Cosmological hydrodynamical simulations in various dark energy scenarios

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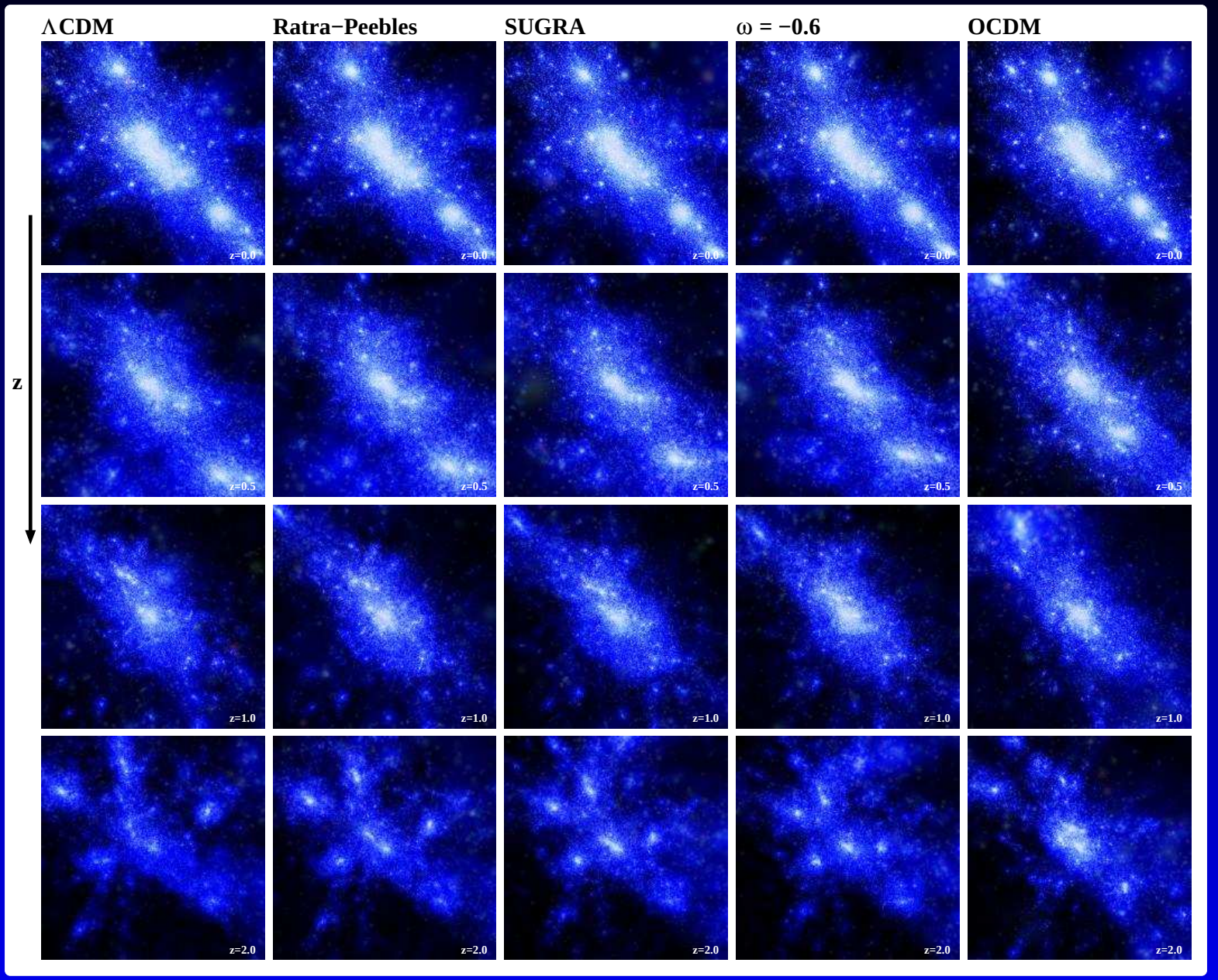
Introduction



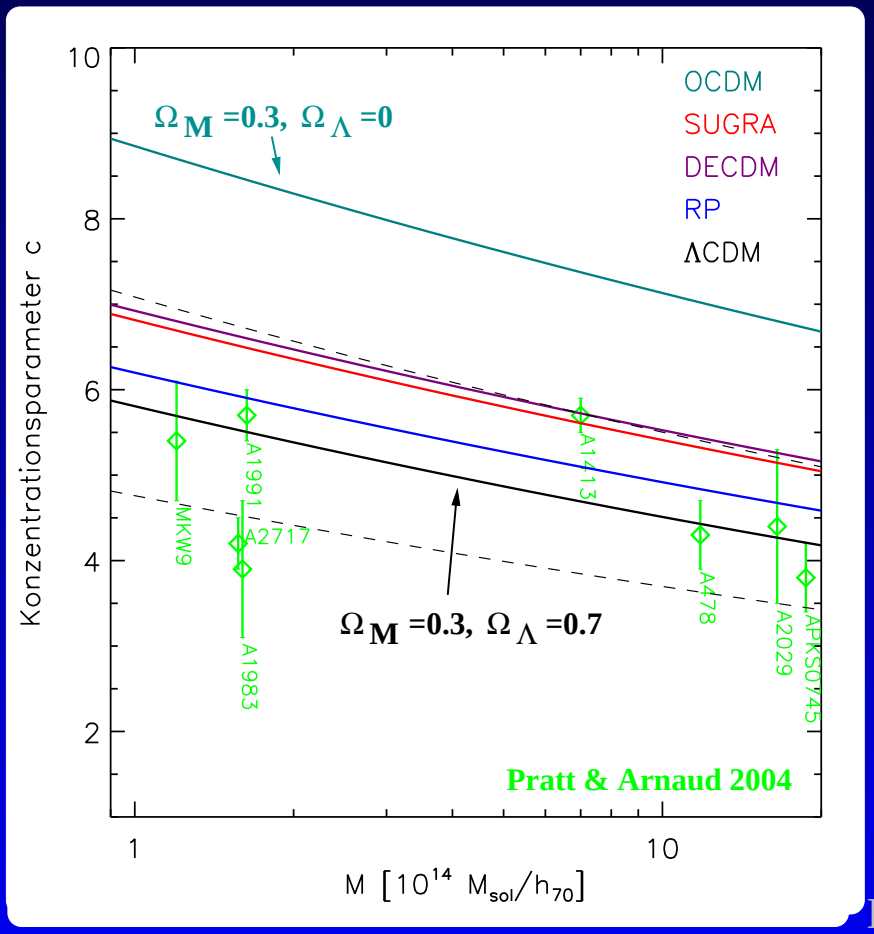
Dolag et al. 2004

Evolutionary sequence of cluster in various DE scenarios.

Introduction

Universal density profile (NFW, 1997):

$$\rho(r) = \frac{\rho_0}{(r/r_\mathrm{s})(1+r/r_\mathrm{s})^2}, c = r_{200}/r_\mathrm{s}$$



Dolag et al. 2004

Inner structure remembers formation history !

