Conventional And Unconventional Studies & Tools In Cosmology

The CAUSTIC Group

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Current collaborations:

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KIPAC-Stanford

Max-Planck-Institut für Astrophysik
Netherlands Institute for Radio Astronomy
Nicolaus Copernicus Astronomical Center
University of Bonn
University of Edinburgh
University of Strasbourg

Universita' e INAF, Oss. Astron. di Trieste
INAF, Oss. Astron. di Torino

This drawing by Emmanuele Turatti depicts the Mole Antonelliana, the symbol of Torino. Designed by the architect Alessandro Antonelli and built between 1863 and 1889, it was originally conceived to be a synagogue. The Mole now hosts the Italian National Museum of Cinema. With its 167m vertical size, it is one of the tallest stone buildings in Europe. The shape of the Mole resembles the trumpet shape of the caustics observed in the redshift diagram of the infall regions of galaxy clusters.

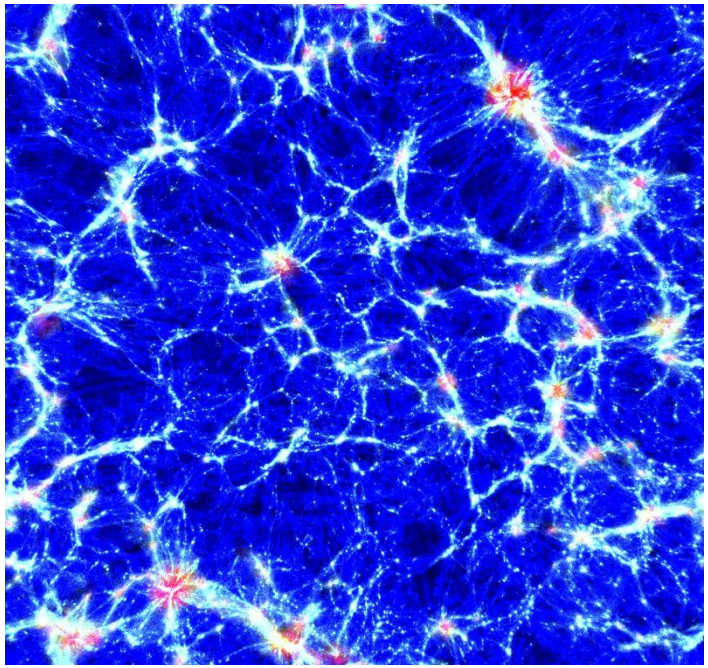
http://www.dfg.unito.it/ricerca/caustic/

