Simulations of Satellite Accretion

From the Milky Way to Ensembles of Nearby Galaxies

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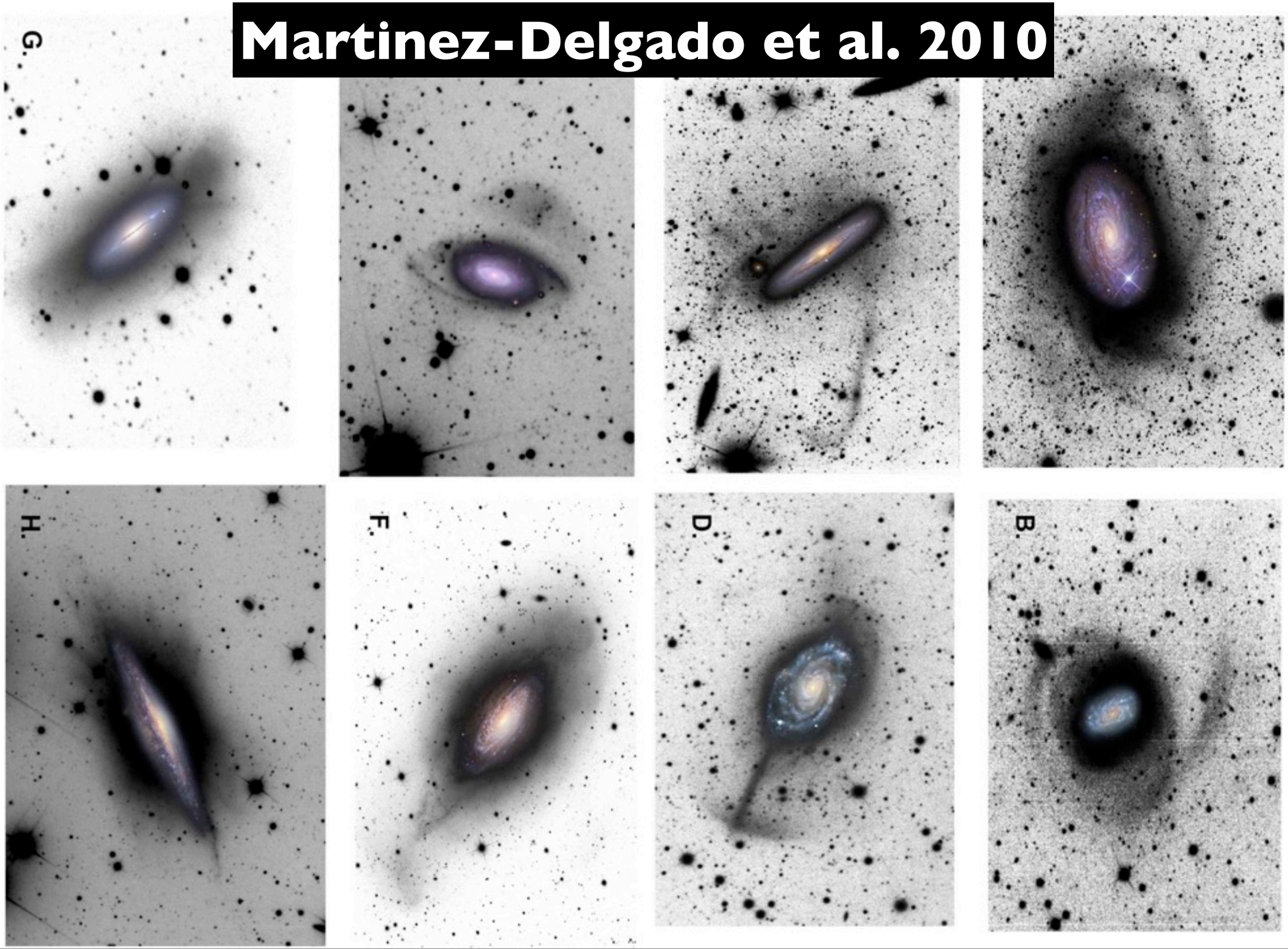
Satellite Accretion and Galaxy Evolution

- Context: at low redshift ($z < 1$) minor mergers onto galaxies of MW mass and above result in a gradual change in morphology, star formation
- Expect relationships between accretion history, morphology, gas supply, SF history
- Stars from merged systems are spatially, kinematically and chemically distinct from ‘in situ’ stars

