The formation and disruption of star clusters

Mark Gieles

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Soeren Larsen, Nate Bastian, Holger Baumgardt,
Remco Scheepmaker & Marcel Haas

ESO Fellow Symposium, Santiago, November 2007

(Formed Dutch Provence)
NORTH SEA
NOORD-HOLLAND
FRIESLAND
GRONINGEN
DRENTHE
FLEVOLAND
OVERIJSSEL
UTRECHT
GELDERLAND
SOUTH HOLLAND
NOORD BRABANT
ZEELAND
LIMBURG
GERMANY
BELGIUM
Delfzijl
Leeuwarden
Groningen
Haren
Drachten
Sneek
Assen
Heerenveen
Stadskanaal
Elsloo
Den Helder
Steenwijk
Emmen
Emmeloord
Meppel
Langedijk
Hoorn
Alkmaar
Kampen
Hardenberg
Edam
Lelystad
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Ommen
Velsen
Zaanstad
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Amsterdam
Heemstede
Hillegom
Hoofddorp
Harderwijk
Wierden
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Nijmegen
Oss
Groesbeek
Katwijk
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Middelburg
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Breda
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Helmond
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Venlo
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Valkenswaard
Tegelen
Roermond
Antwerp
Ghent
Sittard
Stein
Heerlen
Brussels
Maastricht
Kerkrade
Aachen
Bonn
0 20 40 mi
0 30 60 km
53°
52°
51°
4°
5°
6°
7°
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(Formed Dutch Provence)

Happy Birthday Queen Beatrix! ! ! !

Yearly in Amsterdam on April 30th

24H
TVE
elmundo.es

King of Spain!

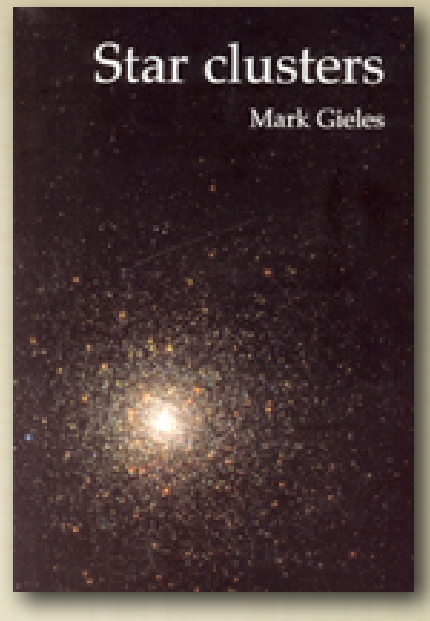
King of Spain!

¨Porque no te callas!? =Why don´t you shut up!?”

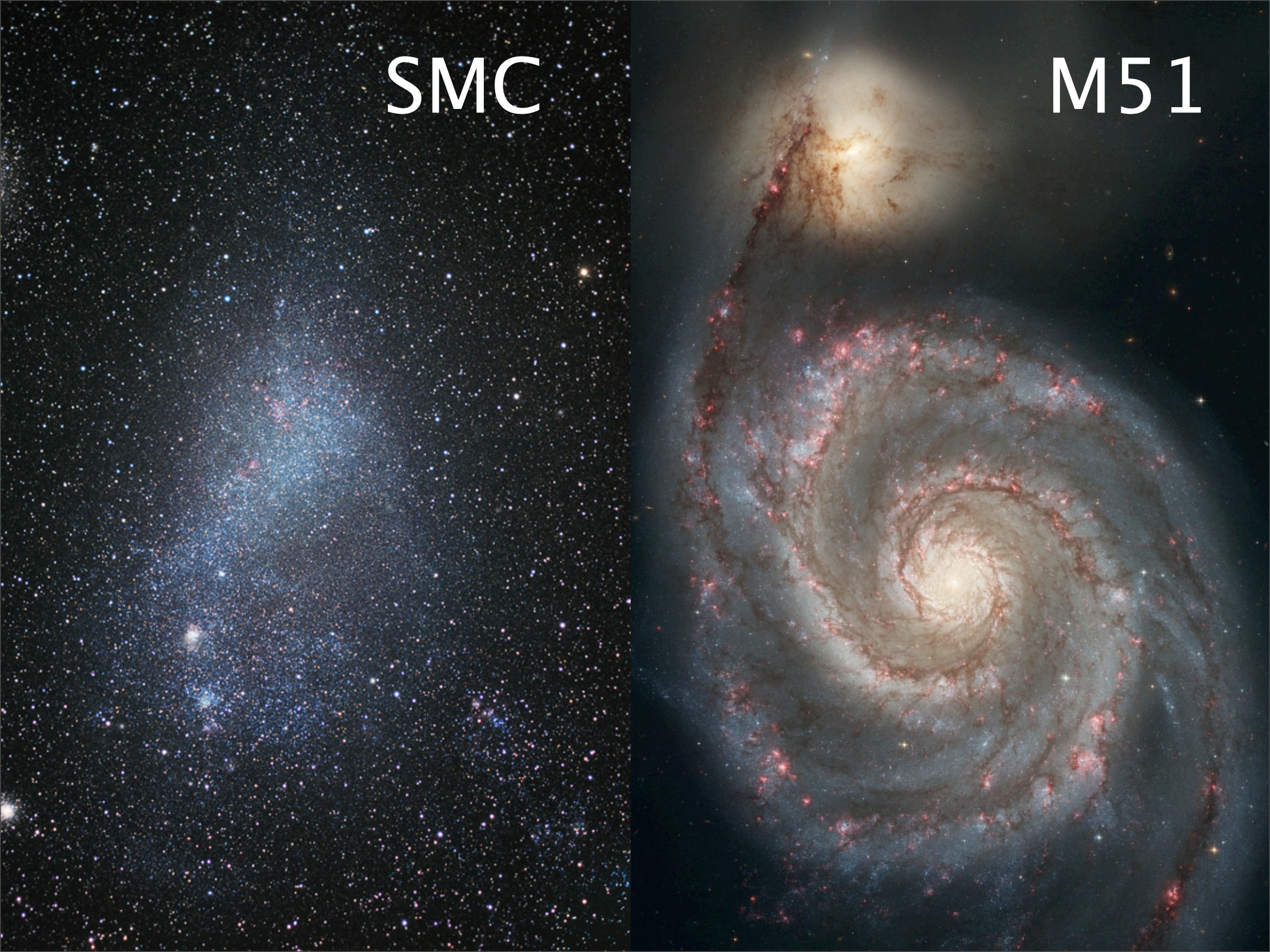
¨Porque no te callas!? =Why don´t you shut up!?”

¨Porque no te callas!?_Why don´t you shut up!?”

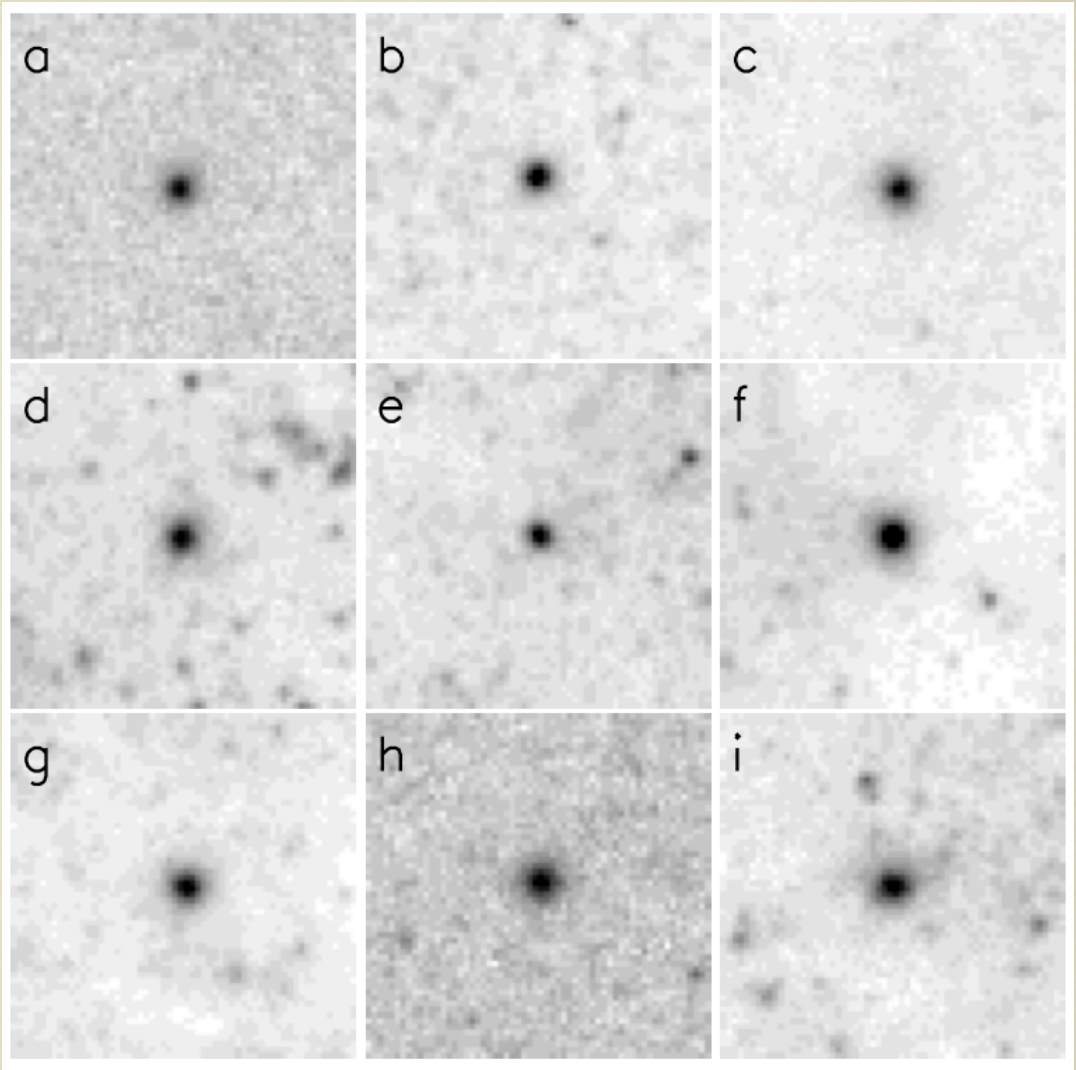
My research interests:



- Star cluster population studies
- The cluster initial mass function
- Maximum cluster mass
- Evolution in a tidal field
- Disruption by giant molecular clouds
- Age distribution