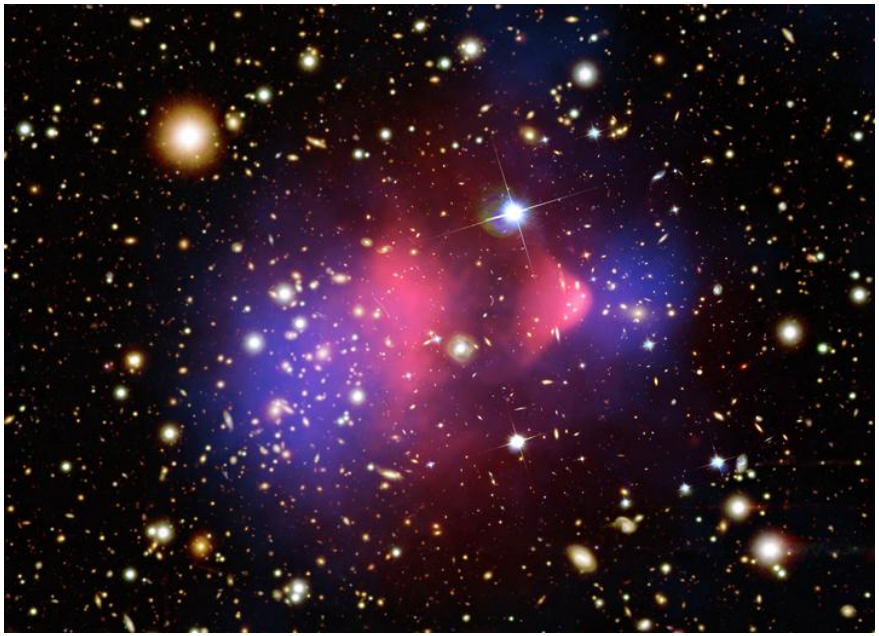
Frascati, June 22, 2010

RESEARCH TOPICS

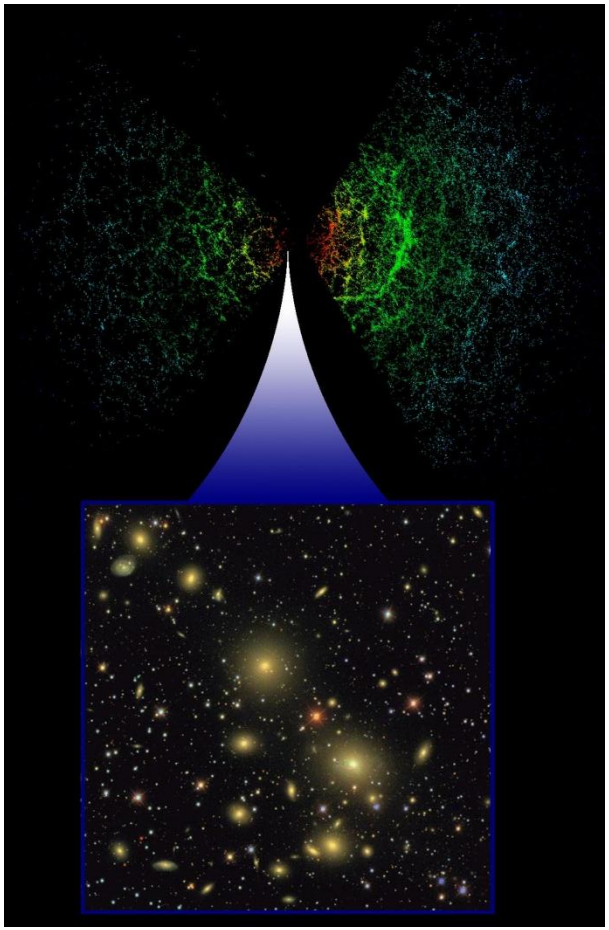
- Large-scale cosmic structures

- Alternative theories of gravity

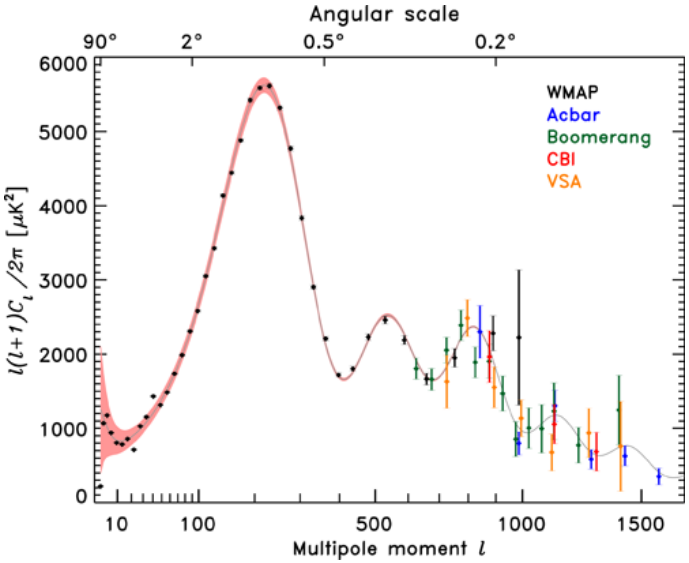


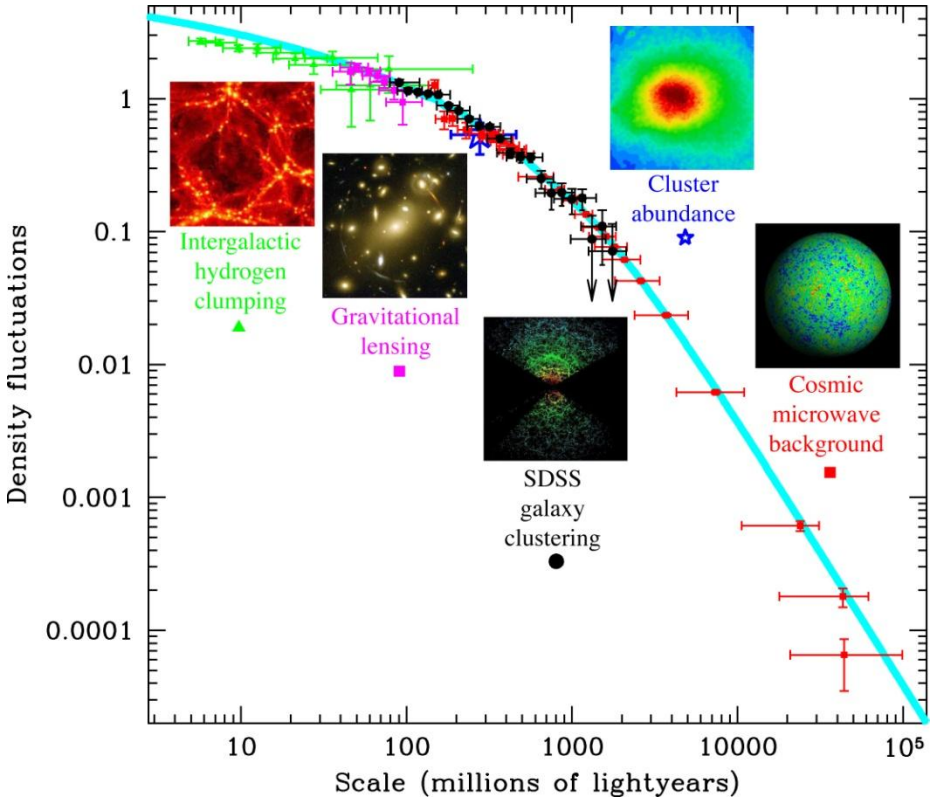


The astrophysics/DM connection



SDSS





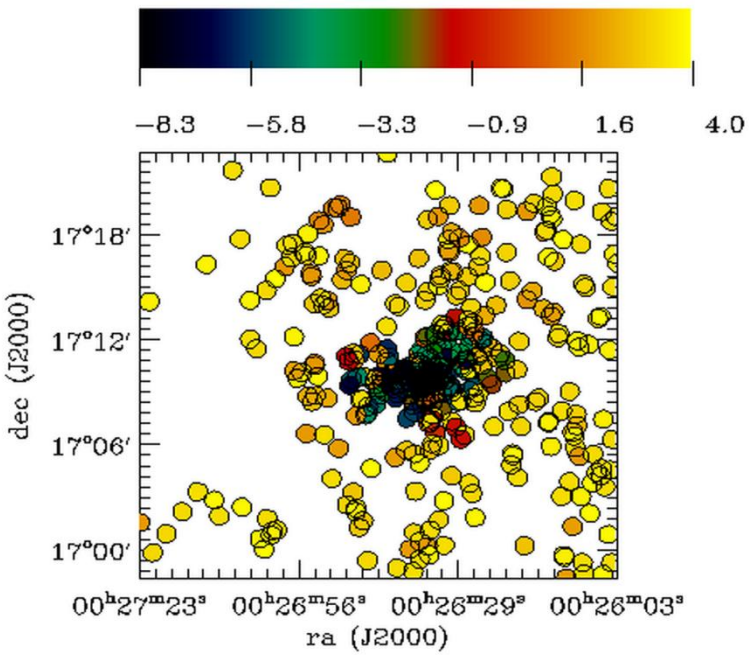
Cosmic structure

THE CAUSTIC METHOD

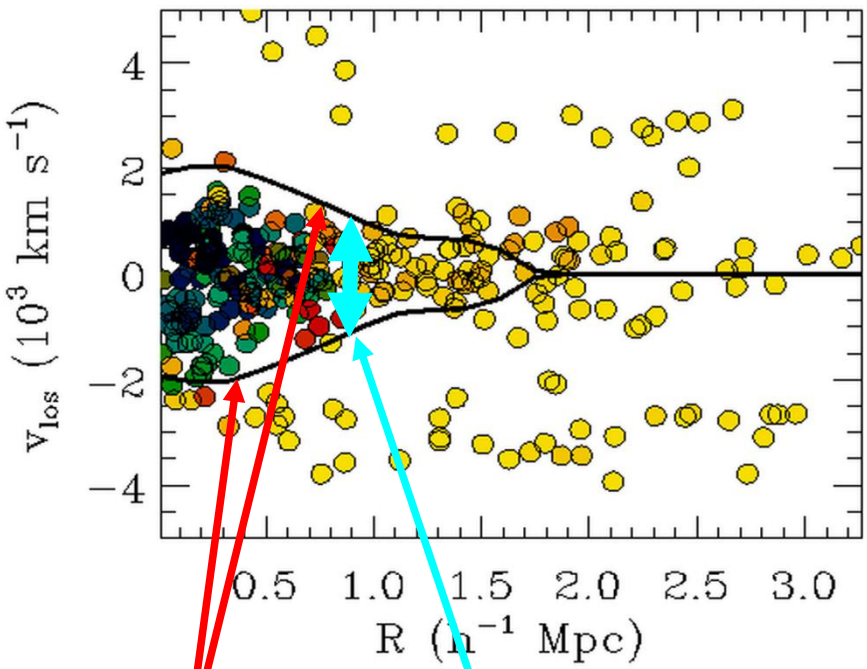
(with. A. L. Serra and I. Davidson)

CL0024

Sky



Redshift diagram



MASS ESTIMATE:

Caustics

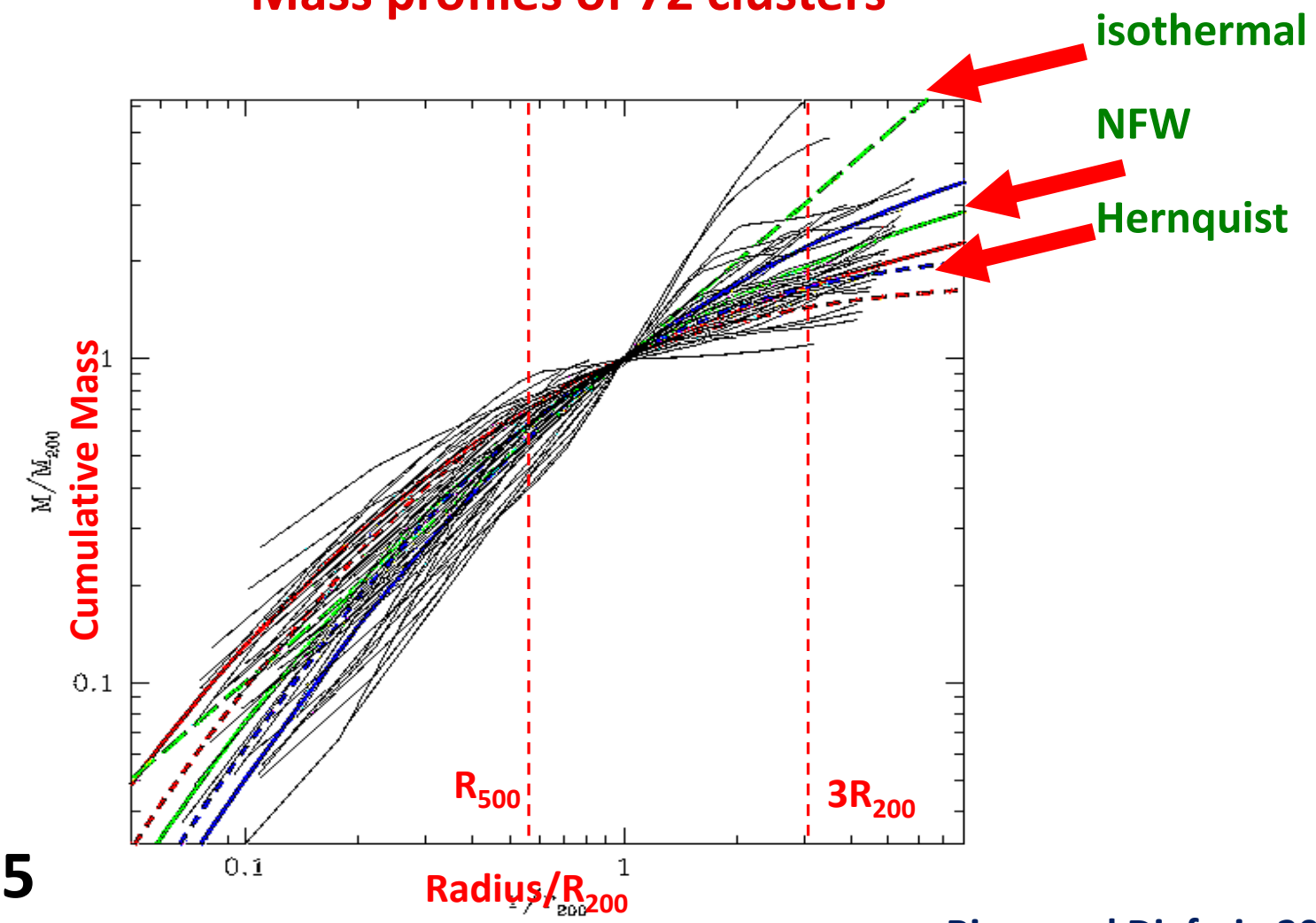
$$GM(<r) = \frac{1}{2}\int_0^r \mathcal{A}^2(x)\,dx$$