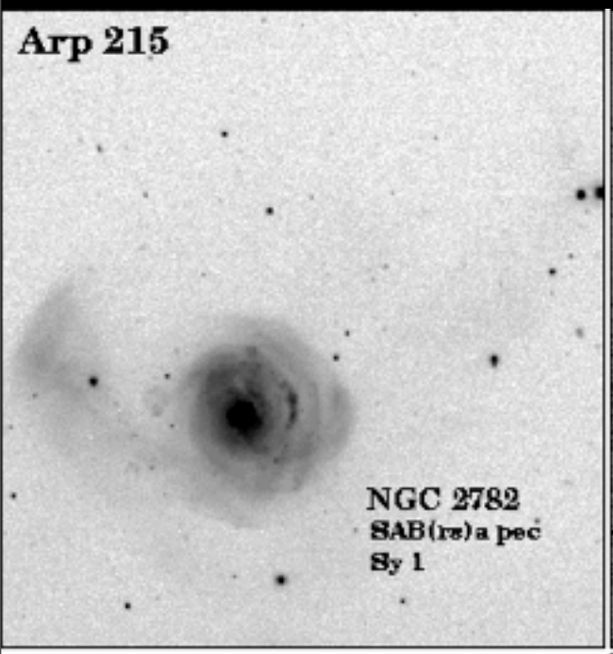
Martinez-Delgado et al. 2010

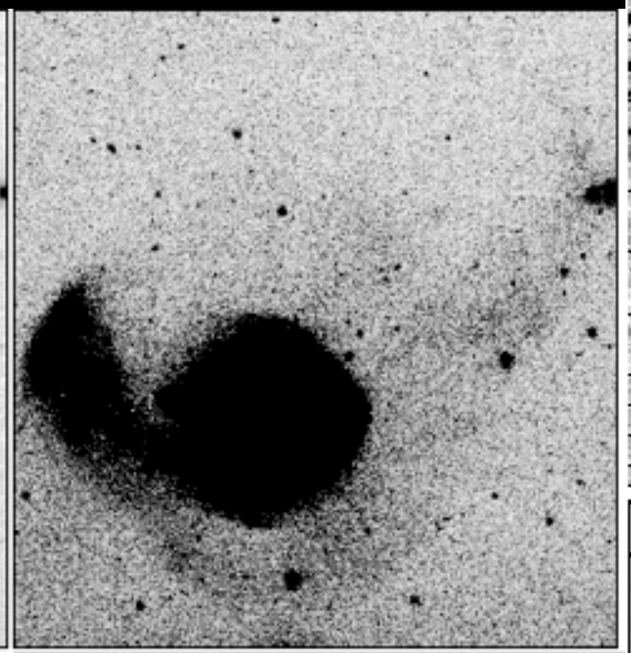


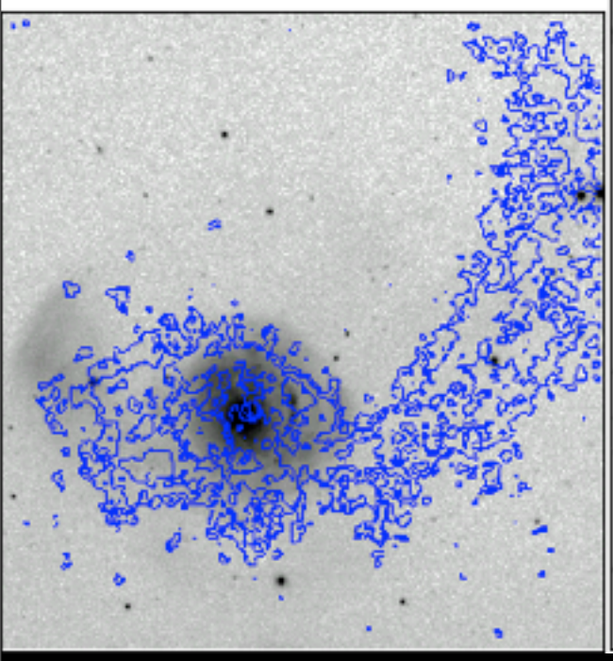
Kaviraj 2010: Stripe82

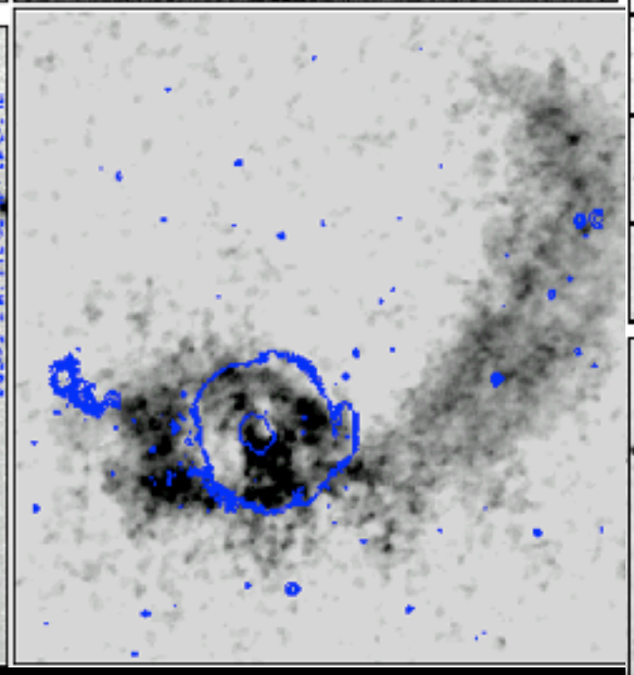
HI and streams

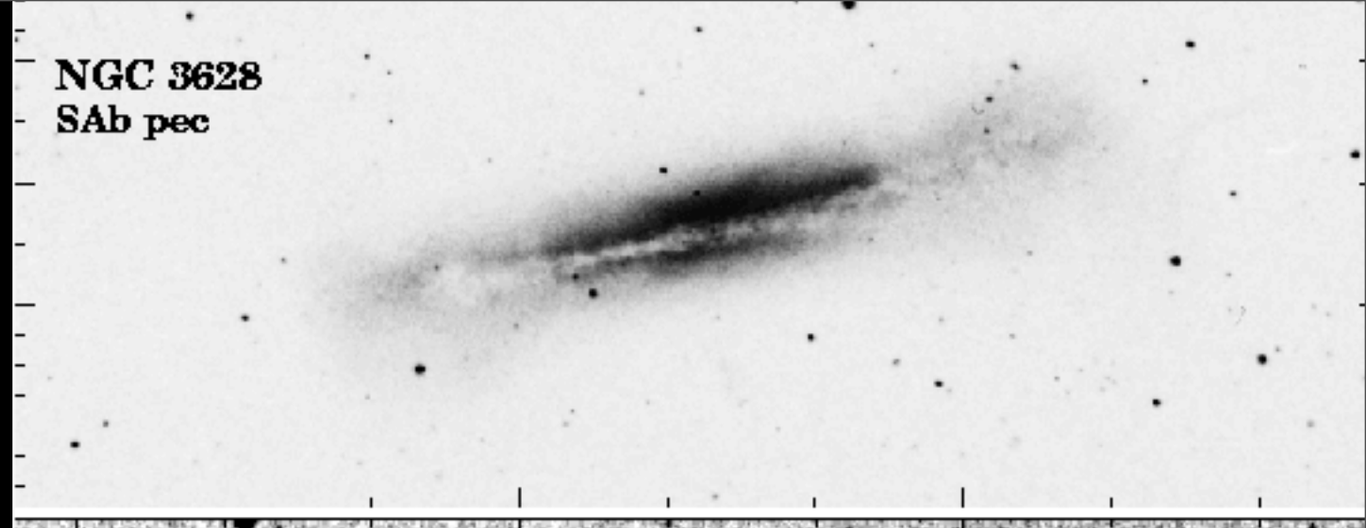
Hibbard et al. 01

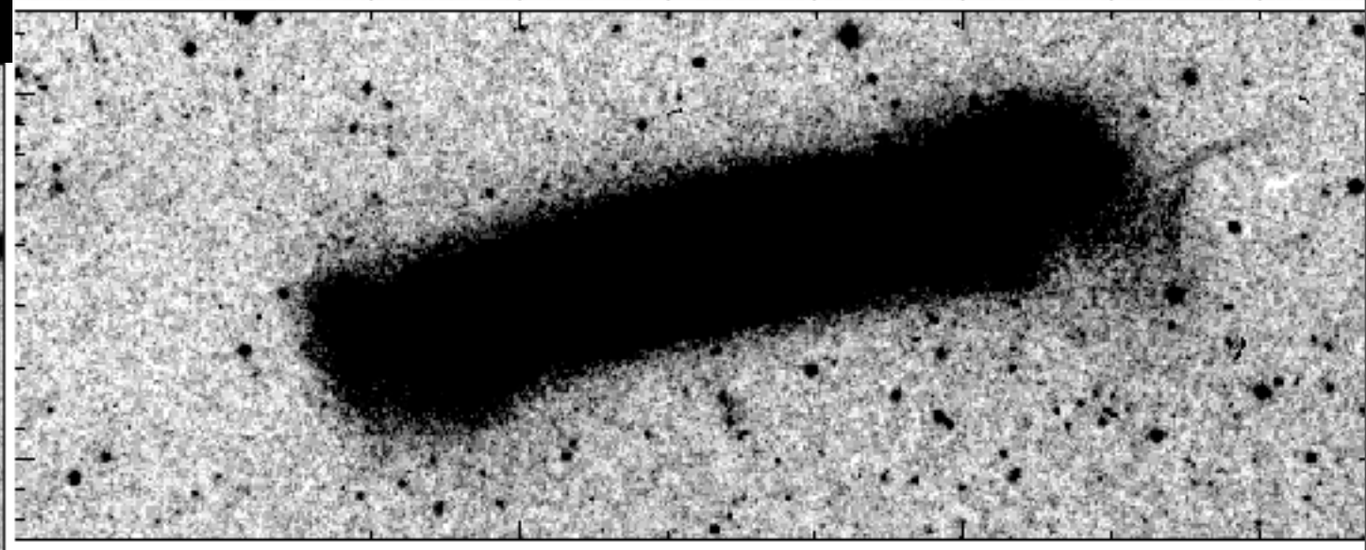


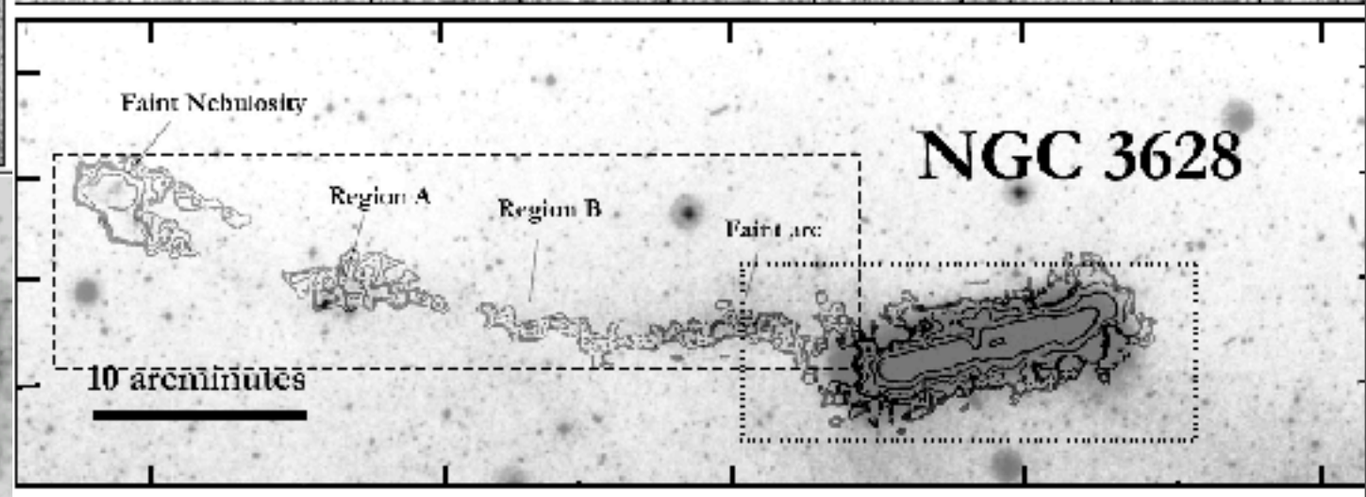


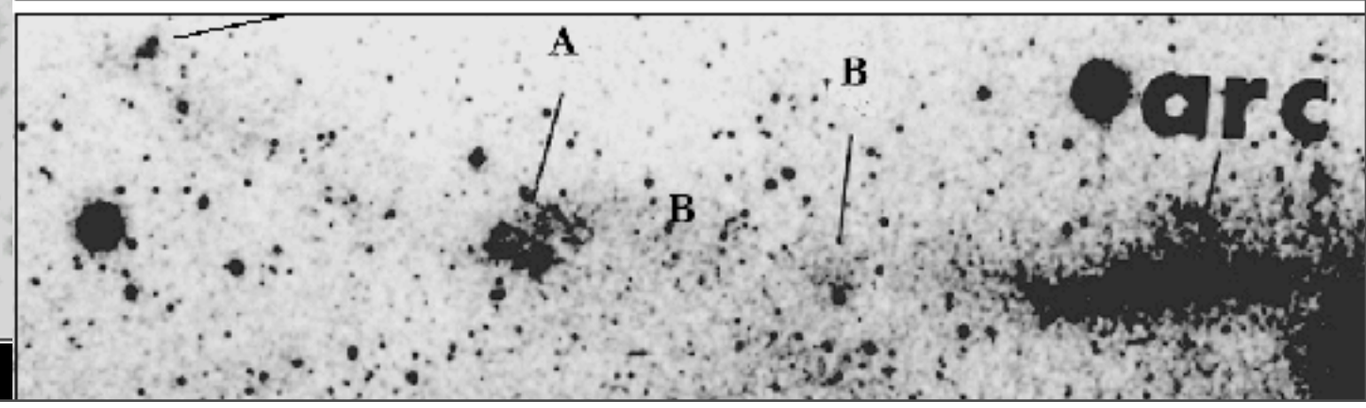






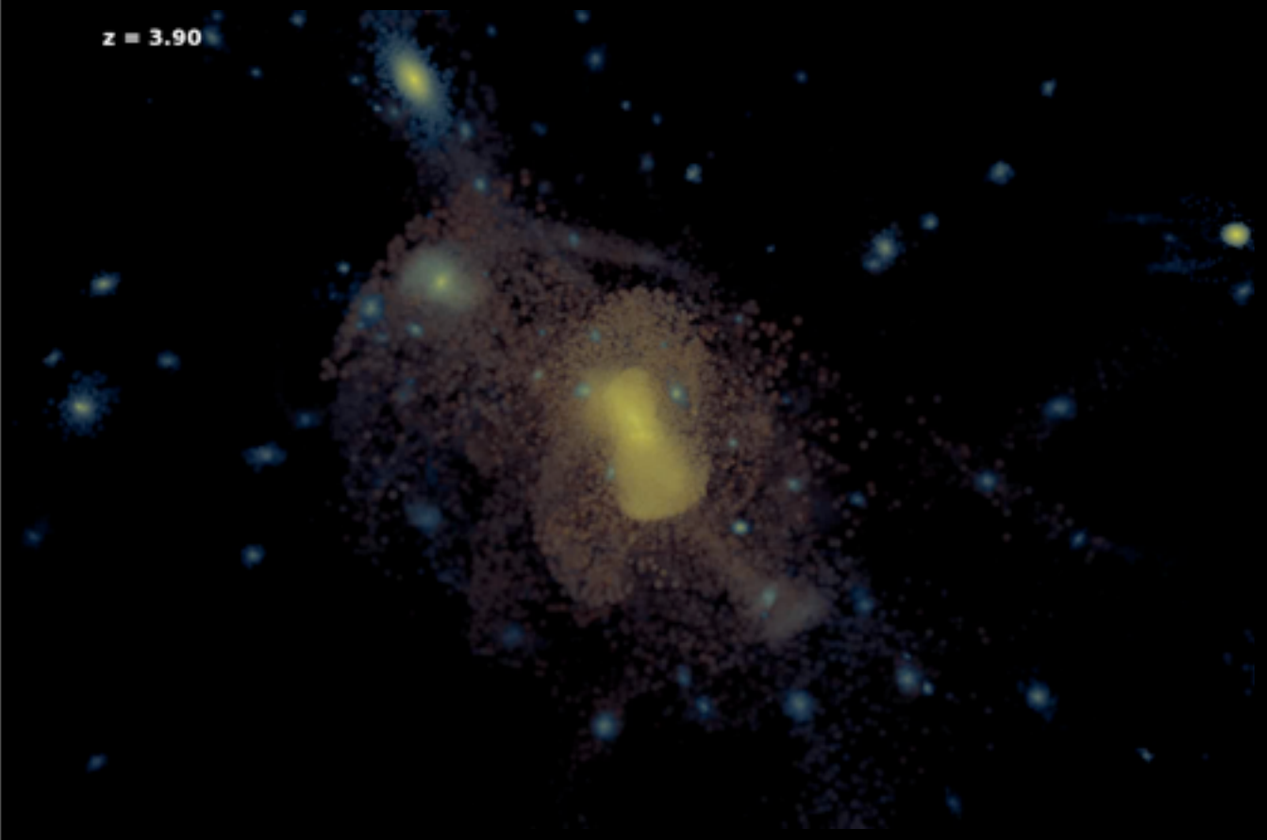


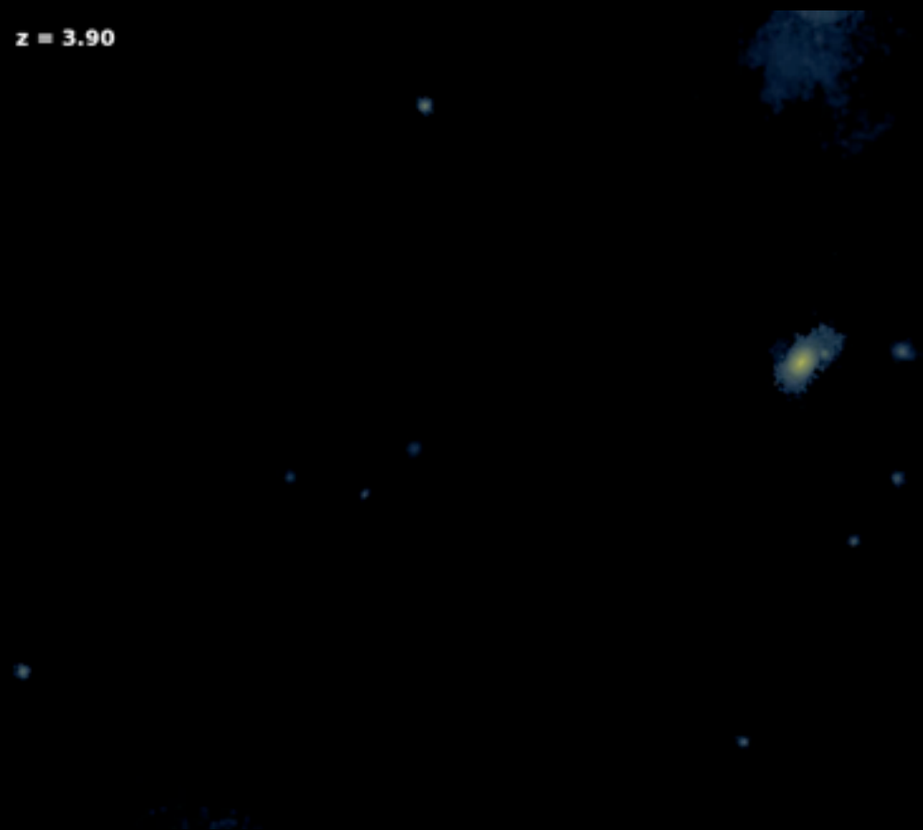




Merger Simulations

- Dynamics, properties of streams (Bullock & Johnston 2005)
