How baryons affect the large-scale structures

... and how we can try to model it

Aurel Schneider – ETH Zurich

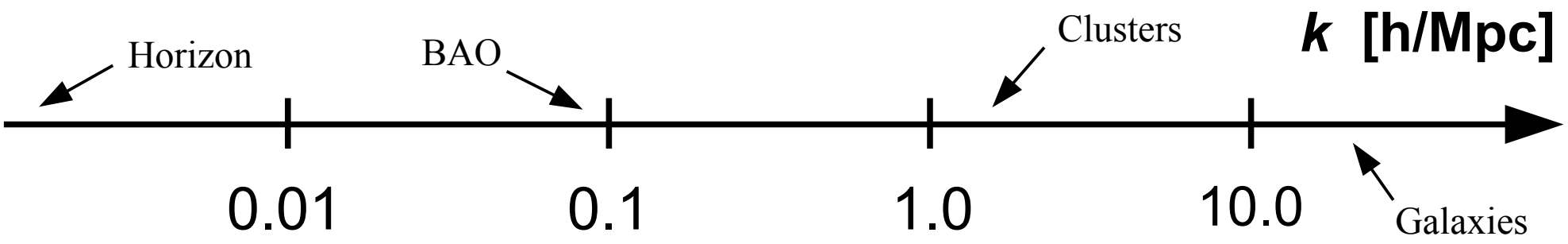
In collaboration with

Romain Teyssier

Davos – Feb 2017

Motivation

Do we understand structure formation ?



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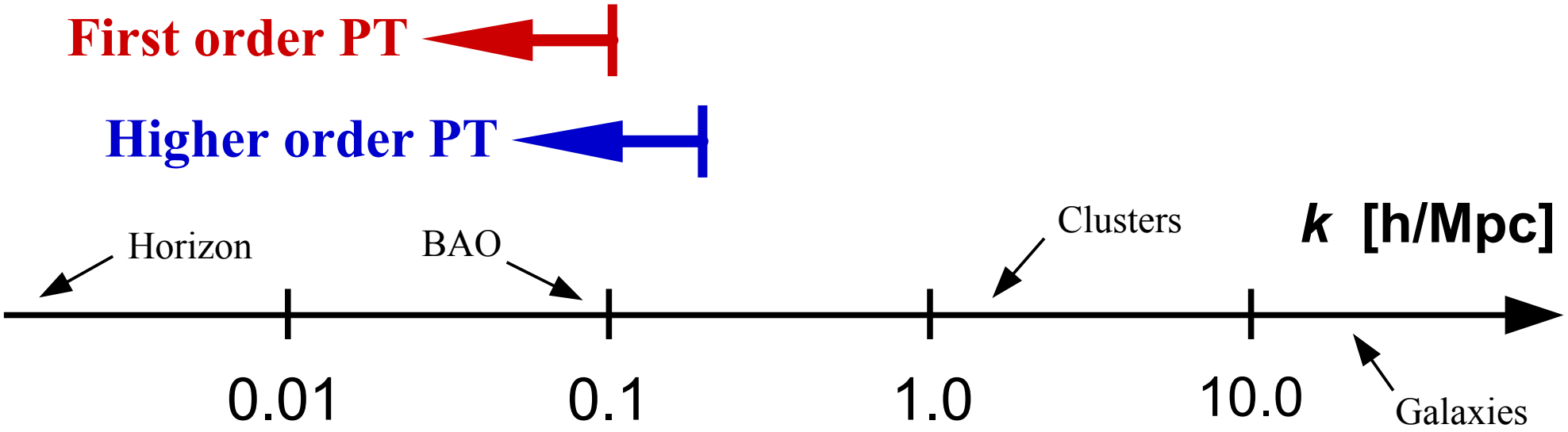

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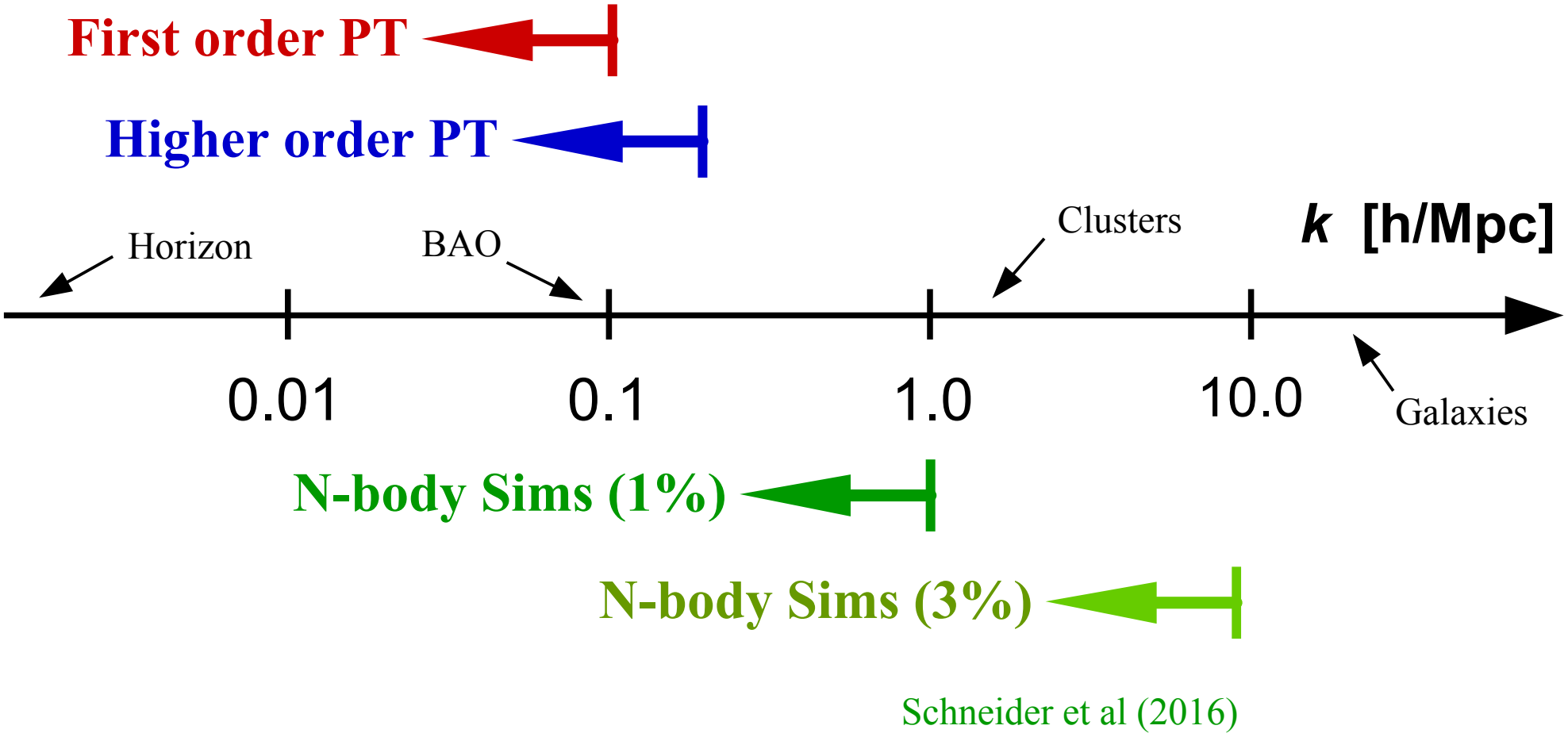


Schneider et al (2016)

Motivation

Do we understand structure formation ?

First order PT

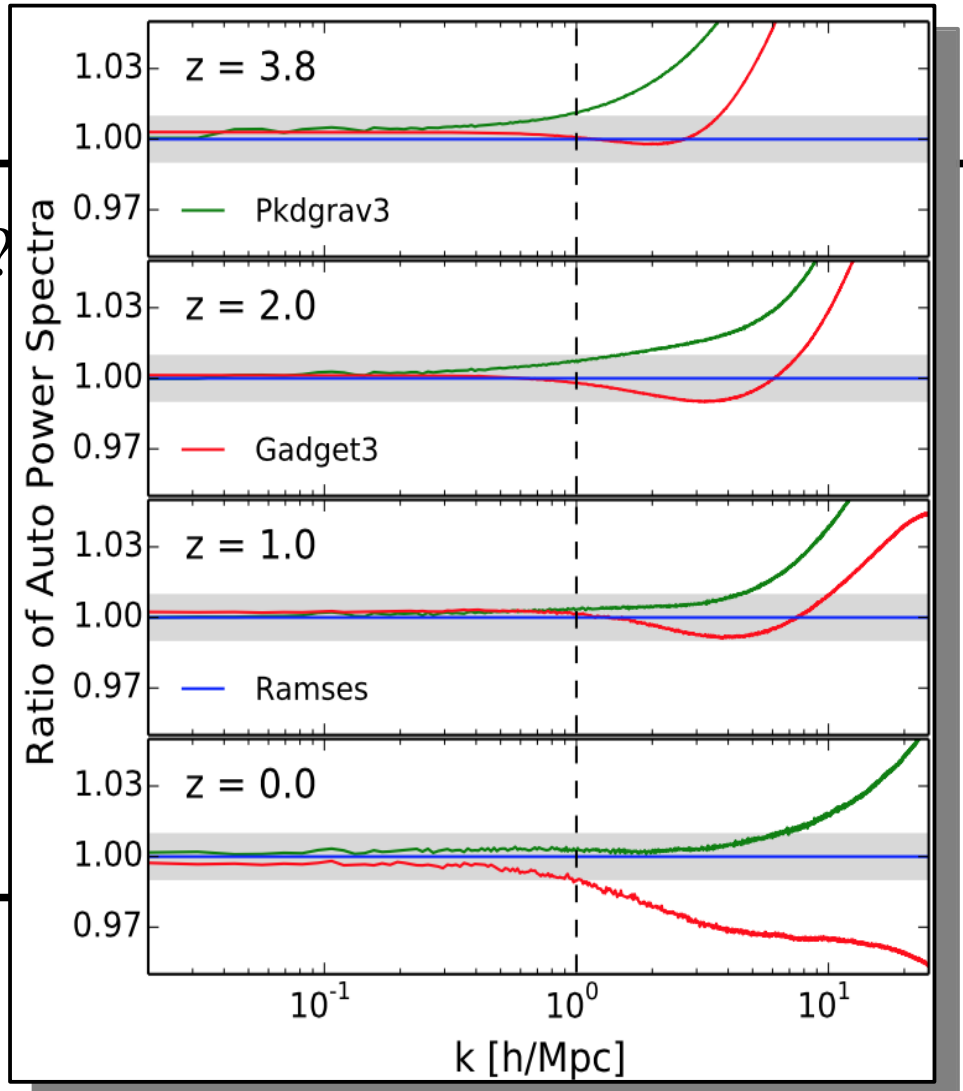
Higher order PT

Horizon

BAO

0.01

0.1



N-body Sims (1%)

