

Galactic scale alignments

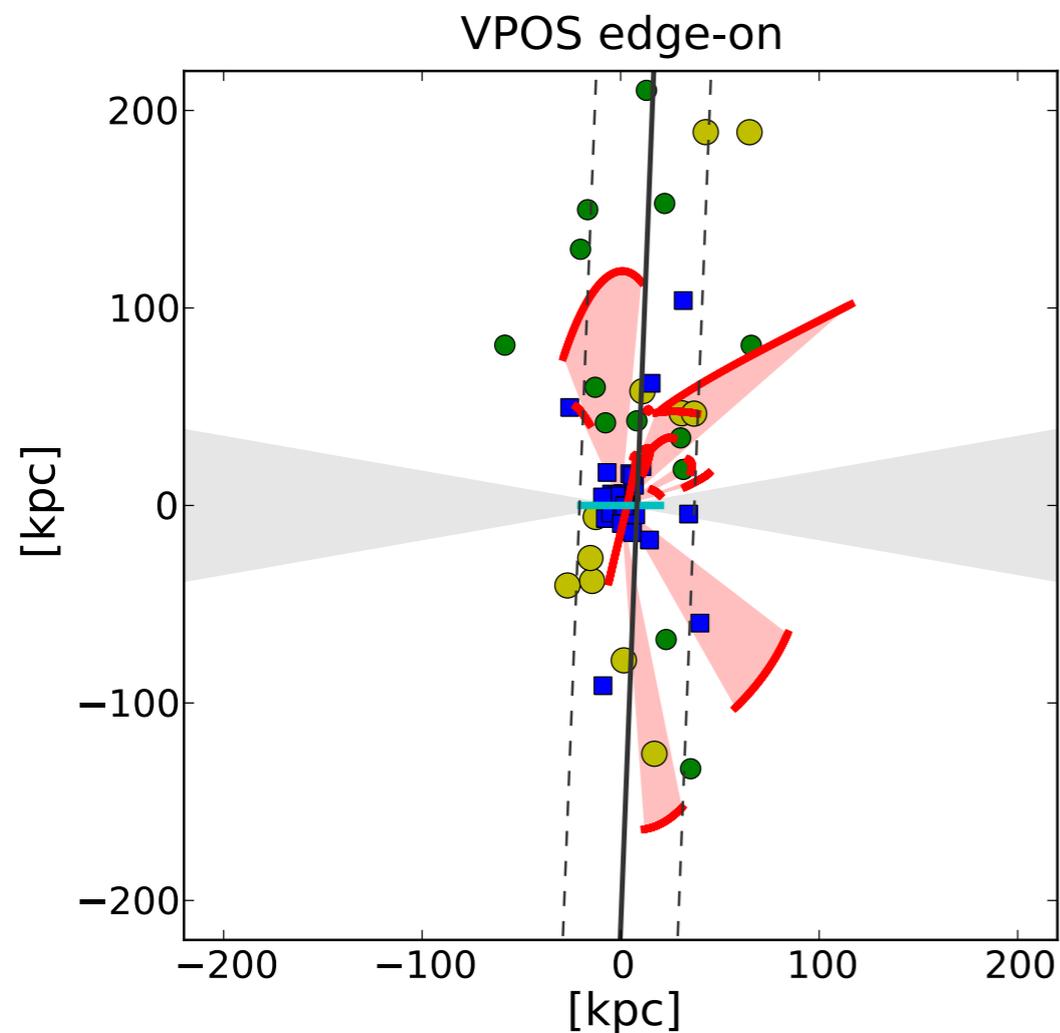
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DEX XII
Durham
6 January 2016

Shao et al., in prep.

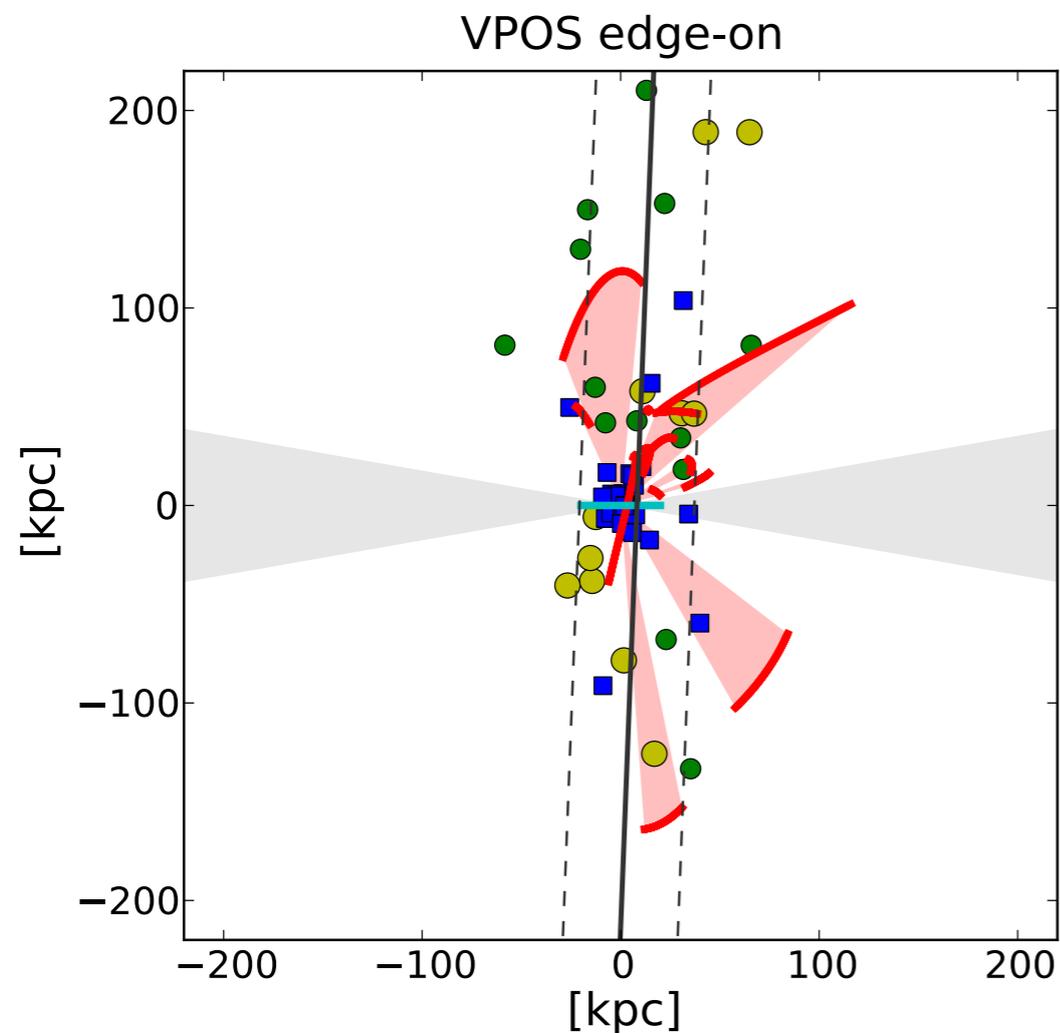
MW's plane of satellites



Pawlowski+ 2012; Pawlowski & Kroupa 2013

- The Galactic satellites are distributed on a thin planar structure.
- A plane too thin plane for LCDM? (Pawlowski & Kroupa 2013)
- No, at least $\sim 10\%$ of LCDM systems have a plane as prominent at the one observed for the MW (Cautun+ 2015).

