On the relation between the most-massive star and the star cluster mass

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The IMF & Clustered Star-Formation

Question

Are star clusters randomly filled with stars from the (invariant) canonical IMF?

Why do we care?

- Nearly all stars ($>$ 70 - 90%) form in a clustered mode (*Adams & Myers, 2001, ApJ, 553, 744;*
  Lada & Lada, 2003, ARA&A 41, 57;
  Allen et al., 2007, Protostars & Planets V, 361).

- Embedded clusters dissolve quickly (90% within 10 to 20 Myr, *Lada & Lada, 2003*).

- Released stars form the galactic field population.

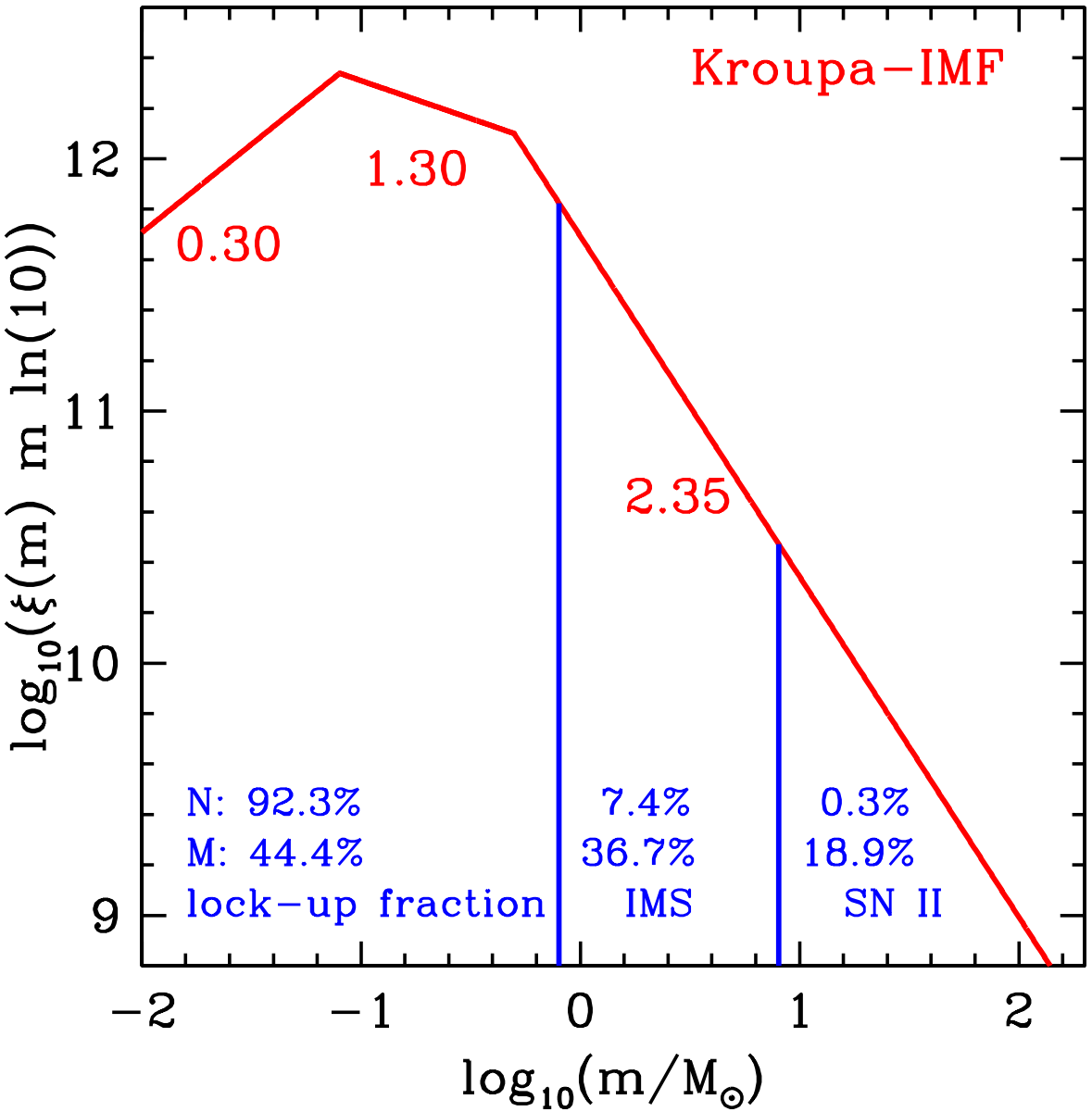
- Must add up all clusters to form composite IMF:
- field $=$ cluster$_1$ $+$ cluster$_2$ $+ \ldots +$ cluster$_N$

Motivation

- If the IMFs of individual clusters depend on cluster parameters
  $\Longrightarrow$ integrated galactic IMF (IGIMF) $\neq$ IMF.

- Might contain information about the star-formation process.

The Canonical IMF

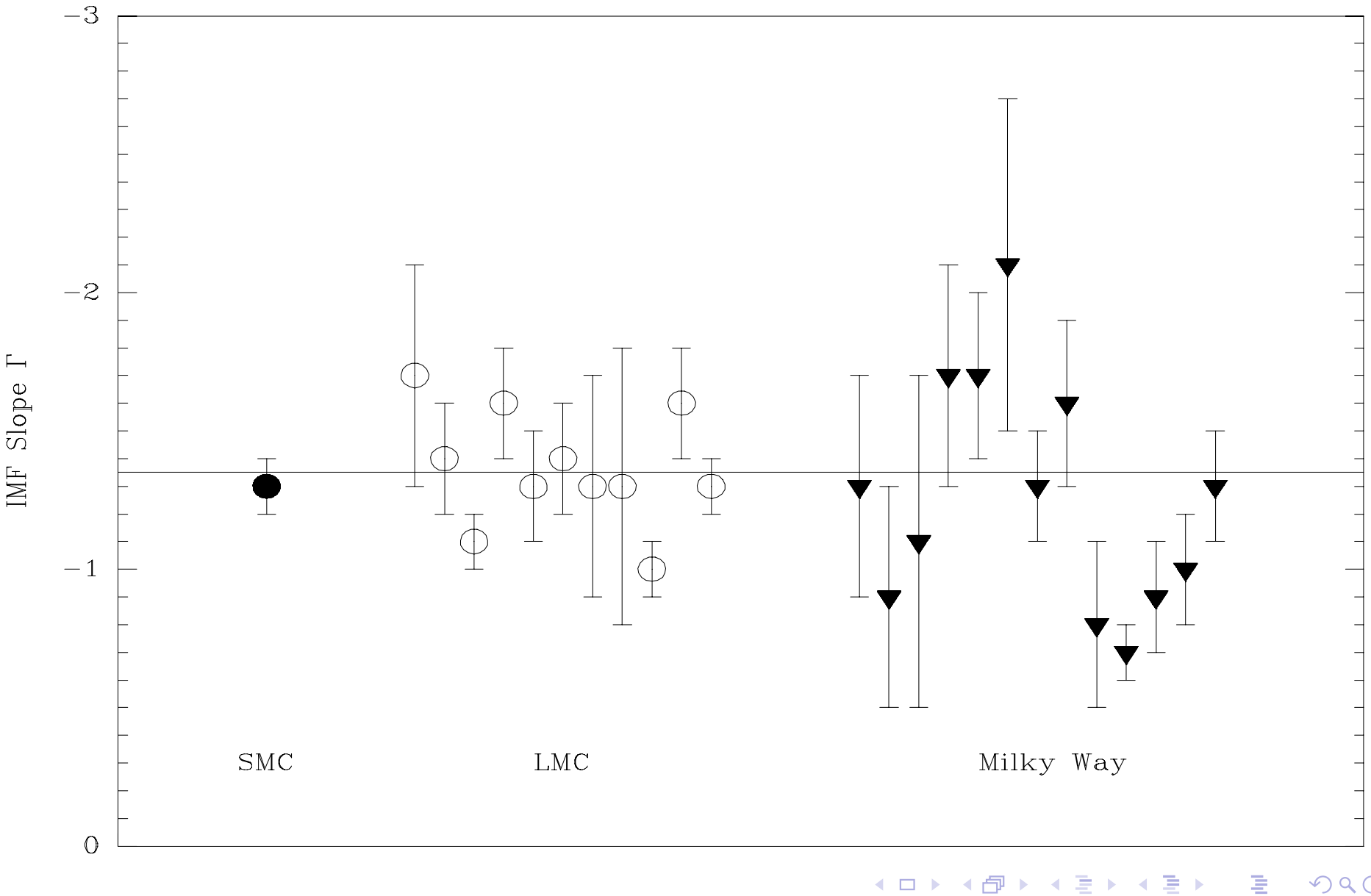


Stellar initial mass function:

$\xi(m) \propto m^{-\alpha_i}$

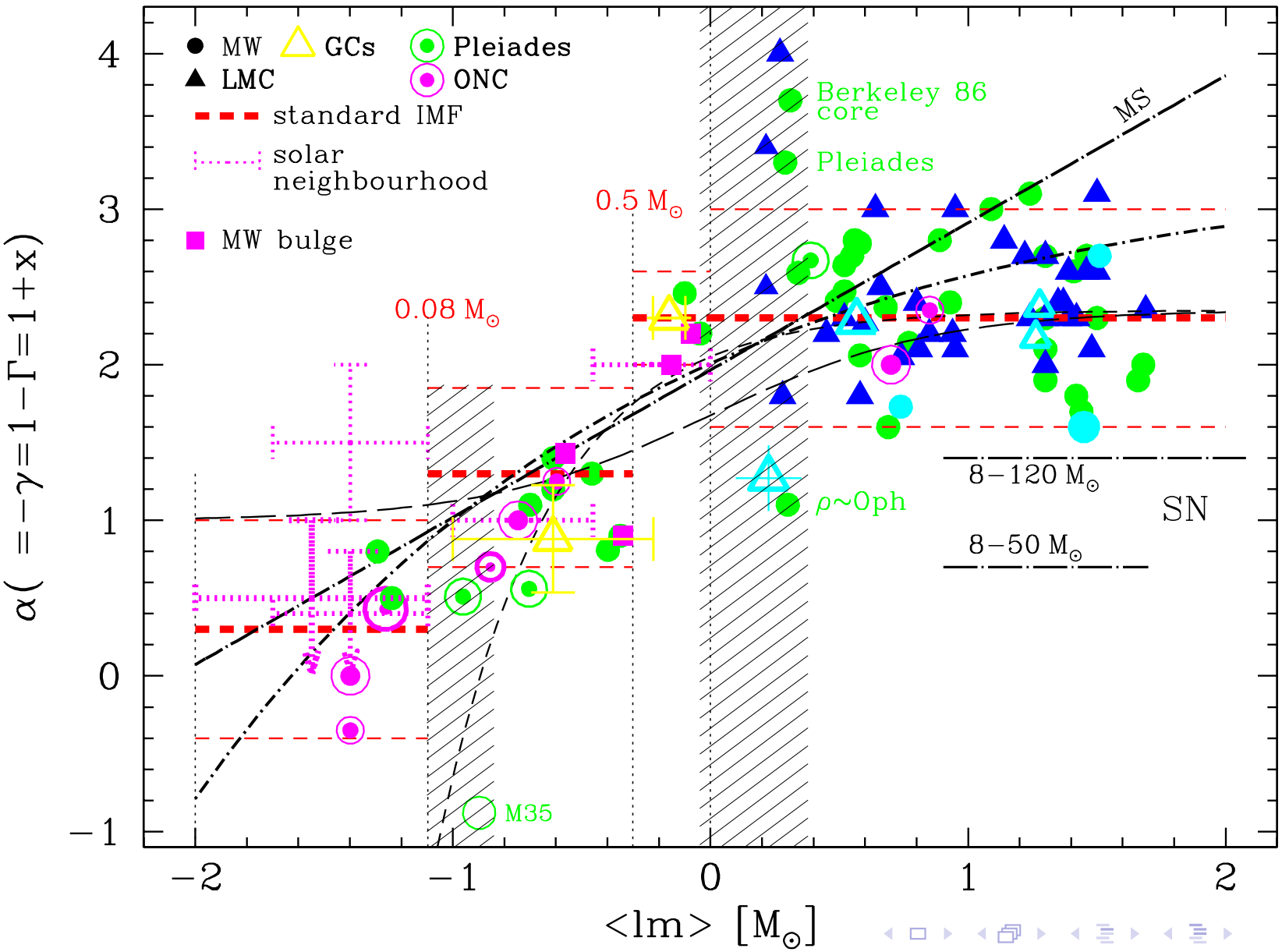
Observed IMF slopes in star clusters

Massey, 2003, ARA&A, 41, 15



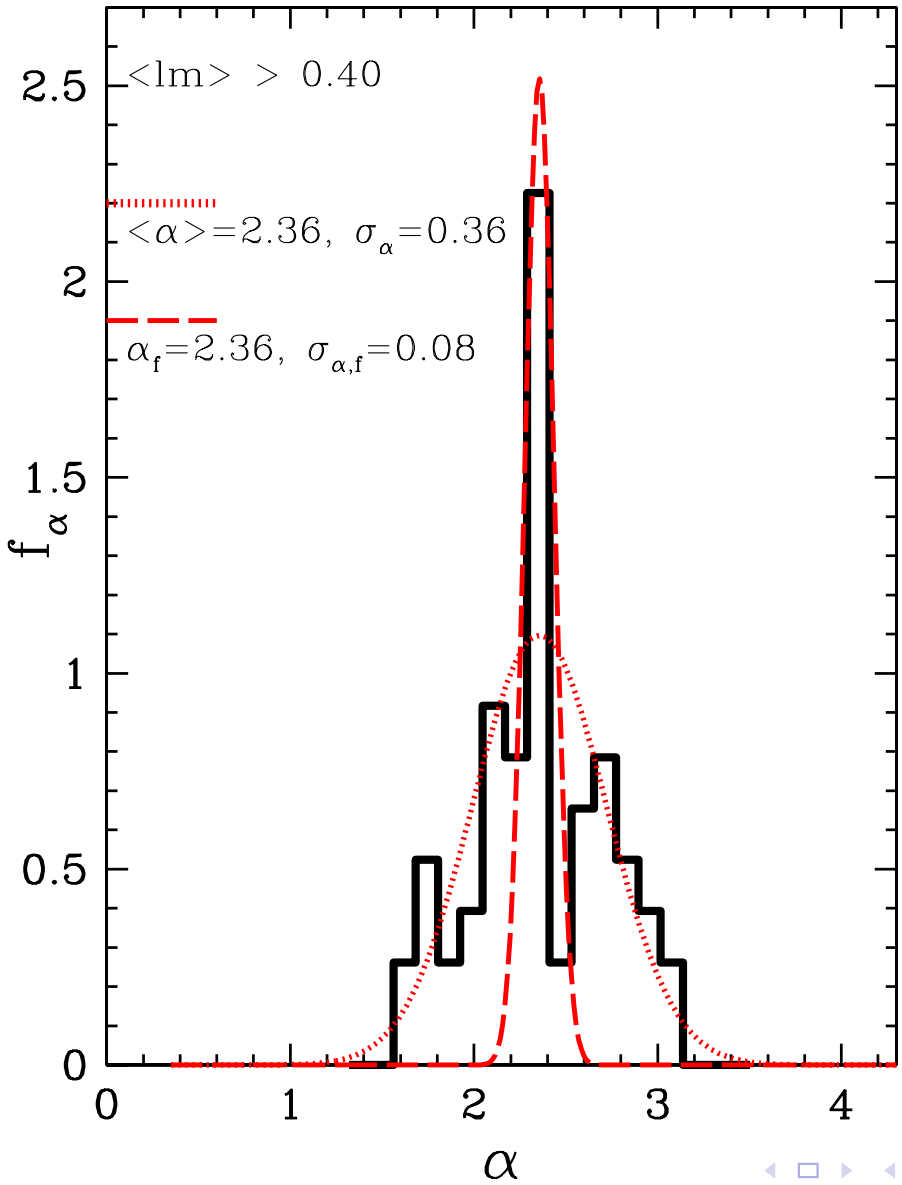
The α-plot

Kroupa, 2002, Science, 295, 82



α-distribution

Kroupa, 2002, Science, 295, 82



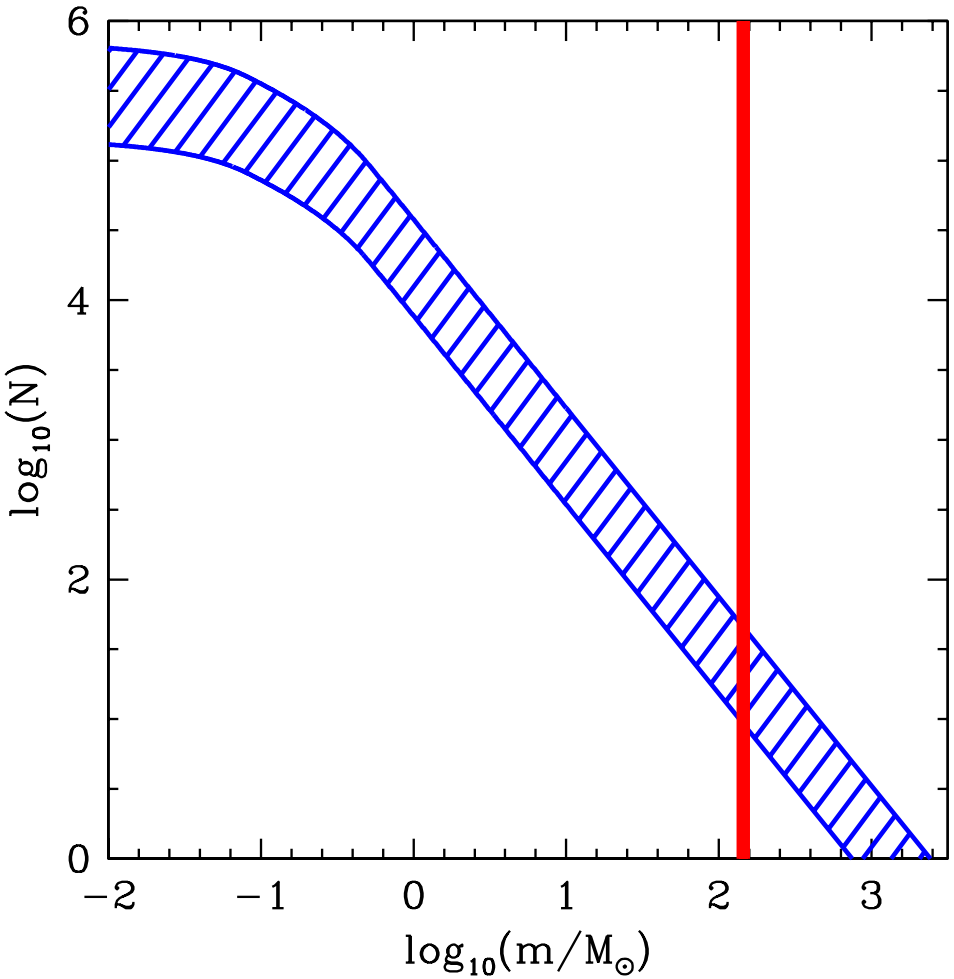
Question

How can we test if the stars in clusters are randomly sampled from an invariant IMF?