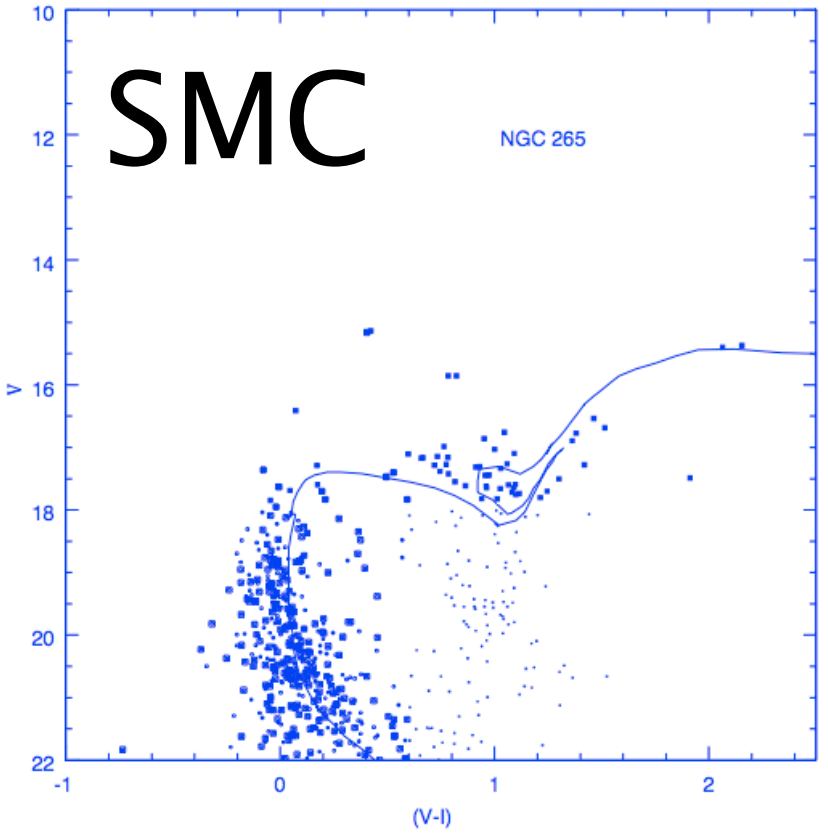

SMC
M51

Some anonymous star clusters in M51



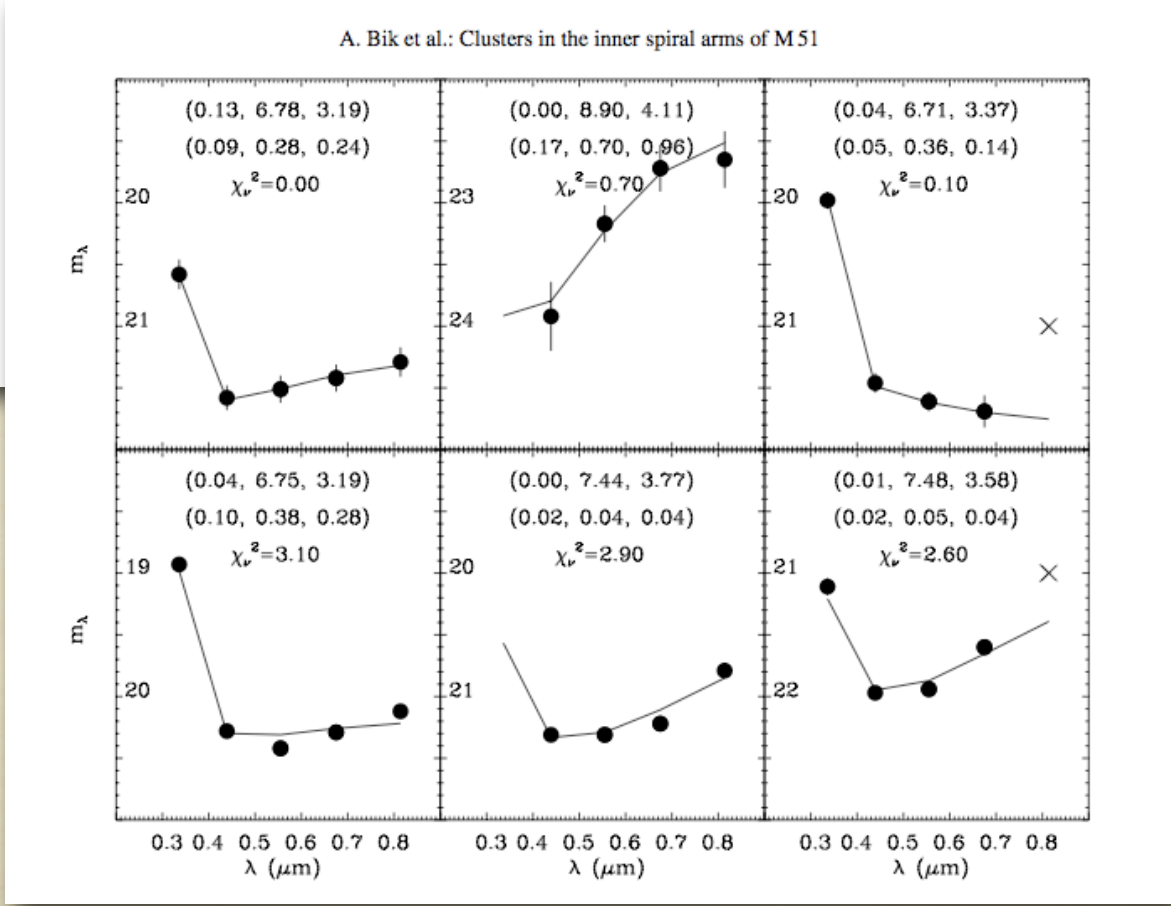
Scheepmaker et al. (2007)

Deriving ages



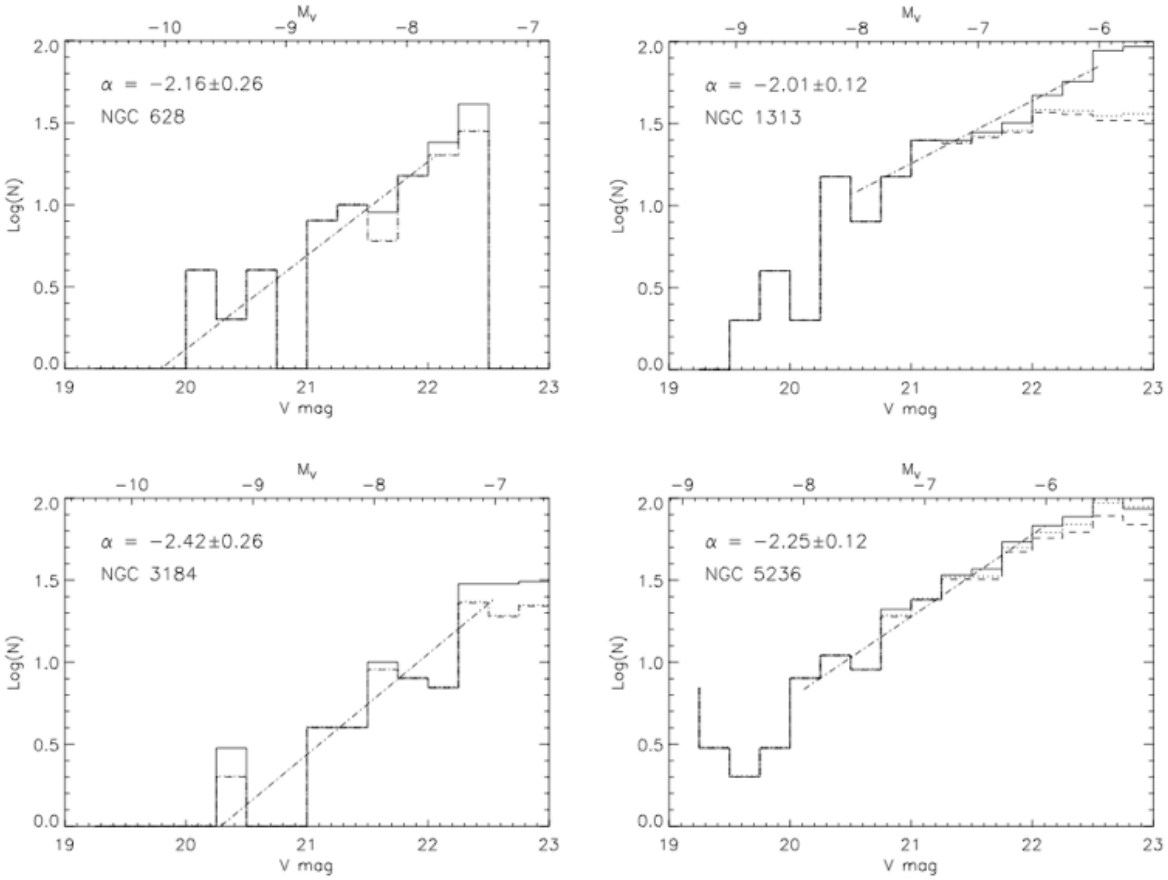
Chiosi (2006)

M51



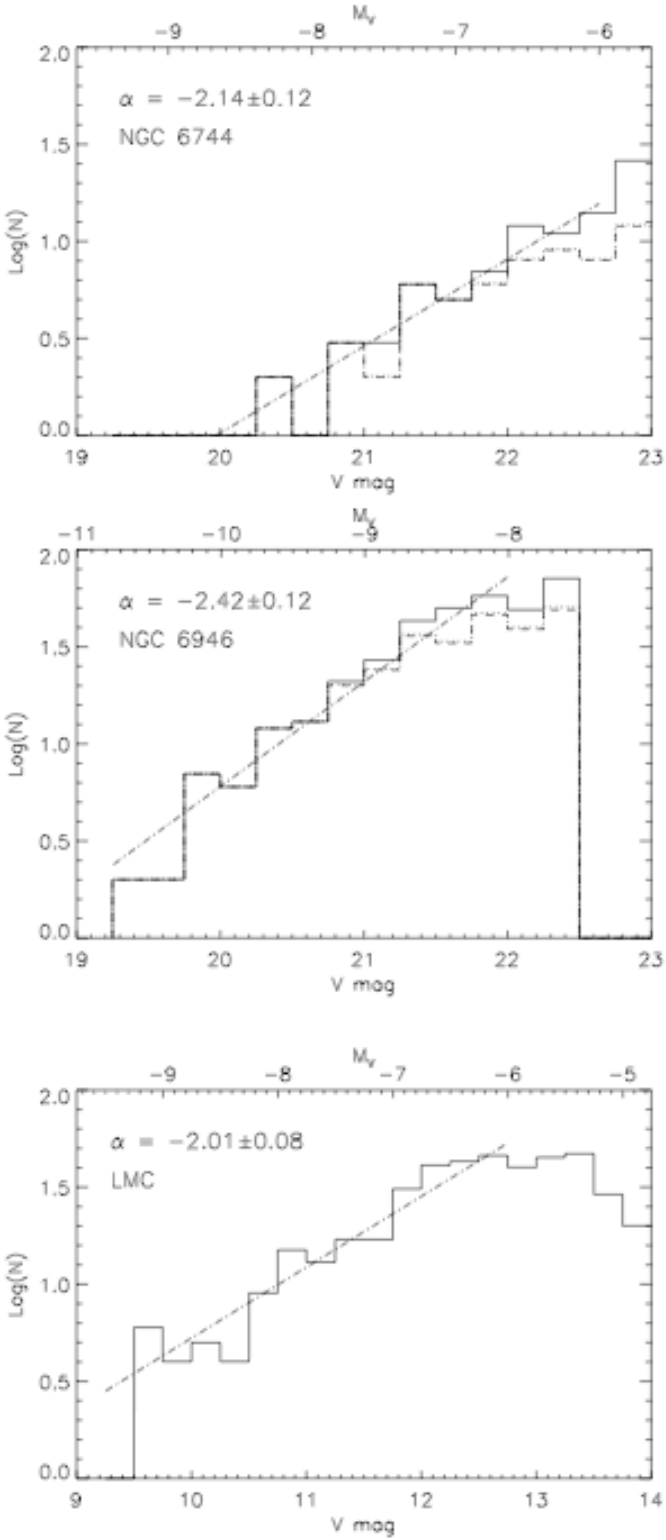
Bik et al. (2003)

Cluster luminosity function

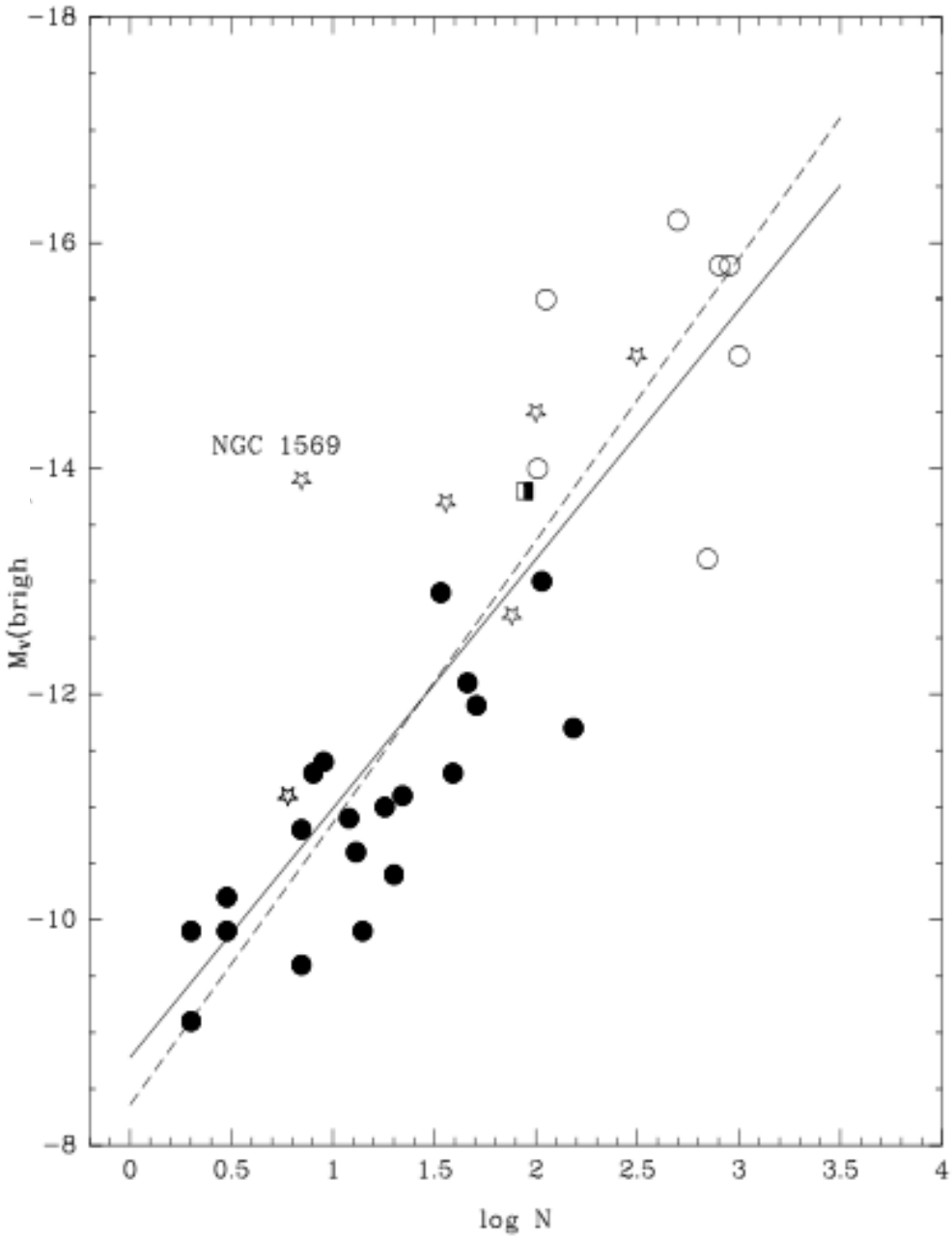


$$\mathrm{d}N/\mathrm{d}L \propto L^{-\alpha}, \text{with} \quad \alpha \simeq 2$$

