Galaxies and Clusters, 3

The Large scale Structure of the Universe

Alain Blanchard

alain.blanchard@irap.omp.eu

3D surveys

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1990: CfA slice ~ 2000 galaxies

3D surveys

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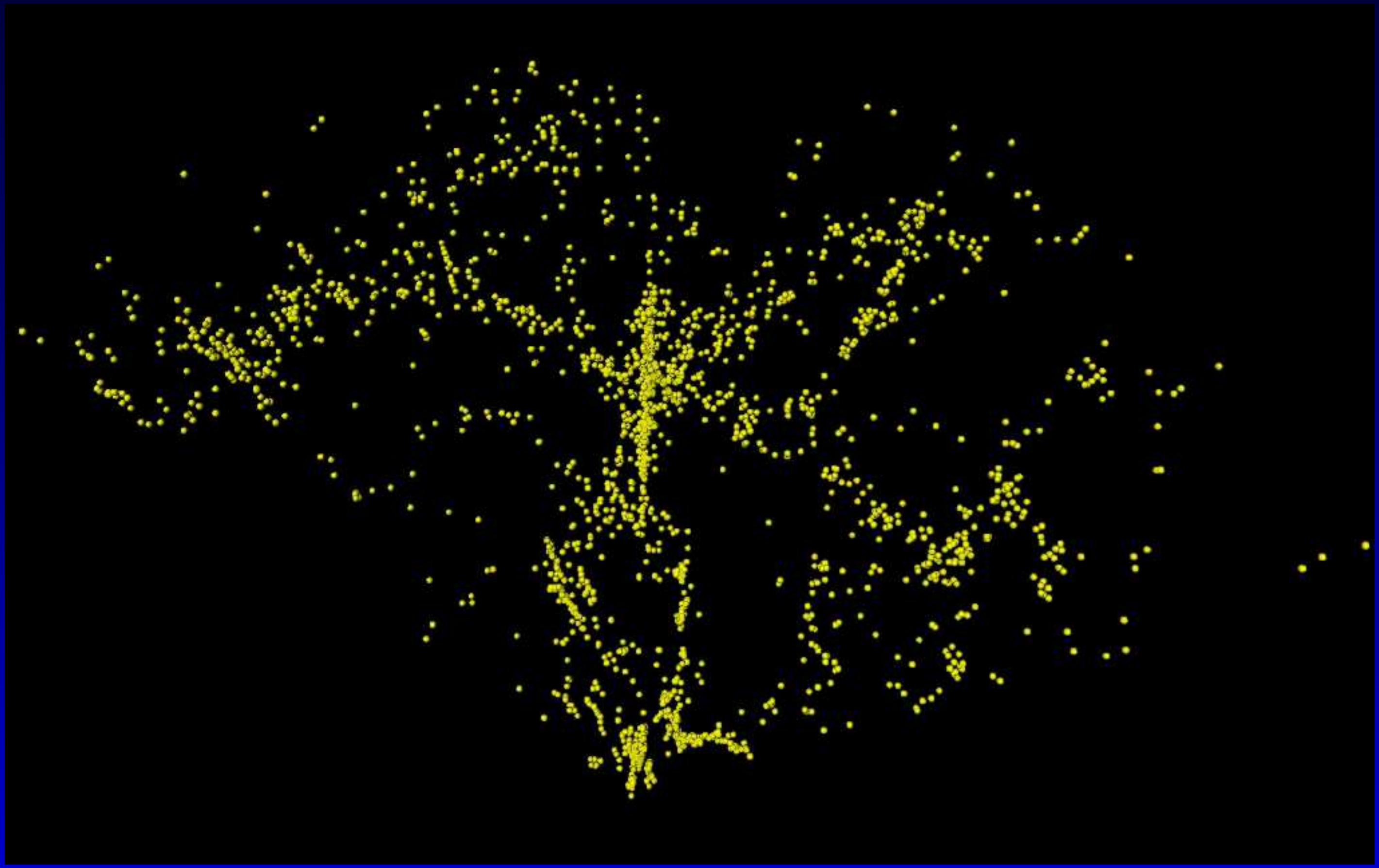

$$v = H_0 D + v_{pec} \cos(\theta)$$

Clusters: a tool for cosmologists

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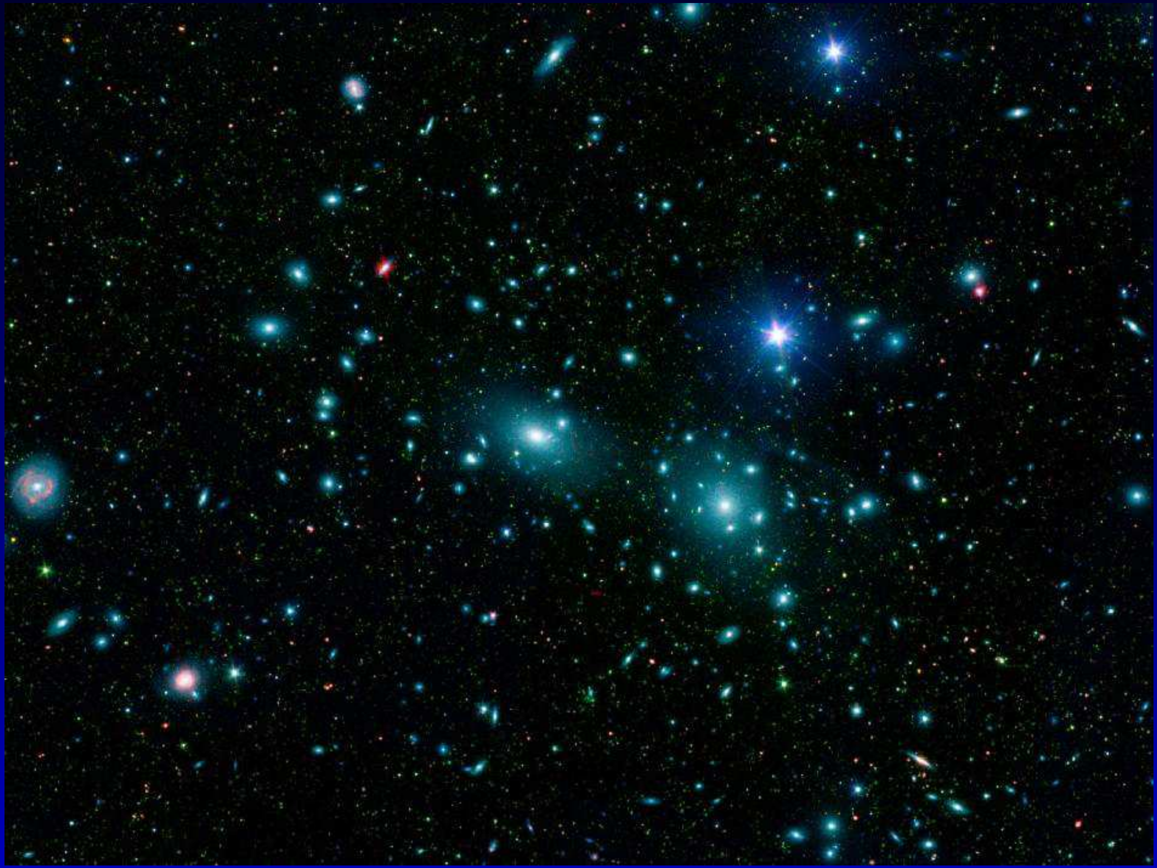

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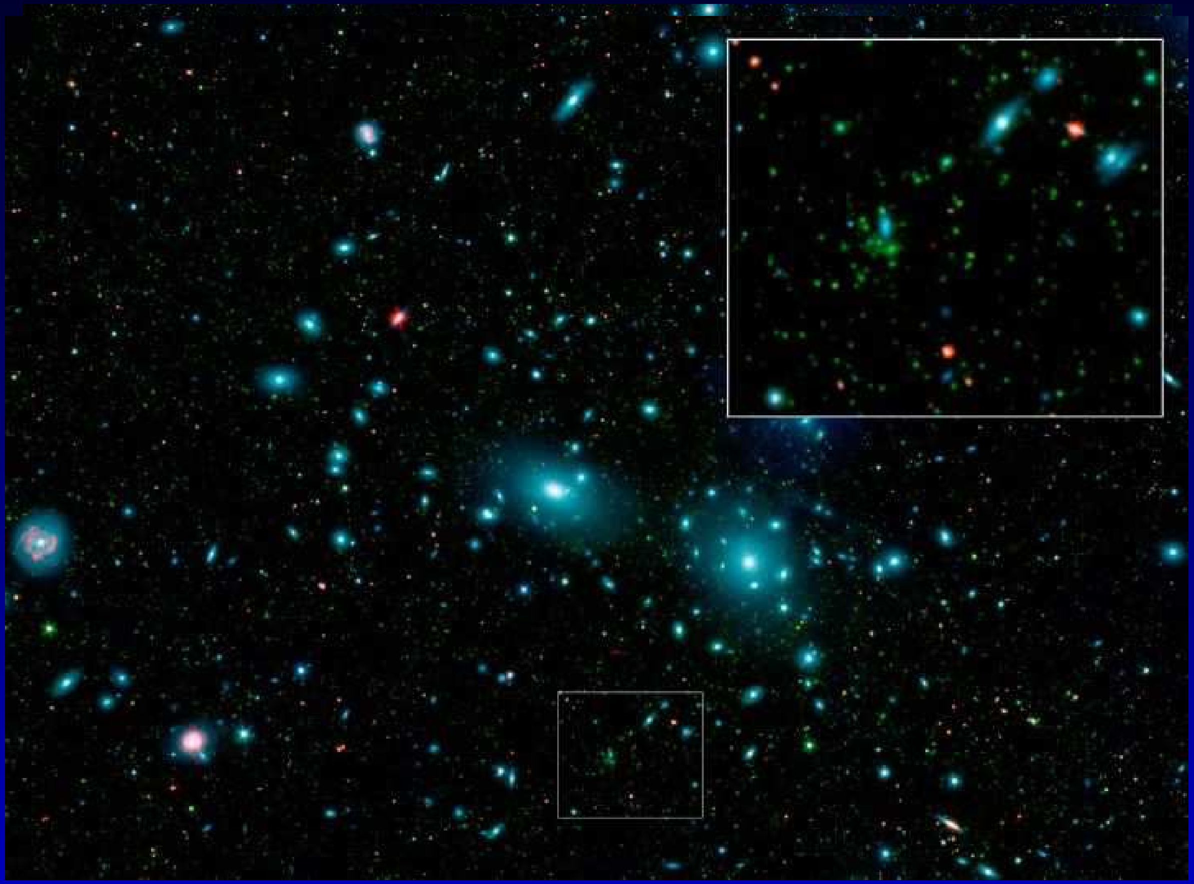