N-body Sims (3%)

Schneider et al (2016)

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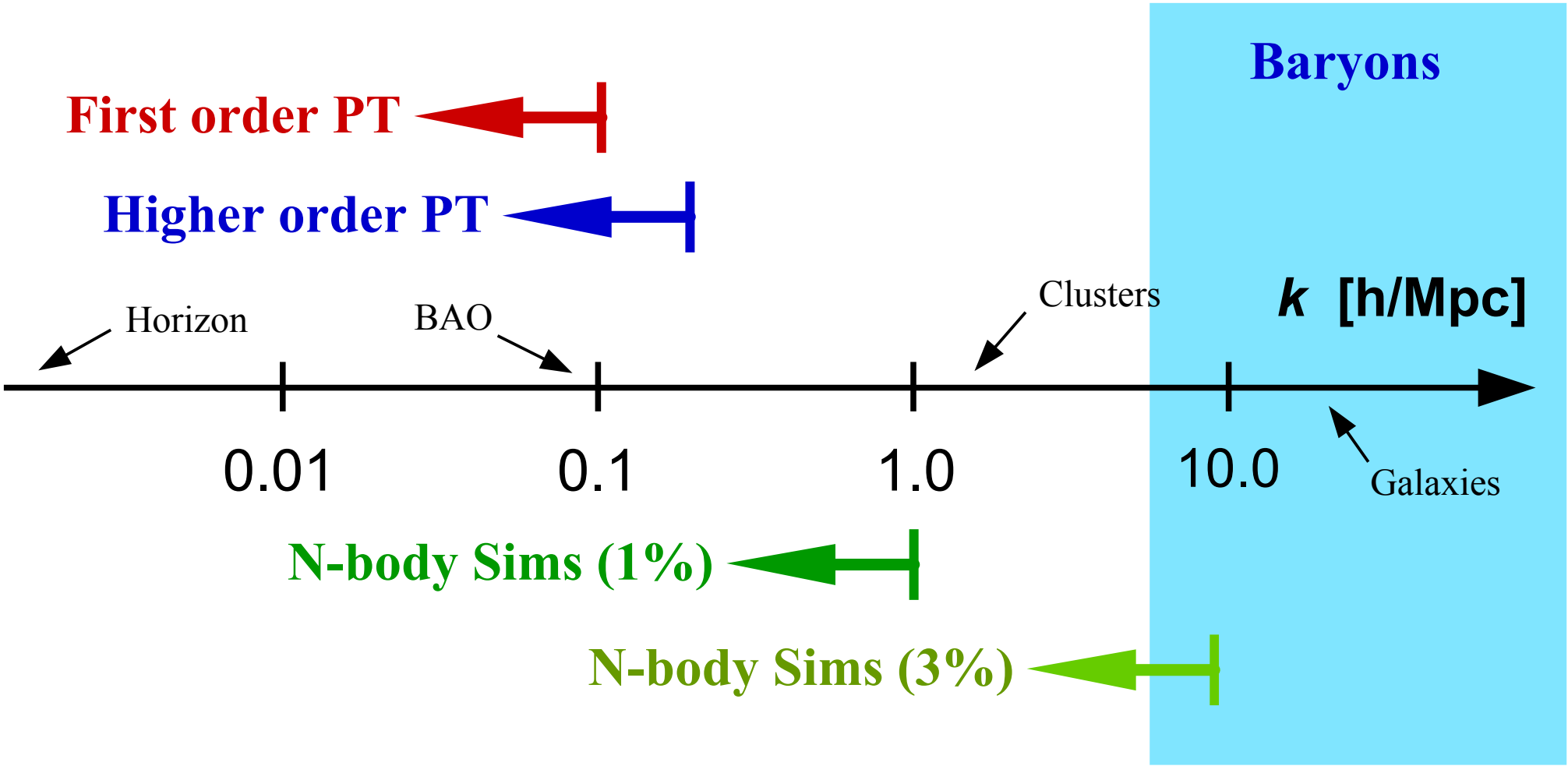

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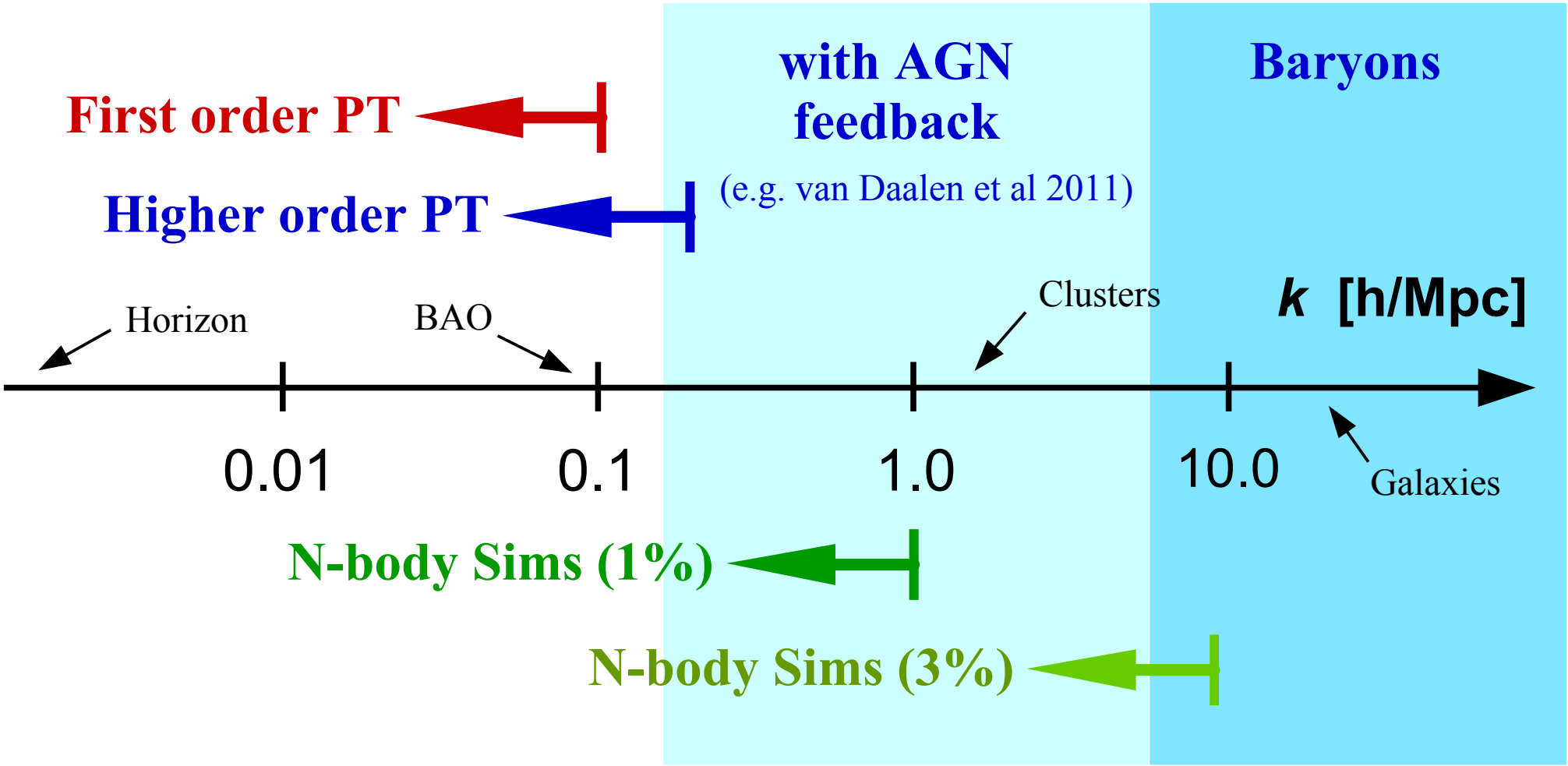

