Dark Matter

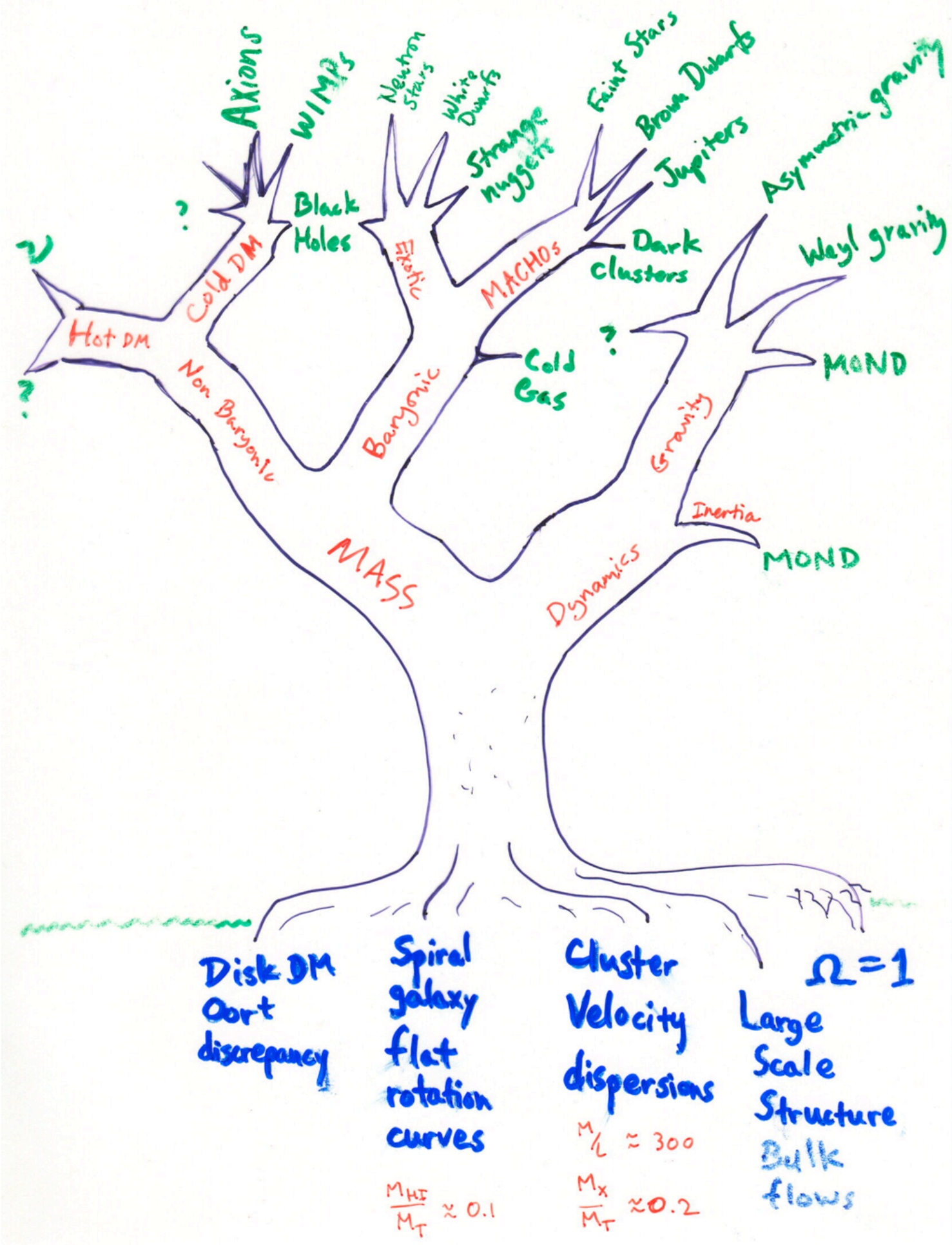
ASTR 333/433

TODAY

Phase Space
Jeans Equations

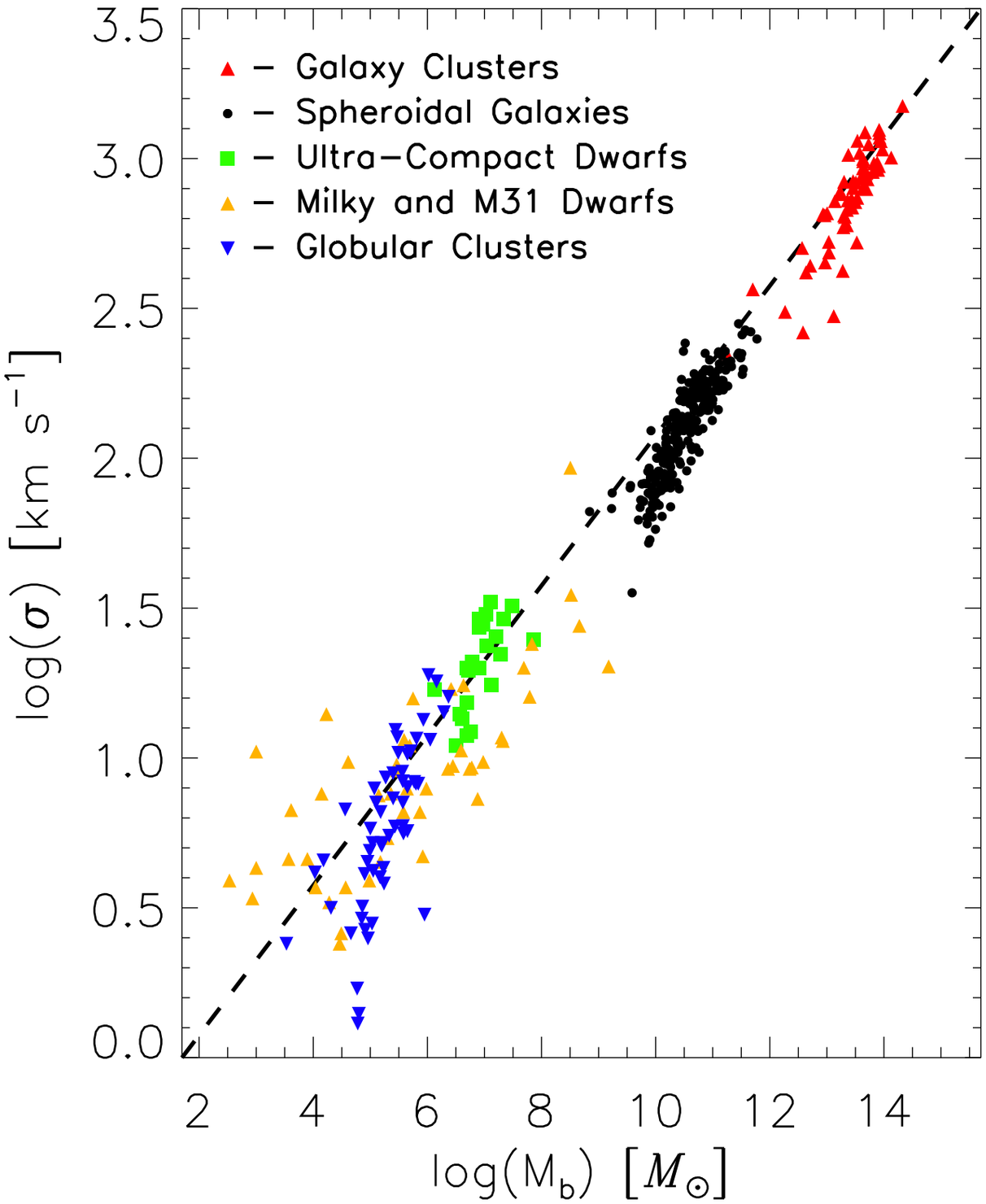
Galaxy Formation
Cosmic Necessities

Homework due next time
Midterm 3/19



Faber-Jackson (pressure supported)

Tully-Fisher for Ellipticals



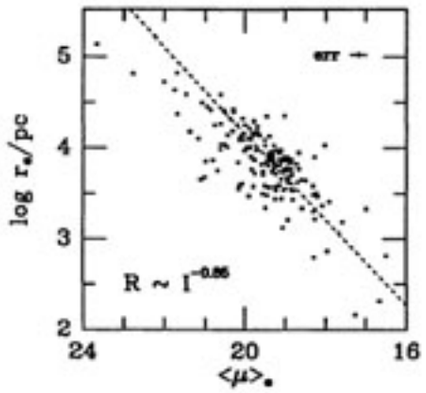