Fundamental upper mass limit

Weidner & Kroupa, 2004, MNRAS, 348, 187

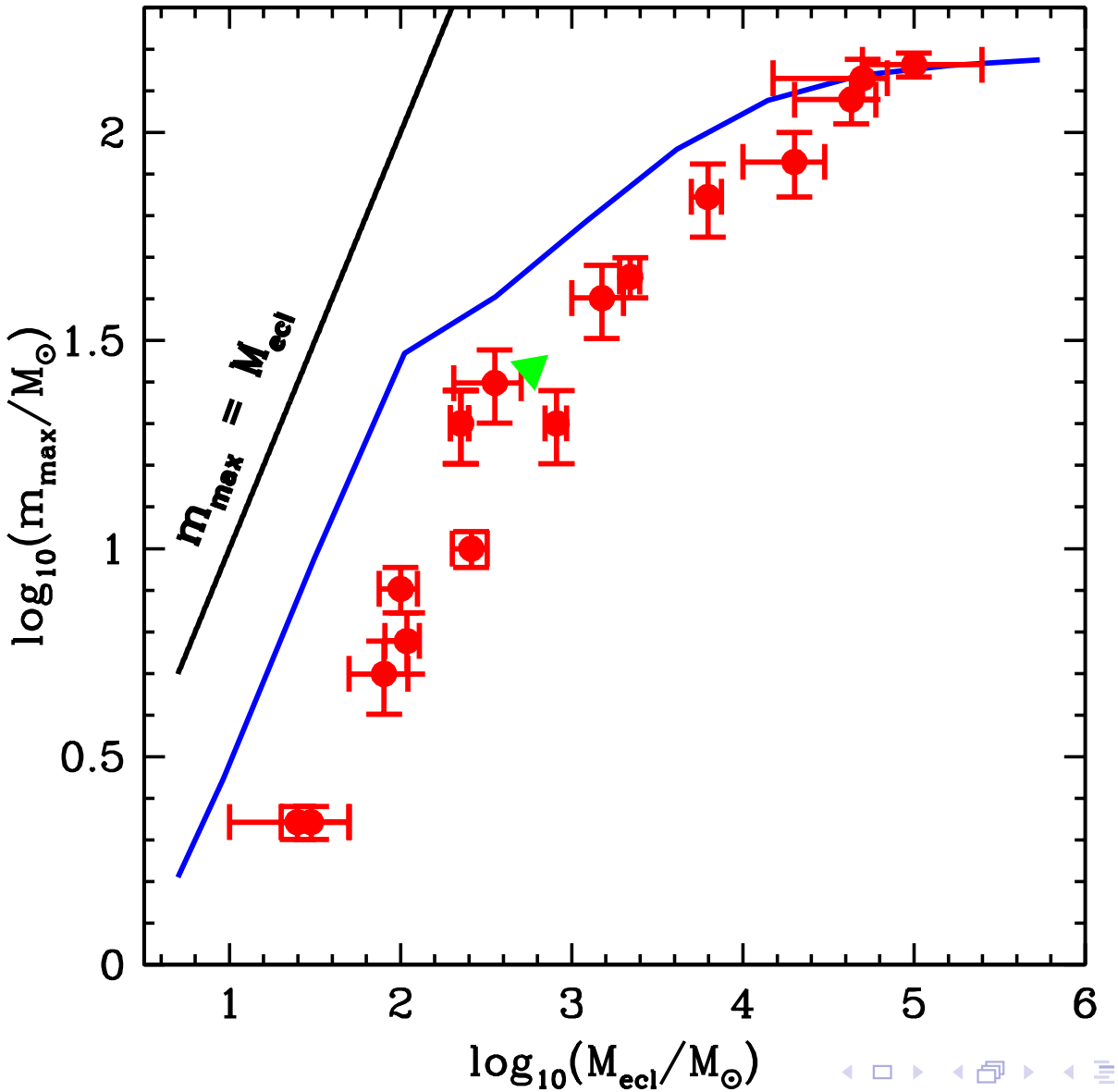
First statistical determination of a physical upper mass limit for stars:



- R136 in the LMC
- Blue region: $M_{\rm ecl}$ estimates
- Red region: $m_{\rm max}$ estimates
- $P < 1 \cdot 10^{-5}$ that no stars are above 150 $M_\odot$

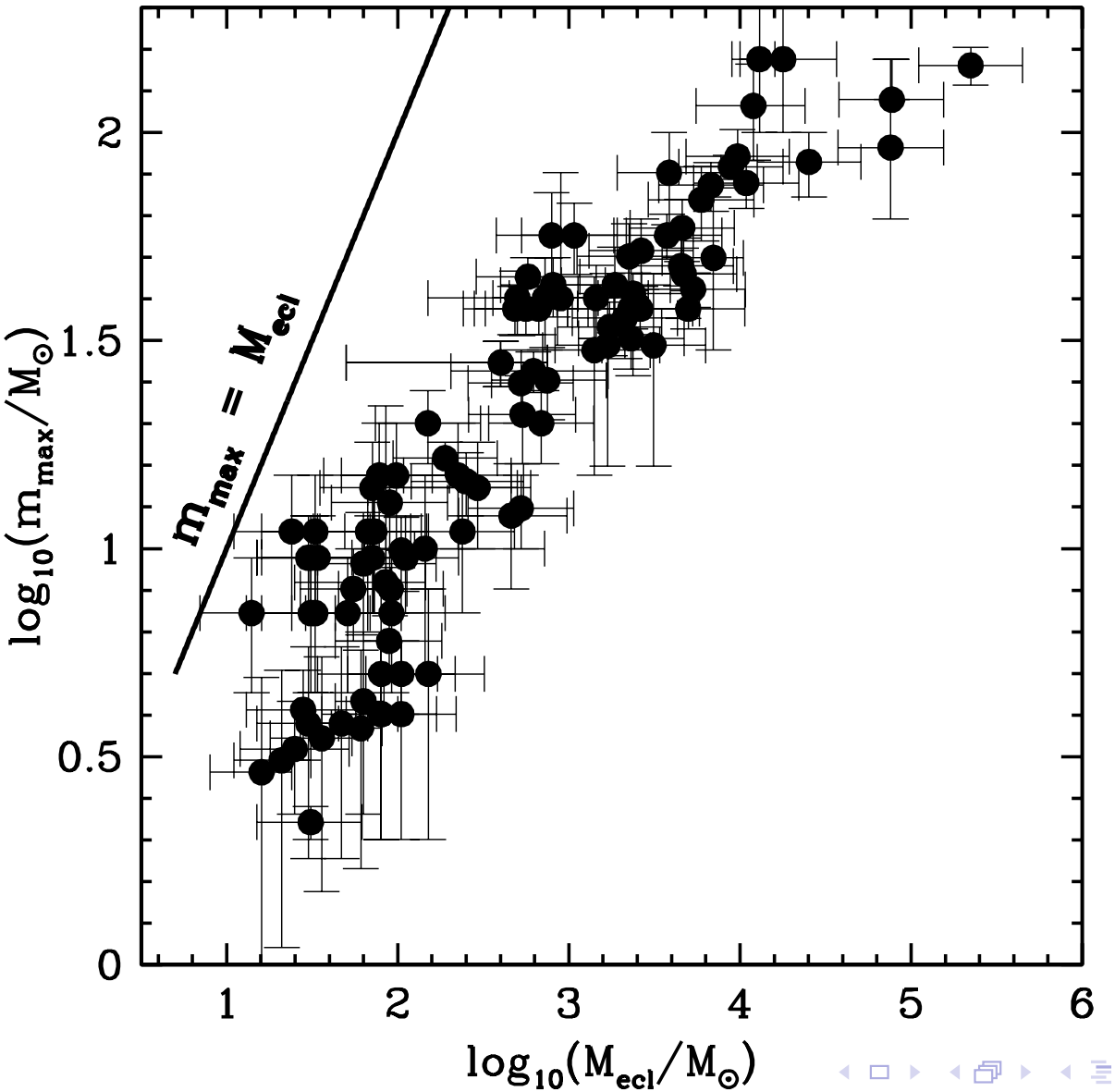
The most massive Star in a Star Cluster

Weidner & Kroupa, 2006, MNRAS, 365, 1333



The new cluster sample - Old O star spectral-type–mass calibration

Weidner et al., 2009, MNRAS, in press (arXiv:0909.1555)



A new calibration of O star parameters

Martins et al., 2005, A&A, 436, 1049

- Taking into account non-LTE effects, stellar winds, line-blanketing in the stellar atmospheres.

- $\Longrightarrow$ Change of the $T_{\rm eff}$-scale of O stars of 2000 to 8000 K.

