Planes of satellite galaxies: a dynamical study
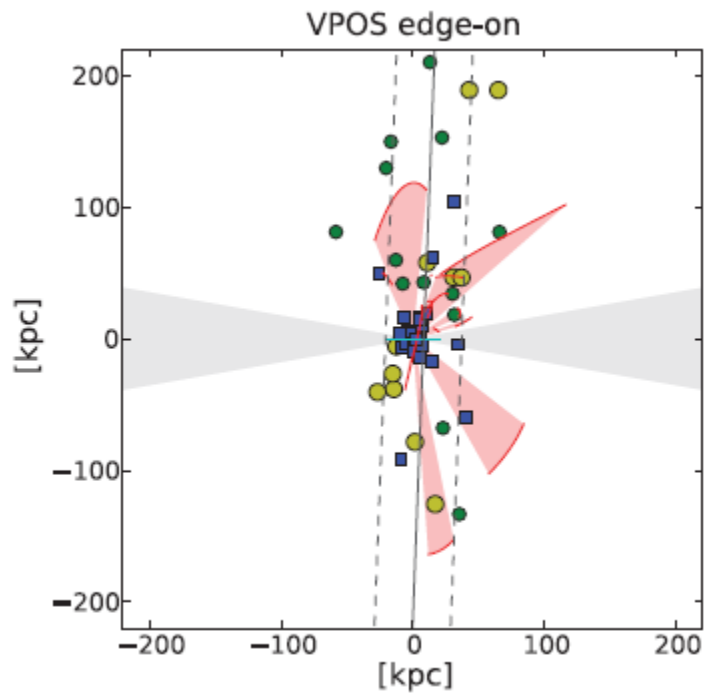
Veronica Arias
Universidad de los Andes,
University of Sydney

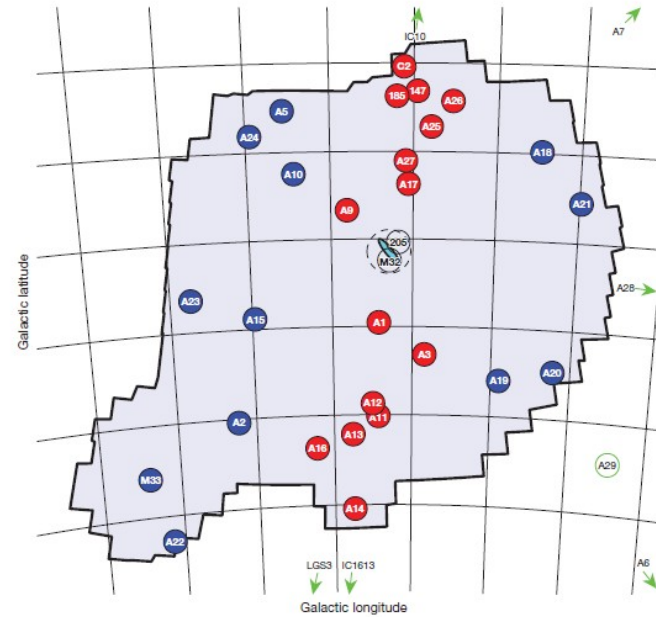Jaime Forero, Geraint Lewis, Magda Guglielmo y Nuwanthika Fernando.

Image: http://www.spacetelescope.org/images/potw1301a/

Satellite Galaxies:
Anisothropic distribution
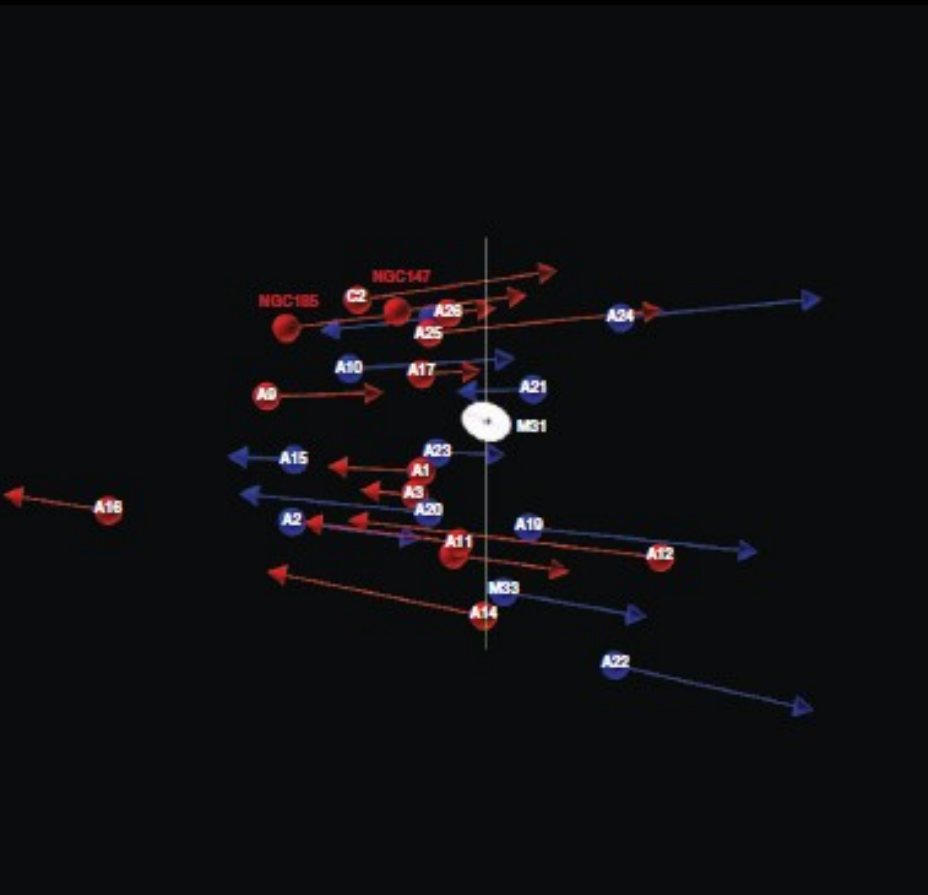
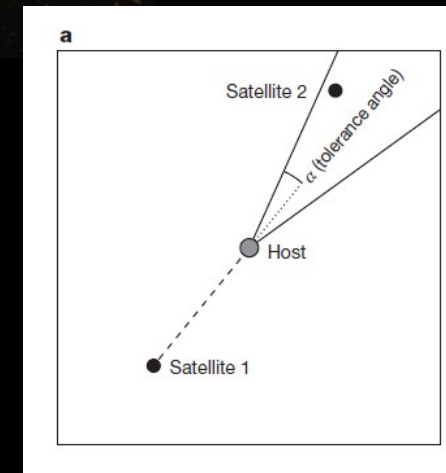**Milky Way**