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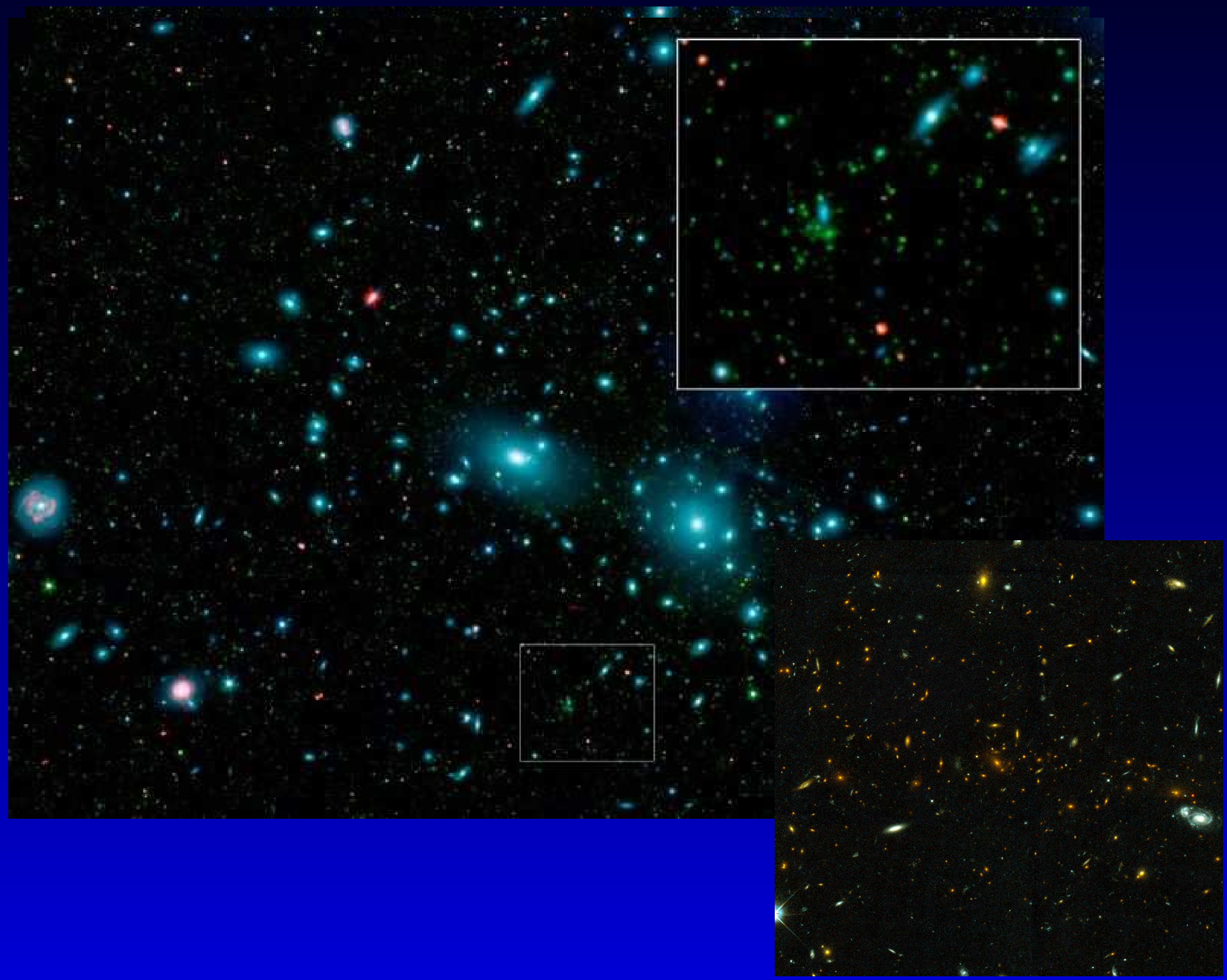

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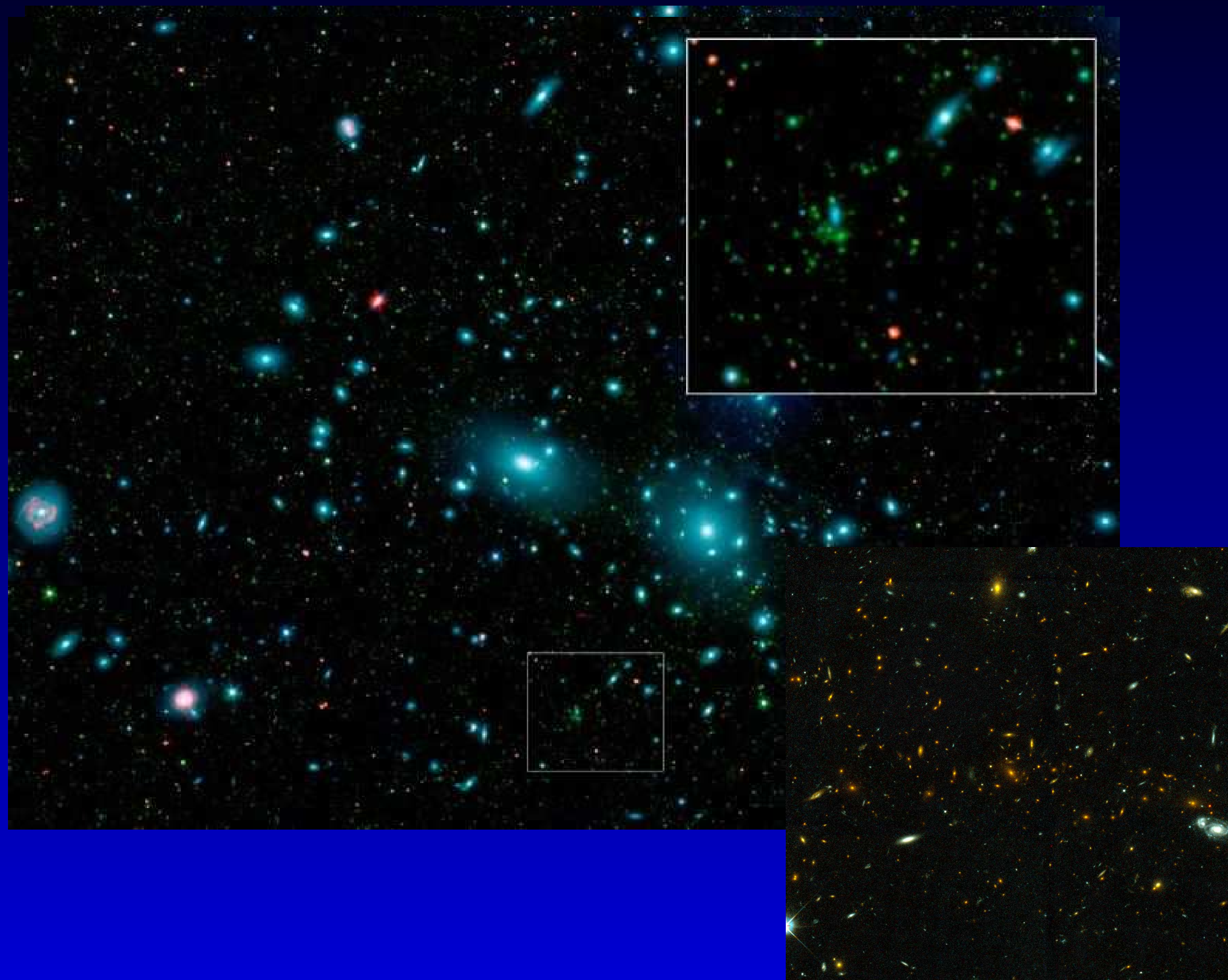

Optical data : Stars, metals, velocity dispersion $\rightarrow$ Mass...

Visions on clusters

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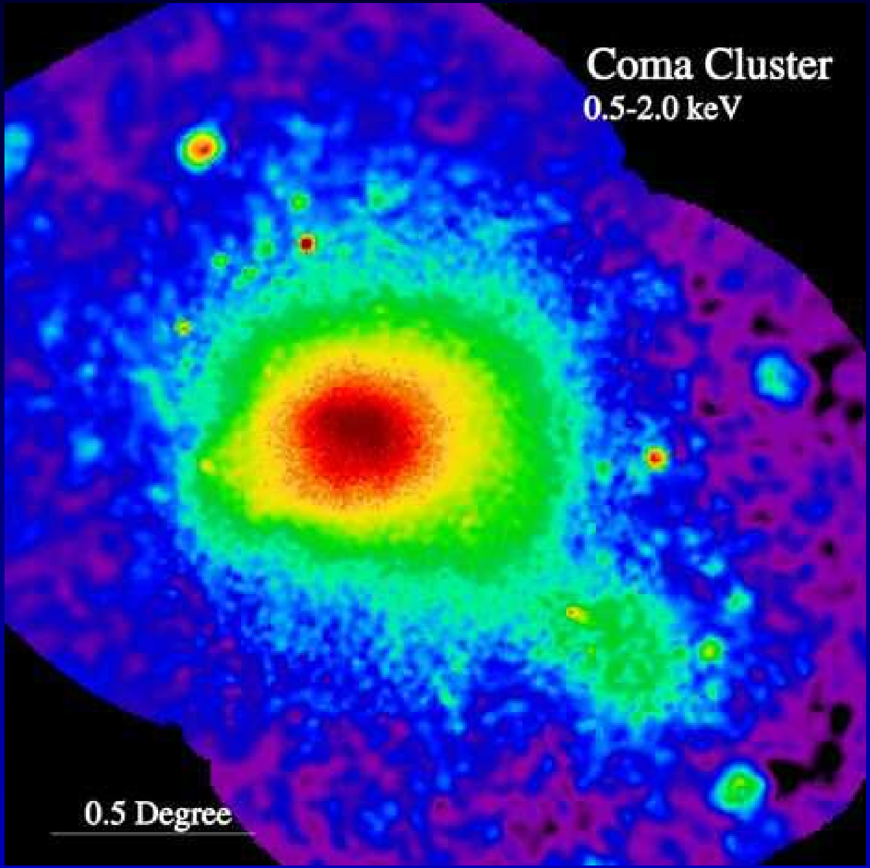

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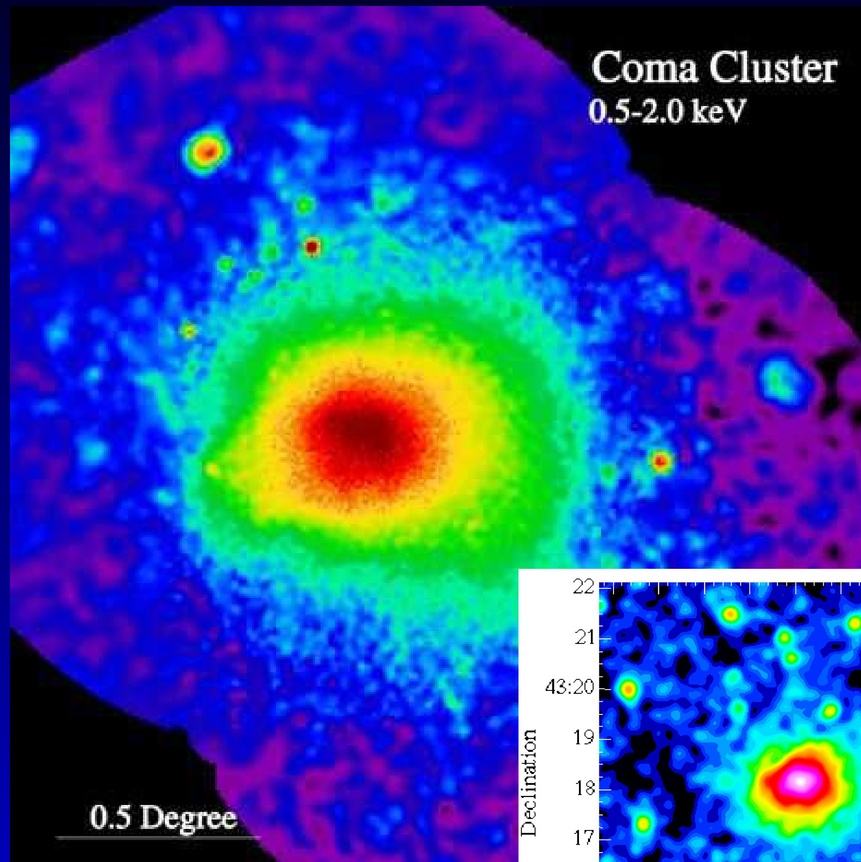

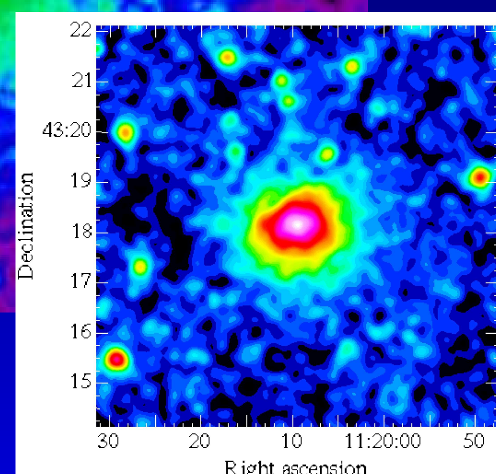

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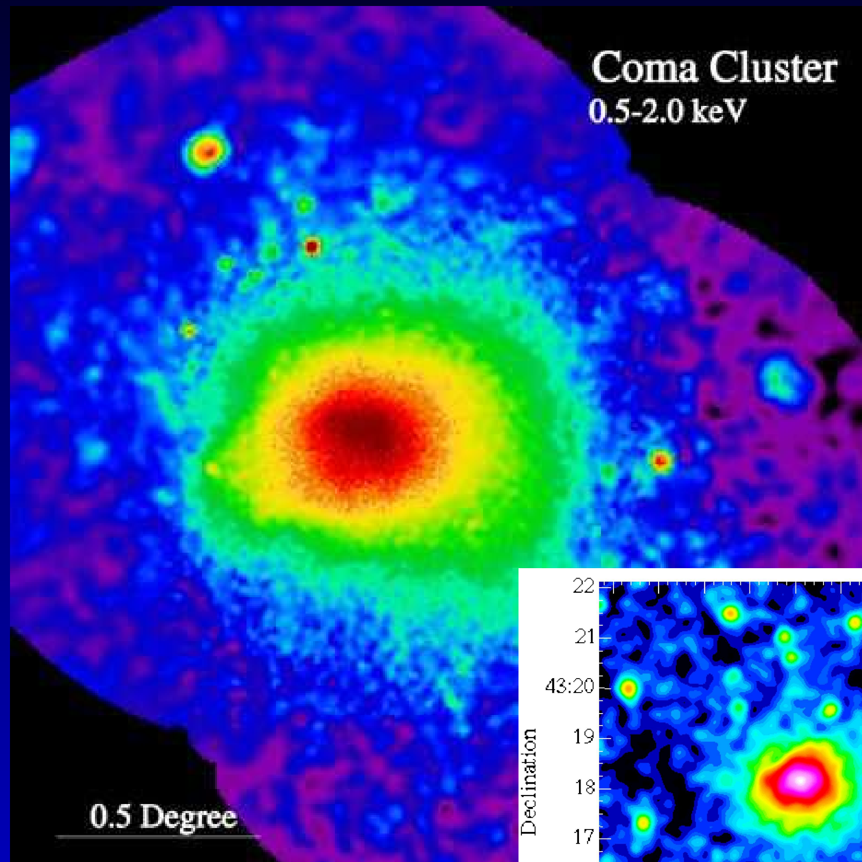

