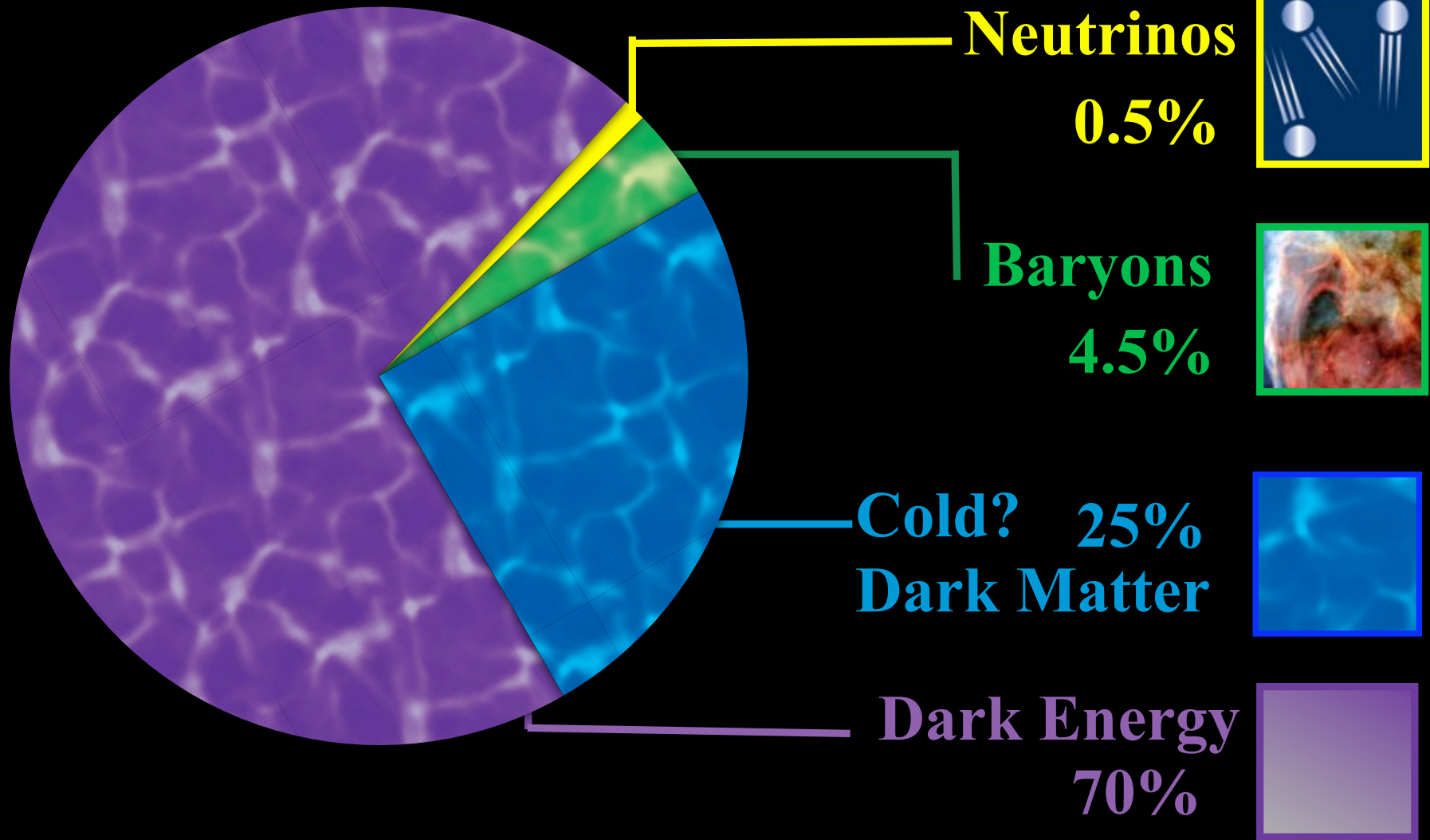


Probing Dark Matter with Dwarf Galaxies and SIM Astrometry

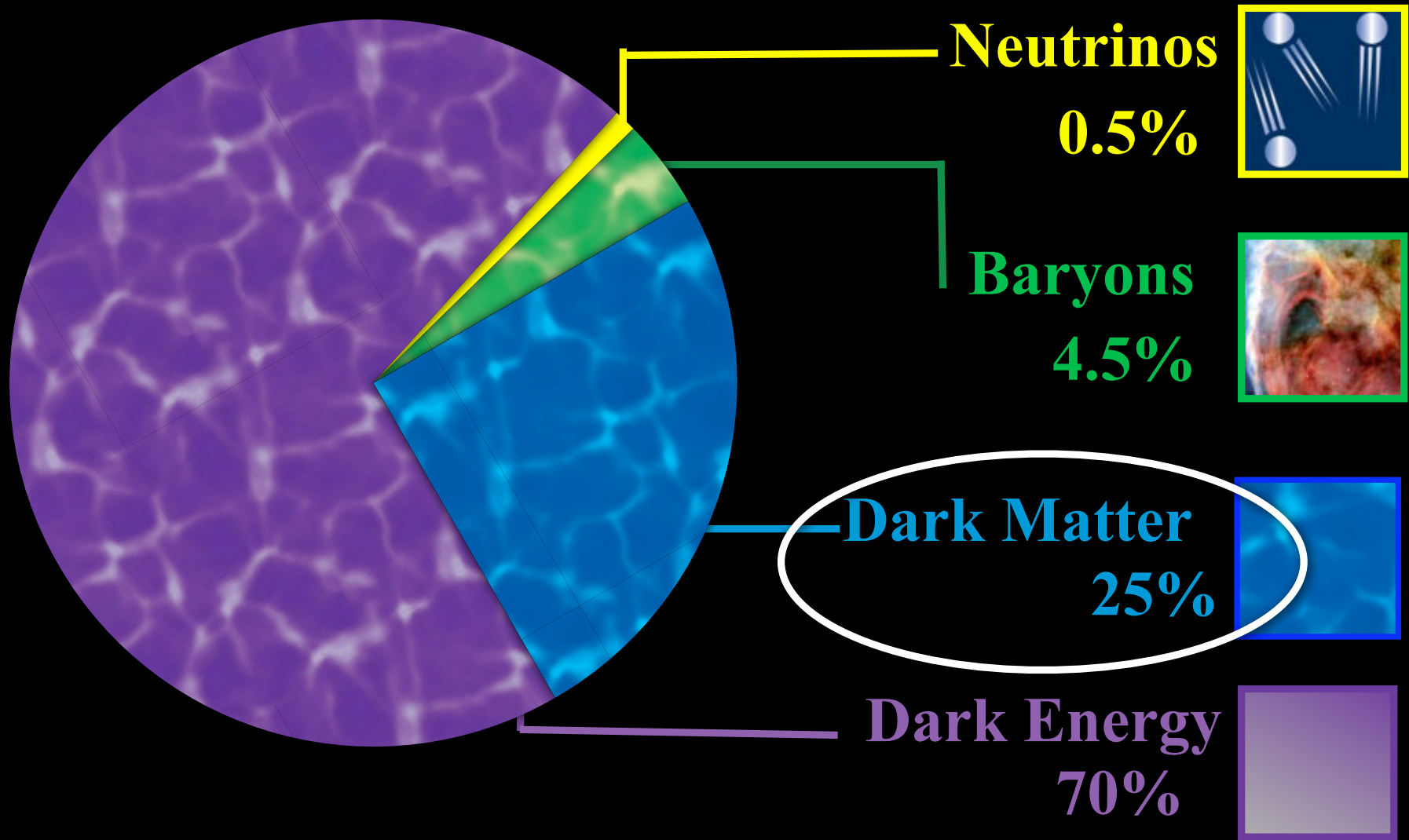


James Bullock
Manoj Kaplinghat
UC Irvine

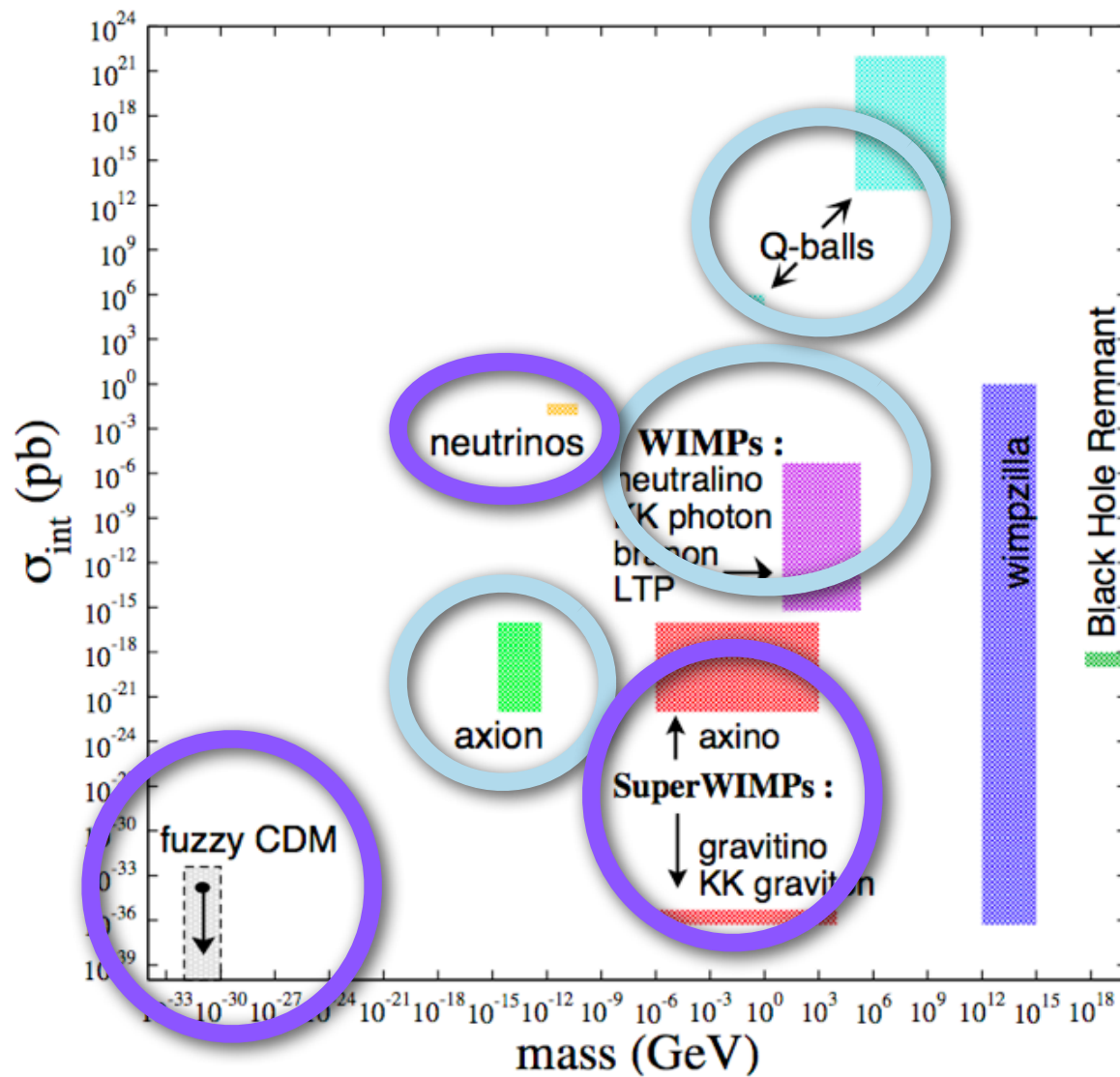
Composition of the Cosmos



Composition of the Cosmos



Dark Matter Scientific Assessment Group (DMSAG)



Cold Dark Matter

Warm Dark Matter

Dark Energy + CDM Cosmology: Current State

★ **Large-scale data: does quite well**

★ **Small-Scale data: not as well...**

● Galaxy Rotation Curves -- rise too quickly? (“cusp/core” problem)

