more Galactic Structure

Read chapter 2
especially the section
on the distance scale

Galactic Structure

- Stars
  - – DISK THIN and older, less massive THICK disk
  - – BULGE and/or BAR
- Gas
  - – atomic gas (HI)
    - in diffuse clouds, more extended than stars
  - – molecular gas (H_2)
    - in dense clouds. Follows stars, spiral arms
  - – hot, ionized gas (HII)
    - low mass, low density, large volume

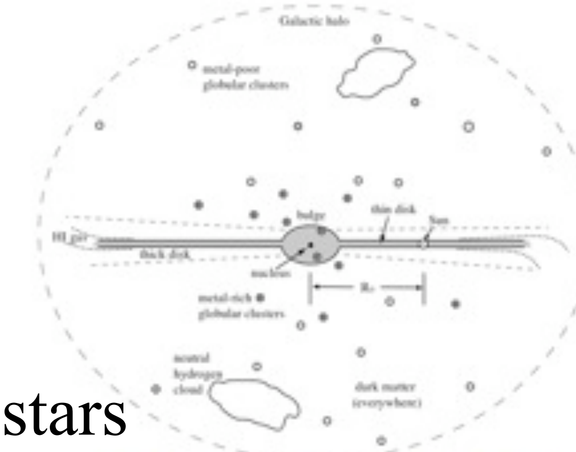


Fig 1.8 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

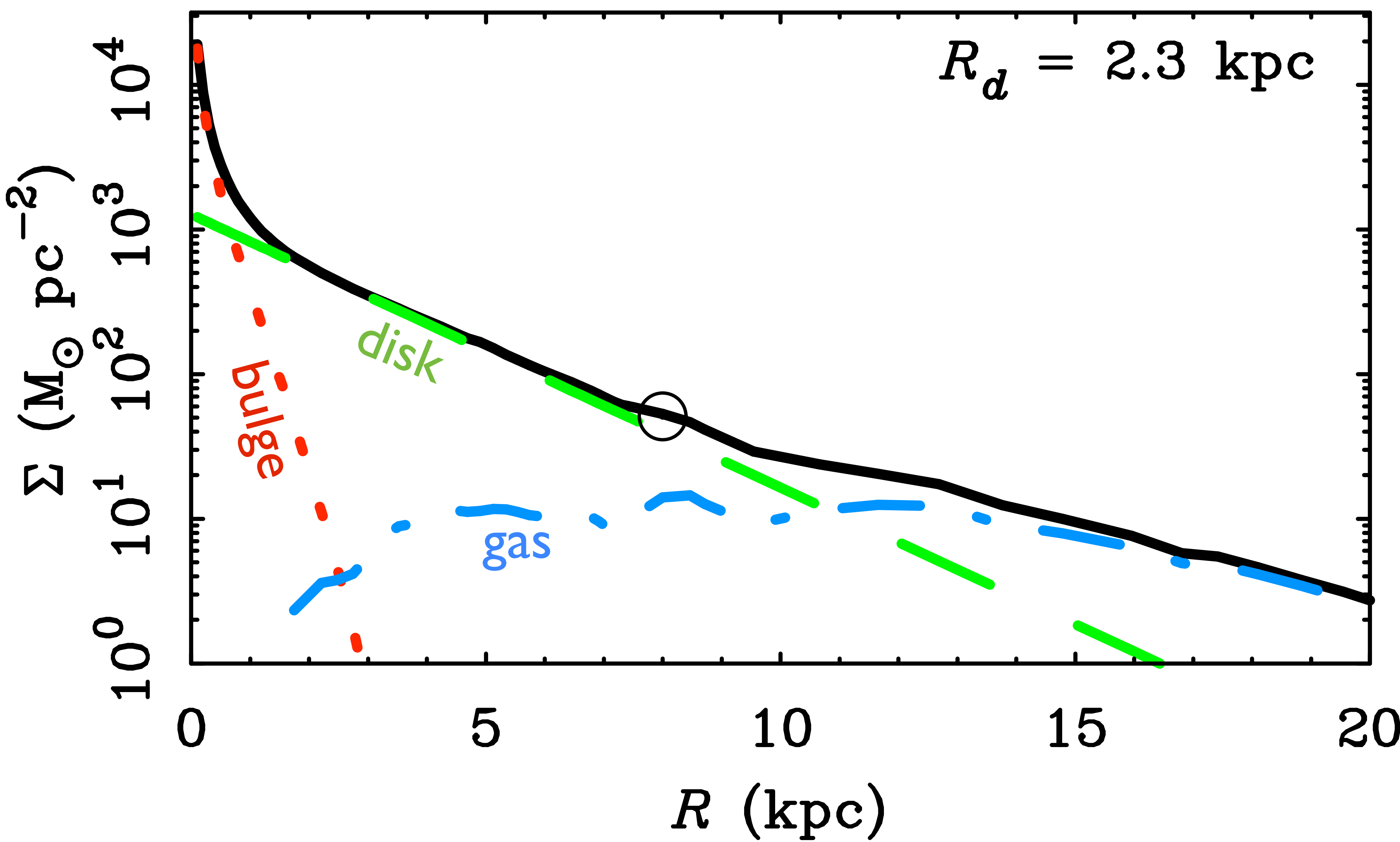
- Dust
  - mostly in spiral arms & molecular clouds

