The expected shape of the Milky Way's dark matter halo

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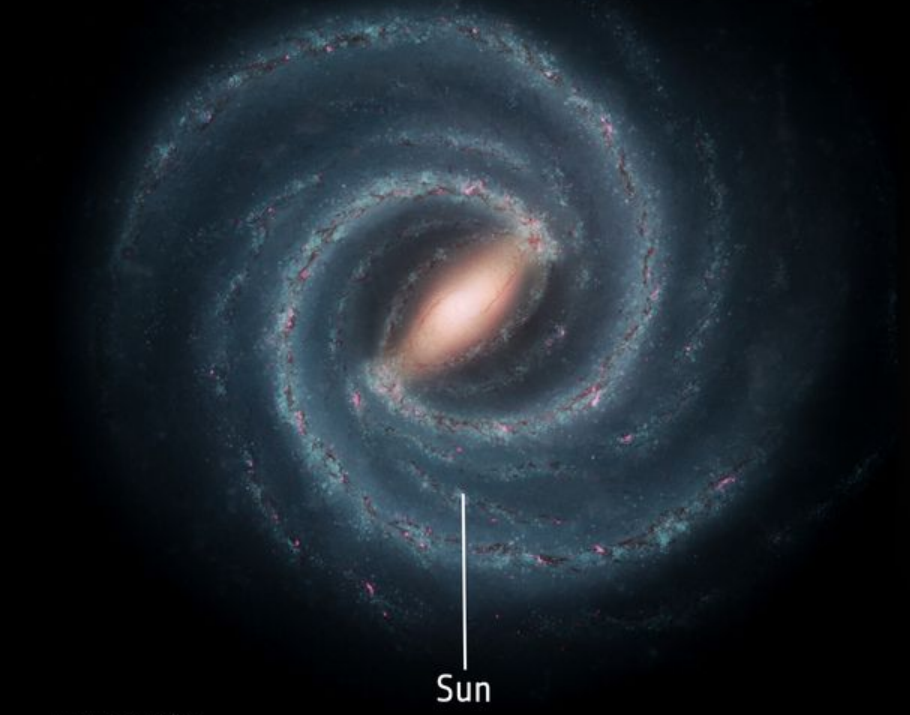
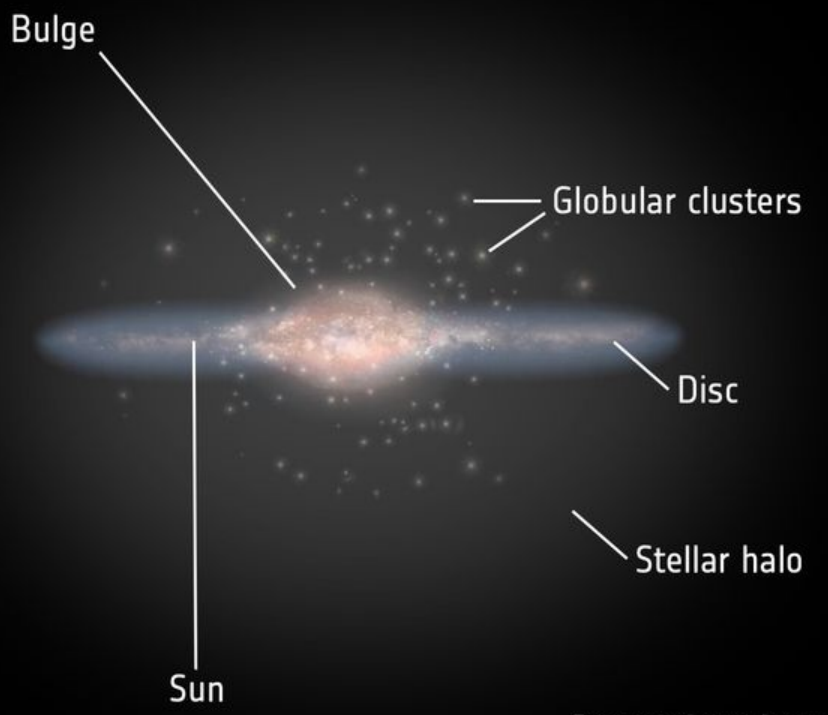
→ ANATOMY OF THE MILKY WAY





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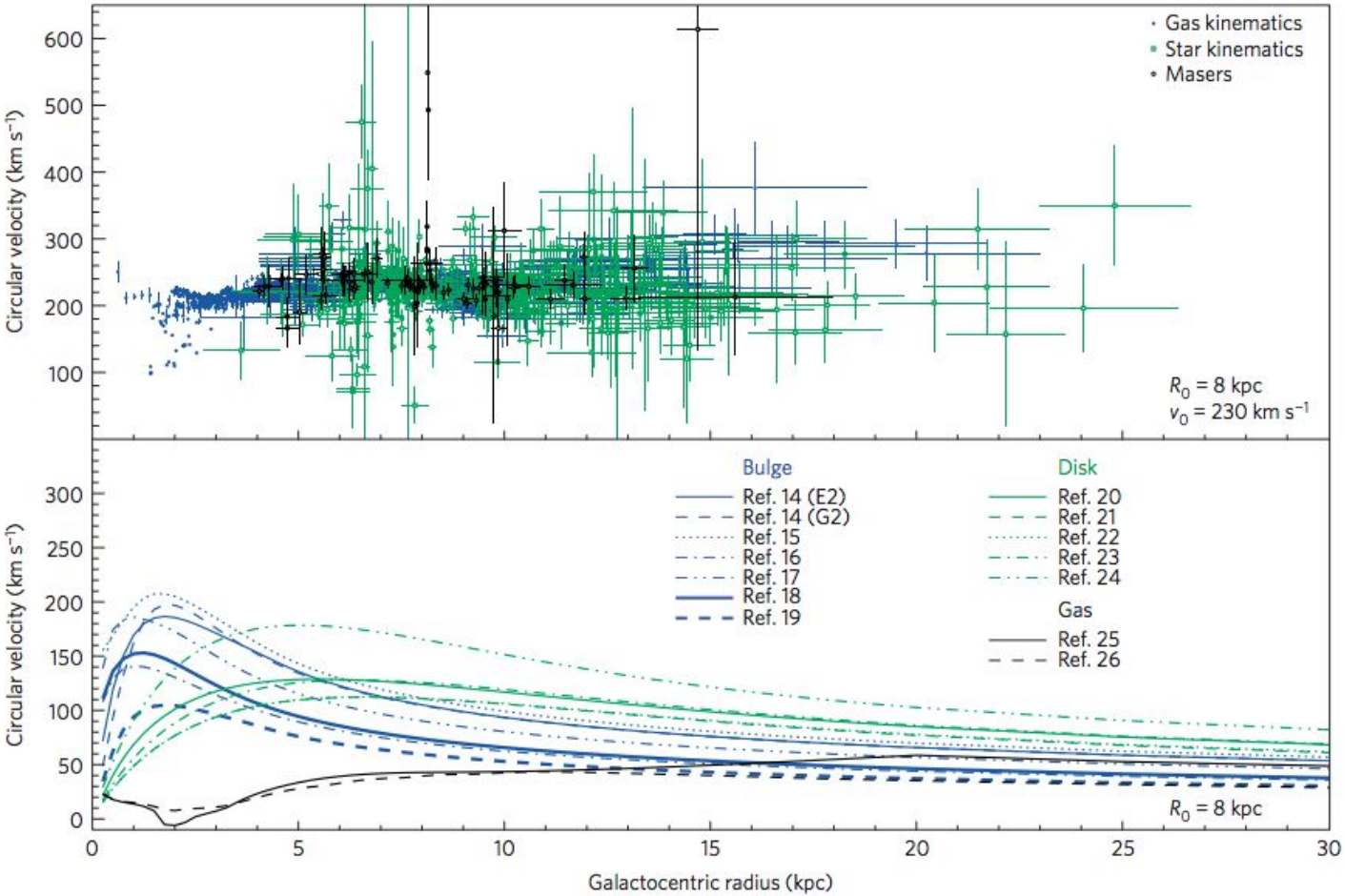
European Space Agency

