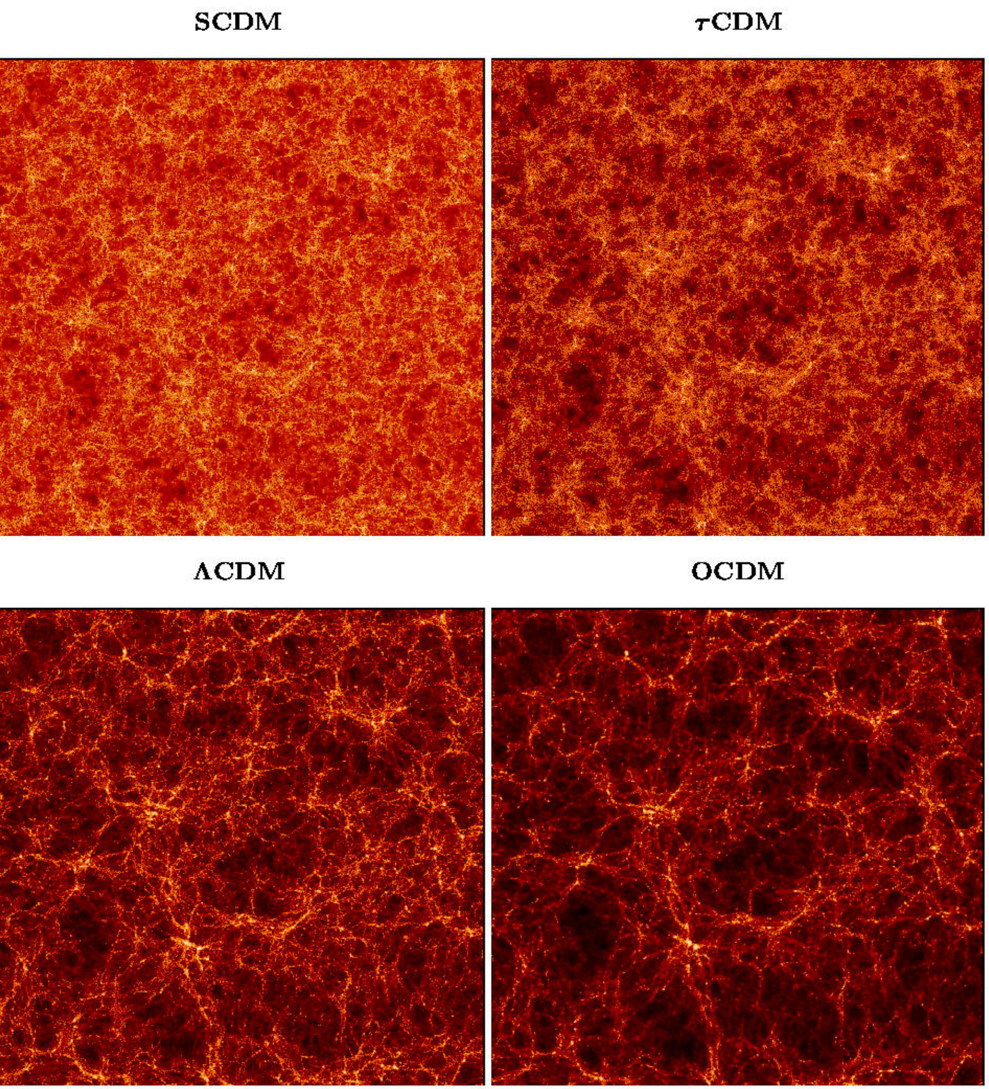
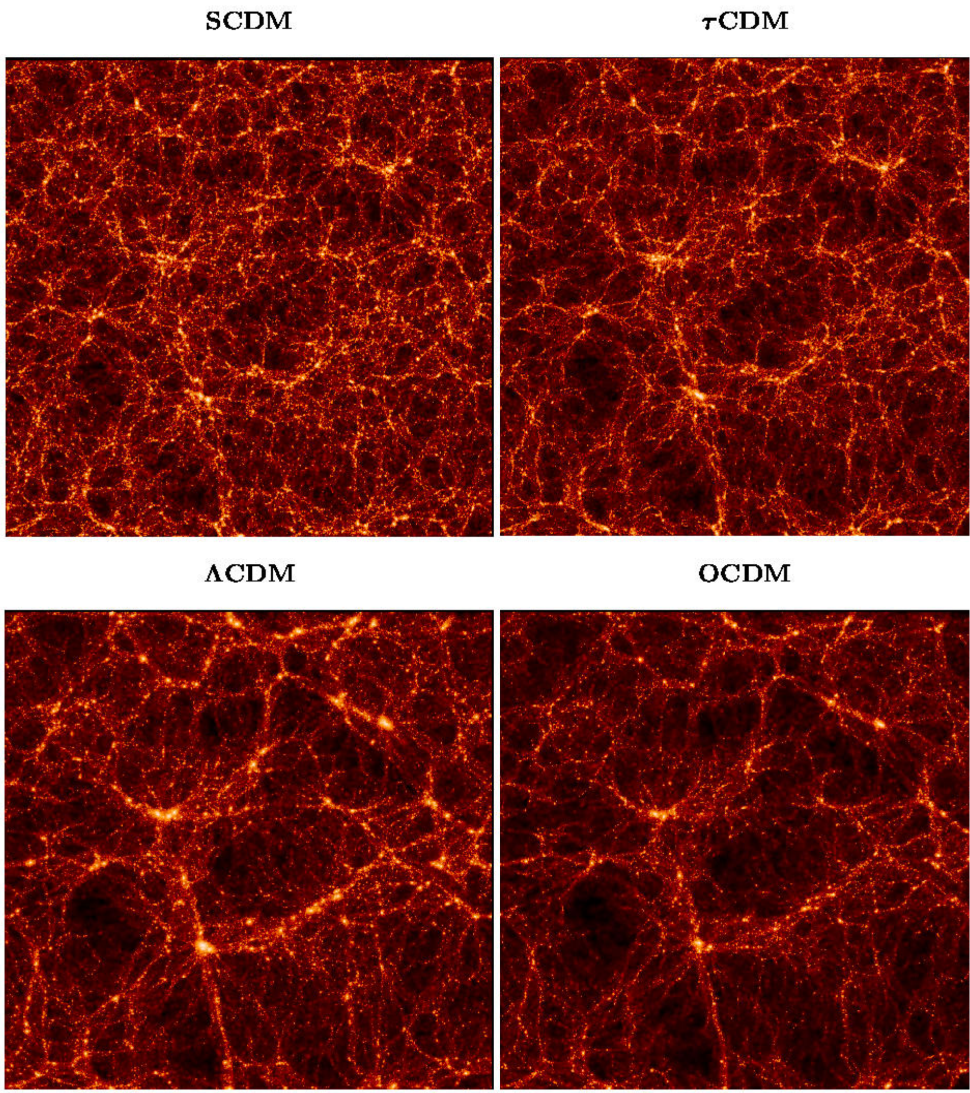
Clusters for Cosmology

Mass function





VIRGO simulations

Theory of the Mass function:

- trivially (!): dV will be in an object with mass > M if included in a NL fluctuation of $\tilde{\delta}_R$ with radius > R

$$\int_M^{+\infty} mn(m)dm = \overline{\rho} \int \mathcal{F}_\delta(\delta) s(\delta) d\delta \sim \overline{\rho} \int_{\delta_{NL}}^{+\infty} \mathcal{F}_\delta(\delta) d\delta$$

The mass function:

$$N(M) = -\frac{\overline{\rho}}{M^2\sigma(M)}\delta_{NL}\frac{d\ln\sigma}{d\ln M}\mathcal{F}(\nu_{NL})$$

Blanchard et al. (1992)

normalization condition:

$$\frac{1}{\overline{\rho}}\int_0^{+\infty} mn(m)dm = \int_0^{+\infty}\mathcal{F}(\nu)d\nu = 1$$

Press and Schechter (1974) used:

$$\mathcal{F}(\nu) = \sqrt{\frac{2}{\pi}} \exp(-\frac{\nu^2}{2})$$

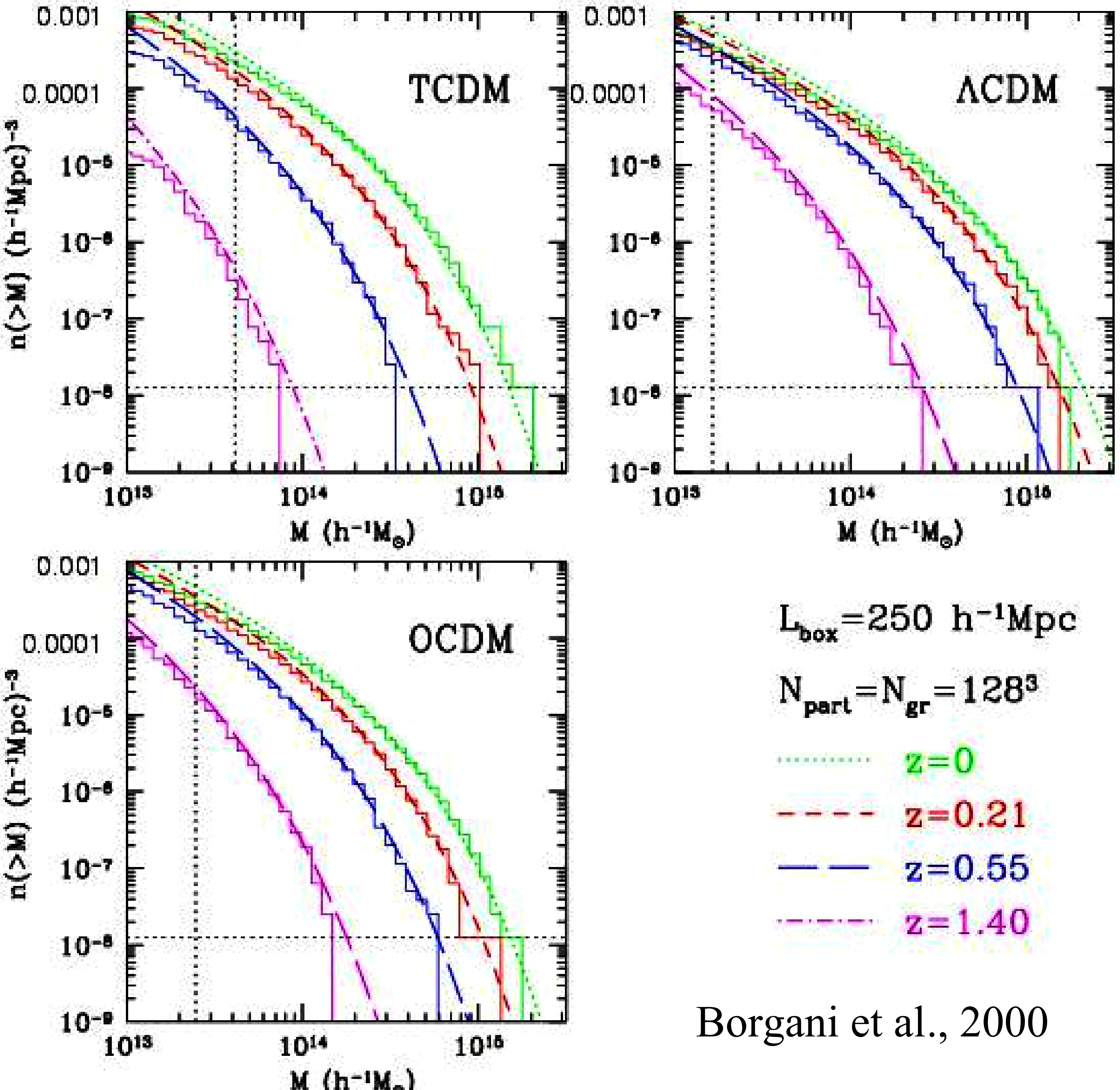
major recent improvements:

$$\mathcal{F}(\nu) = \sqrt{\frac{2A}{\pi}} C \exp(-0.5 A\nu^2)(1. + (A\nu)^2)^Q)$$

with $A = 0.707 \; C = 0.3222 \; Q = 0.3$

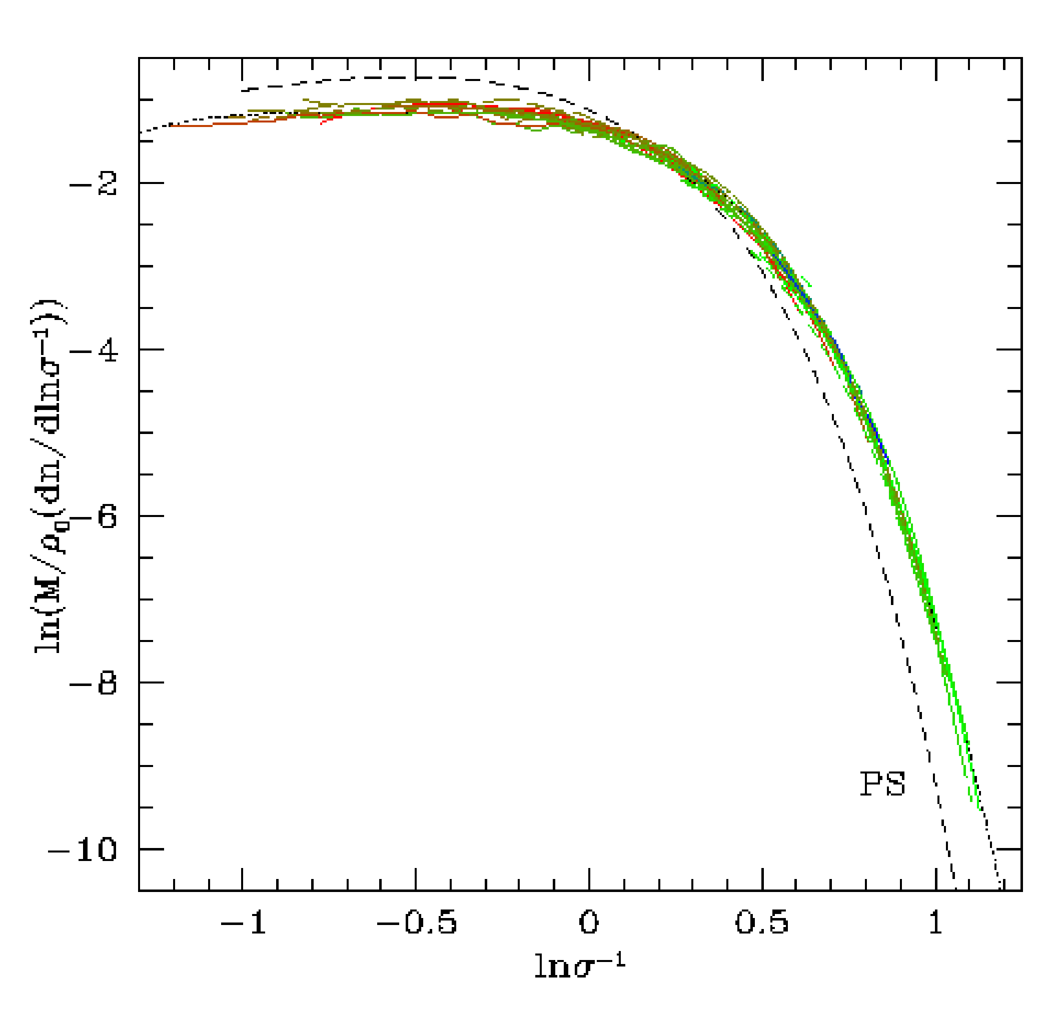
Sheth, Mo, Tormen 2001 MNRAS, 323 1

TESTING THE MASS FUNCTION



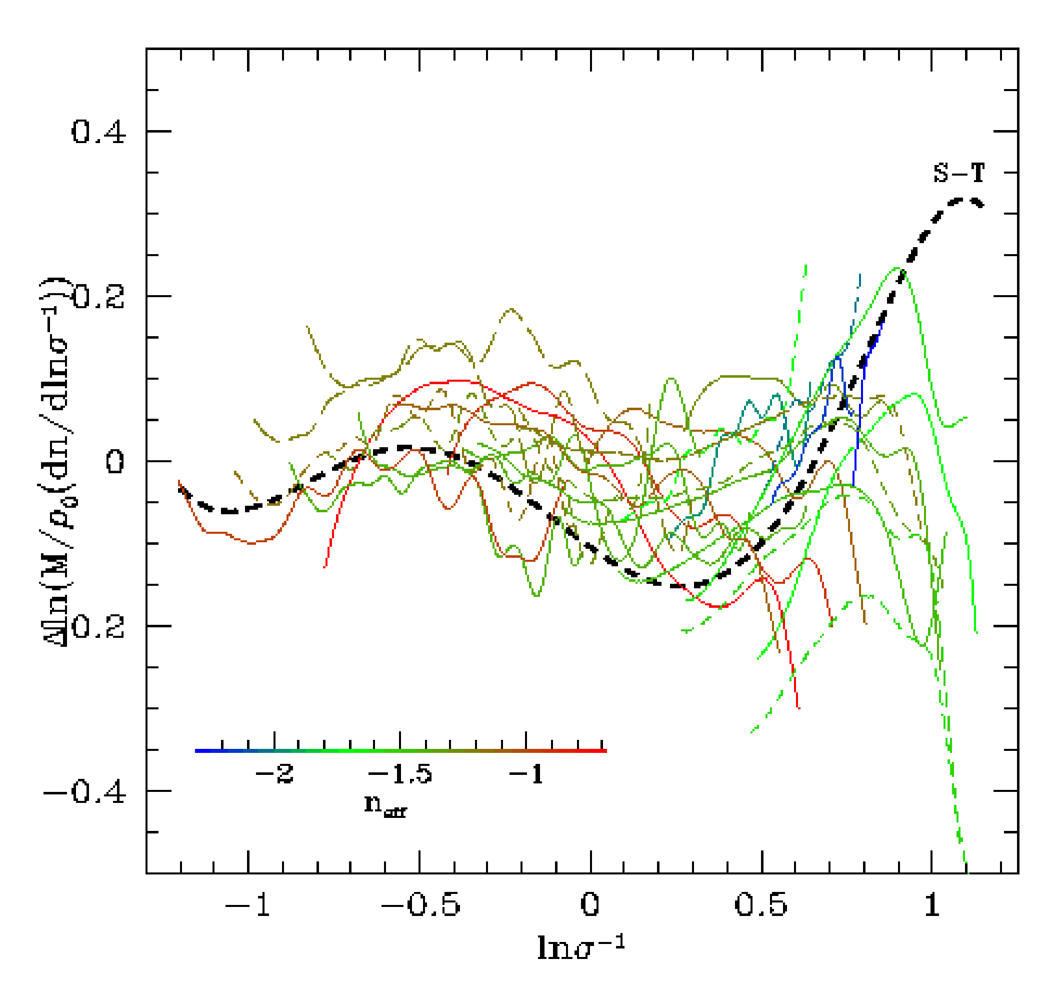
Borgani et al., 2000

Checking N(M)



Jenkins et al., 2001 MNRAS, 321, 372

Checking N(M) (2)



Jenkins et al., 2001 MNRAS, 321, 372

Conclusion I

Reasonable description of the mass function in numerical simulations...

