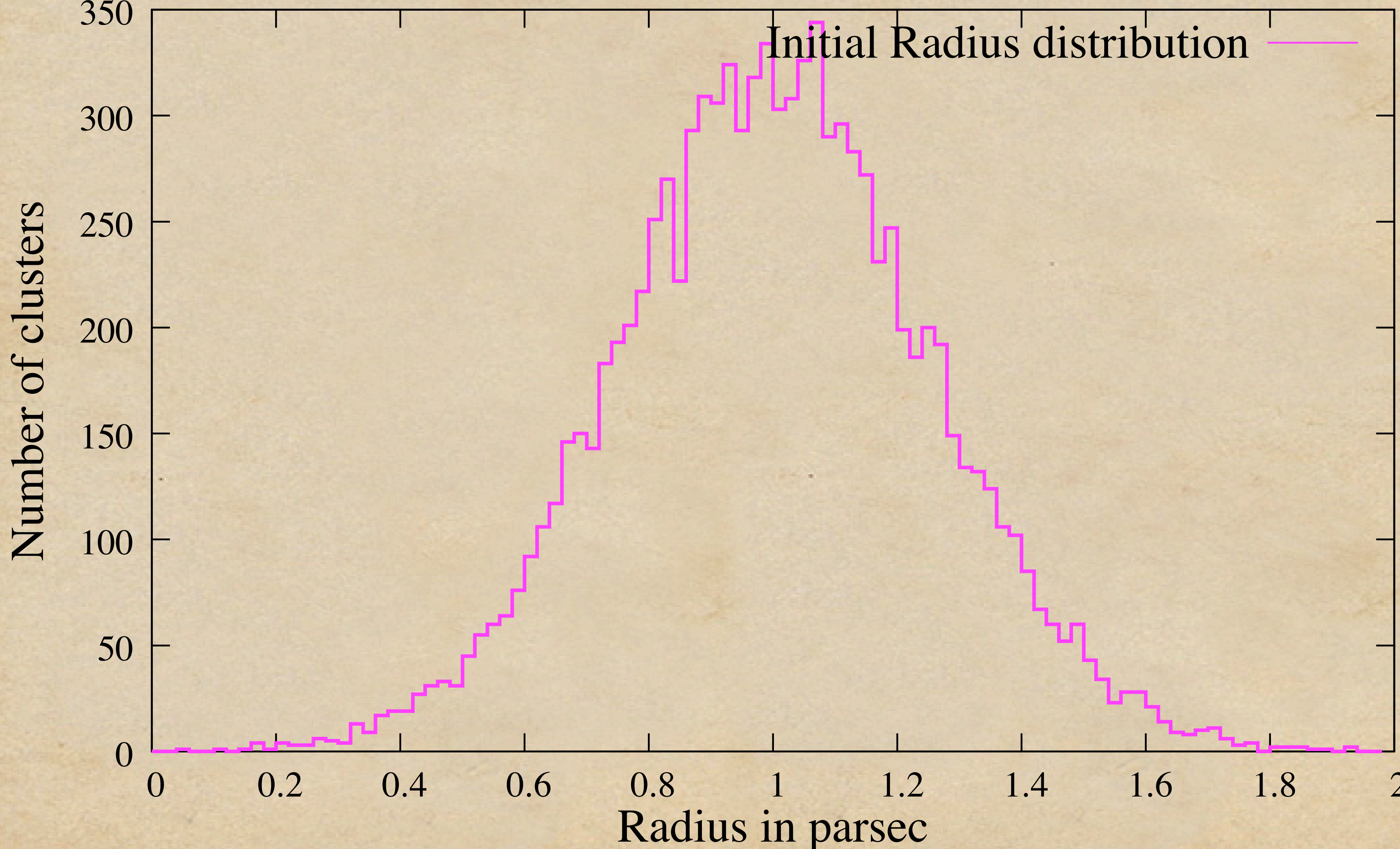

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