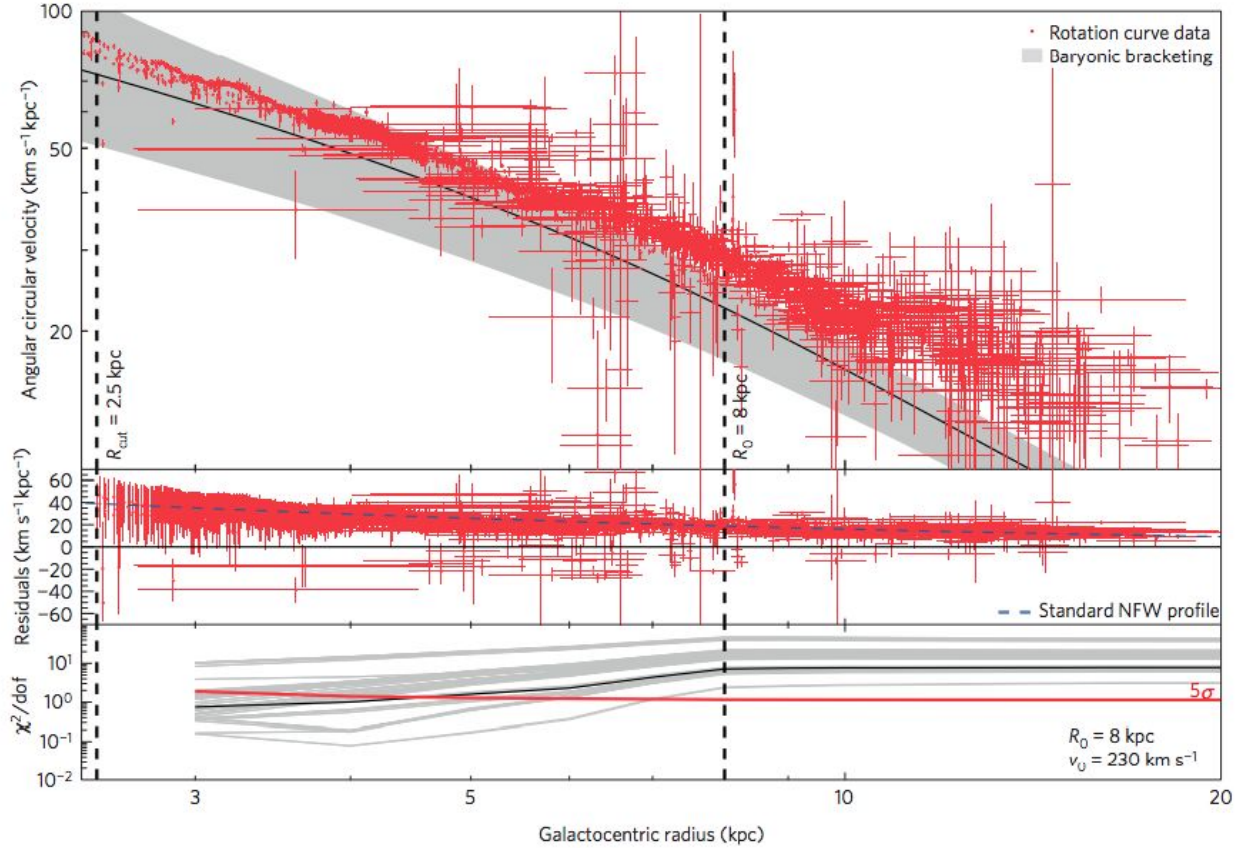


Iocco, Pato, Bertone (2015)

DM is assumed to have spherical symmetry

$$\rho_{\mathrm{DM}}(R) = \rho_0 \left(\frac{R_0}{R}\right)^{\gamma} \left(\frac{R_s + R_0}{R_s + R}\right)^{3-\gamma}$$

DM parameters are derived from global spherical averages



Iocco, Pato, Bertone (2015)

From observations we know that the MW potential is not spherical.

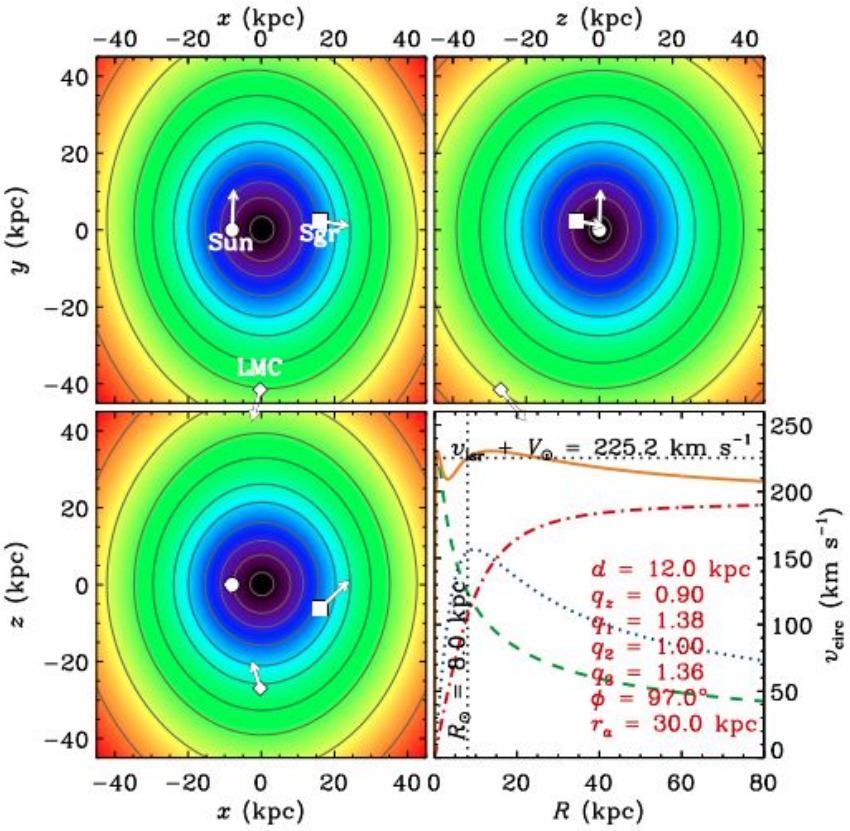
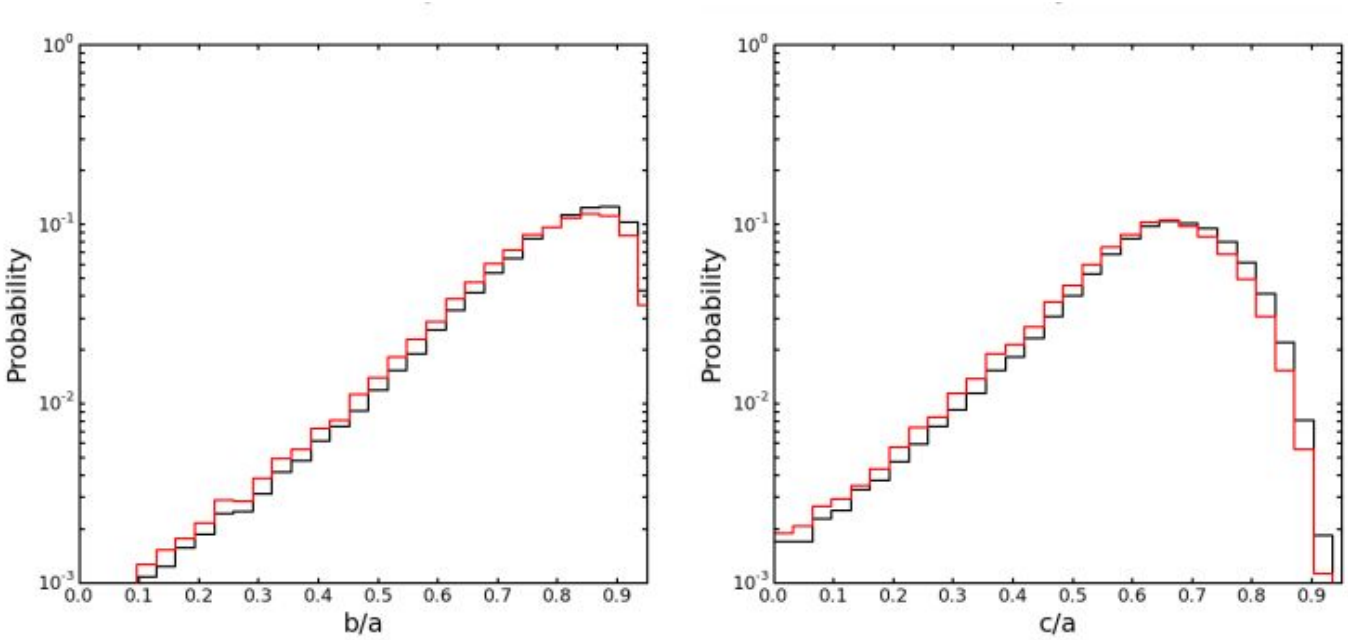


FIG. 1.— Dark halo potential isocontours on the plane $z = 0$ (top left), $y = 0$ (bottom left) and $x = 0$ (top right). For reference, we have included the positions and directions of motion for the Sun (circle), Sgr (square), and the LMC (diamond). The bottom right panel shows the circular velocity profile $v_{\rm circ}$ for the disk (dotted blue), bulge (dashed green), and halo (dash dotted red). The halo makes a transition from oblate to triaxial at $r_a = 30$ kpc.

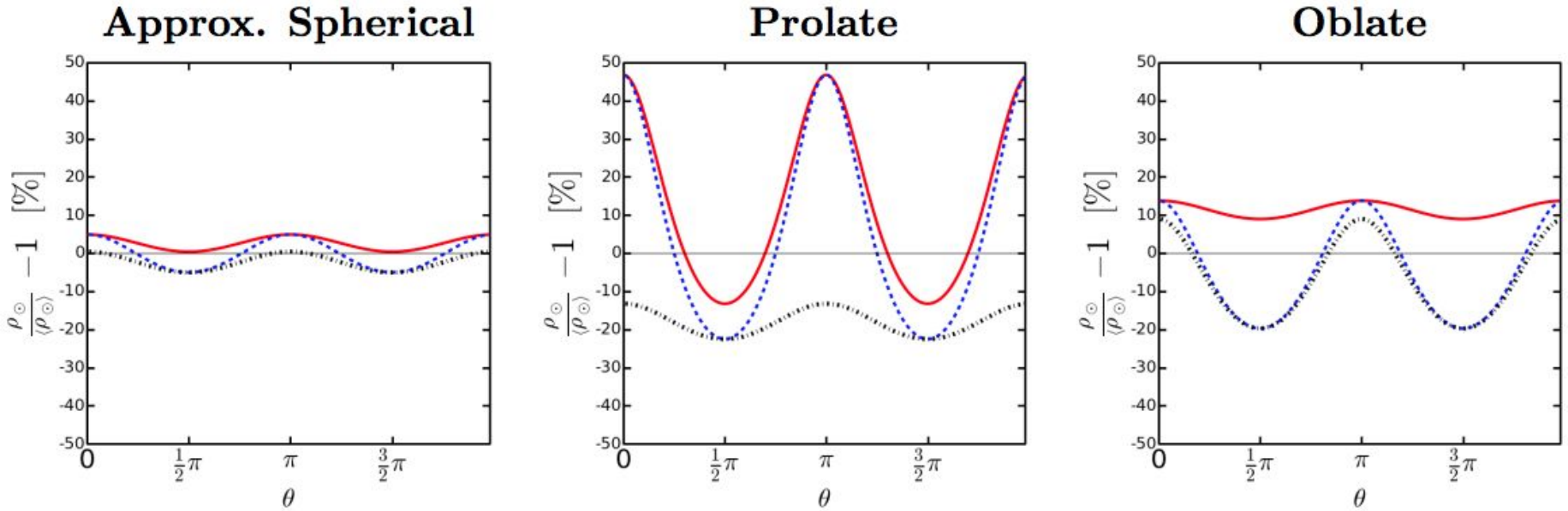
Vera-Ciro, Helmi (2013)