Filamentary accretion

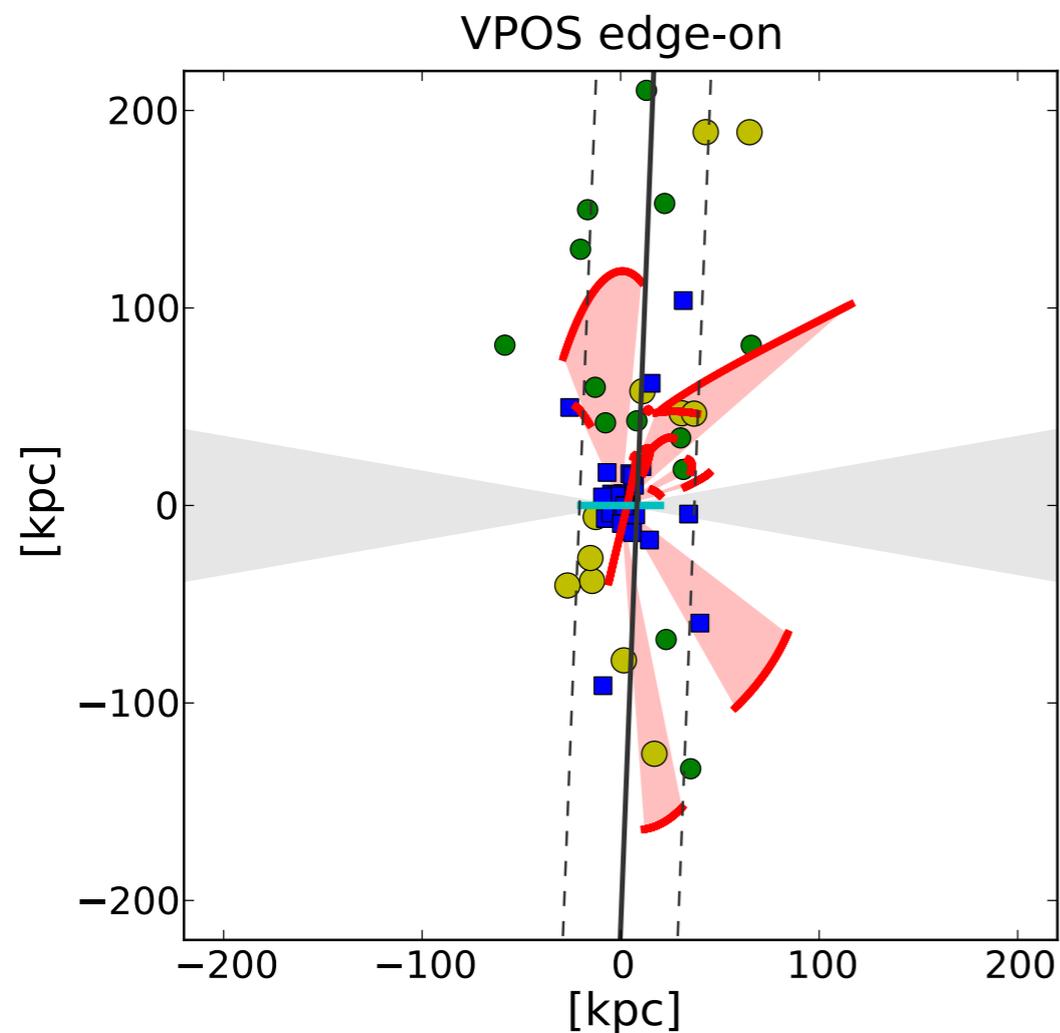


Pawlowski+ 2012; Pawlowski & Kroupa 2013

- The plane of satellites is a manifestation of anisotropic accretion (e.g. Libeskind+ 2007, 2014, Buck+ 2015).
- But the planar structure is nearly perpendicular on disk of the MW.

How do these configurations arise in LCDM?
Is this always the case?