Fundamental Plane (pressure supported)

surface brightness

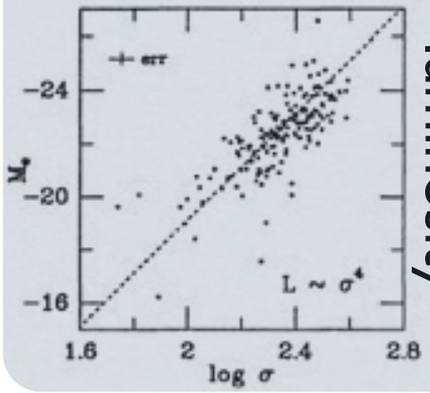
velocity dispersion

Faber-Jackson

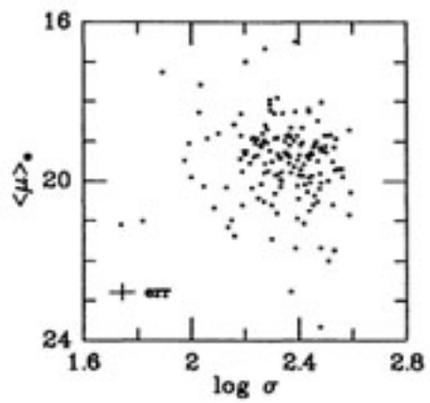
size



luminosity

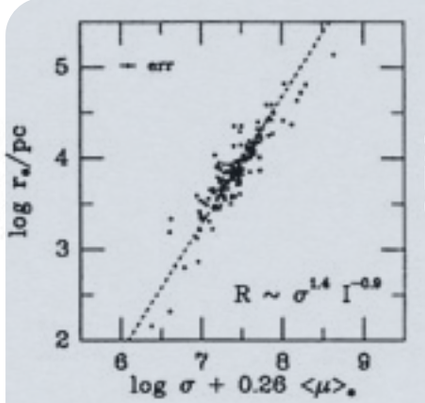


surface brightness



velocity dispersion

size



v-disp & surf bright.

