Galaxies: Luminosities

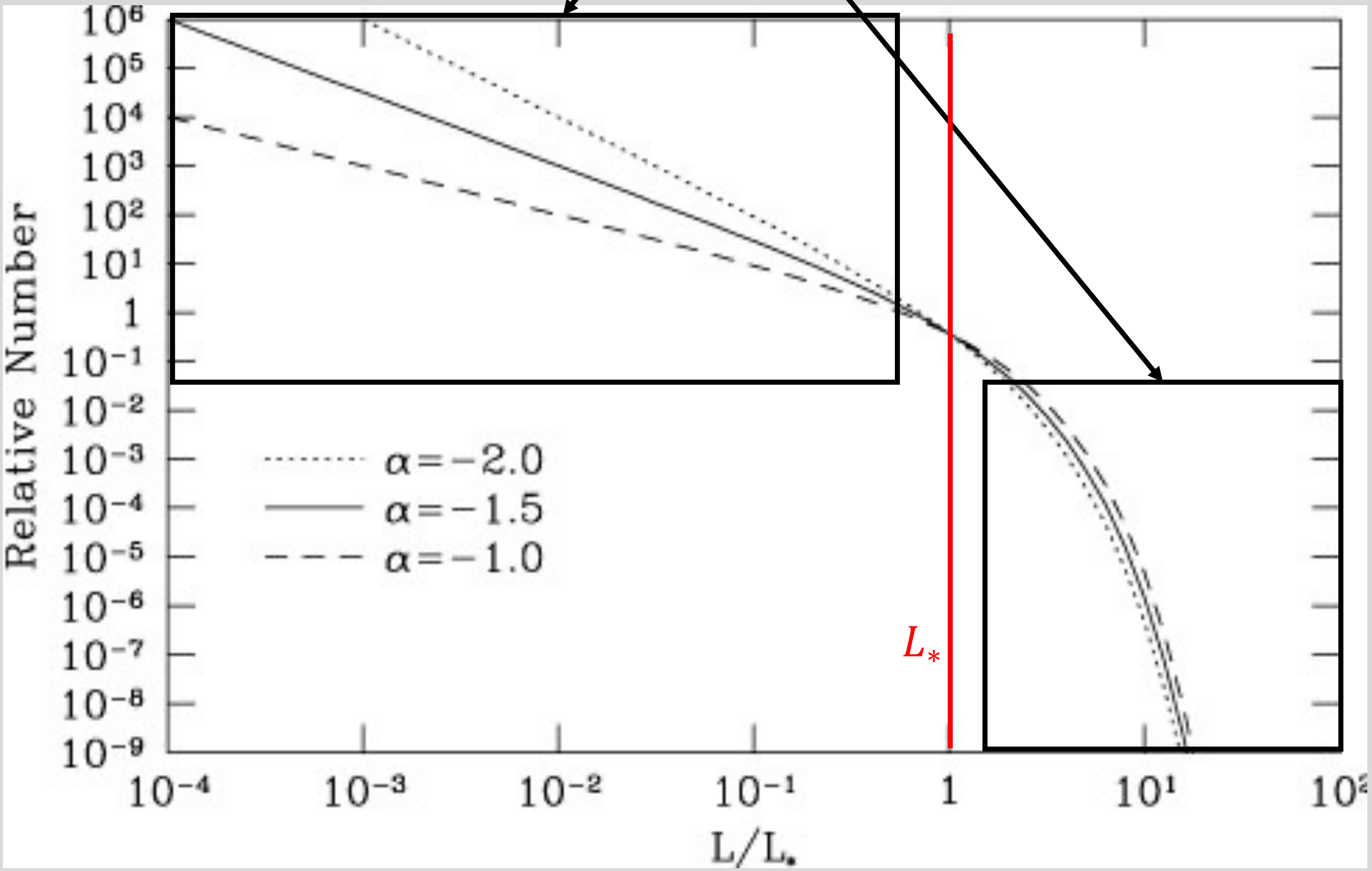
Luminosity function: number of galaxies (per unit volume) in a luminosity range L ⇒ L + dL

Common parameterization is the **Schechter Function**: $\Phi(L)dL = \Phi_* \boxed{\left(\frac{L}{L_*}\right)^\alpha} \boxed{e^{(-L/L_*)}} dL$

Φ_*: overall density (units = #/Mpc^3)