- Peculiarities of CDM and direct comparison with the observations: cosmological initial conditions and full galaxy formation model
- Challenge: realism and resolution (resolving minor mergers)





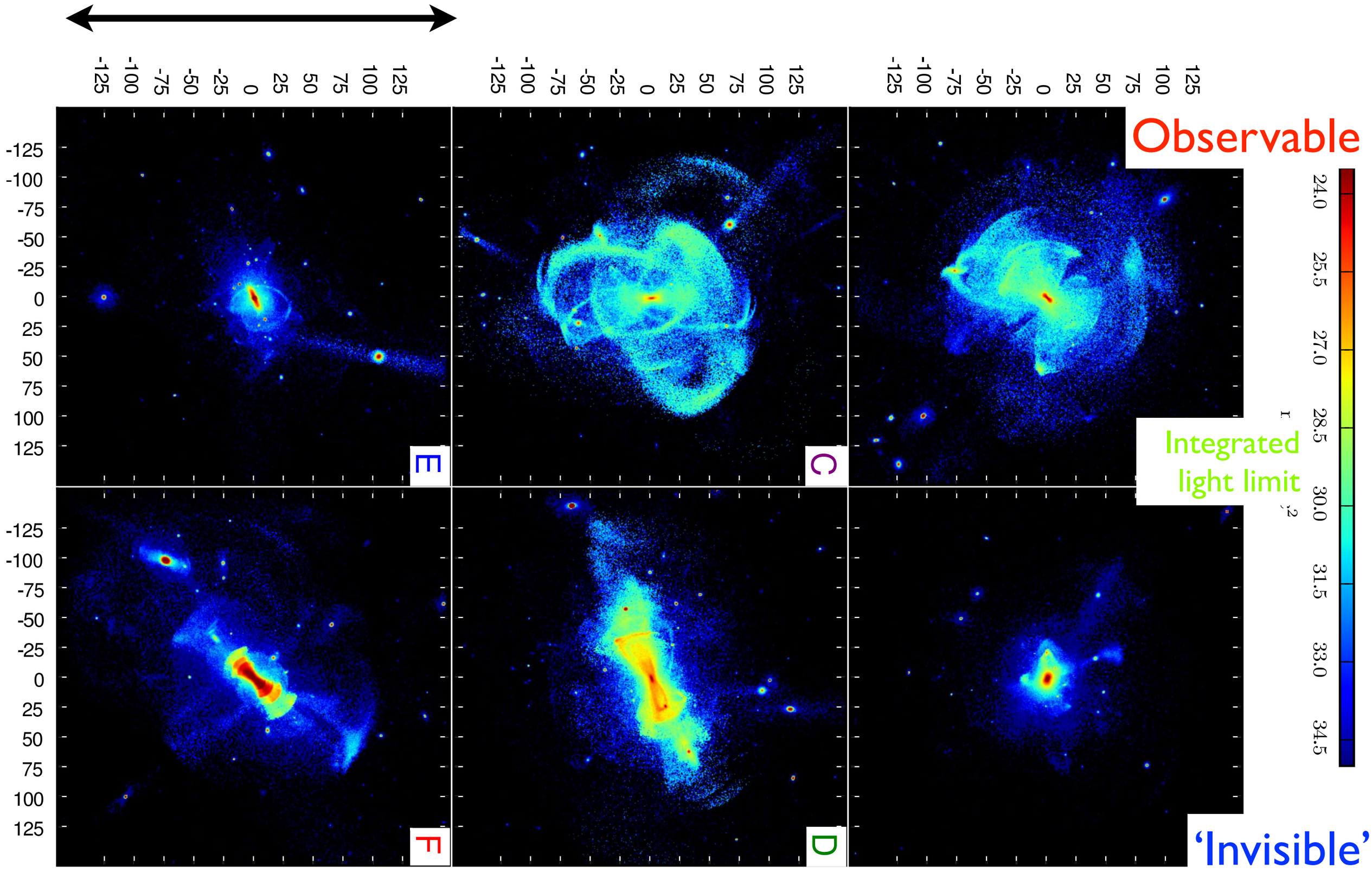
- Hybrid method: tagging DM particles in high-resolution cosmological N-body simulations to represent ‘stars’
- Semi-analytic model to treat baryonic physics: **when** and **where** stars form
- Treat stars as tracers of a tightly-bound region in the **energy** distribution of their host dark halo
  - Tag **most-bound 1%** of halo DM particles in N-body simulation, for every star-formation episode in every galaxy
  - CAVEAT: our ‘stars’ are always massless tracers of DM: no discs!