From simulations we know that DM halos are ellipsoidal



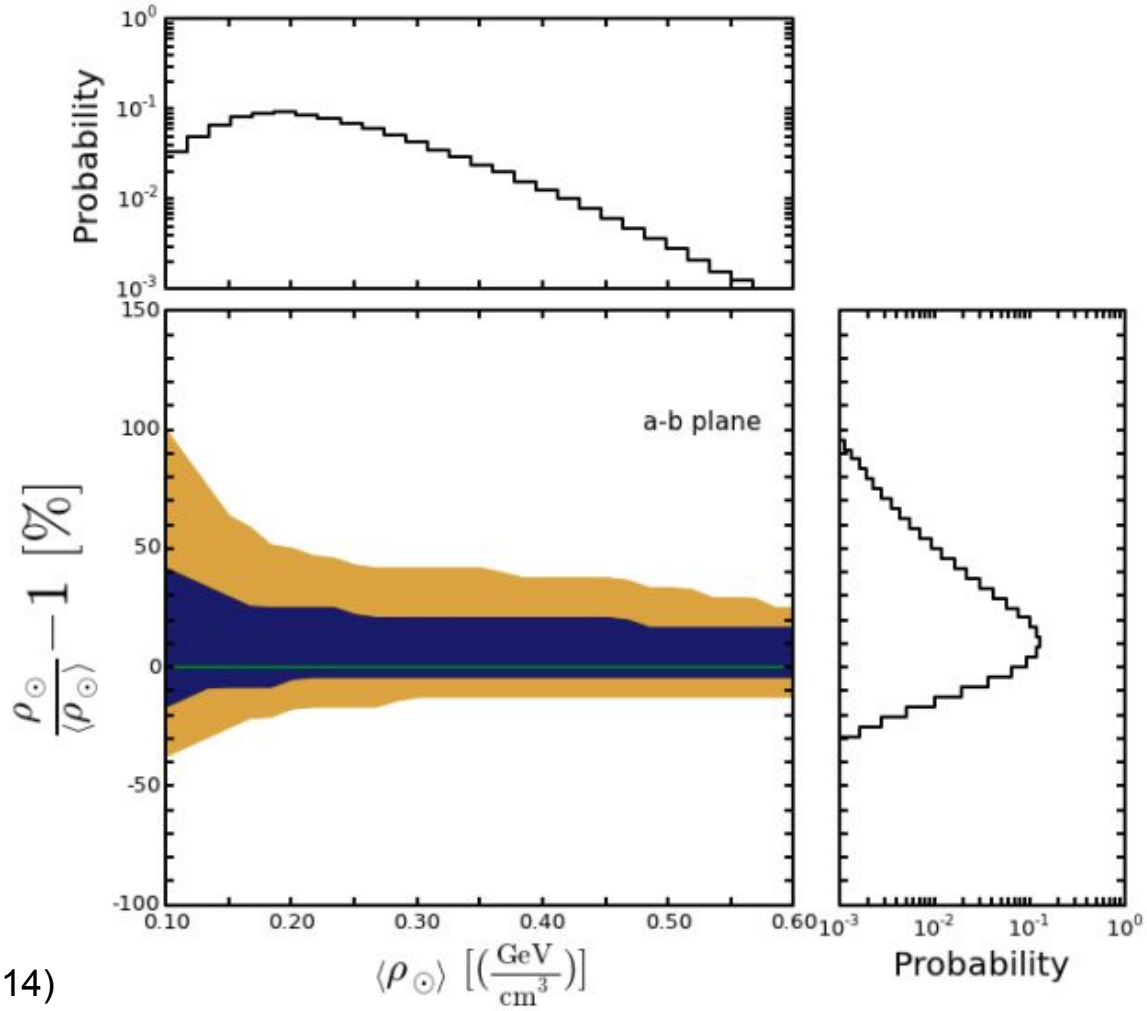
Bernal, FR, Garani, Palomares-Ruiz (2014)

Deviations from spherical symmetry are relevant for DM detection



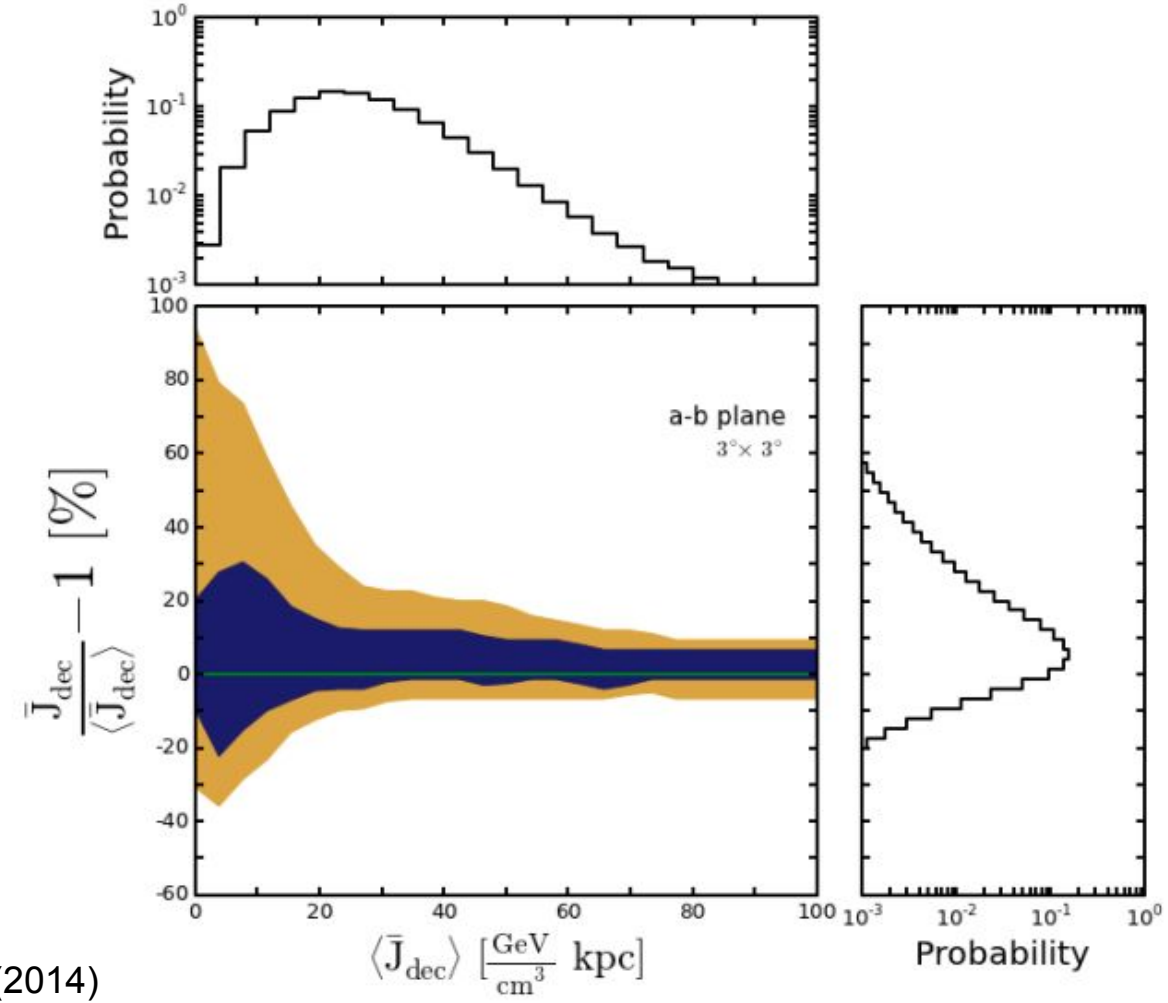
Bernal, FR, Garani, Palomares-Ruiz (2014)

Larger uncertainties on local DM density from asphericity.



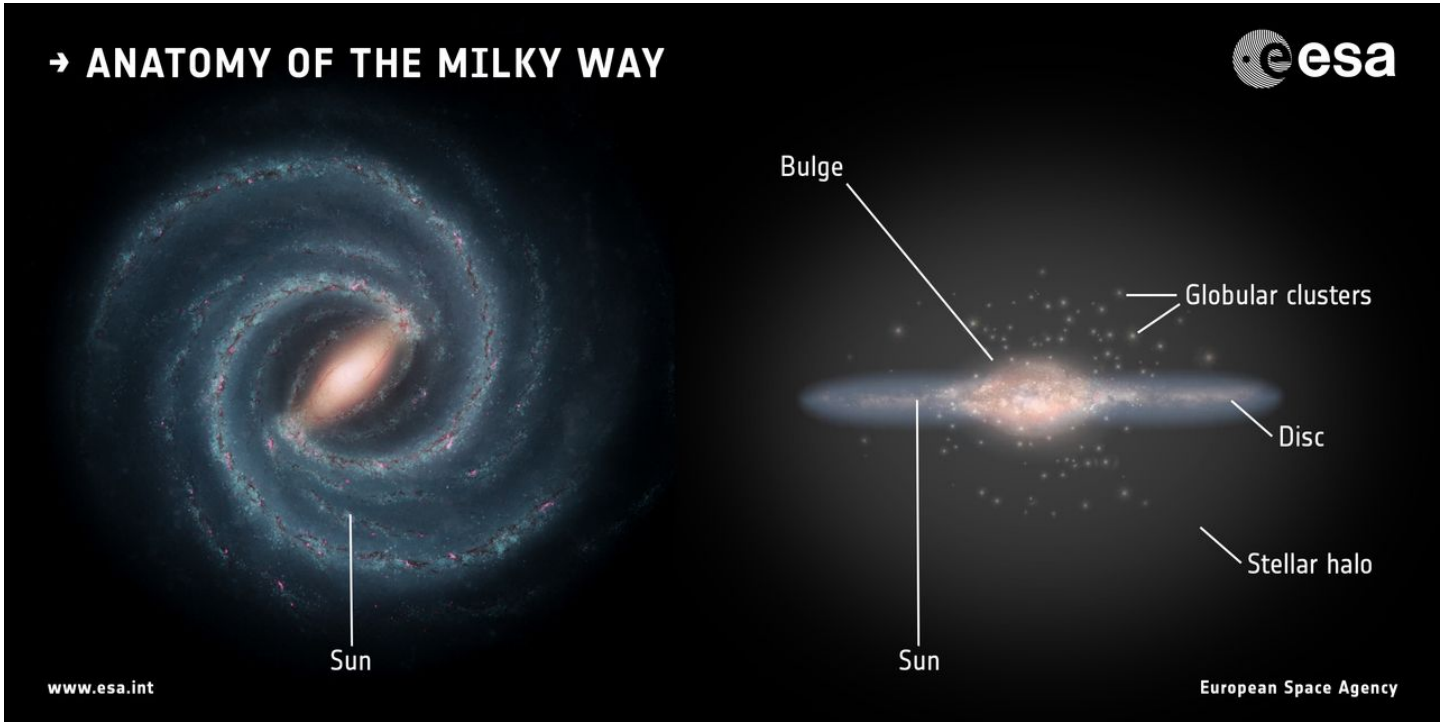
Bernal, FR, Garani, Palomares-Ruiz (2014)

Larger uncertainties on integrated squared density from asphericity.