The New Simulation Set

$$\begin{aligned} \Omega_{matter} &= 0.268 \\ \Omega_{\Lambda} &= 0.732 \\ \Omega_{bary} &= 0.044 \\ H_0 &= 0.704 \\ \Sigma_8 &= 0.776 \\ n &= 0.947 \end{aligned}$$

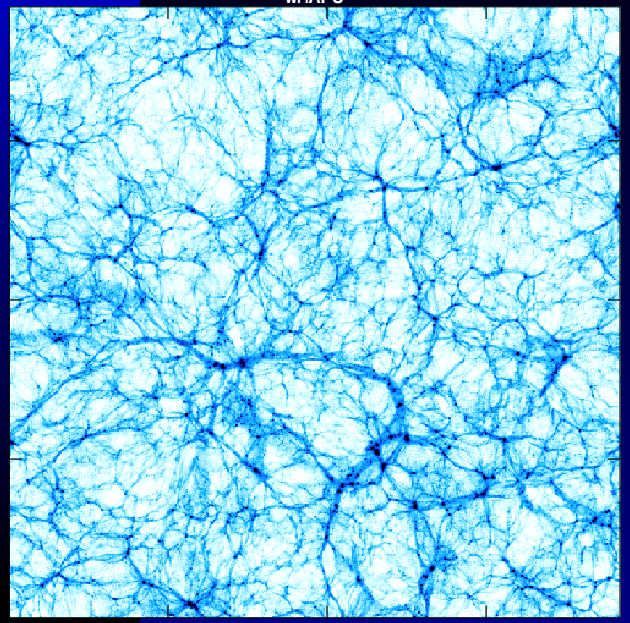
- $L_{box} = 300$ Mpc/h, $n_p = 2 \times 768^3$, $\epsilon_G = 7.5$ kpc/h

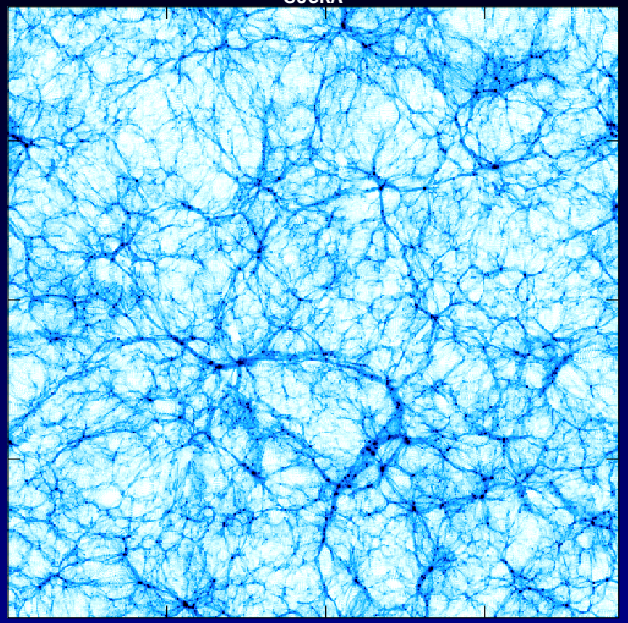
$\Rightarrow$ $m_{DM} = 3.7 \times 10^9 M_{\odot}/h$ and $m_{gas} = 7.3 \times 10^8 M_{\odot}/h$

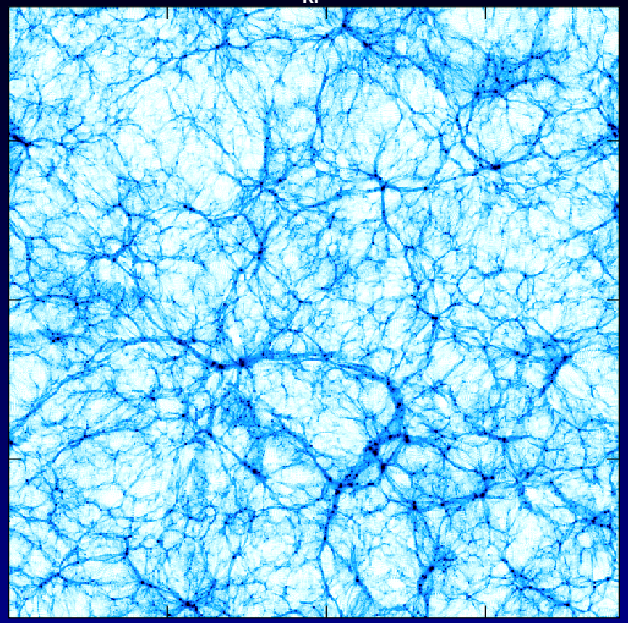
- WMAP3
- SUGRA ($\sigma_8 = 0.69, w_{\phi_0} = -0.9, w(z=0) = -0.93$)
- RP ($\sigma_8 = 0.75, w(z=0) = -0.93$)
- EQn_w120 ($\sigma_8 = 0.73, w_{JBD0} = 120, w_{\phi_0} = -0.9, \alpha = -0.23$)
- EQp_w120 ($\sigma_8 = 0.79, w_{JBD0} = 120, w_{\phi_0} = -0.9, \alpha = 0.64$)

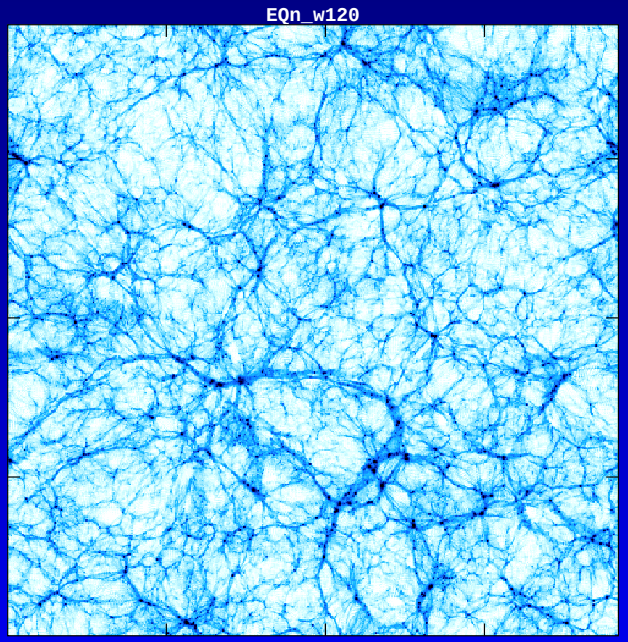
See Pettorino & Baccigalupi 2008 for details on the DE models.