Larsen (2002)



Random sampling
from a power-law function
with index -2:
$L_{\max} \propto N$

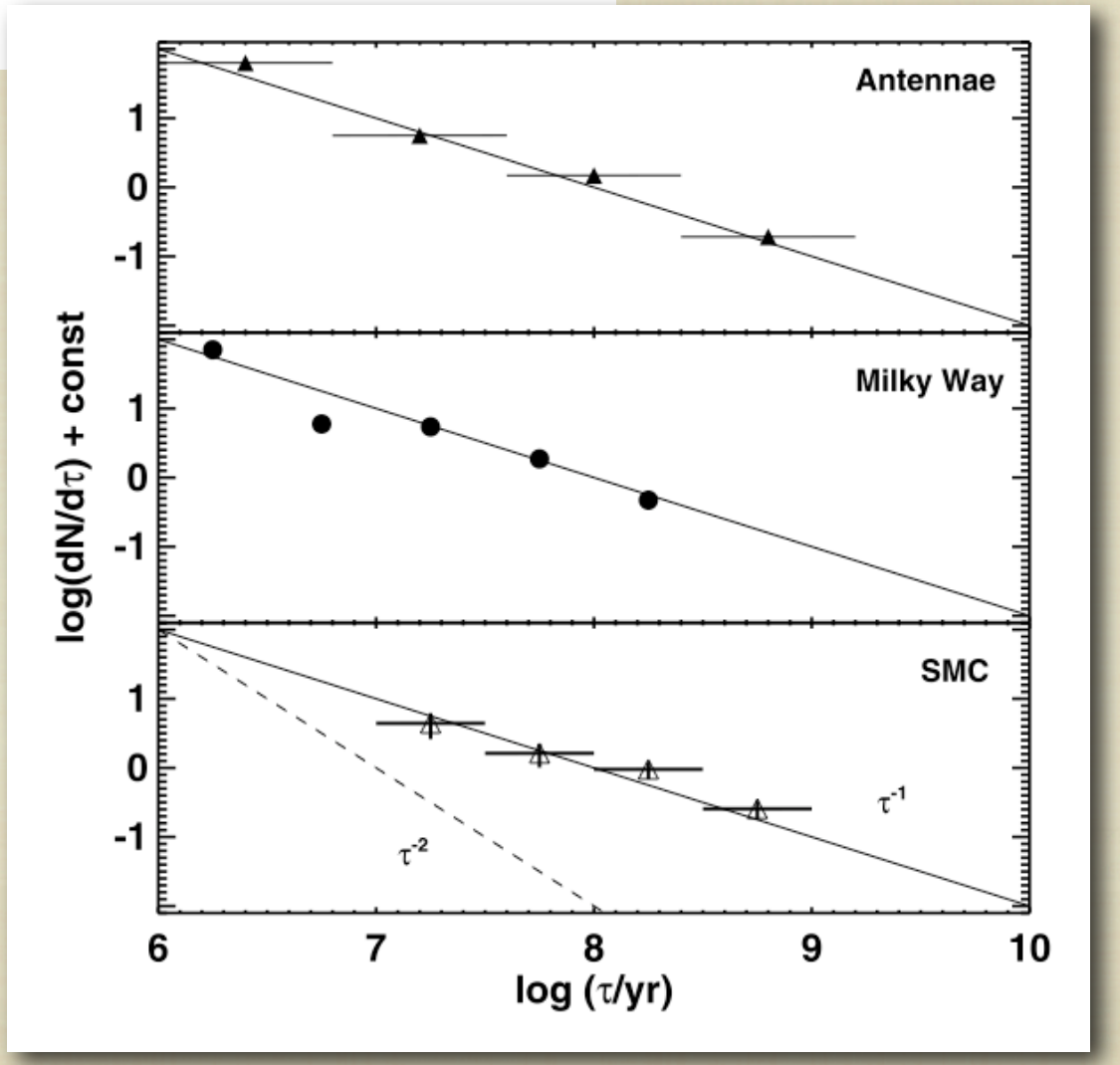


Whitmore (2003)

A universal disruption model?

Mass independent destruction of 90% of the clusters per age dex:

$$dN/dt \propto t^{-1}$$



Whitmore et al. (2007)

Mass independent destruc
of the clusters per age

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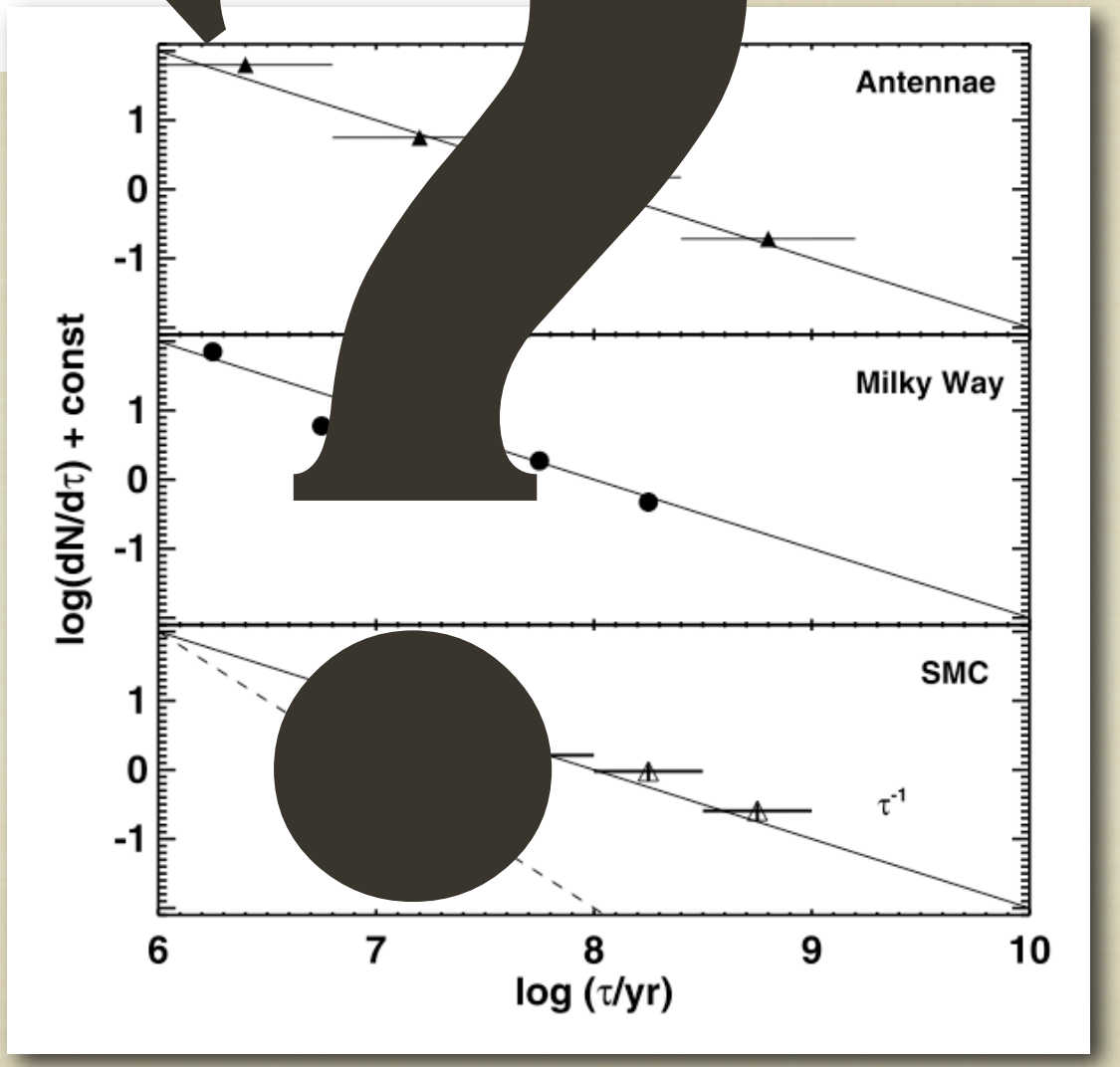
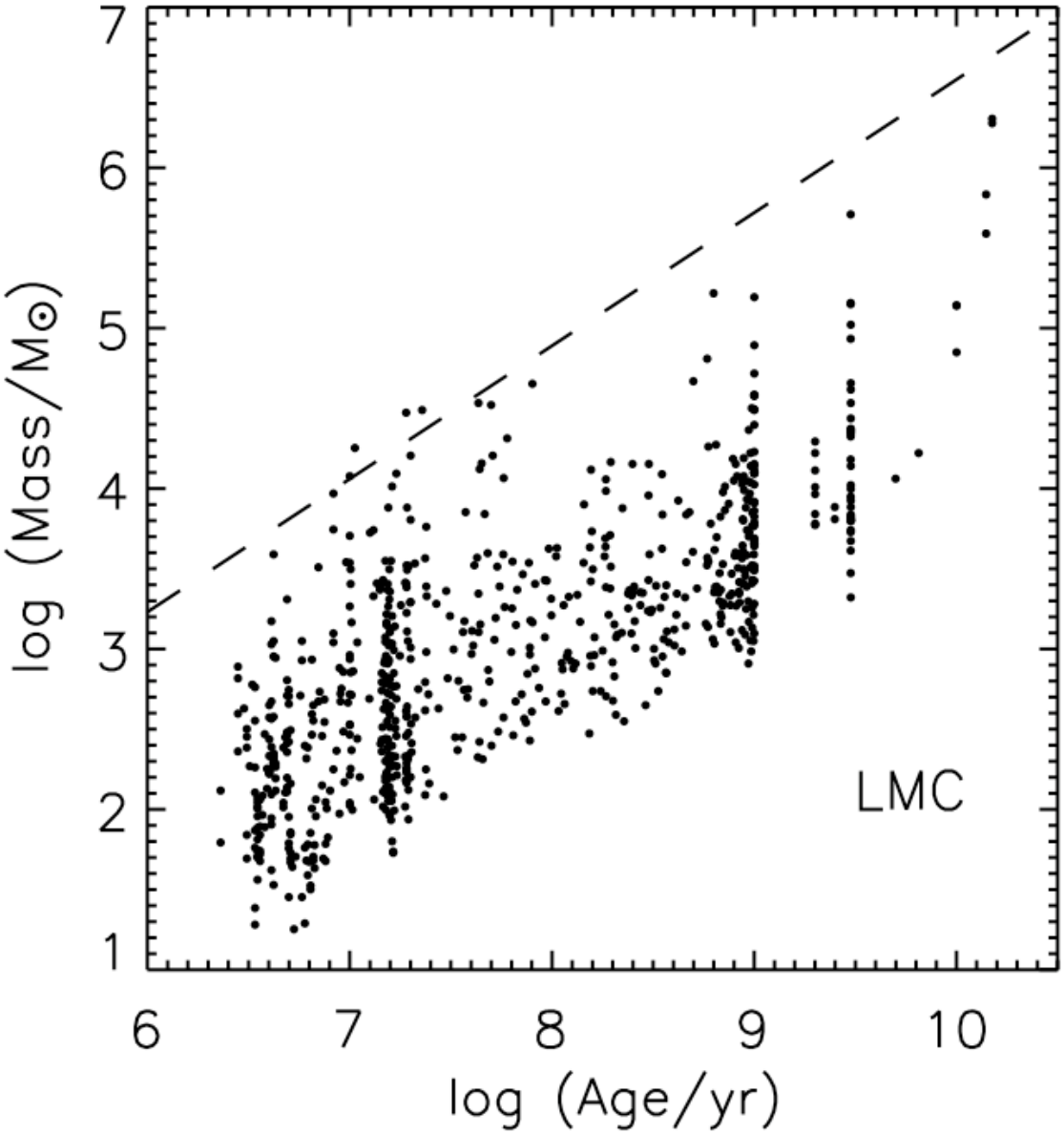
A universal disruption model?