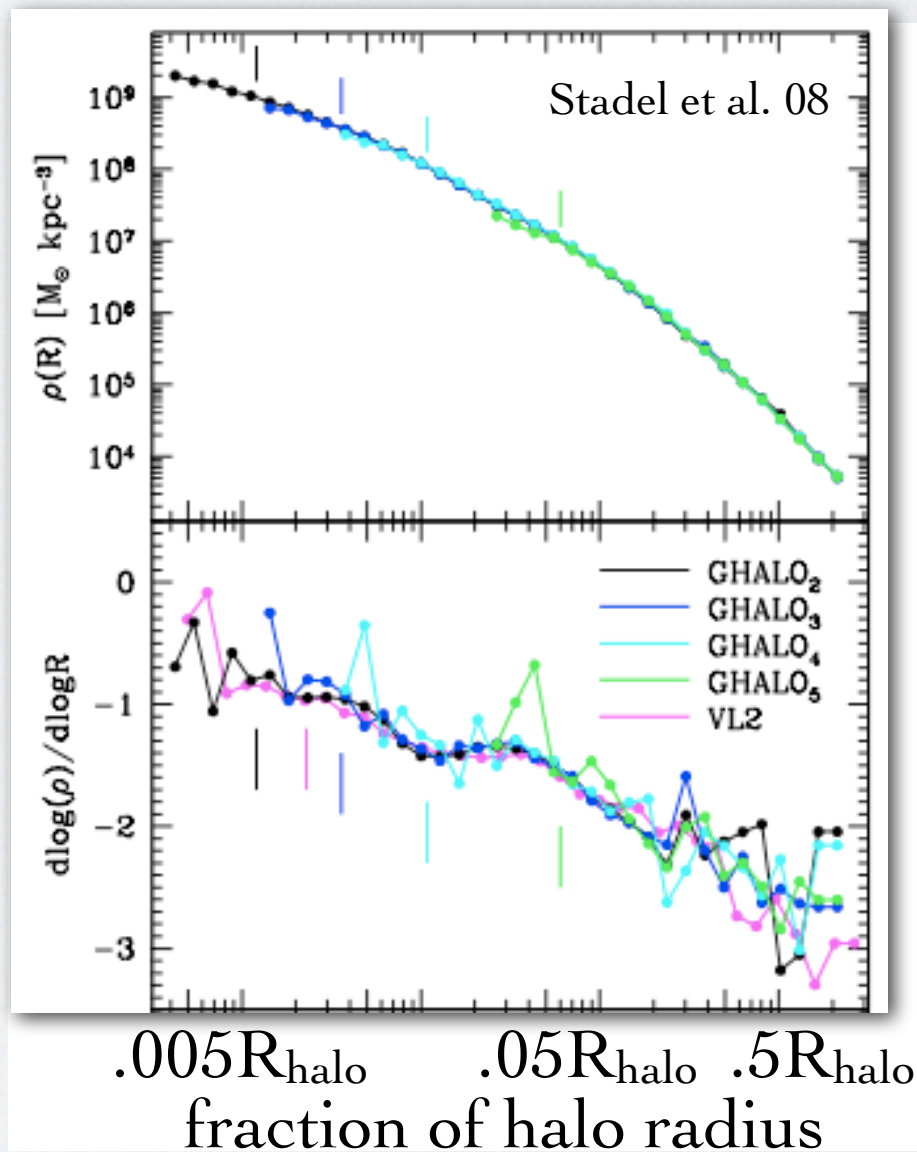
Flores & Primack 94; Simon et al. 05; Kuzio de Naray et al. 07; etc.

● Dwarf Satellites -- too many?

● Disk Galaxies -- hard to make and keep them thin?

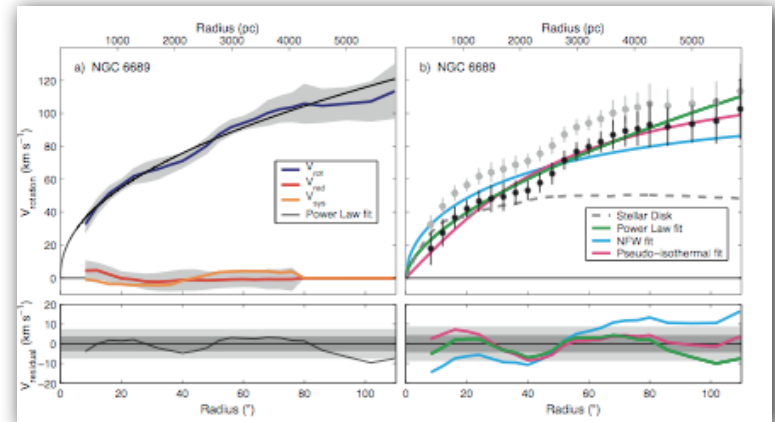
Small-scale CDM predictions: CUSPY Halos Density Profiles, $\sim 1/r$ in center “NFW halos”.

Lots of work on this:
Dubinski & Carlberg 91
Navarro et al. 97
Moore et al. 99
Klypin et al. 01
...
Diemand et al. 06
Navarro et al. 06
...
Stadel et al. 08



Recent 2D Velocity Maps

Galaxy rotation curves rise more slowly than CDM prediction



Simon et al. 05: (Ha & CO)
~3 of 6 look flatter than NFW

Dutton et al. 05: (Ha & HI)
3 of 6 flatter than NFW

Kuzio de Nary et al. 06, 07:
2d H-alpha ~13 of 17 look flatter than NFW

CONCERN: astrophysics may affect interpretation
(Valenzuela, Klypin et al. 07)



What is the Core Problem telling us?



Something about
cosmology

-DARK MATTER NOT COLD?



