# Faber – Jackson Relationship of Ellipticals

# Distances to Elliptical Galaxies

$$L_B \propto \sigma_0^4$$

Luminosity of the elliptical galaxy in the B-band

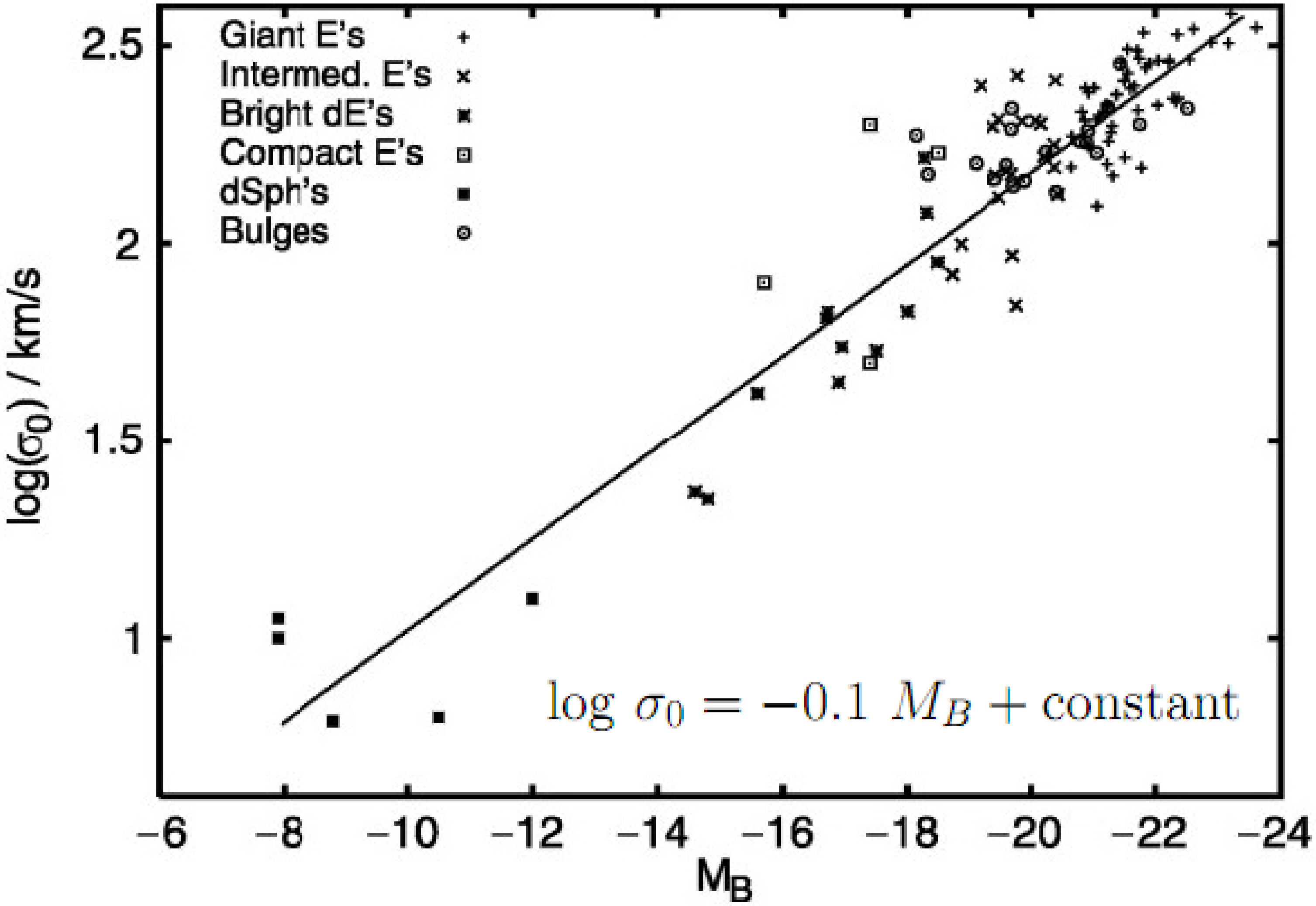
Average velocity dispersion of stars in the centre of the elliptical galaxy

- Elliptical galaxies with a large dispersion in velocity also have high luminosities

- Relationship first reported by Faber & Jackson 1976, ApJ, 204, 668.

