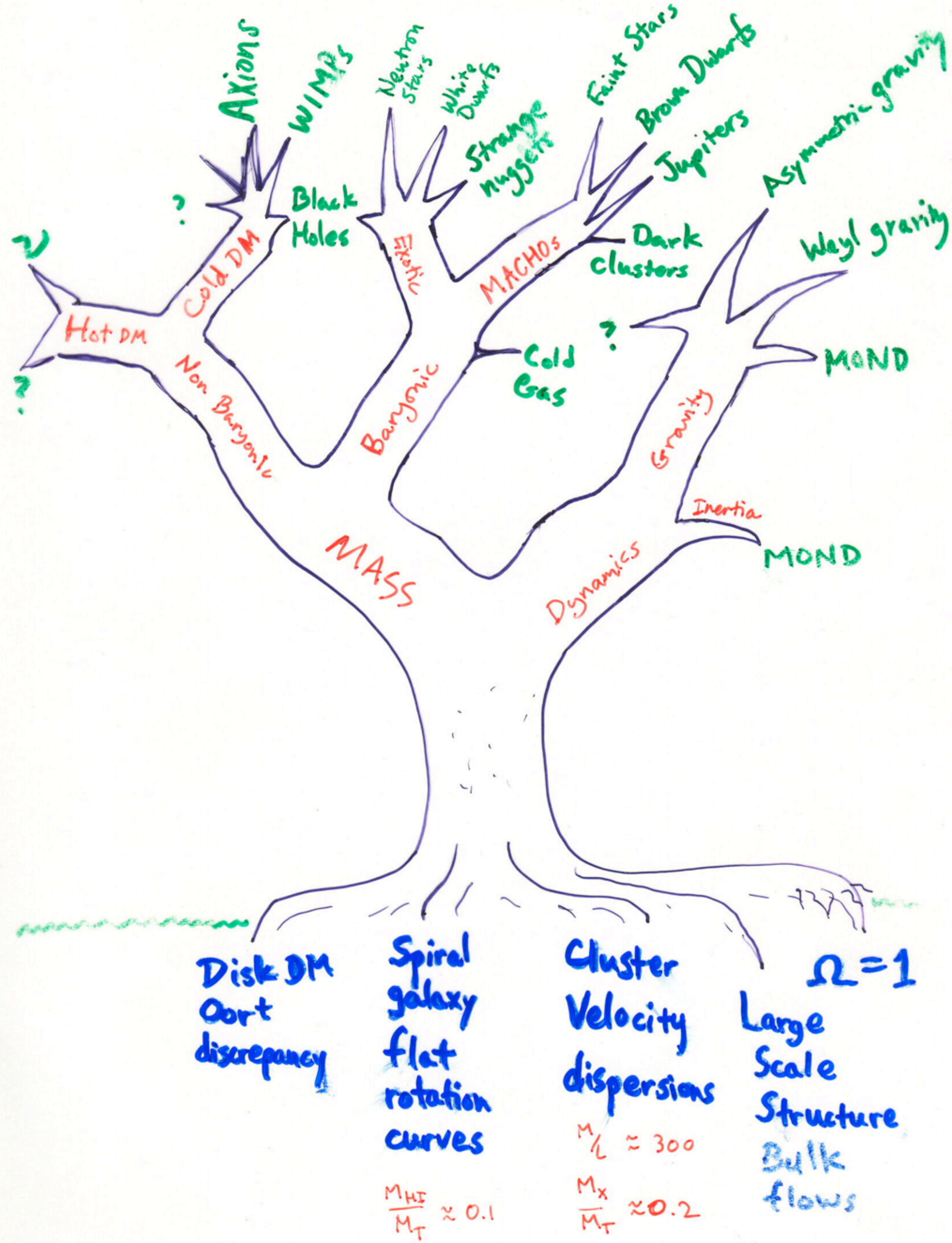
Dark Matter

ASTR 333/433

TODAY

Elliptical Galaxies

anisotropy



Empirical DM halo

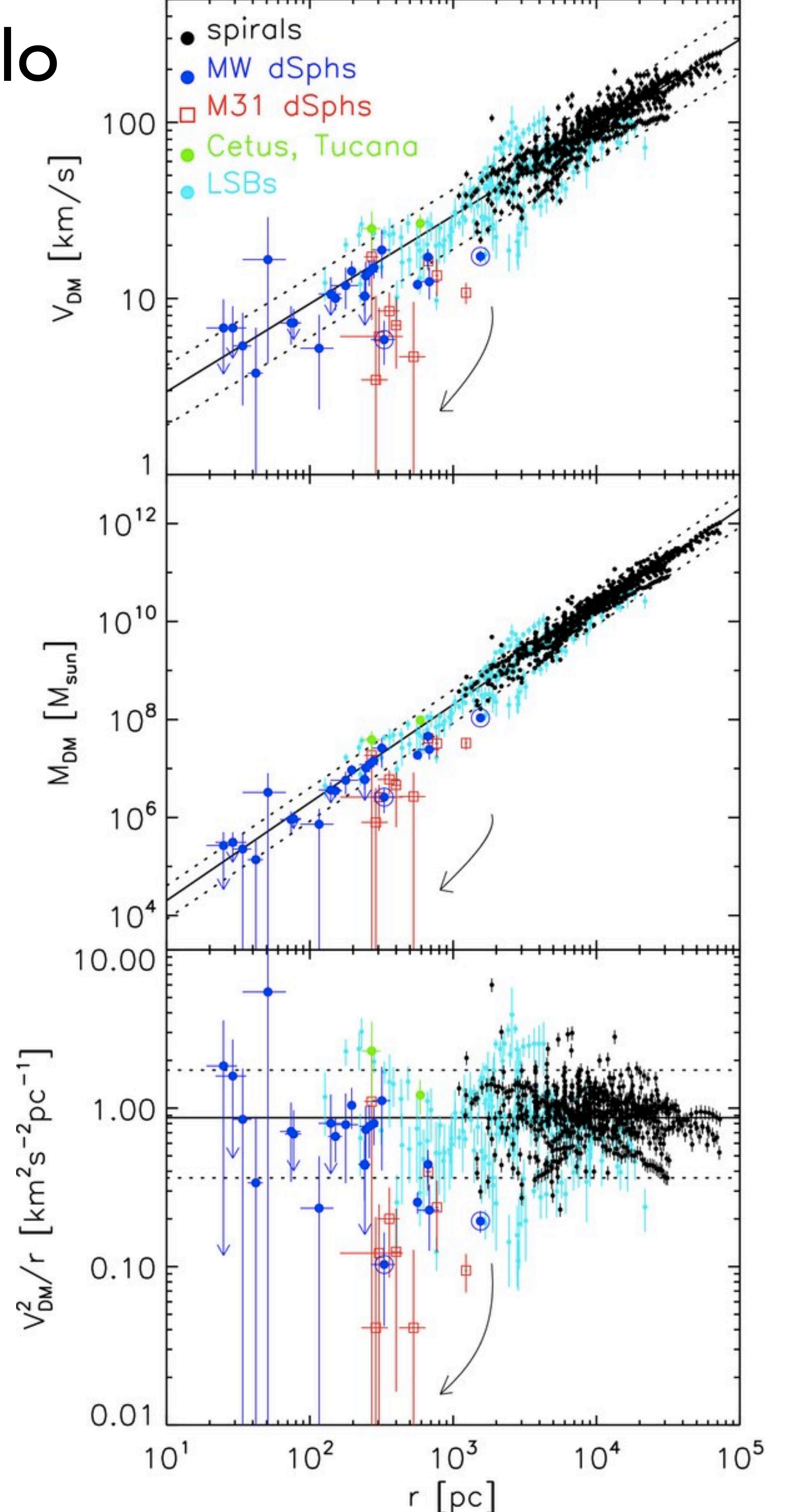
$$\frac{M_{DM}}{\mathrm{M}_\odot} = 200 \left(\frac{R}{\mathrm{pc}}\right)^2$$