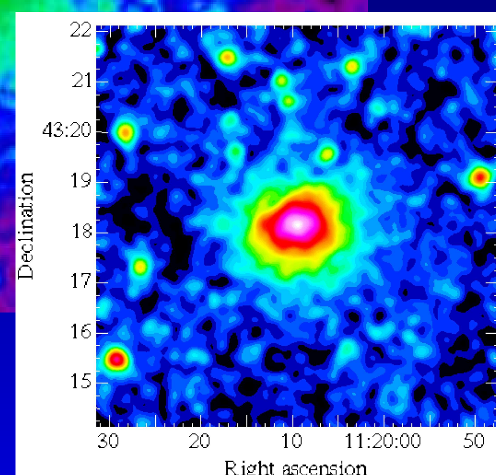

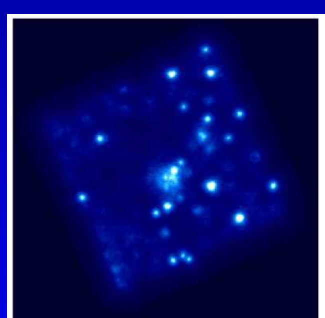

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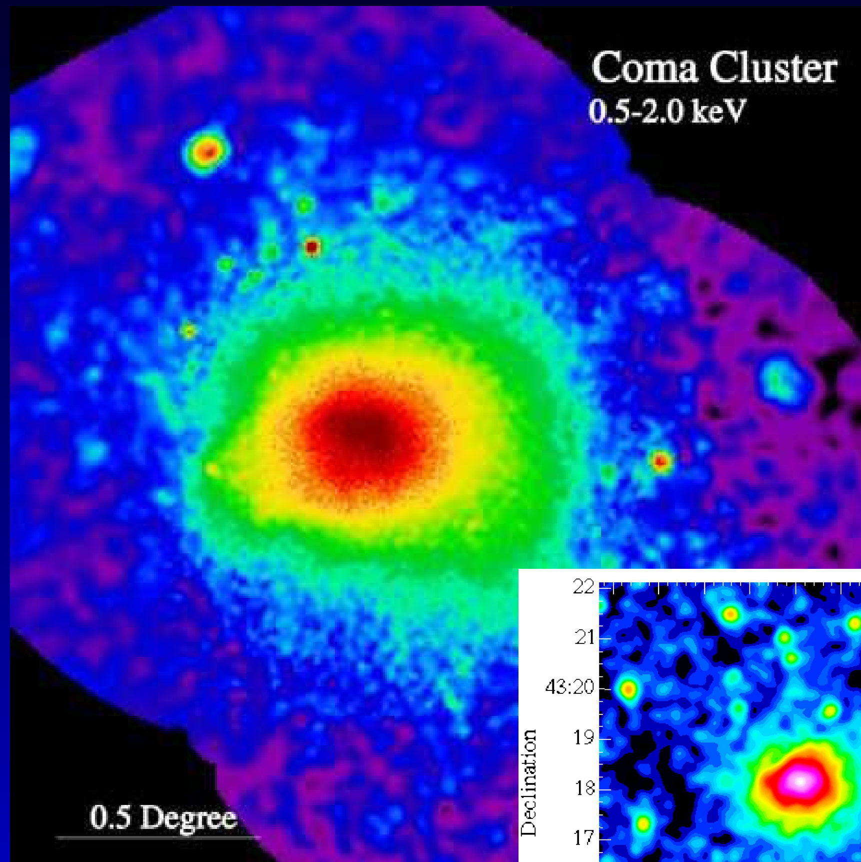

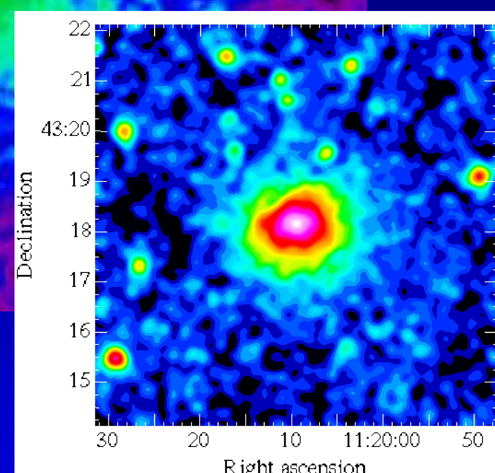

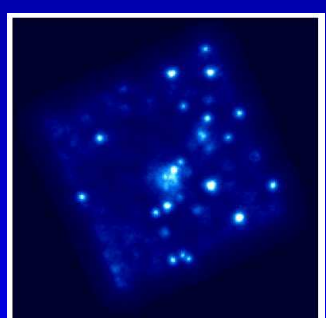

X-ray data : Gas, metals, temperature $\rightarrow$ Mass...

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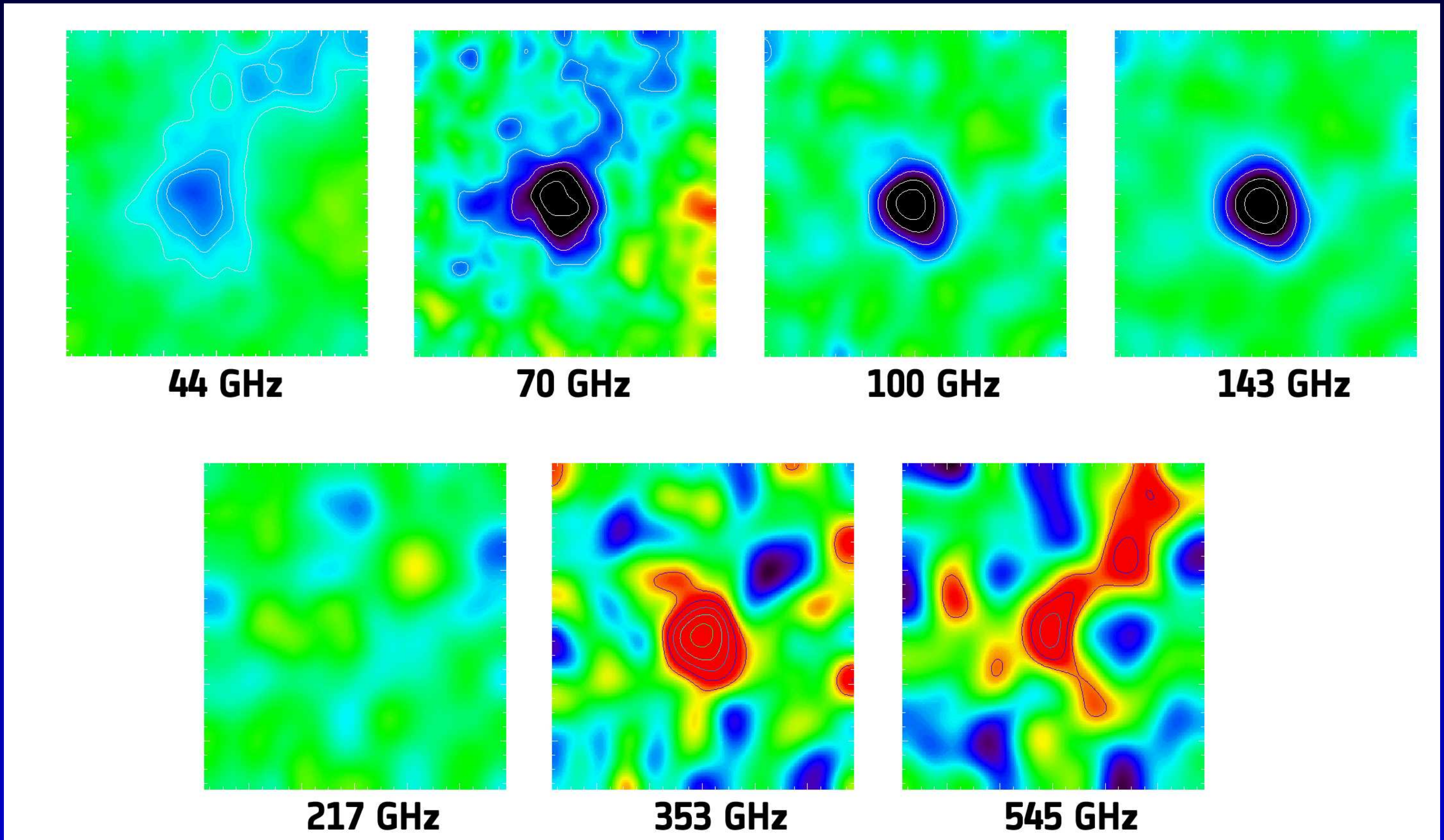
A2319 by Planck



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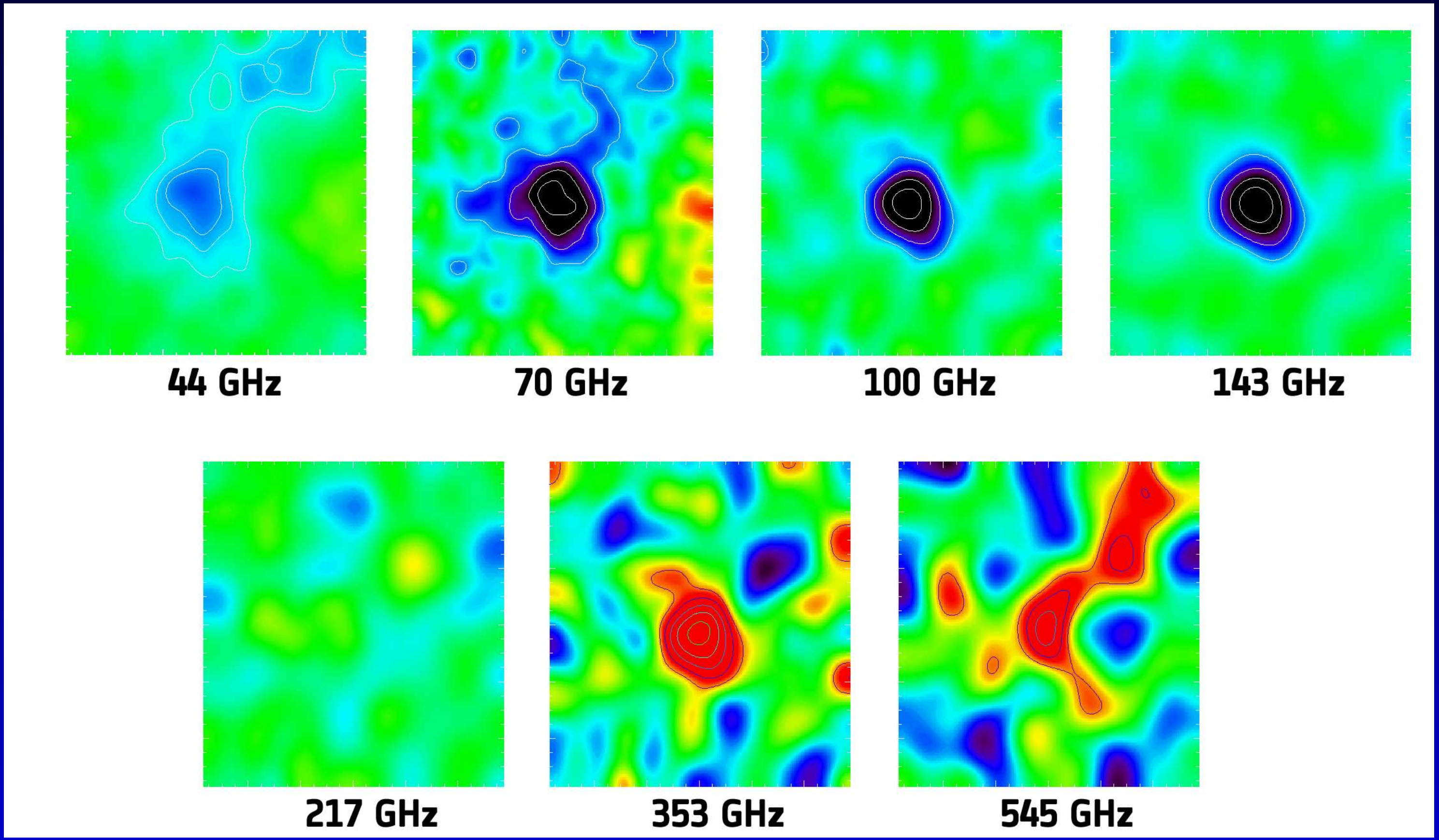