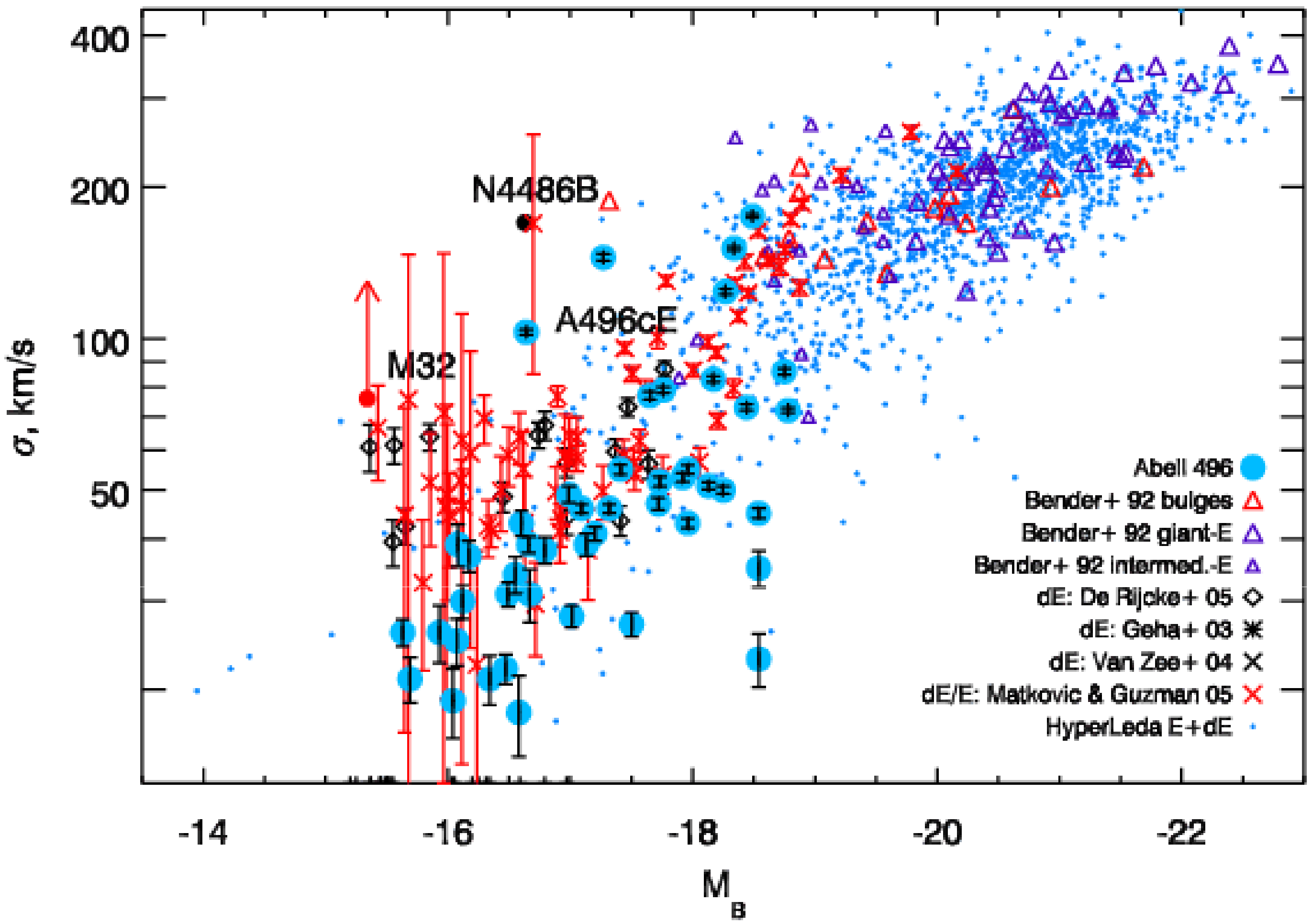
***Distant elliptical galaxies may not be spatially resolved, but the average velocity dispersion of stars in the galaxy can still be determined from the spectrum of the galaxy.***

# Faber-Jackson Relationship




For a diverse sample of elliptical galaxies, the logarithm of the central velocity dispersions of stars are plotted against their absolute magnitudes in the B-band. The solid line is a linear fit to the data points. The figure demonstrates that the central velocity dispersion of stars in elliptical galaxy is correlated with the luminosity of the galaxies, which is known as the Faber Jackson relationship. It should noted that it is not a tight correlation, there is some spread in the distribution. Figure taken from Bender et al. 1992, ApJ, 399, 462