Scaling argument for Clusters:

Clusters are geometrically identical

With virial radius-mass relation

$$M = \frac{4\pi}{3}\rho_0 (1+z)^3 (1+\Delta) R_v^3$$

i.e.

$$R_v = \sqrt[3]{\frac{3M}{4\pi\rho_0(1+\Delta)}} \frac{1}{1+z}$$

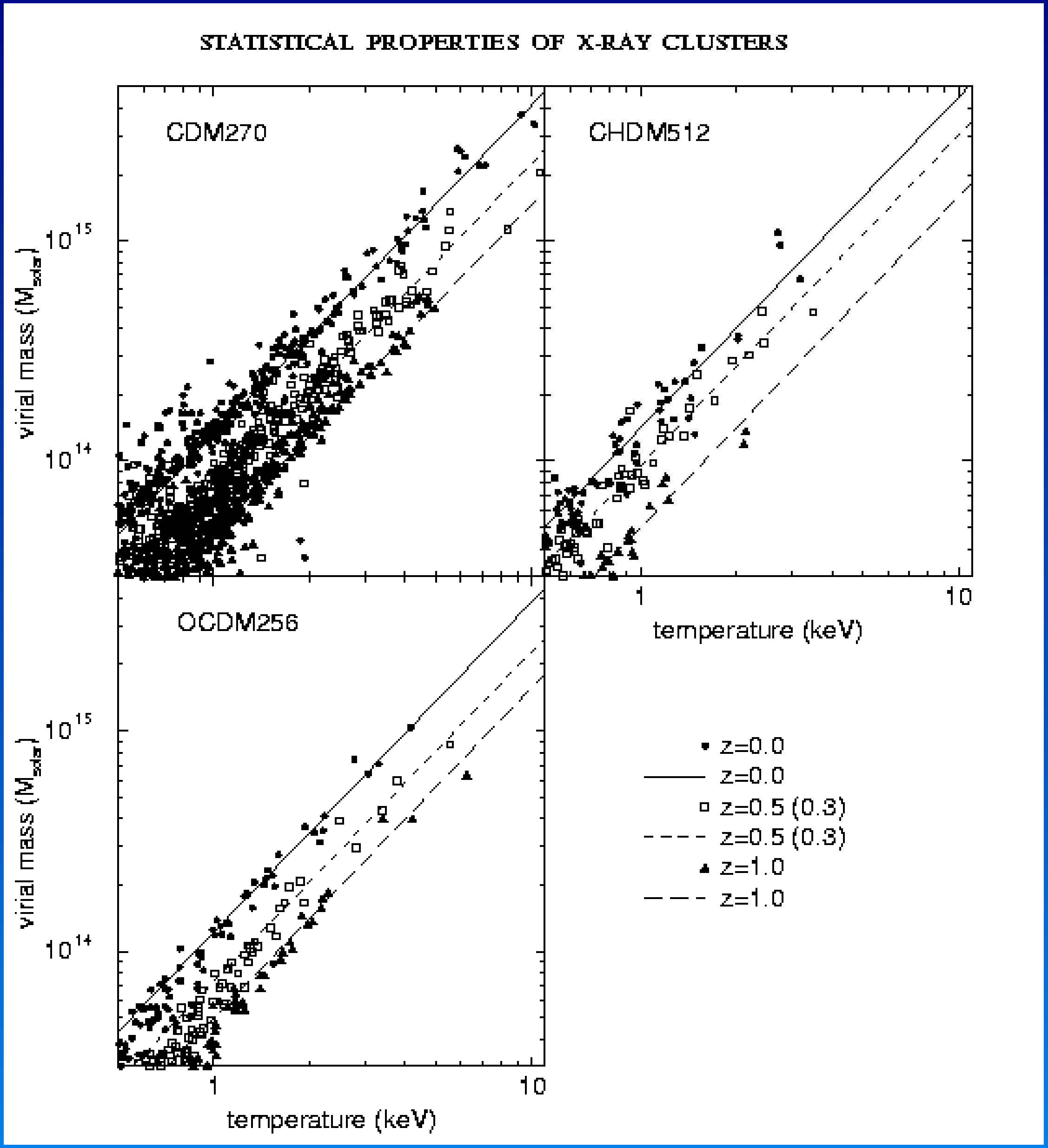
Mass-Temperature Relation :

$T \propto GM/r$

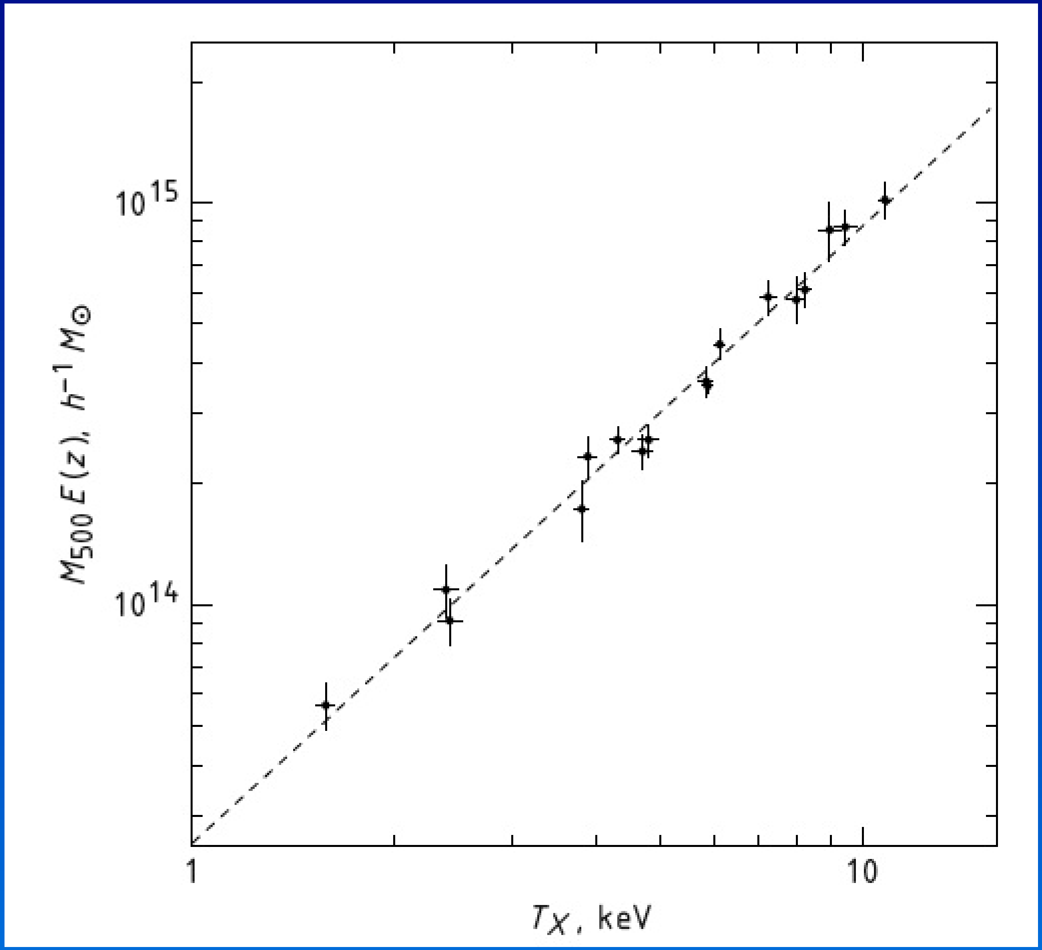
whatever you do with gravity...

$$T_x \simeq A\, M^{2/3}\, (\Omega\Delta)^{1/3} (1+z)\ \mathrm{keV}$$

Numerical simulations, Bryan & Norman, 1998



Bryan & Norman (ApJ 495 80 1998)



Vikhlinin et al (ApJ 2008)

Mass-Luminosity Relation :

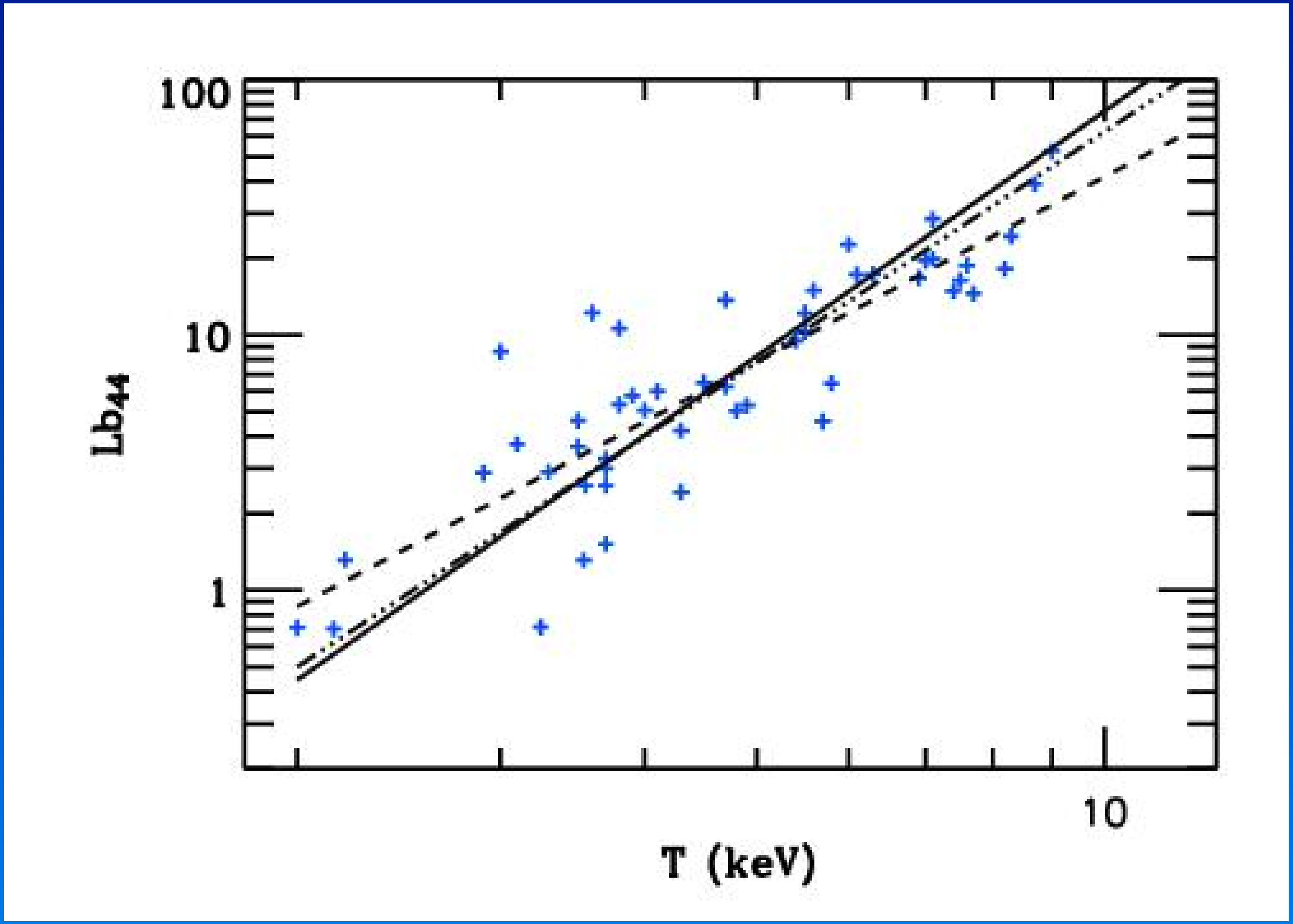
$$L_x \propto n^2 T^{1/2} V$$

...

$$L_x \simeq B\, M^{4/3}\, \Omega^{1/6} \Delta^{7/3} (1+z)^{3.5}$$

$$L_x \propto T^{2}\, \Delta^{1/2} (1+z)^{1.5}$$

Observed Temperature -Luminosity Relation



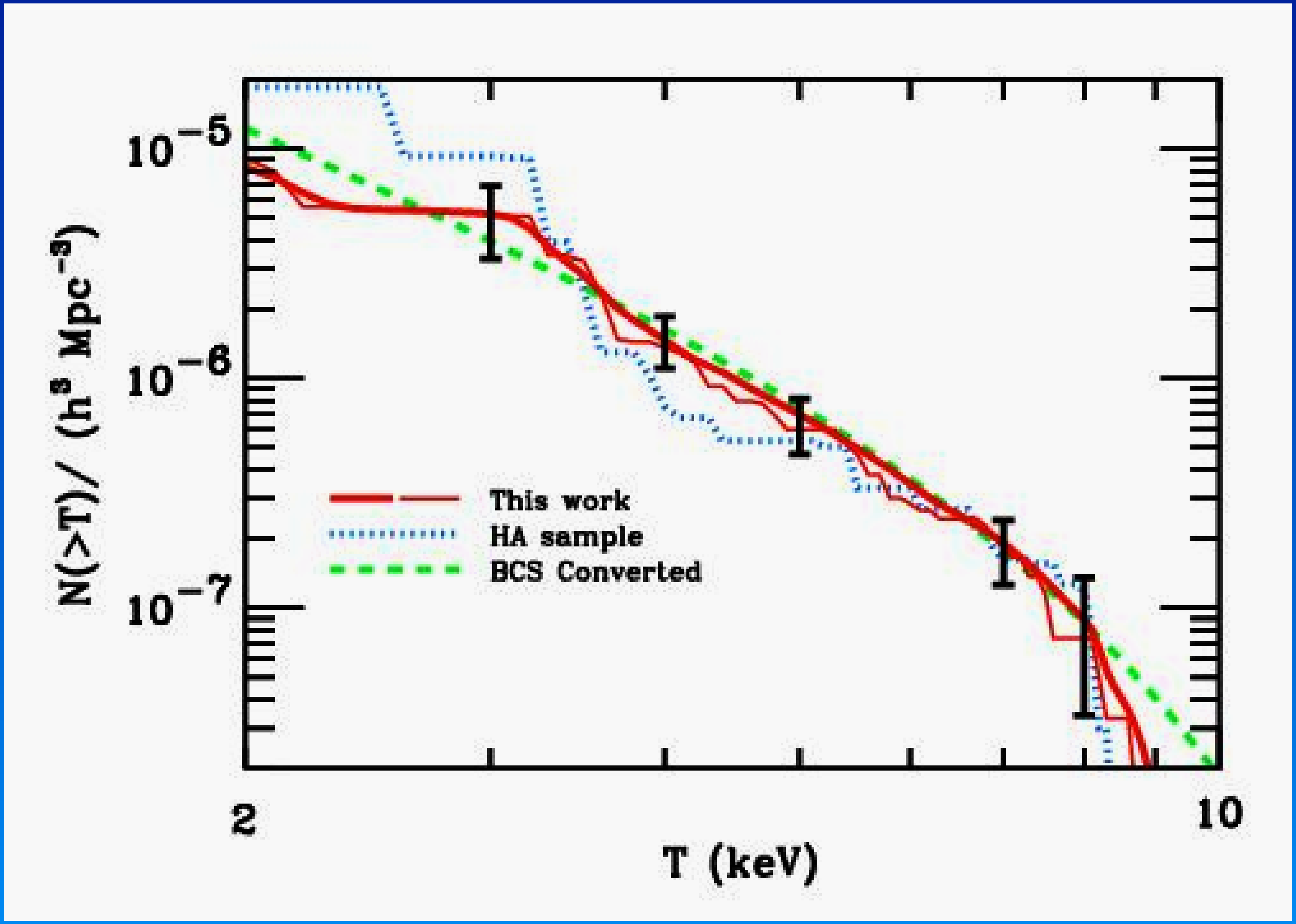
$$L_x \propto T_x^{\sim 3}$$

Conclusions at that point are :

Clusters are not self similar!

No Scaling with redshift...

A new estimation of the local N(T)

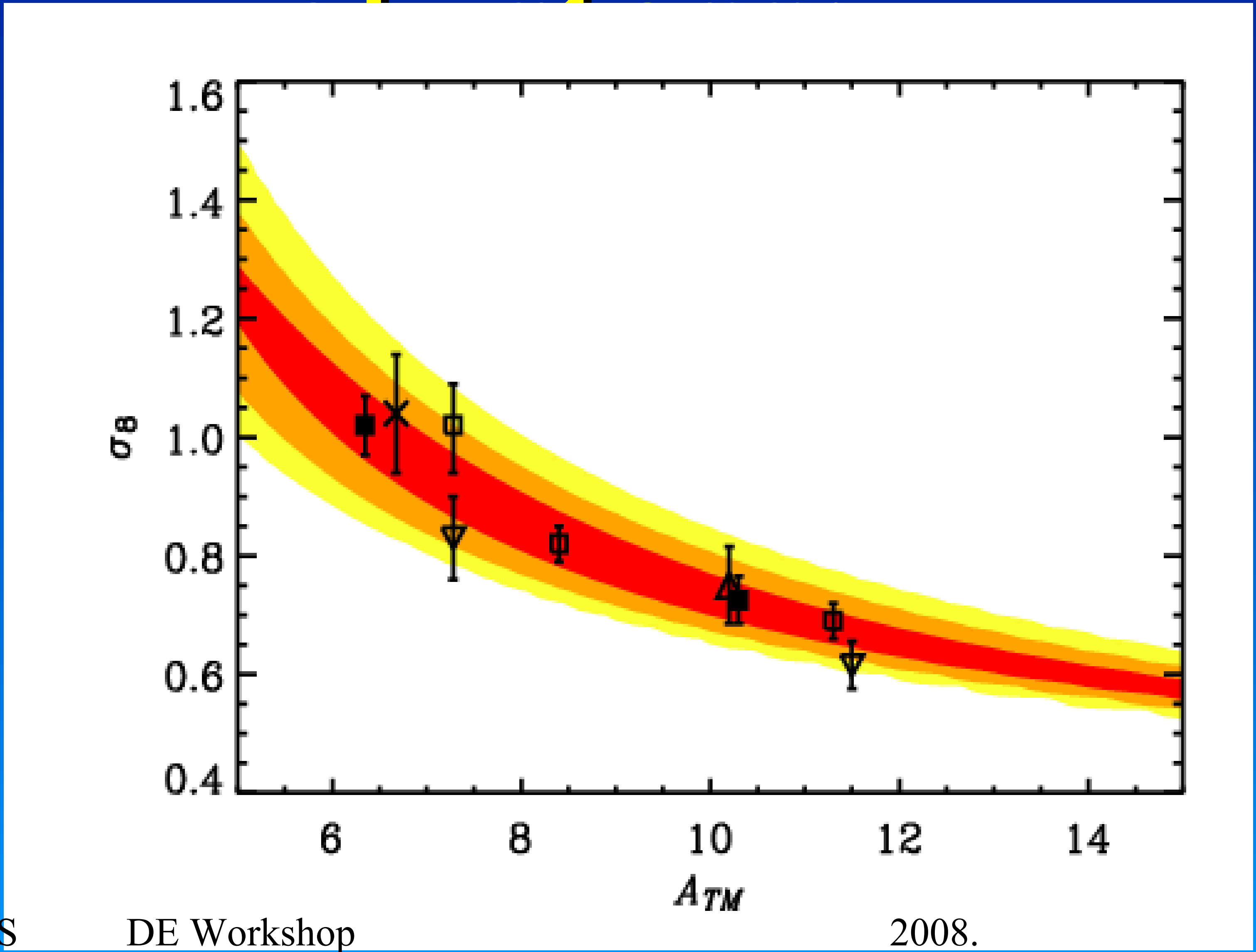


Mass-temperature relation:

$$T_x = A_{TM} (Mh)^{2/3} (1+z)(\Omega\Delta_v/178)^{1/3} \text{ keV}$$

A_{TM} is a free parameter ...

σ_8 from X-ray clusters



Ω_m From X-ray Clusters

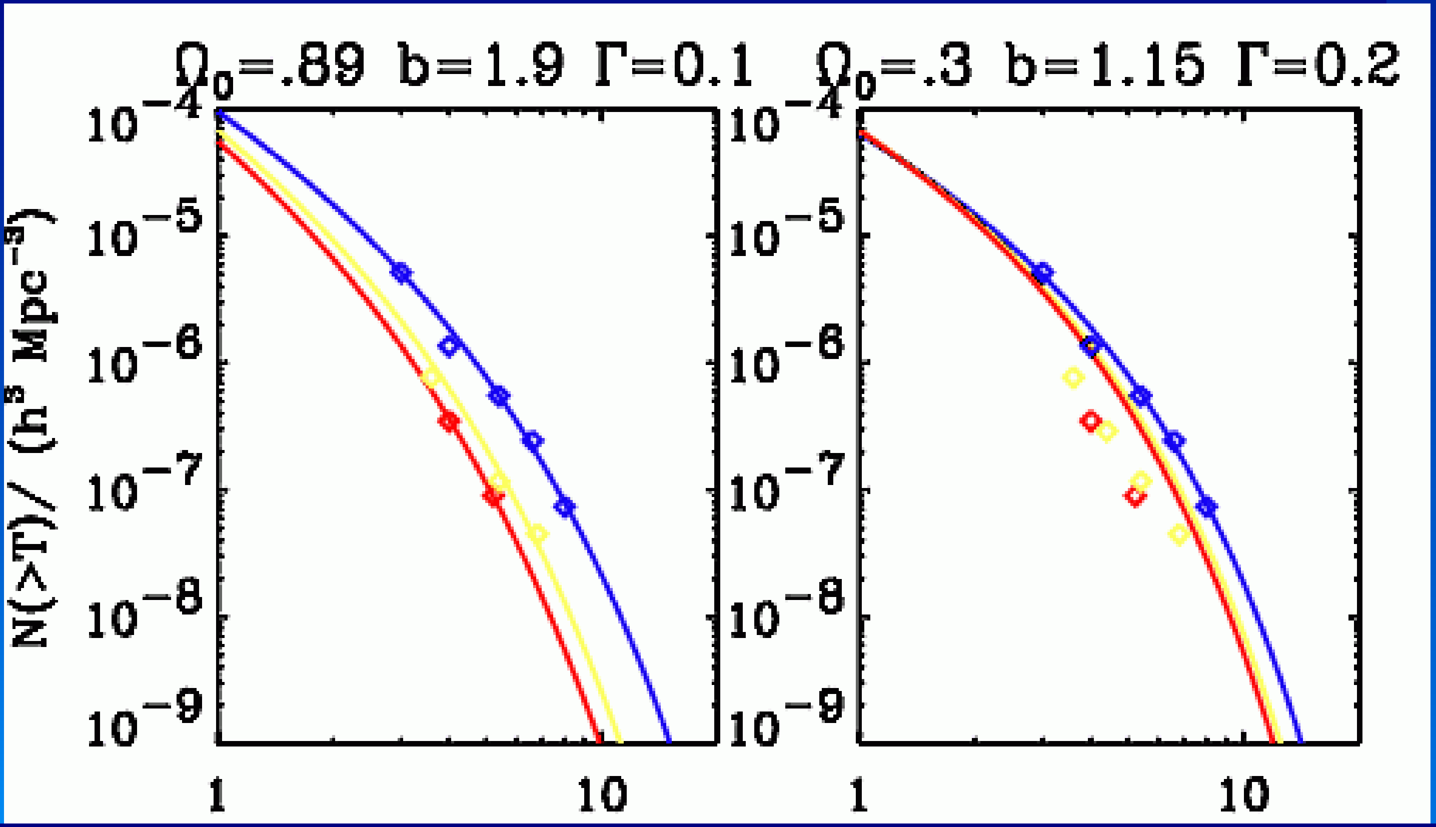
Number evolution

Principle:

Growth rate of linear perturbations:

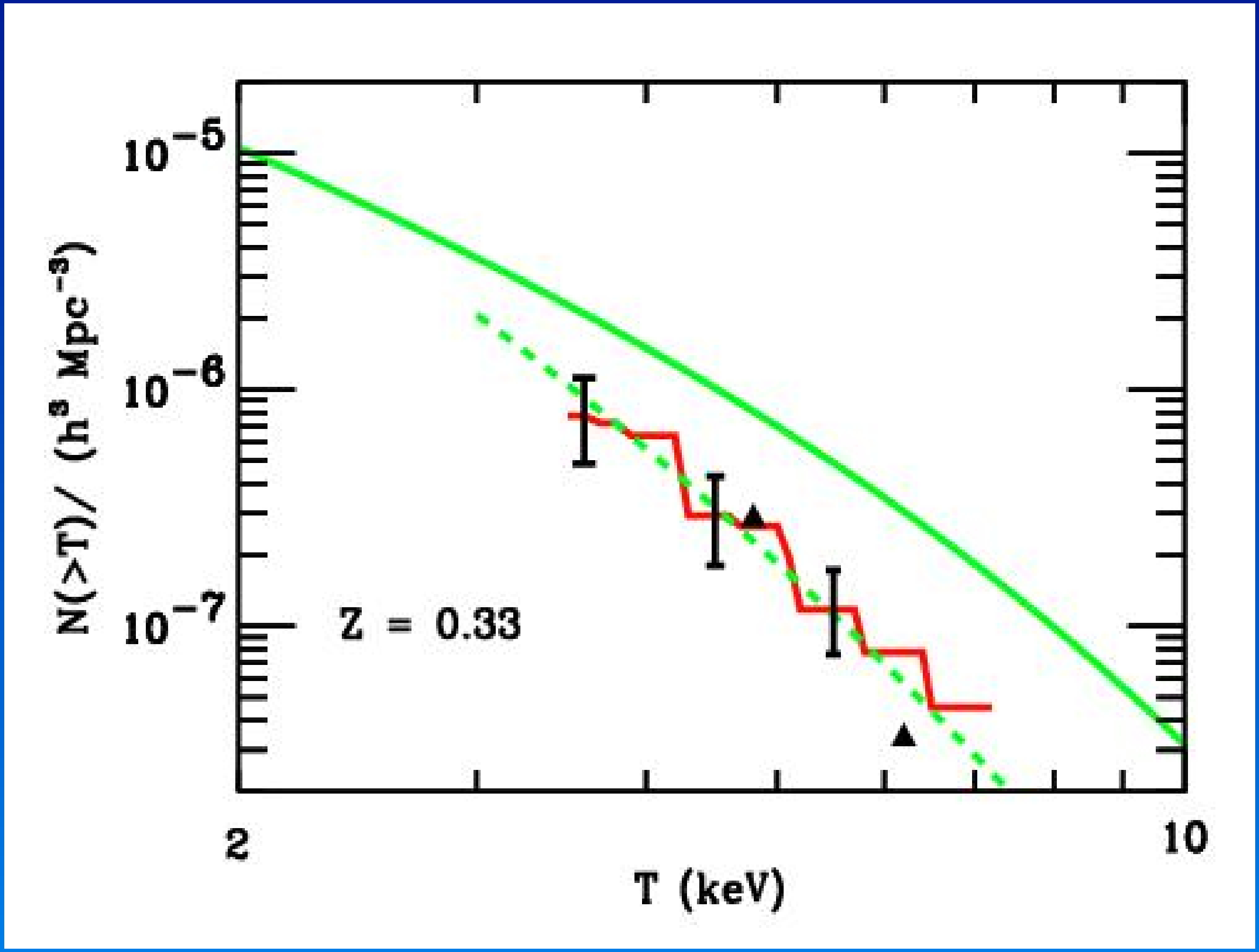
$$\sigma\left(M, z\right) = A(z, \Omega_m, \ldots)\sigma\left(M, 0\right)$$

Principle



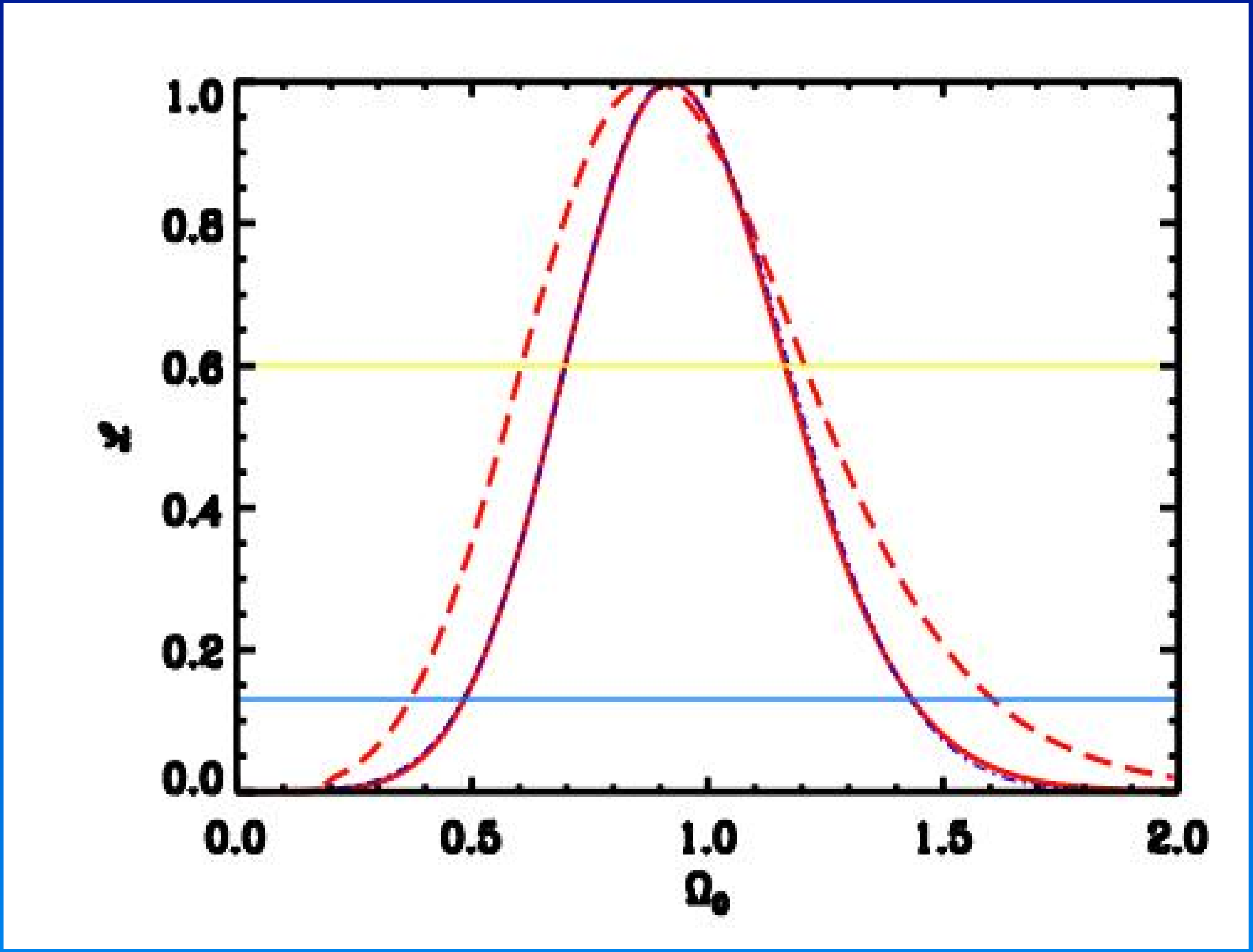
Oukbir, Blanchard, 1992, A&A, 262, L21

Estimated N(T) at z ≈ 0.33



Using Henri's sample (1997)

Likelihood on Ω_m



Blanchard et al (2000)

Ω_m From X-ray Clusters

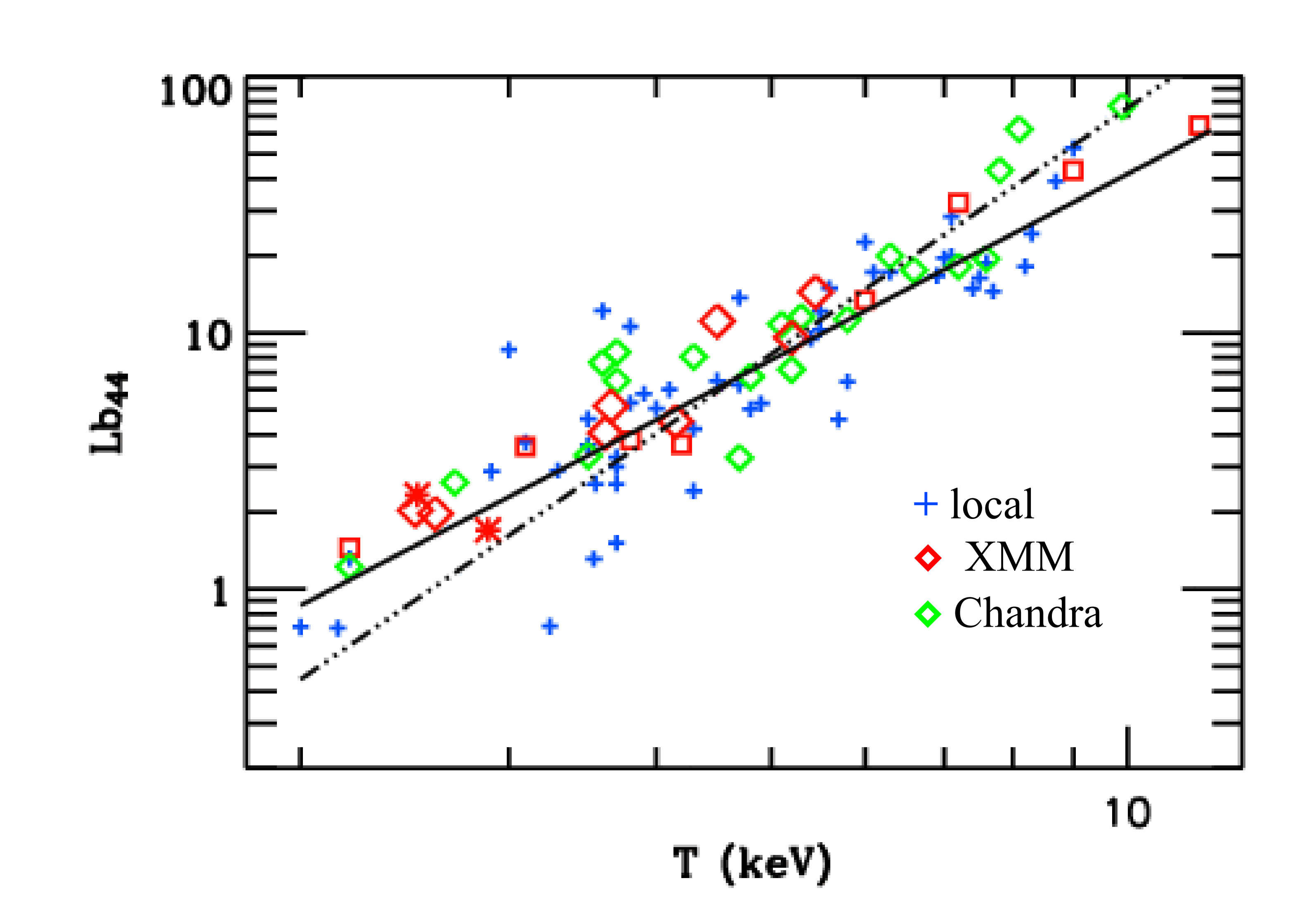
Vauclair et al, 2003
A&A 412, L37

Number counts:

≈300 clusters

with $z > 0.3$

XMM Lx-Tx evolution



Conclusion on evolution:

- remarkable convergence

$$Lx/Tx)_z = Lx/Tx)_{z=0}(1+z)^{\beta}$$

with $\beta = 0.65 \pm 0.28$

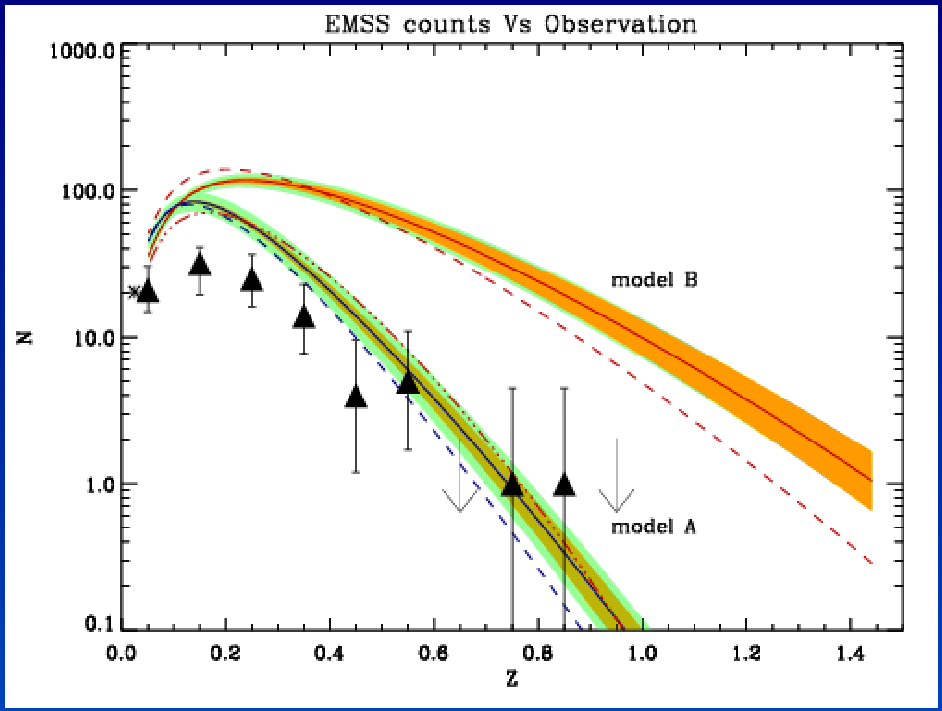
in full agreement with Chandra (Vikhlinin et al, 2002), ASCA (Sadat et al., 1998; Novicki et al., 2003....)

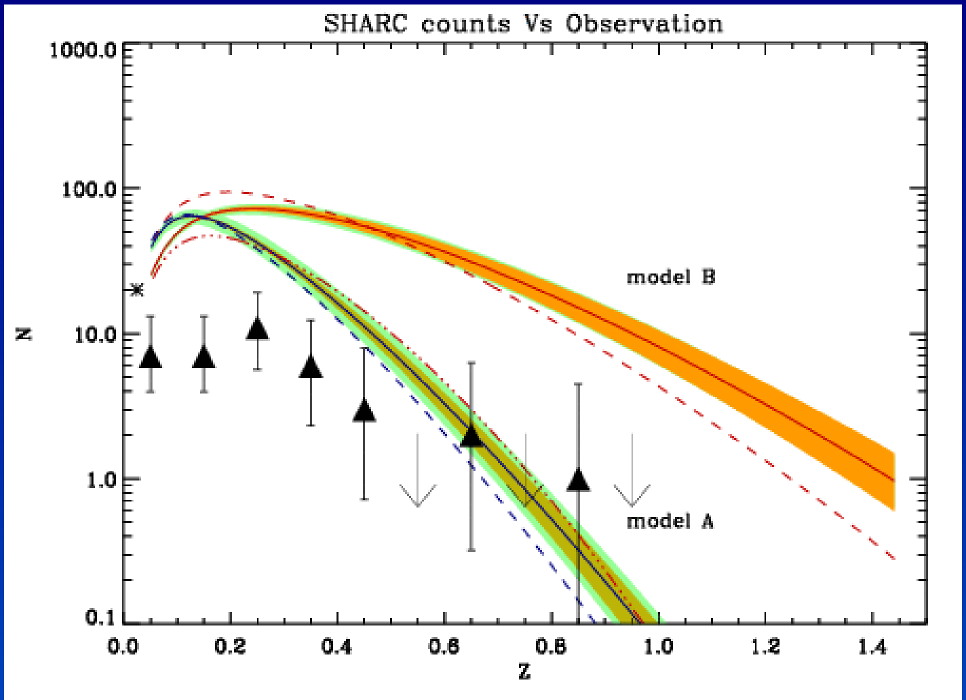
D.Lumb et al., 2003

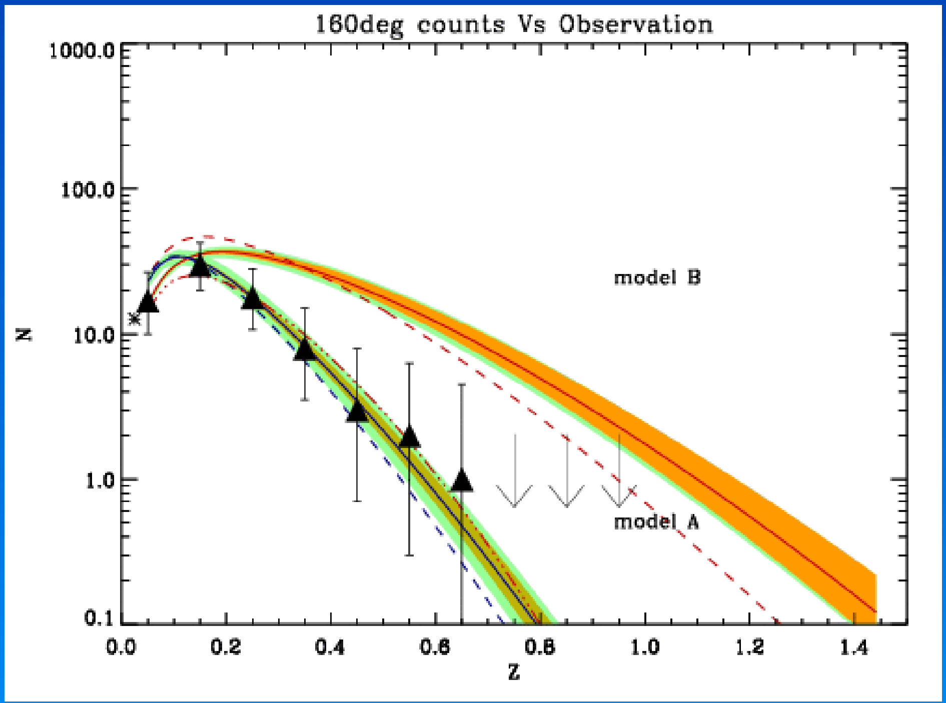
Method:

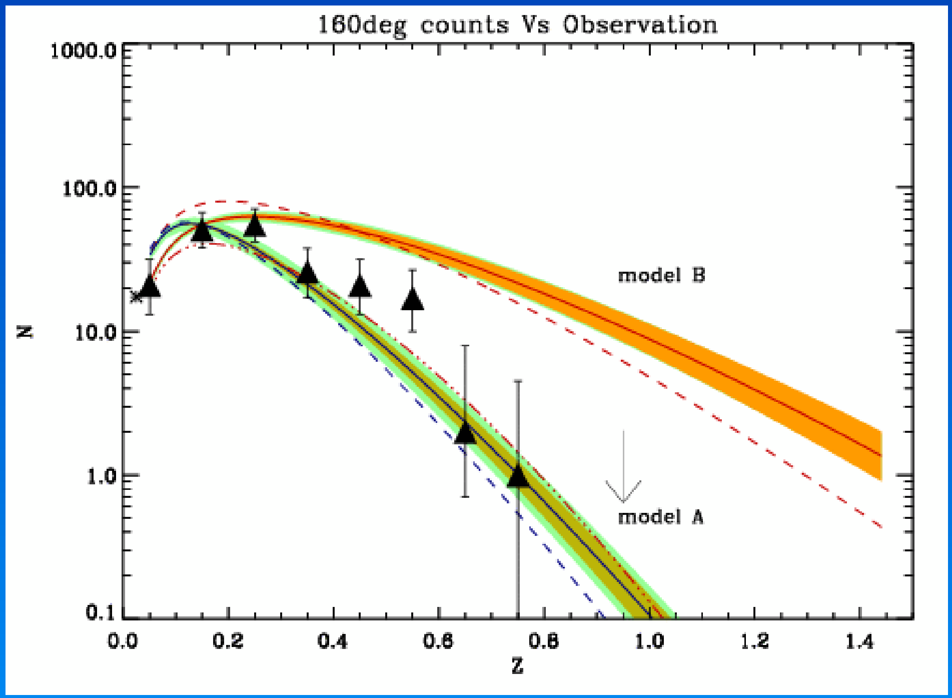
$$f_x \to L_x \to s, T_x$$

$$\begin{aligned} N(> f_x) &= \int_0^{+\infty} \int_0^{+\infty} s(T,z) N(T,z) dT dV(z) \\ &\gtrsim \int_0^{+\infty} N(> T(z)) dV(z) \end{aligned}$$


EMSS counts Vs Observation
1000.0
100.0
10.0
1.0
0.1
N
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Z
model B
model A


SHARC counts Vs Observation
1000.0
100.0
10.0
1.0
0.1
N
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Z
model B
model A


160deg counts Vs Observation
1000.0
100.0
10.0
1.0
0.1
N
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Z
model B
model A


160deg counts Vs Observation
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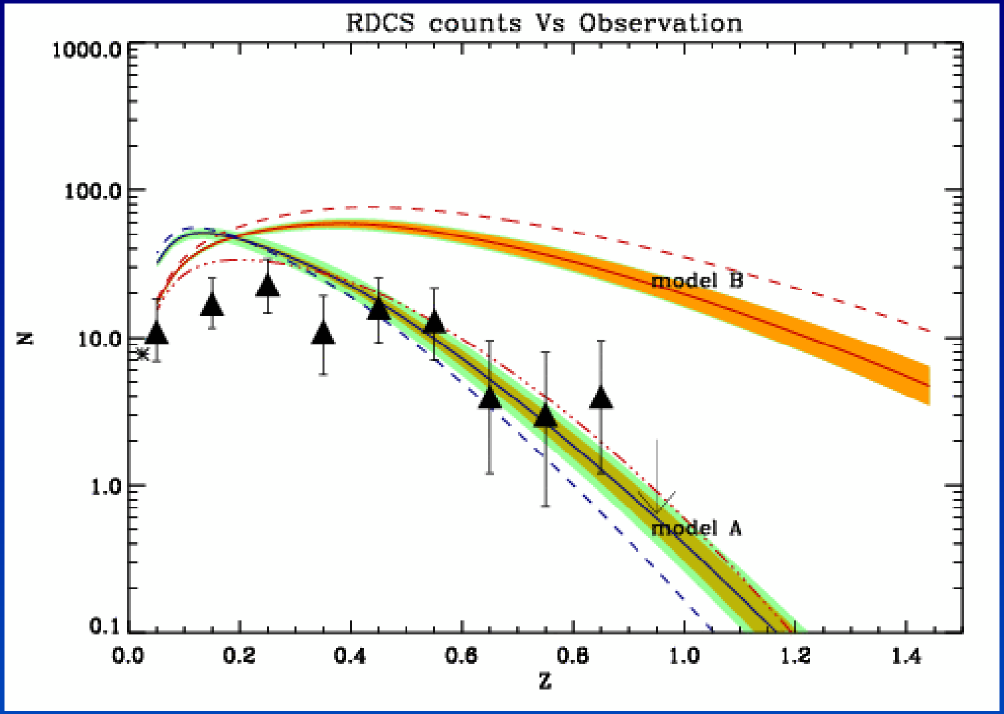
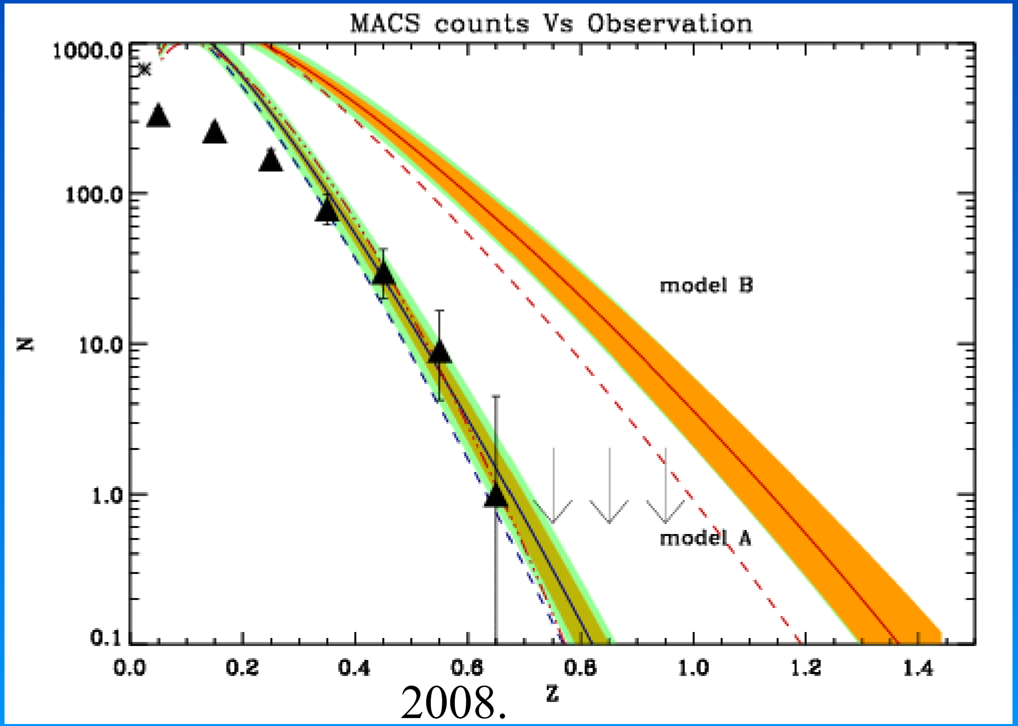
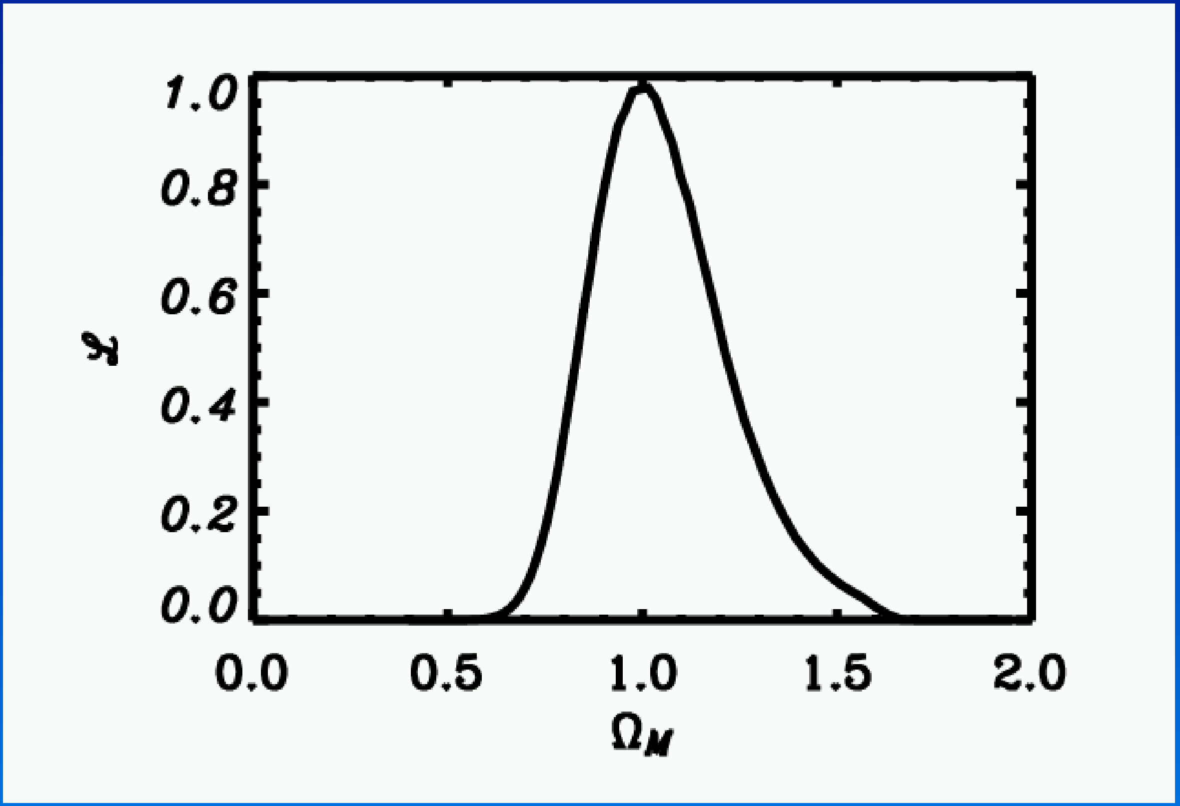


