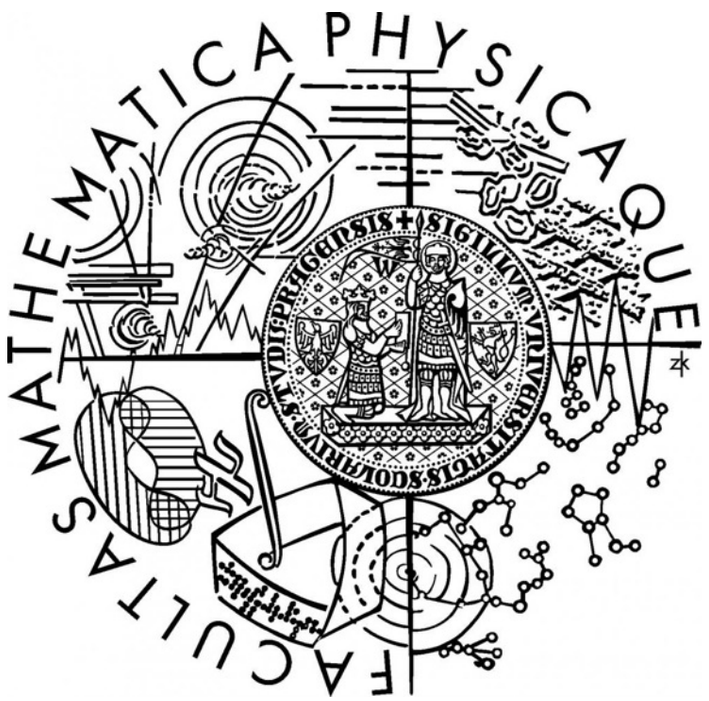
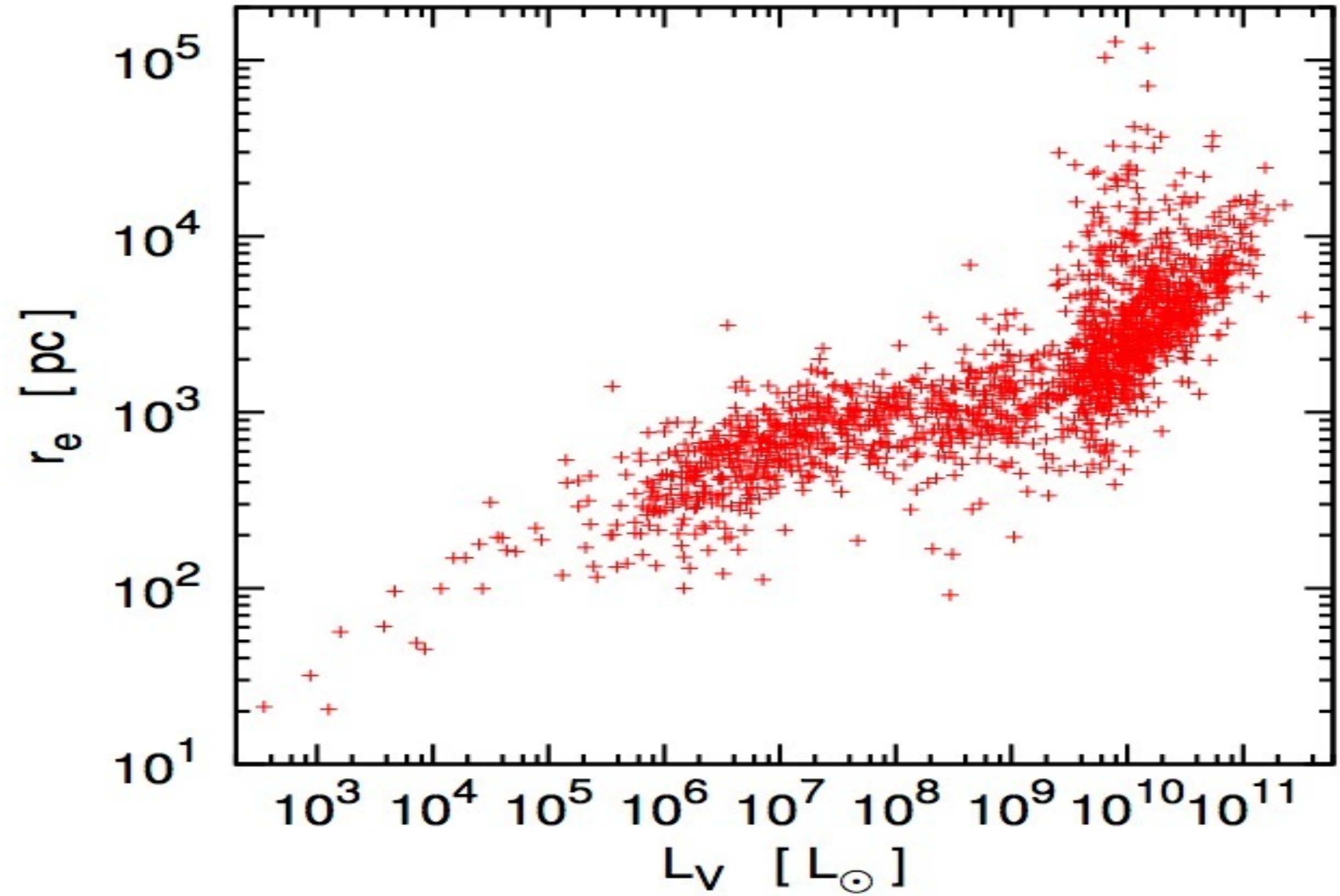
Explaining the dynamics of early-type galaxies without dark matter

Jörg Dabringhausen

Univerzita Karlova
v Praze



Early-type galaxies (ETGs)



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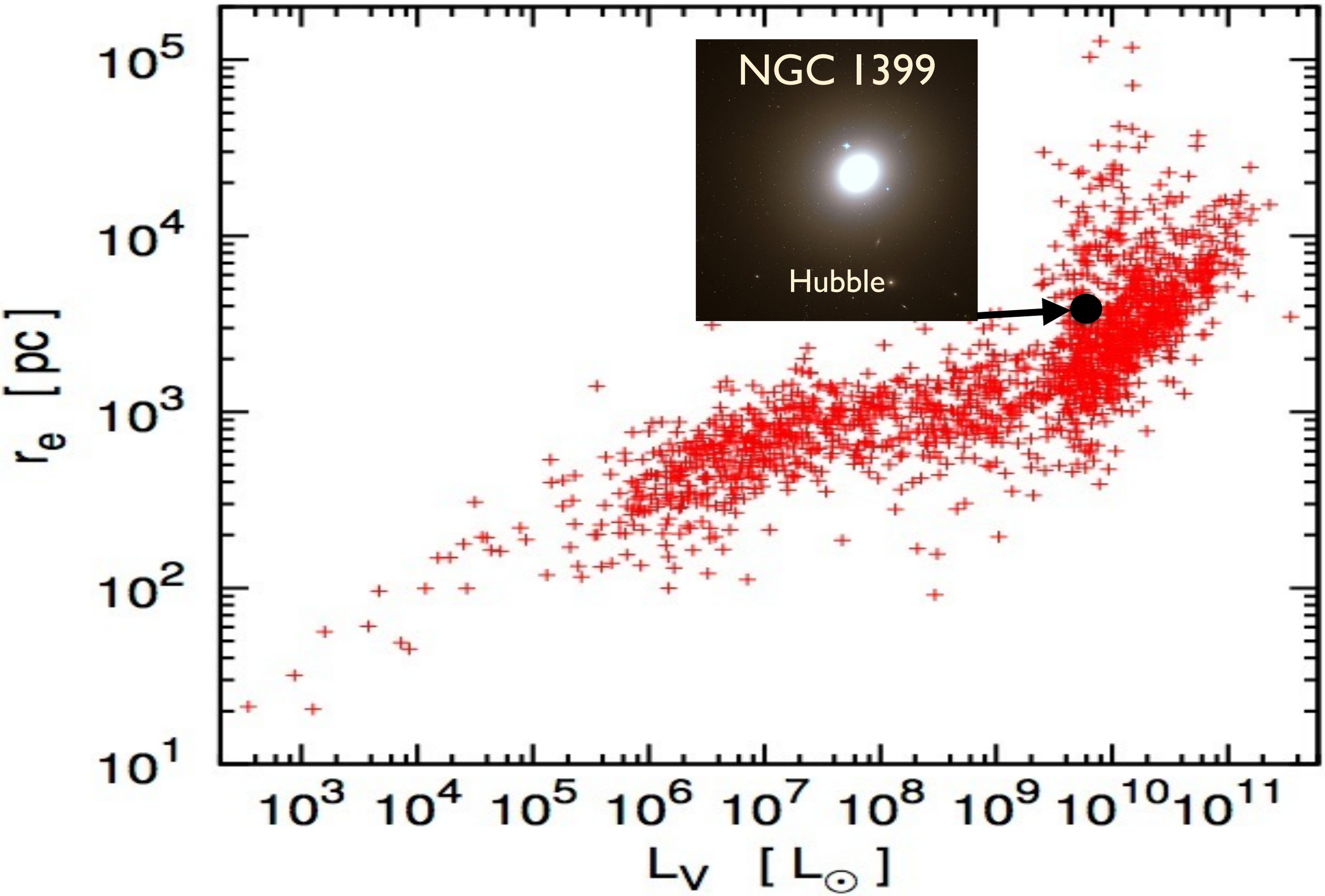

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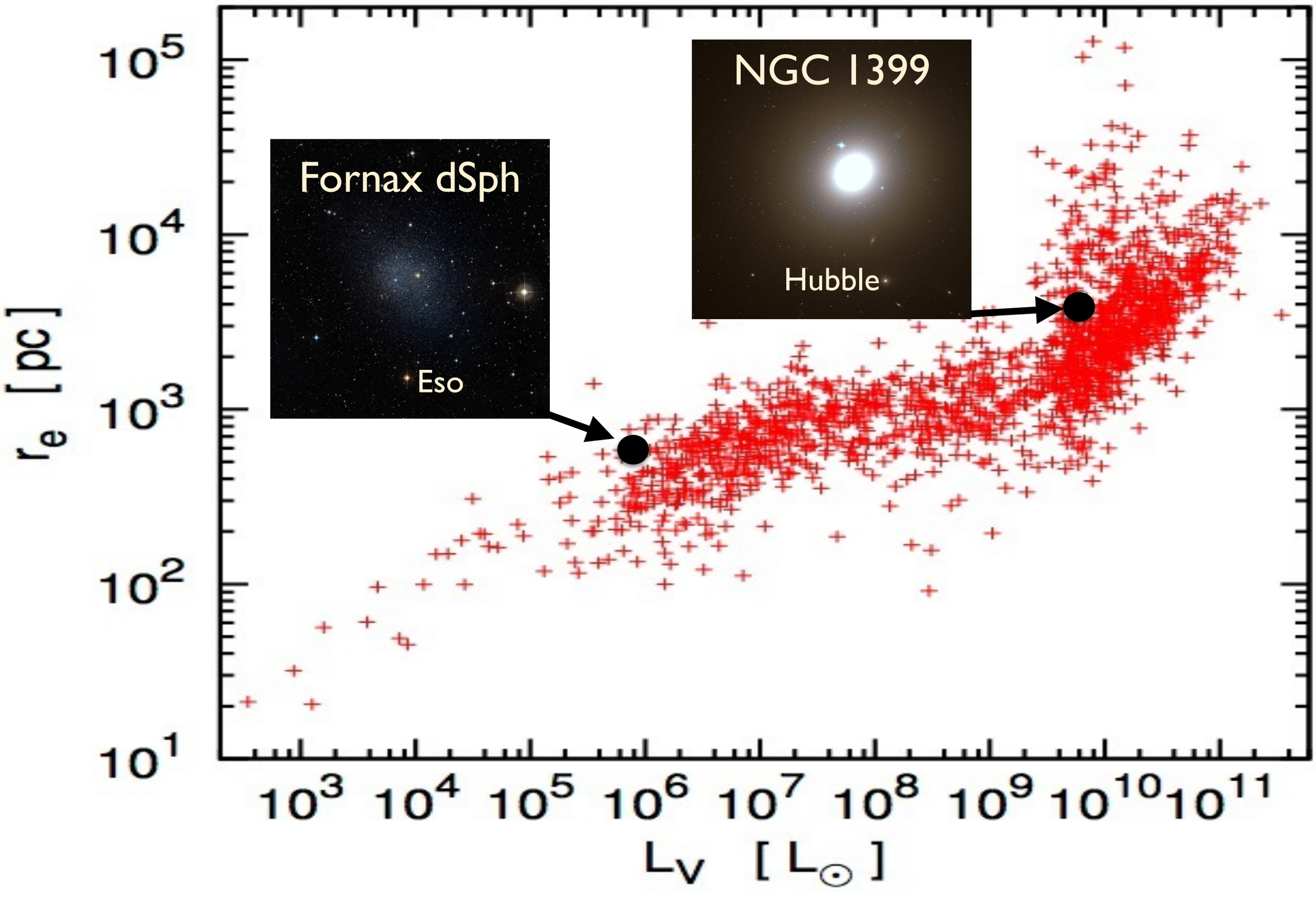

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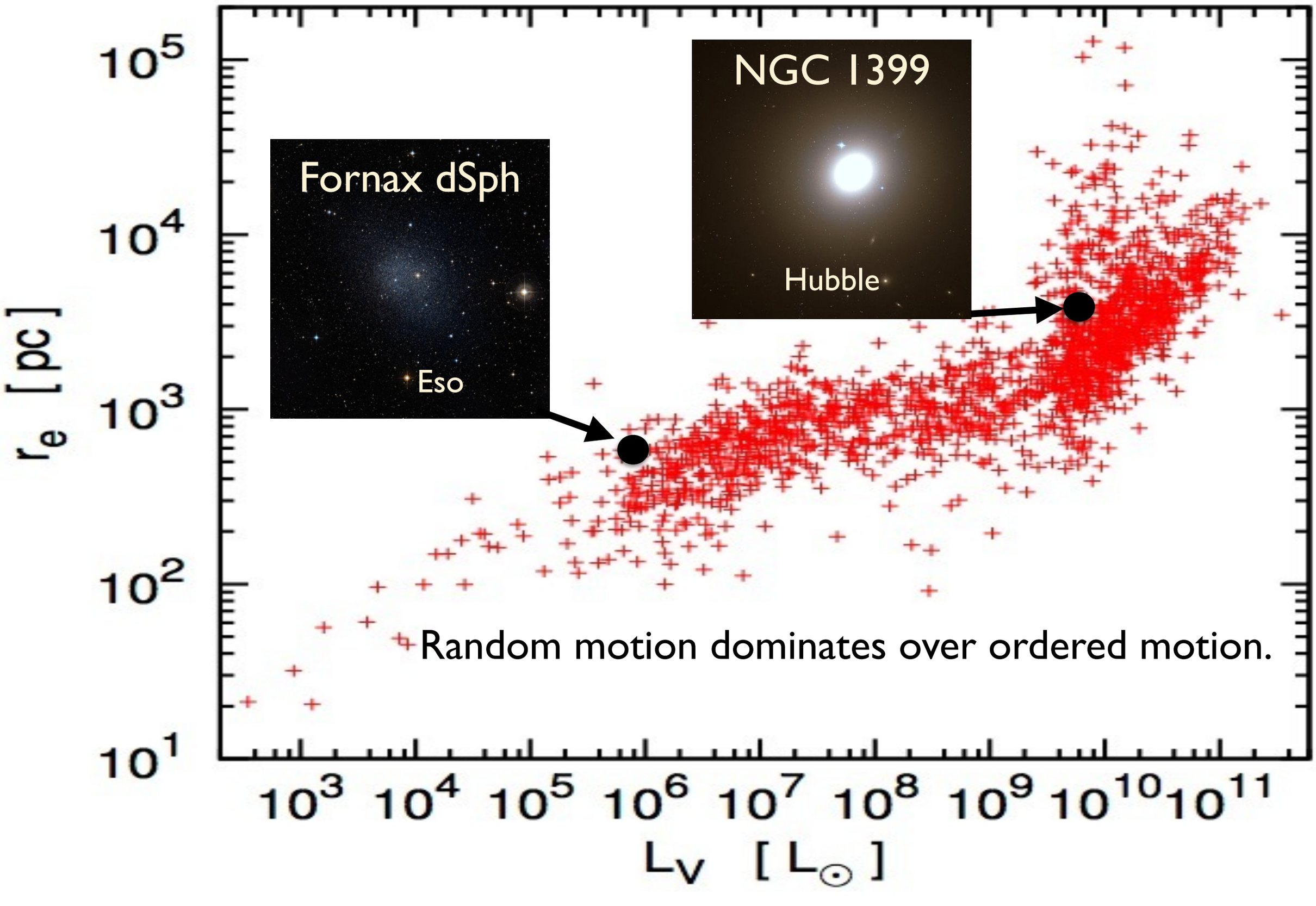

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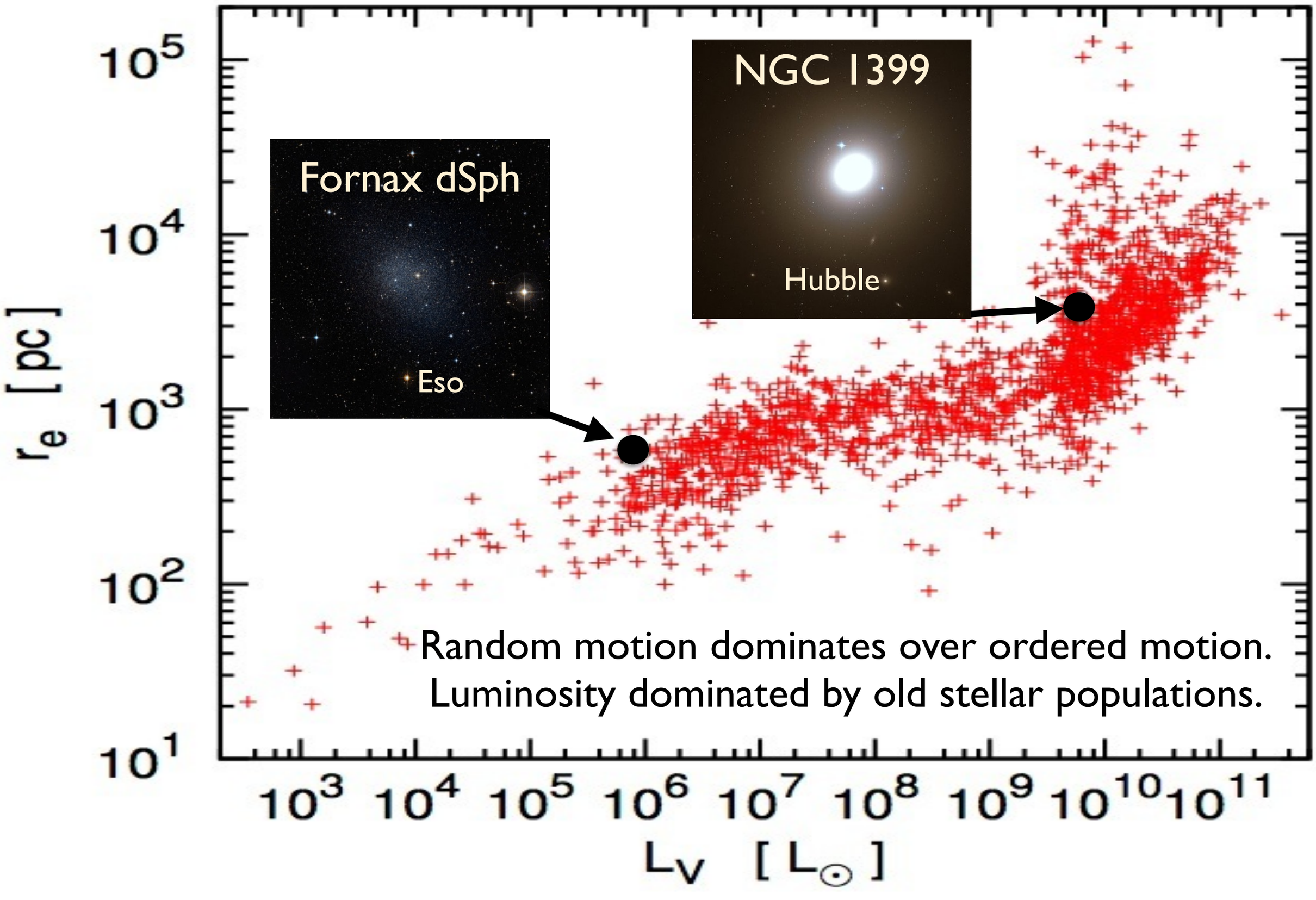

Random motion dominates over ordered motion.
Luminosity dominated by old stellar populations.

Estimating the mass of the ETGs

Method 1: Mass estimate from dynamics

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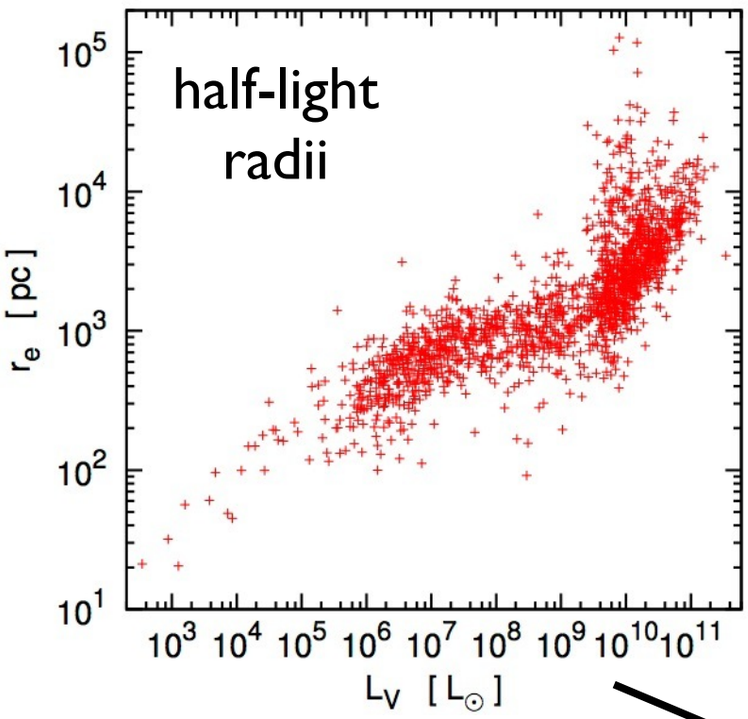

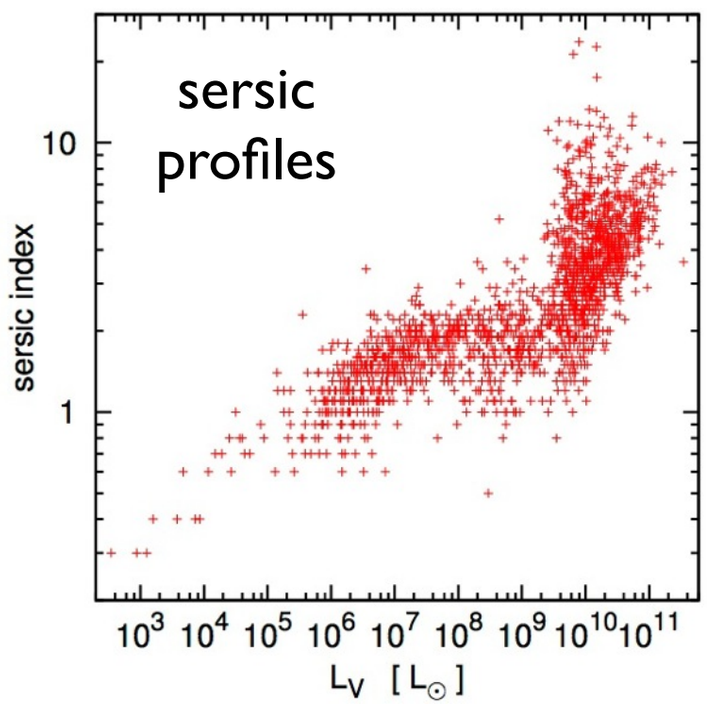

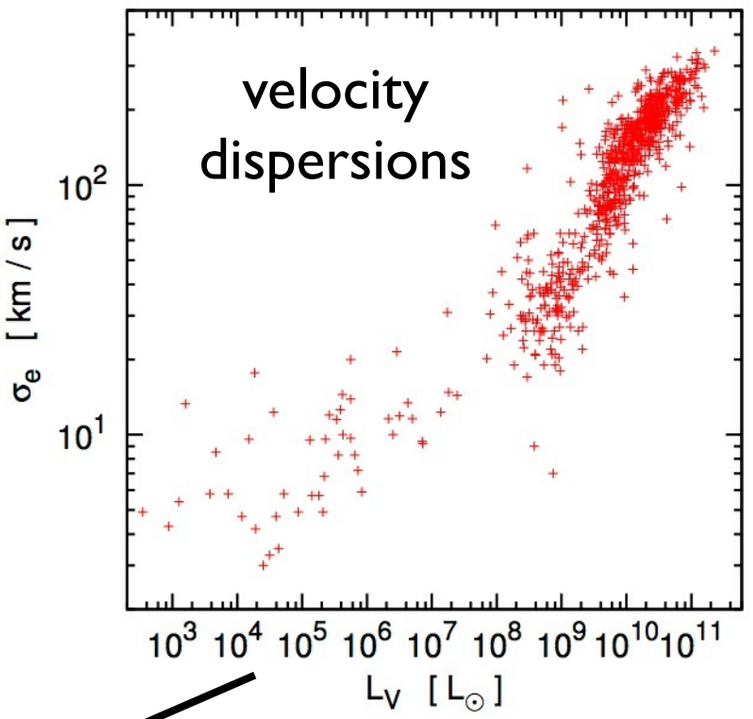

$$M_{\rm dyn} = \frac{K_{\rm V}}{G} R_{\rm e} \sigma_0^2$$

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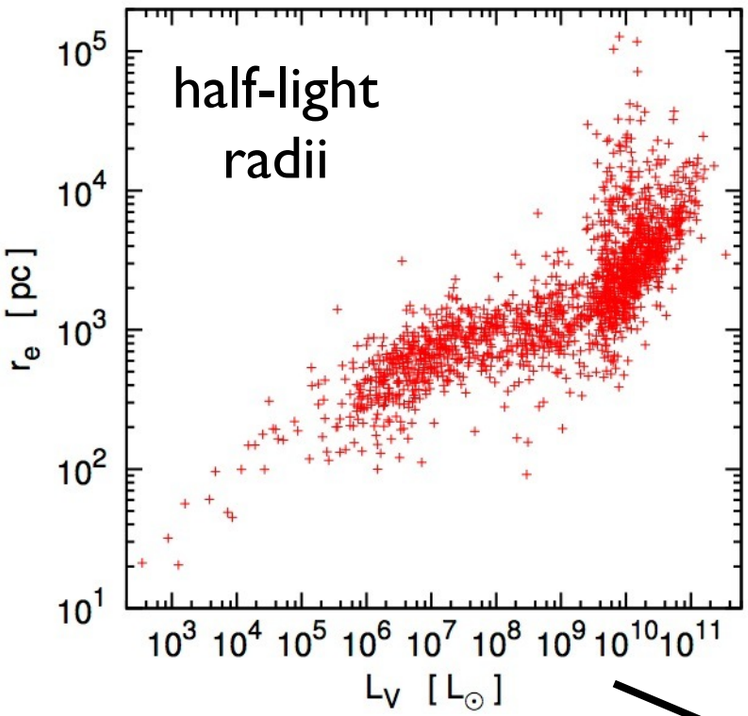

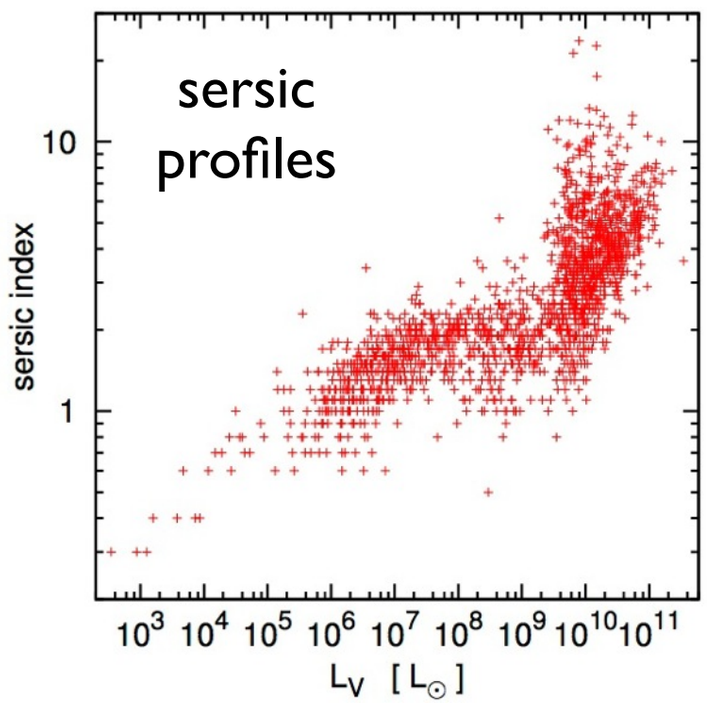

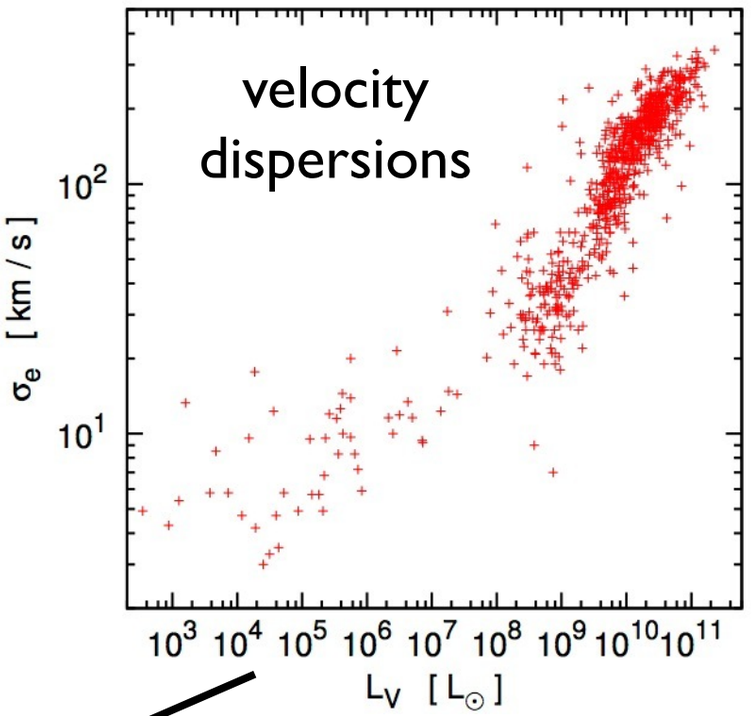

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Virial equilibrium is assumed.

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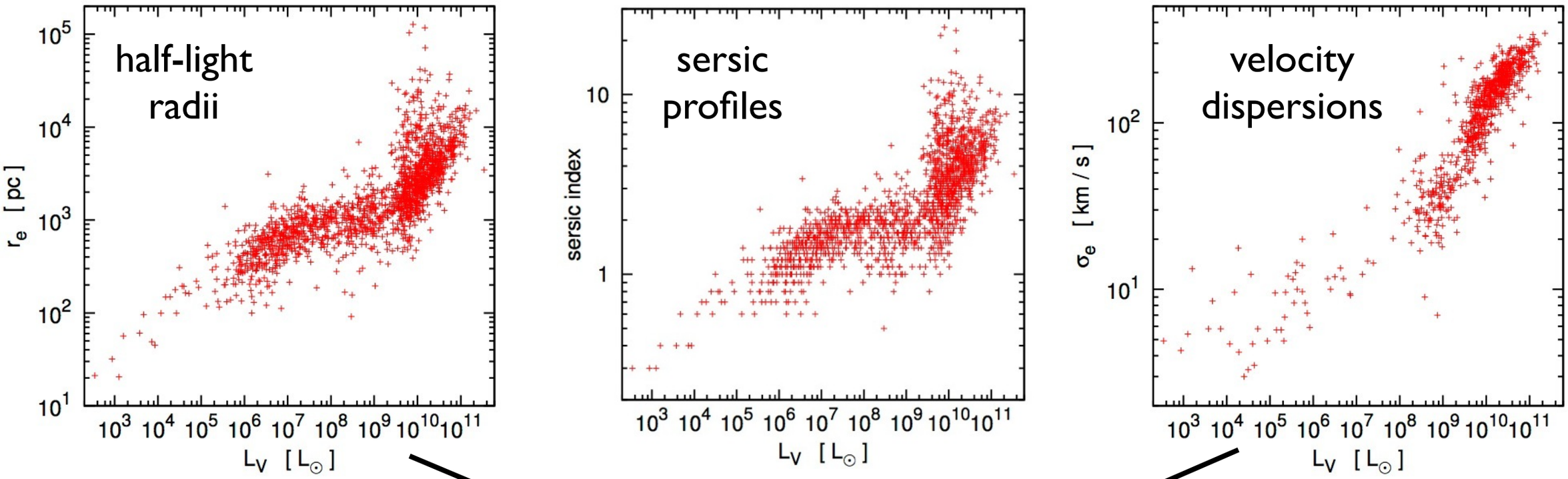

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Newtonian Dynamics is assumed.

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Method 2: Direct matter detection

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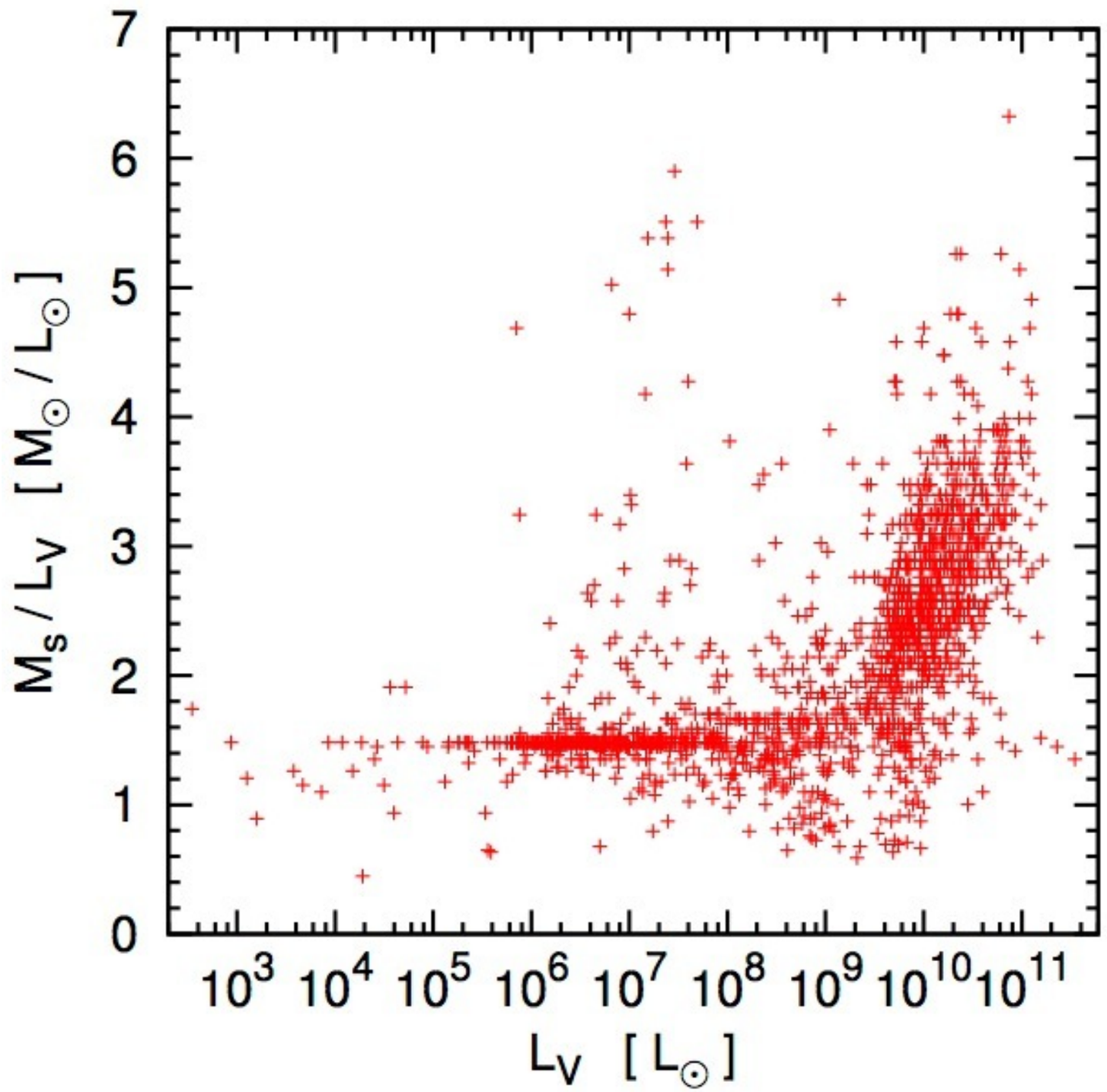

Mass estimates based on luminosity, colour and age using simple stellar population models.

Estimating the mass of the ETGs

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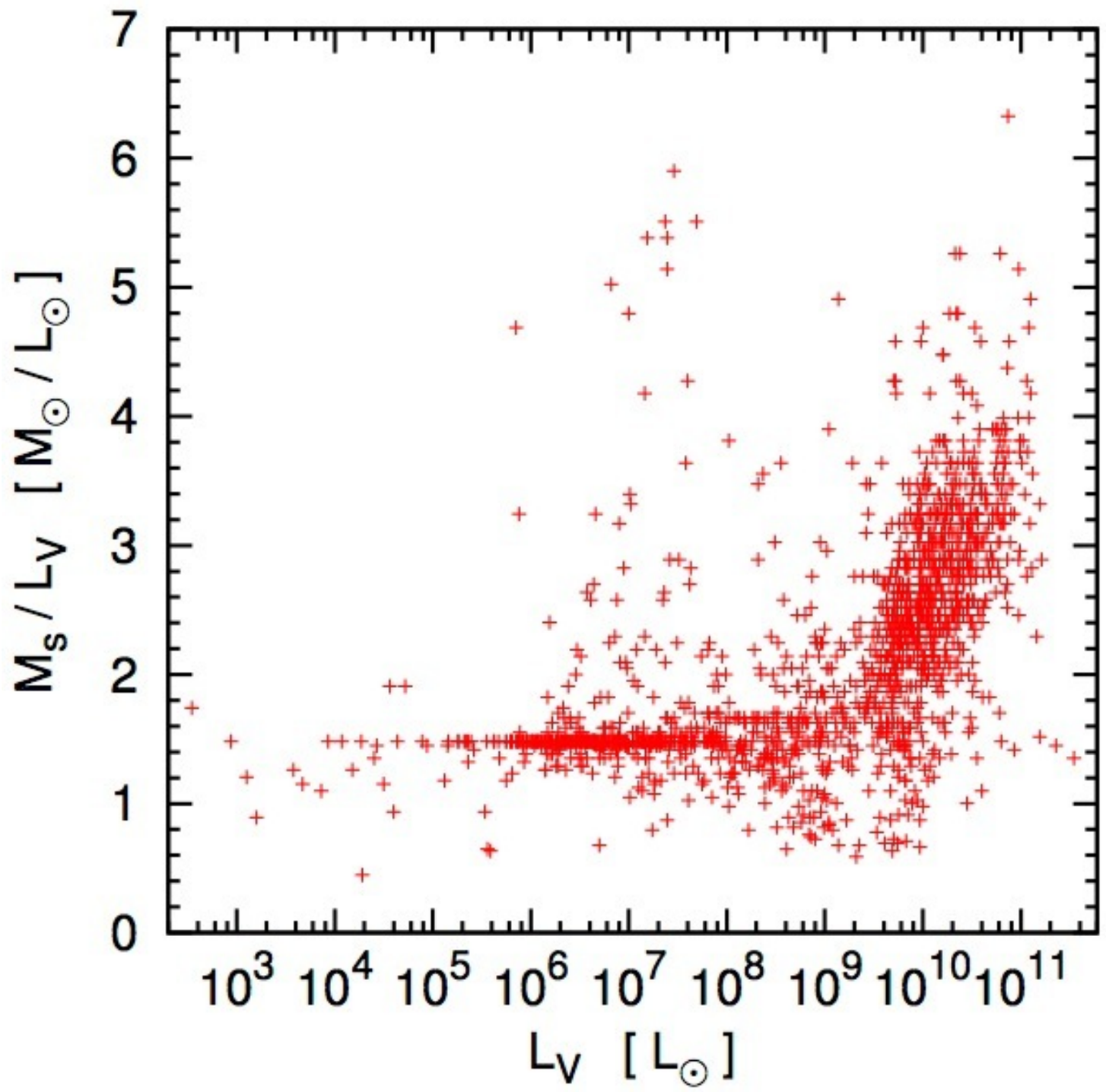
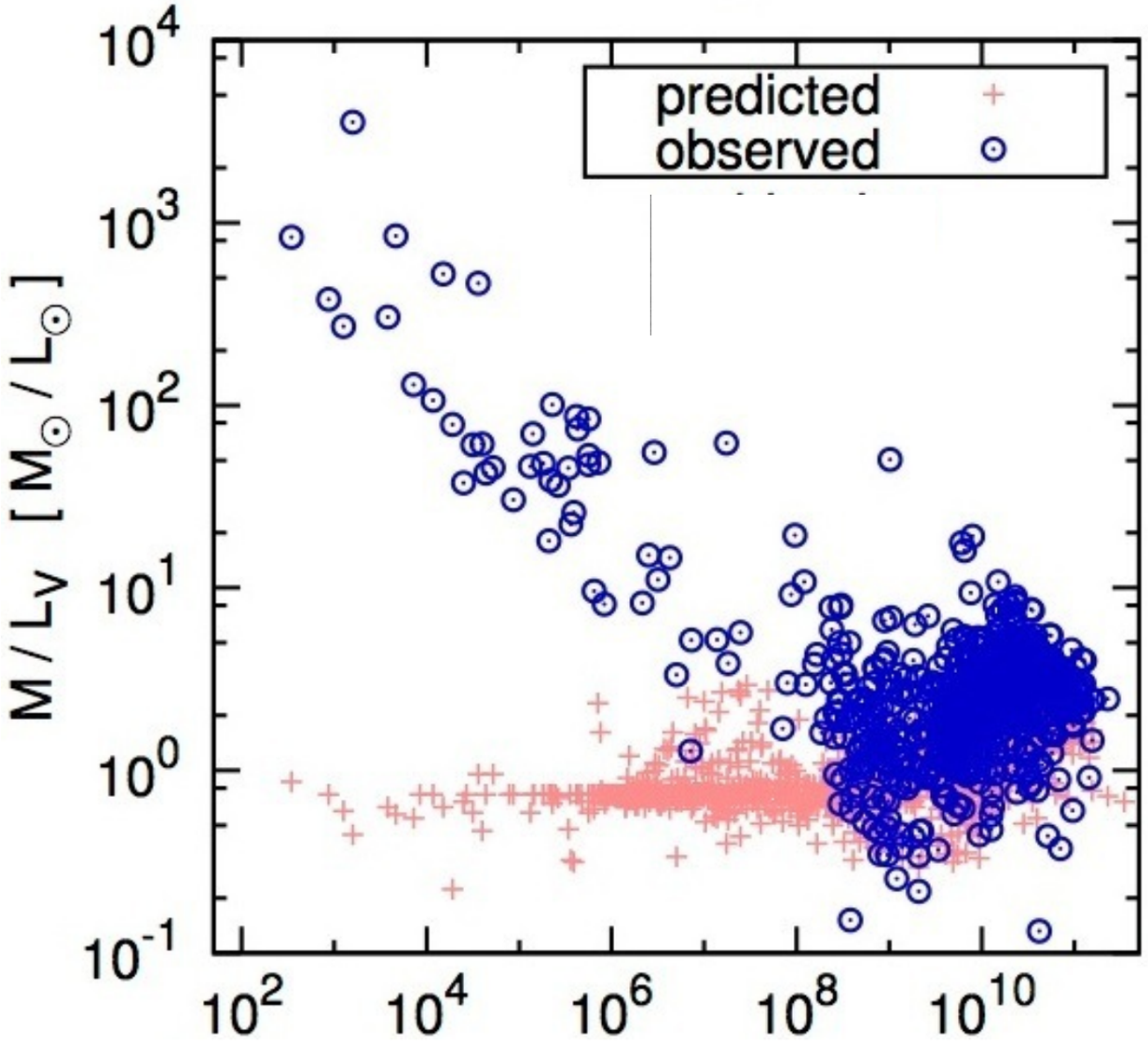


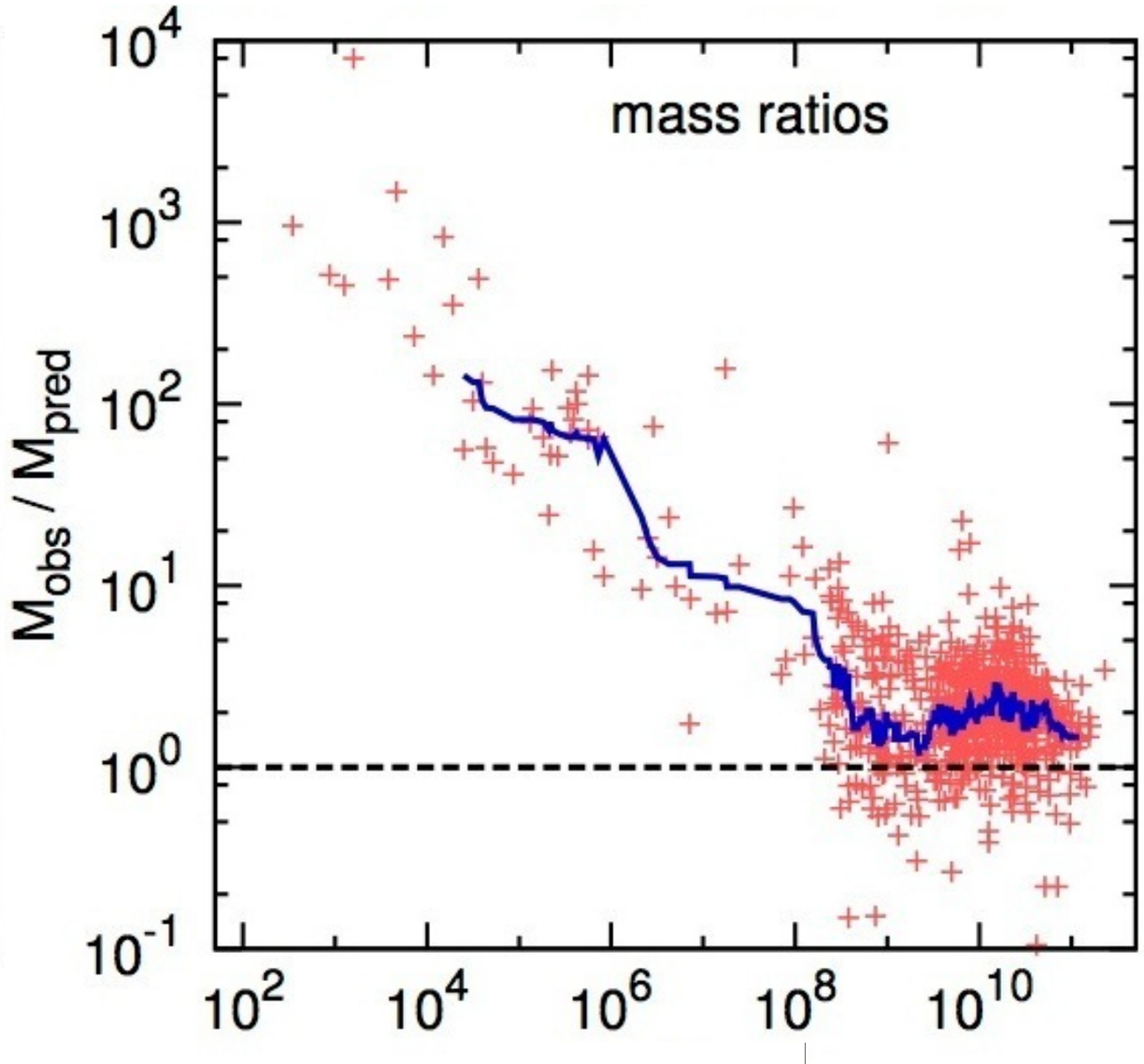
Mass estimates based on luminosity, colour and age using simple stellar population models.

All data on ETGs used here are in Dabringhausen & Fellhauer (2016)

Comparing stellar and dynamical mass-to-light ratios

M/L-ratios - Newtonian dynamics





Dabringhausen et al. (2016)

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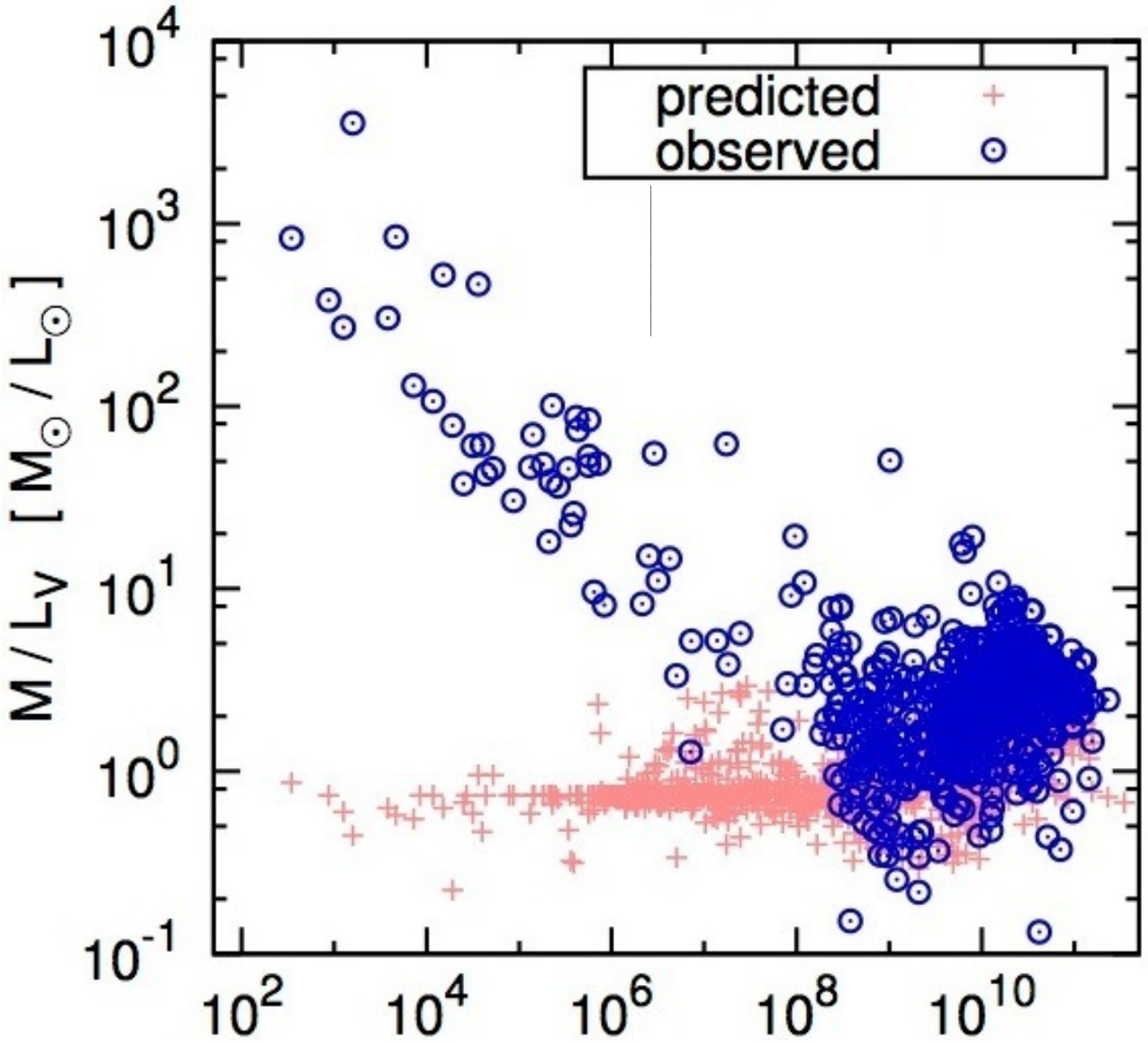

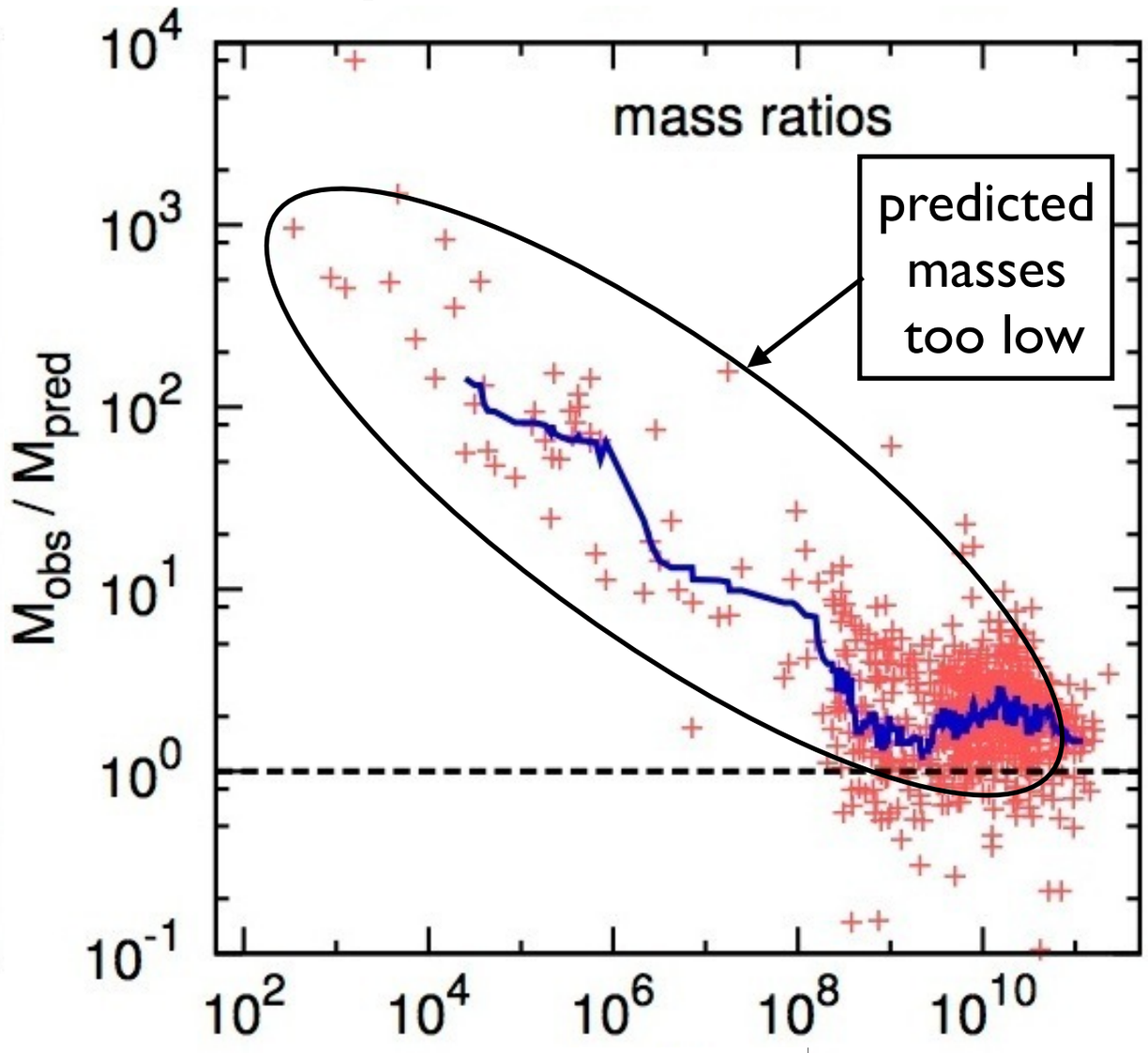

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Milgromian instead of Newtonian dynamics (MOND)

$$M_{\rm M} = \frac{a_{\rm M}\, R_{\rm e}}{G} = \frac{K_{\rm V}\, R_{\rm e}\, \sigma_{\rm V}^2}{G}$$

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Based on the simple μ-function (Famaey 2005).

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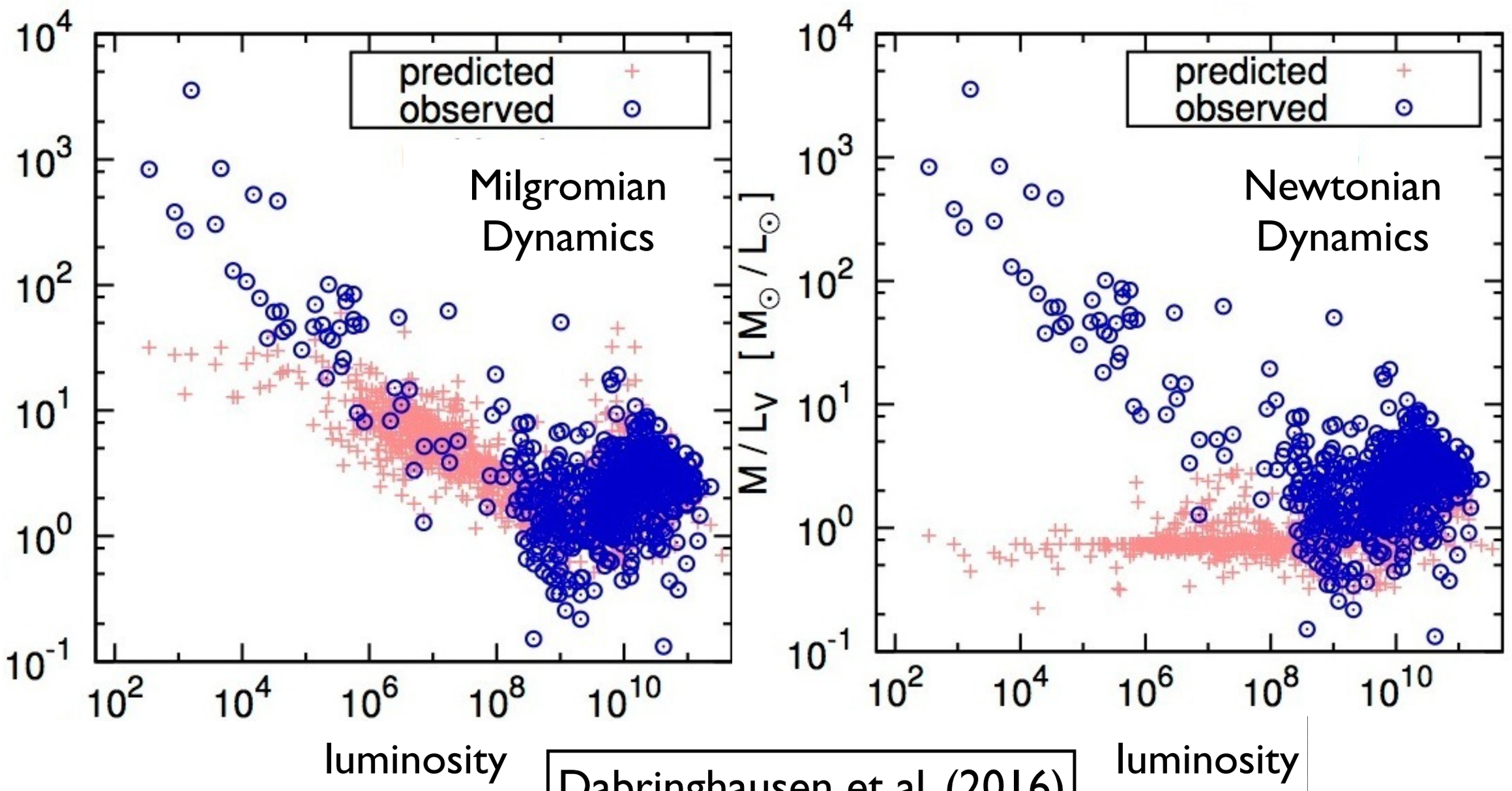

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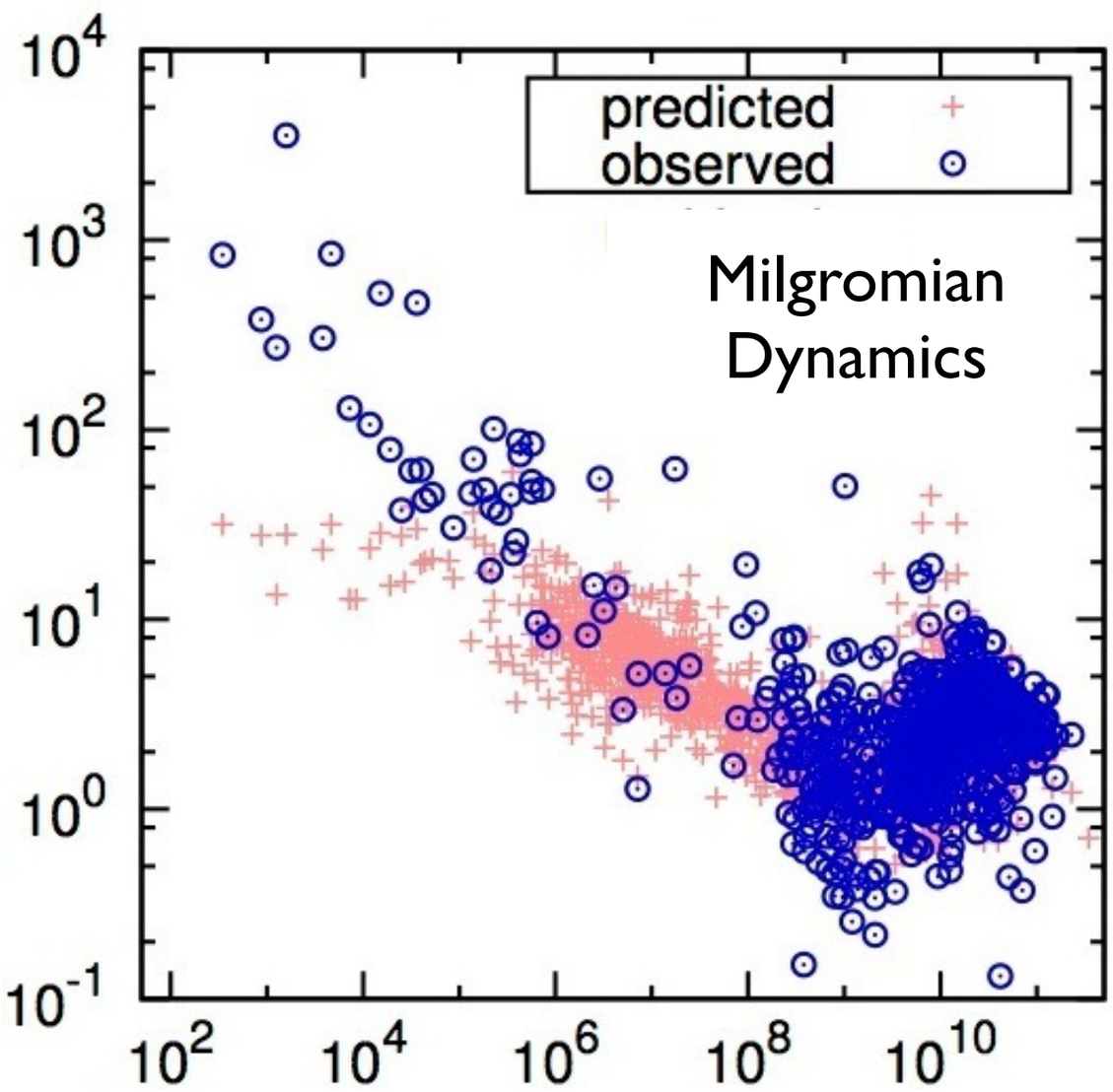

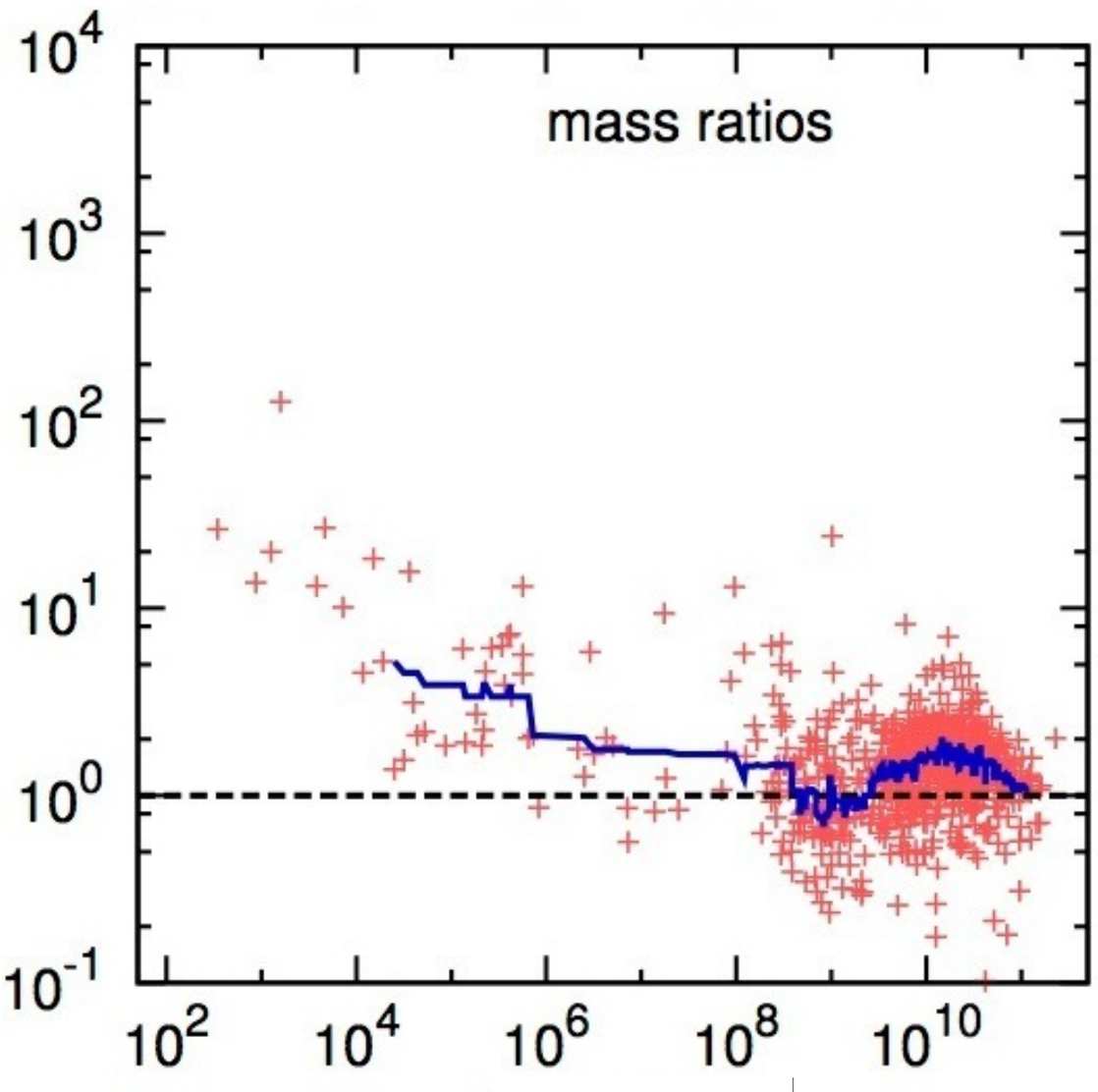

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Comparing stellar and dynamical mass-to-light ratios

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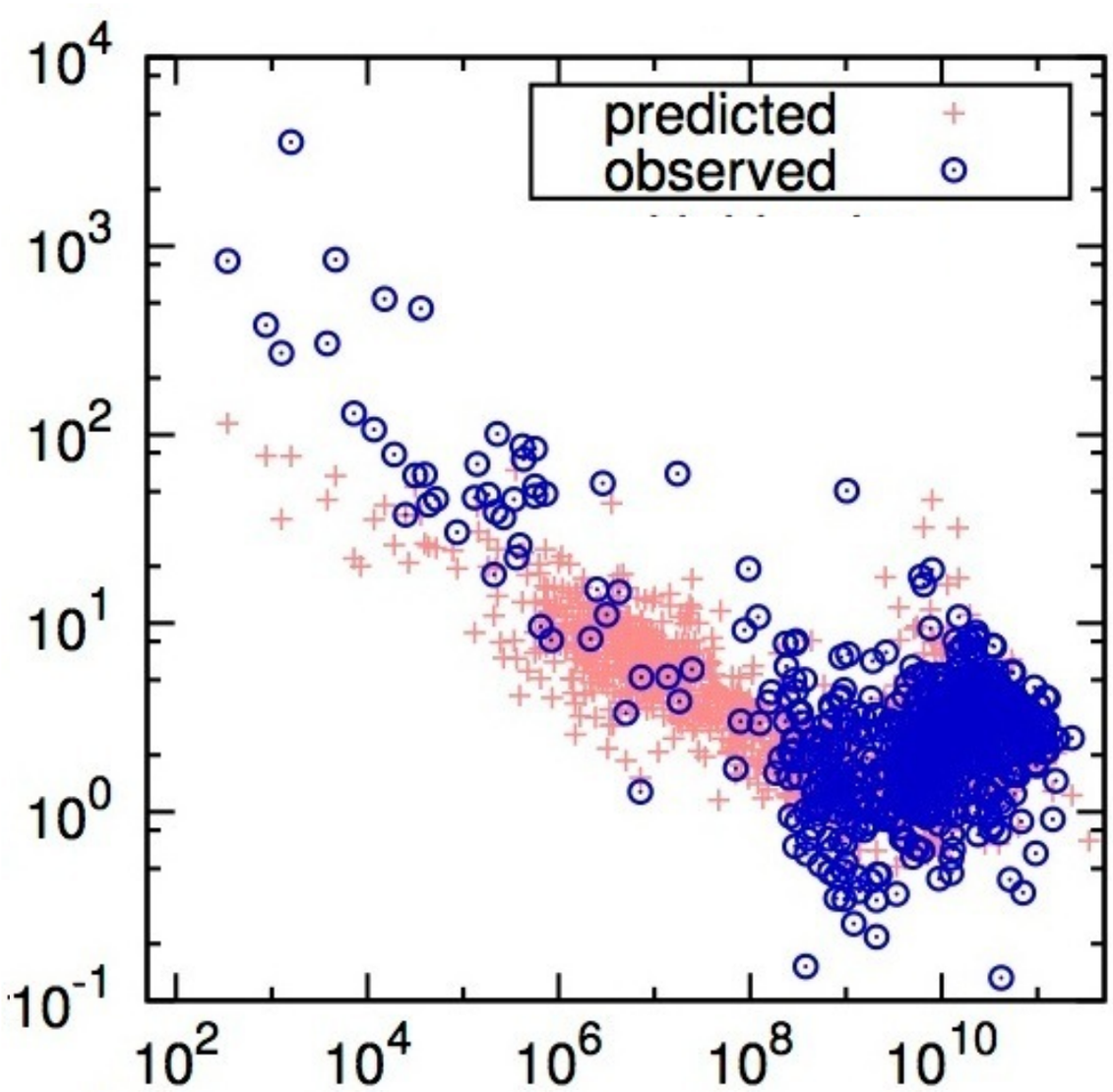
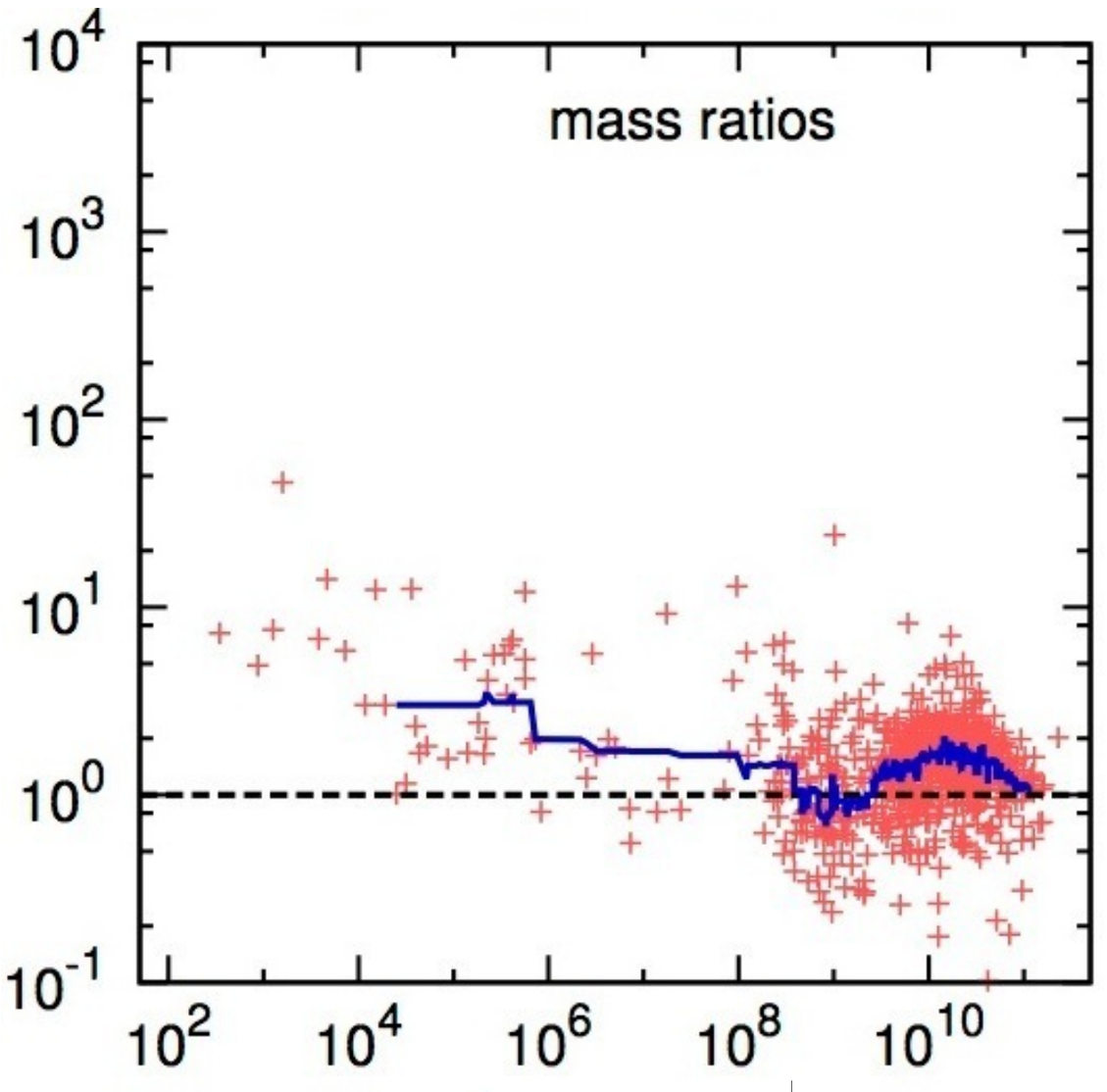


luminosity



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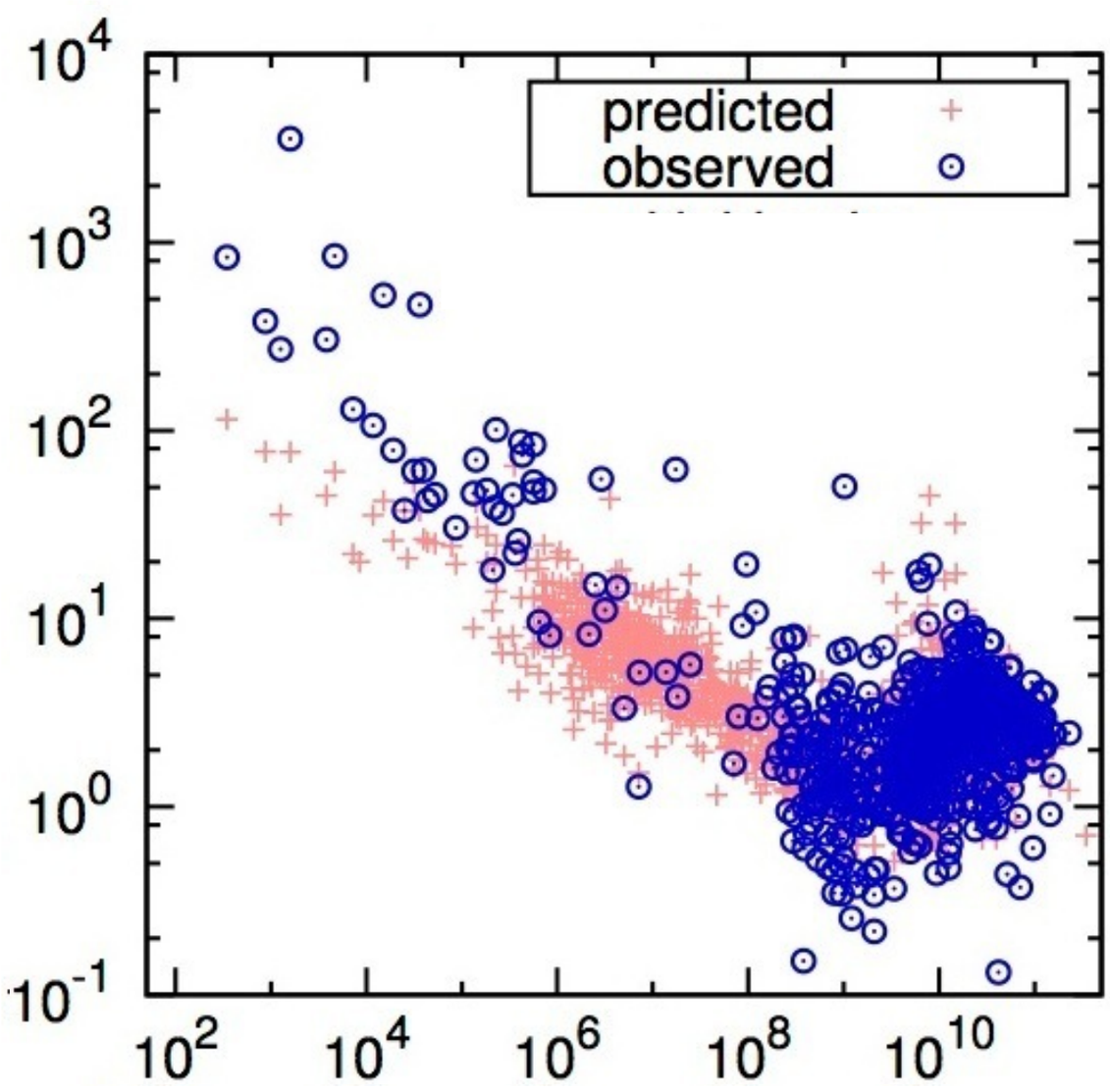

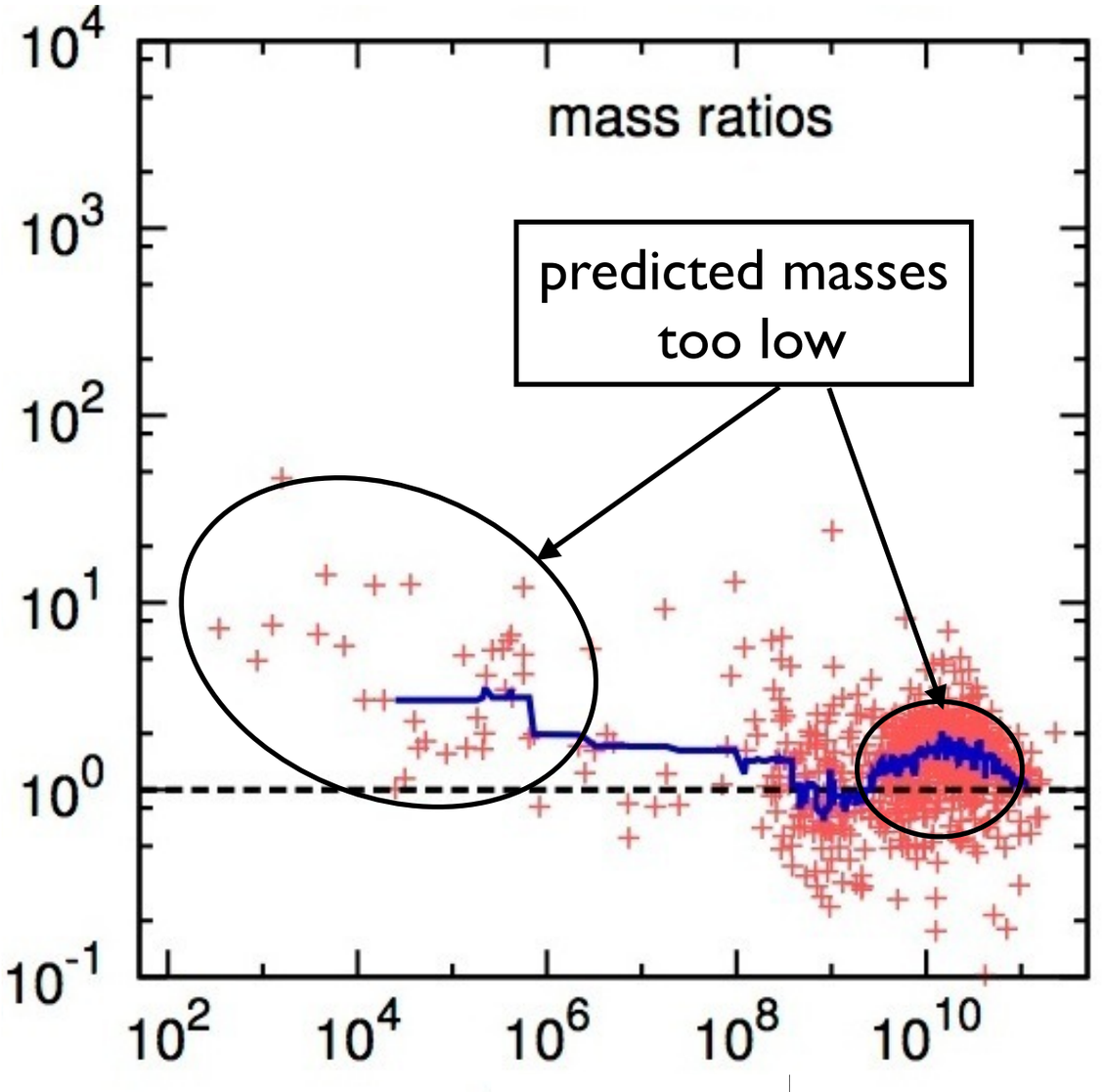

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Newtonian and observational radial accelerations

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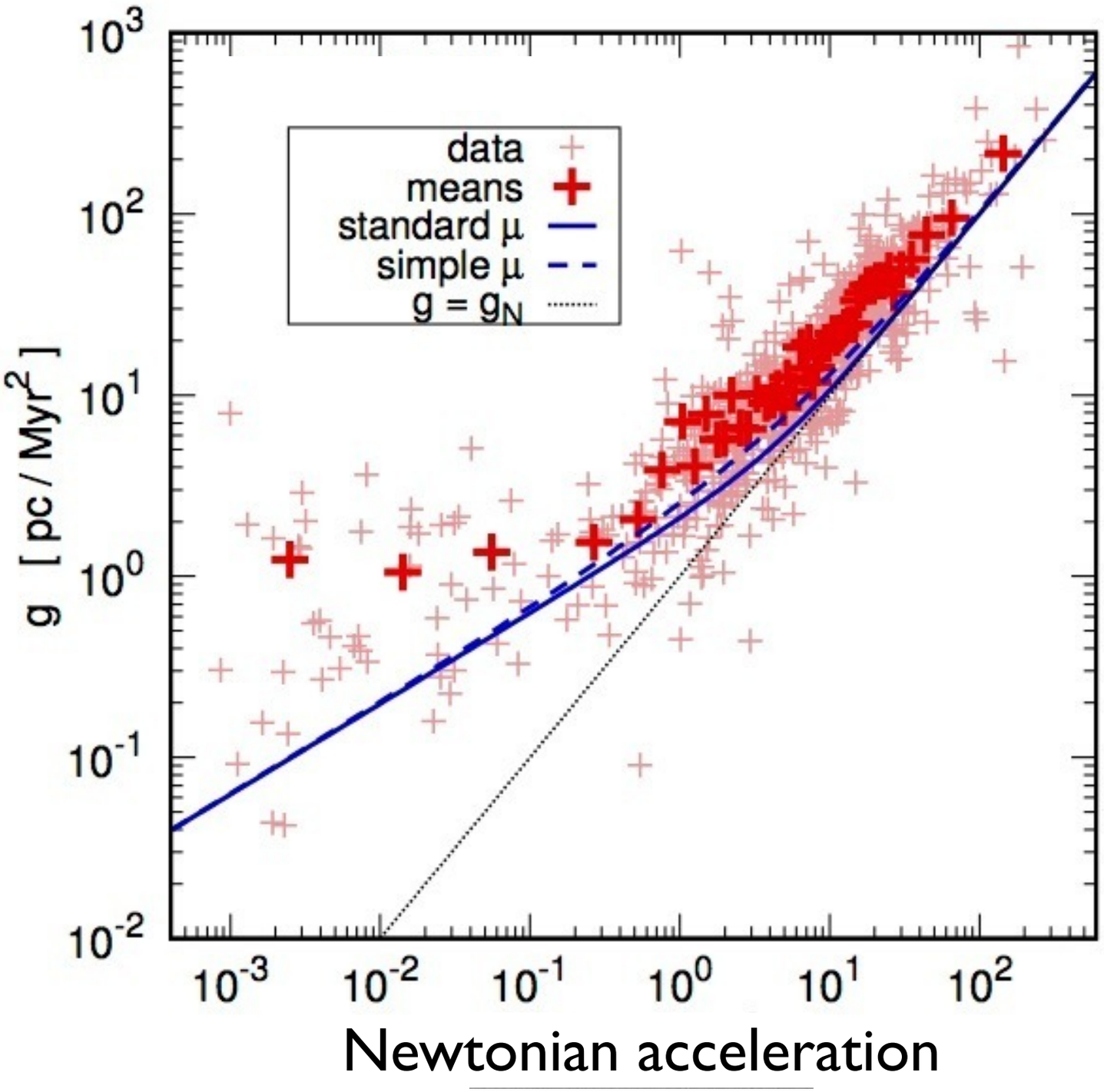

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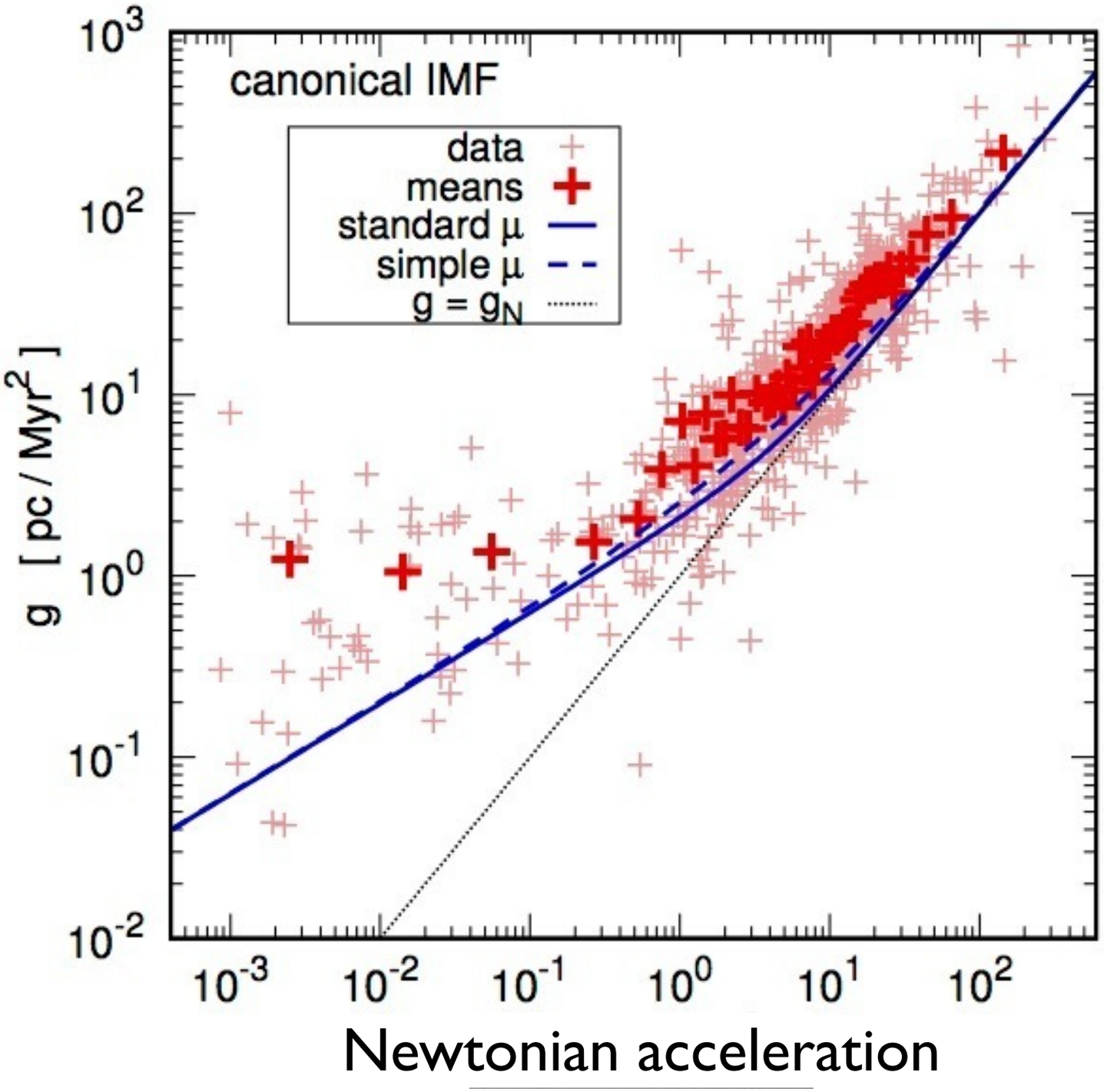
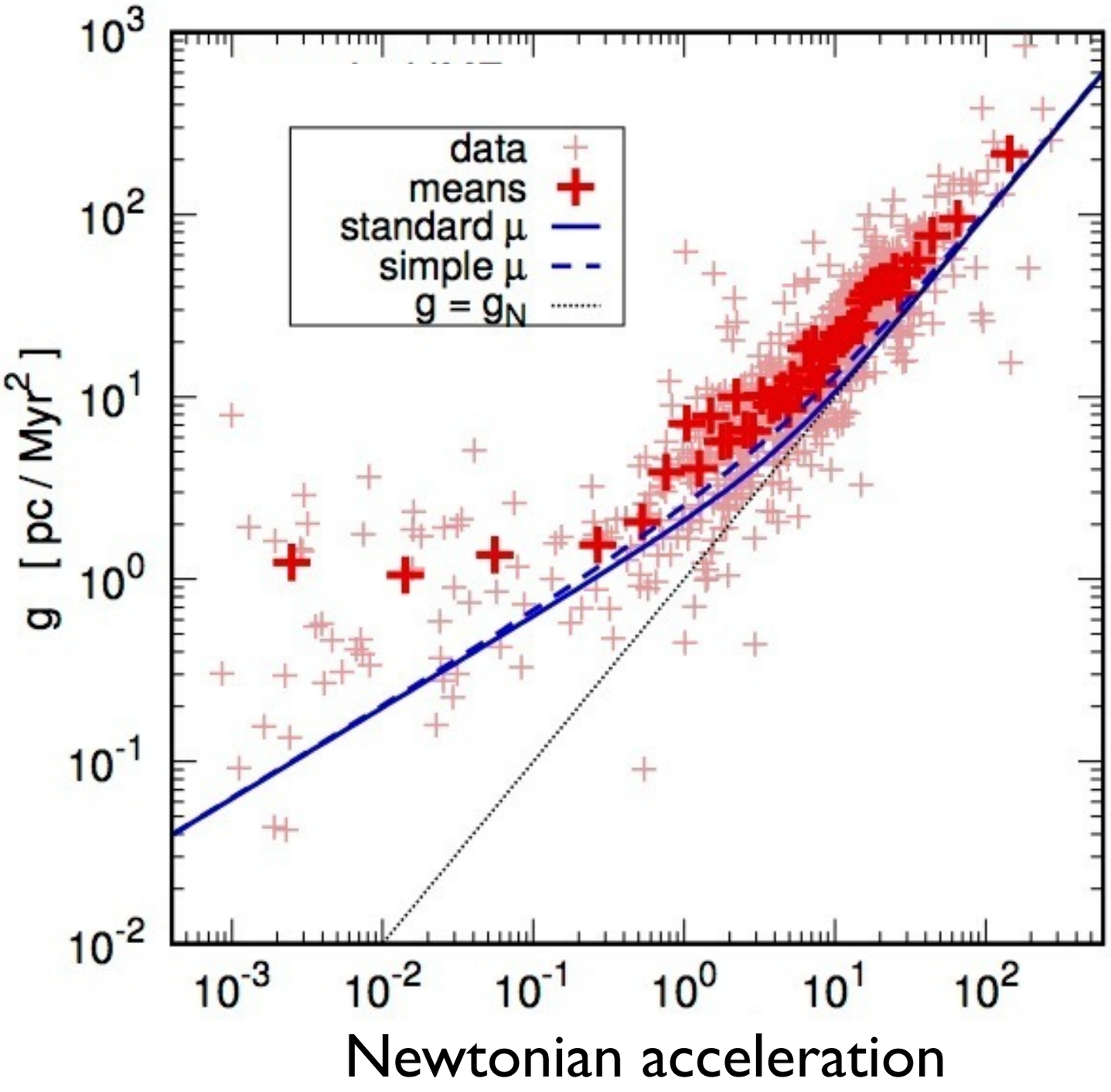


Comparison between the force that should act on particles according to Newtonian dynamics and the actual force according to the dynamical mass

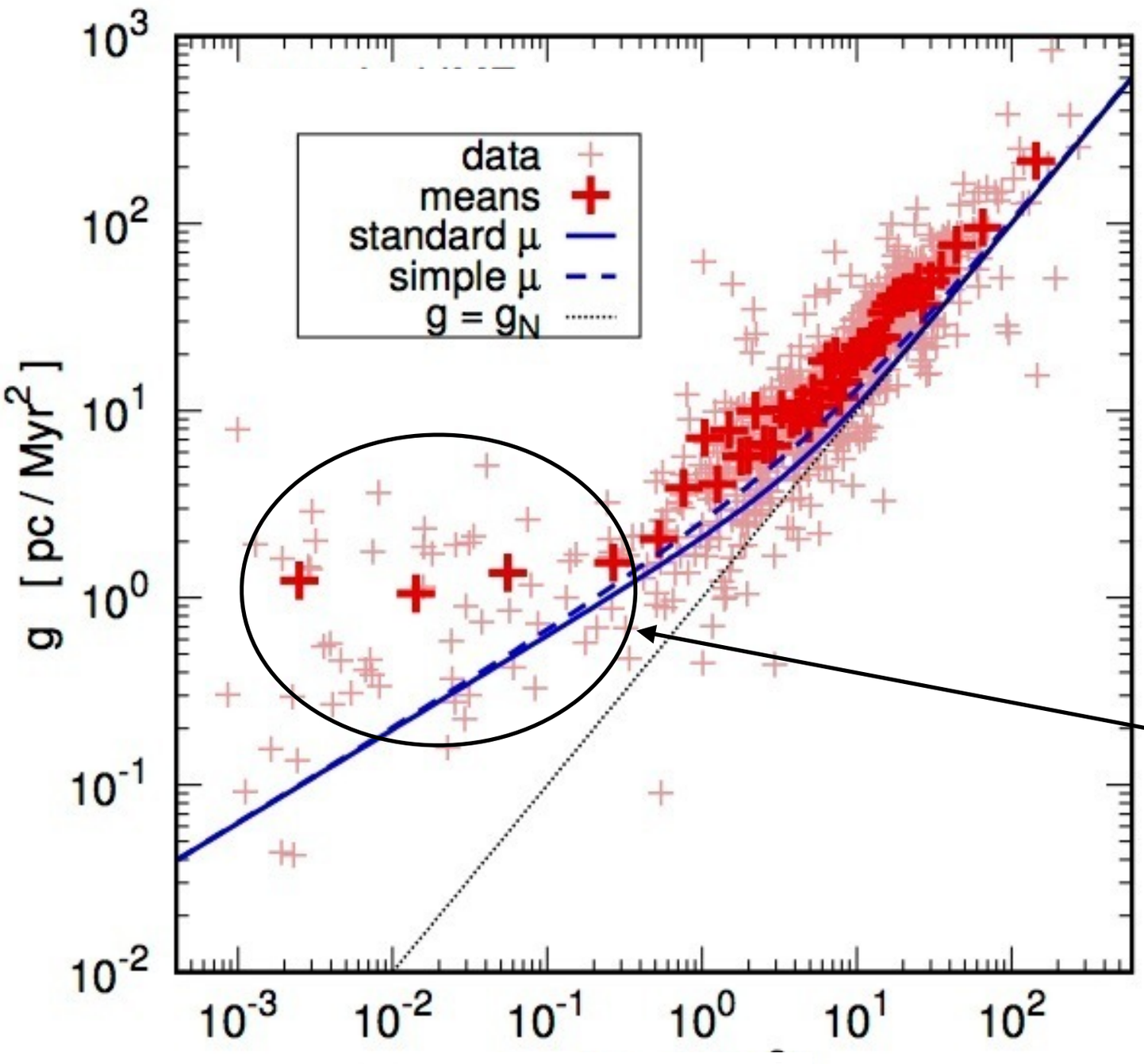
Newtonian and observational radial accelerations



Radial accelerations based on observations too high over the whole range

Explanations not the same over the whole range

Newtonian and observational radial accelerations



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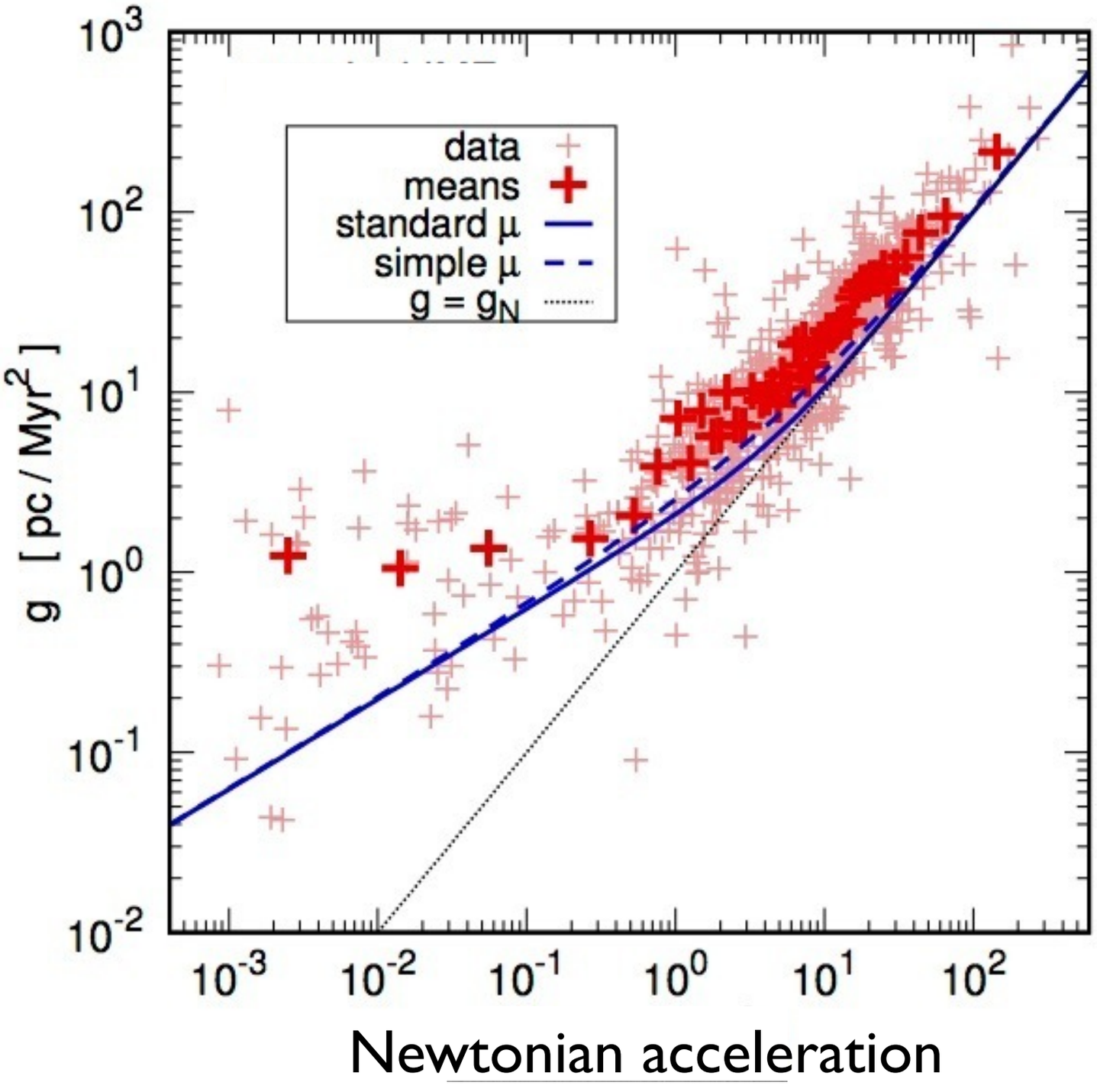
Binaries?



Let's assume that measured internal velocity dispersions have to be corrected for undetected binaries

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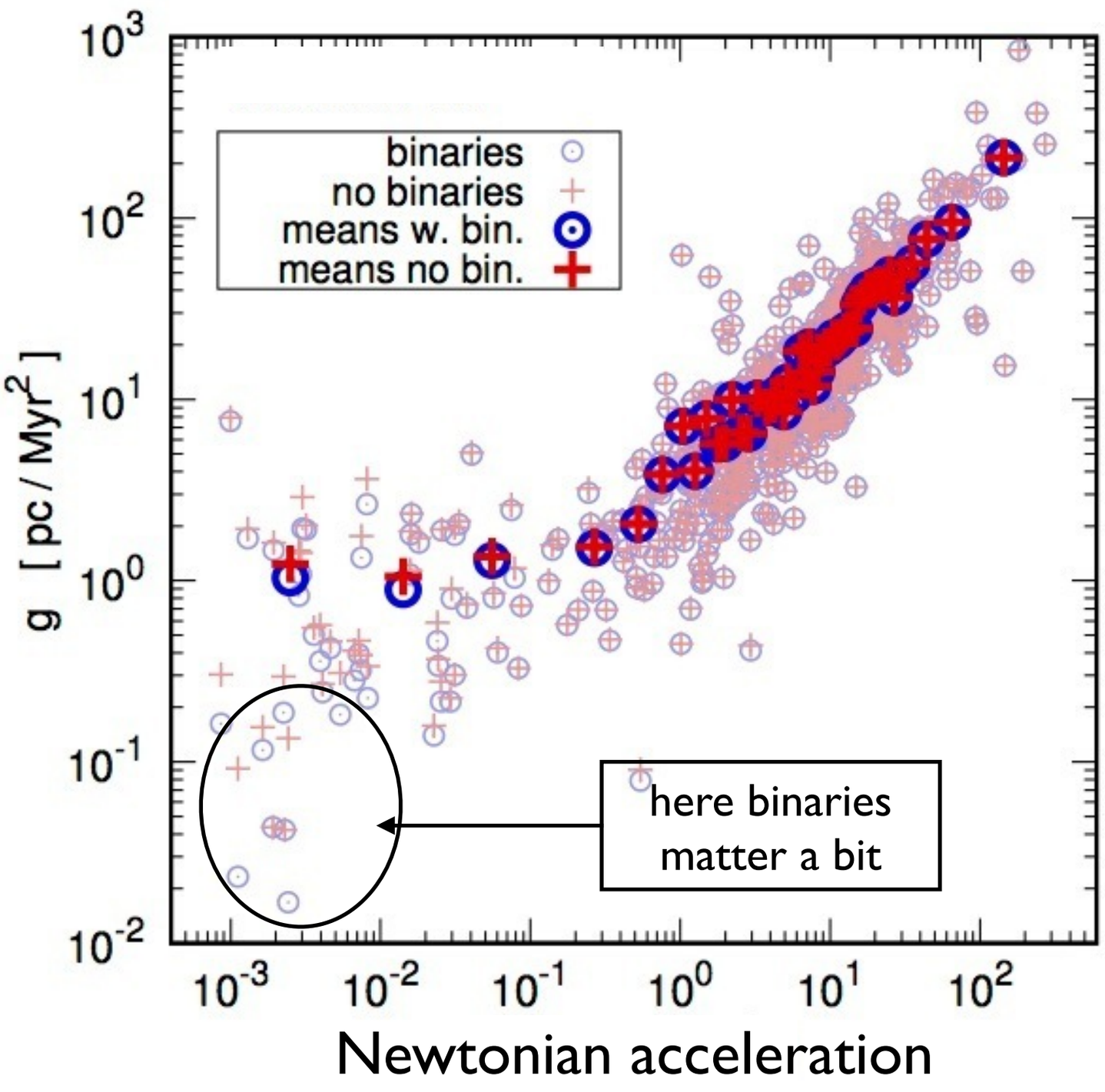

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Binaries hardly matter - even for most dwarf galaxies

The origin of dwarf elliptical galaxies

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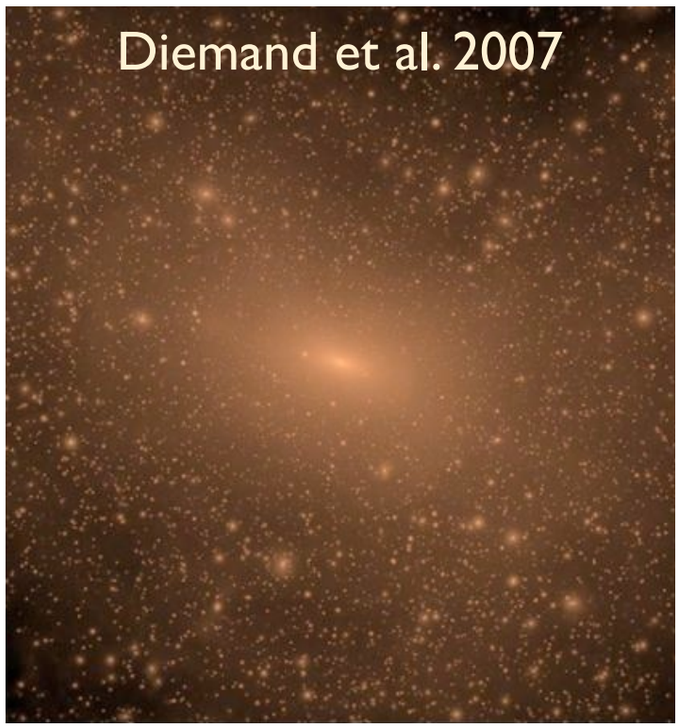
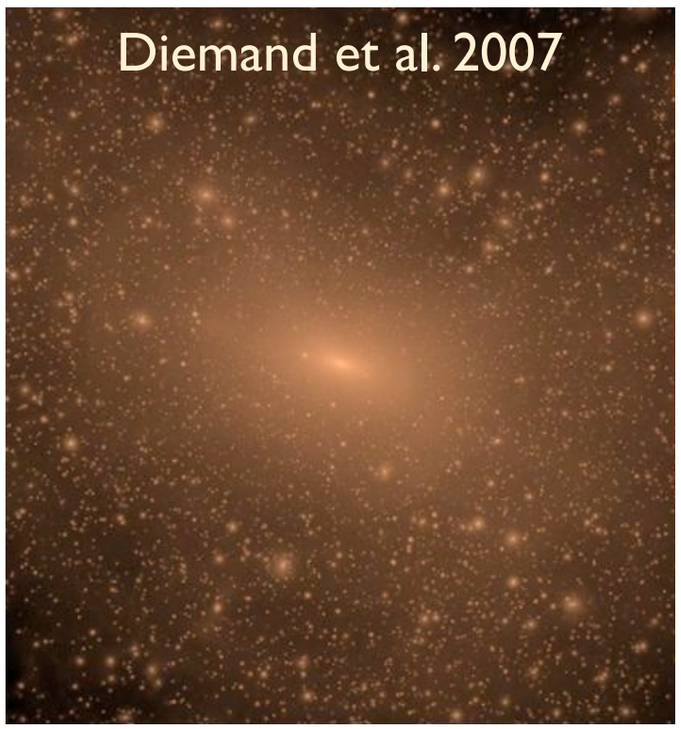


Dwarf elliptical galaxies (dEs) may form Primordial dwarf galaxies (PDGs) in haloes of cold dark matter (CDM).

The origin of dwarf elliptical galaxies



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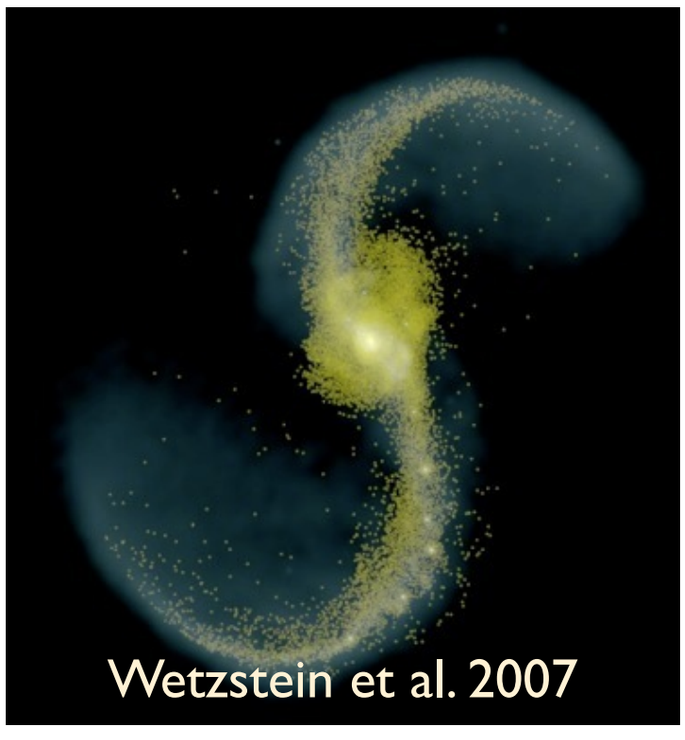

dEs may be created as Tidal dwarf galaxies (TDGs) by the interaction between primordial galaxies. TDGs cannot contain significant amounts of CDM (Bournaud 2010).

PDGs or TDGs?

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Due conservation of angular momentum, TDGs form rotating disks of satellites around host galaxies.

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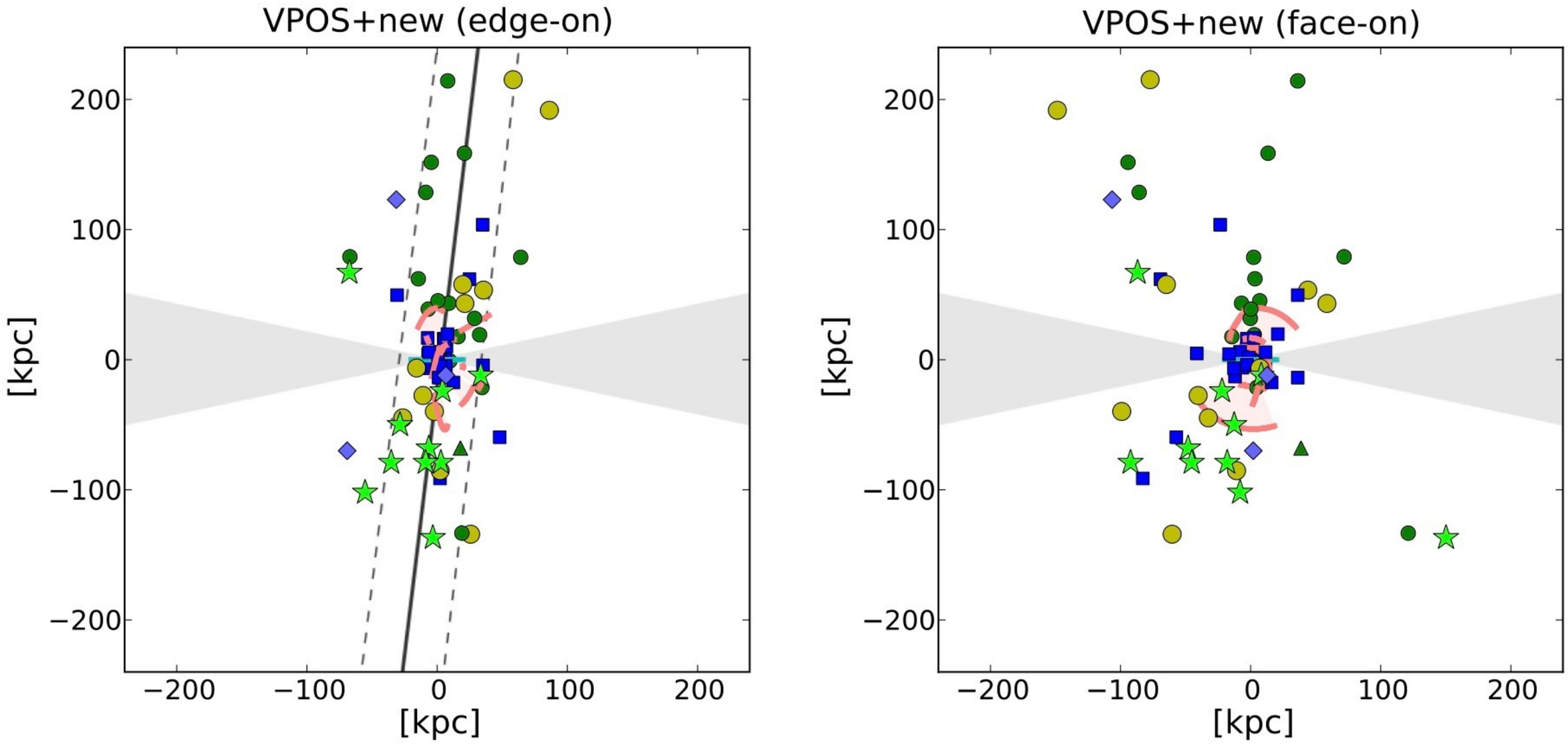

Milky Way satellites (Pawlowski et al. 2015)

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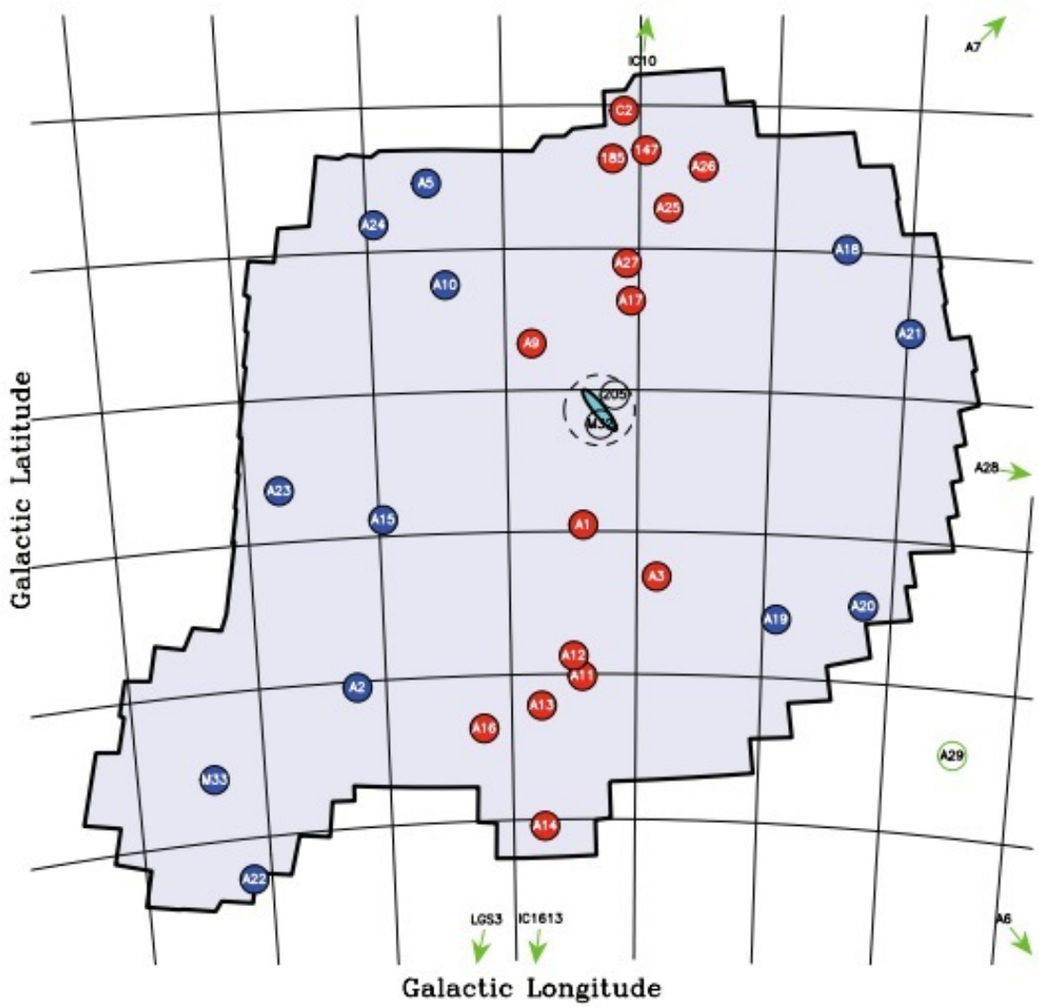