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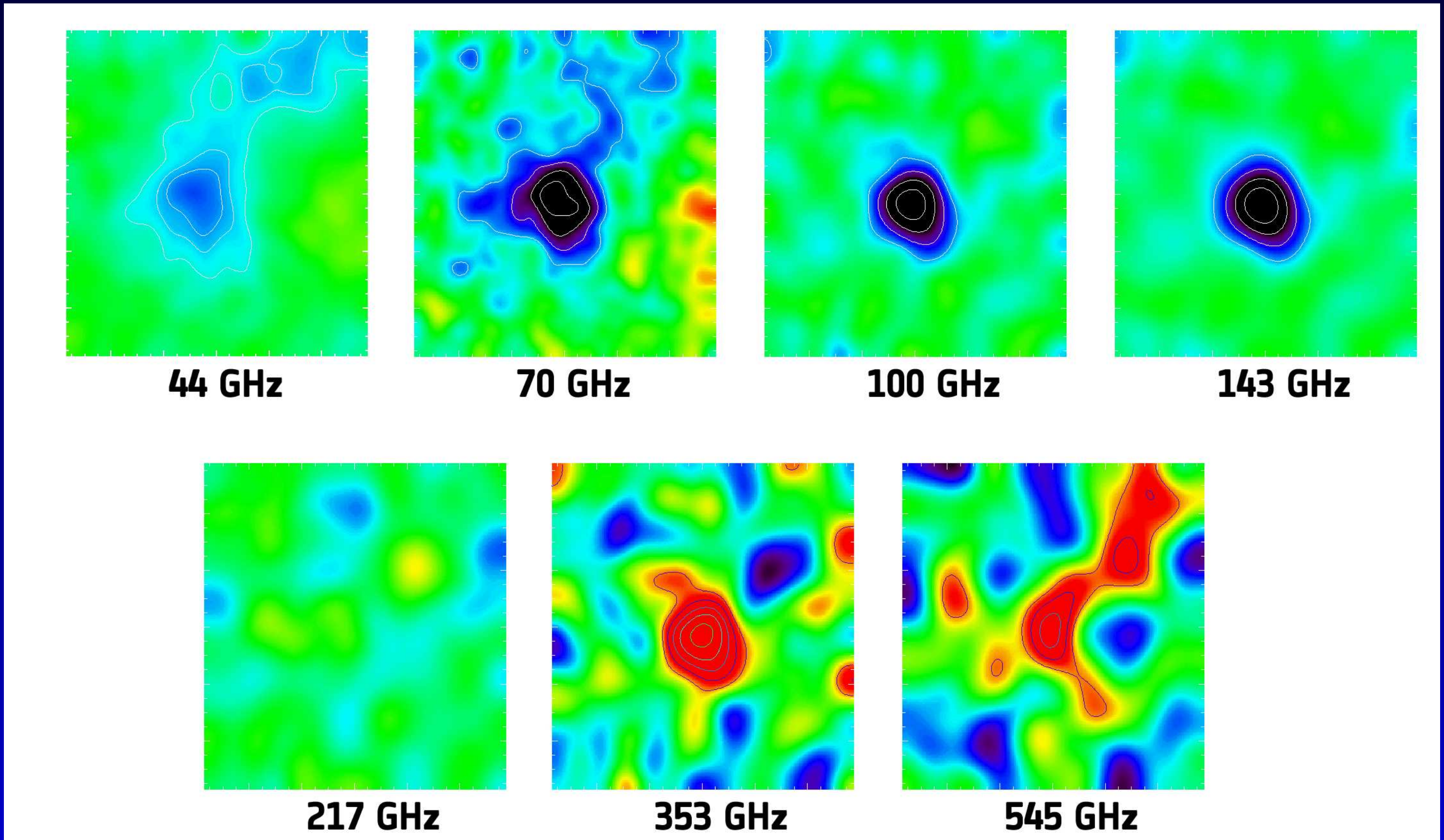

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No dimming with redshift

Final words

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- $\rightarrow$ fundamental probes for cosmology

Cluster as cosmological tools

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Important progresses are due to numerical simulations:

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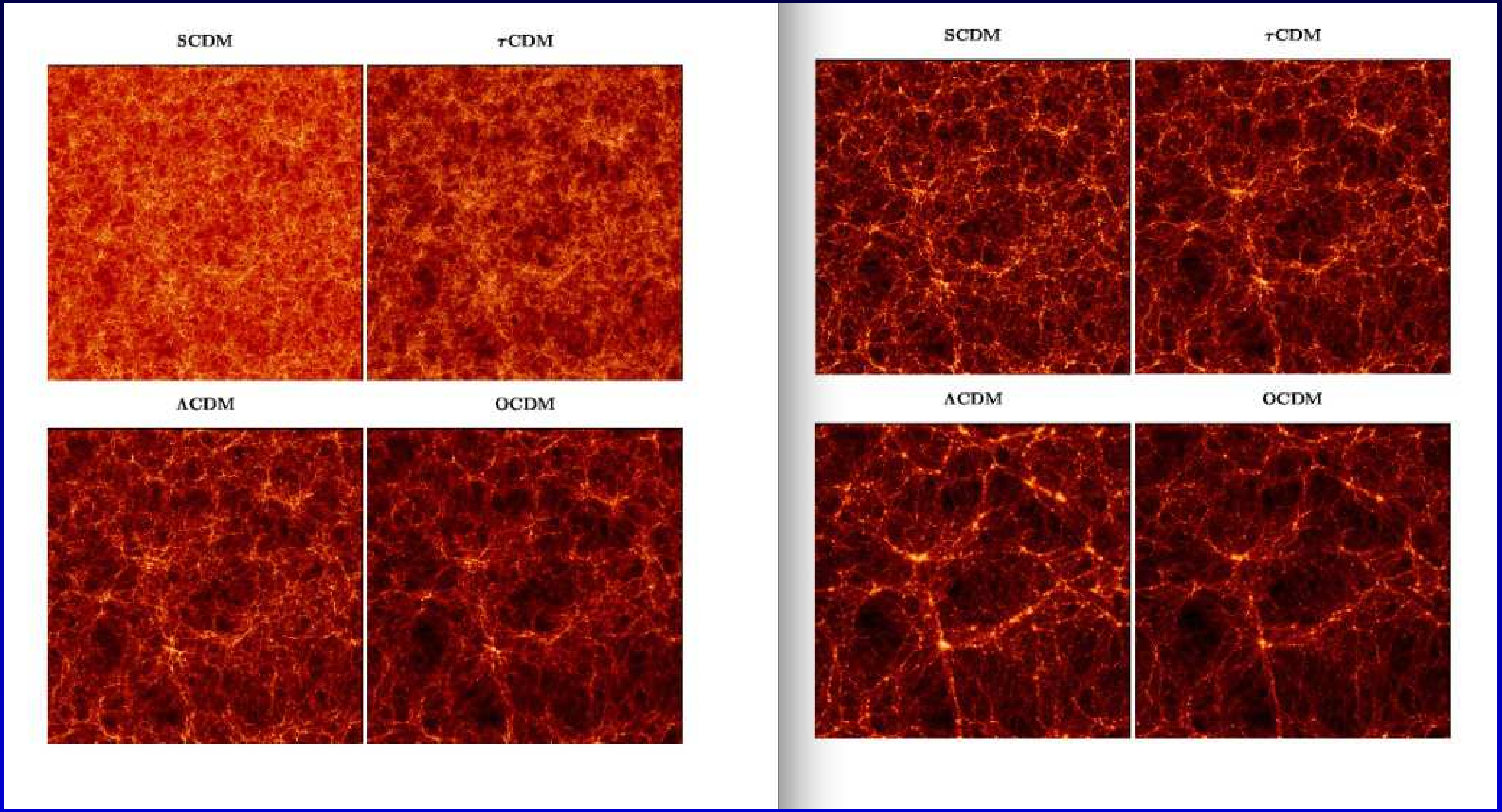

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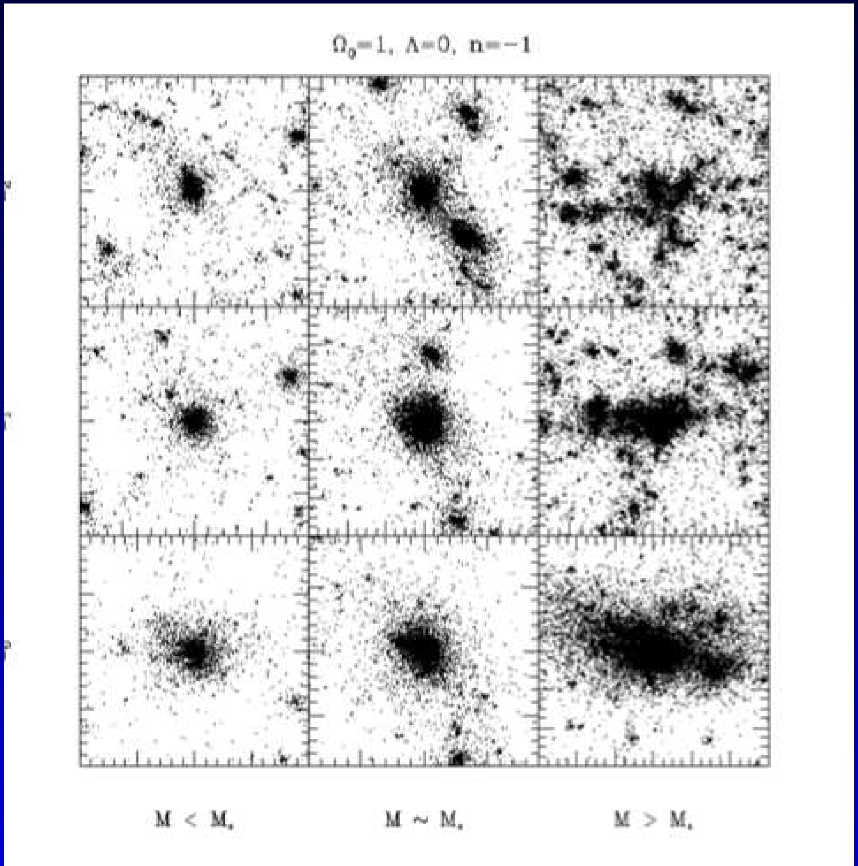

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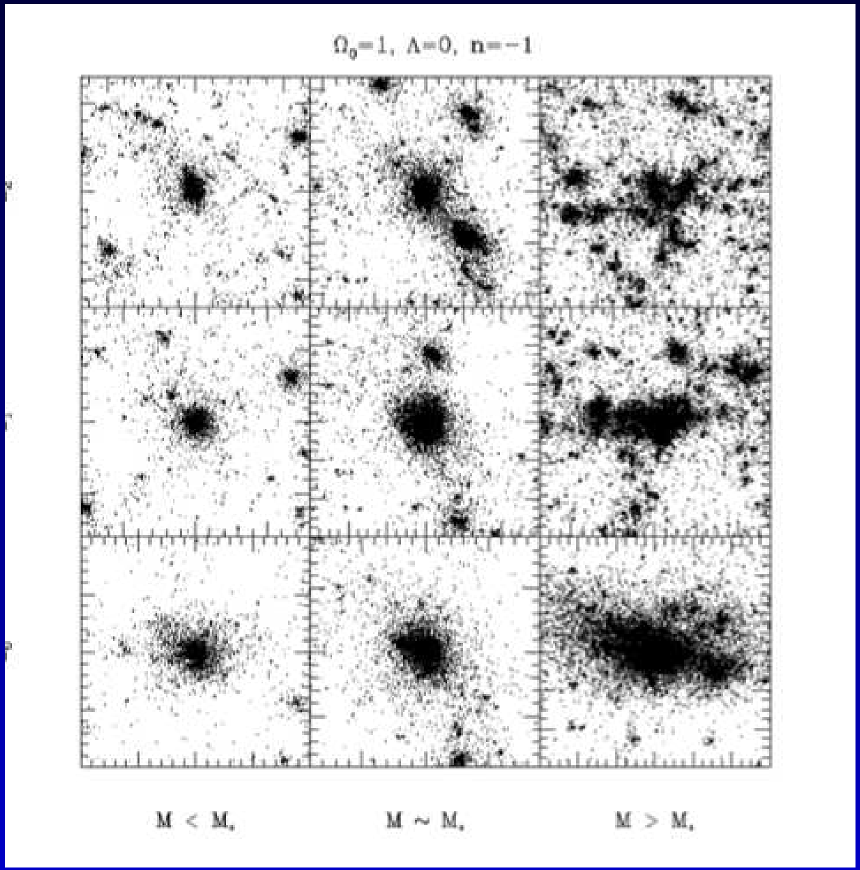

