



Turku, 9.7.2013

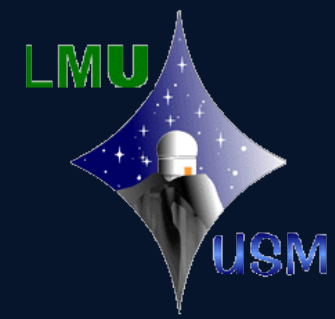


The Dark Halo – Spheroid Conspiracy and the Origin of Elliptical Galaxies

Rhea-Silvia Remus

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

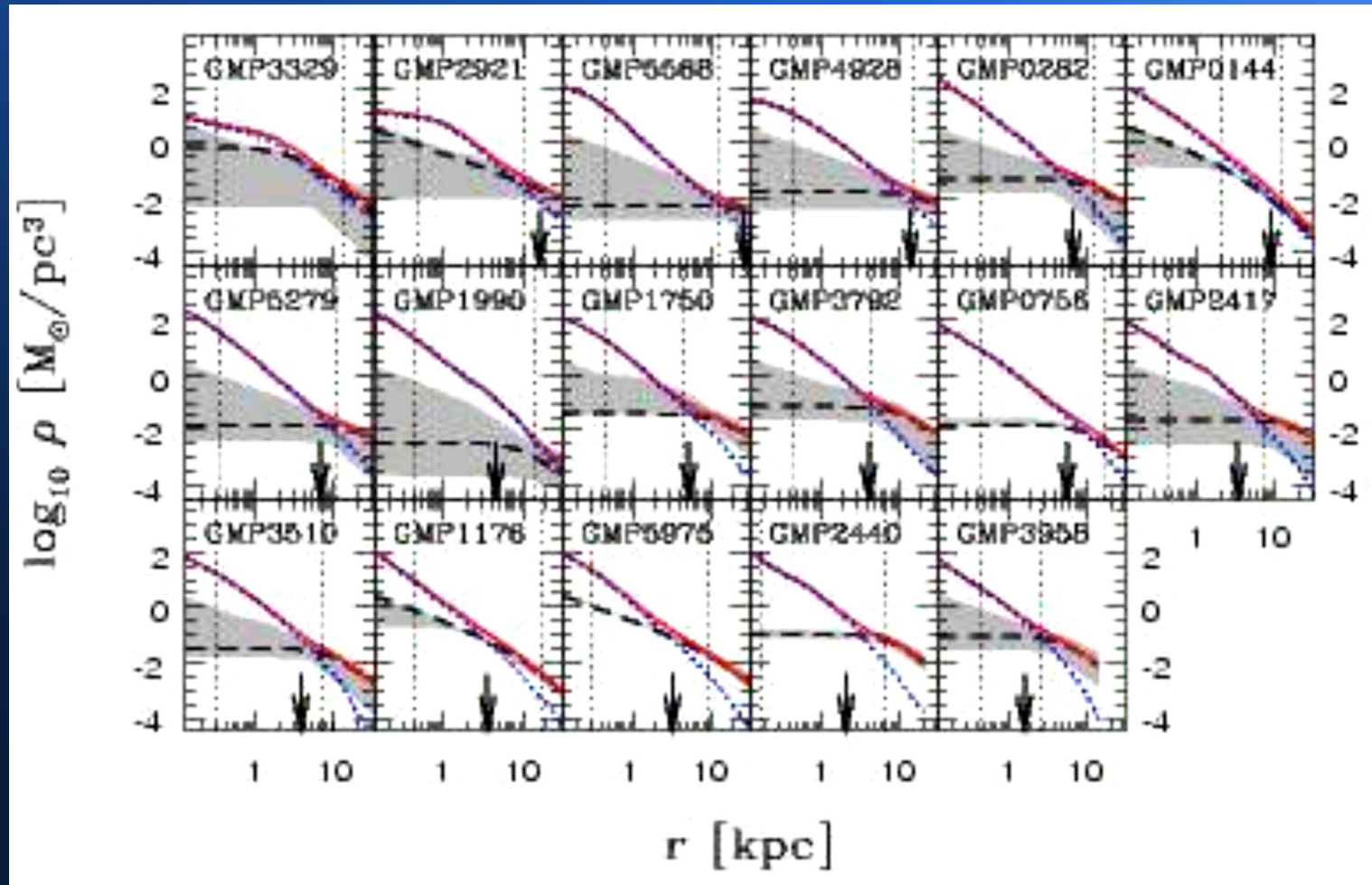
EWASS 2013, „The mystery of ellipticals“



Observational Background

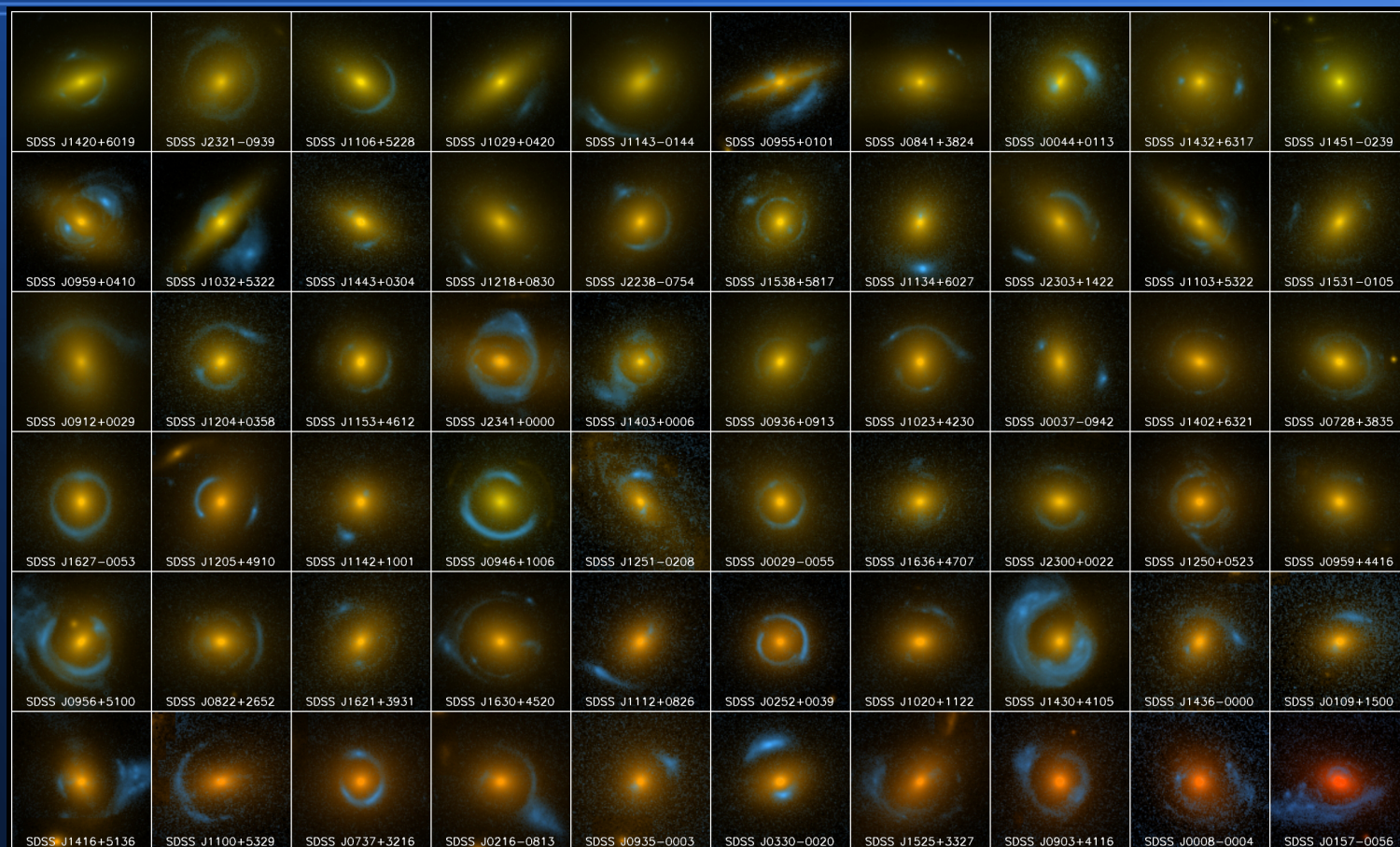


Observational Background I: Dynamical modeling



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

Observational Background II: Strong lensing



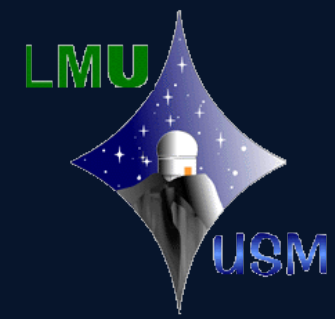
SLACS survey:
Auger et al., 2010,
Barnabe et al., 2011

