Eyjafjallajökull

The very centre

Genzel, Ghez, Alexander, Perets,...

- No doubt about the black hole!
- Its mass is very well determined
- Little extra mass (<5%) DM or stars within the S2 orbit
- No evidence for IMBHs: M < 5000 Msun for P < 5yr
- Beginning to constrain GR parameters but hard to compete with the double pulsars
- Accurate distance to the Galactic Centre: Rsun = 8.2 kpc
- Focus on circum-BH stellar populations – unexpectedly young with complex structure, varying strongly with r
- In some cases hypervelocity stars also surprisingly young and ejected from centre

Precision Galactic Structure

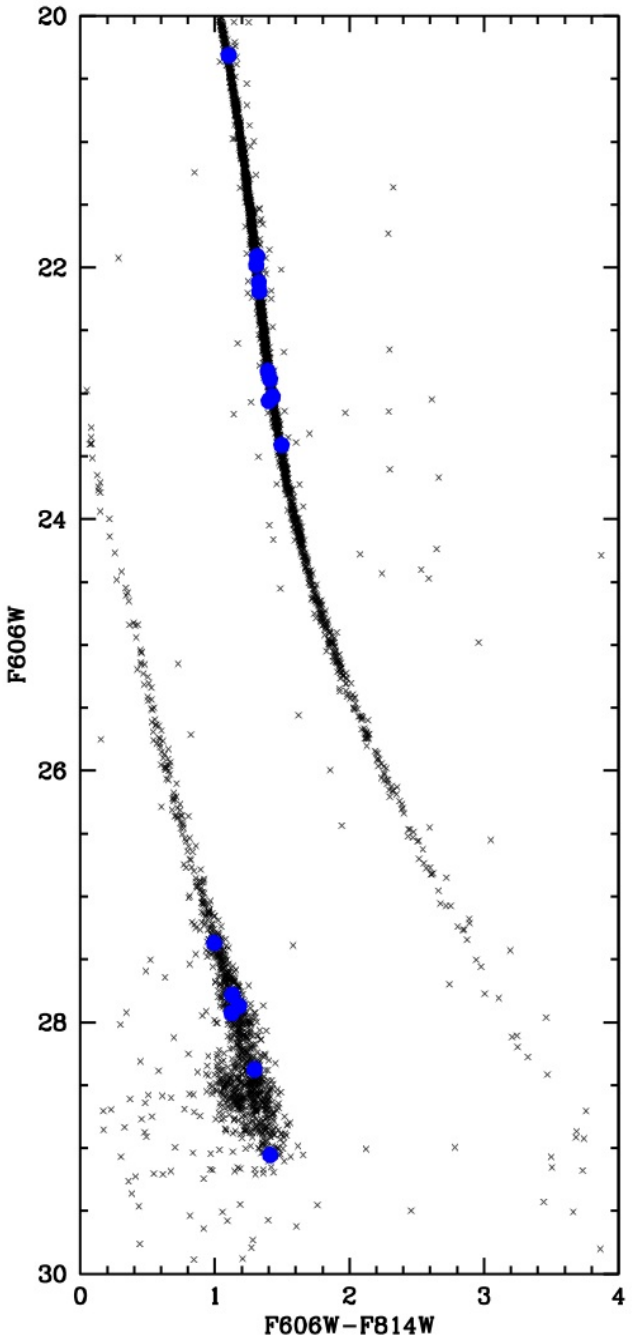
Reid

VLBA observations of masers, Sag A* --> 50 μsec accuracy

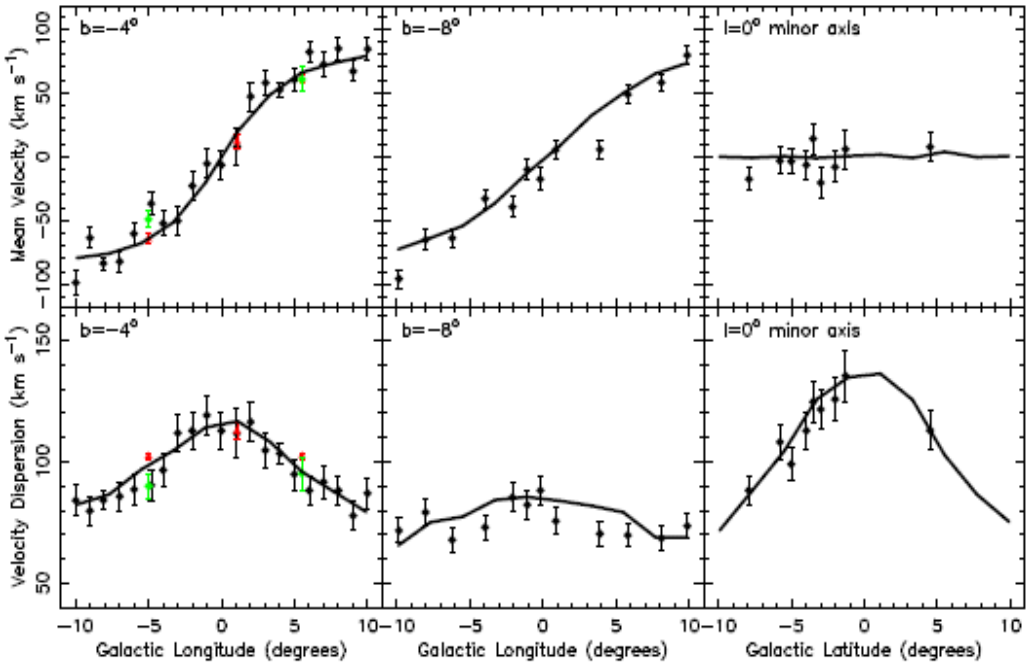
- Vsun/Rsun = 30 +/- 1 km/sec/kpc
  Rsun = 8.4 +/- 0.6 kpc, Vsun = 245 +/- 12 km/s

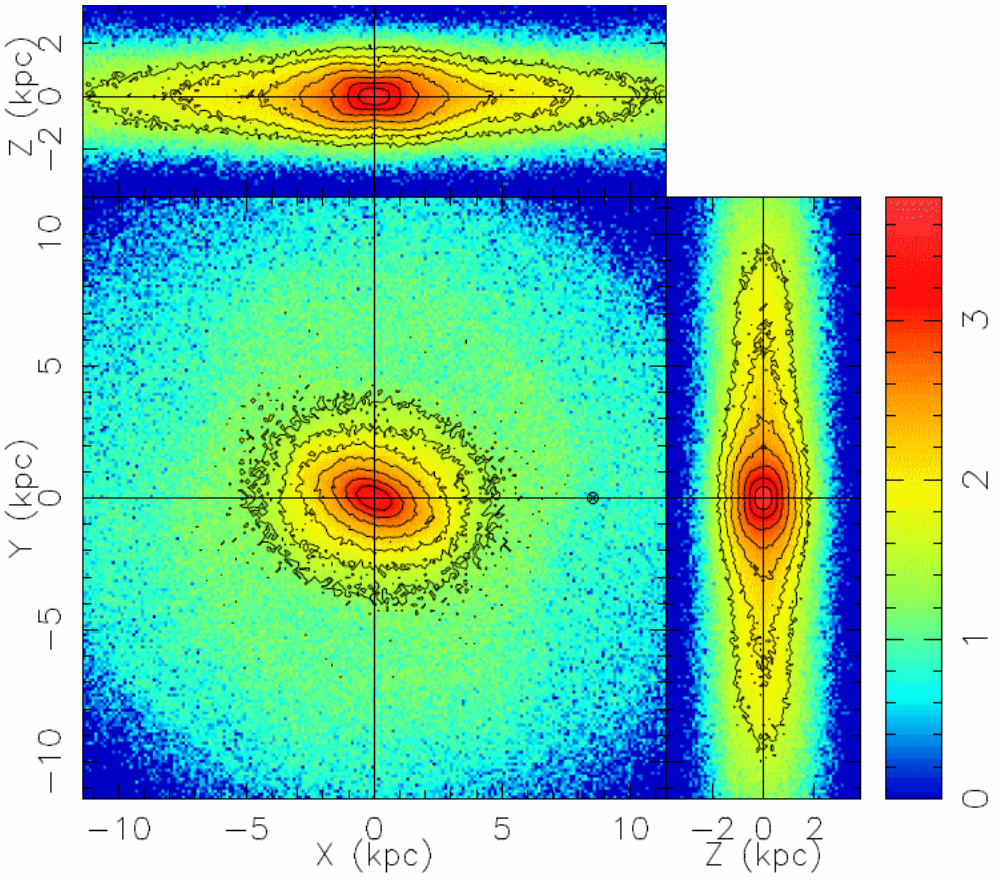
- V_z (Sag A*) < 1 km/s! Constraint on warps...?

Rich, Richer, (richest?)



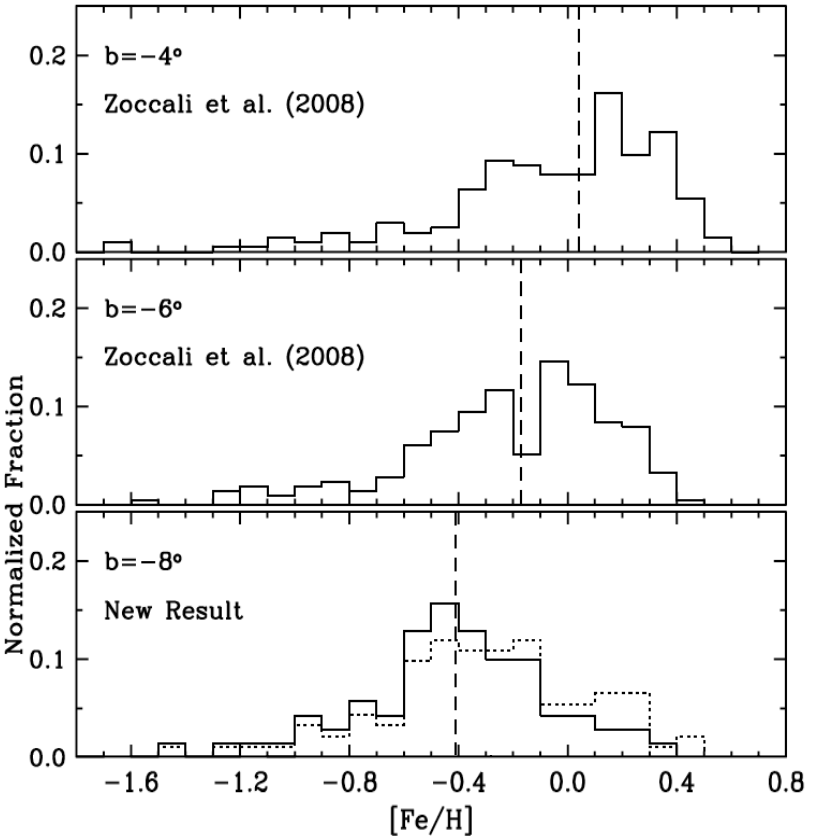
- Proper motion cleaned CM diagram of bulge cluster NGC 6397
- Such data produce precise ages
- Bulge is almost all > 10Gyr old



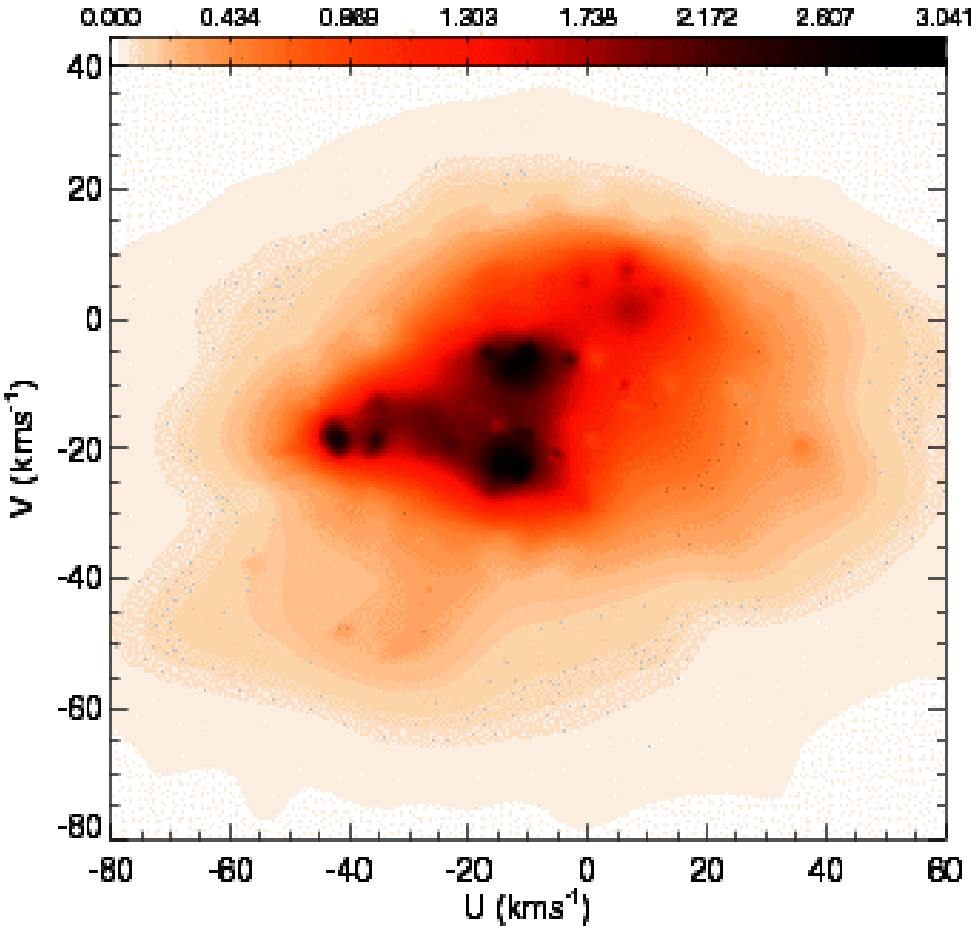


Gerhard, Shen, Rich, Freeman

- Bulge/bar reaches ~4kpc, bigger than disk scale-length ~2.5kpc?
- Formation from a flat bar fits photometry and kinematics
- What about age and metallicity gradient?