Something about
systematics

**-INTERPRETATION?
-NON-CIRCULAR MOTIONS?
-NON-GRAVITATIONAL VELOCITIES?**

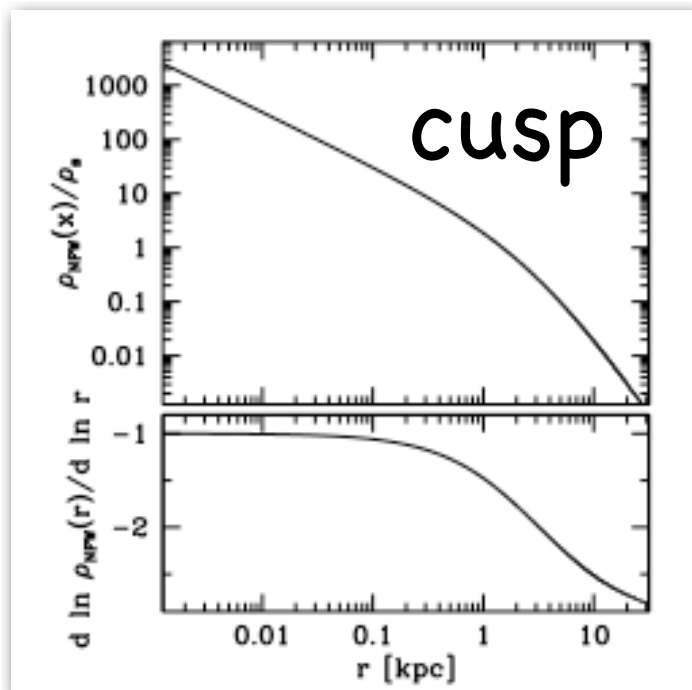
Dark Matter and Galaxy Central Densities