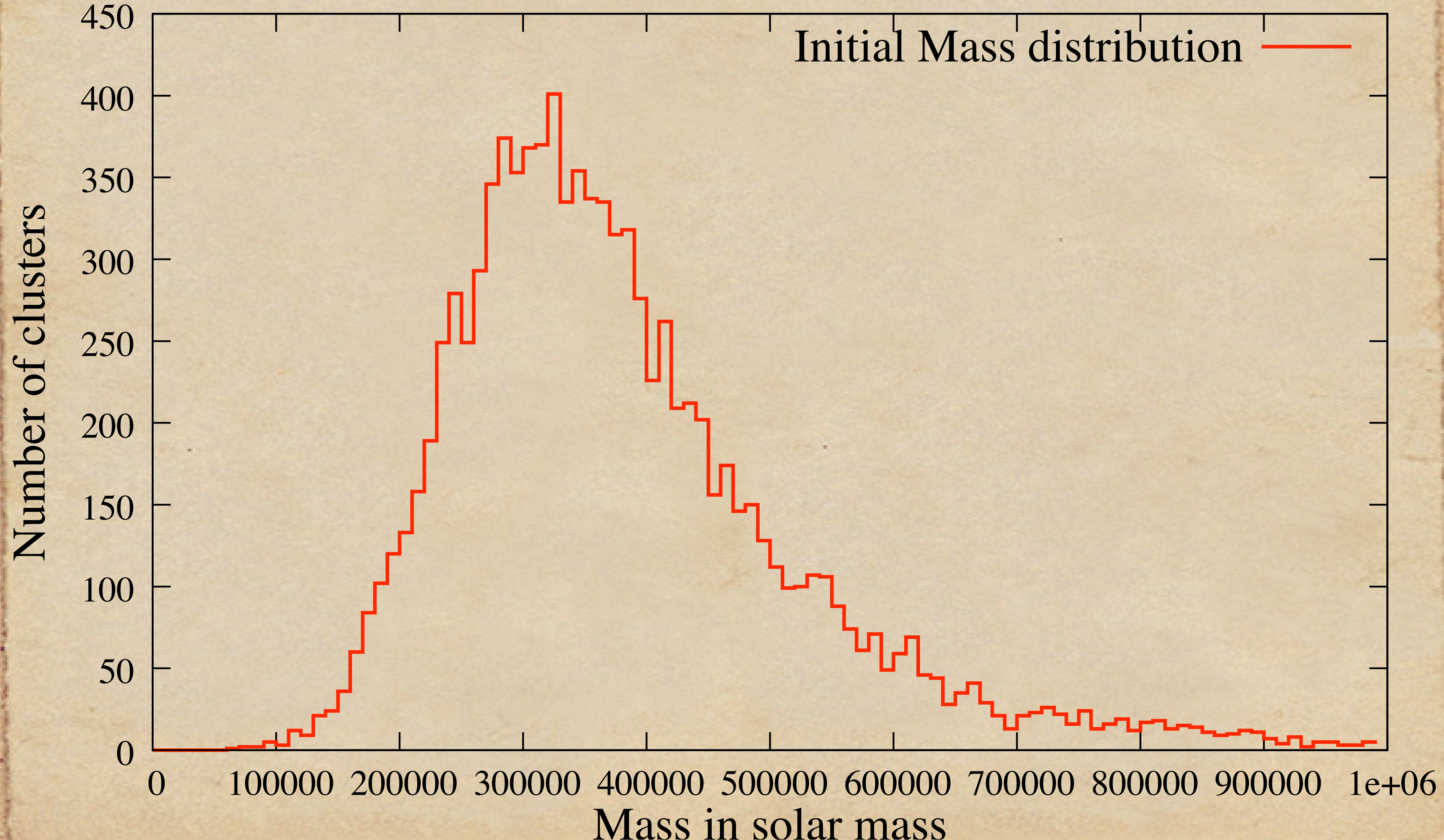

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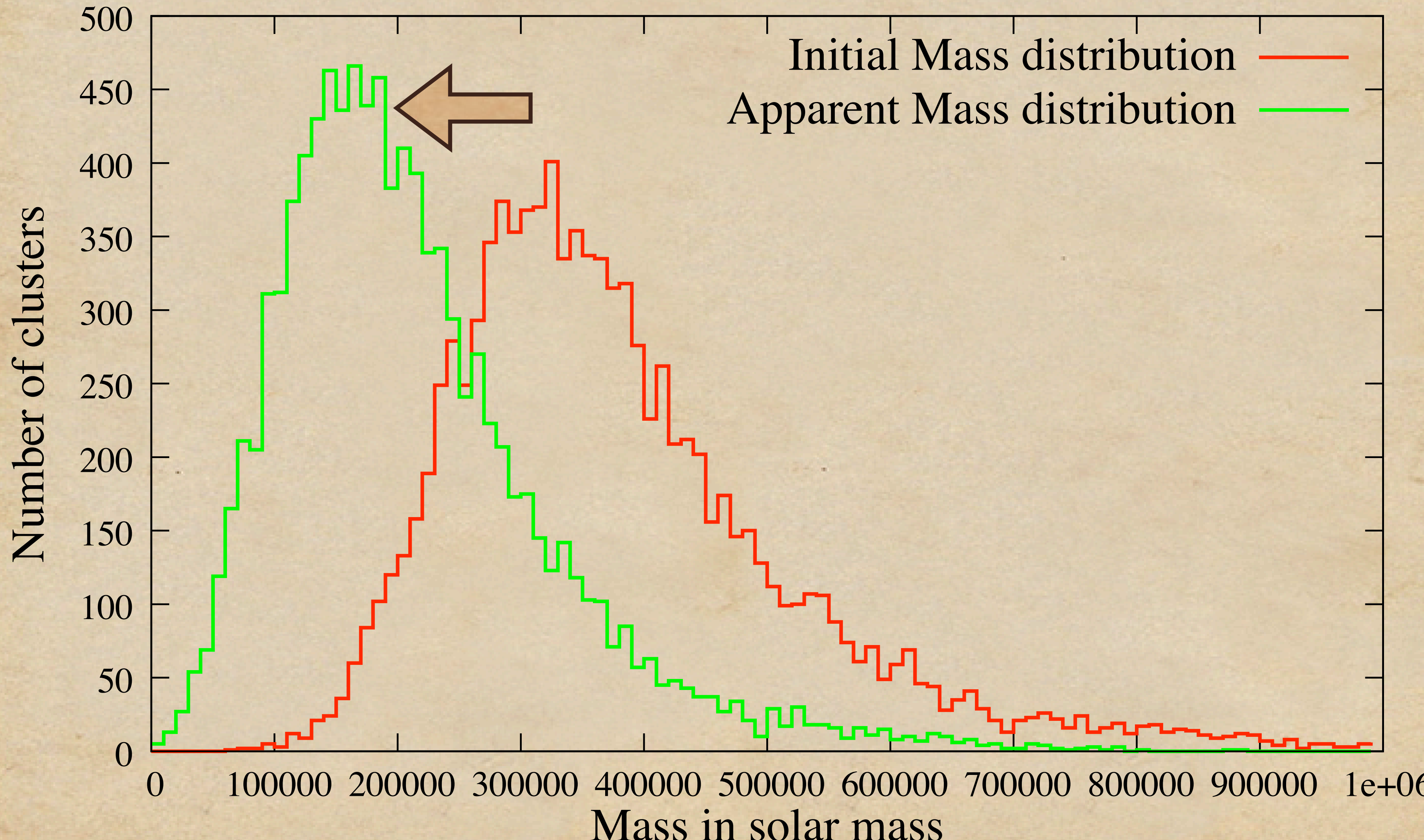

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