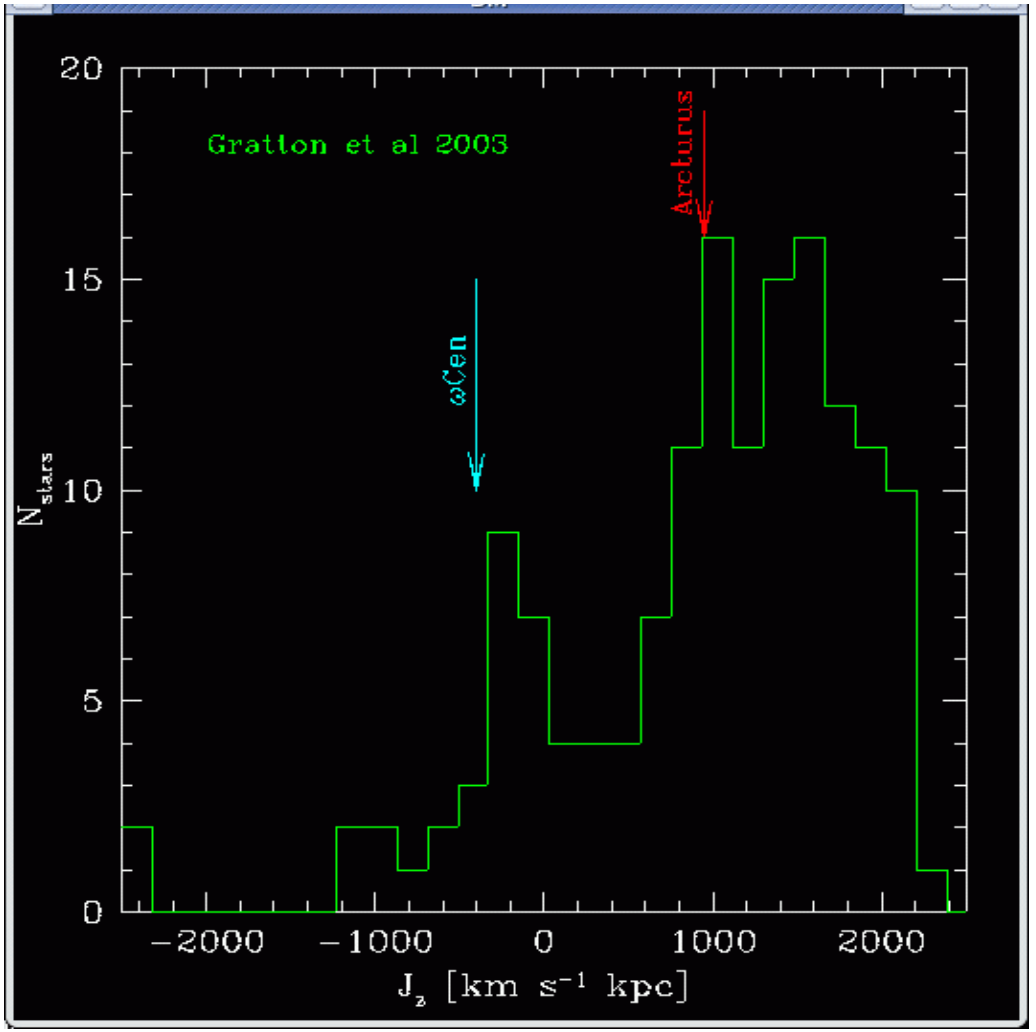


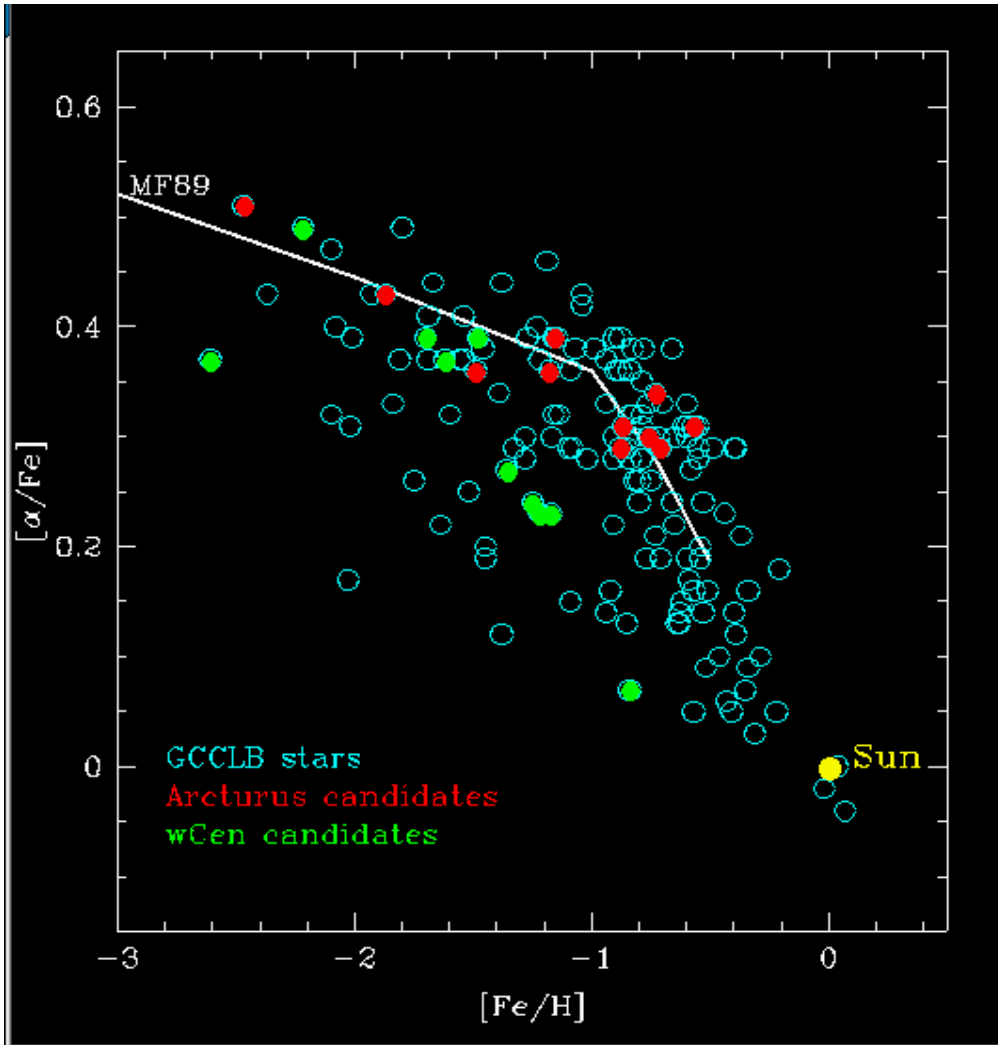
Dehnen, Binney, Sellwood



- Present kinematic samples show MW is neither axisymmetric nor in a steady state
- Description in terms of f(I) must fail
- Structures are a consequence of spiral/bar structures
- Do they *drive* spirals?

Metal poor moving groups in the local disk



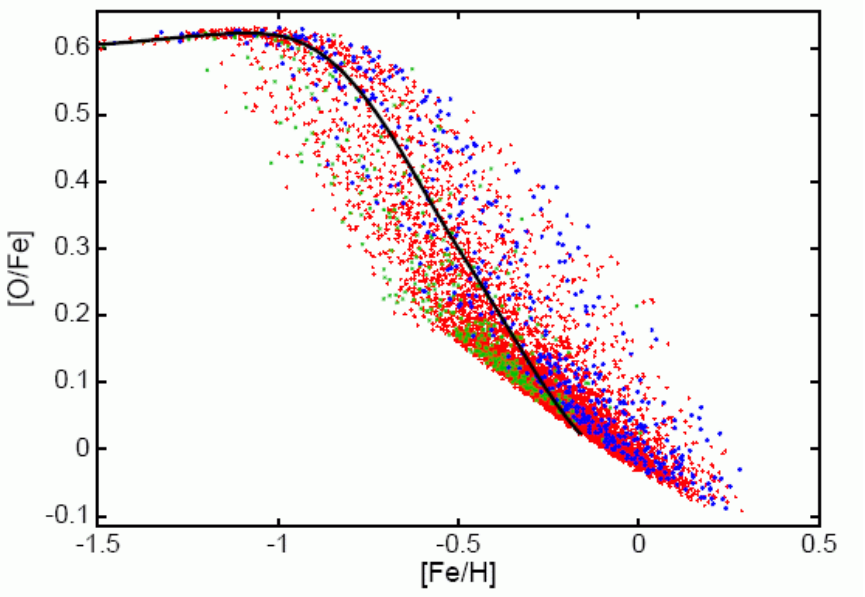


Navarro

Orbits confined to the disk, but strongly sub-circular
Appear to be accreted objects

Migration of disk stars

Binney, Sellwood



Transient spirals give broad resonances exchange J with disk stars

They cause stars to migrate in radius without major increases in eccentricity

Stars can migrate (diffuse) in both directions

This can explain observed lack of age-Z relation near the Sun

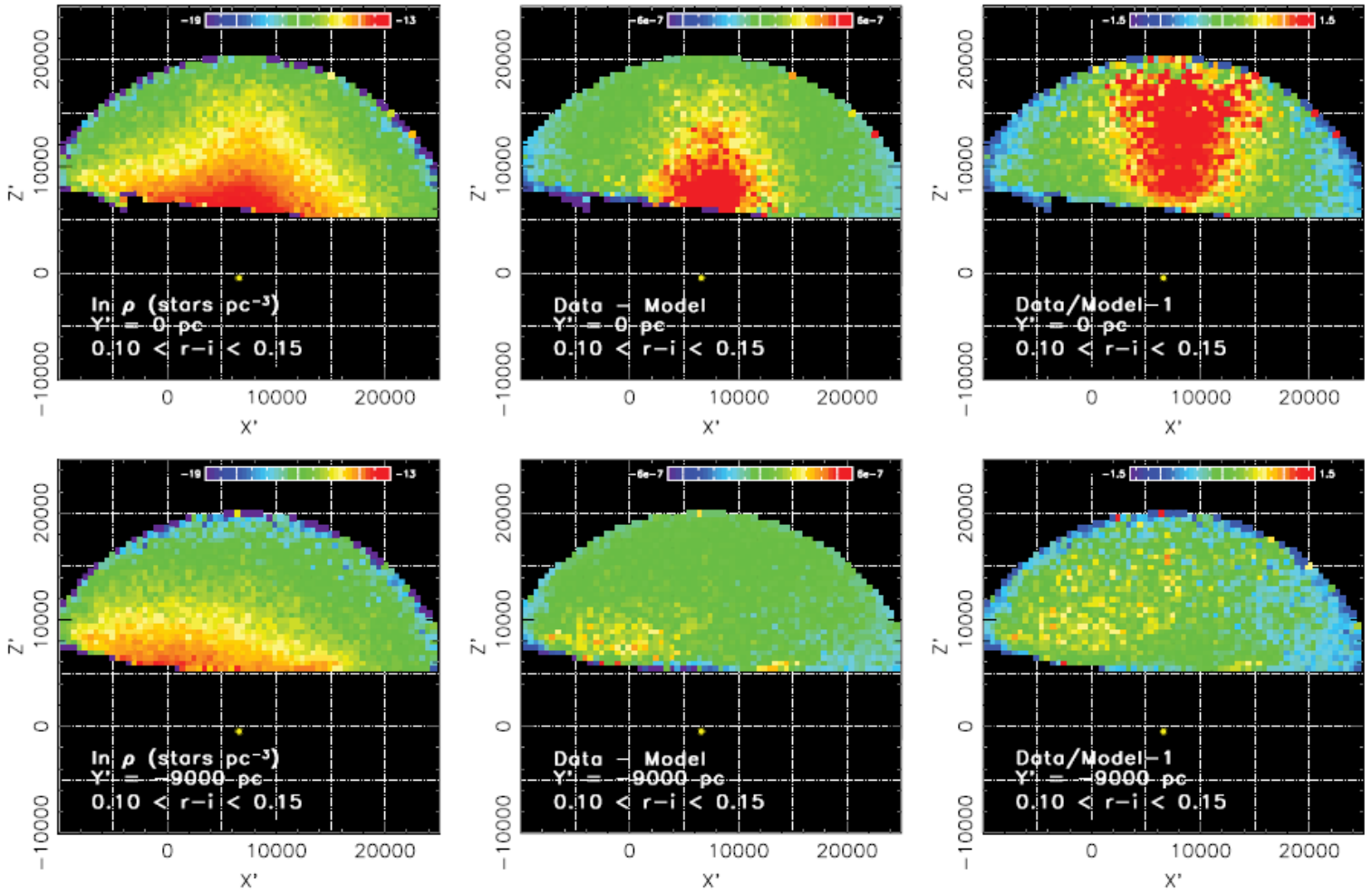
May also explain thick disk properties?

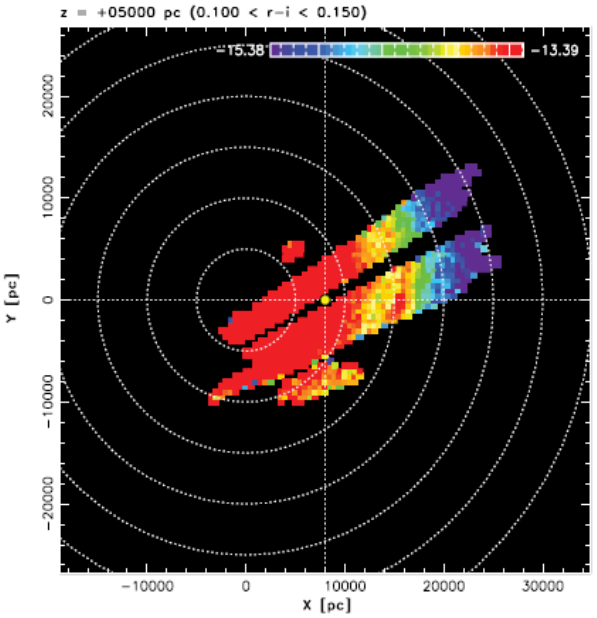
Requires continual disk cooling (new gas?) to maintain activity?

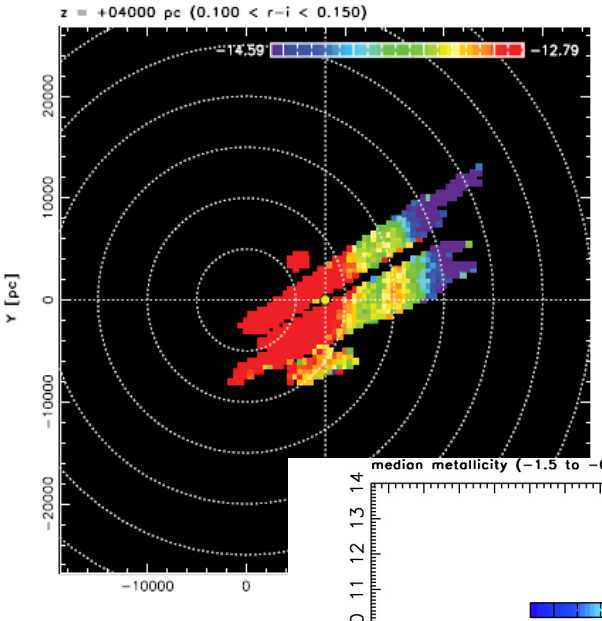
Star clouds?