Strigari, Kaplinghat, JSB 06; ALSO: Kaplinghat 05

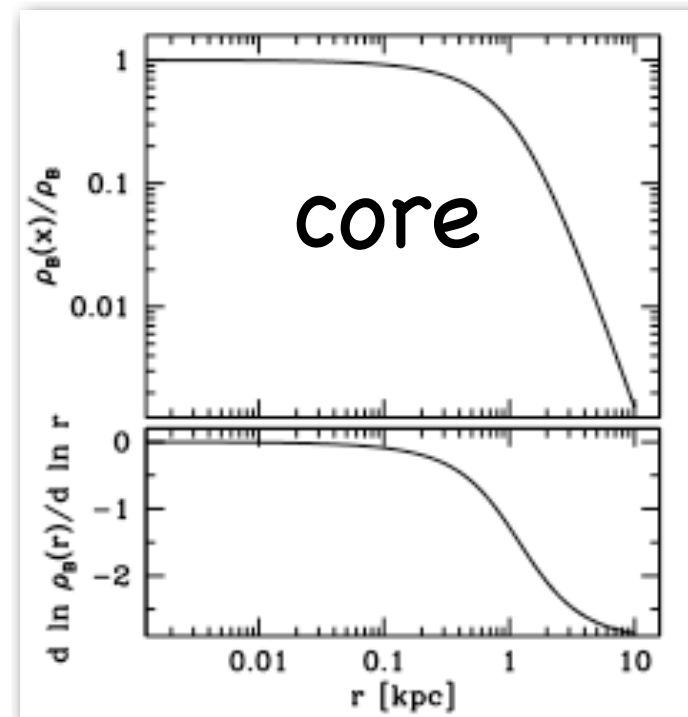
CDM WIMPs:
LSP neutrino

WDM SuperWIMPs:
LSP gravitino

High phase-space density



Low phase-space density



Dwarf Spheroidal Satellites: Best DM Labs in the Universe