L_*: characteristic luminosity, the "knee" of the luminosity function

α: faint end power law slope



Galaxies: Luminosities

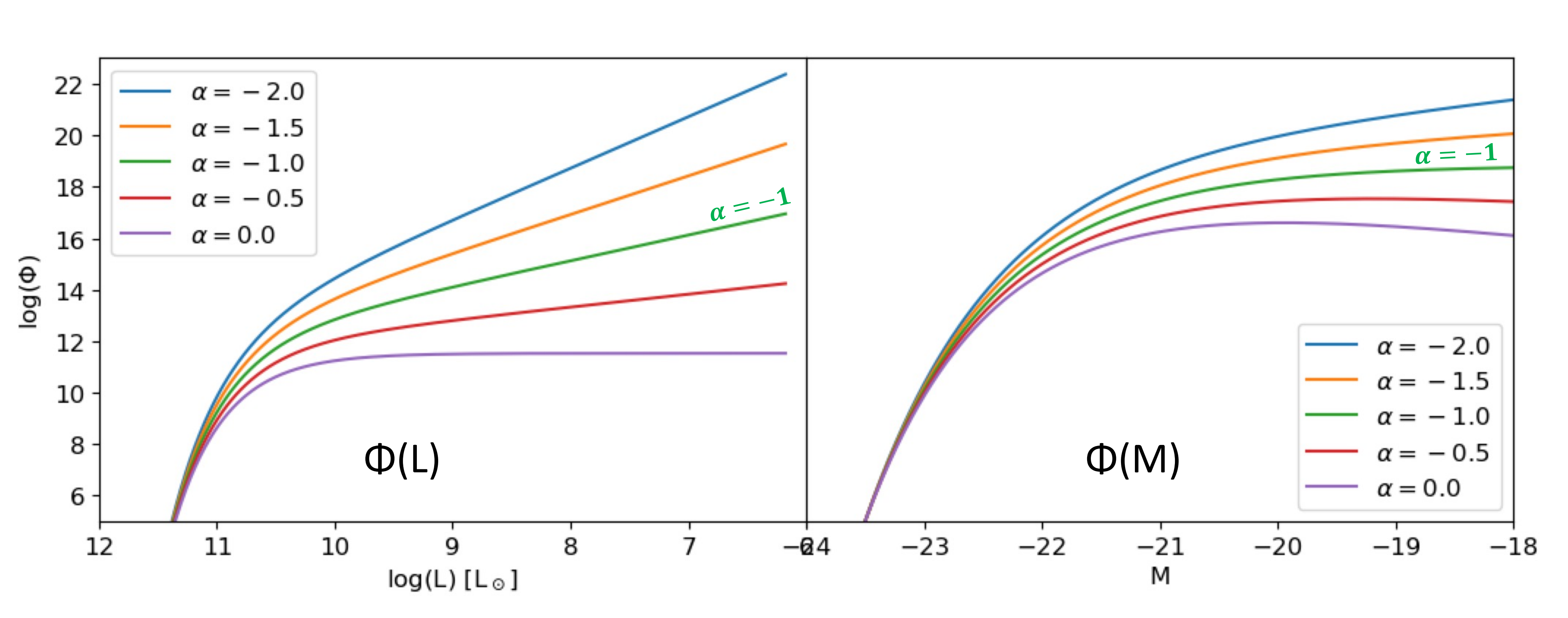
since $M = -2.5\,log\,L + C$,
this means

$$dM \sim \frac{dL}{L}$$

so a magnitude bin is a fractional luminosity bin.

We usually work in magnitudes, looking at the number in an absolute magnitude bin M ⇒ M + dM

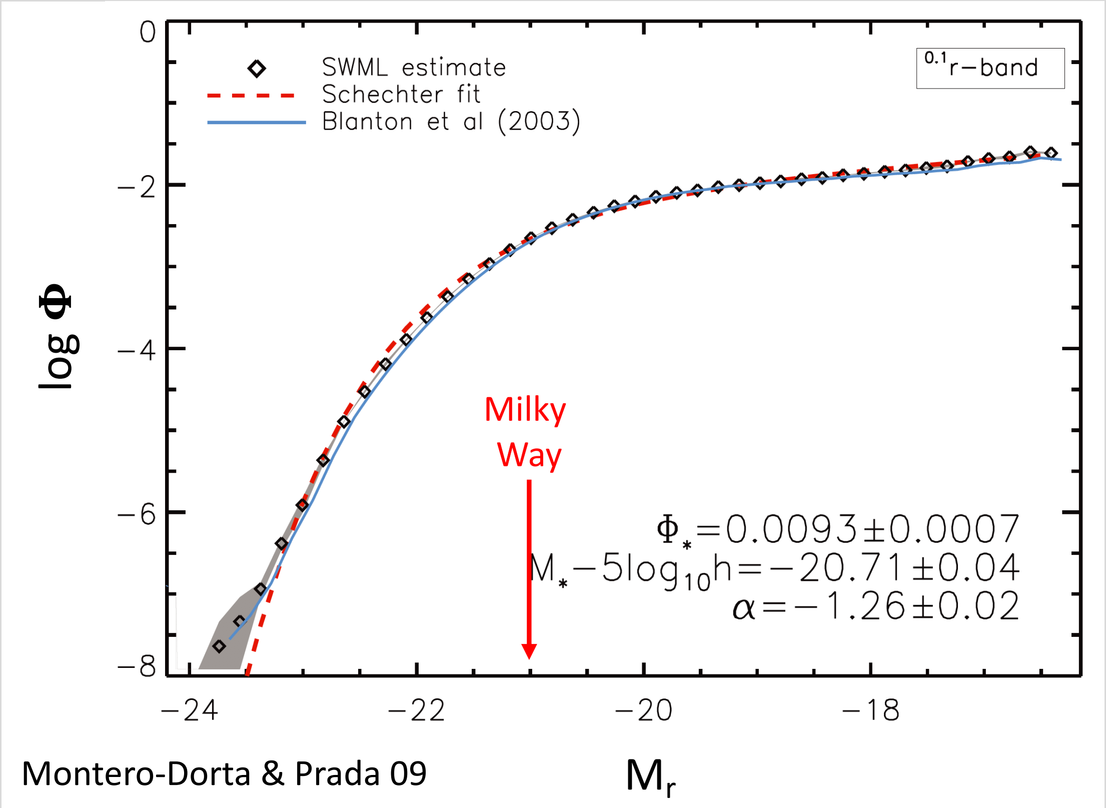
The Schechter LF looks different expressed in magnitudes (Φ(M) dM) rather than luminosity (Φ(L) dL)



Note: α=−1 is referred to as “flat” because of its shape in magnitude plots, not luminosity plots.