# Faber-Jackson Relationship




Faber-Jackson relation for ellipticals and bulges of disc galaxies. Data points marked as Abell 496 are ellipticals that belong to the cluster Abell 496. Giant ellipticals and intermediate-luminosity ellipticals are in small blue points, bulges of disc galaxies in red, dwarf ellipticals and lenticulars in black. Figure from Chilingarian et al. (2008)

# Distances to Elliptical Galaxies

- An empirically derived relationship
- Relationship has considerable scatter (power index ~ 3.6 – 5.4), deviations from a simple power law
- Still a debate whether the Faber Jackson relationship is universal or not
- Reason for specifying this relationship to the central stars is because of observational constraints; it is easier to obtain higher S/N ratio spectrum for the central regions of galaxies

# Why Faber – Jackson Relationship?

- Why the velocity dispersion of stars should be correlated with galaxy luminosity?

$$U \propto \frac{GM^2}{R} \qquad \text{and} \qquad K \propto M\sigma_0^2$$

Elliptical galaxies are virialized structures $2K + U = 0$

$$\sigma_0^2 \propto \frac{GM}{R}$$

$$\sigma_0^2 \propto \frac{GL}{R}$$

*assuming that mass follows light (at least in the central regions of ellipticals) – crucial assumption. L can dependent on environment.*

$$L \propto 4\pi \left(\frac{GL}{\sigma_0^2}\right)^2 \quad \Rightarrow \quad L \propto \frac{1}{4\pi G^2}\,\sigma_0^4$$