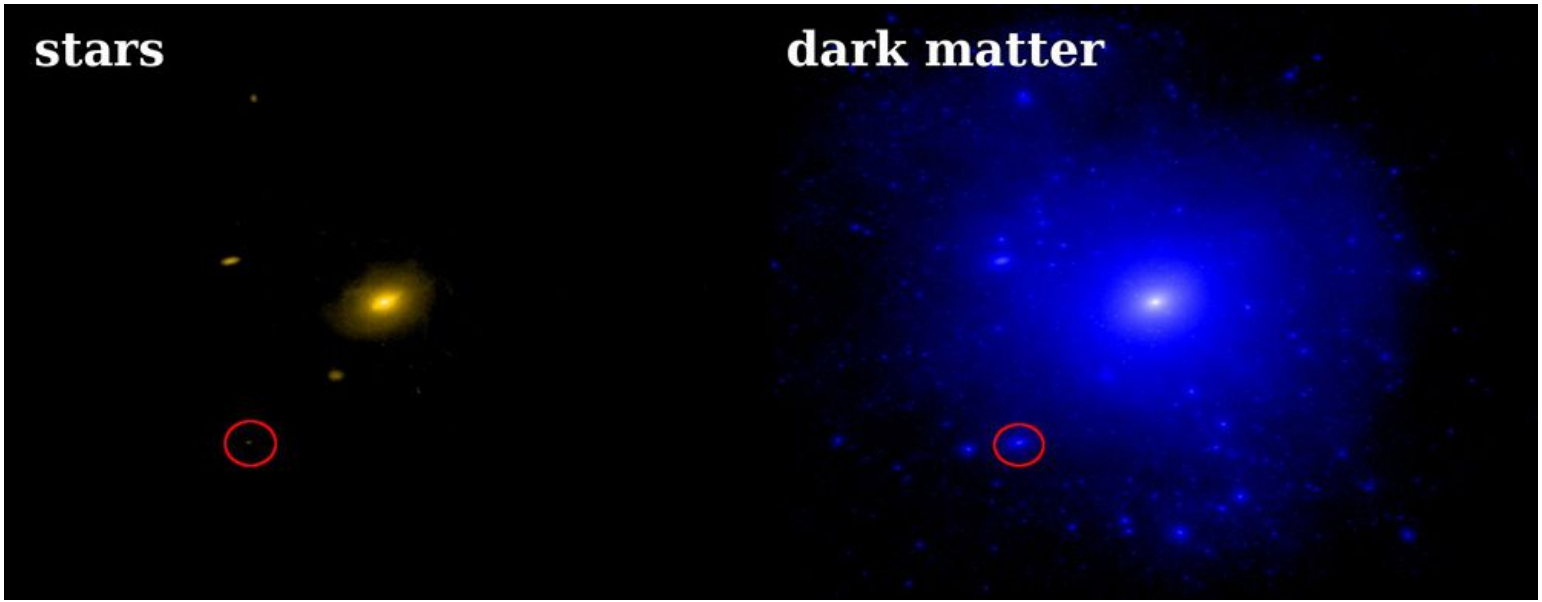


Bernal, FR, Garani, Palomares-Ruiz (2014)

What is the expected shape of the MW DM halo?