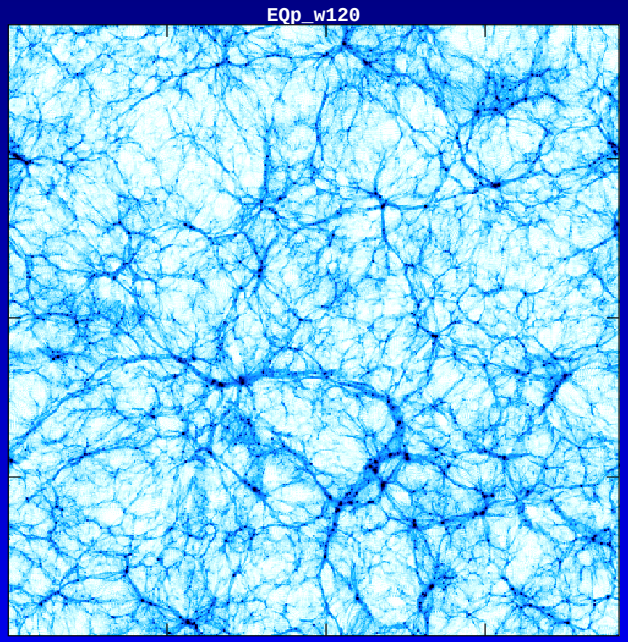
The New Simulation Set





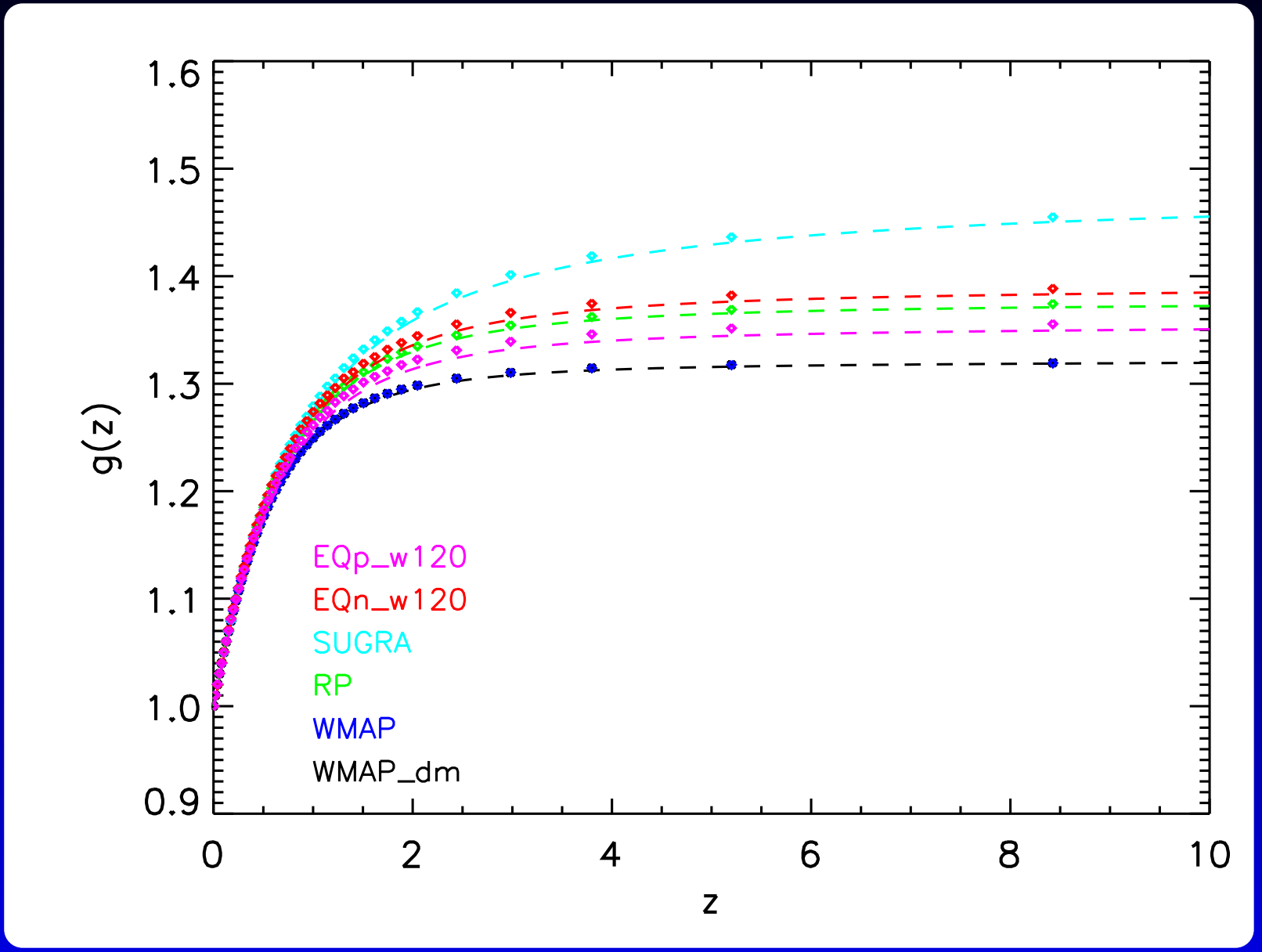






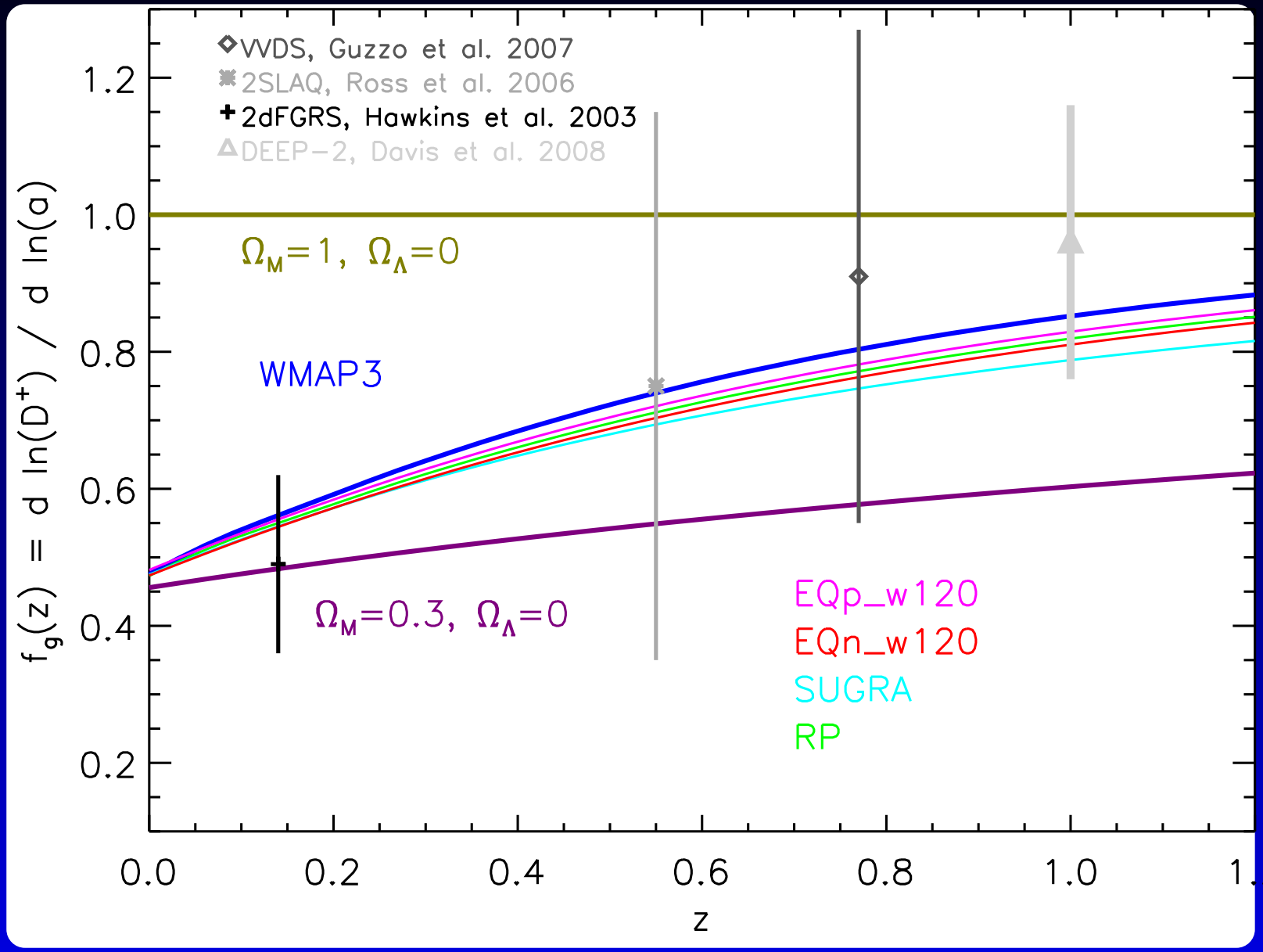
Simulations (cooling + star formation, DM control run)