Galaxies: Luminosities

Luminosity function depends on many things, including filter choice and galaxy color….



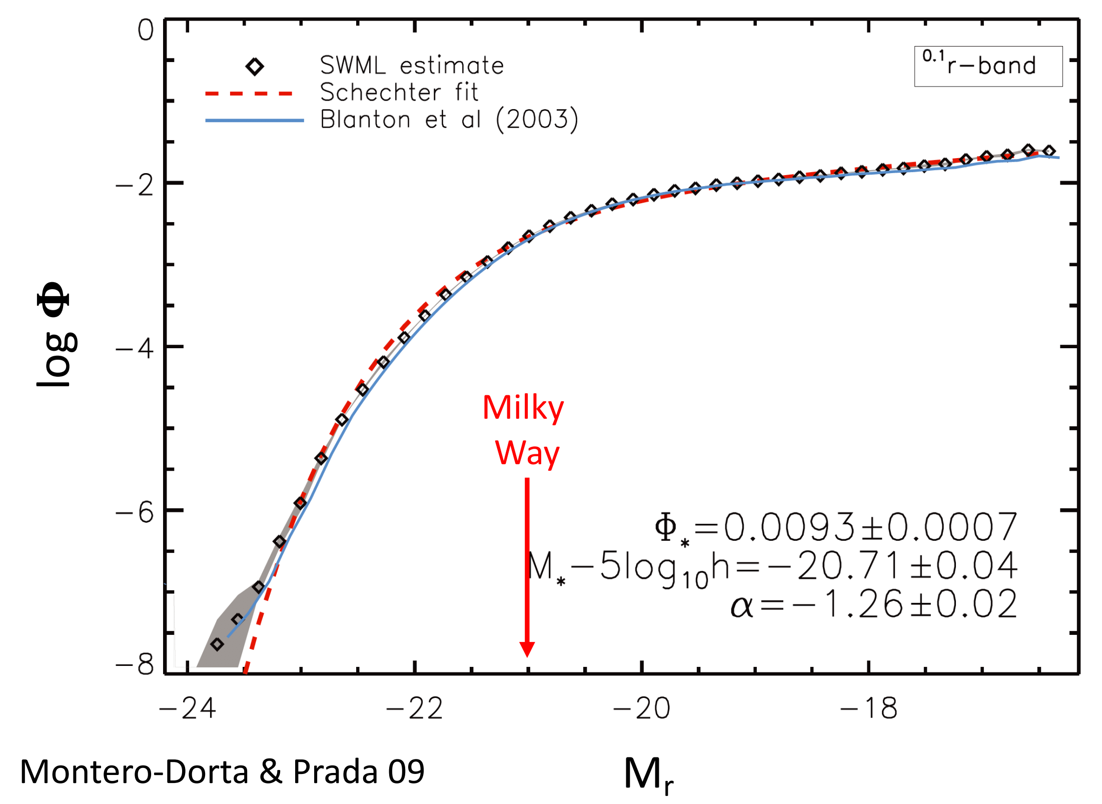
All Galaxies

What's this $M_* - 5\,log\,h$ stuff?

Distances have been derived from the Hubble relation: $v = H_0 d$. So their distances and absolute magnitudes depend on the assumed Hubble constant. We define $h = H_0/100$, and can then scale the magnitude to any Hubble constant we want…..

Galaxies: Luminosities

Luminosity function depends on many things, including filter choice and galaxy color….



Montero-Dorta & Prada 09

All Galaxies

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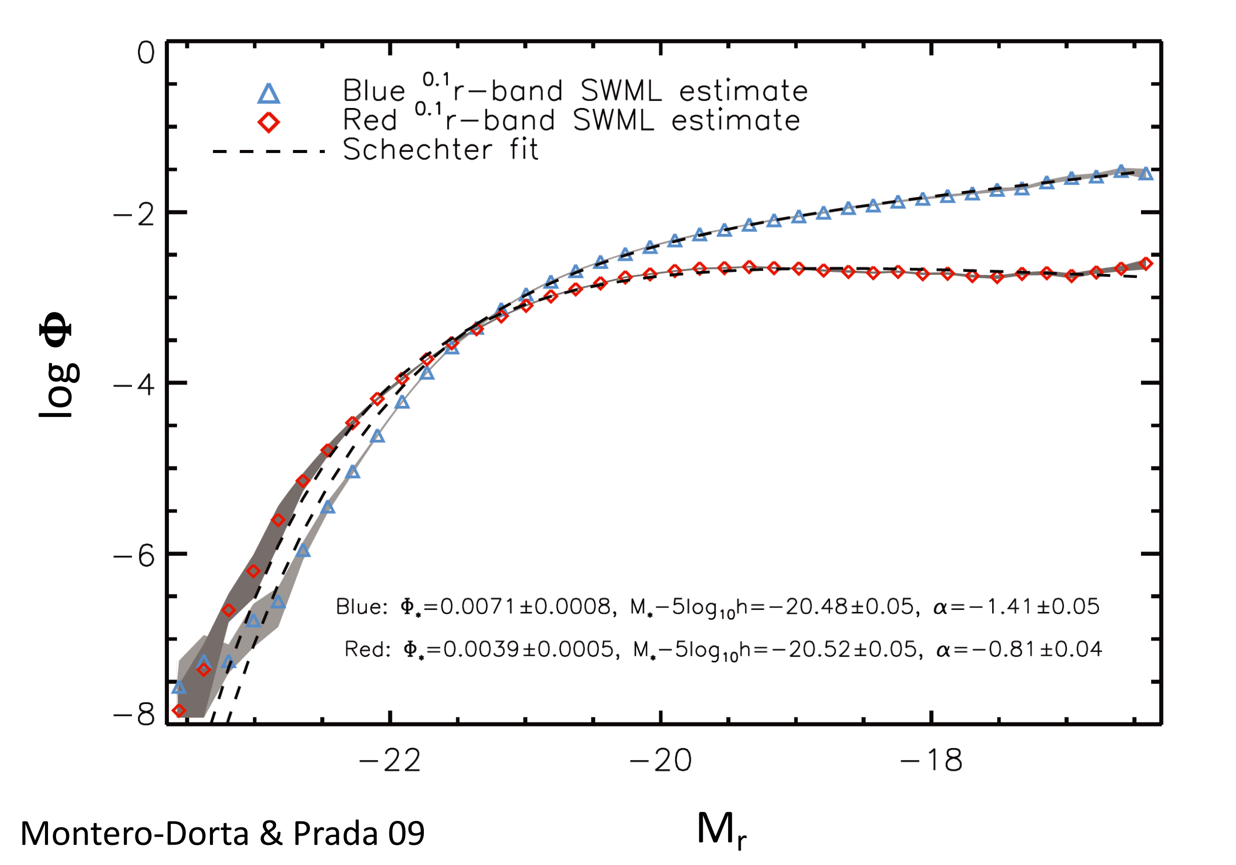