The Exponential Disk

- Stars in the disk of the Milky Way and other spiral galaxies have an azimuthally averaged radial surface density profile that is reasonably well approximated as an
- EXPONENTIAL DISK

$$\Sigma(r) = \Sigma_0 e^{-r/R_d}$$

  - Σ_0 = Central Surface Density
  - R_d = Radial Scale Length



R_d = 2.3 kpc
disk
bulge
gas
Σ ($M_\odot$ pc^{-2})
10^4
10^3
10^2
10^1
10^0
0
5
10
15
20
R (kpc)

also exponential in vertical direction; scale height depends on the population

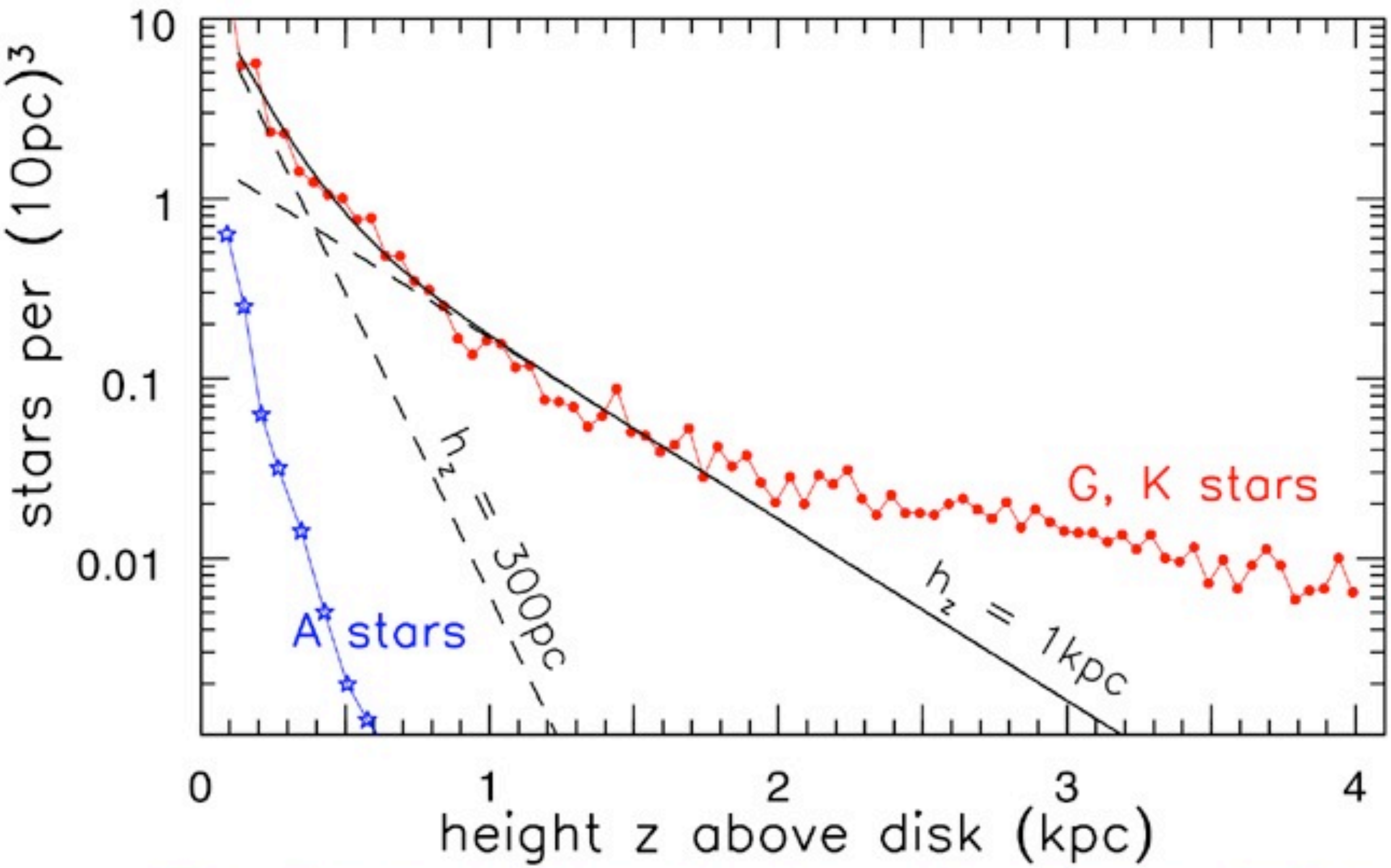


Fig 2.8 (Reid, Knude) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

$$R_d \approx 10 h_z$$

In 3 dimensions

$$\rho(R, Z) = \rho_0 e^{-R/R_d} e^{-|z|/h_z}$$