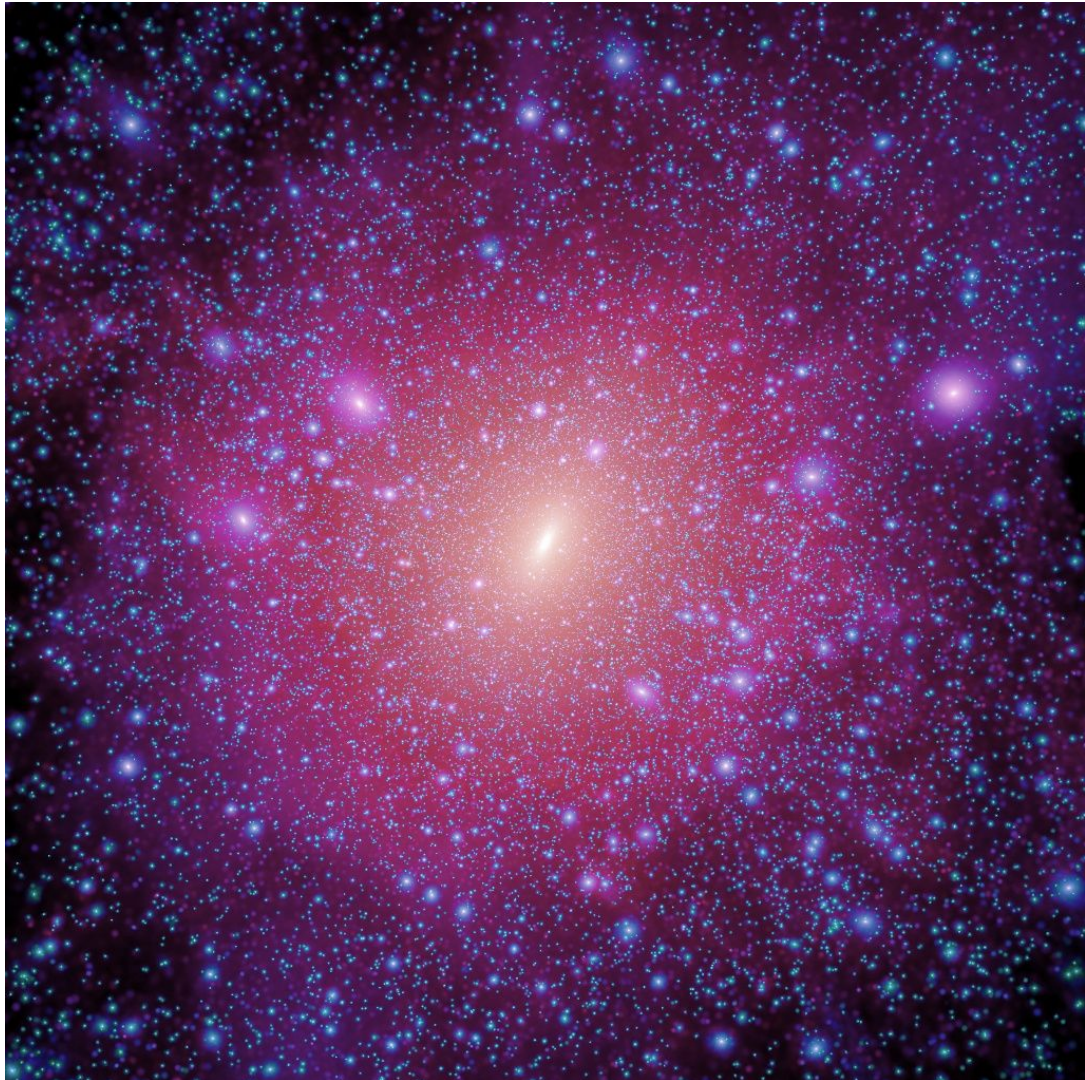


Main approach: use simulations of the MW and measure the DM halo shape



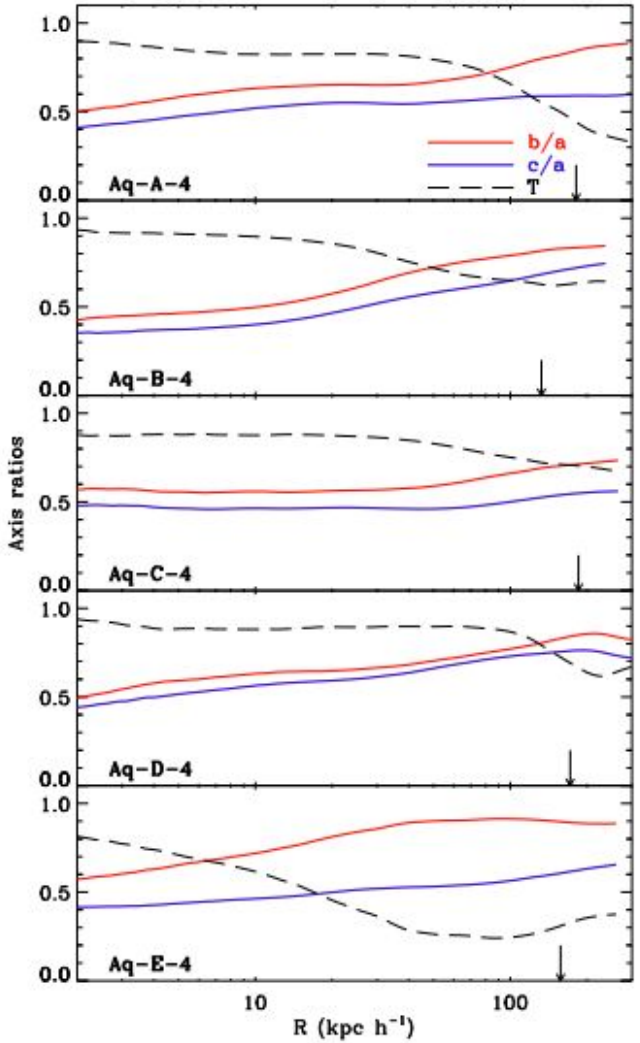
A. Wetzel + P. Hopkins

First attempt: run DM only simulations



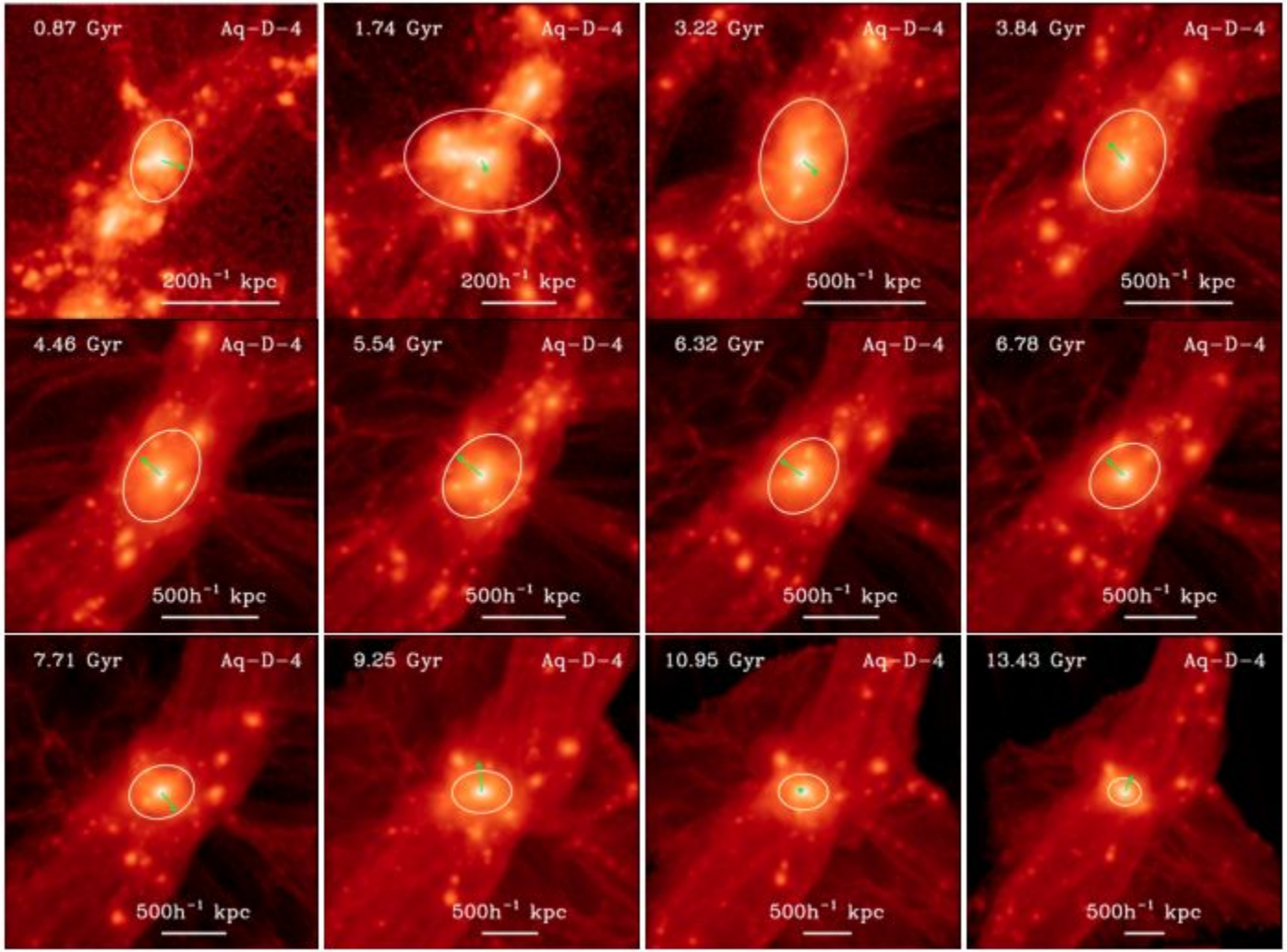
Aquarius Project (2008)

Shape changes inside the halo. It gets slightly rounder at the outskirts.



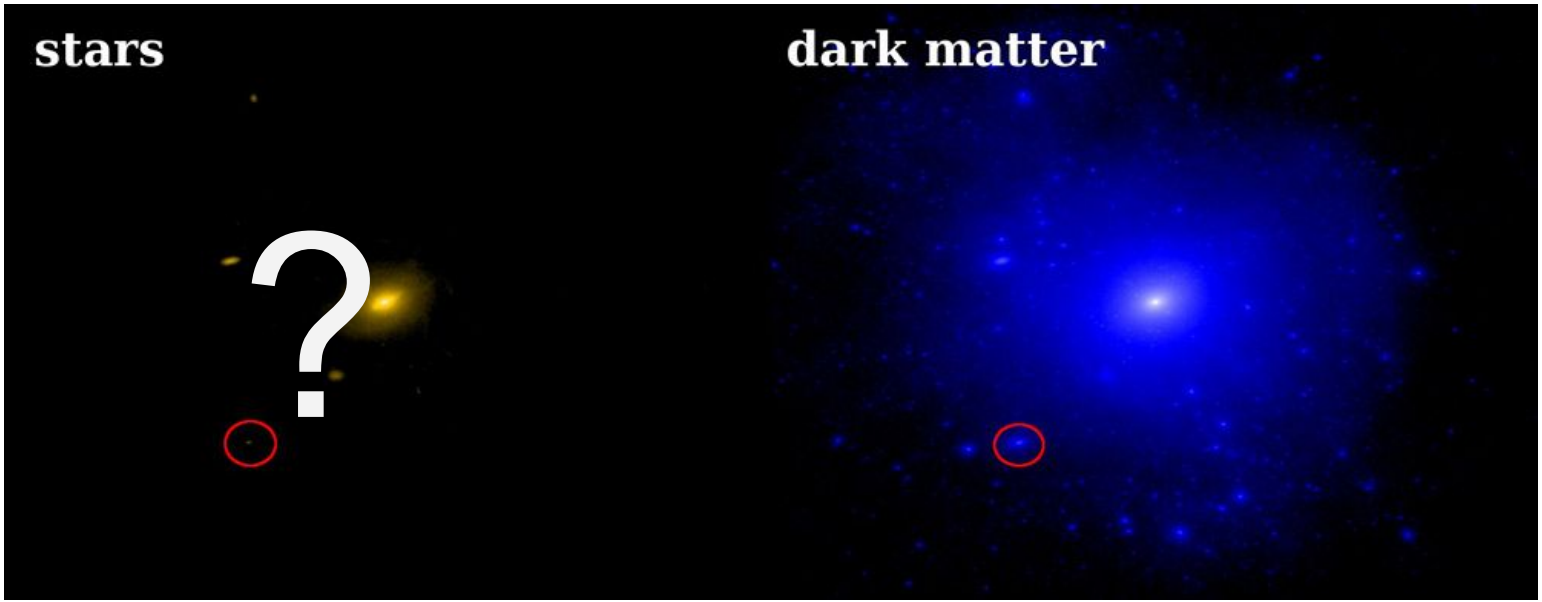
Vera-Ciro+ (2011)

Shape evolves in time.



Vera-Ciro+ (2011)

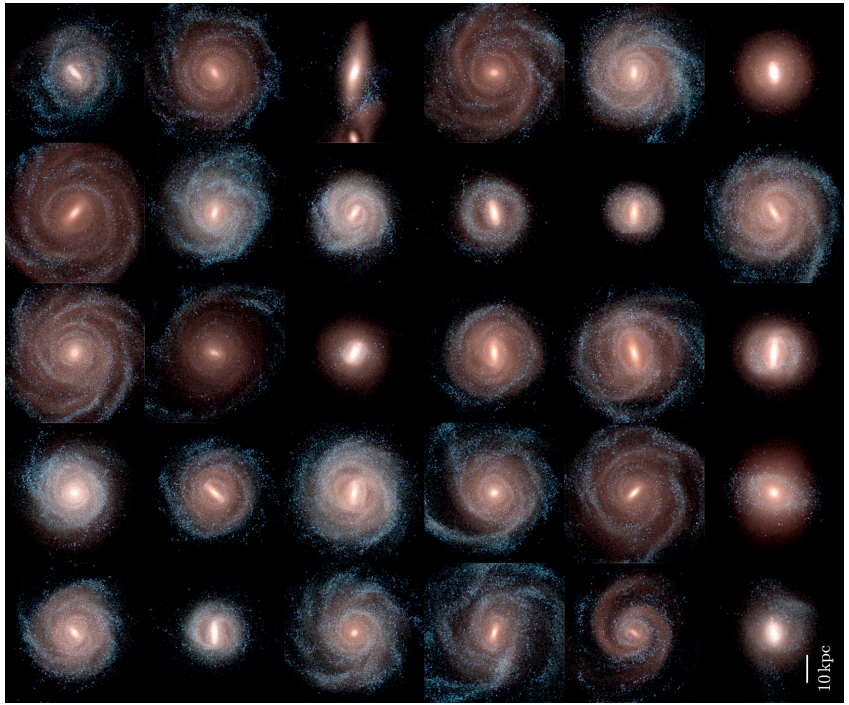
DM only simulations have multiple limitations



