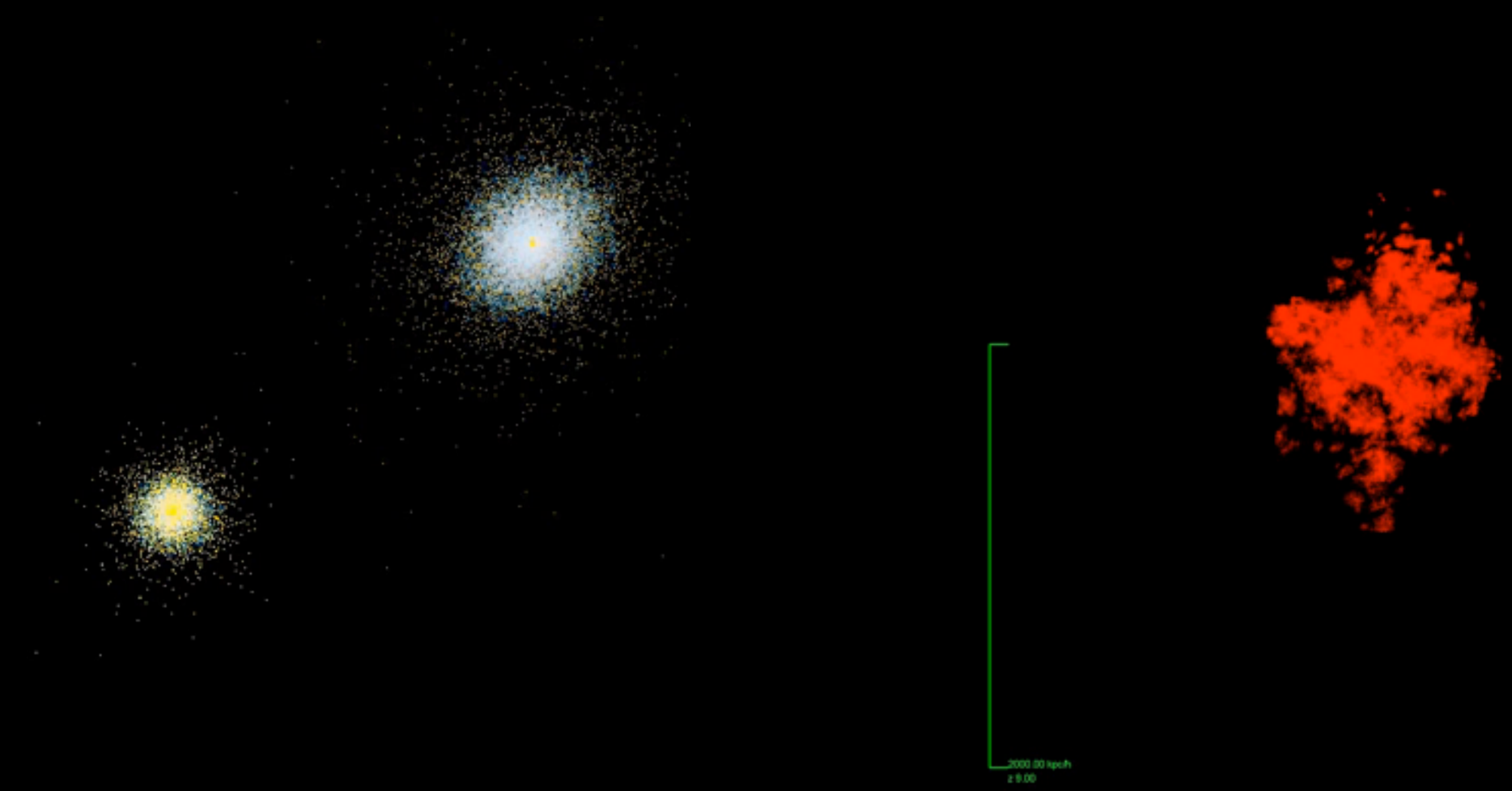
The bulge-halo conspiracy of elliptical galaxies

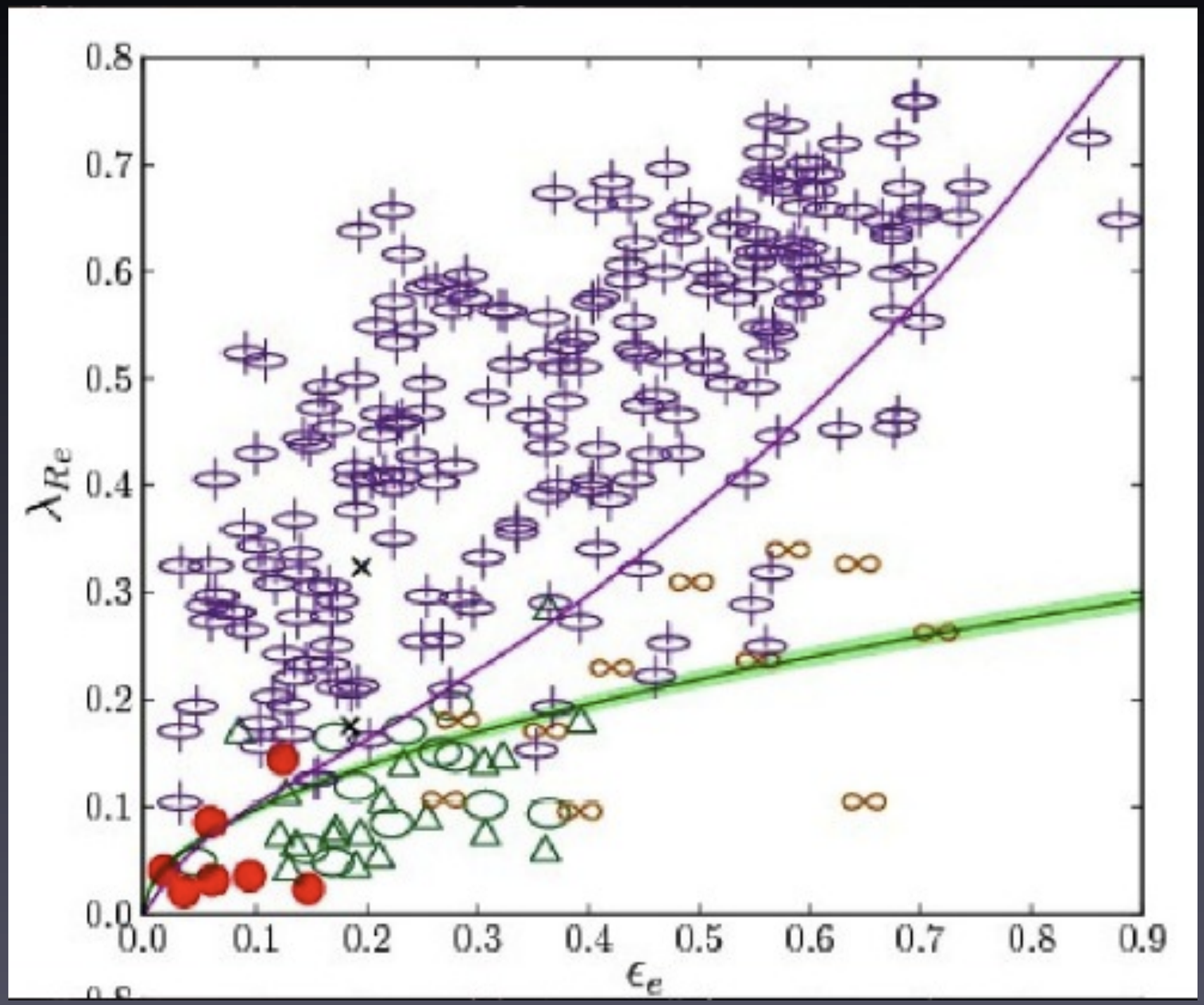
Rhea Remus, Andreas Burkert, Jens Thomas,
Peter Johansson, Thorsten Naab, Ludwig Oser, Klaus Dolag