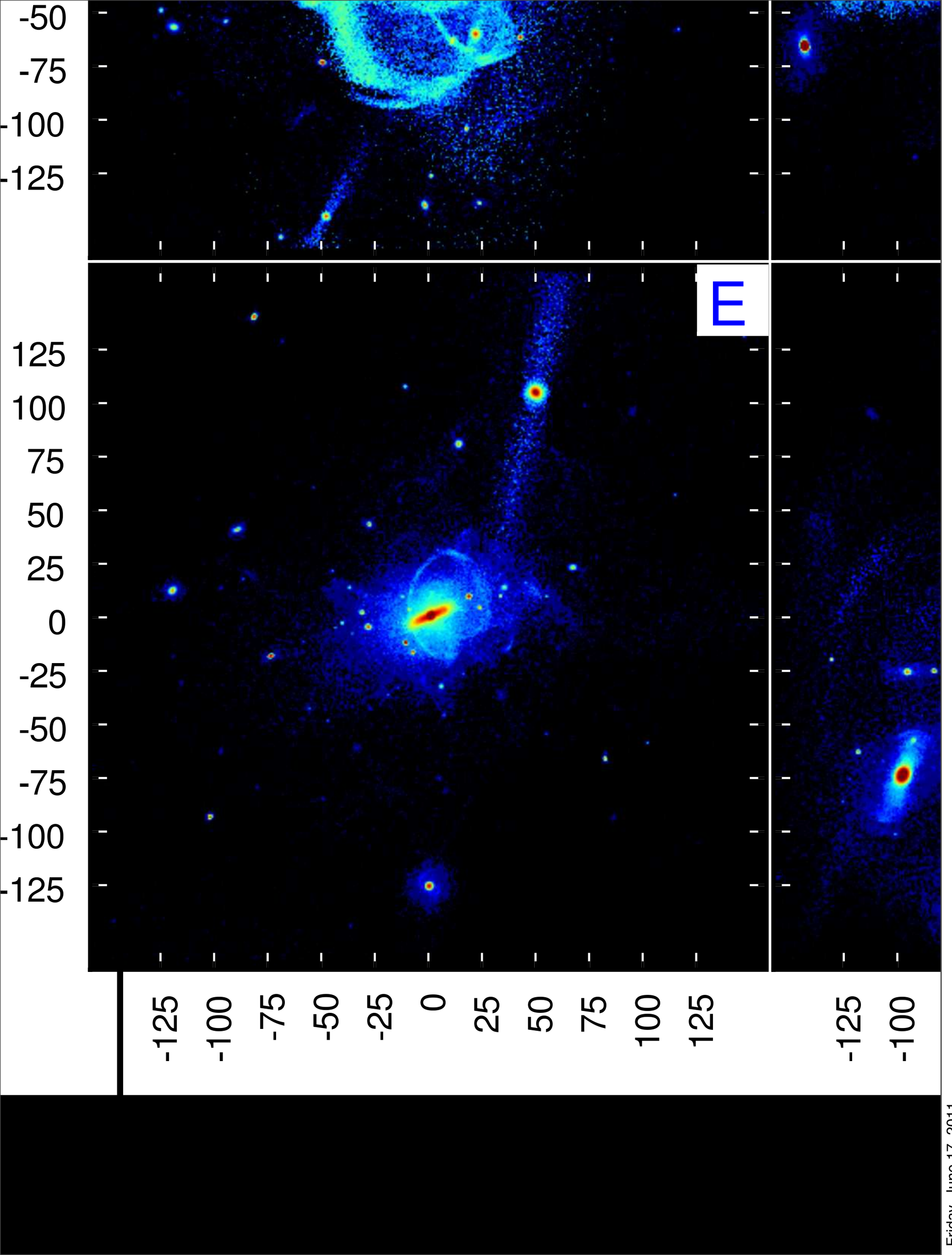
Application I:
Milky Way-like systems

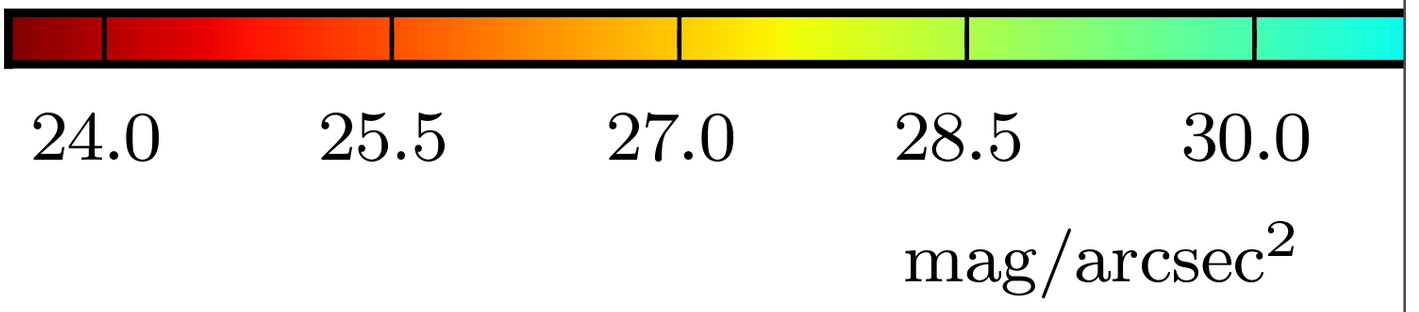
(AC et al. 2010)

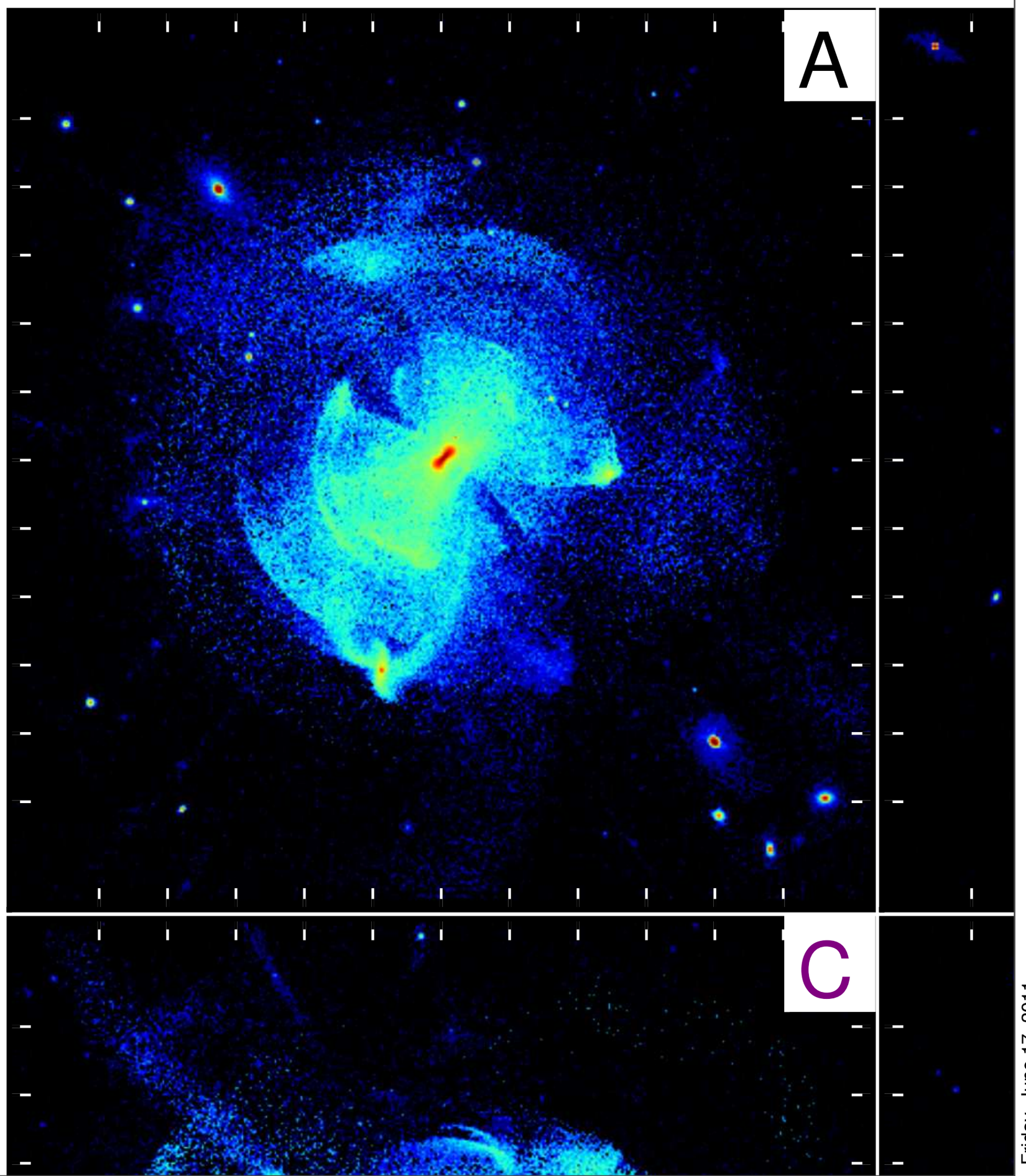
- High resolution
- 6 Aquarius simulations + GALFORM model
- Satellite LF agrees with data
- Tagging model results in reasonable ‘fundamental plane’ for surviving satellites