Caustic amplitude = escape velocity

(Diaferio & Geller 1997)

CIRS:
Cluster Infall Regions in the SDSS

Mass profiles of 72 clusters

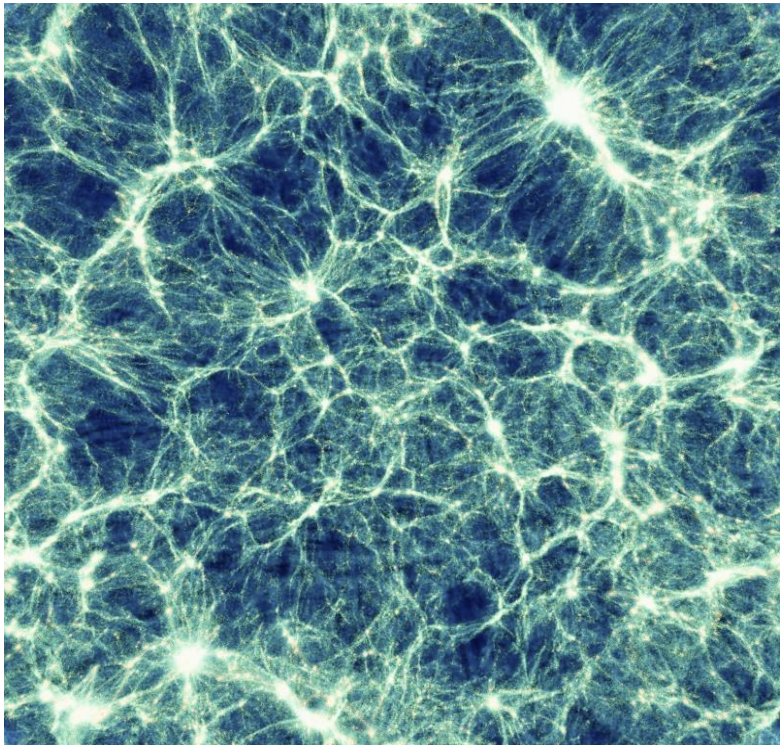


$\Omega_m \sim 0.25$

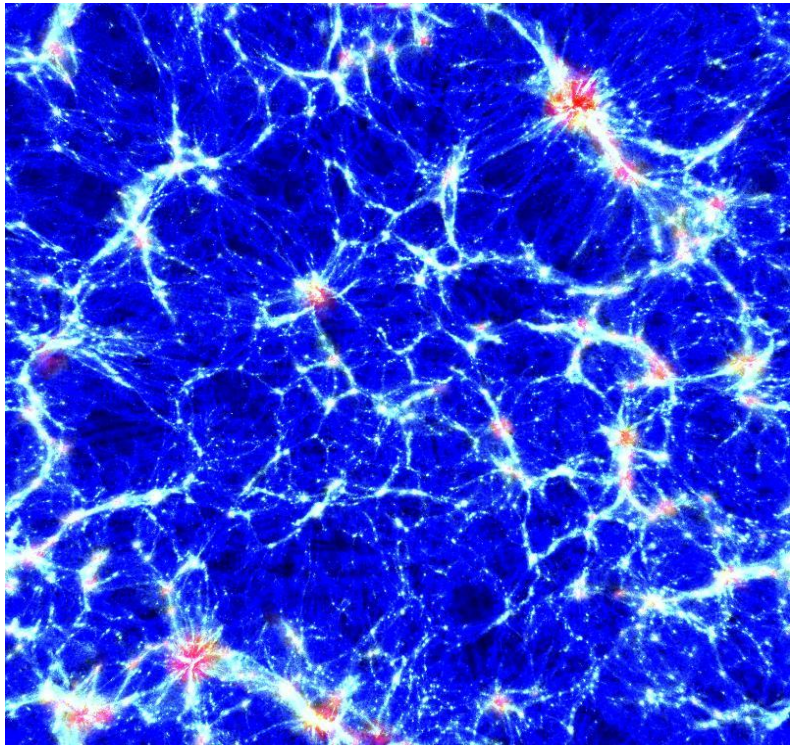
Rines and Diaferio 2006

SIMULATIONS WITH ORDINARY (BARYONIC) MATTER: Diffuse IGM and Galaxies

N-body/hydro-simulations



gas density

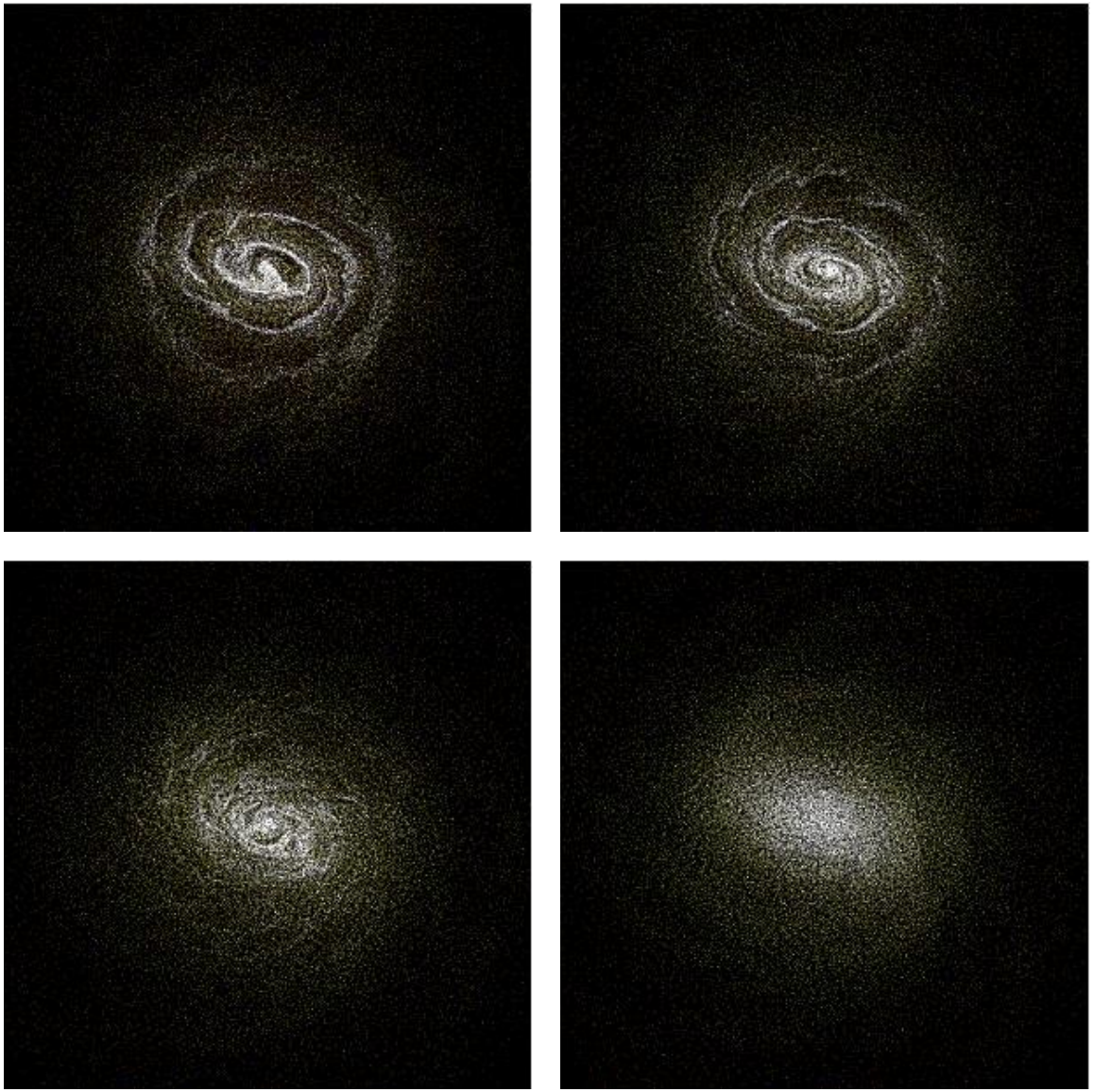


gas temperature

Borgani et al. 2004

Energy feedback algorithm in N-body simulations: MUPPI

narrow cone feedback emission



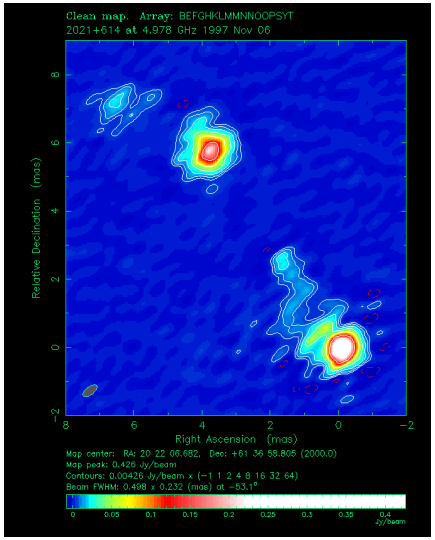
Gas distribution in a MW-like galaxy

isotropic feedback emission

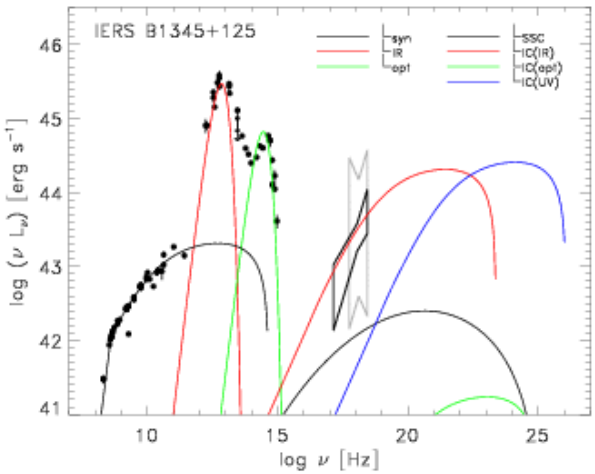
Murante et al 2010

Energy Feedback:
GPS (Young Radio) GALAXIES
and the site of the energy release:
Nuclear or radio lobes?

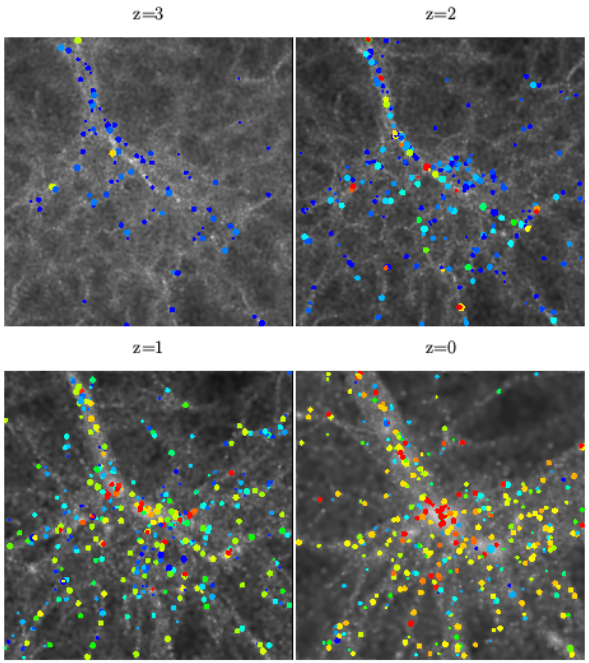
(with L. Ostorero)



SED

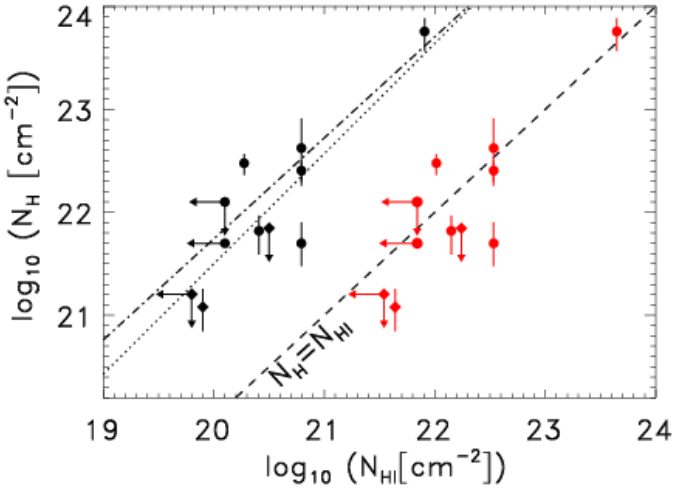


DM+Galaxies
(semi-analytic modelling)



Diaferio et al. 1999 (GIF sims.)

NH-NHI correlation



Ostorero et al. 2010

Cosmic structure
in alternative theories of gravity

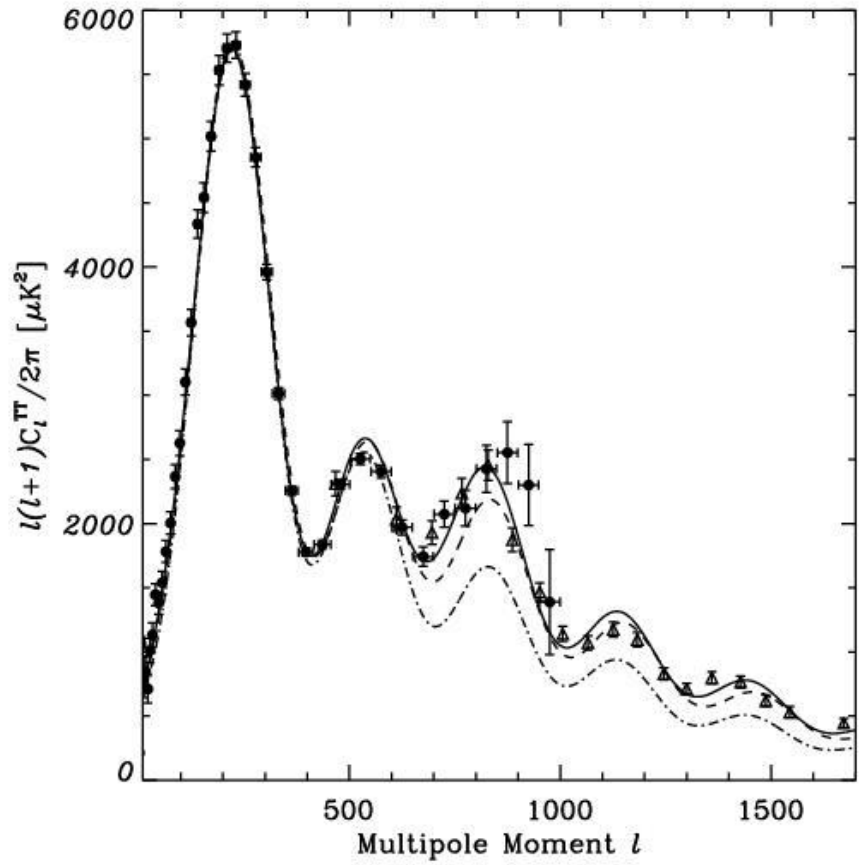
- MOND
- Conformal gravity

The case of a modified
MOdified Newtonian Dynamics:
MOND + 11 eV sterile neutrinos

$$\nabla\cdot[\nabla\phi\ \mu(|\nabla\phi|/a_0)]=4\pi G\rho$$

$a_0 = 1.2\times10^{-10}$ m s^{-2}

(Milgrom 1983)

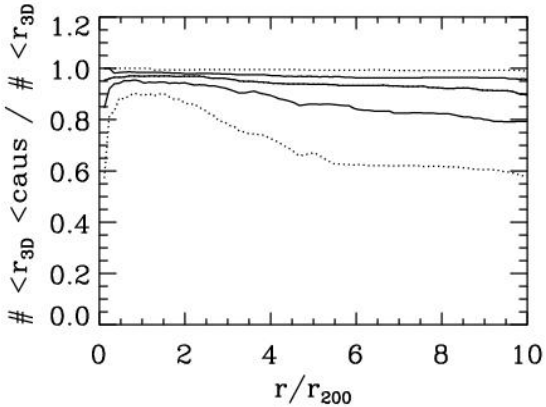


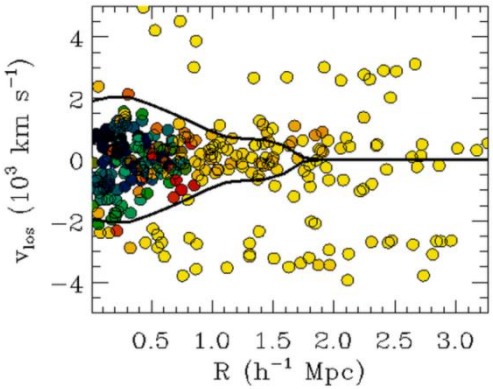
(Angus 2009)

