Dark matter density profiles in the Galactic classical dwarf spheroidal galaxies

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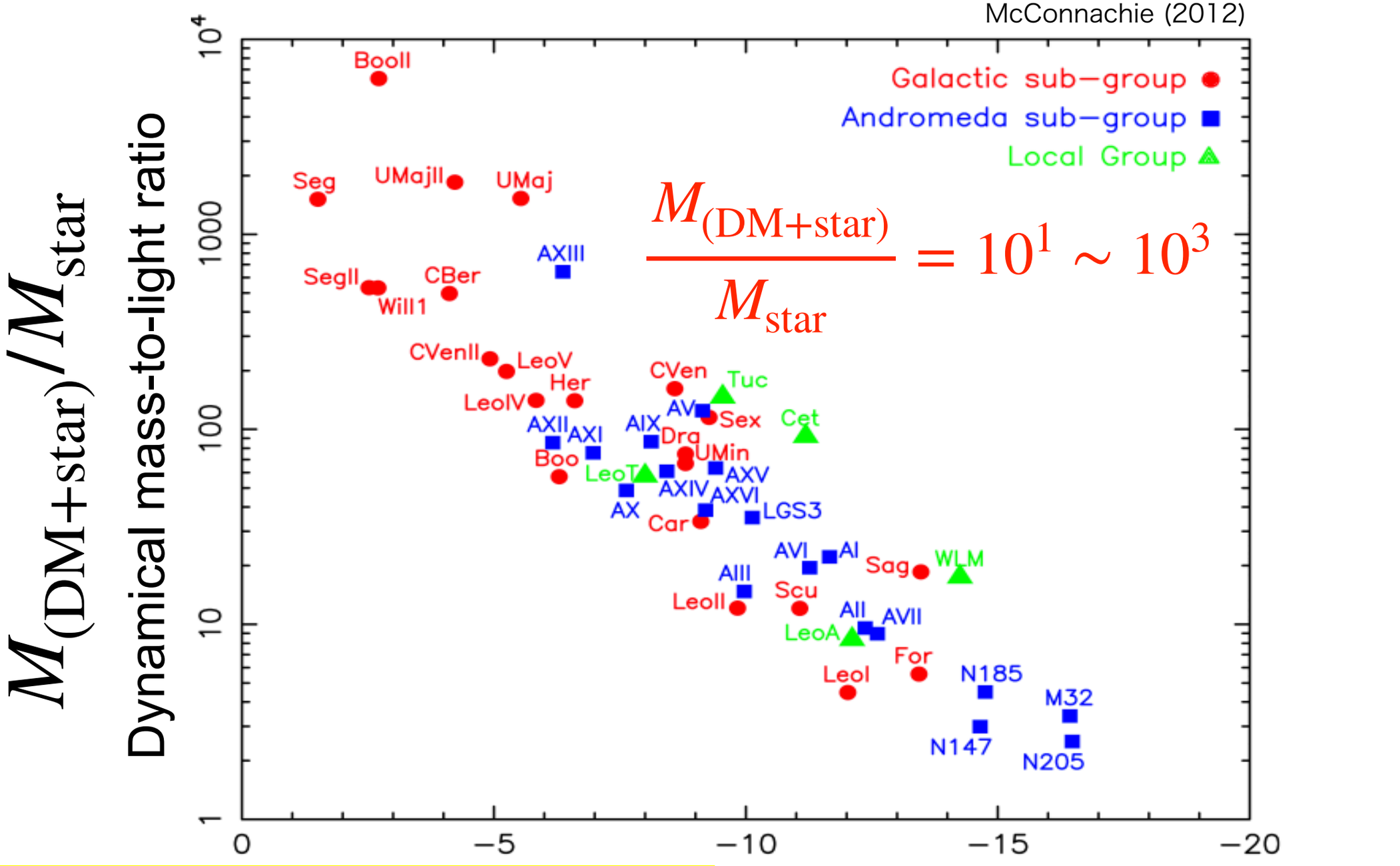
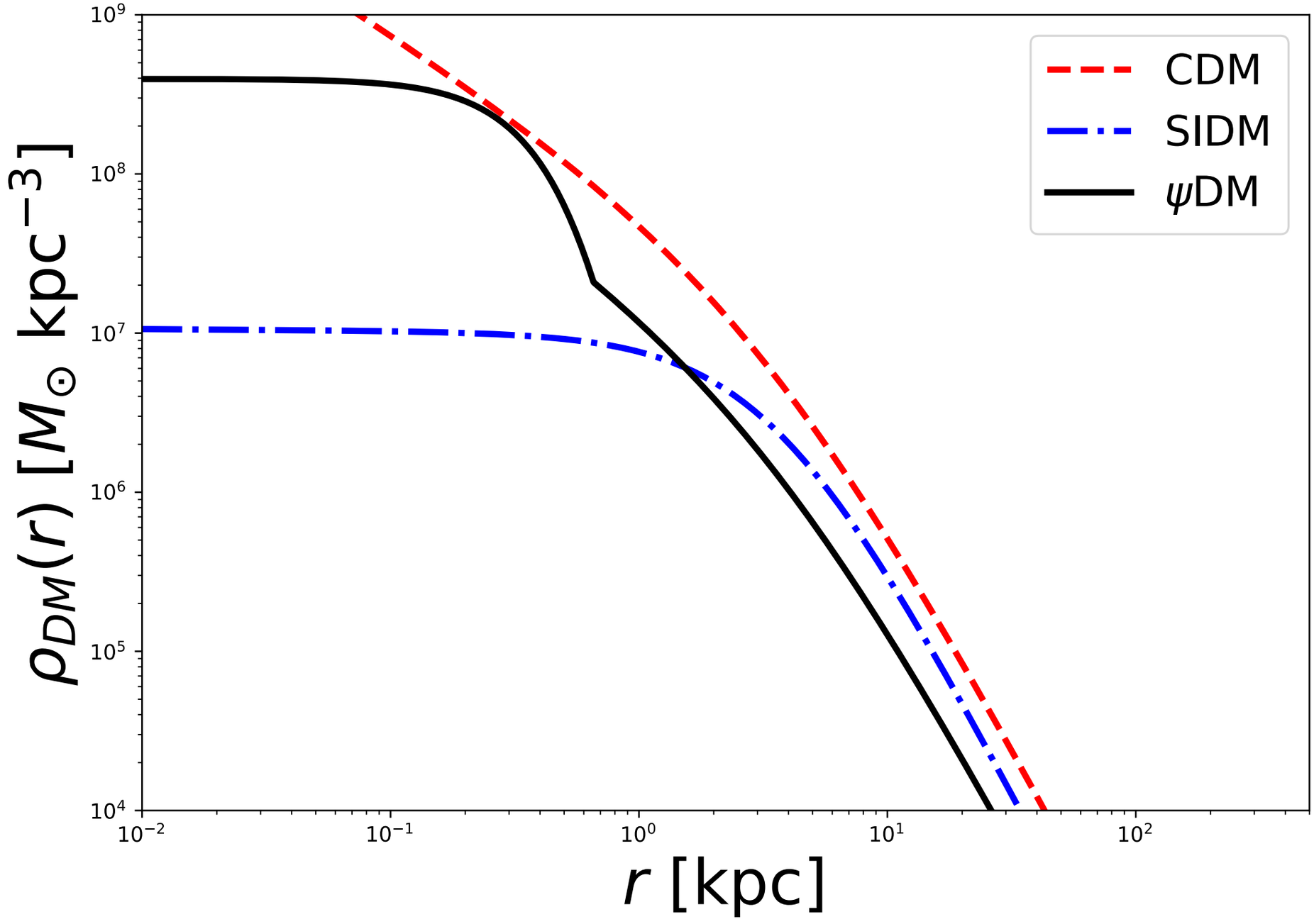
dSphs: dark-matter dominated system