Montero-Dorta & Prada 09

By Color

Brightest galaxies tend to be red
Blue galaxies dominate the counts at fainter magnitudes

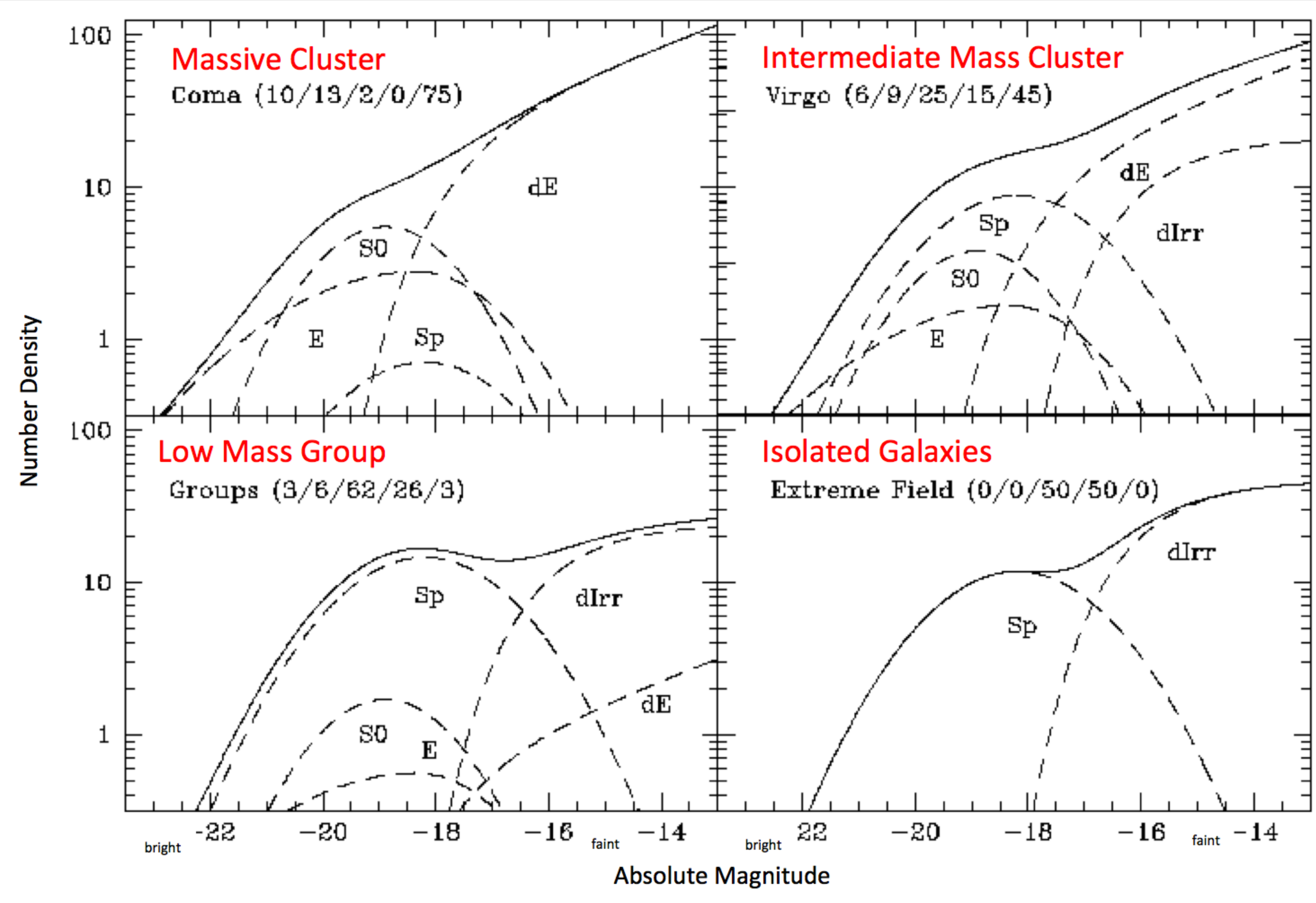
Galaxies: Luminosities

…and a very strong dependence on galaxy type and environment

These are schematic LFs, not real

Inside big galaxy clusters:
- E/S0 dominate
- faint end mostly red things

In groups and field:
- Spirals dominate
