Streams in Lumpy Potentials

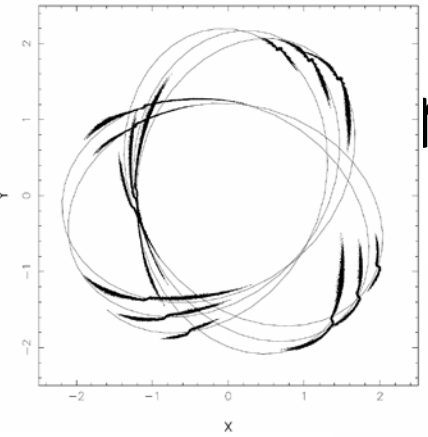
Ray Carlberg, Wayne Ngan
University of Toronto

Gaps: tell about sub-halos

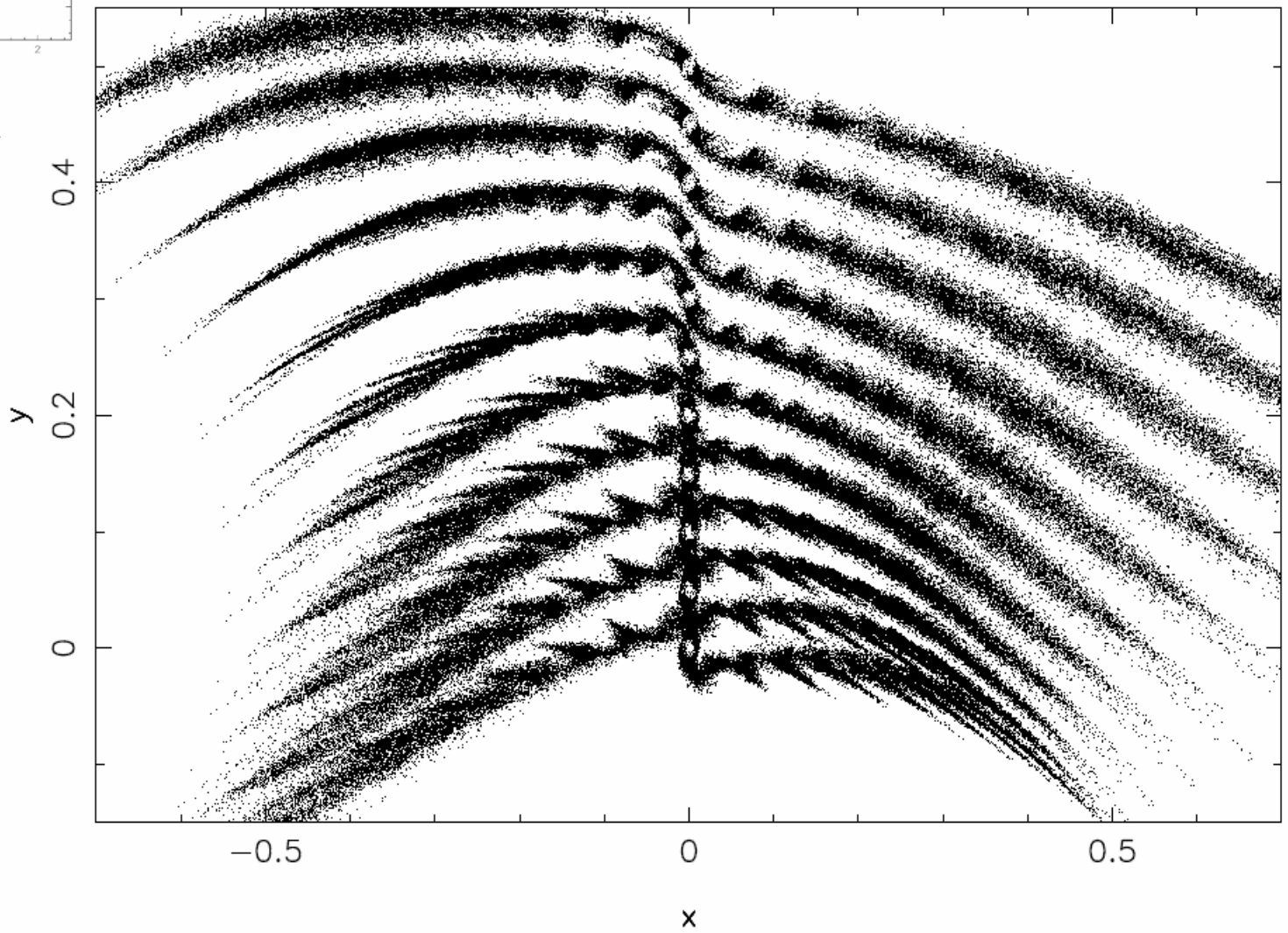
This talk: cosmological potentials **Stream velocity distributions**

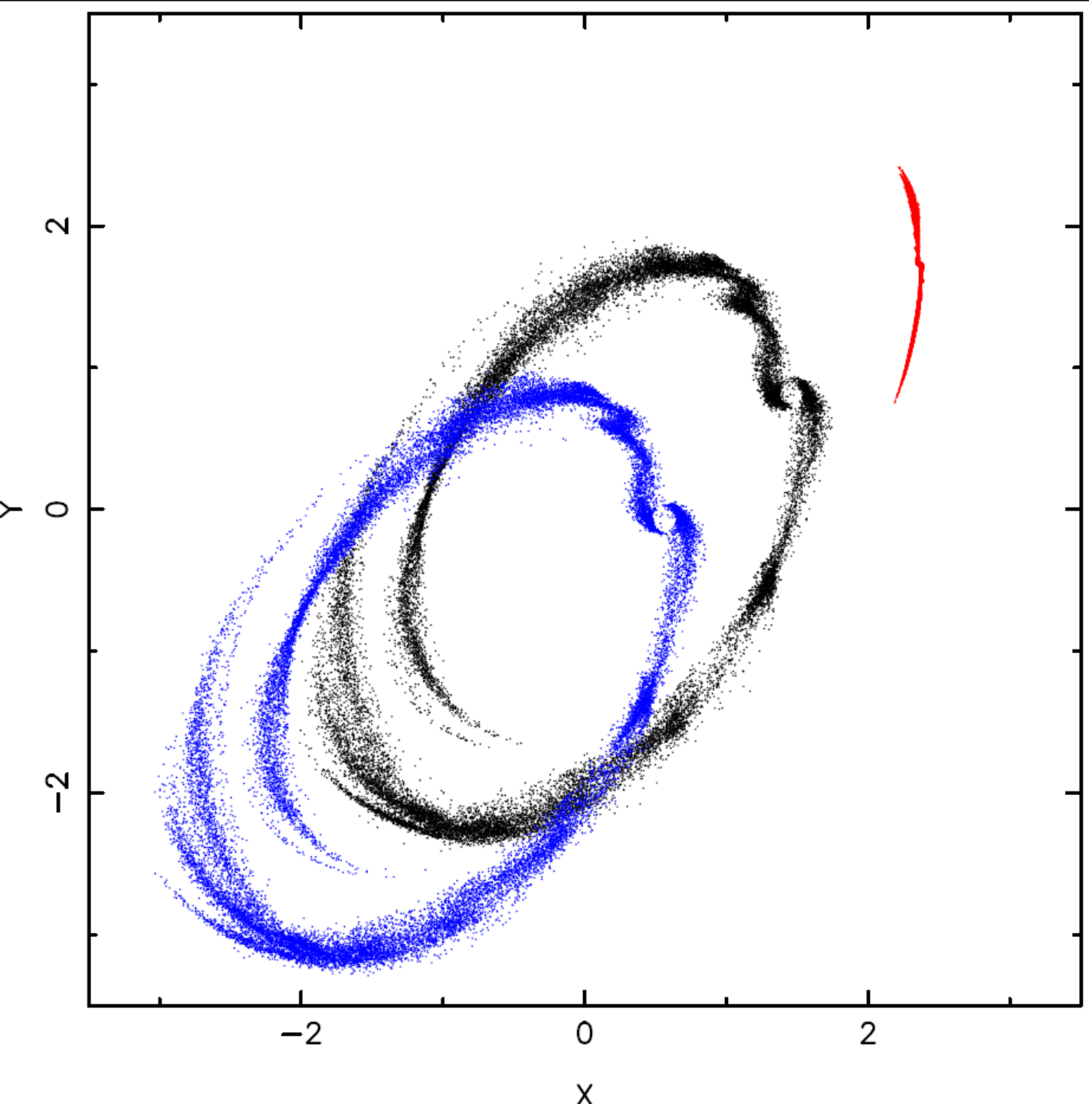
- Streams in a static realistic cosmological halo
  - Comparison to NFW
  - New effects
- Streams in an idealized cosmological halo
  - Understanding the new effects
- Gaia velocity data will allow new tests of DM distribution

reams in smooth potentials well understood



Time



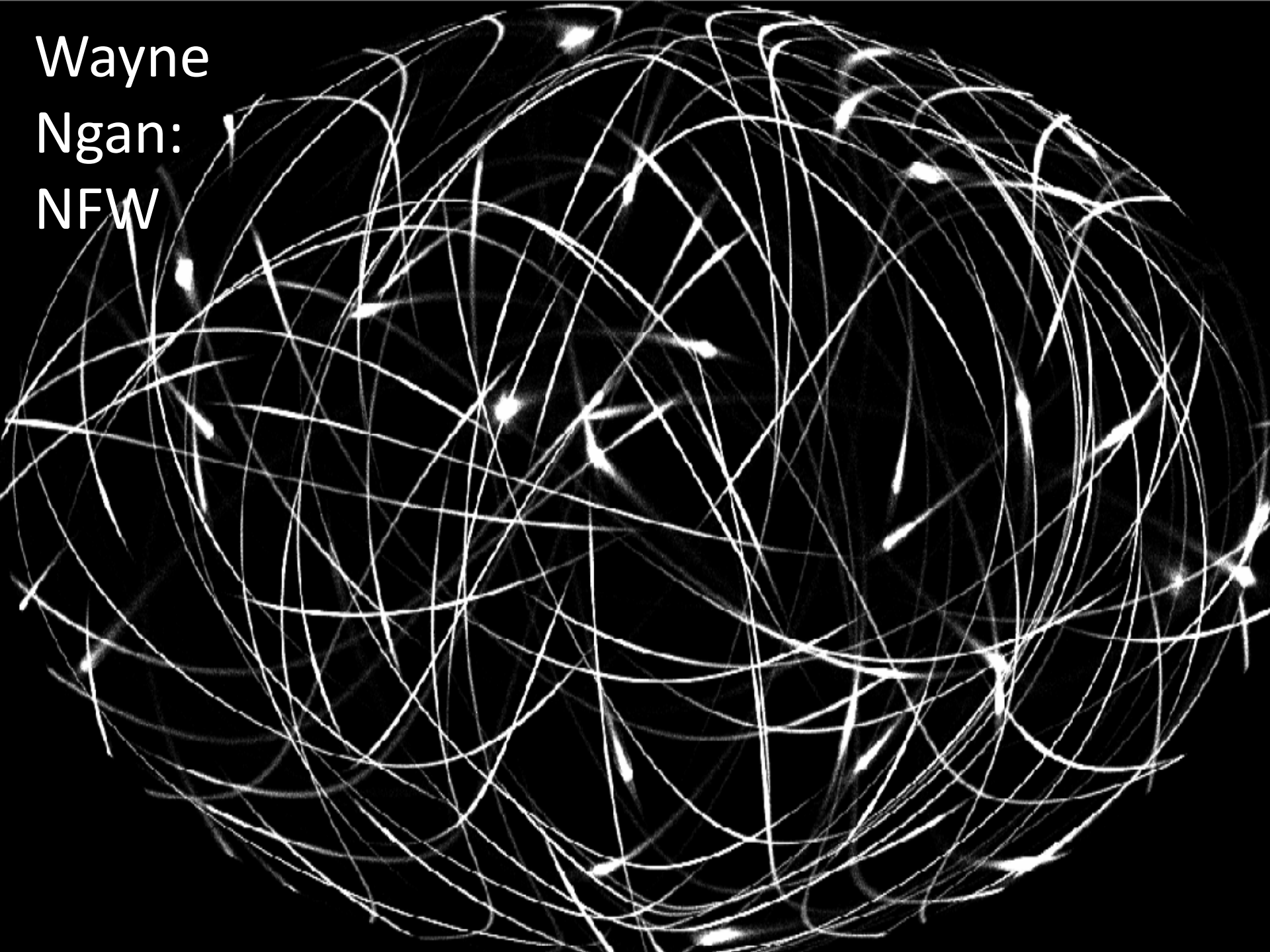


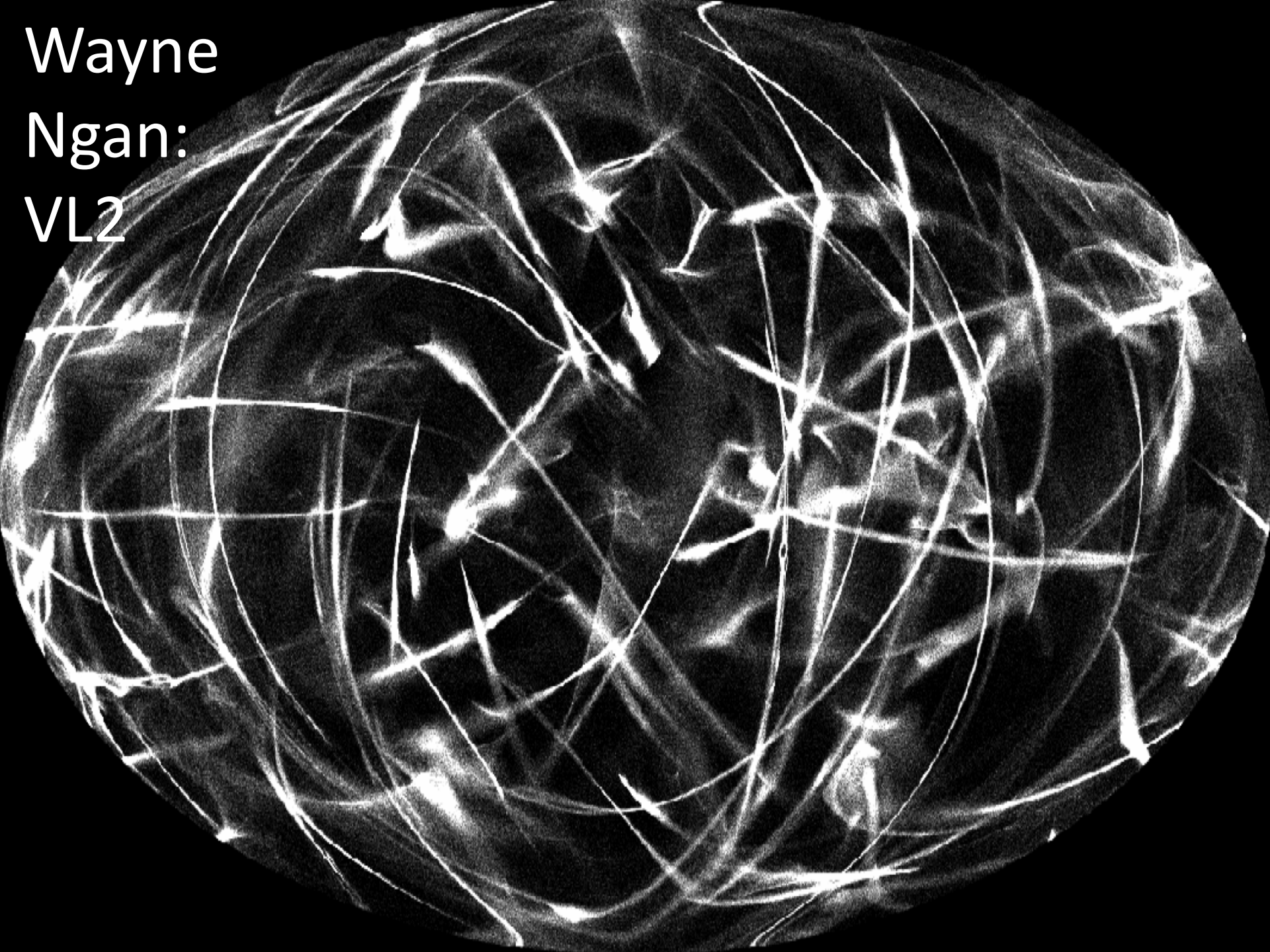
Scaling

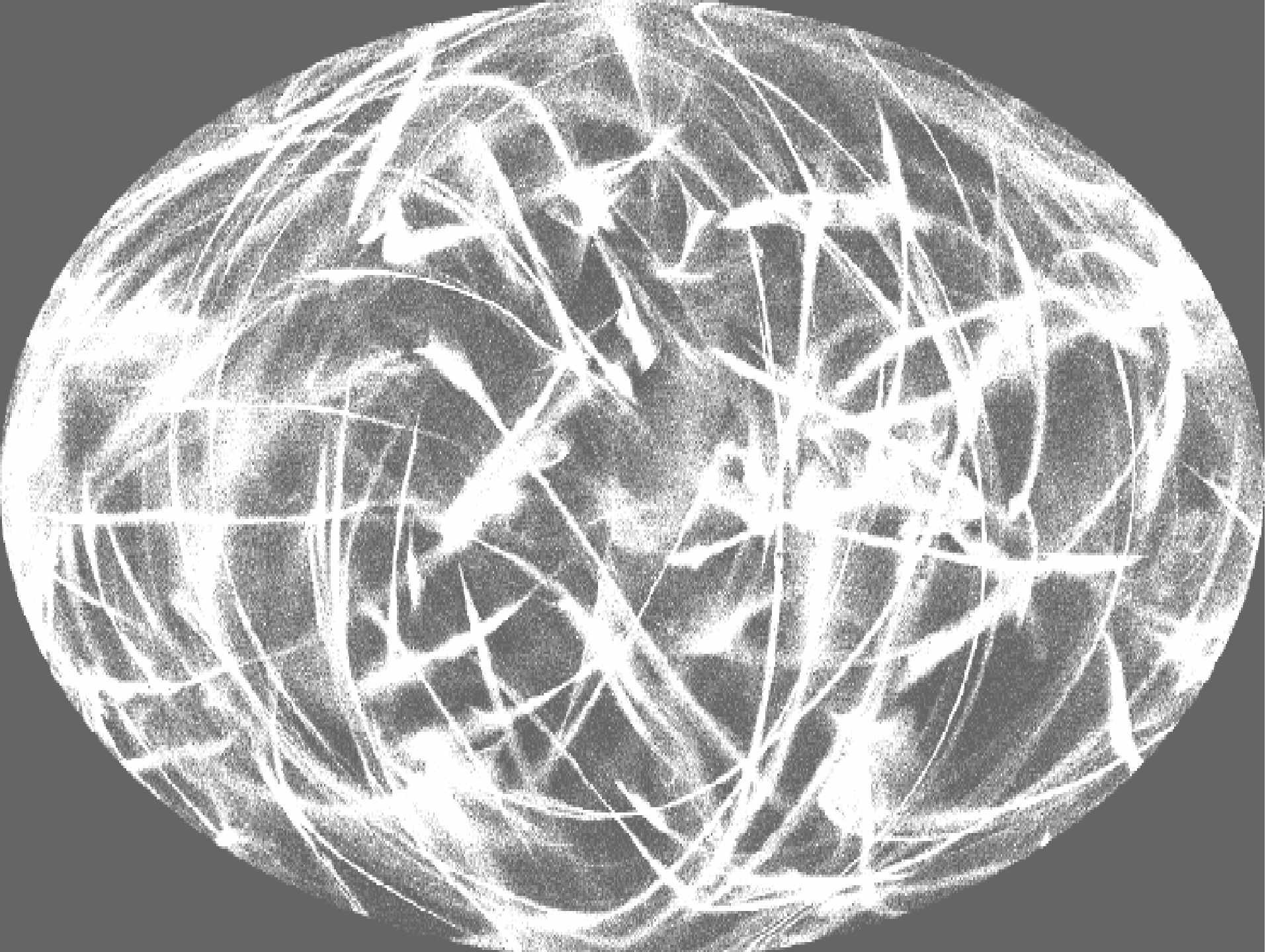
red: 10^{-7}

blue: 10^{-4}

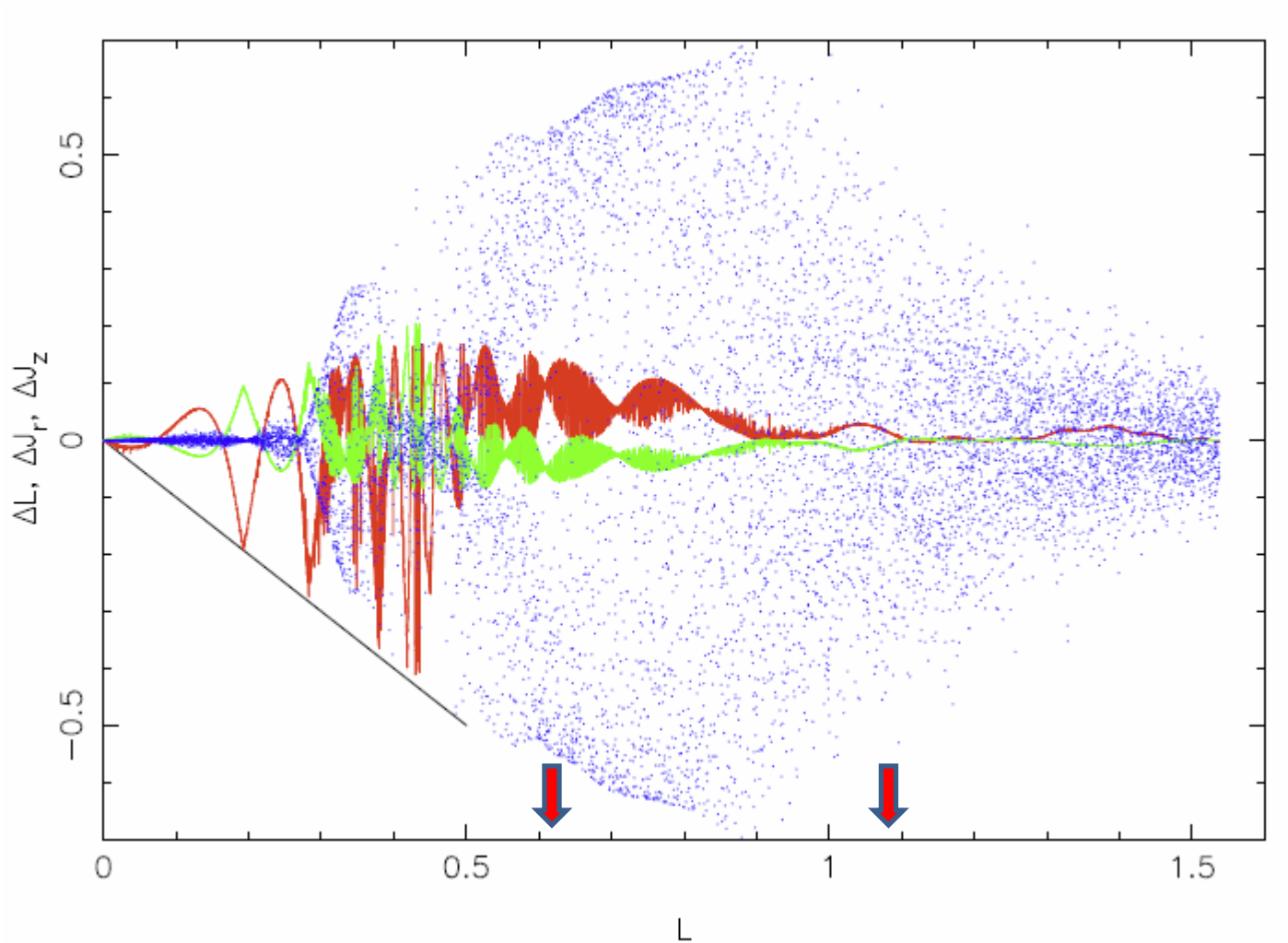
black:scaled from 10^{-7} to 10^{-4} with tidal radius


Wayne
Ngan:
NFW

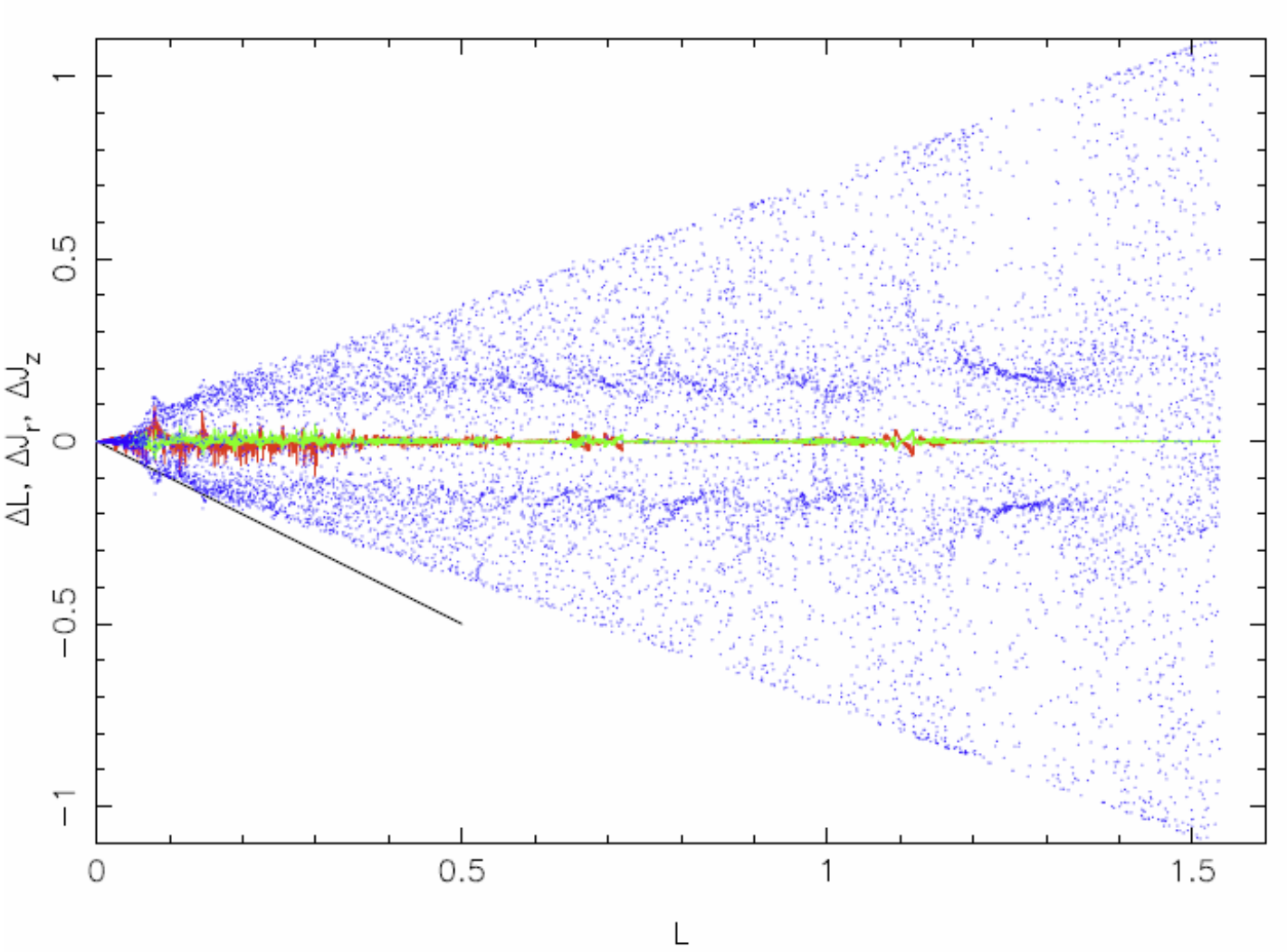

Wayne
Ngan:
VL2

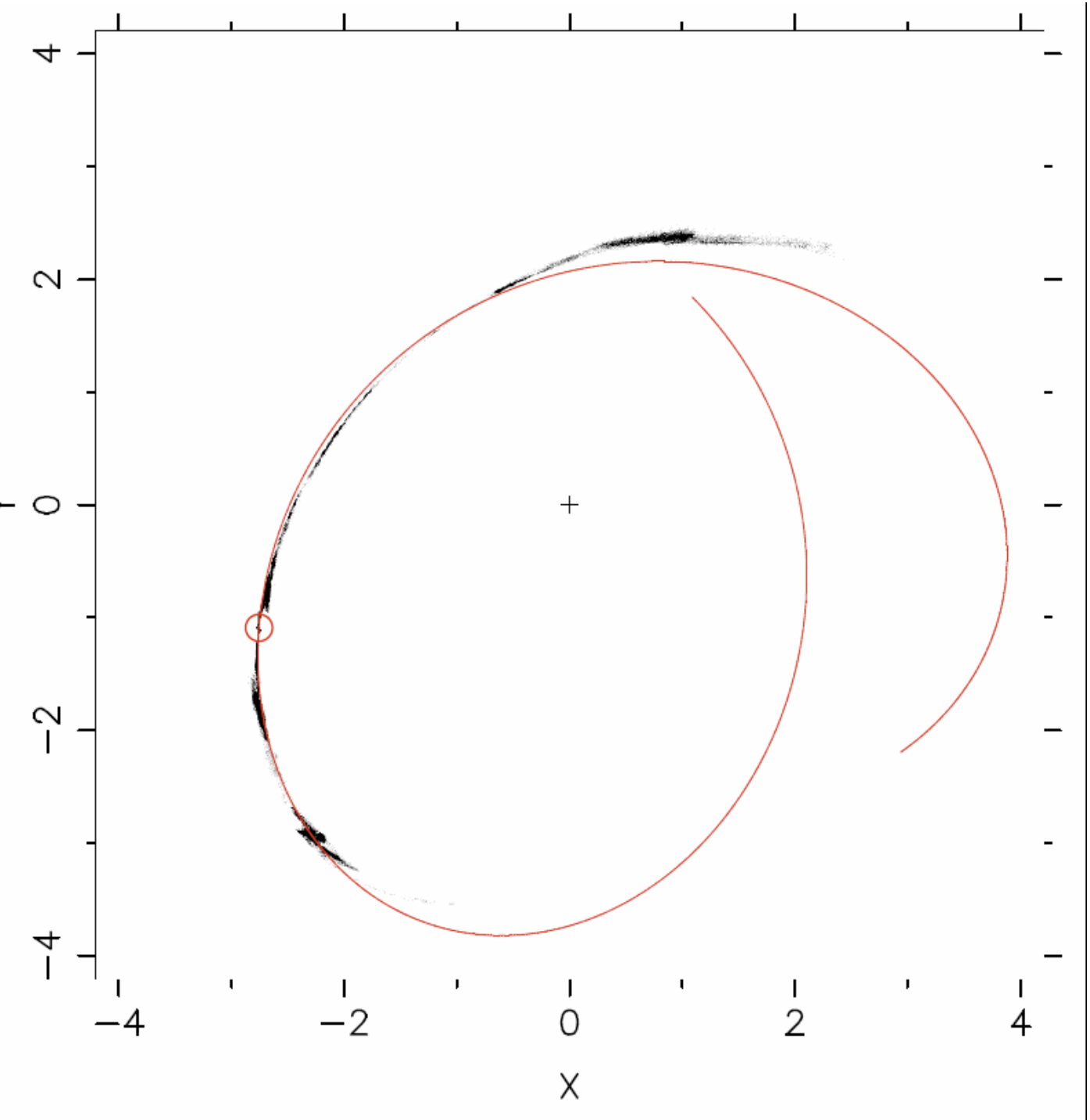


Triaxial isochrone, -10% y, -5% z: J conservation: new orbits available



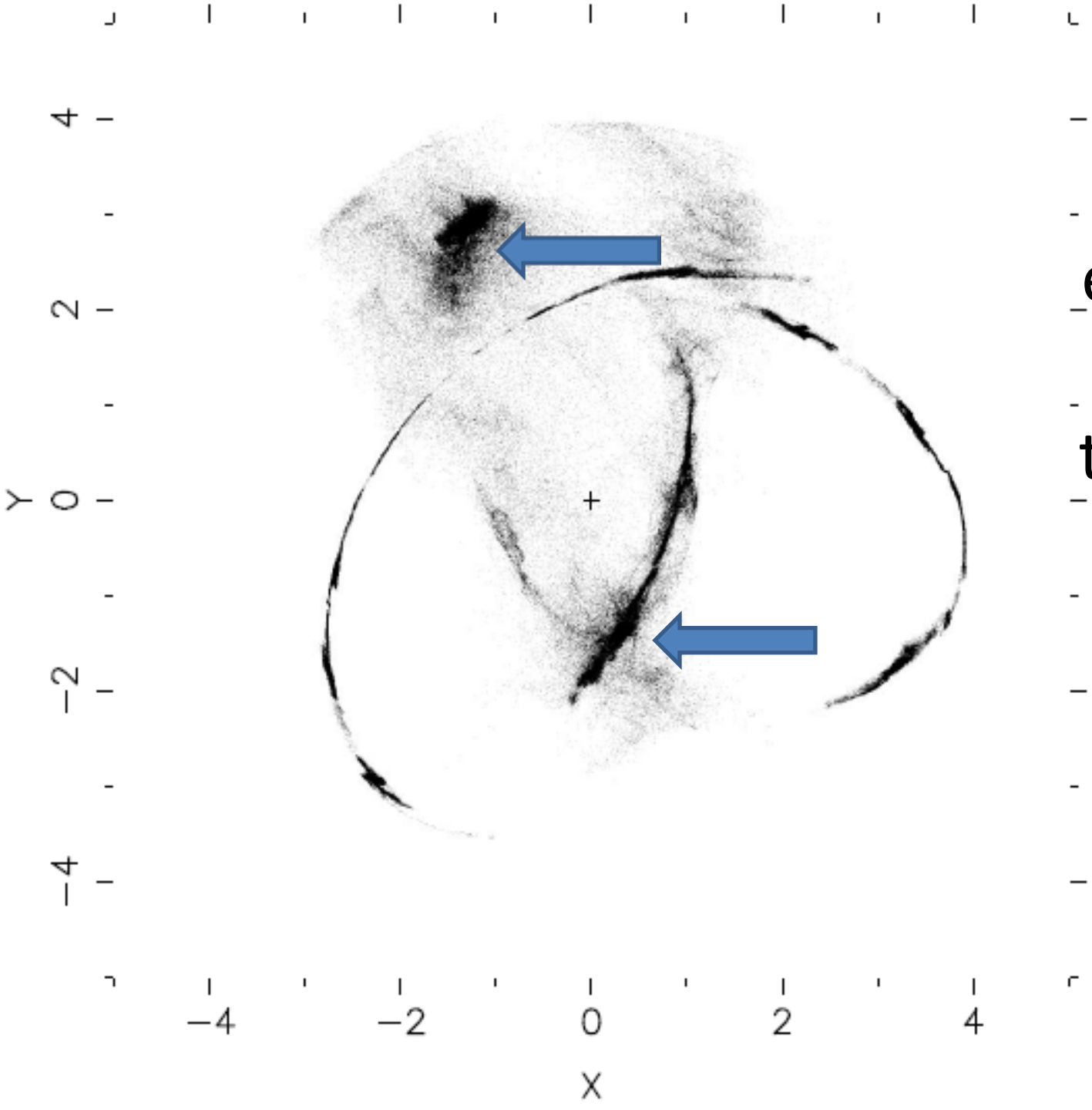
Triaxial isochrone, +10% y, +5% z: time to change increased by 30





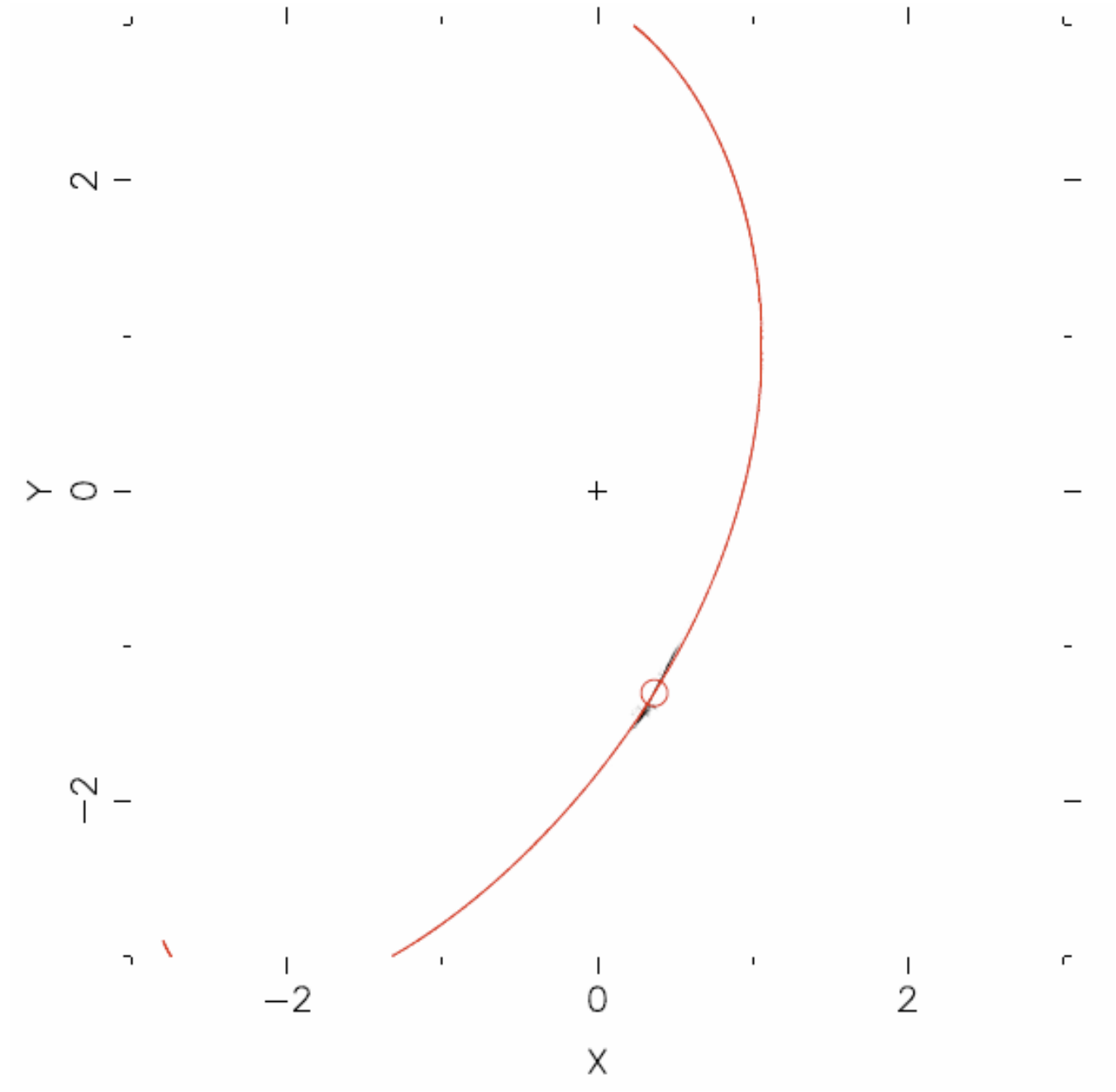
Low eccentricity orbit triaxial with 1000 sub-halos 2% mass

complex stream



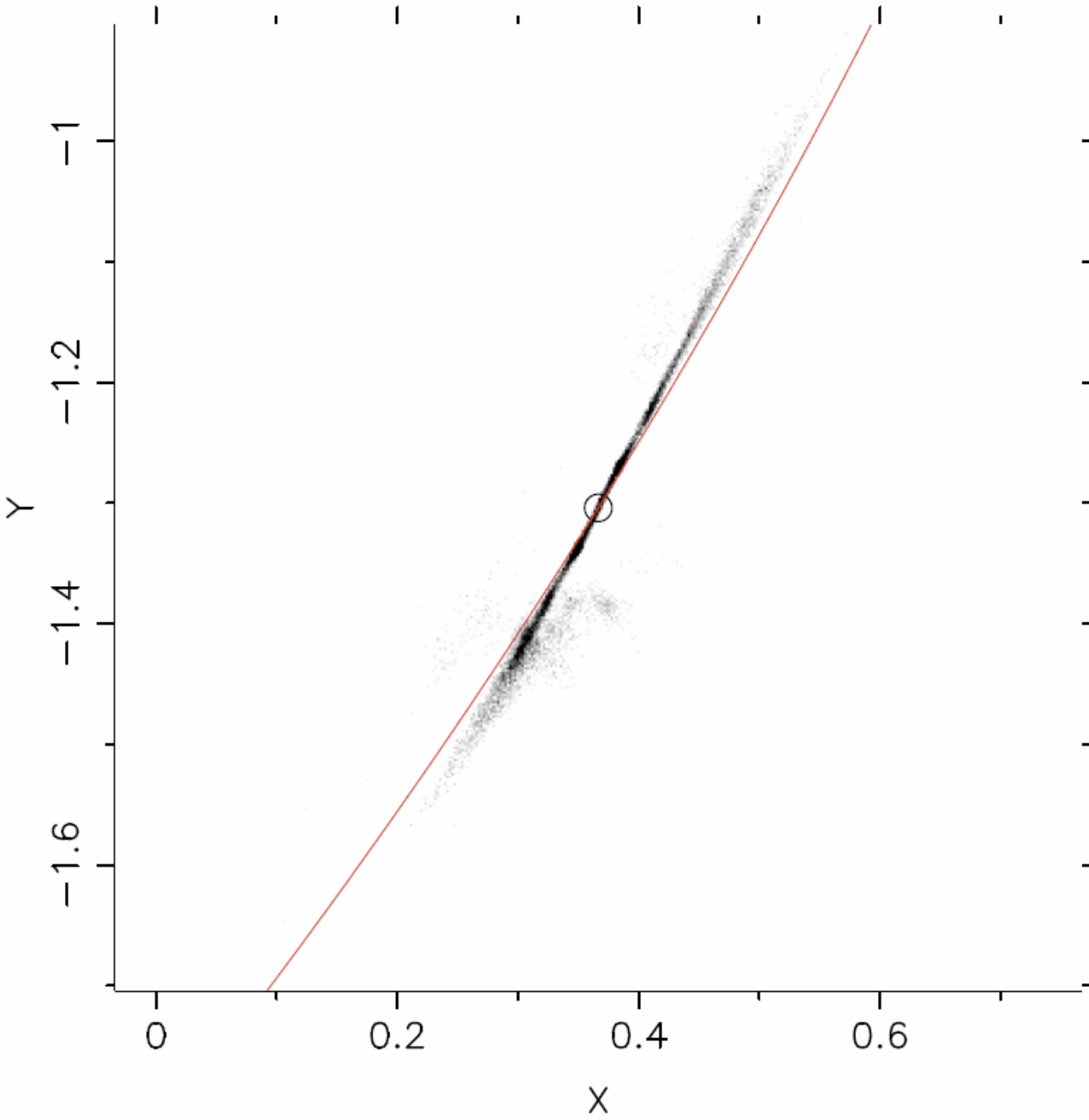
High/low eccentricity orbit triaxial with 1000 sub-halos 2% mass

2 times



High eccentricity stream again, but only high density parts plotted, down to 10% of peak.

Small, straight segment near pericenter



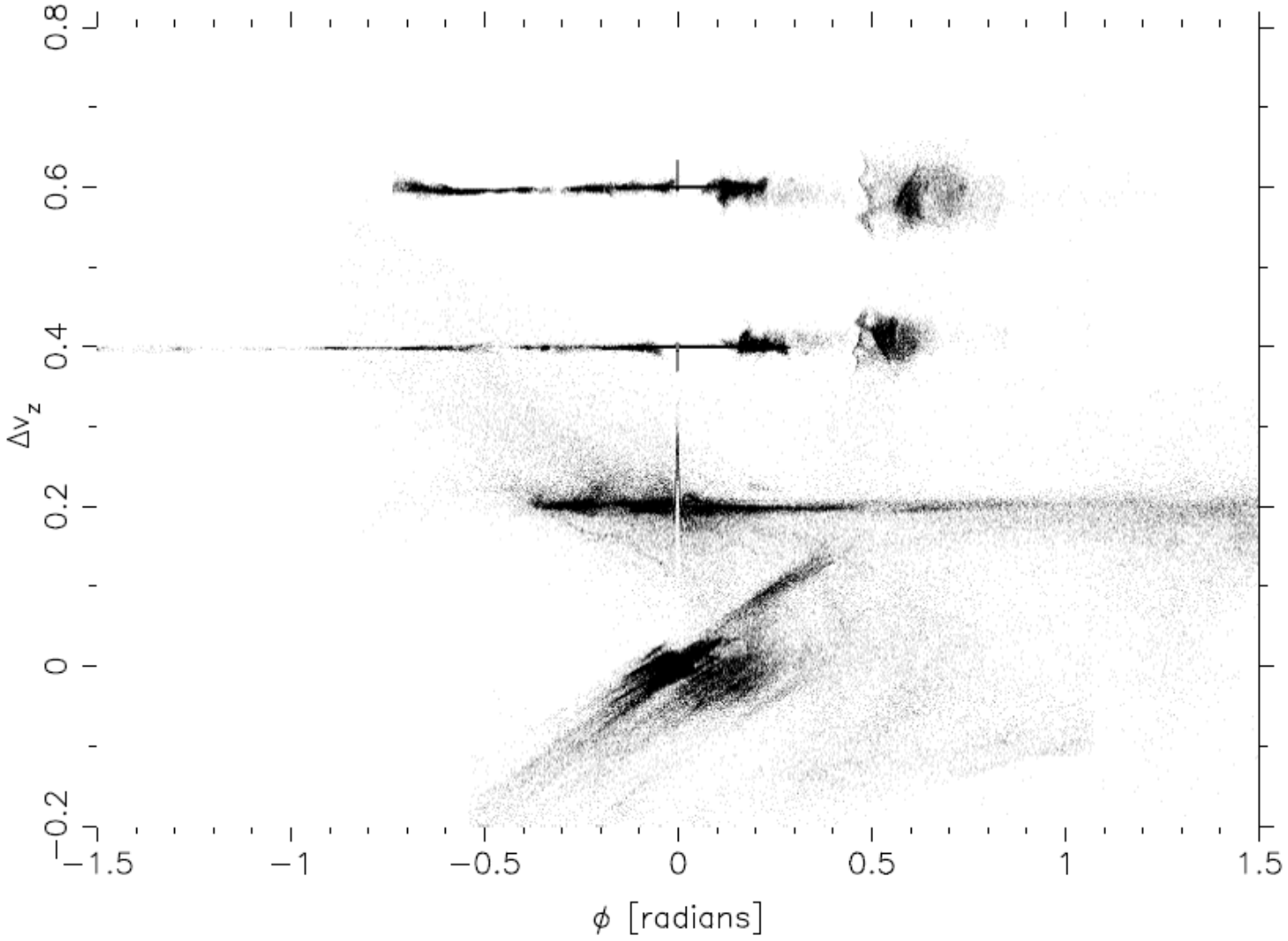
High eccentricity stream again, but only high density parts plotted, 10% of peak

ZOOMED IN 5x

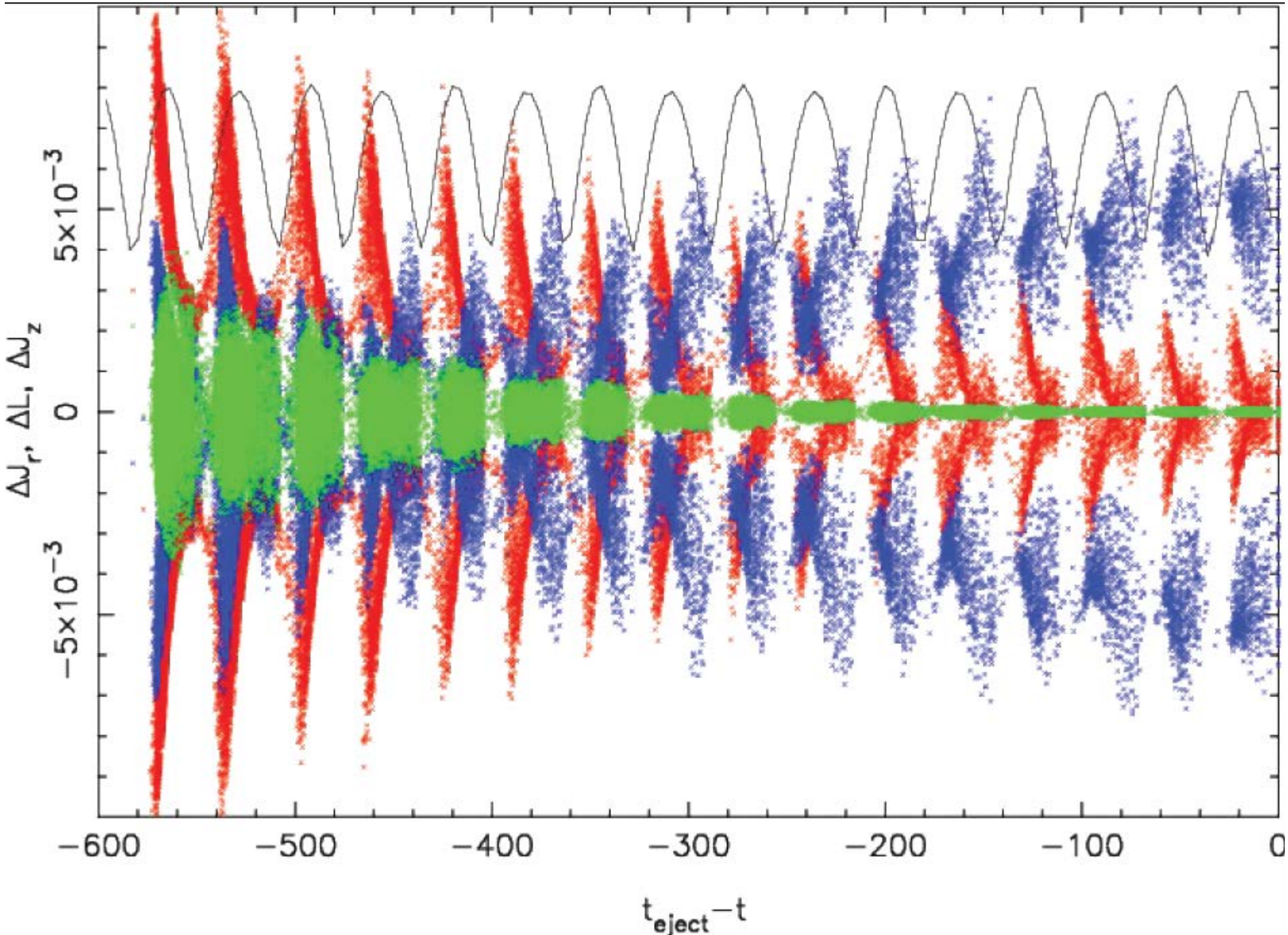
Ophiuchus?

Ghost stream: 95% is low visibility on sky, still there in velocity

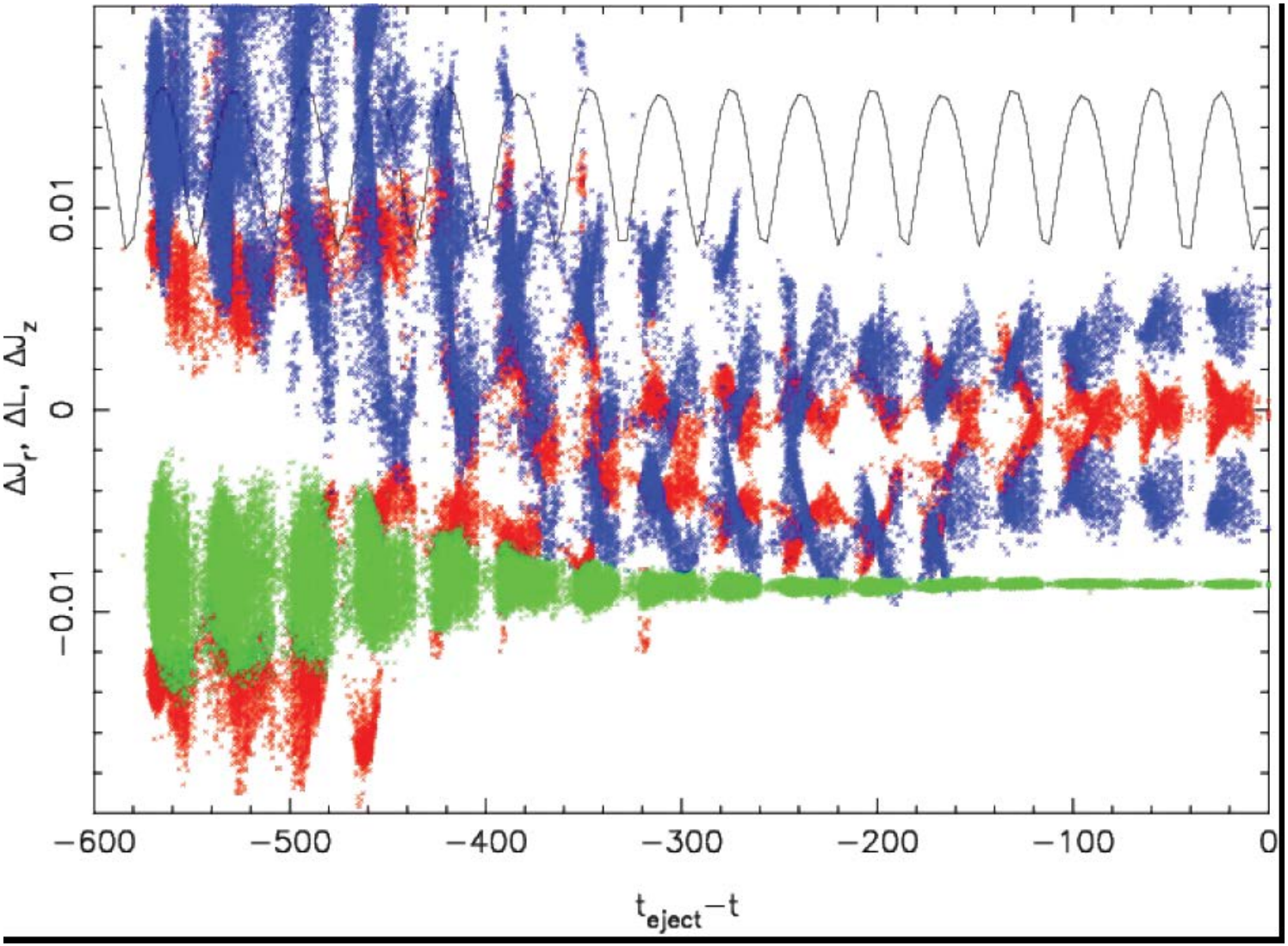
Vertical velocities (radial similar) stream still fairly coherent at peri (top 2, low e, bottom 2 high e, a/e)



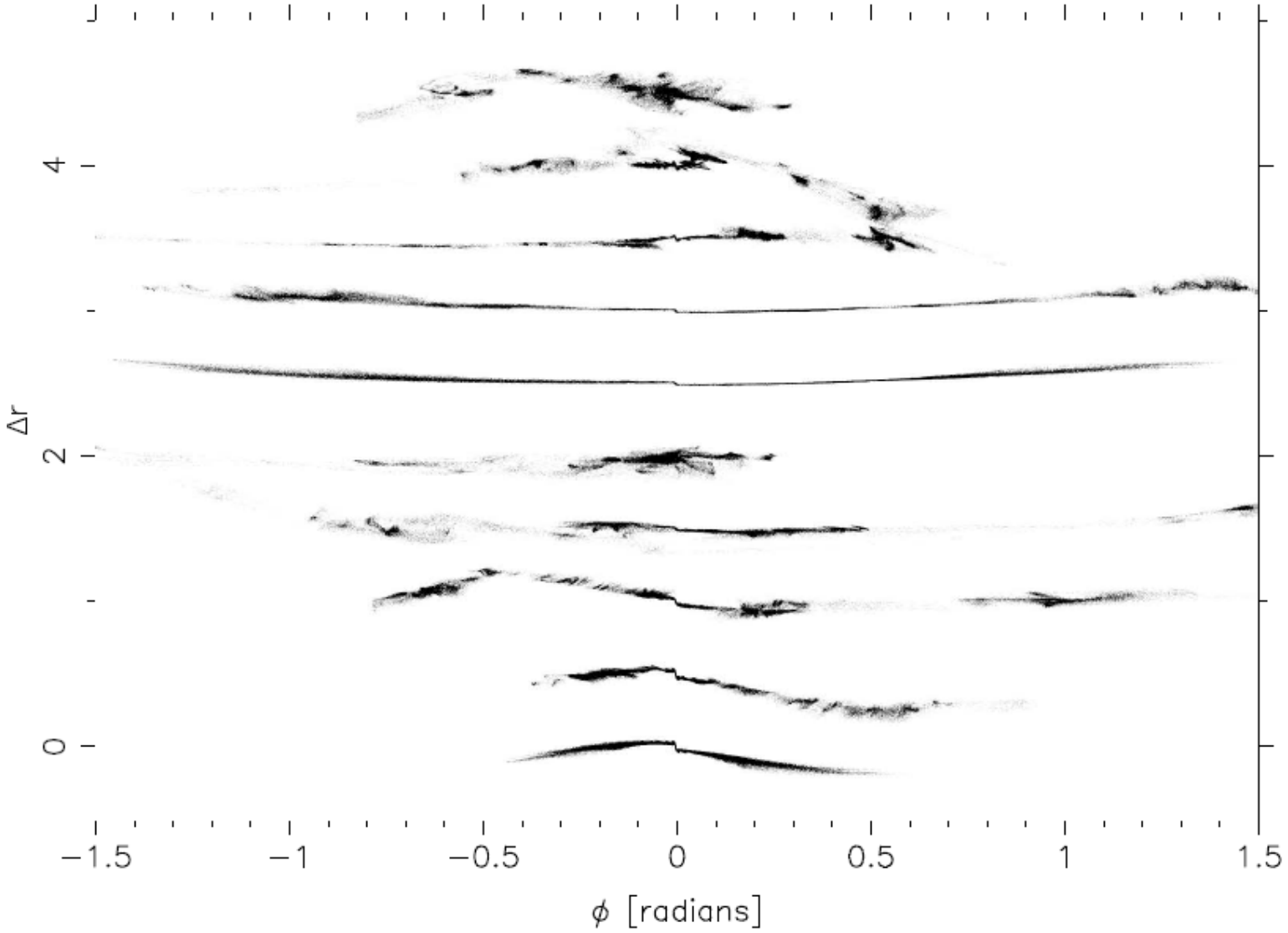
Action changes in a triaxial potential (smooth changes, exp growth in Jz)



N=1000 2% sub-halo triaxial sub-halos and triaxiality reinforce

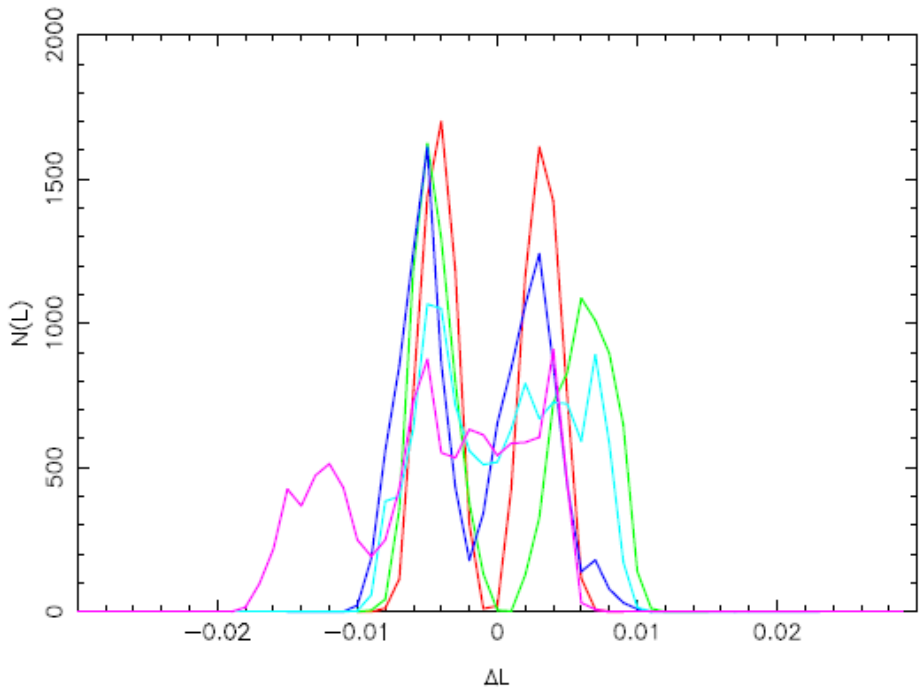


Increasing sub-halo fraction
2 times, 0, 0.01, 0.02, 0.03, 0.04

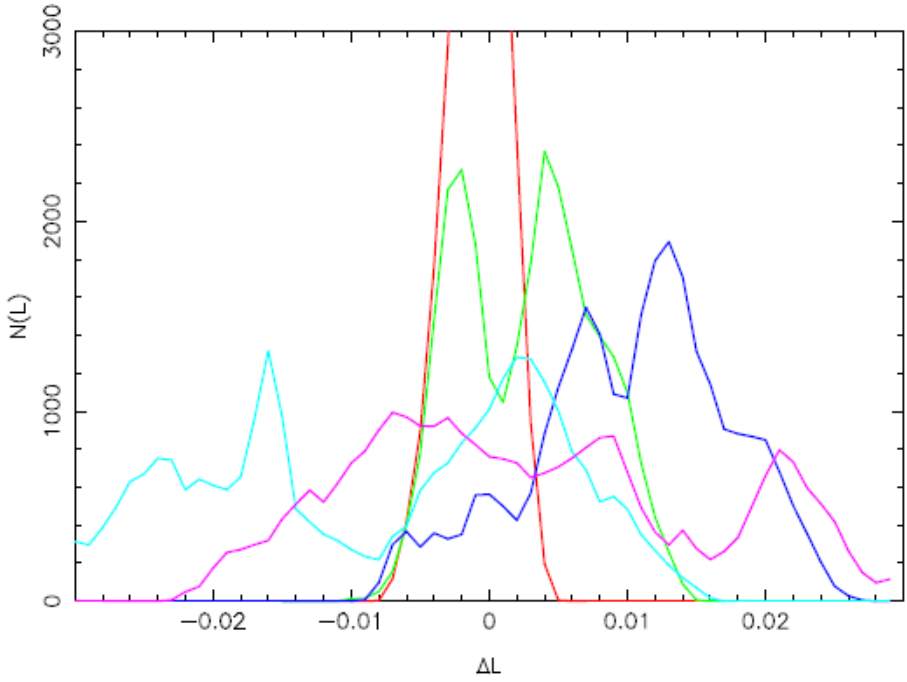


Velocity changes are 2-3x with 5x excursions at 2%
Can be used to rule out sub-halos
(red no sub-halos)