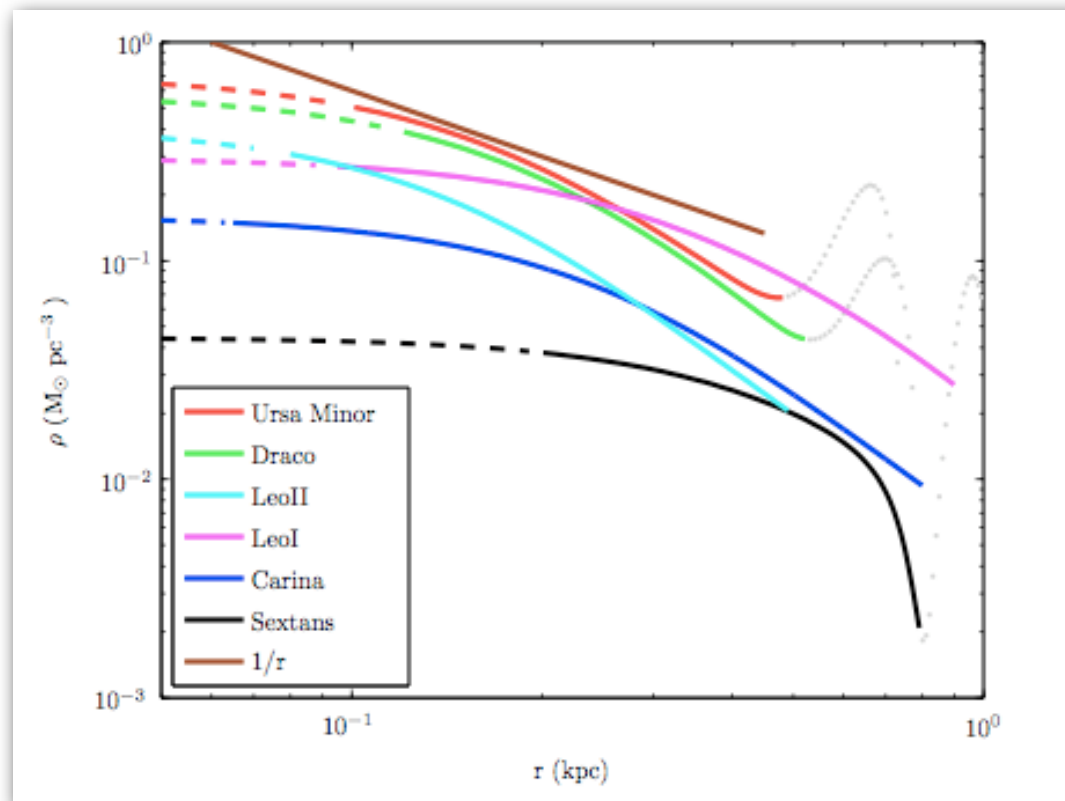
$$L \sim 10^5 - 10^6 L_{\odot}$$

$$M/L \sim 100$$



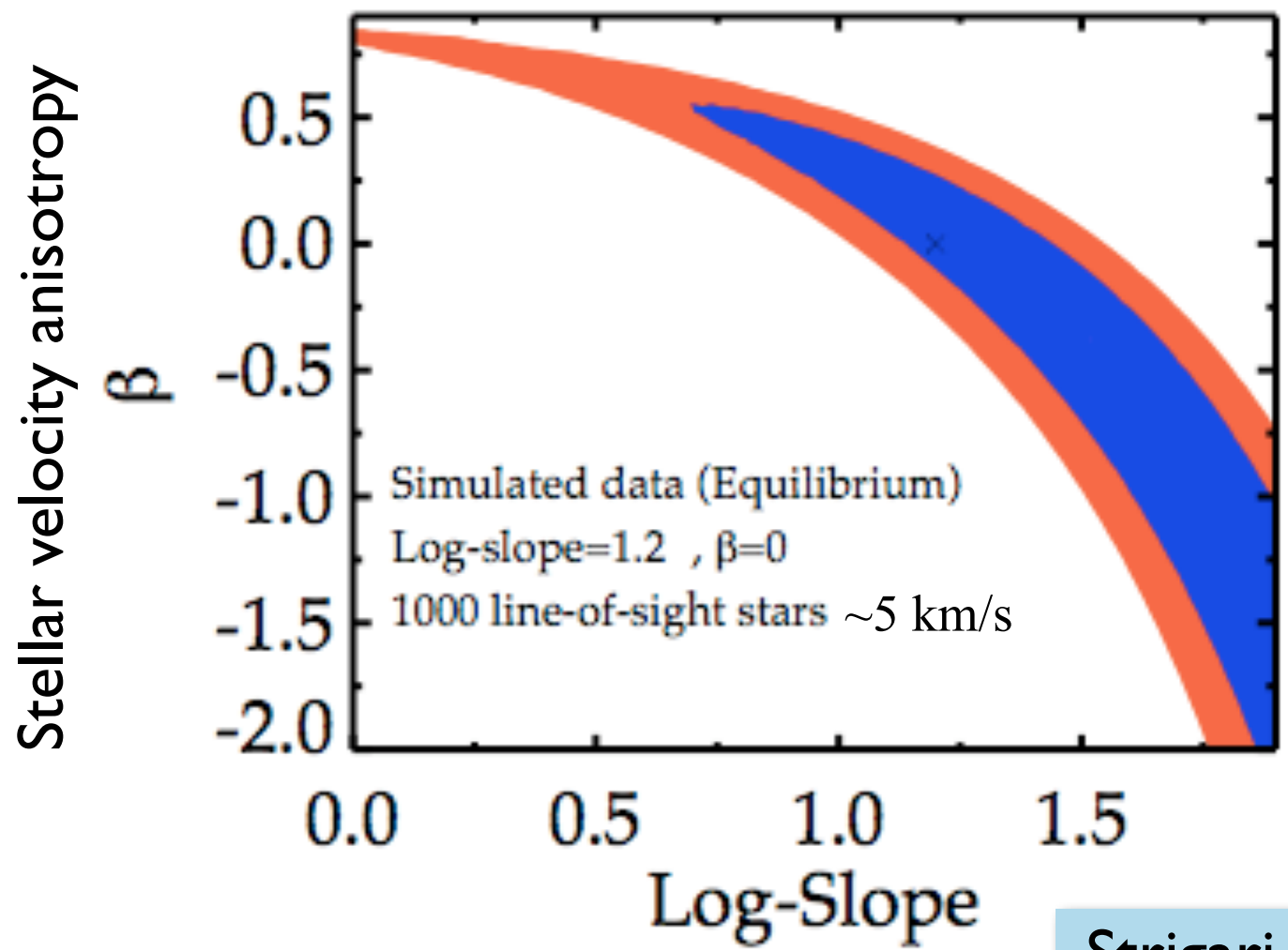
1. Dark Matter Dominated => Easy to interpret
2. Proximity (~ 100 kpc) => Individual Stellar Kinematics
3. High Phase Space Densities => WDM cores?