# Luminosity & M/L correlation

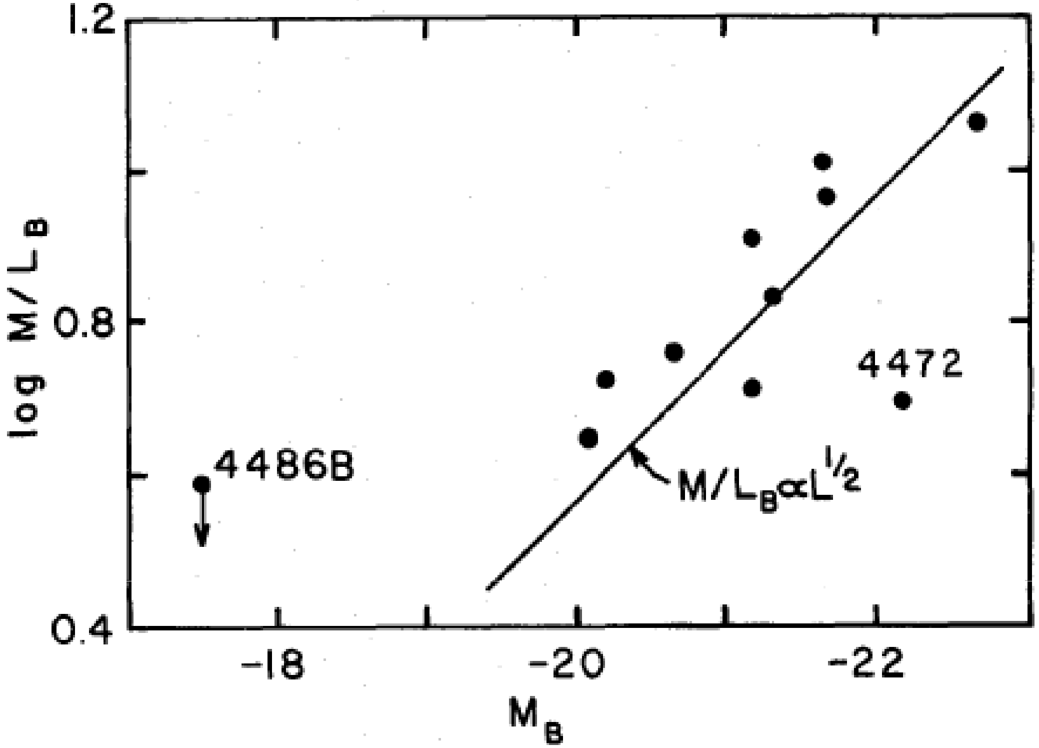


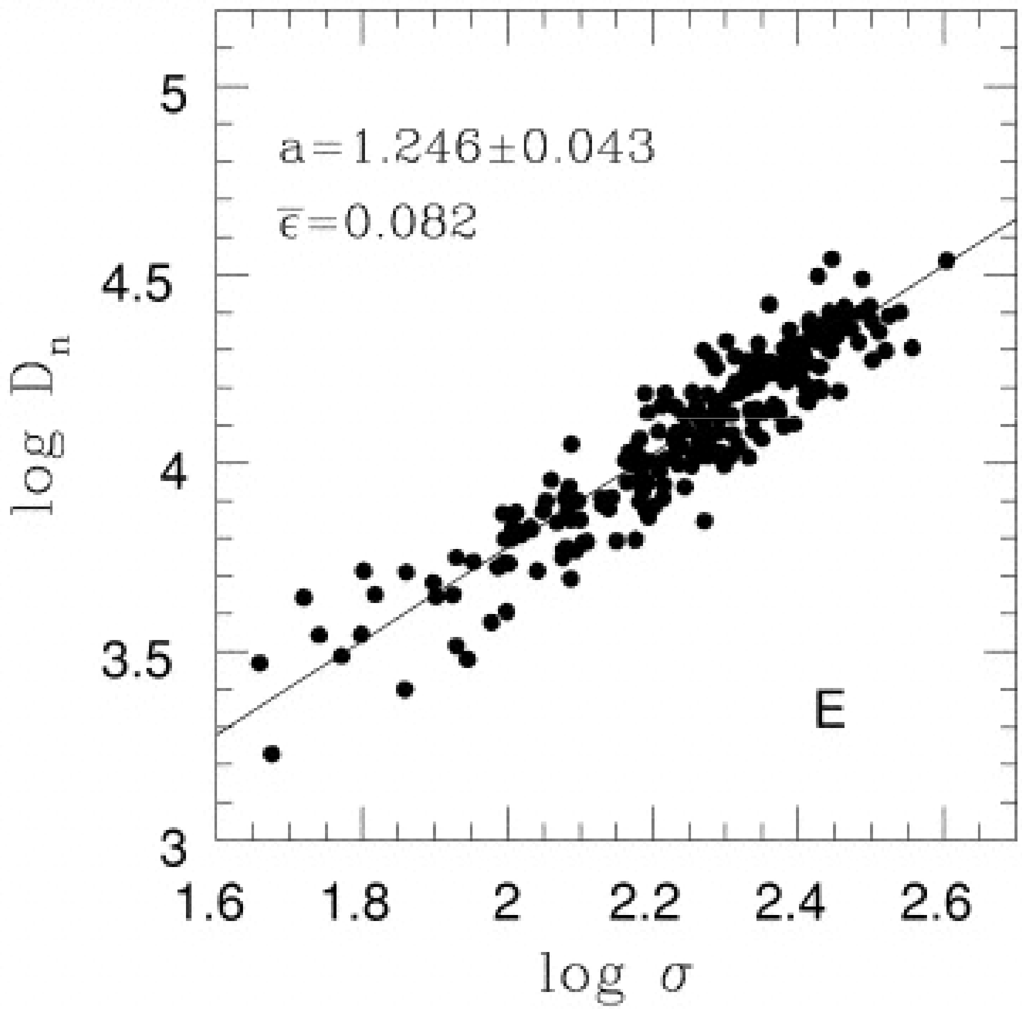

FIG. 17.—Mass-to-light ratio in solar units versus absolute magnitude from Table 3. The predicted relation based on King's data and on the power-law $L \propto v^4$ is shown as the straight line.