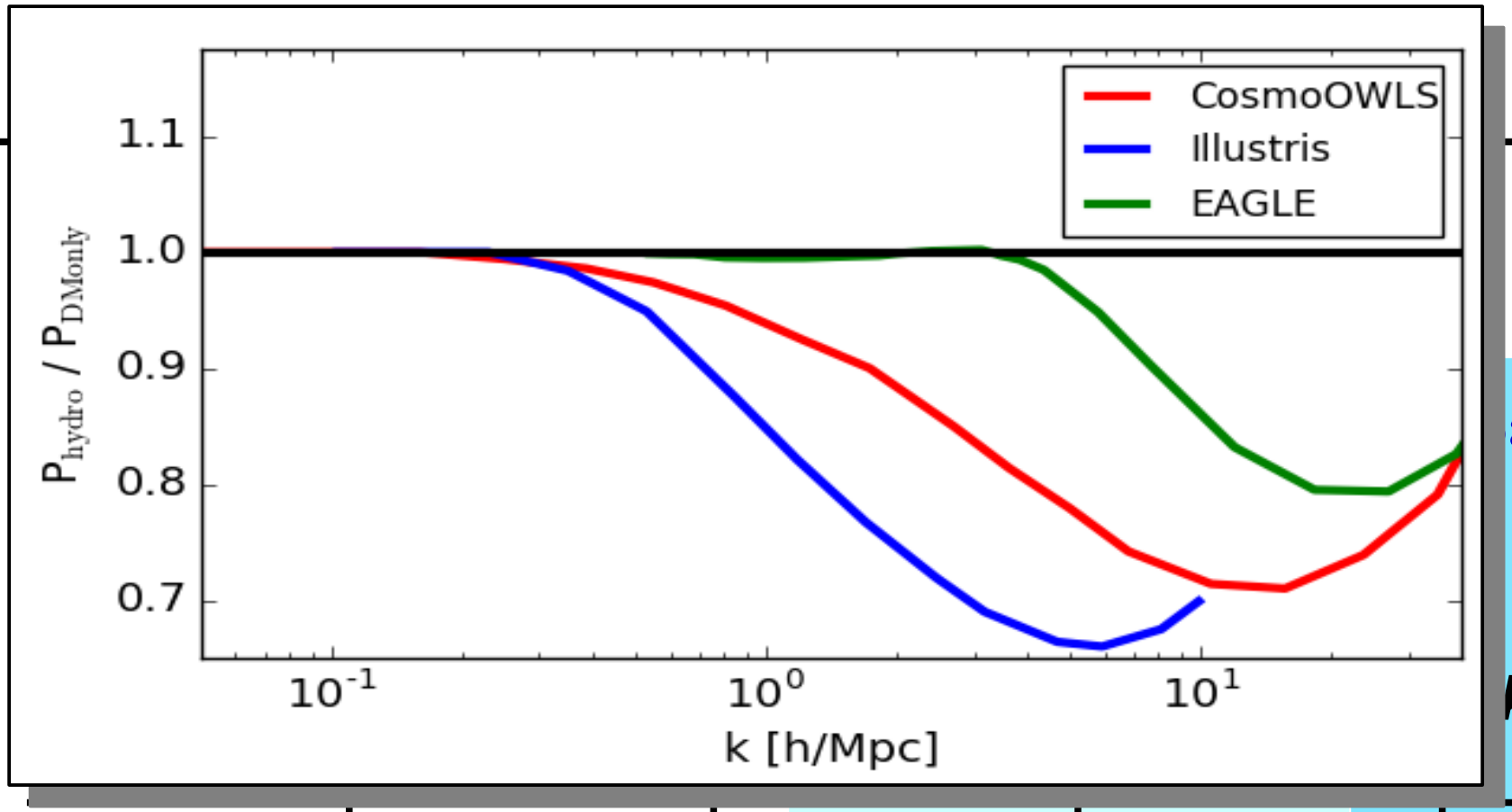

aryons

k [h/Mpc]

0.01 0.1 1.0 10.0

Galaxies

N-body Sims (1%)

N-body Sims (3%)

How to address the problem …

Parametrising of baryonic effects !

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- Hydro simulations with varying

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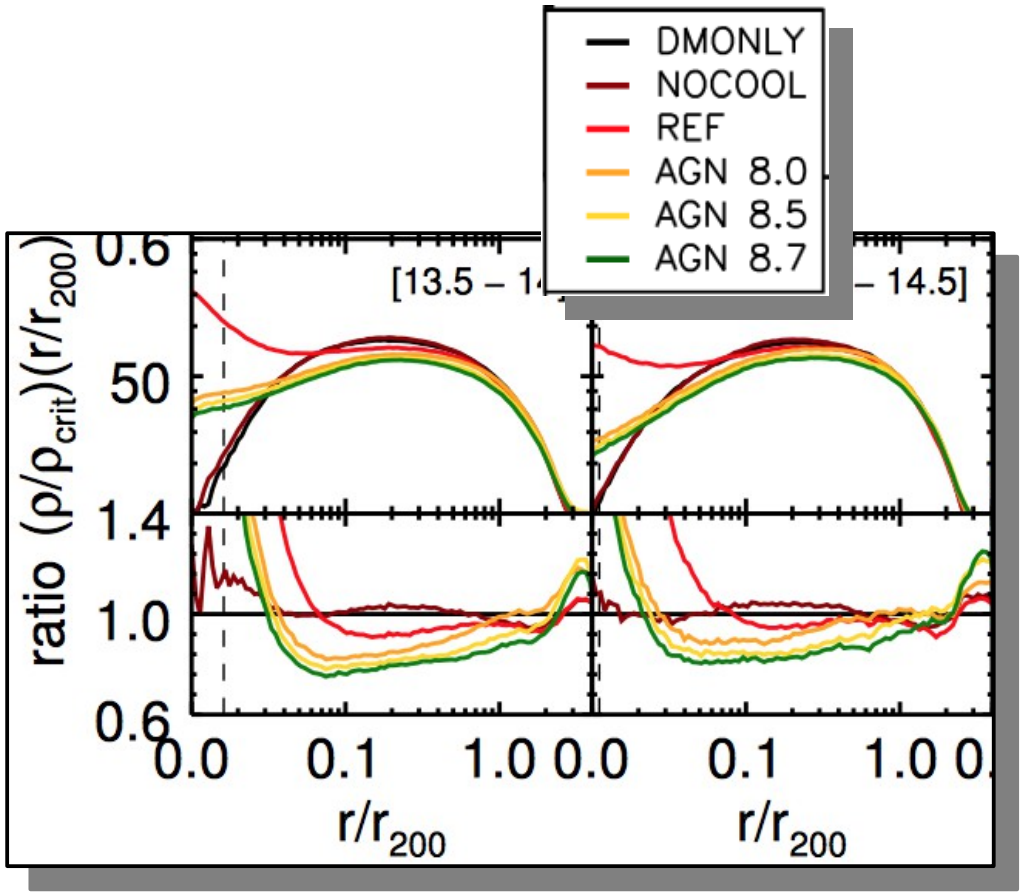


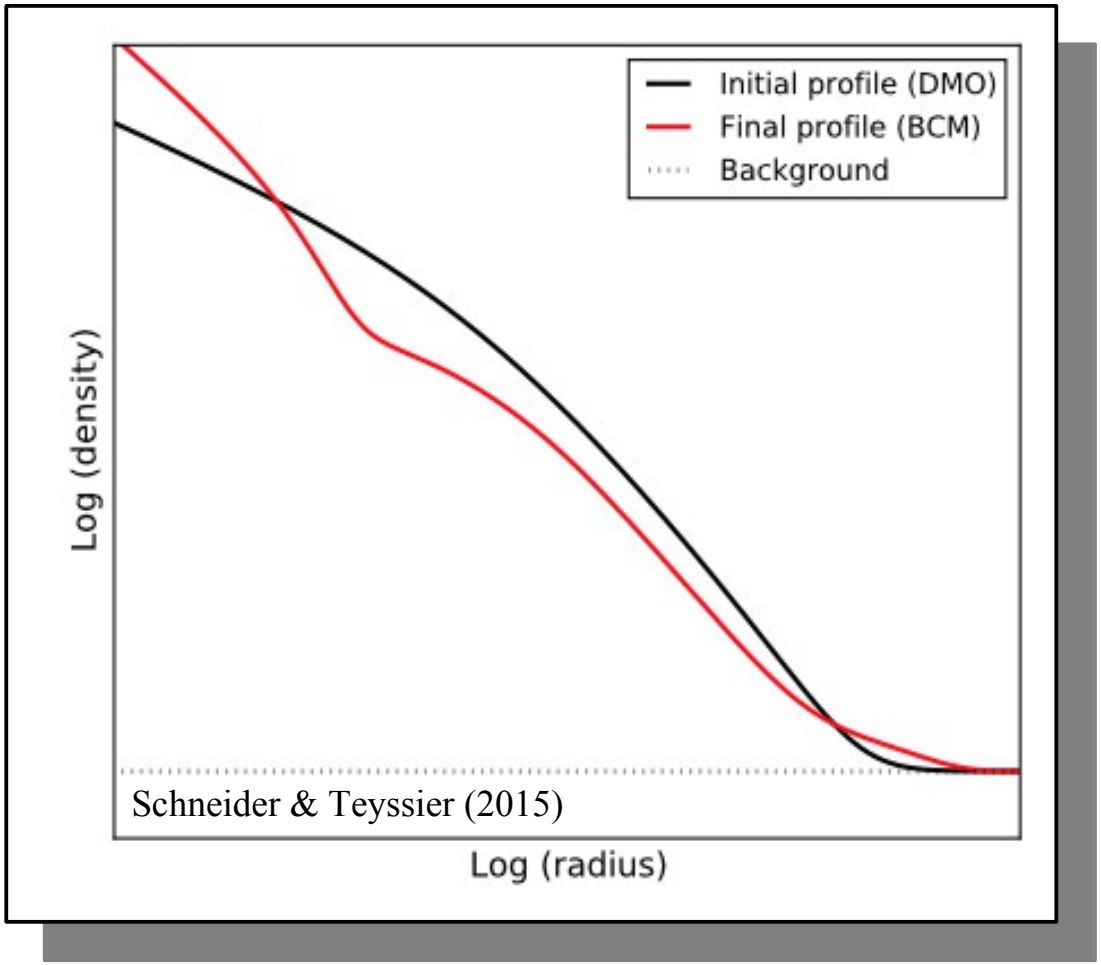
BAHAMAS (Mummery et al 2017)

How to address the problem …

Parametrising of baryonic effects !

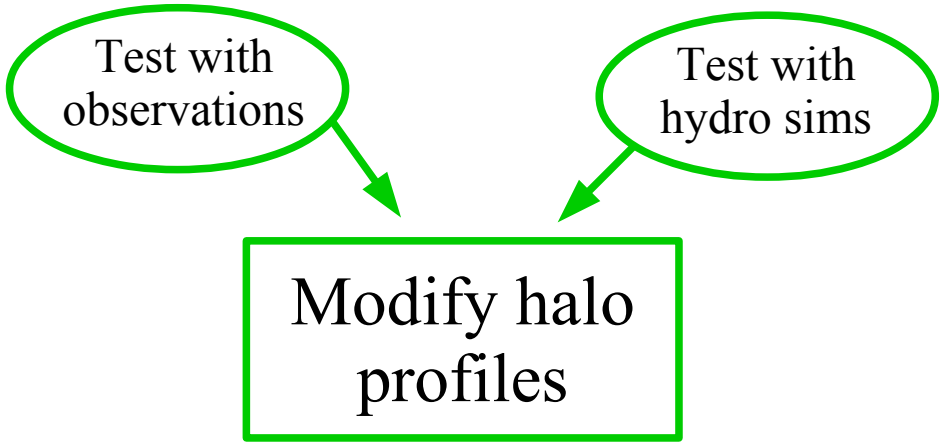
- Hydro simulations with varying AGN energy deposit.

- Parametrisation at higher level (e.g. changes in halo profiles)



Baryonic Correction Model

Schneider & Teyssier (2015)



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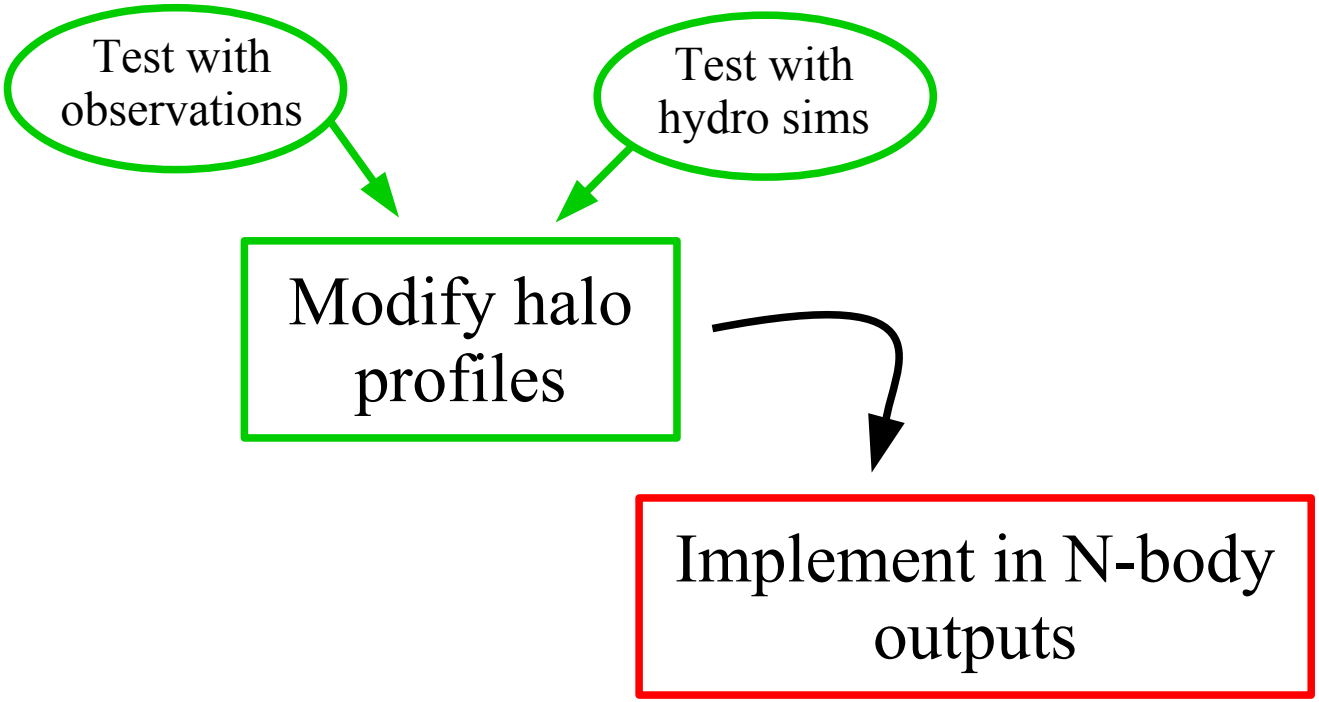

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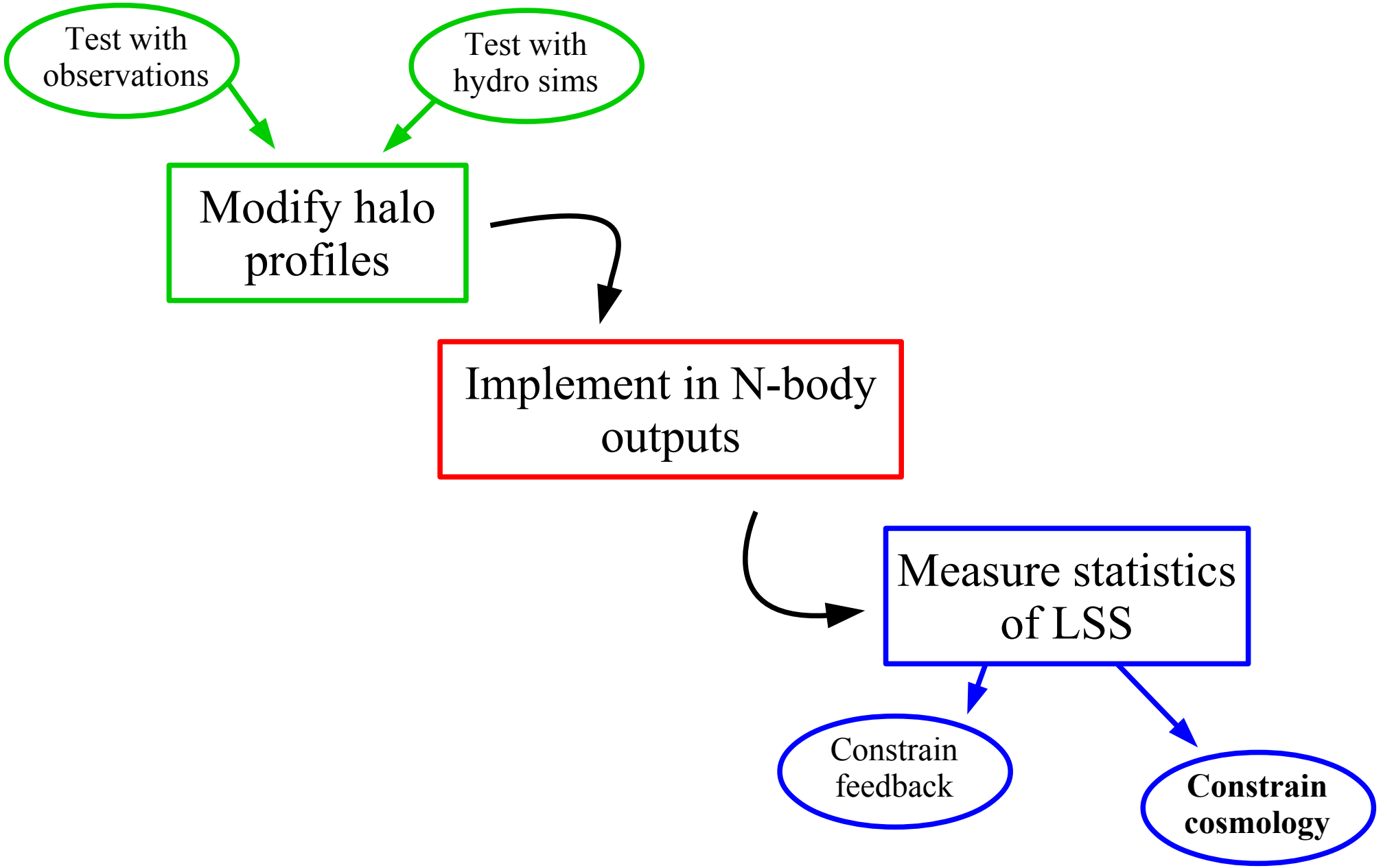

How it works:

Initial halo profiles:

$$\rho_{\rm dmo}(r) = \rho_{\rm nfw}(r) + \bar{\rho}_{\rm bg}$$

background

truncated NFW

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ejected gas

background

adiabatically relaxed DM

bound gas

central galaxy

How it works:

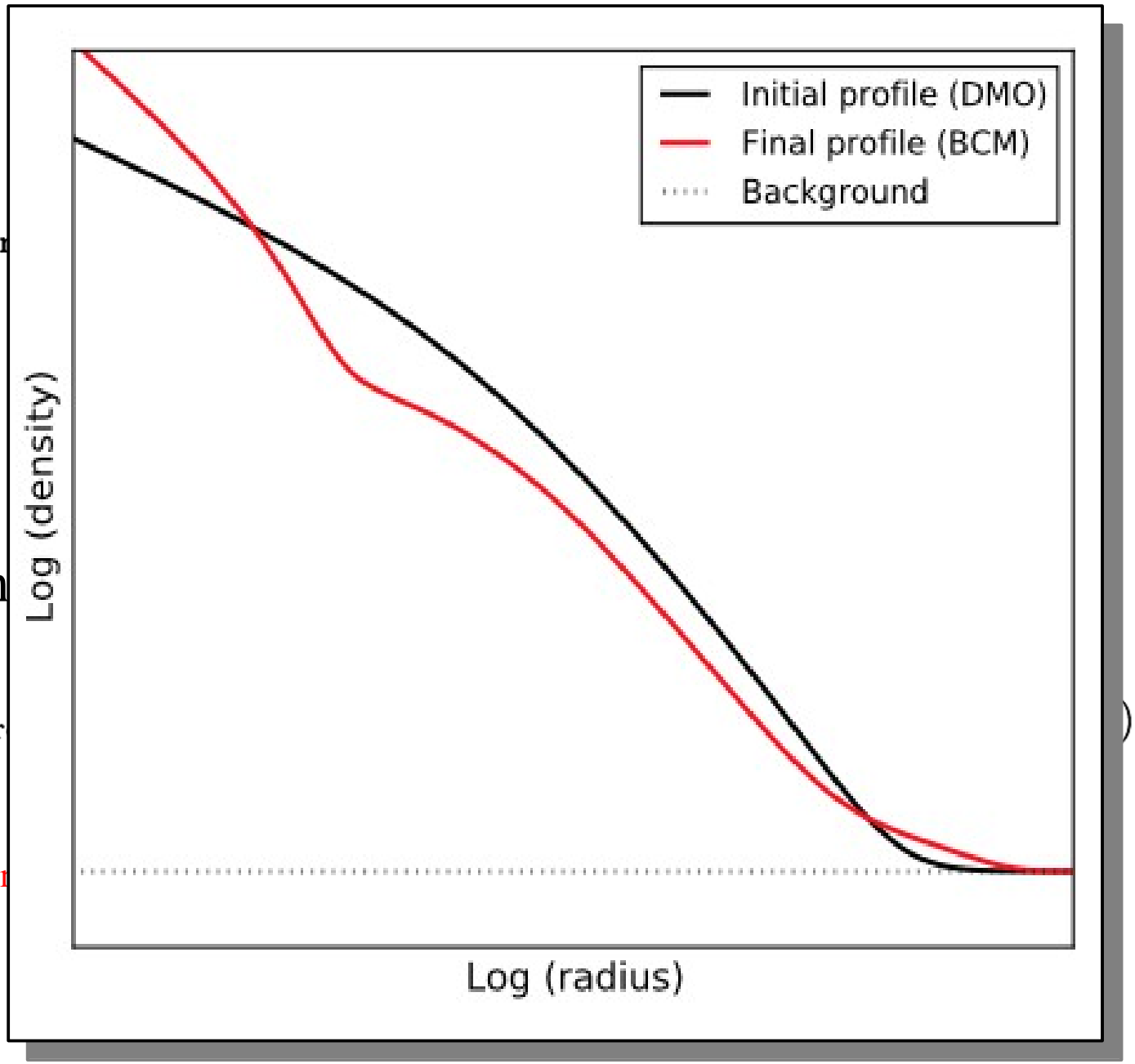
Initial halo

$\rho_{\rm dmo}(r) = \rho_{\rm r}$

Corrected h

$\rho_{\rm bcm}(r) = f_{\rm r}$

adiabatically r



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$)y_{\rm cgal}(r) + \bar{\rho}_{\rm bg}$

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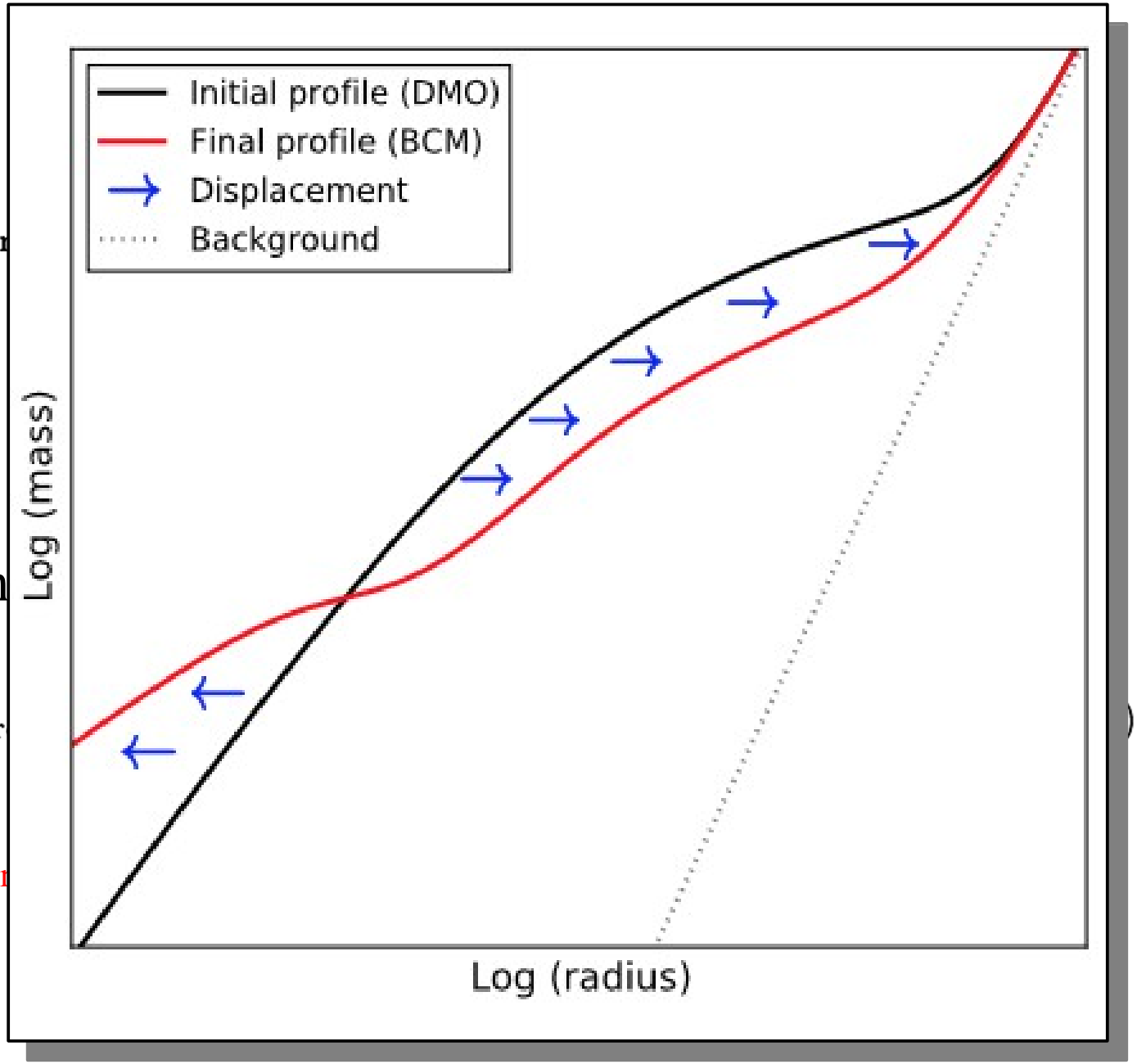

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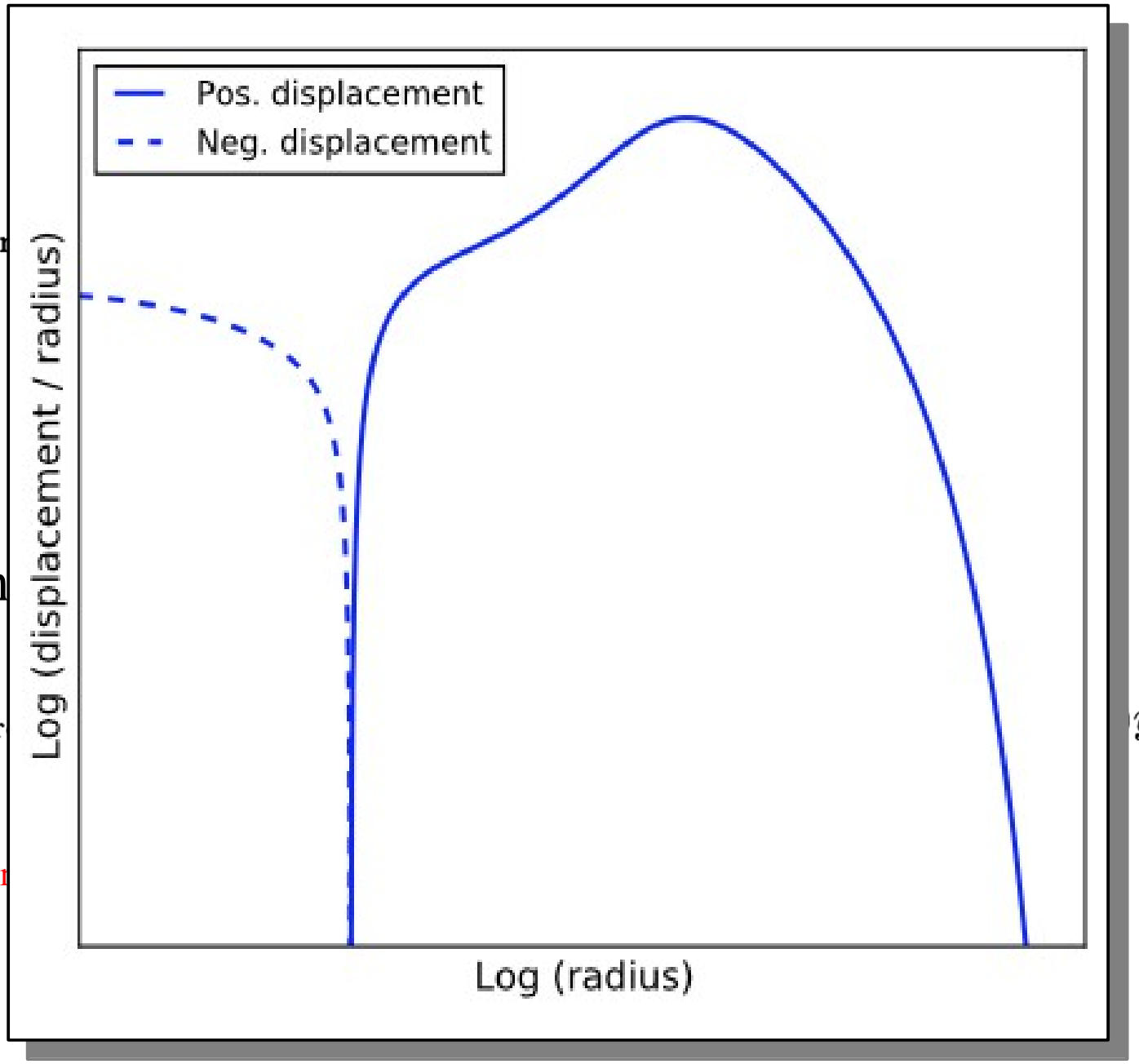

background

$y_{\rm cgal}(r) + \bar{\rho}_{\rm bg}$

Some more about the model:

$$\rho_{\rm bcm}(r) = f_{\rm rdm}\, y_{\rm rdm}(r) + f_{\rm bgas}(M)\, y_{\rm bgas}(r) + f_{\rm egas}(M)\, y_{\rm egas}(r) + f_{\rm cgal}(M)\, y_{\rm cgal}(r) + \bar{\rho}_{\rm bg}$$

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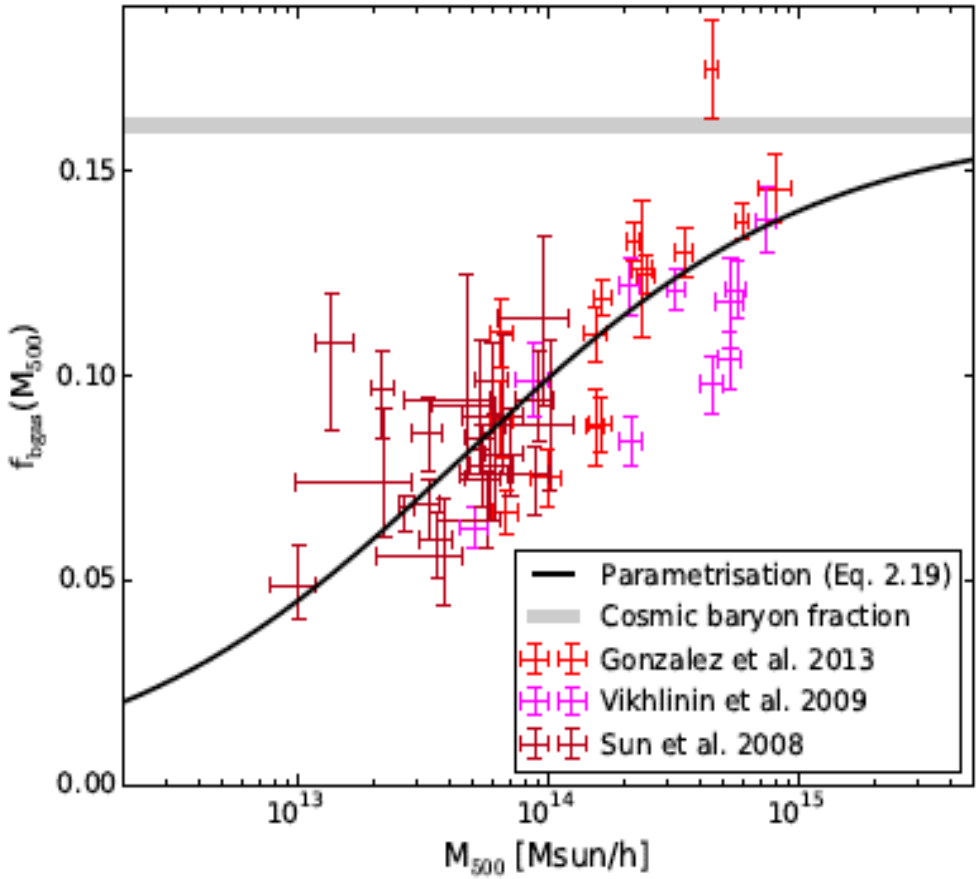
$$f_{\rm egas}(M) = \Omega_b/\Omega_m - \frac{\Omega_b/\Omega_m}{1 + (M_c/M)^{\beta}}$$

$$y_{\rm egas}(r) \propto \exp\left[-\frac{r^2}{2r_{\rm ej}^2}\right]$$

… or this: $$y_{\rm egas} \propto \left[1 + \left(\frac{r}{r_{\rm ej}}\right)^{\gamma}\right]^{-\frac{7}{\gamma}}$$



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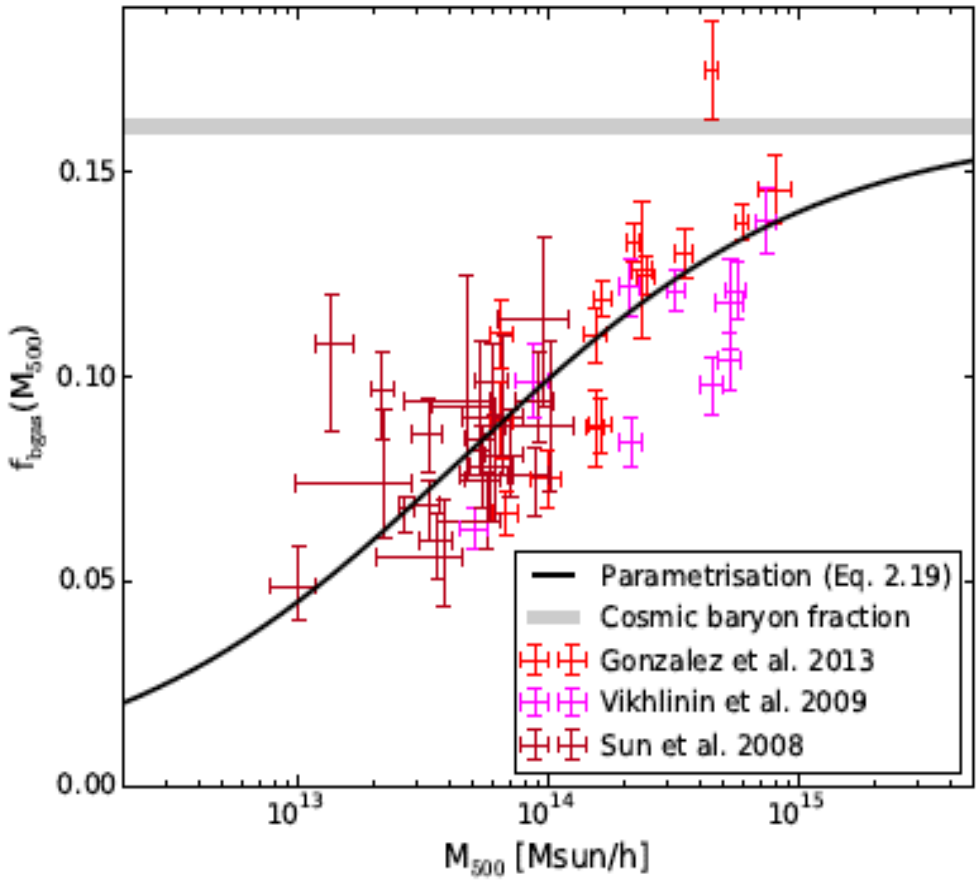

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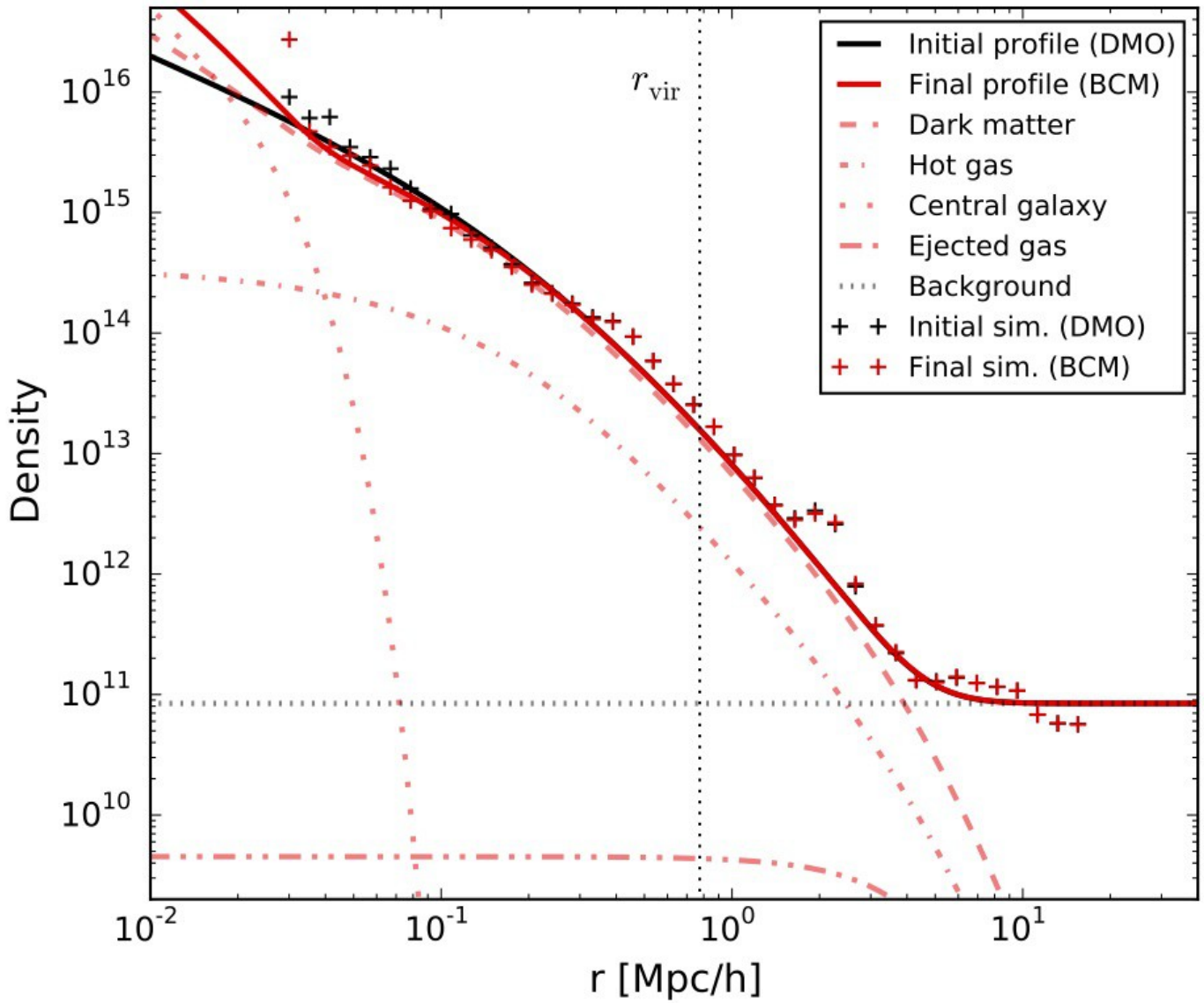
$f_{\rm rdm} = 1 - \Omega_b/\Omega_m$ = cosmic DM fraction

$\rho_{\rm rdm}(r)$ = with adiabatic relaxation (roughly based on angular momentum conservation)

Displacing particles in N-body sims

Density profile :



Gas mainly bound

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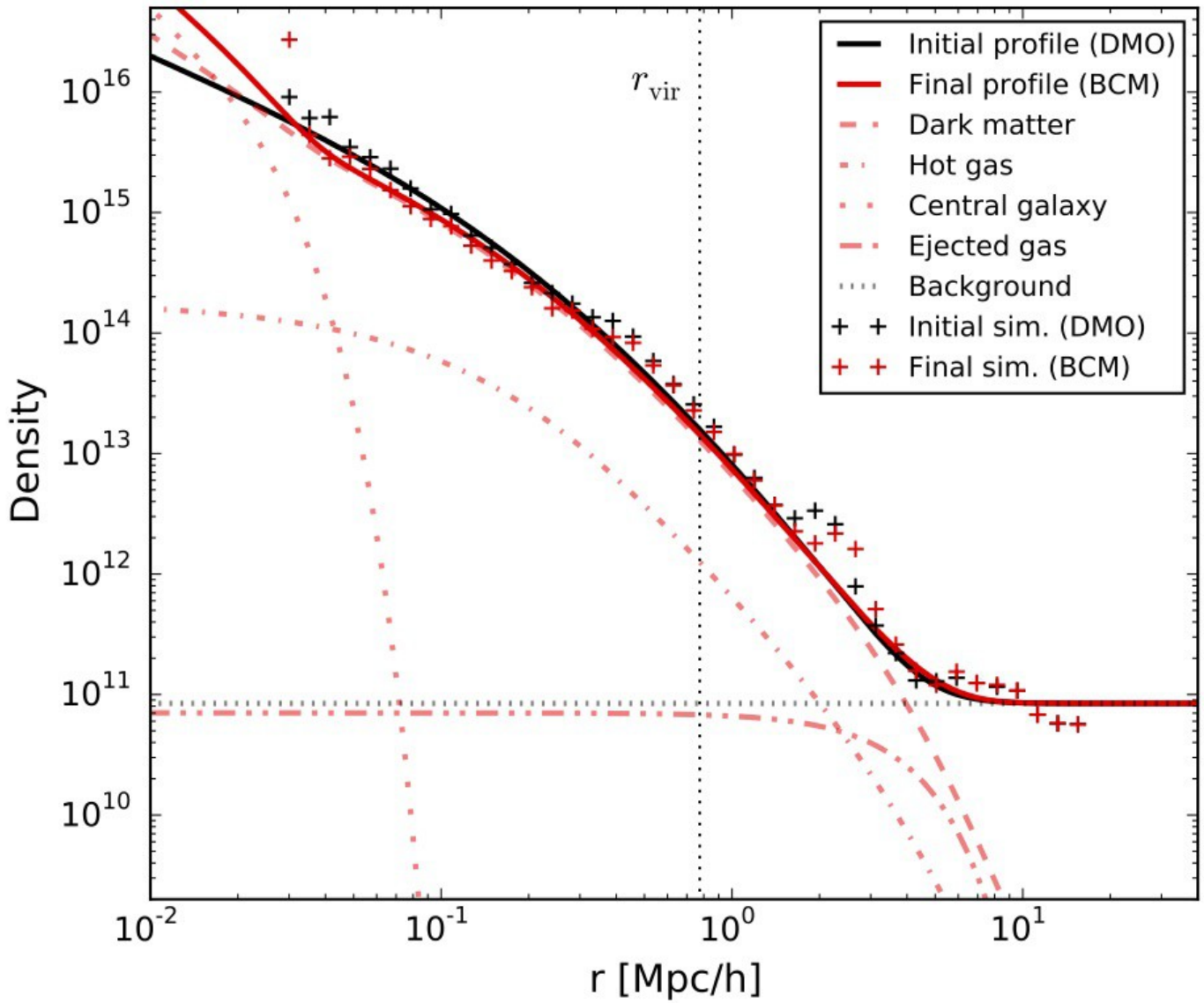