Andromeda

Pawlowski et al. 2012
Linden-Bell 1976

Ibata et al. 2013
Conn et al. 2013

Evidence of corotation:

In Andromeda
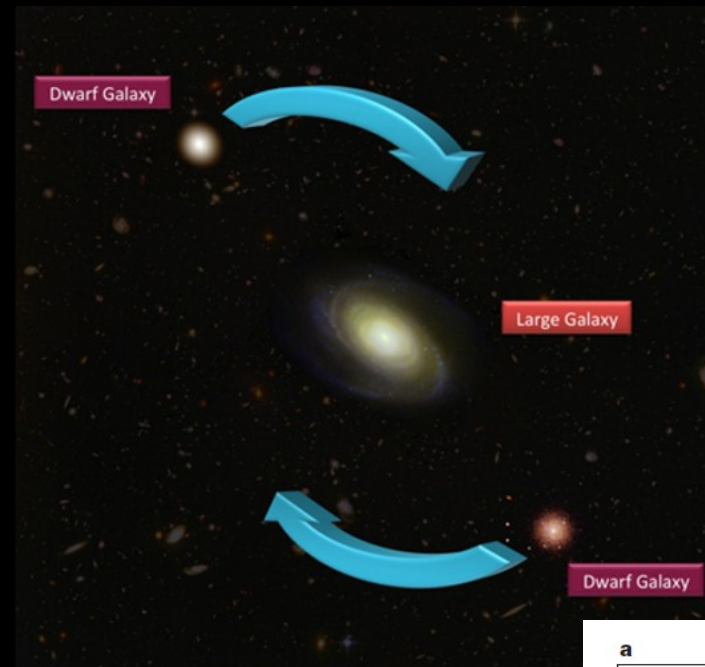
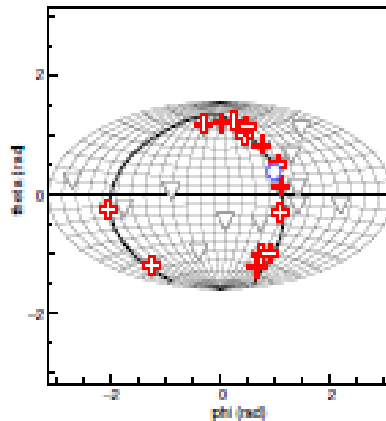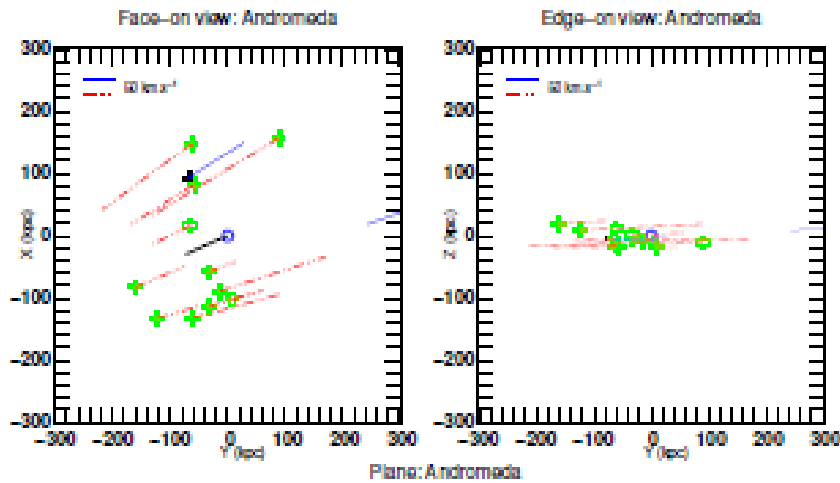Ibata et al. 2013, Collins et al. 2013

In other galaxies

Ibata et al. 2014
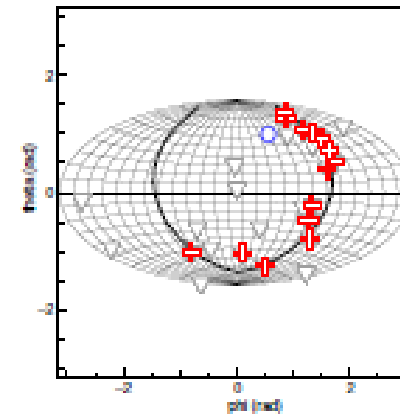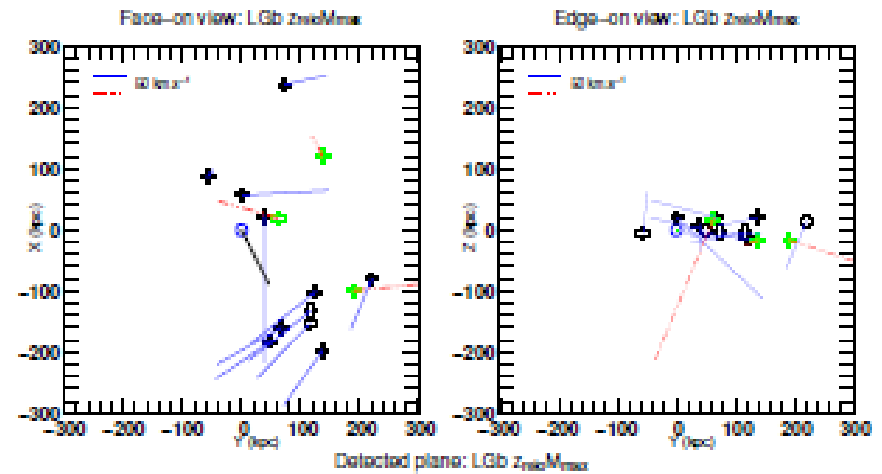
Looking for plane in the simulations:

Millenium II, Aquarius. Not really

In CLUES Gillet et al. (2015) found planes (se also Buck et al 2015, Sawalla et al. 2015)

Observationss
(Andrómeda)

Simulations
(CLUES)