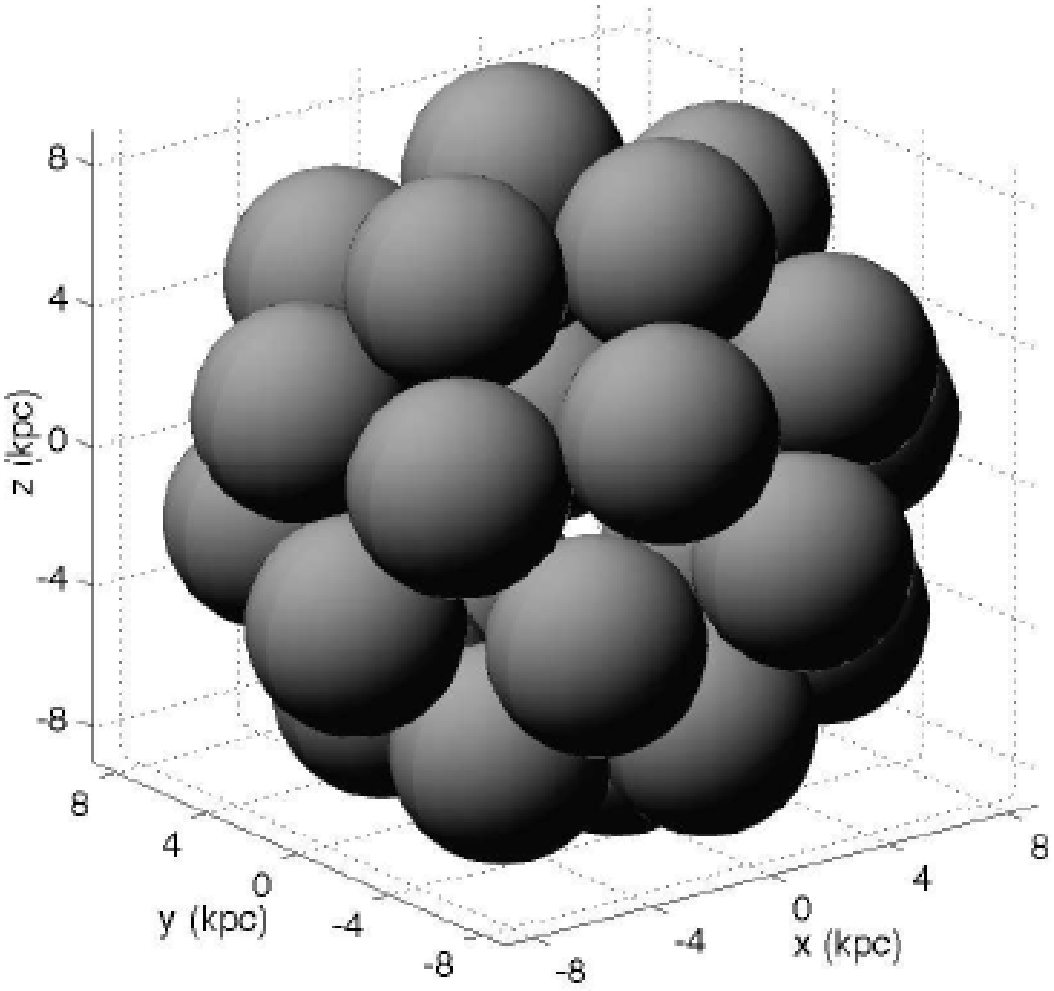
First half



Last half



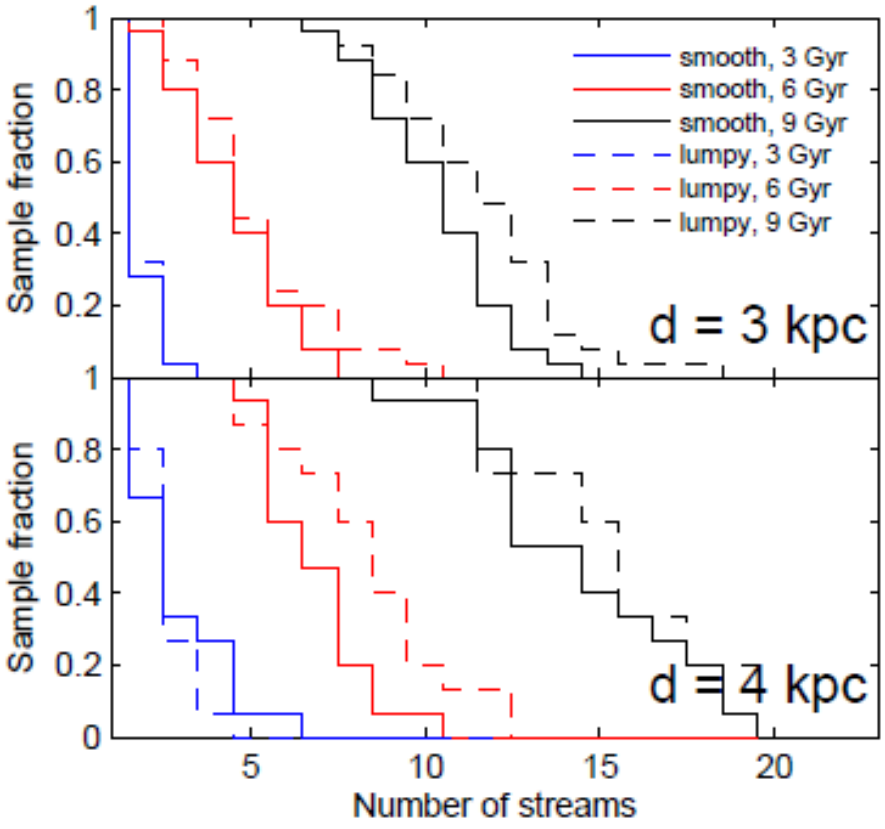
3 kpc diameter volumes at solar radius

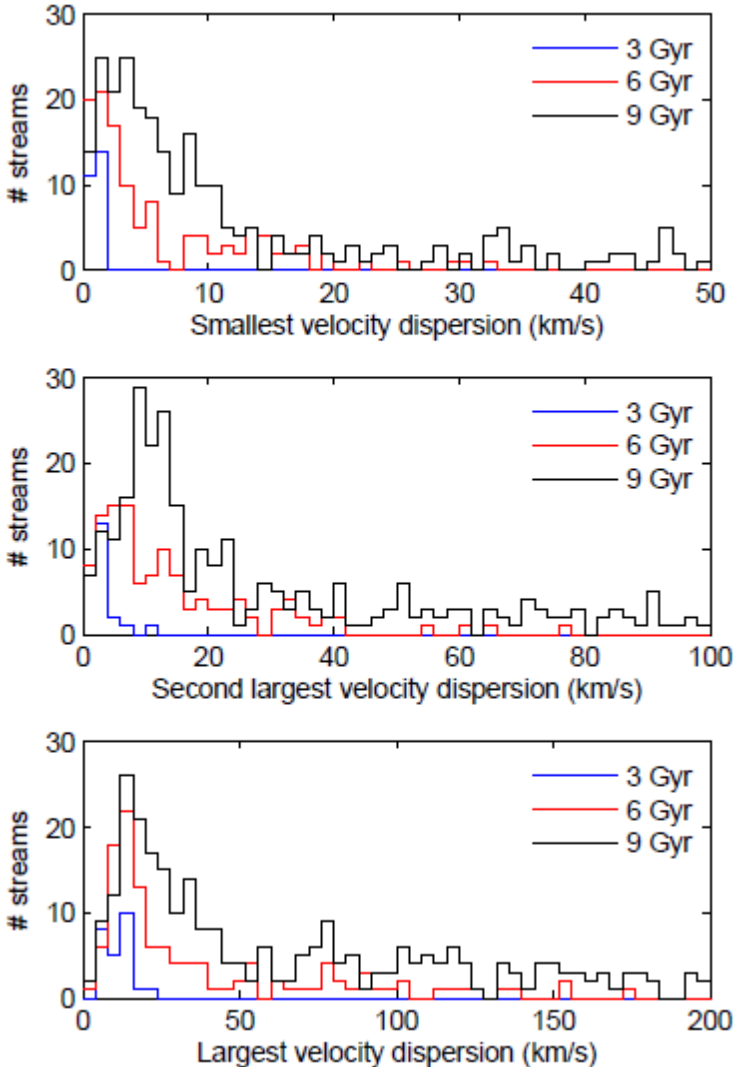


Wayne Ngan

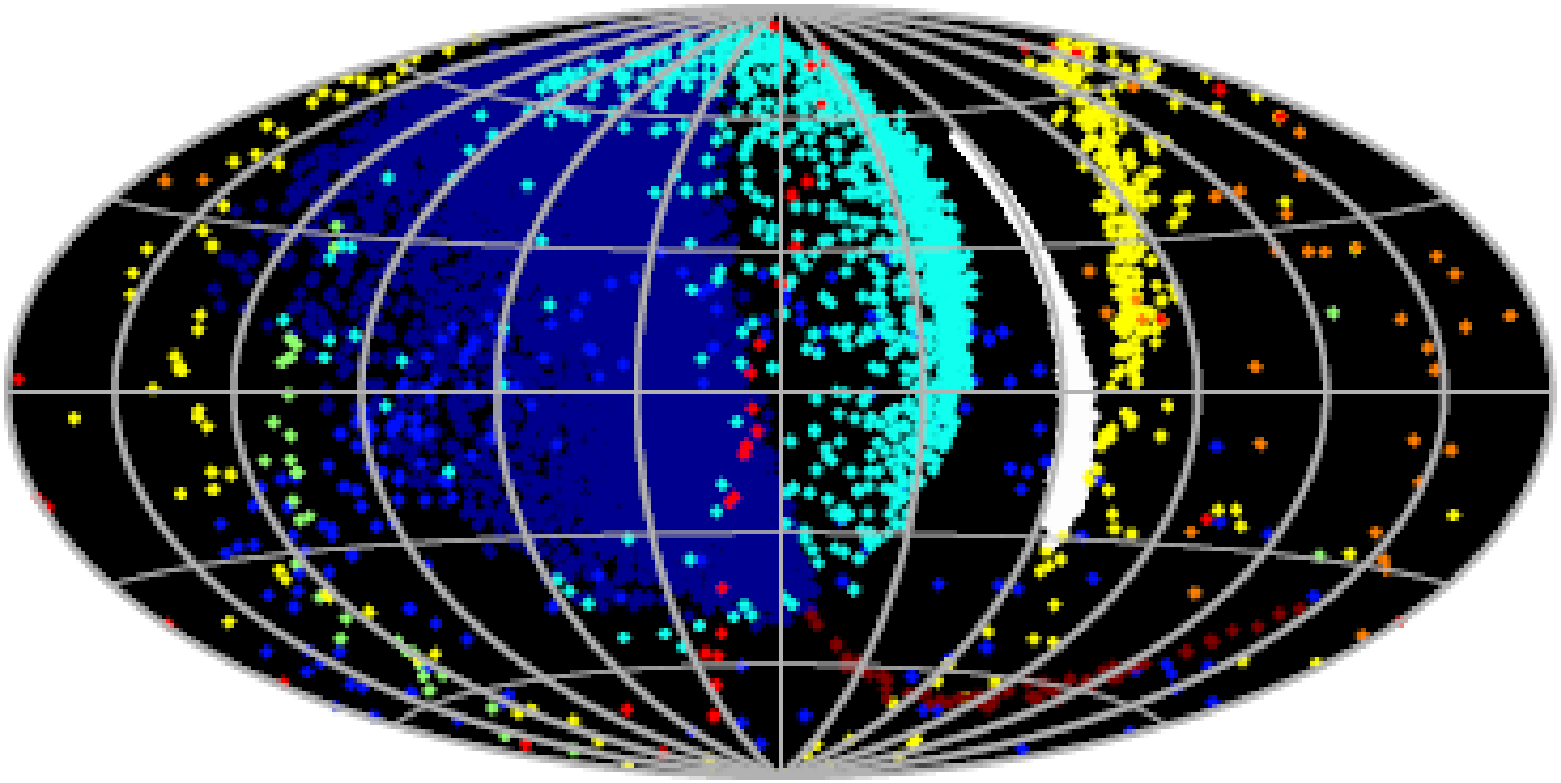
N=25, d=3kpc, r=8kpc

100 star clusters (15-30 kpc) statistics in GAIA volumes (Wayne Ngan)

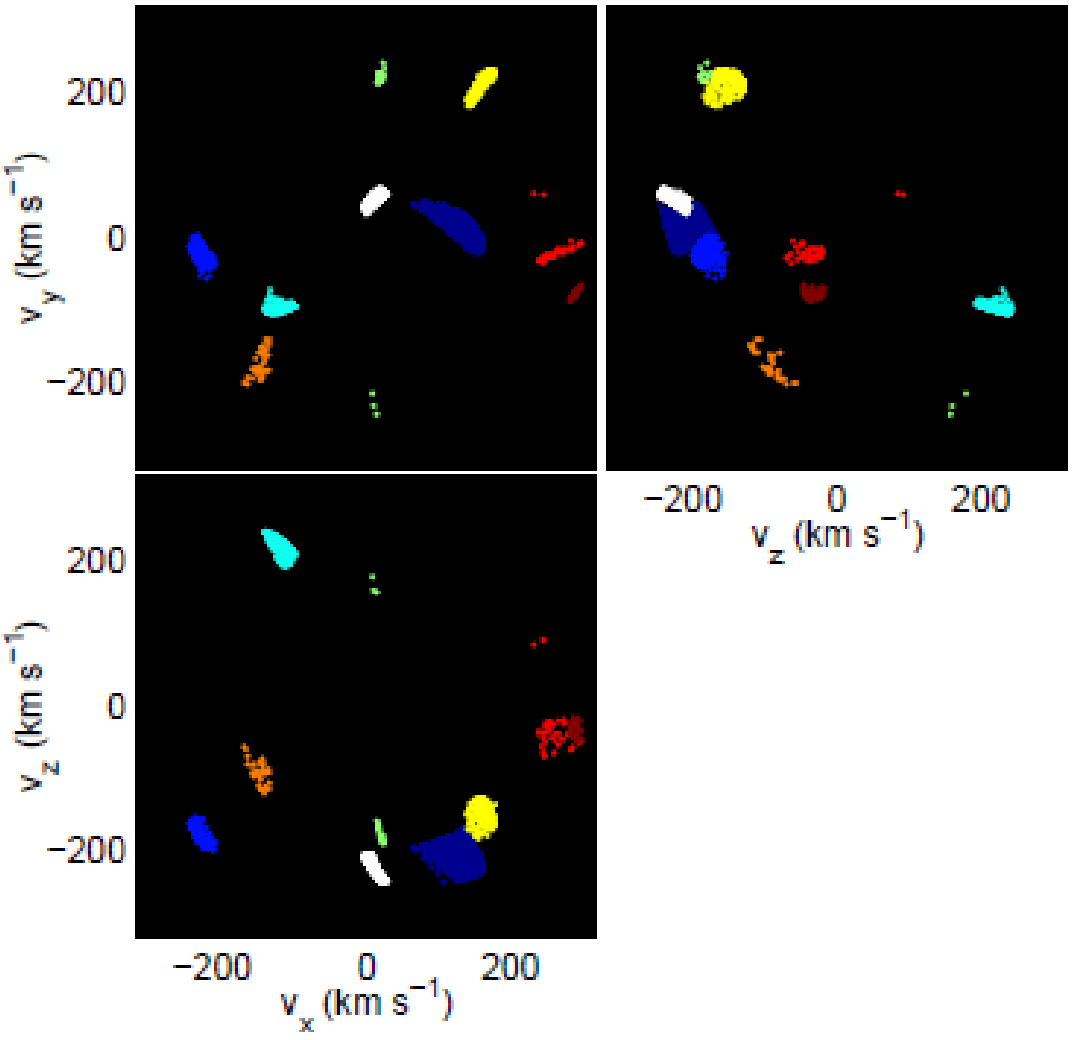




Streams in a Gaia 3kpc volume sky



Gaia volume velocities (100 initial clusters)



Conclusions

- Initial stream velocities from star clusters can be accurately calculated
- Sub-halos and triaxiality interact to diffuse orbits along the stream
  - Spherical/axisymmetric potentials not representative
  - High eccentricity streams diffuse to low density
    - Pericenter densities can remain high
    - Remain visible in velocity space
- Changes in velocities (ang mom)
  - Small in stream near progenitor
  - Velocities can spread 5x above injection at 2% sub-halos in >8 orbits