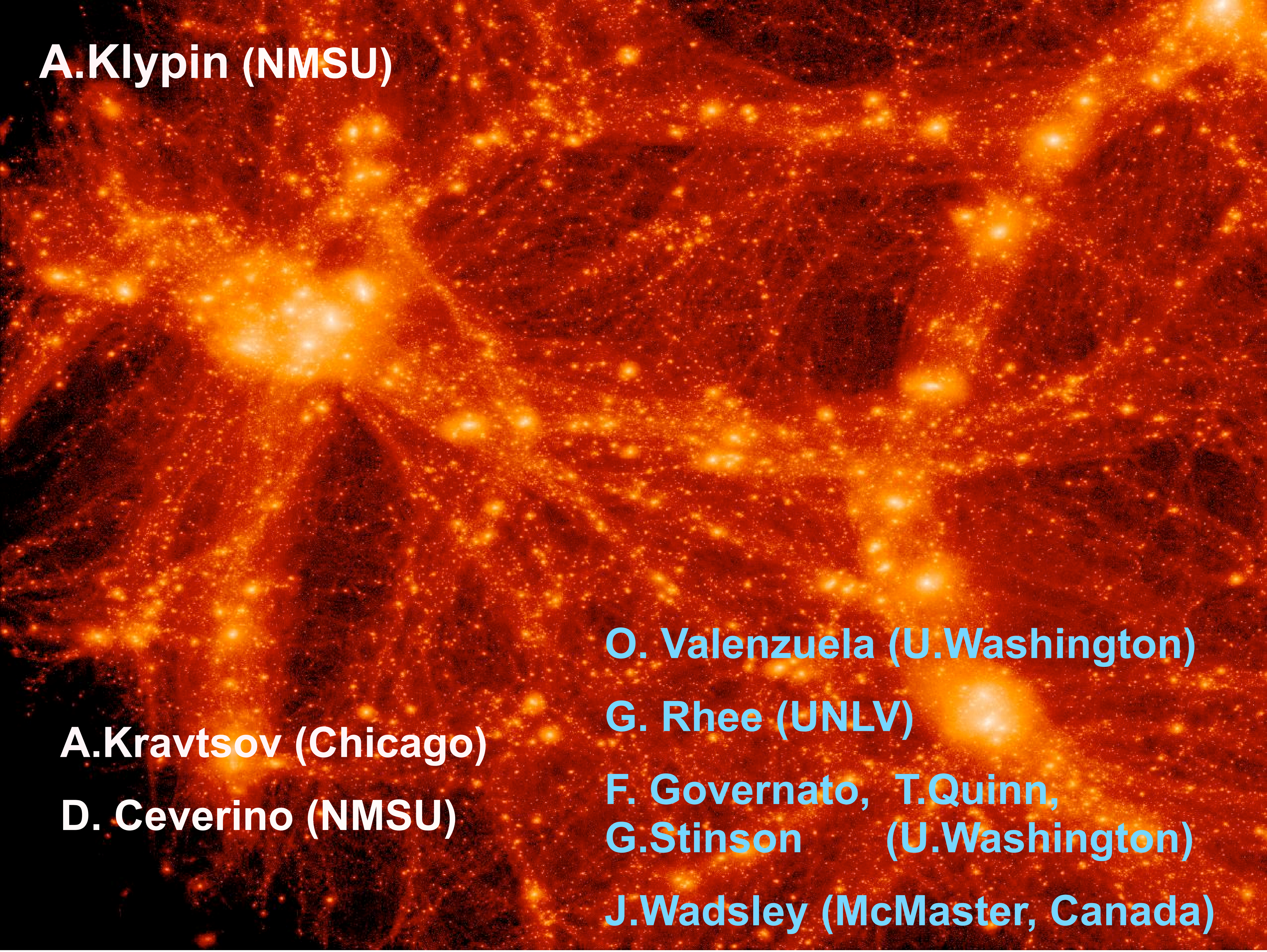

A.Klypin (NMSU)
O. Valenzuela (U.Washington)
G. Rhee (UNLV)
A.Kravtsov (Chicago)
D. Ceverino (NMSU)
F. Governato, T.Quinn,
G.Stinson (U.Washington)
J.Wadsley (McMaster, Canada)

A.Klypin (NMSU)

Dark Matter Halos

O. Valenzuela (U.Washington)

G. Rhee (UNLV)

A.Kravtsov (Chicago)

F. Governato, T.Quinn, G.Stinson (U.Washington)

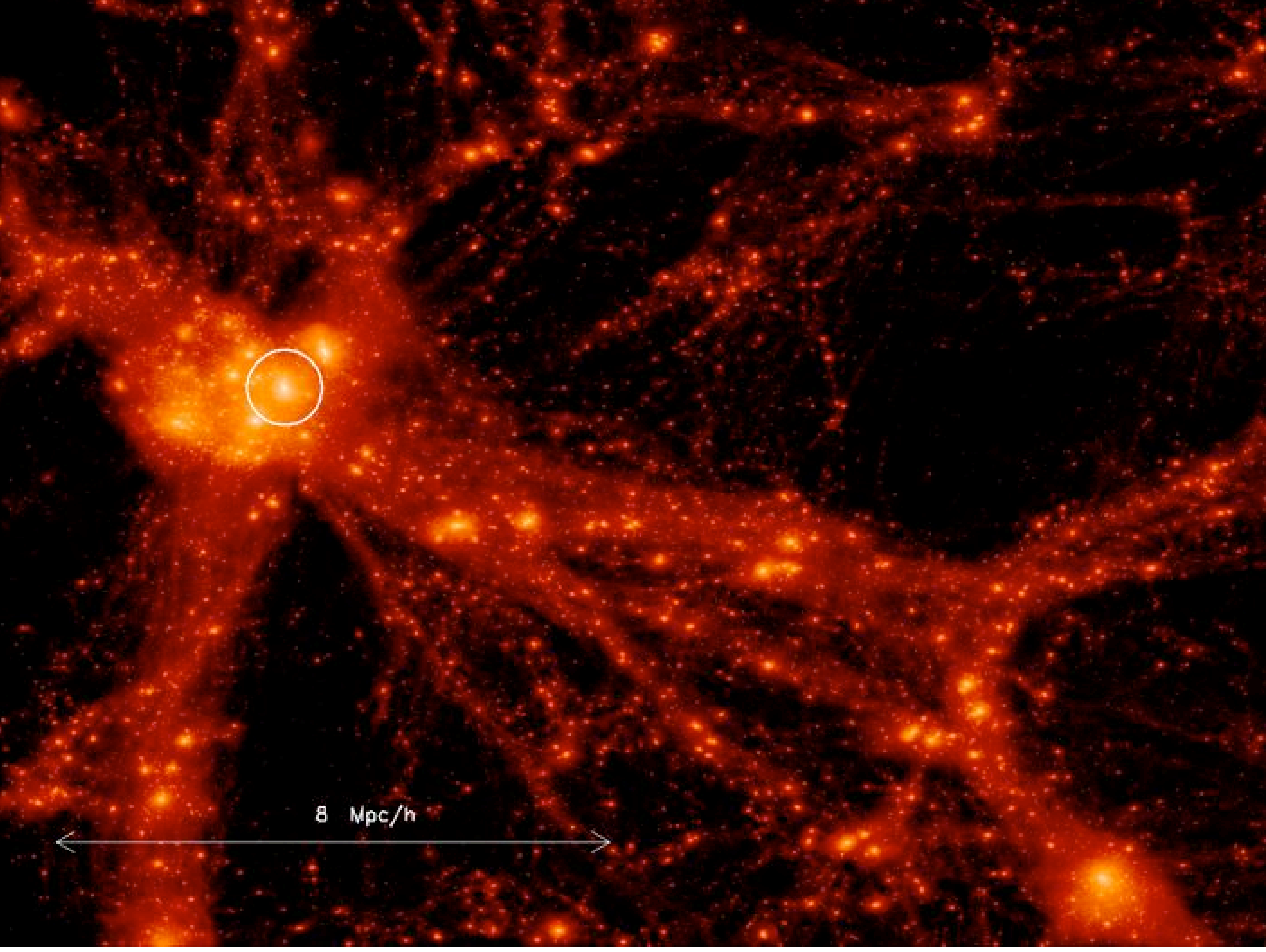
D. Ceverino (NMSU)

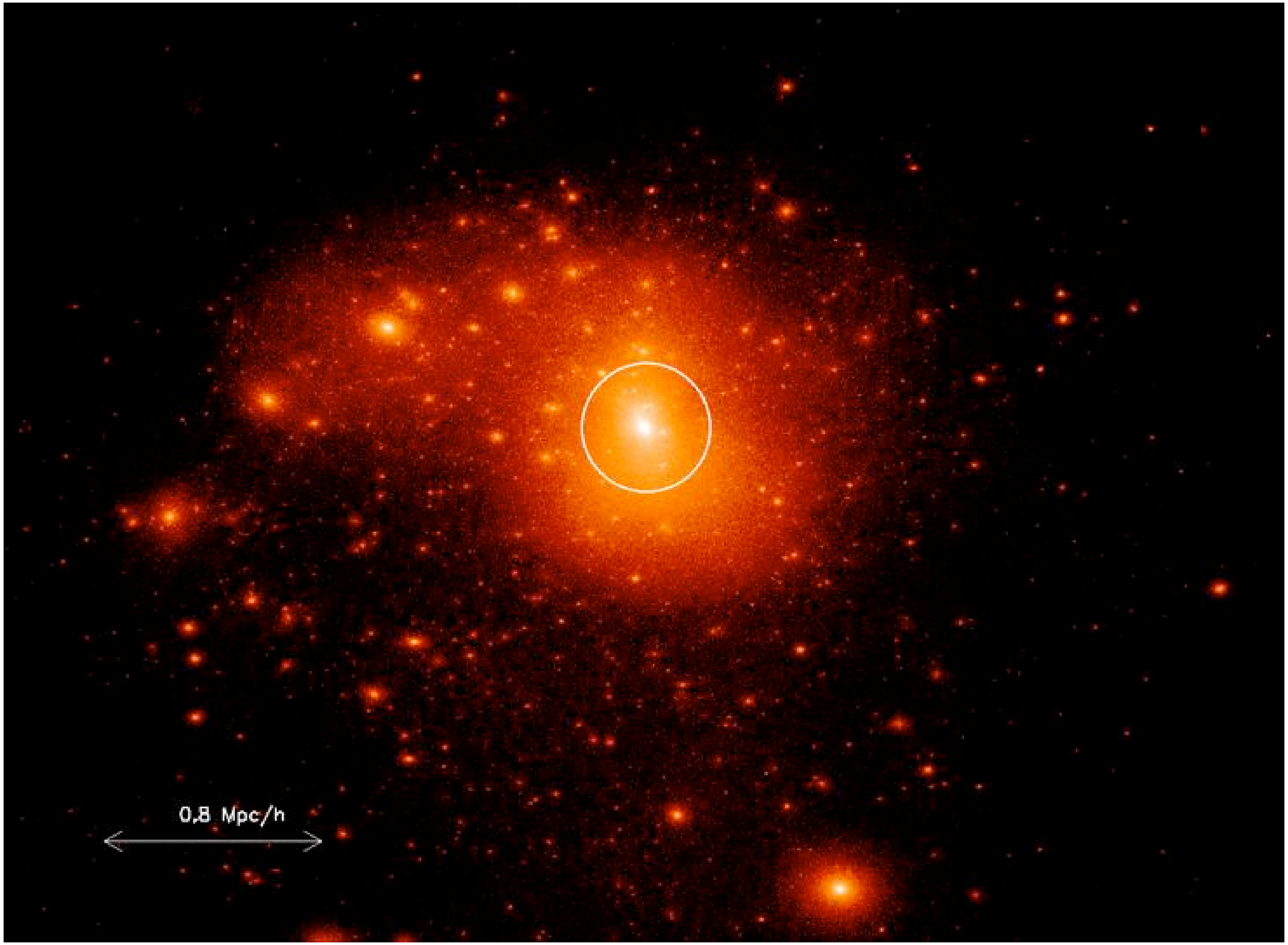
J.Wadsley (McMaster, Canada)

Major codes:

- N-body
- Hydro
- Cooling/Heating/SF
- Metal enrichment
- Radiative transfer
- Multistepping/Multiple masses