McConnachie (2012)



DSphs are ideal sites for studying the nature of DM!

The nature of DM: DM profiles



Revealing DM profile should be essential

Deriving DM profiles in the dSphs

Generalized dark matter density profile

$$\rho_{\rm DM}(r) = \frac{\rho_s}{(r/r_s)^{\gamma}[1+(r/r_s)^{\alpha}]^{(\beta-\gamma)/\alpha}}$$

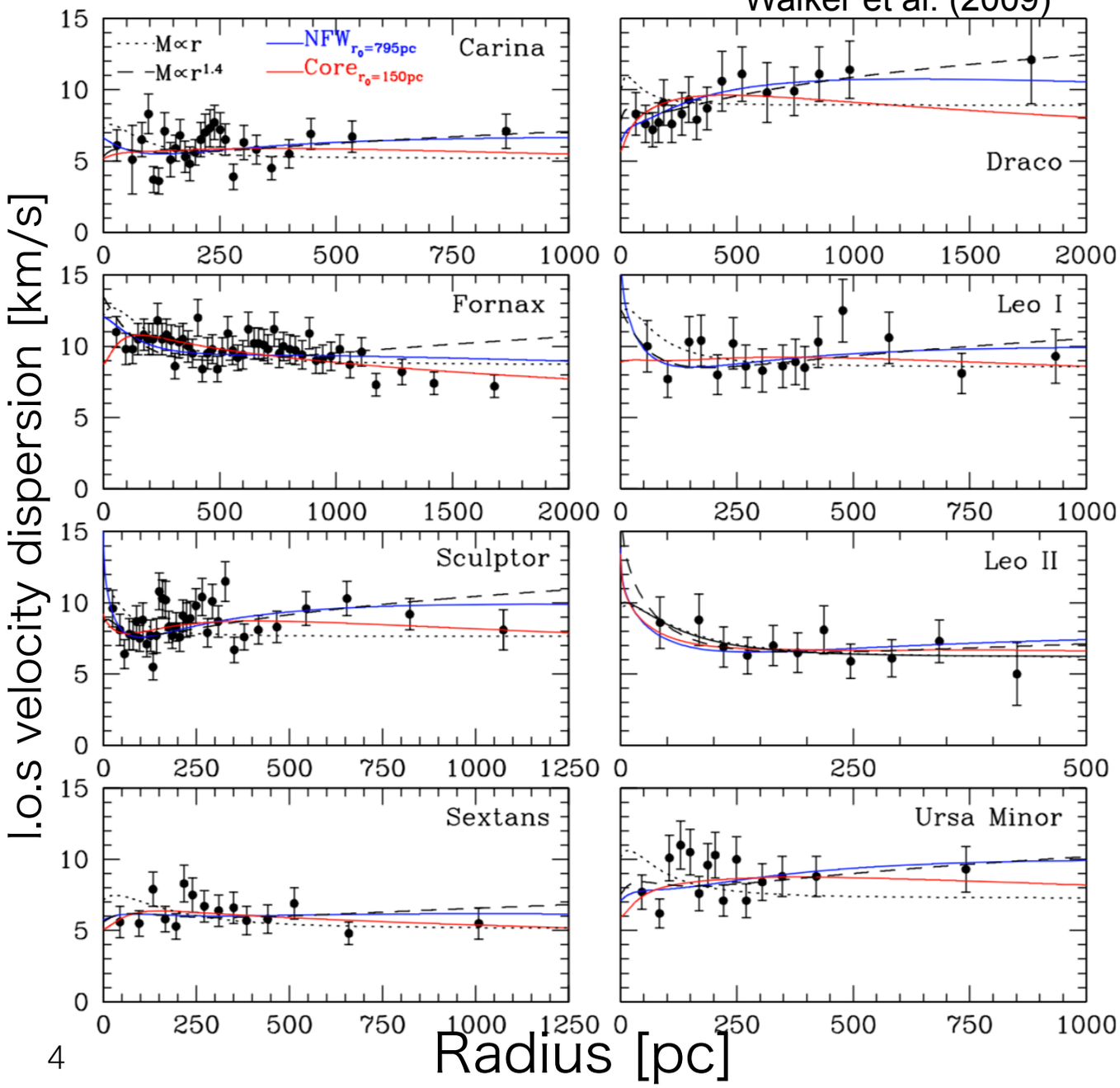
Cusp (NFW) $(\alpha,\beta,\gamma) = (1,3,1)$

Core (Burkert) $(\alpha,\beta,\gamma) = (1.5,3,0)$

Dynamical models for stars
ex) Spherical Jeans equation

$\sigma_{\rm l.o.s}^{\rm (Theory)}$ **FIT** $\sigma_{\rm l.o.s}^{\rm (obsrved)}$

Walker et al. (2009)