A new O star spectral-type–mass calibration

Weidner, 2009, MNRAS, submitted

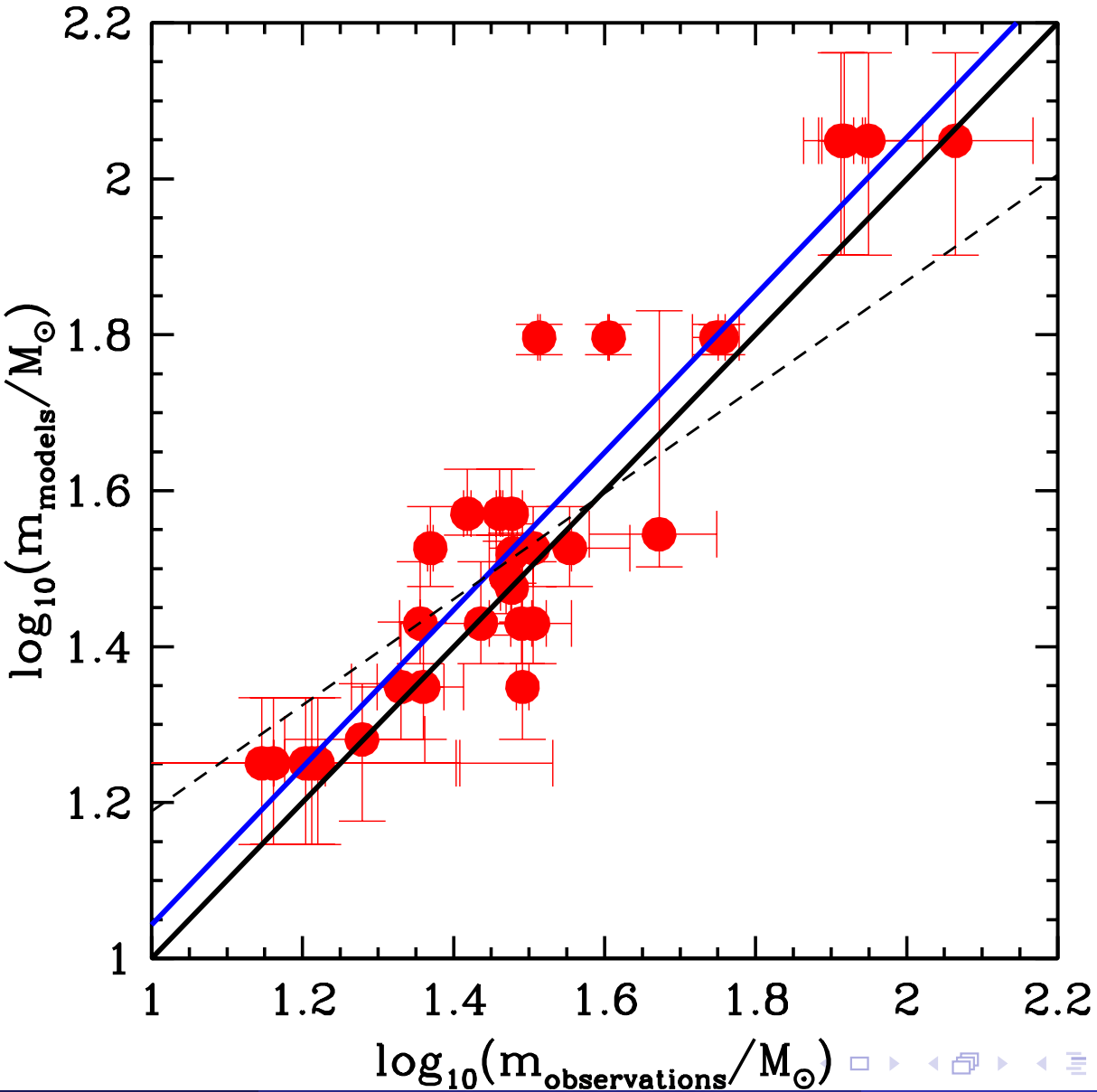
- By tracking when the rotating stellar evolutions models (300 km/s) by *Meynet & Maeder (2003, A&A, 404, 975)* pass through the new definitions of the spectral types of O stars by *Martins et al. (2005, A&A, 436, 1049)*,

- and comparing the evolved masses with dynamical mass measurements for eclipsing O star binaries,

- a new calibration of O star spectral types with their initial and current masses could be achieved.

The new O star spectral-type–mass calibration

Weidner, 2009, MNRAS, submitted



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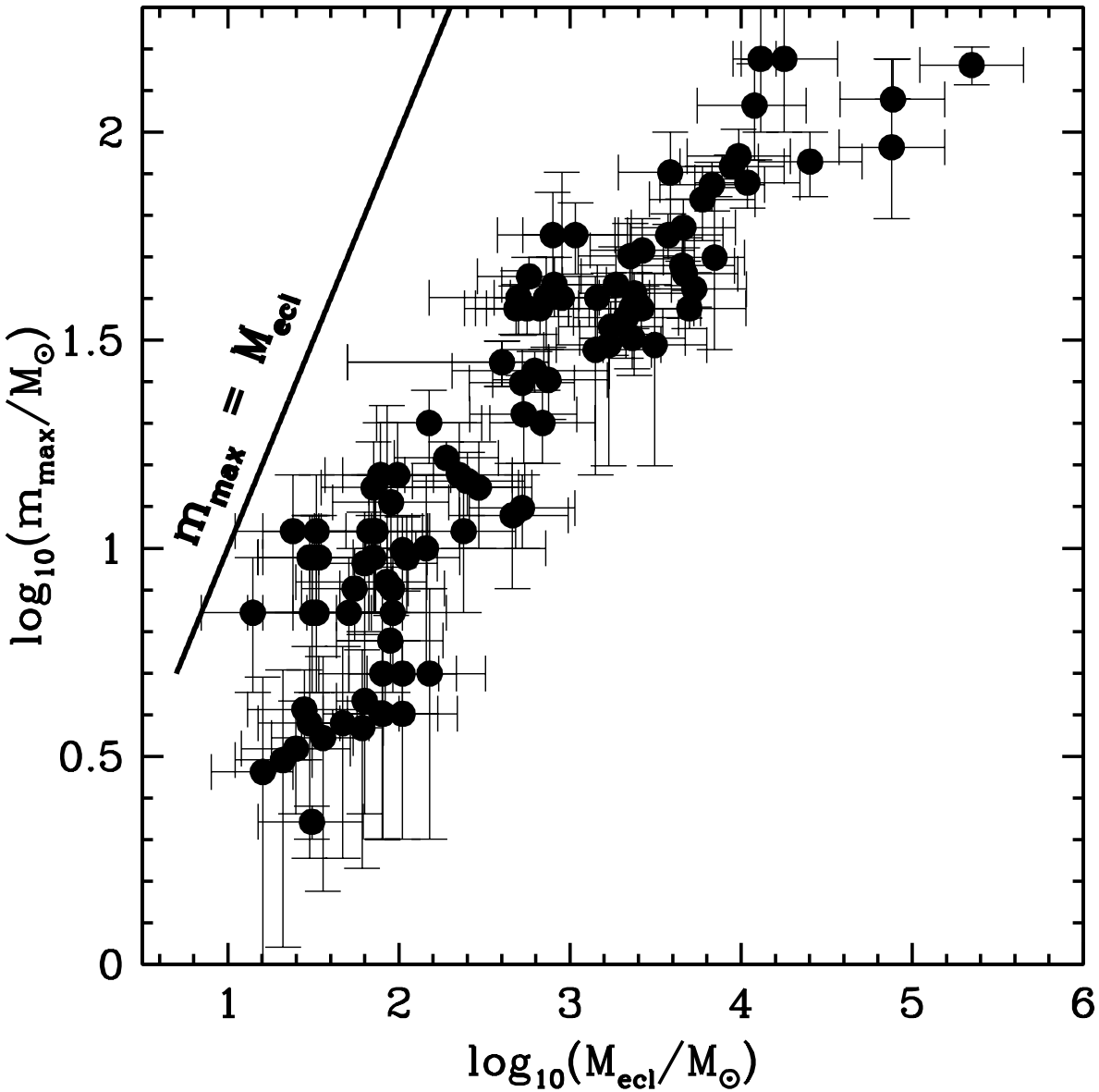