$\sigma(M_*) \sim 1$

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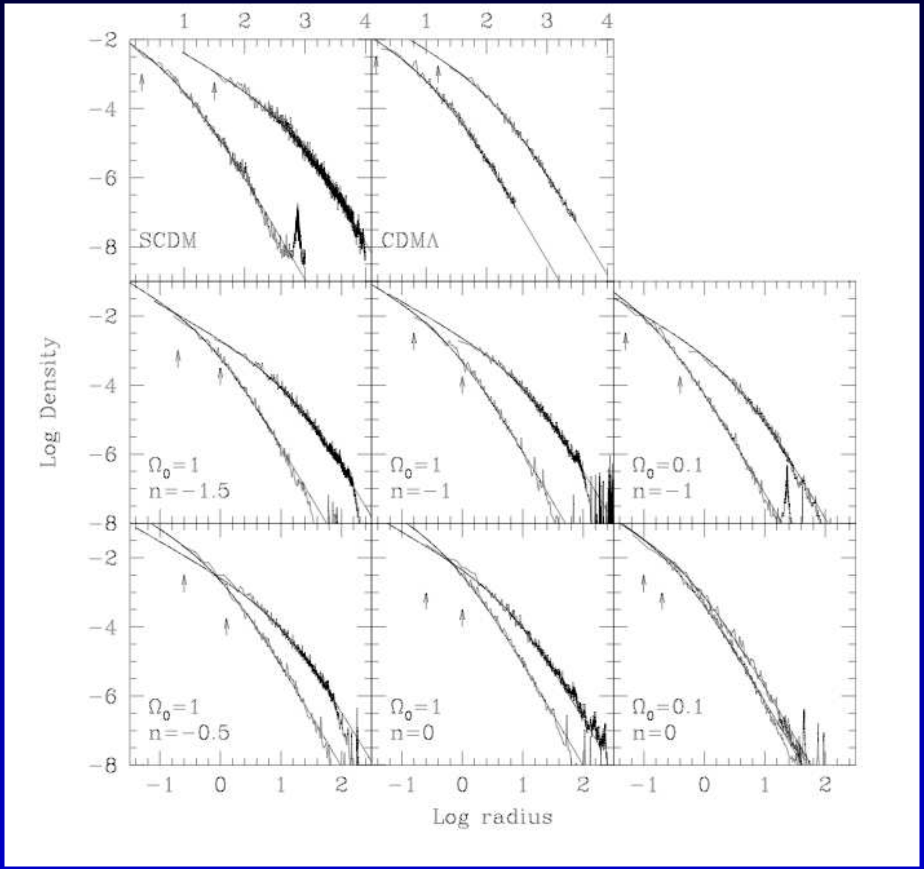

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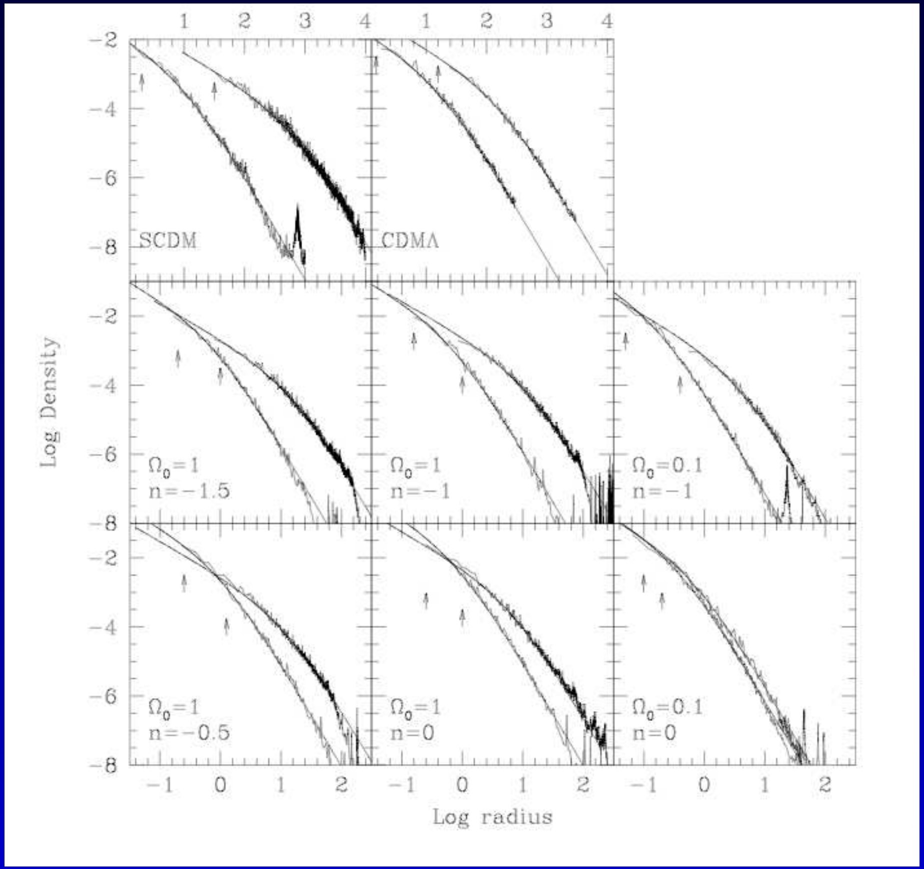

NFW profiles

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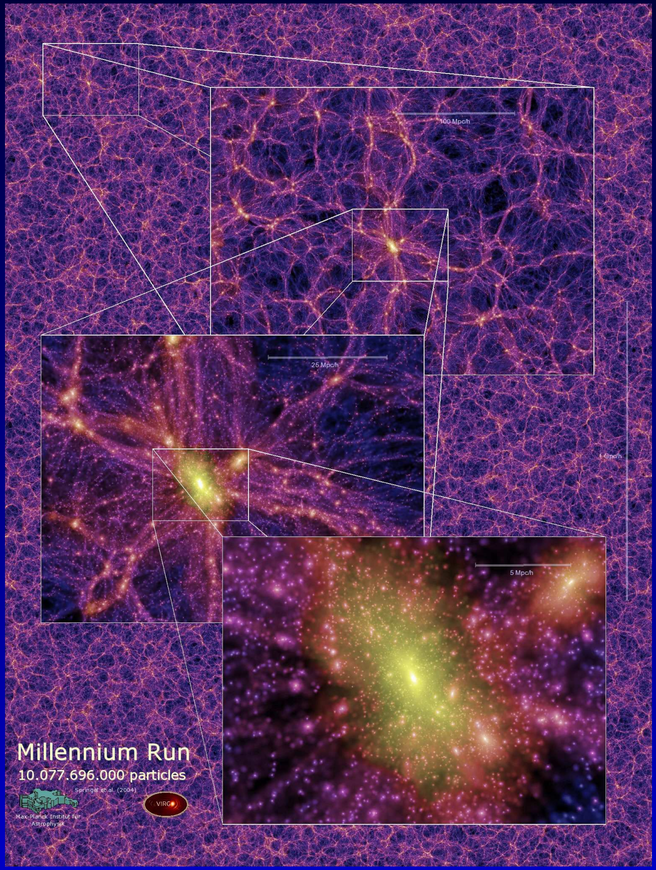

Millenium simulation: much more detailled pictures...

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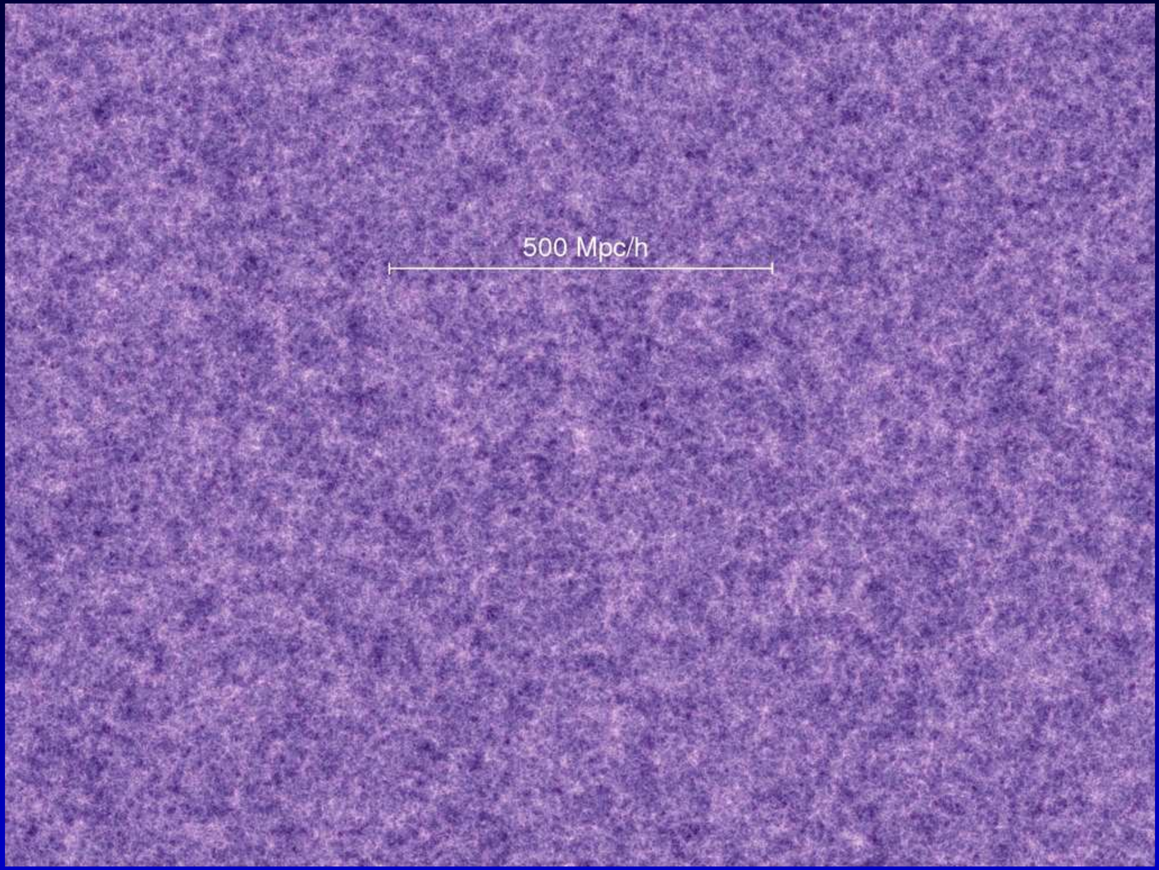