McGaugh et al. (2007)
Walker et al. (2010)

$$\log\left(\frac{V_{DM}}{\mathrm{km\,s^{-1}}}\right) = 1.47 + \frac{1}{2}\log\left(\frac{R}{\mathrm{kpc}}\right)$$

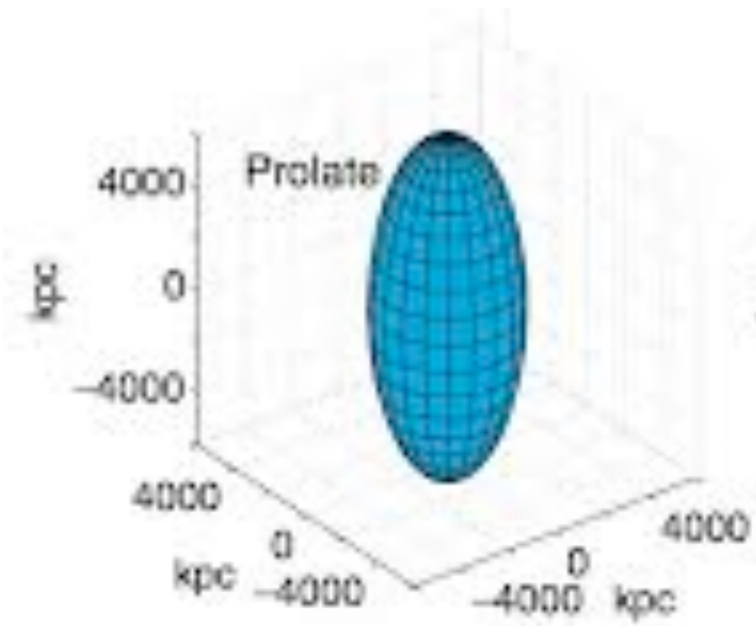
$$g_{DM} = 3 \times 10^{-11}\ \mathrm{m\,s^{-2}}$$