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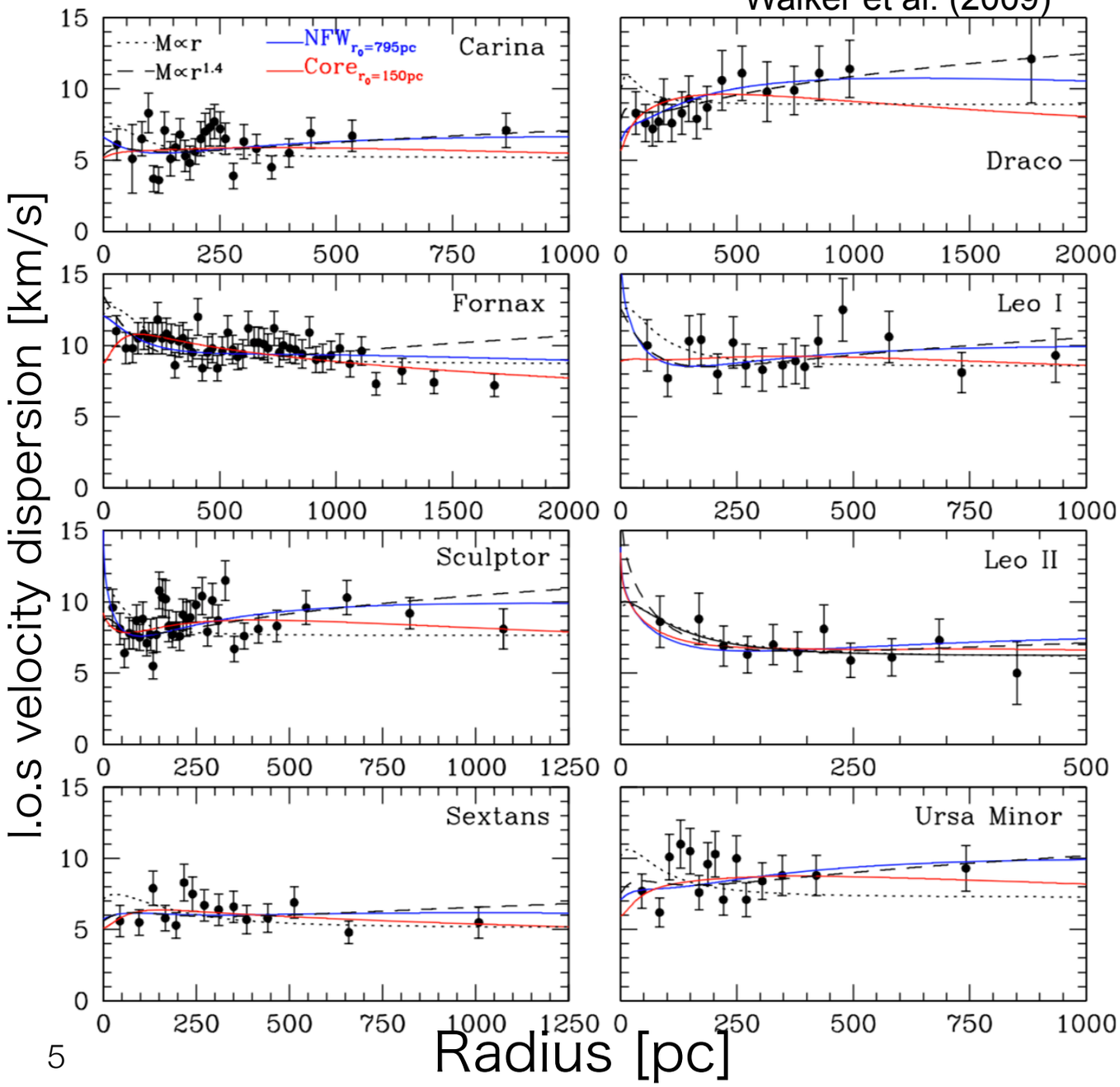
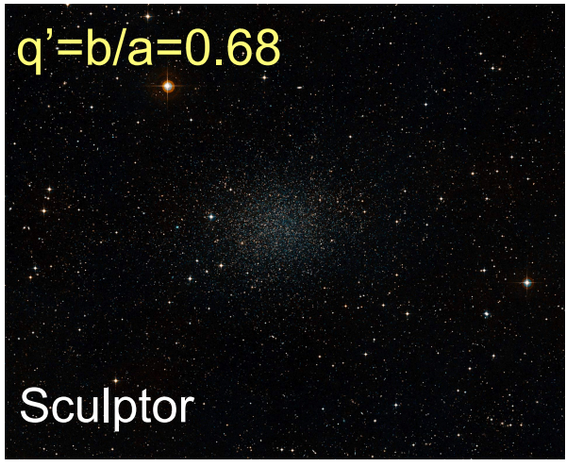
More general dynamical model is needed!

Walker et al. (2009)

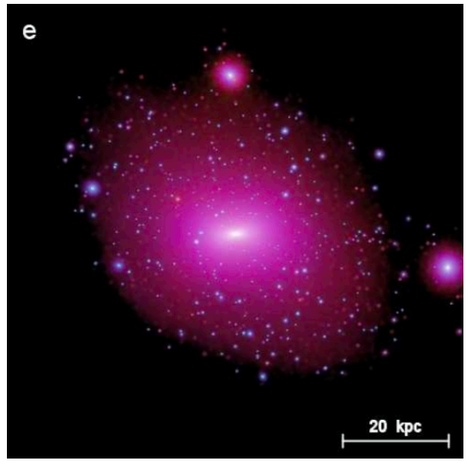


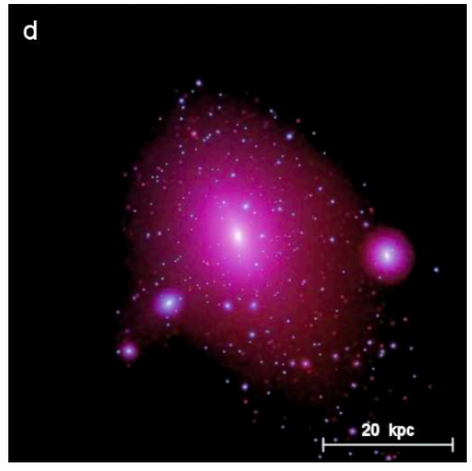
Major systematic uncertainty: Spherical Symmetry