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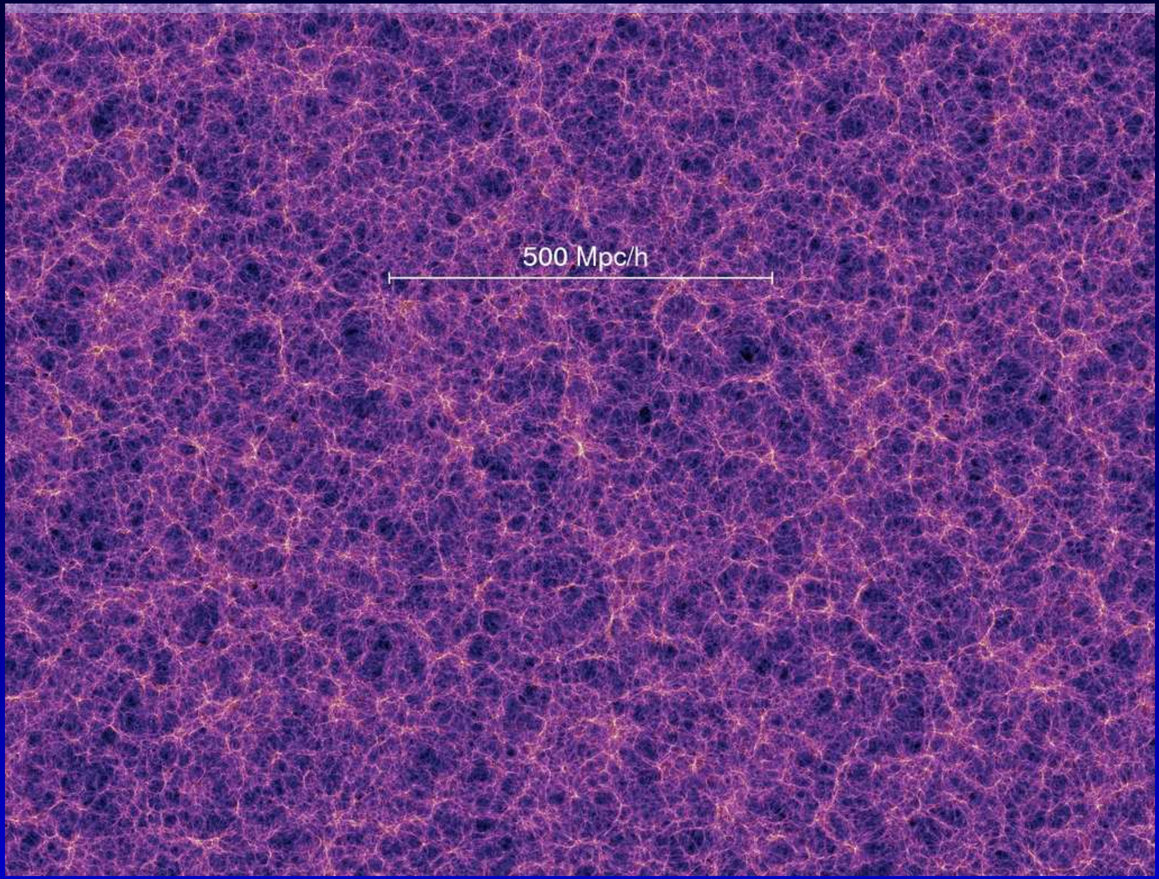

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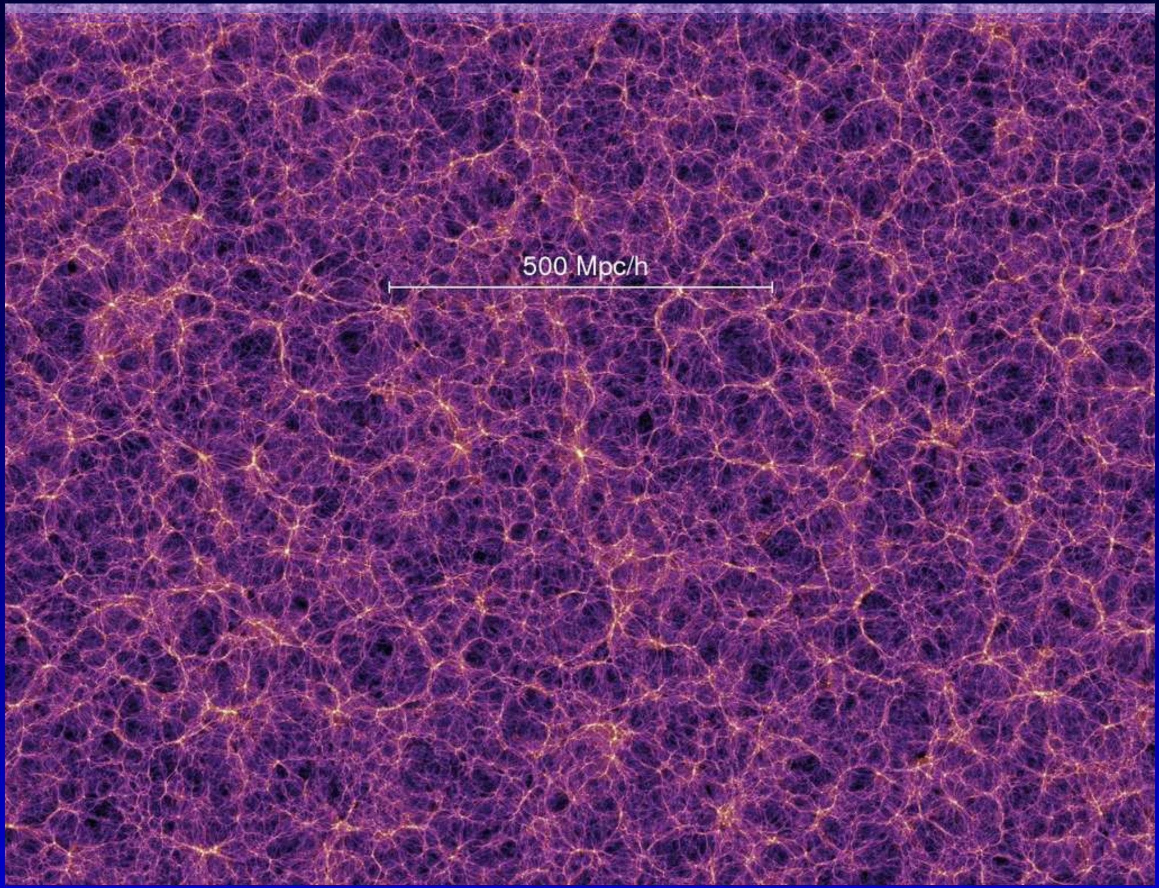

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Which reference contrast (Δ_{th})? Δ_v, 178, 200, 500, 2000...

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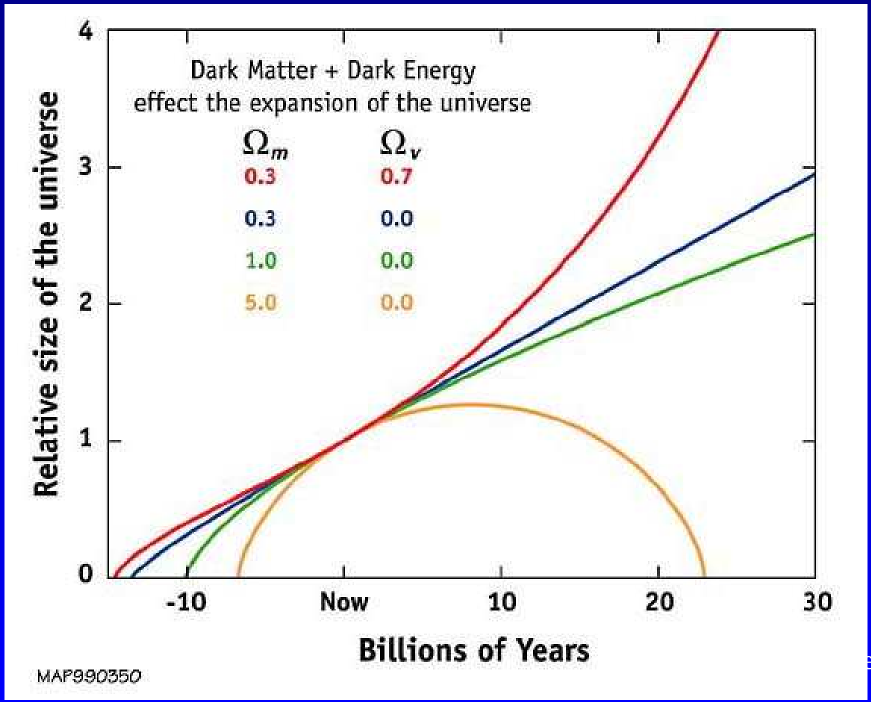

Spherical Model I

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$$\tilde{H}_0\, t = \frac{\tilde{\Omega}_0}{2(\tilde{\Omega}_0 - 1)^{3/2}}(\phi - \sin(\phi))$$

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Density at maximum:

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$$\Delta_m = \frac{9}{16}\pi^2 - 1. \simeq 4.55$$

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let's estimate the linear expected amplitude at viriliza-tion.

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so:

$$\psi^6 = \left(\frac{6\pi t}{t_m}\right)^2 [1 + \frac{\psi^2}{10}]$$

Virialization IV

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and

$$\tilde{\rho} = (1 + \frac{\psi^2}{4} - \frac{\psi^2}{10})\frac{64\rho_m t_m^2}{(6\pi)^2 t^2}$$

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so with : $\tilde{\rho} = \rho(1 + \delta)$

$$\delta = \frac{3}{20}\psi^2 = \frac{3}{20}\left(\frac{6\pi t}{t_m}\right)^{2/3} = \frac{3(6\pi)^{2/3}}{20}\frac{1 + z_m}{1 + z}$$

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Can be generalized to other models

Cluster mass function

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Test beyond geometrical characterisation of the universe. (Oukbir and A.B, 1992)

From mass to observables

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so that M and z are the only two numbers to characterize a cluster. (you can add further ingredients like c NFW concentration parameter, ν...)

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so that:

$$T_x = A_{TM} M^{2/3}(1+z)(\Omega_m \Delta/178)^{1/3}$$

(this depends on the choice of ρ_r).

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From mass to observables

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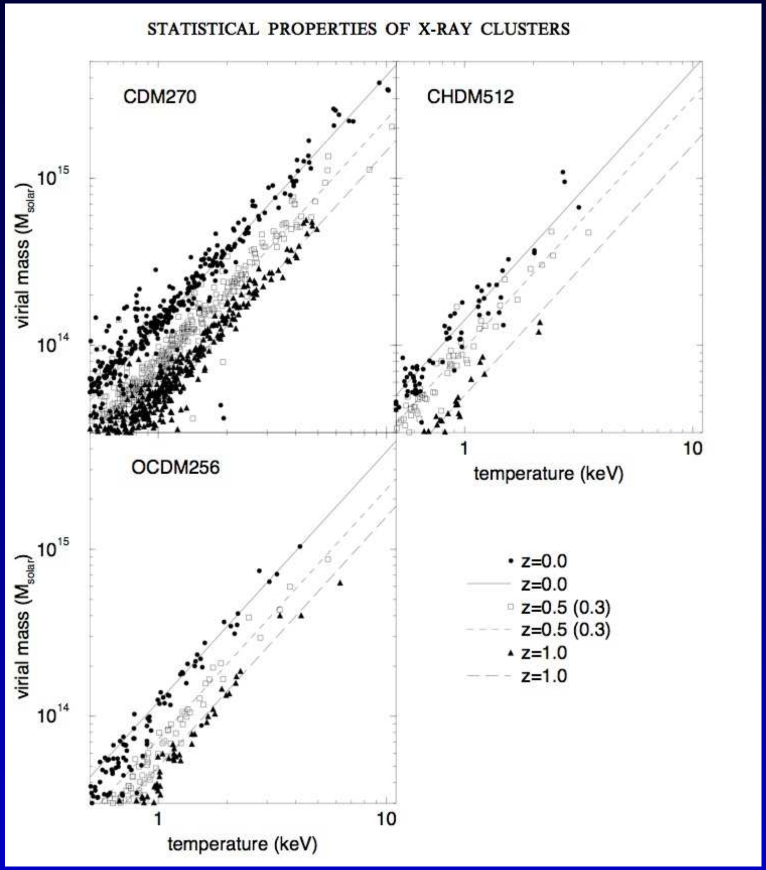