Dwarf galaxies in MOND+11eV ν's

(The caustic technique as a member identifier)

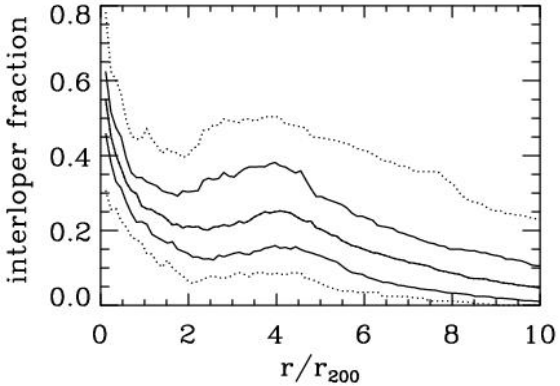
Fraction of real members within the caustics





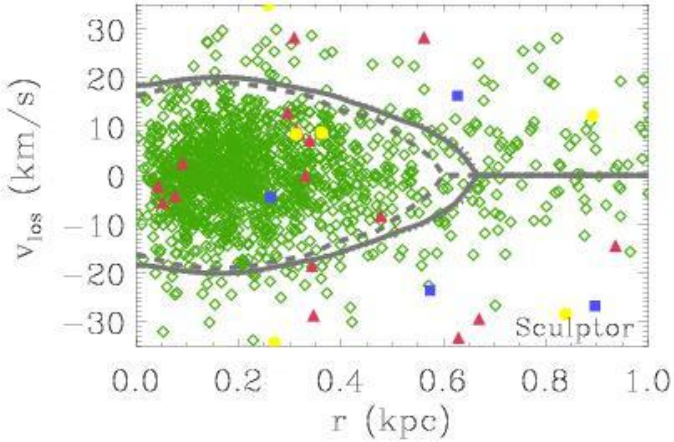
Serra et al. 2010

Fraction of interlopers within the caustics

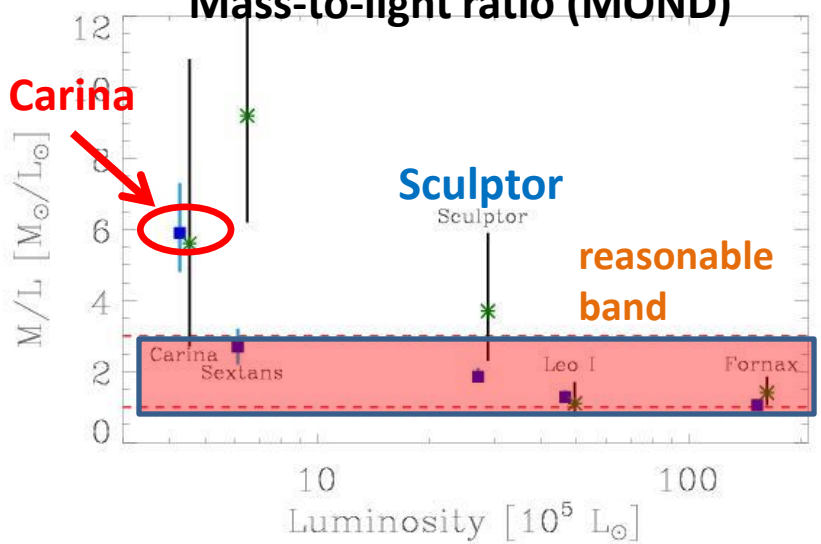


It also applies to stars in dwarf galaxies…

Sculptor

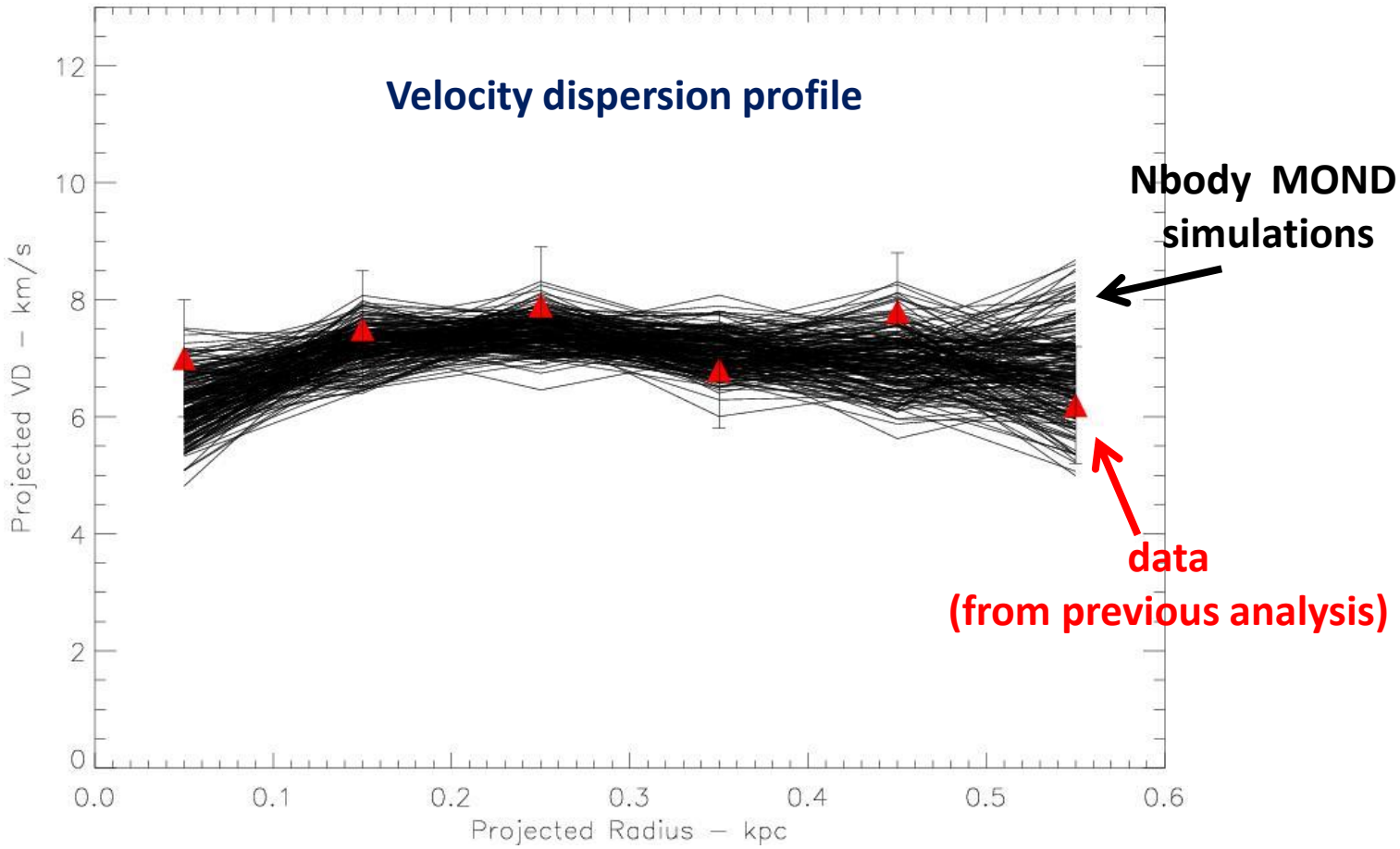


Mass-to-light ratio (MOND)



