Effects of baryon removal on the structure of dwarf spheroidals

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Understand galaxy formation and evolution

Understand satellite galaxy formation and evolution

Where do dwarf spheroidal galaxies come from?

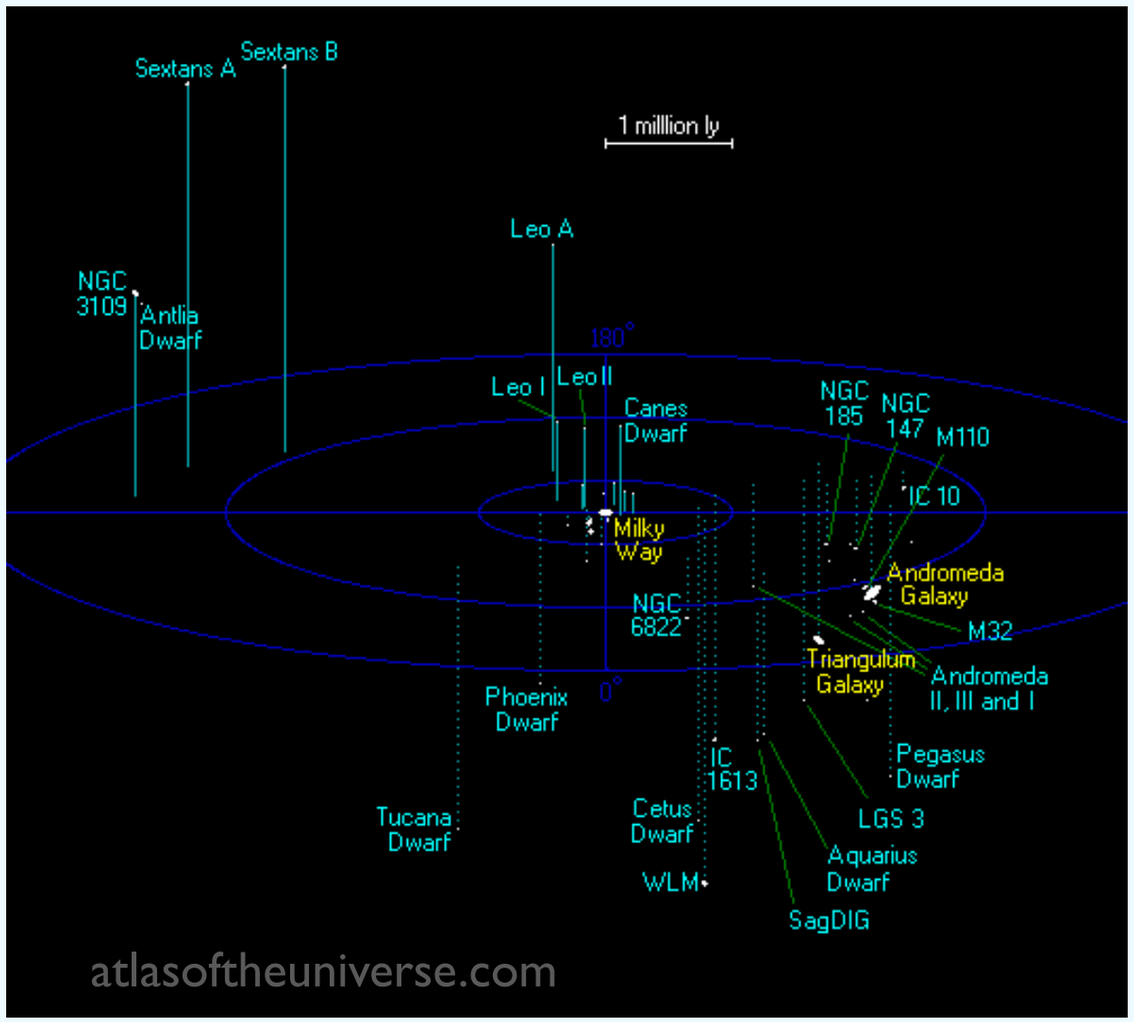
Which processes are important in their evolution?

Observational

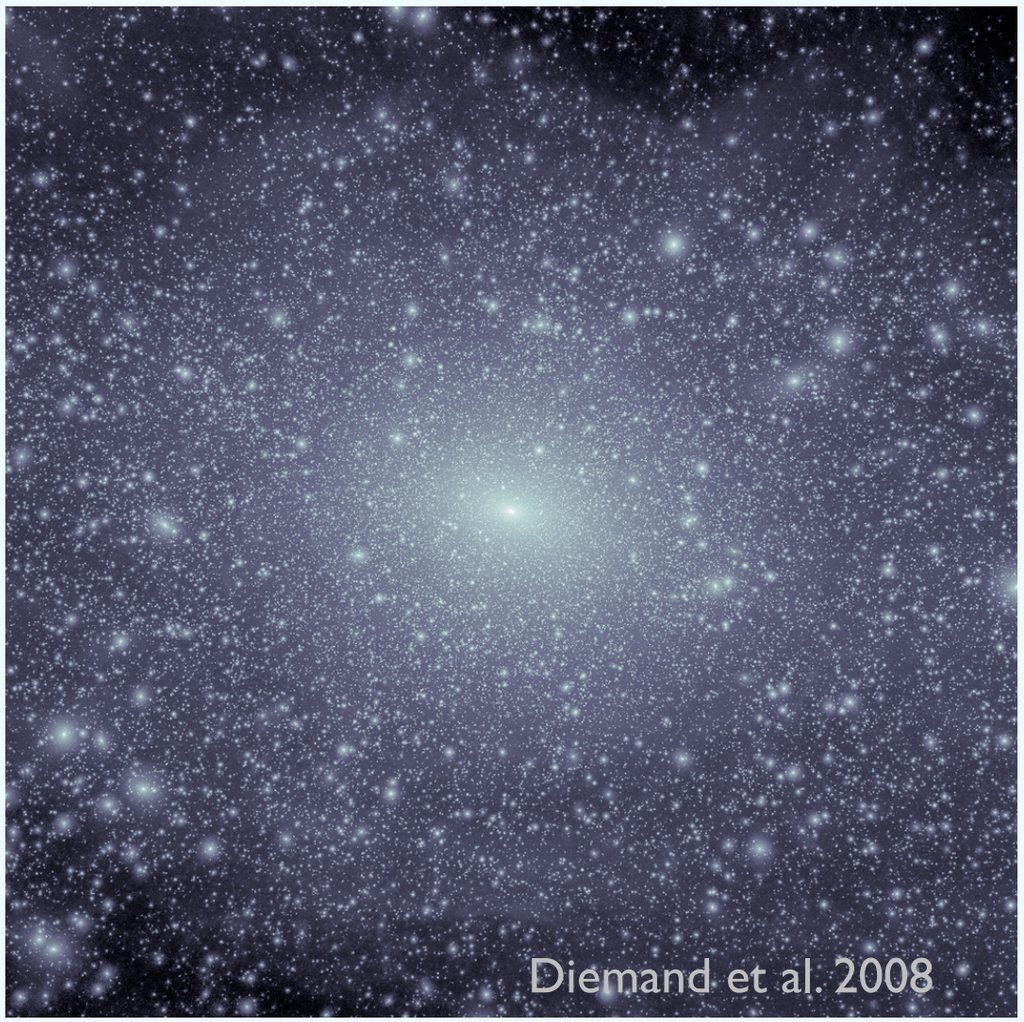
Numerical

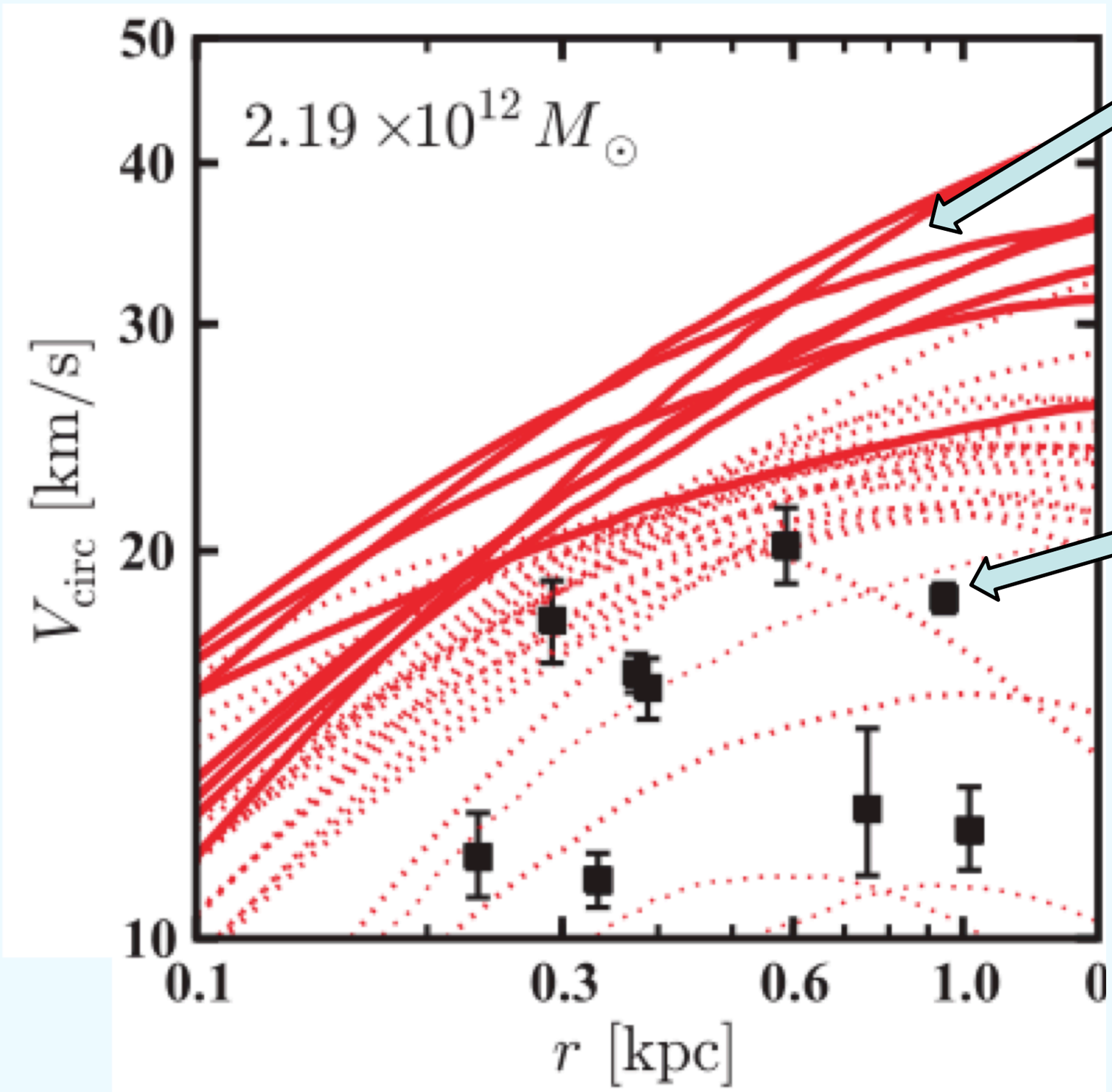
How do they compare?