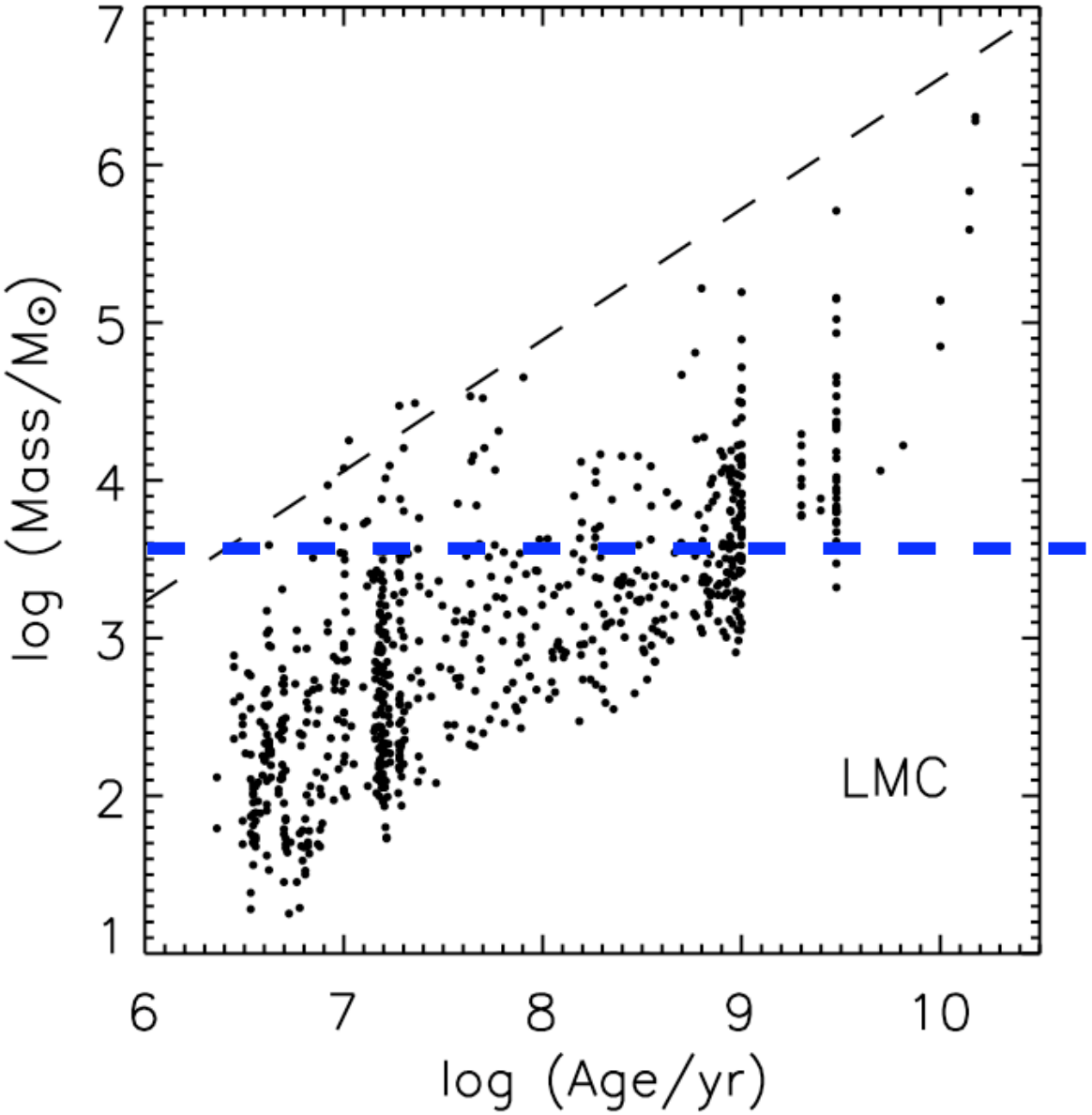
Whitmore et al. (2007)



Hunter et al. (2003); Gieles et al. (2006)

Formed: | 1 | 10 | 100 | 1000 |

$$\mathrm{d}N/\mathrm{d}t = \text{constant}$$

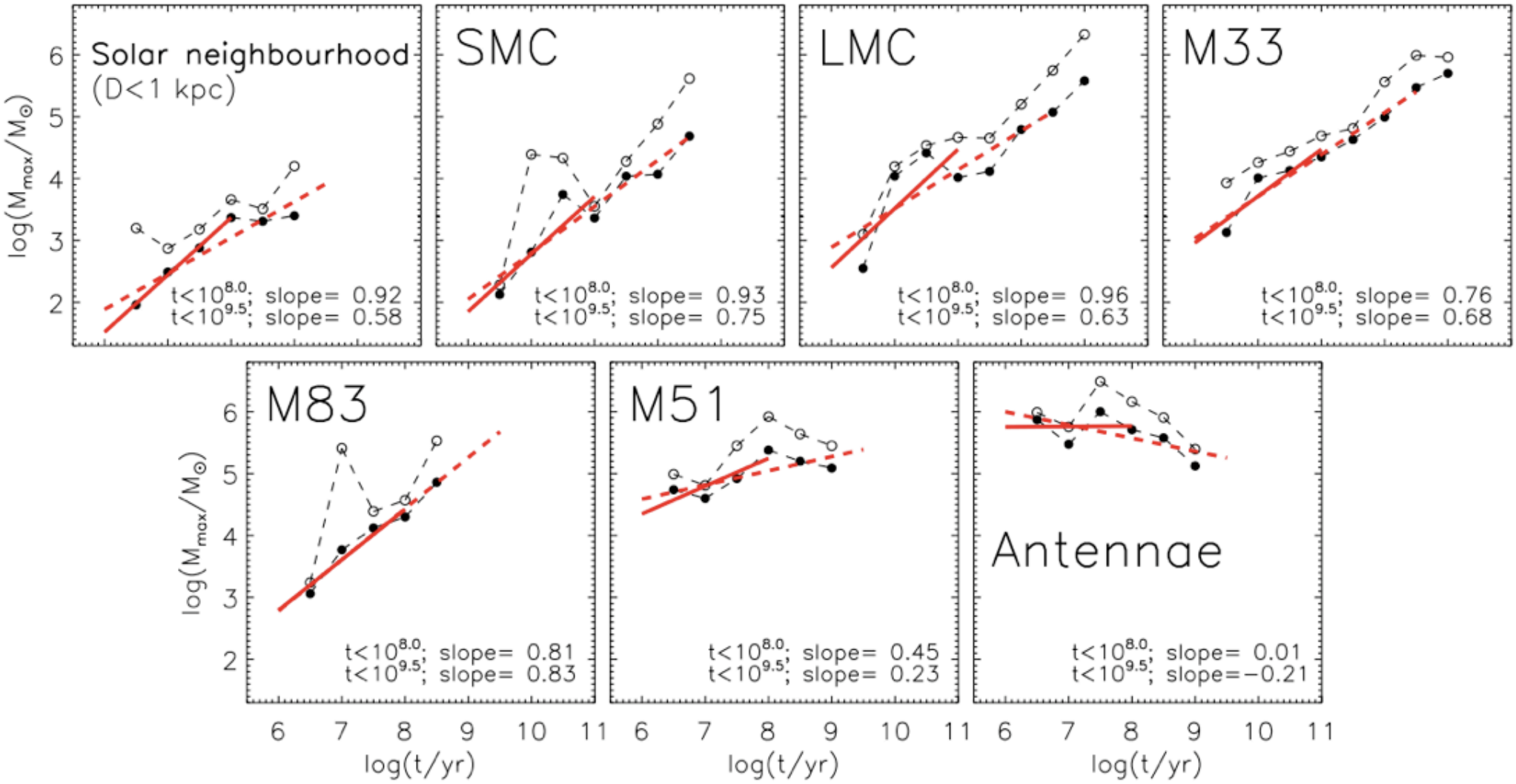


Hunter et al. (2003); Gieles et al. (2006)