**The more luminous ellipticals also have higher M/L ratio.**

Faber & Jackson 1976, ApJ

# Another Correlation for Ellipticals :

## $D_n - \sigma$ correlation



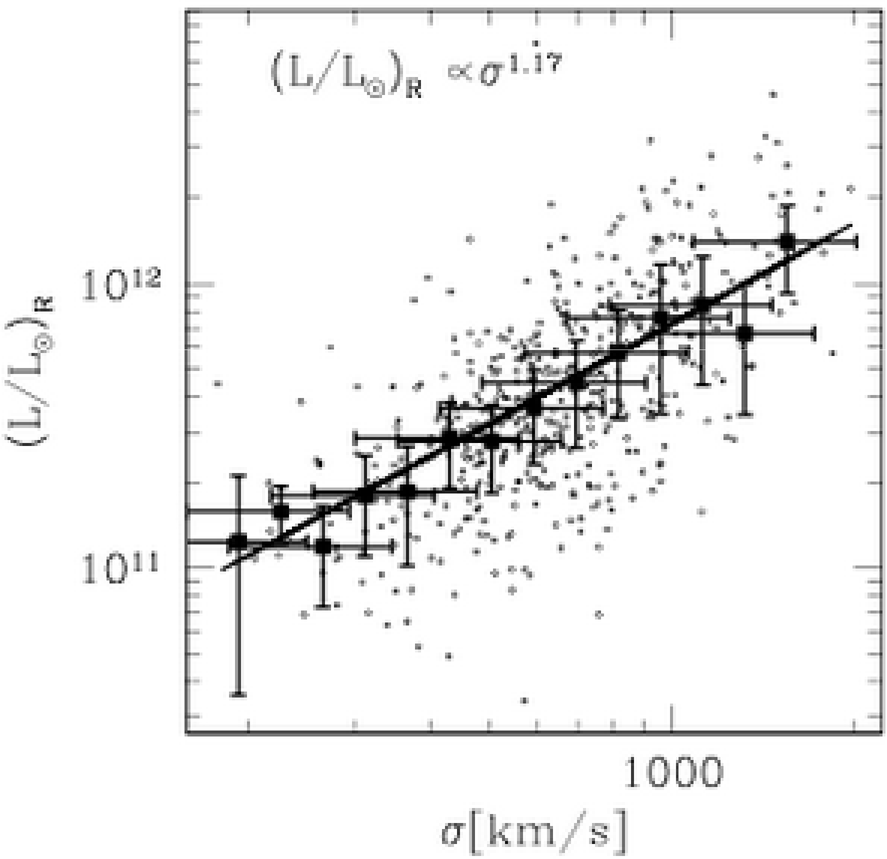

**Y-axis is isophotal diameter for surface brightness of 20.75 mag per sq. arcsecond.**

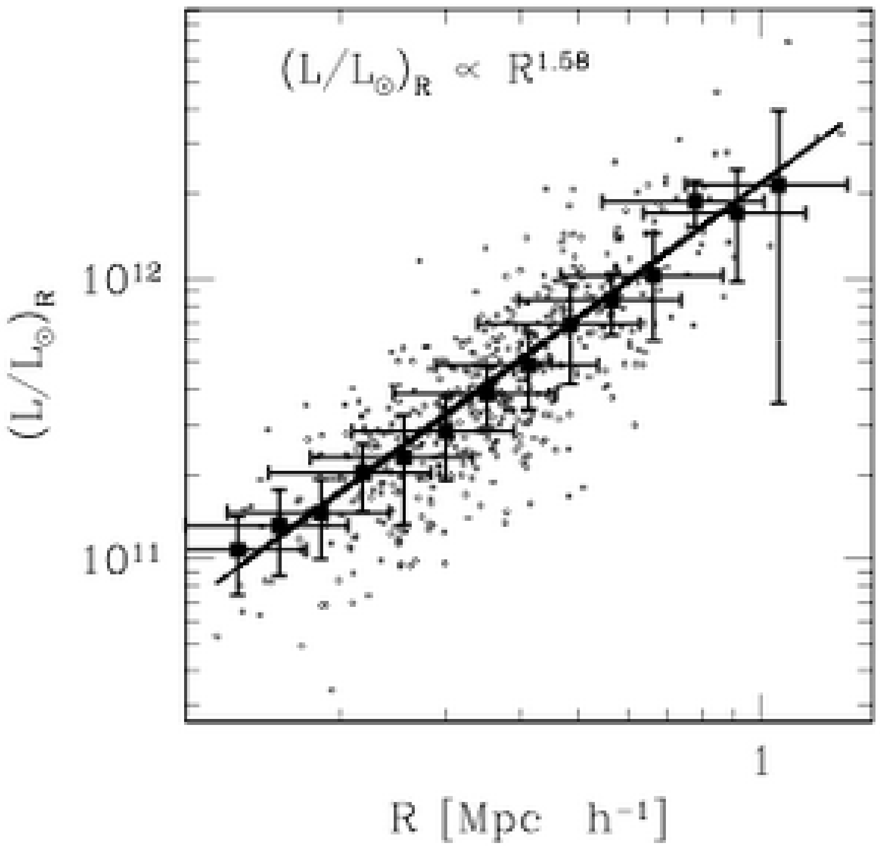
**X-axis is log of velocity dispersion in km/s**

Dressler et al., 1987, ApJ 313, 42.