Serra, Angus & Diaferio 2010

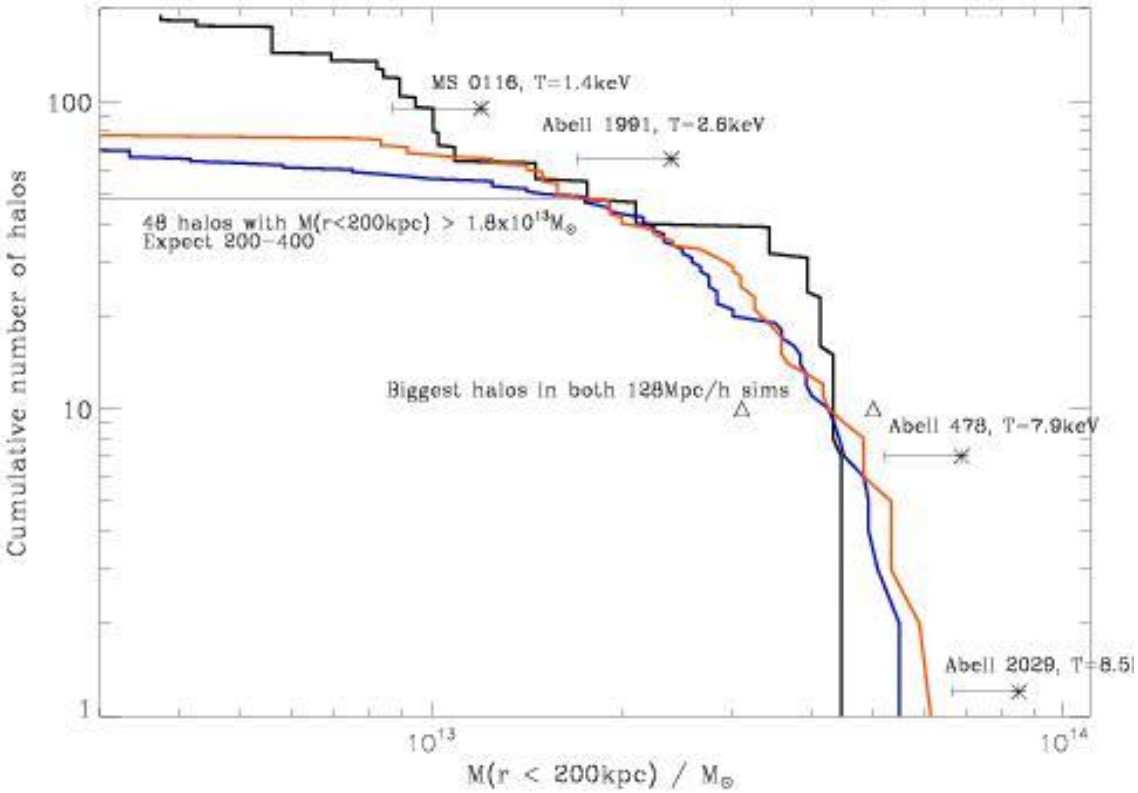
Carina dSph: The only MOND failure out of 5



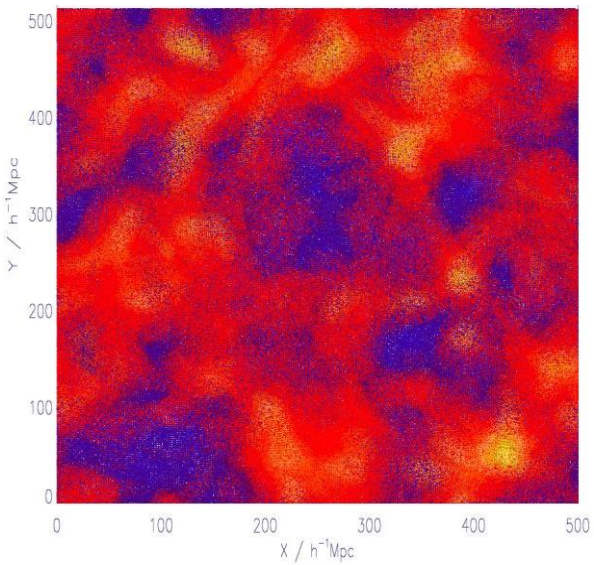
Good fit only with mass-to-light ratio M/L ~ 6 solar units

LSS N-body simulations in a MOND+11eV ν's cosmology

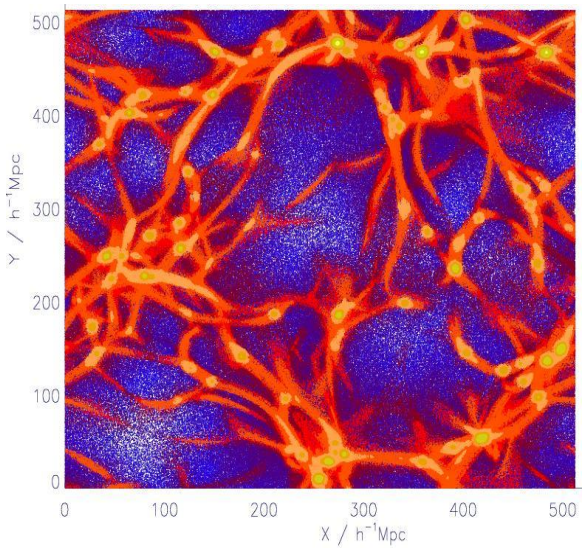
Cluster abundance



Standard gravity



MOND



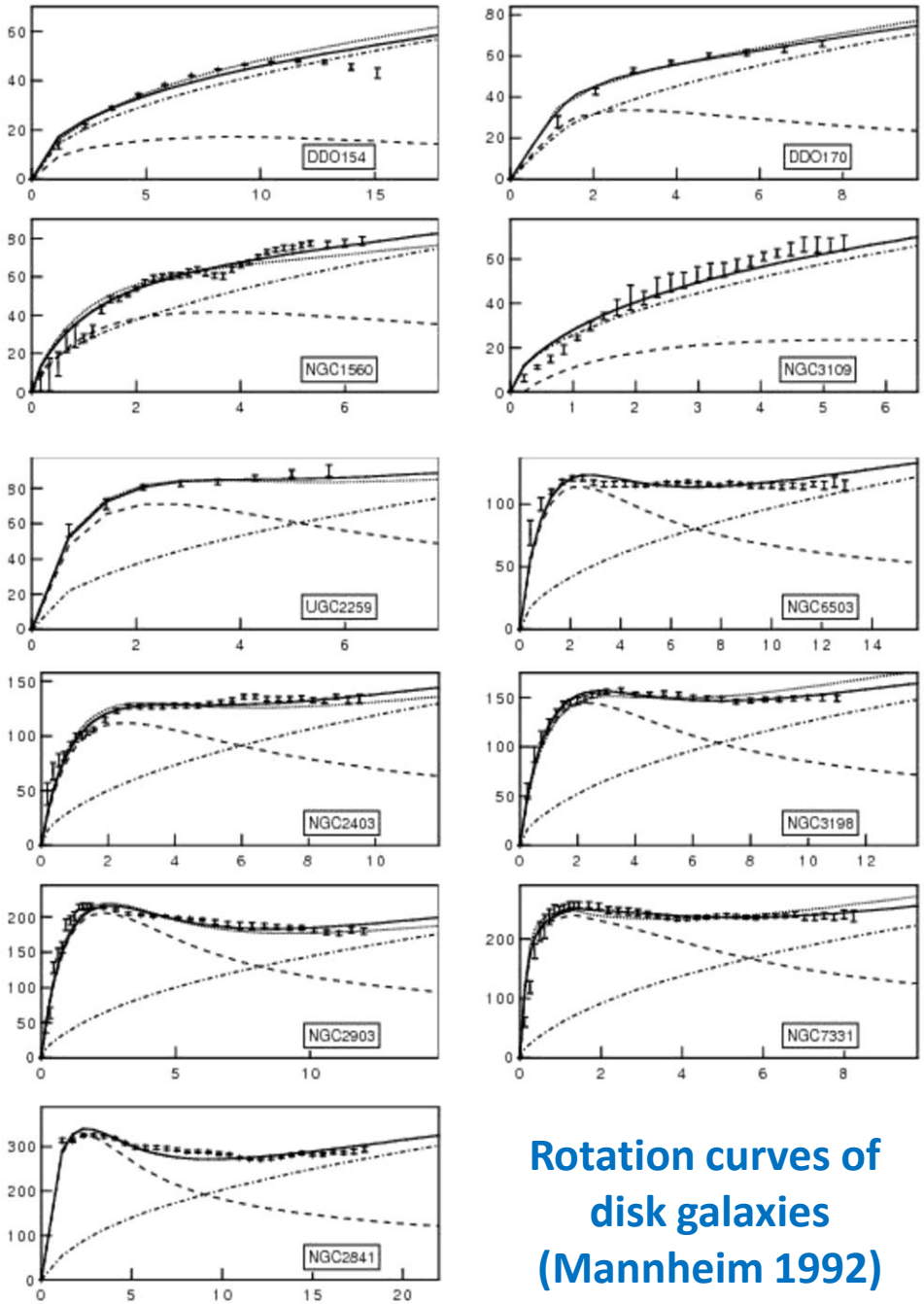
CONFORMAL GRAVITY (with. L. Ostorero and E. Boera)