The New Simulation Set



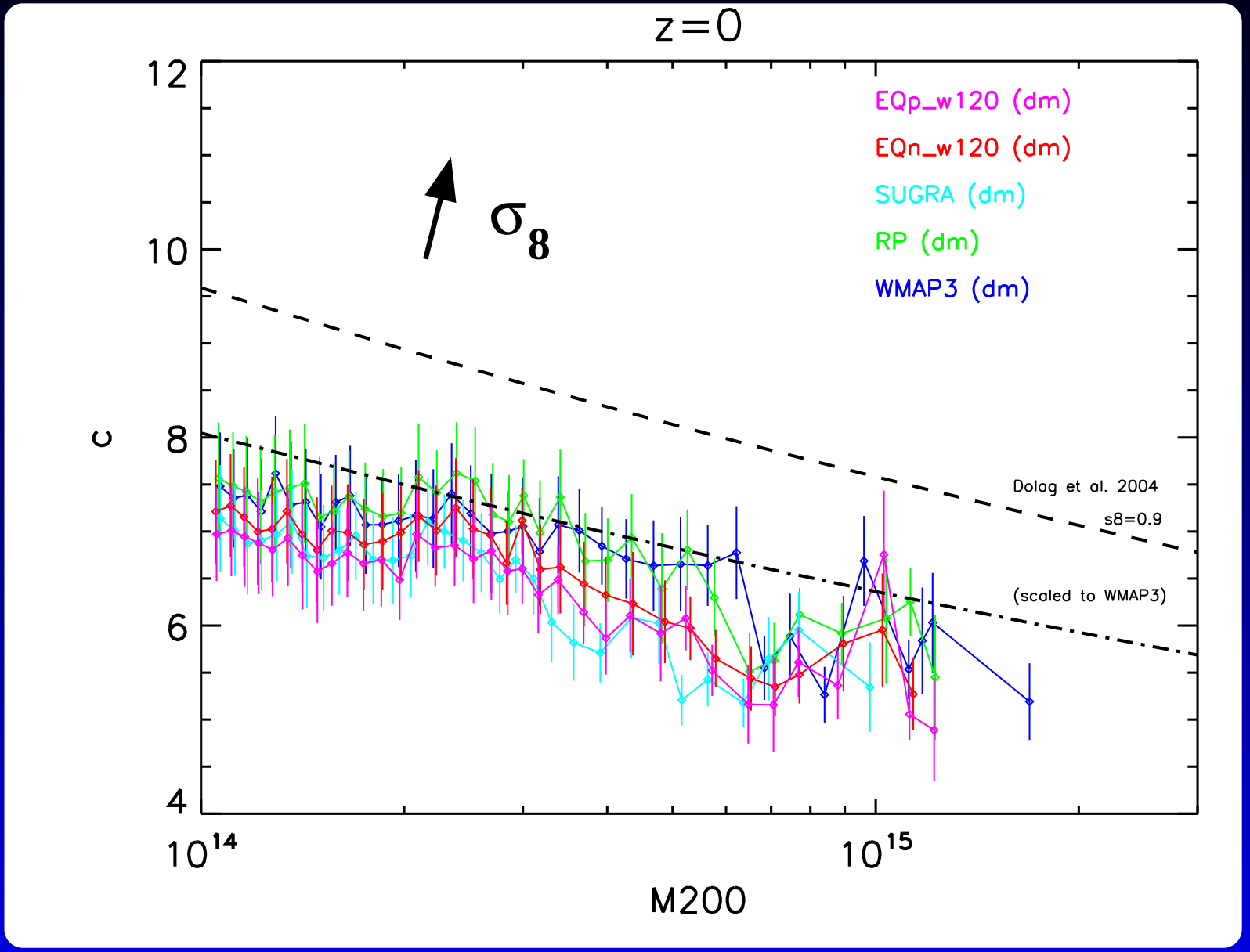
Comparing linear growth (D^+): Theory vs. Simulations.

The New Simulation Set



Comparing linear growth (f_g): Theory vs. Observations.