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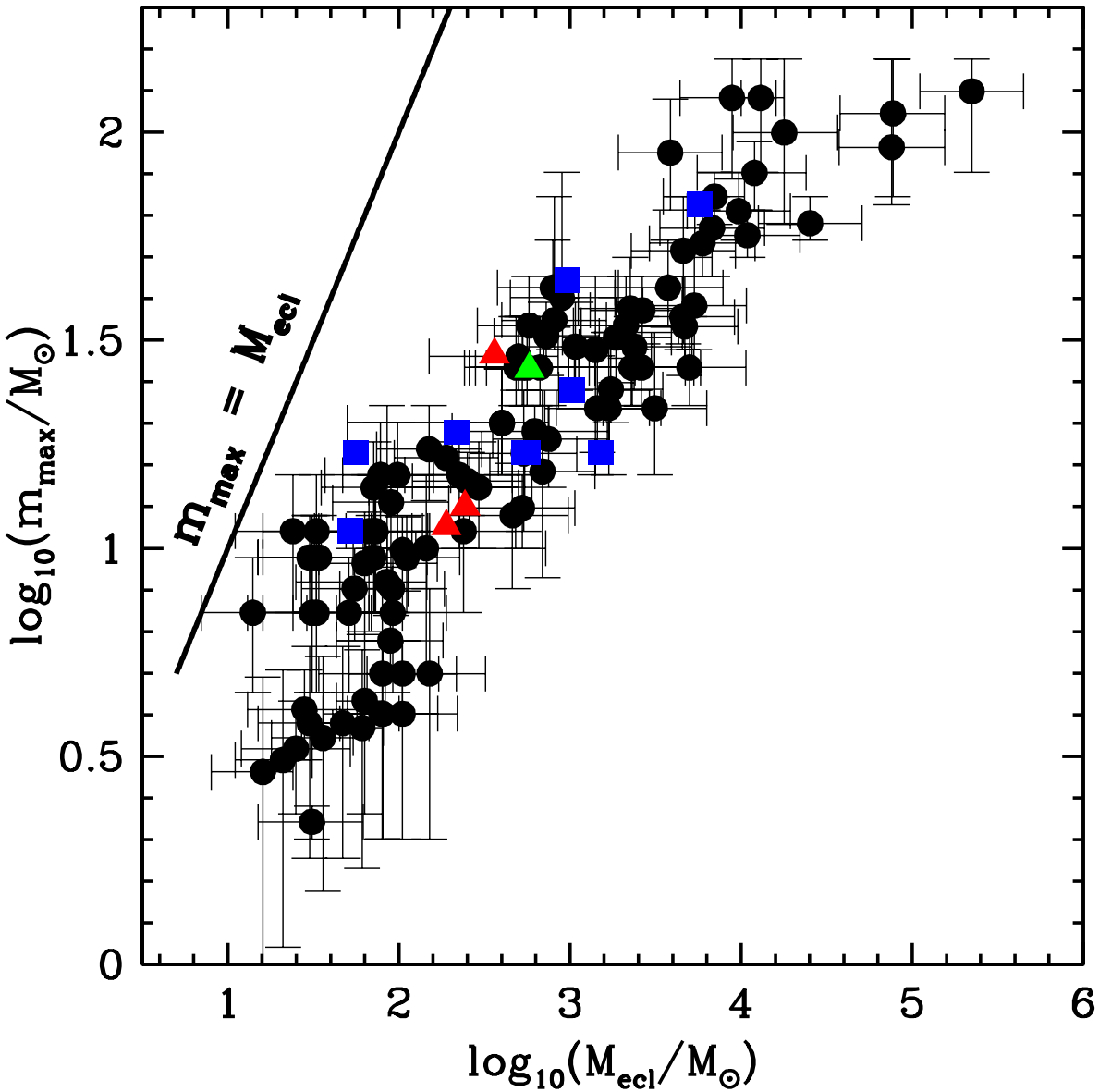
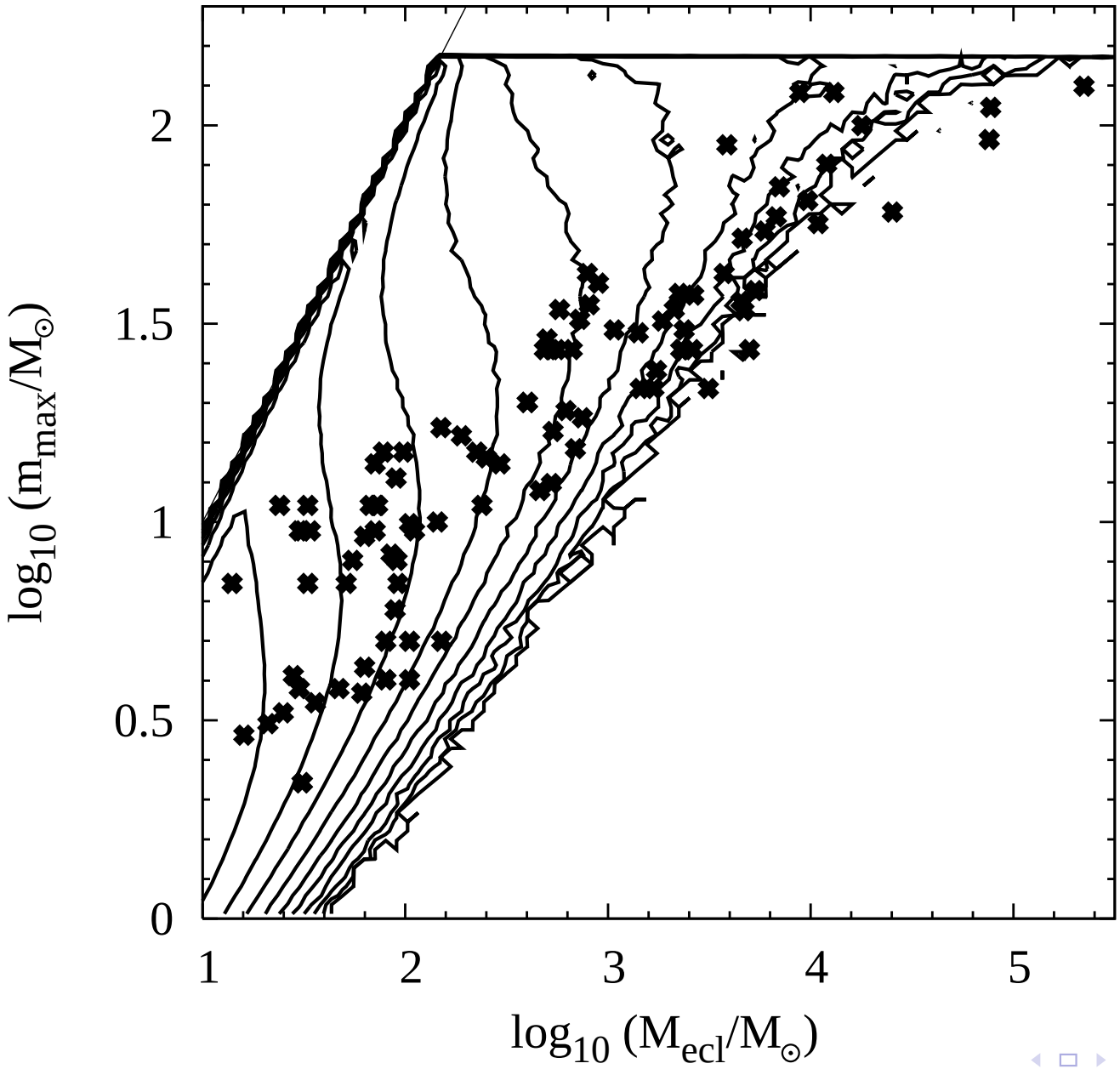


Model data from *Bonnell et al., 2003, MNRAS, 343, 413*

Model data from *Smith et al., 2009, in press (arXiv: 0908.3910)*

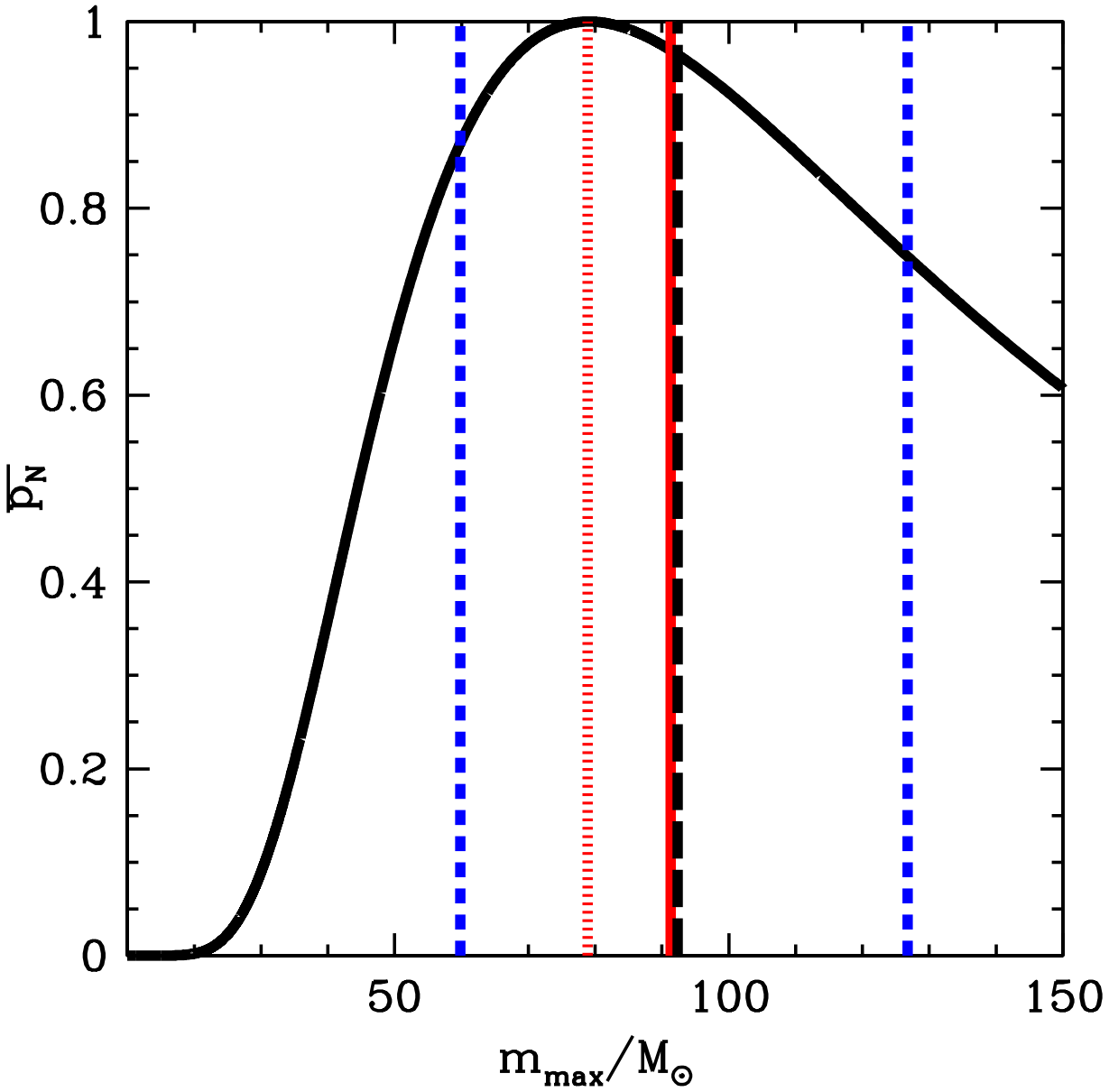
mm Observations from *Johnston, 2009, submitted*