Juric

The Virgo overdensity is huge and asymmetric



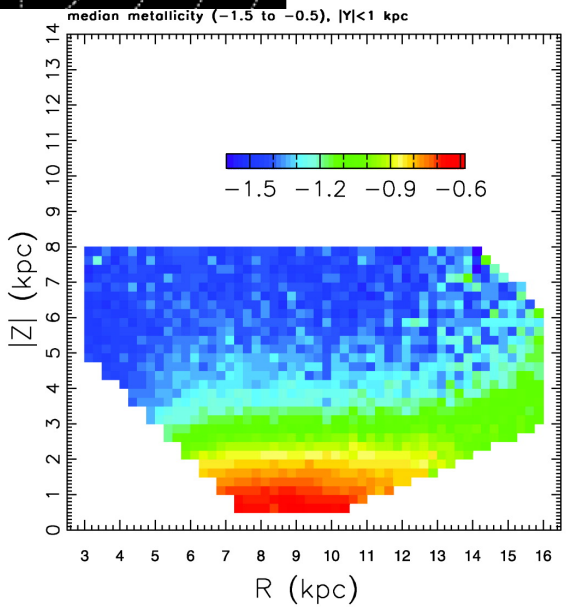


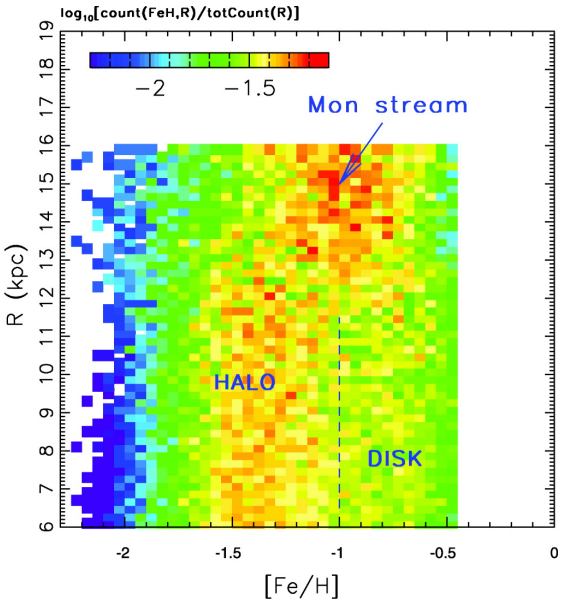


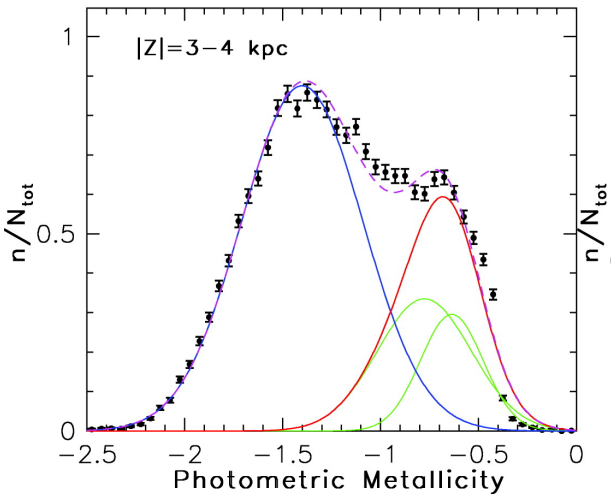
Star clouds?

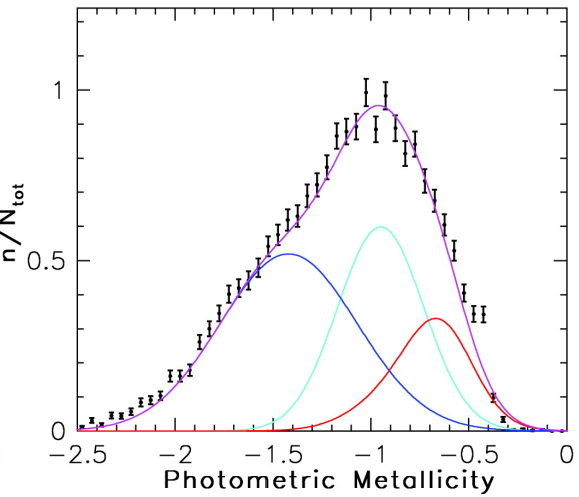
Monoceros looks like a disrupting dwarf

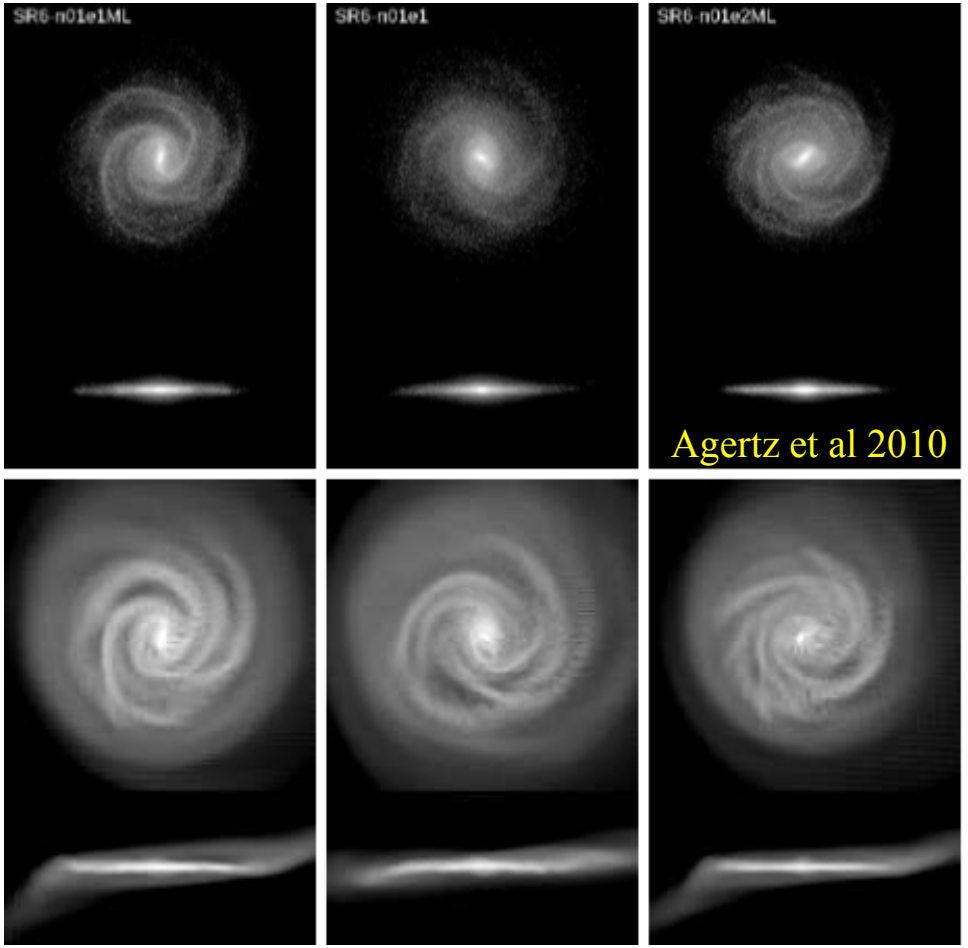
Juric

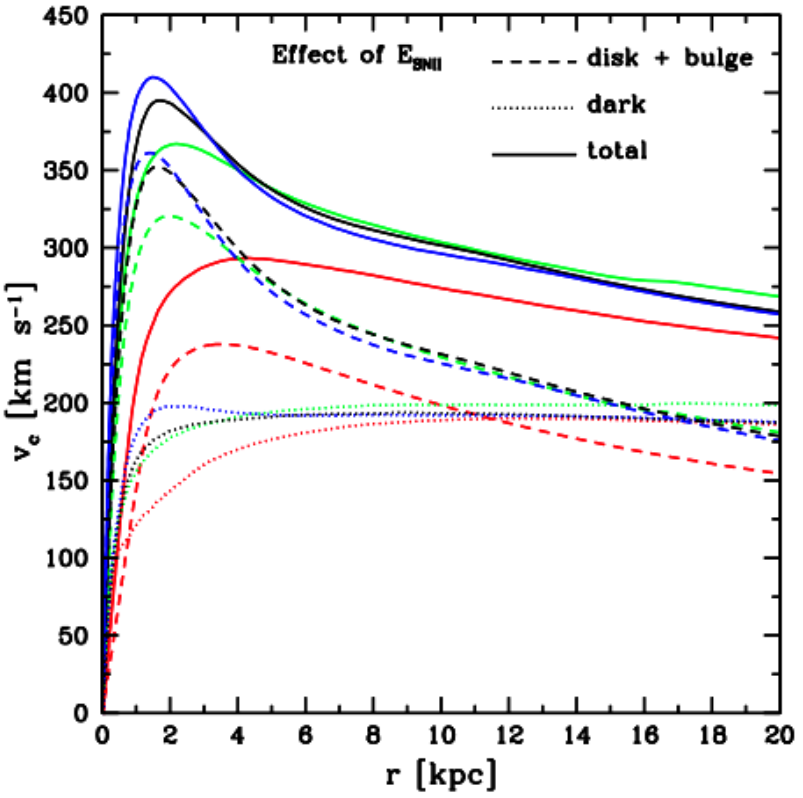












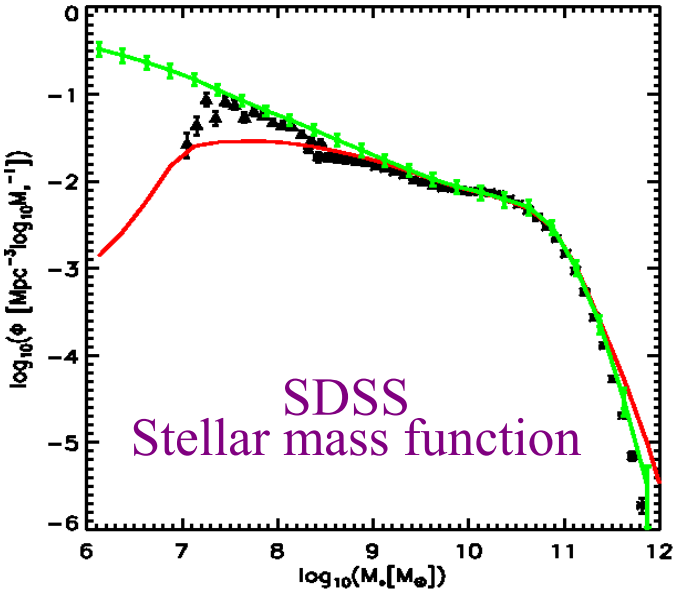
$$M_{200} = 10^{12}\, M_{\odot}$$

LCDM disk formation simulations don't

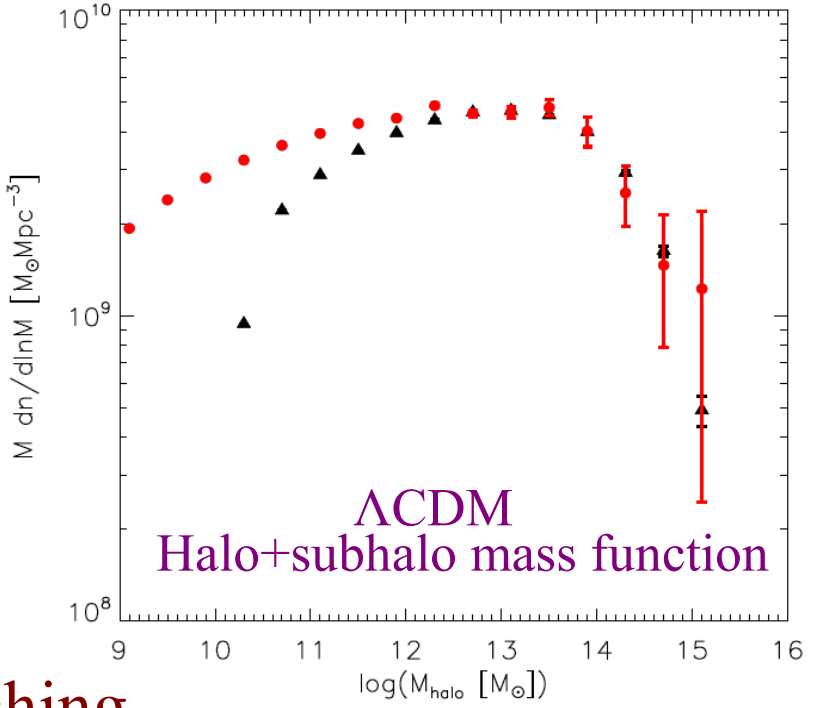
---Those with nice disks are much too massive

--- Those with proper formation efficiency make poor disks.

Navarro

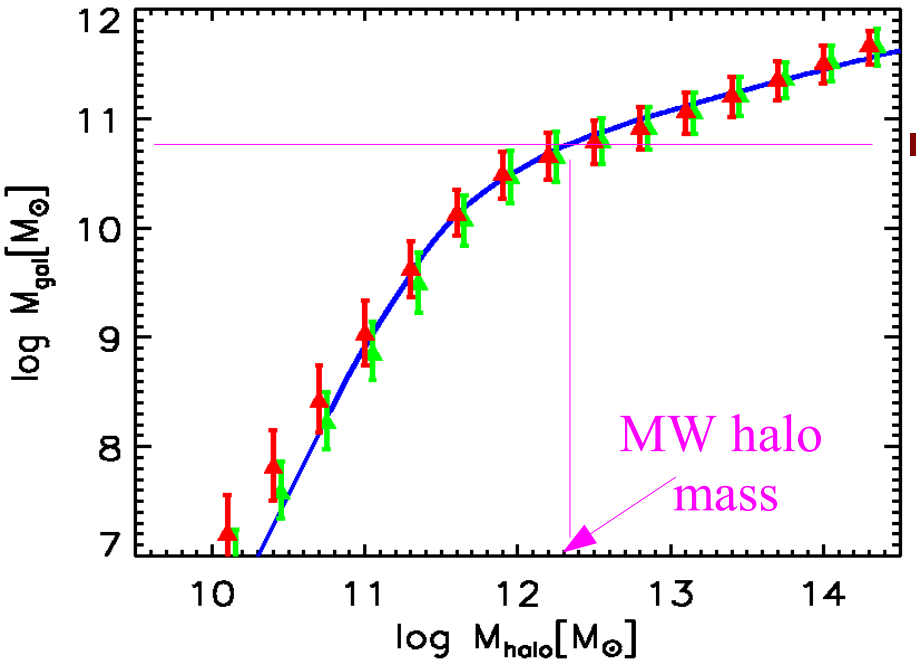


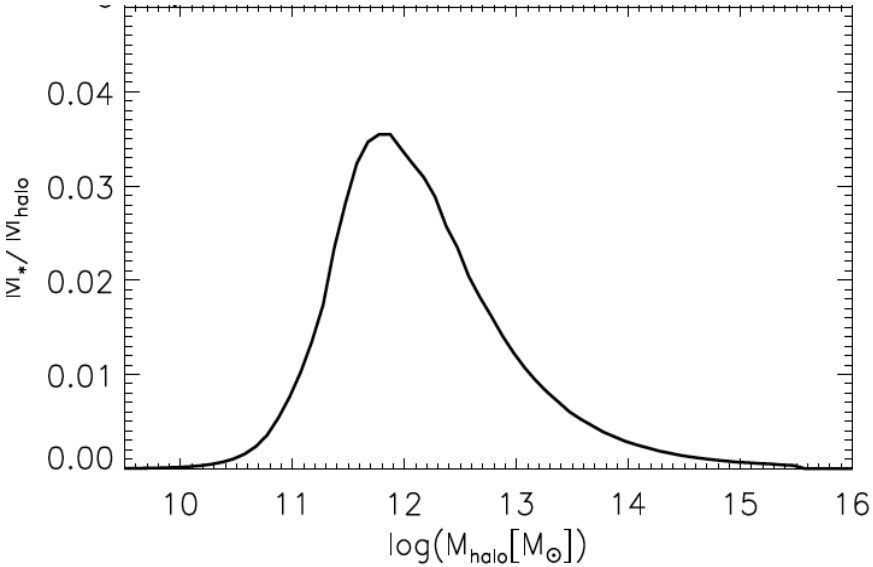
+



Rix, Kuhlen, Navarro

abundance matching

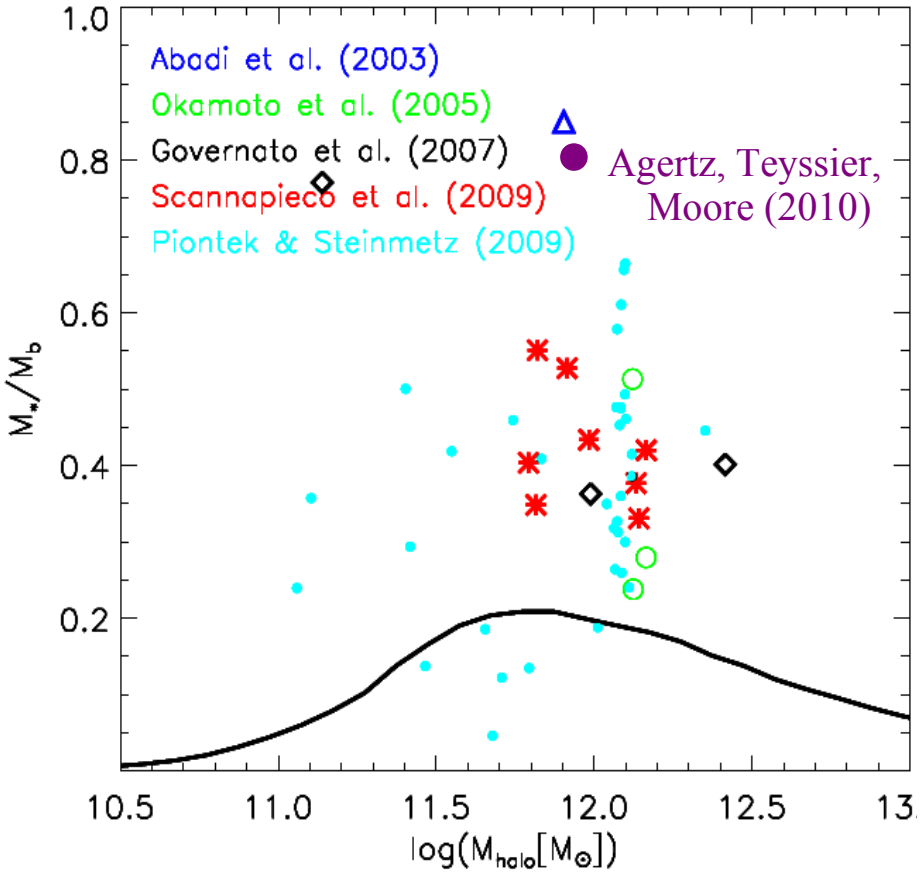




$M_* < 0.035\ M_{200}$

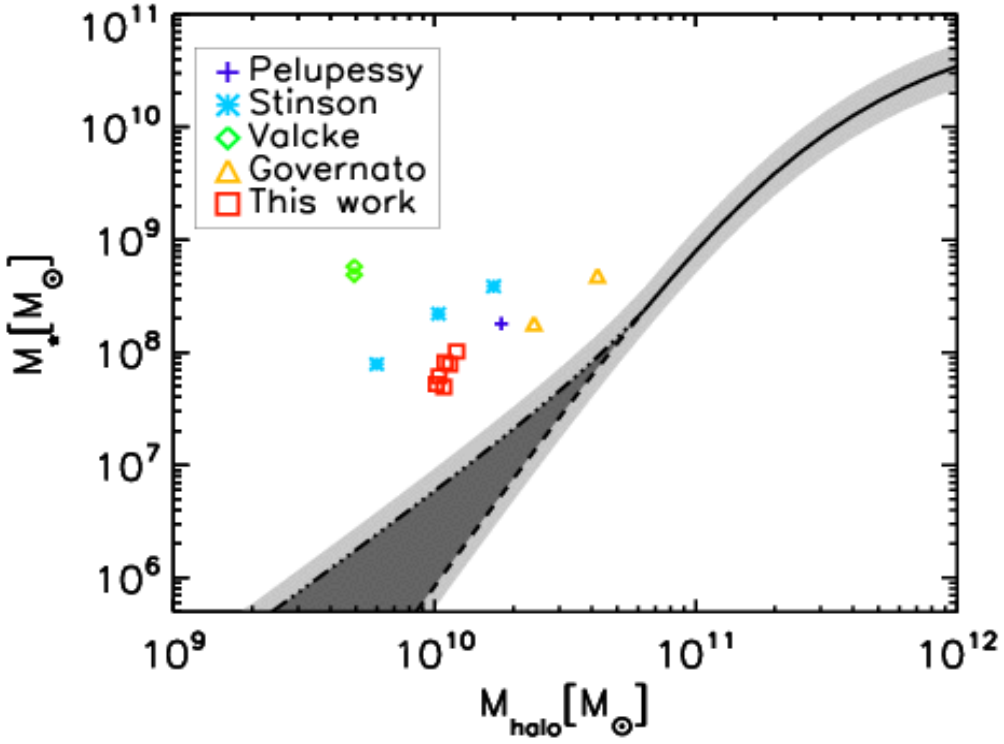
Low galaxy formation efficiency

Giants



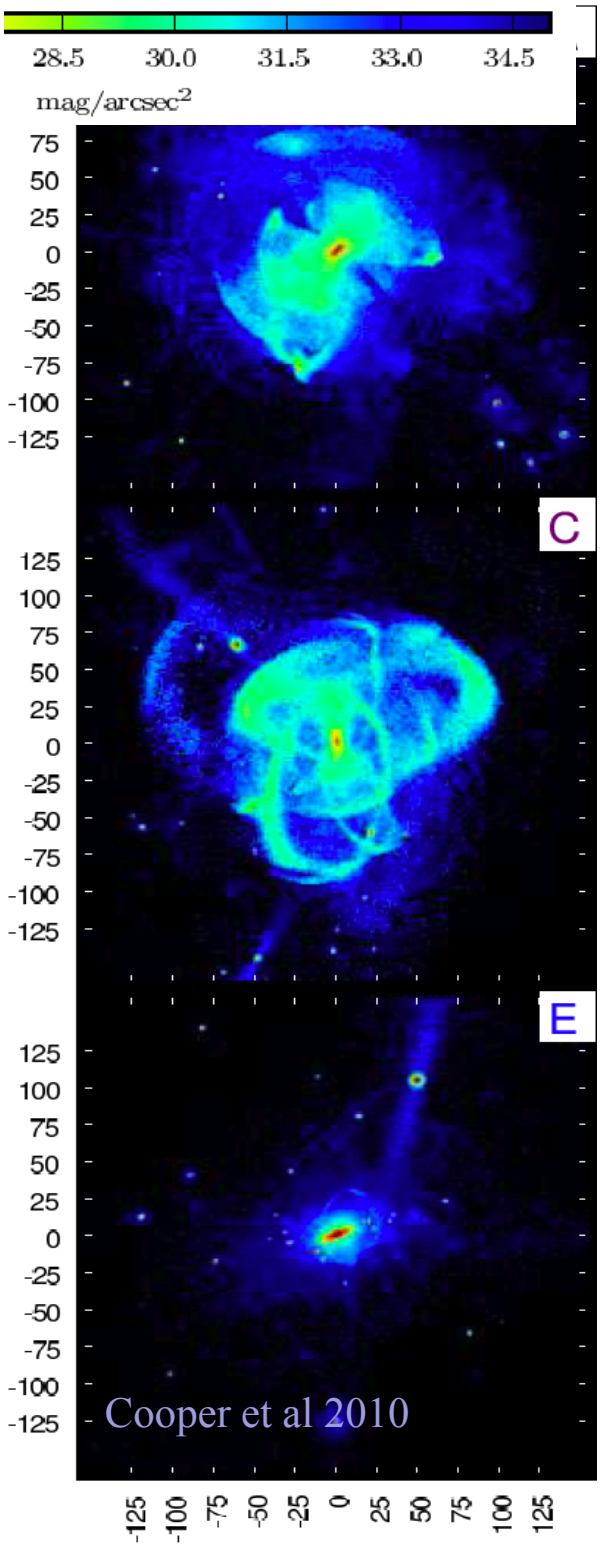
Guo et al 2010

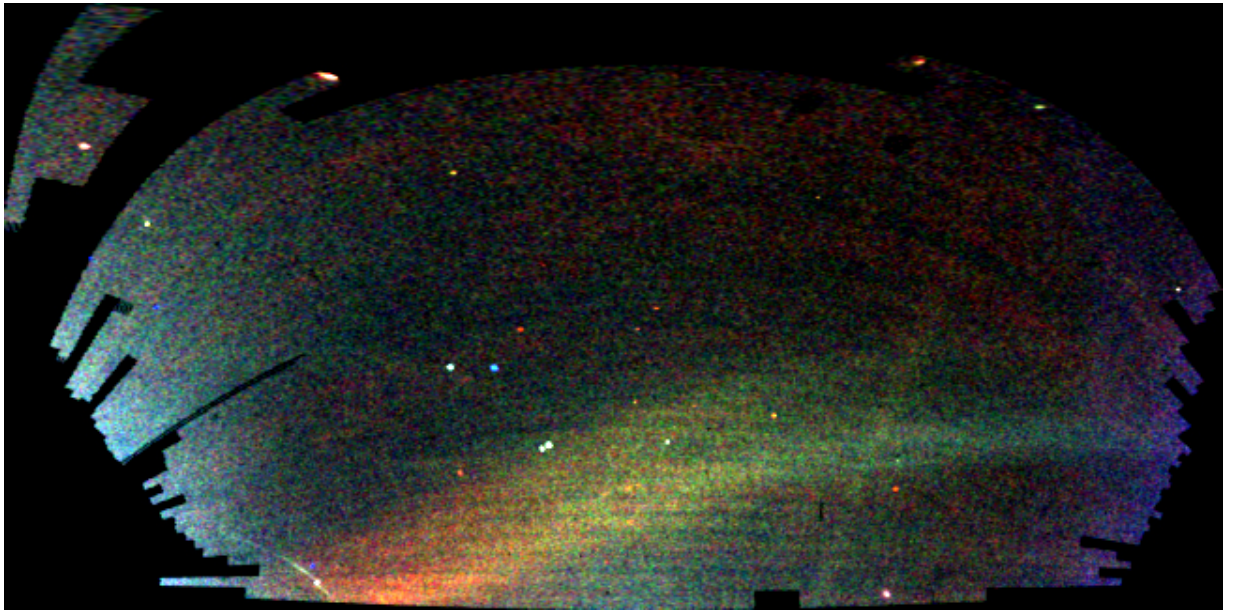
Dwarfs



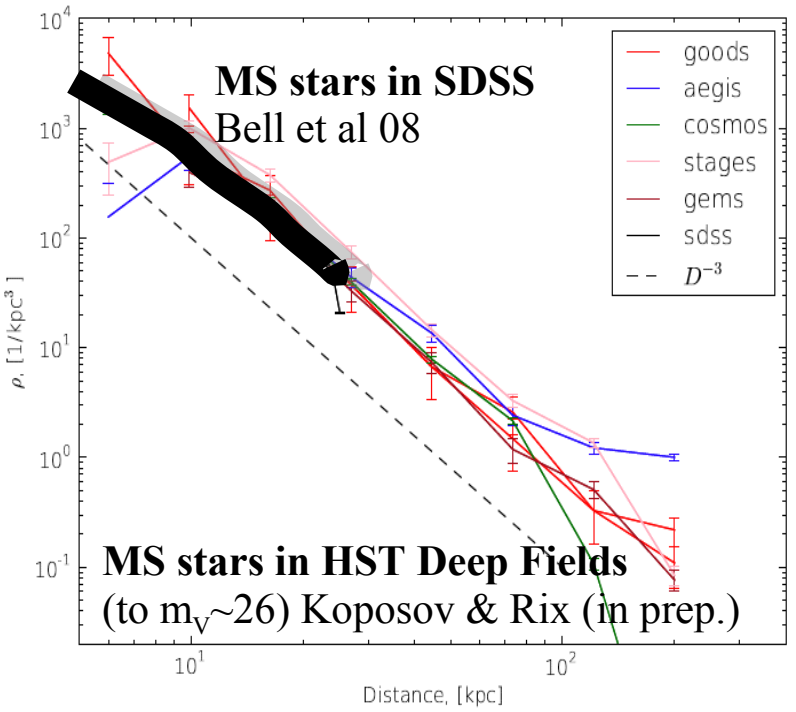
Sawala et al 2010

All LCDM simulations form overly massive galaxies
Those with the best disks are the most overly massive

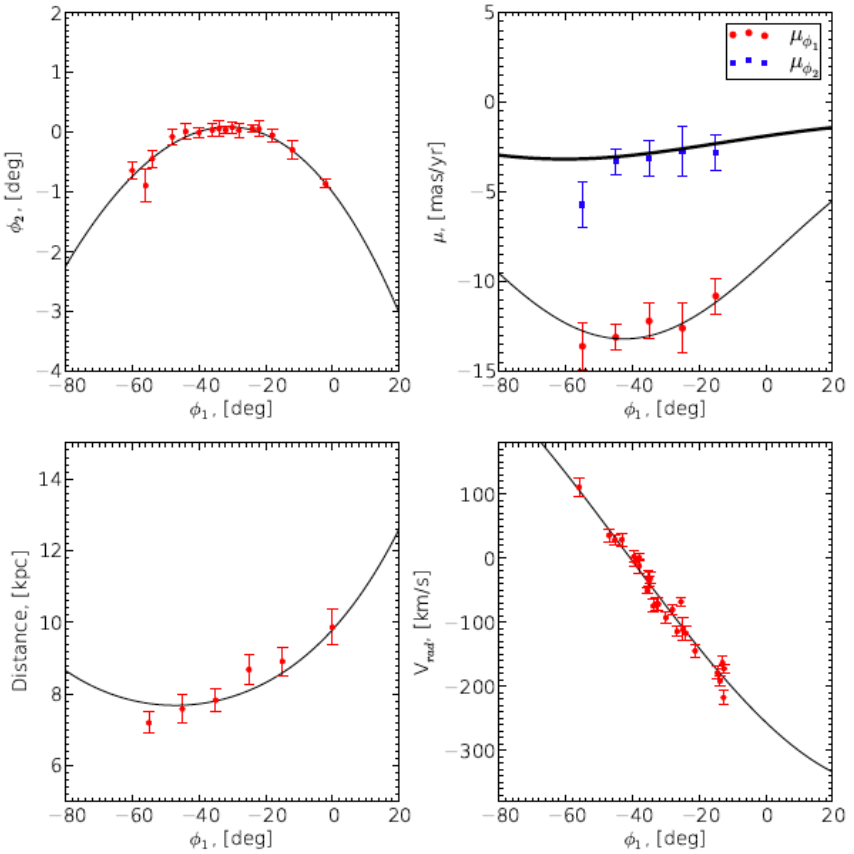




Rix, Belokurov, Vogelsberger, Wilkinson

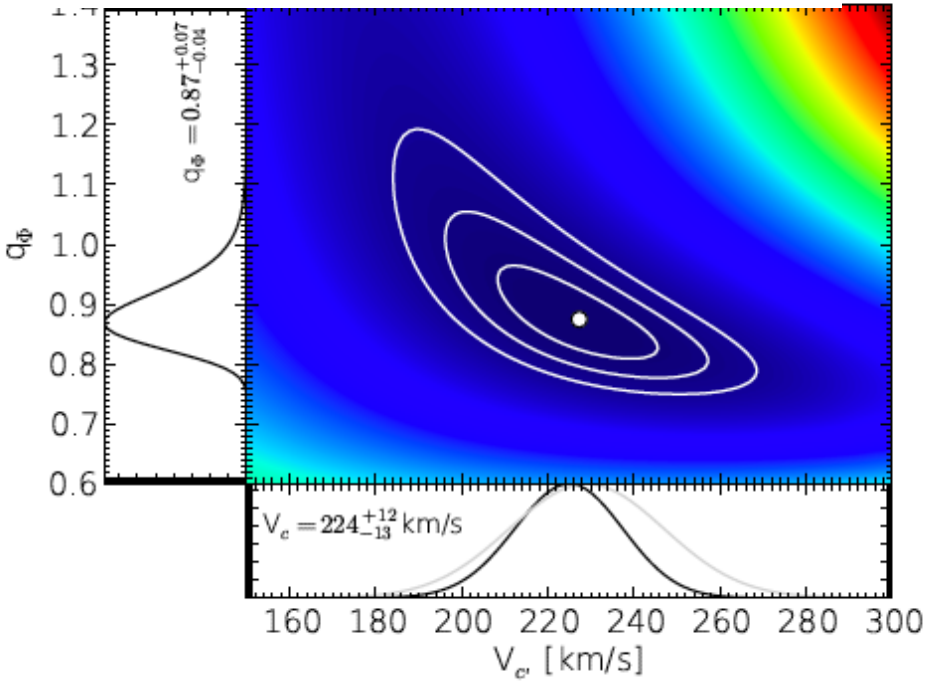


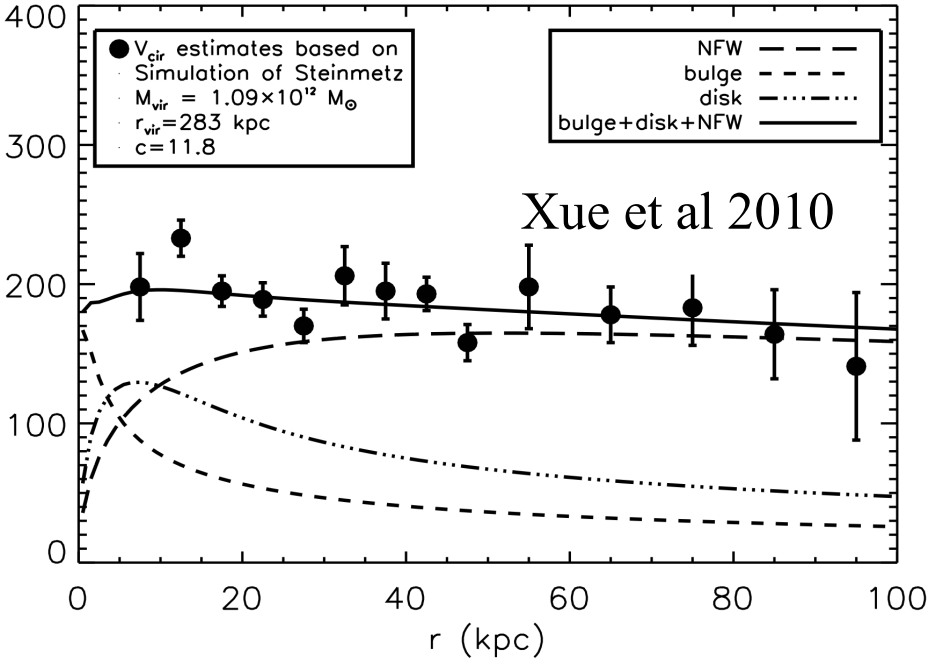
- Stellar halo made of streams at big r
- But profile seems regular....
- Can we use Jeans' models to get mass?
- DM structure should be more regular



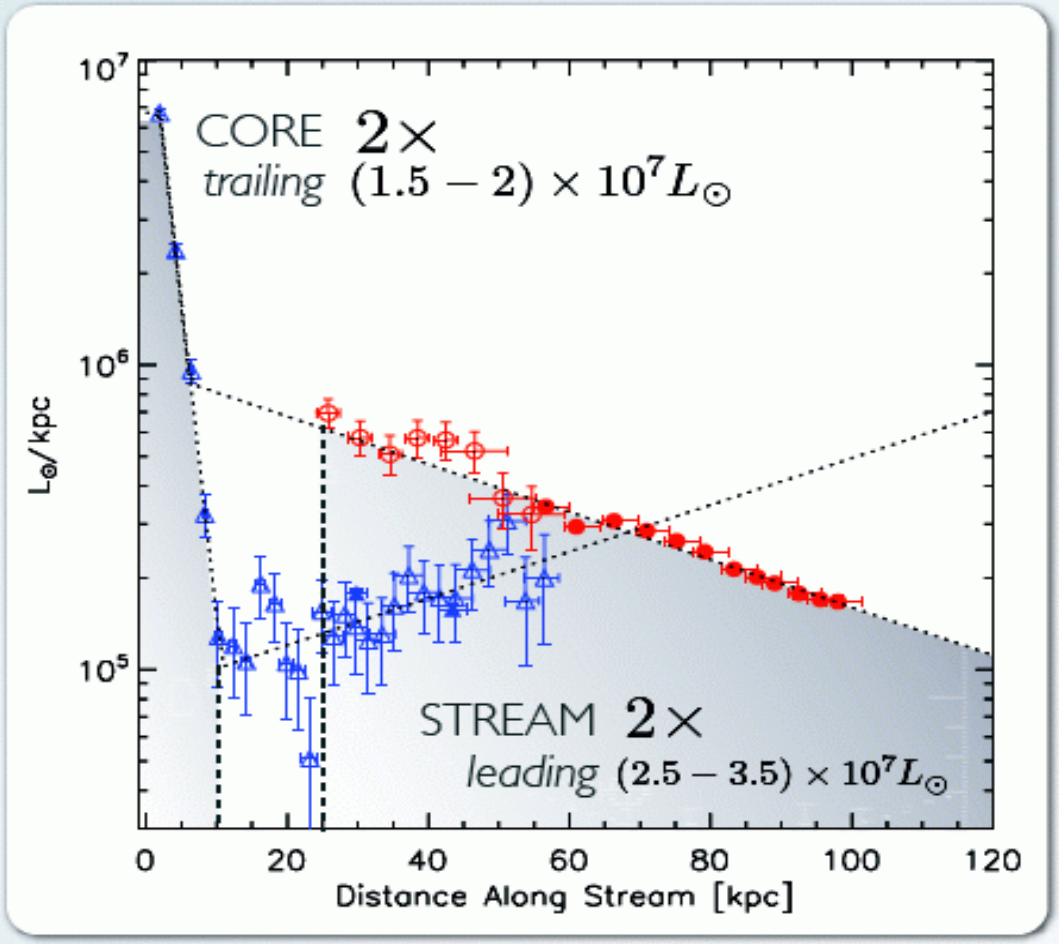
Rix, Reid, Majewski

- GD1 stream gives accurate orbit
- Constrains shape and circular velocity of halo
- Constraints also from BHB stars
- Agreement with VLBA data?
- Agreement with Sag stream? potential shape?





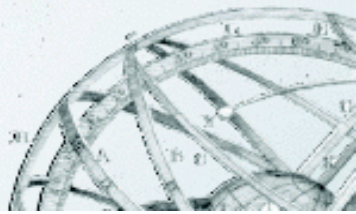
RE-ASSEMBLING SAGITTARIUS



The progenitor of the Sgr dSph had a luminosity of

$\sim 10^8 L_\odot$

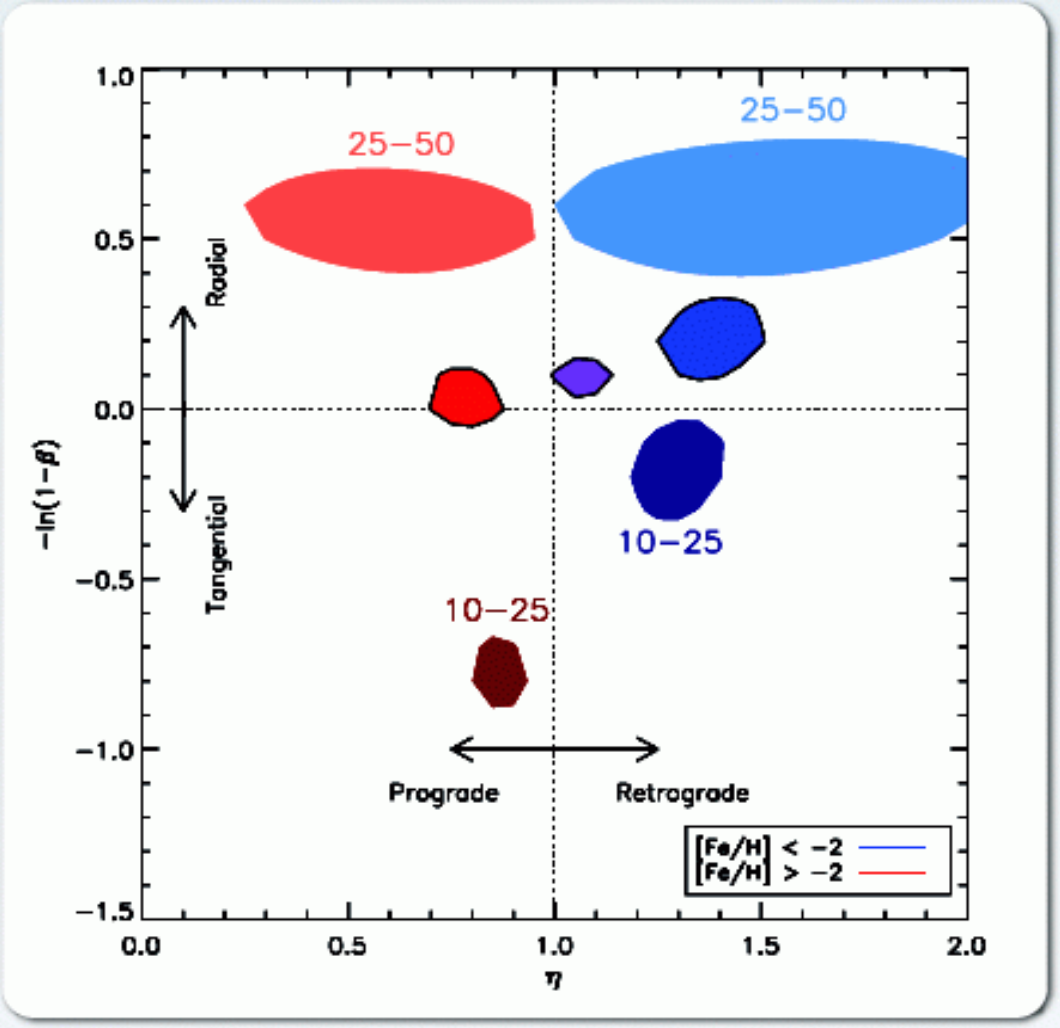
and lost $\sim$ **60%** of its stellar mass during tidal disruption



Belokurov

CHEMO-DYNAMICAL VIEW OF THE OUTER HALO

2125 stars

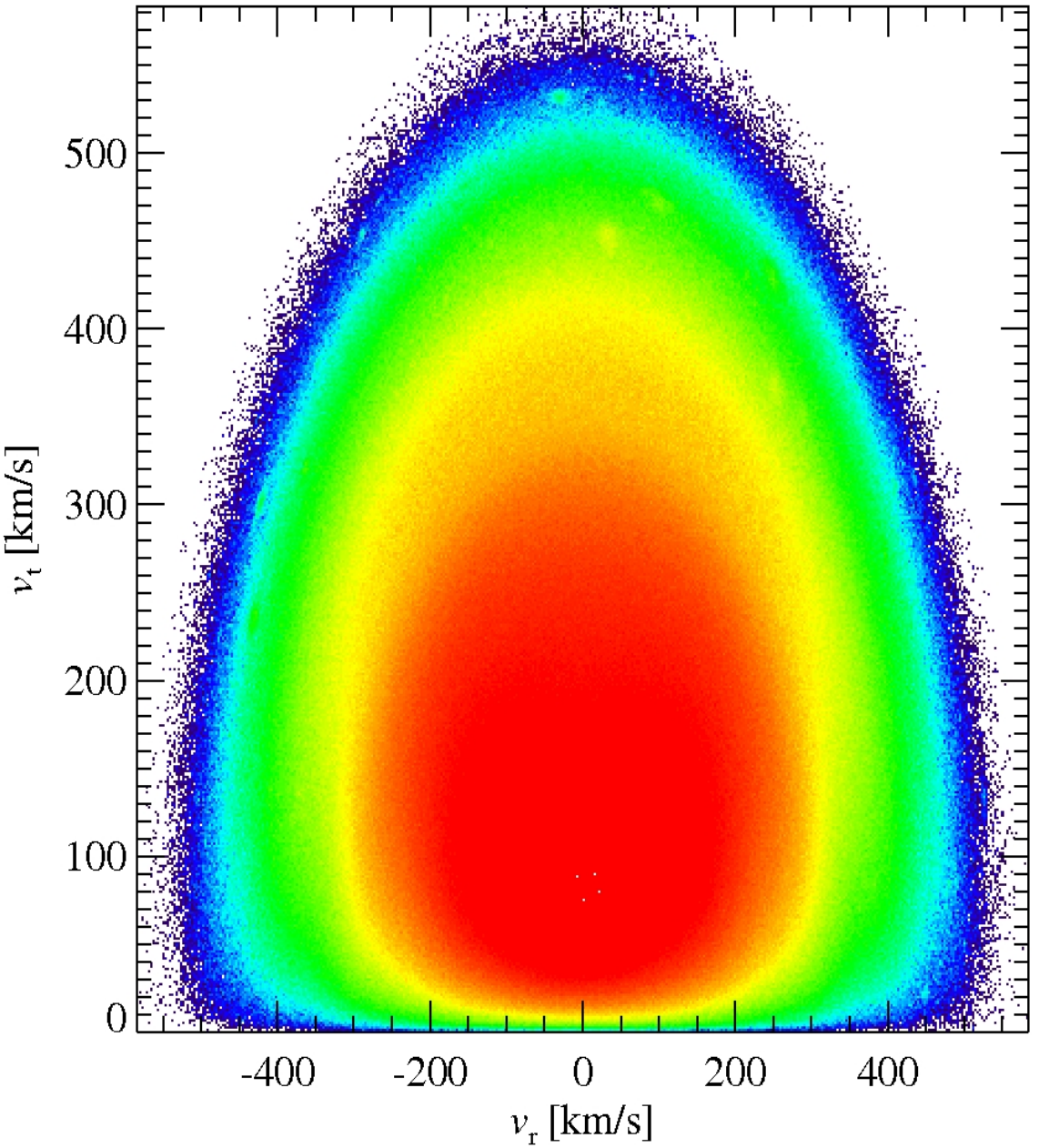


1135 stars

Belokurov

Dark matter phase-space structure in the inner MW

M. Maciejewski



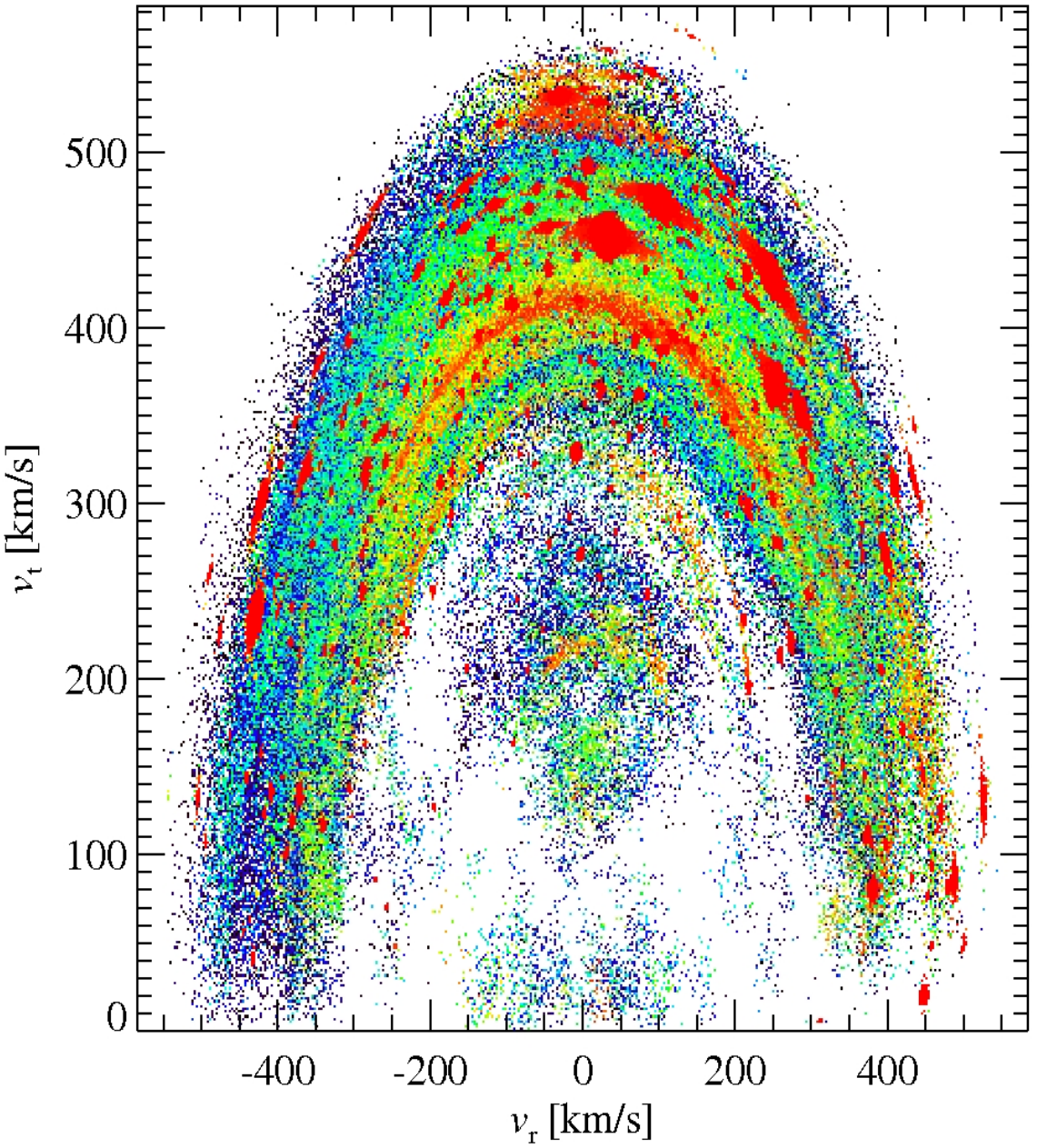
6 kpc < r < 12 kpc

All particles

N = 3.8 x 10^7

Dark matter phase-space structure in the inner MW

M. Maciejewski

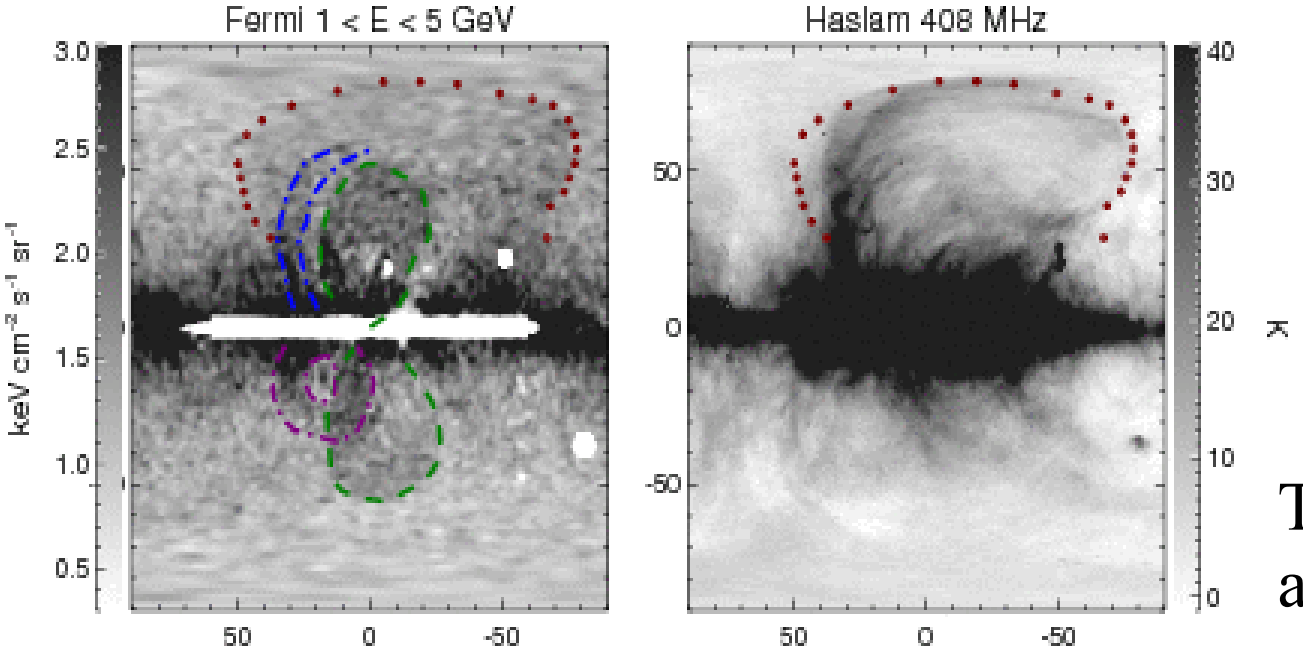


6 kpc < r < 12 kpc

Particles in detected phase-space structure

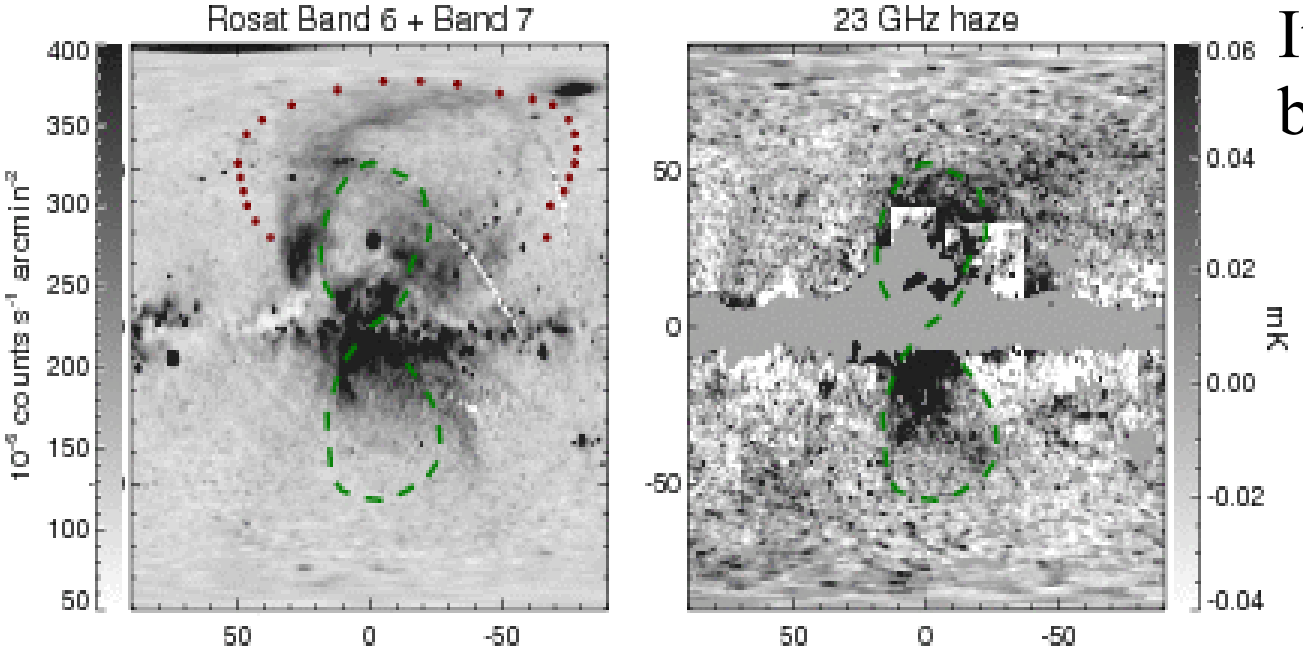
$N = 3.0 \times 10^5$

$N_{subhalo} = 3.9 \times 10^4$



Finkbeiner

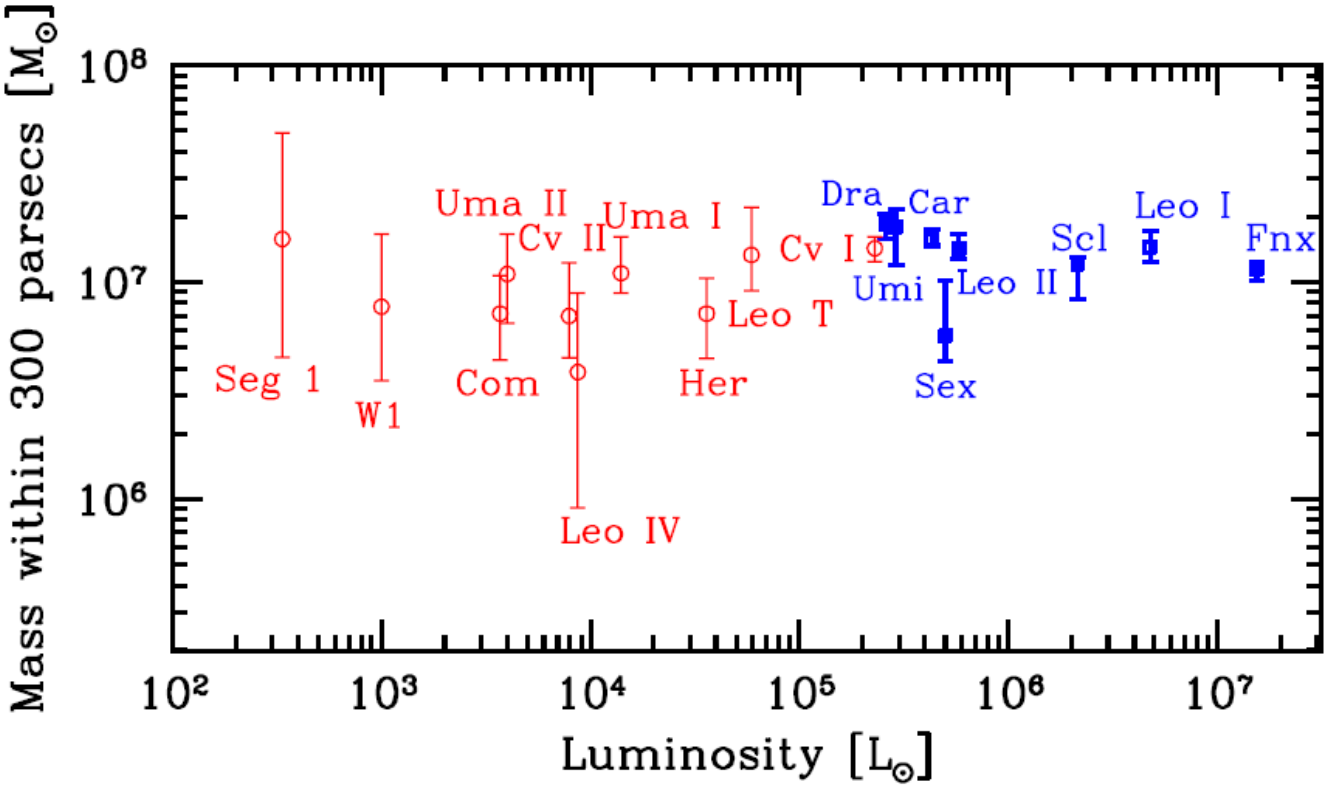
The WMAP haze is now also Fermi+Rosat haze



It is probably not caused by DM annihilation

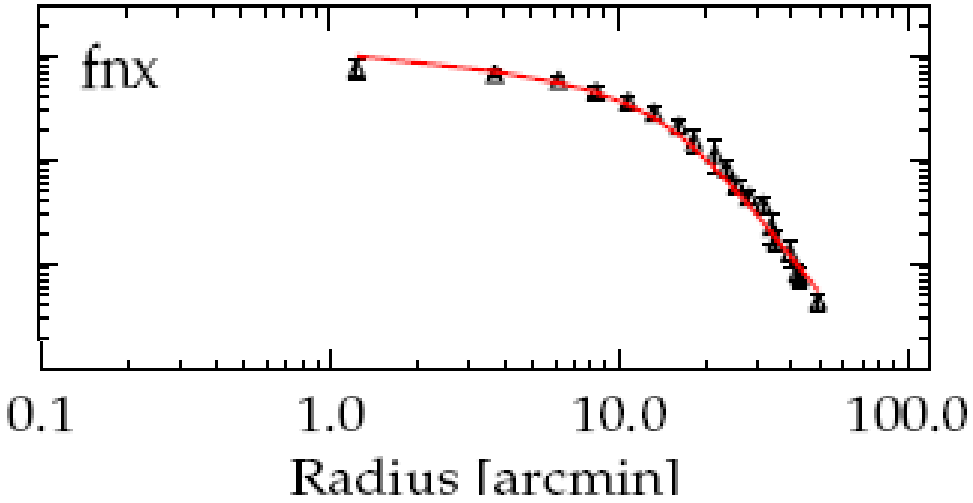
A common mass scale for local dwarfs?