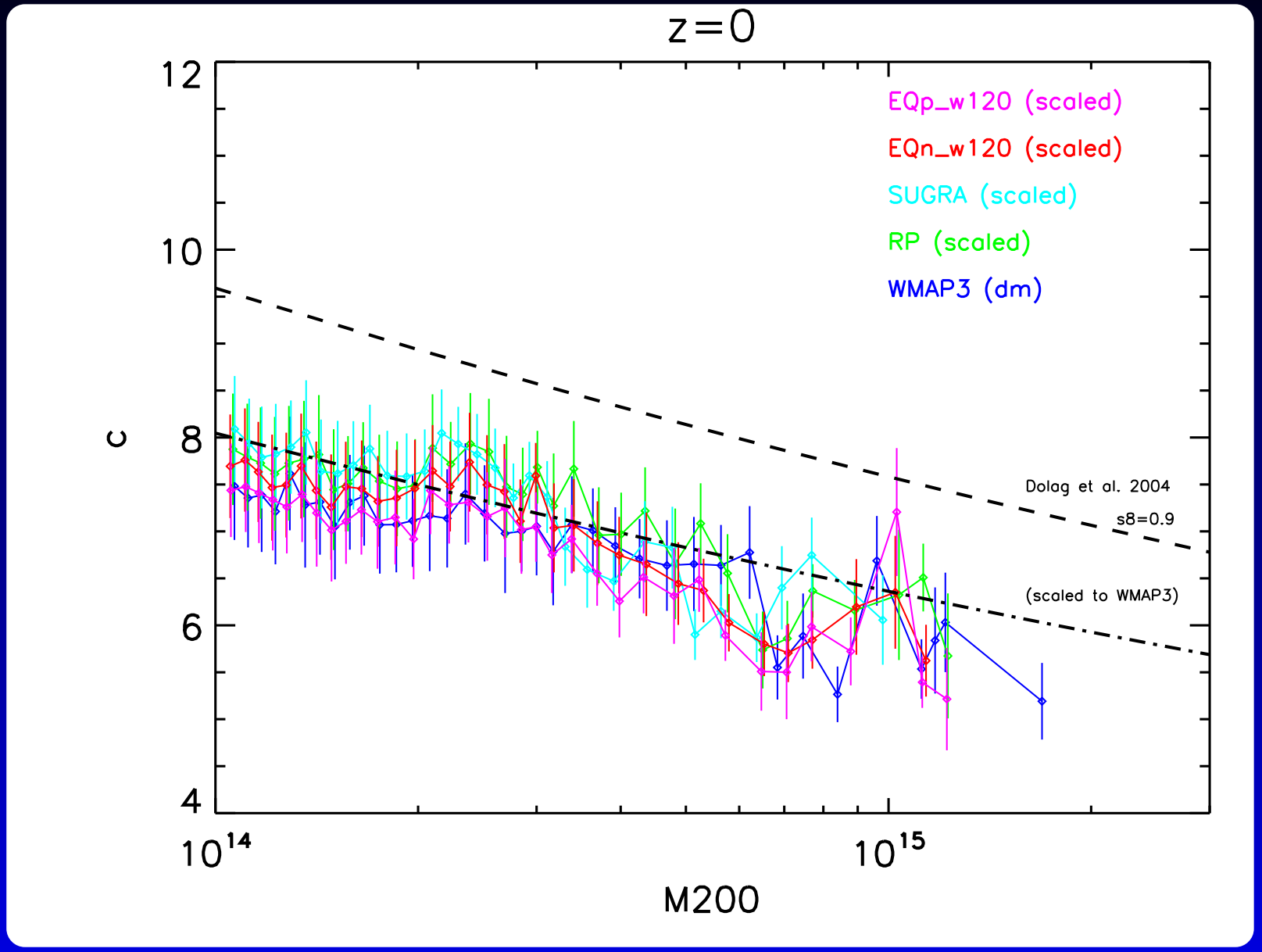
Mass-Concentration Relation



C-M relation from DM-only control run.

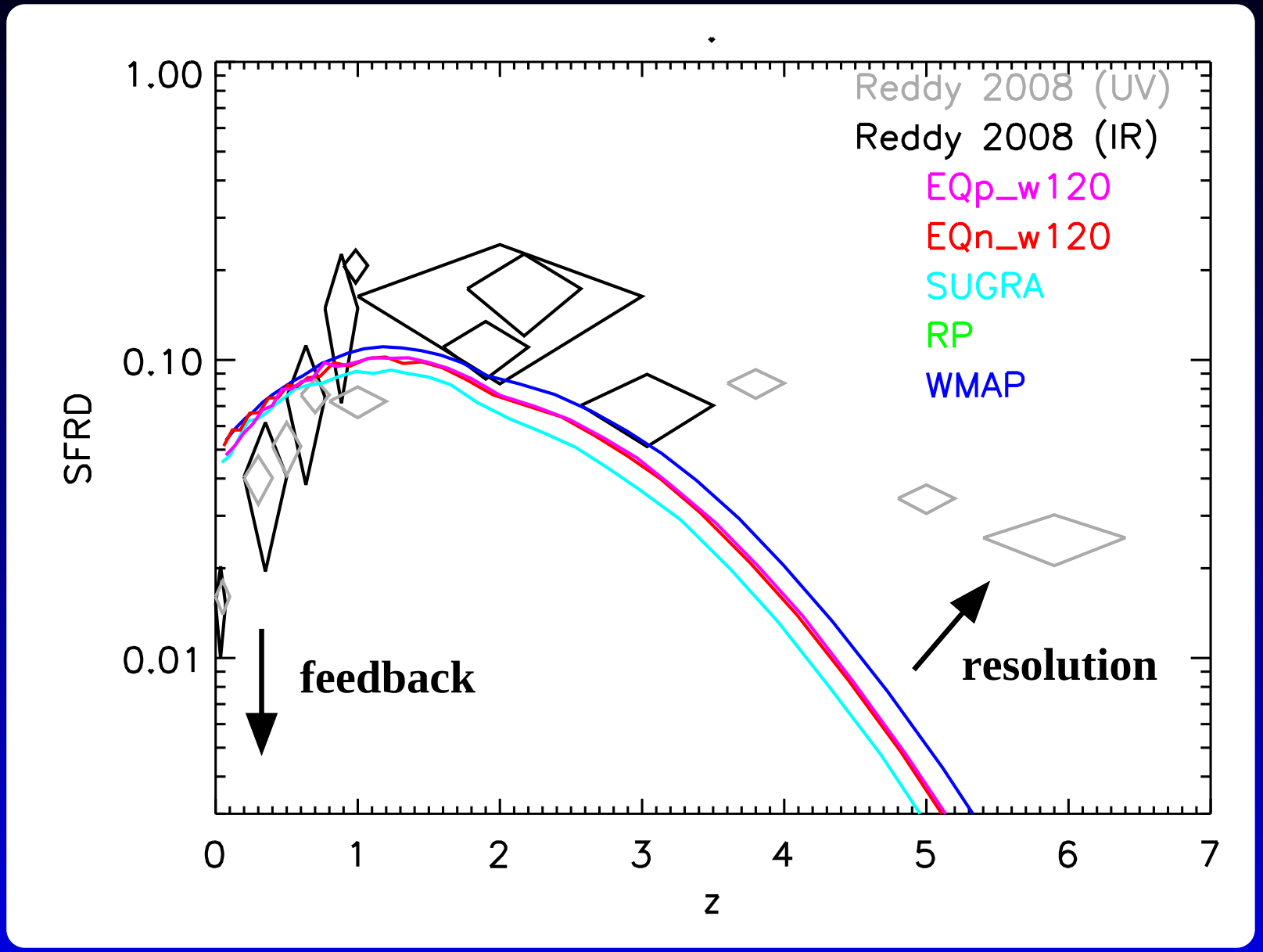
In general c much lower because σ_8 changed ($0.9 \rightarrow 0.776$).