Monte-Carlo random sampling



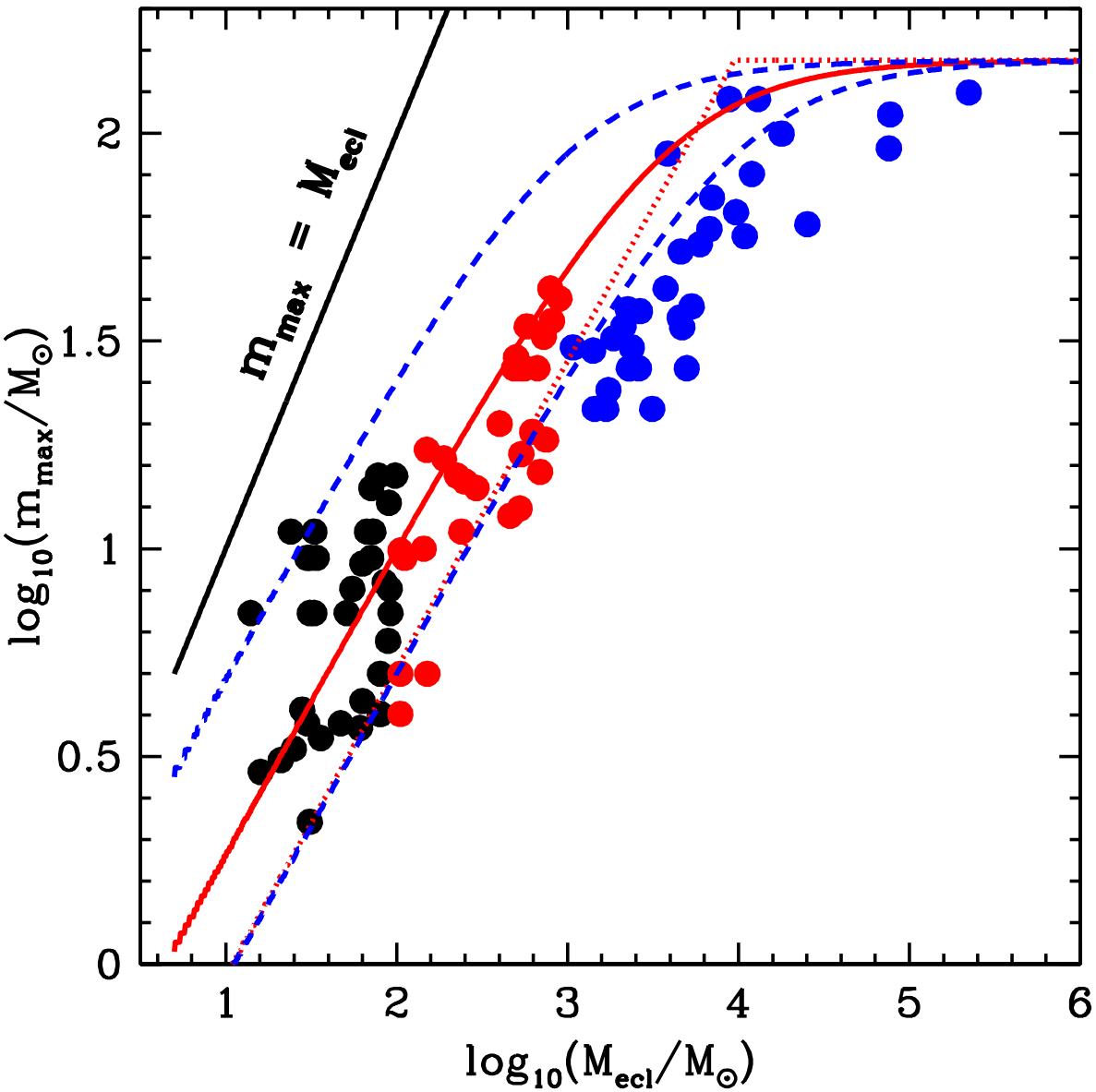
The most massive Star in a Star Cluster

Weidner et al., 2009, MNRAS, in press (arXiv:0909.1555)



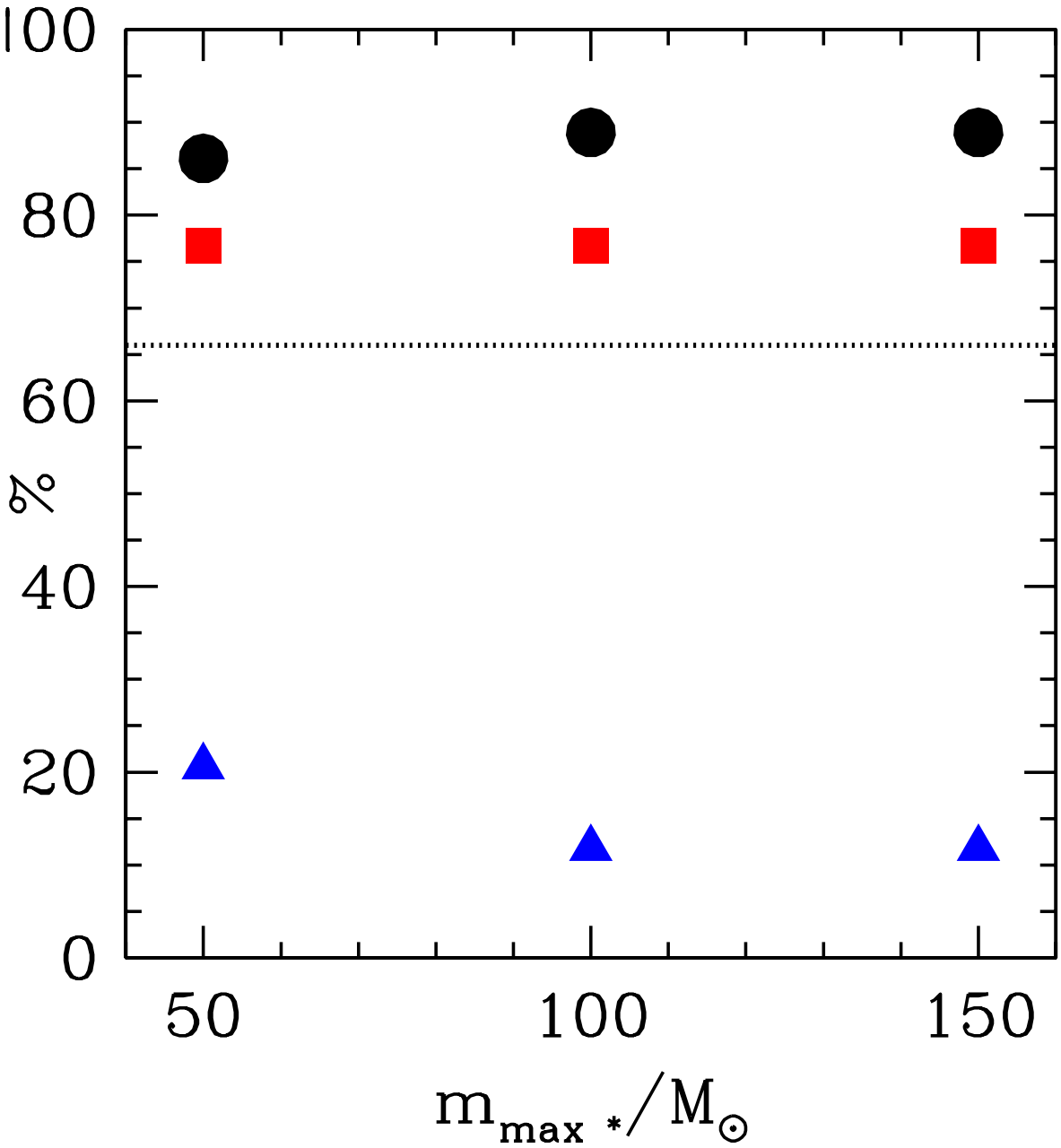
mean (*long-dashed*)
mode (*dotted*)
median (*solid*)
1/6th and 5/6th
quantiles (*short-dashed*)