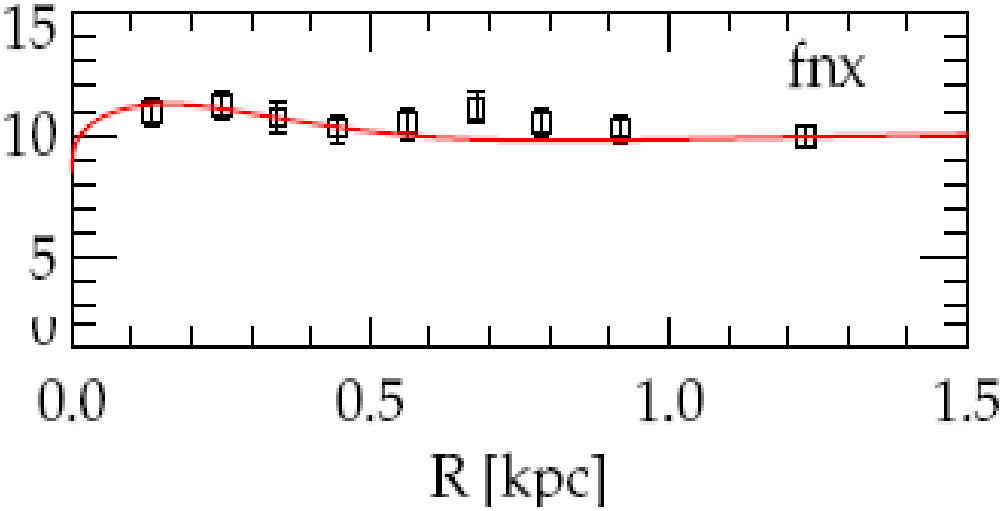
Grebel

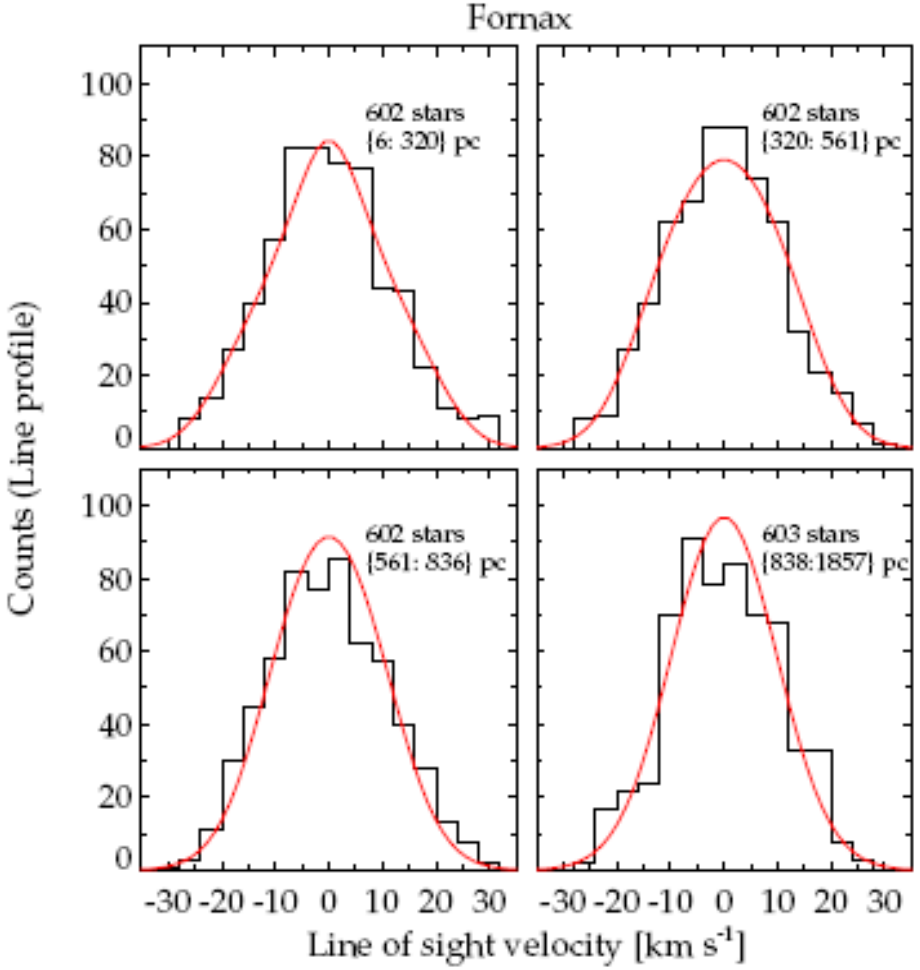


contamination..
M31 data...

Does “common” mass mean similar DM halo?
Can dwarfs indicate the nature of DM?





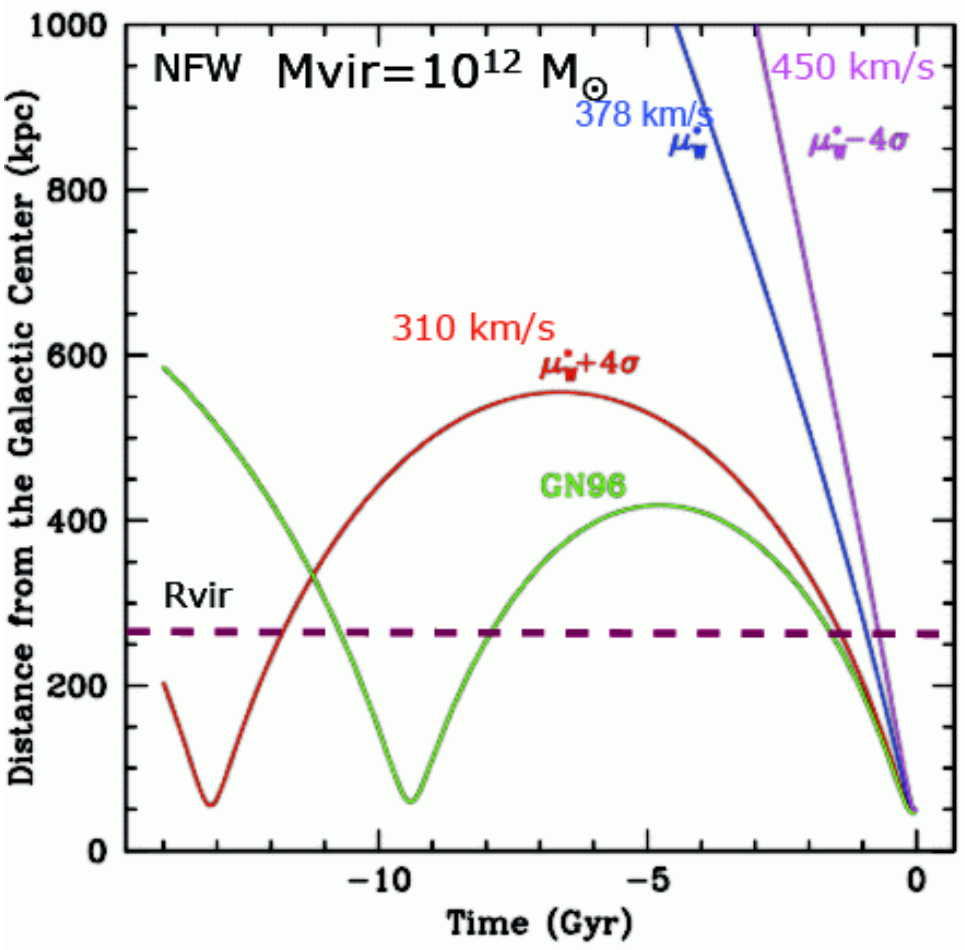


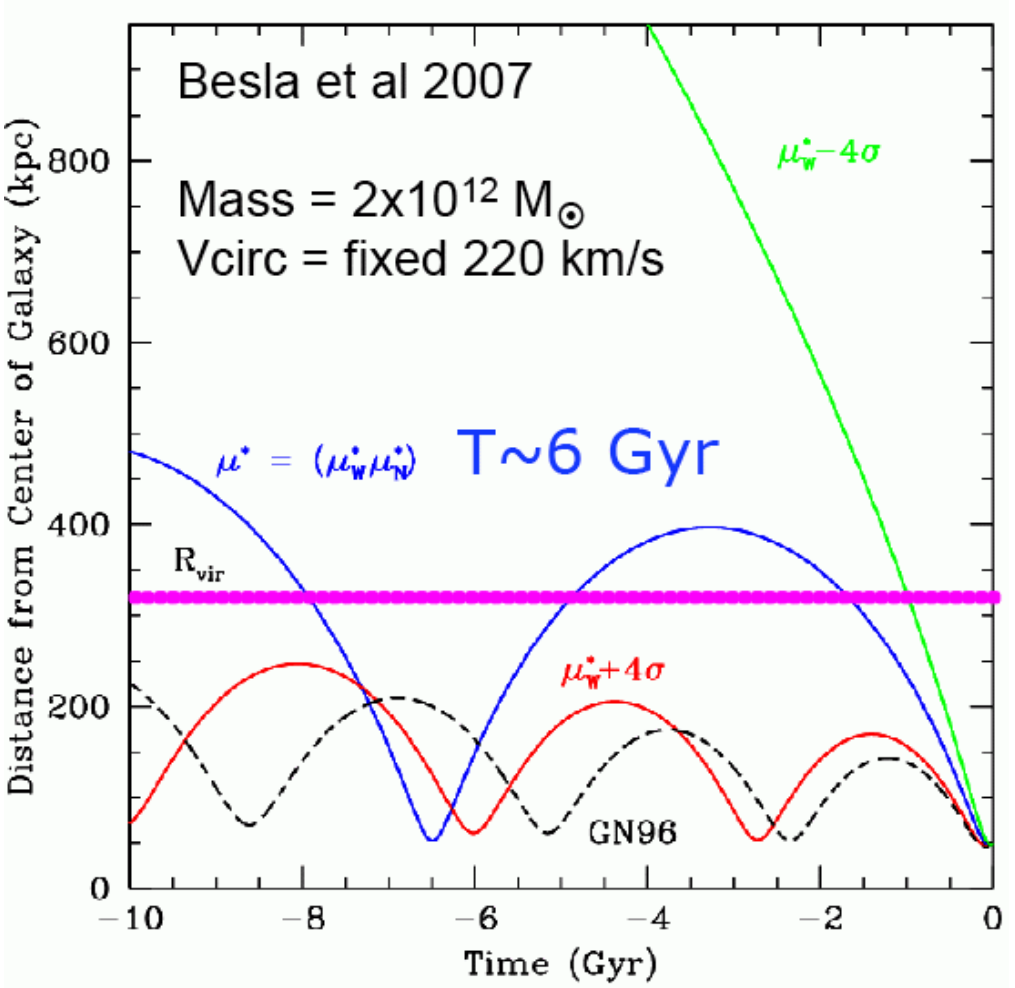
Dwarf Spheroidal data are consistent with LCDM cusps provided one allows for *stellar* cusps

Strigari, Frenk, White 2010

New MC proper motions

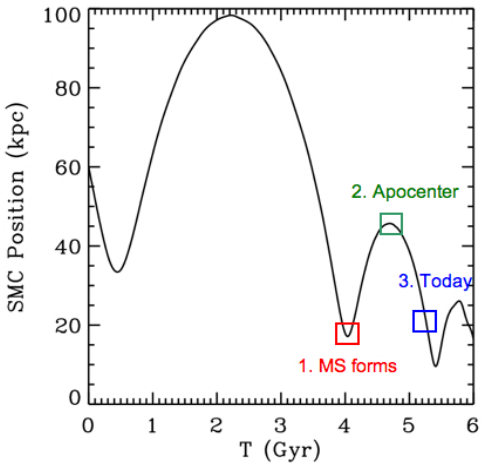
Kallivayalil

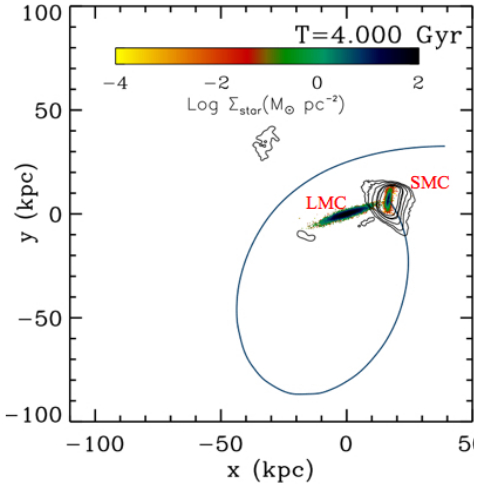


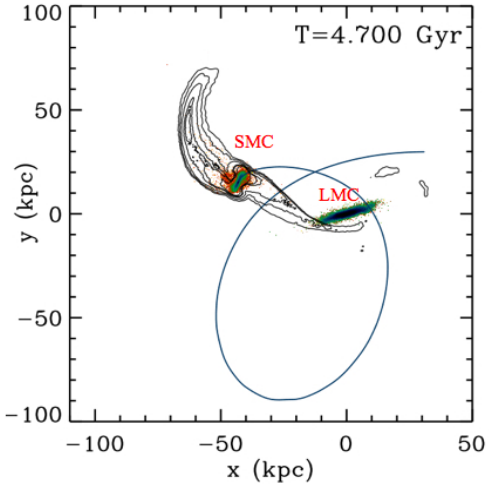


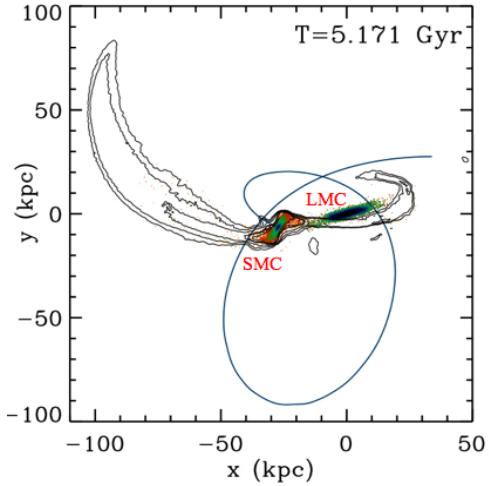
Longer (infinite?) orbital period, more massive MW?
More massive MW needed (in LCDM) for MC's to be "plausible"