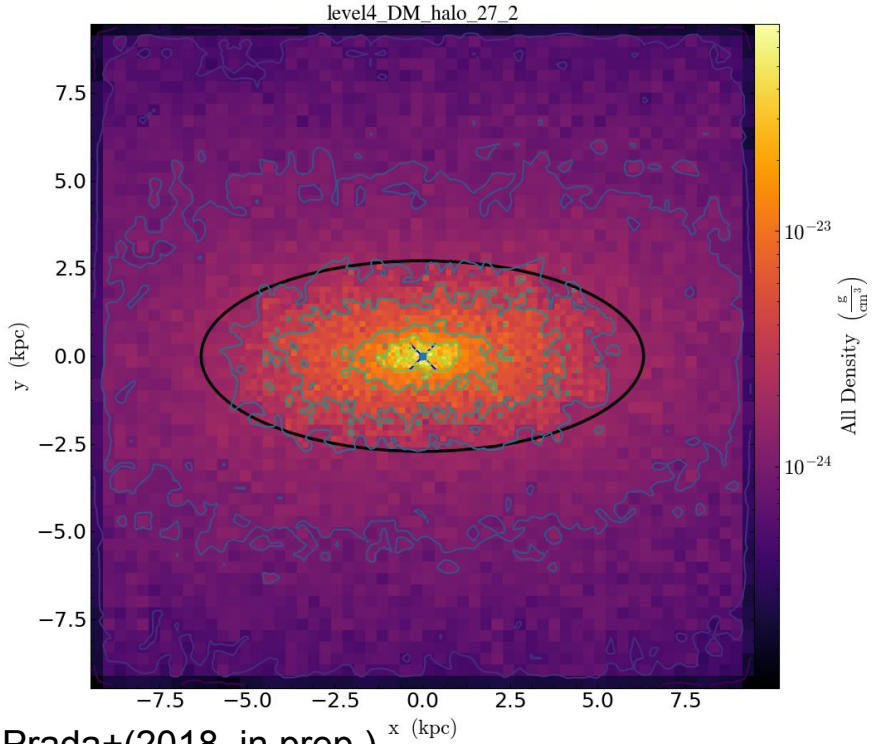
A. Wetzel + P. Hopkins

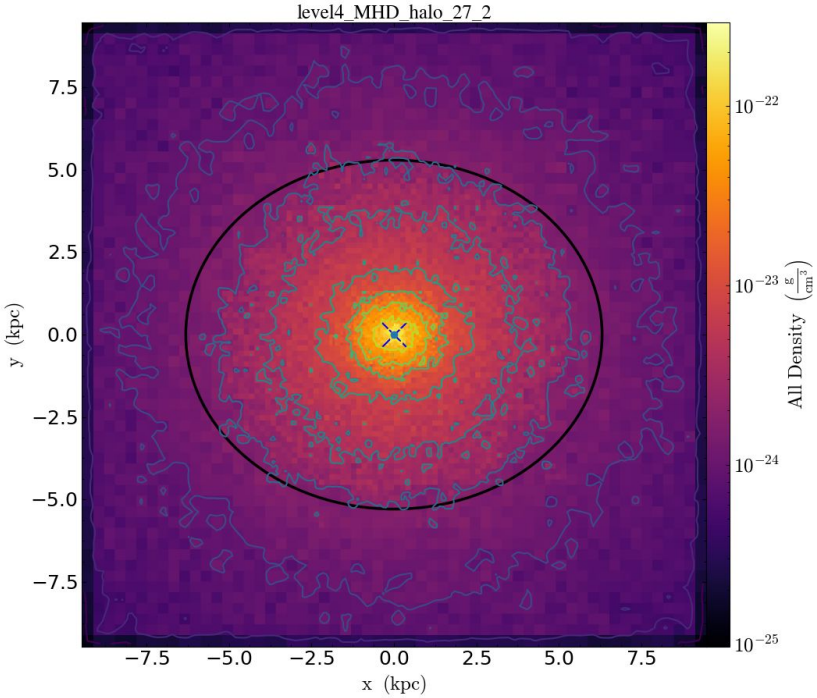
The Auriga Project overcomes these limitations

Includes gas, star formation and magnetohydrodynamics (MHD).
There are identical DM only simulations to compare.