Mass-Concentration Relation



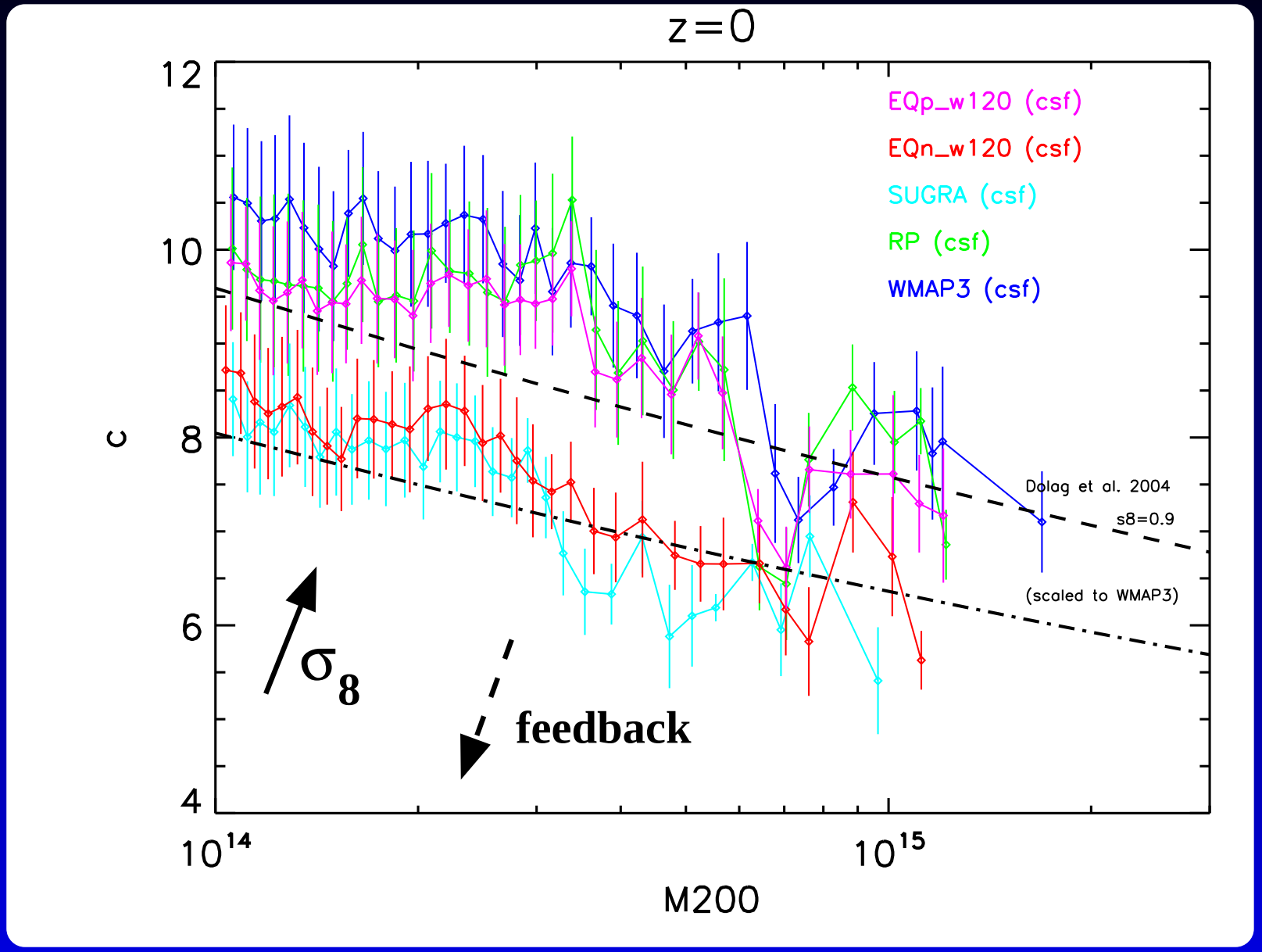
Scaling with D^+ (Dolag et al. 2004) holds also for EQ models.
Also confirmed by Grossi & Springel 2008 for EDE models.

Mass-Concentration Relation



Interplay between formation history and baryon physics.

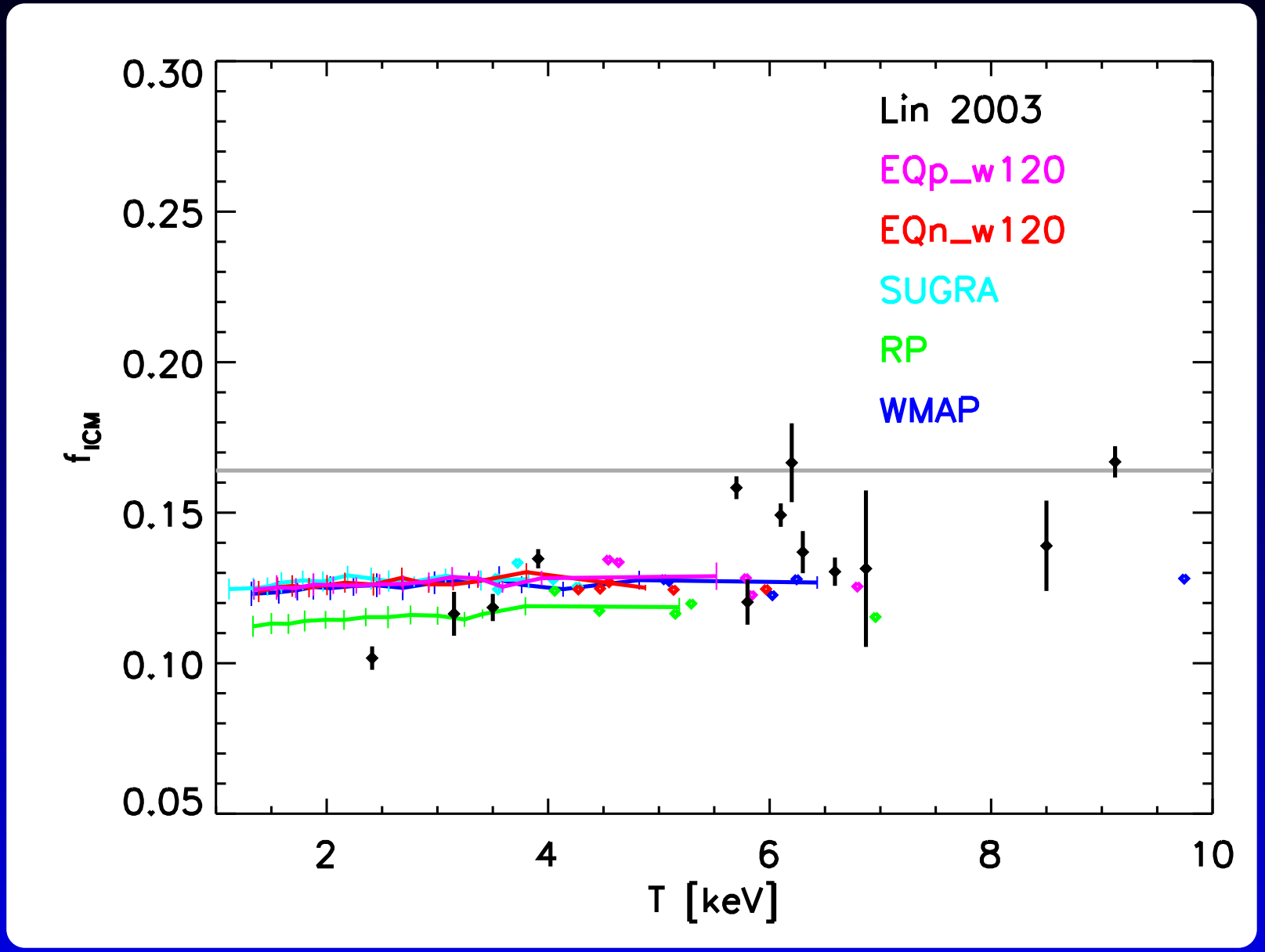
Mass-Concentration Relation



Baryon physics breaks scaling (adiabatic contraction, Gnedin 2004)!