V-band Surface Brightness, 150x150 kpc

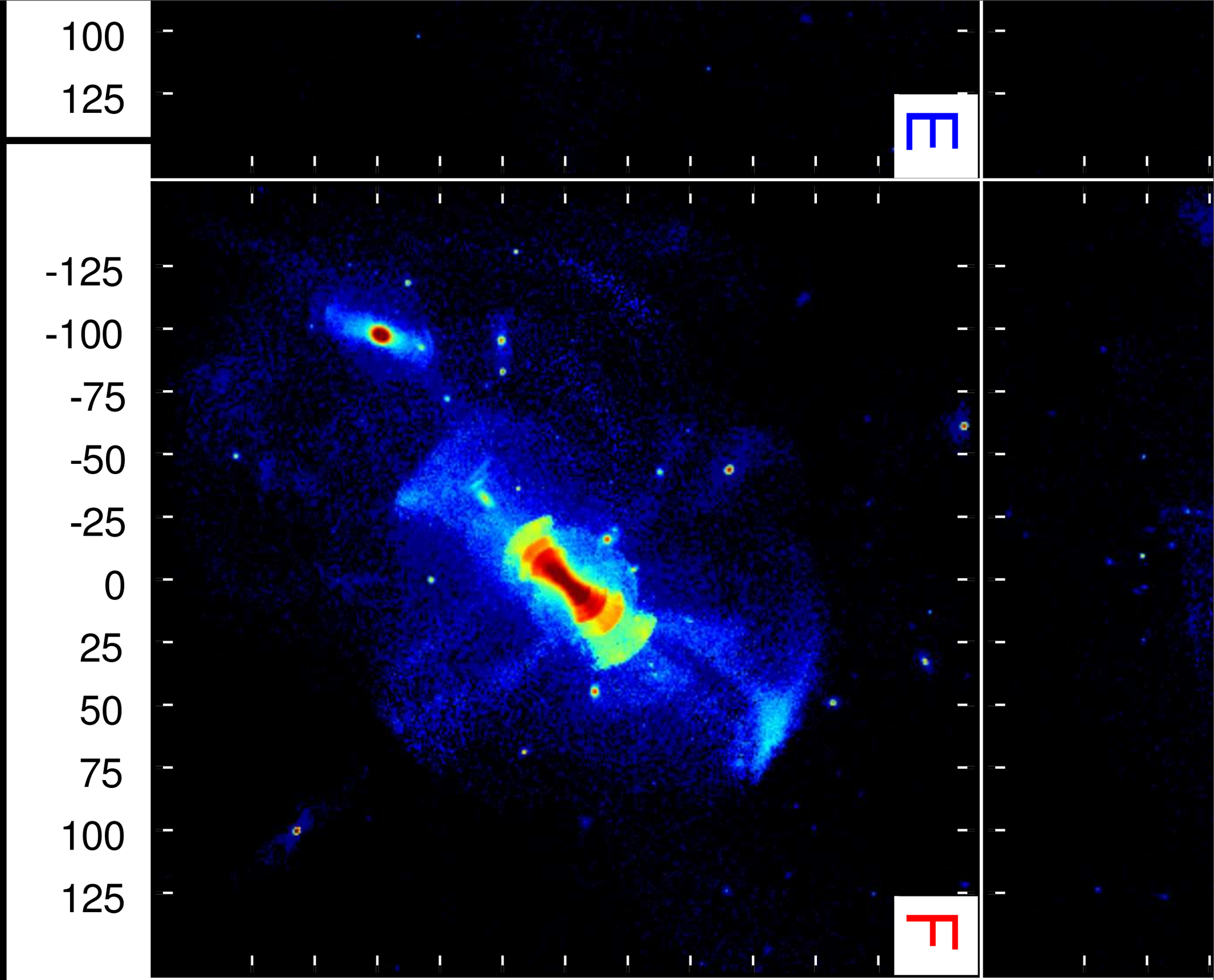








Friday, June 17, 2011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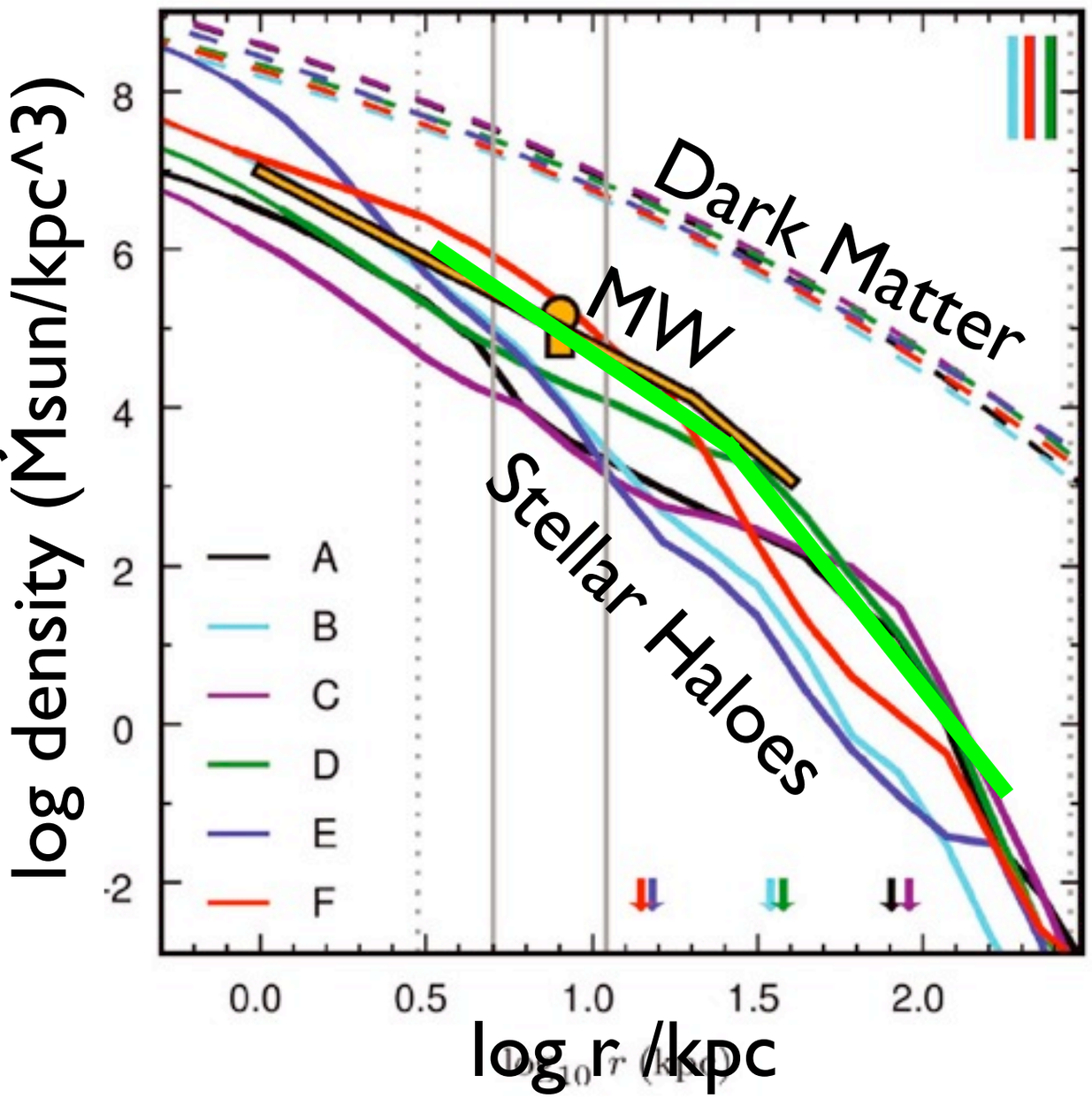
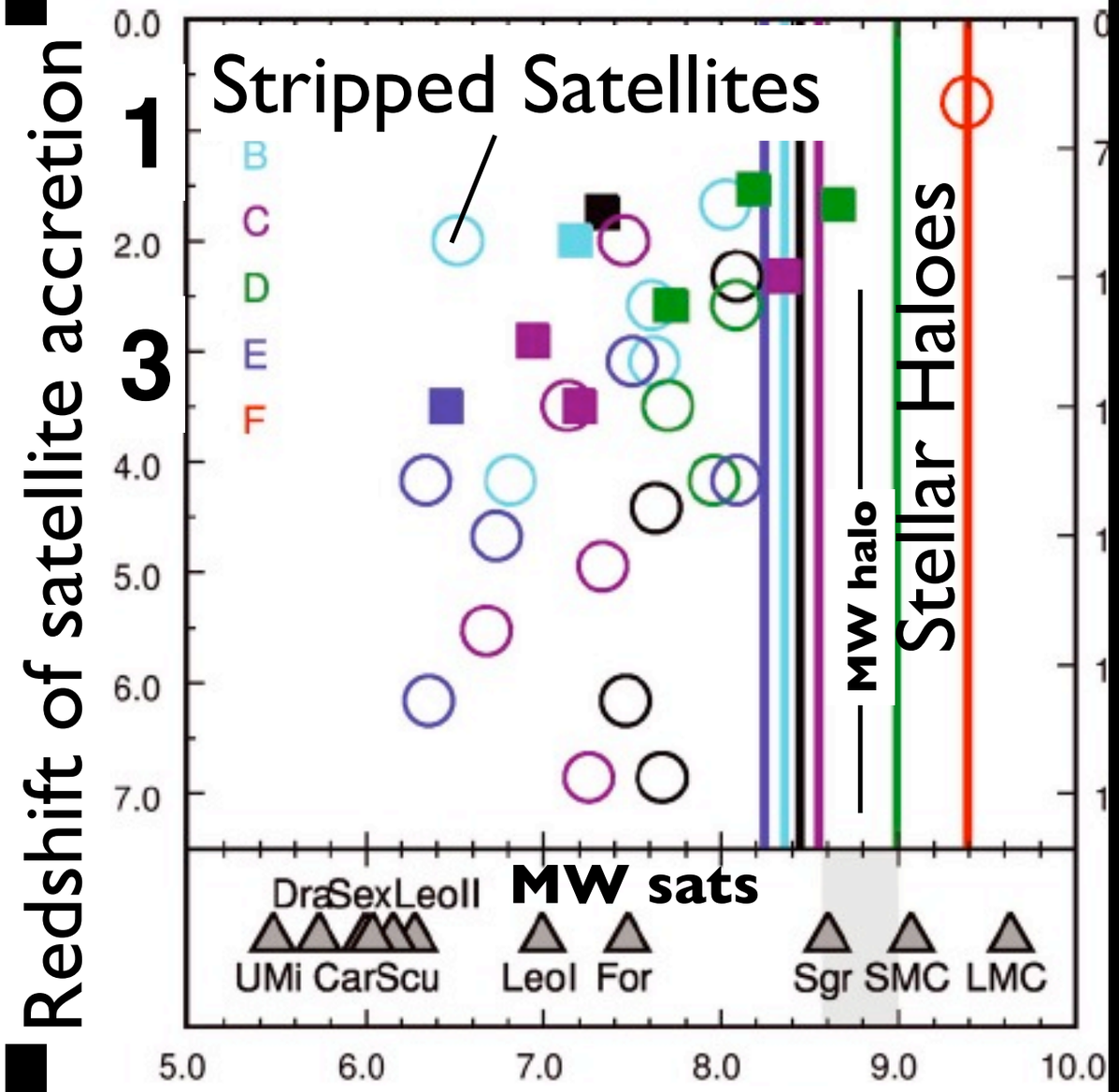


Deason et al. 2011 (BHBs, arbitrary normalization!)

Density profiles: broken powerlaws, slope consistent with MW (density slightly lower than solar neighbourhood)



Usually dominated by latest, most massive and metal rich progenitor, mass between Fornax and Sgr. Final assembly of stellar halo mostly underway by z=1 except for elliptical

log (density * r^-2)

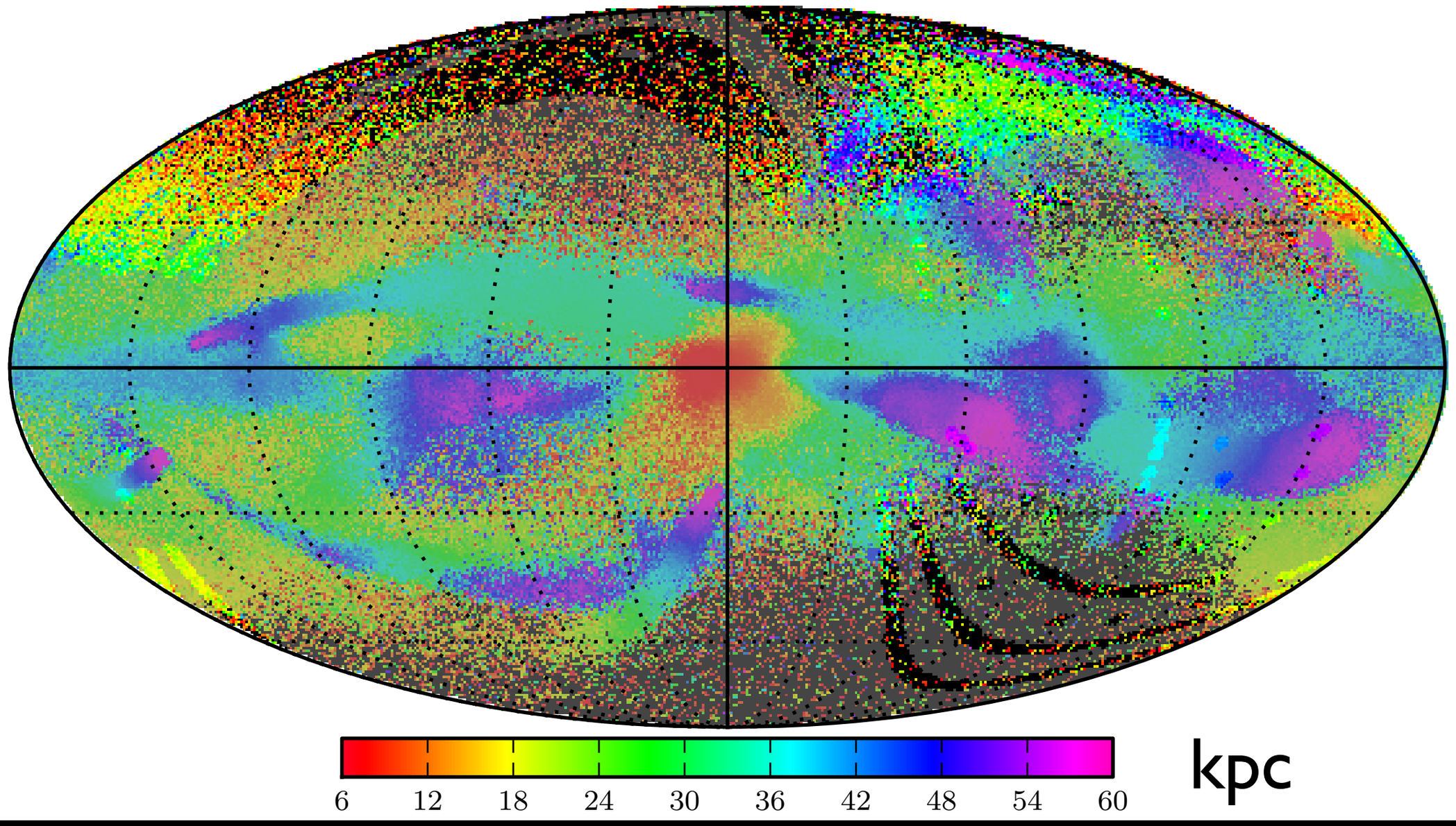
log r /kpc

log Z/Zsun

log r /kpc

Flat Haloes

Galactic coordinates, observer at Sun,
Z axis aligned with minor axis of dark halo