Remus + 2012, submitted



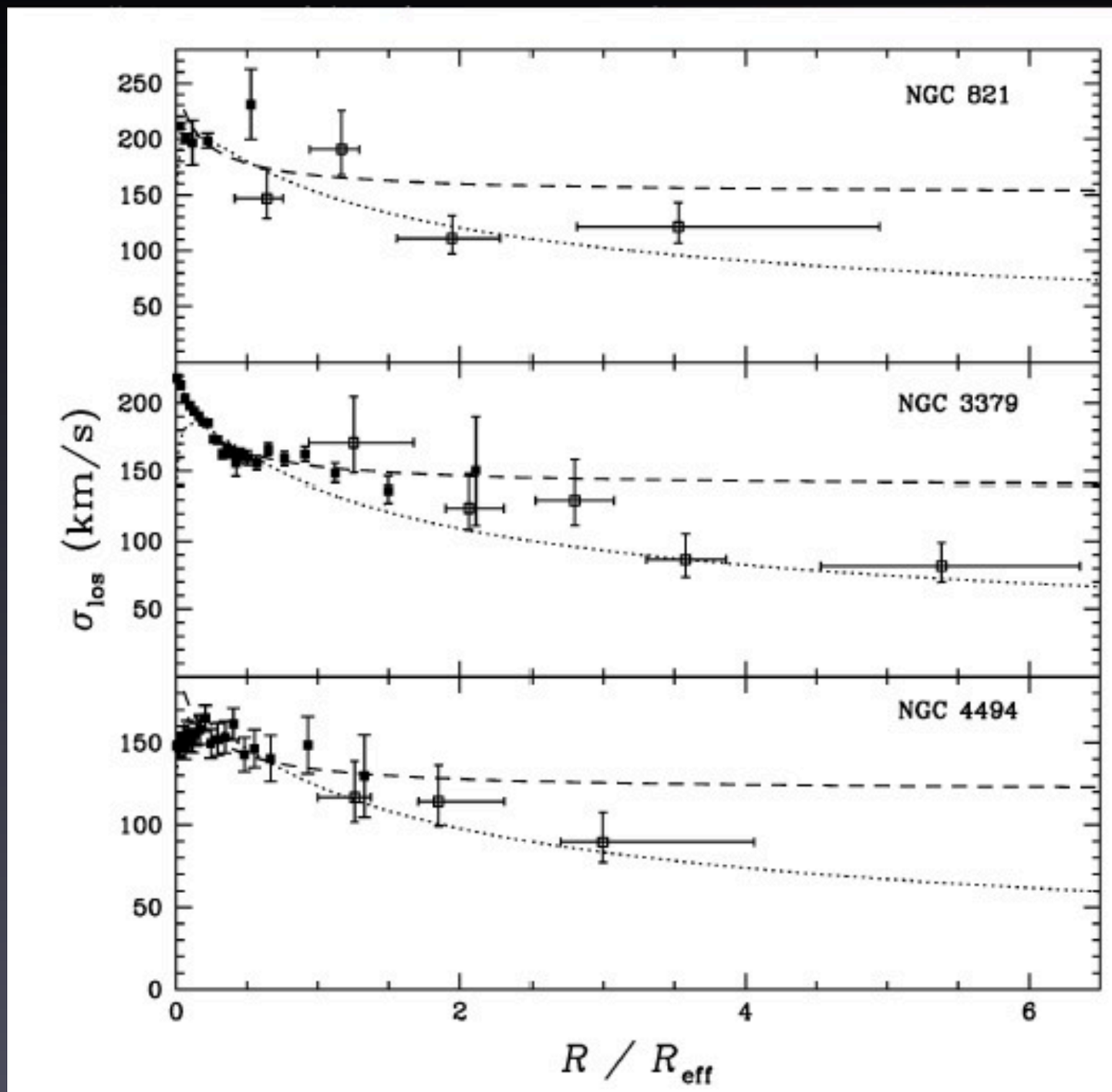
Barnes 88; Hernquist 89; Springel+ 02; Naab+ 06; Khochfar+ 06; Cox+ 06;
Lotz+ 08,10; Hopkins+ 08; Johansson+ 09; Jesseit+09; Oser+ 10

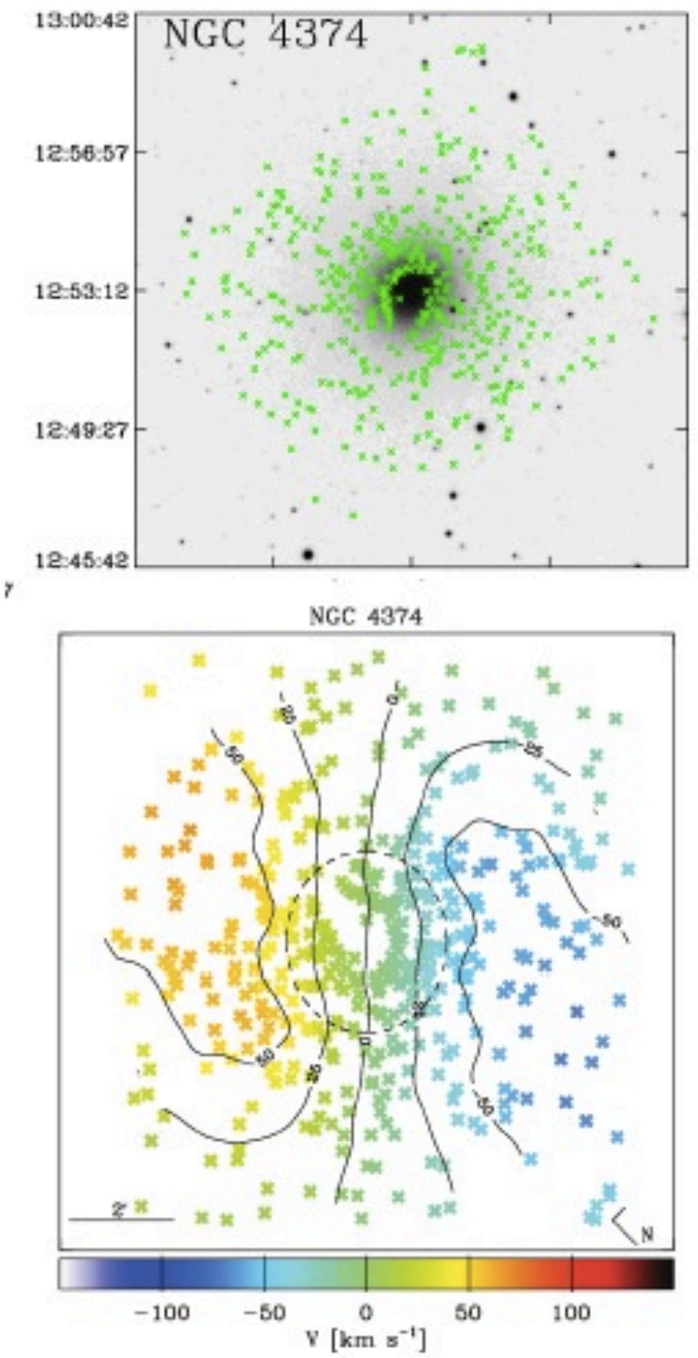
Atlas 3D and the stellar structure of ellipticals



(Cappellari+11; Emsellem+11; Bois+ 11)

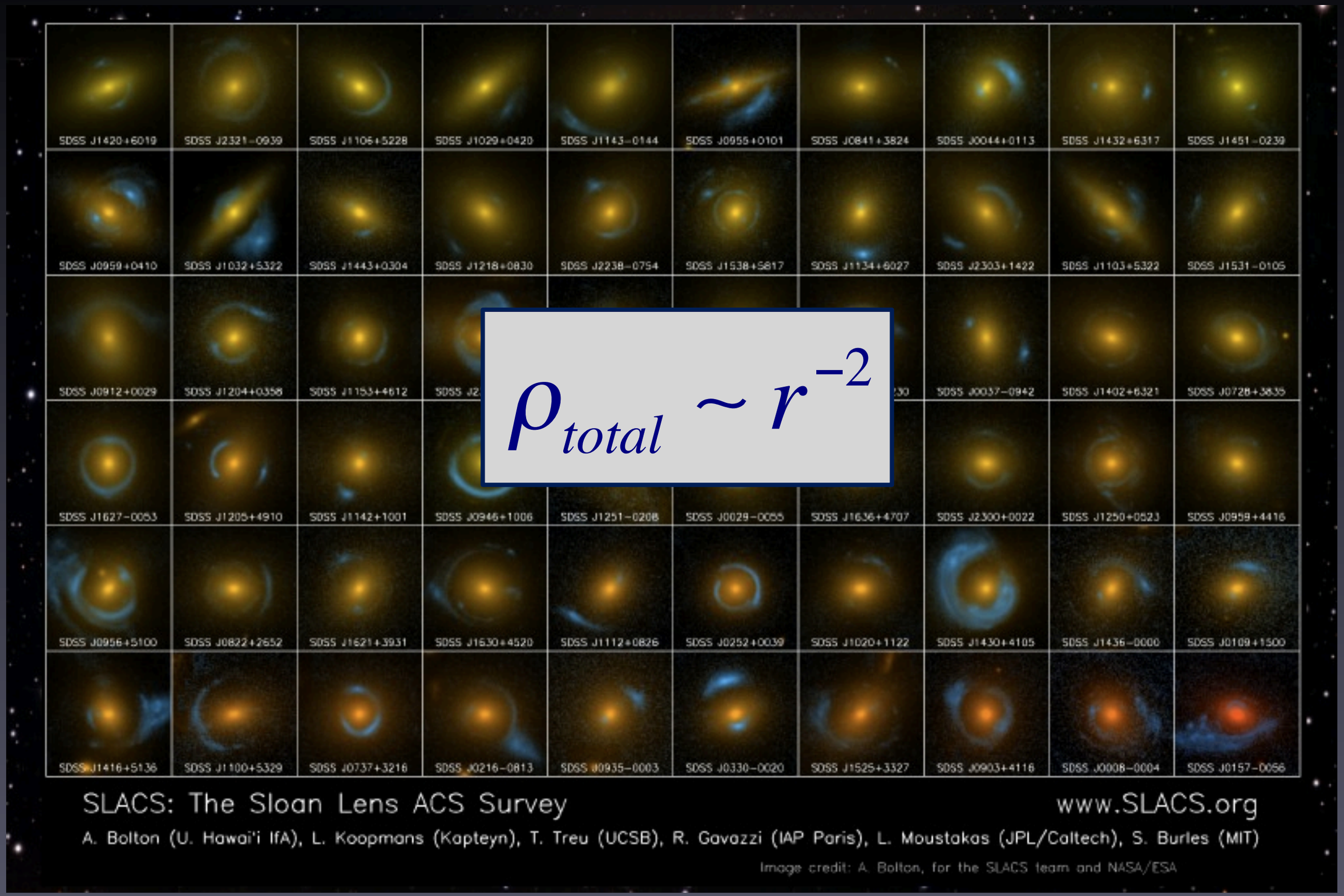
Dark matter in ellipticals: The PN survey





(Mendez+ 01; Romanowski+ 03; Dekel+ 05)

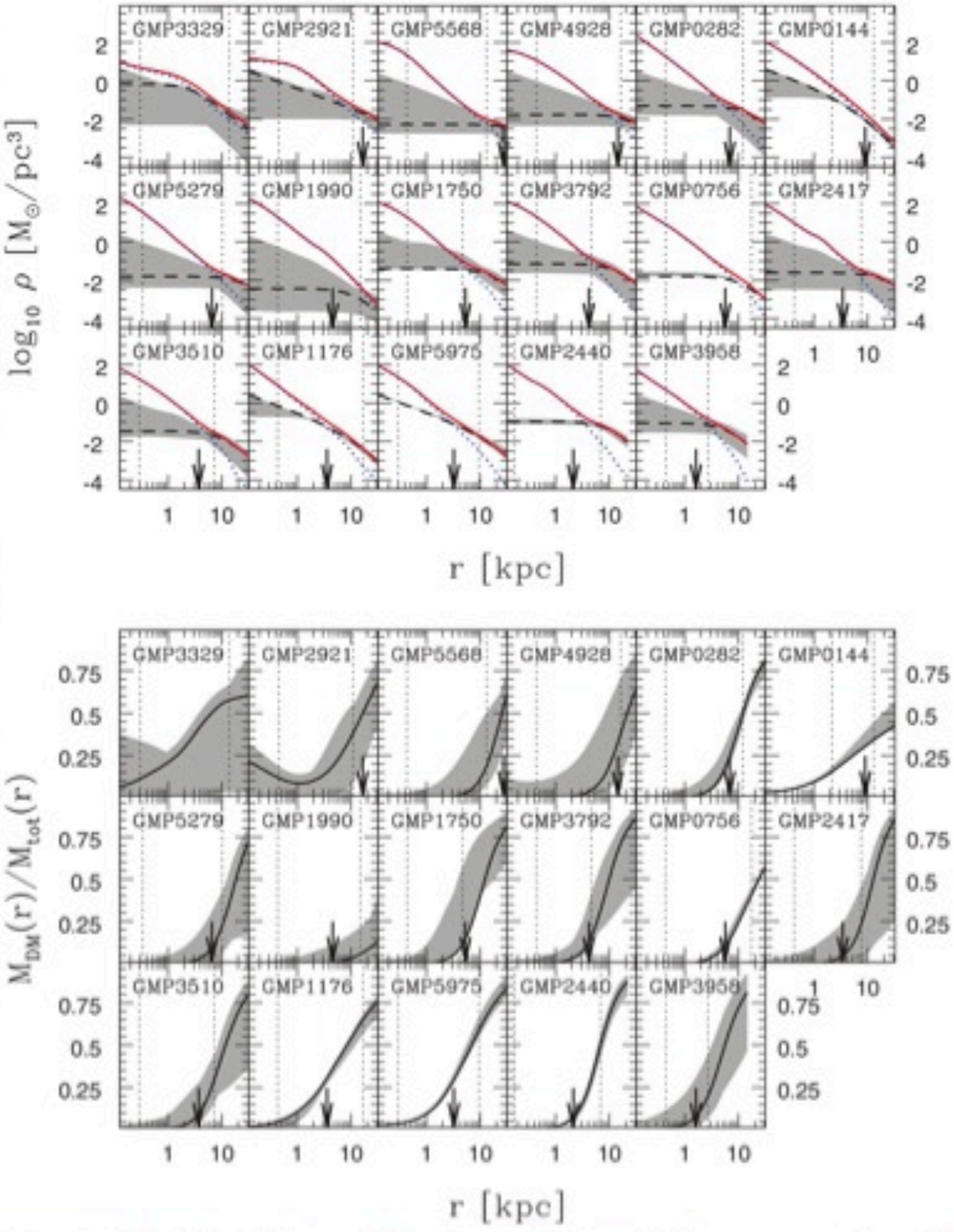
SLACS strong lensing survey (Auger+ 10; Barnabe+ 11; Lyskova+ 12)



$$\rho_{total} \sim r^{-2}$$

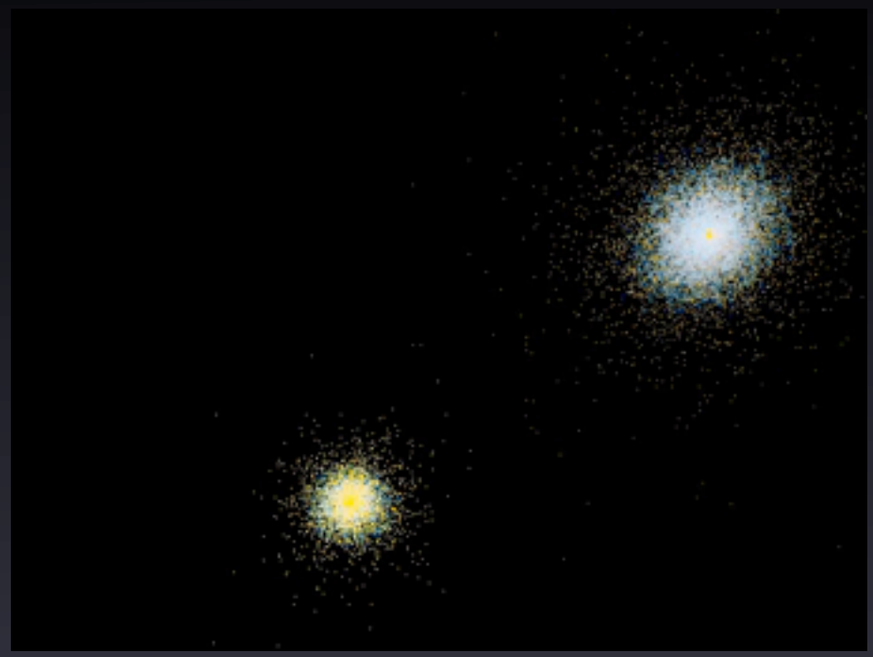
Coma Survey

- Schwarzschild models
- 10%-50% dark matter within half light radius



Mehlert et al 2000, Thomas et al 2007, 2009, 2011

Isolated binary mergers (Johansson+ 09)



- Gadget 2 code
- Star formation and Supernova feedback according to Springel & Hernquist 2003
- BH-feedback using Springel 2005
- Hernquist Dark matter profiles
- Baryonic mass fraction of 0.044

Our sample:

- 4 Ellipticals from 1:1 spiral merger
- 5 Ellipticals from 3:1 spiral merger
- 1 Elliptical from a E-Sp merger

Initial gas fractions (0%, 20%, 80%)
Initial orbits (G13, G09, G01)

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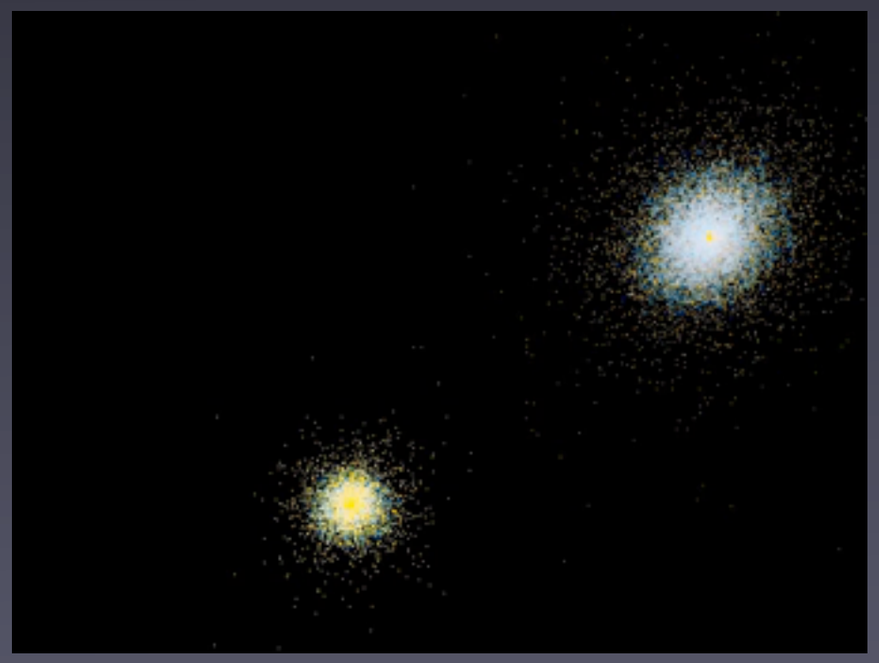
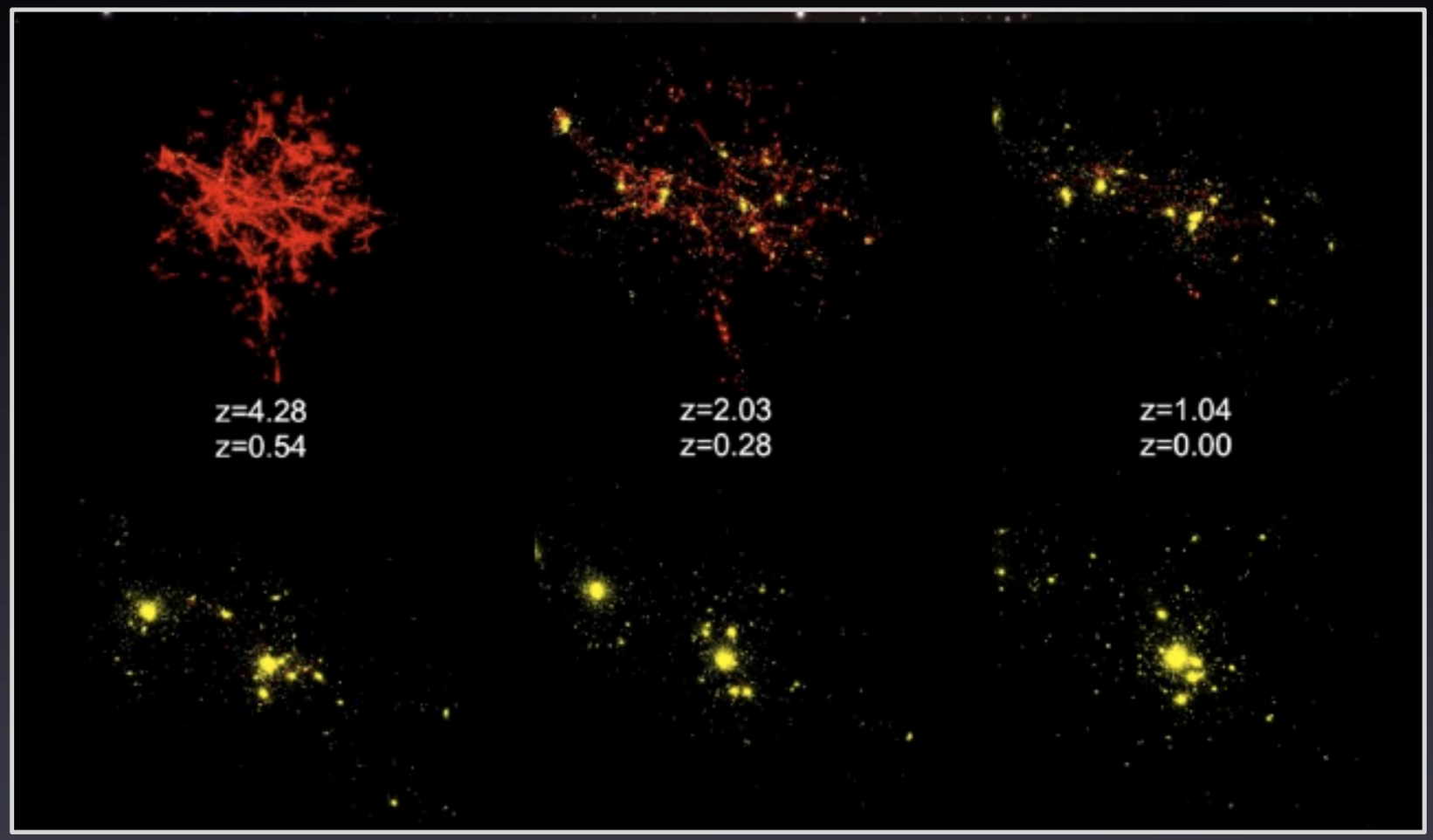
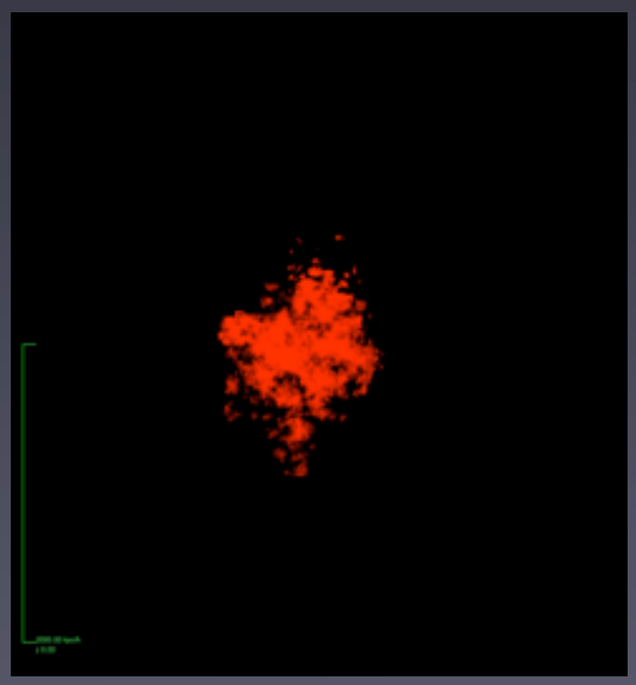


- Controlled initial conditions
- Observed formation scenario
- Realistic progenitor spirals

- No cosmological treatment

Cosmological resimulations (Oser+ 10, 11)



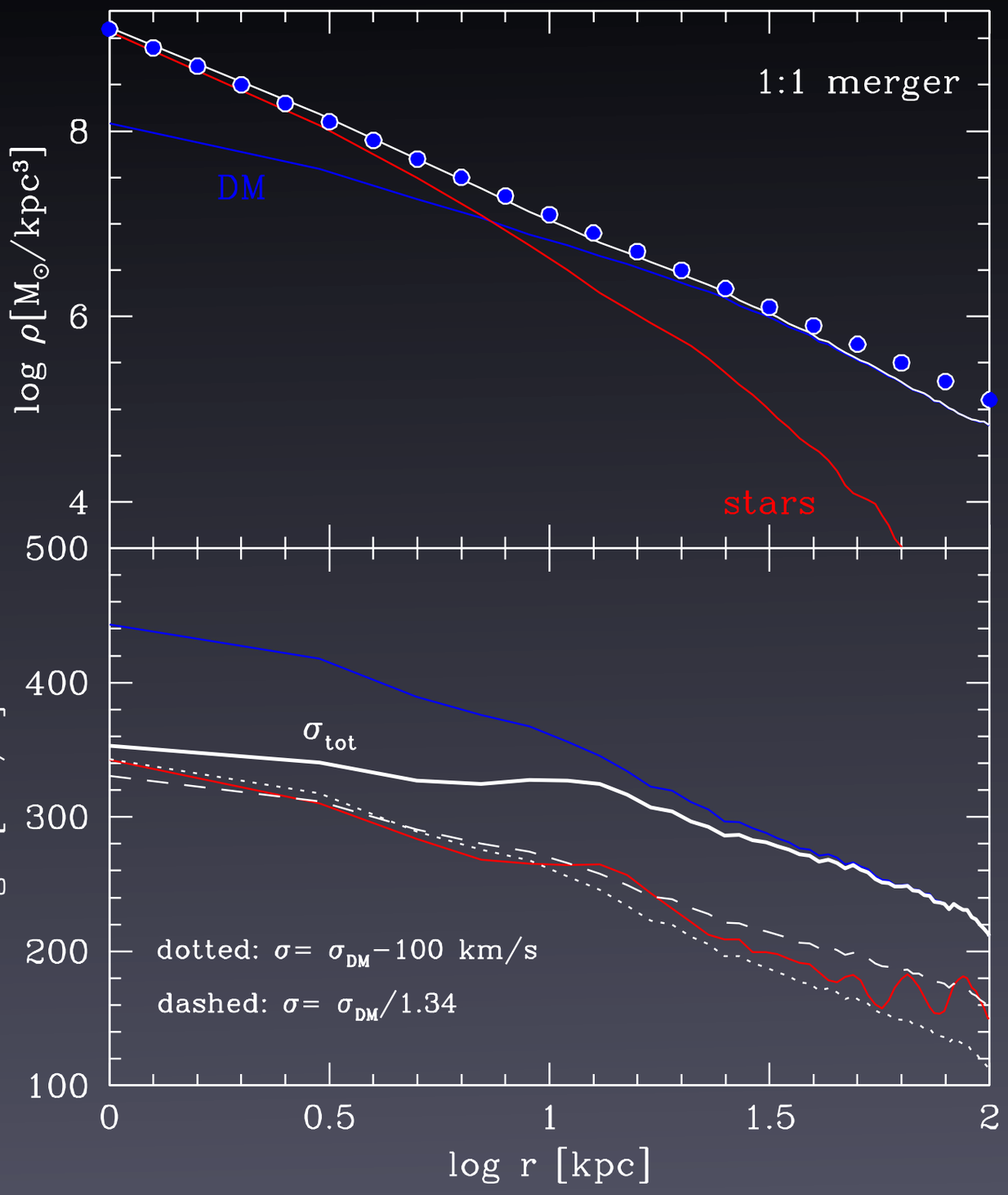


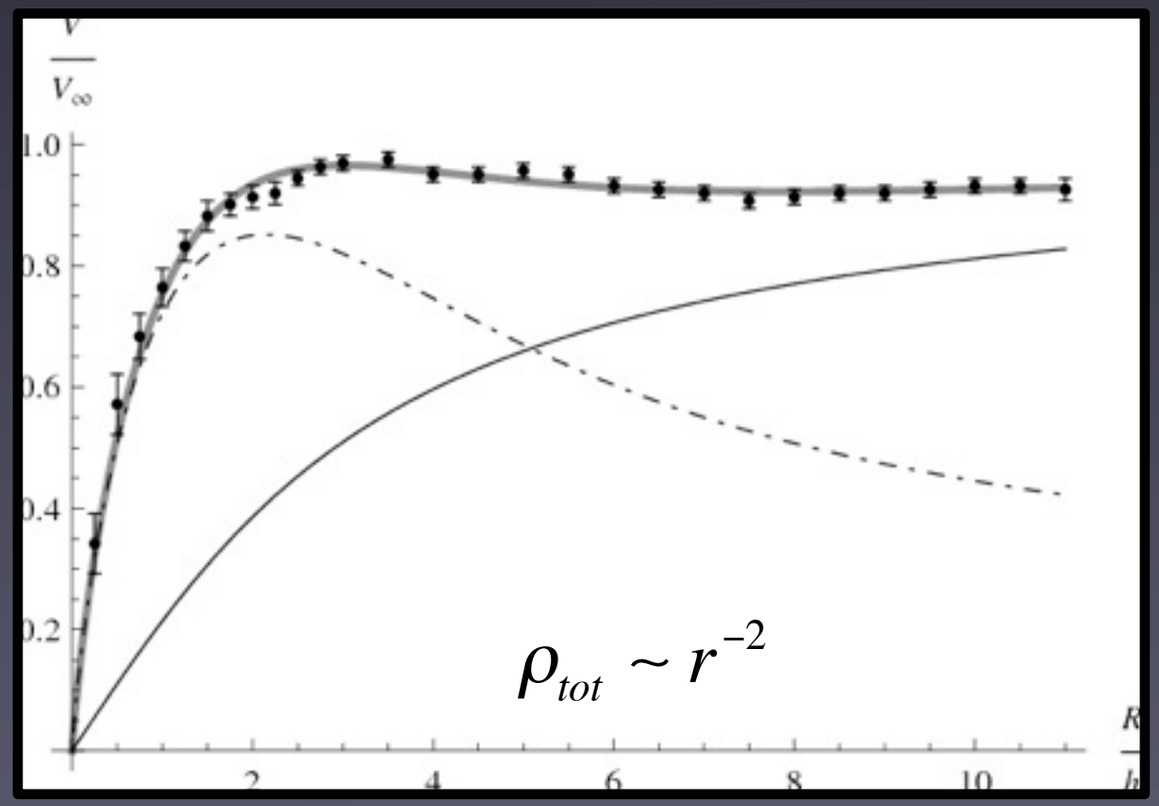
- More “realistic” (???) initial conditions
- Full mass range of ellipticals

- No spirals as progenitors

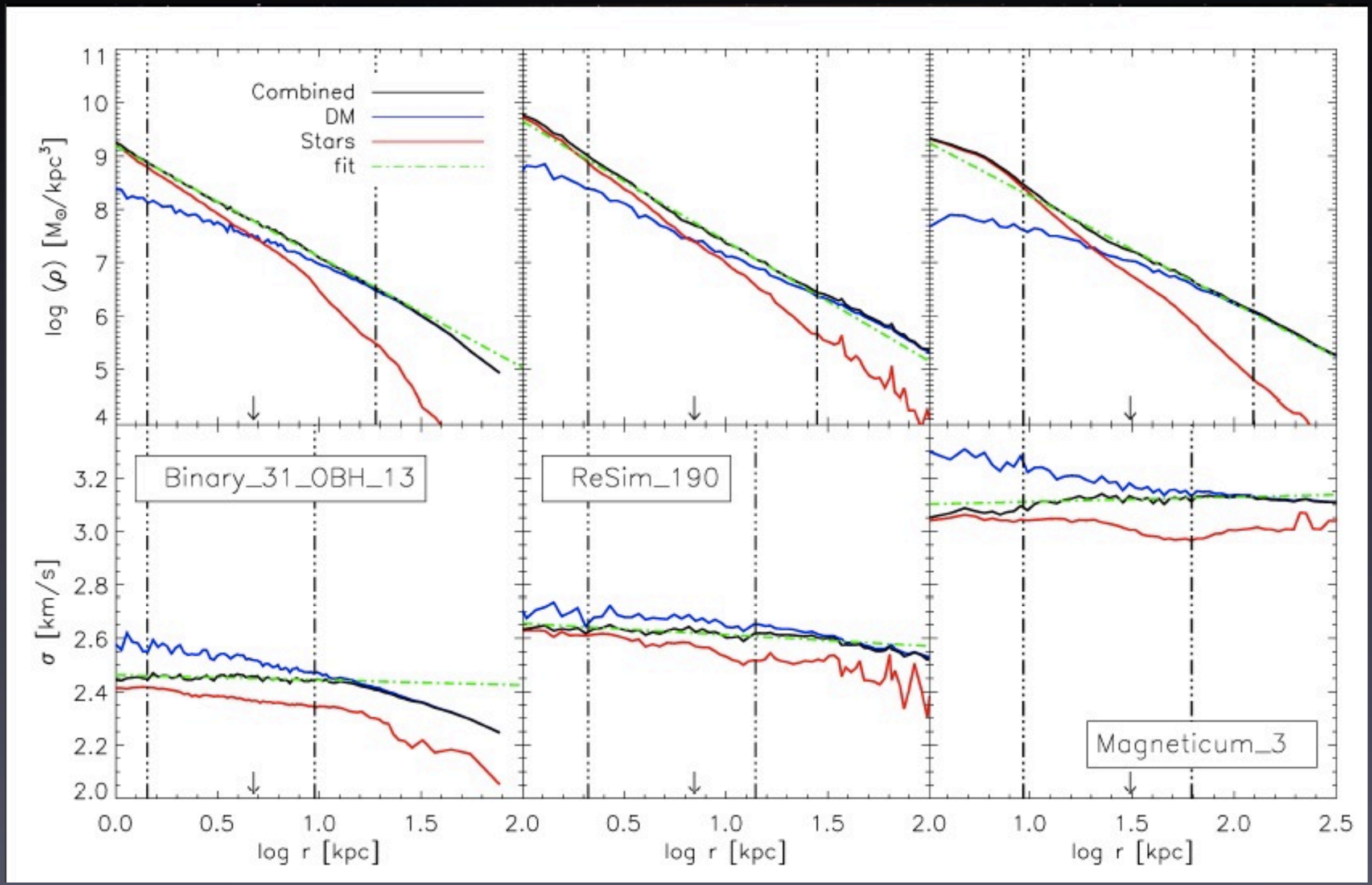
17 central ellipticals, 4 substructure ellipticals

The halo-spheroid conspiracy





The halo-spheroid conspiracy in cosmological simulations



Binary mergers

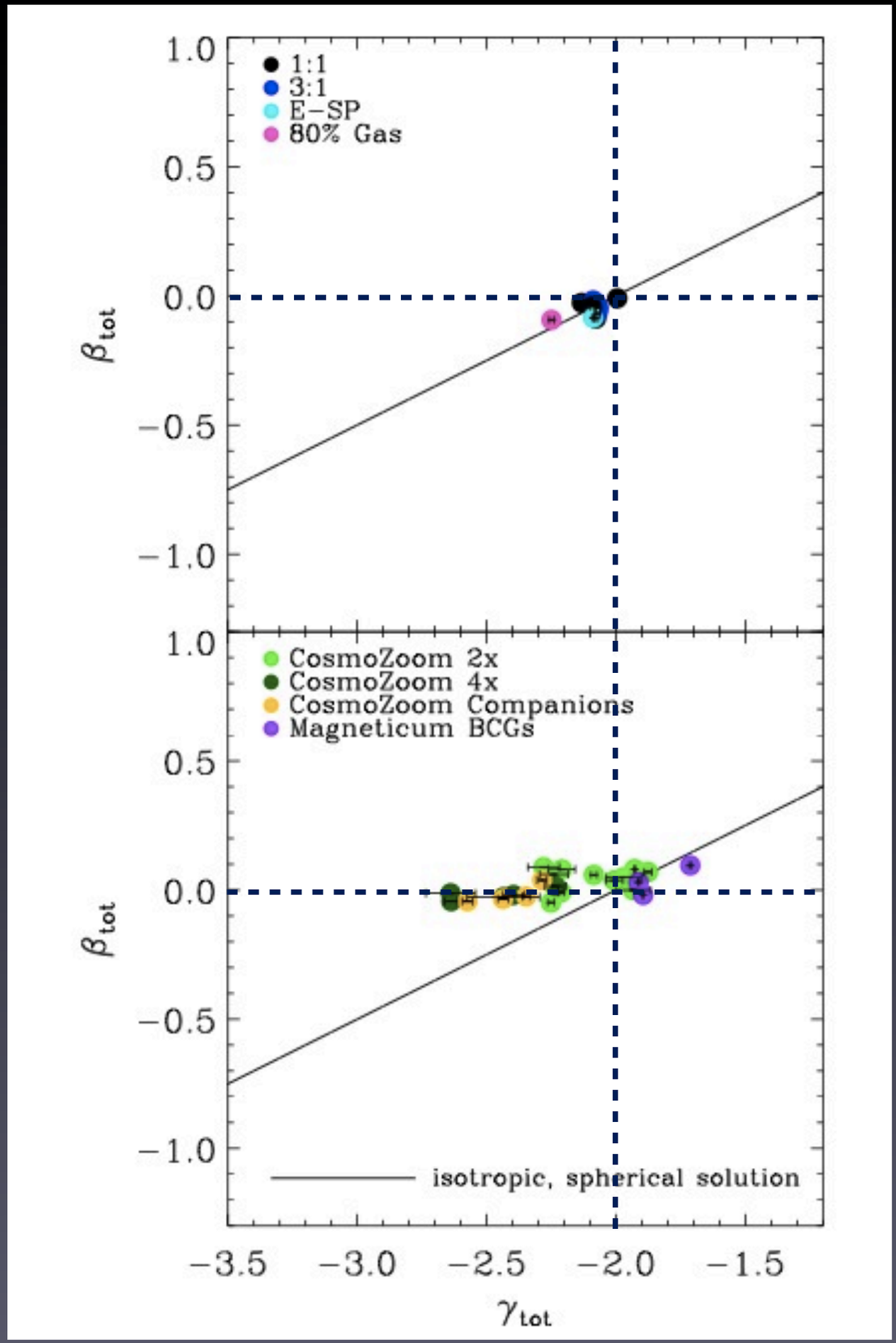
- Close to solution of isotropic Jeans equation

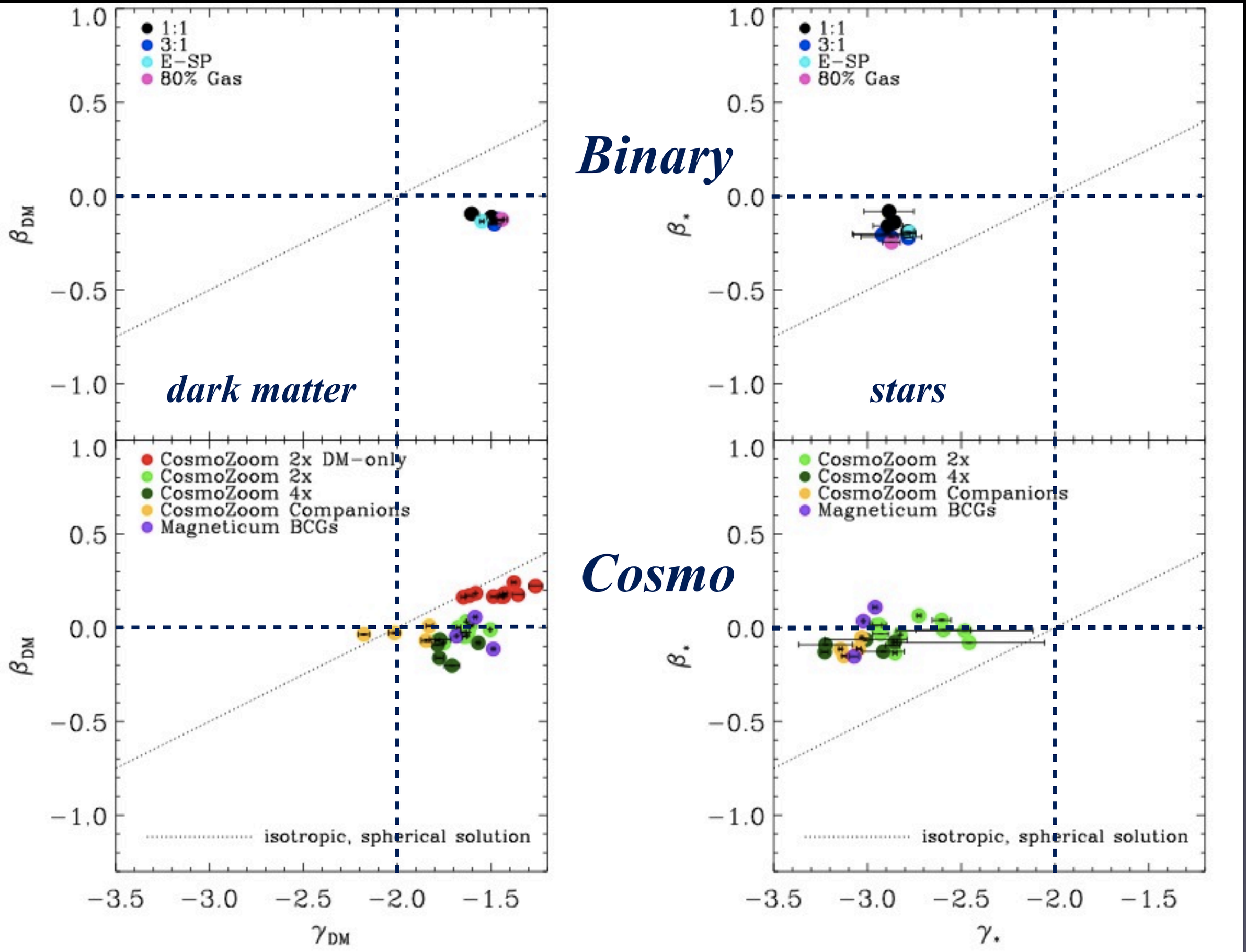
- Very close to isothermal

$$\rho(r) = \frac{C\sigma(r)^2}{4\pi G r^2}$$

Cosmo

- Very close to isotermal
- Large spread in density slope
- Steep slopes show large deviation from isotropic Jeans solution



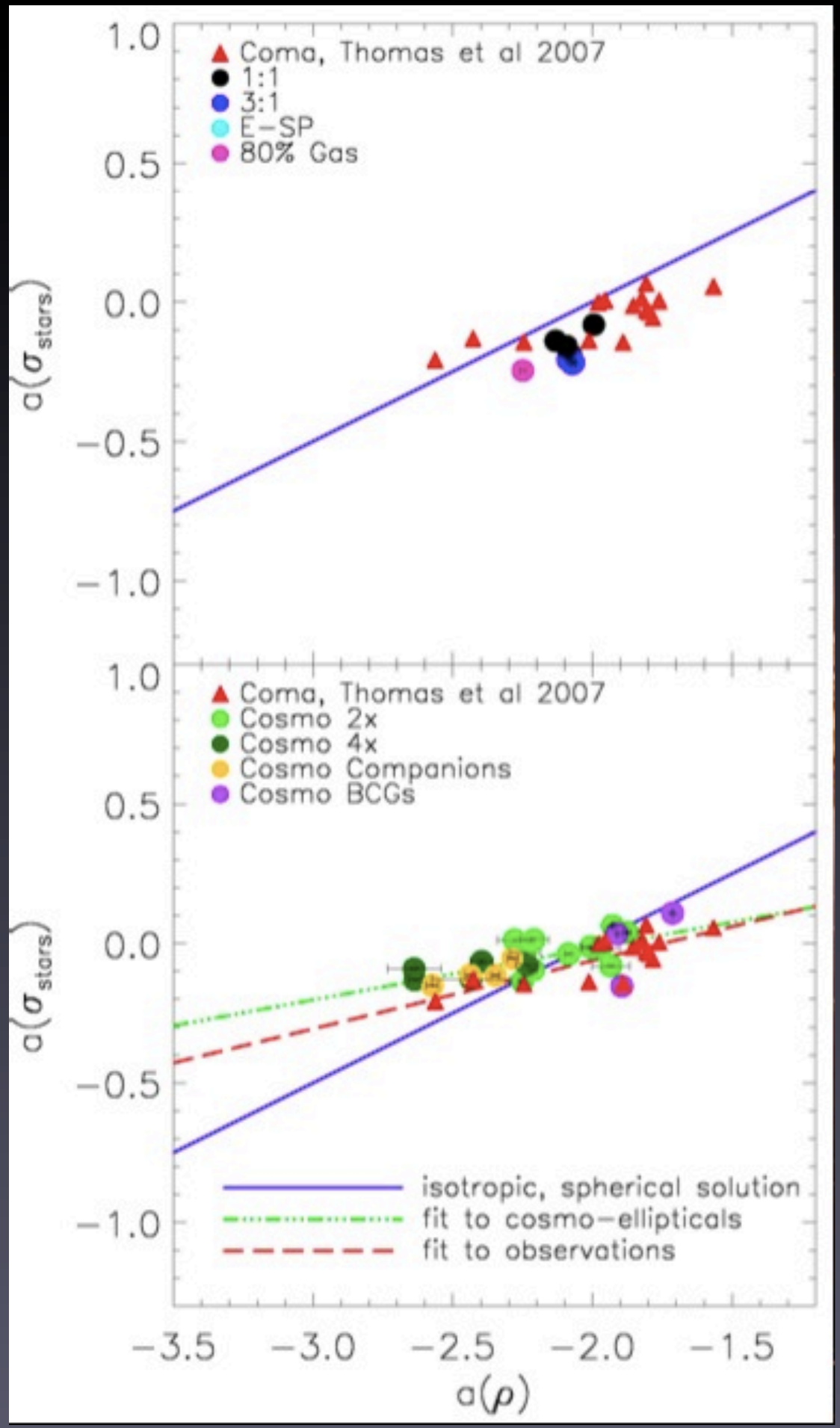

1:1
3:1
E−SP
80% Gas
CosmoZoom 2x DM−only
CosmoZoom 2x
CosmoZoom 4x
CosmoZoom Companions
Magneticum BCGs
dark matter
stars
Binary
Cosmo
isotropic, spherical solution
β_{DM}
γ_{DM}
β_*
γ_*
1.0
0.5
0.0
−0.5
−1.0
−3.5
−3.0
−2.5
−2.0
−1.5

Stellar dispersion slope versus total density slope

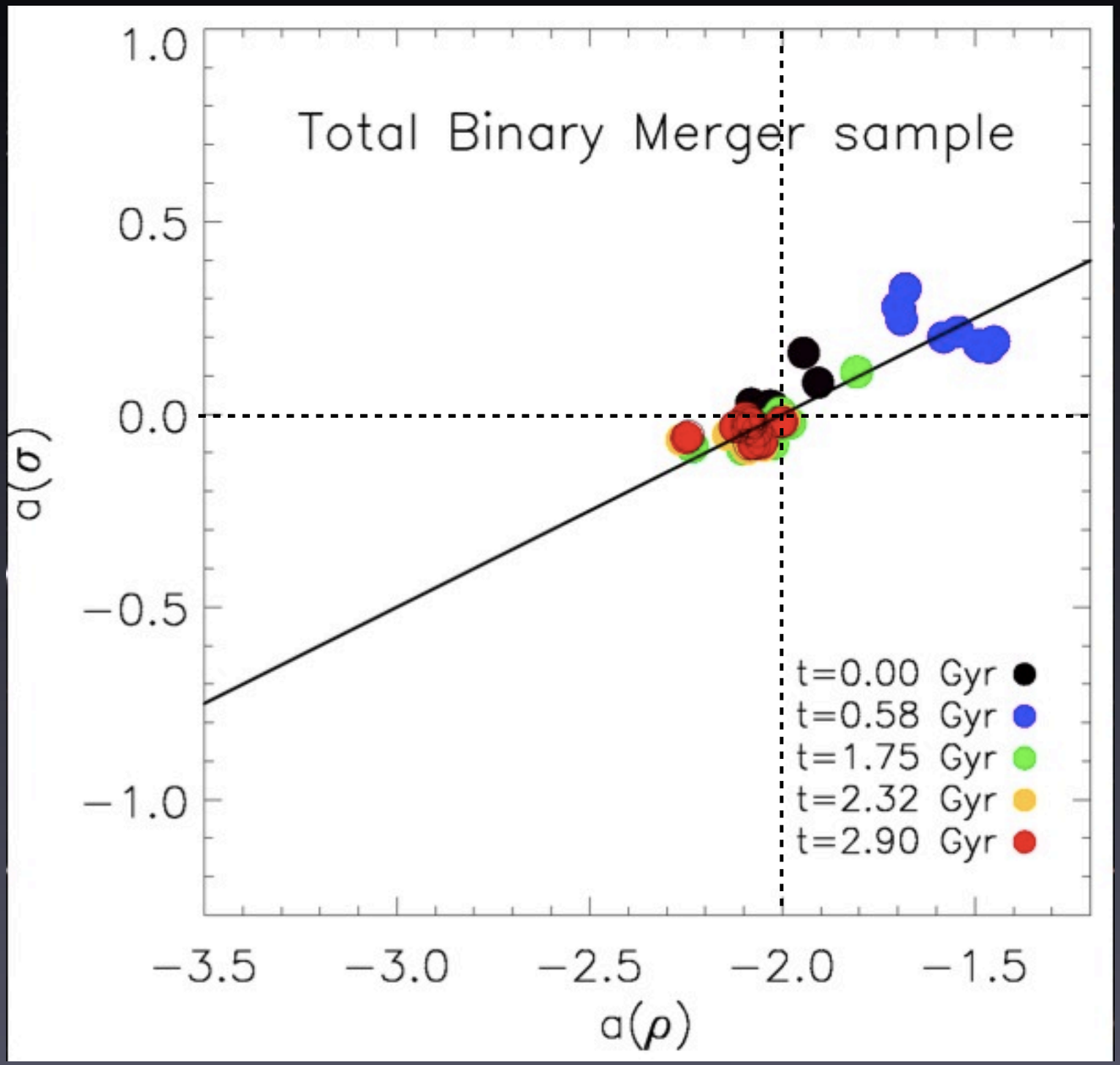
- Comparison with Thomas et al. favors multiple merger origin

- Steepness of density slope depends critically on central concentration of baryonic component

(see however van Dokkum & Conroy 11,12: Conroy & van Dokkum 12)



Slope evolution and violent relaxation



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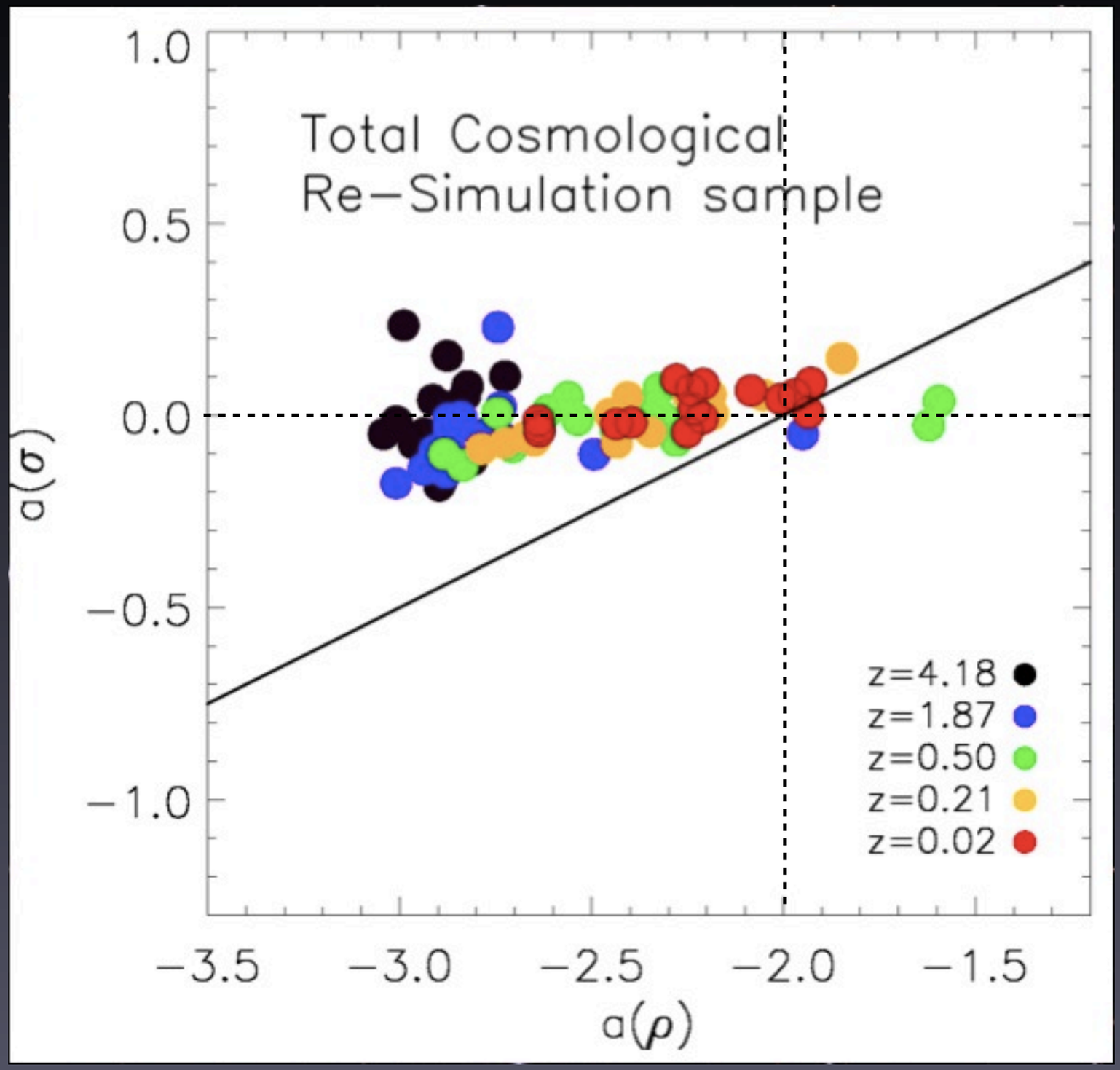
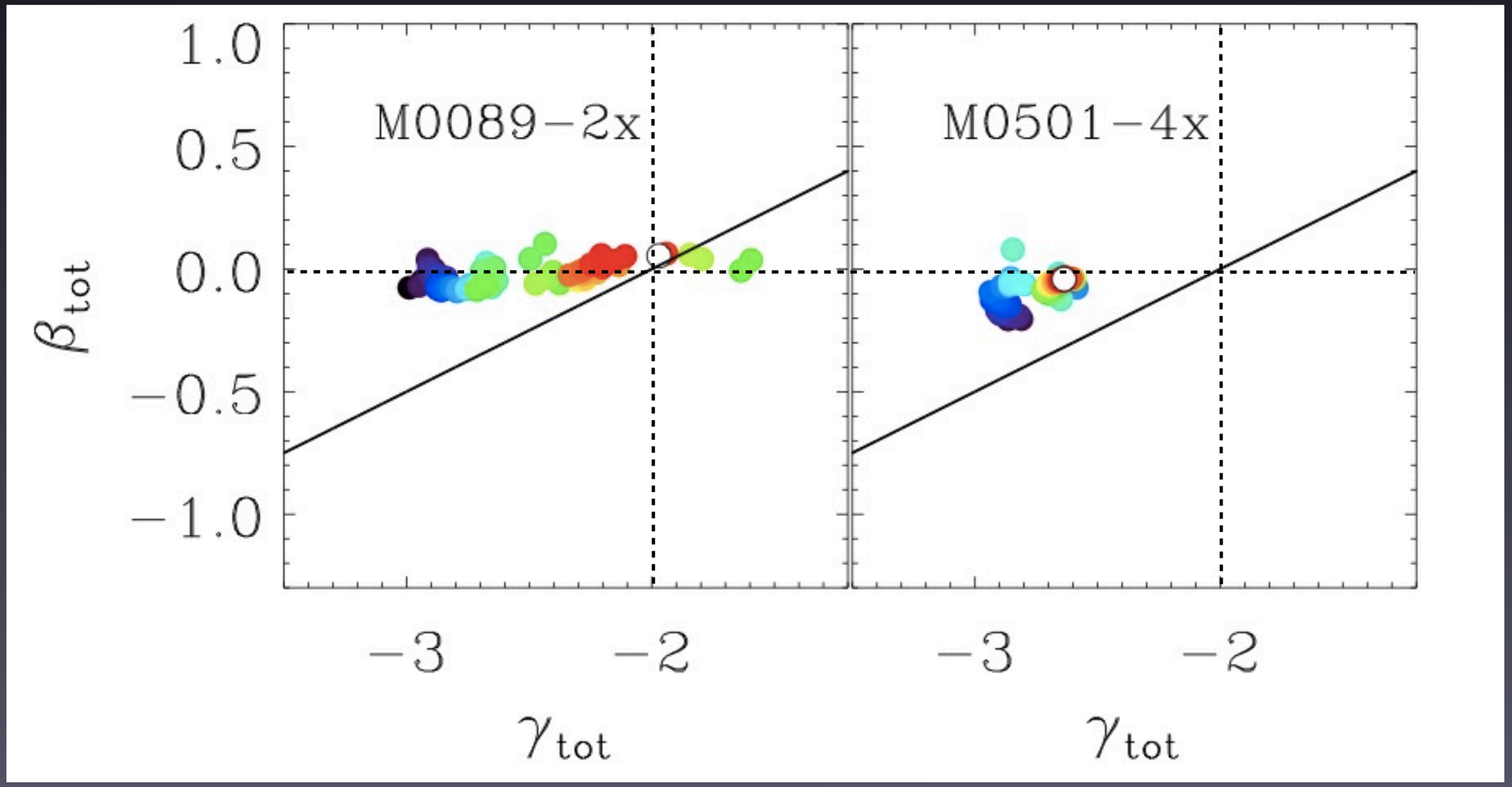


Slope evolution and violent relaxation

Massive elliptical:
multiple substantial mergers

Low-mass elliptical:
minor mergers and accretion



Summary

- *The stellar and dark matter density and velocity dispersion profiles of ellipticals are **not** power laws.*

- *Their combined profiles can however be well fitted by **power-laws** in the radius range of 0.1 to 3 reff.*

- ***Mergers** of 2-component systems lead to combined power-law profiles that are isothermal (violent relaxation???).*

- ***Deviations** from isothermal profiles therefore contain valuable information about the accretion history of a given galaxy.*

- *Cosmological simulations, despite their known caveats, are in good agreement with recent observations of Coma ellipticals.*