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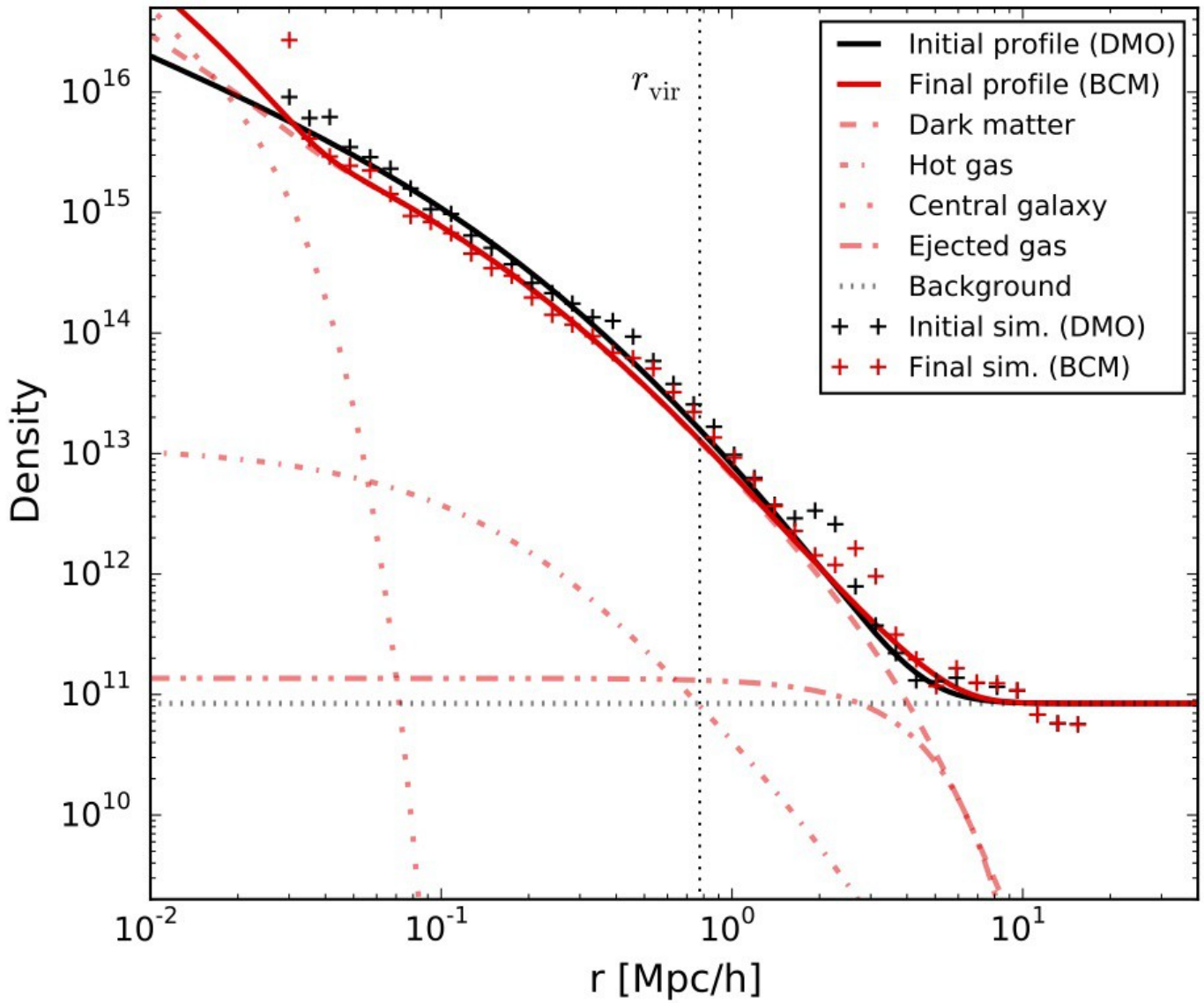
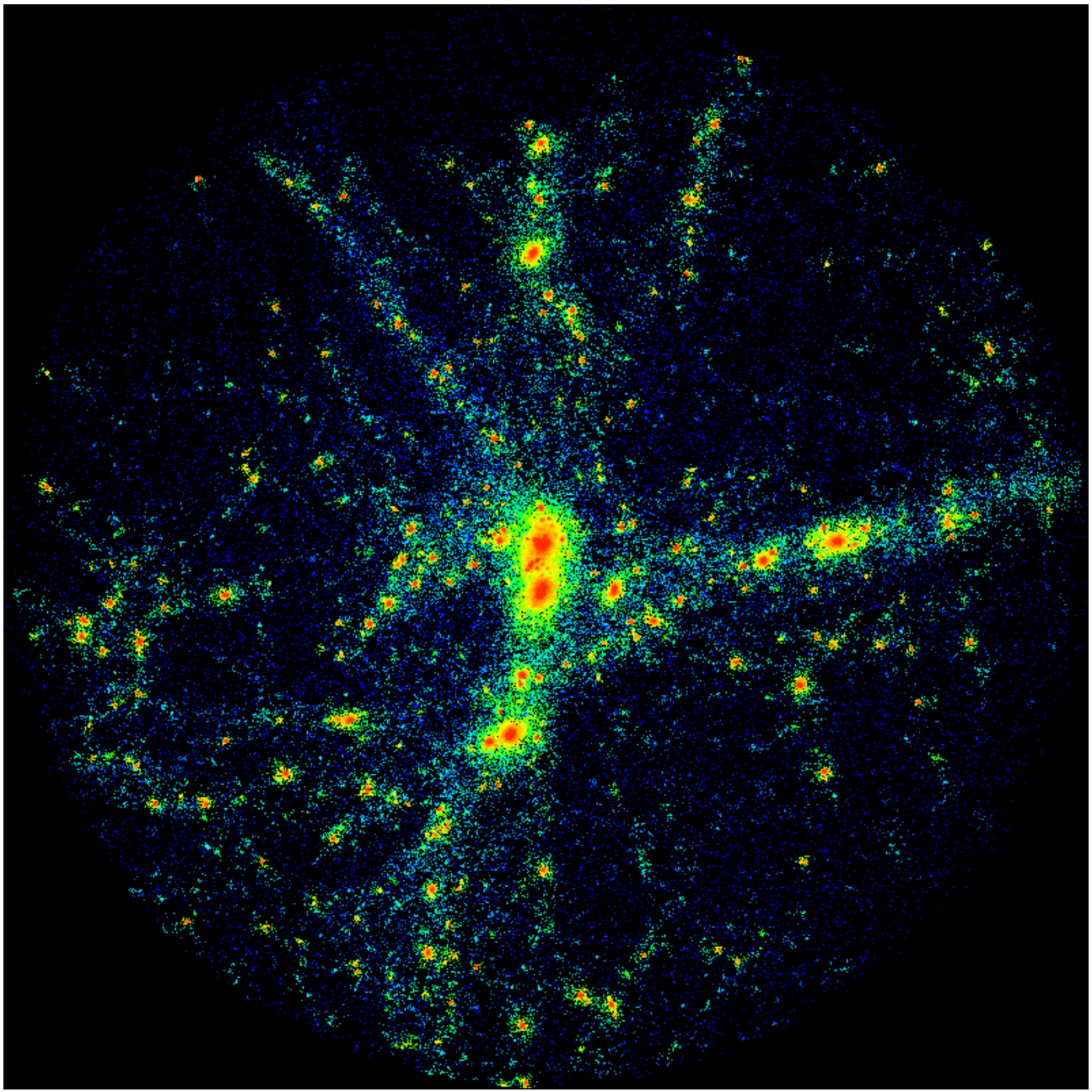


Gas mainly ejected

Displacing particles in N-body sims

Picture :