1. Observed dSphs are **NOT** spherical shape



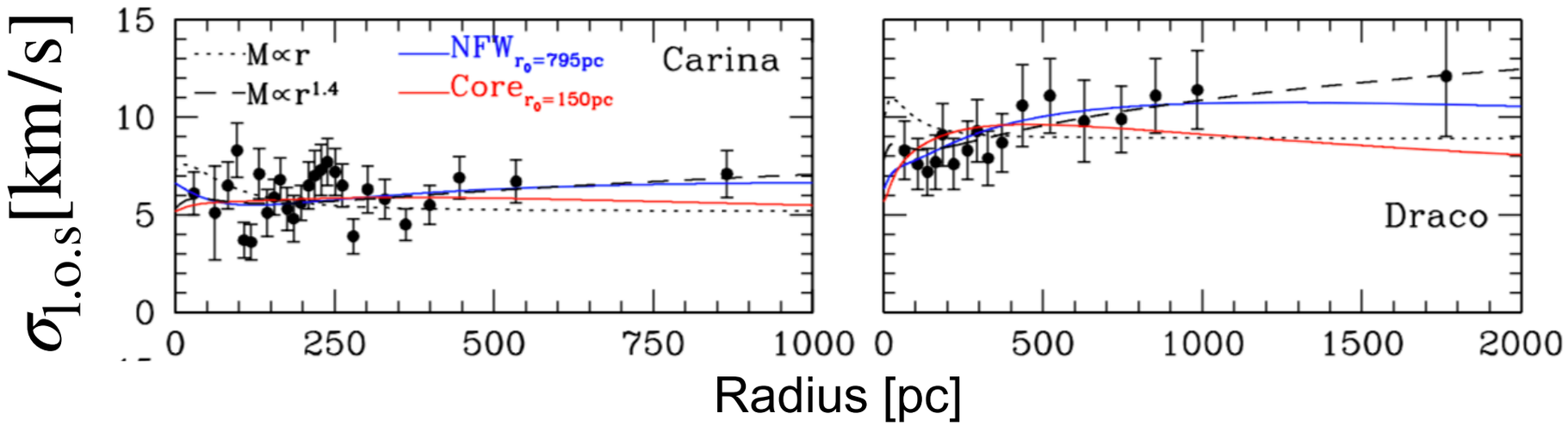
2. DM models predict **NON-spherical** DM halo





credit: Aquarius project

3. 1D spatial information



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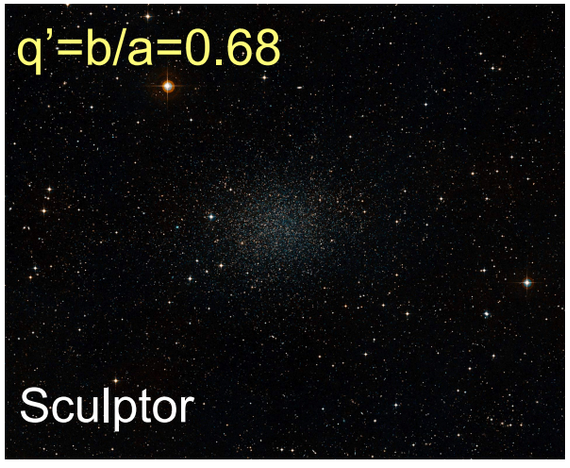

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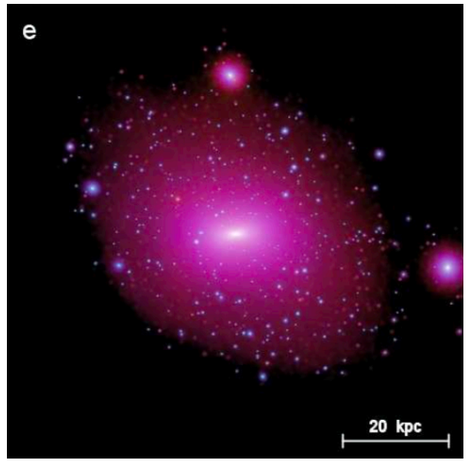

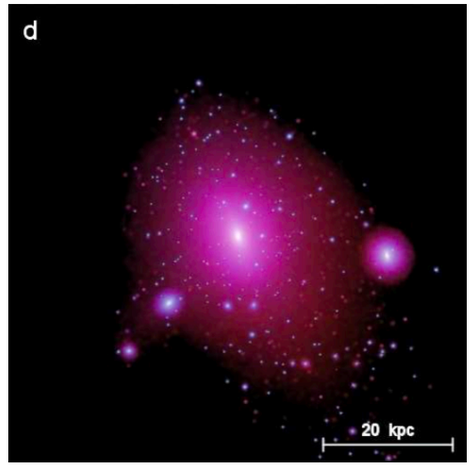

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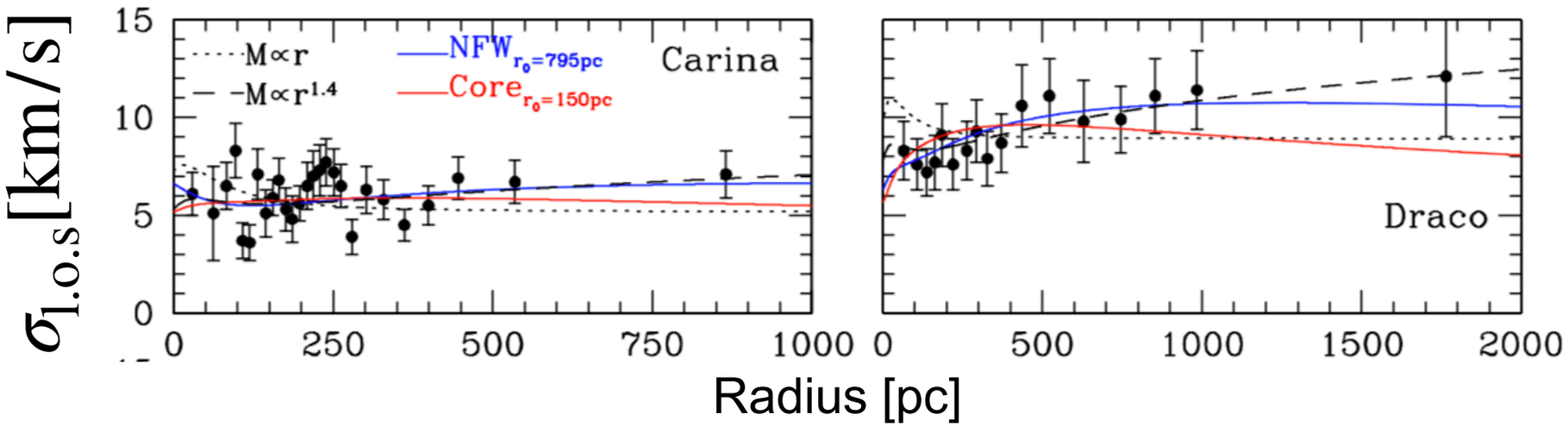