- faint end mostly blue things



E = Elliptical	dE = dwarf elliptical
S0 = S0	dIrr = dwarf irregular
Sp = Spiral	

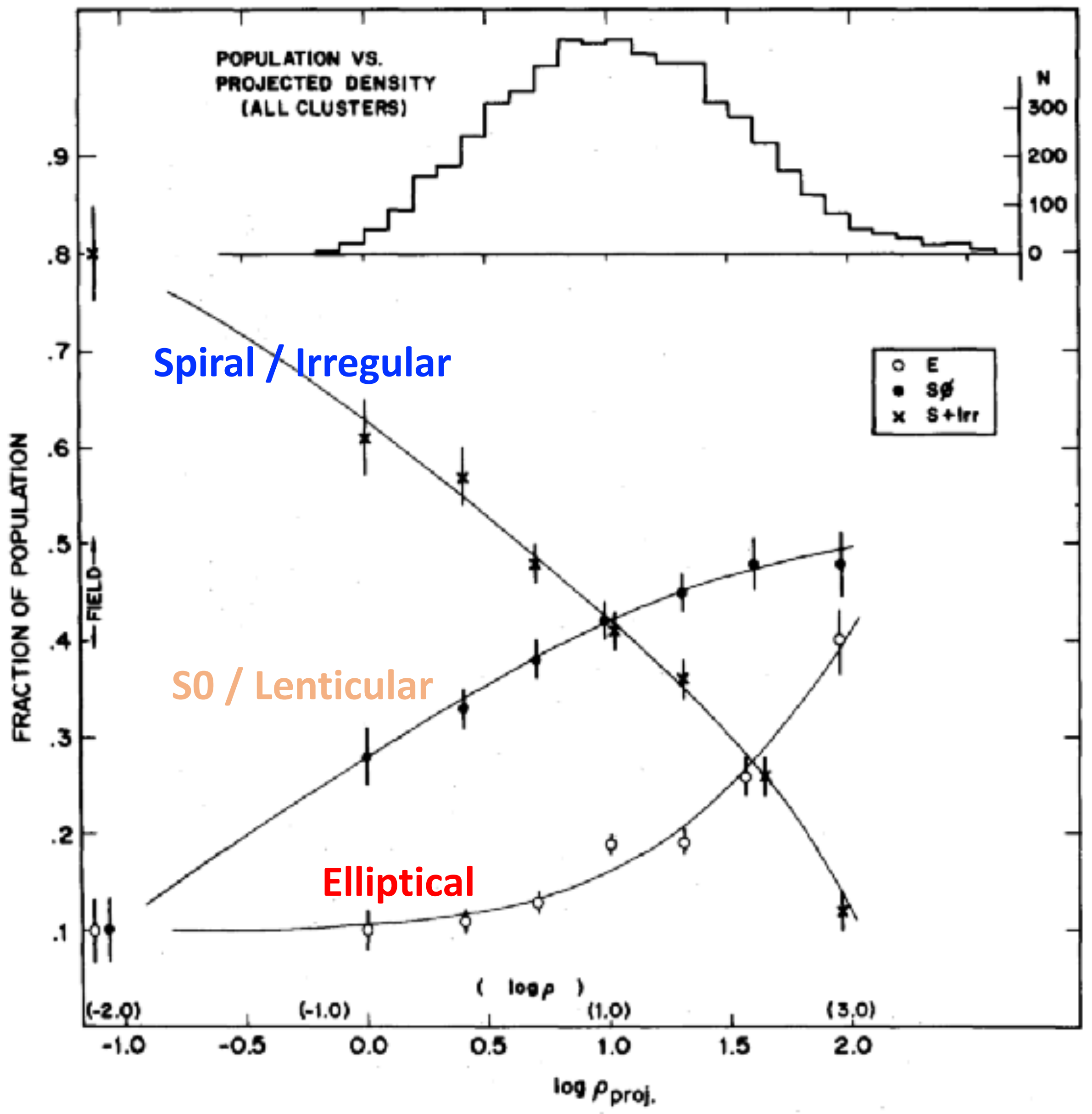
Galaxies: Morphology-Density Relationship

In the local universe, the fraction of galaxy types is a strong function of local environment.

Spirals/Irregulars dominate the in the field environment.

S0's and E's dominate in galaxy clusters.