GADET	Springel, SDM White
PKDGRAV - GASOLINE	Quinn, Steidel, Wadsley, Governato, Moore
ART	Kravtsov, Klypin, N.Gnedin, Gottlober
ENZO	Bryan, Norman


8 Mpc/h


0.8 Mpc/h

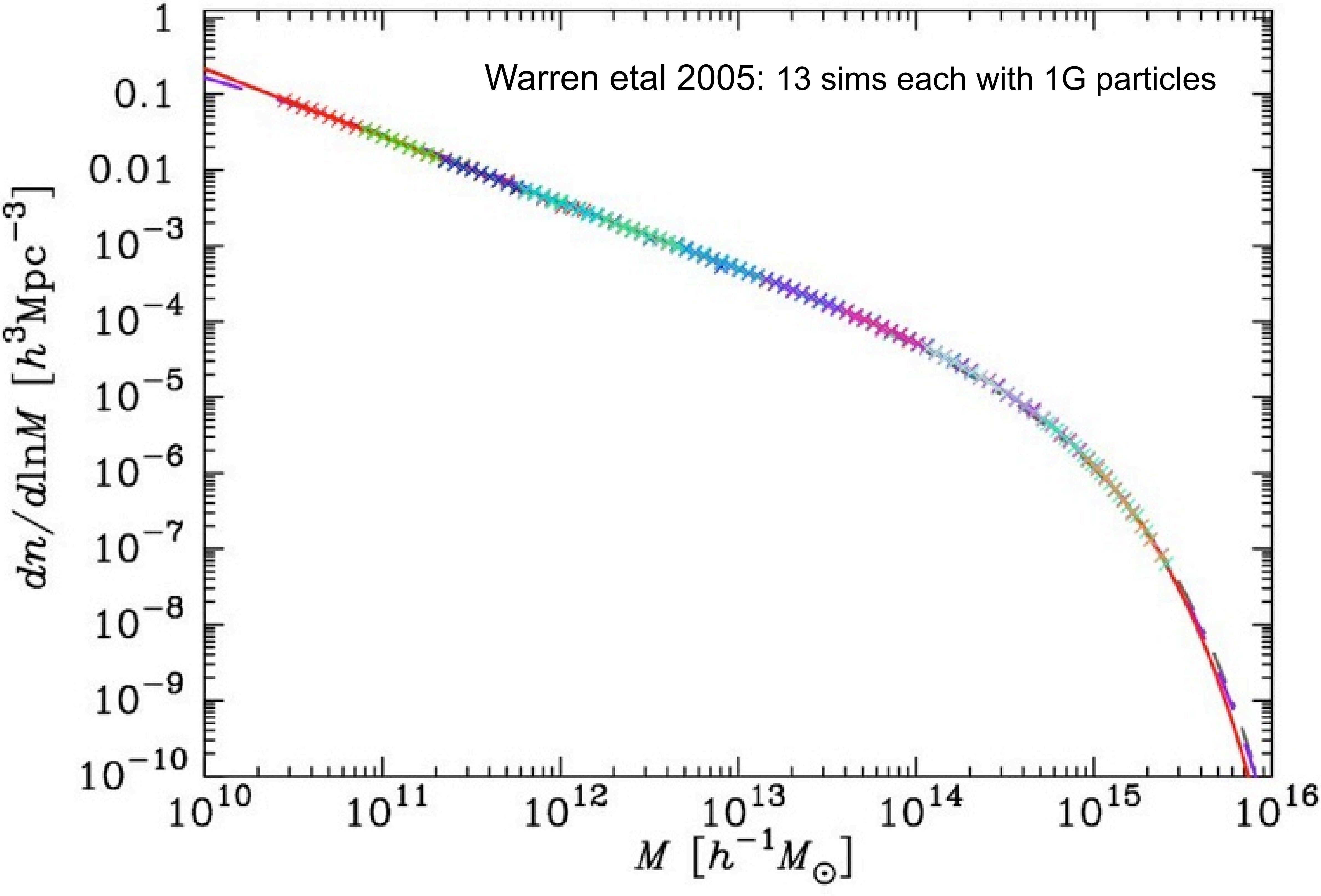
Mass function of distinct halos

5

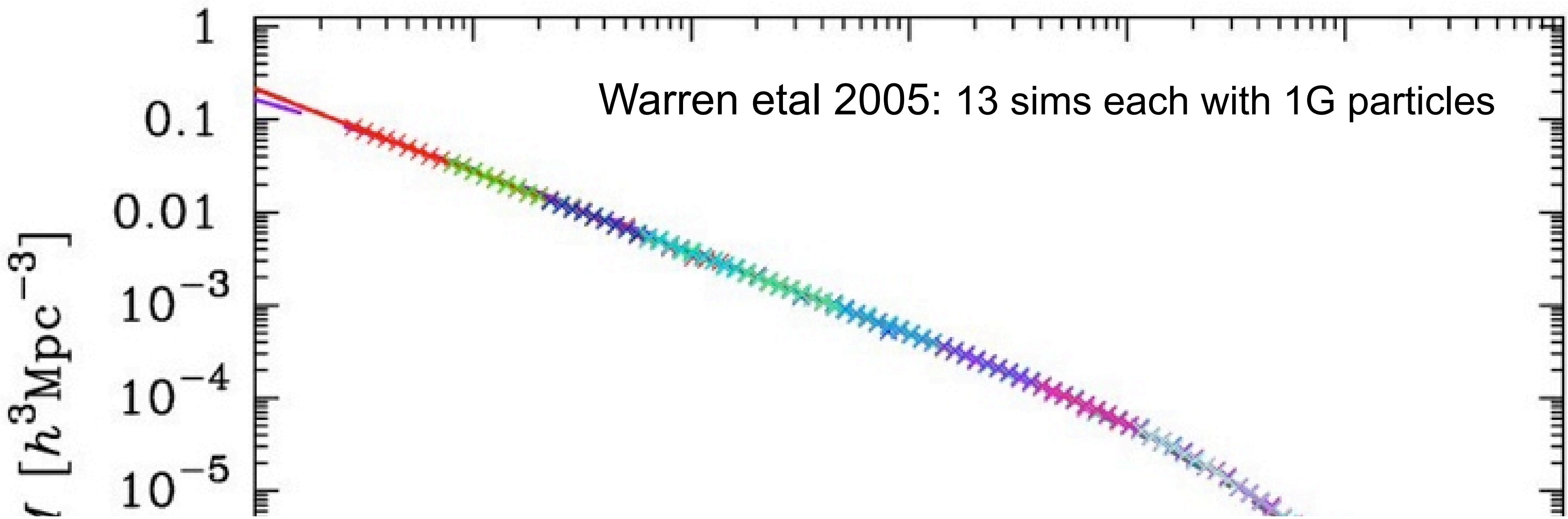
Mass function of distinct halos

- It started long ago: 32 years to be precise
- Now we live through 5th generation of this.

Mass function of distinct halos



Mass function of distinct halos



Mass Function of Dark Matter Halos 3

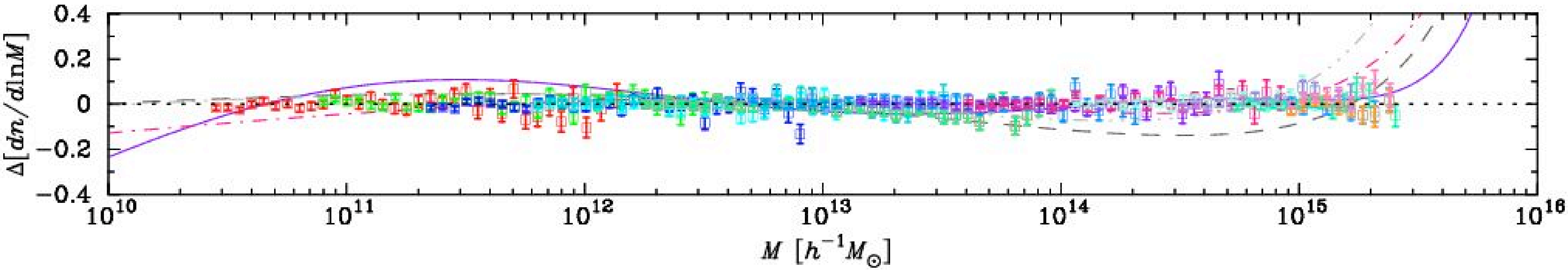
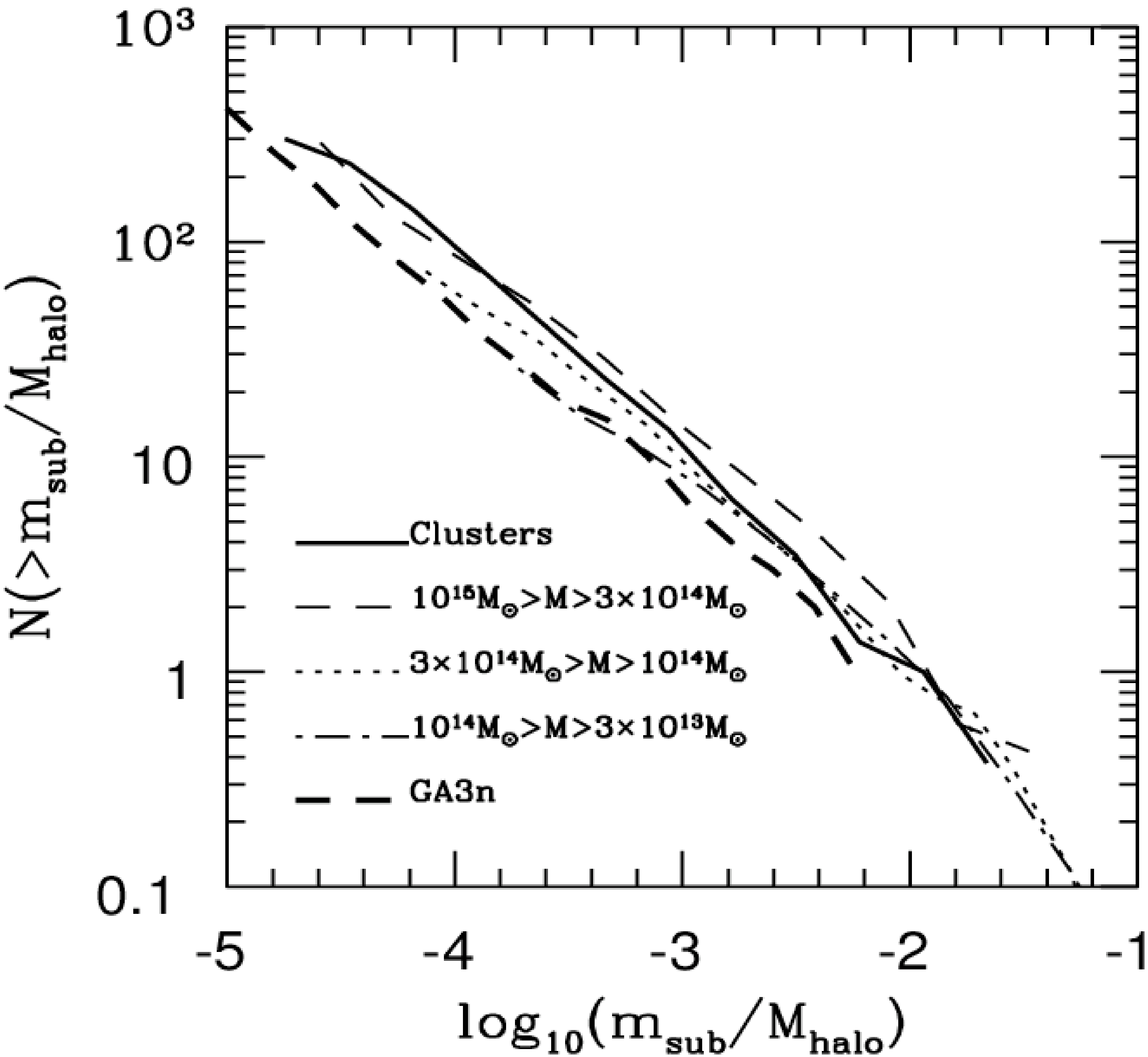


FIG. 2.— Shown are the residuals from the binned simulation data to the fit presented in this work as square data points of different colors per simulation. The Jenkins fit is the solid (purple) line, ST original fit the dashed (dark gray) line, the ST fit with parameters A, a, p free with dot-dashed line (red), and the ST fit with a, p free and amplitude A set to require all dark matter in halos as a triple-dot-dashed line (light gray). The binned mass function from the Virgo Hubble Volume simulation are the asterisk points with errors (pink).