R_d Radial scale length $R_d \approx 2 \text{ to } 3 \text{ kpc}$

h_z vertical scale height $h_z \approx 300 \text{ pc}$

for external galaxies, typically $R_d/h_z \approx 6 \text{ to } 10$

other models possible, e.g., $\mathrm{sech}(|z|/z_0)$

Integrating

3d $$\rho(R,Z) = \rho_0 e^{-R/R_d} e^{-|z|/h_z}$$

over z gives

$$\Sigma_0 = 2\rho_0 h_z$$

Integrating

2d $$\Sigma(r) = \Sigma_0 e^{-r/R_d}$$ face-on

over R gives

total mass/luminosity $$M = 2\pi\Sigma_0 R_d^2$$

Star counts towards North Galactic Pole

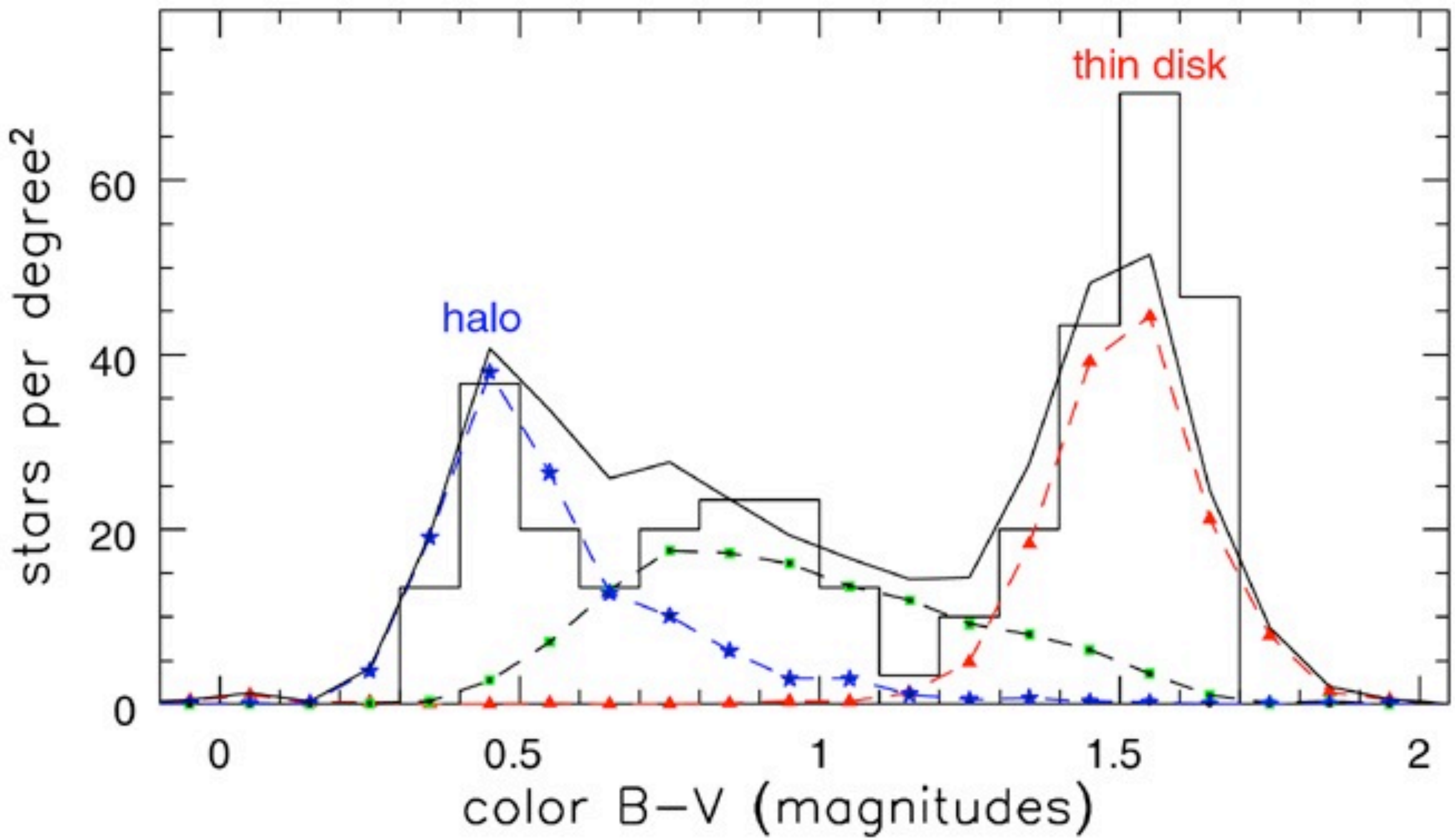


Fig 2.16 (N. Reid) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

How would this be different for b = 0?