Formed:	1	10	100	1000
Surviving:	1	1	1	1

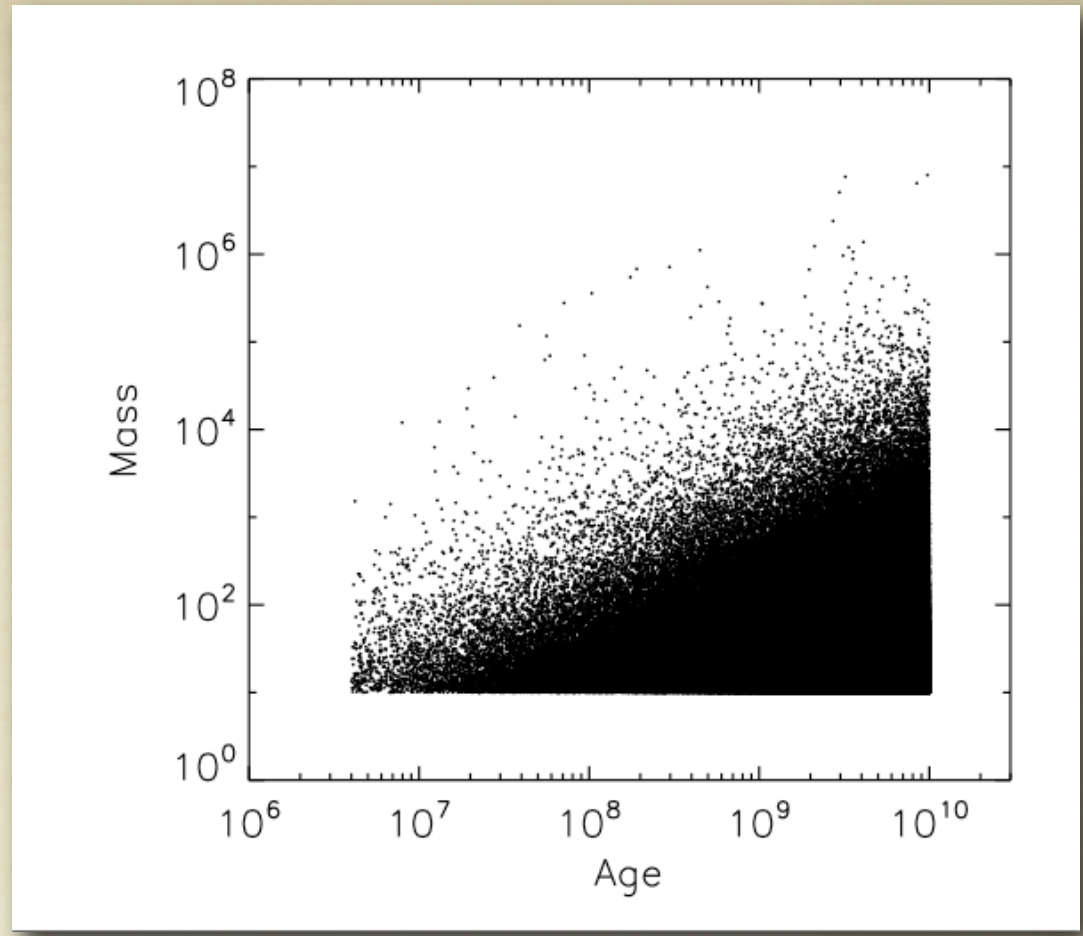
$$dN/dt = \text{constant}$$

$$dN/d\log t = \text{constant}$$



Gieles & Bastian, submitted

- Constant CFR
- $dN/dM \propto M^{-2}$
- mass limit



Gieles, Lamers & Baumgardt IAUS 246, arXiv:0710.2374

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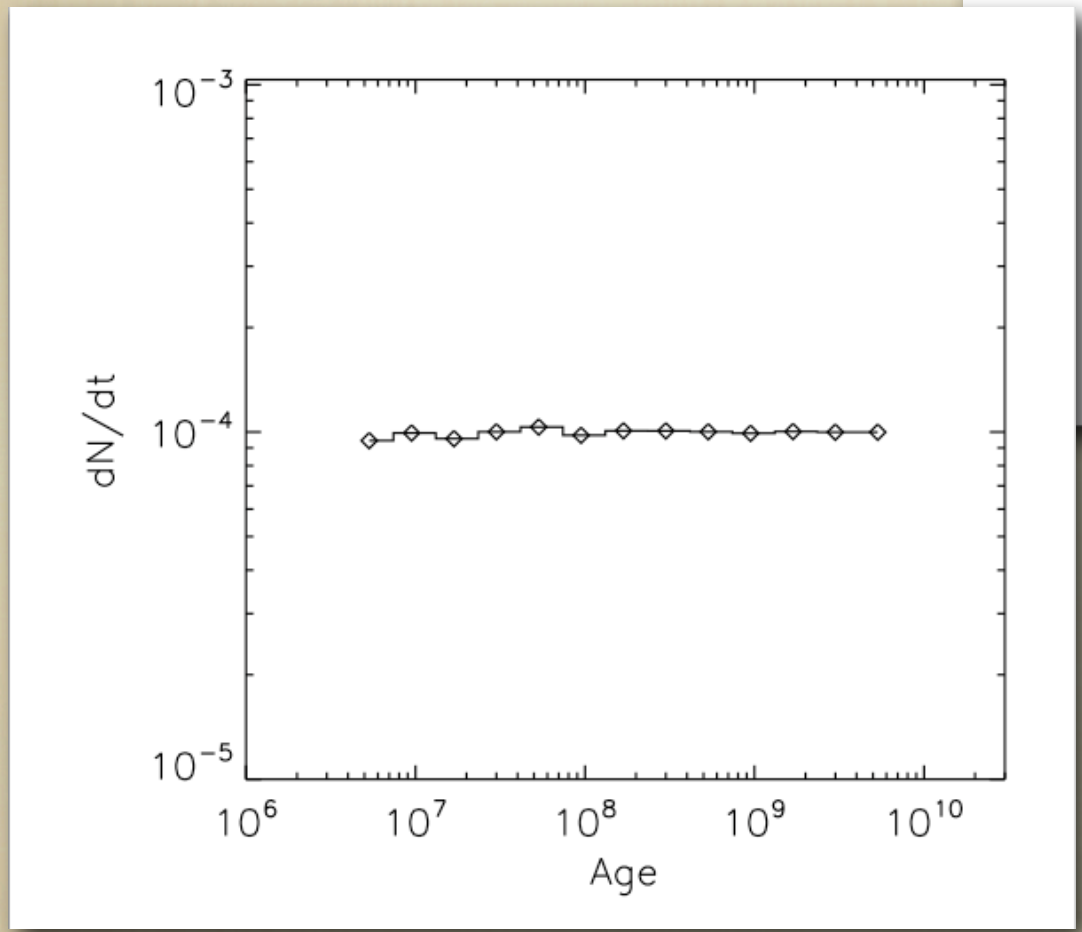

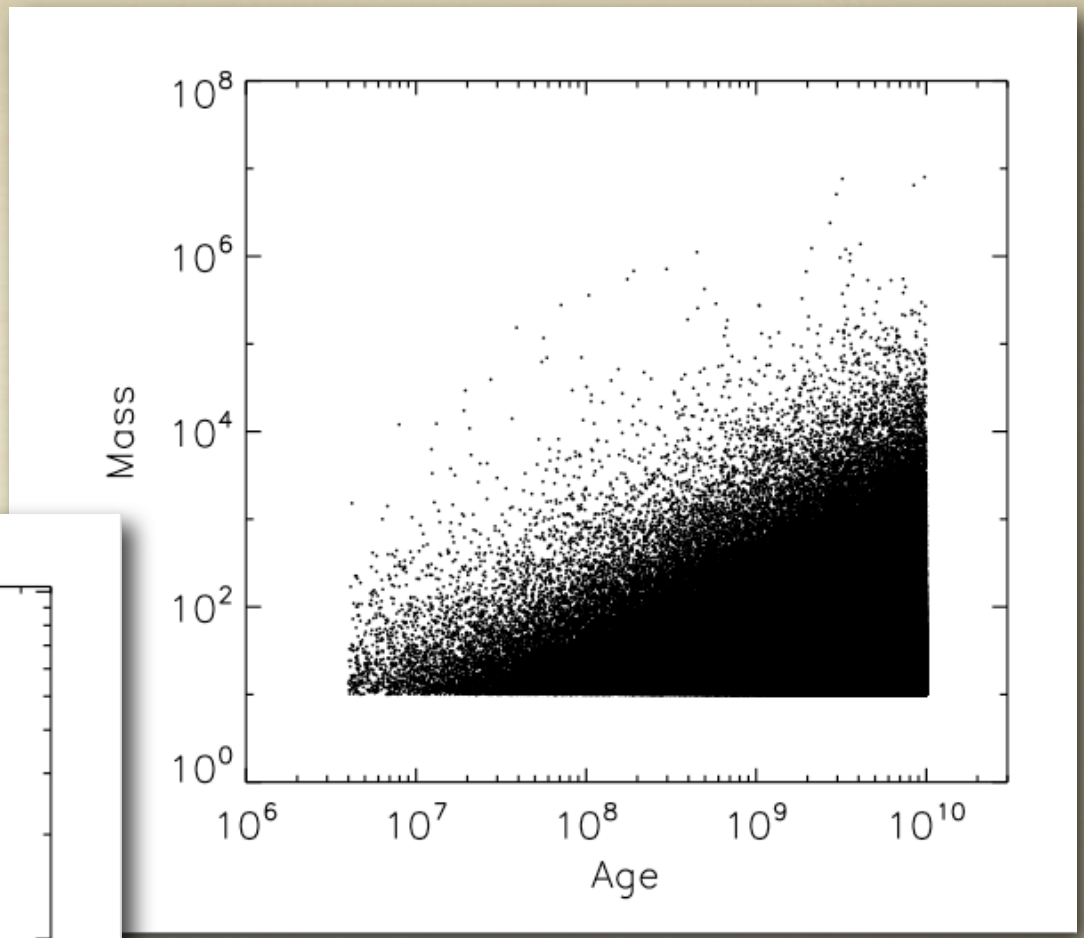

Gieles, Lamers & Baumgardt IAUS 246, arXiv:0710.2374

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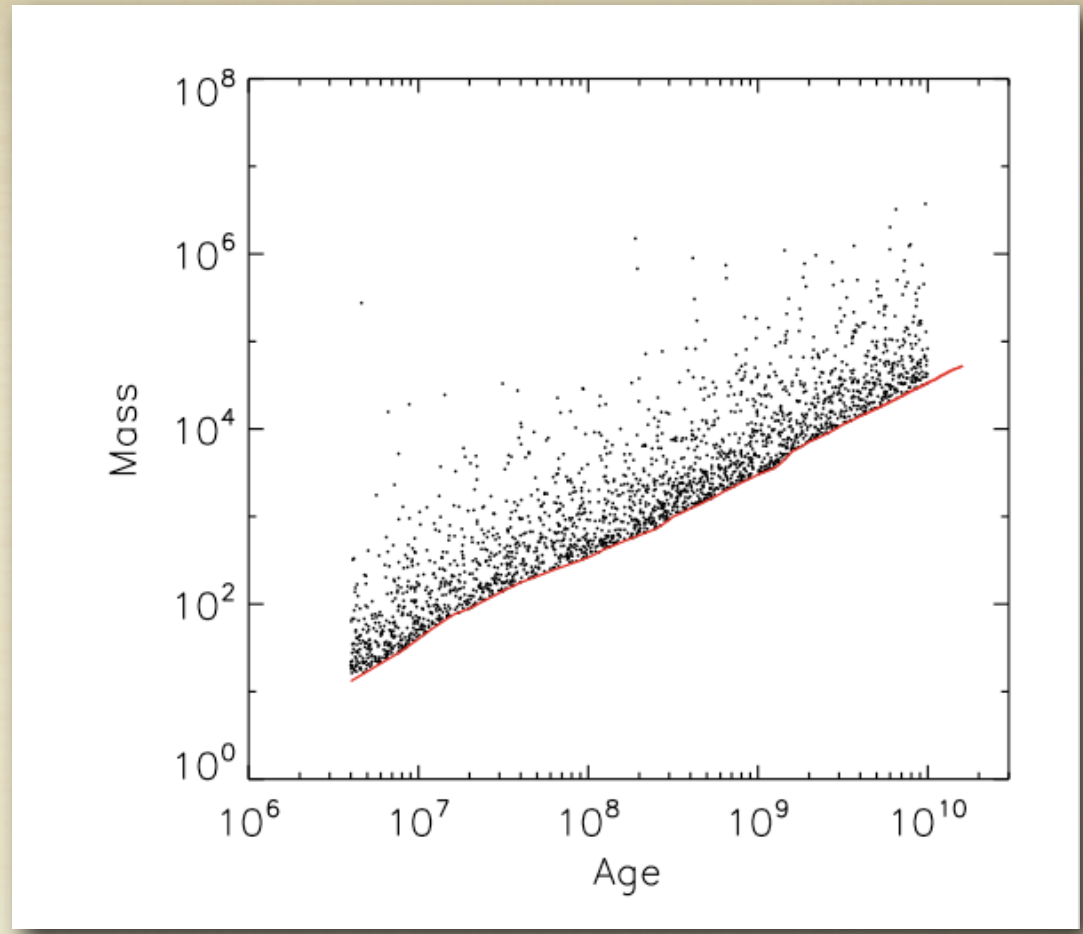