Subhalo mass function

Gao et al 2004

Halos are not self-similar:
Large halos have more substructure.
Yet the effect is very weak.



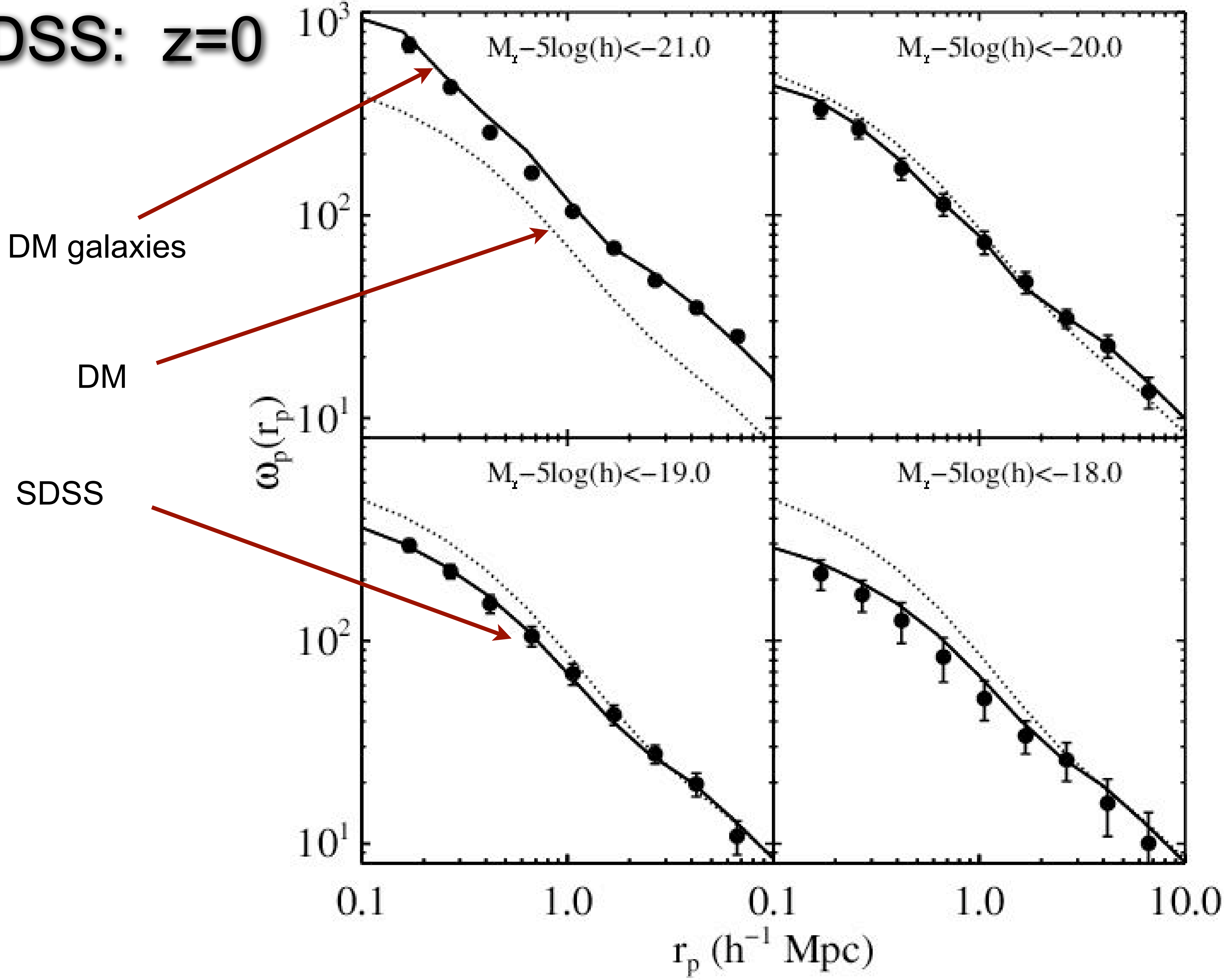
Clustering: DM halos and L

Conroy, Wechsler, Kravtsov (2005): **N-body only**

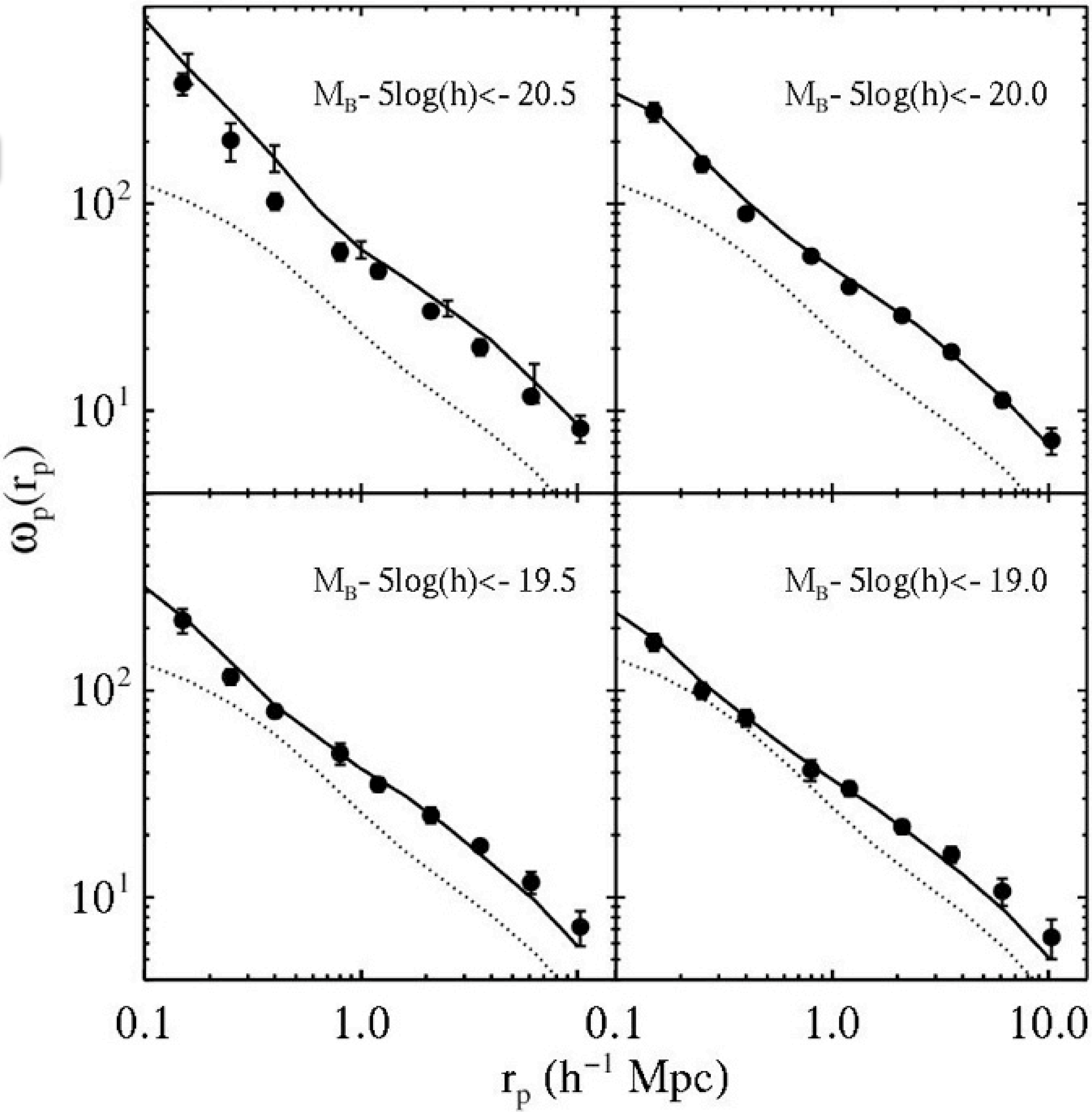
- Get all halos from high-res simulation
- Use maximum circular velocity (NOT mass)
- For subhalos use V_{max} before they became subhalos
- Every halo (or subhalo) is a galaxy
- Every halo has luminosity: **LF is as in SDSS**
- No cooling or major mergers and such. Only DM halos

Reproduces most of the observed clustering of galaxies

SDSS: z=0


DM galaxies
DM
SDSS
10^3
10^2
10^1
$\omega_p(r_p)$
$M_r - 5\log(h) < -21.0$
$M_r - 5\log(h) < -20.0$
$M_r - 5\log(h) < -19.0$
$M_r - 5\log(h) < -18.0$
0.1
1.0
10.0
r_p (h^{-1} Mpc)

DEEP: z=1



M_B- 5log(h)<- 20.5
M_B- 5log(h)<- 20.0
M_B- 5log(h)<- 19.5
M_B- 5log(h)<- 19.0
10^2
10^1
$\omega_p(r_p)$
0.1
1.0
10.0
r_p (h^{-1} Mpc)

Dark Matter and Galaxies

Dark Matter and Galaxies

- **Central** DM closely correlates with L: Tully-Fisher, Faber-Jackson

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Young etal(2003-5), Berrier etal(2005) : Halo occupation distribution→the same conclutions

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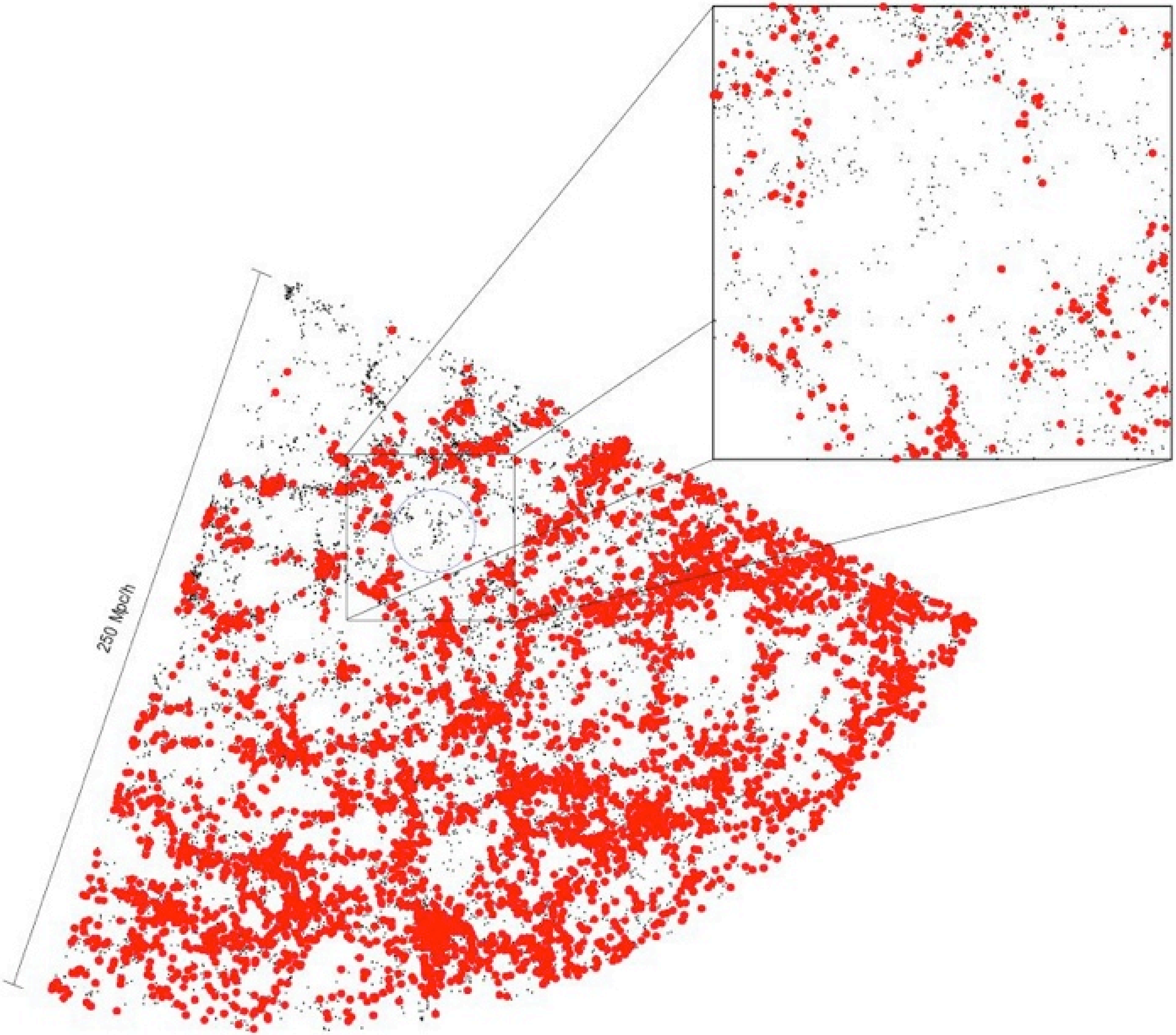
Young etal(2003-5), Berrier etal(2005) : Halo occupation distribution→the same conclutions