Atomic HI gas

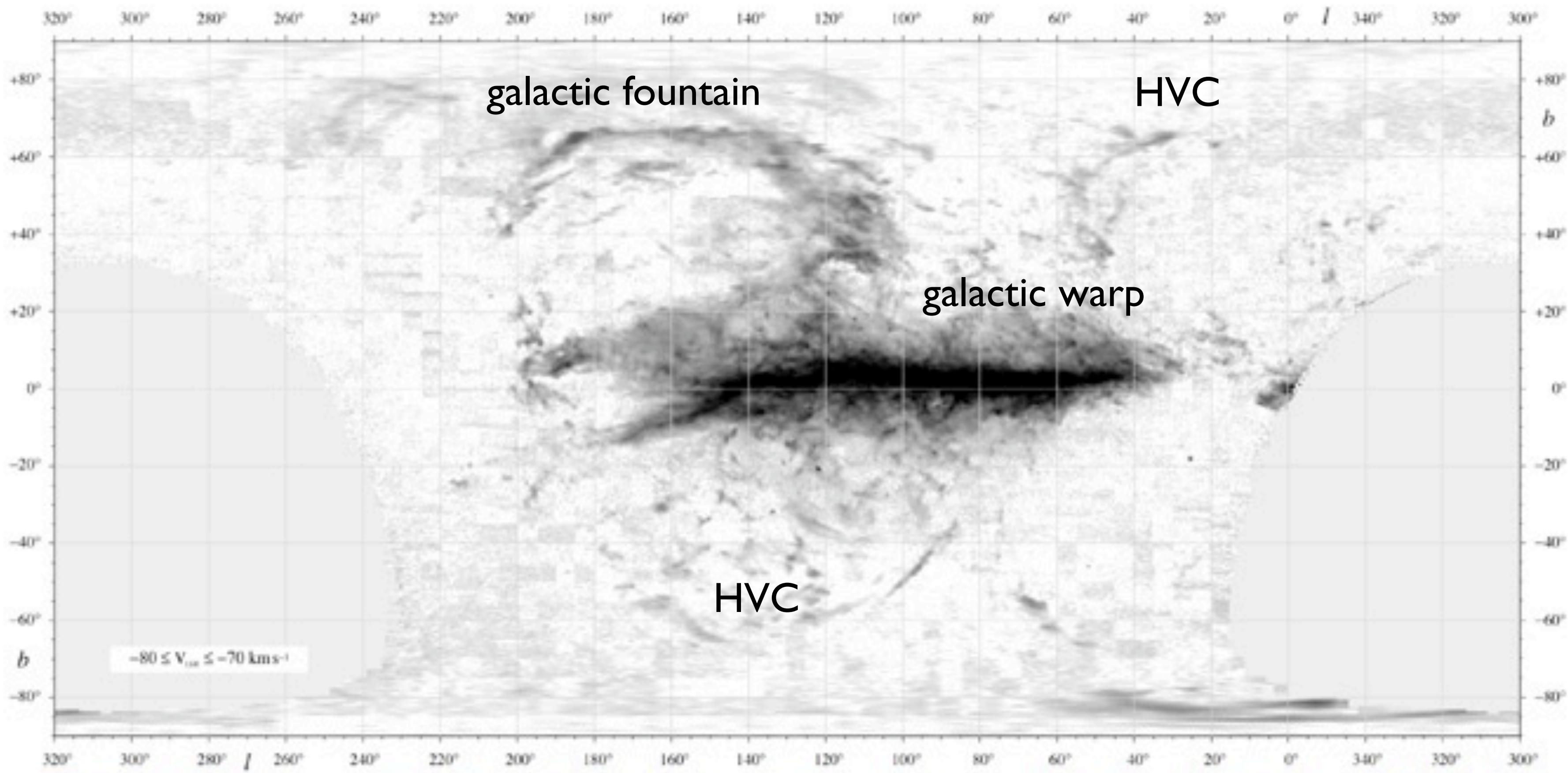
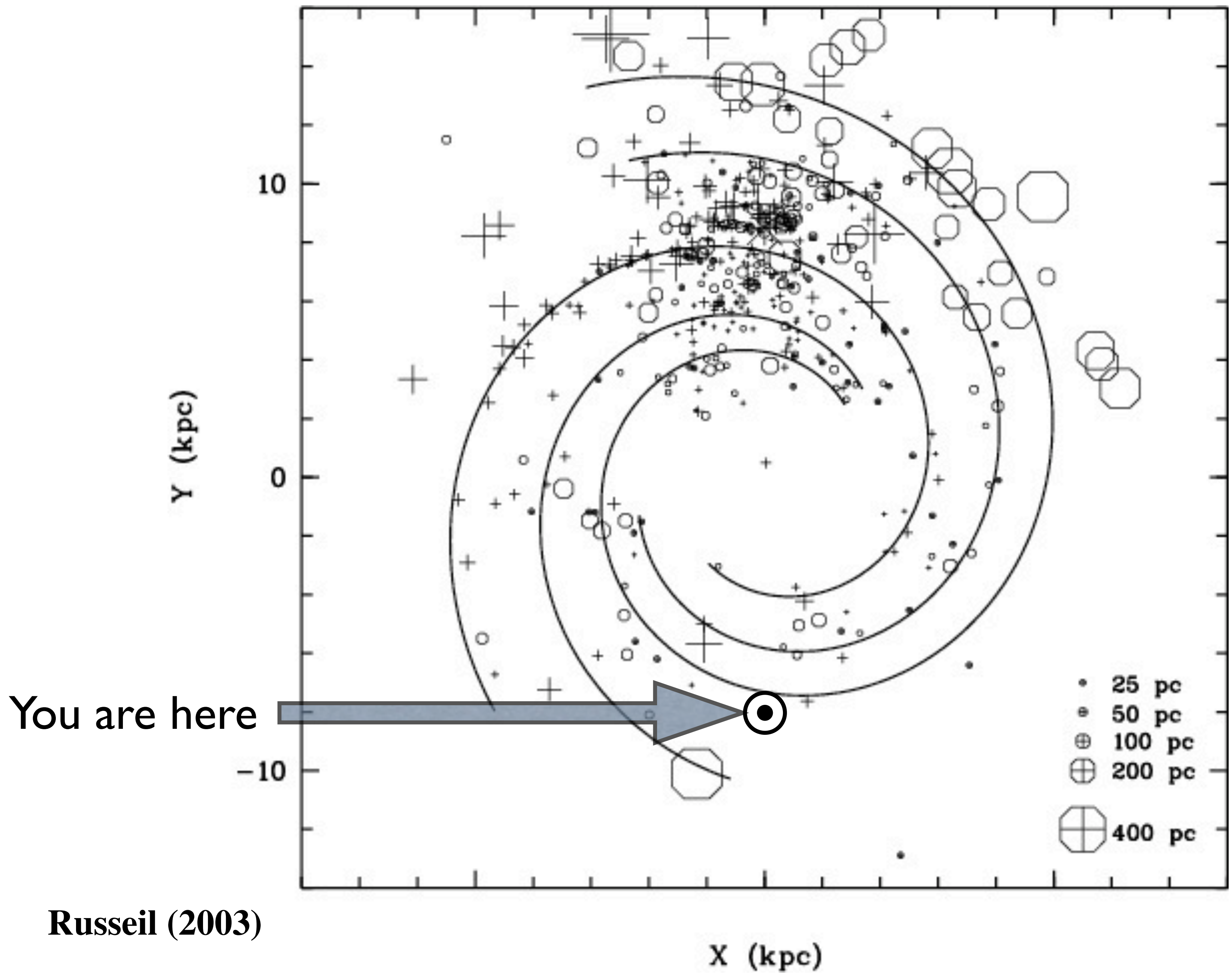


Fig 2.23 (Hartmann & Burton) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

Galactic OB associations trace spiral arms, warp



Russeil (2003)

crosses below plane; open symbols above

ESO 510-G13

tilted ring model

accounts for varying inclination of warp

Galactic Structure

- Stars
  - DISK THIN and older, less massive THICK disk
  - BULGE and/or BAR
  - stellar halo, globular clusters
- Gas
  - atomic gas (HI)
  - molecular gas (H_2)
  - hot, ionized gas (HII)
- Dust
- Supermassive Black Hole
  - Radio source Sgr A* marks center of Milky Way $M_\bullet \approx 3 \times 10^6\ M_\odot$ within ~ 100 AU

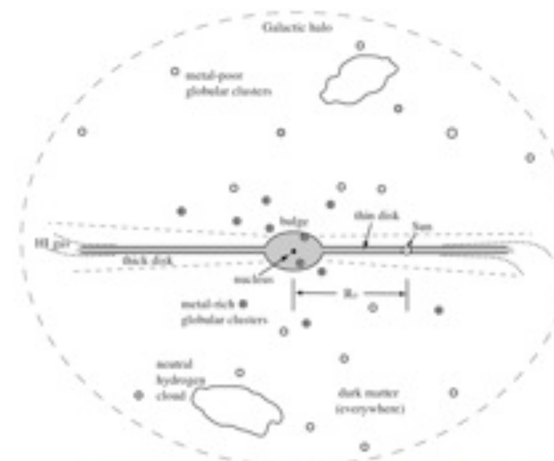


Fig 1.8 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

The beast in the center:

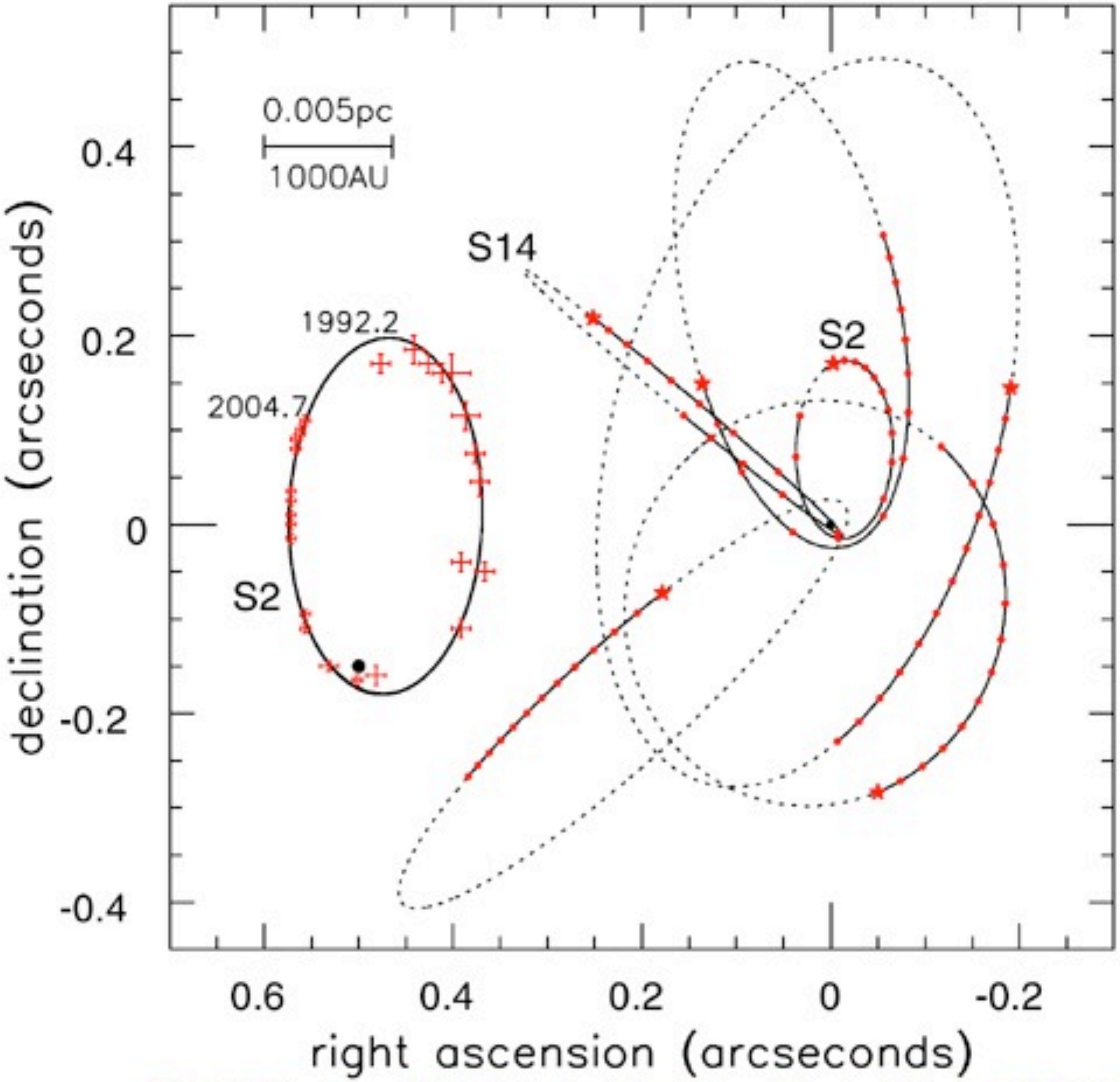


Fig 2.17 (Eisenhauer/MPE) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

The Milky Way hosts a ~3 million solar mass black hole

Dust & Interstellar Extinction

- Interstellar Dust
- absorbs some light
  - re-radiates in infrafred
- scatters some light
  - creates both dark nebulae
    - e.g., Bok Globules
    - and Reflection nebulae