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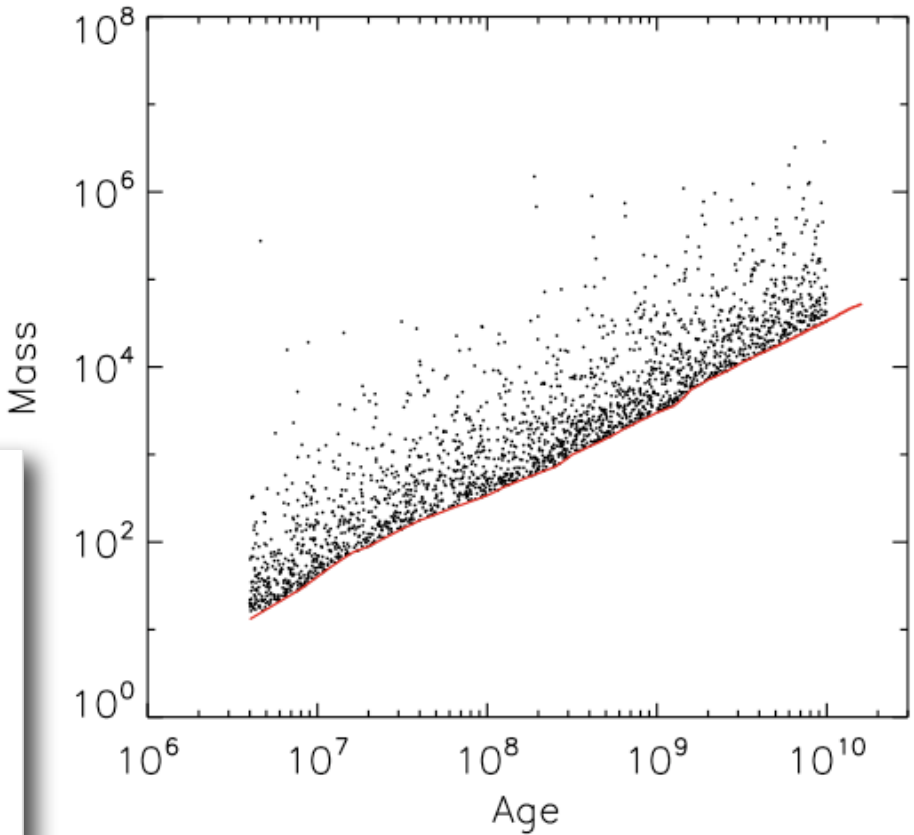
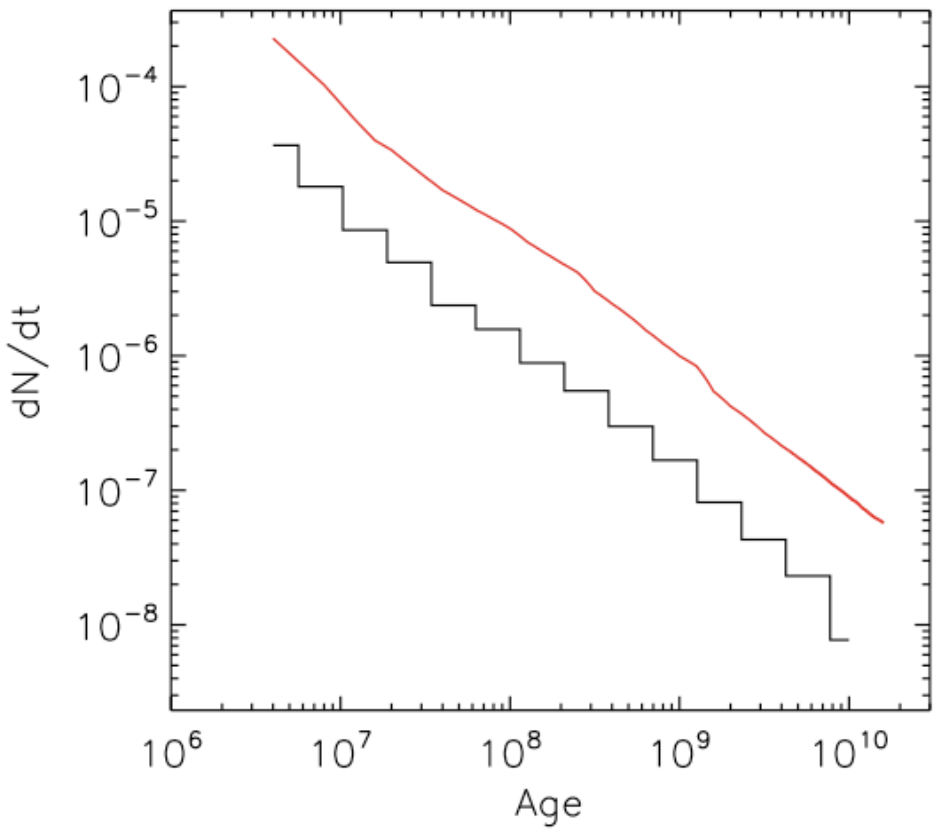
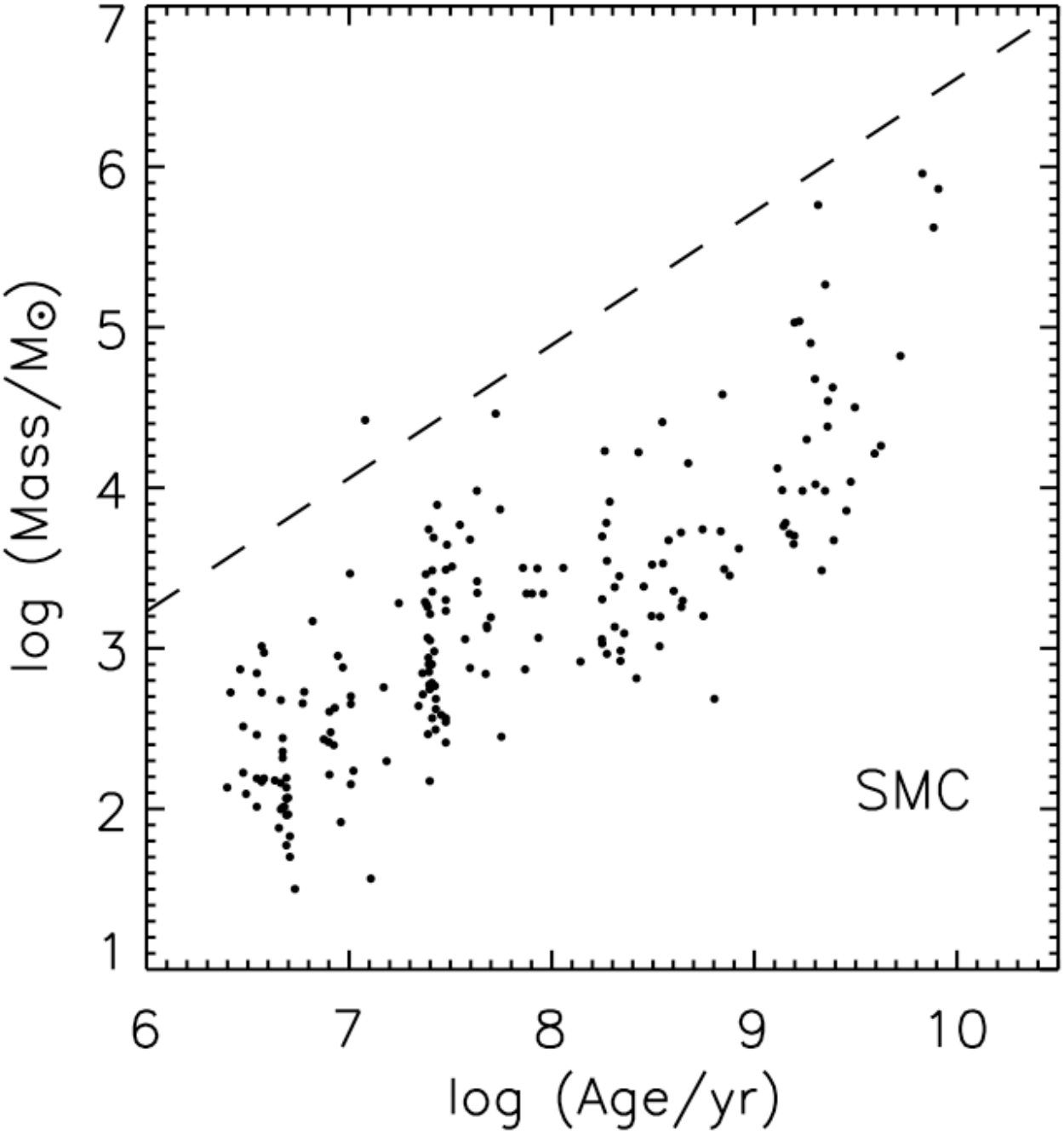




Limiting detection in U results in $\mathbf{d}N/\mathbf{d}t \sim t^{-1}$

Gieles, Lamers & Baumgardt IAUS 246, arXiv:0710.2374



Hunter et al. (2003); Gieles et al. (2006)

SMC dN/dt from isochrone ages

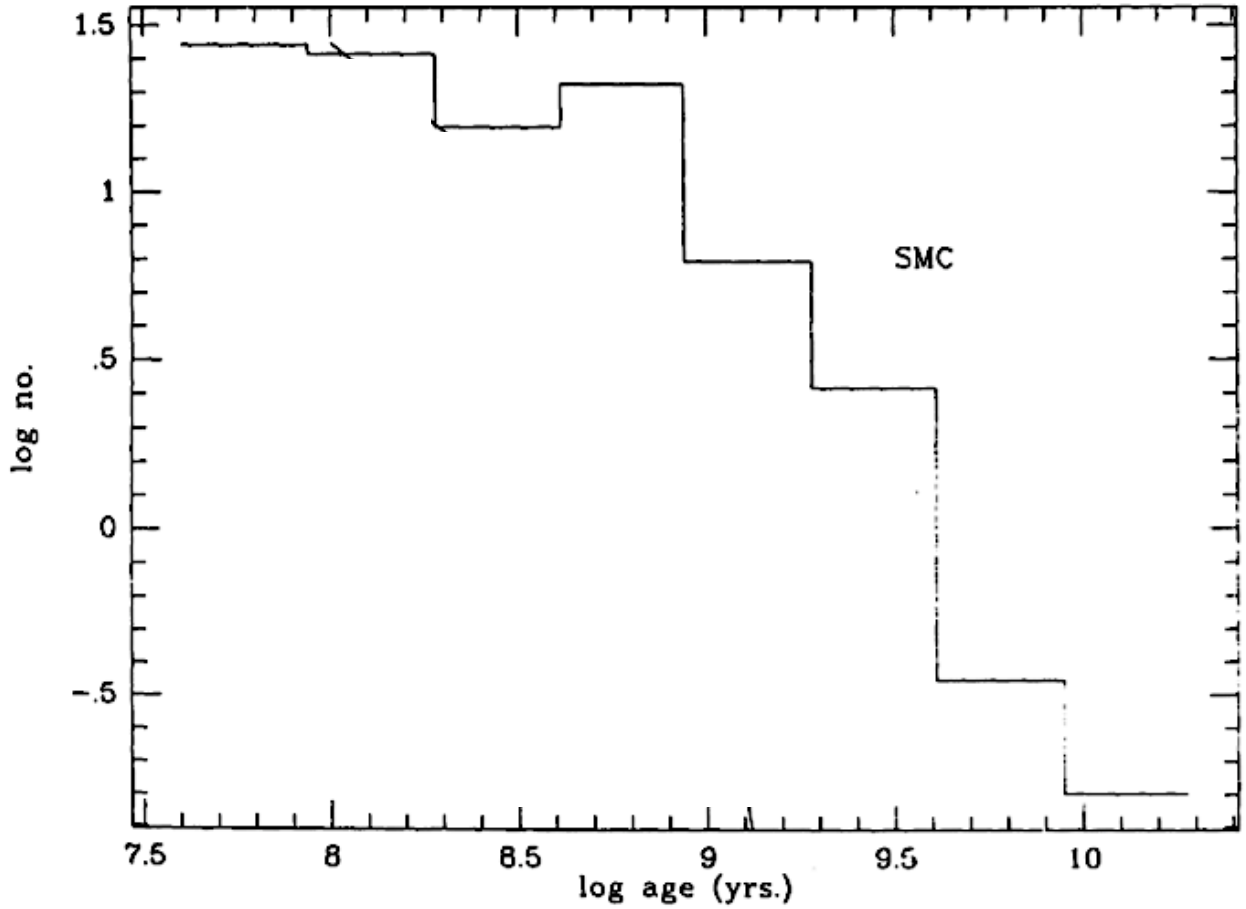
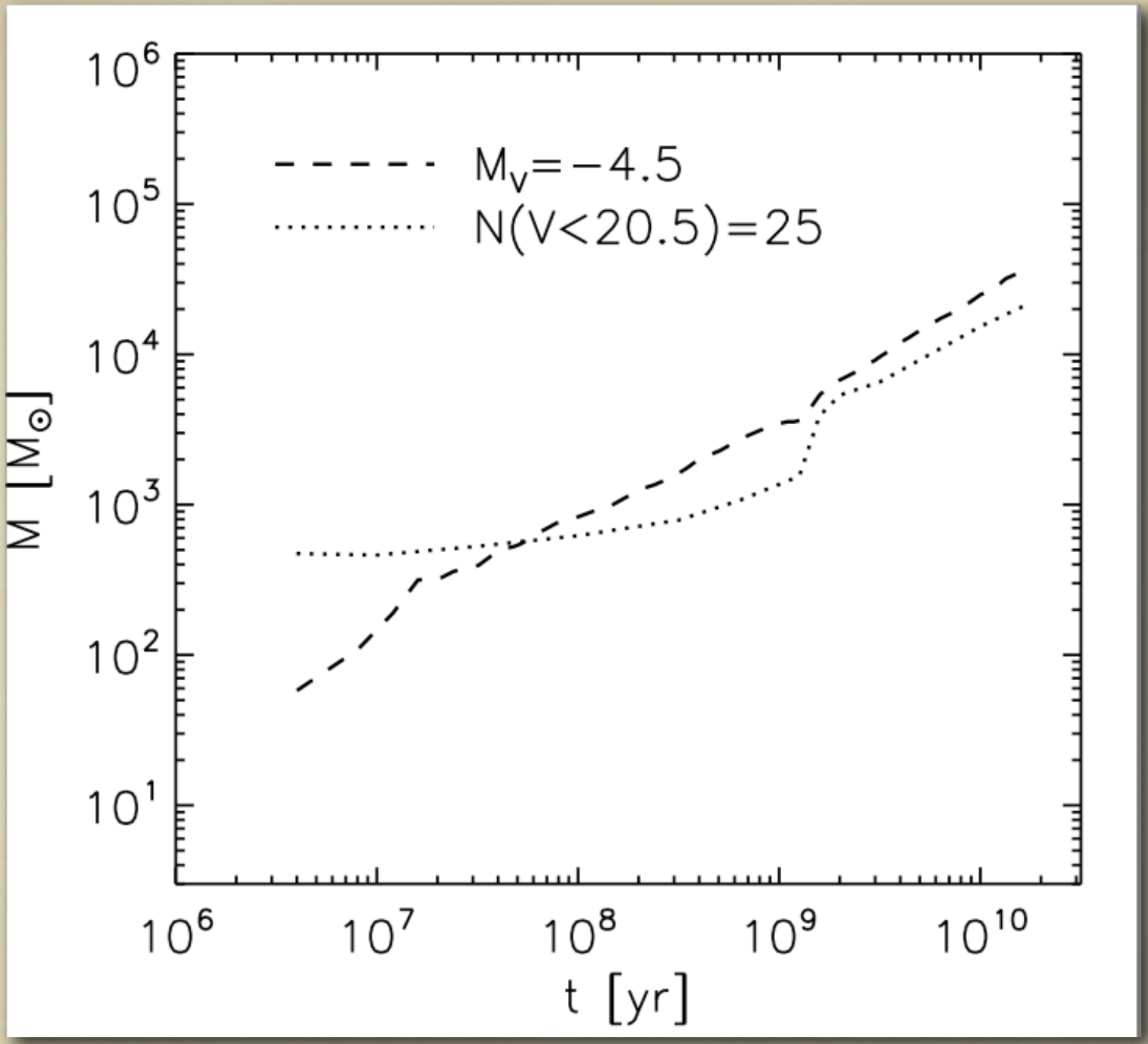


FIG. 4–The age distribution for all SMC clusters in the 4-m fields. Wielen's (1971) distribution for Galactic clusters is also shown, normalized at 10^8 yrs. Units in the ordinate are clusters per 10^8 yrs.