Filamentary accretion

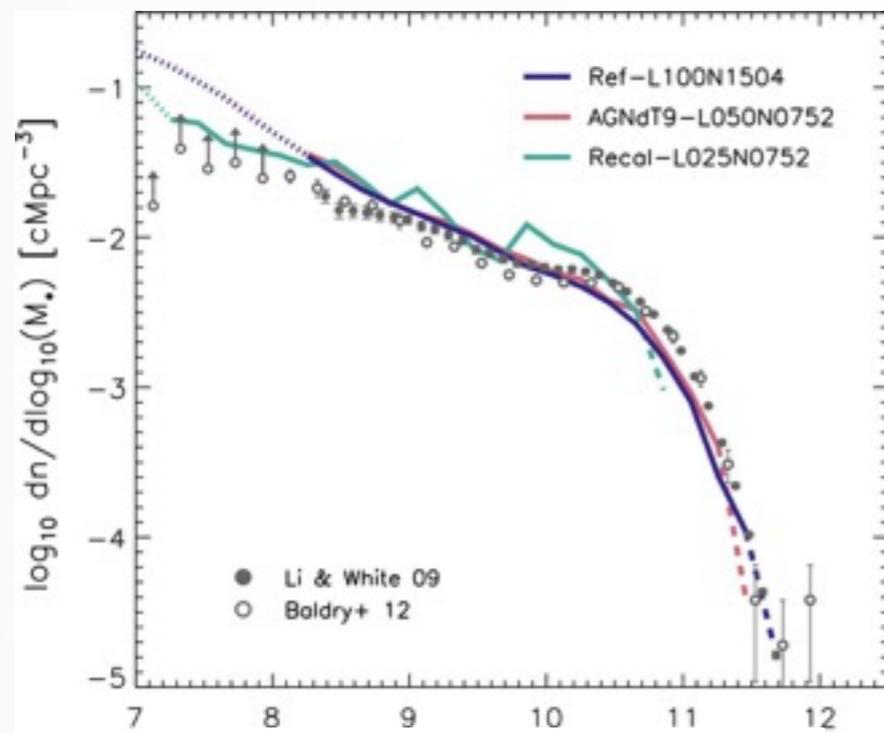
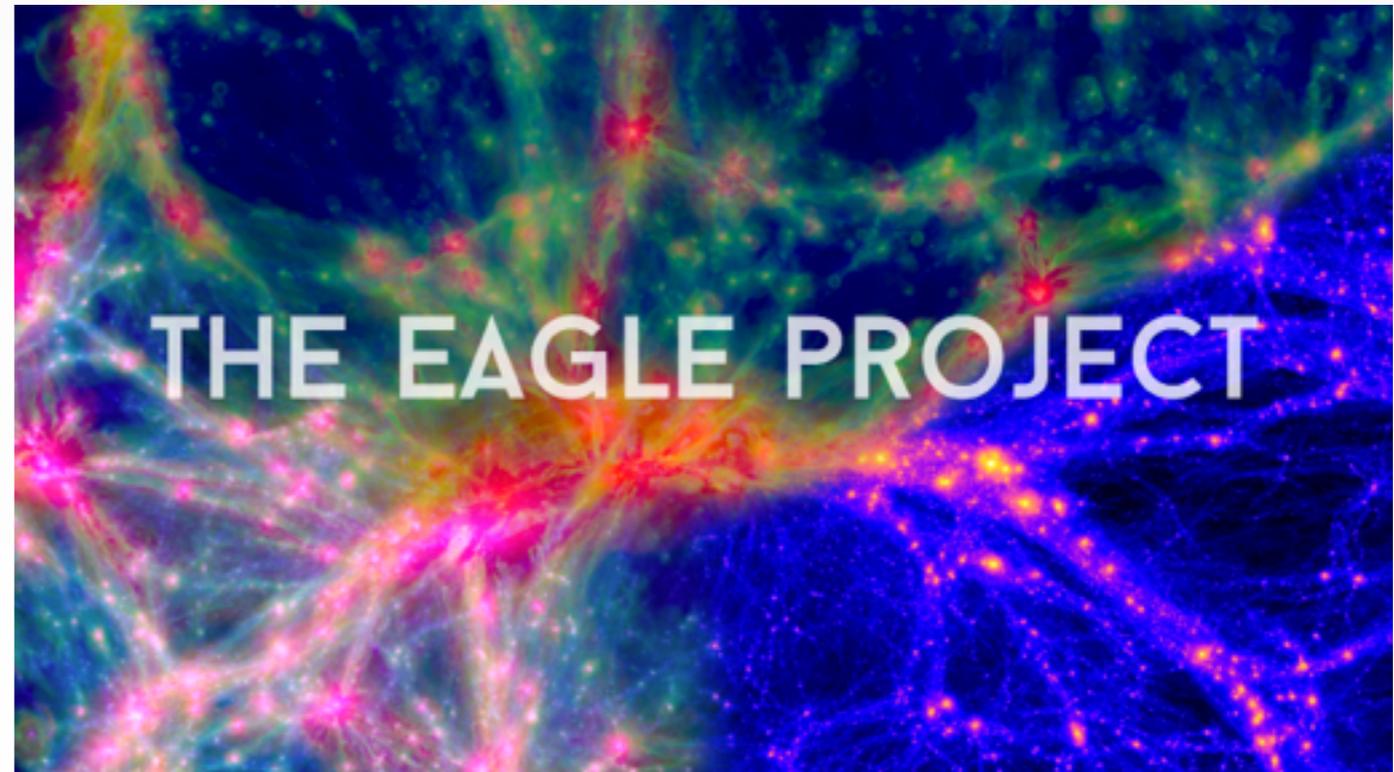


Pawlowski+ 2012; Pawlowski & Kroupa 2013

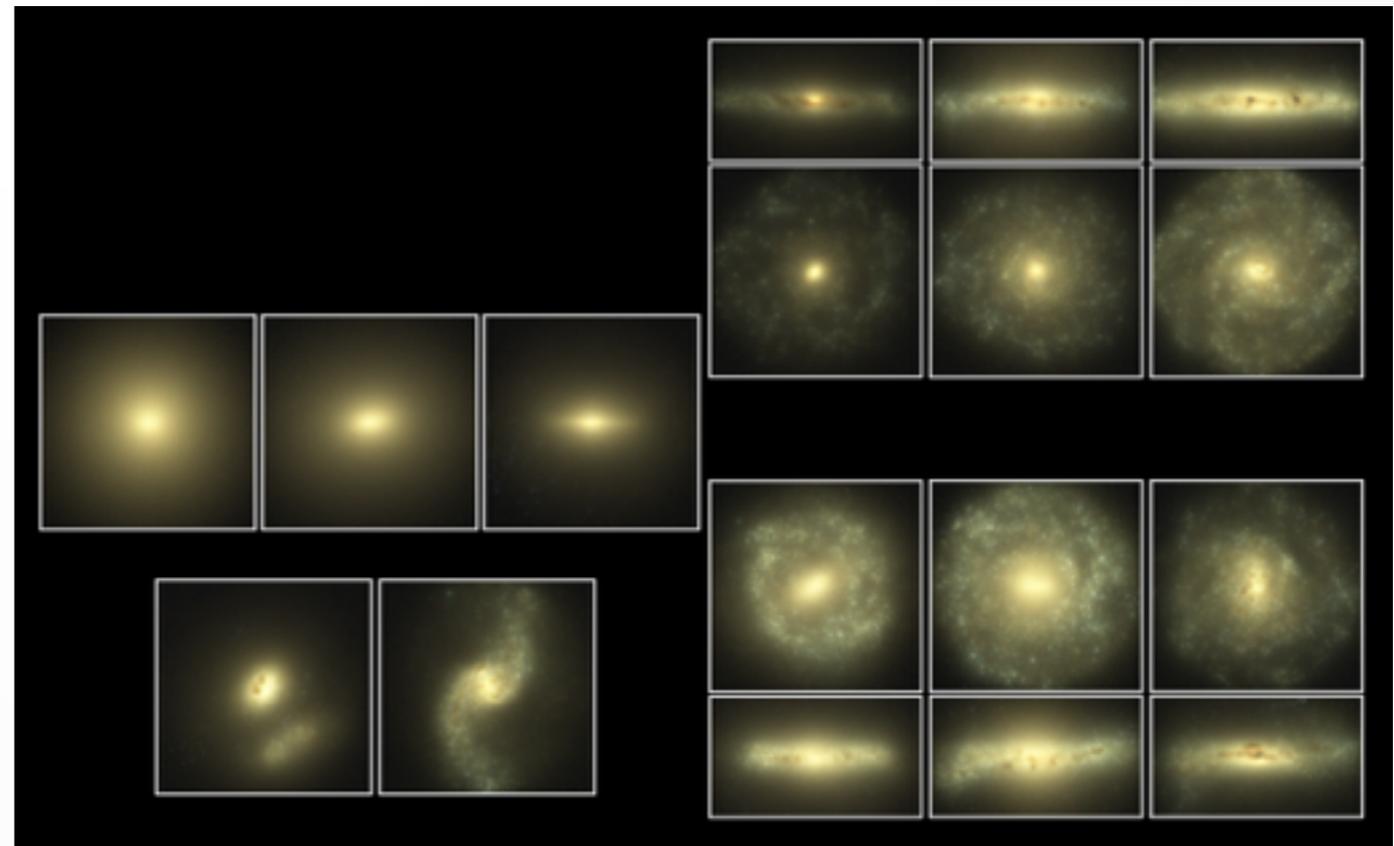
- The plane of satellites is a manifestation of anisotropic accretion (e.g. Libeskind+ 2007, 2014, Buck+ 2015).
- But the planar structure is nearly perpendicular on disk of the MW.
- Can such configurations arise in LCDM? How often is this the case?