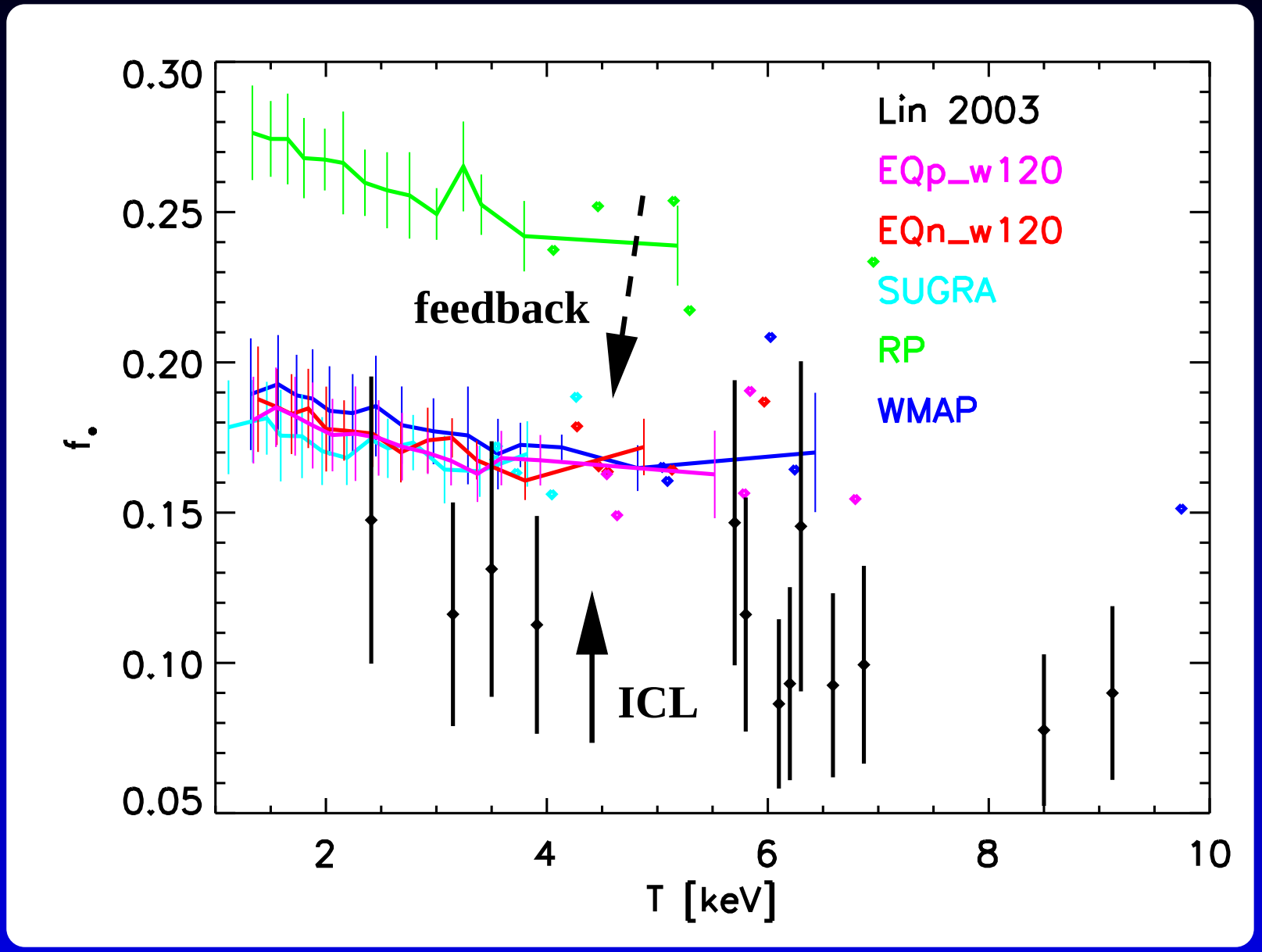
Large separation between different DE models !

X-Ray Cluster Properties



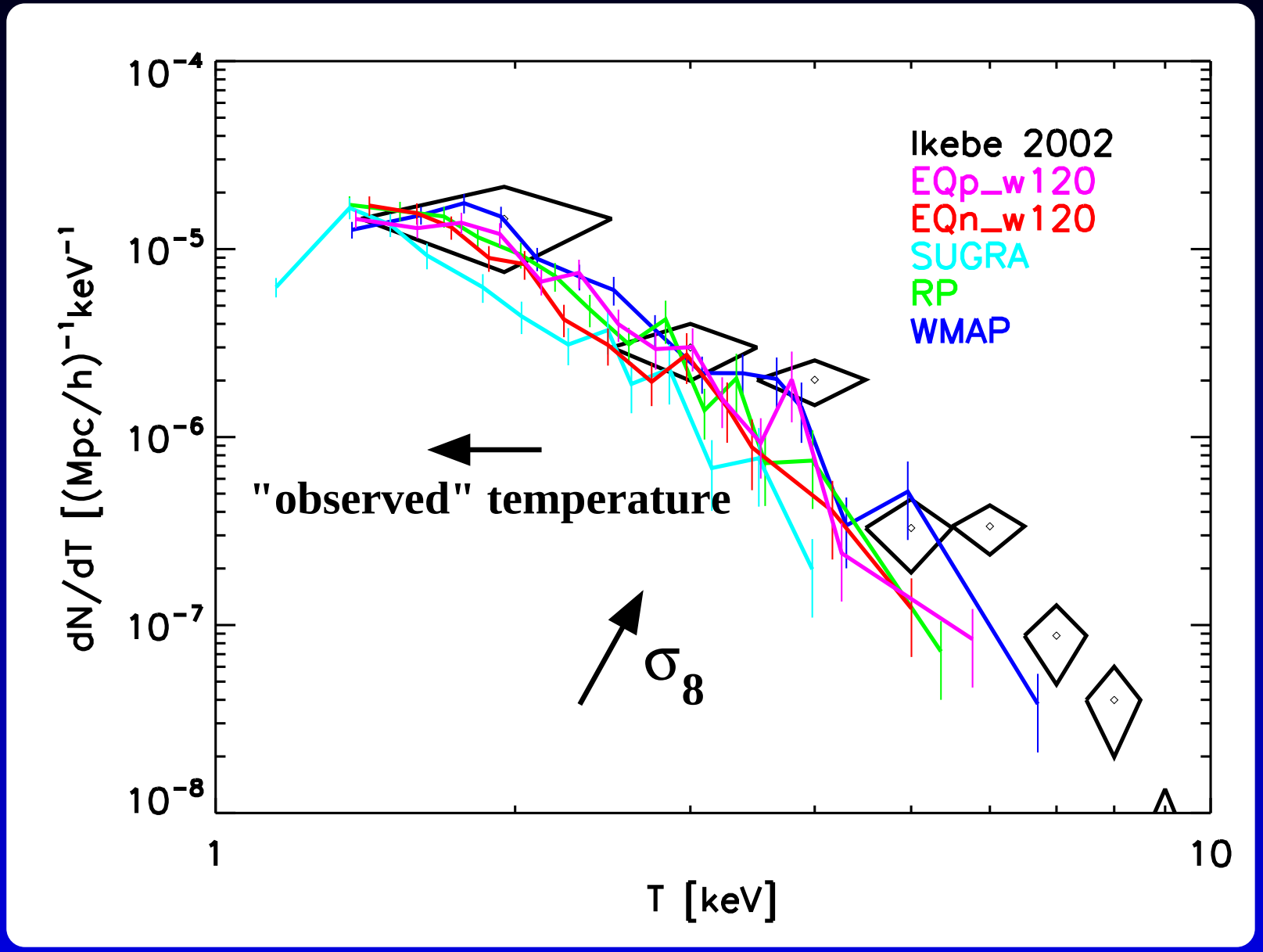
Baryon fraction in clusters: Simulations vs. Observations.