SLACS: The Sloan Lens ACS Survey

www.SLACS.org

A. Bolton (U. Hawai'i IfA), L. Koopmans (Kapteyn), T. Treu (UCSB), R. Gavazzi (IAP Paris), L. Moustakas (JPL/Caltech), S. Burles (MIT)

Image credit: A. Bolton, for the SLACS team and NASA/ESA

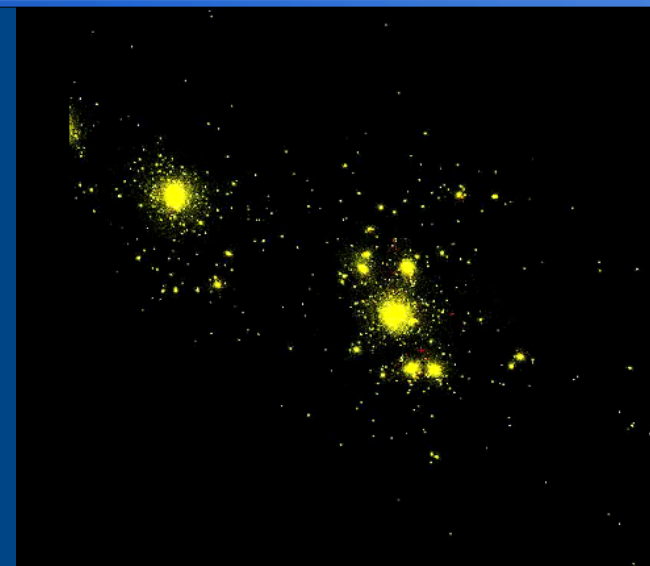


Simulations





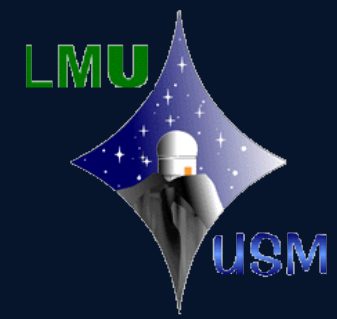
- ★ SpH Code Gadget-2
- ★ Star formation and Supernova feedback according to Springel & Hernquist 2003
- ★ 100^3Mpc^3 Λ CDM DM only box with 512^3 particles, $H_0 = 72$, $\lambda_0 = 0.74$, $\Omega_M = 0.26$, $M_{\text{Part}} = 2 \cdot 10^8 M_\odot$
- ★ Baryon fraction for Re-Simulations: $\Omega_b = 0.044$, $\Omega_{\text{DM}} = 0.216$
- ★ $M_{\text{DM}} = 2.5 \cdot 10^7 M_\odot h^{-1}$, $M_{\text{Star}} = M_{\text{Gas}} = 4.2 \cdot 10^6 M_\odot h^{-1}$



Oser et al 2010, 2012

Our sample: 17 central Ellipticals, 4 substructure Ellipticals

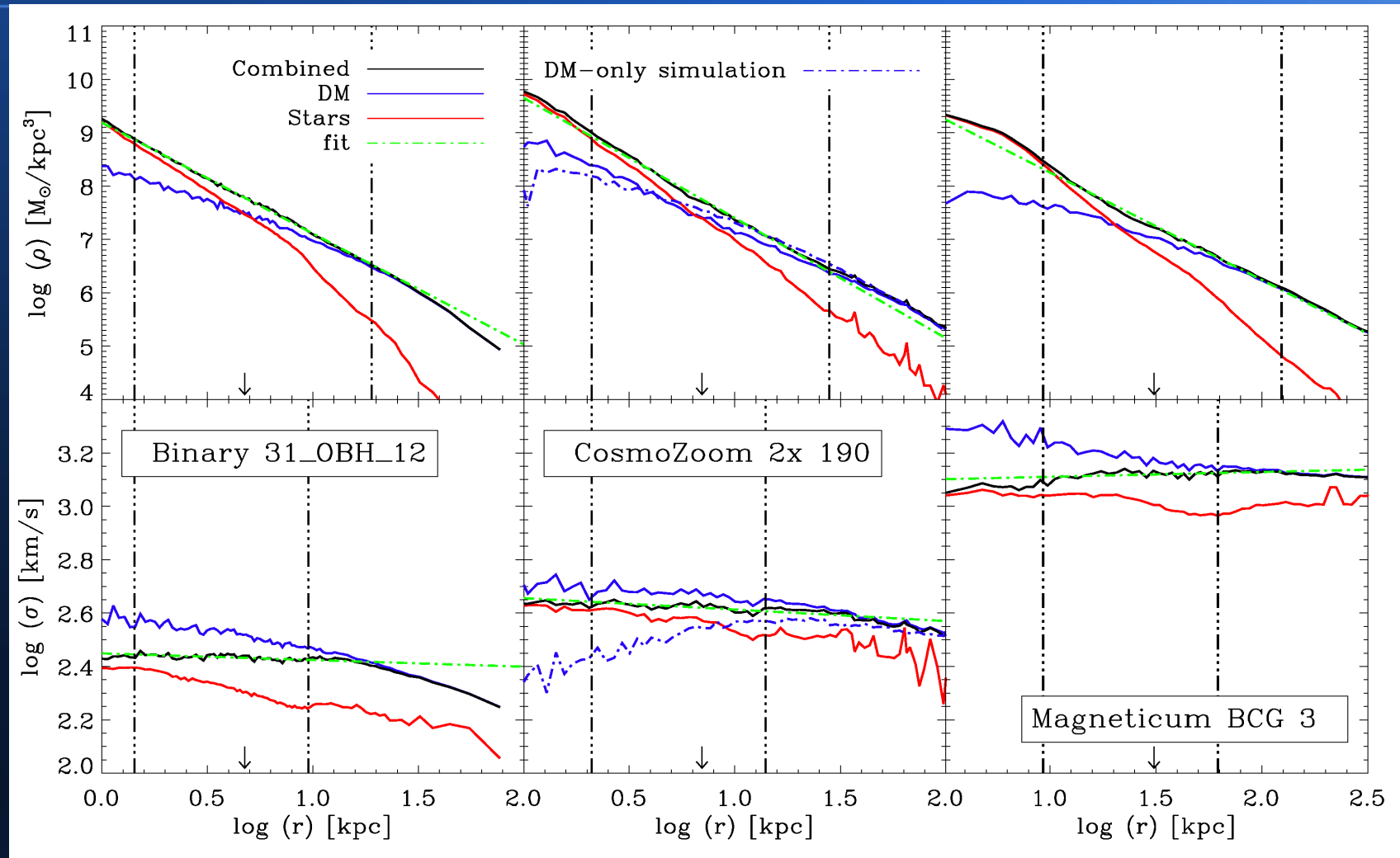
Different merger histories: multiple minor merger, major merger and mixed merger histories