Fundamental Plane

$$M \propto \sigma^2 R_e$$ virial theorem

$$L \propto I_e R_e^2$$ luminosity, surface brightness size

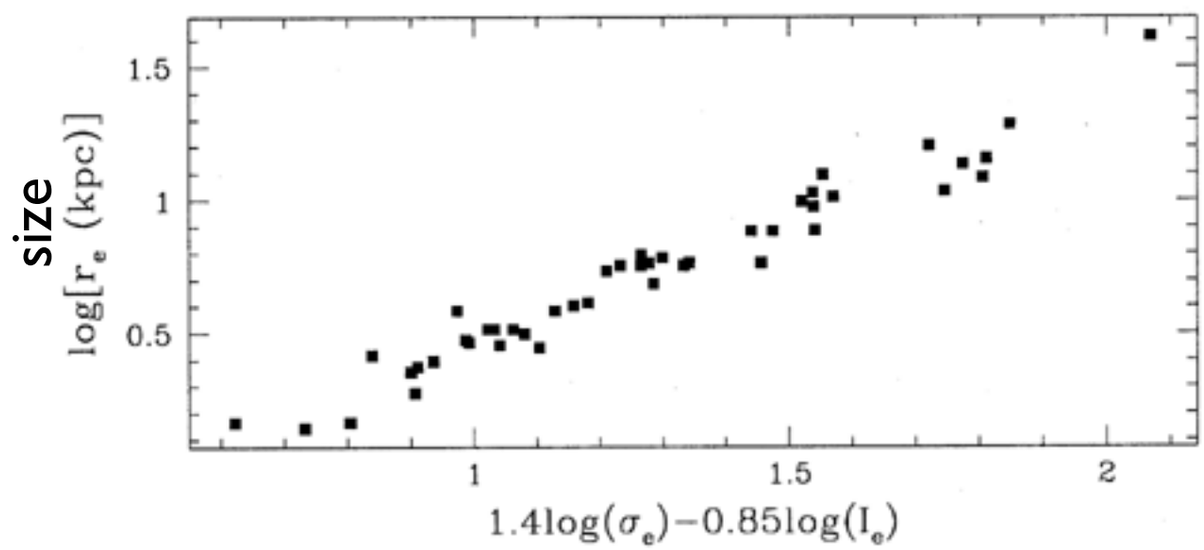
"Viral" fundamental plane

$$R_e \propto \sigma^2 I_e^{-1}$$

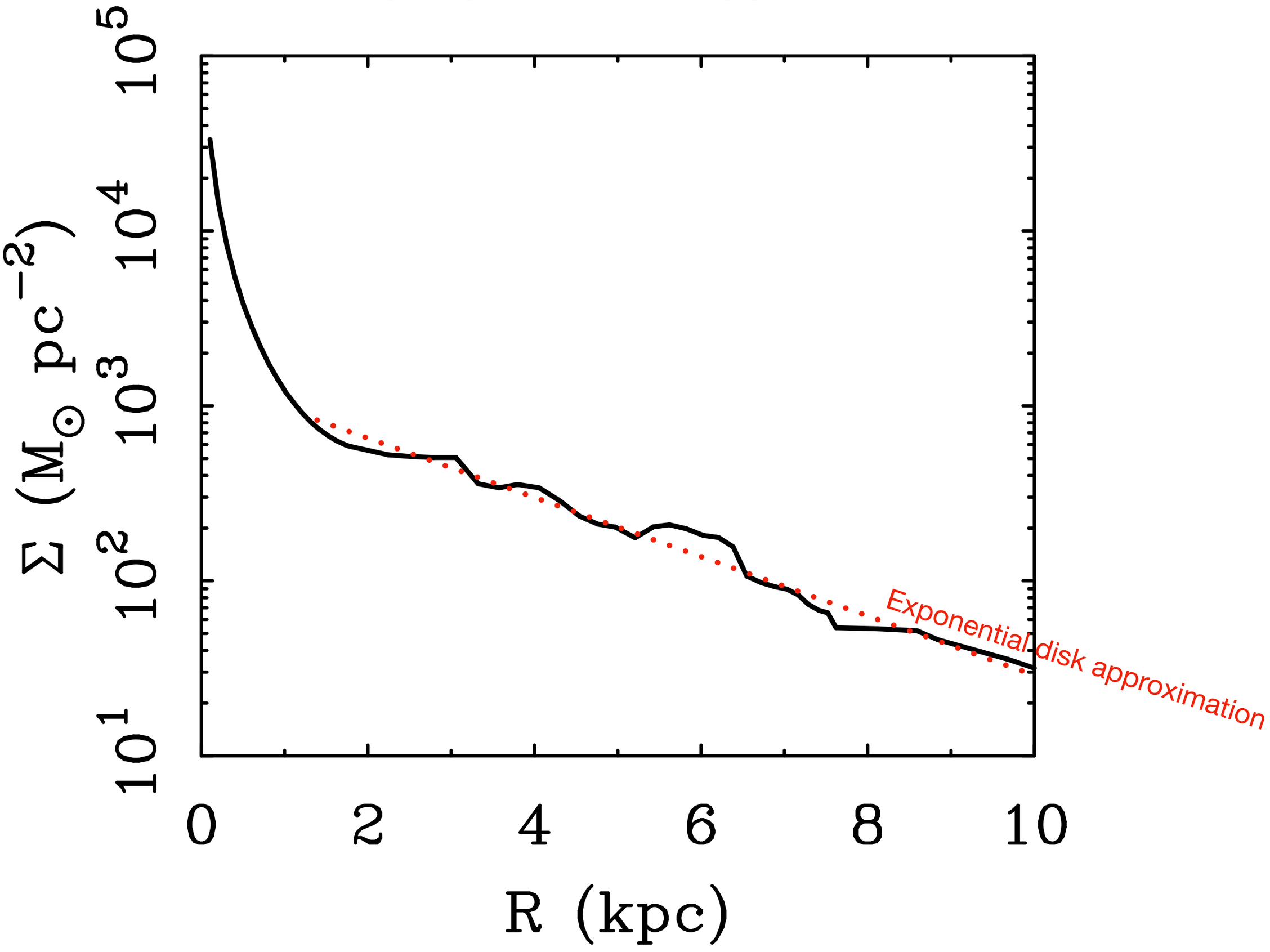
observed fundamental plane "tilted" wrt virial expectation:

$$R_e \propto \sigma^{1.4} I_e^{-0.85}$$

velocity dispersion & surface brightness



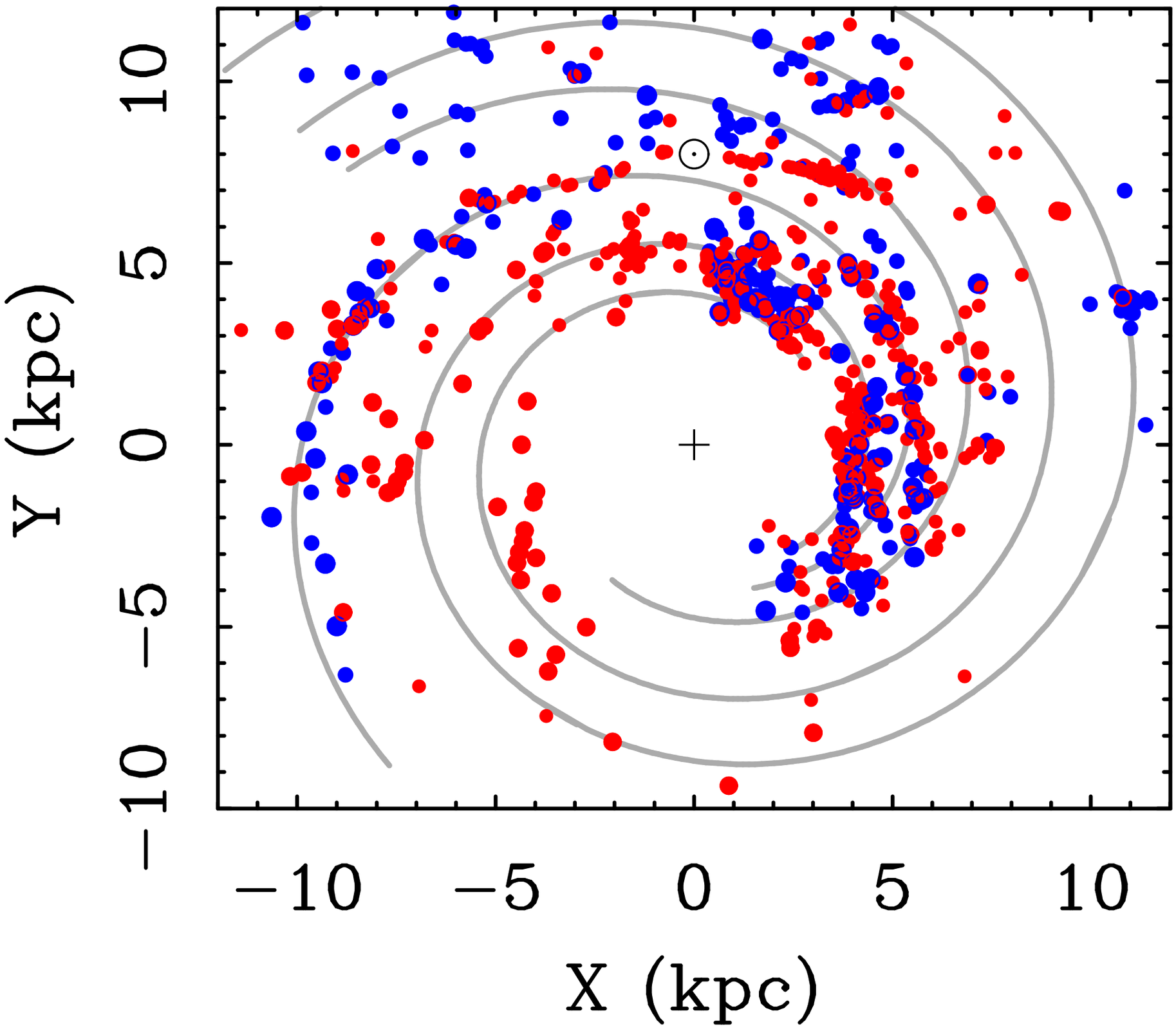
Milky Way surface density profile



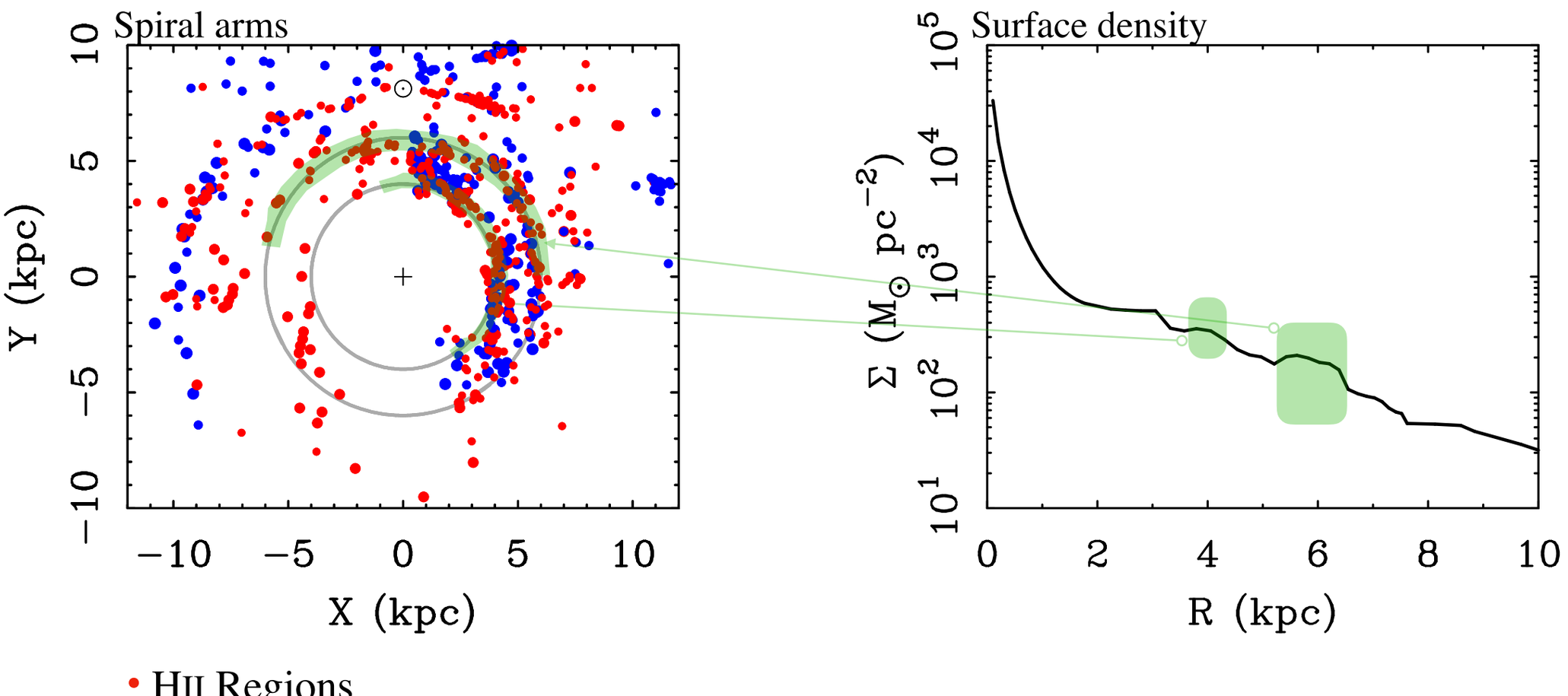
HII Regions
GMCs

logarithmic spiral: $r = ae^{\phi/b}$

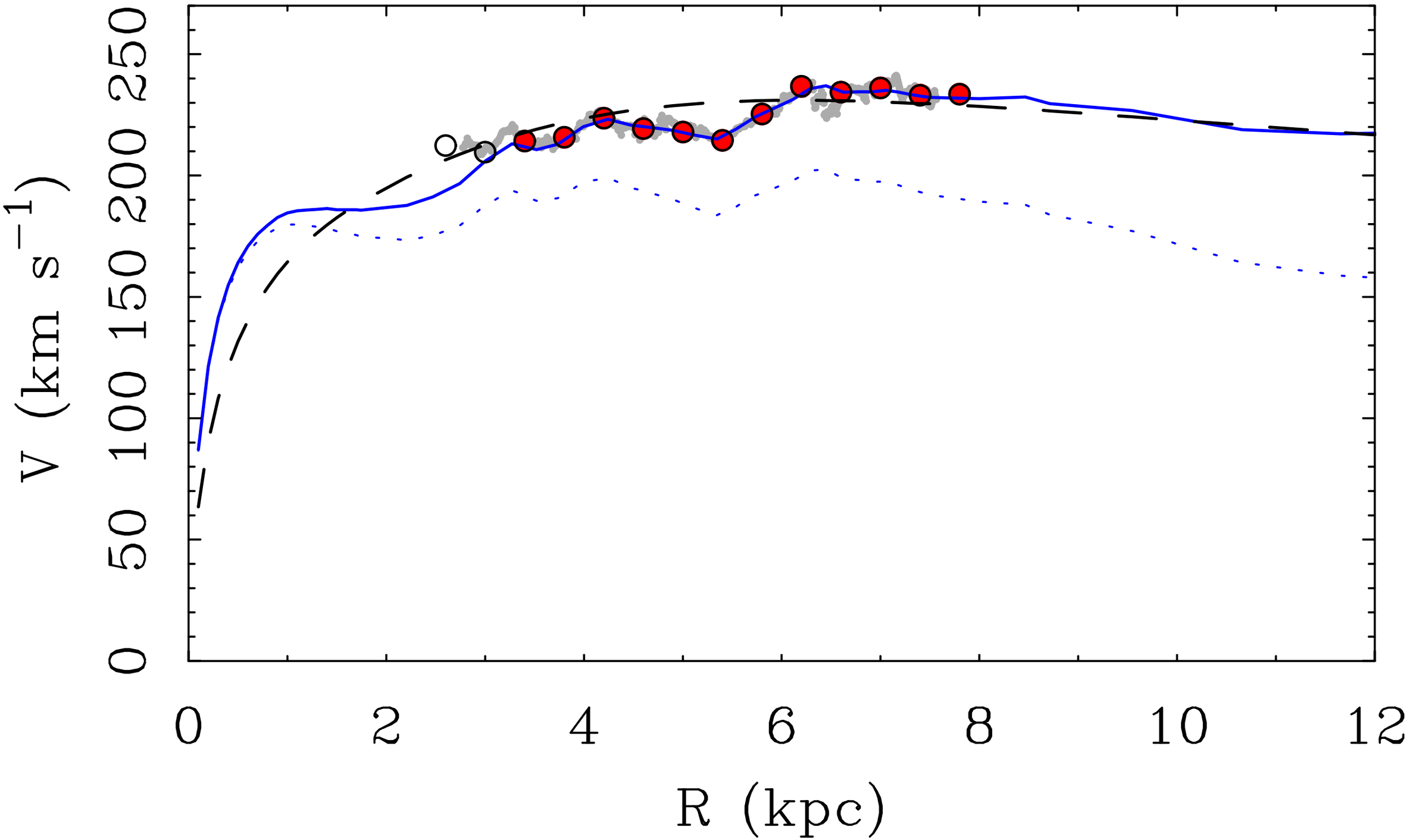
with opening angle $b = \tan\psi$



Bumps in the surface density profile correspond to spiral arms