action $$I_W = \alpha \int C_{\mu\nu\lambda\kappa} C^{\mu\nu\lambda\kappa} (-g)^{1/2} d^4x \qquad g_{\mu\nu}(x) \to \chi^2(x) g_{\mu\nu}(x)$$

metric $$ds^2 = \chi^2(r)[-B(r)c^2dt^2 + A(r)dr^2 + r^2 d\Omega]$$

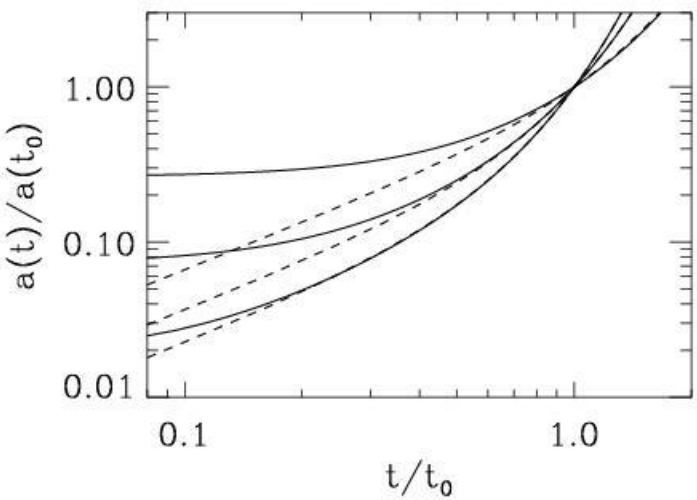
geodesic equation $$\frac{A(r)}{B^2(r)}\left(\frac{dr}{cdt}\right)^2 + \frac{J^2}{r^2} - \frac{1}{B(r)} = -\frac{E}{c^2}\chi^2(r)$$

Mannheim 1992



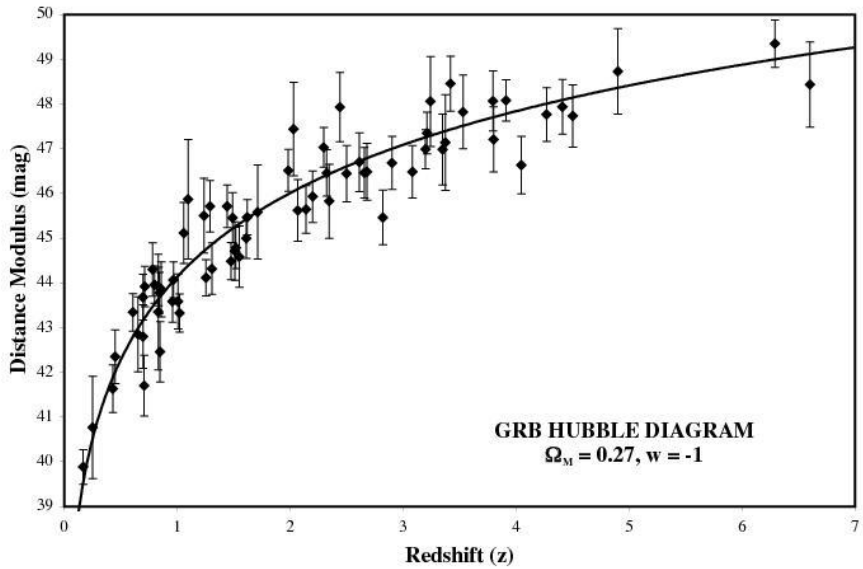
Rotation curves of disk galaxies (Mannheim 1992)

Accelerated expansion at all times



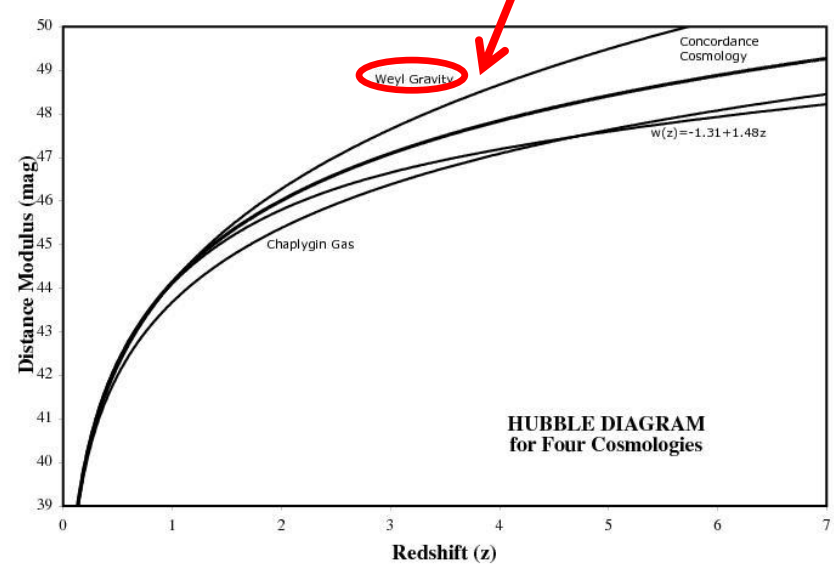
Possible drawback?