X-Ray Cluster Properties



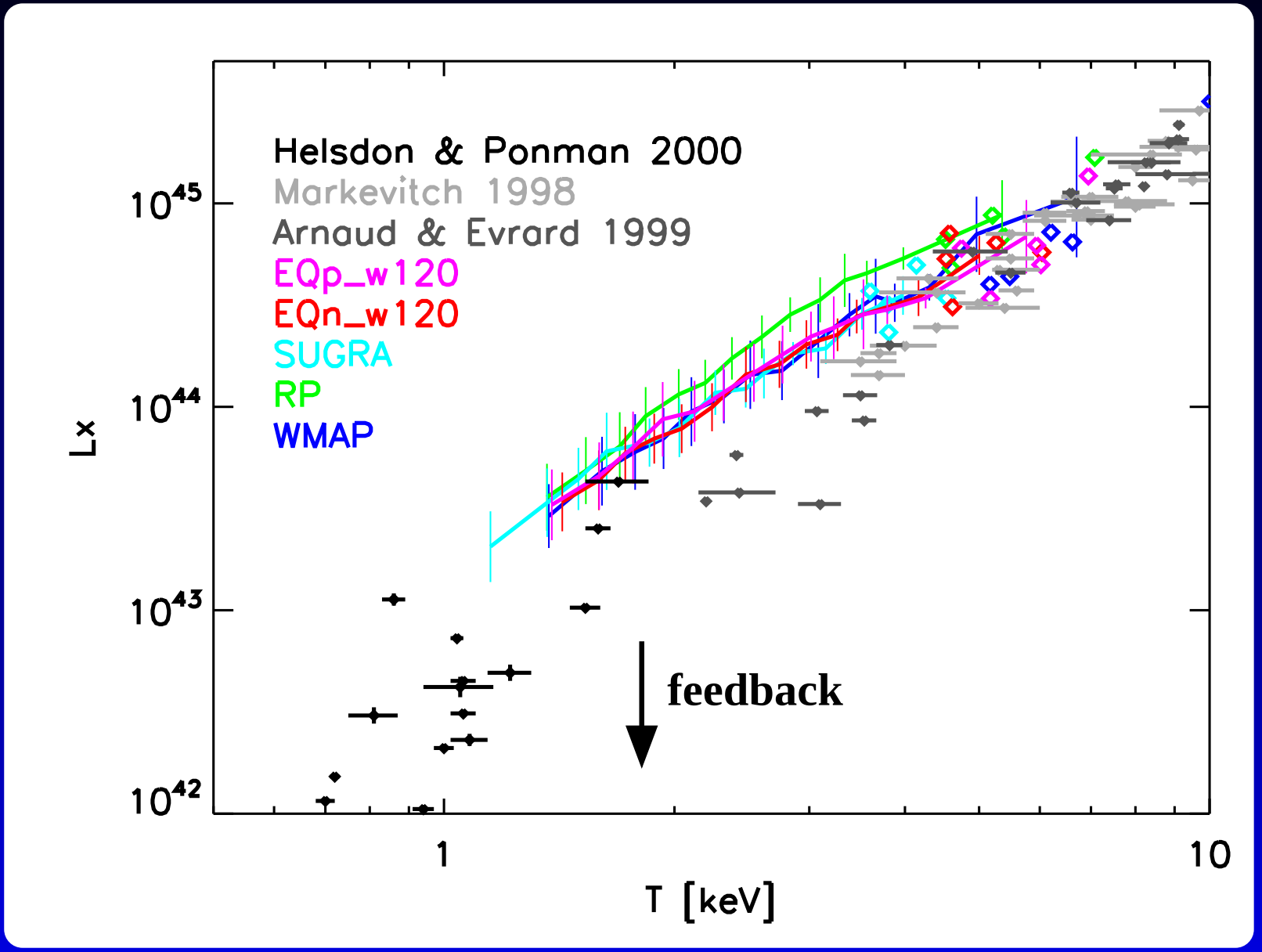
Star fraction in clusters: Simulations vs. Observations.
Fine for all except the RP model.

X-Ray Cluster Properties



X-ray temperature function: Simulations vs. Observations.
Almost fine for all, very low for the SUGRA model.

X-Ray Cluster Properties



$L_{xray} - T$ relation: Simulations vs. Observations.
Almost fine for all (at high T), except maybe the RP model.

Conclusions

- Galaxy clusters are powerful tools to investigate DE models.
- Universal C-M relation in pure DM scenarios holds also for more *exotic* DE models.
- Baryonic physics can strongly interact/respond to DE background.
- Universal C-M relation can break down in presence of cooling.
- C-M relation is a powerful tool to challenge DE models (even Λ !).
- X-Ray observations of clusters allow various further cross-checks.

Investigating 5 different models we find indications that:

	WMAP3	RP	SUGRA	EQn_w120	EQp_w120
C-M	–	-	+	+	-
F_*	+	–	+	+	+
xTf	++	+	-	+	+
Lx-T	+	-	+	+	+

Outlook (besides trying to understand what we are doing):

- Larger simulations (increasing statistics for massive clusters) and further test: