Santiago de Chile, 19.11.2013

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

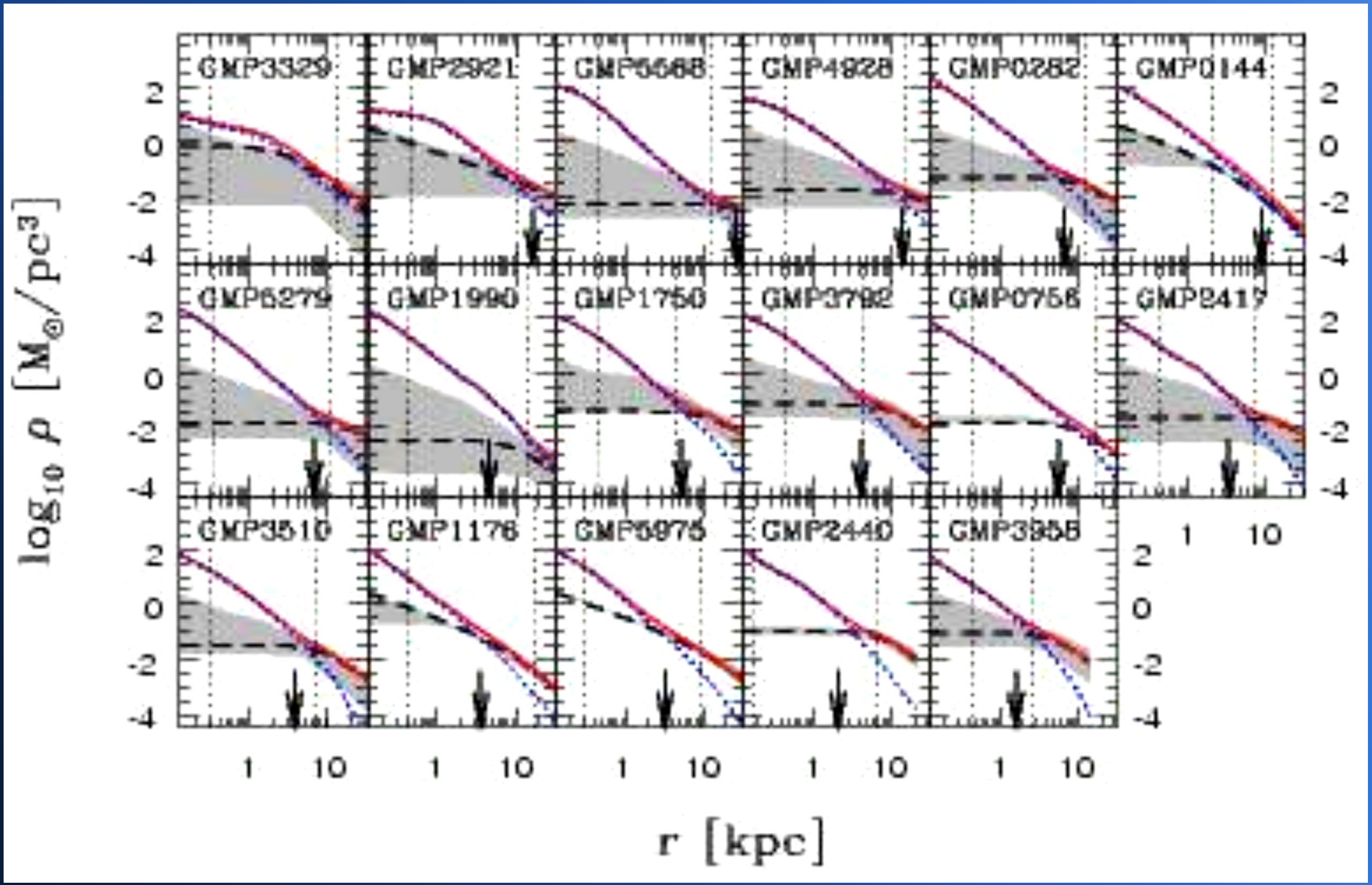
Rhea-Silvia Remus

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

Morph 2013, „Deconstructing Galaxies"

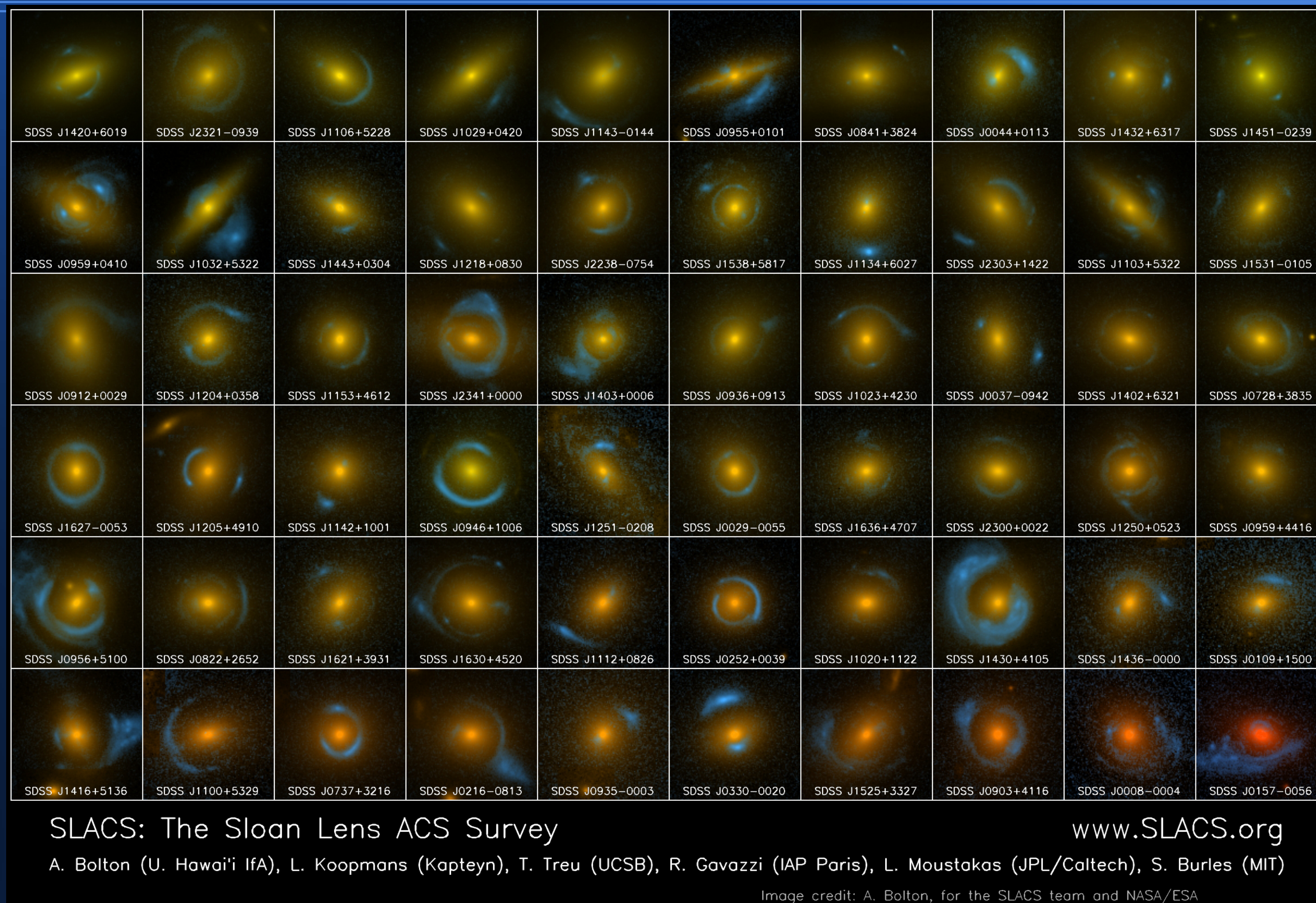
Observational Background

Observational Background I: Dynamical modeling



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

Observational Background II: Strong lensing

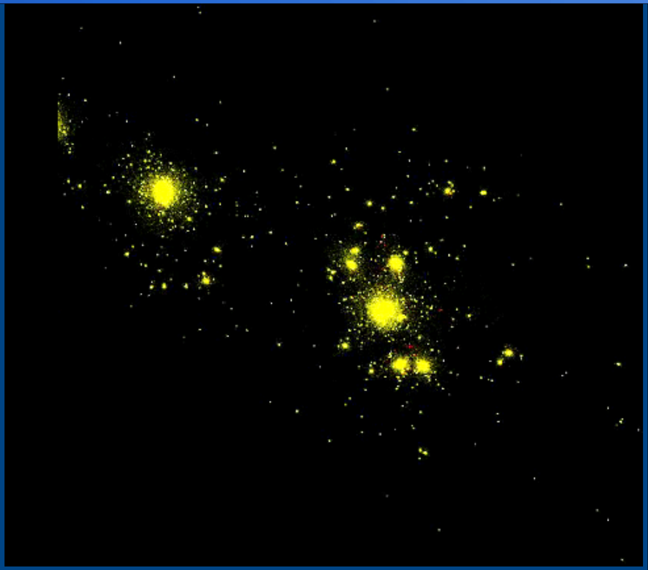


SLACS survey:
Auger et al., 2010,
Barnabe et al., 2011

Simulations

Simulations

- SpH Code Gadget-2
- Star formation and Supernova feedback according to Springel & Hernquist 2003
- $100^3 Mpc^3$ ΛCDM DM only box with 512^3 particles, $H0 = 72$, $\lambda_0 = 0.74$, $\Omega_M = 0.26$, $M_{Part} = 2 \cdot 10^8 M_\odot$
- Baryon fraction for Re-Simulations: $\Omega_b = 0.044$, $\Omega_{DM} = 0.216$
- $M_{DM} = 2.5 \cdot 10^7 M_\odot h^{-1}$, $M_{Star} = M_{Gas} = 4.2 \cdot 10^6 M_\odot h^{-1}$