Libeskind et al. 2014,
Kubik(in this meeting)

eigen-frame at 4 r_{vir}

$\tilde{M} > 10$

$\tilde{M} < 0.1$

$1 < \tilde{M} < 10$

$0.1 < \tilde{M} < 1$

eigen-frame at 8 r_{vir}

eigen-frame at 16 r_{vir}

> 2.0

1.5

1

0.5

0

Factor above uniform
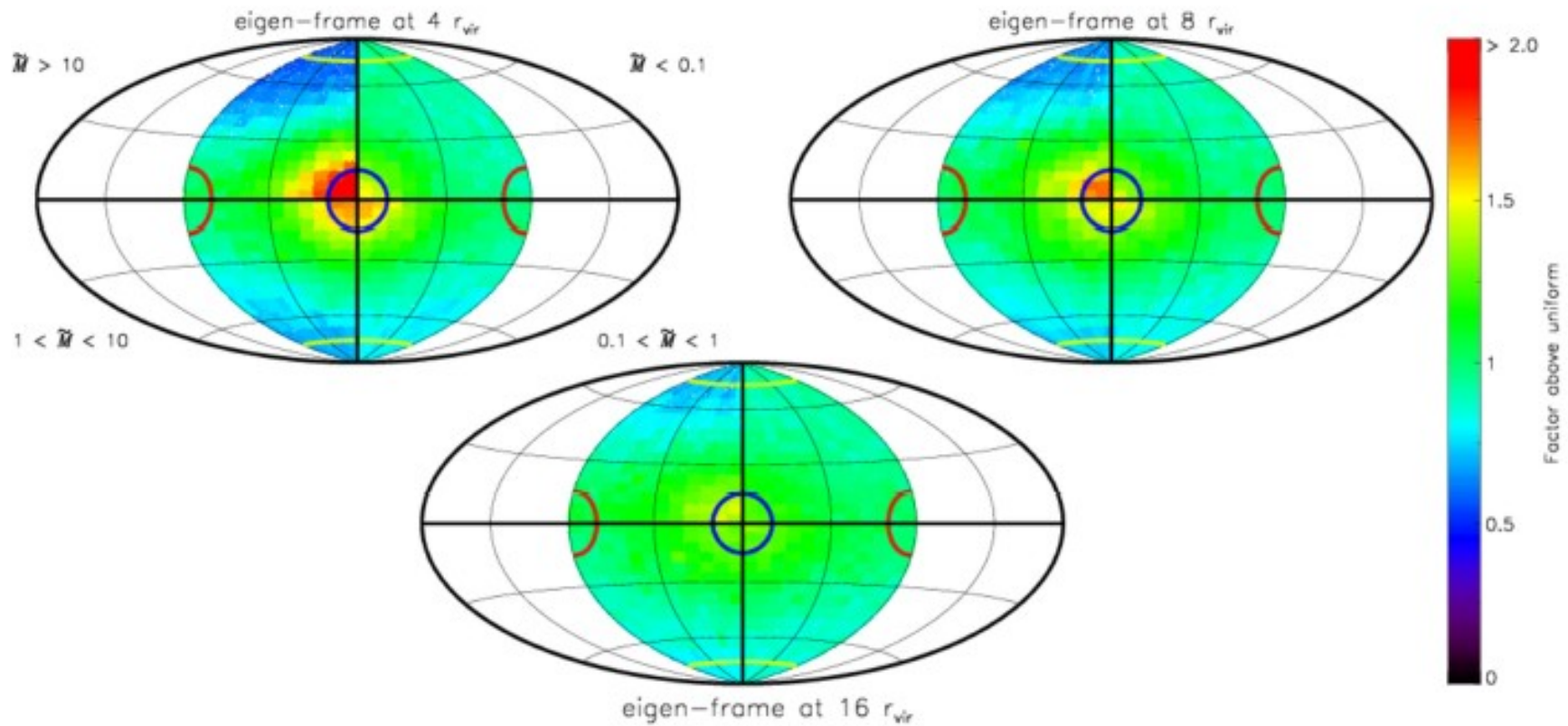
Alignments with the large scale structure (observational)

Liebeskind et al. 2015
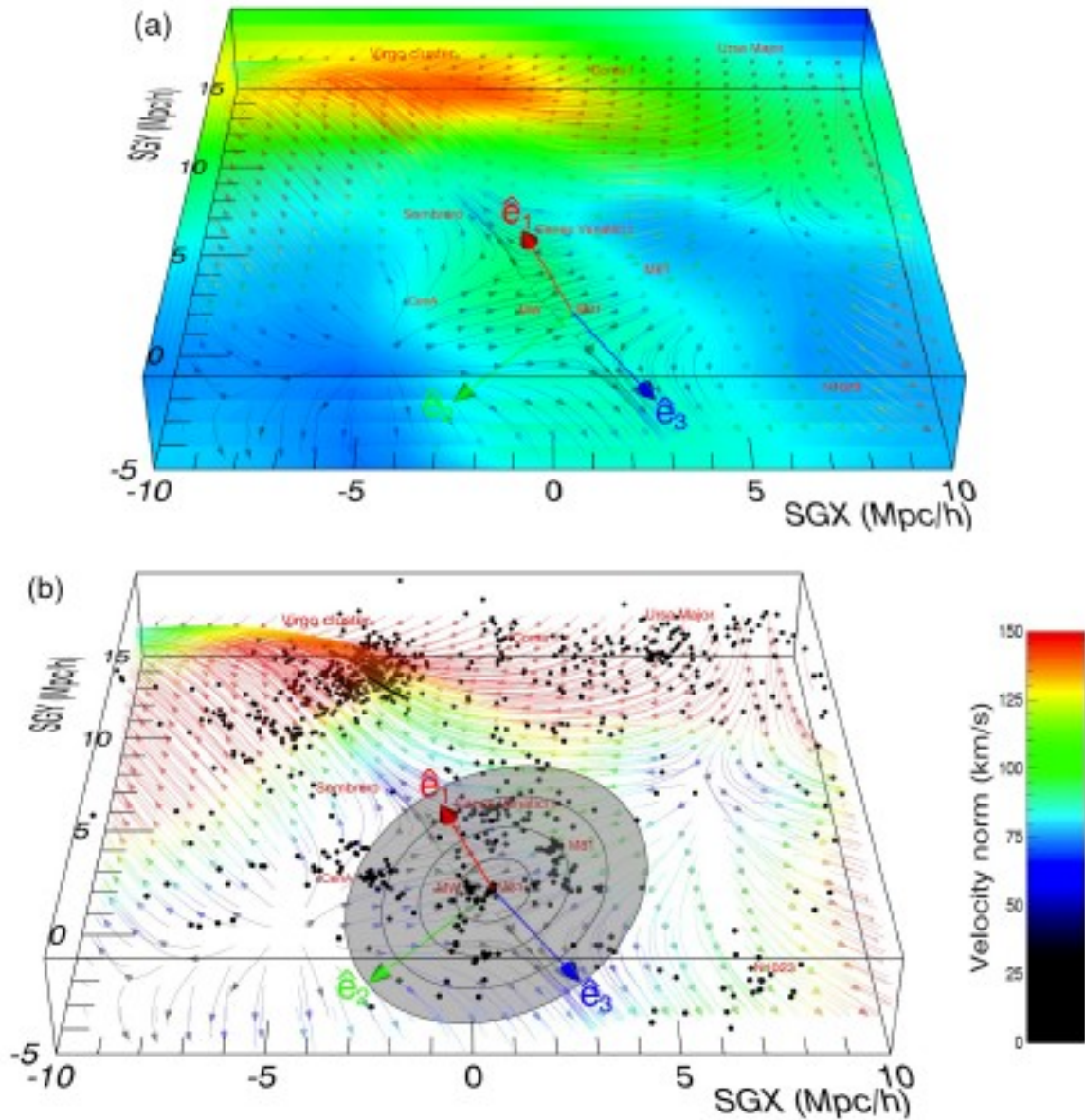
My aproach:

Find the orbits of the Andromeda satellites

We have:

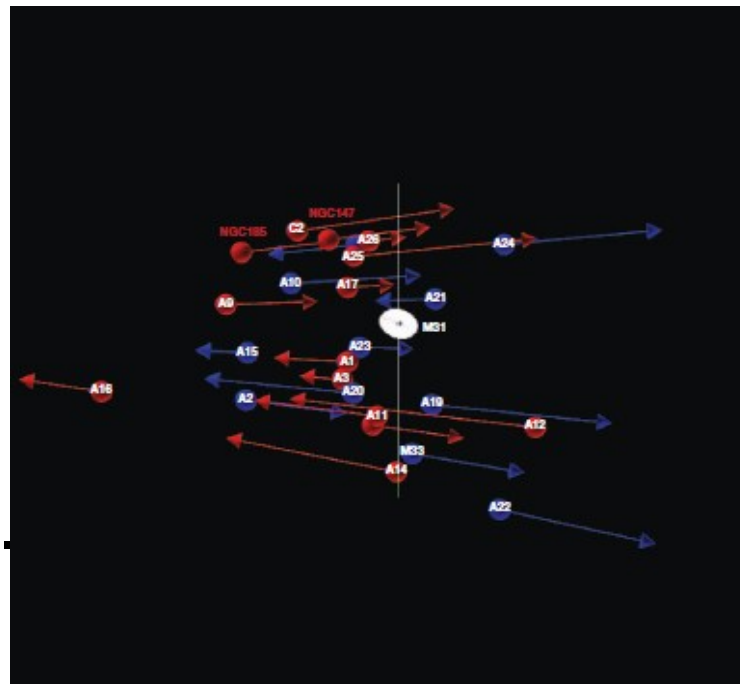*** positions**

* radial velocities

Ibata et al. 2013, Conn et al. 2012, Collins et al 2013, Tollerud et al 2012)

Unknown:

* Tangential velocities

Rigid potential for Andromeda
+
Point mass approximation for the satellites
=
Orbit integration

$$\Phi_{\text{halo}}(r) = -\frac{GM_{\text{halo}}}{r} \log \left(\frac{r}{r_{\text{halo}}} + 1 \right)$$
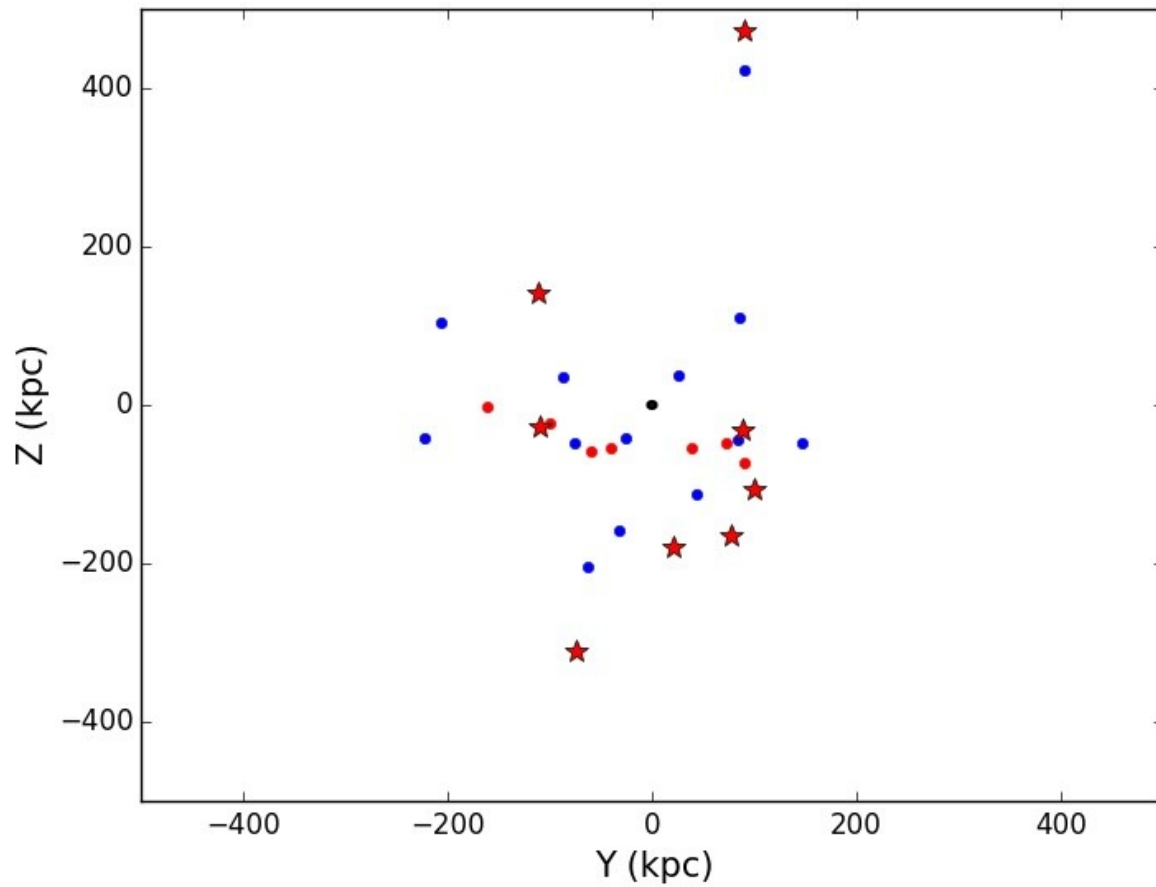
$$\Phi_{\text{disk}}(r) = -2\pi G \Sigma_0 r_{\text{disk}}^2 \left[\frac{1 - \exp^{-r/r_{\text{disk}}}}{r} \right]$$