Gilmore et al. 07: Density profiles of dSph Galaxies - isotropic Jeans modeling



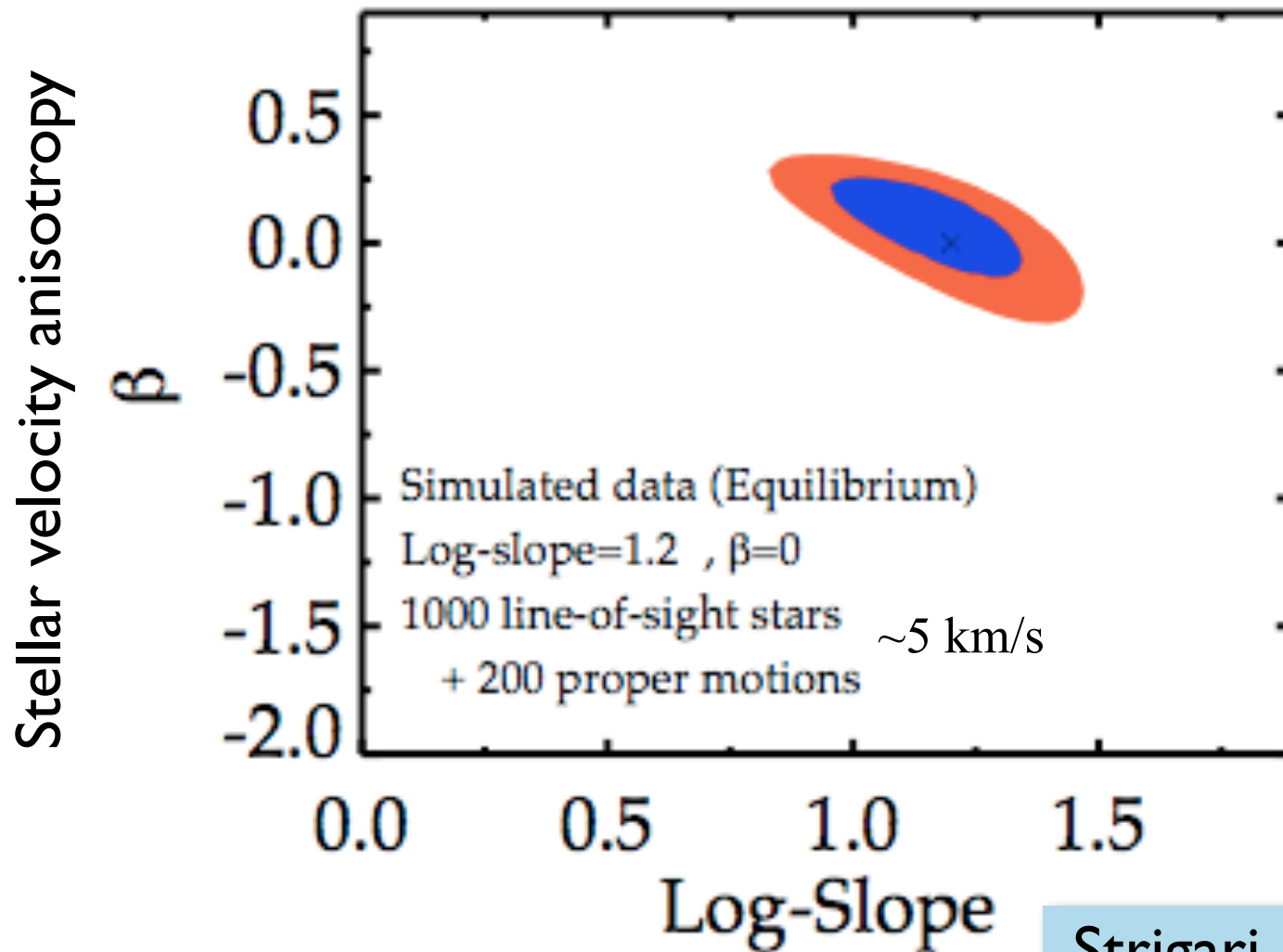
IF $\beta \equiv 1 - \frac{\sigma_{\theta}^2}{\sigma_r^2} = 0 \Rightarrow$ Cored profiles are better fits.

Without assumptions, Dark Matter Halo Slope is hard to measure even with radial velocities of ~ 1000 s of stars

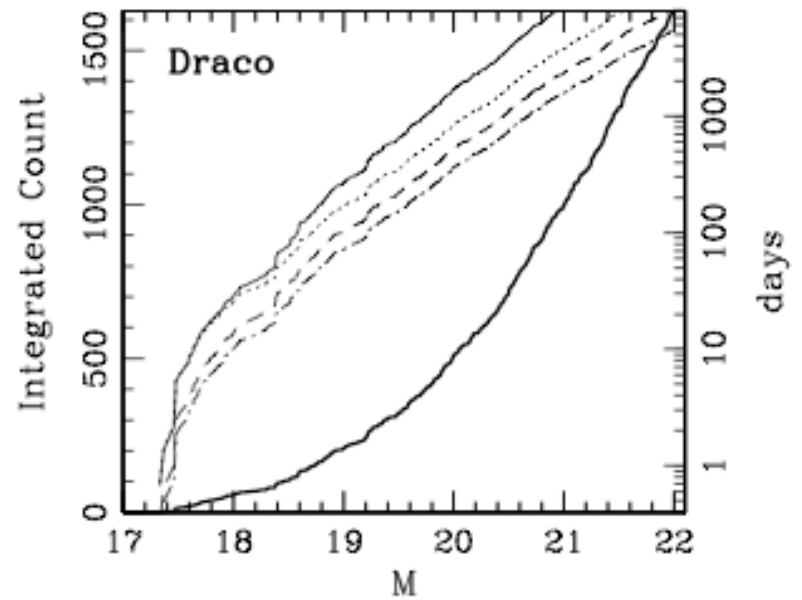
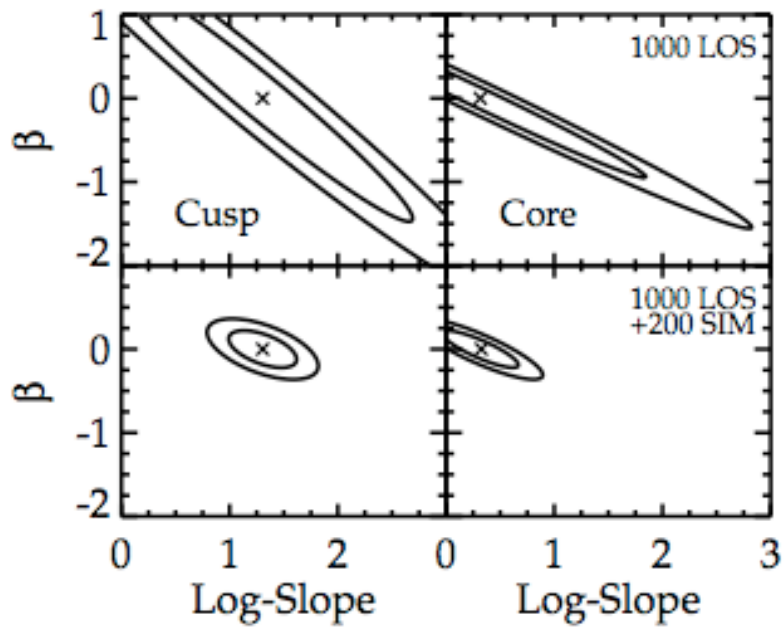


Strigari, JSB, MK 07

Add Proper Motions (200 Stars from SIM)



Strigari, JSB, MK 07



Strigari et al., in prep.