RDCS: 50 deg²
fx ≈ 3. 10^{-14} erg/s/cm²



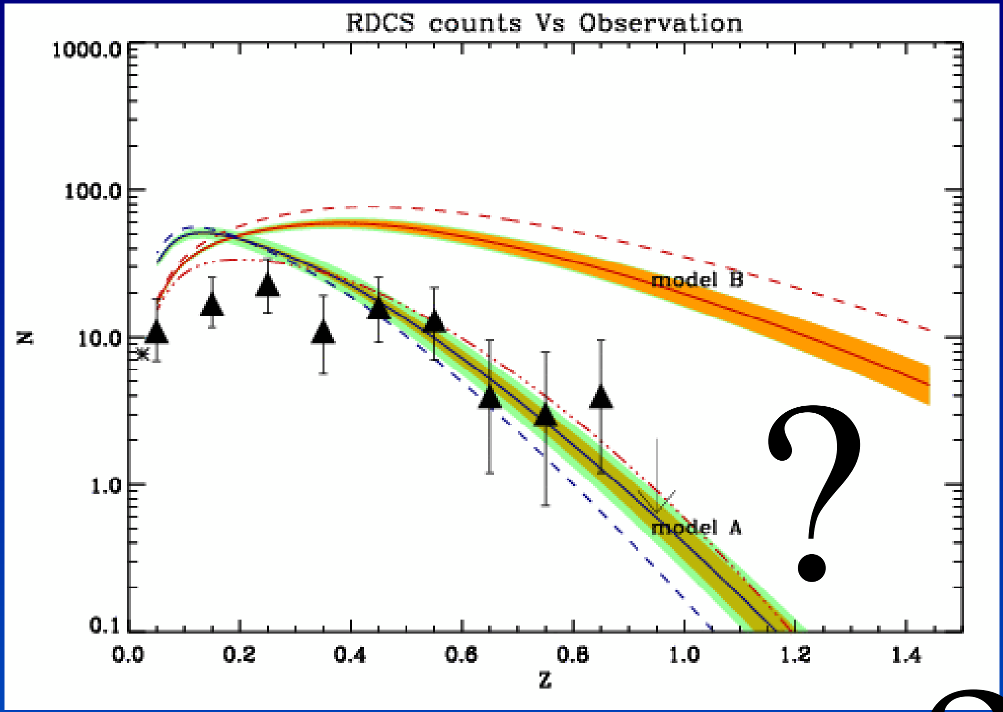
MACS: 22 000 deg²
fx ≈ 10^{-12} erg/s/cm²

Likelihood analysis:



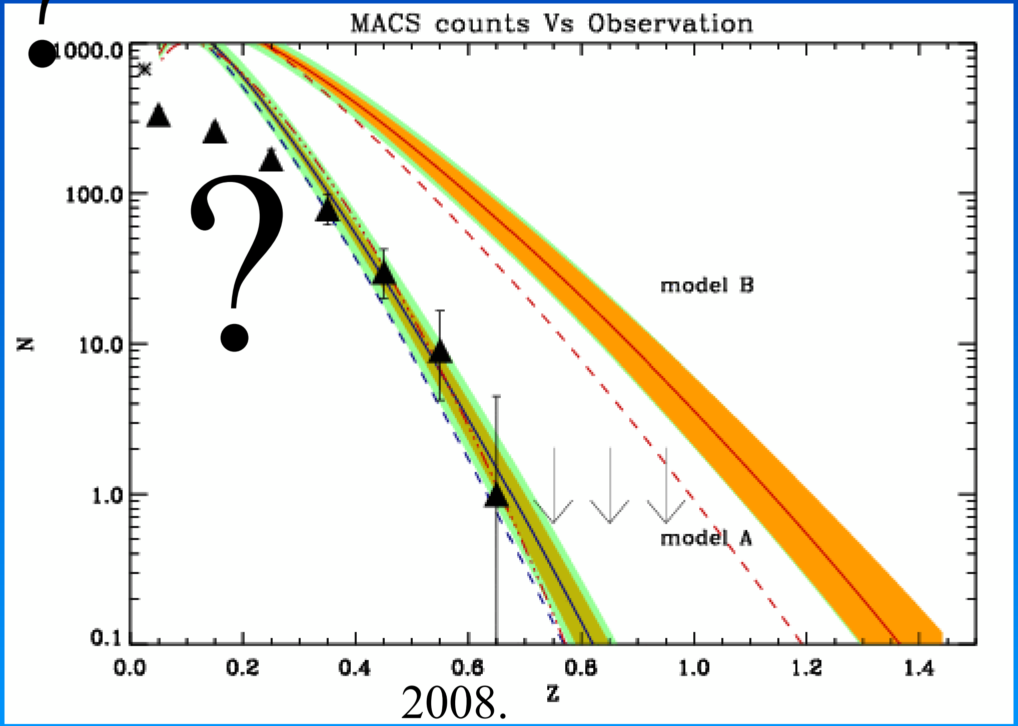
(Vauclair et al., 2005)

$\Omega_m = 0.99 \pm 0.15 \pm 0.15$



RDCS: 50 deg^2
fx ≈ 3. 10^{-14} $erg/s/cm^2$

? ?



?

MACS: 22 000 deg^2
fx ≈ 10^{-12} $erg/s/cm^2$

Yet an other degeneracy?

Kill the Mass-Temperature Relation :

$$T \propto GM/r + ... \propto GM/r\,/(1+z)$$

i.e. ~ forget gravity...

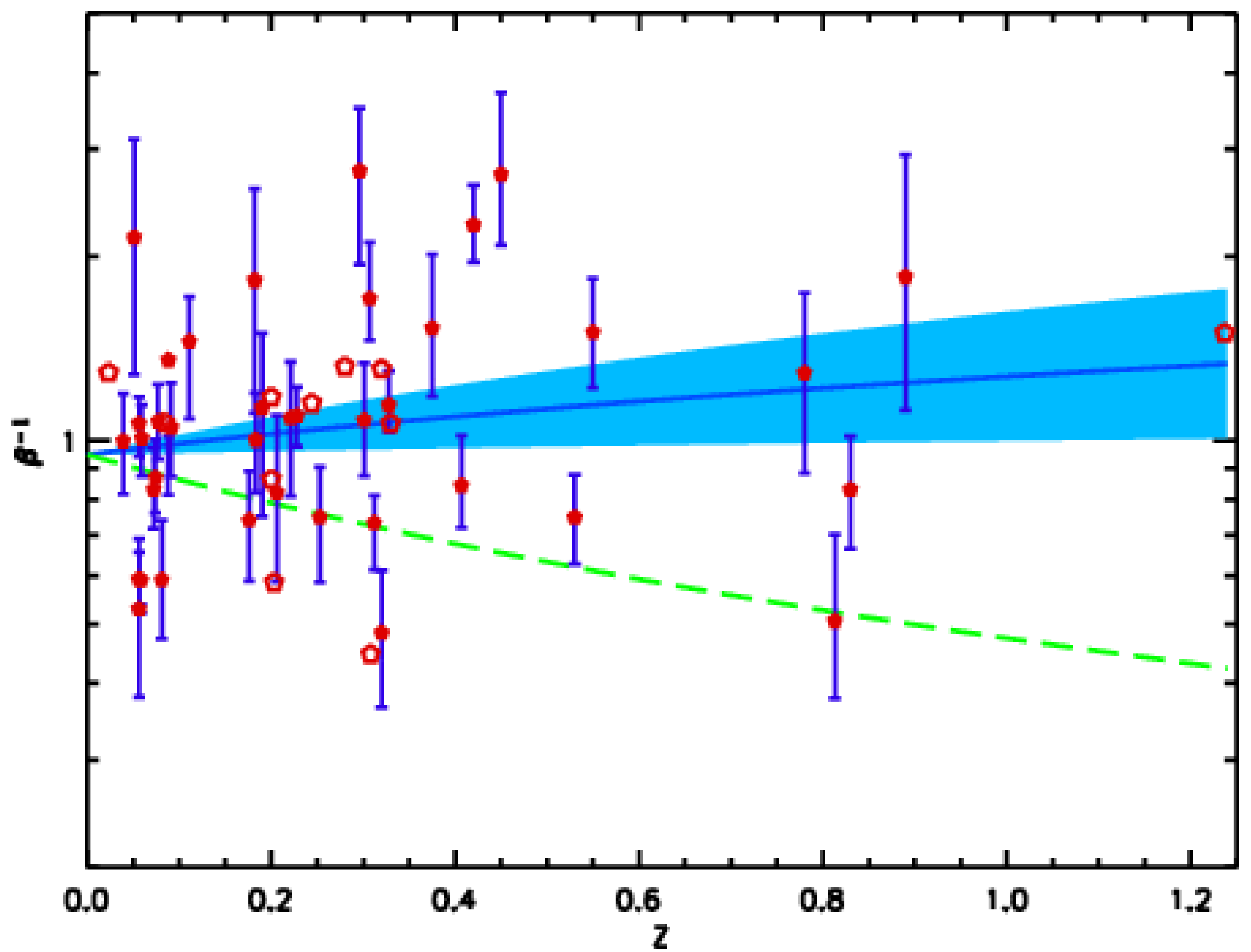
$$T_x \propto M^{2/3}$$

Breaking the degenracy...

$$T \propto GM/r\,/(1+z) \propto \sigma^2/(1+z)$$

➢ **Testable... i.e.**

$$\beta^{-1} \propto T/\sigma^2 \propto 1/(1+z)$$


0.0
0.2
0.4
0.6
0.8
1.0
1.2
z
1
β^{-1}