$$\Phi_{\text{bulge}}(r) = -\frac{GM_{\text{bulge}}}{r_{\text{bulge}} + r}$$
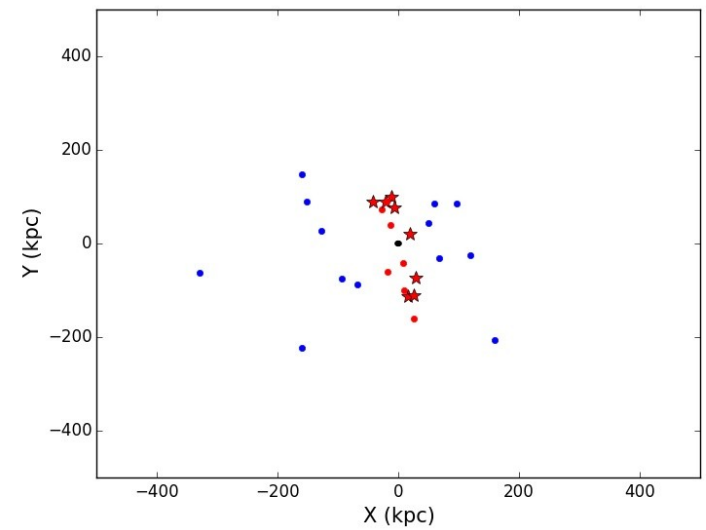
M31	
M_{bulge}	$2.86 \times 10^{10} \, M_\odot$
r_{bulge}	$0.61 \, \text{kpc}$
M_{disk}	$8.4 \times 10^{10} \, M_\odot$
r_{disk}	$5.4 \, \text{kpc}$
Σ_0	$4.6 \times 10^8 \, M_\odot \text{kpc}^{-2}$
M_{halo}	$103.7 \times 10^{10} \, M_\odot$
r_{halo}	$13.5 \, \text{kpc}$

Geehan et al. (2006)
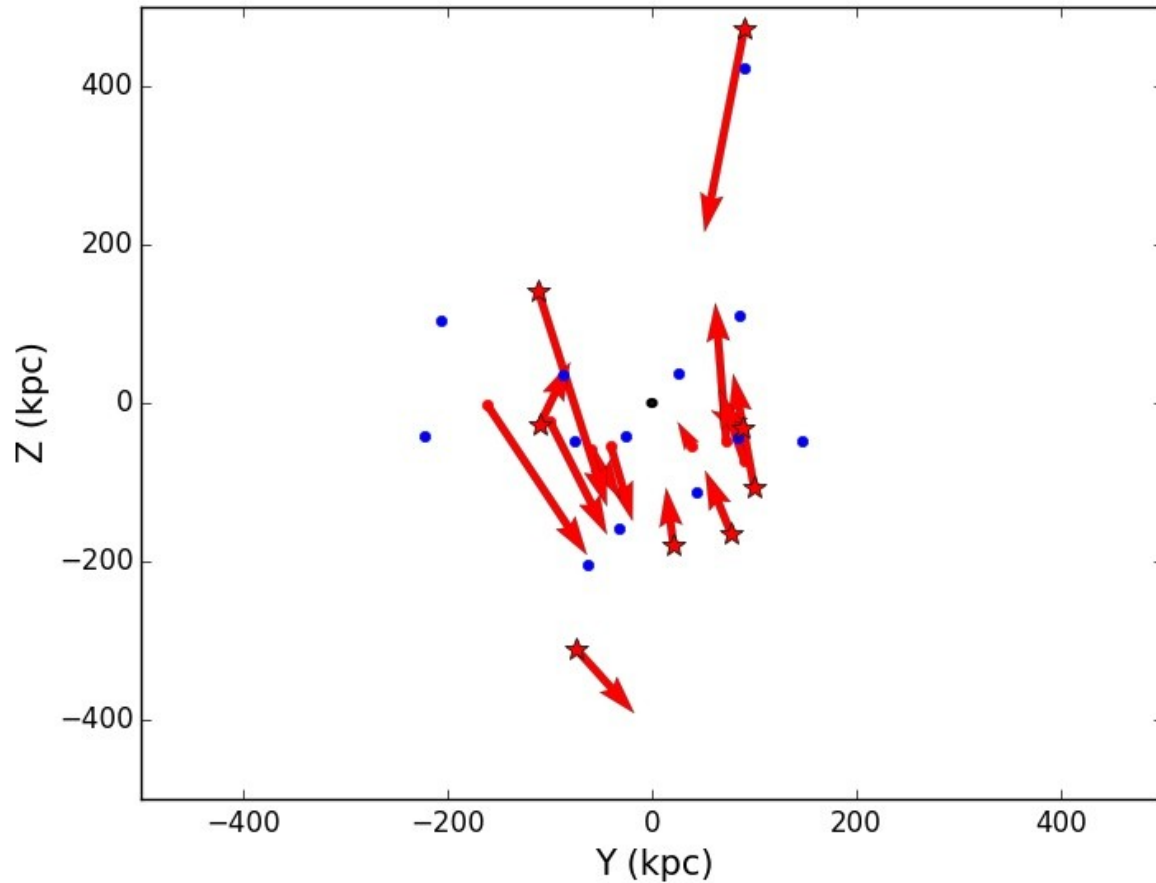
We have the positions