The most massive Star in a Star Cluster

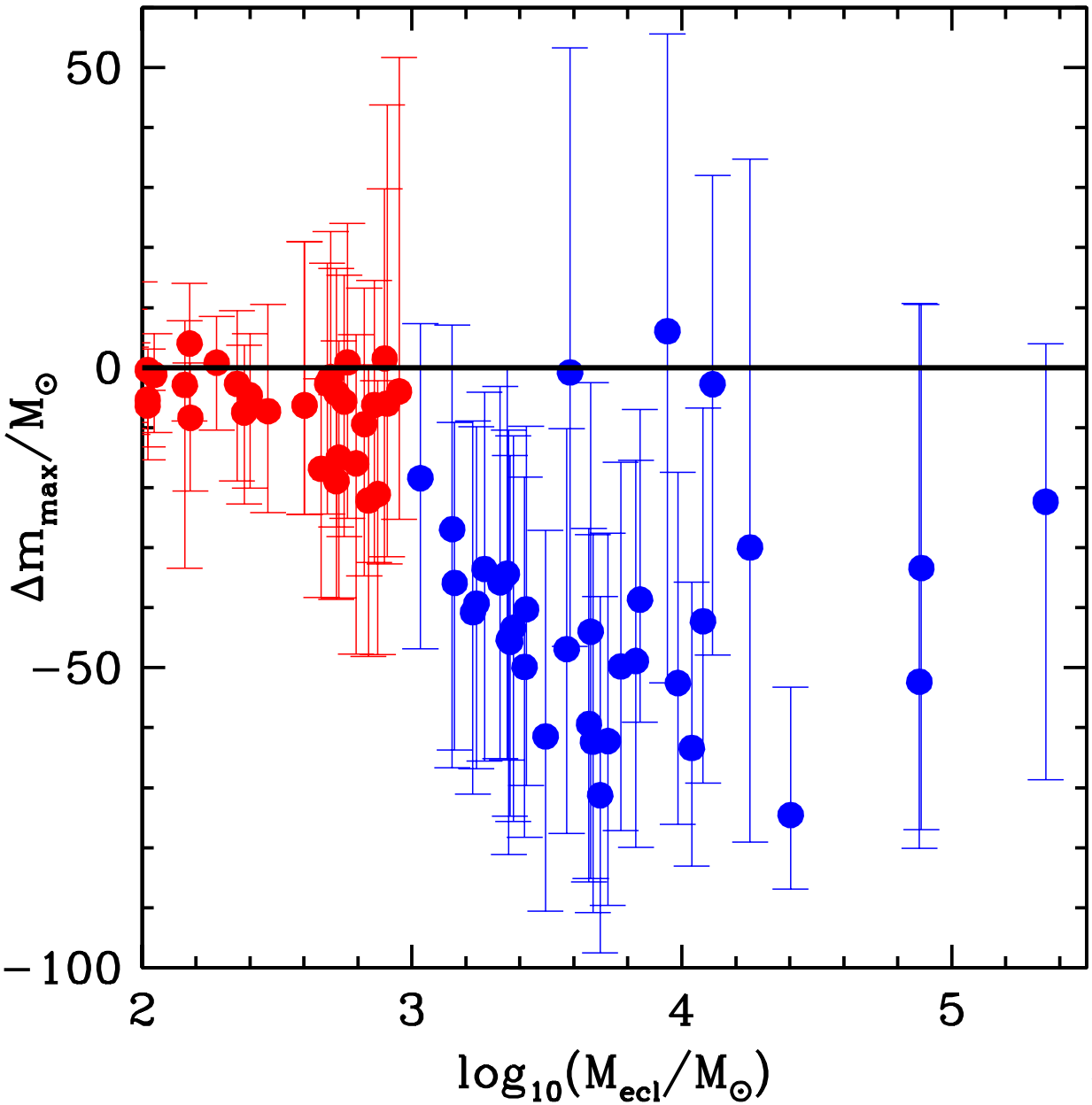


Random sampling from the canonical IMF is unable to explain observed distribution!

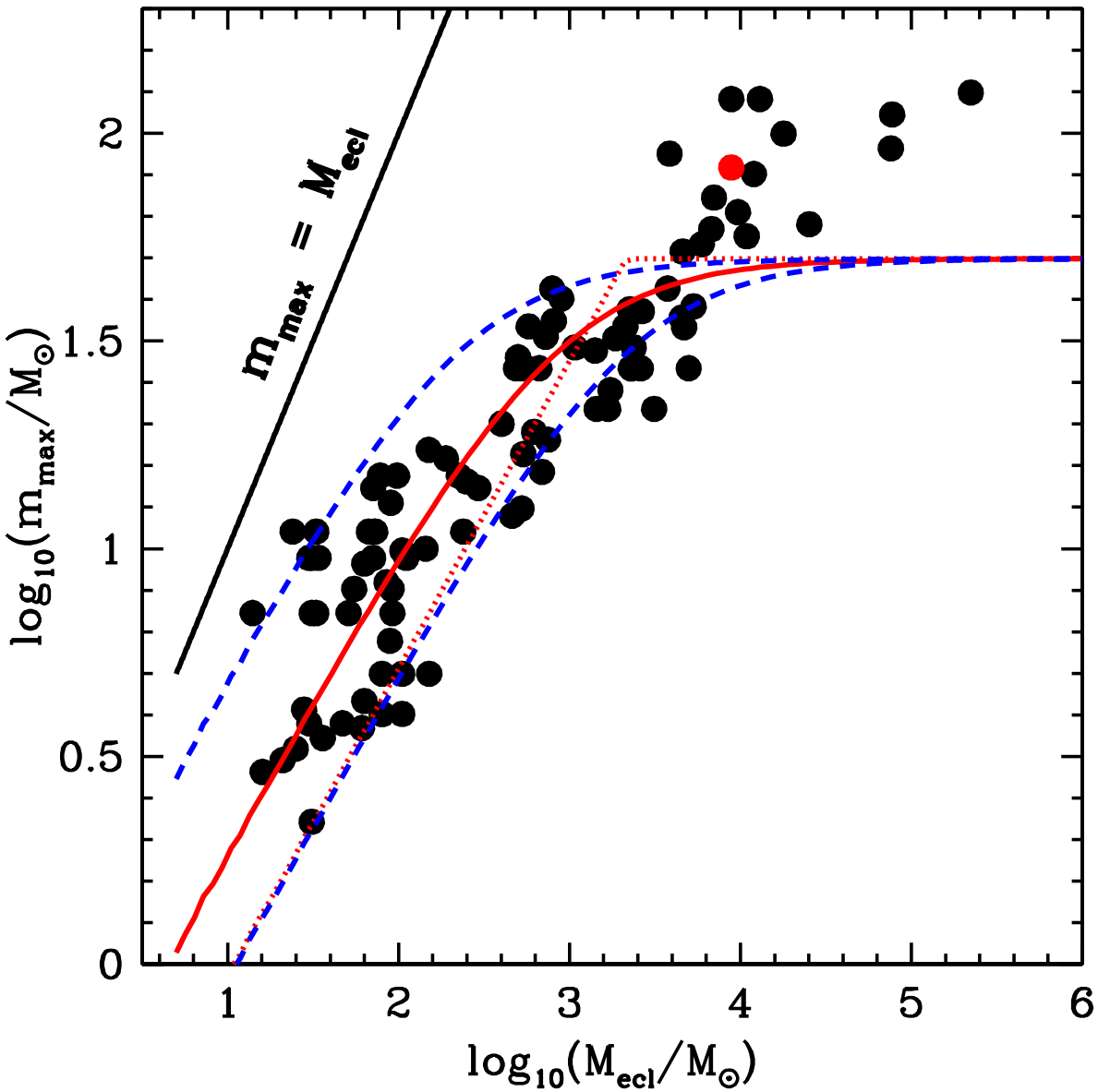
Percentage within the 1/6th and 5/6th quantiles