EAGLE

- Evolution and Assembly of GaLaxies and their Environments
- A hydrodynamical cosmological simulation
- Box length of 100 Mpc
- Used 2×1504^3 particles (DM & gas)



Stellar mass function



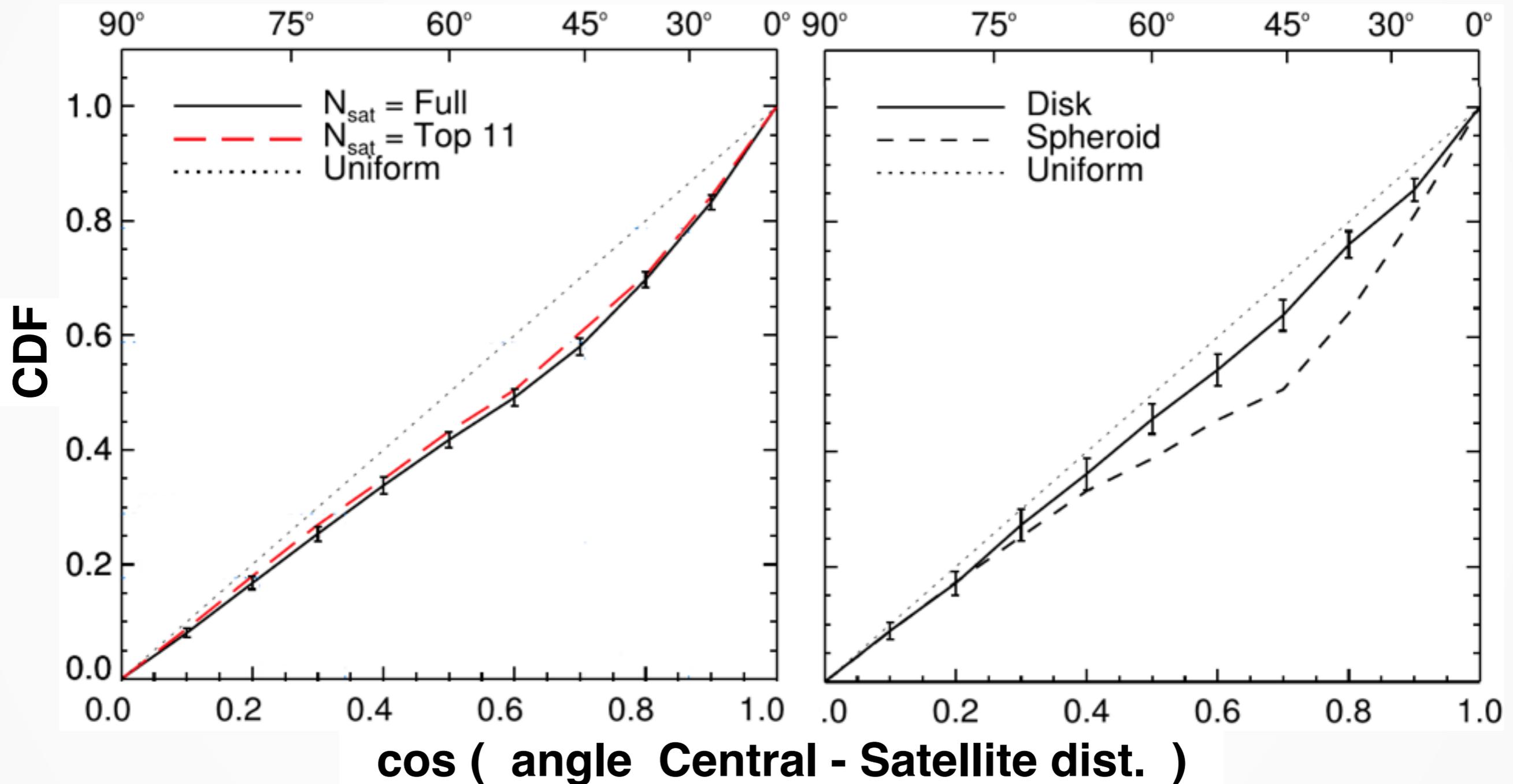
EAGLE sample selection

1. All centrals residing within MW-mass haloes.
2. Systems with at least 10 luminous satellites within 300 kpc.

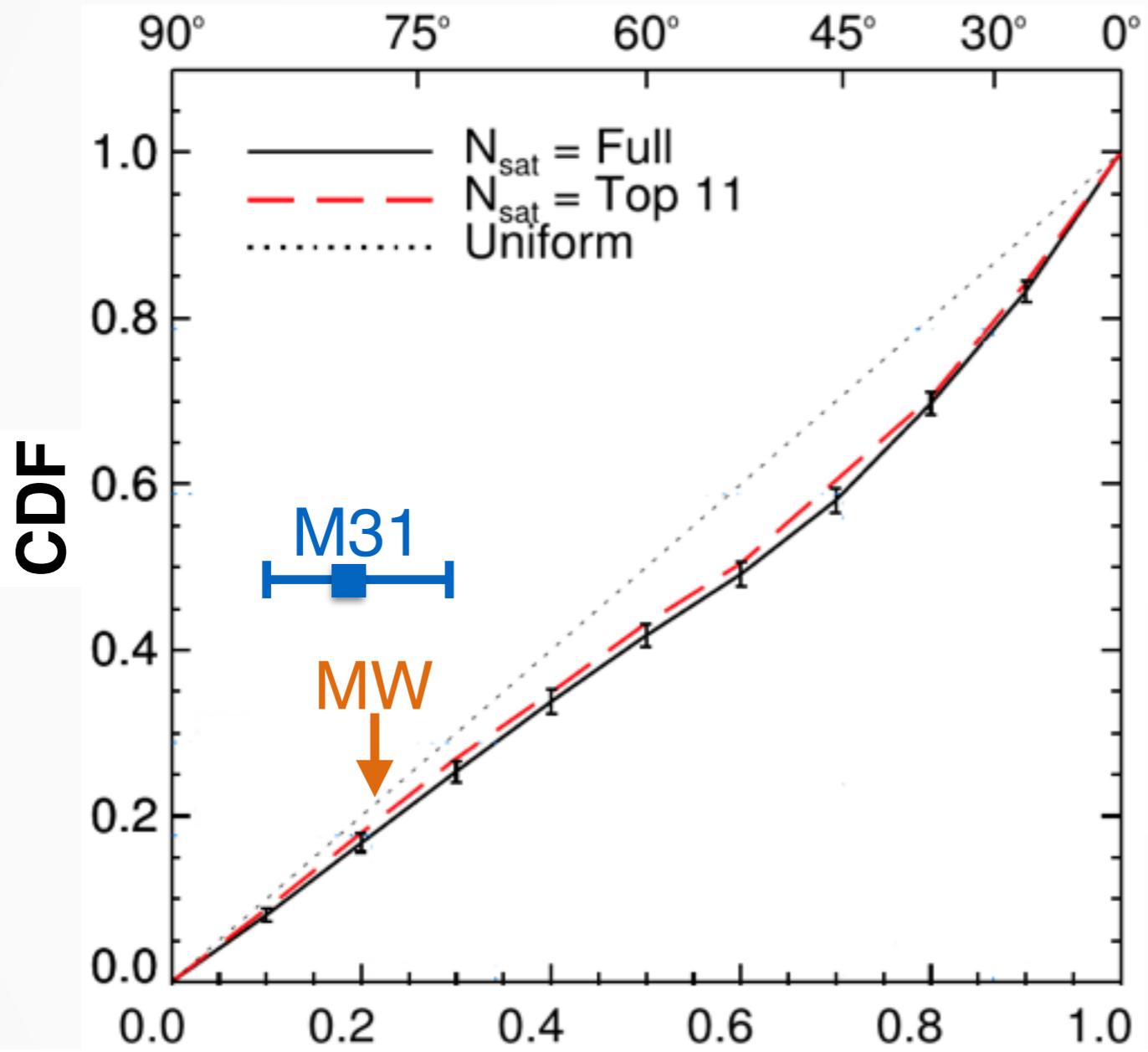
1080 systems

3. Find the principal axes of the inertia tensor for:
 - the distribution of satellite galaxies
 - central galaxy
 - the dark matter halo
4. Compute the misalignment angle between the minor axes of the various components.

The central - plane of satellites alignment



The LG systems



cos (angle Central - Satellite dist.)

Milky Way:

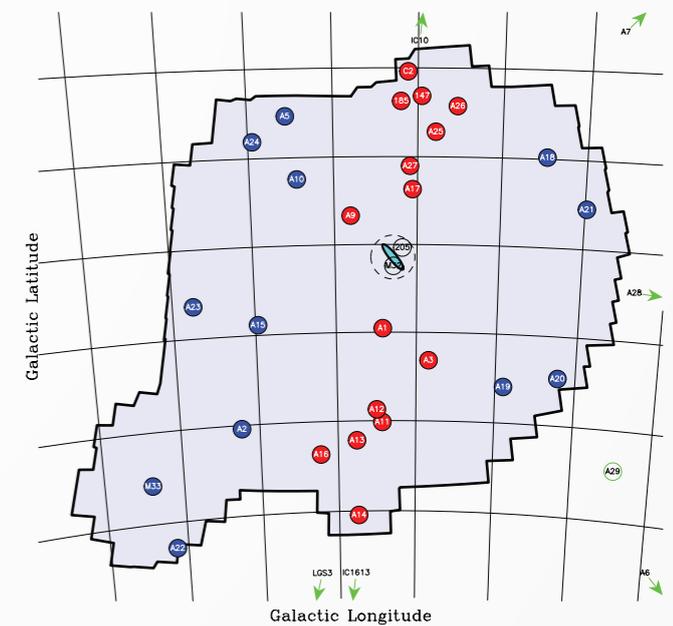
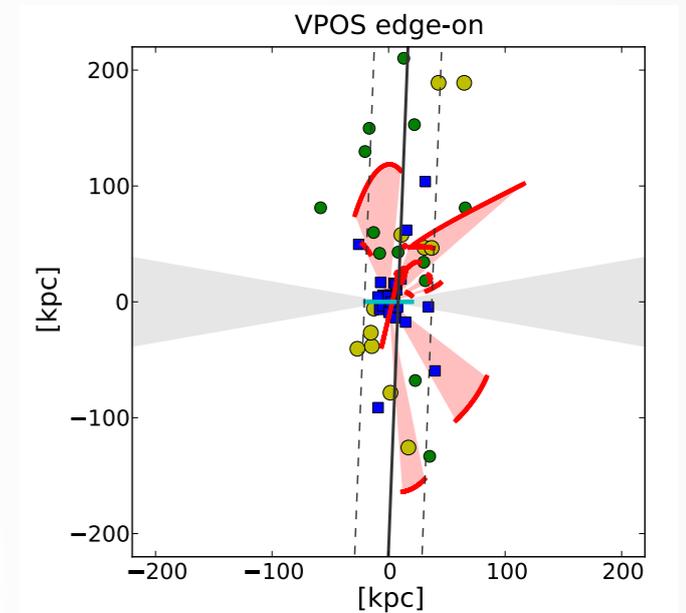
$$\cos \theta_{C-S} = 0.21$$

$$\theta_{C-S} = 77^\circ$$

Andromeda:

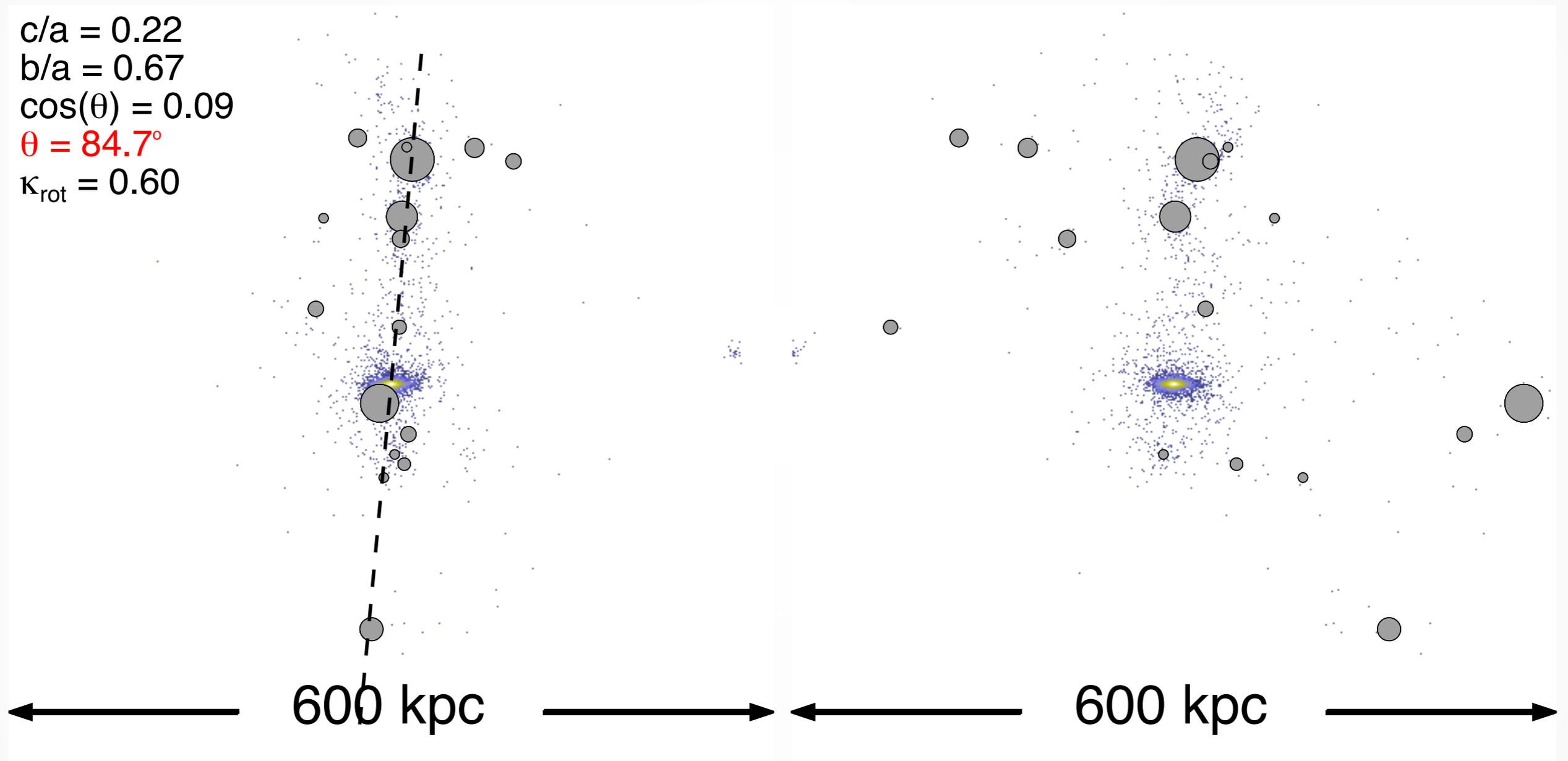
$$\cos \theta_{C-S} = 0.17$$

$$\theta_{C-S} = 80^\circ$$