Roughly constant acceleration -
equivalent to constant surface density



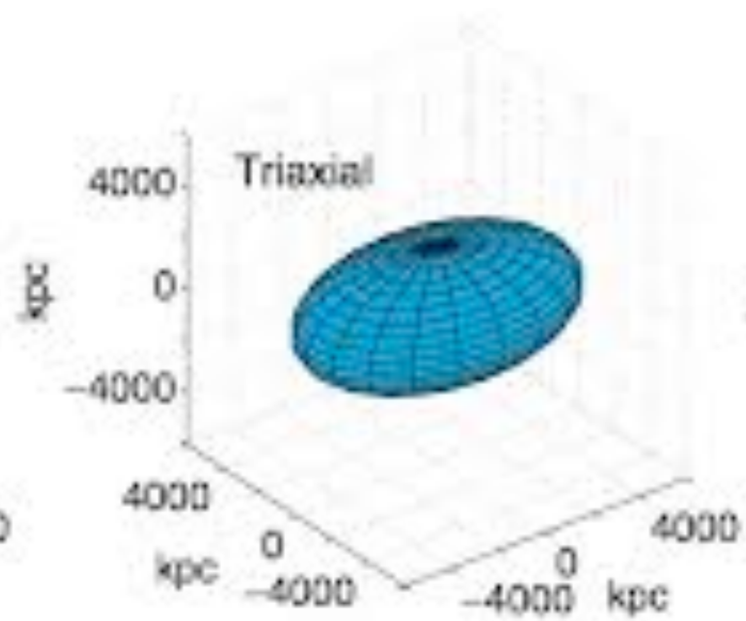
3D halo shapes

prolate



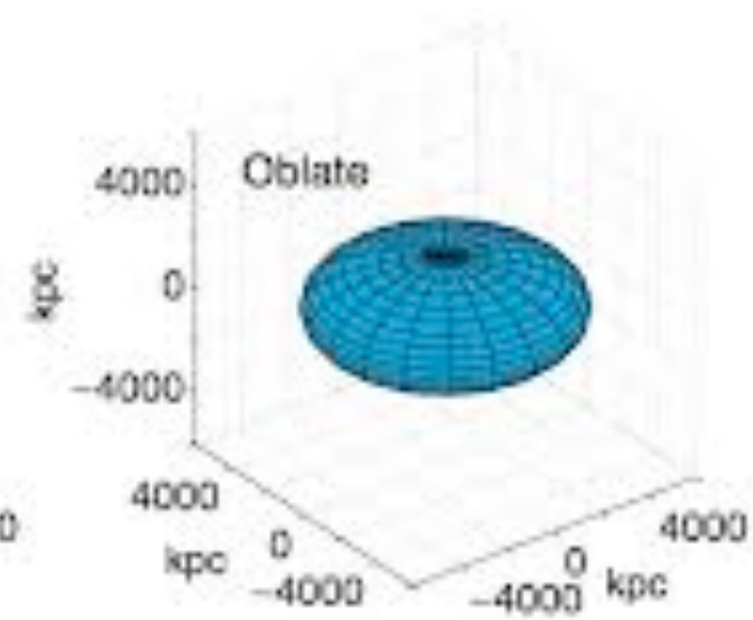
$a > b = c$

triaxial



$a > b > c$

oblate



$a = b > c$

Simulations blobby and even more complicated