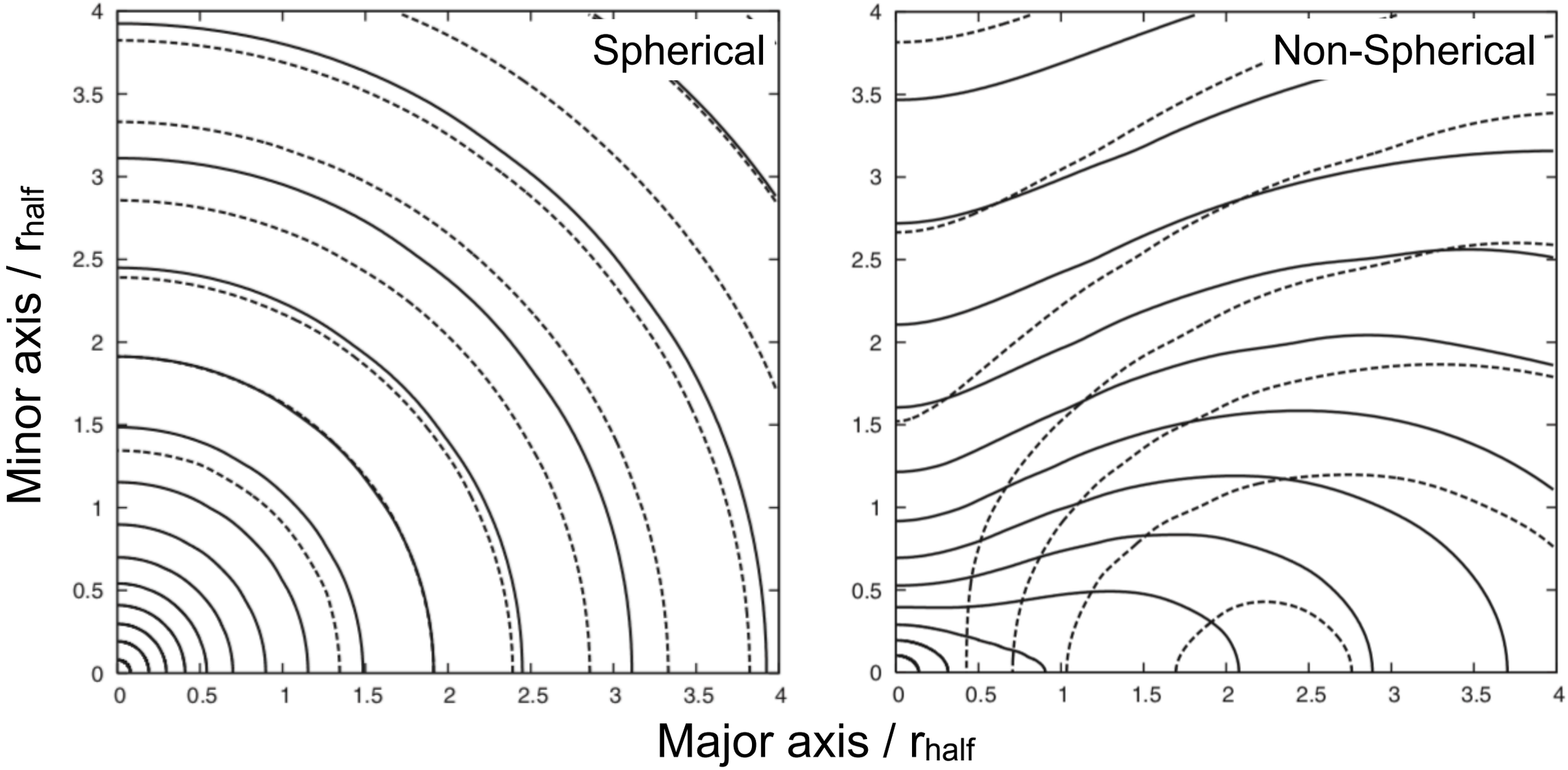
Non-spherical mass model

Non-spherical dynamical mass models

Hayashi & Chiba (2012)

Solid: CUSP
Dashed: CORE

Contours of line-of-sight velocity dispersion



Non-sphericity ➡ distinguish **Cusp or Core**

Non-spherical dynamical mass models

Unobservable

Non-spherical dark matter density profile

$$\rho_{\rm DM}(r) = \frac{\rho_s}{(r/r_s)^{\gamma}[1+(r/r_s)^{\alpha}]^{(\beta-\gamma)/\alpha}}$$