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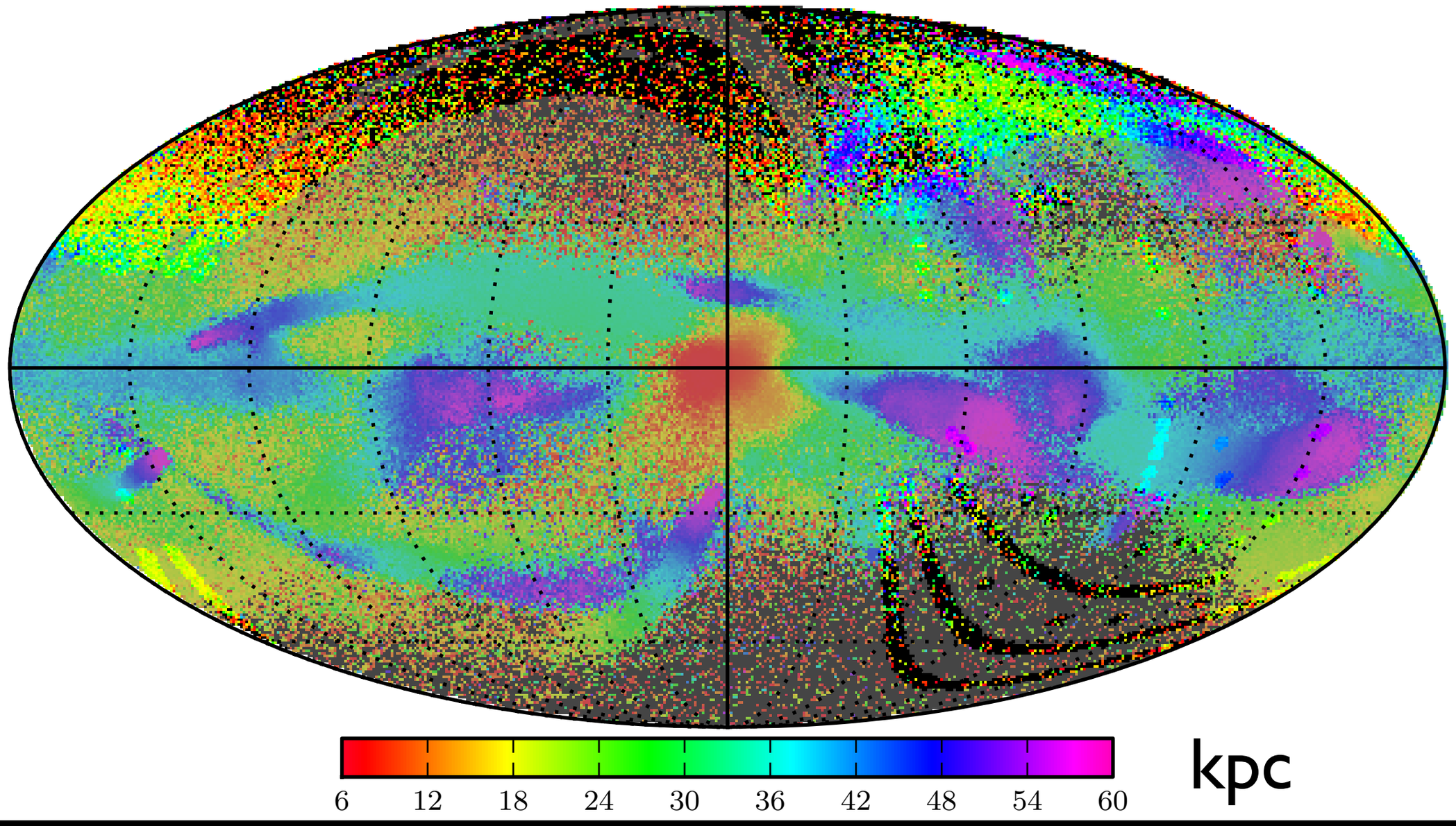

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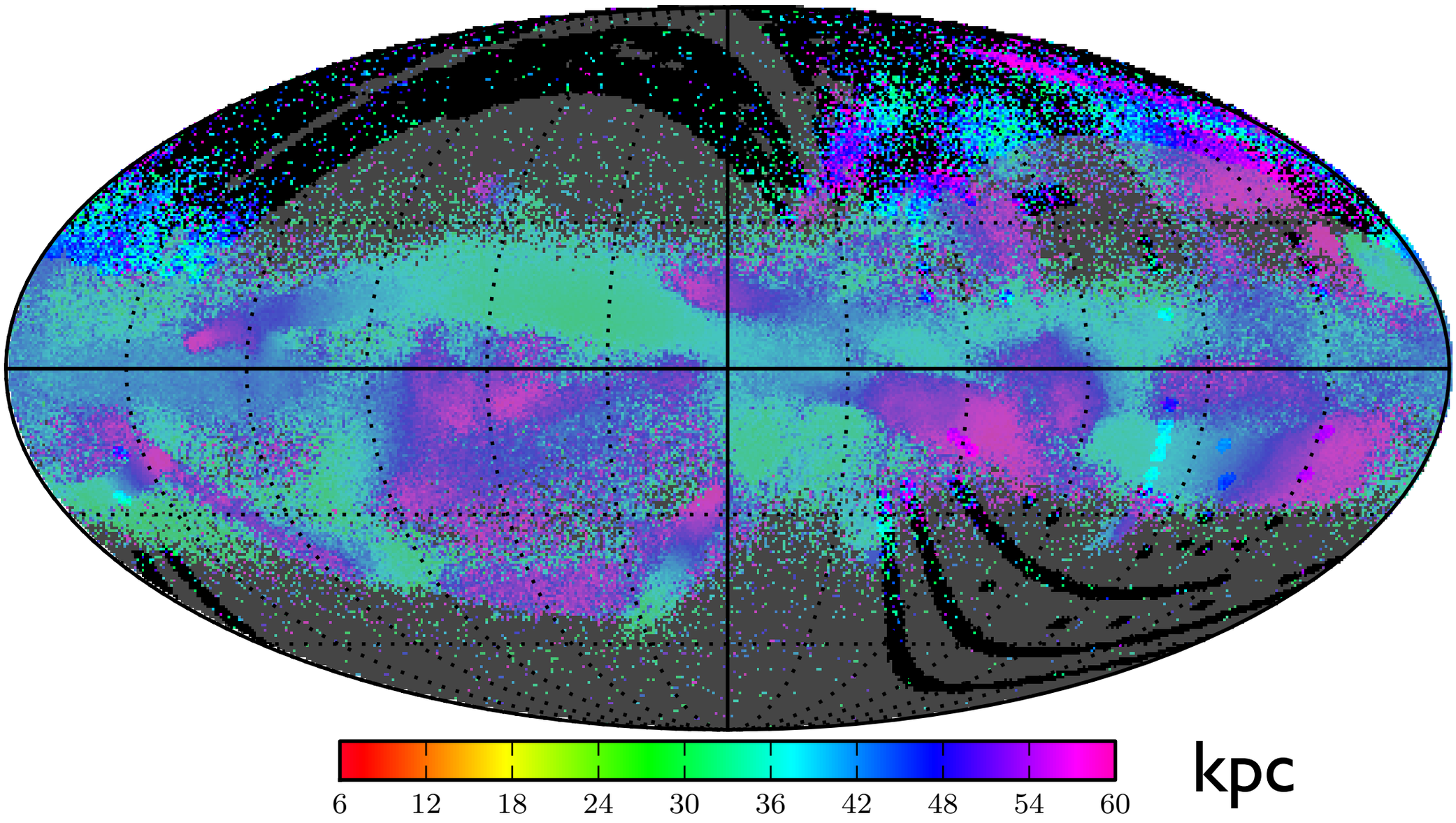
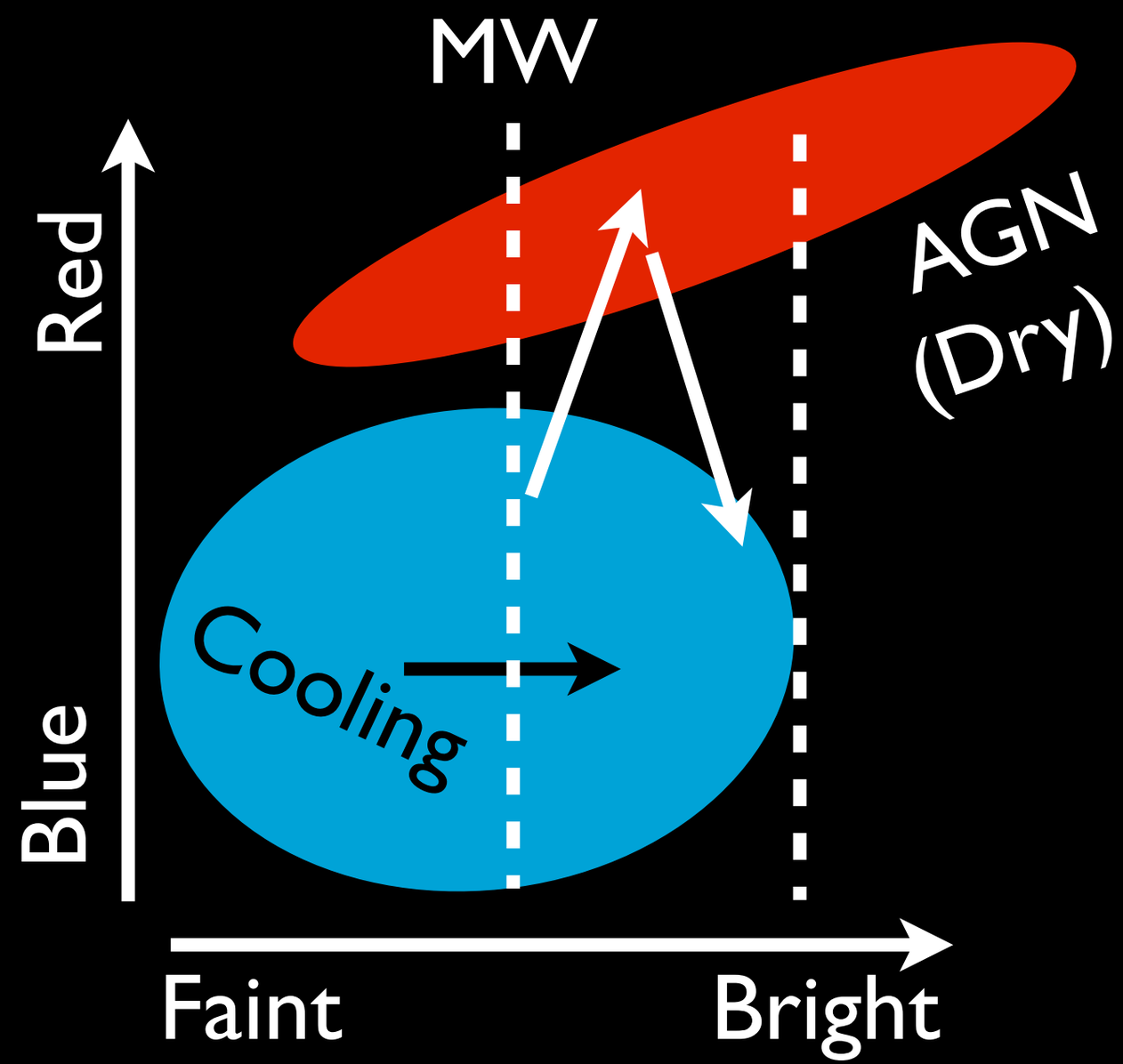


Application II:
An ensemble of nearby galaxies

- Influence of mergers on low-z evolution:
  - Shutdown and spheroid growth?
  - Renewal from extra gas?