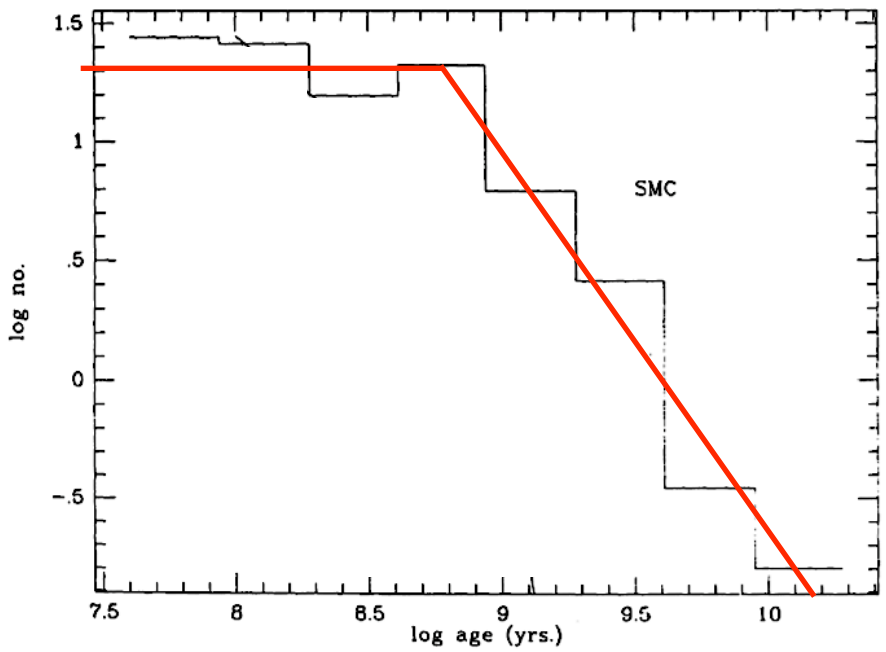
Hodge (1987)



Gieles, Lamers & Portegies Zwart (2007)

SMC

$$M \gtrsim 10^2\, M_\odot$$



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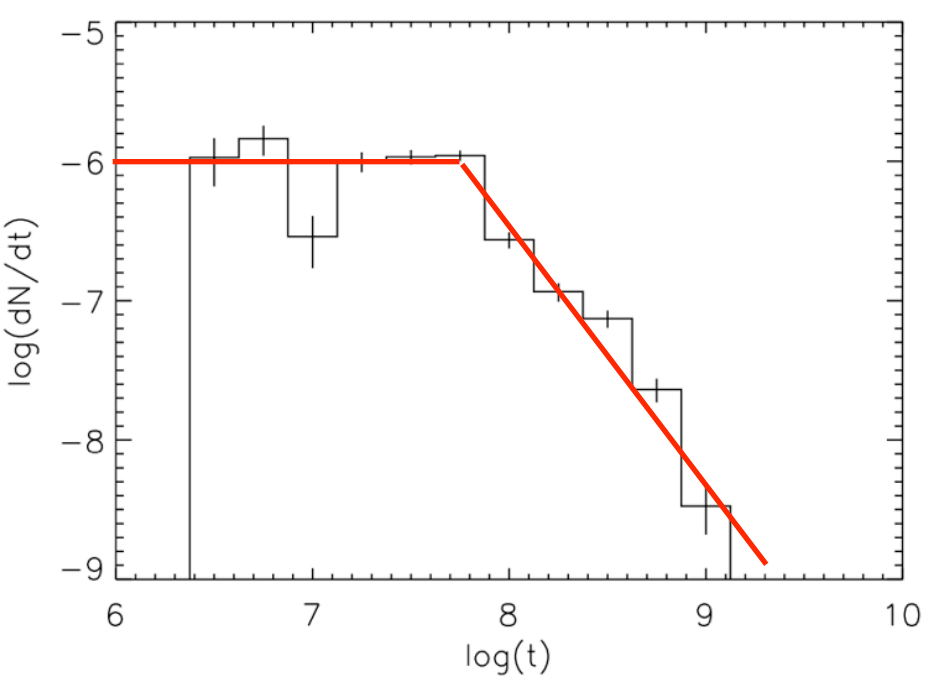
Hodge (1987)

M51

$$M > 10^{4.5}\, M_\odot$$



Bastian et al. (2005);
Gieles et al. (2005)

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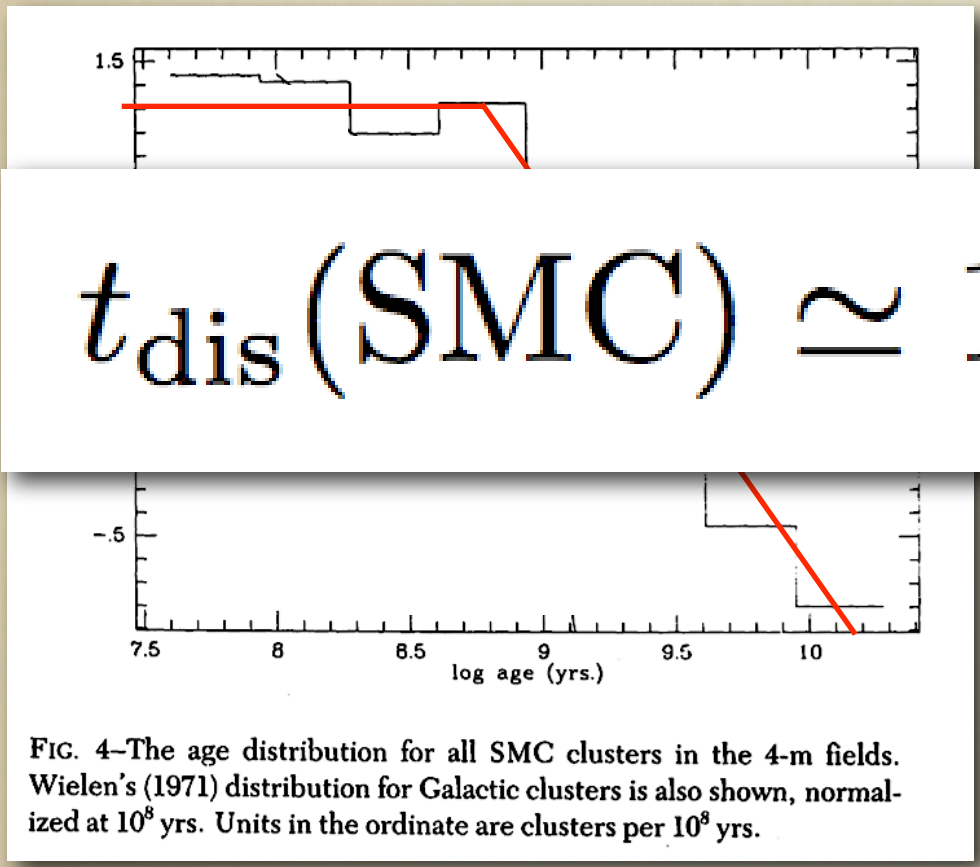

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M51

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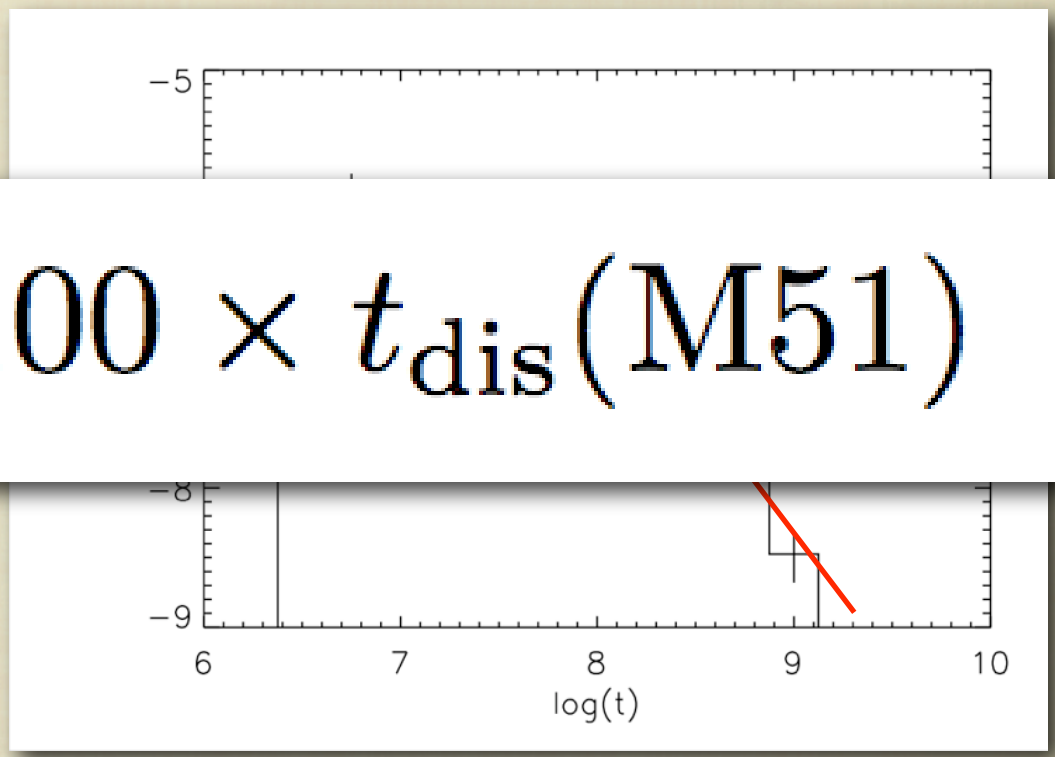
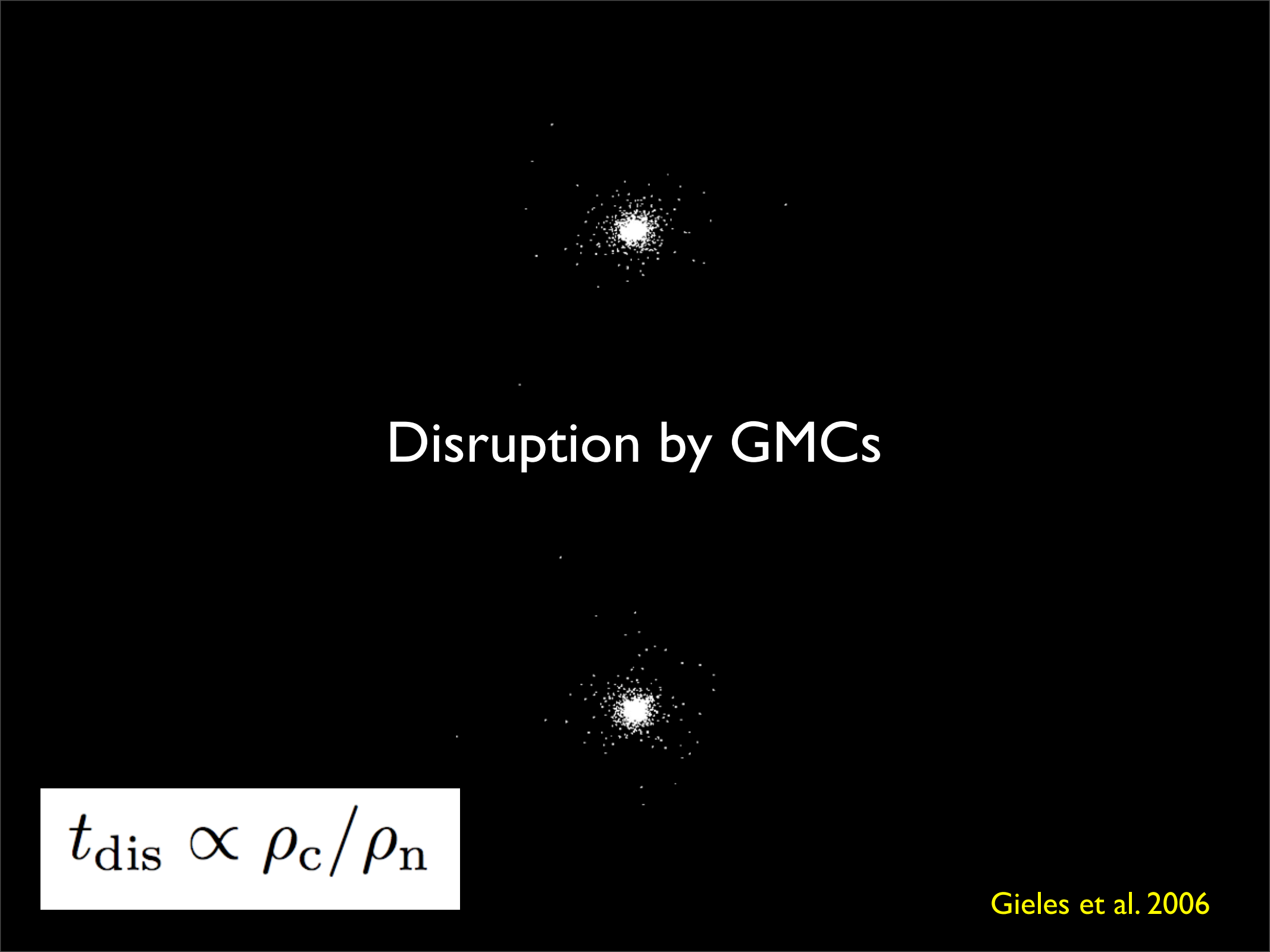
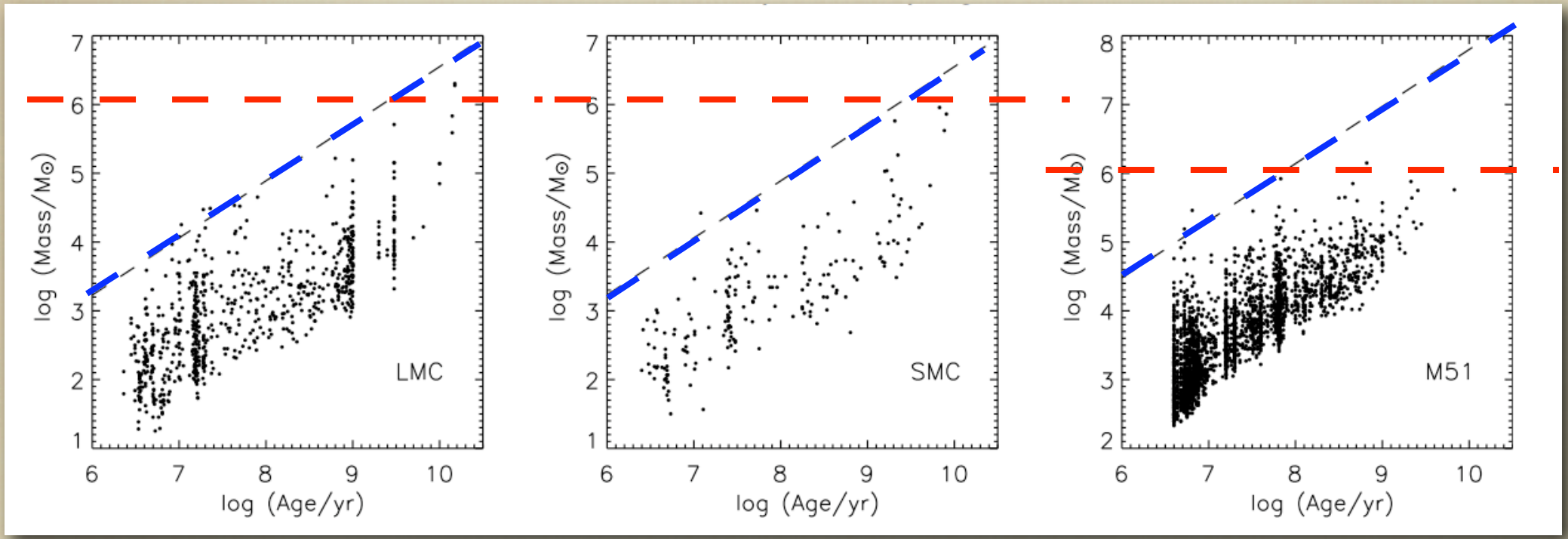