M 31 satellites
(R. Ibata et al. 2013)

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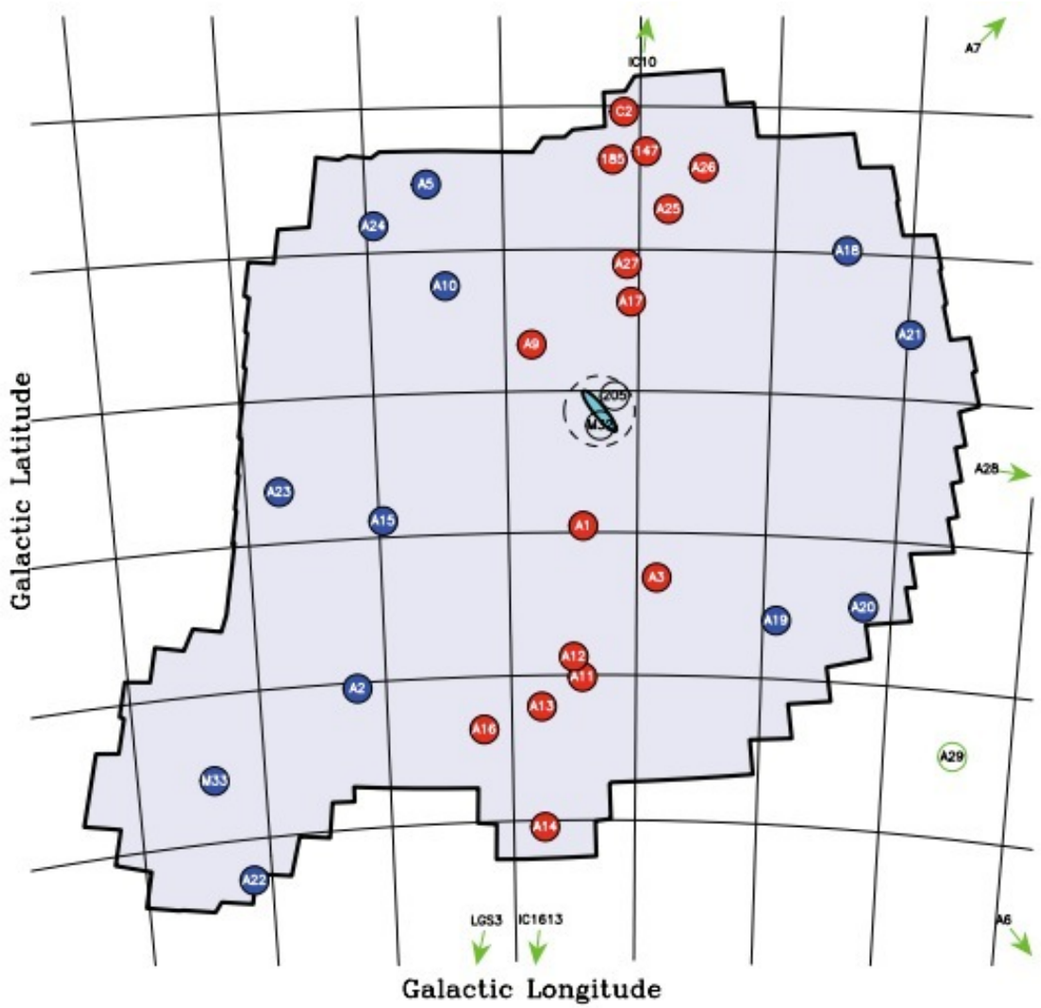
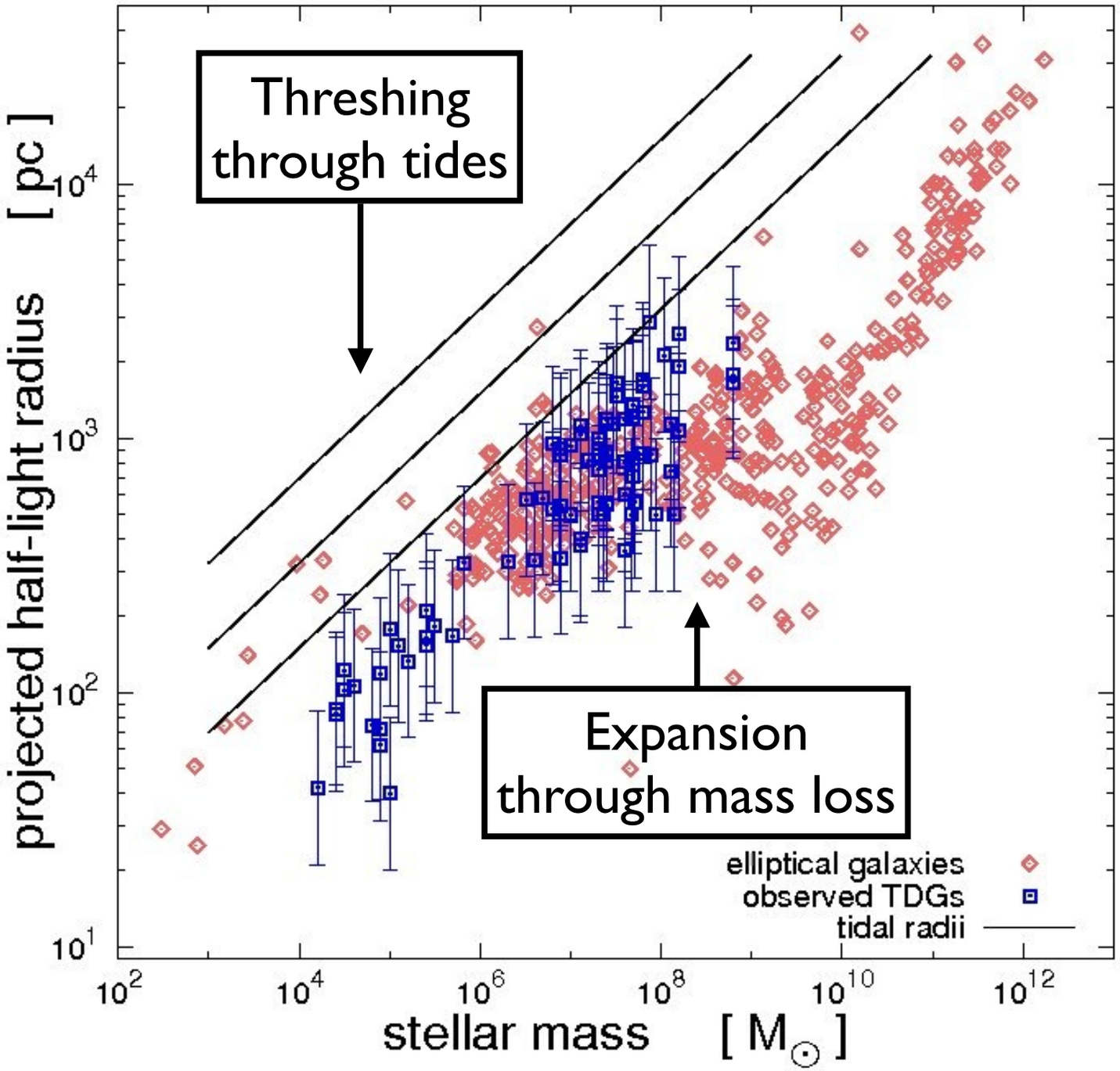


M 31 satellites
(R. Ibata et al. 2013)

There is strong evidence that disks of satellites are also very common around galaxies outside the local group.
(N. Ibata et al. 2014)
(R. Ibata et al. 2015)

PDGs or TDGs?

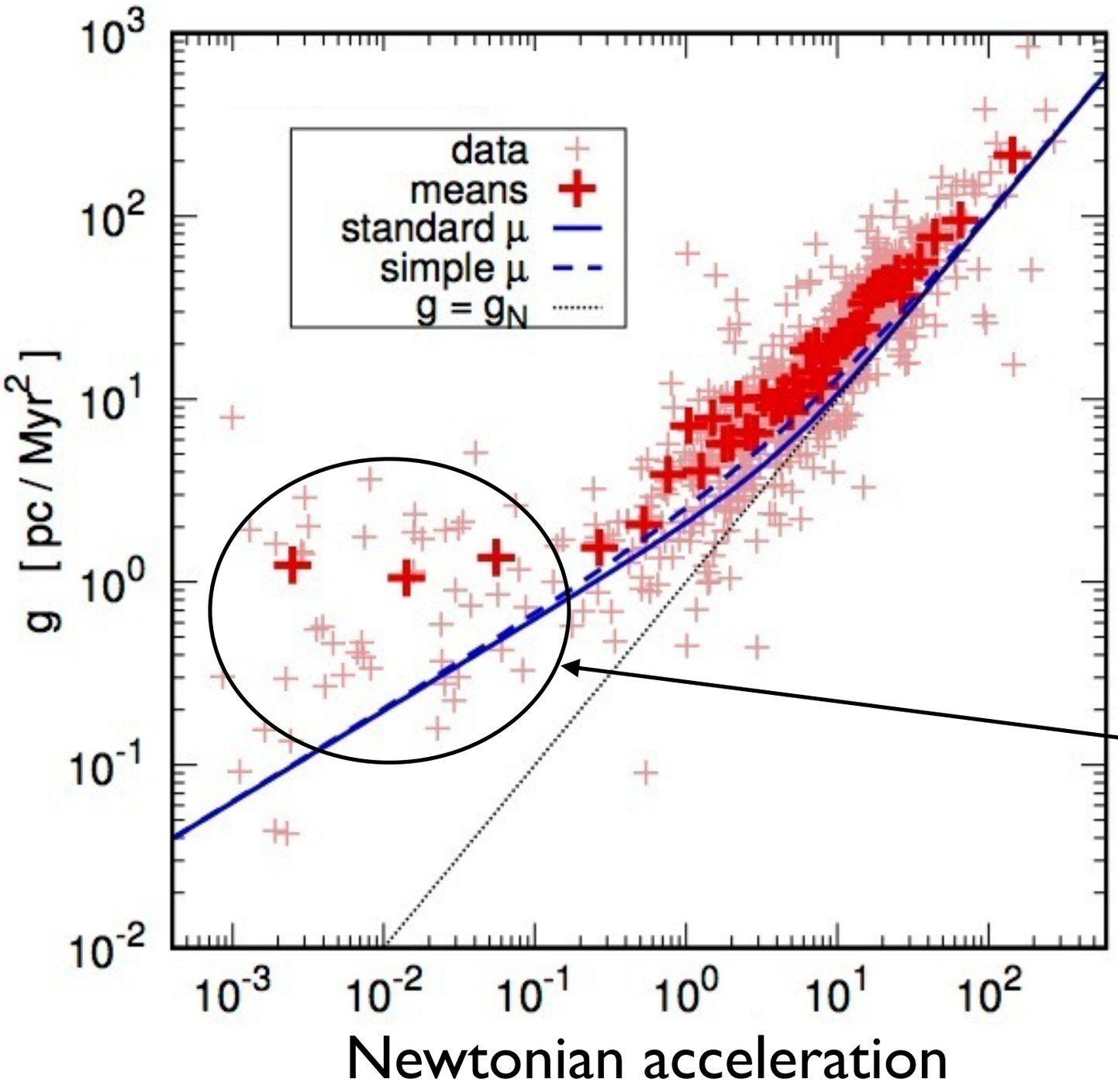
The radii of old tidal dwarfs



TDGs would naturally evolve onto the mass-radius sequence of low-mass ETGs.

Dabringhausen & Kroupa (2013)

Newtonian and observational radial accelerations



Low-mass ETGs are TDG and thus without dark matter.
Inprecise data?
Tidal fields?
Modified gravity?

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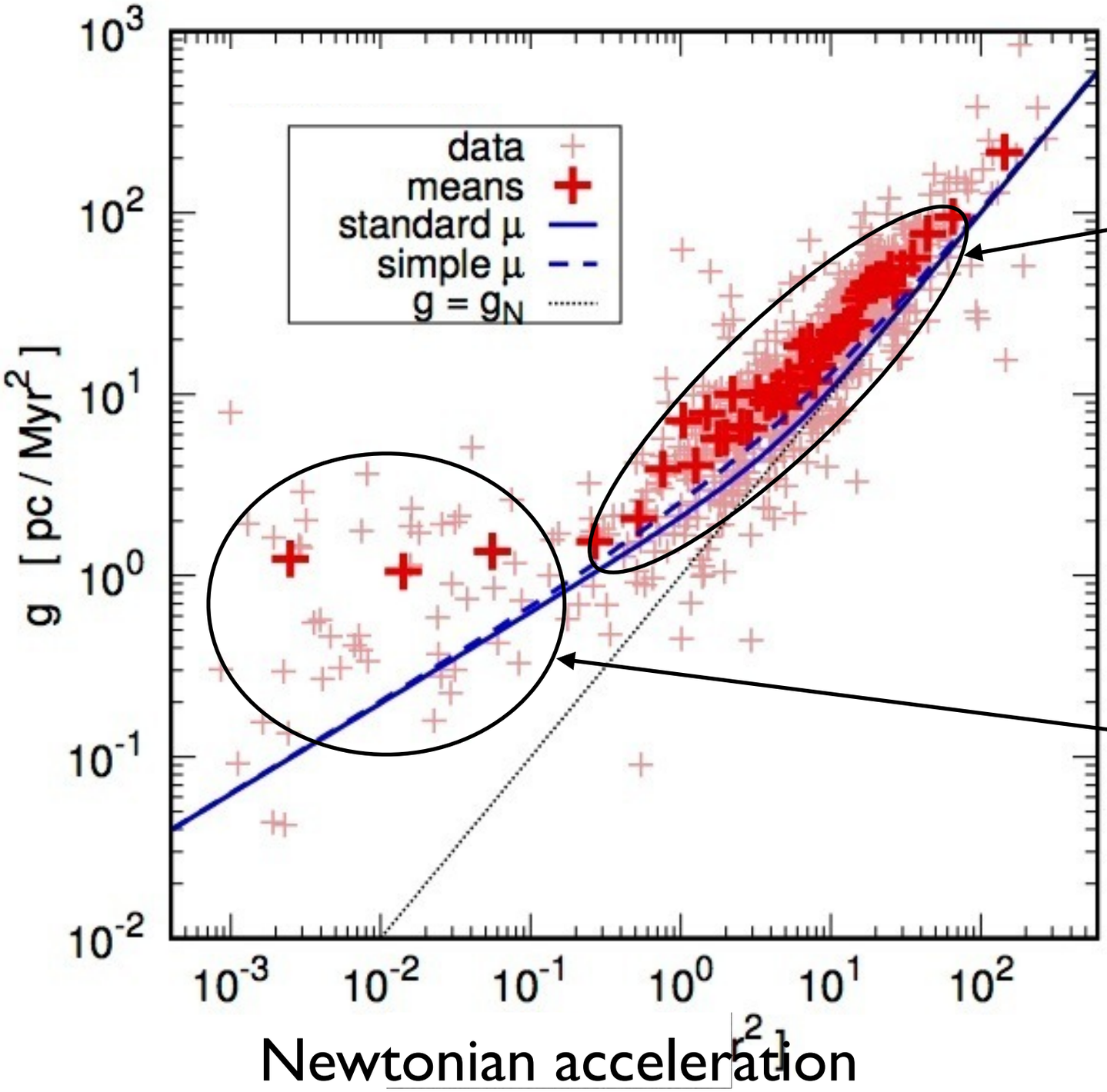

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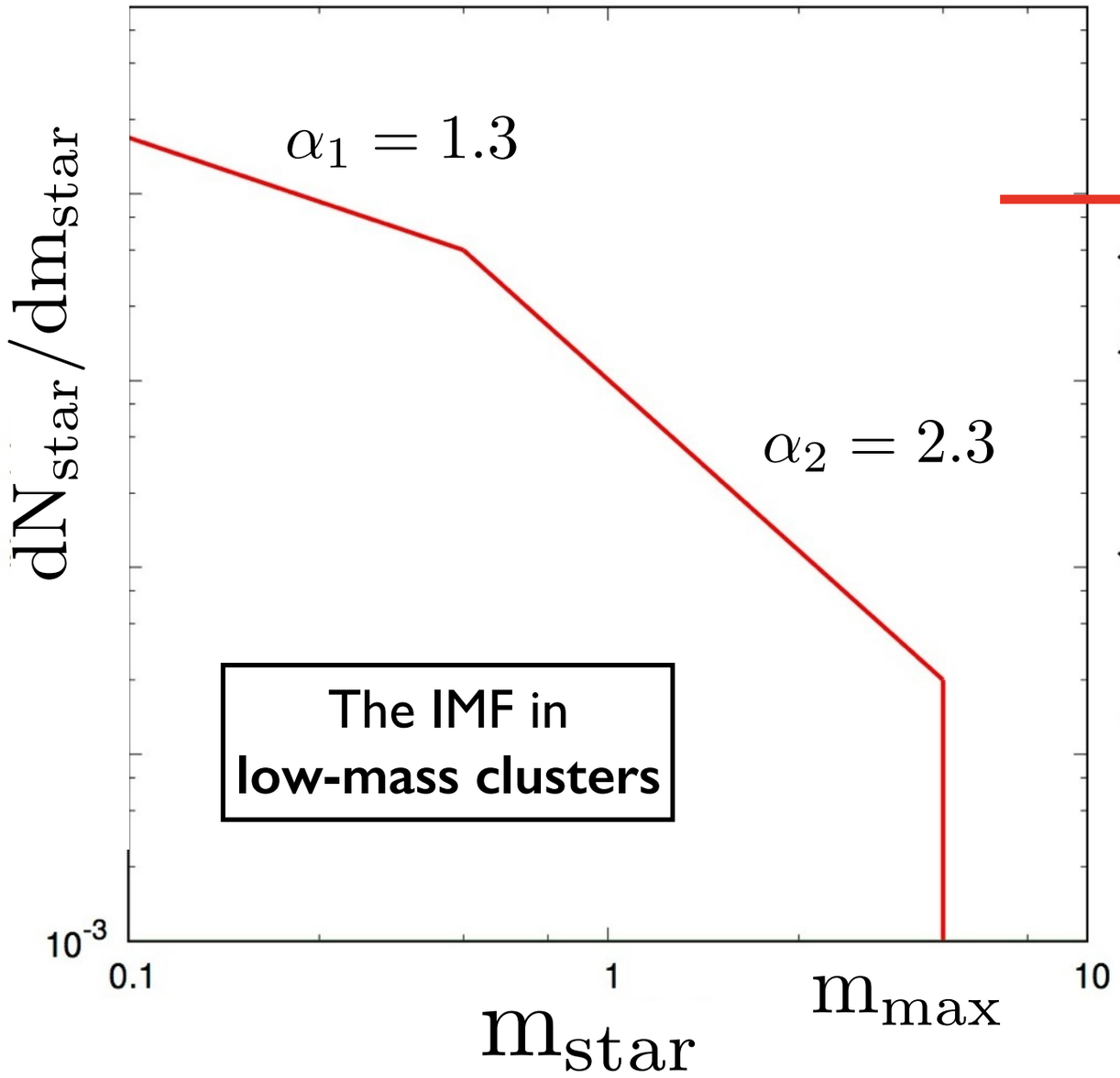
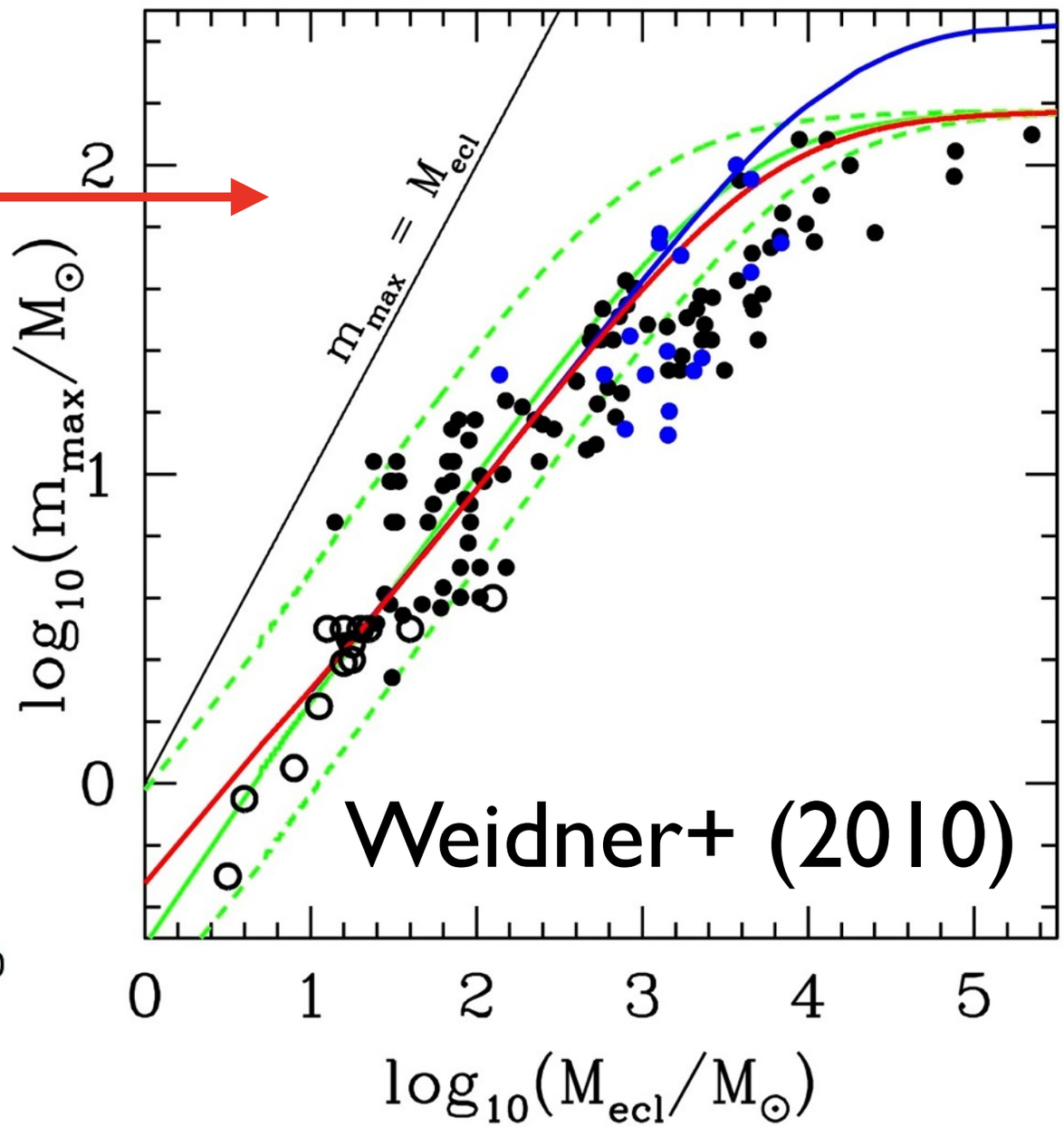
NO WEAPONS
IT IS ILLEGAL TO CARRY
A FIREARM, DEADLY WEAPON, OR
DANGEROUS ORDNANCE ANYWHERE
ON THESE PREMISES
A VALID LICENSE DOES NOT AUTHORIZE THE LICENSEE
TO CARRY A WEAPON ONTO THESE PREMISES.
No person shall knowingly possess, have under the person's control, convey, or attempt to convey a deadly weapon or dangerous ordnance onto these premises, unless otherwise authorized by law.
Posted Pursuant to the Ohio Revised Code