Galaxy Population Fraction



Dressler 1980

Projected Number Density of Galaxies log(# per Mpc^2)

Galaxy Structure: Surface Brightness Profiles

Remember, surface brightness is intrinsic, does not depend on distance:

Surface Brightness [μ in mags/arcsec^2] ⇒
Flux Density on Sky [I in erg/s/cm^2/arcsec^2] ⇒
Luminosity Density in Galaxy [Σ in $L_\odot$/pc^2]

Galaxy Disks: roughly exponential with radius:

$$I(r) = I_0 e^{-r/h}$$

or, expressed in mag/arcsec^2:

$$\mu(r) = \mu_0 + \frac{2.5}{h \ln(10)} r$$

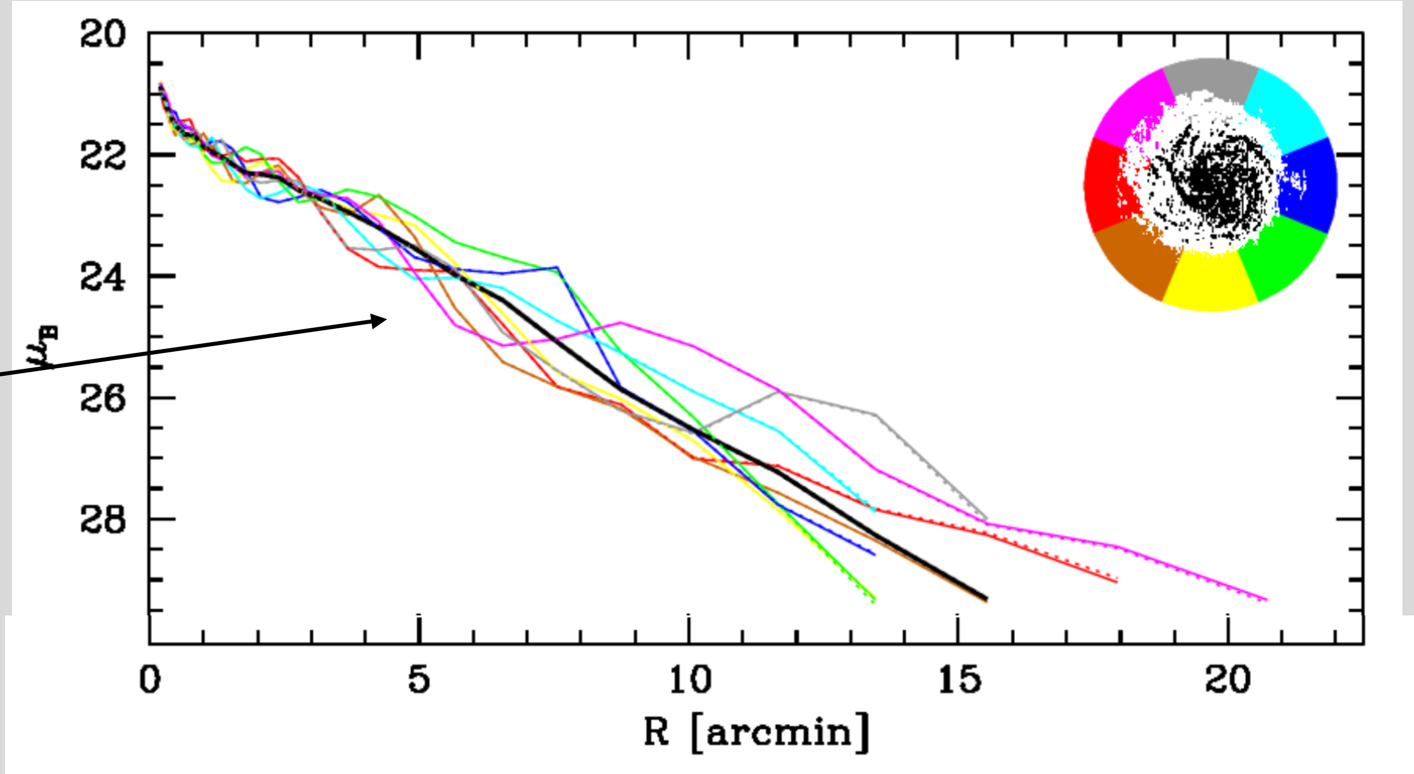
this is the equation for a line

so surface brightness falls linearly with radius.

where

h : exponential scale length

μ_0 : central surface brightness

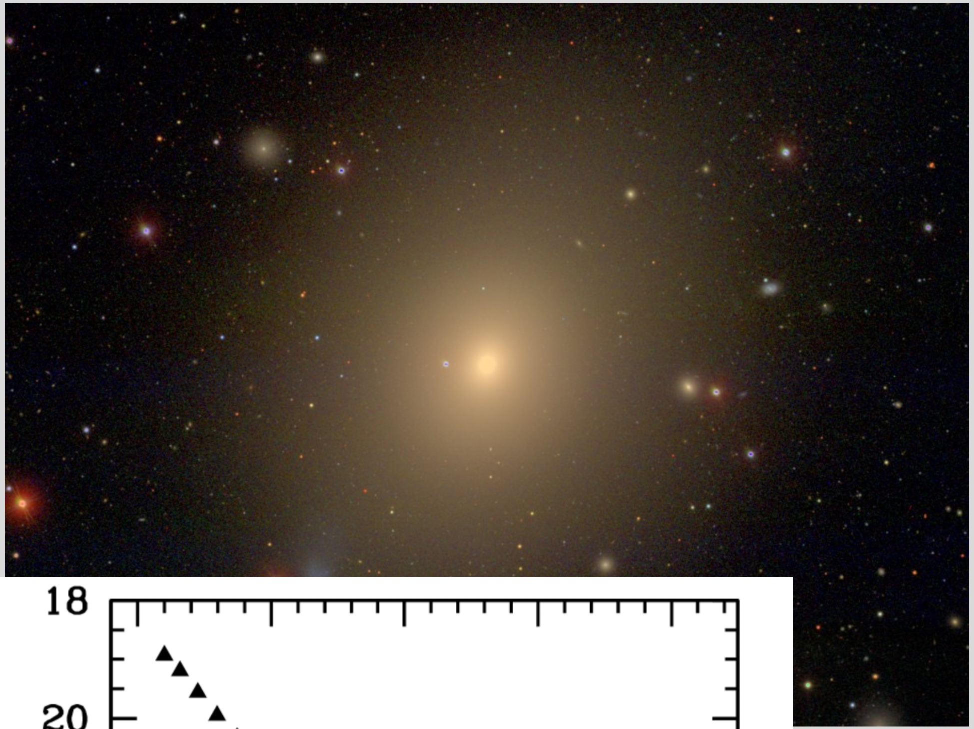


then total mag is: $m_{tot} = \mu_0 - 2.5 \log(2\pi h^2)$

Galaxy Structure: Surface Brightness Profiles

Remember, surface brightness is intrinsic, does not depend on distance:

Surface Brightness [μ in mags/arcsec²] ⇒
Flux Density on Sky [I in erg/s/cm²/arcsec²] ⇒
Luminosity Density in Galaxy [Σ in L⊙/pc²]



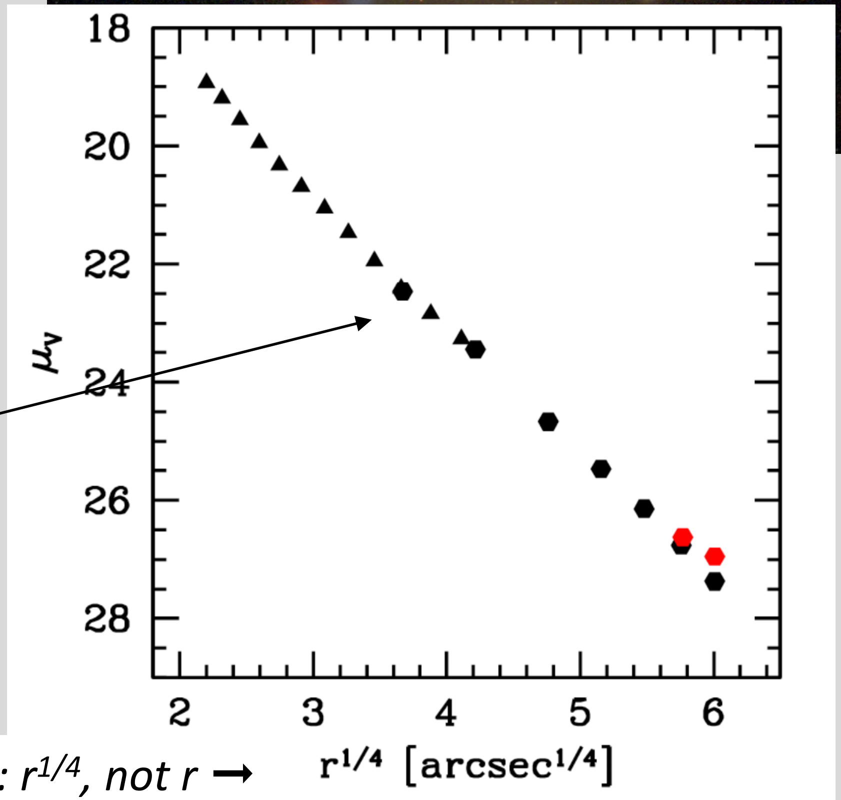
Ellipticals and Spiral Bulges:
classically, a de Vaucouleur "r-to-the-quarter" law:

$$I(r) = I_e e^{-7.669\left[(r/r_e)^{1/4}-1\right]}$$

or in mag/arcsec²:

$$\mu(r) = \mu_e + 8.3265\left[(r/r_e)^{1/4} - 1\right]$$

this will be a straight line when plotted against $r^{1/4}$.



note: $r^{1/4}$, not r ➞

Where

r_e : effective or "half-light" radius, contains half the total light

μ_e : surface brightness ***at*** the effective radius

Galaxy Structure: Surface Brightness Profiles

Most spiral galaxies are some **combination** of disk and bulge. Can fit the components separately and arrive at a bulge:disk or bulge:total luminosity ratio (“B/D” or “B/T”):