Millennium II

- Boylan-Kolchin et al. 2009 / Guo et al. 2010
- L = 100 h^-1 Mpc^3, softening ~ 3 kpc, particle mass ~ 10^7 Msol
- ~2000 haloes hosting galaxies > 5x10^10 Msol

1+z

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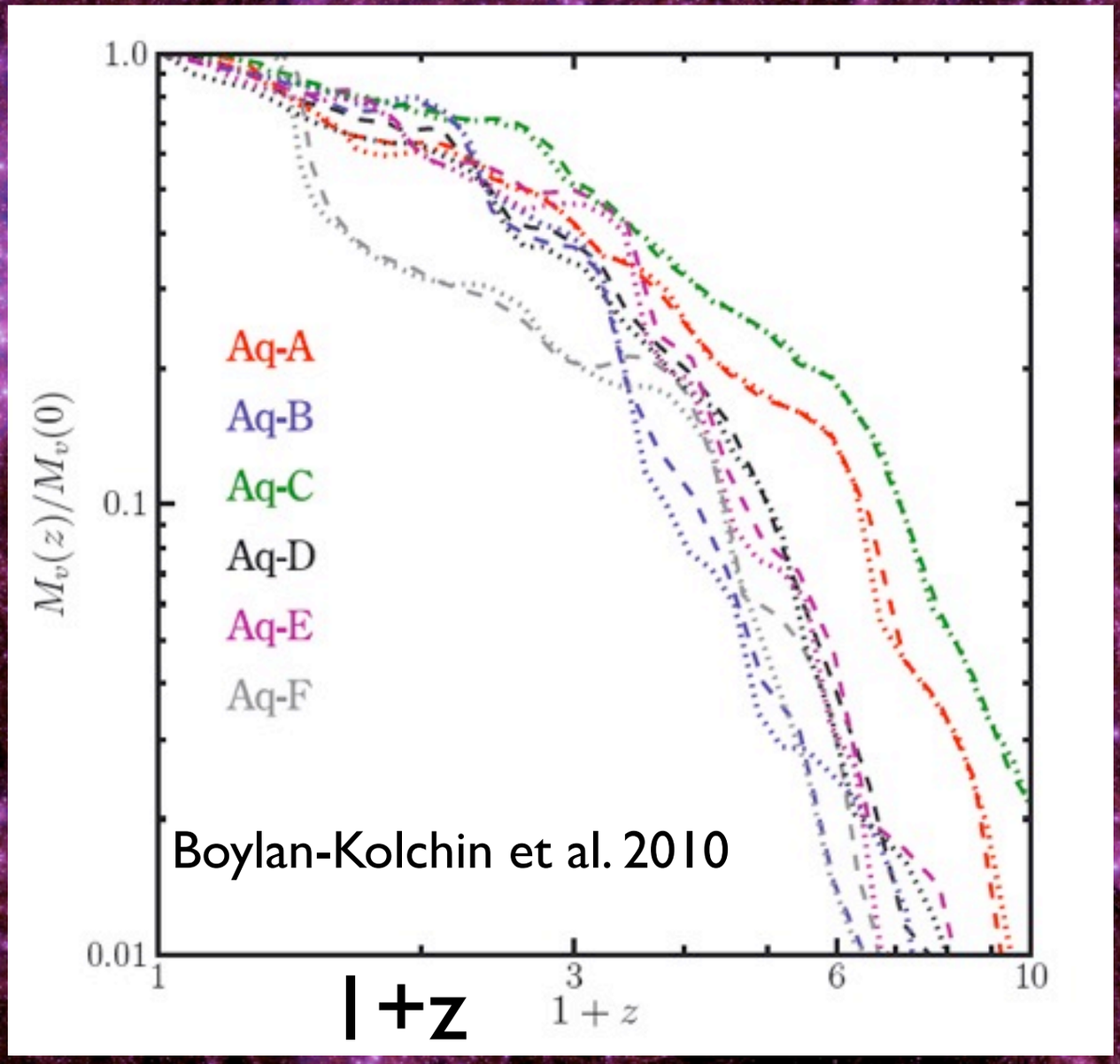


Mass accretion histories of individual Aquarius haloes are well reproduced despite 'low' resolution