Bastian et al. (2005);
Gieles et al. (2005)

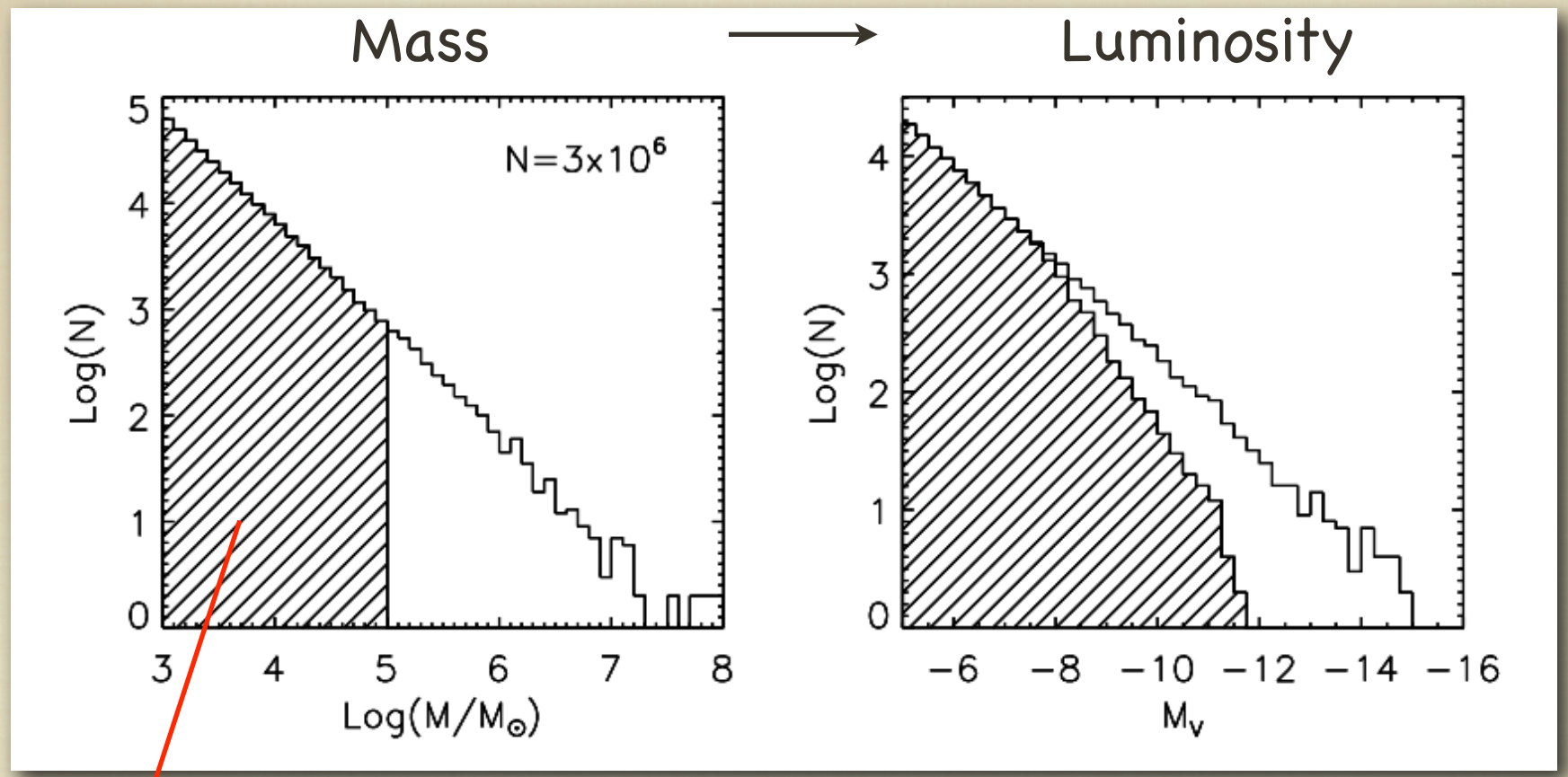
$$t_{\rm dis}({\rm SMC}) \simeq 100 \times t_{\rm dis}({\rm M51})$$


Disruption by GMCs
$t_{\rm dis} \propto \rho_{\rm c}/\rho_{\rm n}$
Gieles et al. 2006



Gieles et al. (2006)

Study mass function truncation through luminosity function

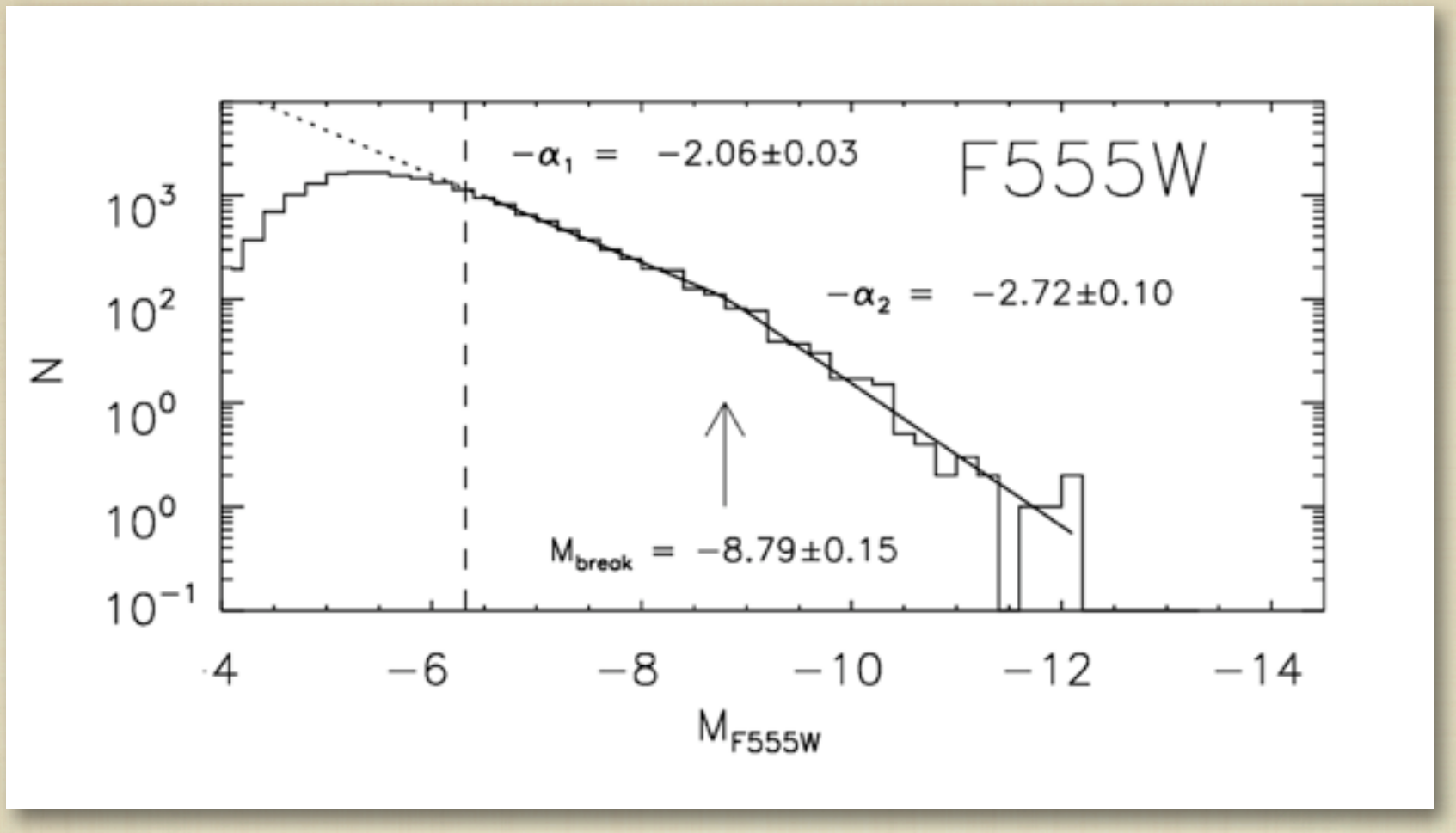


Larsen 2006

$N \propto SFR \times \Delta Time \times Area$

(more details in: Gieles, Larsen, Bastian & Stein 2006)

The LF of ±5000 star cluster in M51



Gieles, Larsen et al. (2006b)

Young star clusters:

- Universal power-law initial mass function (index -2)
- Mass function truncated around ~10^6 $M_\odot$
- Disruption time strongly dependent on environment

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- Universal power-law initial mass function (index -2)
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- Disruption time strongly dependent on environment

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