From mass to observables: applications

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Fitting $N(T_x)$

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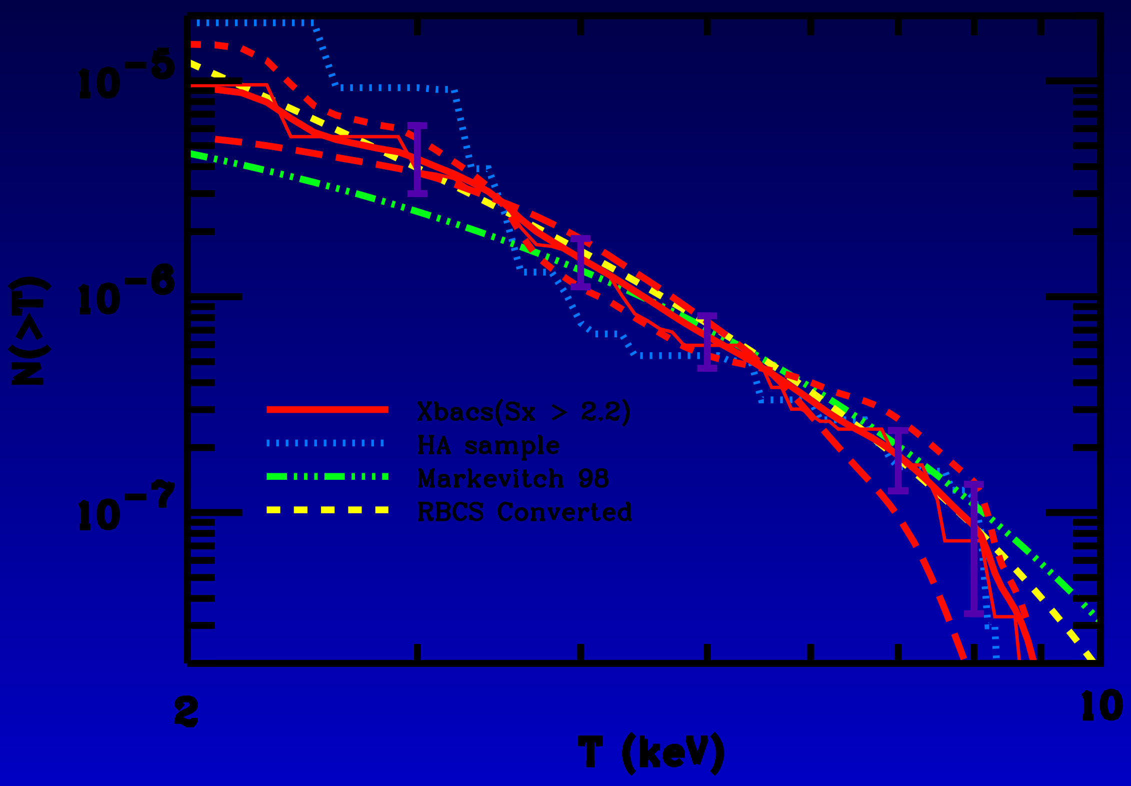

From mass to observables: ap-plications

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Measuring local matter fluctuations:

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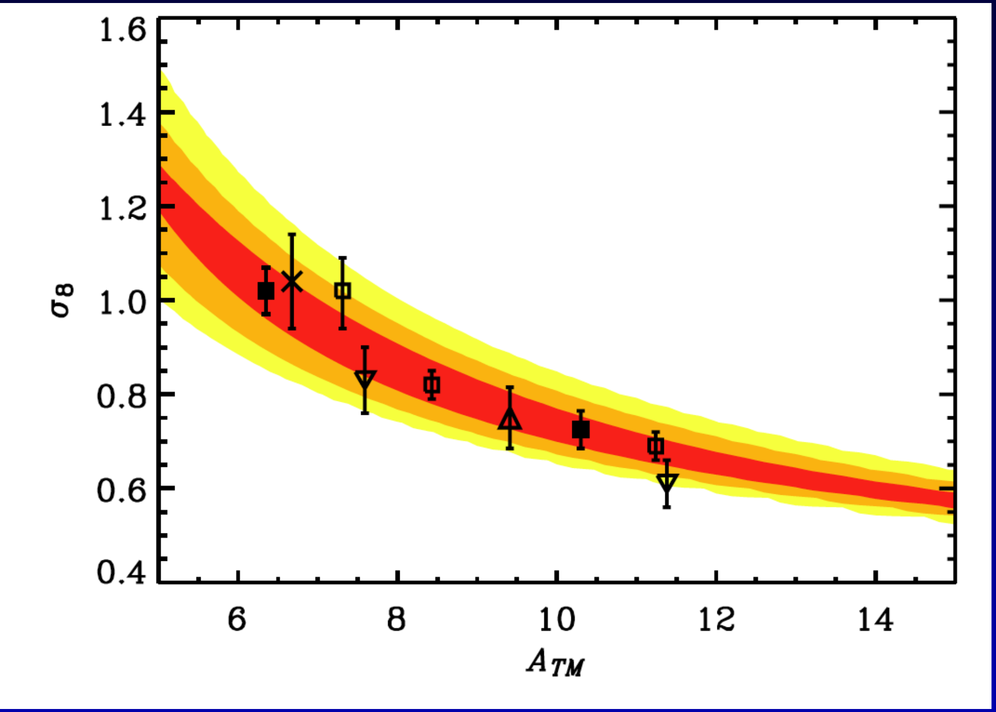

Evard et al (2002), Pierpaoli et al. (2003), Seljak (2002), Vauclair et al. (2003), Viana et al. (2003)

From mass to observables: applications

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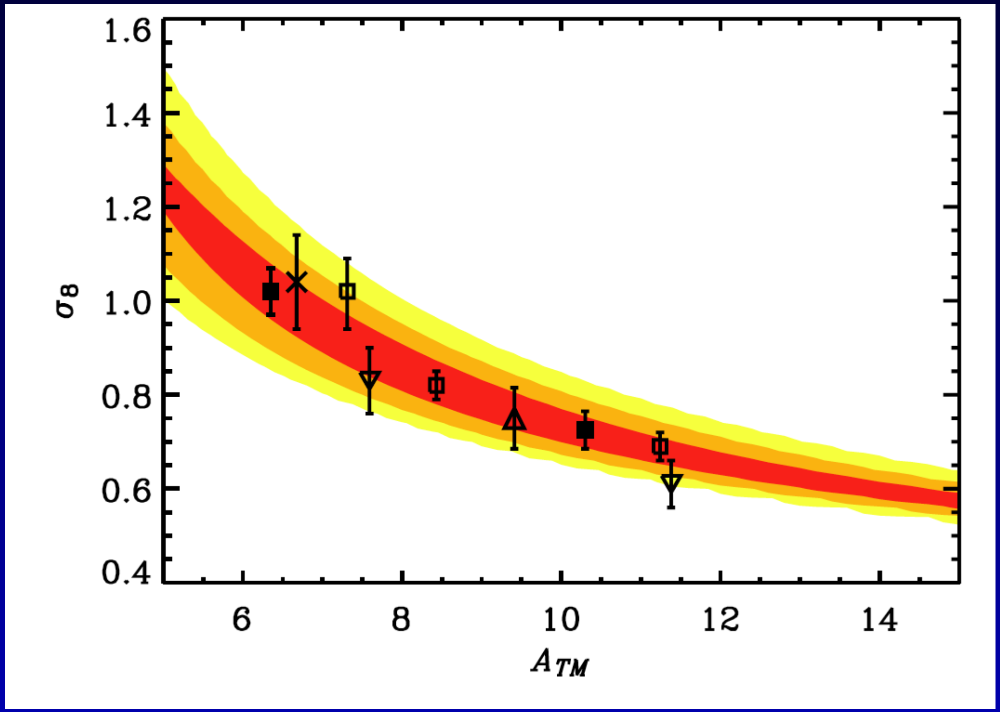

Evard et al (2002), Pierpaoli et al. (2003), Seljak (2002), Vauclair et al. (2003), Viana et al. (2003)
Consistency and degeneracy...

From mass to observables: troubles...

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Gas in clusters needs extra heating.

From mass to observables: not so troubles?

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Scaling of the gas content:

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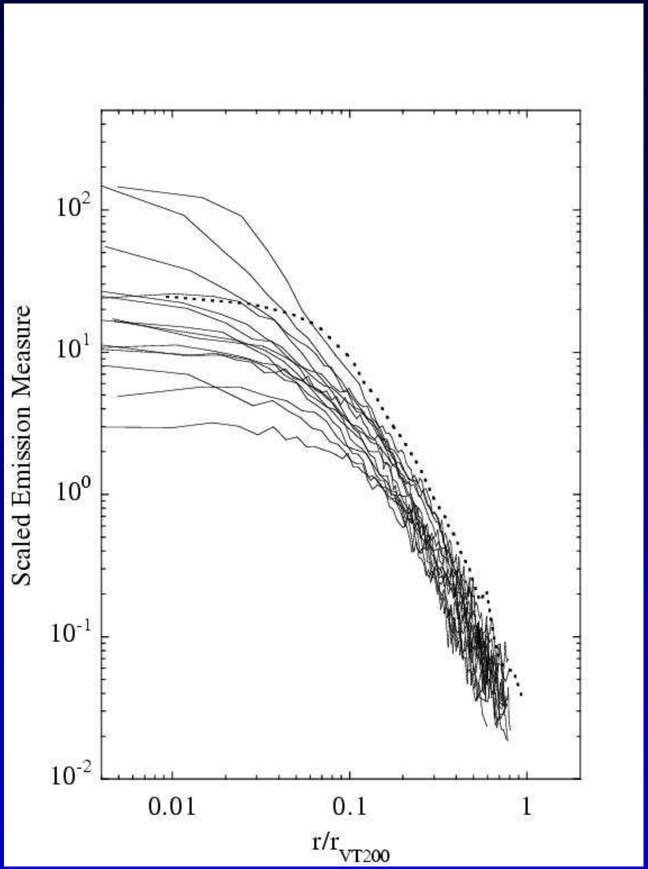
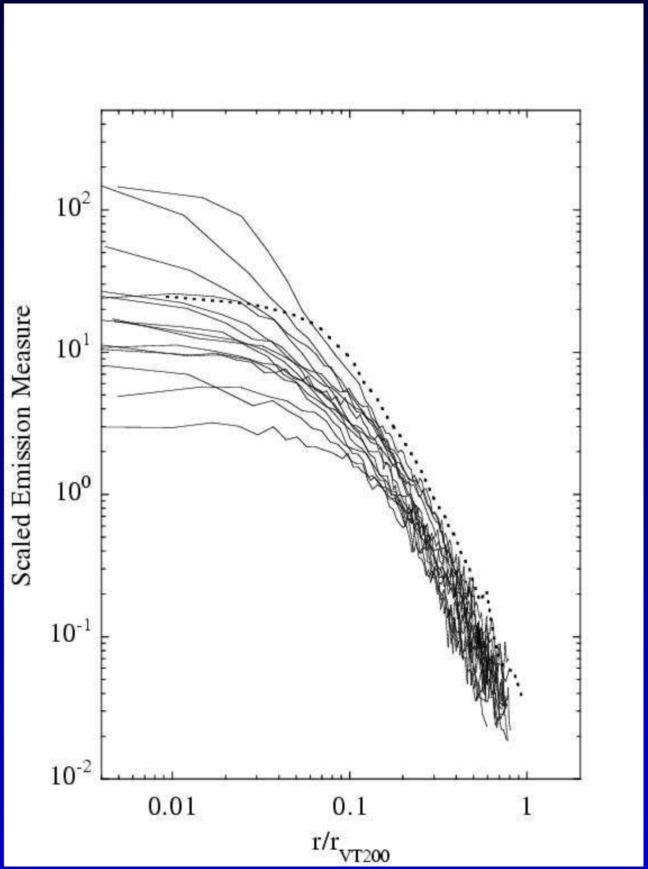


From mass to observables: not so troubles?

Scaling of the gas content:



So clusters may be self-simlar after all...

Cluster gas physics

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Rather than using clusters to constraint the Cosmology, why not using the Cosmology to constraint the **physical state** of clusters ?