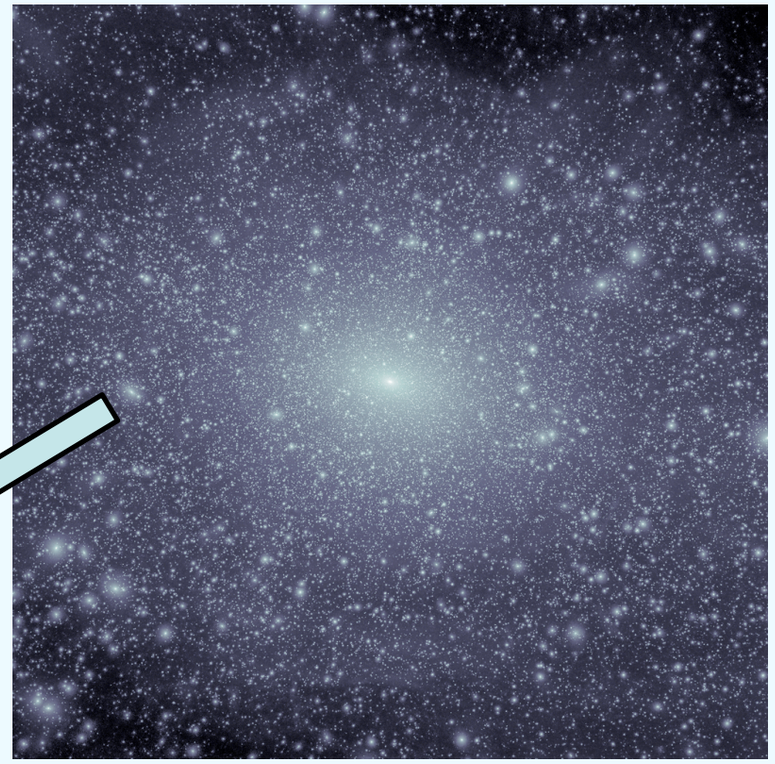
Observational

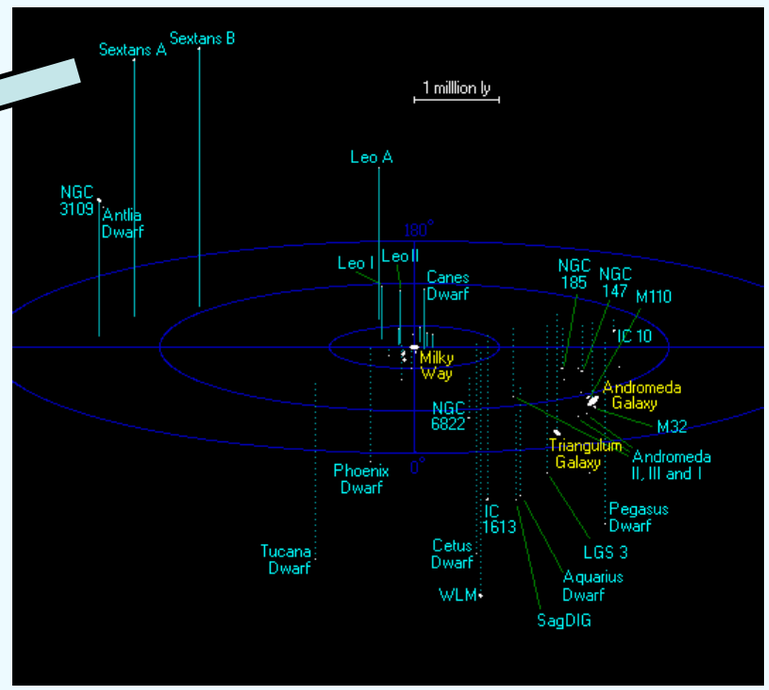


Numerical

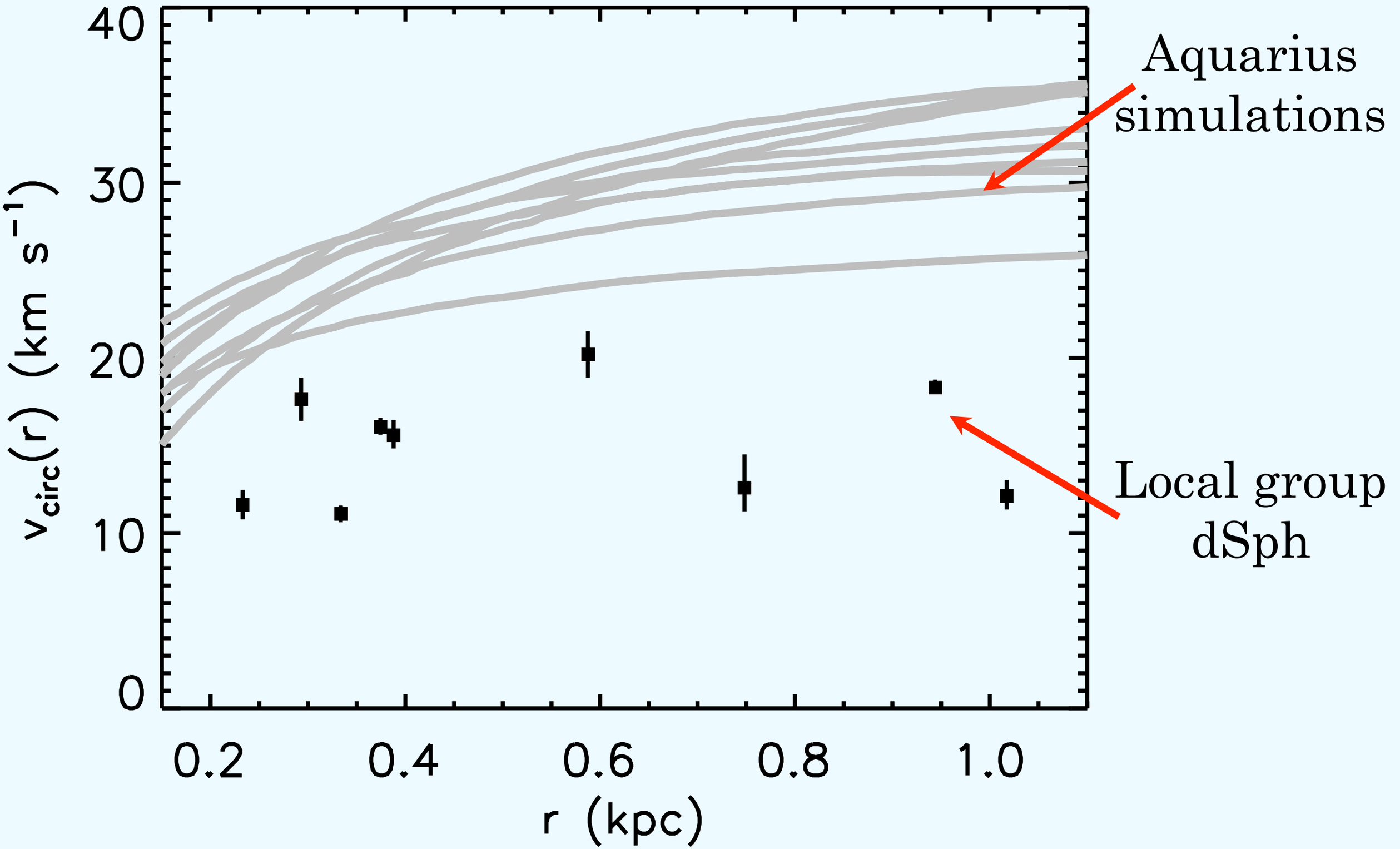








Boylan-Kolchin et al. 2012
Walker et al. 2009


40
30
20
10
0
0.2
0.4
0.6
0.8
1.0
r (kpc)
$v_{circ}(r)$ (km s^{-1})
Aquarius simulations
Local group dSph

Cosmological *N*-body simulations:

- Baryons are included in particles
- Milky Way has no disk

Our *N*-body simulations:

- Baryon fraction removed
- Add disk mass to MW

Cumulative effect!

our simulations

Initial dSph satellite:

$V_{max} = 63$ km/s

$M \sim 3x10^{10}\, M_{\odot}$

$R_s = 4$ kpc

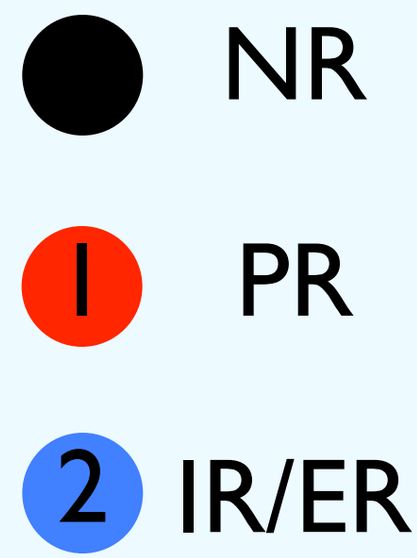
Resolution:

$\varepsilon = 20$ pc; $M_p = 10^3\, M_{\odot}$

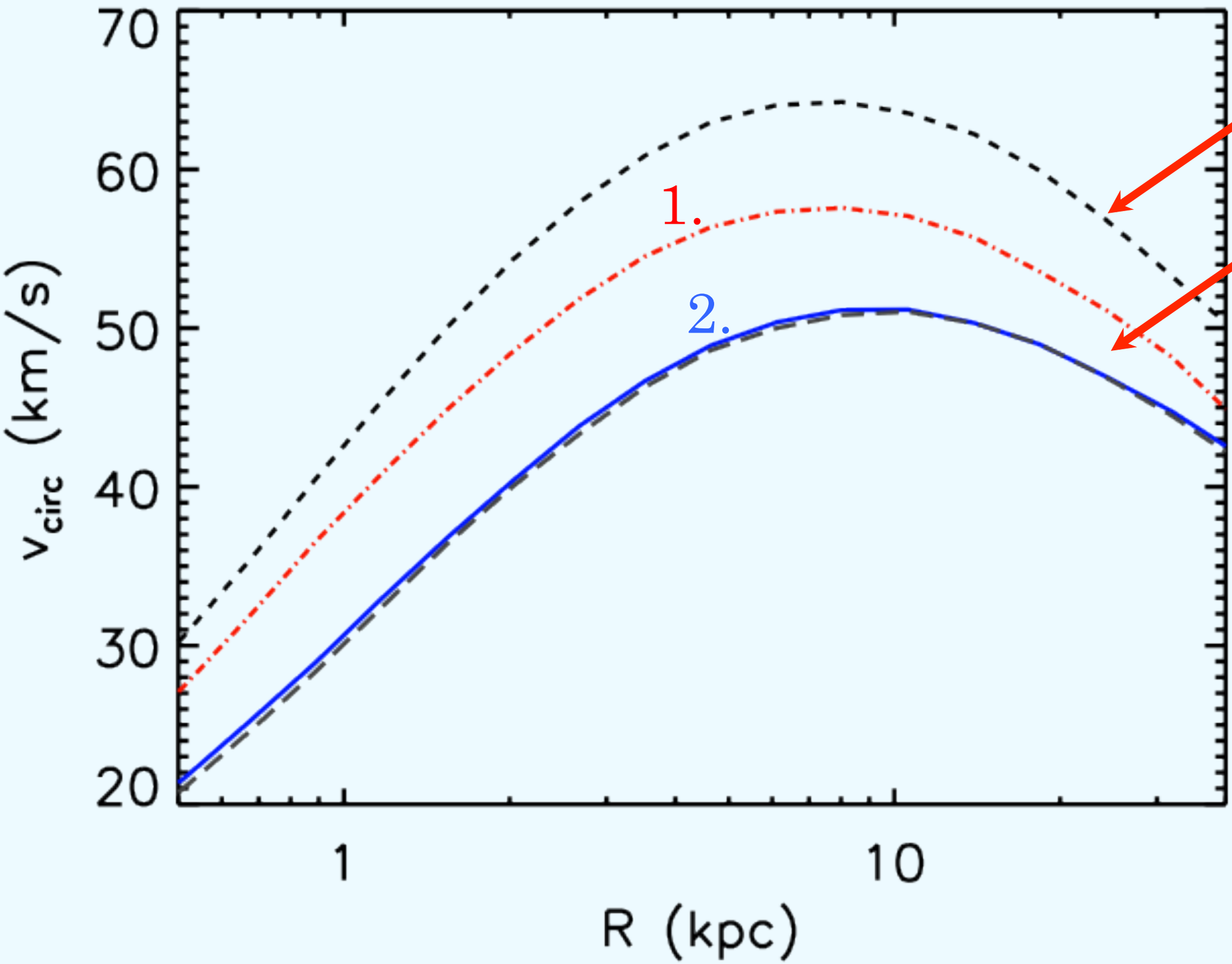
our simulations

- 4 different dSph galaxies
  - Same initial total mass ($M \sim 3x10^{10}\,M_{\odot}$)
  - Different circular velocity/density profiles

- Test baryons removal methods
  - No removal
  - Pre-halo formation removal
  - Instantaneous/exponential removal



baryon removal



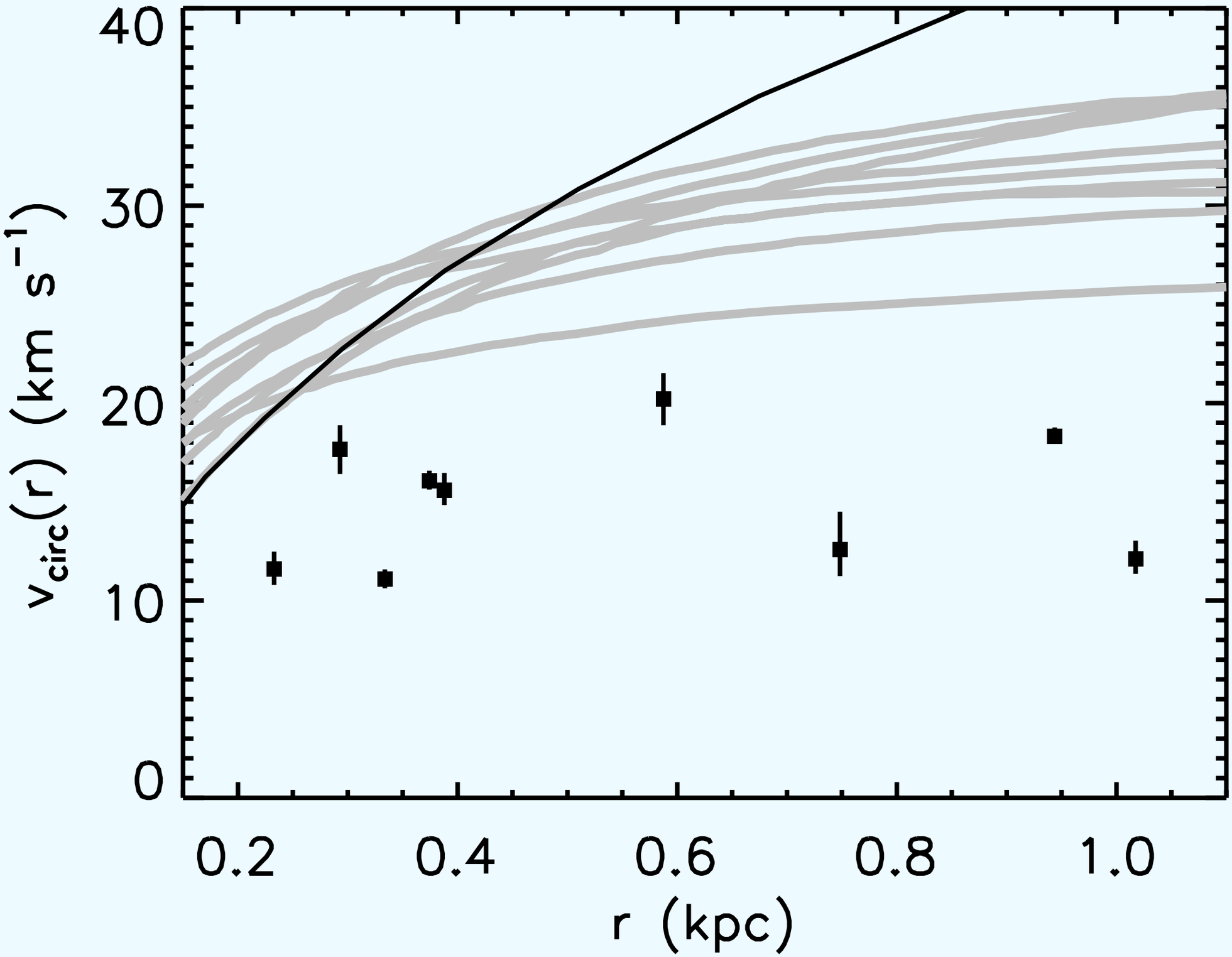
No baryon removal

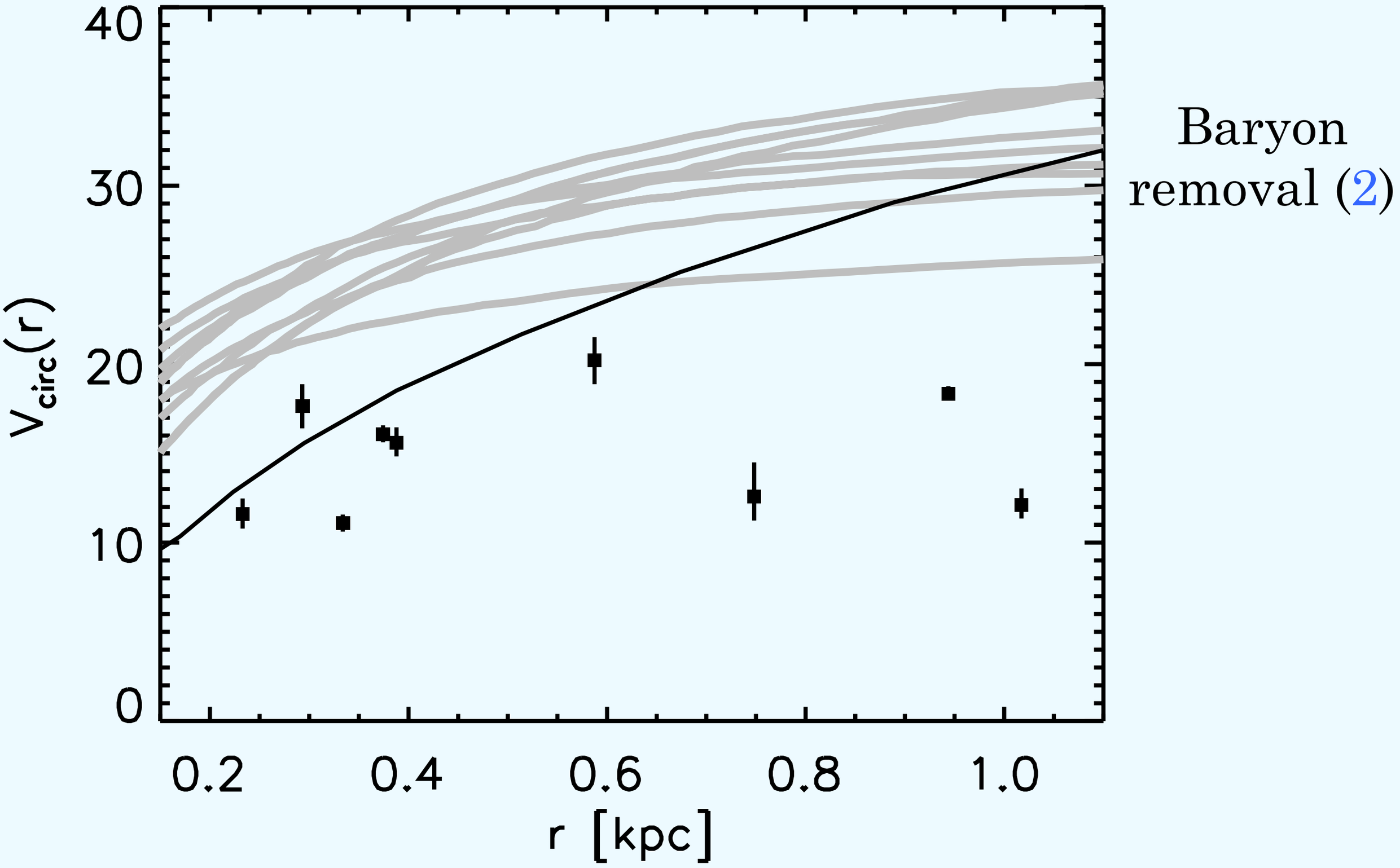
Baryon removal

1. Before the halo formed

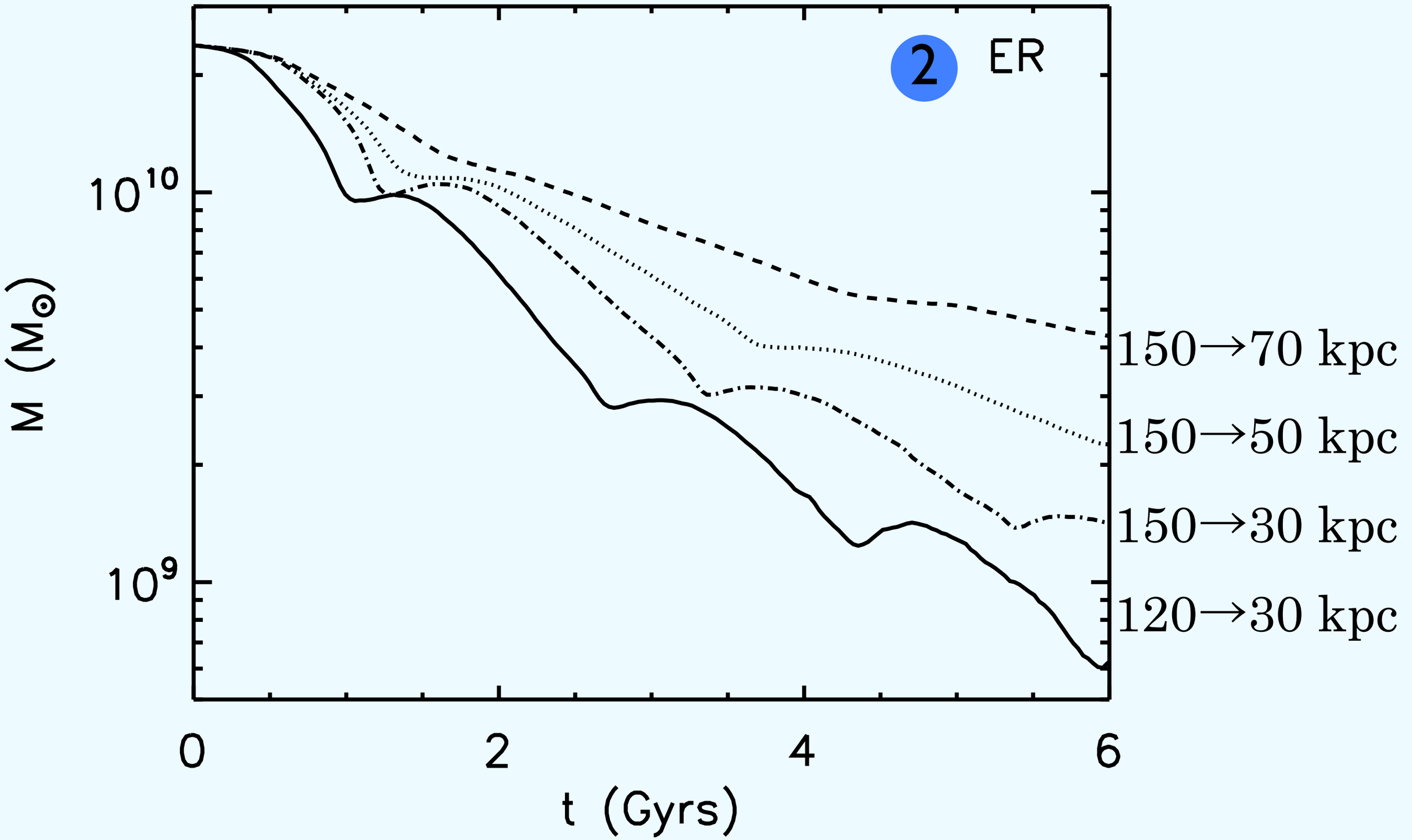
2. After the halo formed

No baryon removal

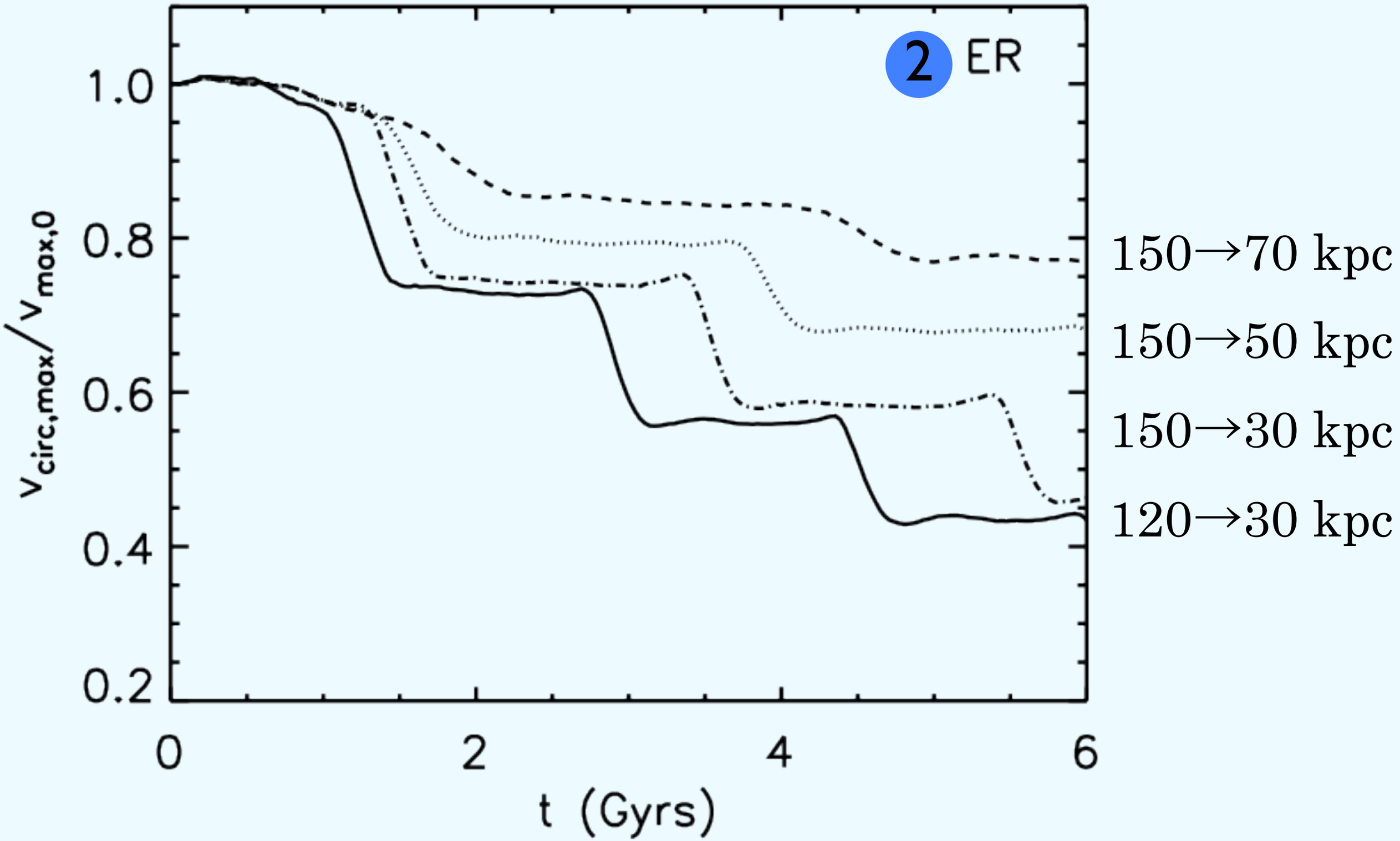



40
30
20
10
0
$V_{circ}(r)$
0.2
0.4
0.6
0.8
1.0
r [kpc]
Baryon
removal (2)

evolution with disk

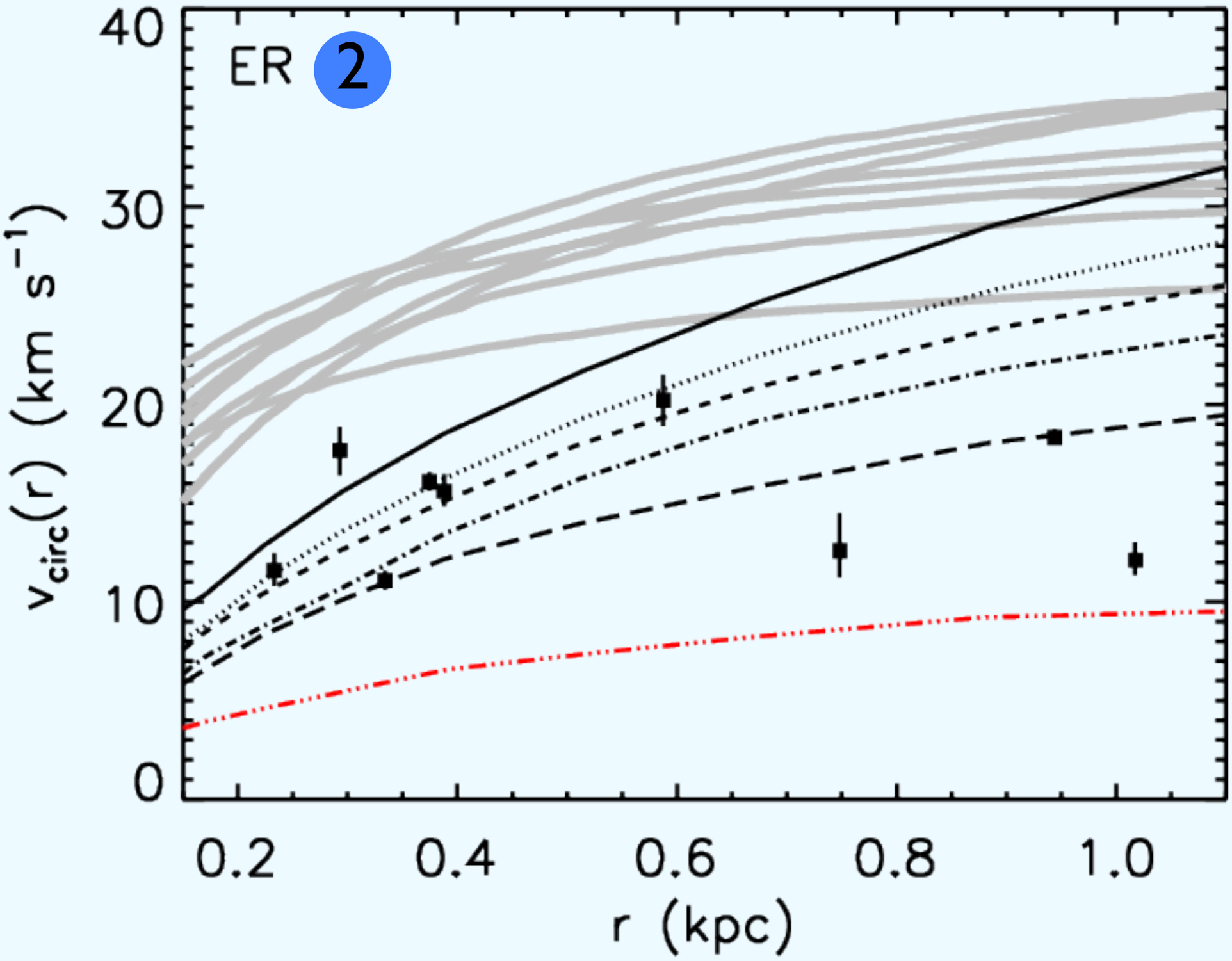


evolution with disk



results

Baryon removal with disk



initial

150→70 kpc

150→50 kpc

150→30 kpc

120→30 kpc

50 kpc
circular orbit

- Recent simulations find ~20 dwarf galaxies too dense and massive to match *any* observed LG dwarfs
- Cosmological simulations do not account for baryonic physics
- Combining *baryon removal* and a *MW disk* brings a very massive satellite into agreement with LG dwarfs
- Baryons are very important!

arXiv:1212.6651