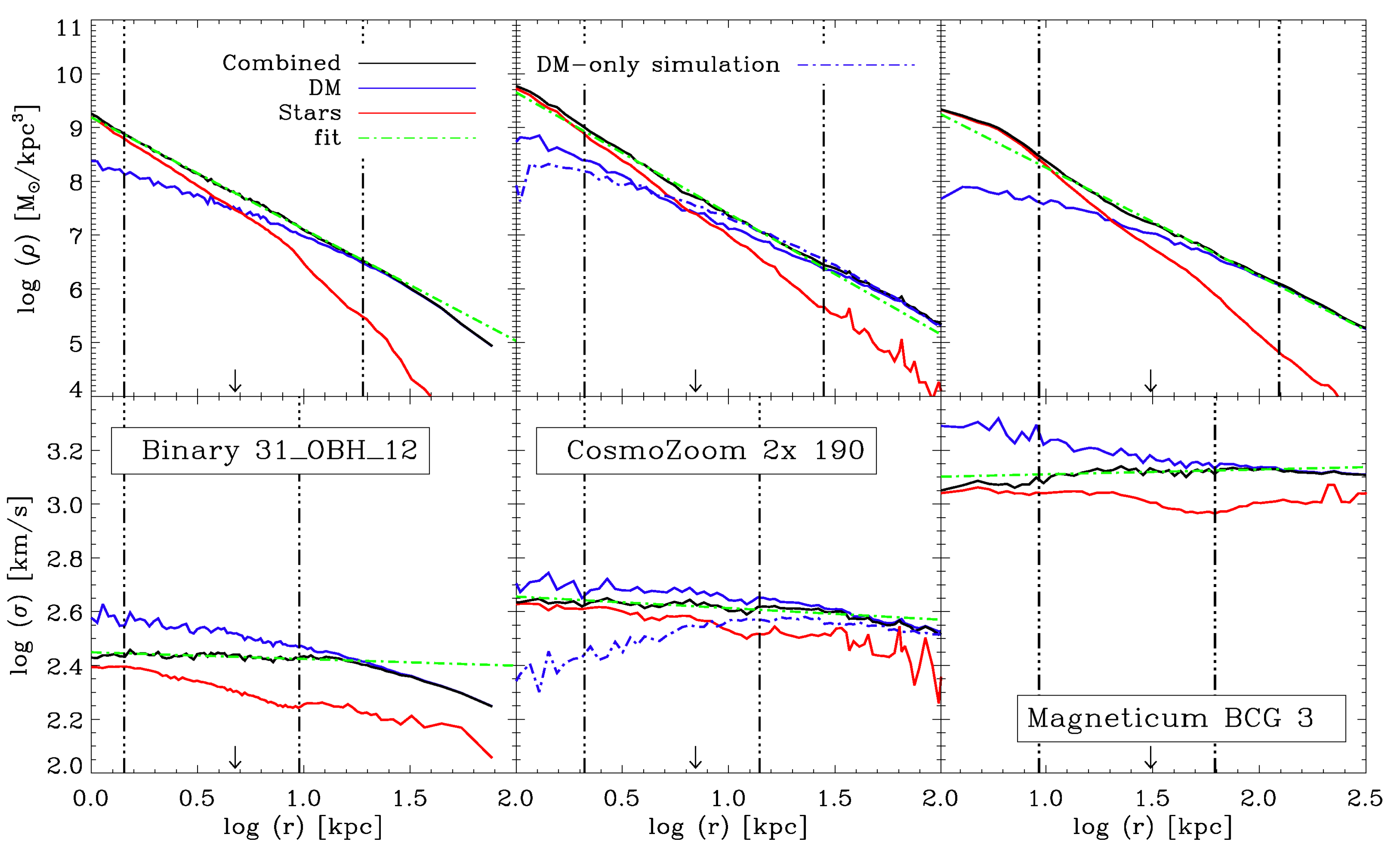
Oser et al 2010, 2012, Naab et al 2013

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

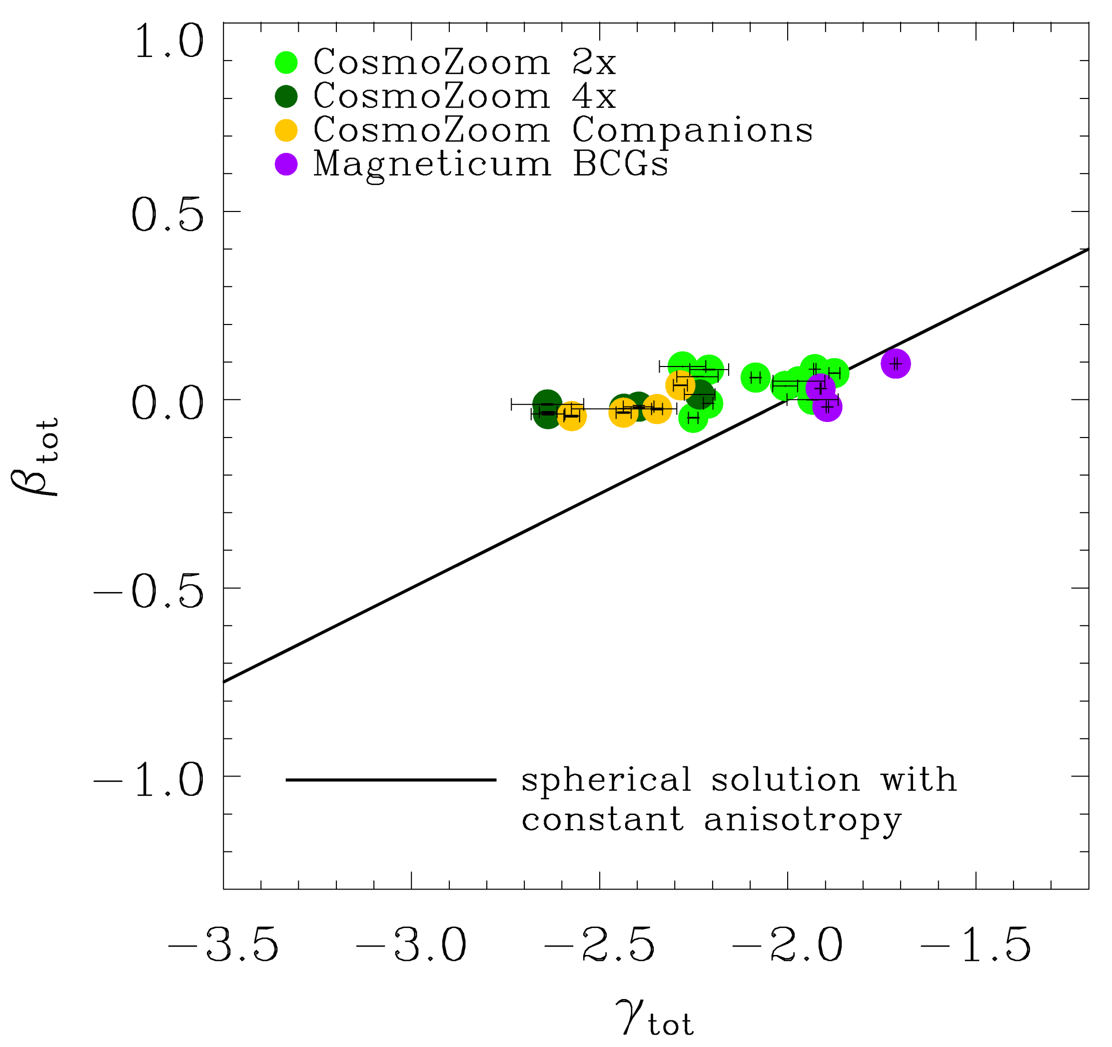
Conspiracy I
Total slopes

Solution of the Jeans Equation for an isothermal sphere:

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

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

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



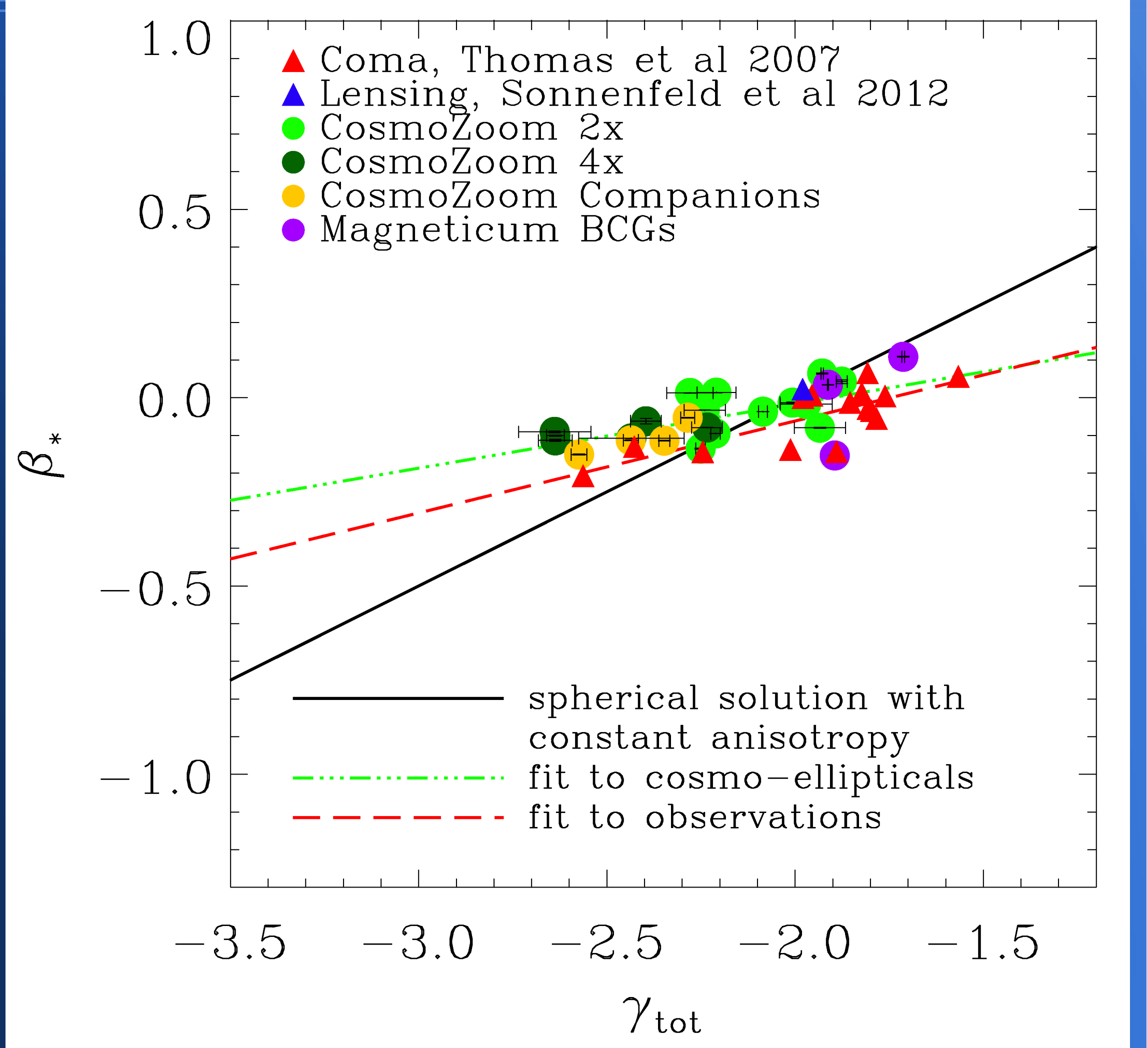
Conspiracy II slopes

Solution of the Jeans Equation for an isothermal sphere:

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

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

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



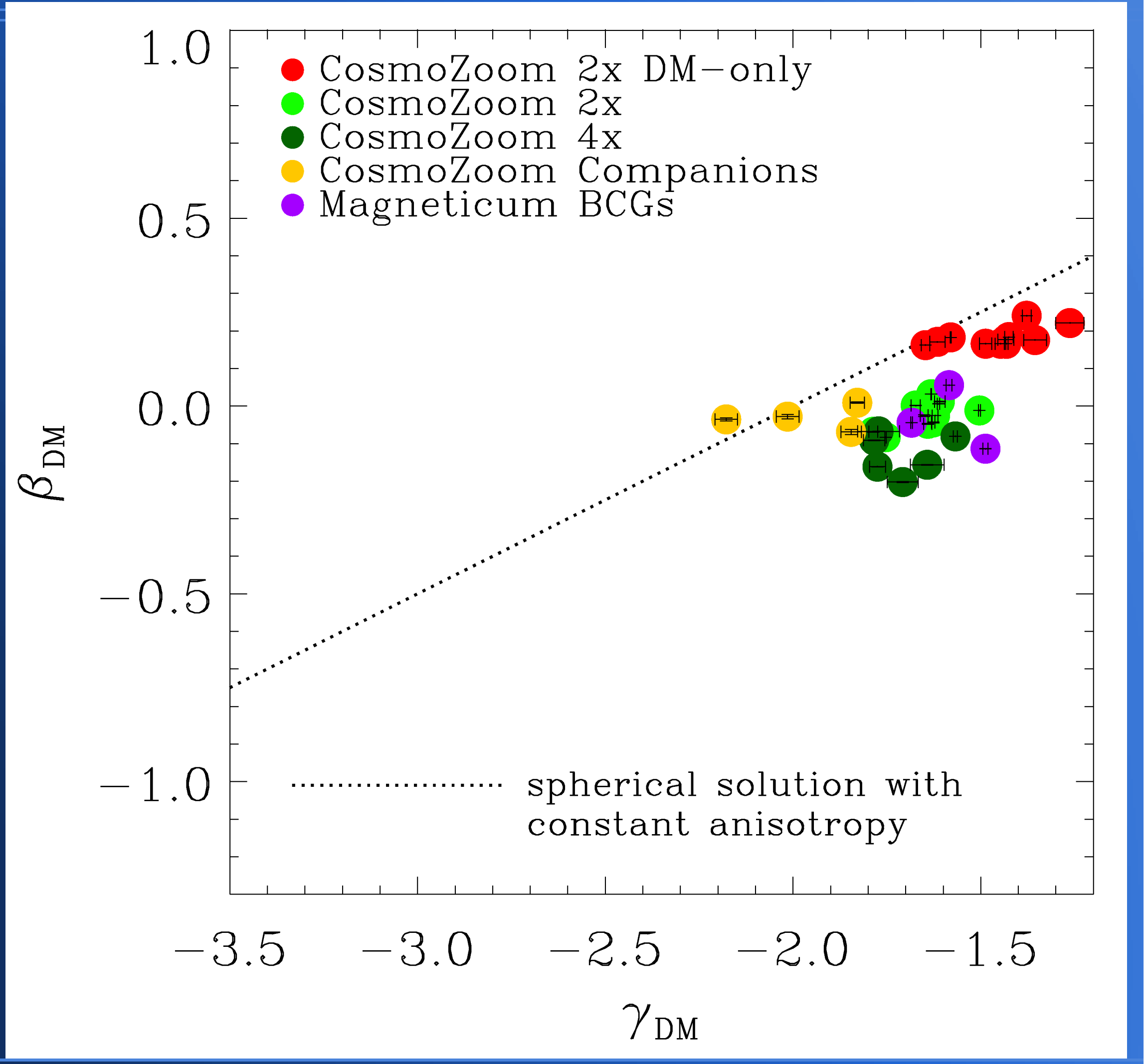
Conspiracy III
Dark Matter

Solution of the Jeans Equation for an isothermal sphere:

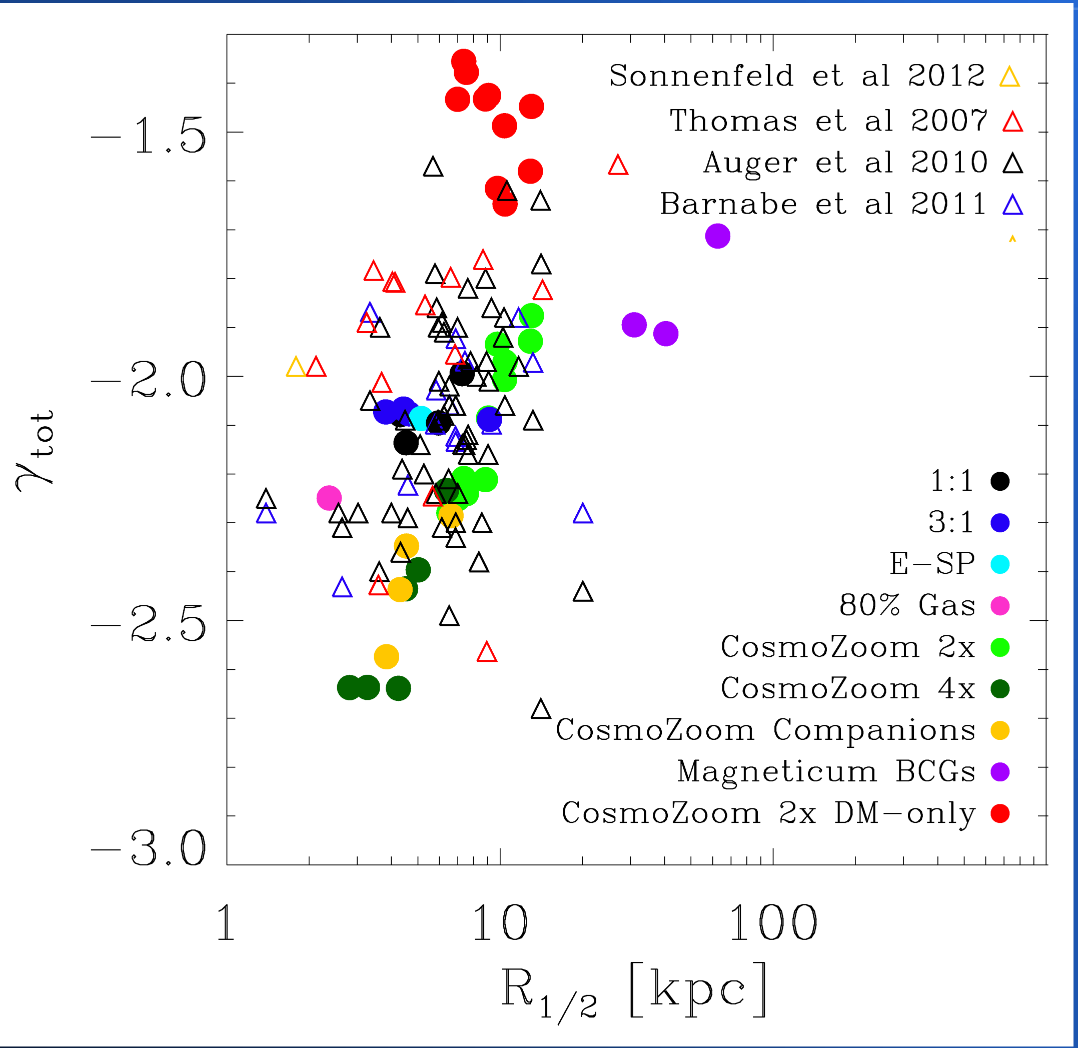
$$\rho(r) = \frac{\sigma^2}{2\pi G r^2}$$

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

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



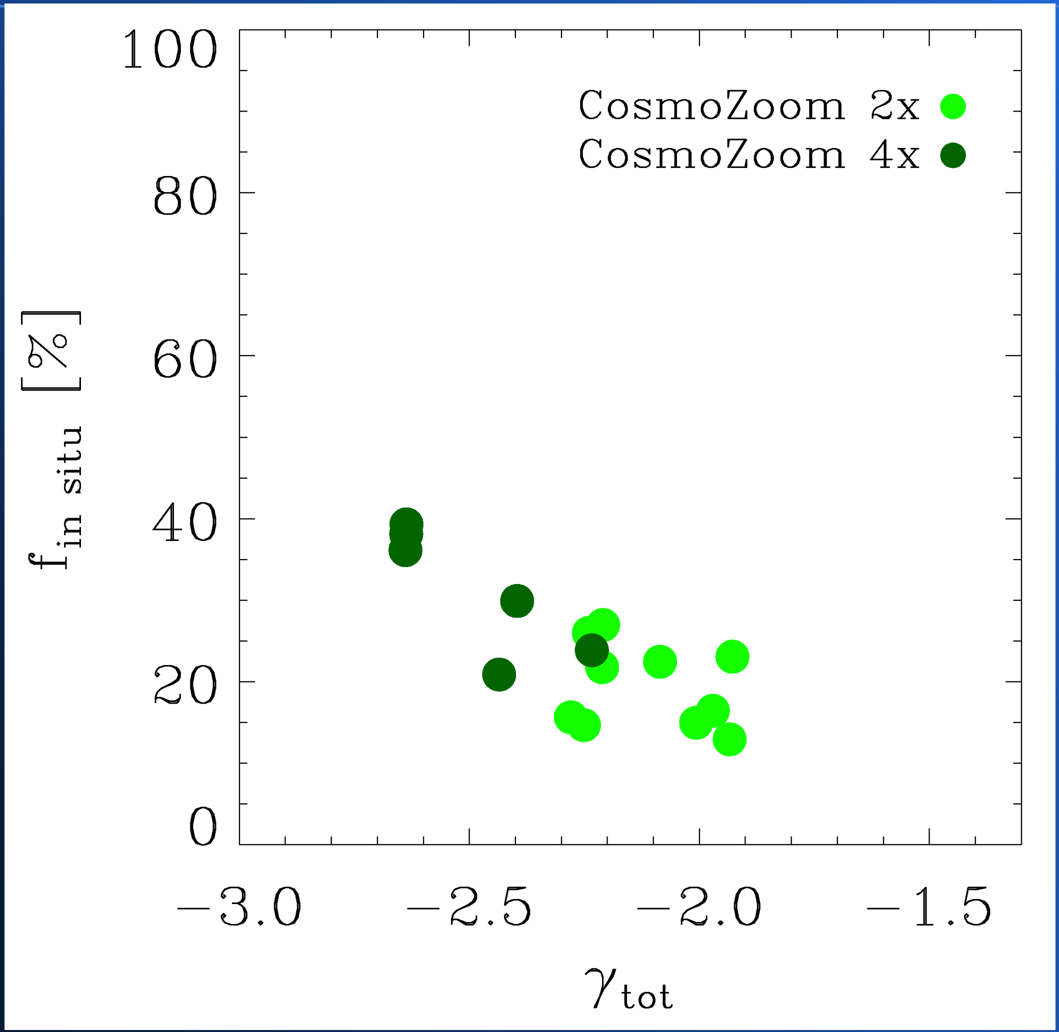
Density Slope versus Size



Remus et al. 2013

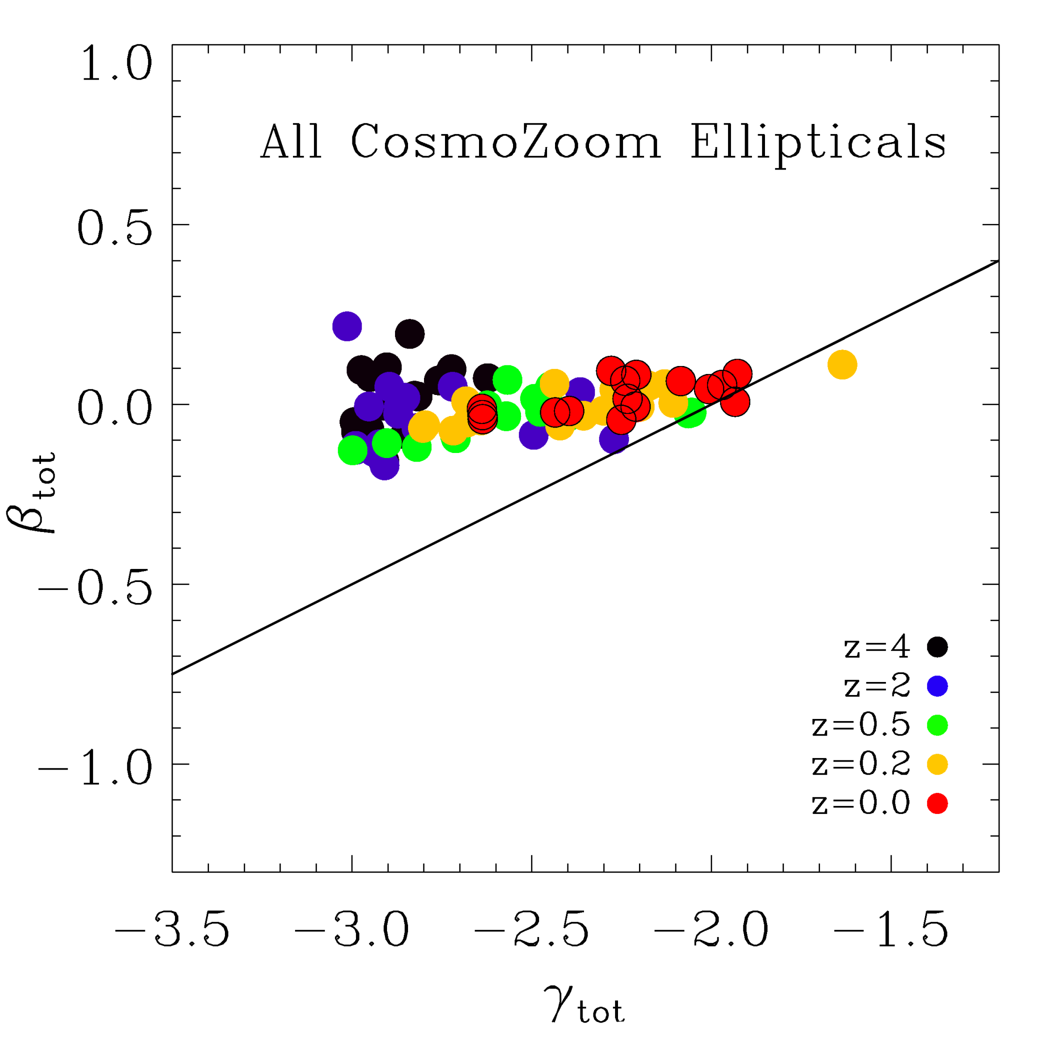
Thomas et al. 2007
Auger et al. 2010
Barnabe et al. 2011
Sonnenfeld et al. 2012

Density slope versus In-situ fraction

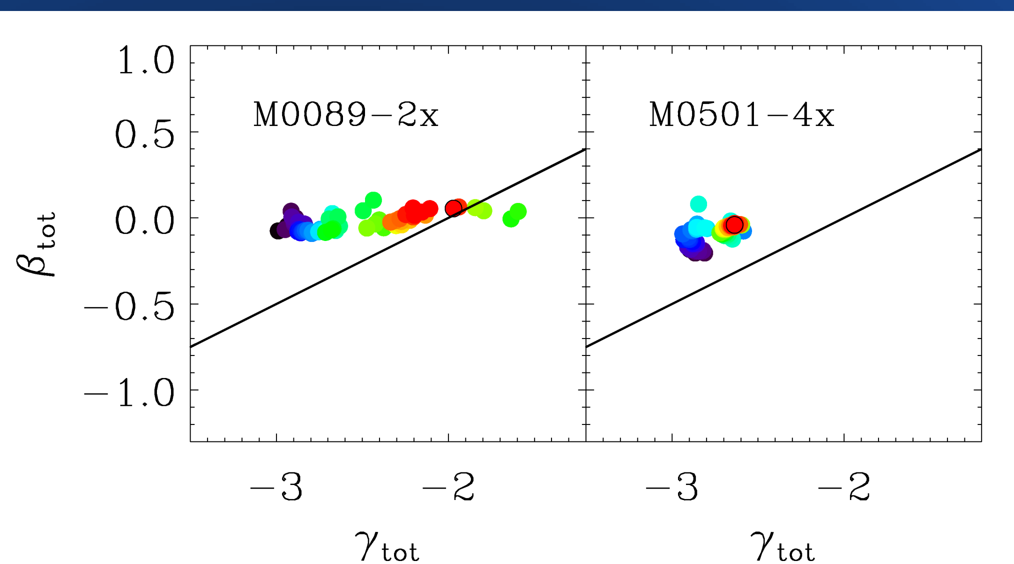


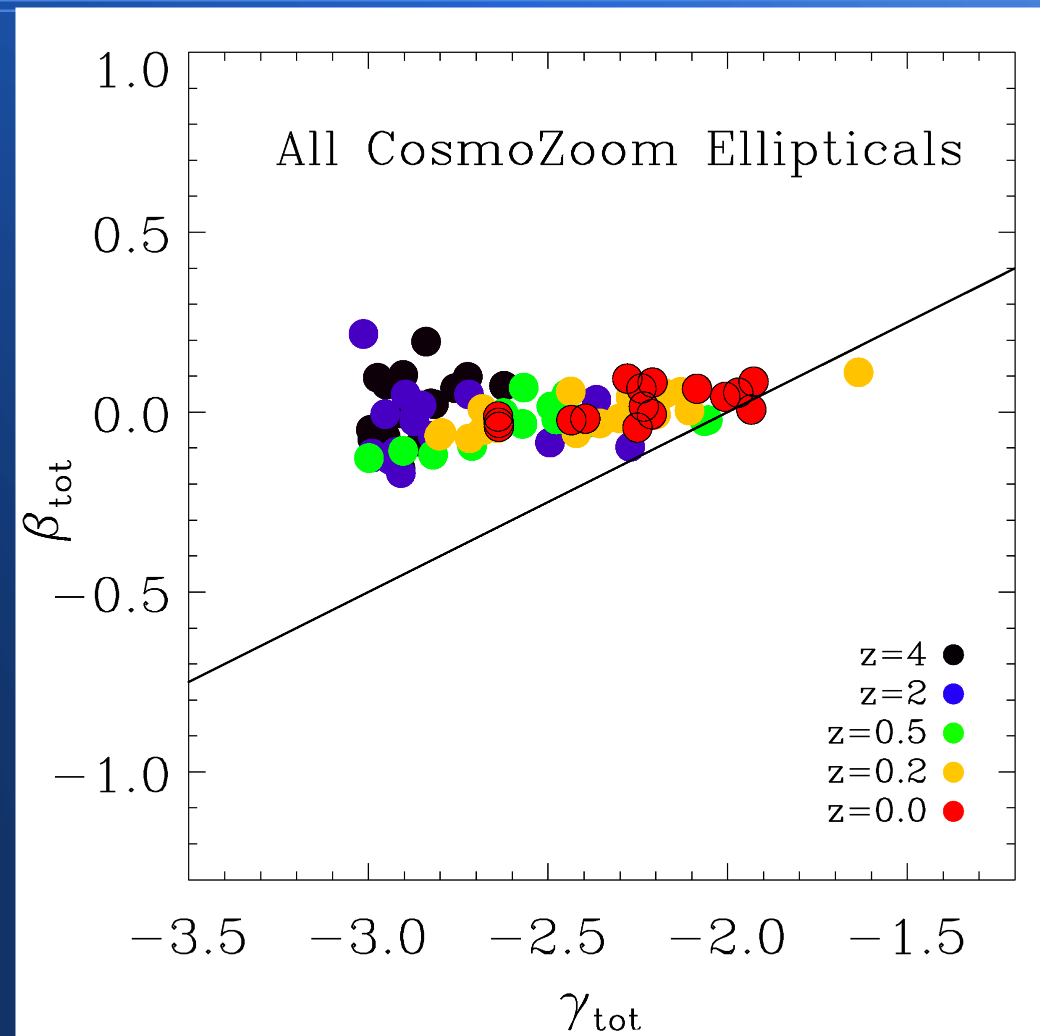
See also Oser et al. 2012 for the in-situ fractions

Evolution with redshift



Evolution with redshift



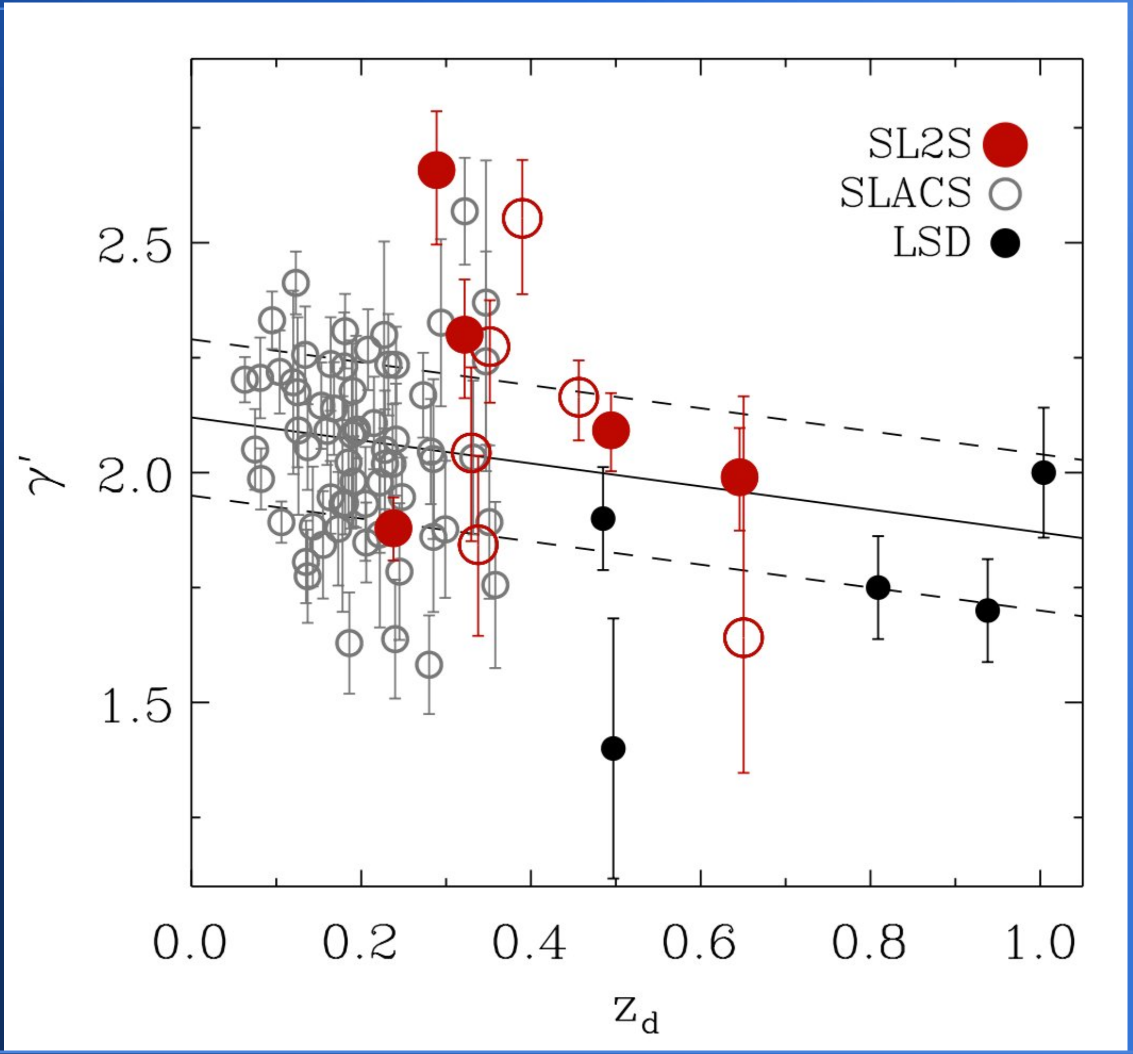


Evolution with redshift - Observations

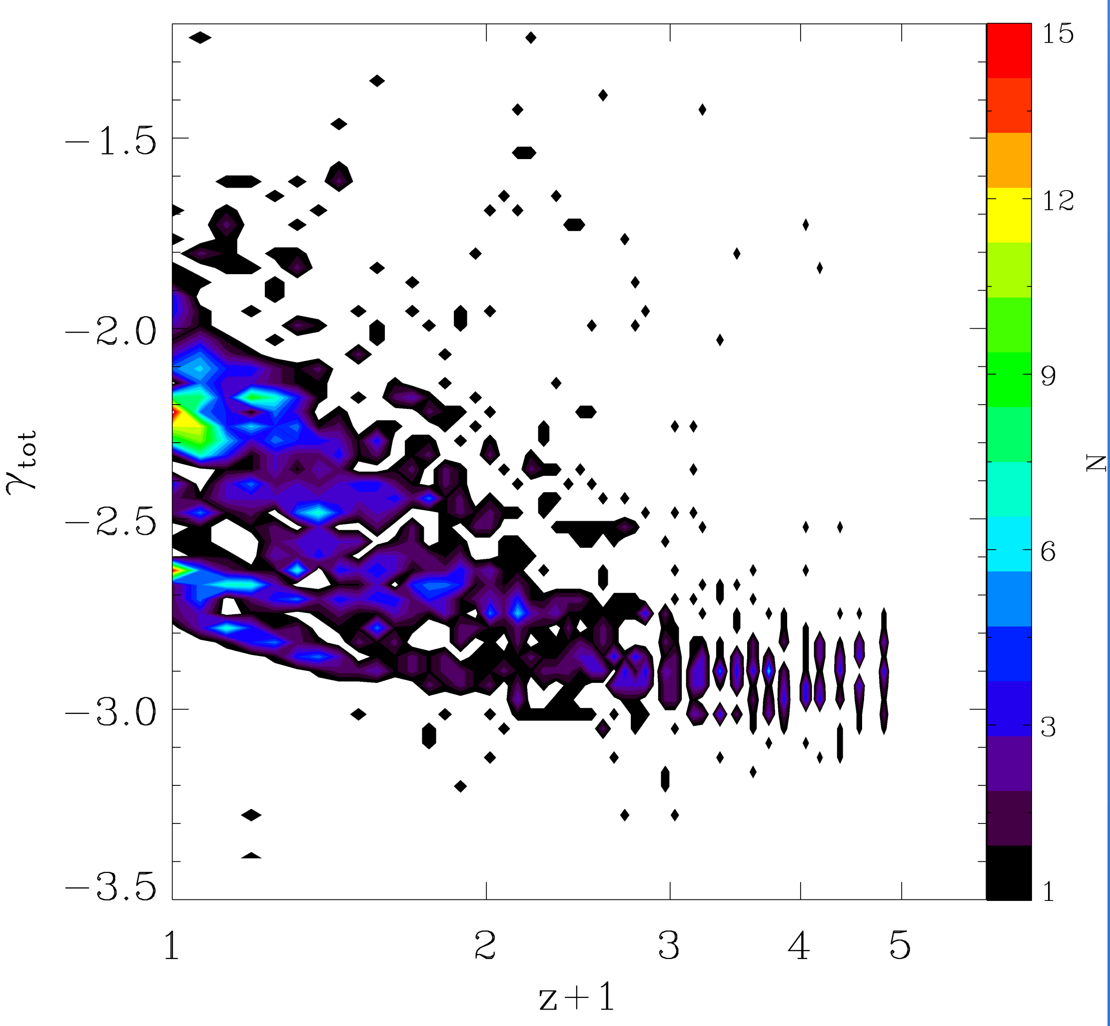
SLACS Survey (Auger et al. 2010, Barnabe et al. 2011):
z=0.063 – 1.071

LSD-Survey (Treu & Koopmans, 2002, 2004, Koopmans & Treu 2003):
z=0.485 – 1.004

SL2S Survey (Ruff et al 2011, Sonnenfeld et al 2013): **z=0.24 - 0.65**

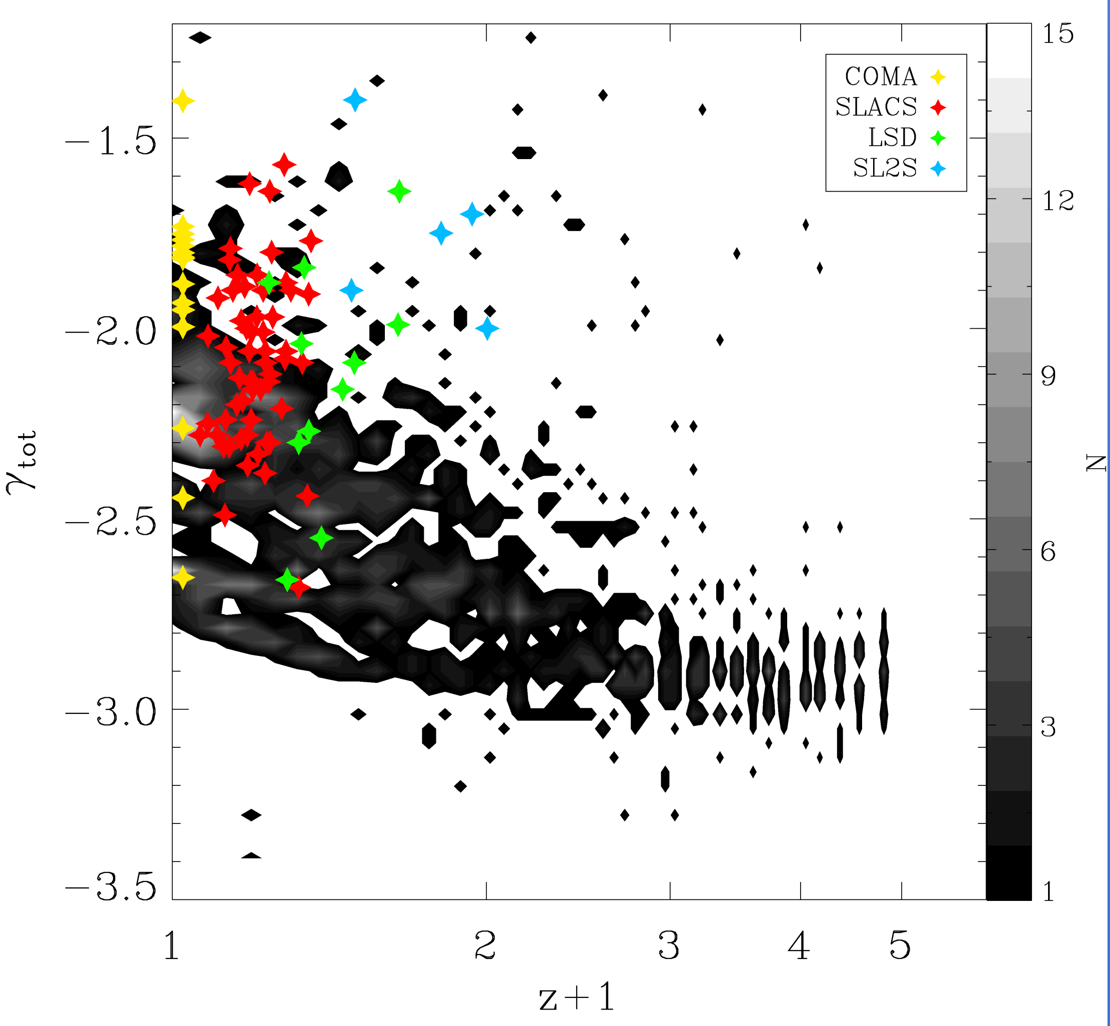


Evolution with redshift



Cosmo-Zoom Spheroidals:
no lower mass cut

Evolution with redshift



Cosmo-Zoom Spheroidals:
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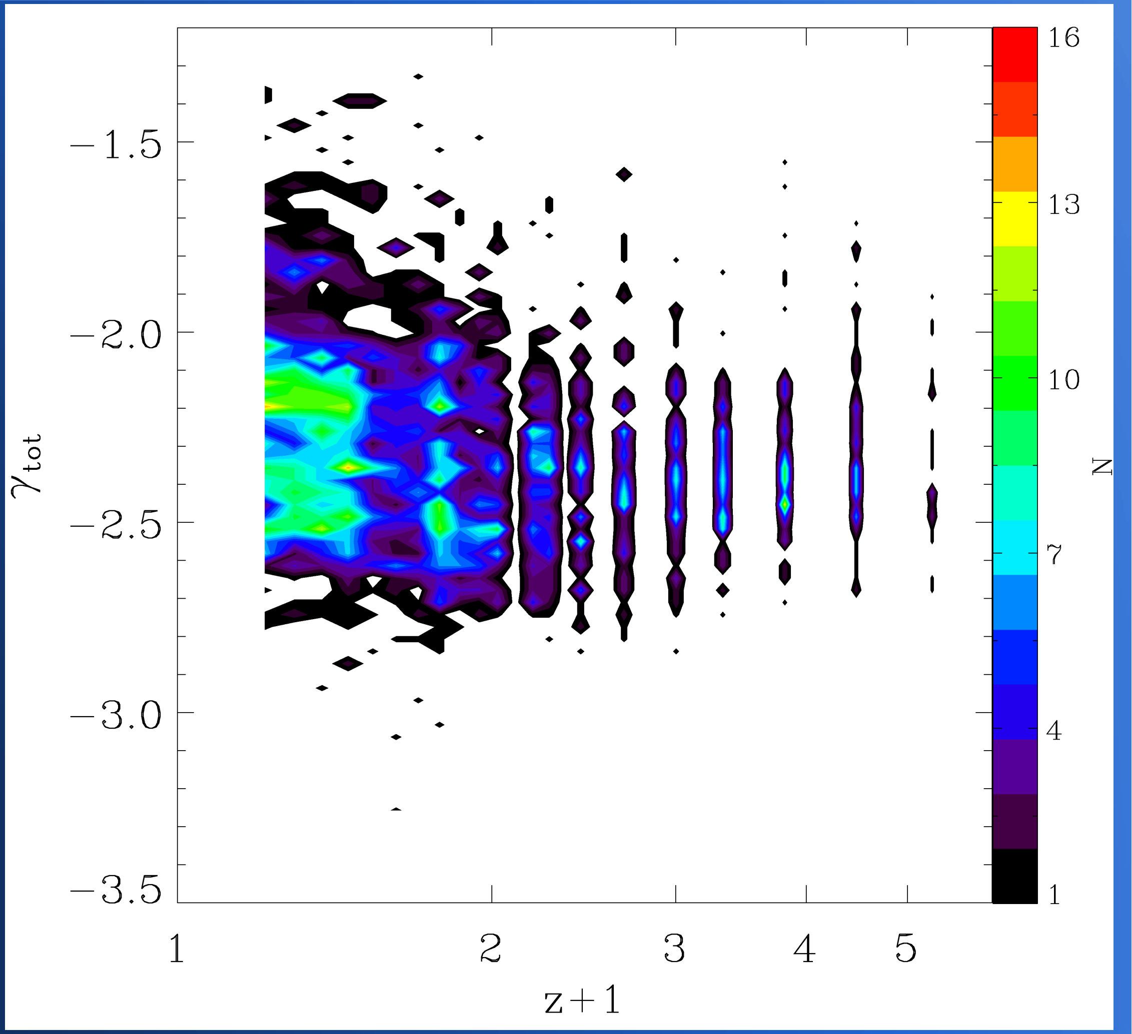
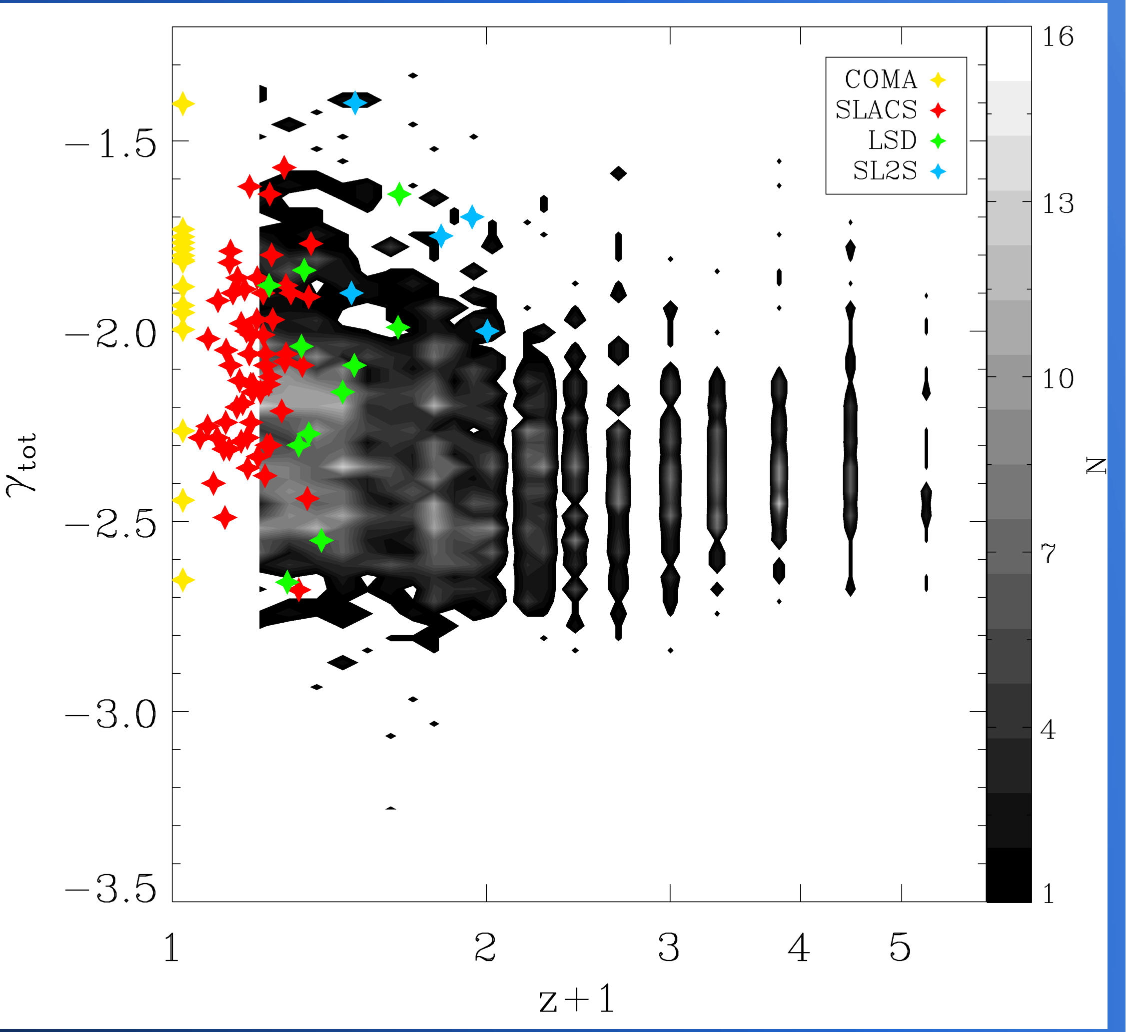


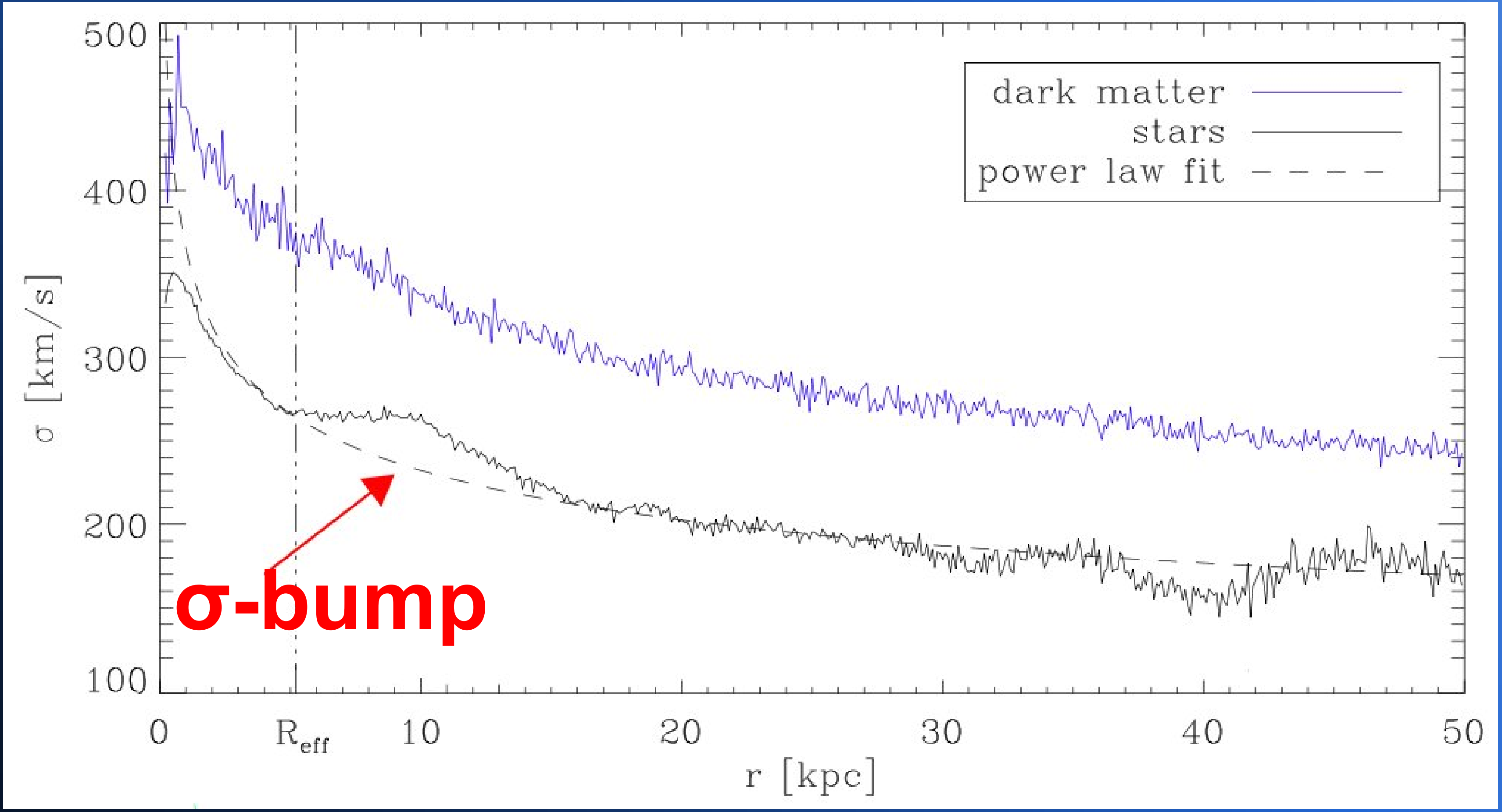
Spheroidals from a full hydrodynamic cosmological simulation: lower mass cut at $M_{tot} = 10^{12} M_{sun}$

Evolution with redshift



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

Poster by A. Schauer: Velocity-Dispersion-Feature



Schauer et al 2014

Conclusions

- The total combined density profiles of speroidal 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 $\gamma \sim -2$.