# Fundamental Plane for Elliptical Galaxies

Figures taken from Diaz & Muriel, 2005, MNRAS 364, 1299



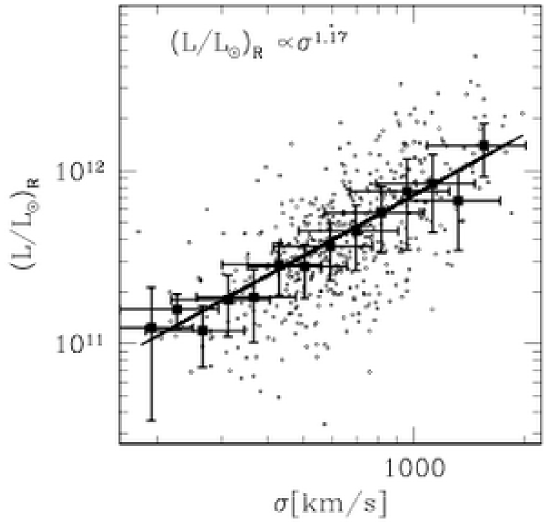



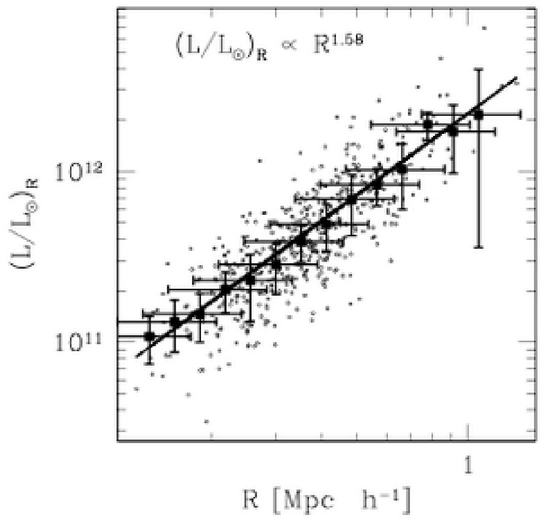

Faber – Jackson result

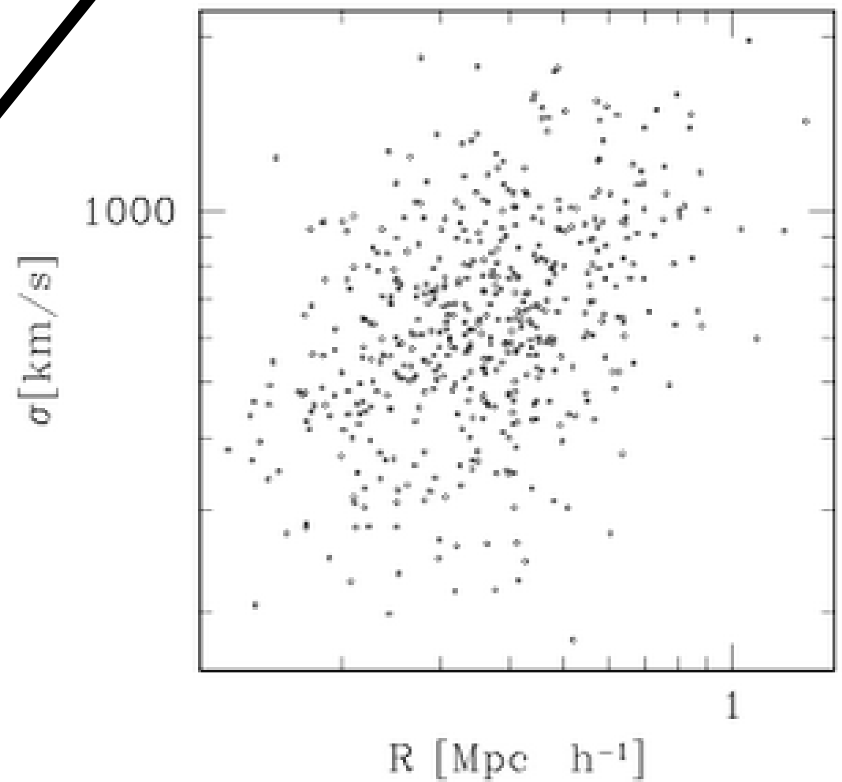
$$L \propto 4\pi R^2 \propto \mu(\pi R^2)$$