$$r^2 = R^2 + \frac{z^2}{Q^2}$$ ← **DM halo axial ratio**

Non-spherical stellar profile

$$\rho_*(r_*) = \frac{3L}{4\pi r_p^3}\left[1+\frac{r_*^2}{r_p^2}\right]^{-5/2}$$

$$r_*^2 = R^2 + \frac{z^2}{q^2}$$ ← **stellar axial ratio**

Axisymmetric Jeans equations

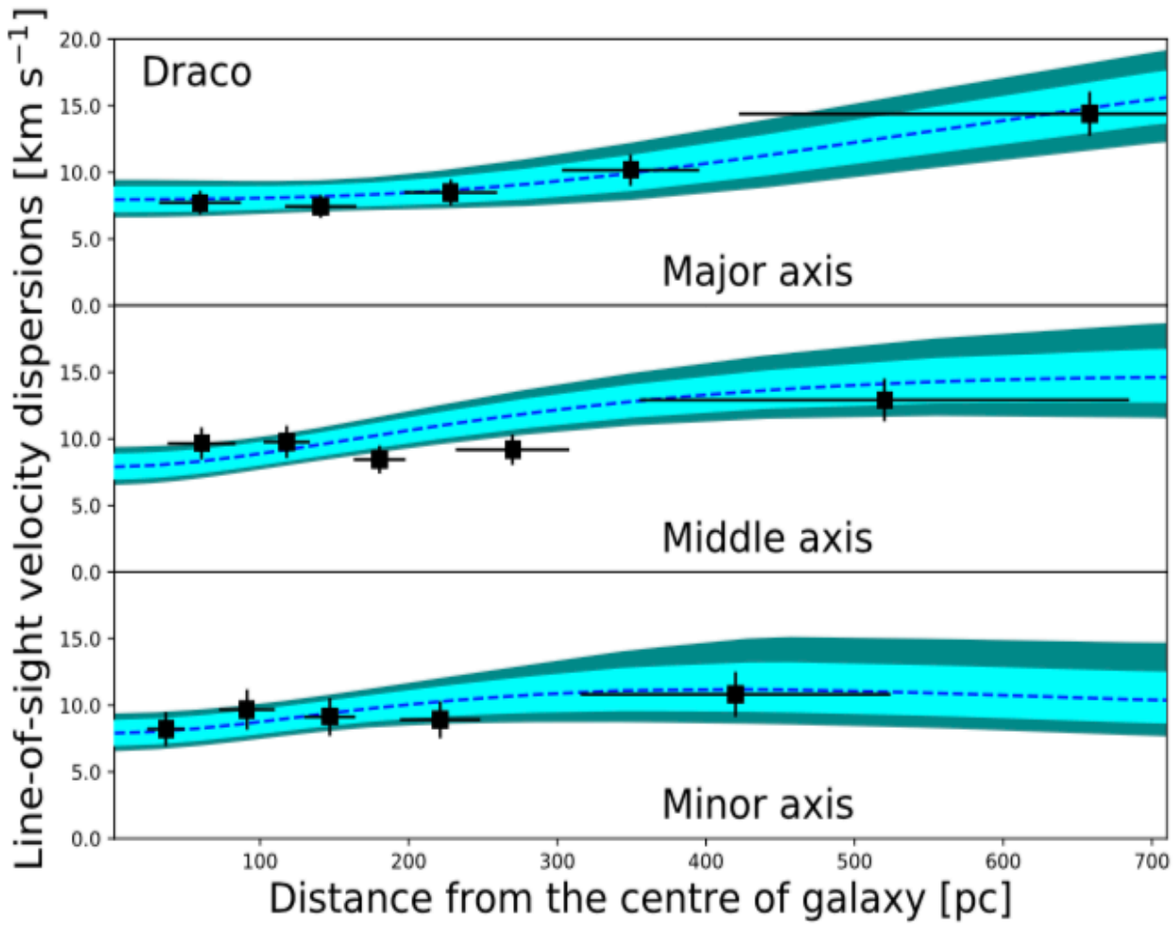
$(\overline{v_z^2}, \overline{v_\phi^2})$

$\overline{v_R^2}$ is unknown parameter as $\beta_z = 1 - \overline{v_z^2}/\overline{v_R^2}$