Voids
R>10Mpc

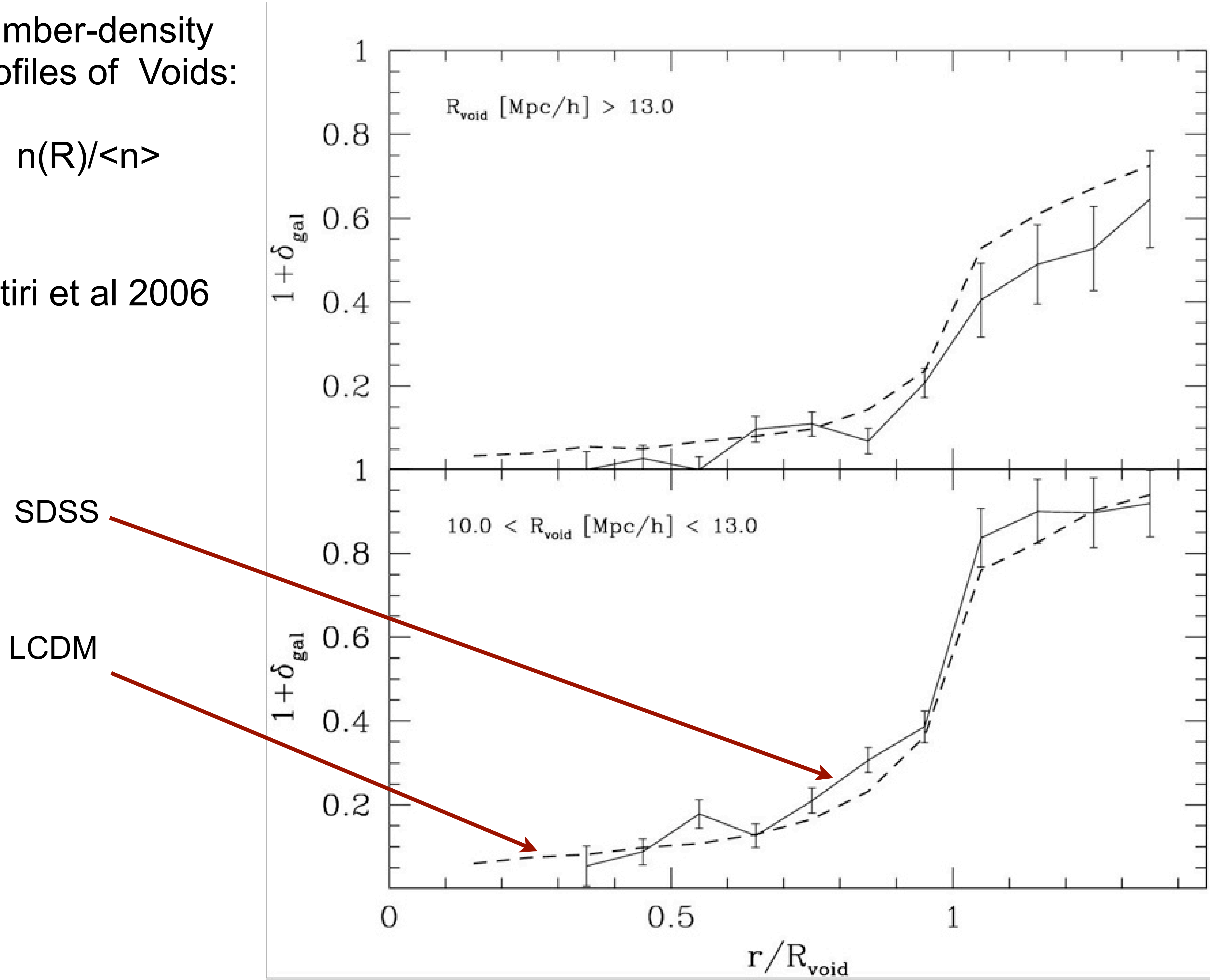
Patiri et al 2006: SDSS



Number-density Profiles of Voids:

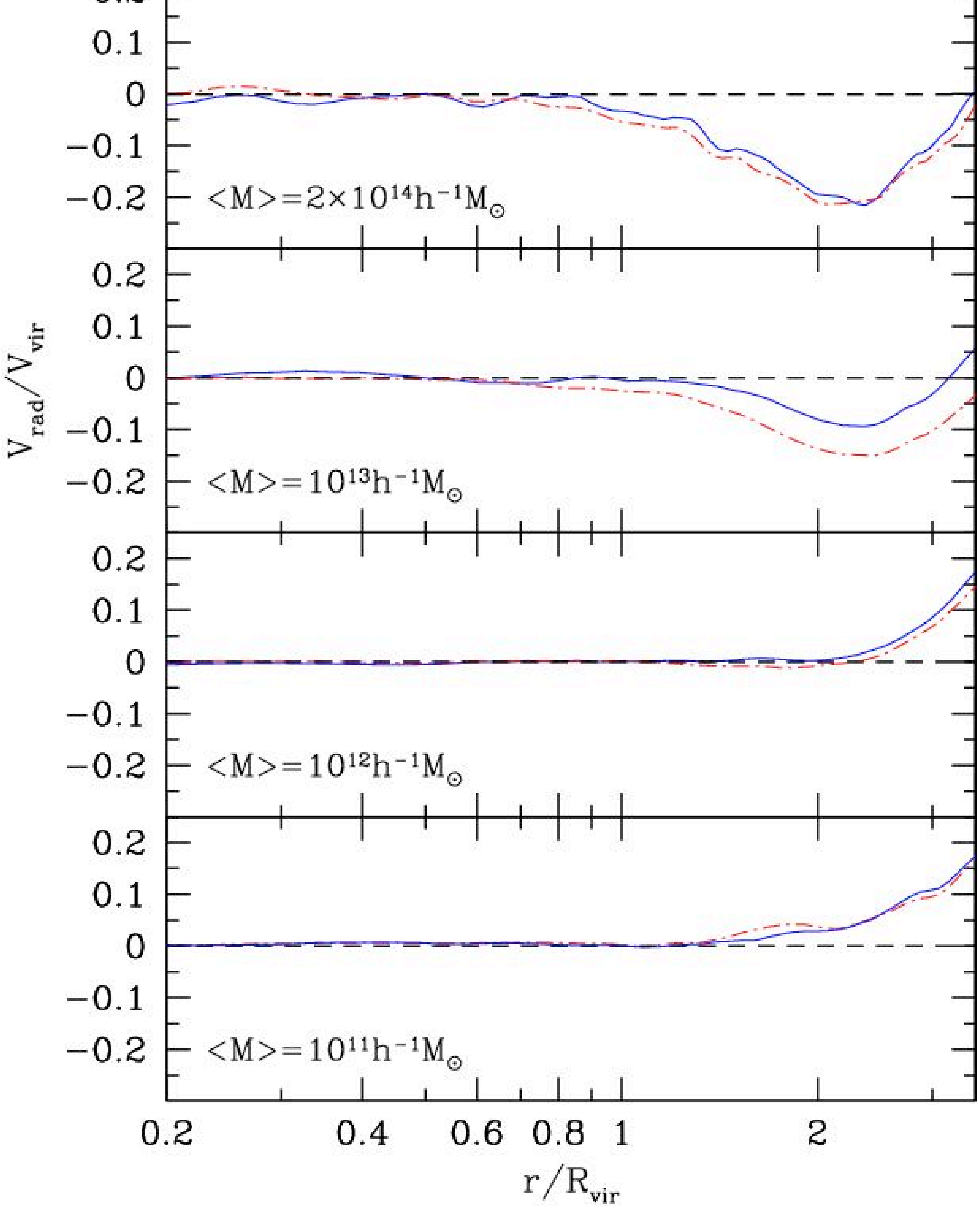
n(R)/<n>

Patiri et al 2006

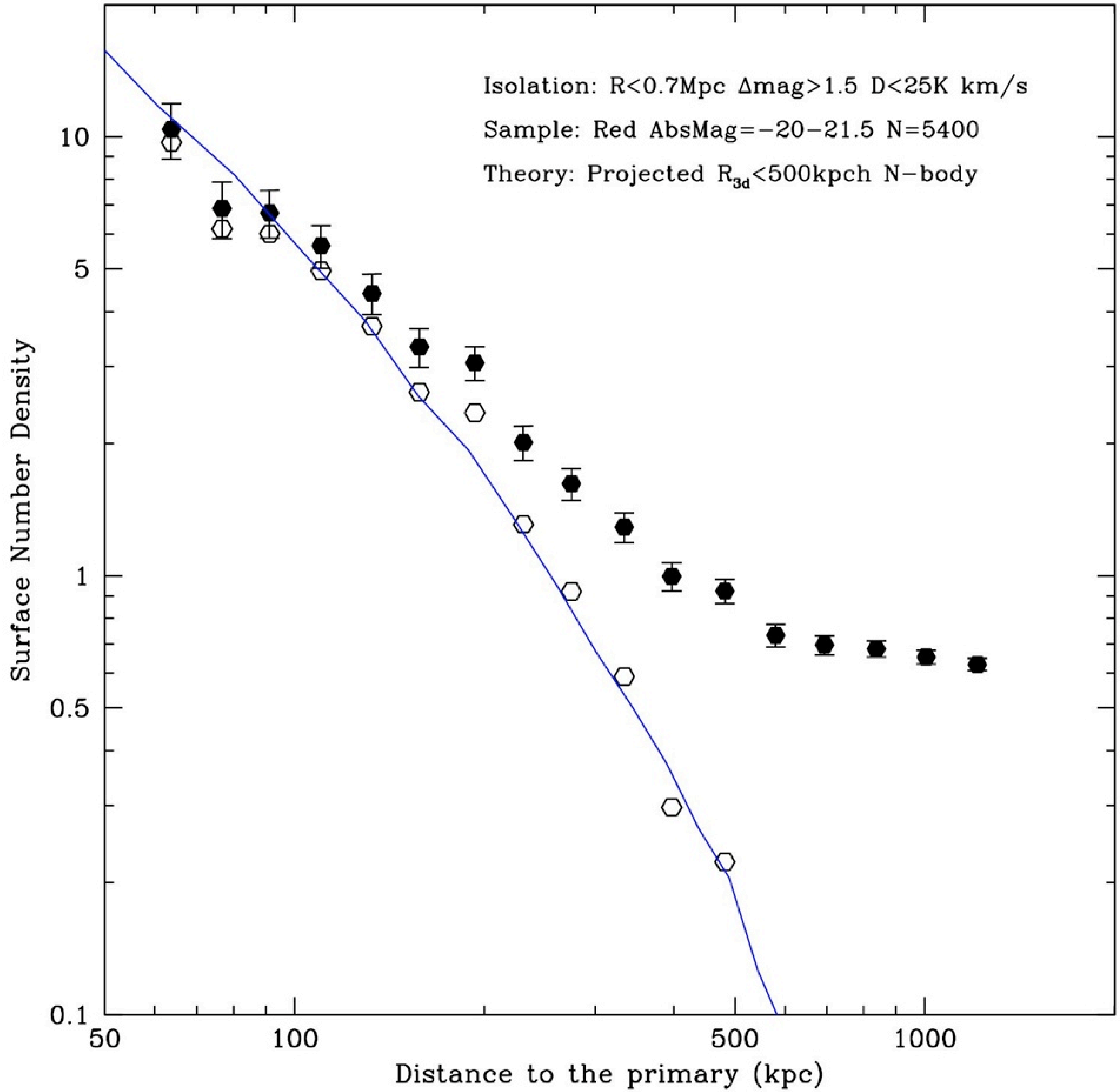


Infall velocity for halos of different mass:

Average radial velocity at a given distance from the center of a halo



SDSS and LCDM: surface number density of satellites around isolated galaxies



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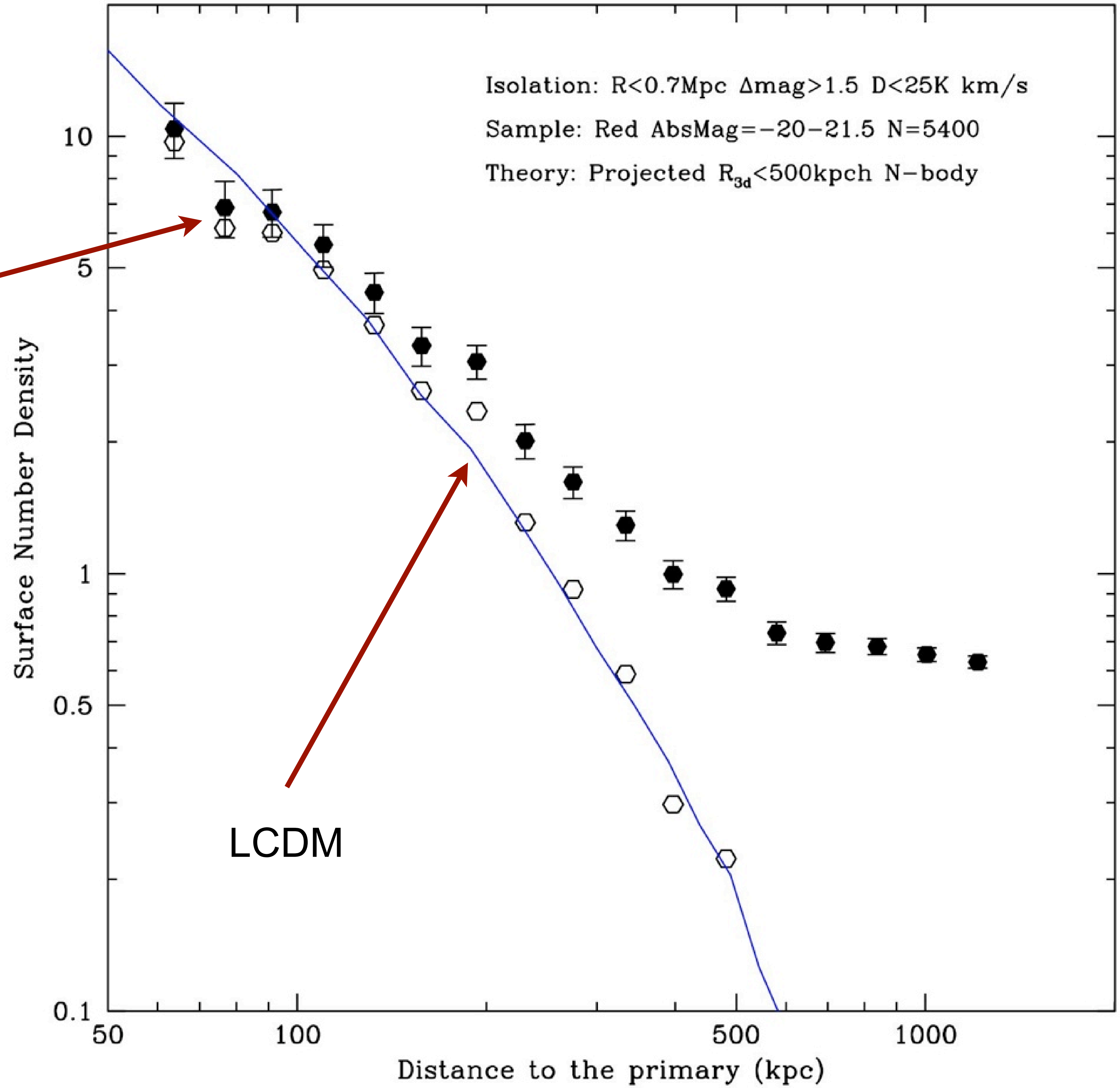
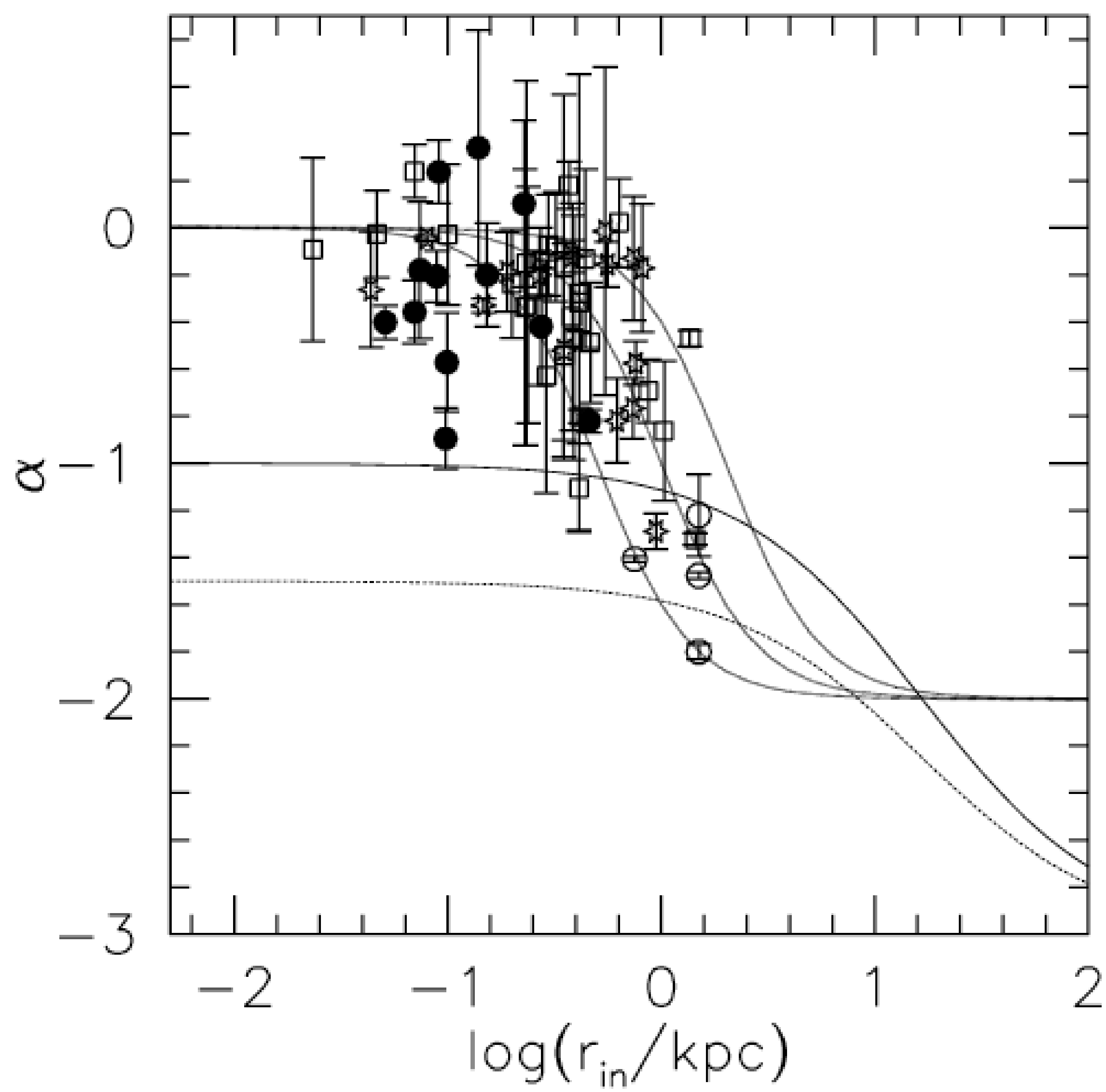
SDSS and LCDM: surface number density of satellites around isolated galaxies



Very small scales

Cusps and rotation curves



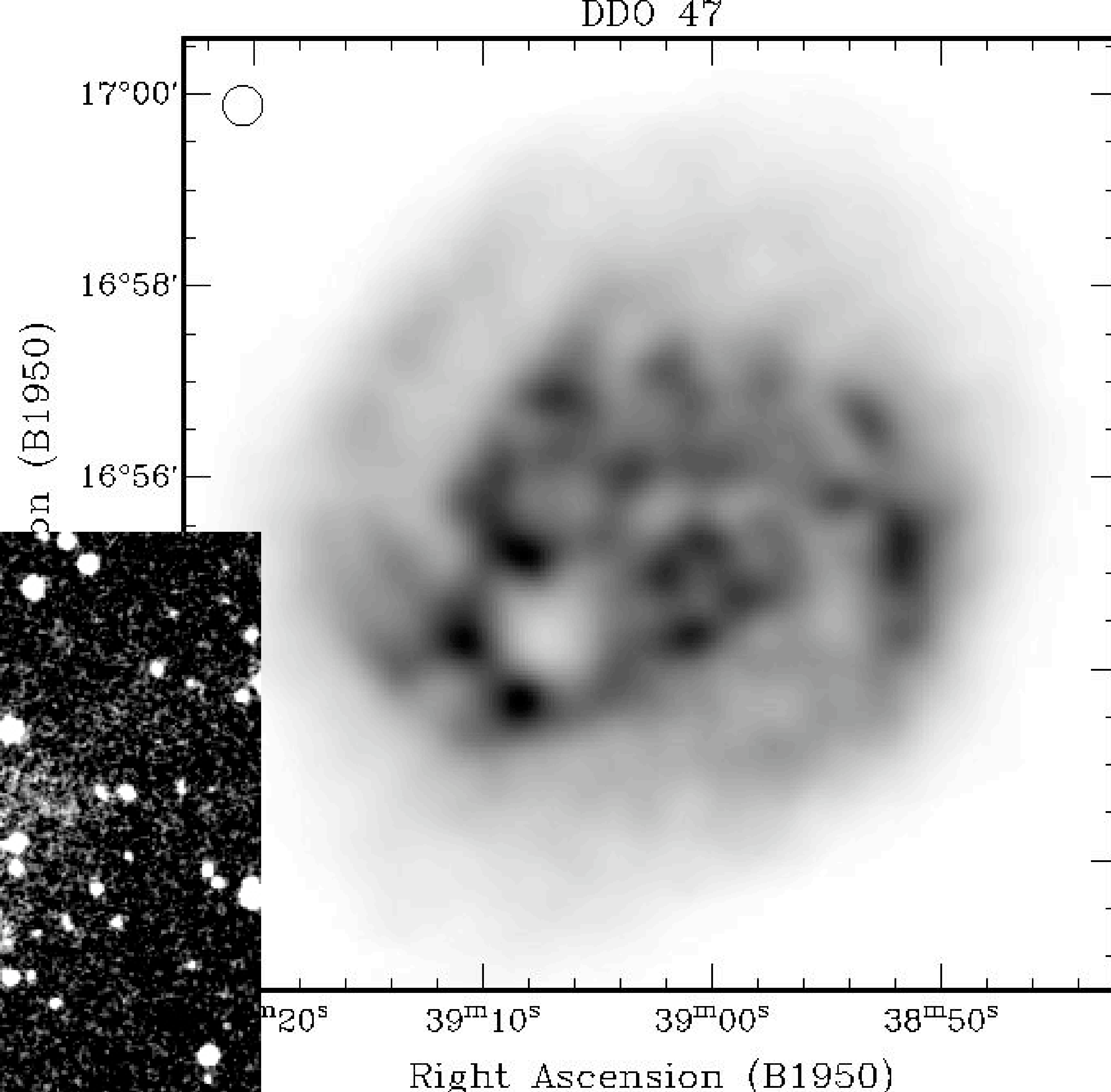
DDO 47:

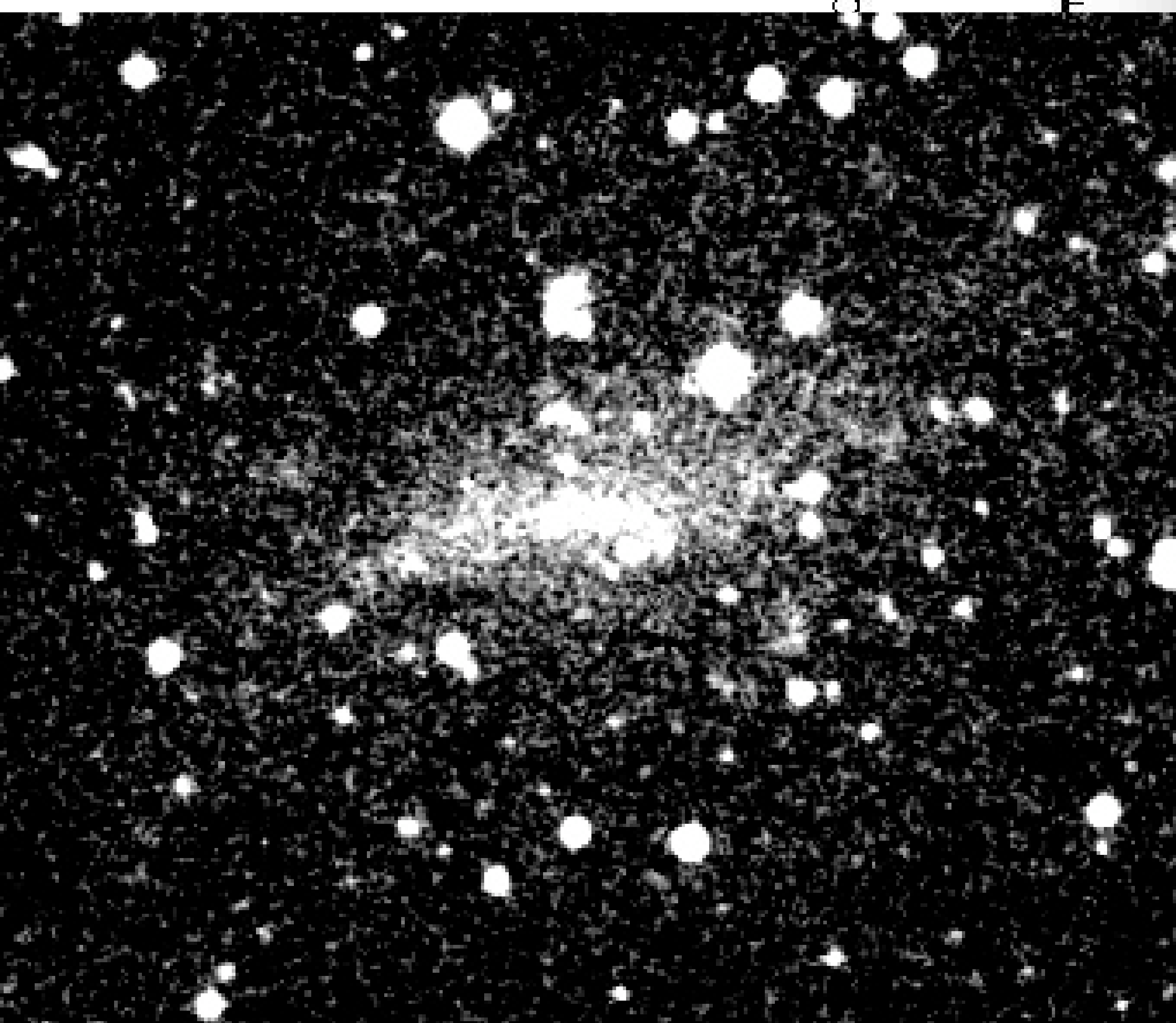
Vmax = 80km/s

Distance = 4Mpc

HI is very lumpy

Stellar light does not align with HI





Observations:

- A large fraction of dwarf Galaxies in the central 1kpc has a maximal disk: stellar populations with observed colors.
- Signs of a weak bar are frequent.
- ISM is very clumpy.

DM in central regions of galaxies:

Can cusps be destroyed?

– bars (Weinberg & Katz 2002).

- Answer **no**: Colin etal 2005: DM density increases as bars form

– baryons:

El-Zant, Shlosman, Hoffman (2001)
Gnedin & Zhao (2002)
Mashchenko, Couchman, Wadsley (2006)

- Very artificial and unrealistic setup
- Real N-body+Hydro sims (**30pc** resolution) show **increase in DM density**

Valenzuela et al 05

Code: GASOLINE

Isolated Galaxy:

NFW halo 1-2M particles

Exponential disk 200K particles

Gas 100K

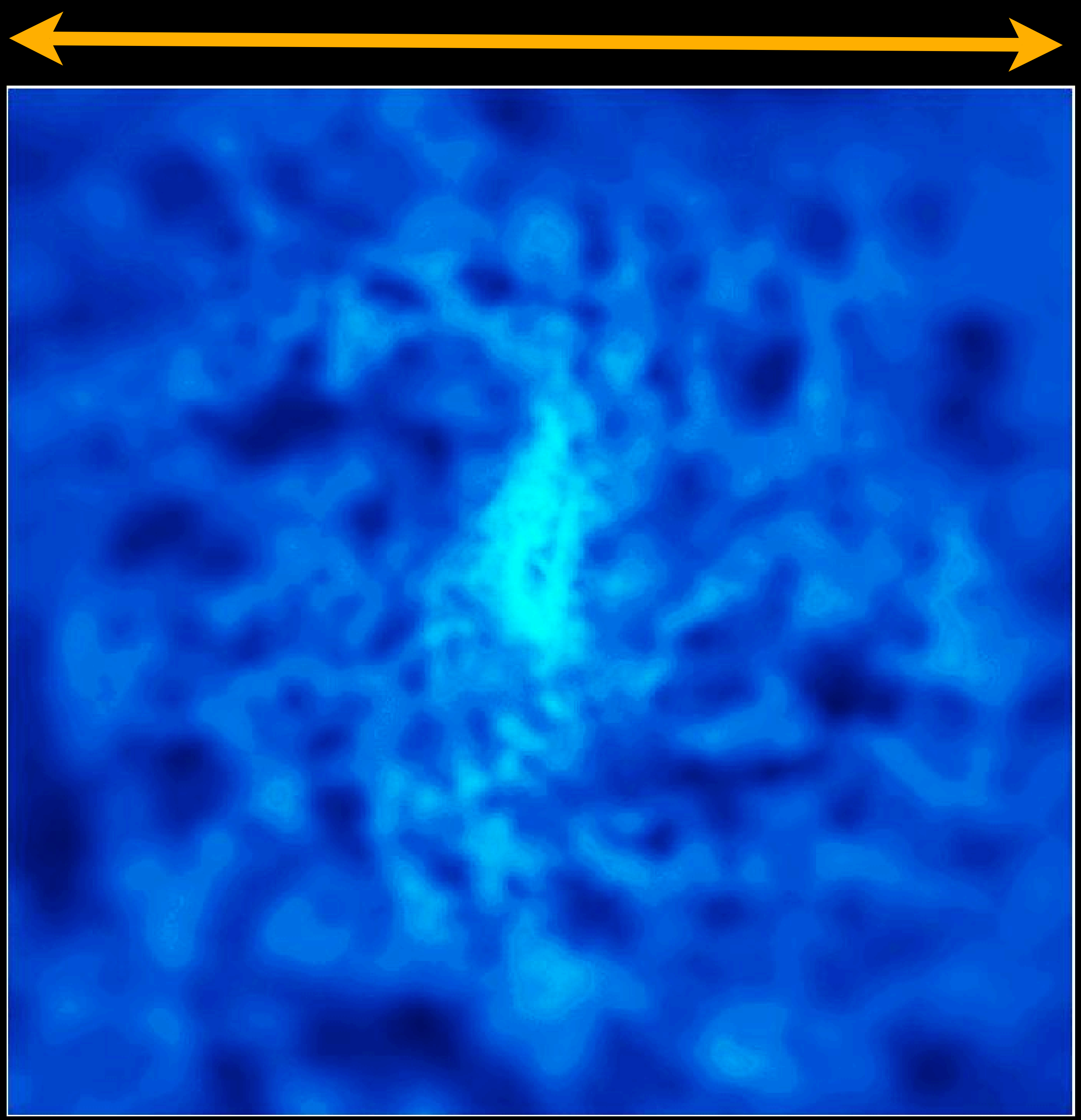
Resolution 60 pc

Star formation, feedback ….

simulations:

dwarf: 70km/s

Cold gas in central 2kpc region

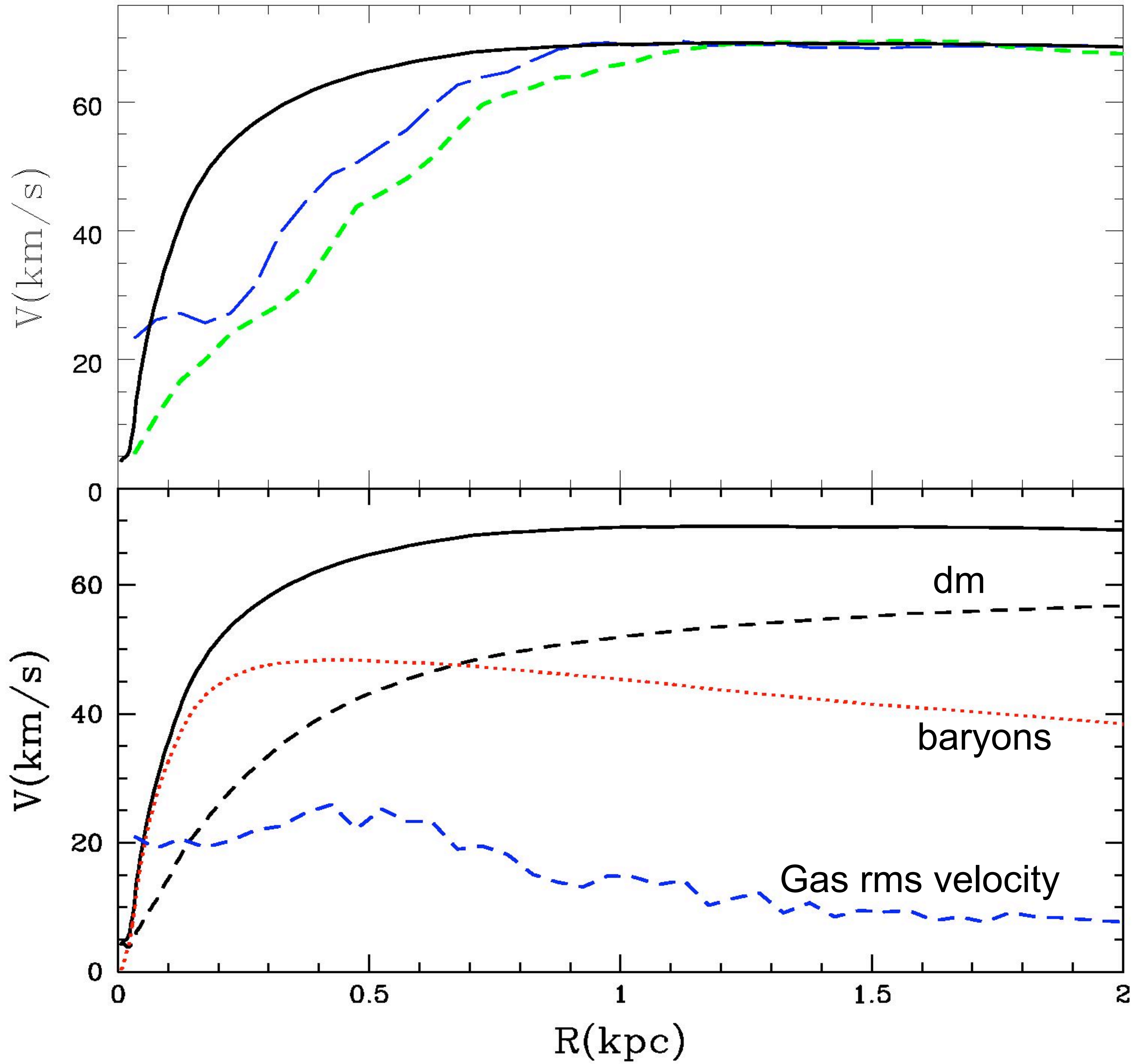


Simulation: dwarf 5

Resolution: 60pc

Valenzuela, Rhee, Klypin, Governato et al. 2005

Models of NGC3109 and NGC6822



Simulation: dwarf 5

Resolution: 60pc

Valenzuela, Rhee, Klypin, Governato et al. 2005

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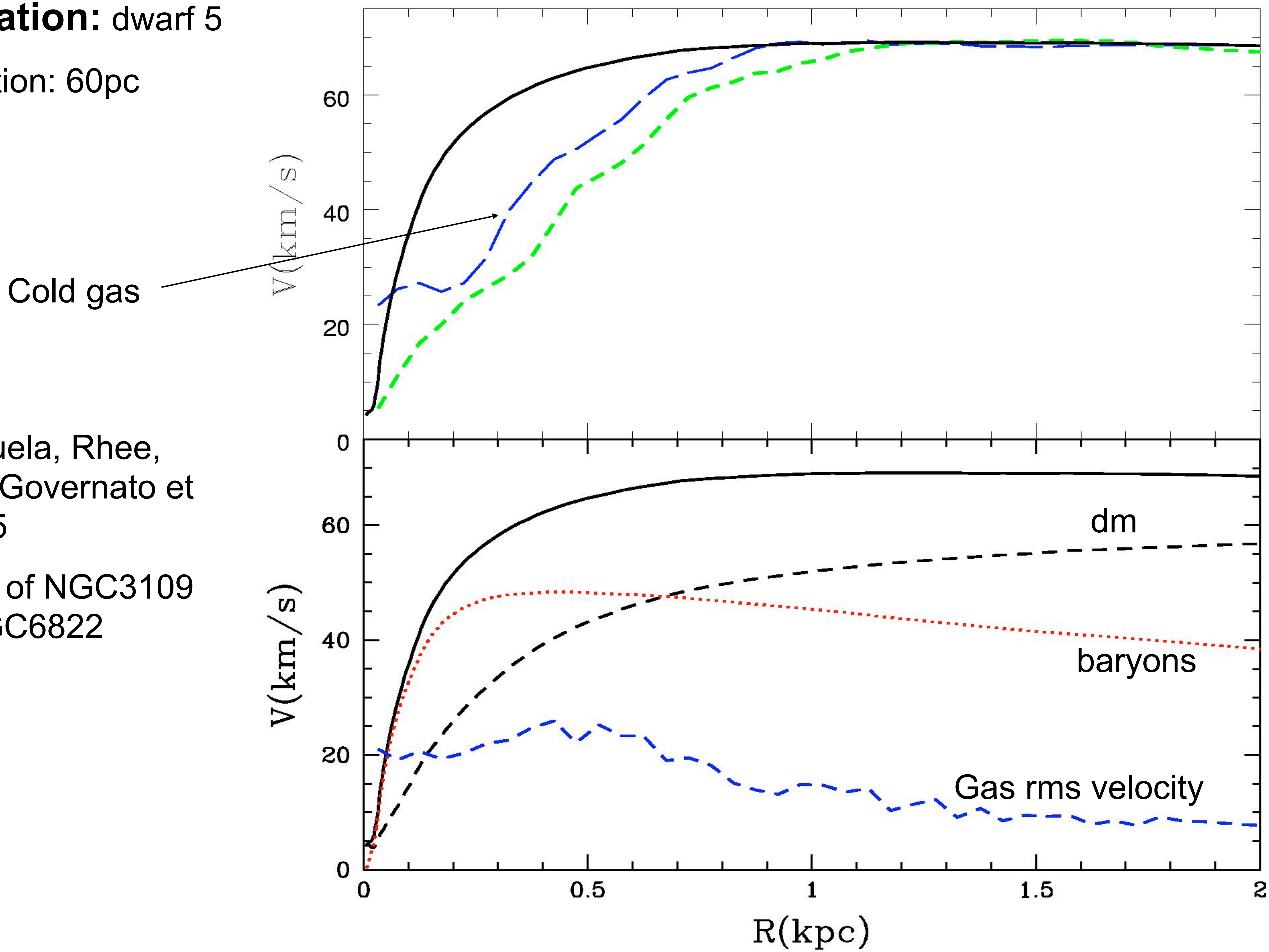

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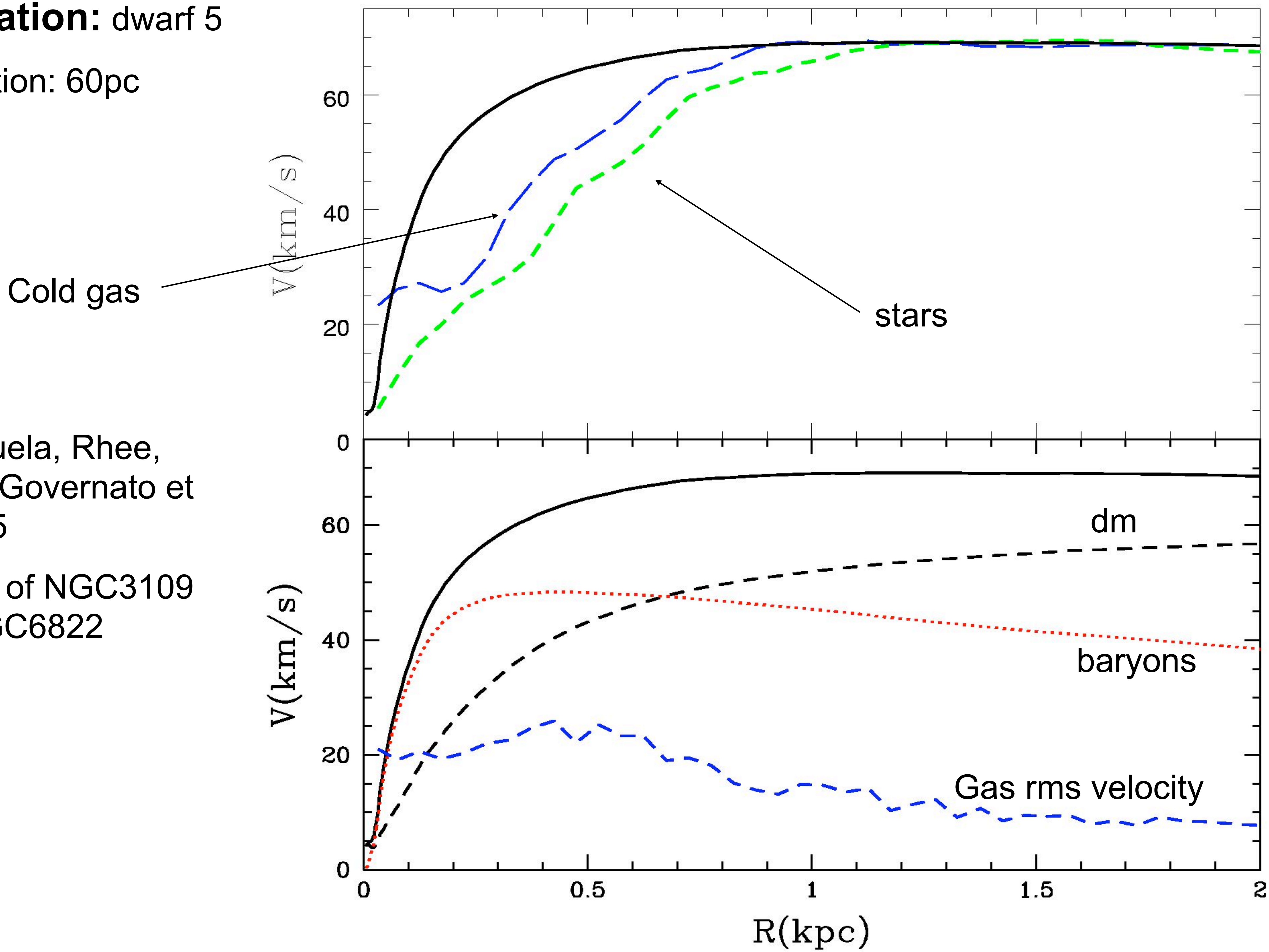
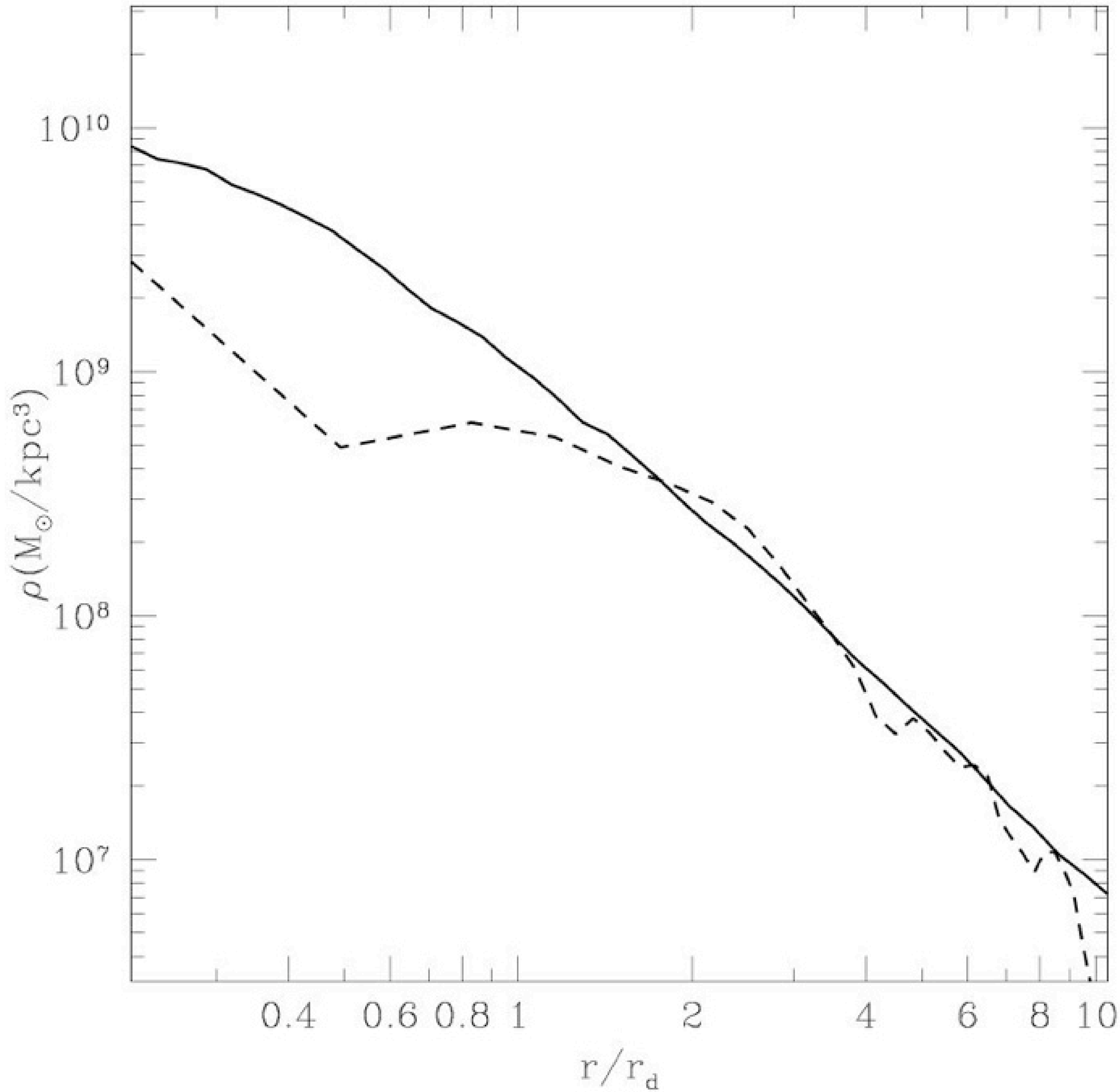
Models of NGC3109 and NGC6822



True and recovered density profiles

Vrot(r) ⇒ ρ(r)