Plane face-on

Plane edge-on
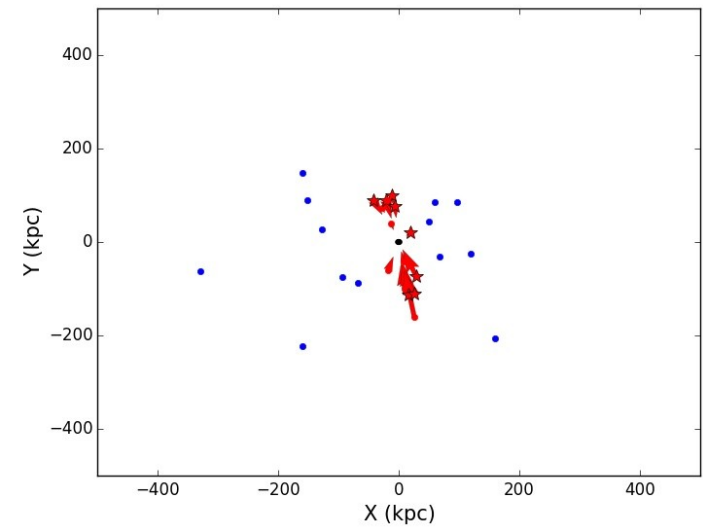(as observed)

MW

We have the line of sight velocities

Plane face-on
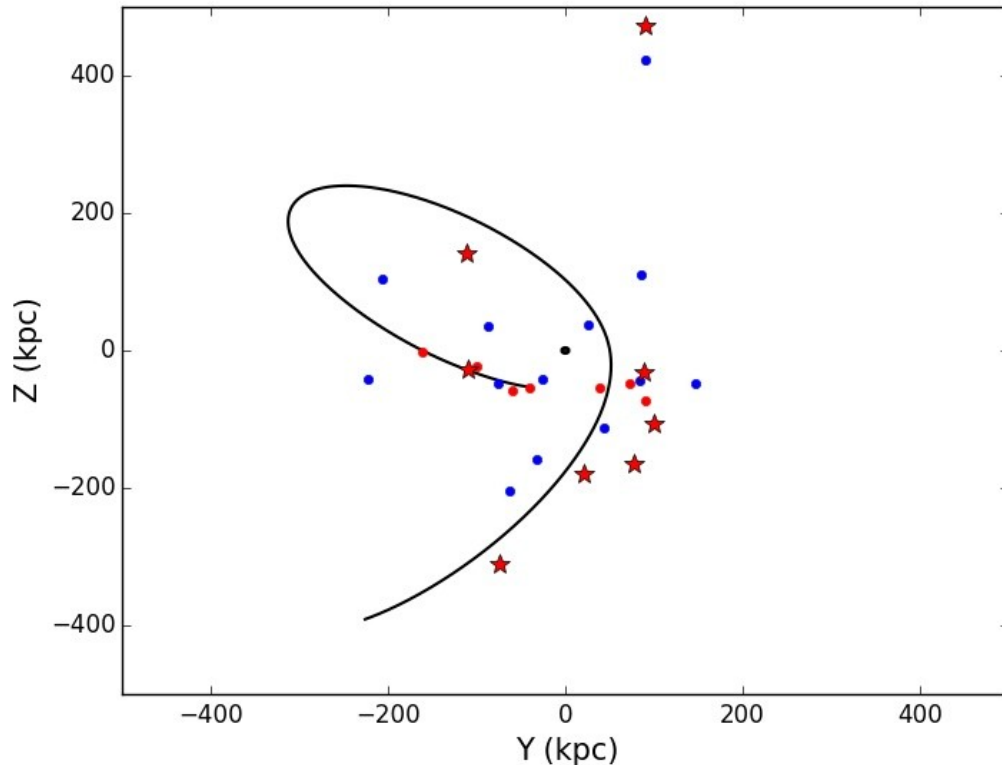

Plane edge-on
(as observed)

MW

We construct a tangential velocity

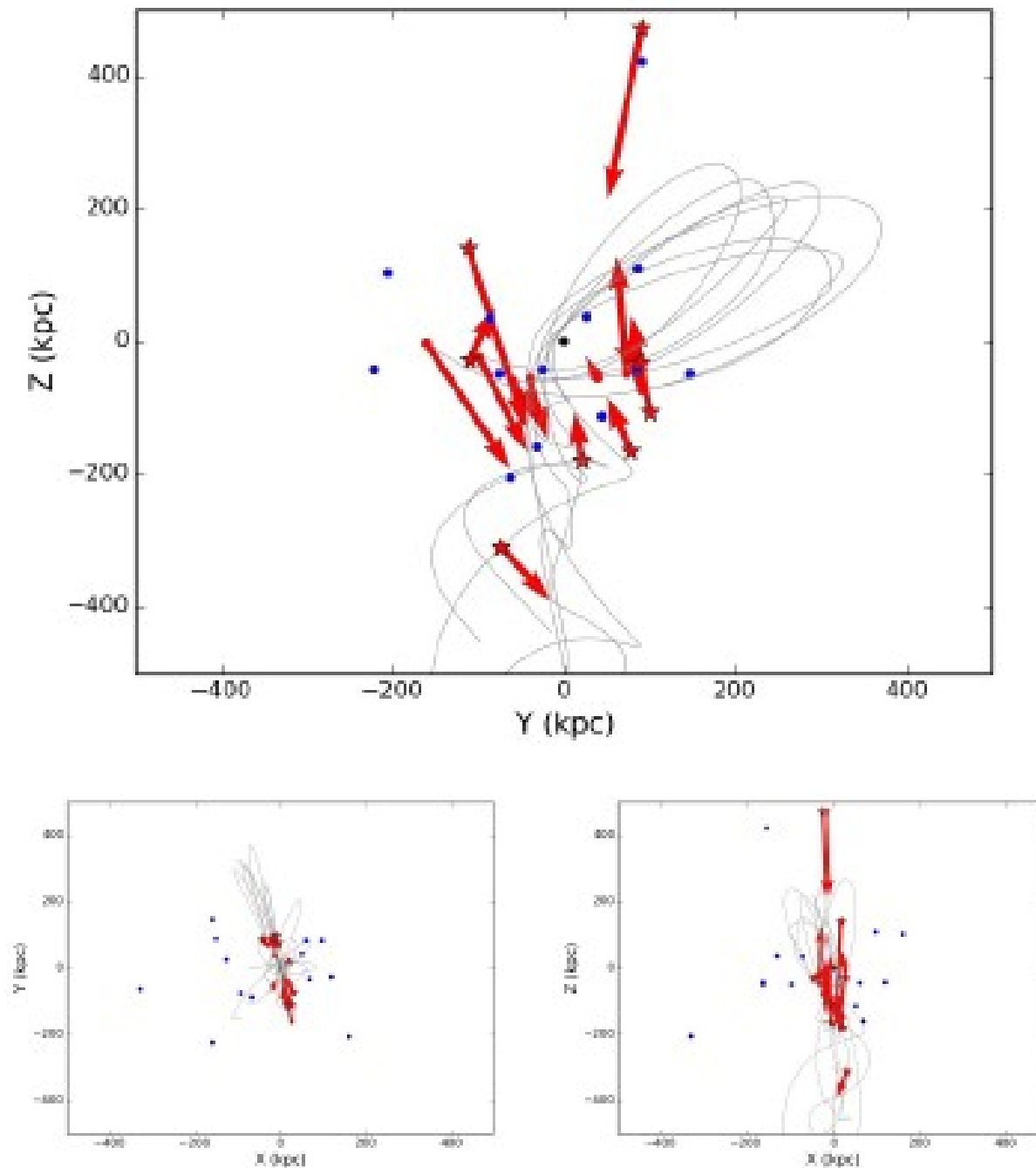**Assuming** that the total velocity is on the plane