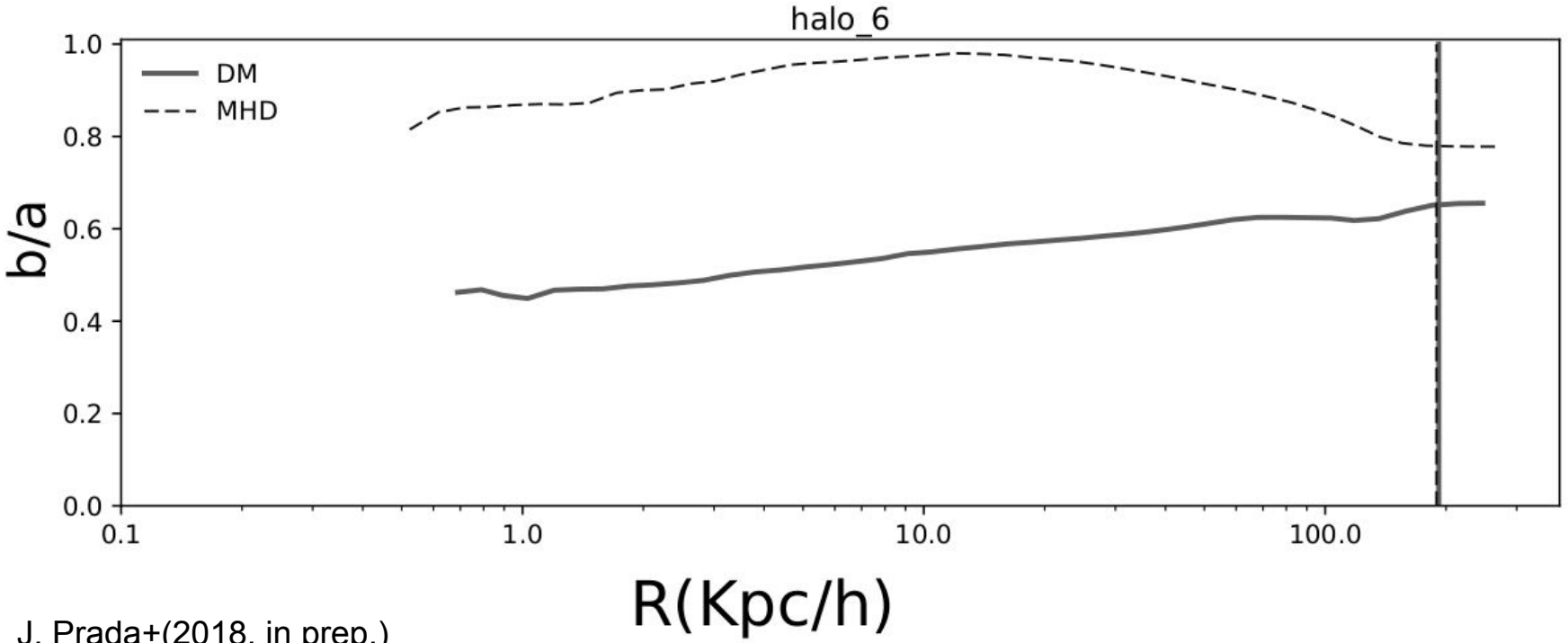
MHD physics produces rounder halos





J. Prada+(2018, in prep.)

MHD halos are closer to axisymmetric

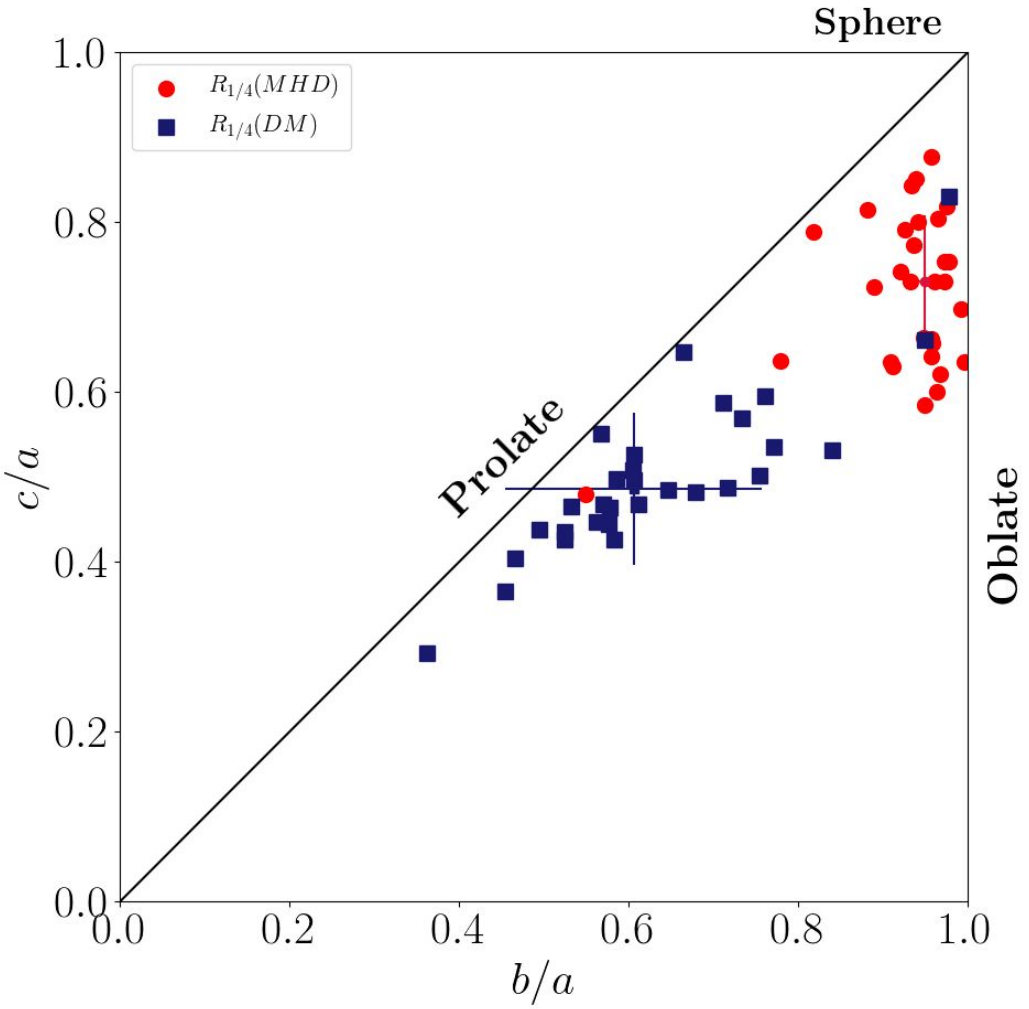


J. Prada+(2018, in prep.)

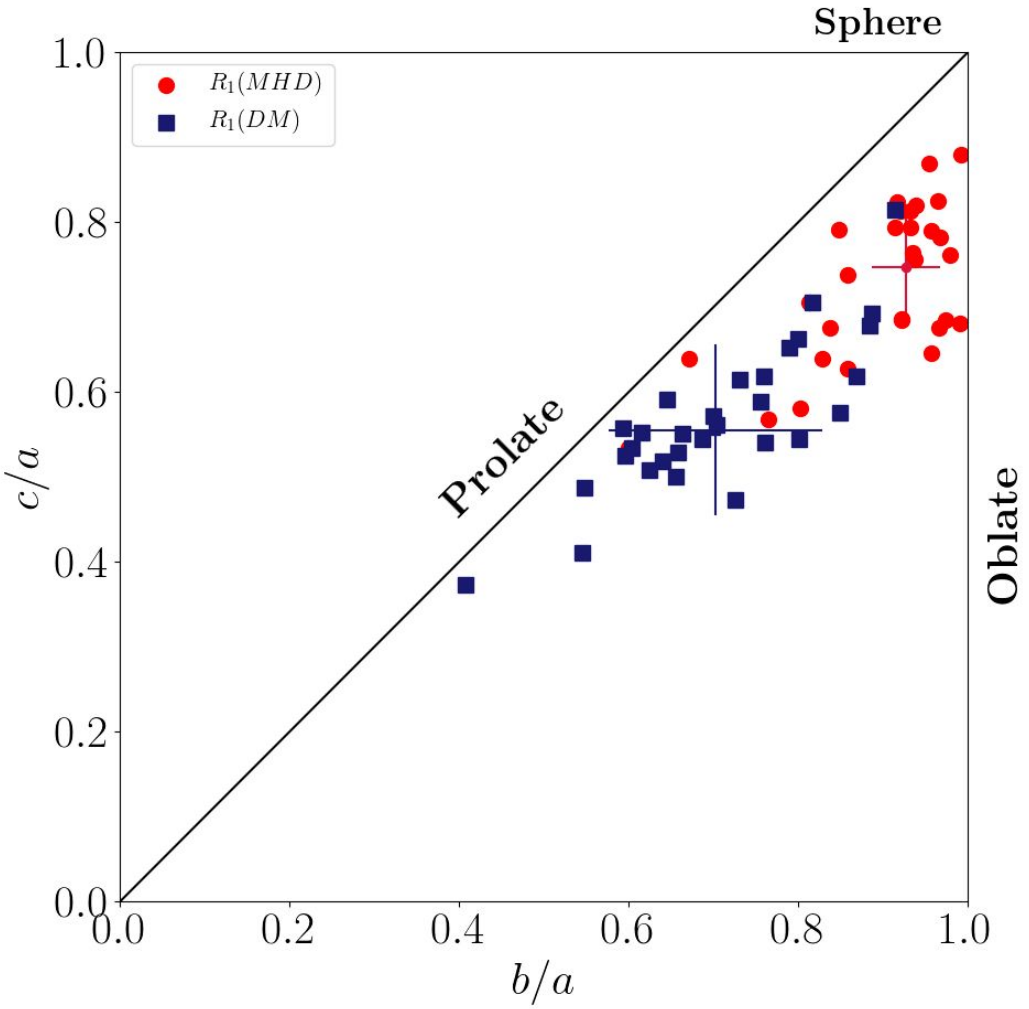
Close the galactic disk the MHD halos are almost spherical.

DM only halos are prolate, far from spherical.

J. Prada+(2018, in prep.)

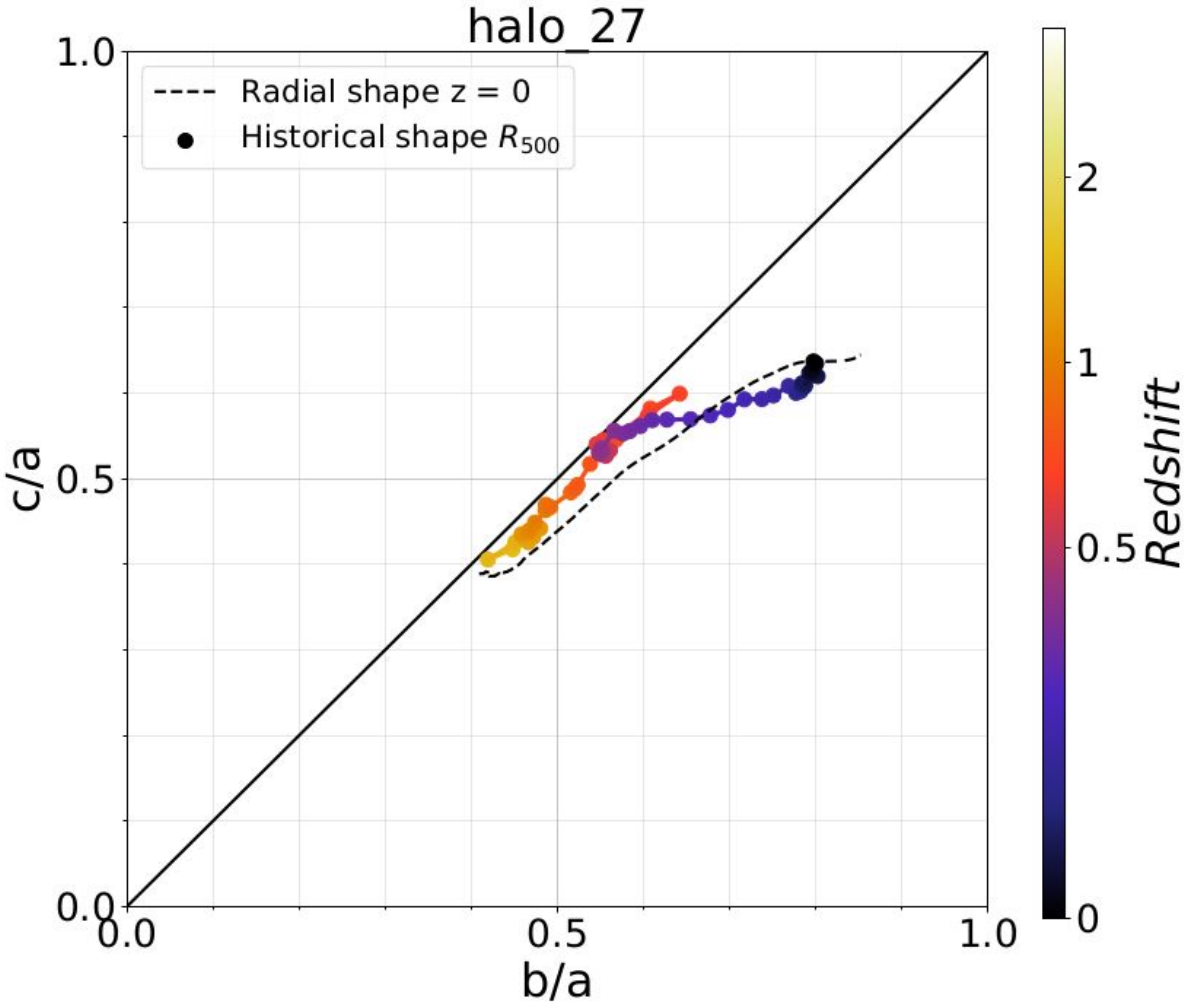


Far from the the galactic disk both (MHD, DM) give rounder halos.