NFW shape

NFW halos triaxial. More massive halos less round

perhaps because they are still building up hierarchically ?

Maccio et al (2007)

Concentration, spin and shape of dark haloes 63

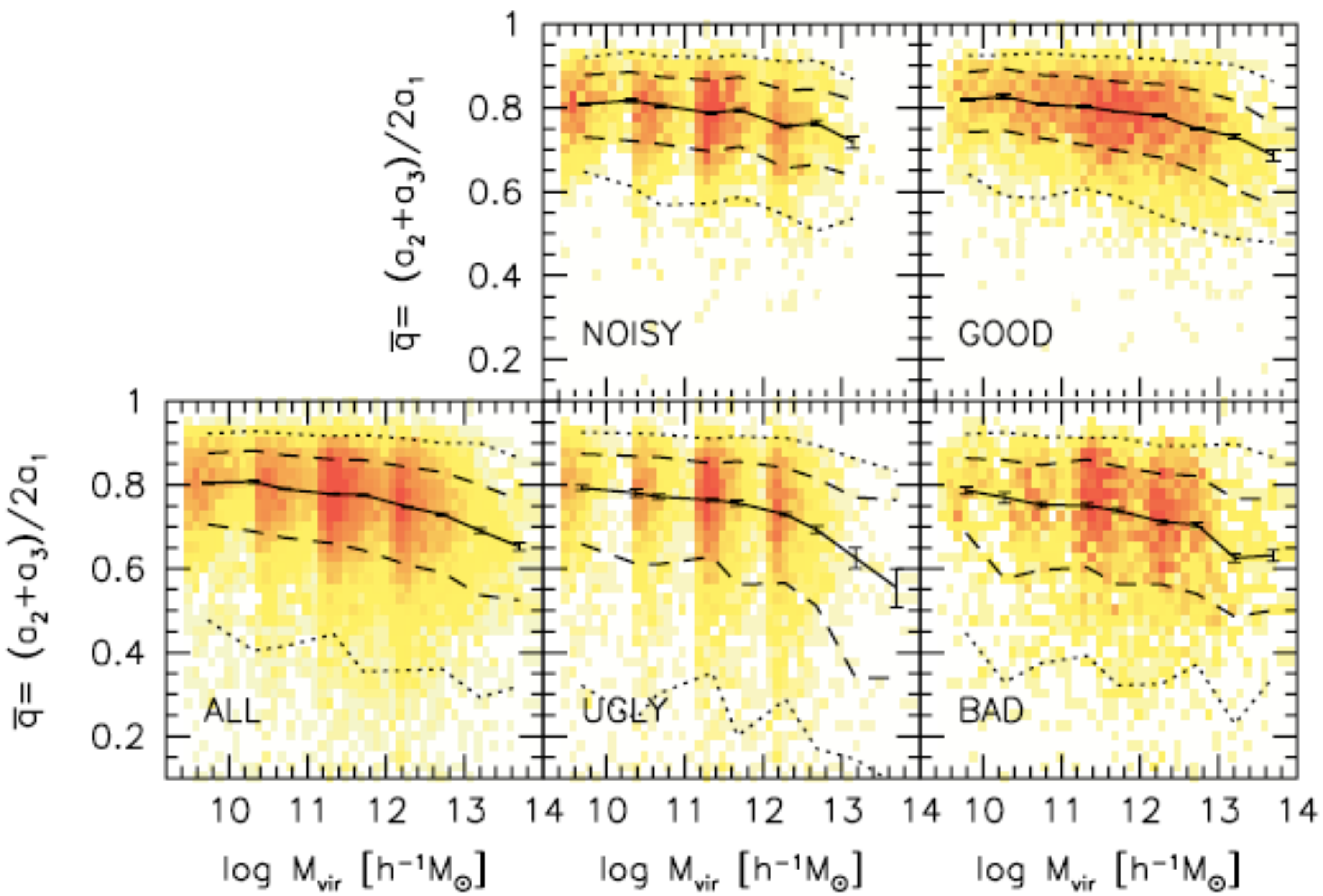
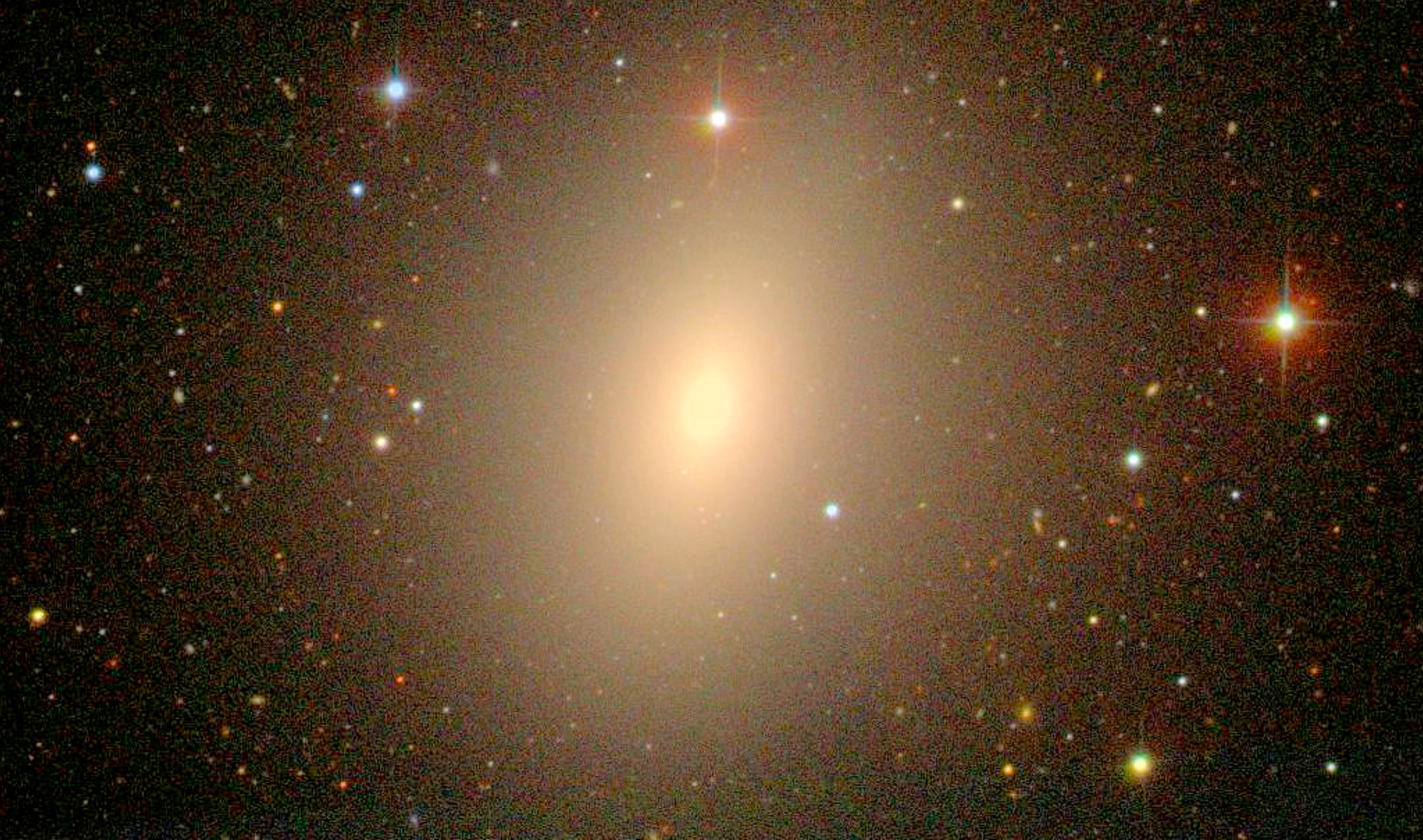