Deviation from the median

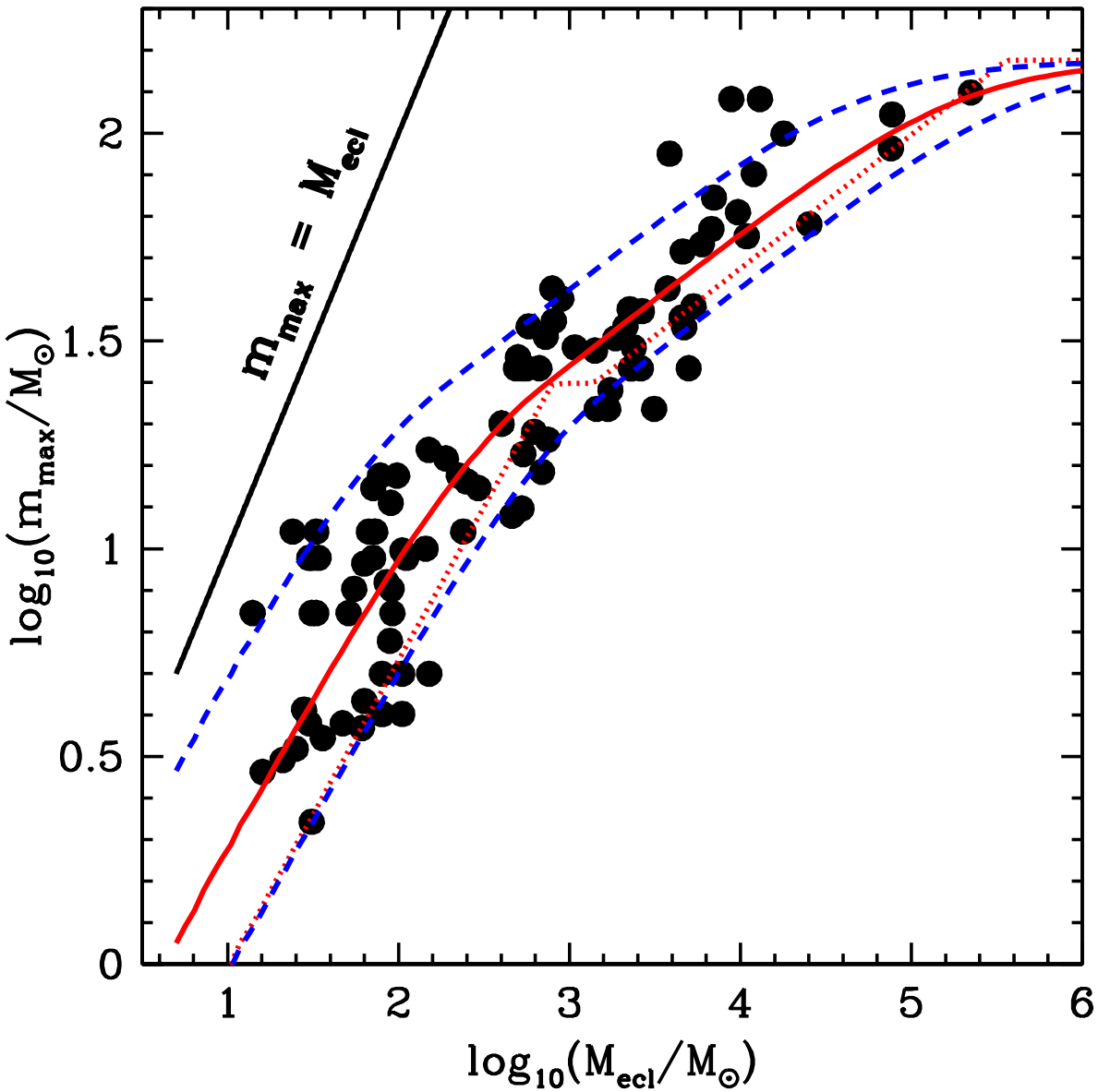


The most massive Star in a Star Cluster



Changing the fundamental upper mass limit $m_{\max *} = 50\ M_\odot$

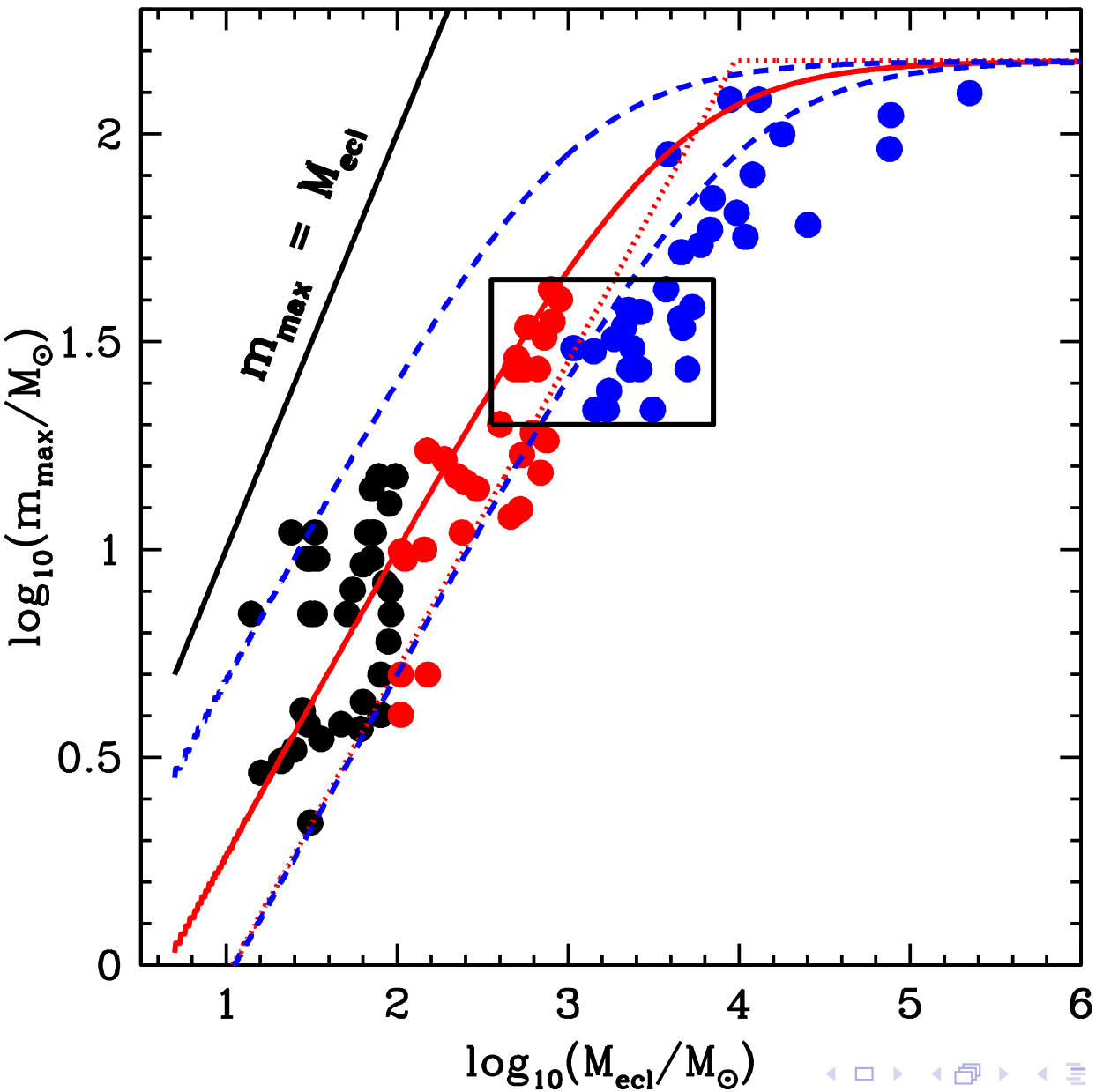
The most massive Star in a Star Cluster



Changing the IMF slope above 25 $M_\odot$

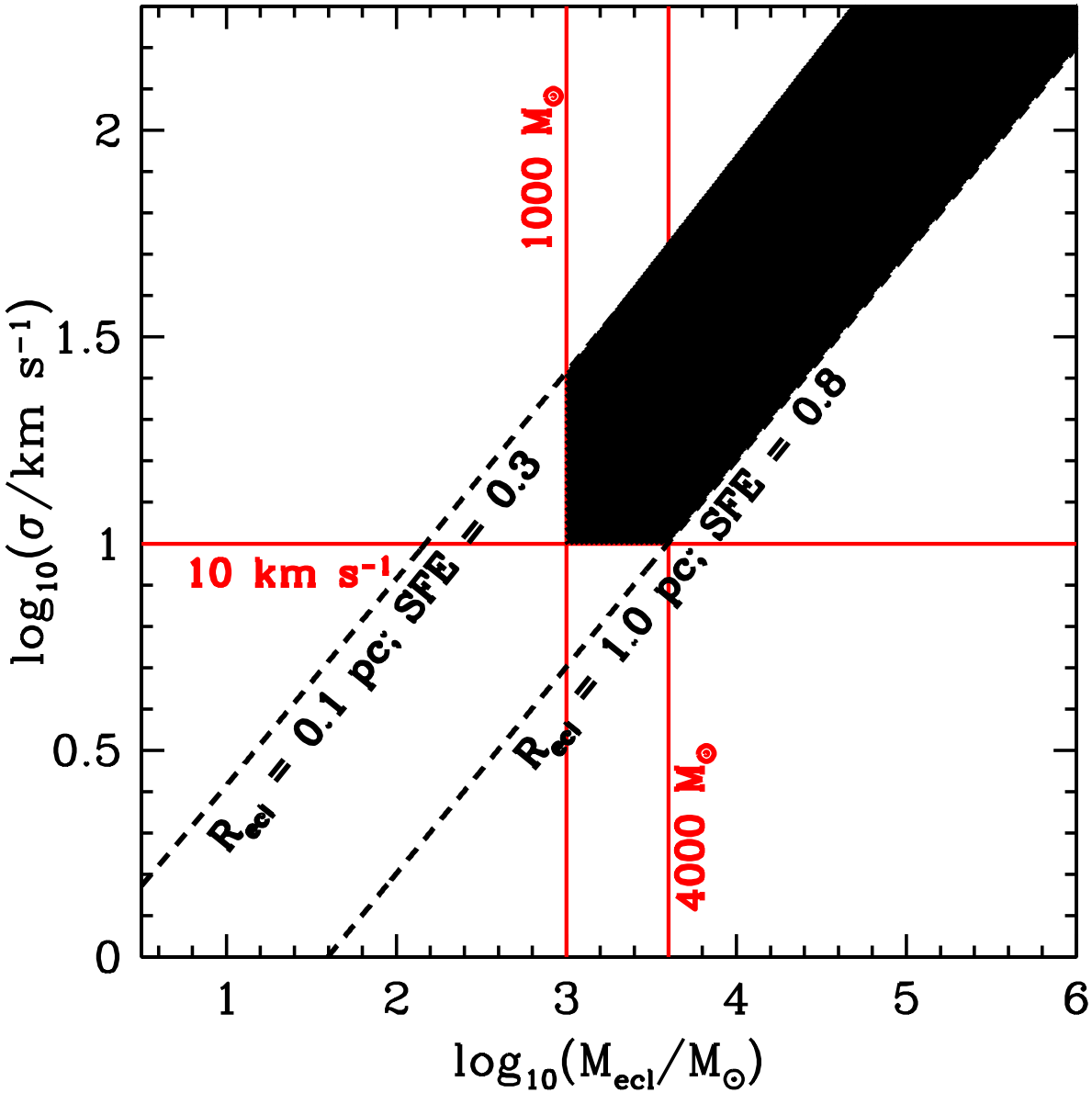
$\alpha_4 = 4.1$

The plateau at $\sim 25\ M_\odot$



A simple model

Weidner et al., 2009, MNRAS, in press (arXiv:0909.1555)



When does the velocity dispersion of a pre-cluster cloud core becomes larger than the typical velocity of the ionised gas?

Conclusion

Random sampling from the canonical IMF is unable to explain the observed distribution!