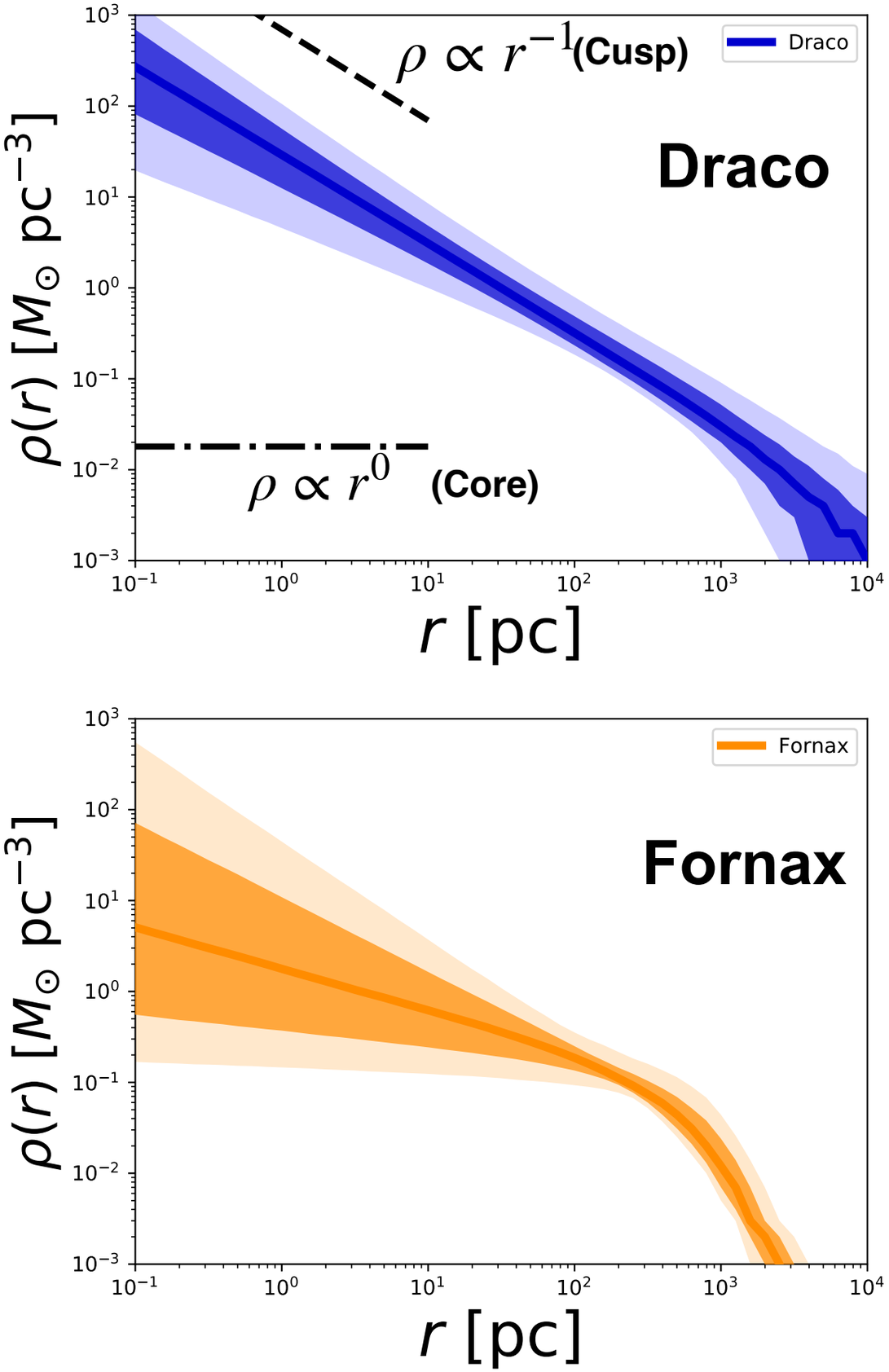
FIT

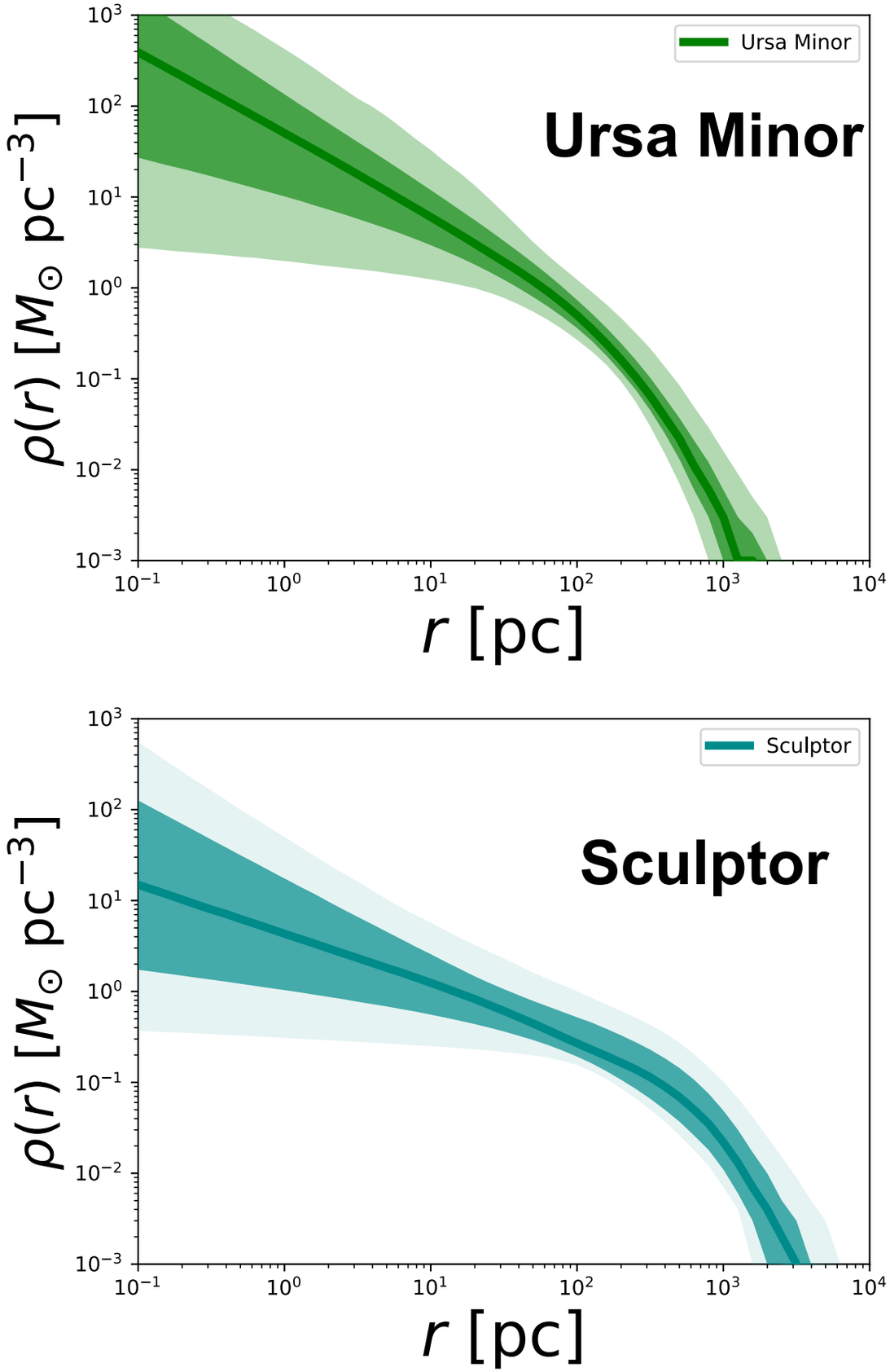
$\sigma_{\rm l.o.s}^{\rm (Theory)}$ ⟷ $\sigma_{\rm l.o.s}^{\rm (obsrved)}$

Draco dSph



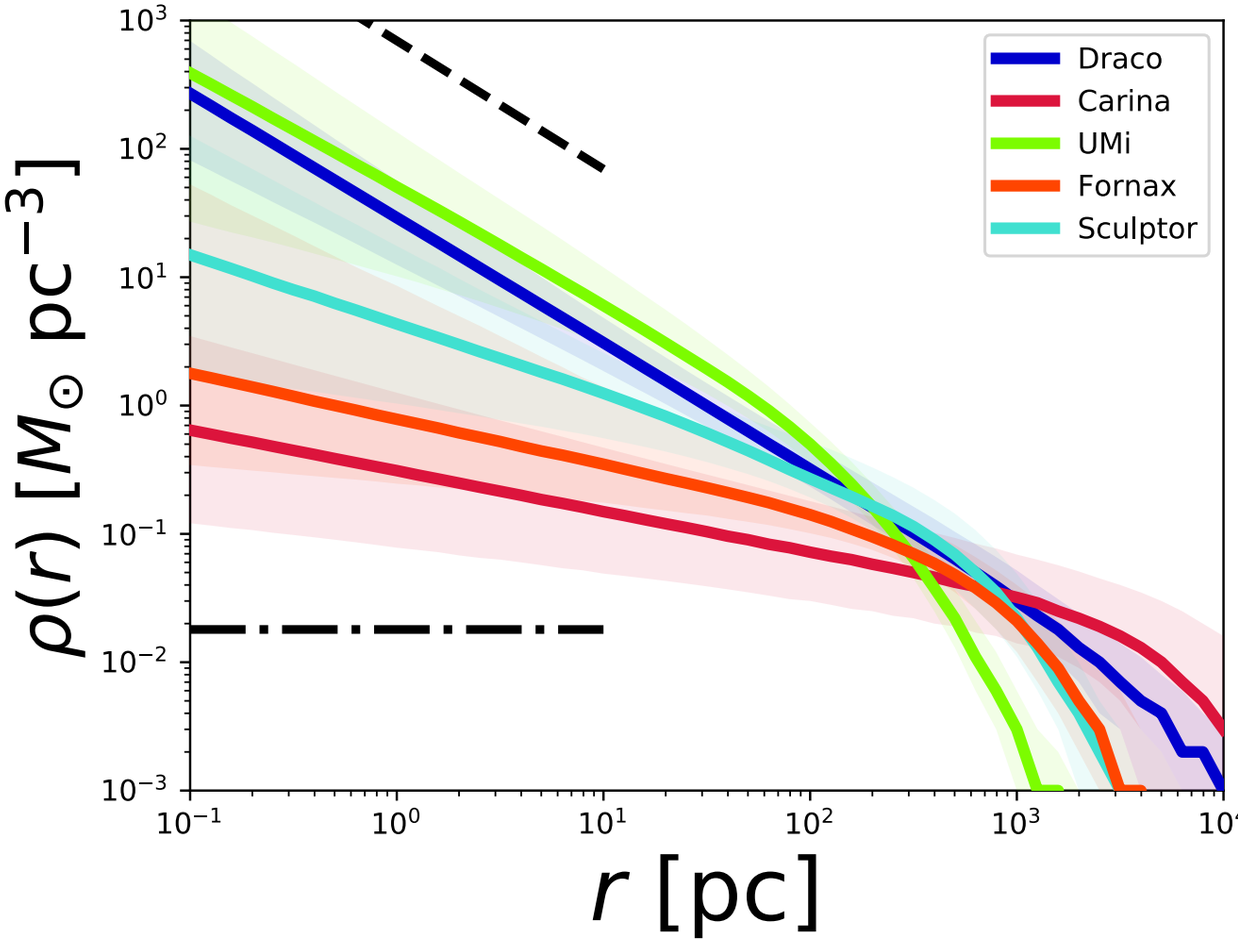
DM profiles of the classical dwarfs

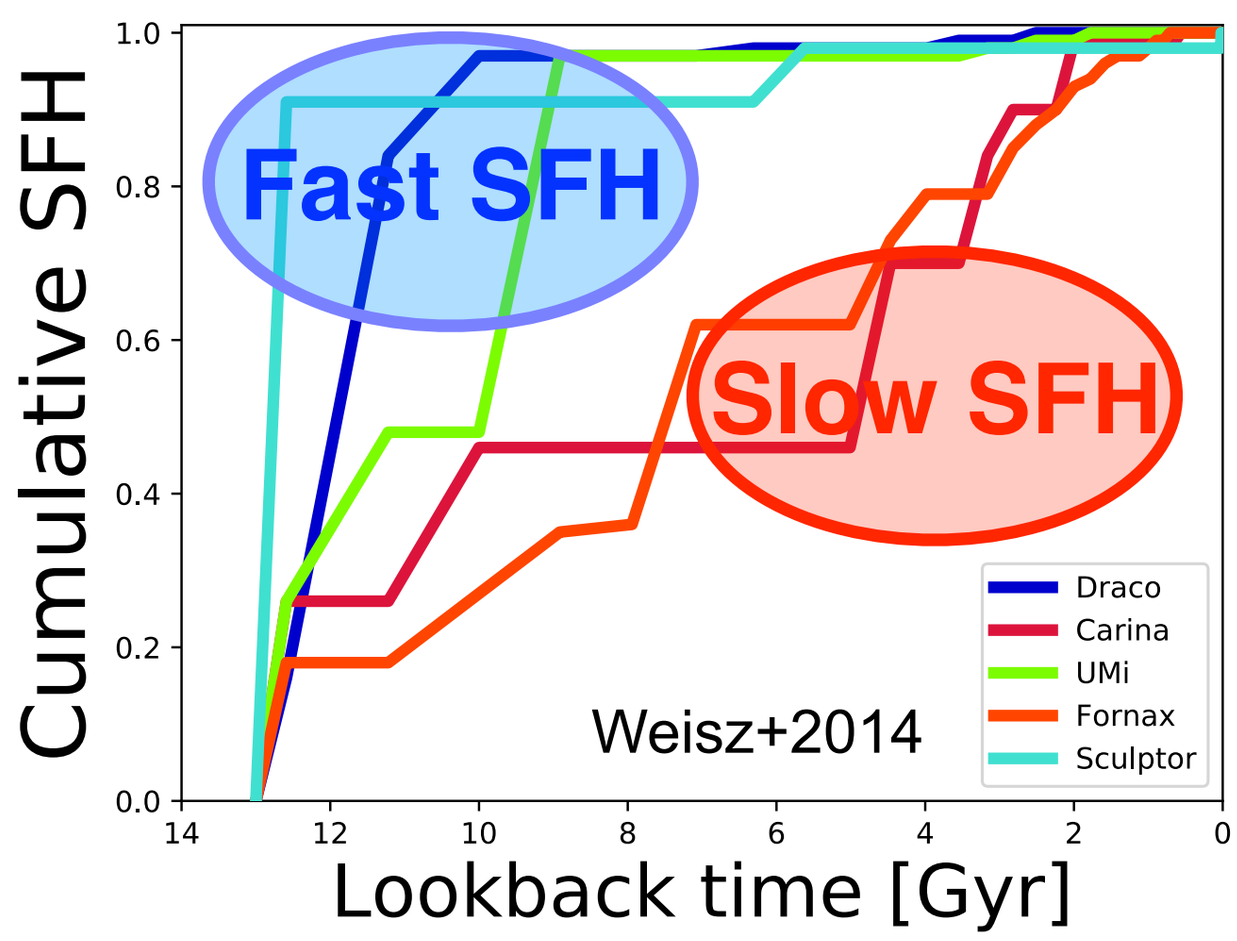




DM profile & star formation history

Hayashi et al. (in prep.)





DM density profile of the dSph ⟷ Formation history of galaxy

Summary

- The MW dSphs are ideal sites for studying the nature of dark matter.
- Construct new dynamical modeling taking into account non-sphericity
- Our mass models for the dSphs can put constraints on density profiles of dark matter.
- Find that the dSphs with fast SFH favor cusped DM halo, while ones with slow SFH prefer to have shallower cusped dark halo.