# Fundamental Plane for Elliptical Galaxies

**L – size of galaxy – σ are mutually related**

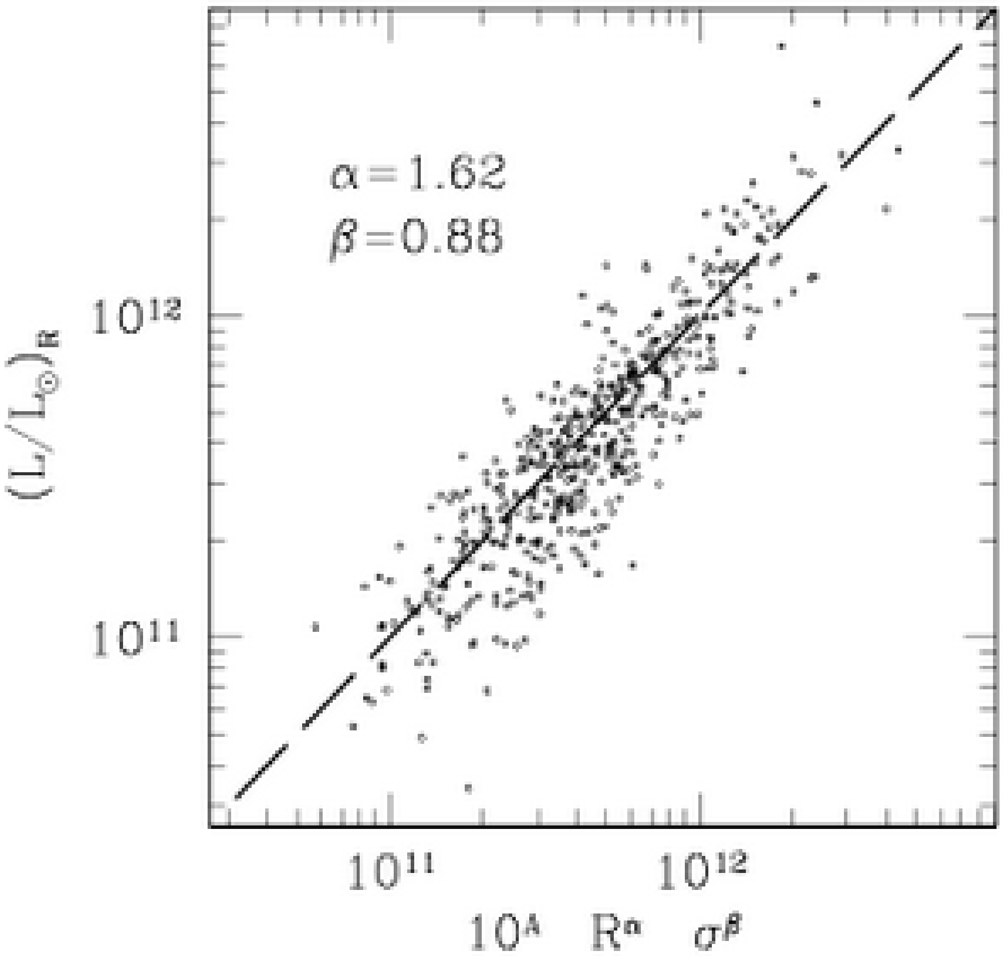



**$D_n$ – σ relationship**

# Fundamental Plane for Elliptical Galaxies




**The correlation gets tighter if one of the three parameters is plotted against a combination of the other two.**

**This relationship is called the Fundamental Plane for Elliptical Galaxies**

Figure taken from Diaz & Muriel, 2005, MNRAS 364, 1299

# Summarizing for Ellipticals

| Low mass ellipticals | High mass ellipticals |
|---|---|
| Lower luminosity | Higher luminosity |
| Smaller velocity dispersion | Larger velocity dispersion |
| Smaller mass-to-light ratio | Larger mass-to-light ratio |