Magnitude of the tangential velocity is the only free parameter

When we explore the **possible magnitudes** of the tangential velocity we find that:
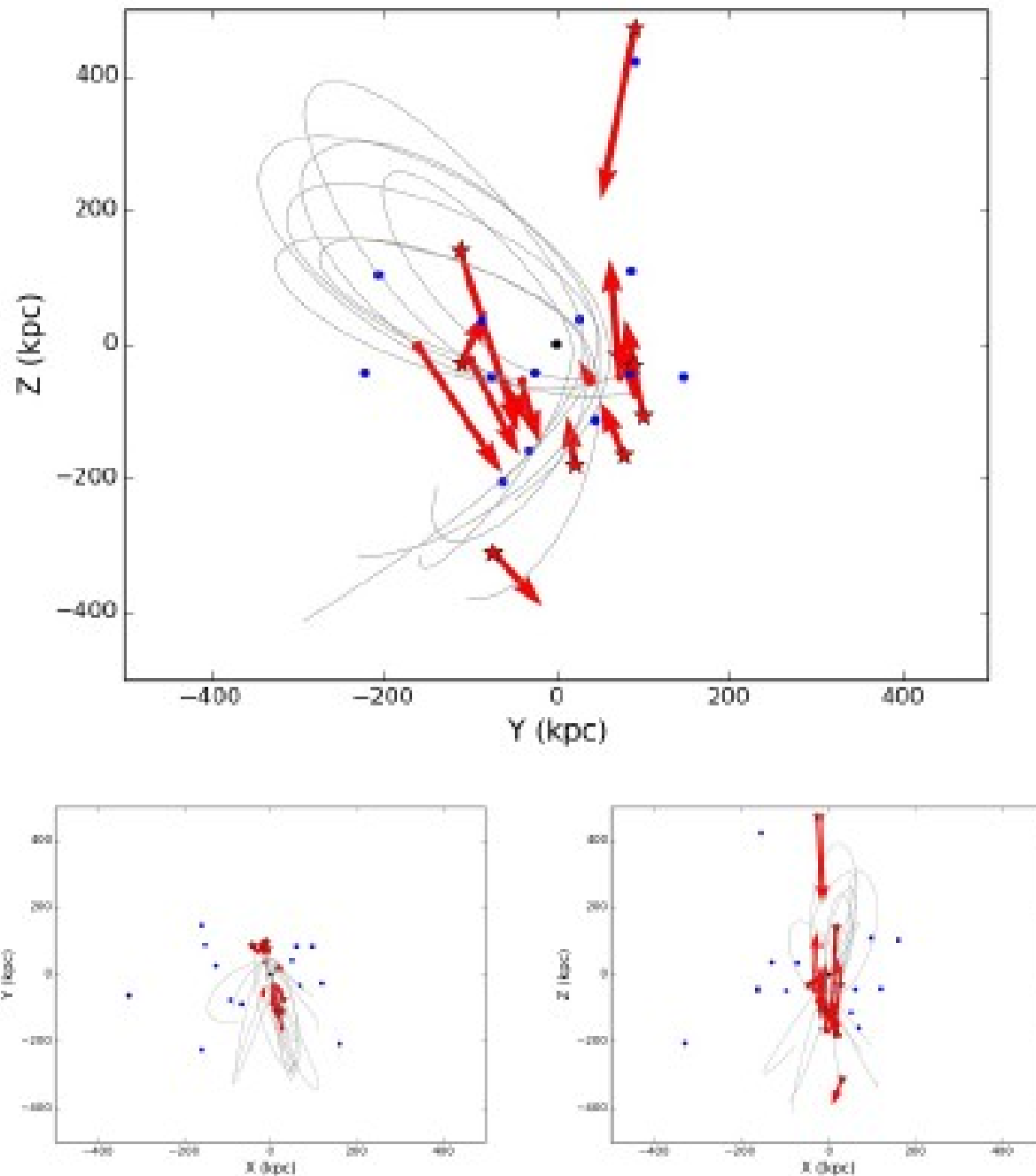
For a certain tangential velocity some resulting orbits go through most of the plane satellites
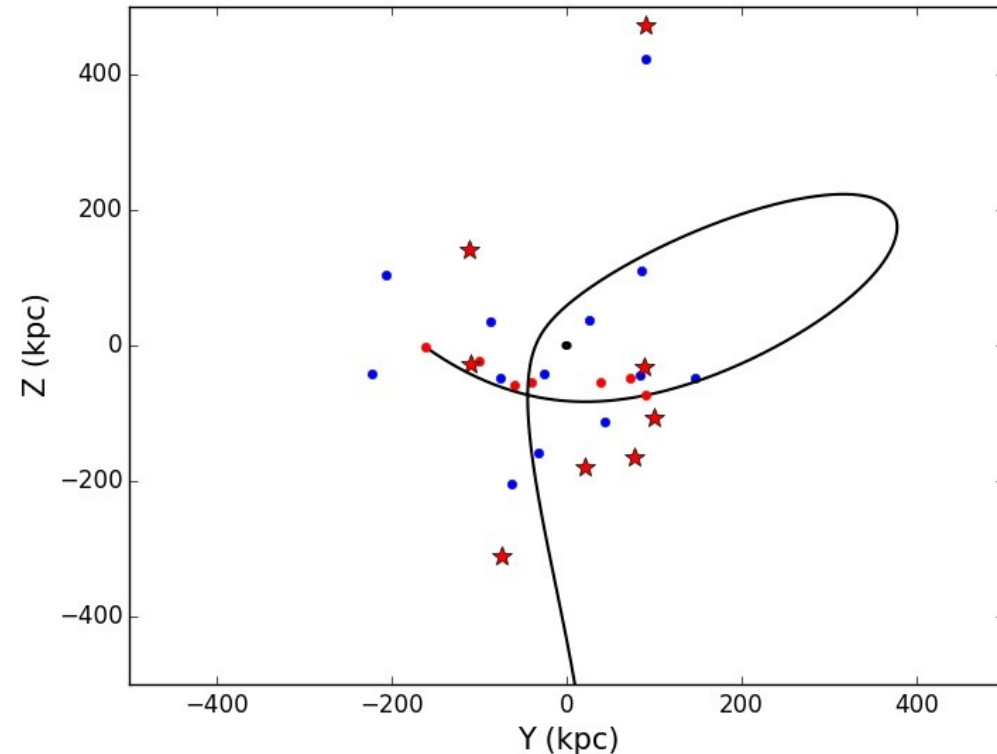
For 8 out of 15 satellites we found such orbits