Results



Density and Velocity Dispersion Profiles



Remus et al.
2013



Conspiracy I

Total slopes

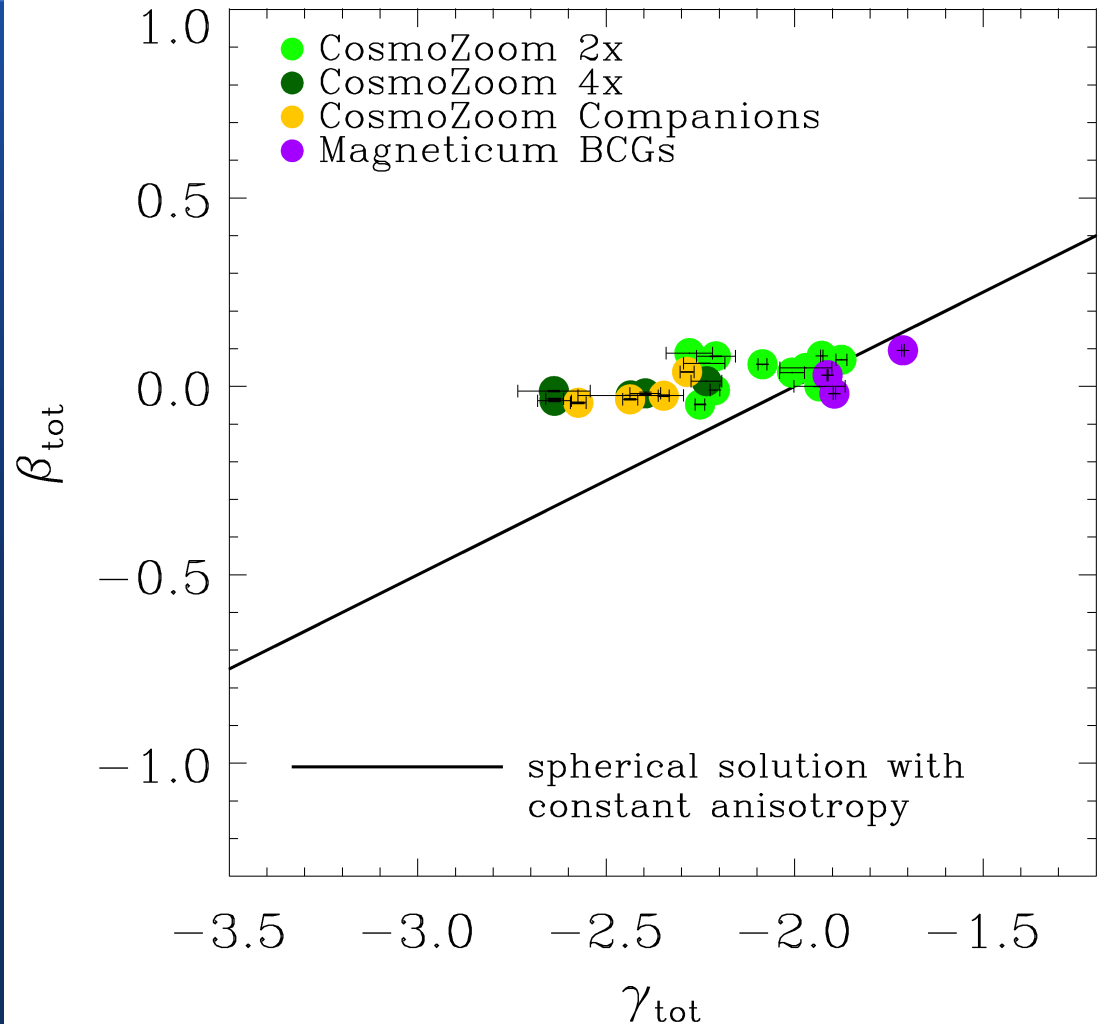


Solution of the Jeans Equation for an isothermal sphere:

$$\rho(r) = \frac{\sigma^2}{2\pi Gr^2}$$

Solution of the Jeans Equation for an isotropic sphere, assuming the density and velocity can be described by a simple power law:

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





Conspiracy II slopes

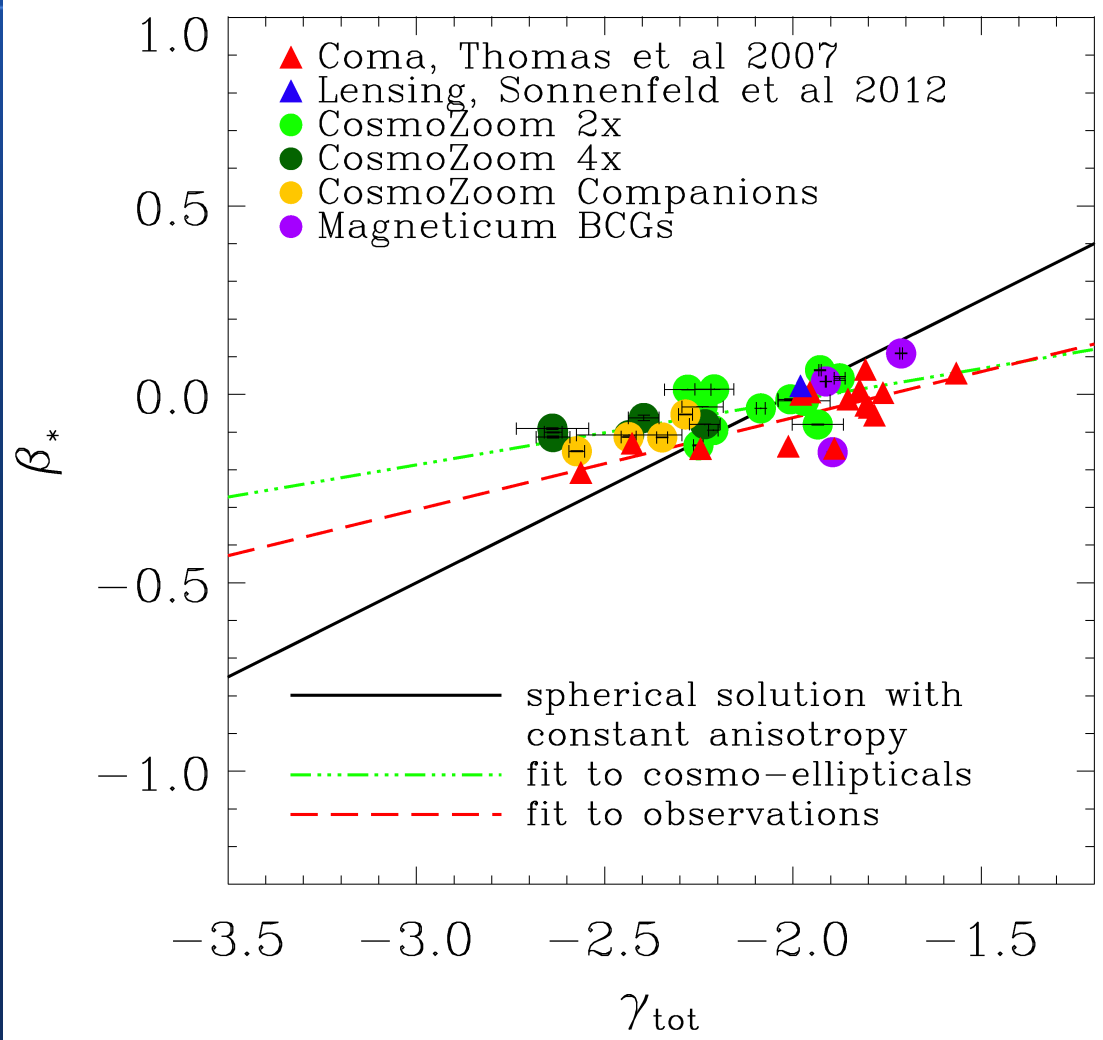


Solution of the Jeans Equation for an isothermal sphere:

$$\rho(r) = \frac{\sigma^2}{2\pi Gr^2}$$

Solution of the Jeans Equation for an isotropic sphere, assuming the density and velocity can be described by a simple power law:

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





Conspiracy III

Dark Matter

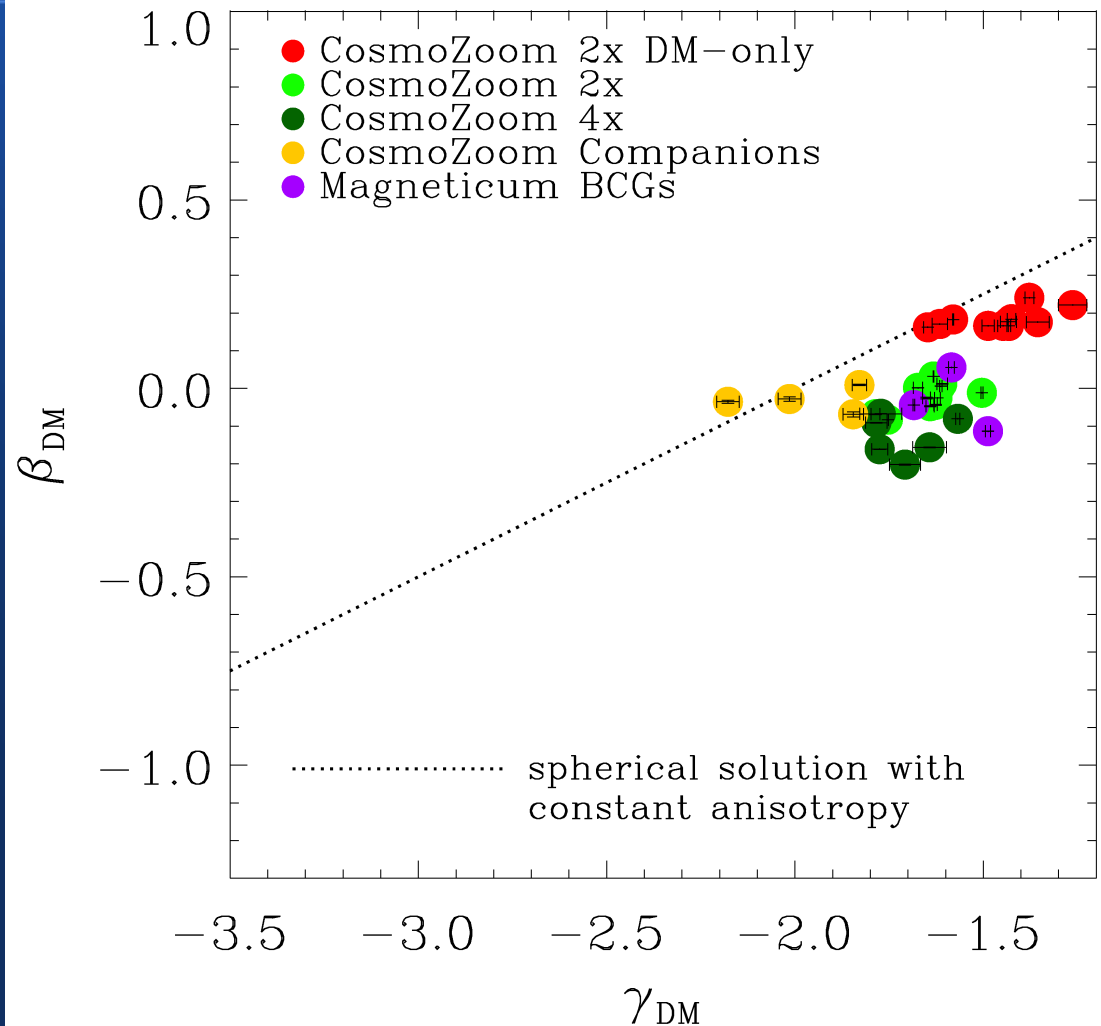


Solution of the Jeans Equation for an isothermal sphere:

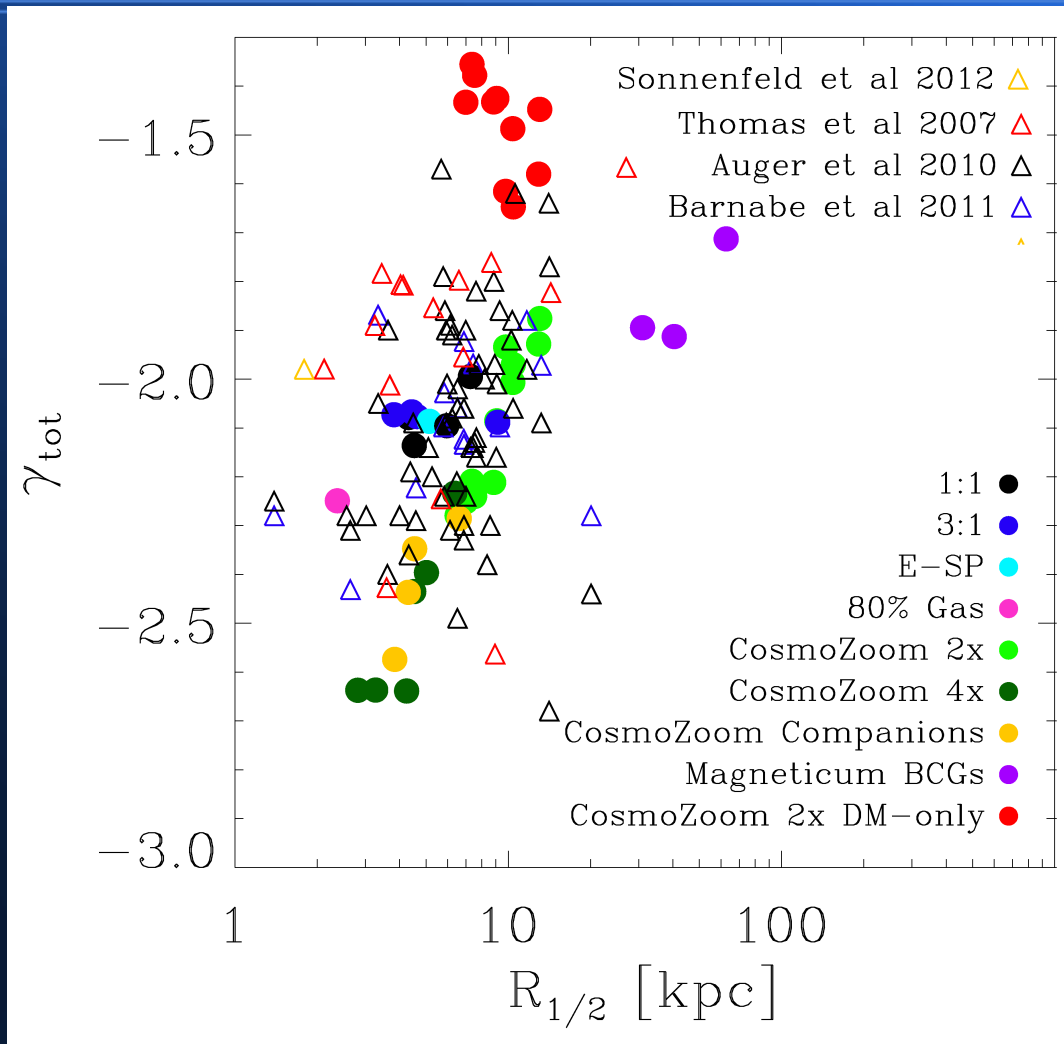
$$\rho(r) = \frac{\sigma^2}{2\pi Gr^2}$$

Solution of the Jeans Equation for an isotropic sphere, assuming the density and velocity can be described by a simple power law:

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



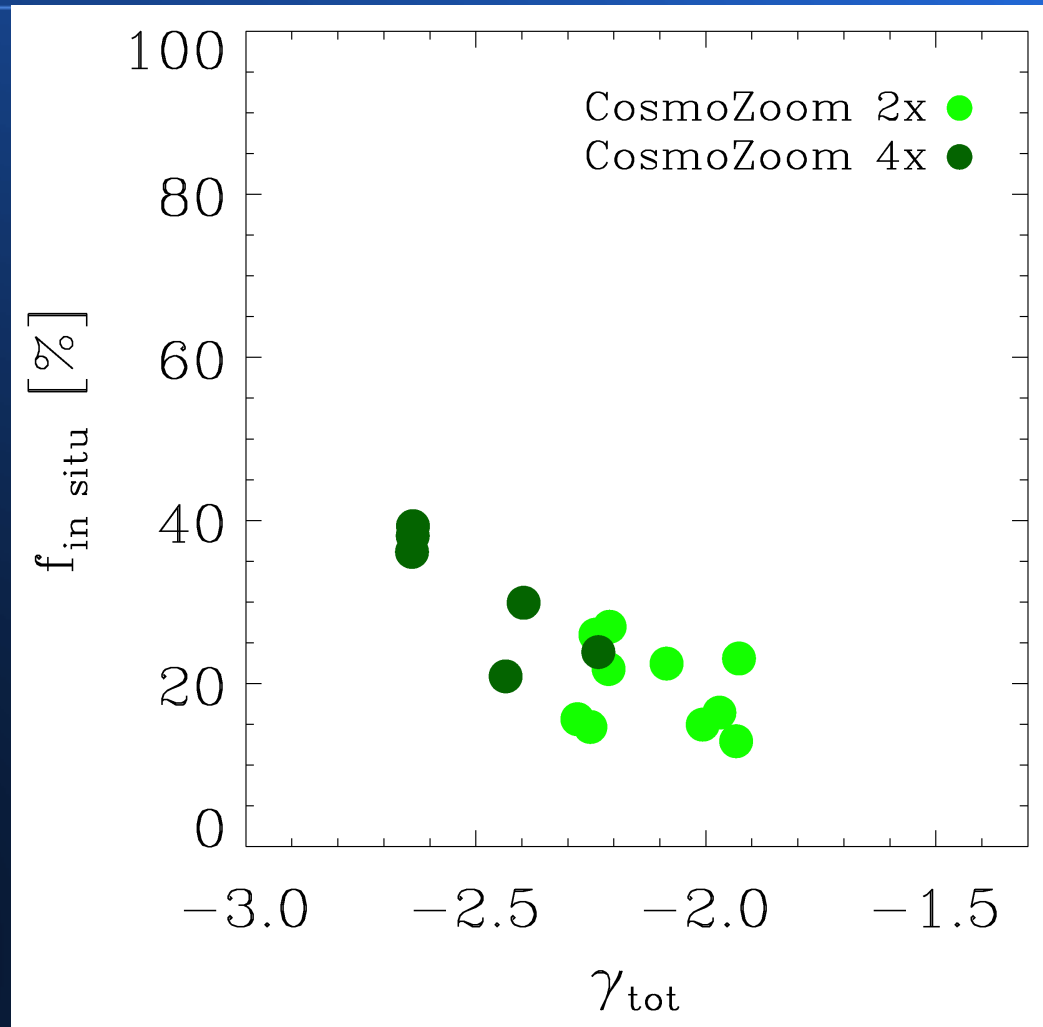
Density Slope versus Size



Remus et al.
2013

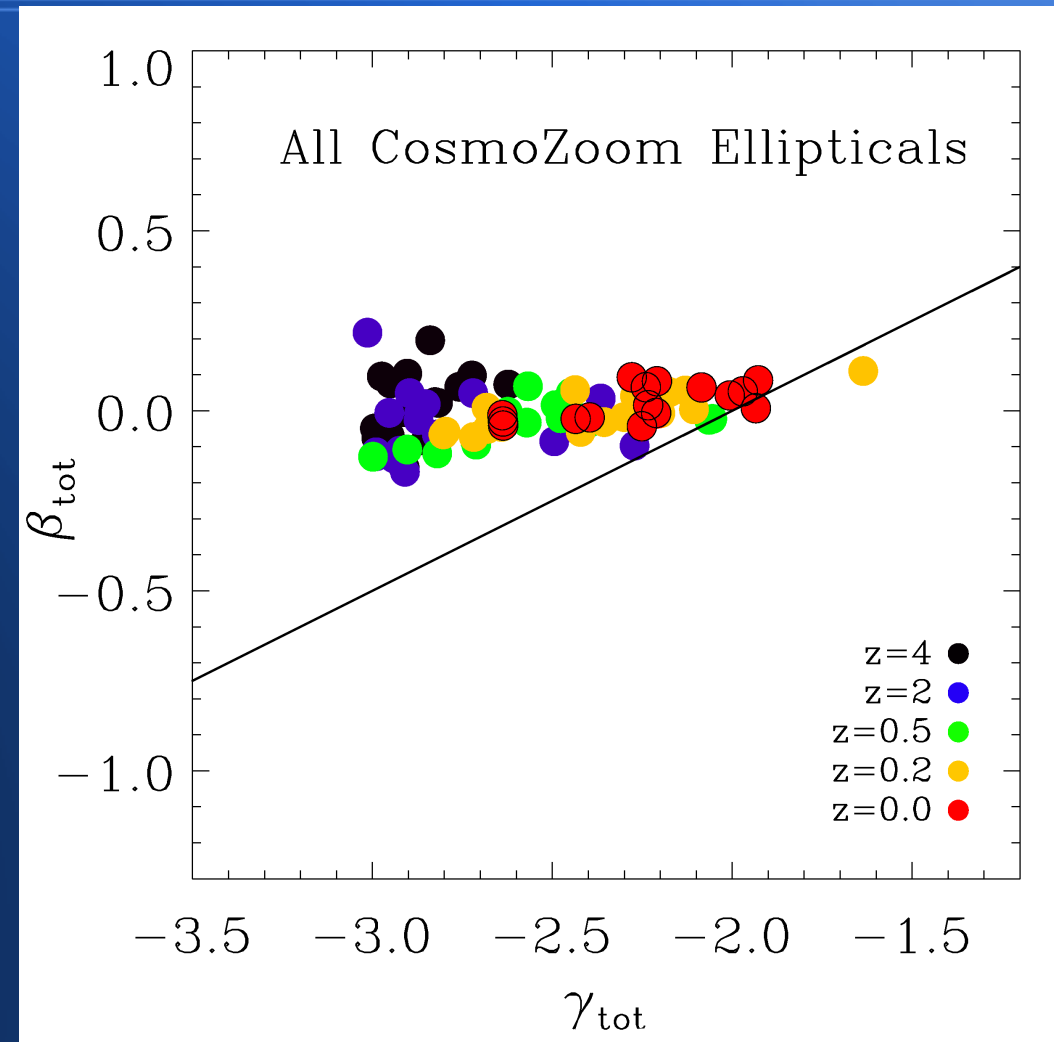
Thomas et al.
2007
Auger et al.
2010
Barnabe et al.
2011
Sonnenfeld et
al. 2012