True slope: -1.8
Recovered: -0.5



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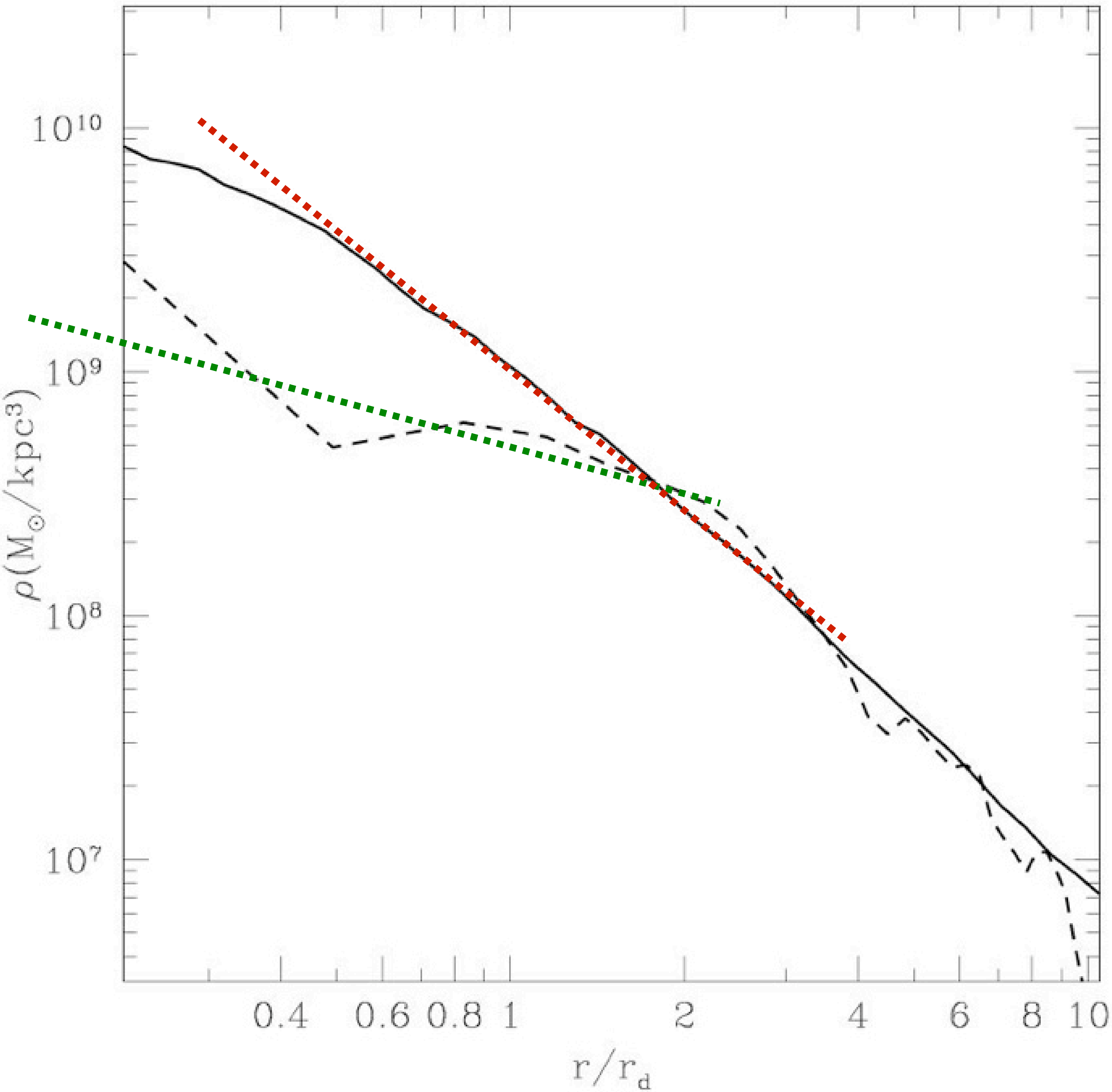


Effects at $r=r_d$

$V_{rotation}$ = 37 km/s

$V_{circular}$ = 58 km/s

V_{RMS} = 22 km/s

Temp = 25e3 K

log-log slope density = -1.8

Naive correction for asymmetric drift:

$V_{circular}$ = 39 km/s

V_{RMS} = 10 km/s

error in density= 2.2 times

Accurate corrections for asymmetric drift:

for rms velocities only: $V_{circular}$ = 47 km/s

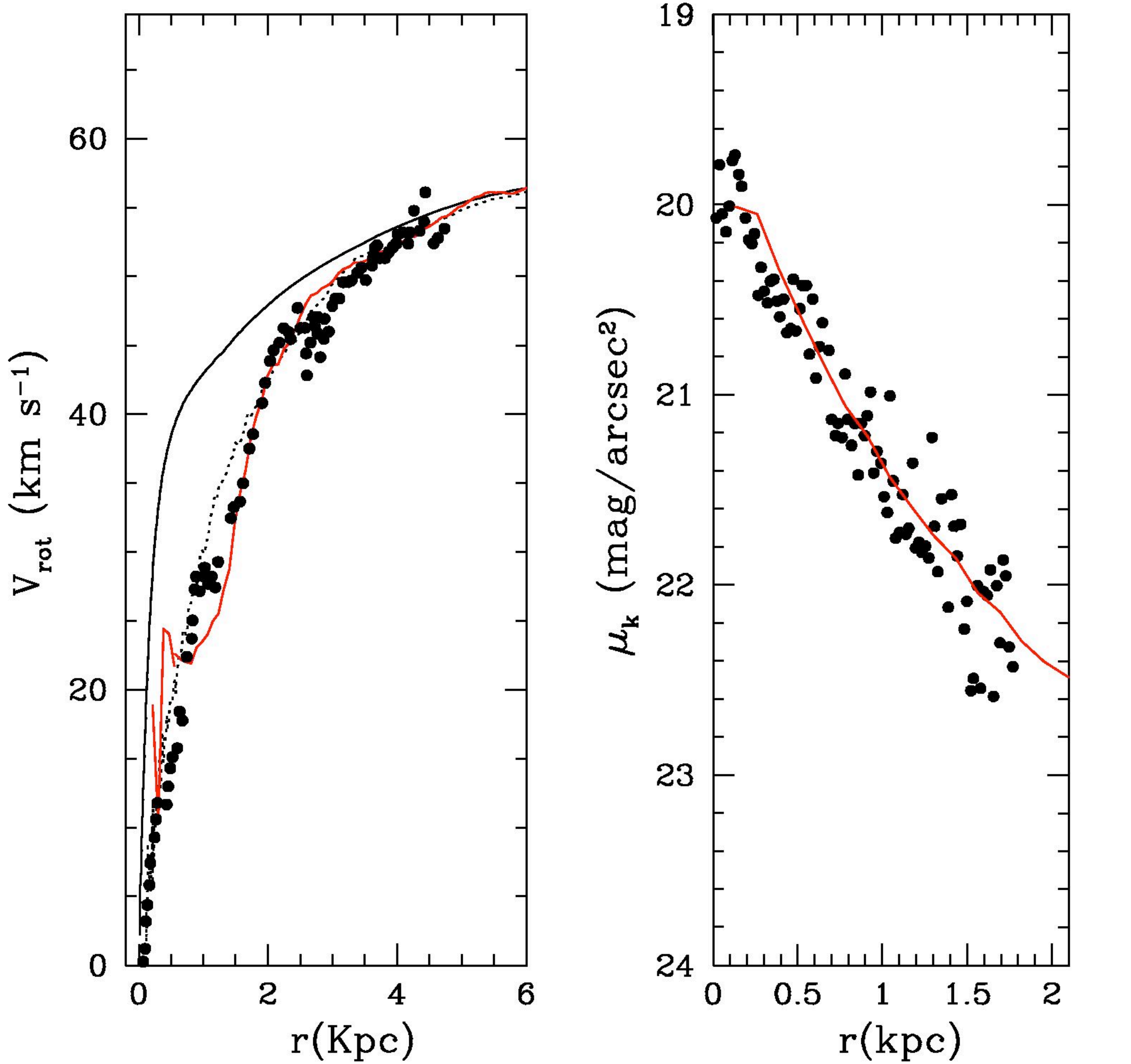
for pressure gradient only: $V_{circular}$ = 49 km/s

Total: $V_{circular}$ = 57 km/s

NGC 6822

Magellanic-type dwarf irregular

0.5Mpc from Milky Way



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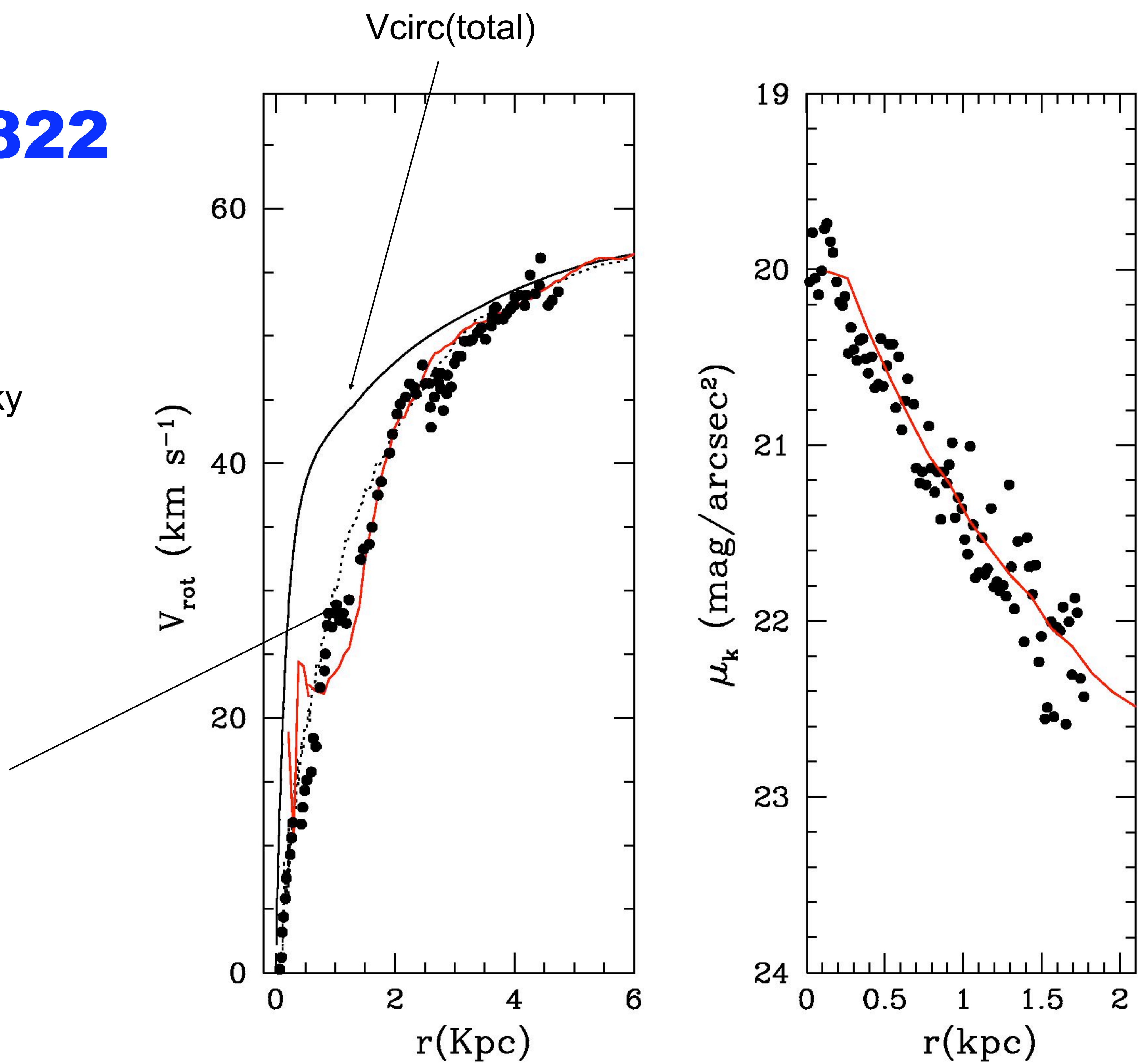

CONCLUSIONS

- ⭐Cusps are not destroyed by baryons
- ⭐Adiabatic compression makes cusps steeper
- ⭐Cores are ‘observed’ where there is a real cusp.
- ⭐Observations are compatible with cuspy DM profiles