Variation of the IMF with star cluster parameters

1. variation of the mass of the most massive star in a star cluster





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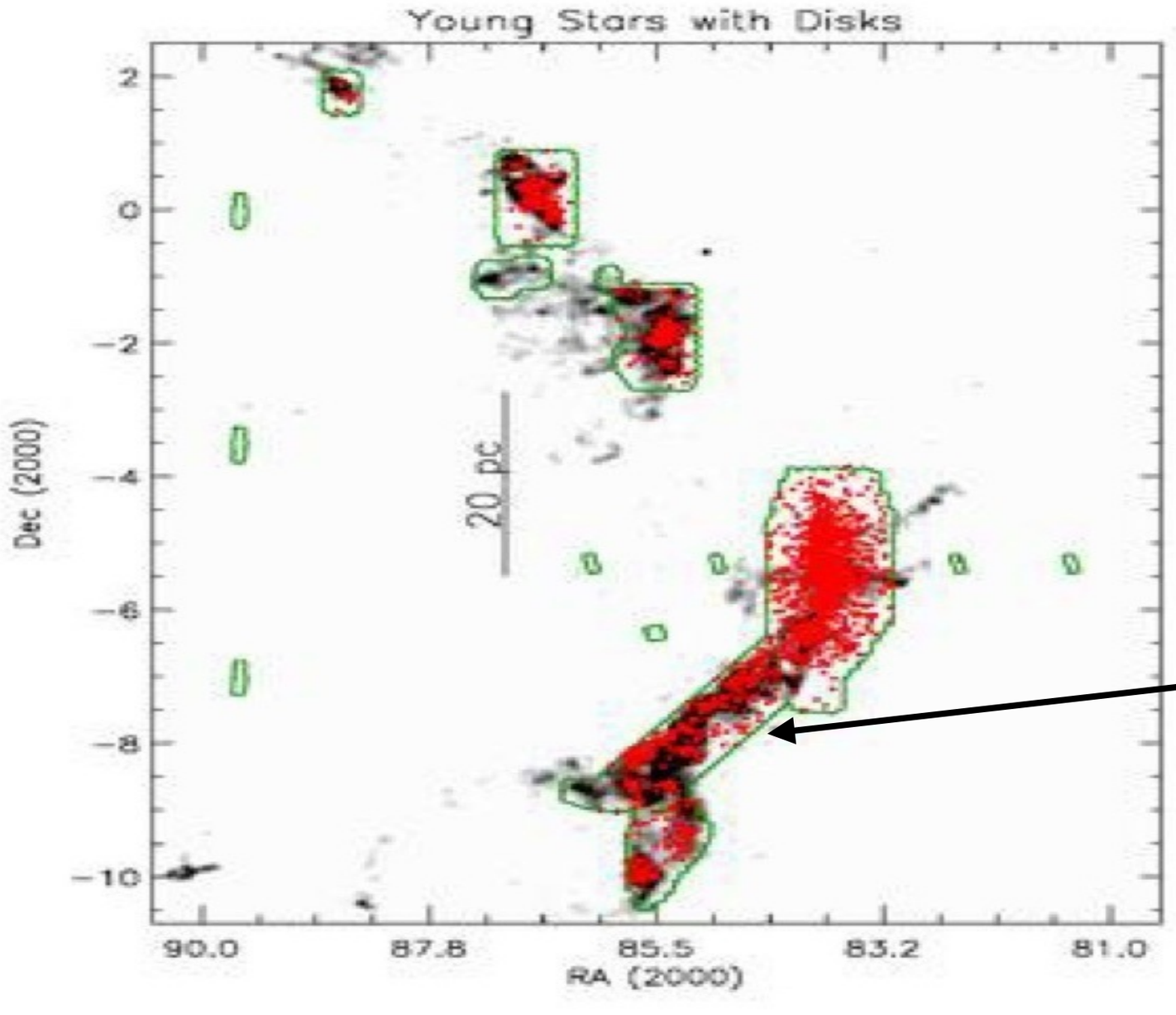
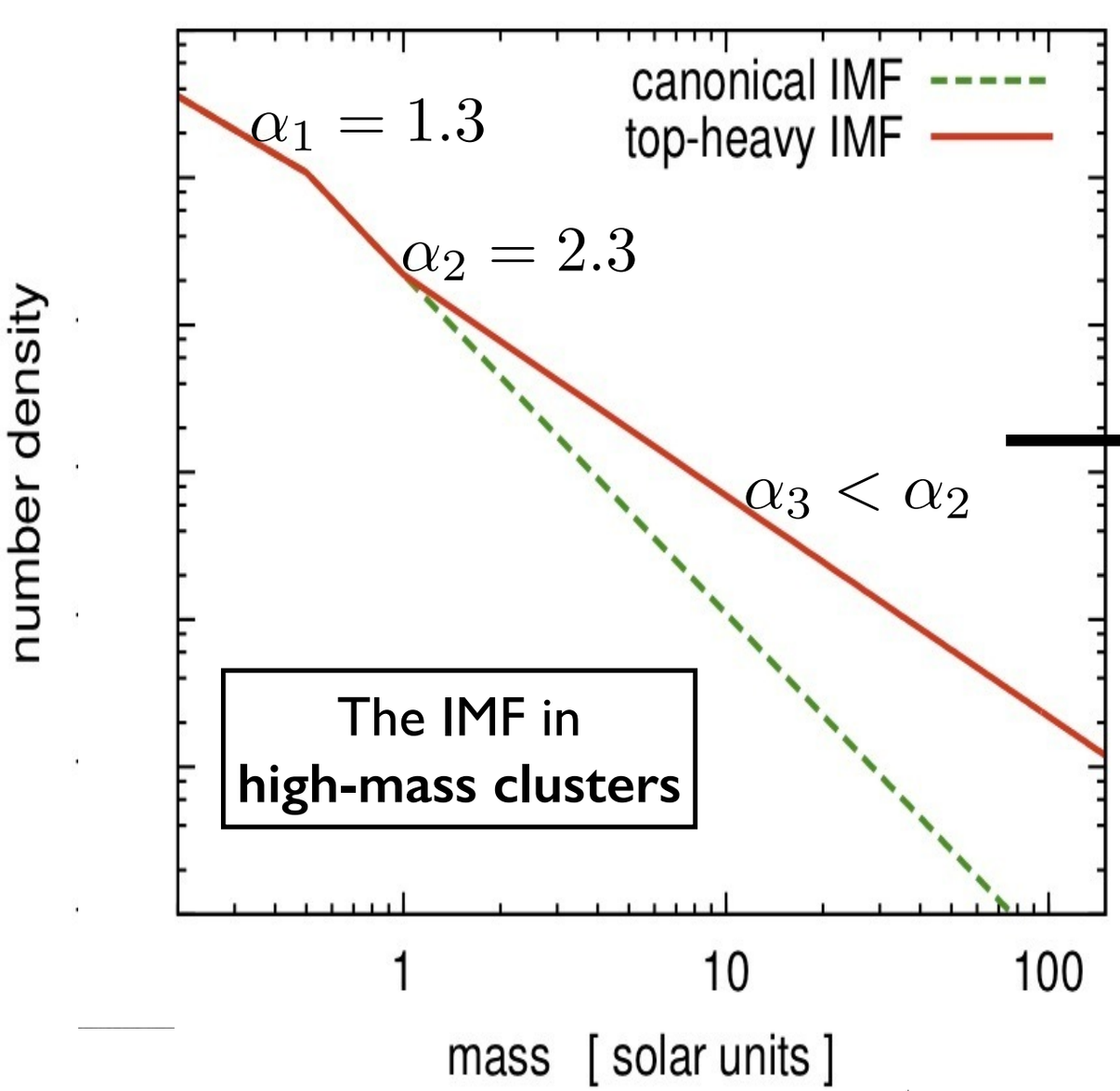


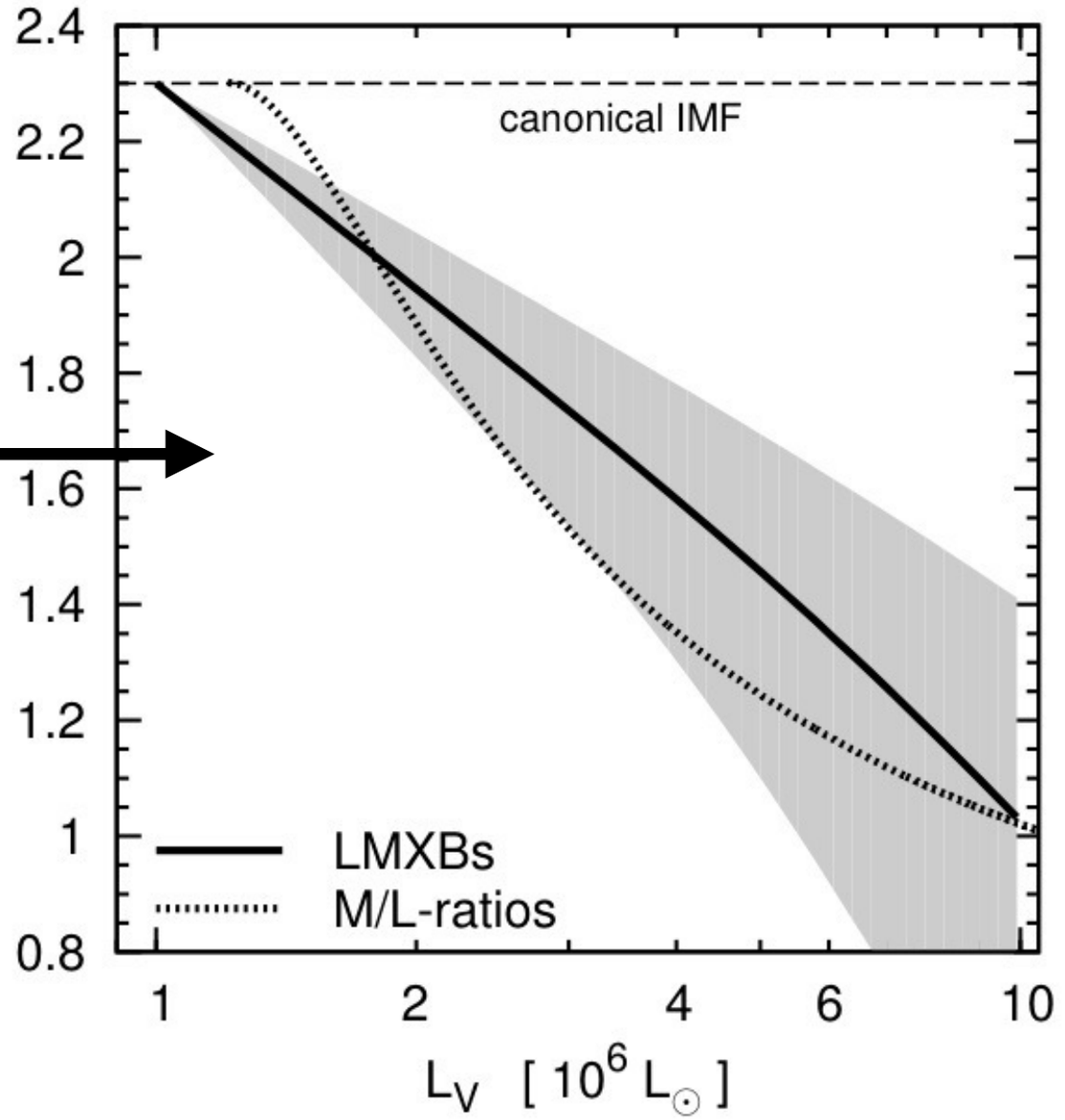
Young stellar objects in the ONC (Megeath+ 2012)

A deficit of massive stars here
Hsu+ (2012, 2013)

Variation of the IMF with star cluster parameters

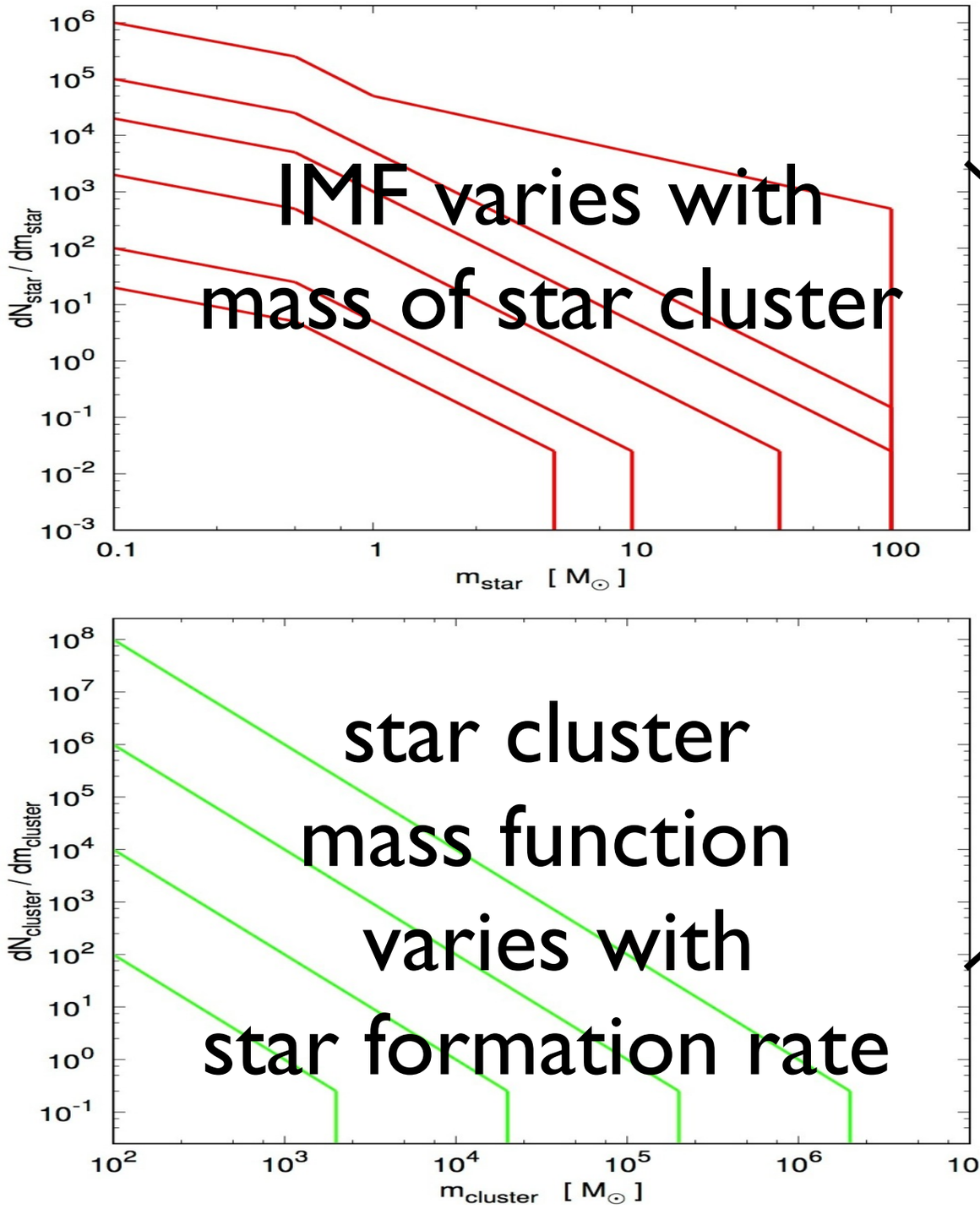
2. variation of the high-mass slope of the IMF



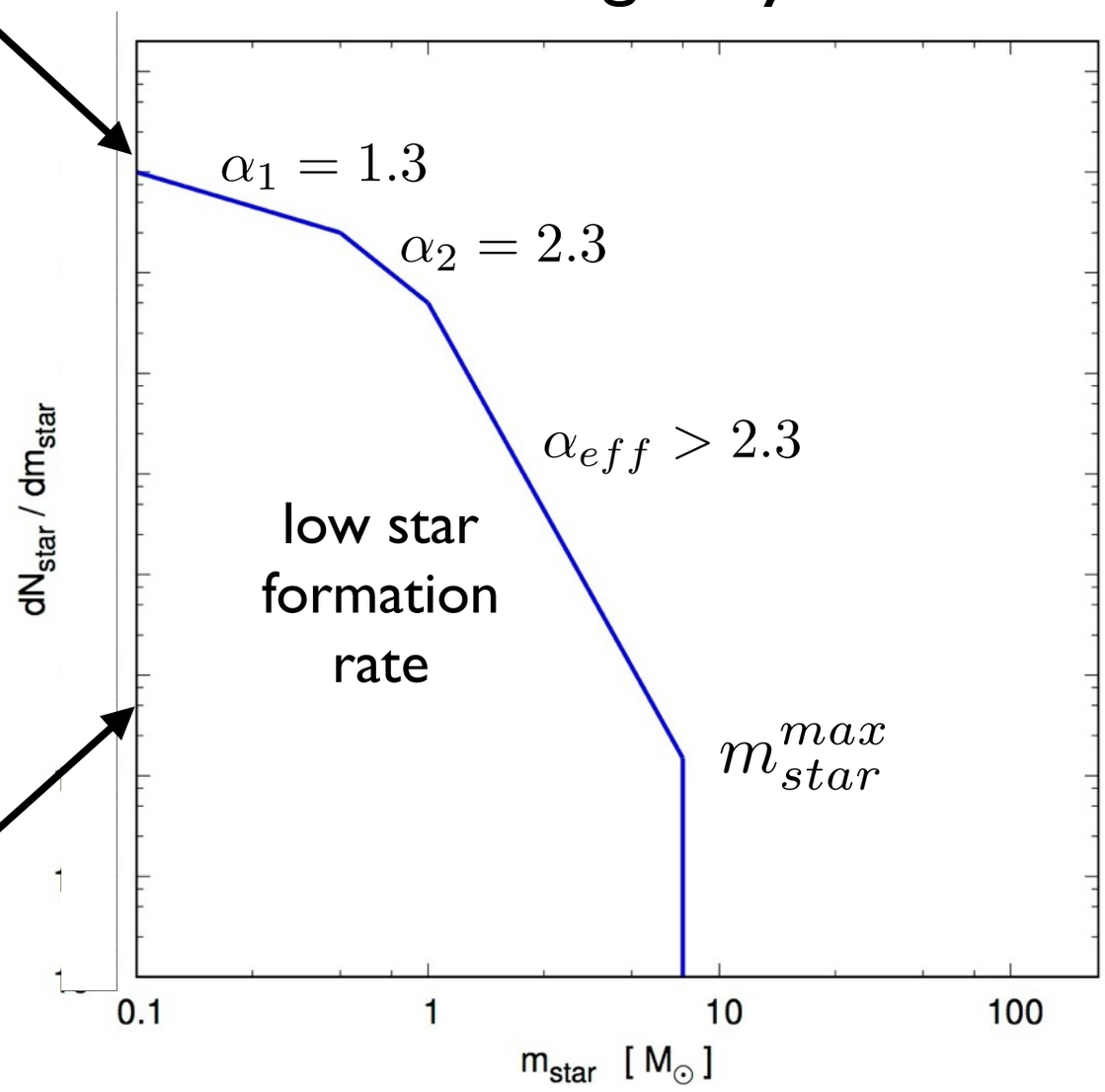


Dabringhausen+ 2012, Marks+ 2012

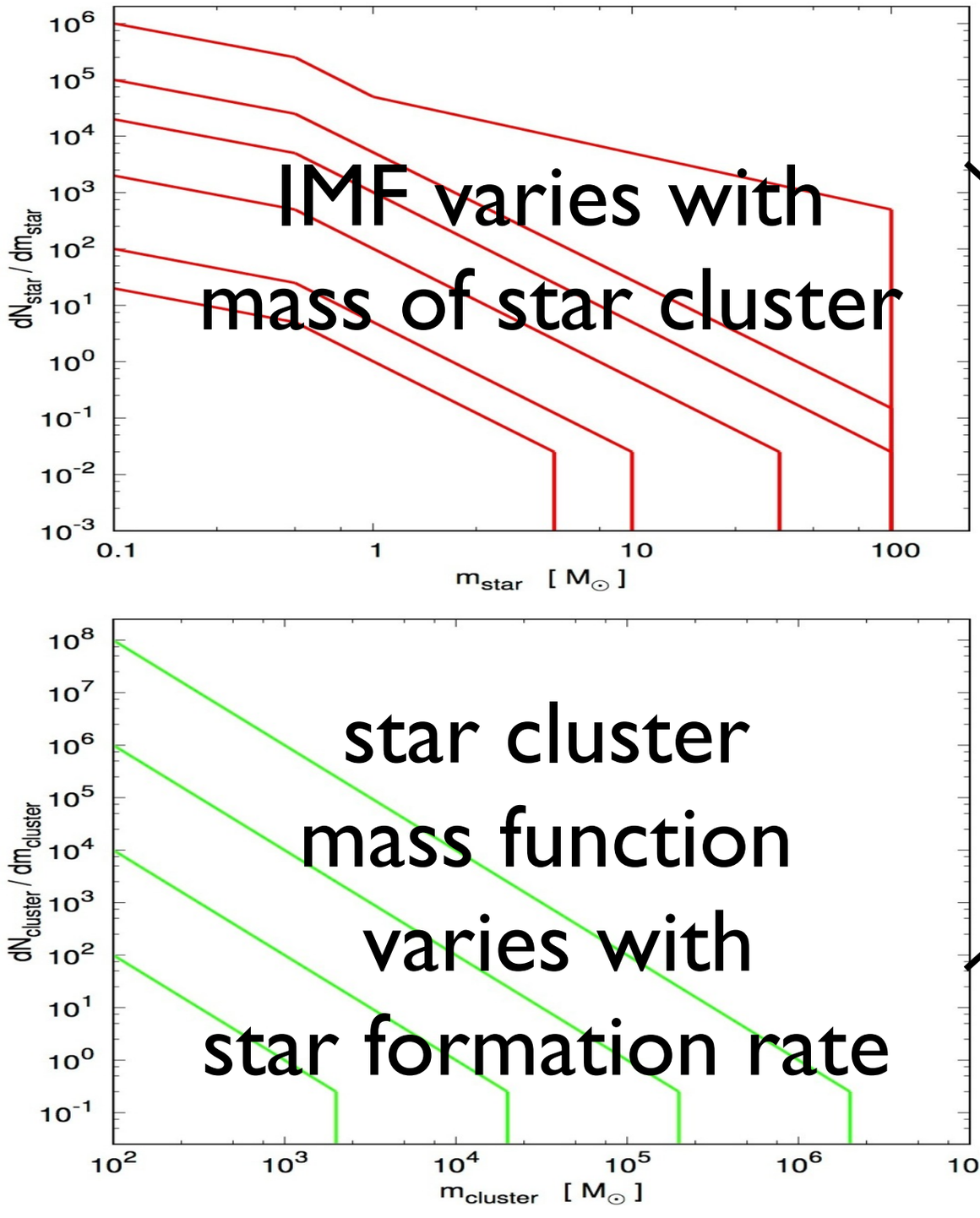
The galaxy-wide stellar initial mass function (IGIMF)