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Let's assume:

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Cluster gas physics

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Try to estimate A_{TM}

Cluster gas physics

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Use CosmoMC on SNIa+$P(k)$+CMB + $N(T_x)$

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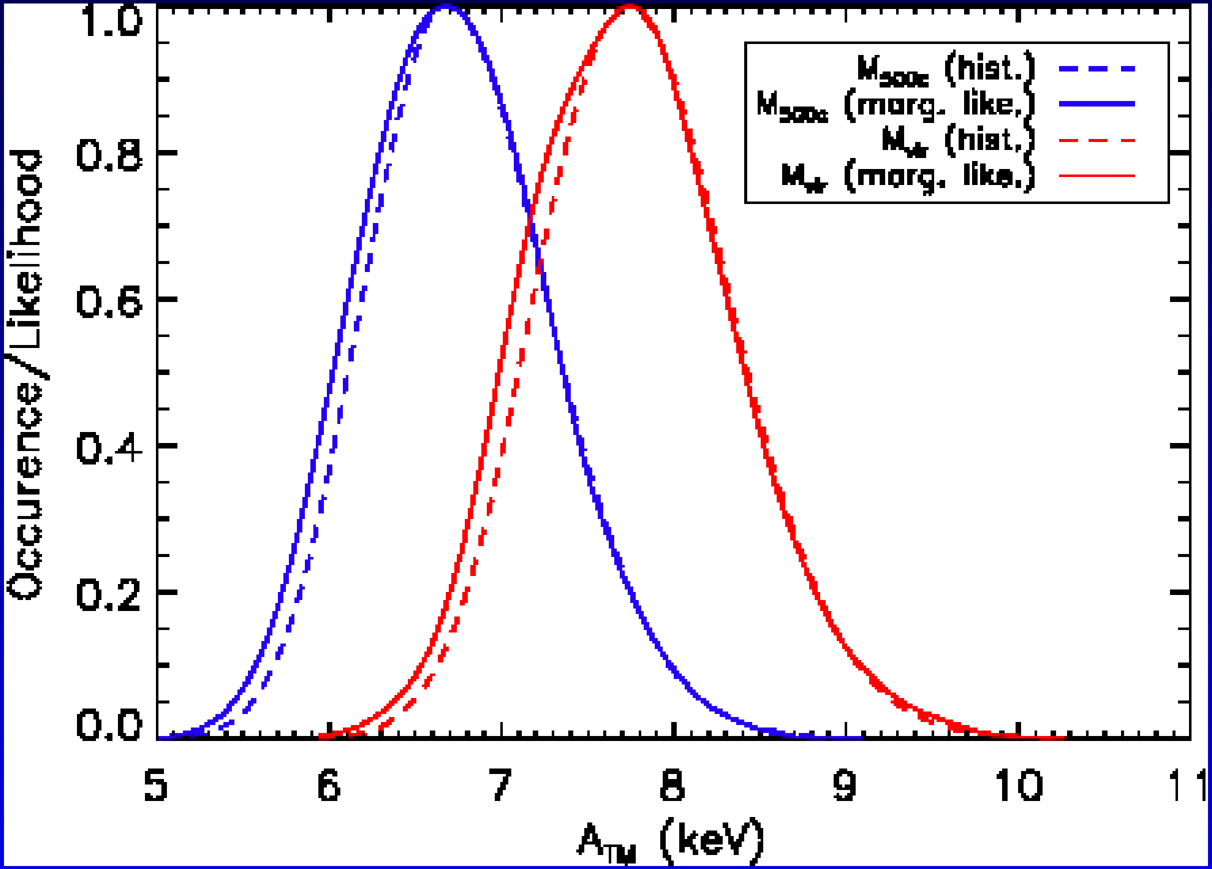

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Estimates A_{TM} (Tinker)

$A_{TM} = 7.7 \pm 0.7$ keV (R_{vir})
$A_{TM} = 6.7 \pm 0.6$ keV (R_{500})

Cluster gas physics

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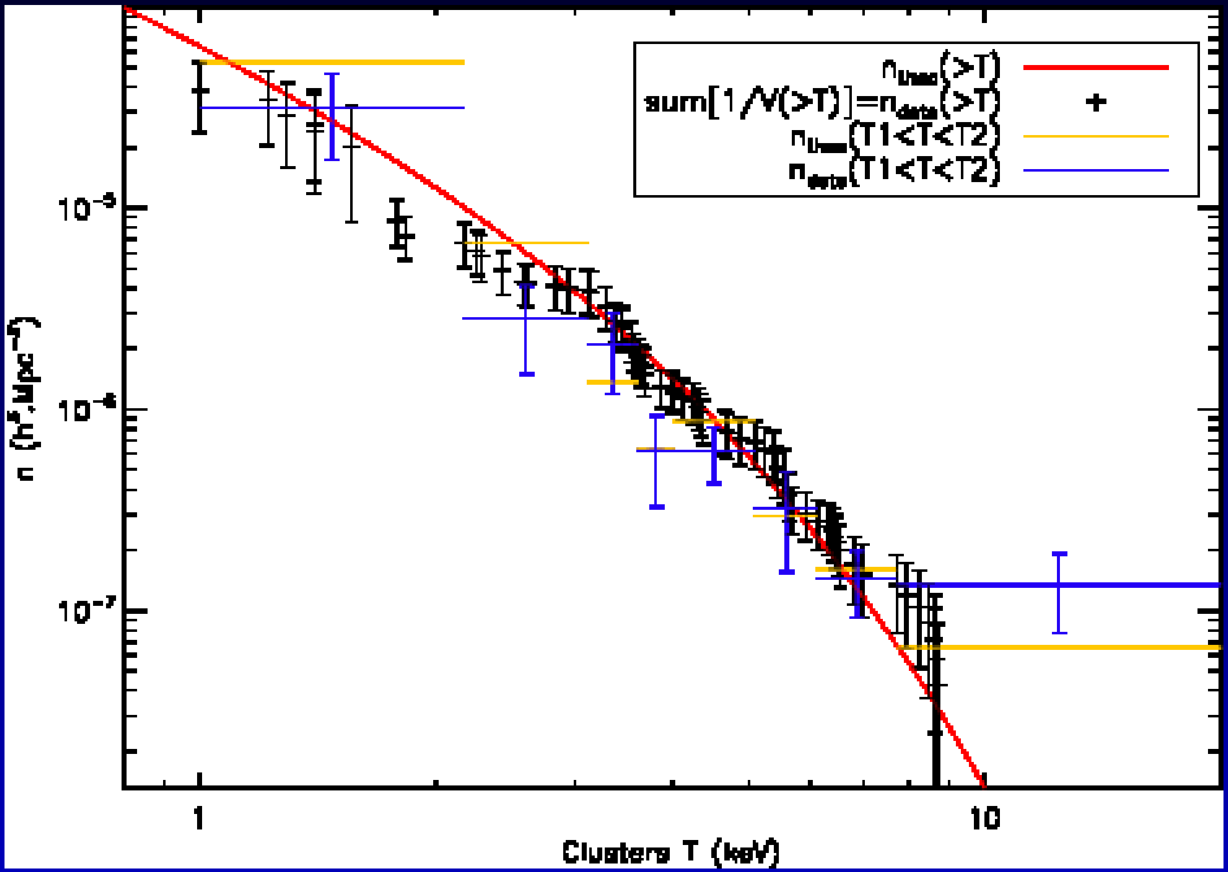

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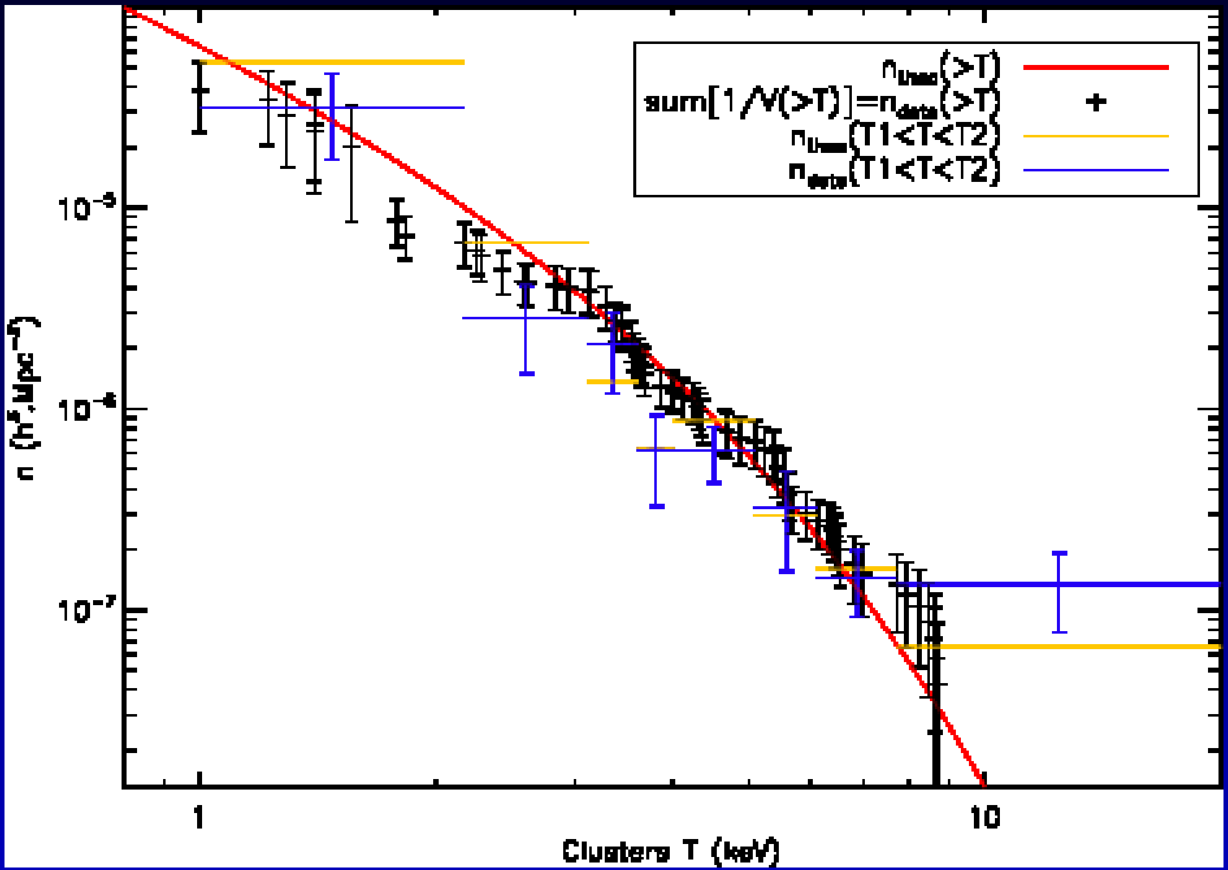
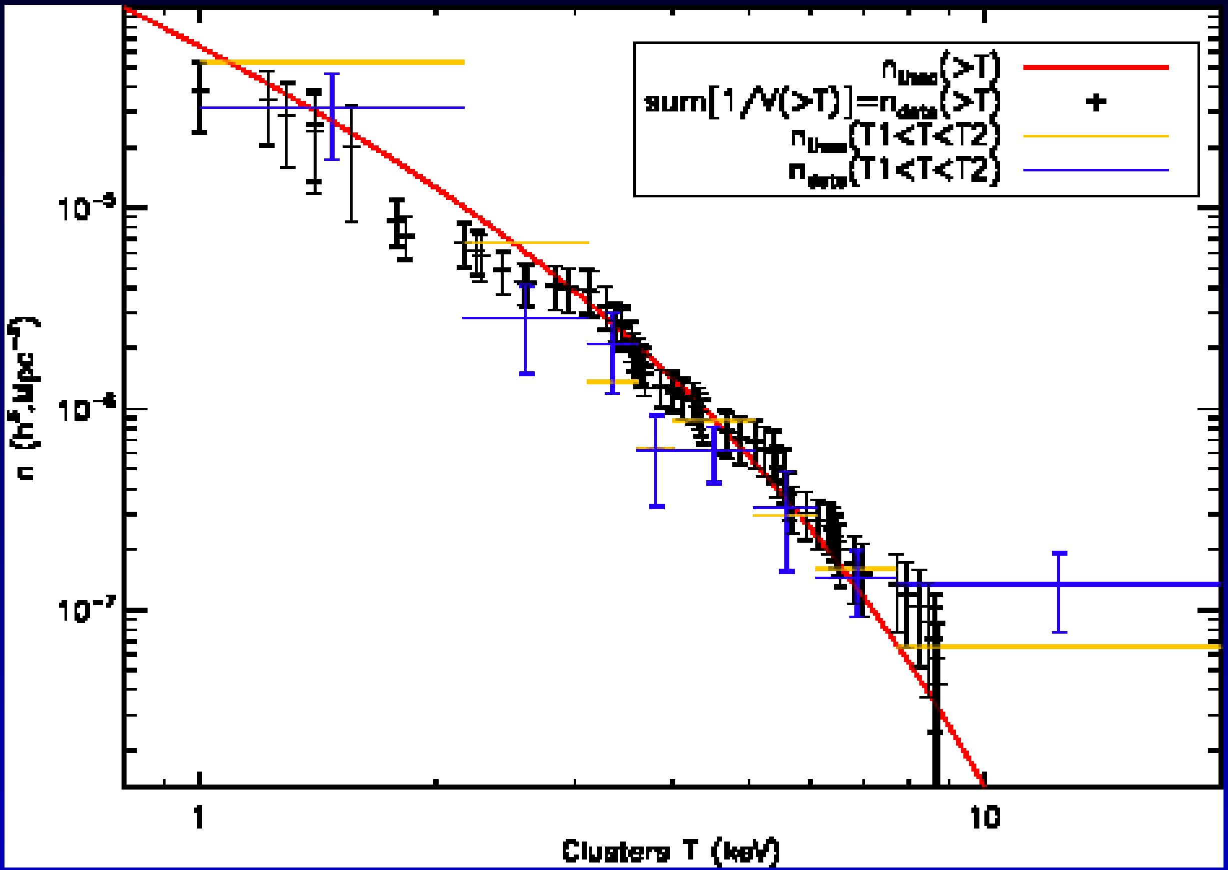


We need large sample of clusters...

Cluster gas physics



We need large sample of clusters... X-ray, SZ, optical ?