Density slope versus In-situ fraction

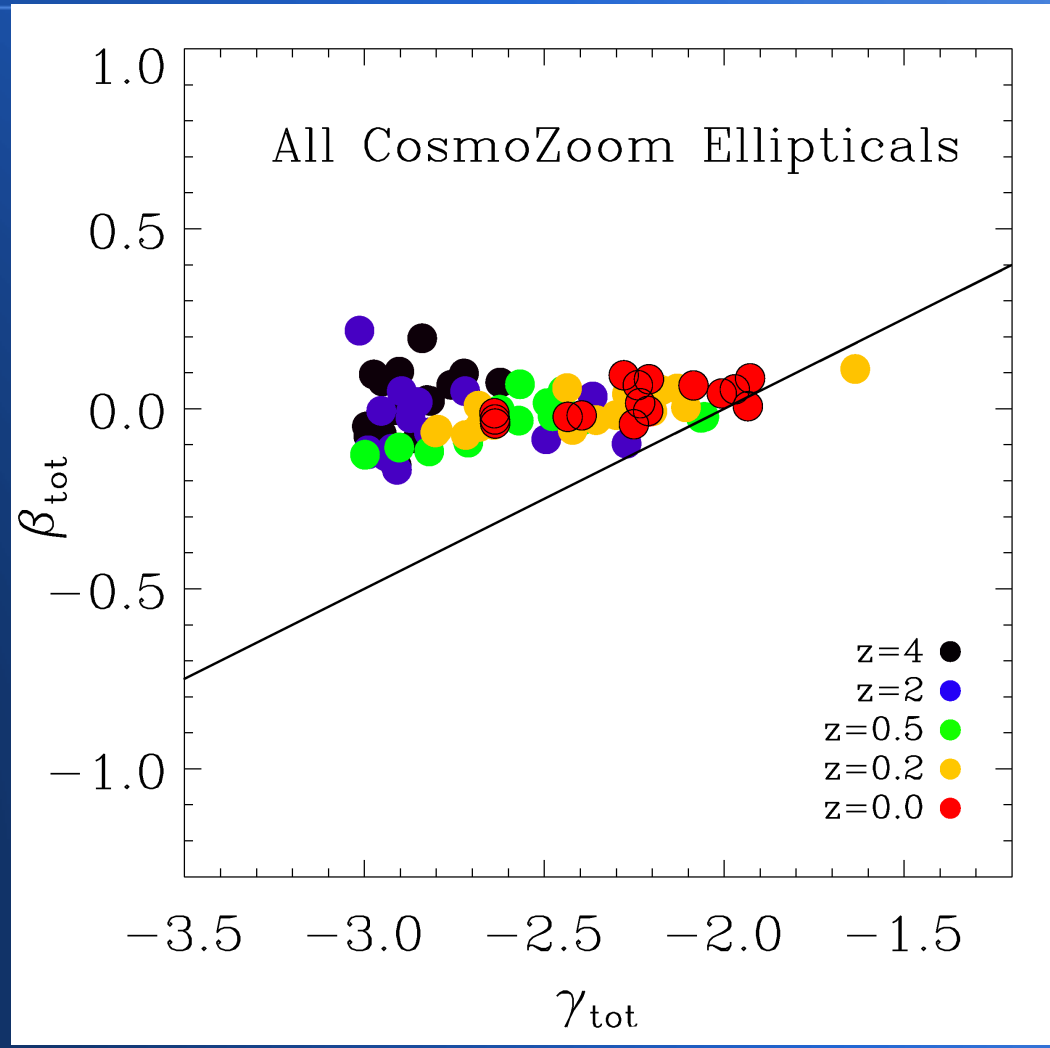
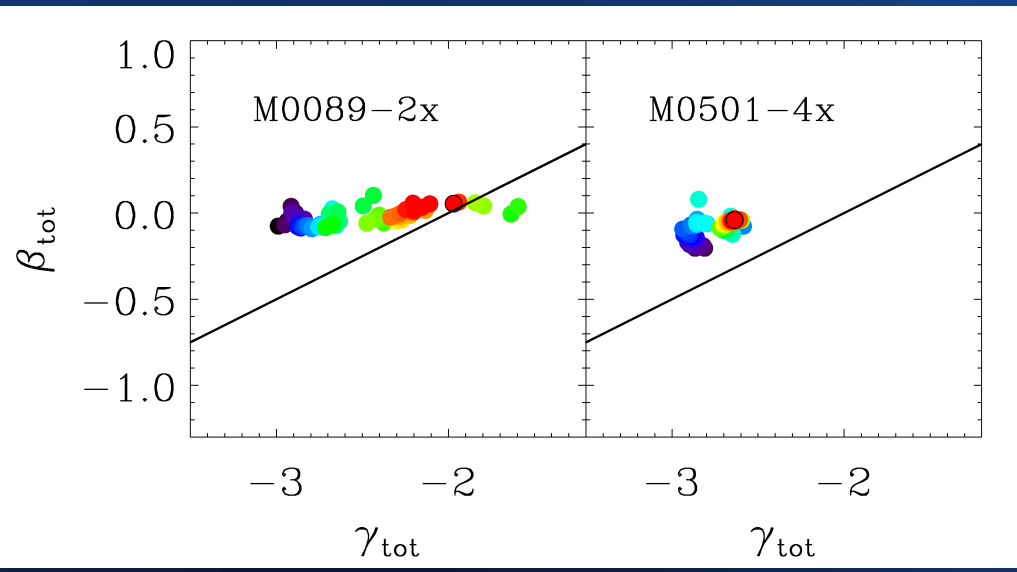


See also Oser
et al. 2012 for
the in-situ
fractions

Evolution with redshift



Evolution with redshift



Evolution with redshift - Observations

SLACS Survey (Auger et al. 2010, Barnabe et al. 2011):

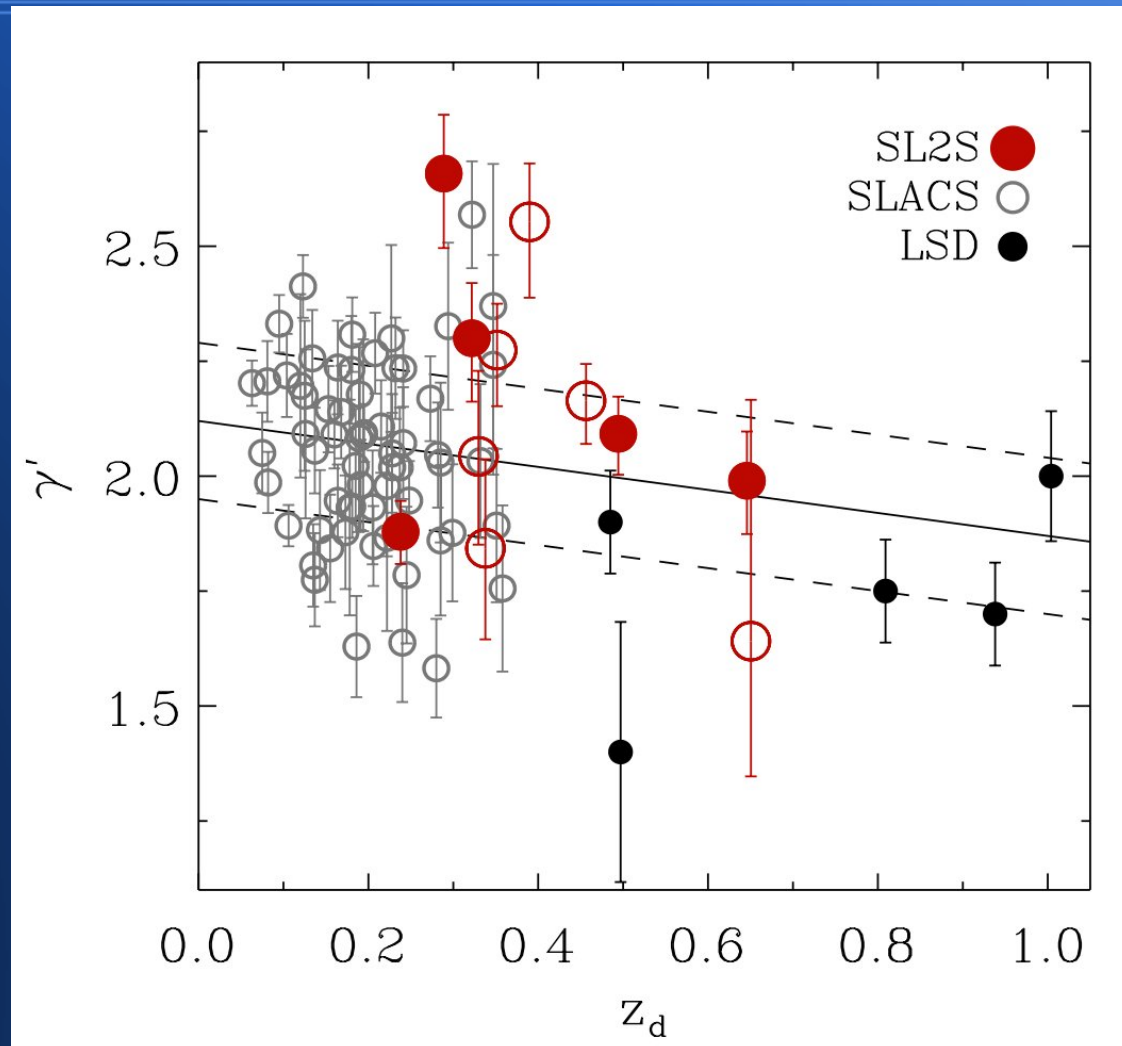
$z=0.063 - 1.071$

LSD-Survey (Treu & Koopmans, 2002, 2004, Koopmans & Treu 2003):