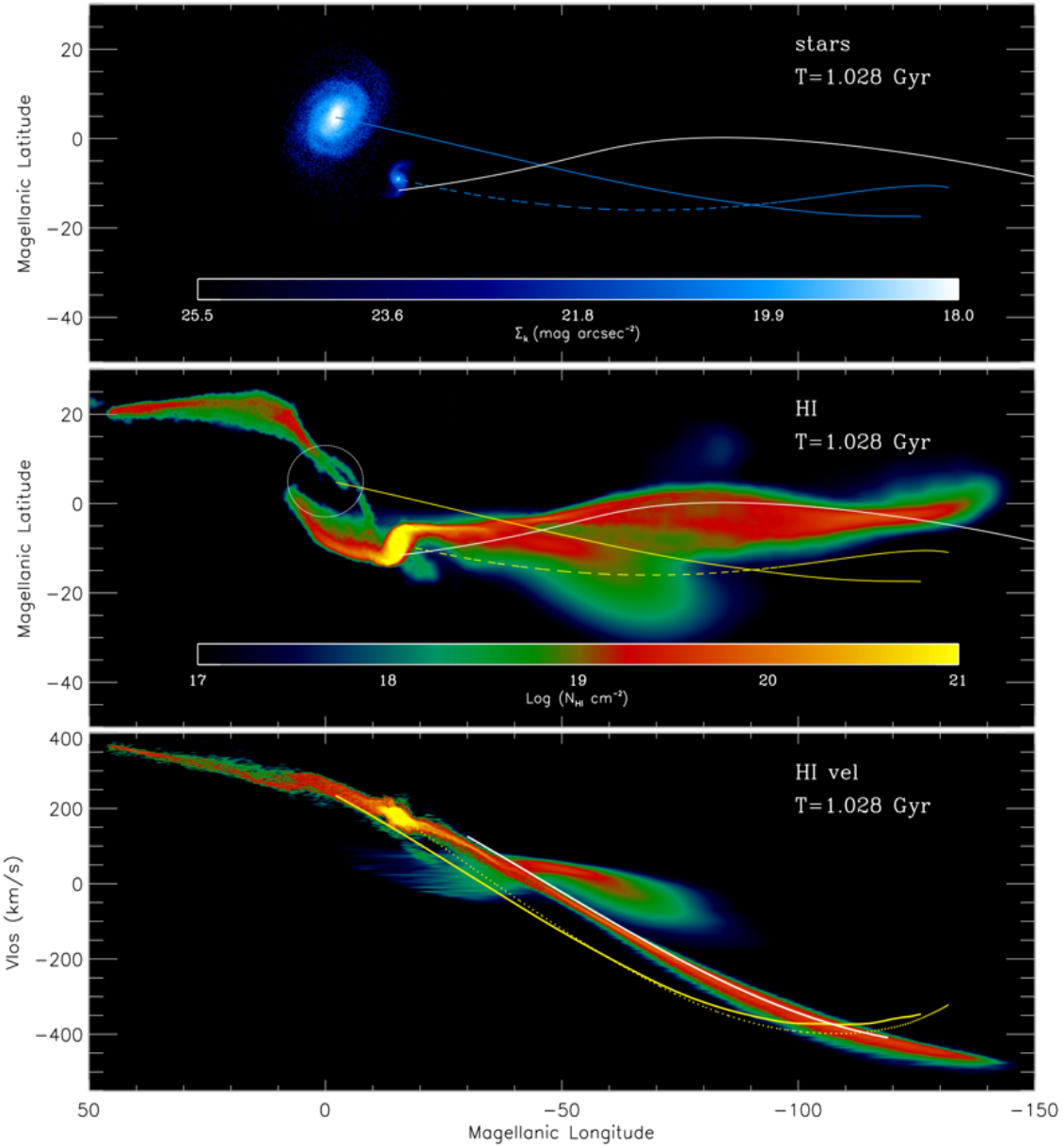
Making the Magellanic Stream





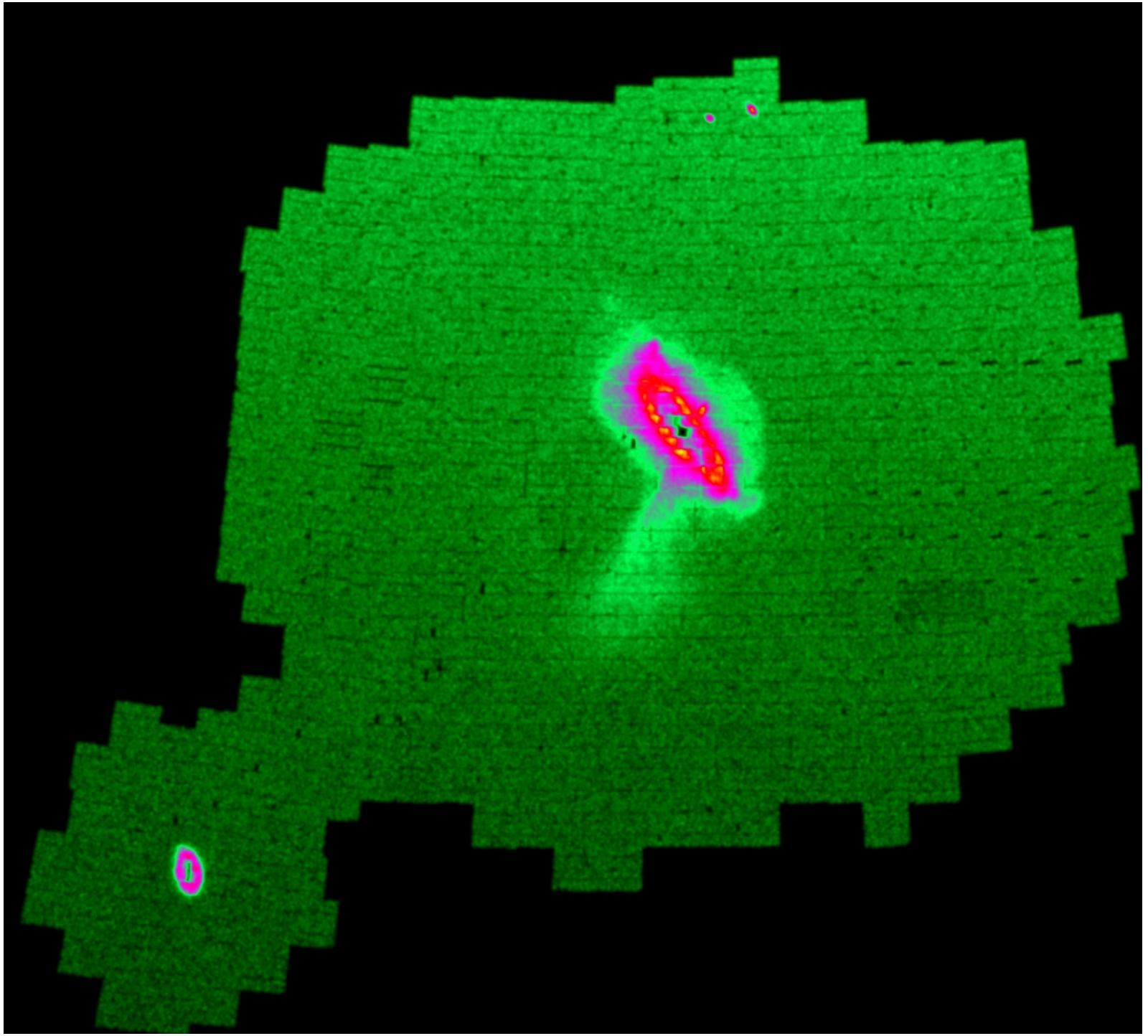






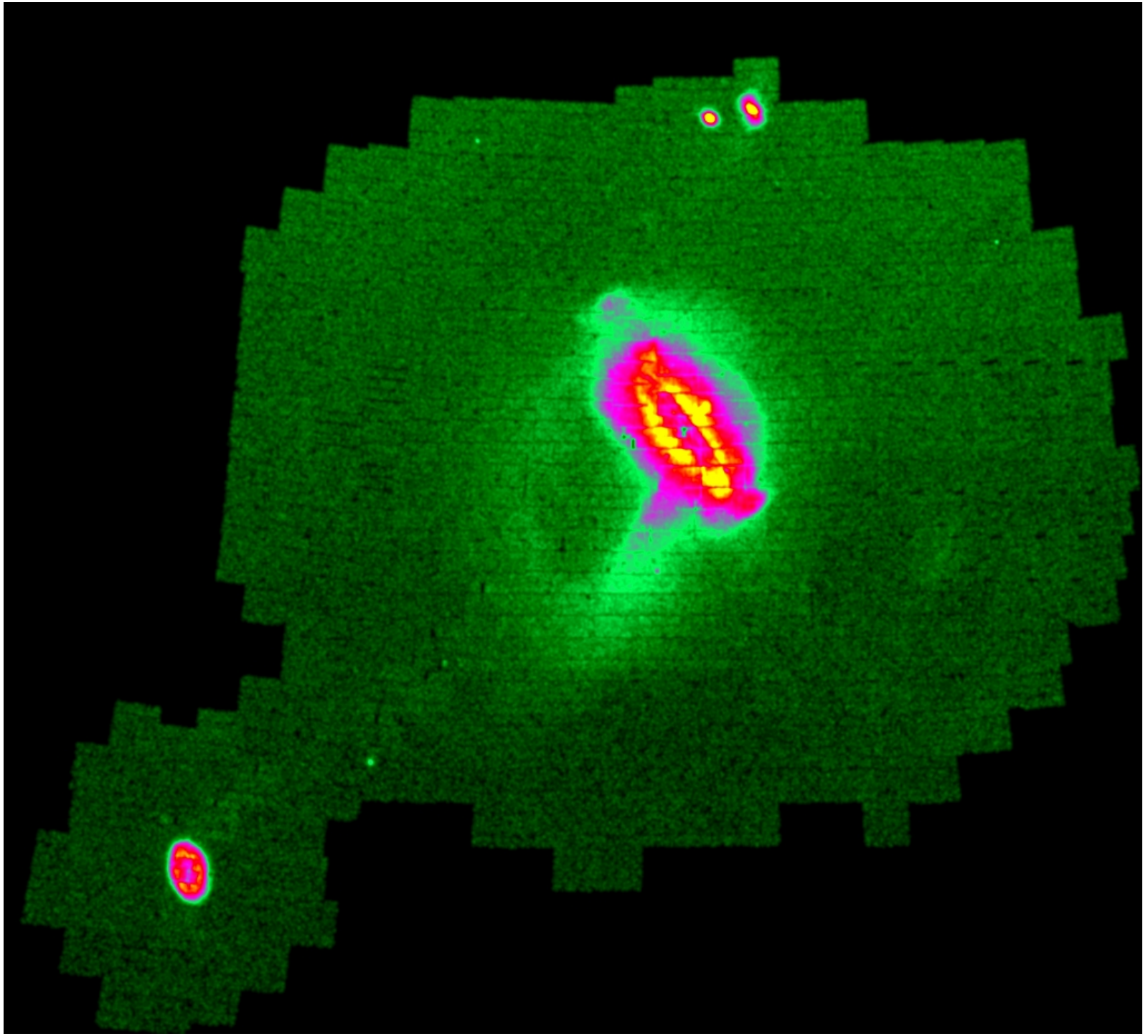
Besla,...

..the gas came from the SMC...



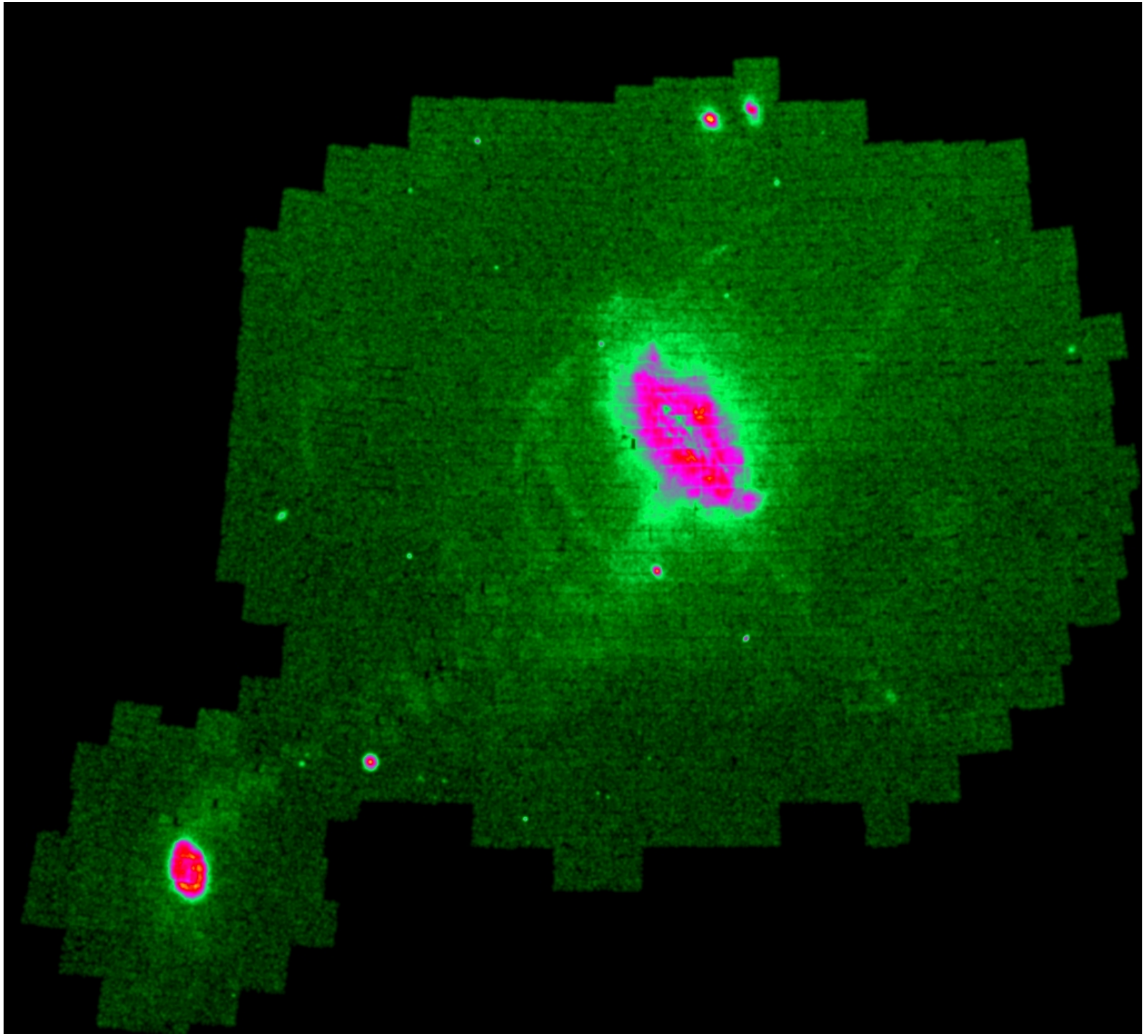
Ibata,
Navarro

hi-Z stars
around M31



Ibata,
Navarro

mid-Z stars
around M31



Ibata,
Navarro

low-Z stars
around M31

GCs follow
streams
Made in
dwarfs?

The way forward?

Try to see the whole elephant.

Beware of equilibrium/symmetric models

Move beyond botany to physics

Link to other galaxies/other times

Find and follow the gas

Questions?

What can we learn from streams? hypervelocity stars? S-stars? Can chemical tagging work? How do we link high and low z? Can we separate secular and externally driven evolution? Where are the MW baryons today?