The GRB Hubble diagram



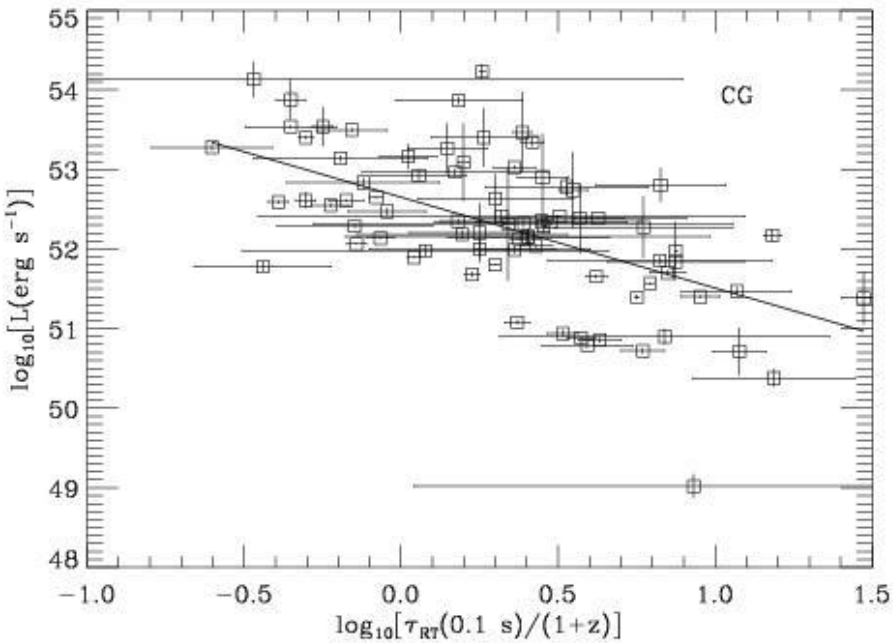
ΛCDM model

Conformal gravity



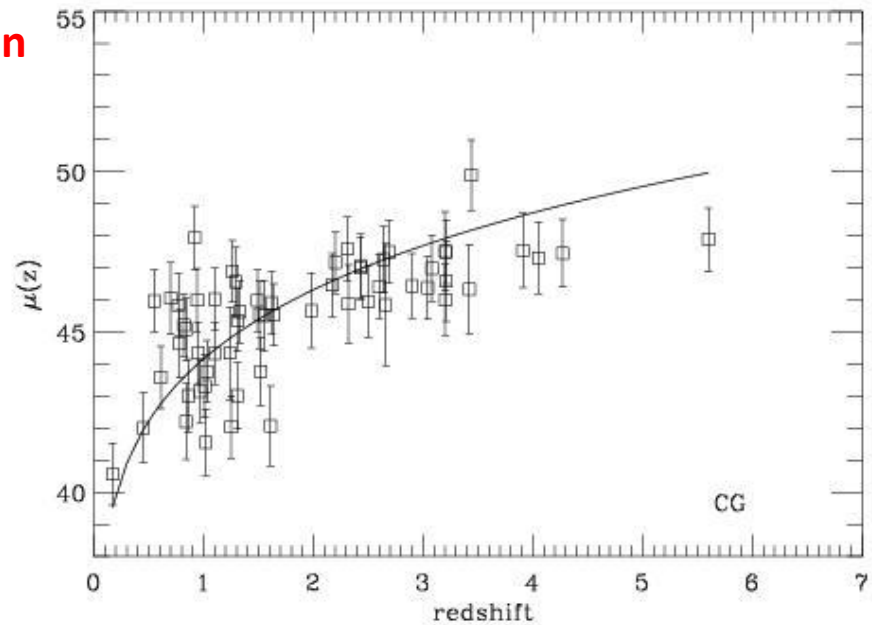
Schaefer 2007

The GRB procedure



Luminosity vs. rise time calibration

The resulting Hubble diagram



The SNIa calibration

for each SNIa

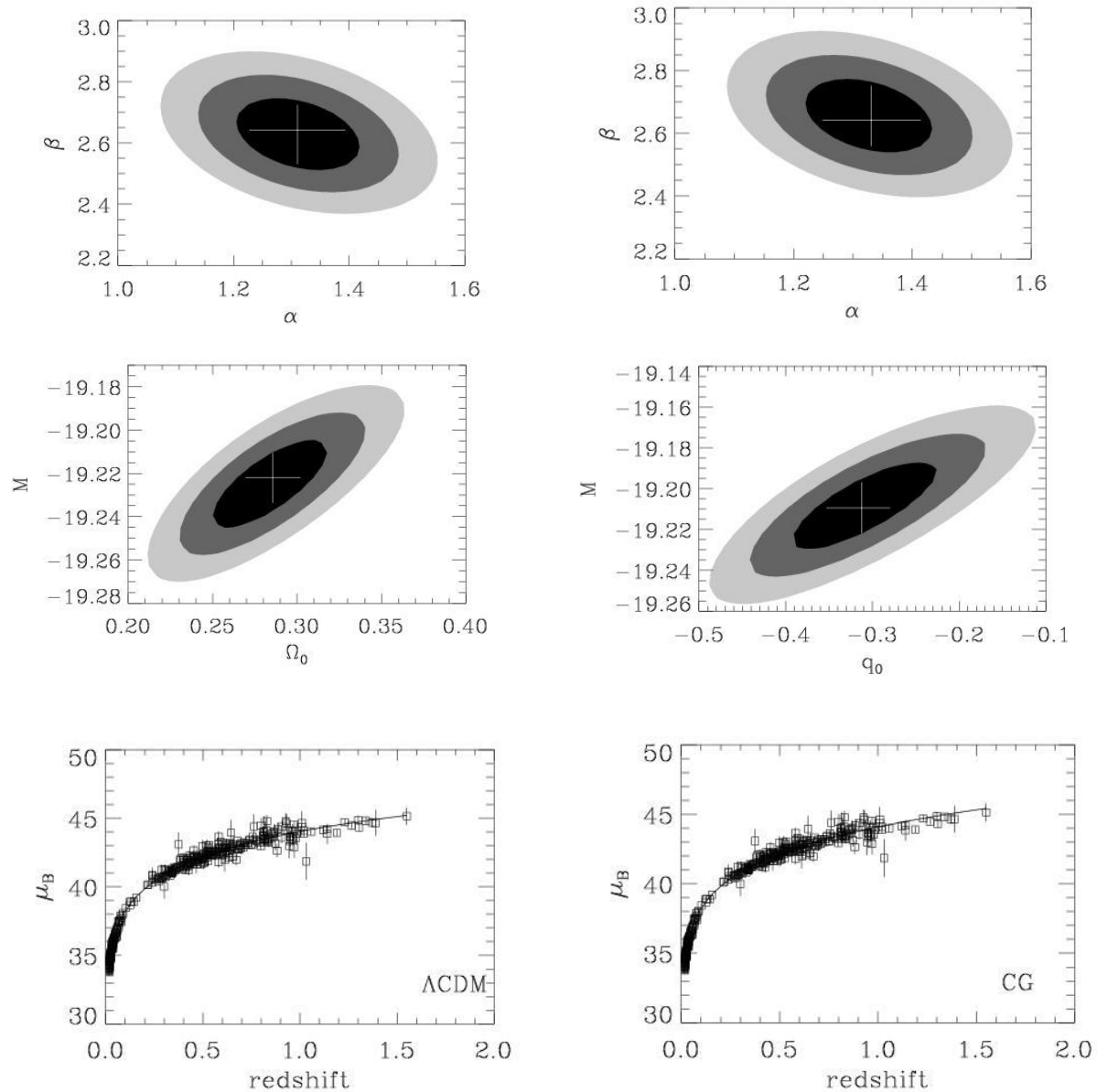
$$\mu_B = m_B - M + \alpha(s-1) - \beta c$$

M, α, β
and
the cosmological parameters {p}
by minimizing

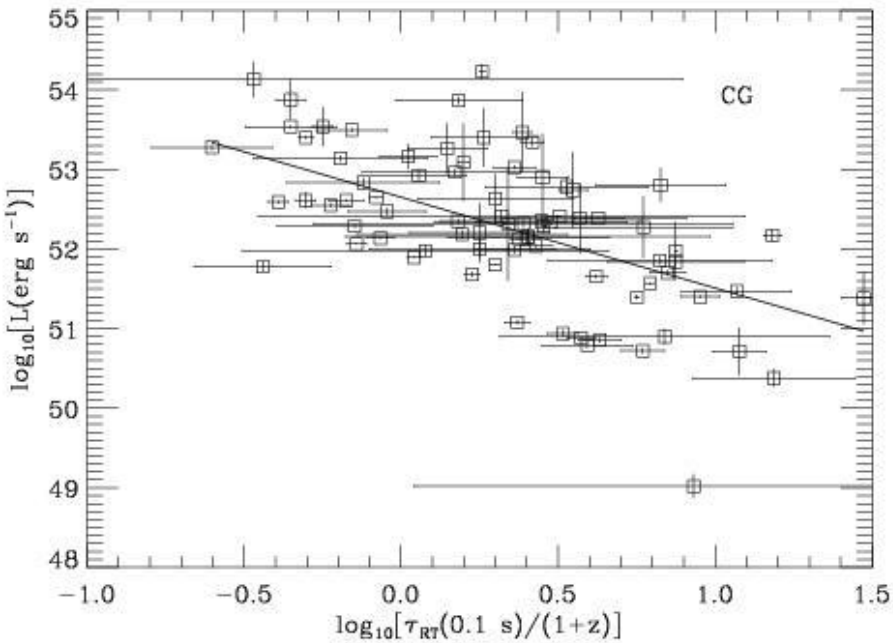
$$\chi^2 = \Sigma[m_B - m(p)]^2/\sigma^2$$

ΛCDM

Conformal gravity

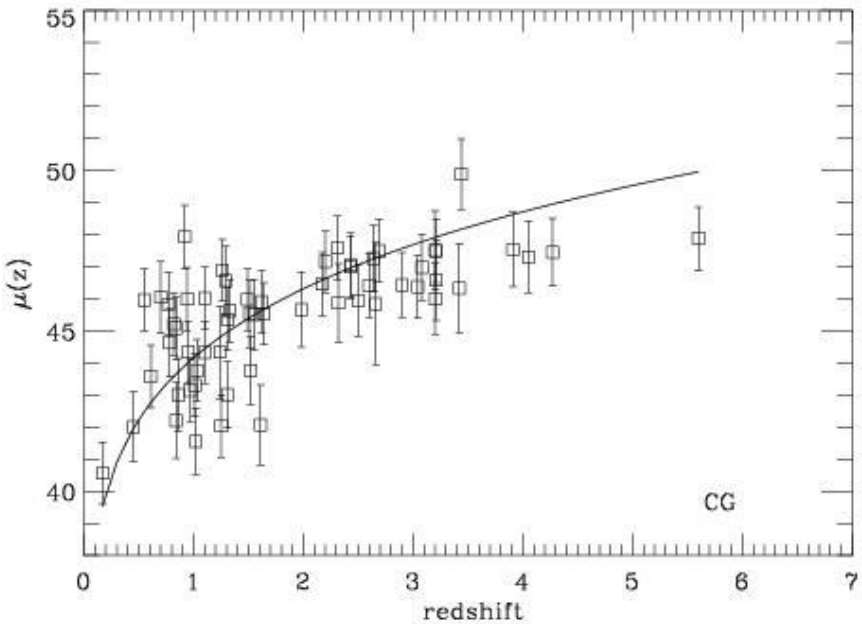


The GRB procedure



Luminosity vs. delay calibration

The resulting Hubble diagram



Ongoing/future projects

- Evolution of matter power spectrum in MOND+11eV ν's
- Weak lensing power spectrum in more alternative theories
- Linear theory of density perturbations in conformal gravity (SW and ISW)
- Mass and galaxy distribution around clusters with the caustic method
- Further investigation of AGN feedback
- More…