- Net effect: dims and reddens light from stars

Dust & Interstellar Extinction

Extinction at a particular wavelength denoted by A_λ

$$m_V^{corrected} = m_V^{observed} - A_V$$

$$m_V - M_V = 5\log D + 5 + A_V$$

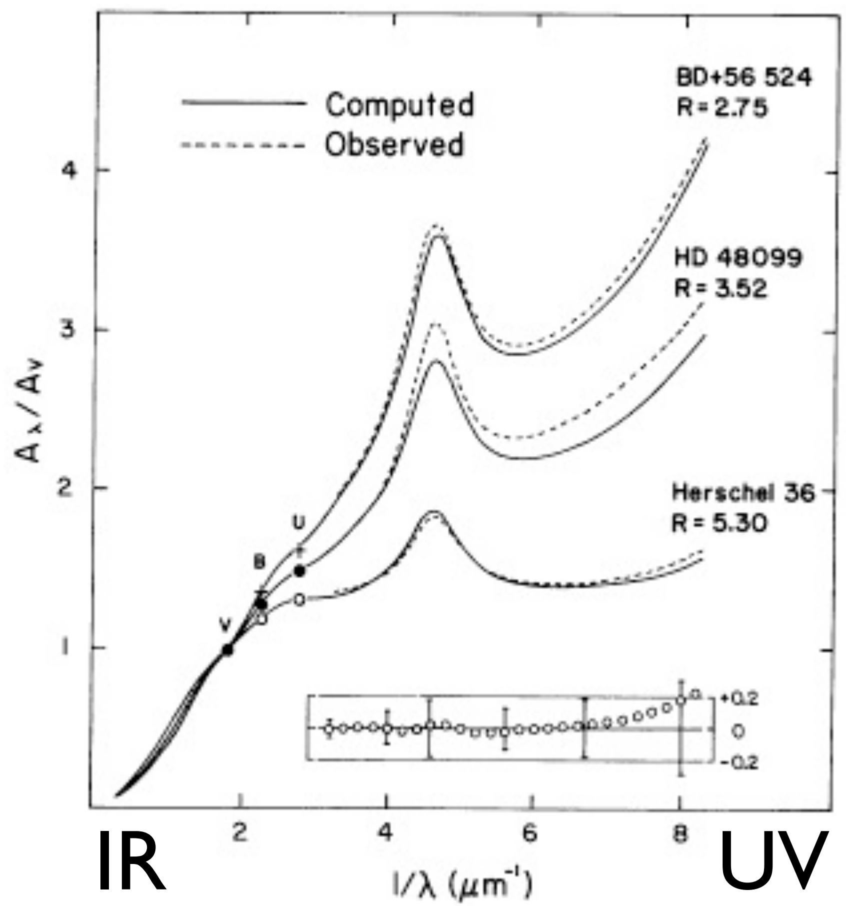
dimming by inverse square law

dimming caused by dust

Dust & Interstellar Extinction

Extinction is wavelength dependent:

$$\frac{A_\lambda}{A_V}$$



IR UV

$$1/\lambda$$

The amount of dust is usually quantified by the "reddening" E(B-V):

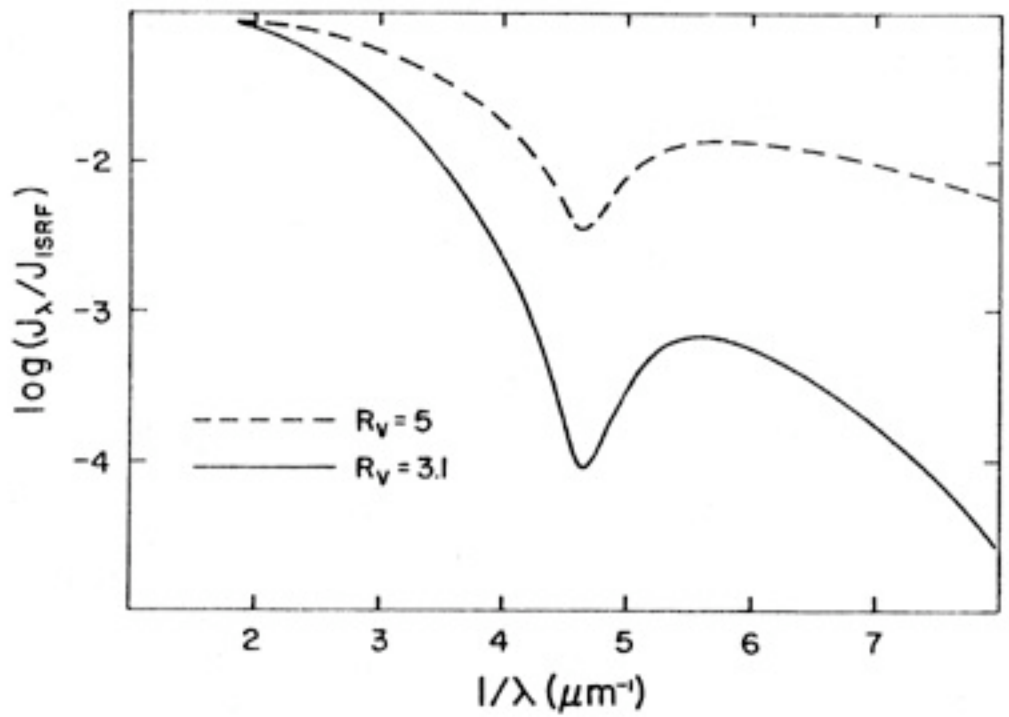
$$E(B - V) = A_B - A_V$$

For some amount of reddening there is a corresponding amount of extinction:

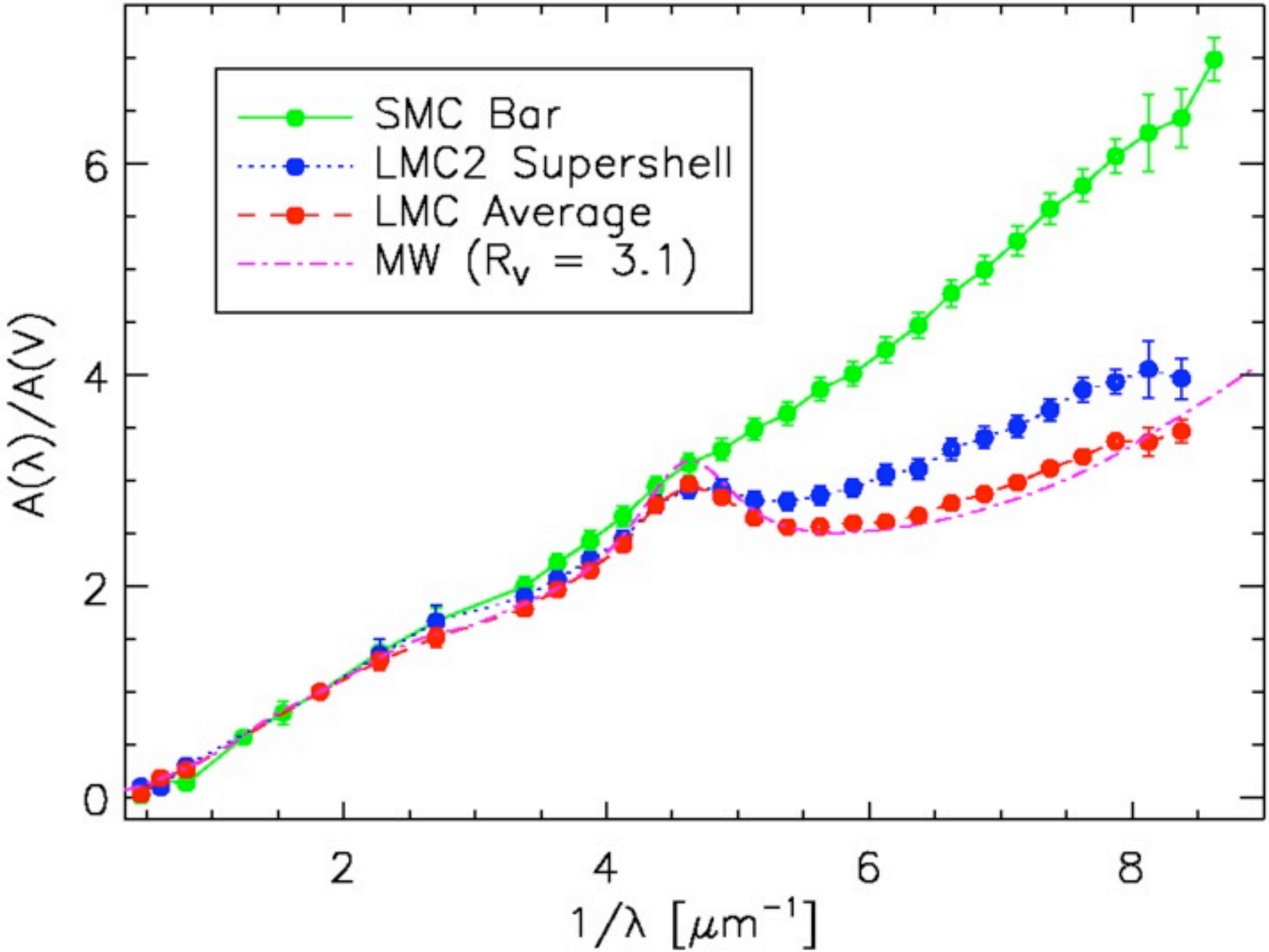
$$A_V = R_V E(B - V)$$

$R_V \approx 3.1$ in the Milky Way

Effect of different R values



The extinction law varies with environment



The dust-to-gas ratio is approximately constant so that

$$N_{HI} \approx 1.8 \times 10^{21}\ \mathrm{cm}^{-2}\ A_V$$

This has been used to map extinction within the Galaxy. NED will tell you how much Galactic dust there is along the line of sight to other galaxies.