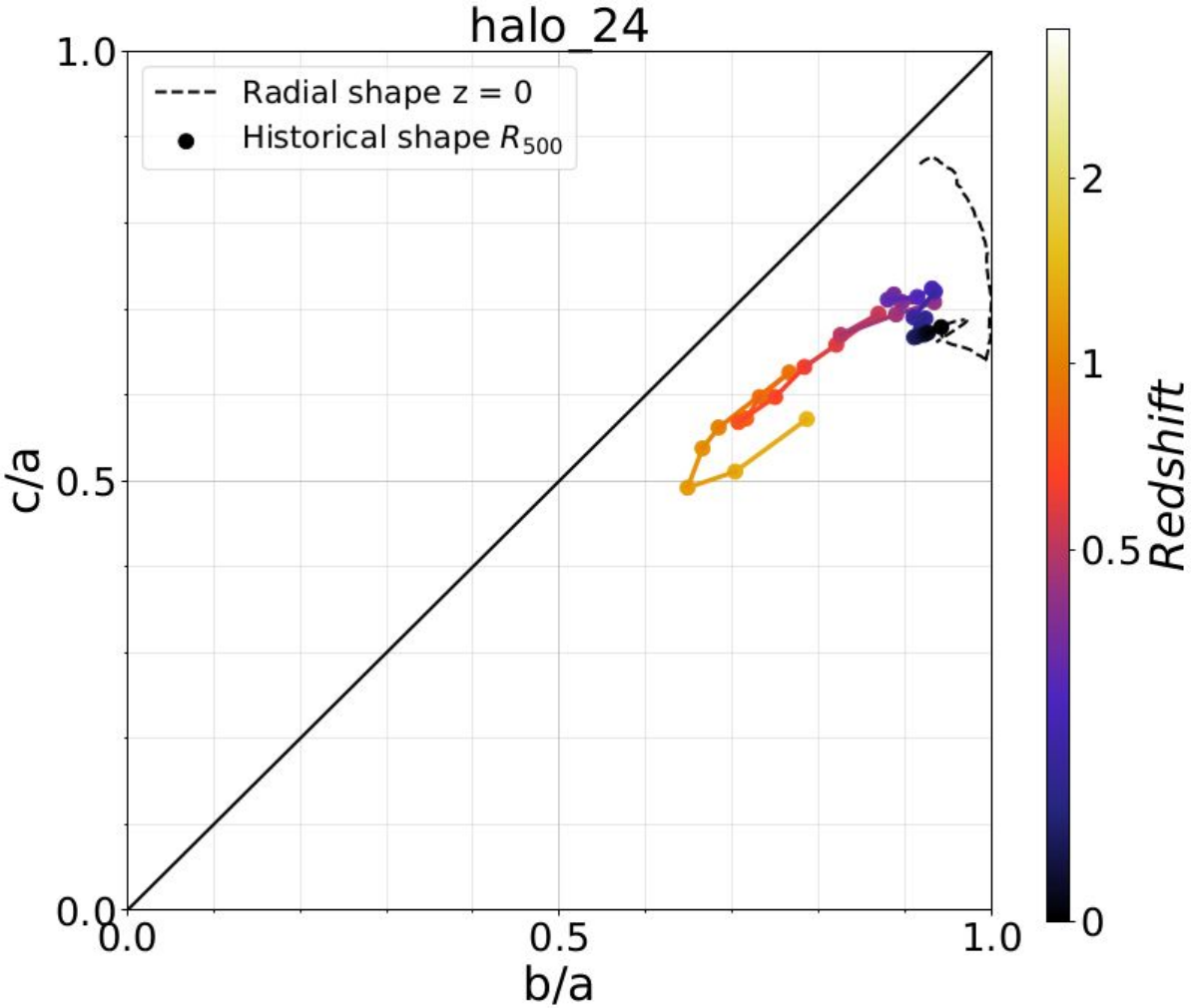
J. Prada+(2018, in prep.)

DM only simulations keep a memory of the assembly process in the current DM halo shape.



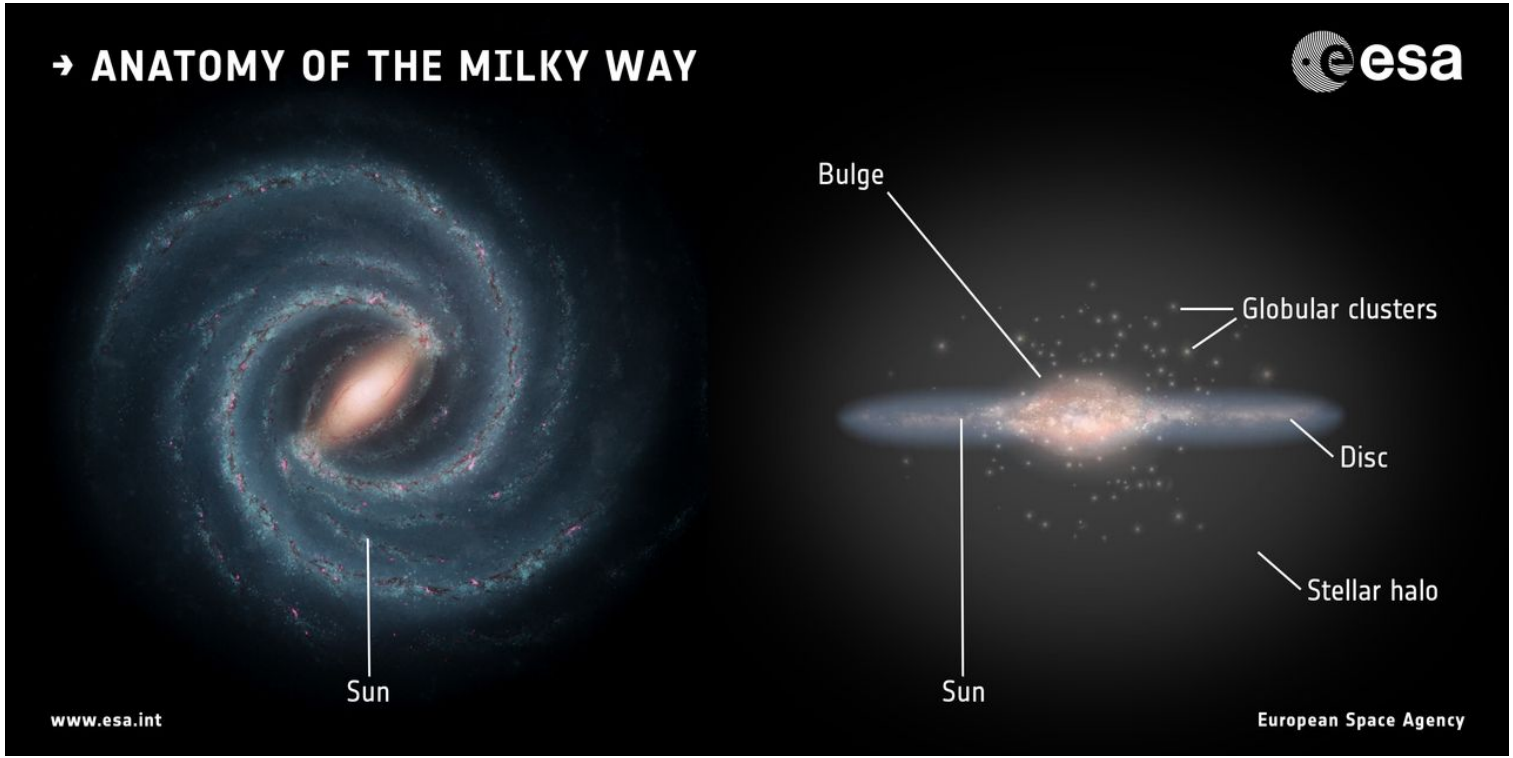
J. Prada+(2018, in prep.)

MHD simulations don’t keep a trace of their formation process.

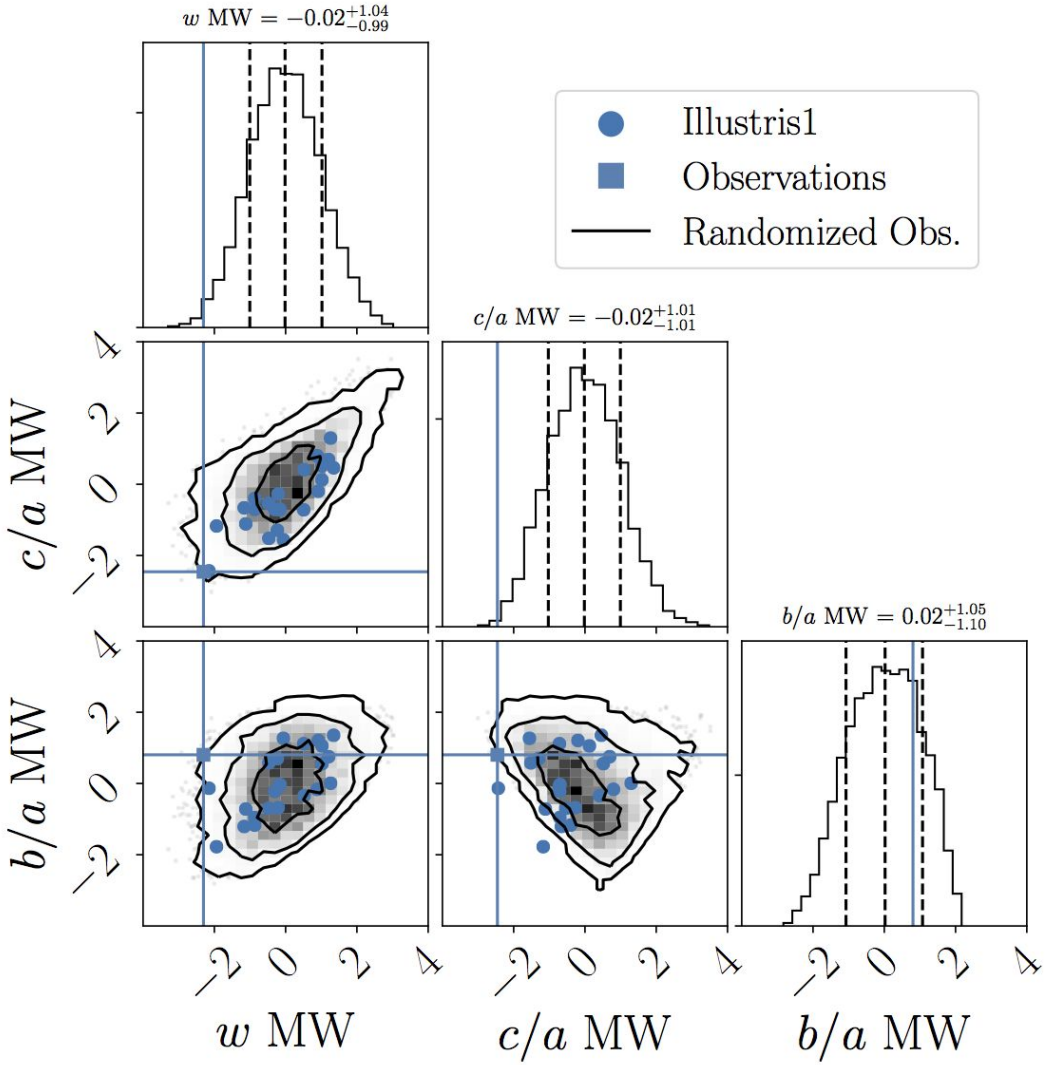


J. Prada+(2018, in prep.)

What is the shape of **OUR** DM halo?



The distribution of satellites around our MW is atypically aspherical.



FR + Arias (2018)

Conclusions

- Asphericity of MW DM halos has an impact on direct+indirect DM detection.
- The DM halo of our galaxy is not spherical.
- Detailed simulations support that our DM halo has **low asphericity.**
- Observations of satellites hint that our DM is **highly aspherical.**