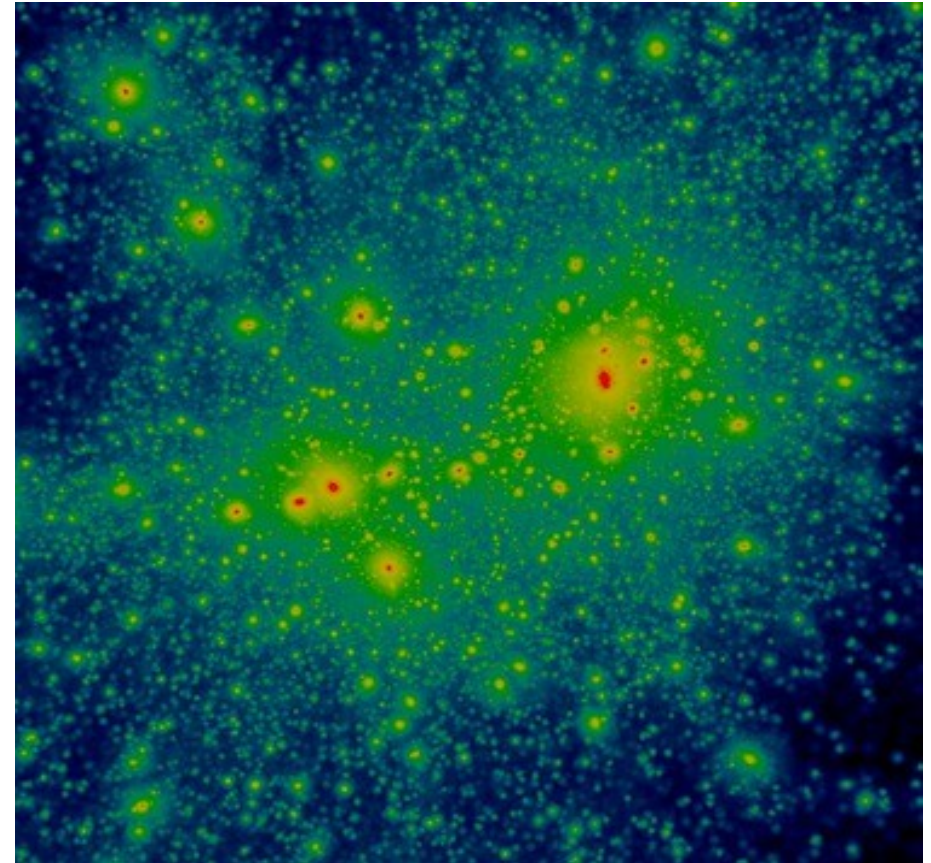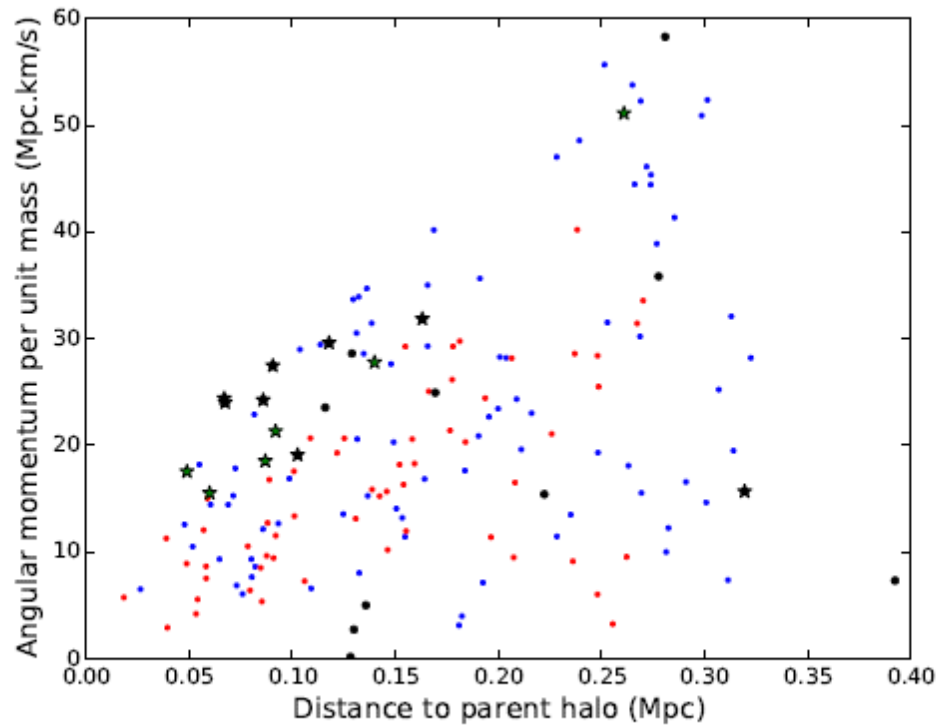# For 8 out of 15 satellites we found such orbits

These results are puzzling
(but remember the big assumption)

How does such an organized structure form?

We plan to use cosmological simulations to answer this question.

Work in progress...

Comparison with ELVIS

Next step:

Use Clues to explore the orbits of satellites