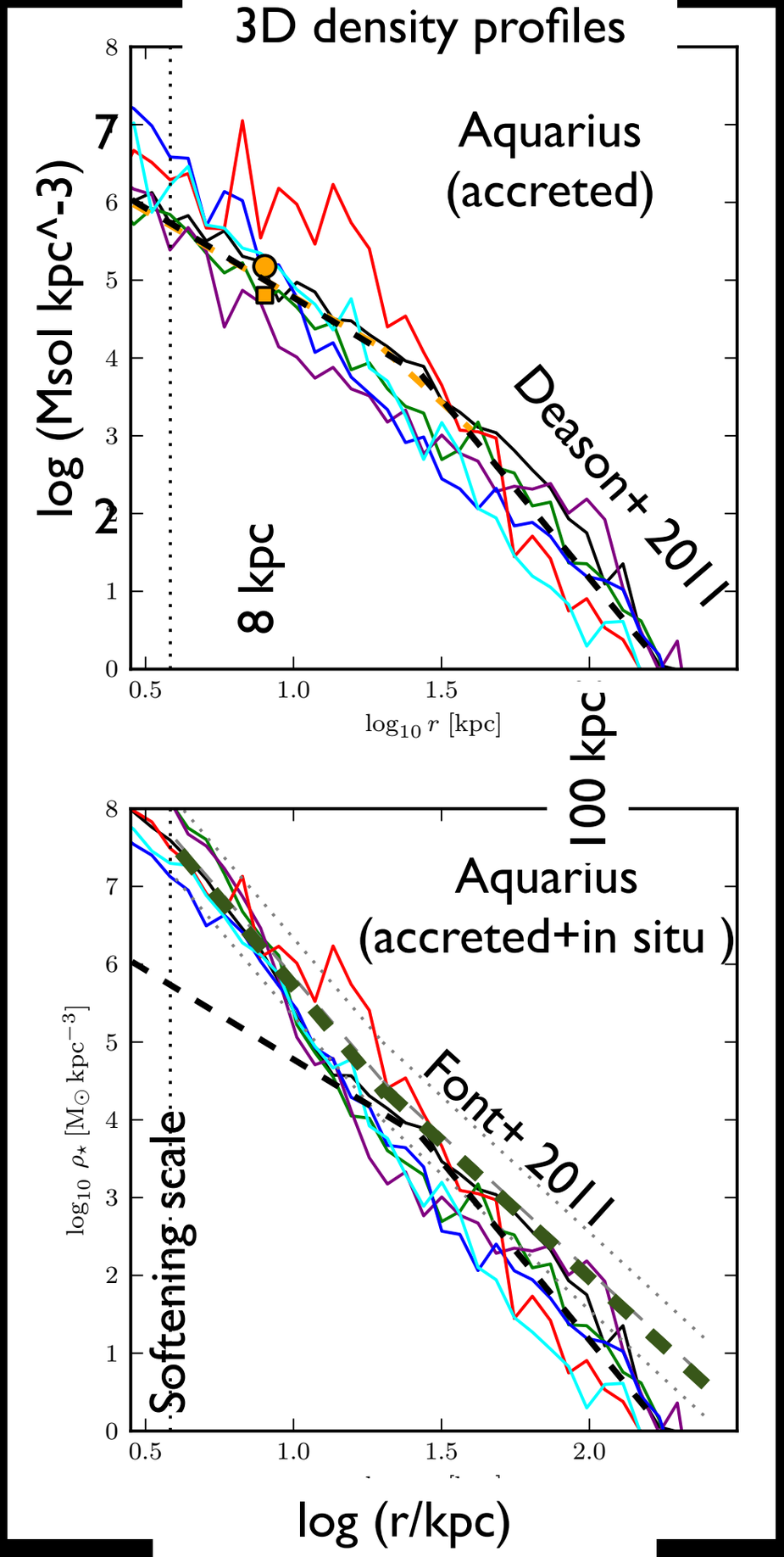
500x500 kpc

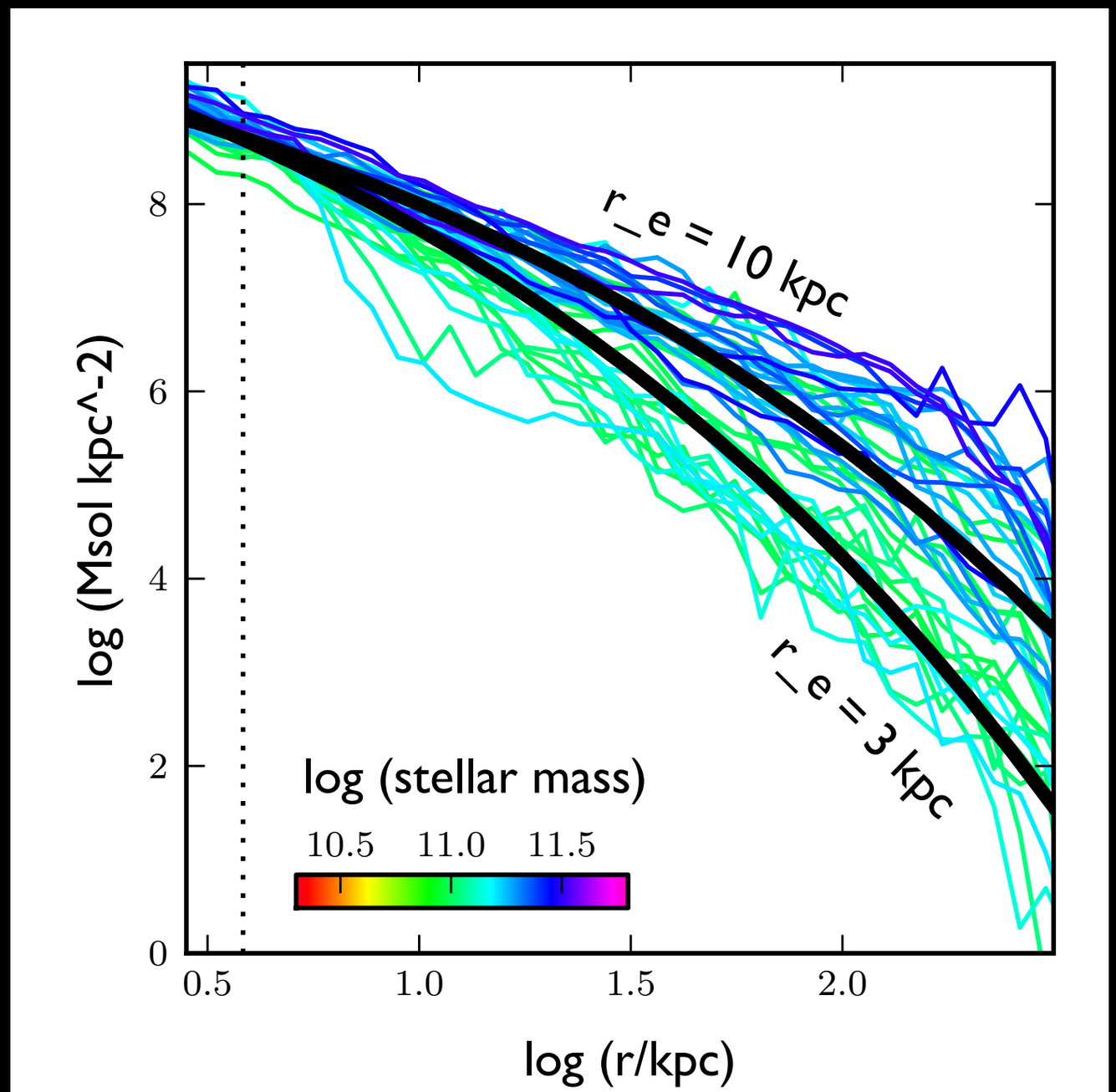
log(Msun) = 11

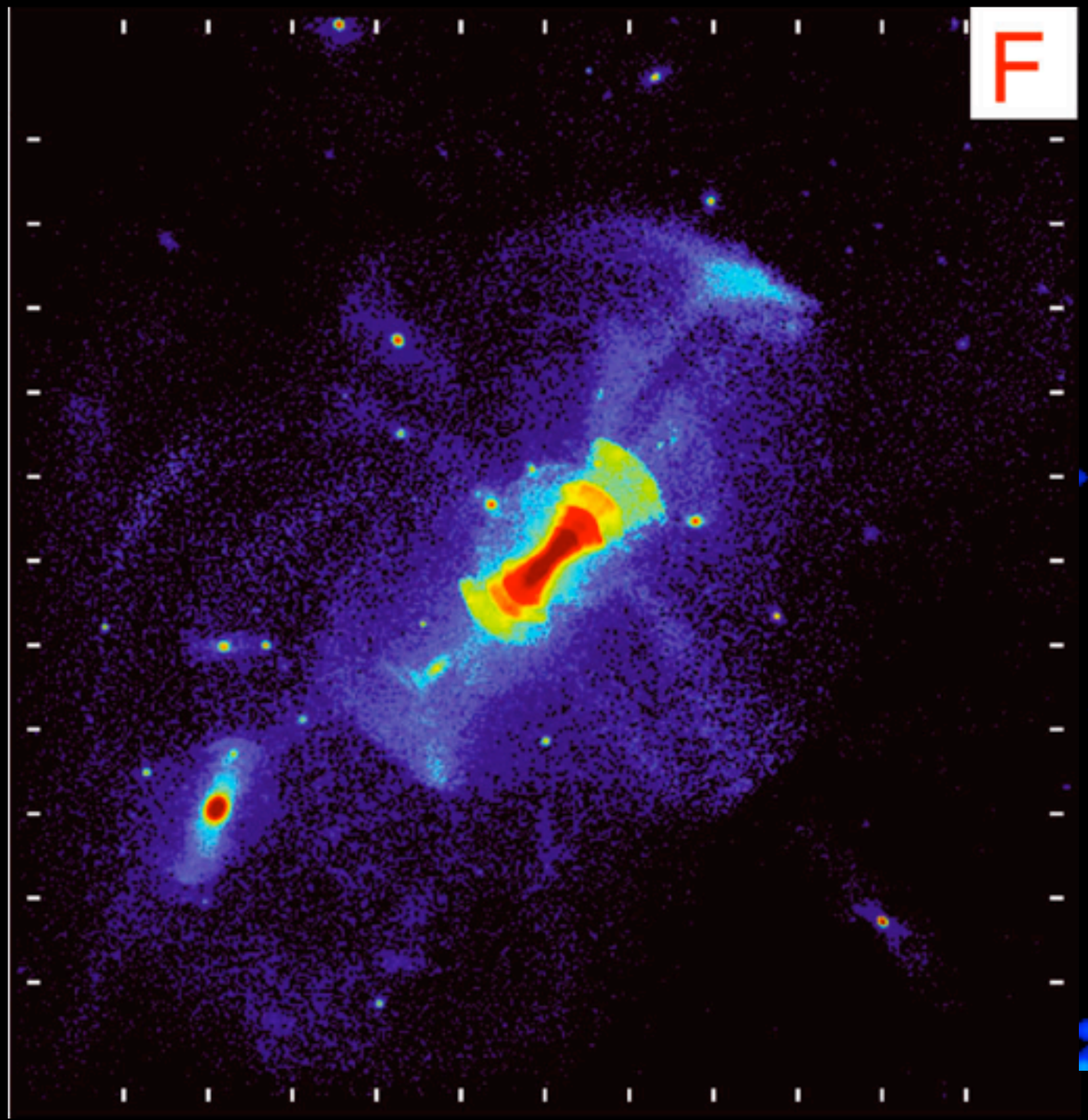
log(Msun) = 11.6

Aquarius haloes reproduced in MII

Total mass surface density profiles
40 galaxies, 11 < log(M/Msol) <11.5



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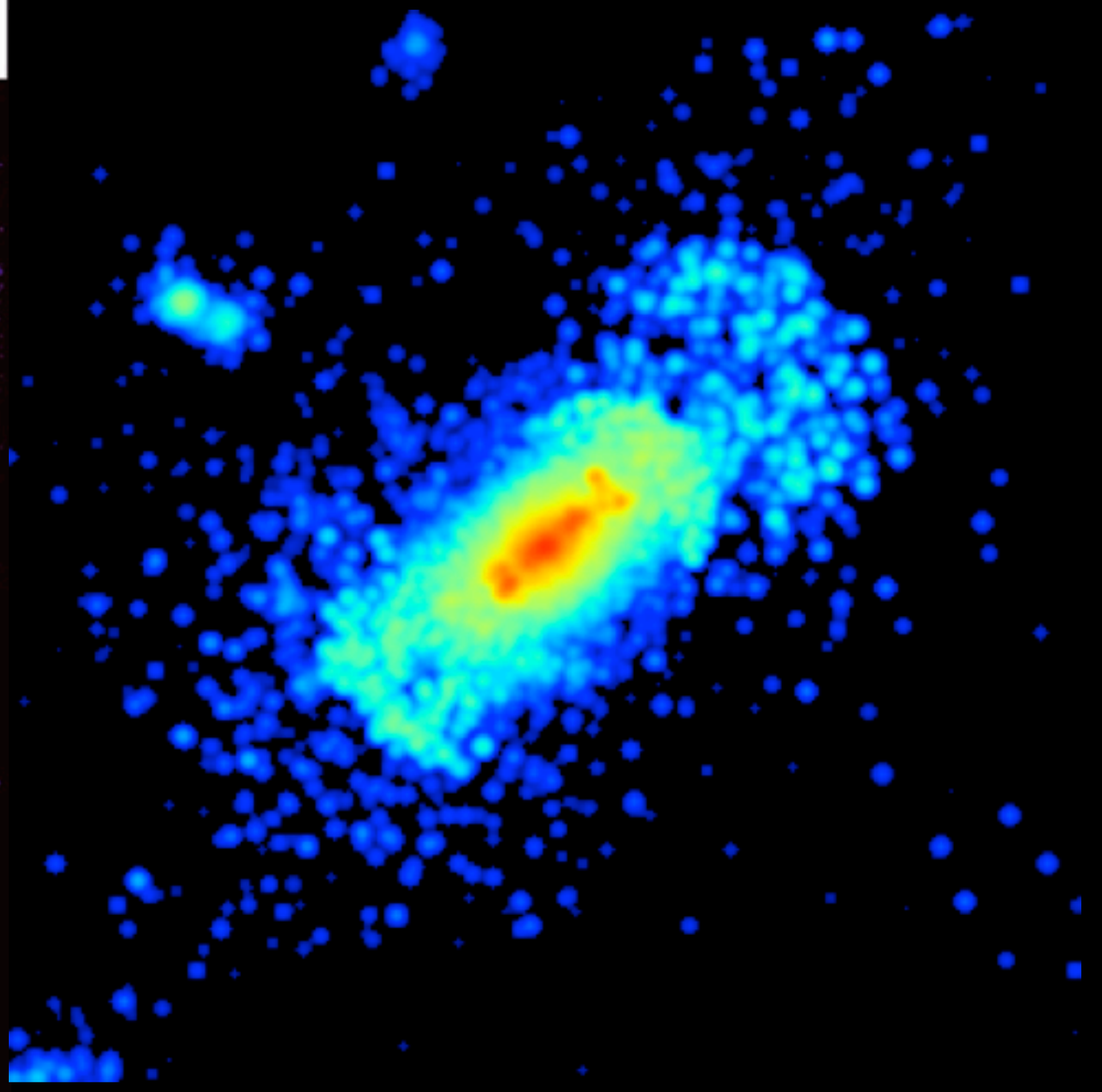

Summary

- Diffuse light probes differences in the accretion histories of galaxies: as yet, limited understanding of how to tie this to other properties of galaxies (e.g. gas content) or how best to carry out the necessary systematic deep imaging.
- MW galaxies: one progenitor (accreted $1 < z < 2$) dominates gross structure of accreted stars, haloes are flattened by correlated infall. Can check models in detail against MW, M31, but require much larger samples to really test CDM.
- Massive galaxies (haloes) suffer many minor mergers at low z, with bright companions: systematic correlations between diffuse light and other properties might be observable around the ‘transition mass’.