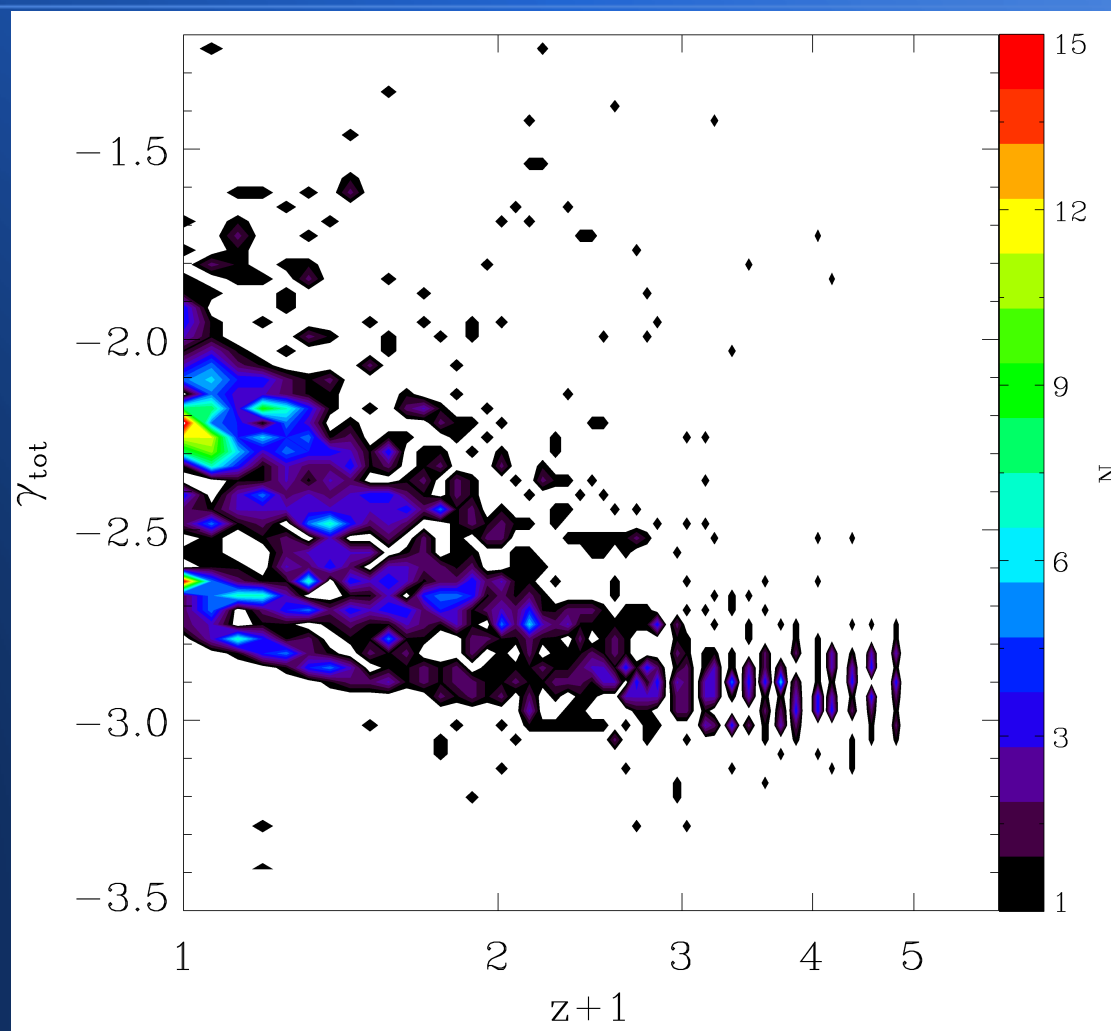
$z=0.485 - 1.004$

SL2S Survey (Ruff et al 2011):