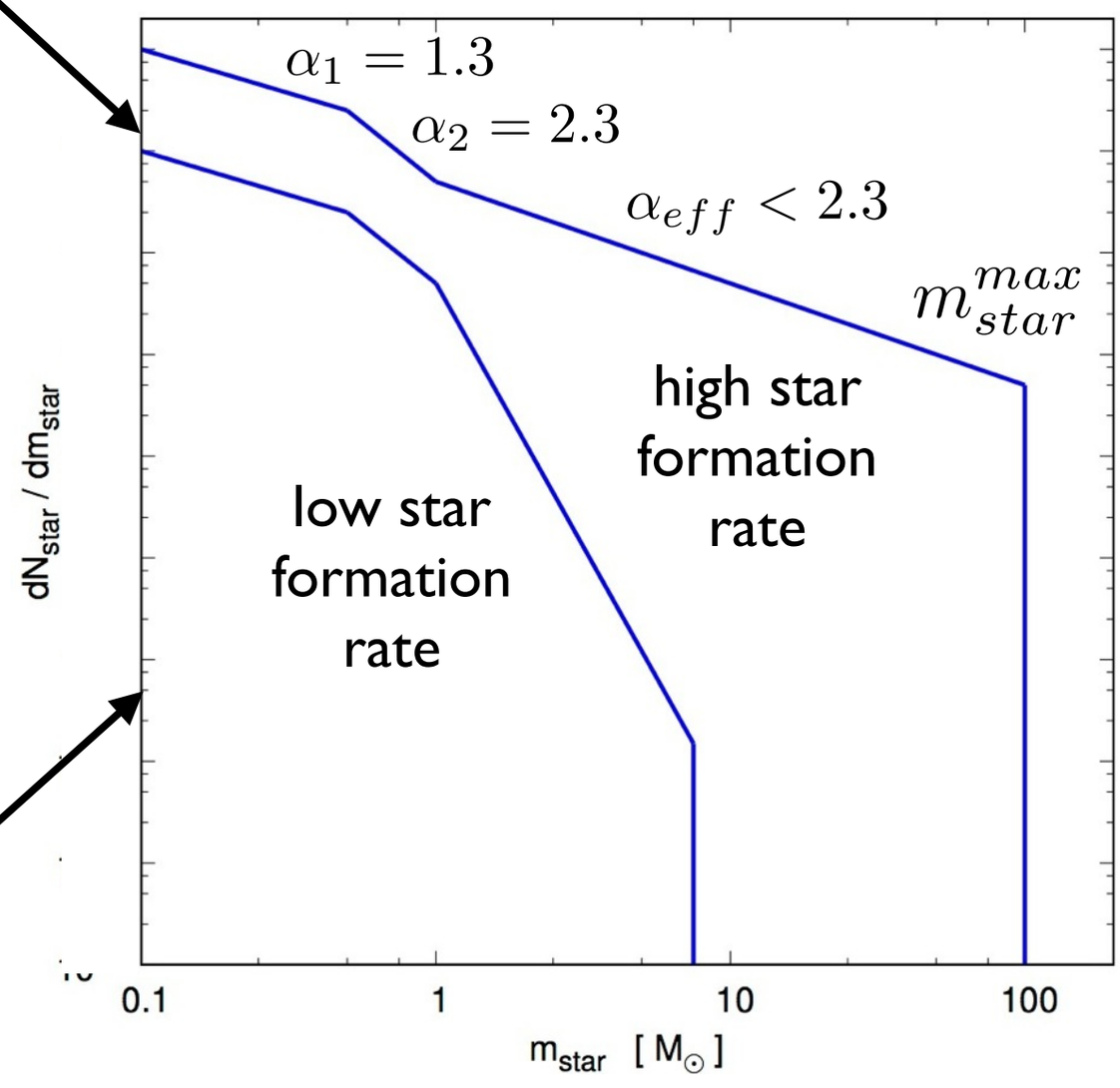
The effective IMF in a galaxy



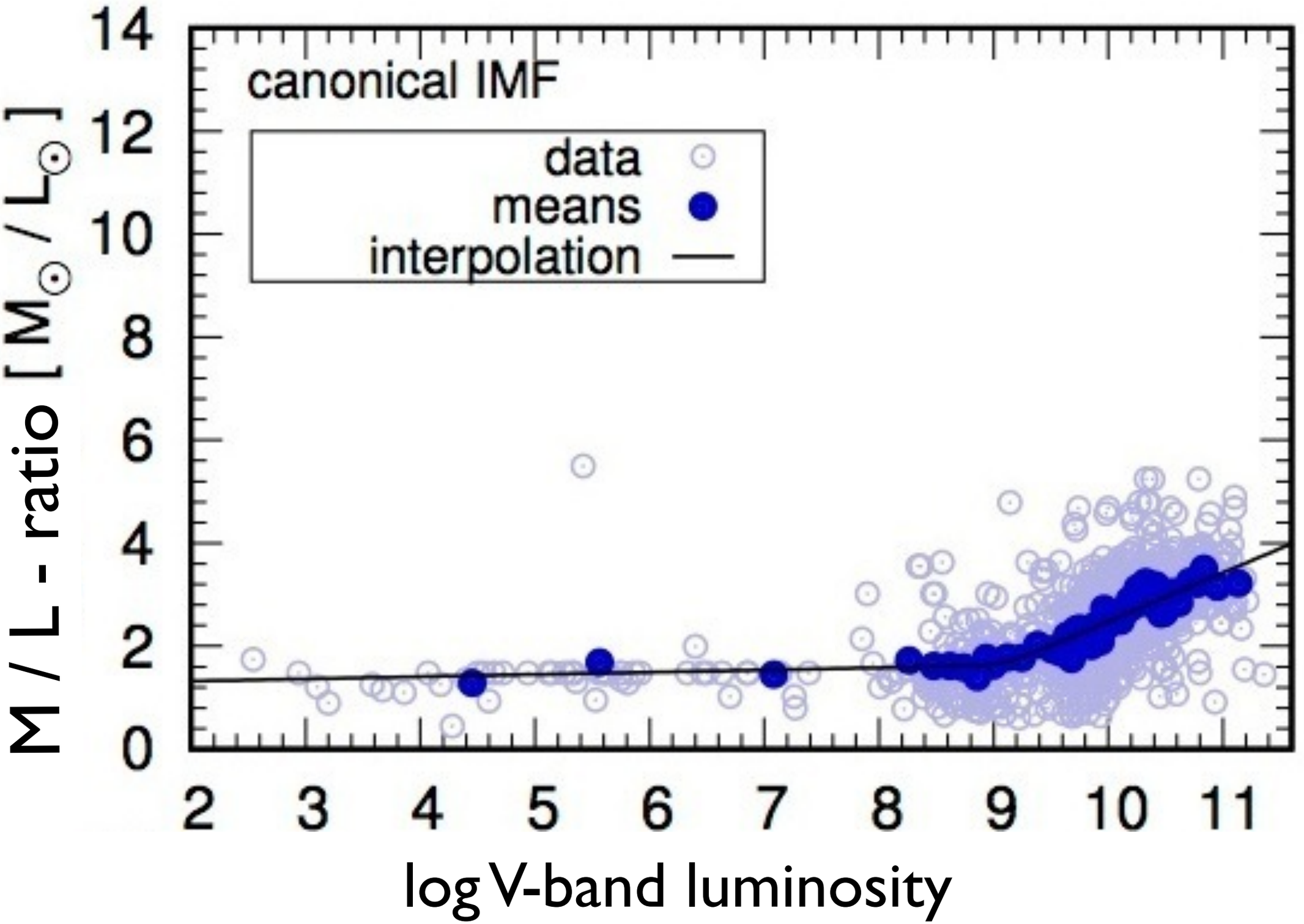
The galaxy-wide stellar initial mass function (IGIMF)



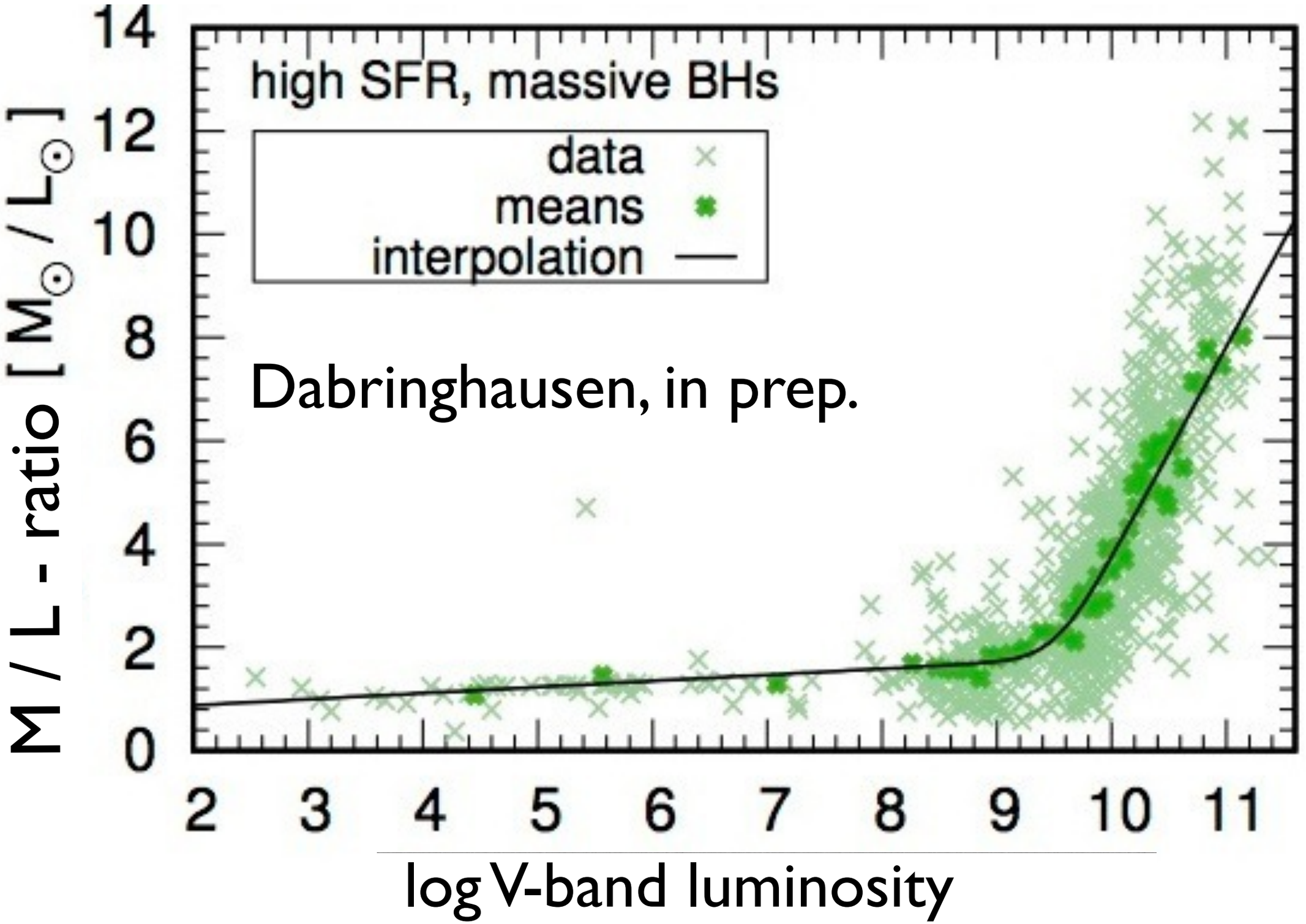
The effective IMF in a galaxy



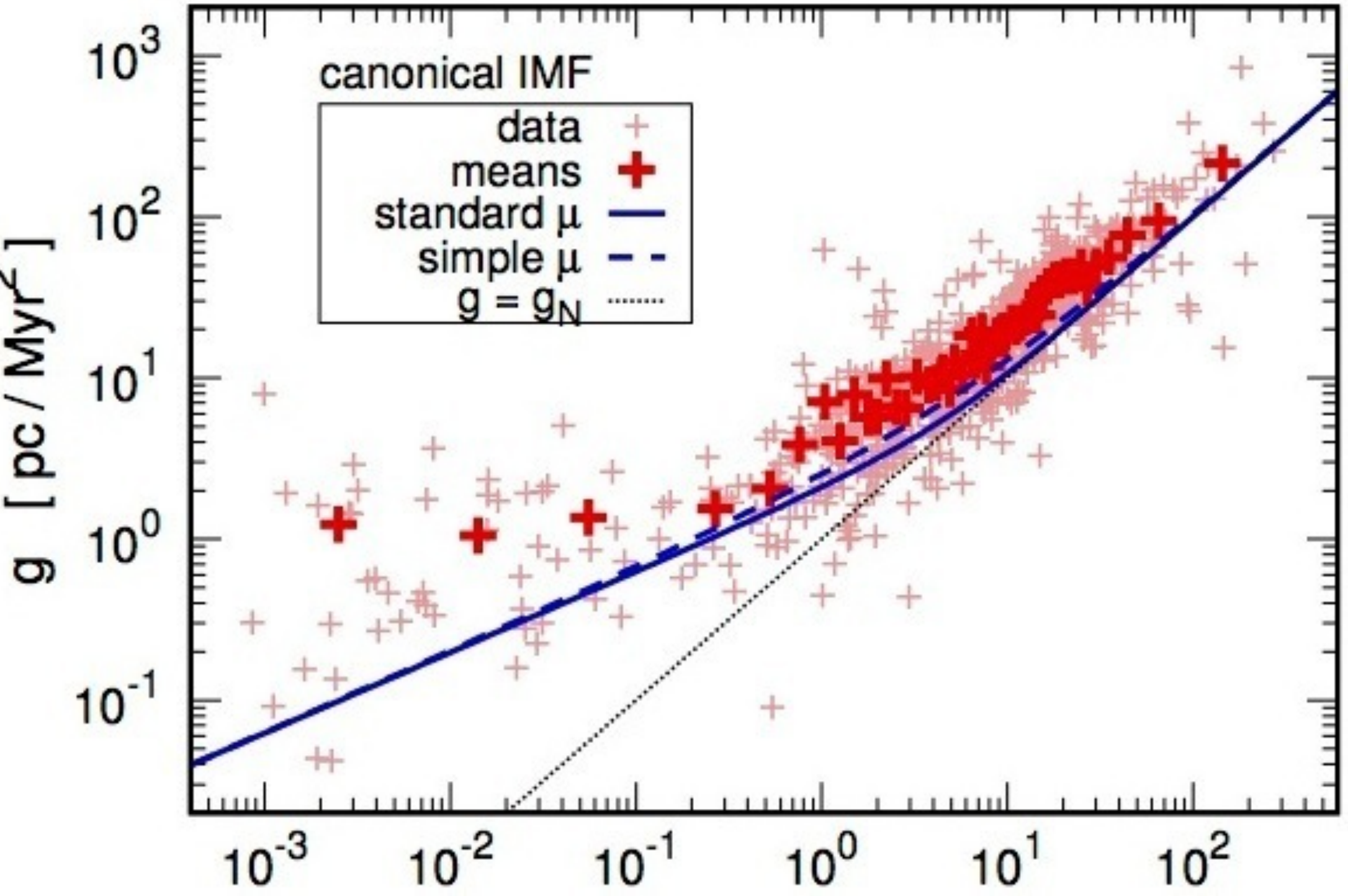
Simple interpolations for the IGIMF



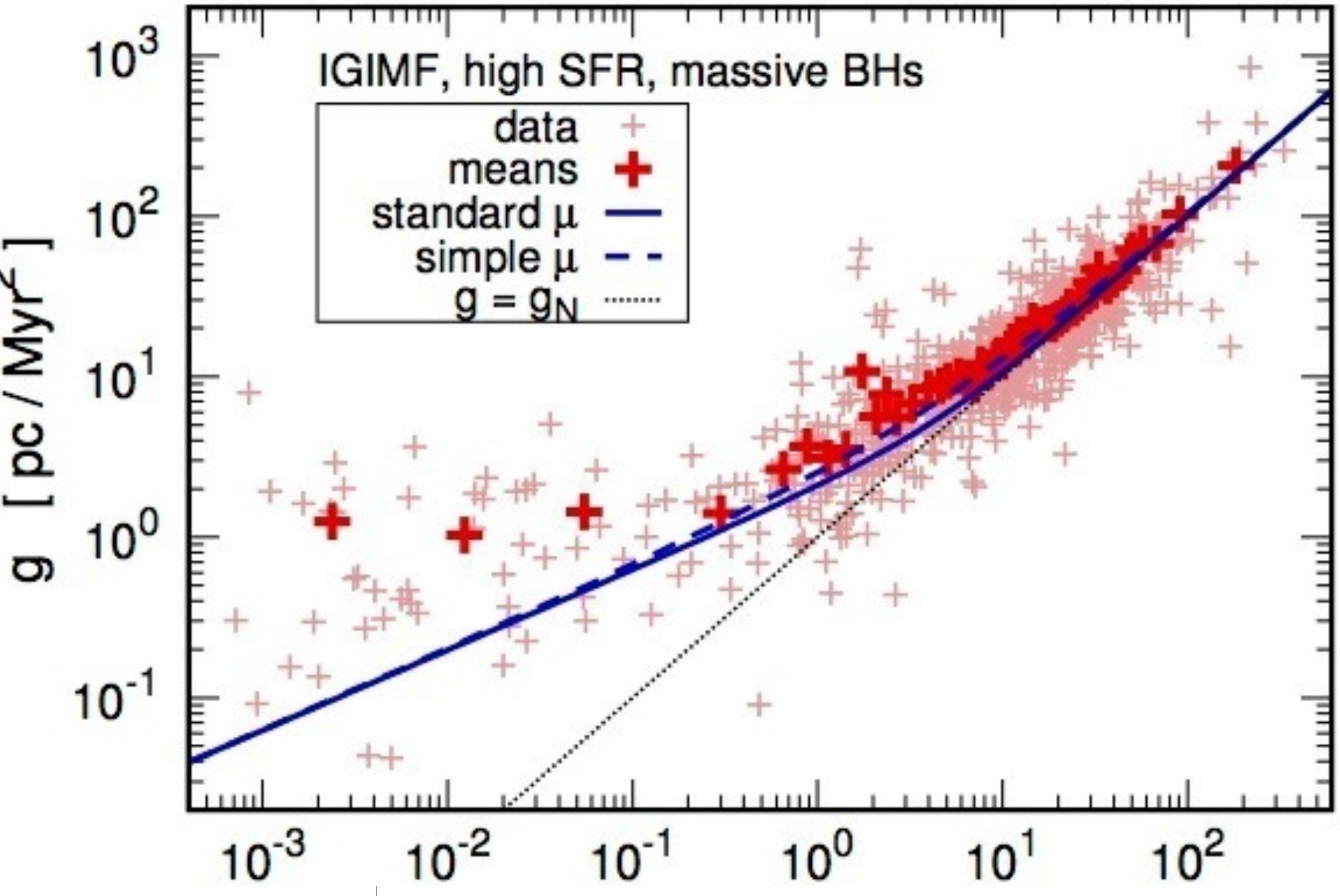
Simple interpolations for the IGIMF



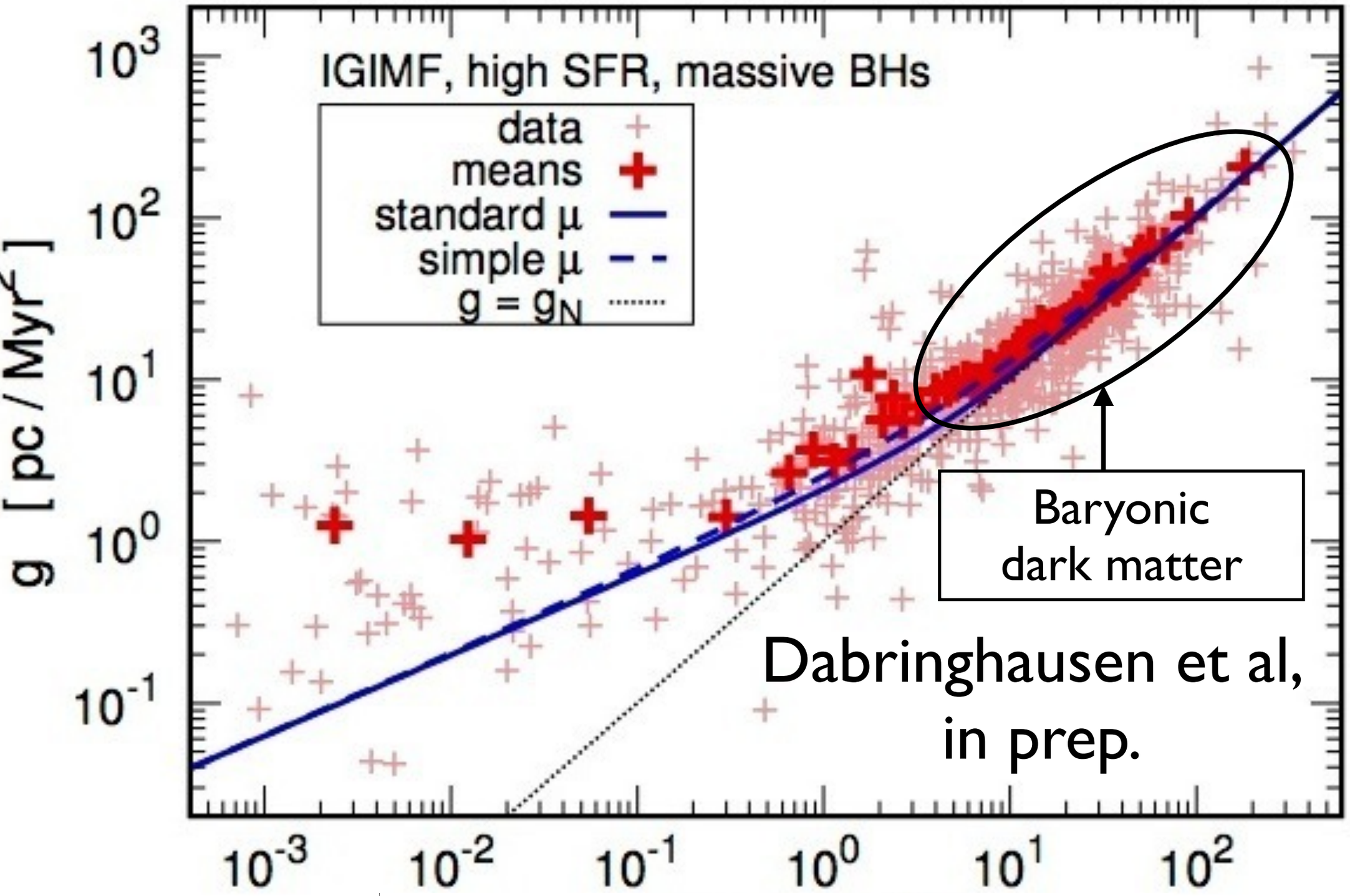
Radial accelerations for varying IGIMF



Radial accelerations for varying IGIMF



Radial accelerations for varying IGIMF



Radial accelerations for varying IGIMF