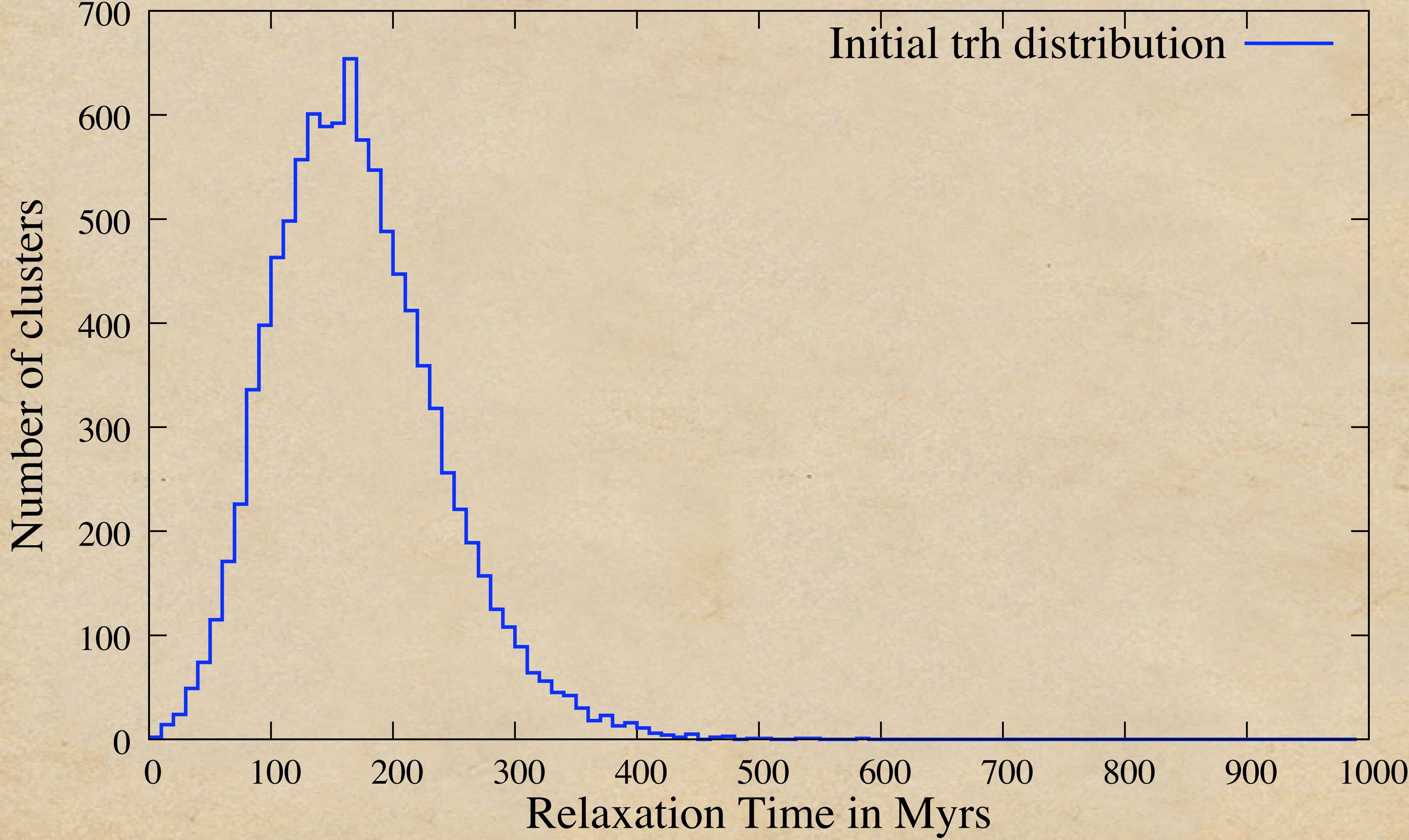

Cluster mass function