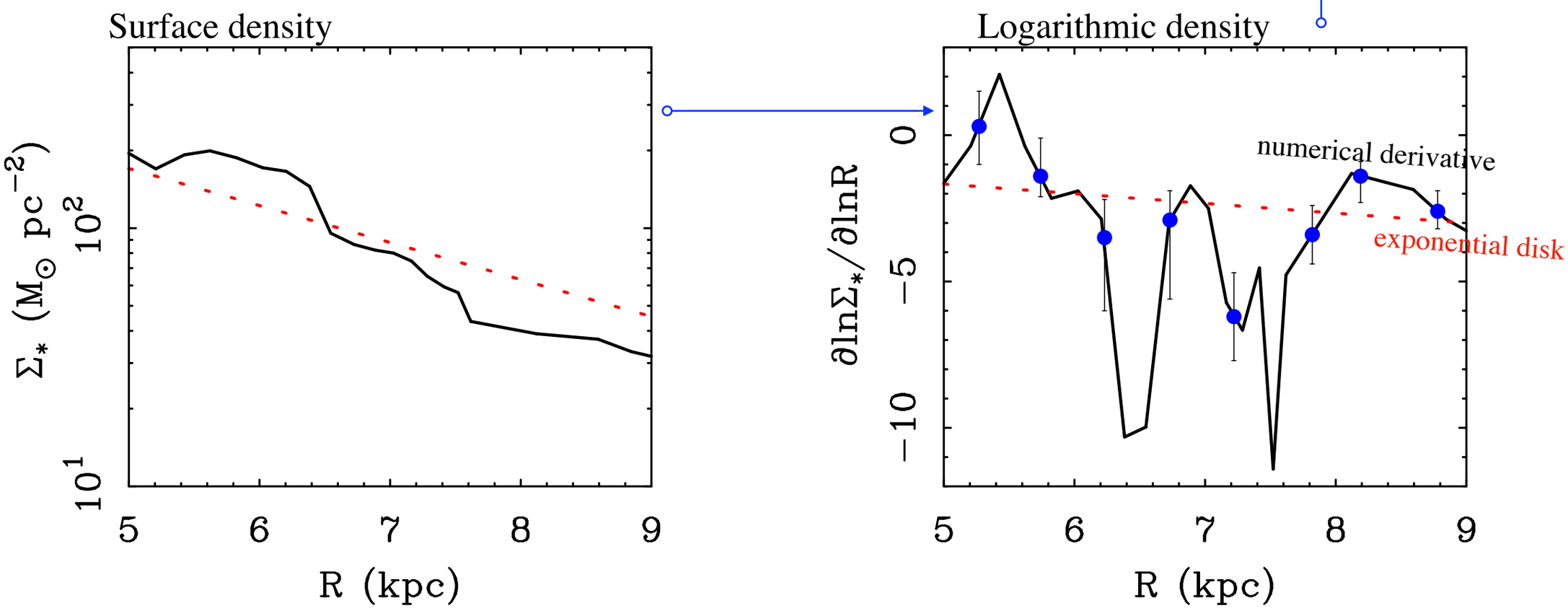


data: rotation curve from terminal velocities
dashed line: exponential disk + dark matter halo
solid line: detailed surface density + RAR

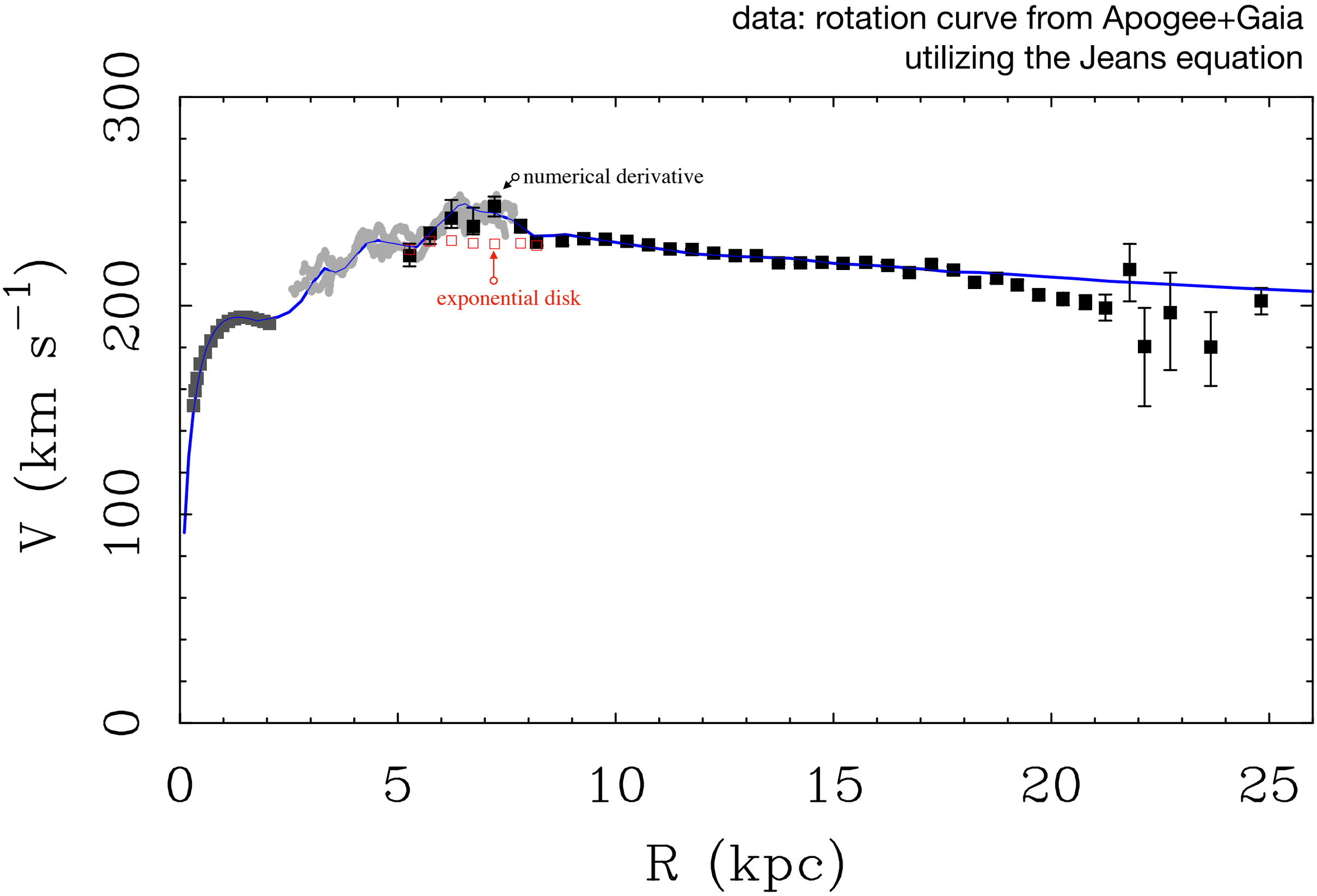


Can improve on the exponential disk approximation in the

$$V_c^2(R) = \langle v_\phi^2 \rangle - \langle v_R^2 \rangle \left(1 + \frac{\partial \ln \Sigma}{\partial \ln R} + \frac{\partial \ln \langle v_R^2 \rangle}{\partial \ln R} \right)$$



Milky Way Rotation Curve



Galaxy Formation

A many faceted problem

(sort of like Cthulhu being a multi-tentacled nightmare cult god)

Competition between gas accretion (to form disks)
and lumpy fragments (forms spheroids, substructure)

Monolithic galaxy formation

collapse of one big gas cloud

(e.g., Eggen, Lynden-Bell, & Sandage 1962)

Hierarchical galaxy formation

"bottom up" formation from sequence of mergers

(big galaxies are built by piling up small galaxies - happens with cold dark matter)

Searle-Zinn (1978) fragments:

"…halo [globular] clusters originated within transient protogalactic fragments that gradually lost gas while undergoing chemical evolution and continued to fall into the Galaxy after the collapse of its central regions had been completed."