Figure 6. Relation between $\bar{q}$ and $M_{\rm vir}$ for different subsamples of haloes. The solid lines show the 50th percentile, dashed lines show the 16th and 84th percentiles, and the dotted lines show the 2.5th and 97.5th percentiles. The error bar gives the Poisson error on the median.

Elliptical Galaxies

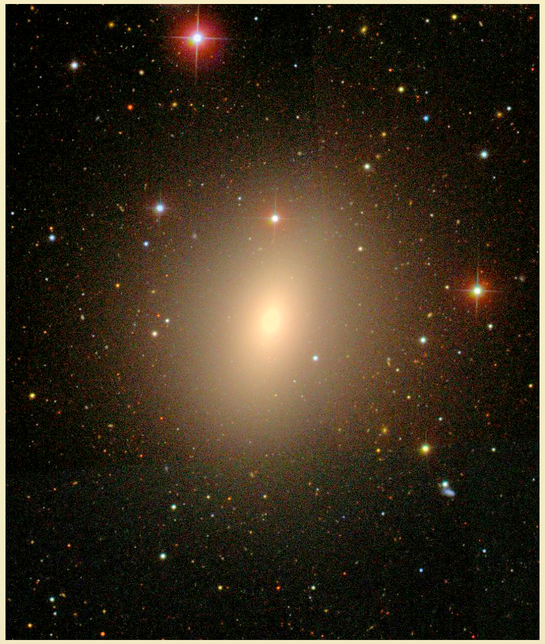
Elliptical galaxies are presumed to reside in dark matter halos, but the evidence is less obvious than for spirals.



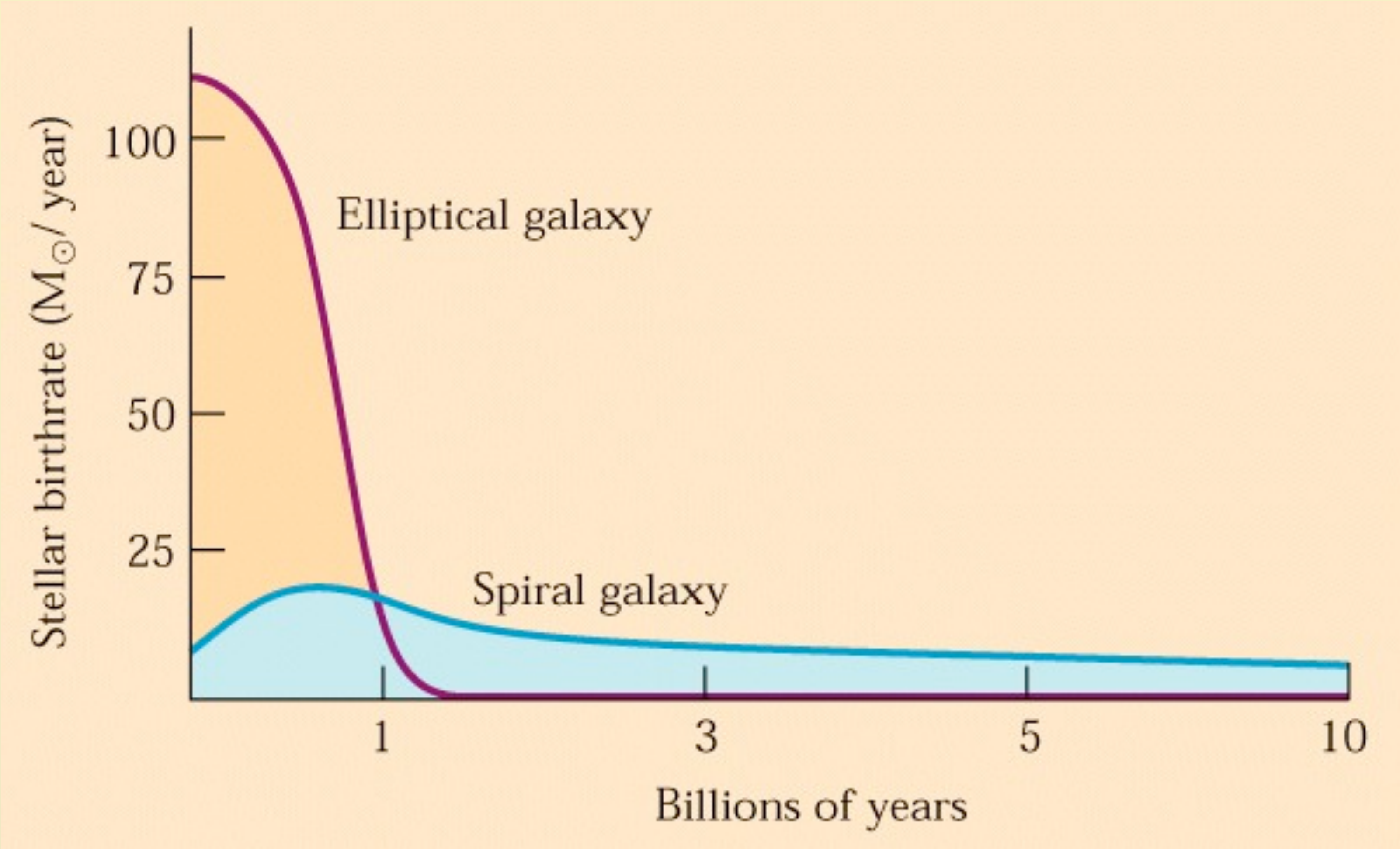
Elliptical Galaxies

Generic Star Formation History

Elliptical



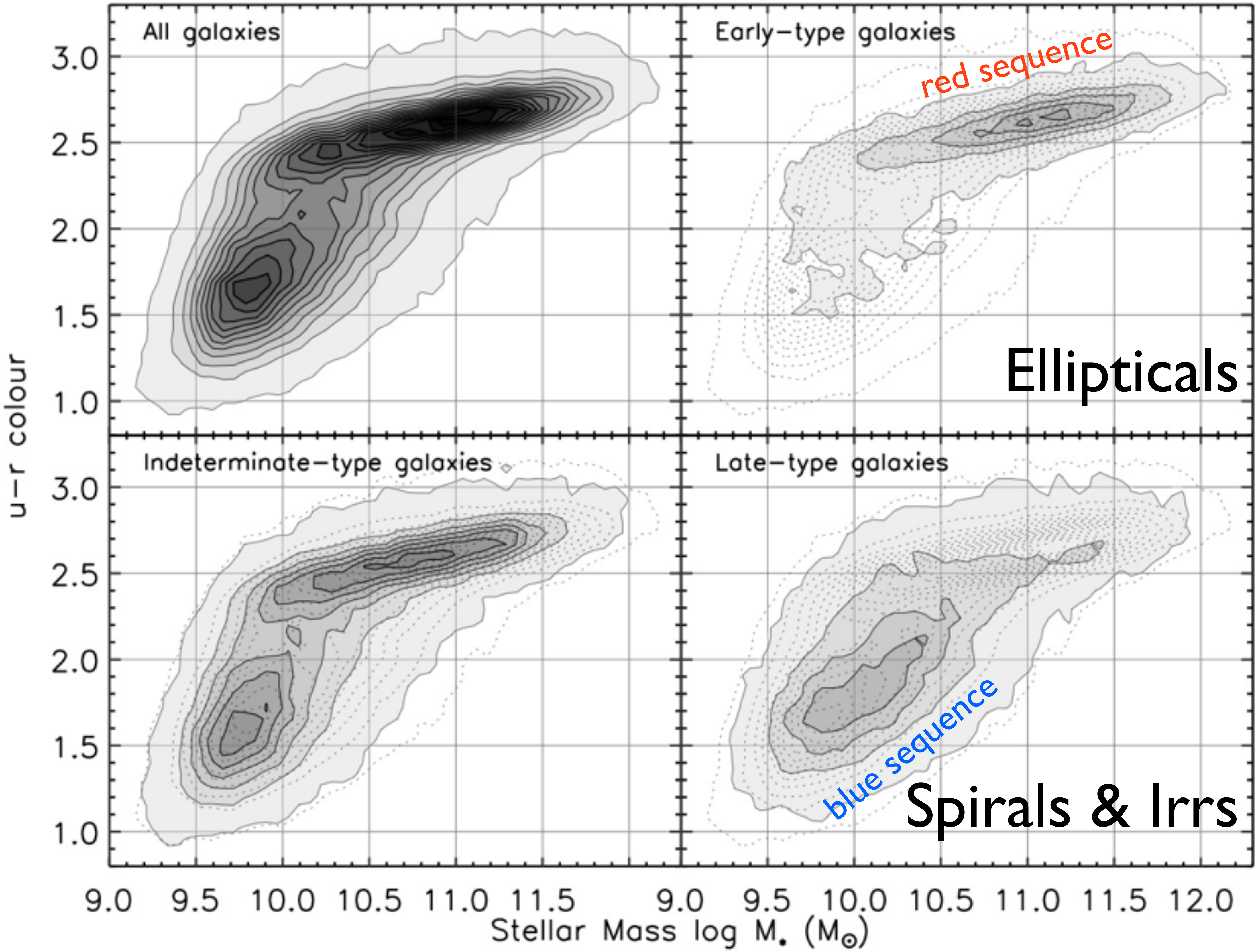
old stars



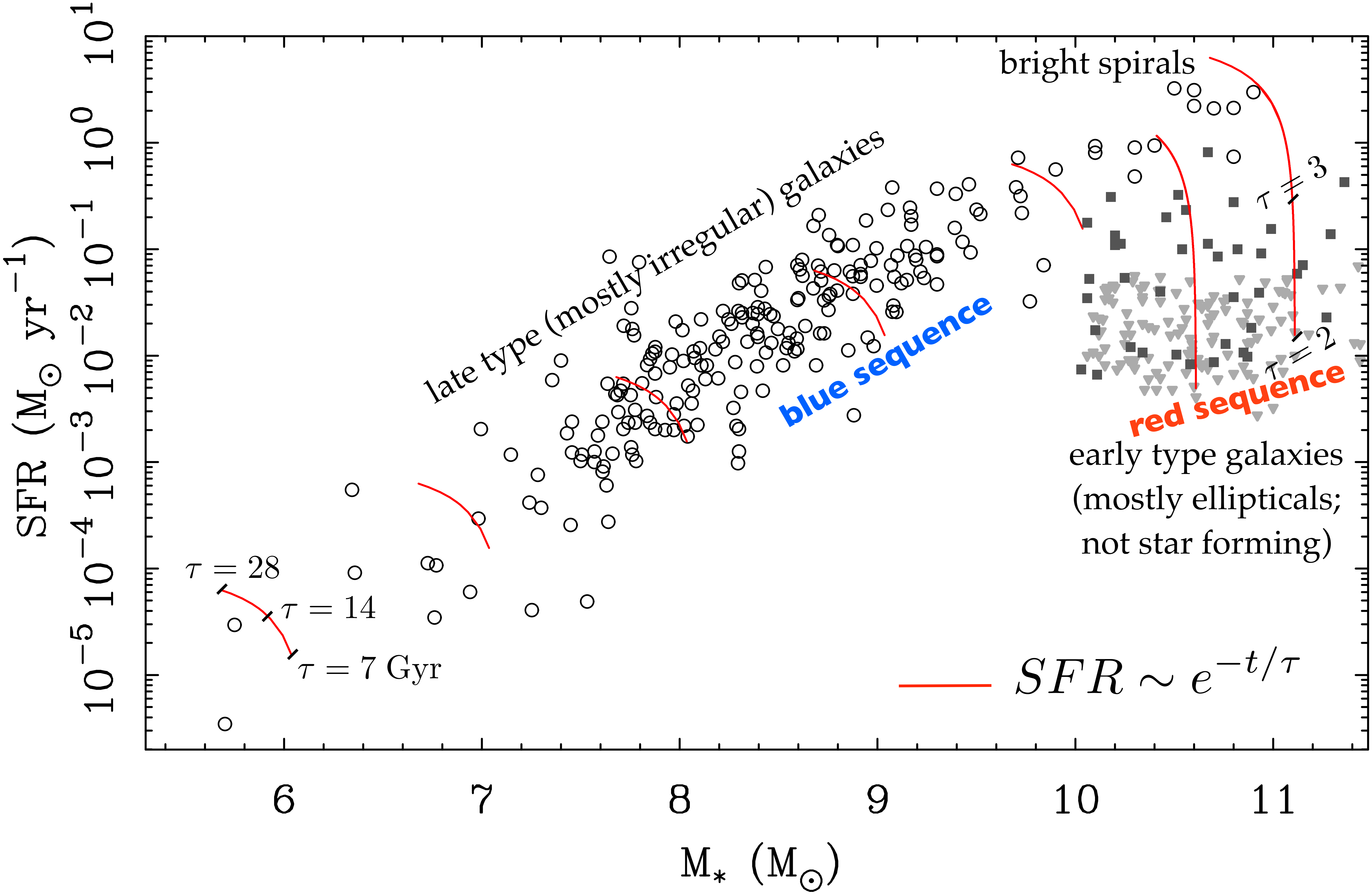
Spiral

old stars
young stars
cold gas

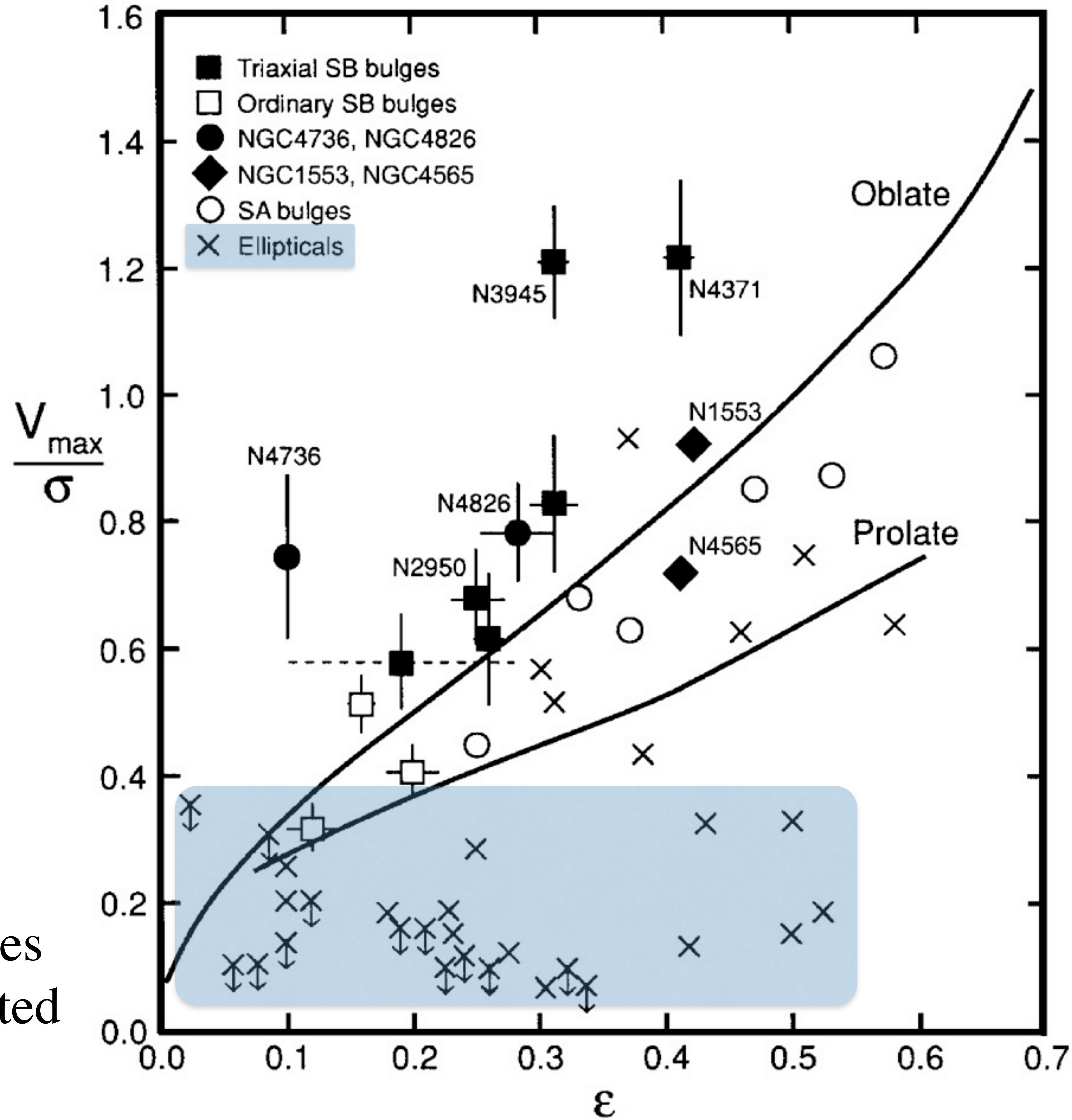
color-magnitude relation for galaxies



“Main Sequence of Star Forming Galaxies”



Spiral galaxies way off scale

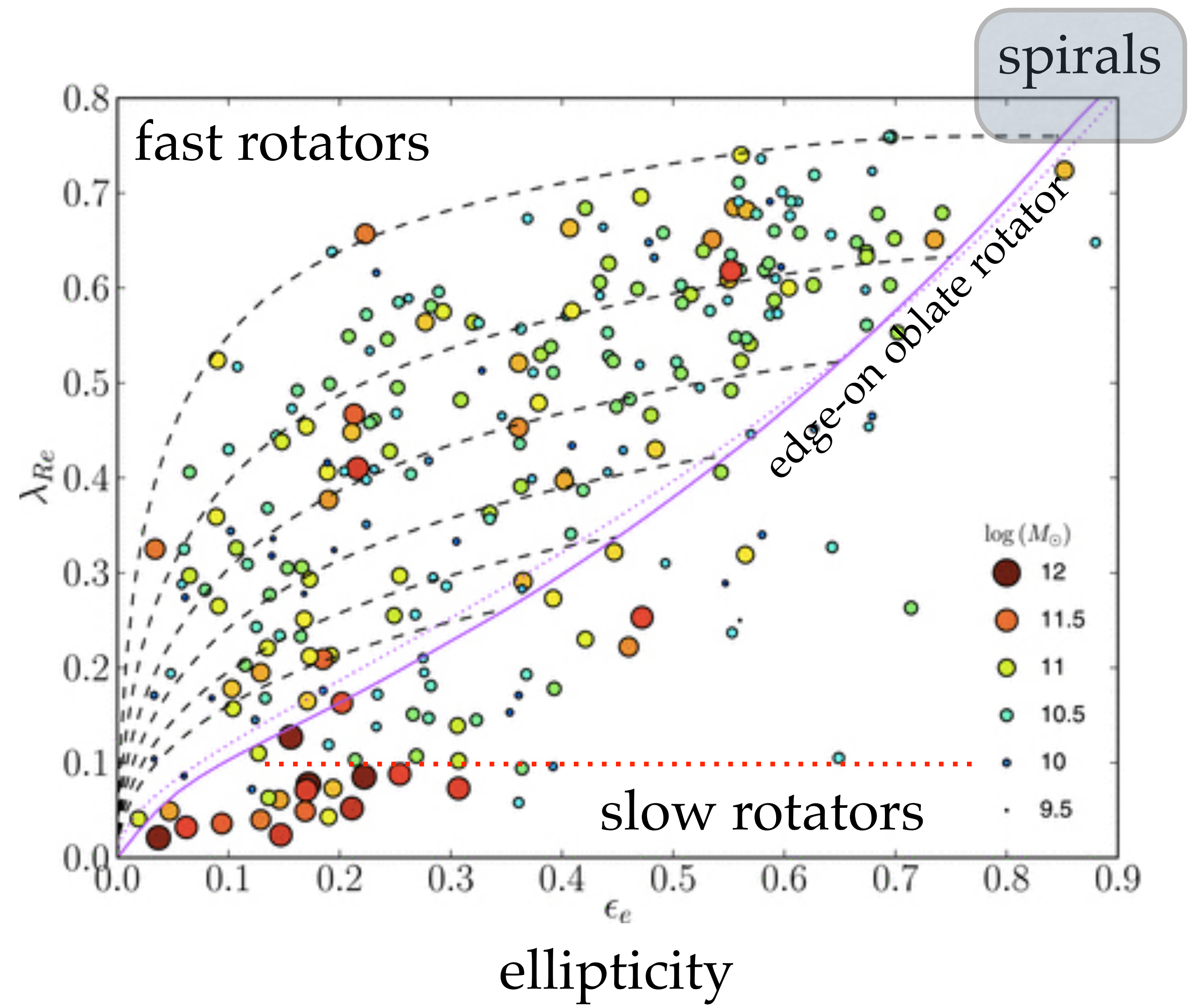


Elliptical galaxies pressure supported

$$\lambda_R = \frac{\langle R|V|\rangle}{\langle R\sqrt{V^2+\sigma^2}\rangle}$$

specific angular momentum

Massive ellipticals mostly pressure supported (slow rotators) while many (not all) lower mass ellipticals are fast rotators. These are often S0 galaxies.



Dashed lines represent different inclinations for different intrinsic ellipticities

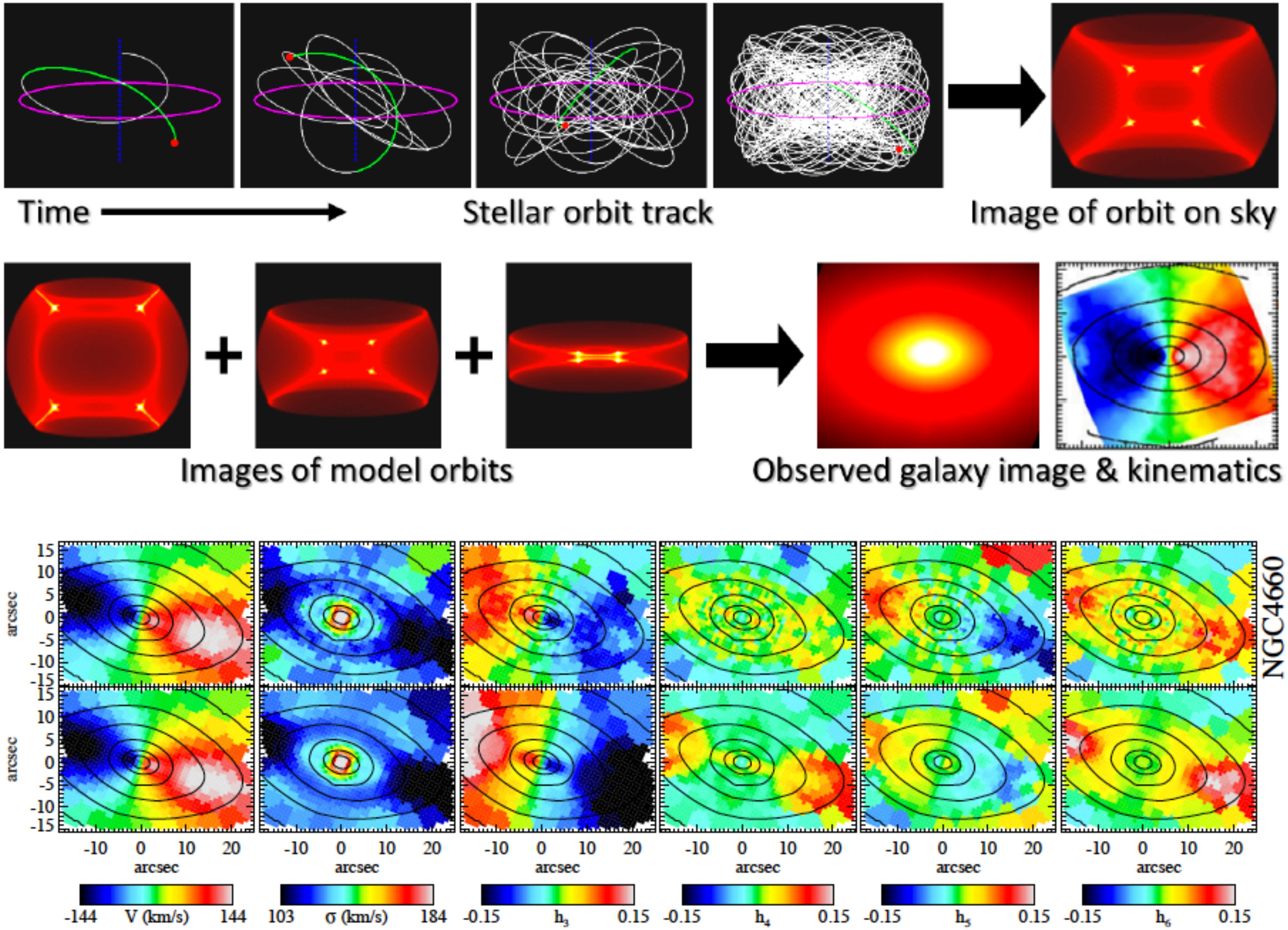


Figure 3. Schwarzschild's orbit-superposition method. *Top Row:* numerical integration of a single orbit in the adopted gravitational potential. After a sufficiently long time the density (of regular orbits) converges to a fixed distribution. *Middle Row:* the method finds the linear combination of thousands of orbits (three representative are shown here) which best fits the galaxy image and stellar kinematics. *Bottom two rows:* data (top) versus model (bottom) comparison. The model can fit the full stellar line-of-sight velocity distribution, here parametrized by the first six Gauss-Hermite moments (from Cappellari et al. 2007).

Velocity dispersion profiles for 3 ETGs

measured from stars at small R, PN at large R