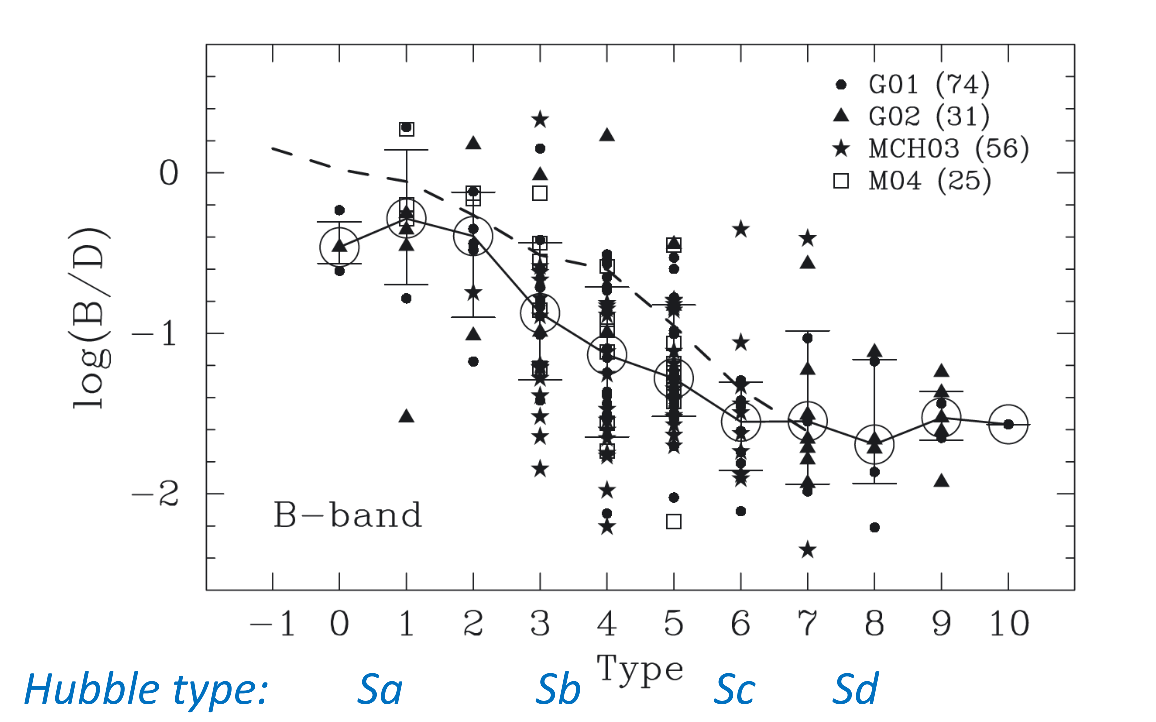


Figure 6. Logarithm of the *B*-band, bulge-to-disc flux ratio as a function of galaxy type (see Table 5, column 7). The dashed line traces the *B*-band values from Simien & de Vaucouleurs (1986).

Graham & Worley 08

μ(R) vs R

Boroson 81

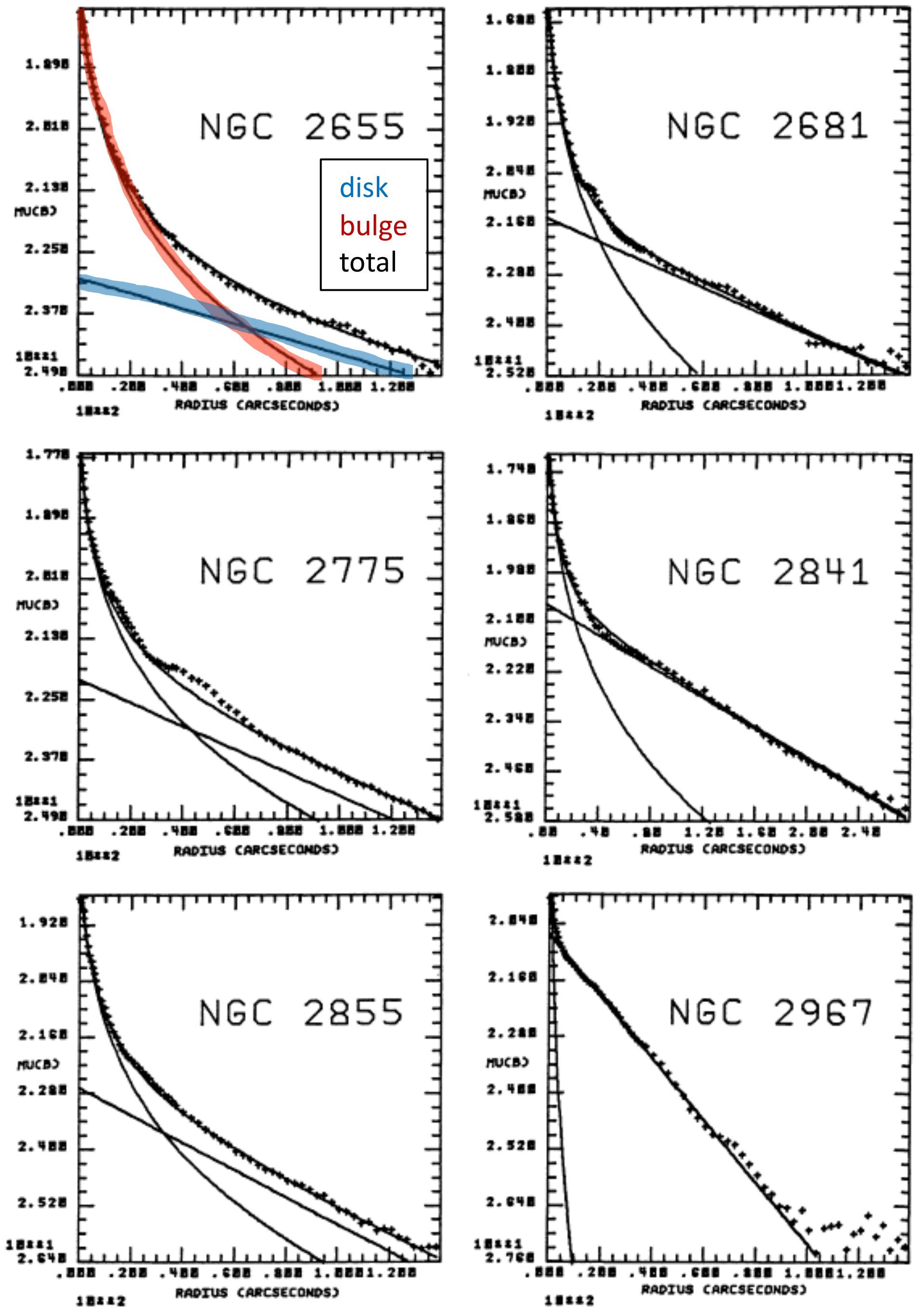


FIG. 6.—*Continued*