Hierarchical galaxy formation (*not* monolithic)

Small objects conglomerate to make big ones

Gas dissipates and cools to form thin disks.

Stars cannot cool: if hot coming in, stay hot.

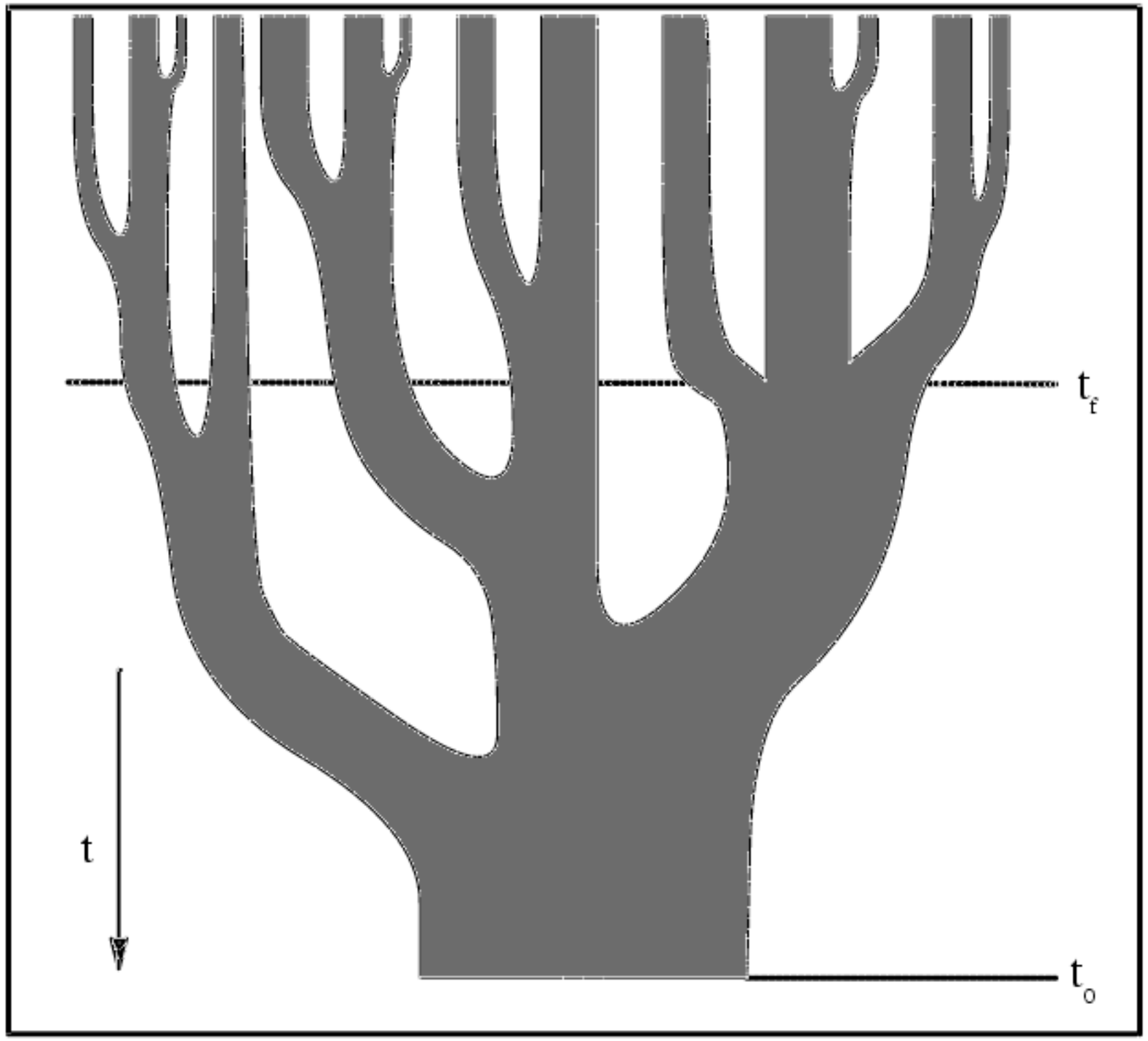


Figure 6. A schematic representation of a "merger tree" depicting the growth of a halo as the result of a series of mergers. Time increases from top to bottom in this figure and the widths of the branches of the tree represent the masses of the individual parent halos. Slicing through the tree horizontally gives the distribution of masses in the parent halos at a given time. The present time t_0 and the formation time t_f are marked by horizontal lines, where the formation time is defined as the time at which a parent halo containing in excess of half of the mass of the final halo was first created.