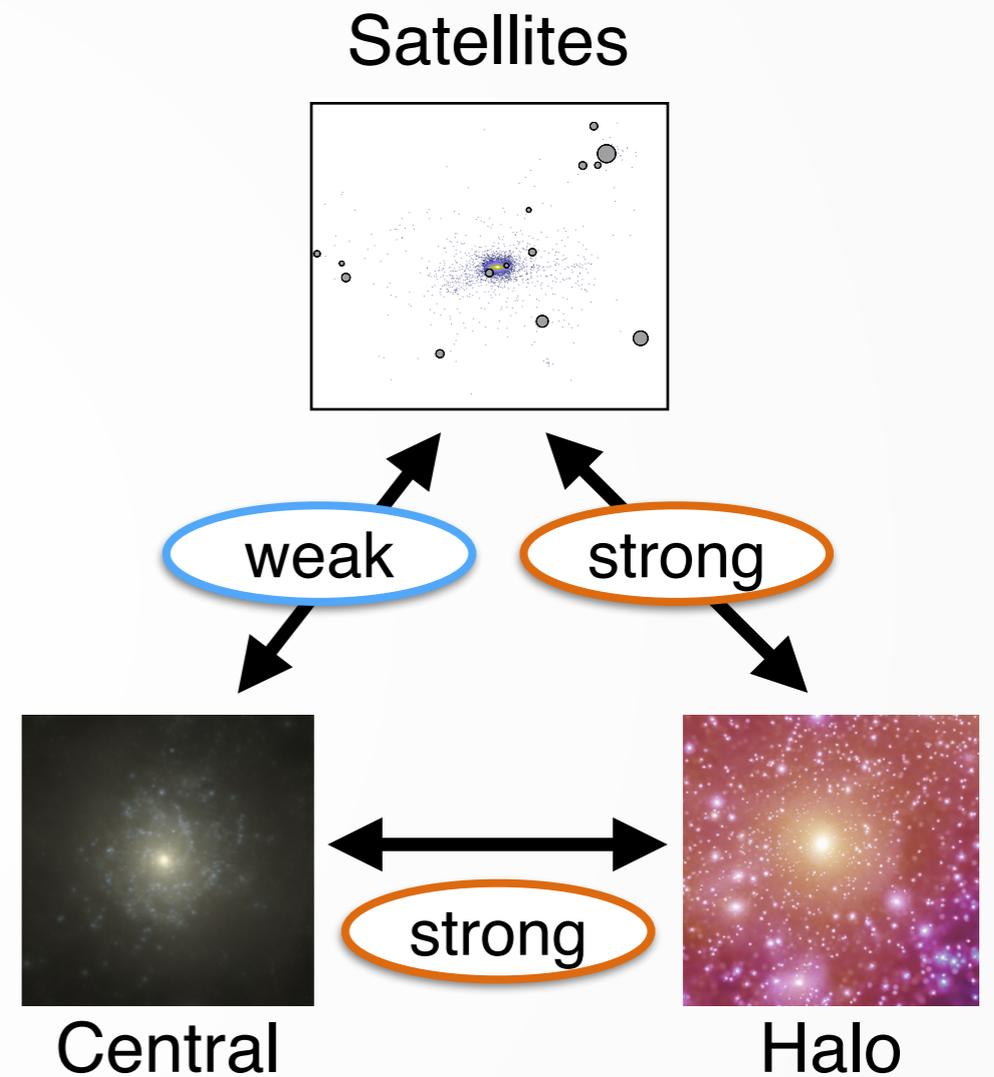
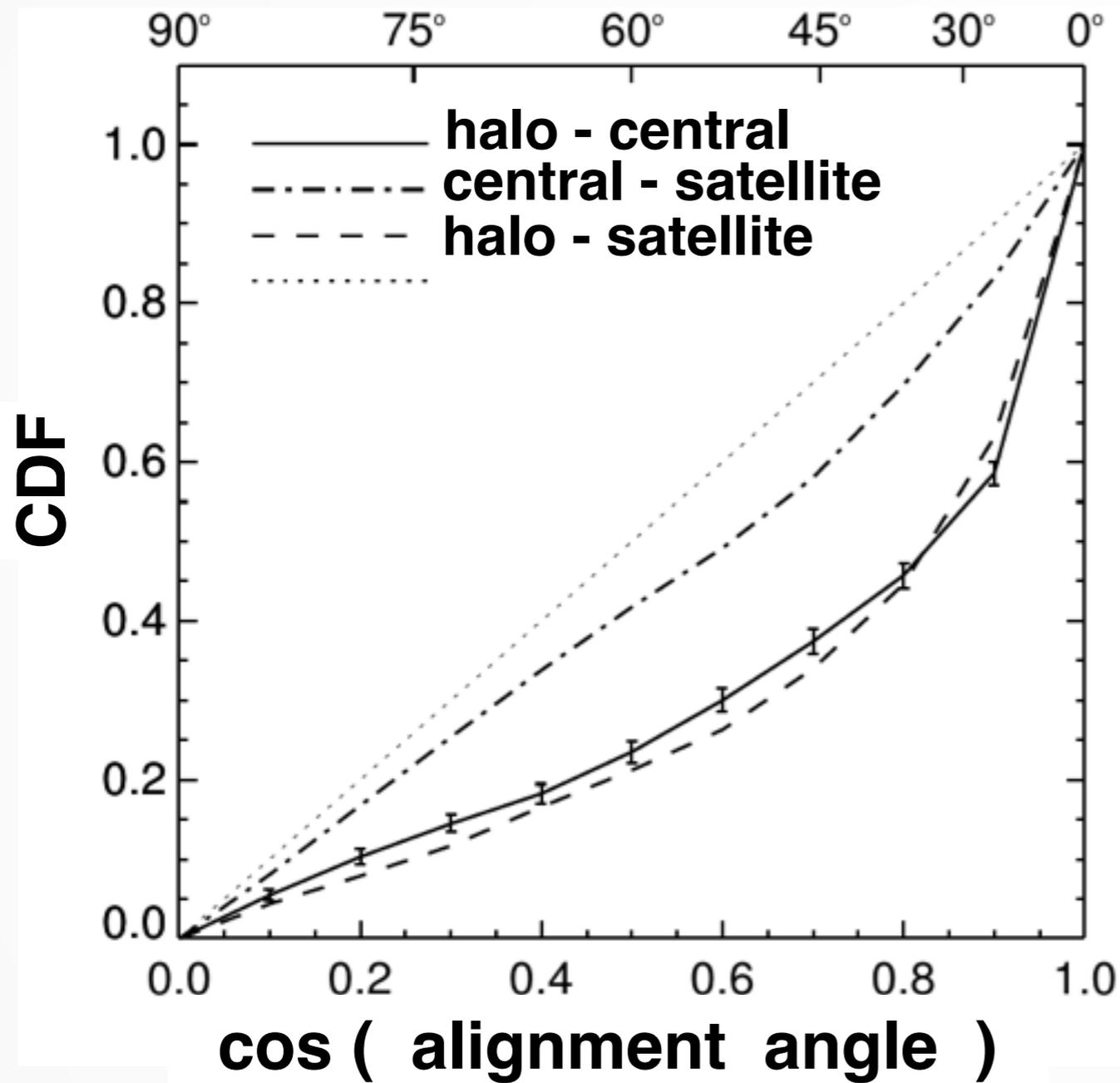
MW-like EAGLE galaxy

$c/a = 0.22$
 $b/a = 0.67$
 $\cos(\theta) = 0.09$
 $\theta = 84.7^\circ$
 $K_{\text{rot}} = 0.60$

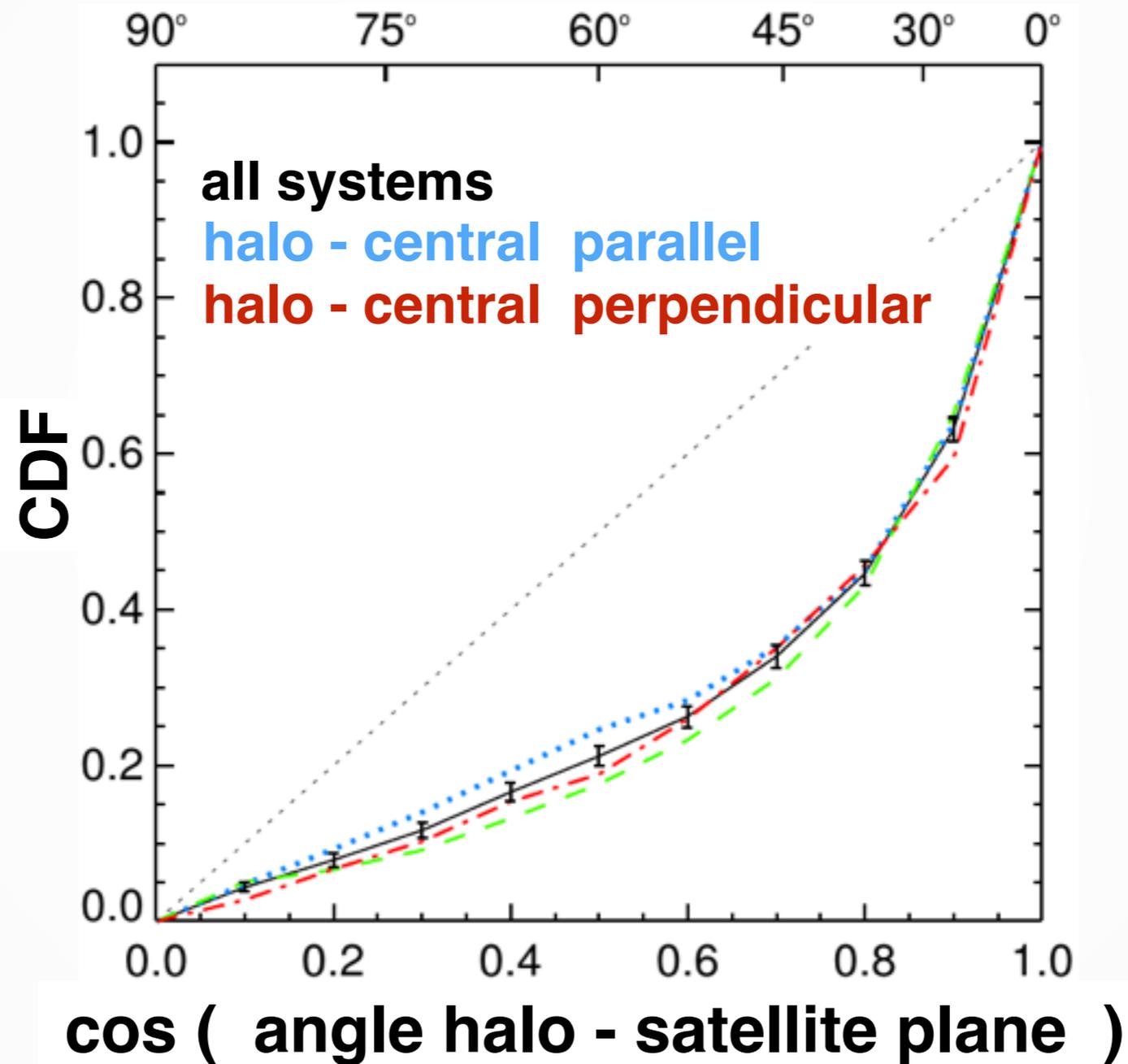


one of many more similar systems

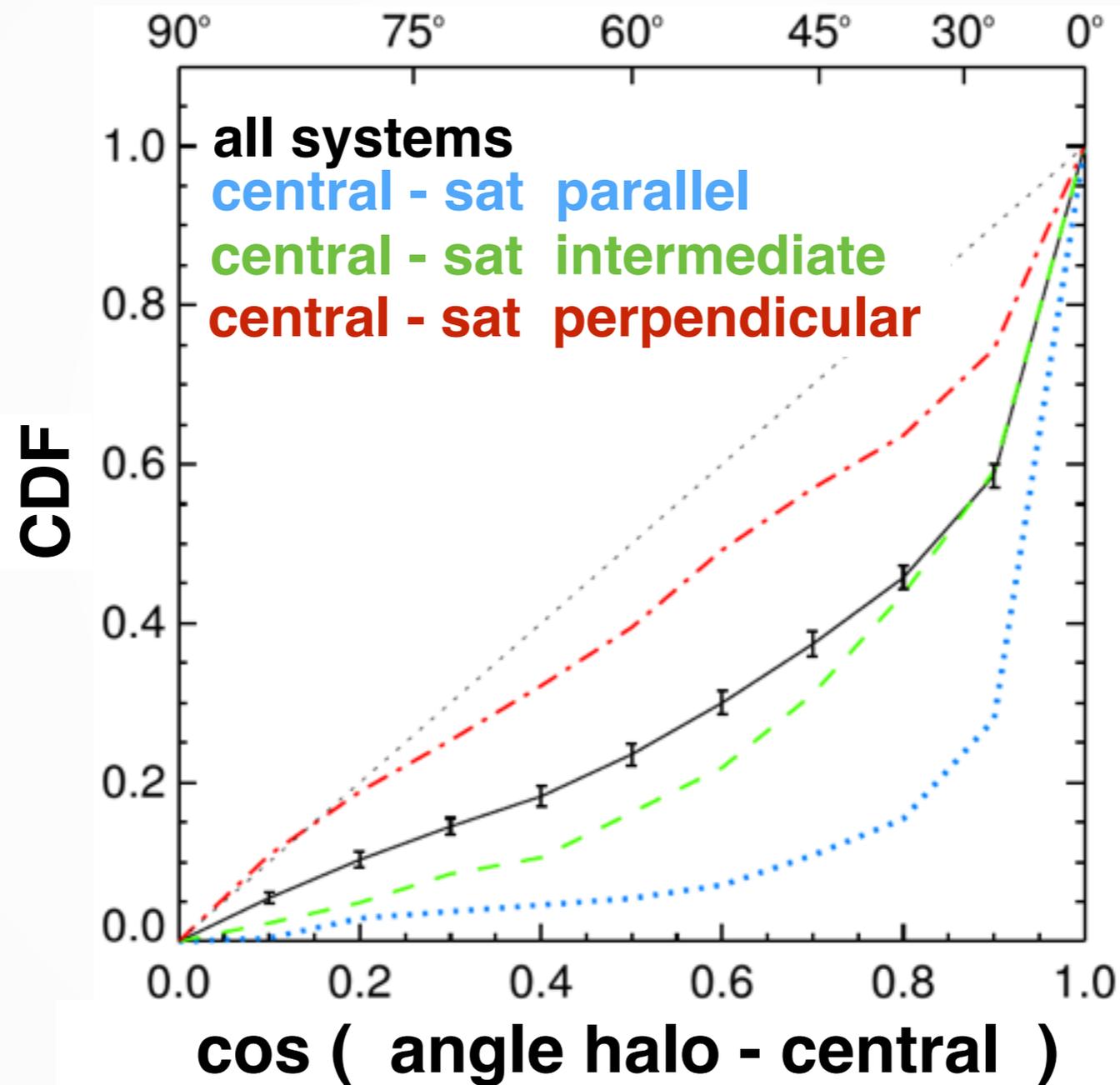
Overview



The central - satellite plane alignment

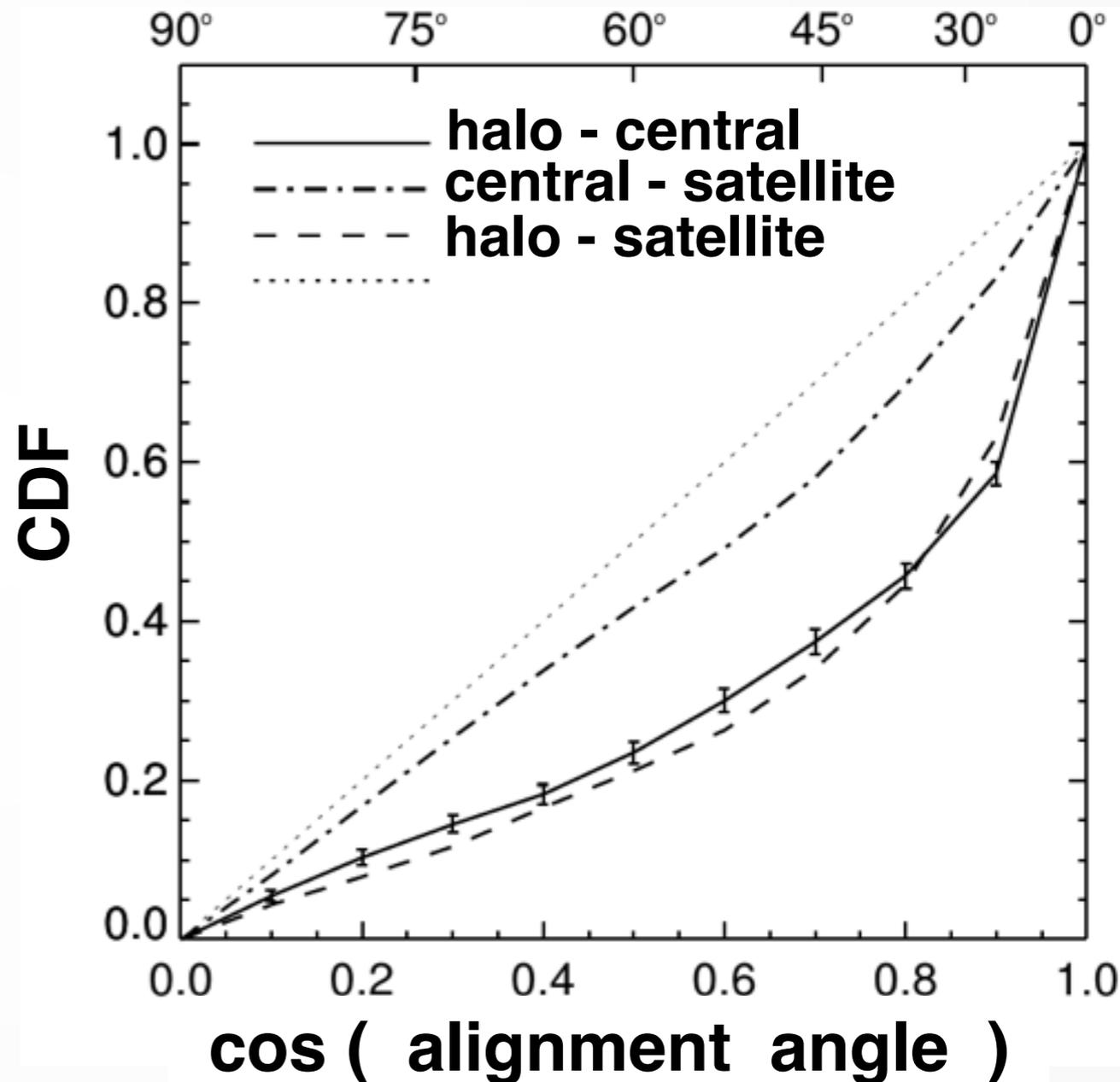


The central - satellite plane alignment



Summary

- Weak alignment between the **central & satellite plane** that arises from the strong alignment of both with the halo.
- Satellite distributions perpendicular to the central are common (20% are as perpendicular as the MW systems)
- The halo is very strongly aligned with the central and satellite plane for systems where the **central & satellite plane are parallel**



The question

What information is encoded
in the planes of satellite galaxies?

Alignment with LSS