$z=0.24 - 0.65$

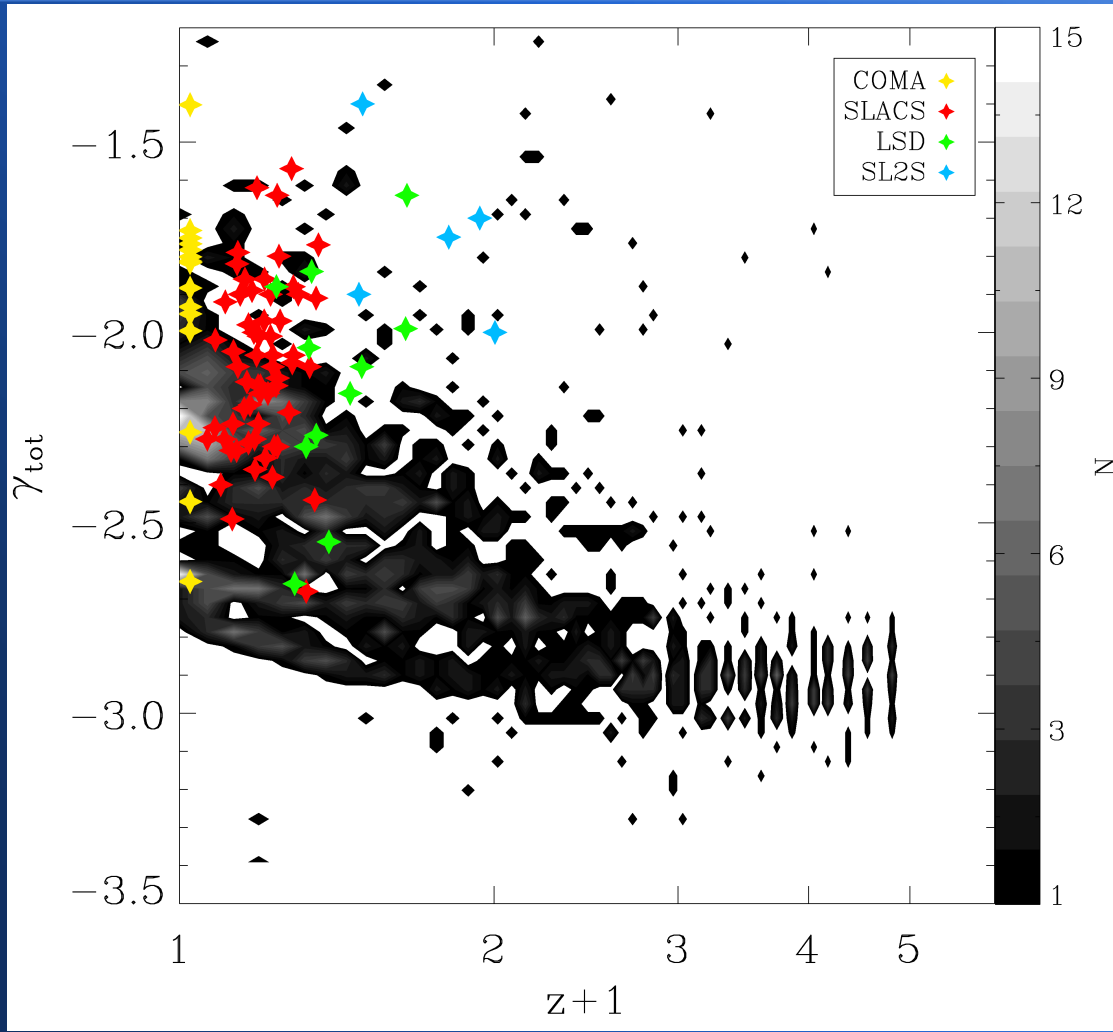


Evolution with redshift



Cosmo-Zoom Spheroidals:
no lower mass cut

Evolution with redshift

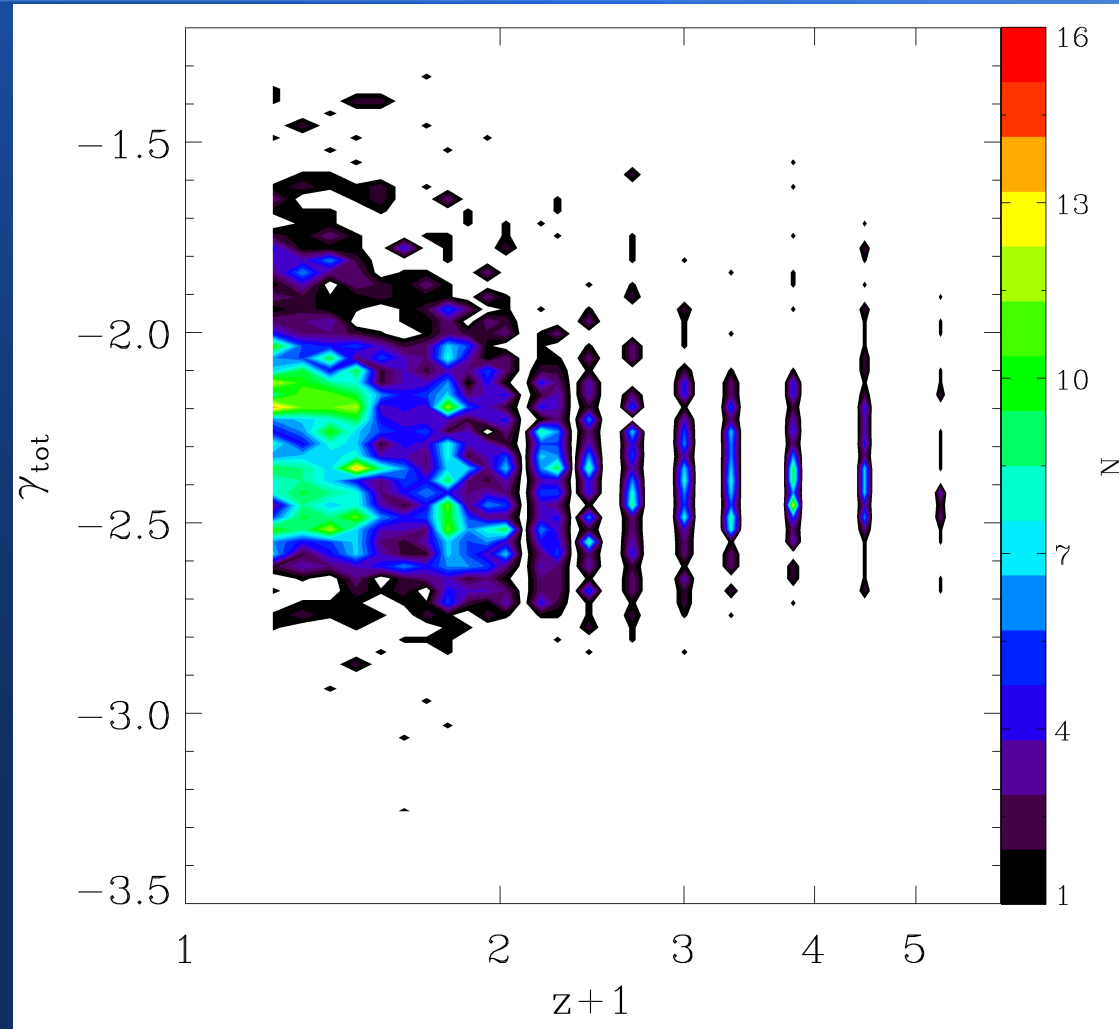


Cosmo-Zoom Spheroidals:
no lower mass cut

Evolution with redshift



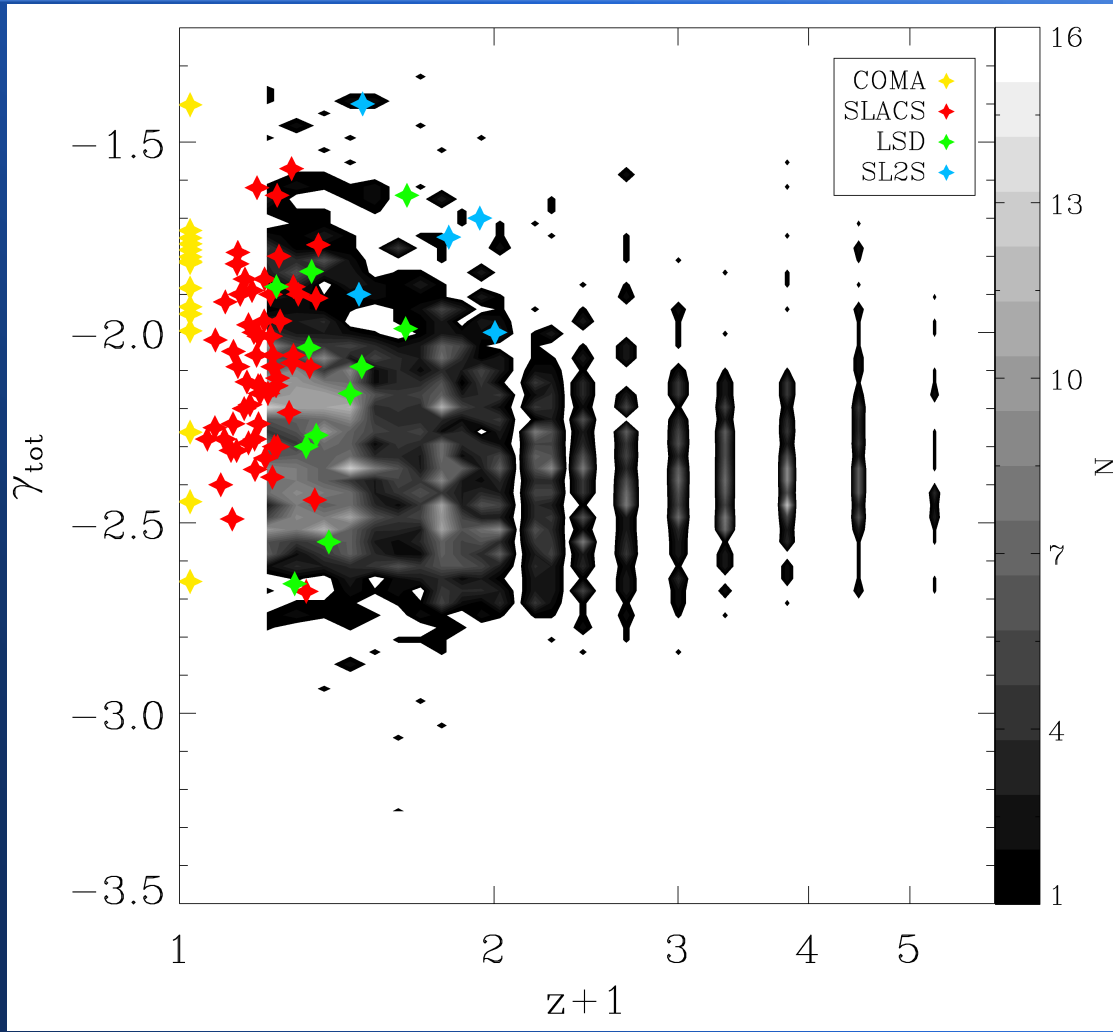
Spheroidals from a full hydrodynamic cosmological simulation: lower mass cut at $M_{\text{tot}} = 10^{12} M_{\text{sun}}$



Evolution with redshift



Spheroidals from a full hydrodynamic cosmological simulation: lower mass cut at $M_{\text{tot}} = 10^{12} M_{\text{sun}}$





Conclusions



- ★ The total combined density profiles of spheroidal galaxies can be fit by a power law with the slope of on average $\gamma \sim -2$
- ★ There is a tendency towards steeper slopes for more compact, lower-mass ellipticals with higher fractions of stars formed in-situ
- ★ At higher redshifts, the density slopes are generally steeper ($\gamma \sim -3$), and each gas-poor merger event evolves the slope towards $\gamma \sim -2$.