N-body output

Displacing particles in N-body sims

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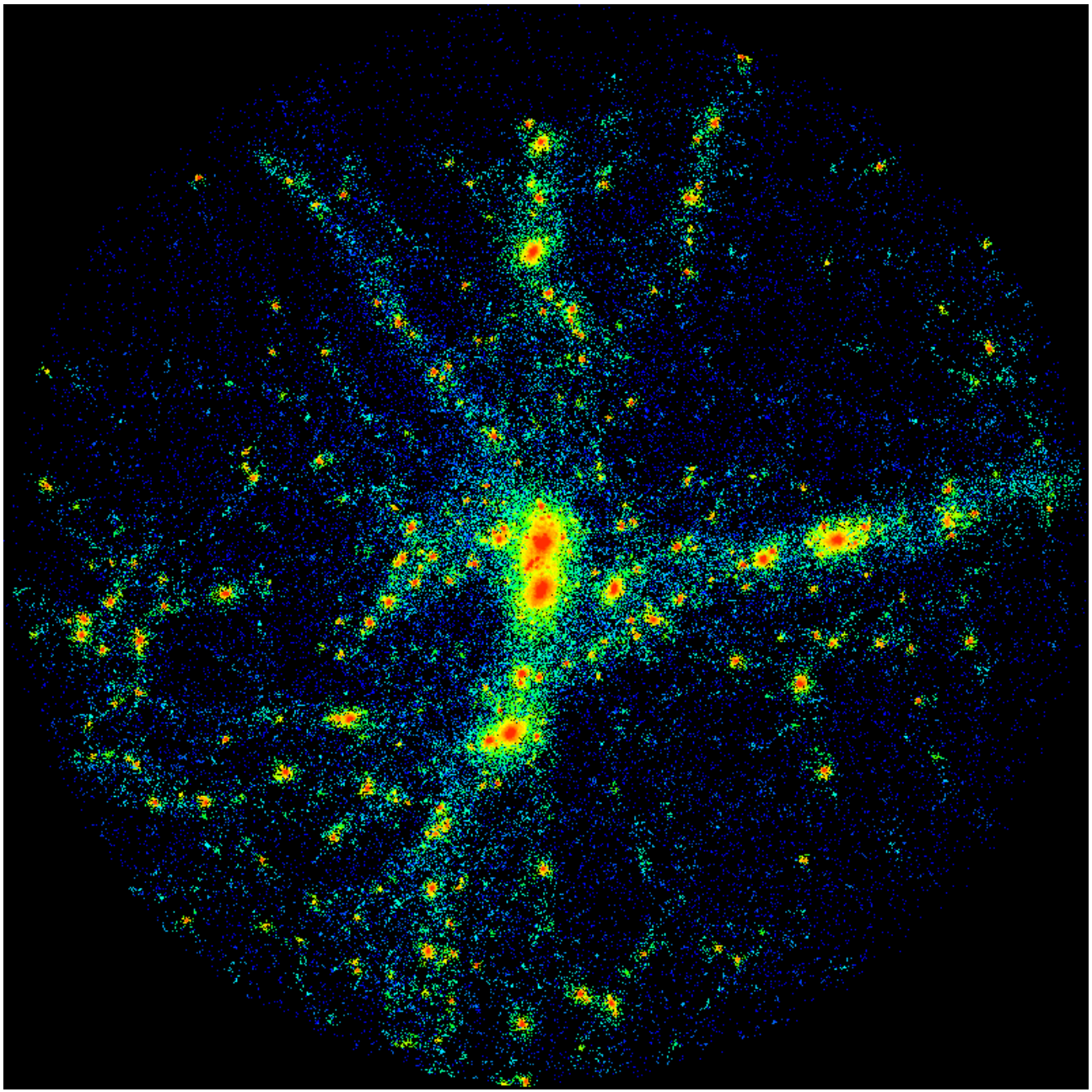

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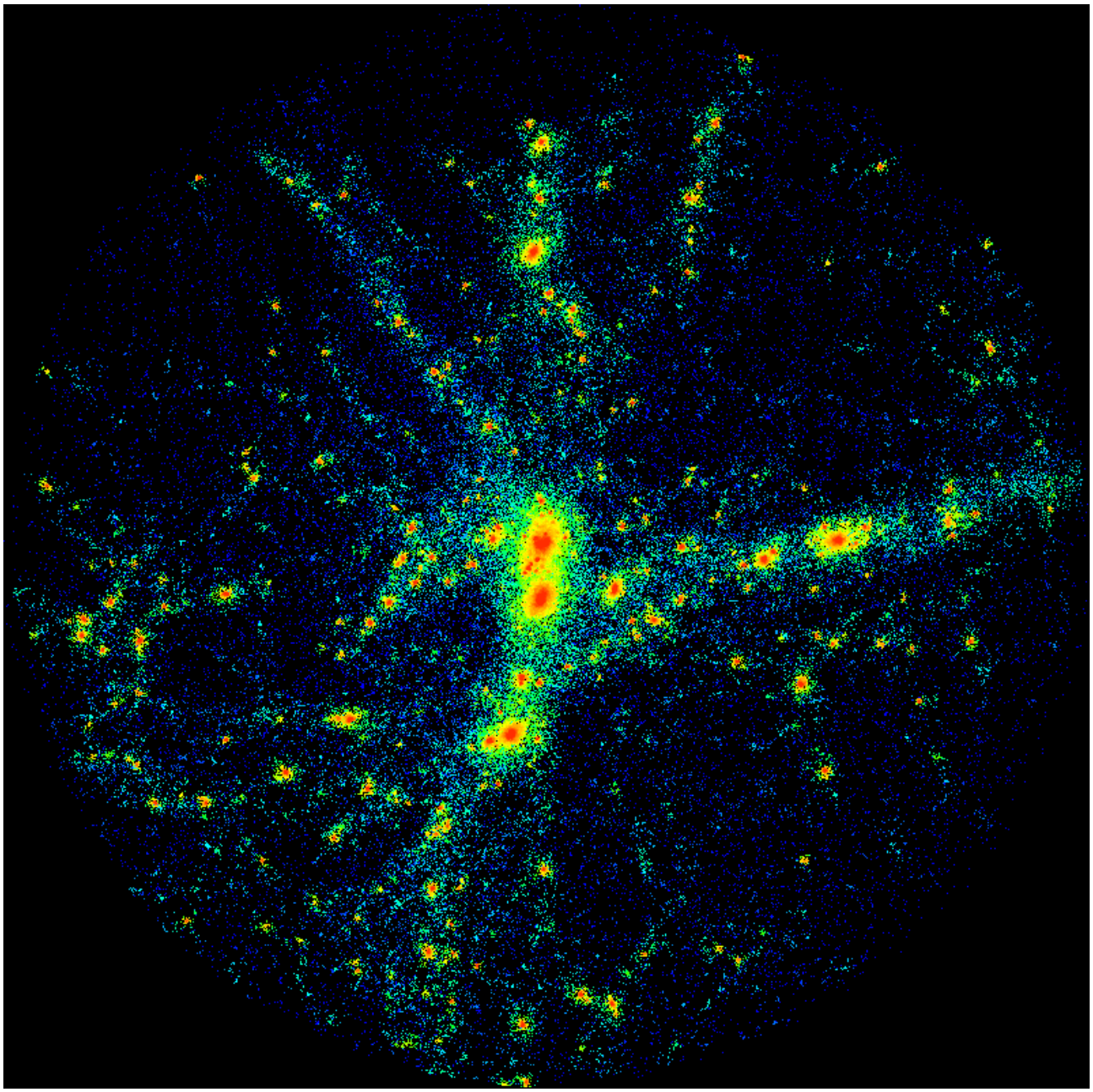

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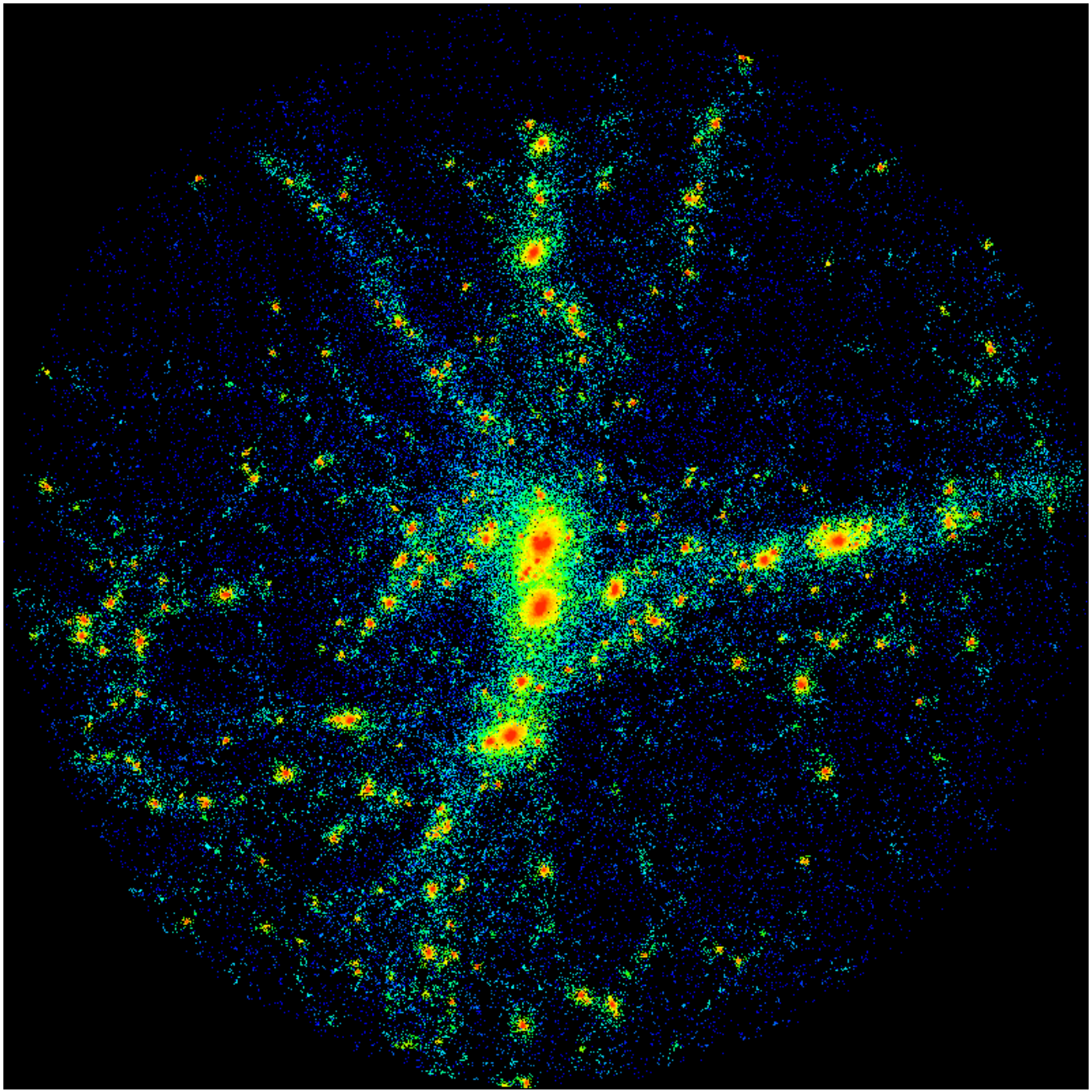

Gas mainly ejected

And finally the power spectrum !

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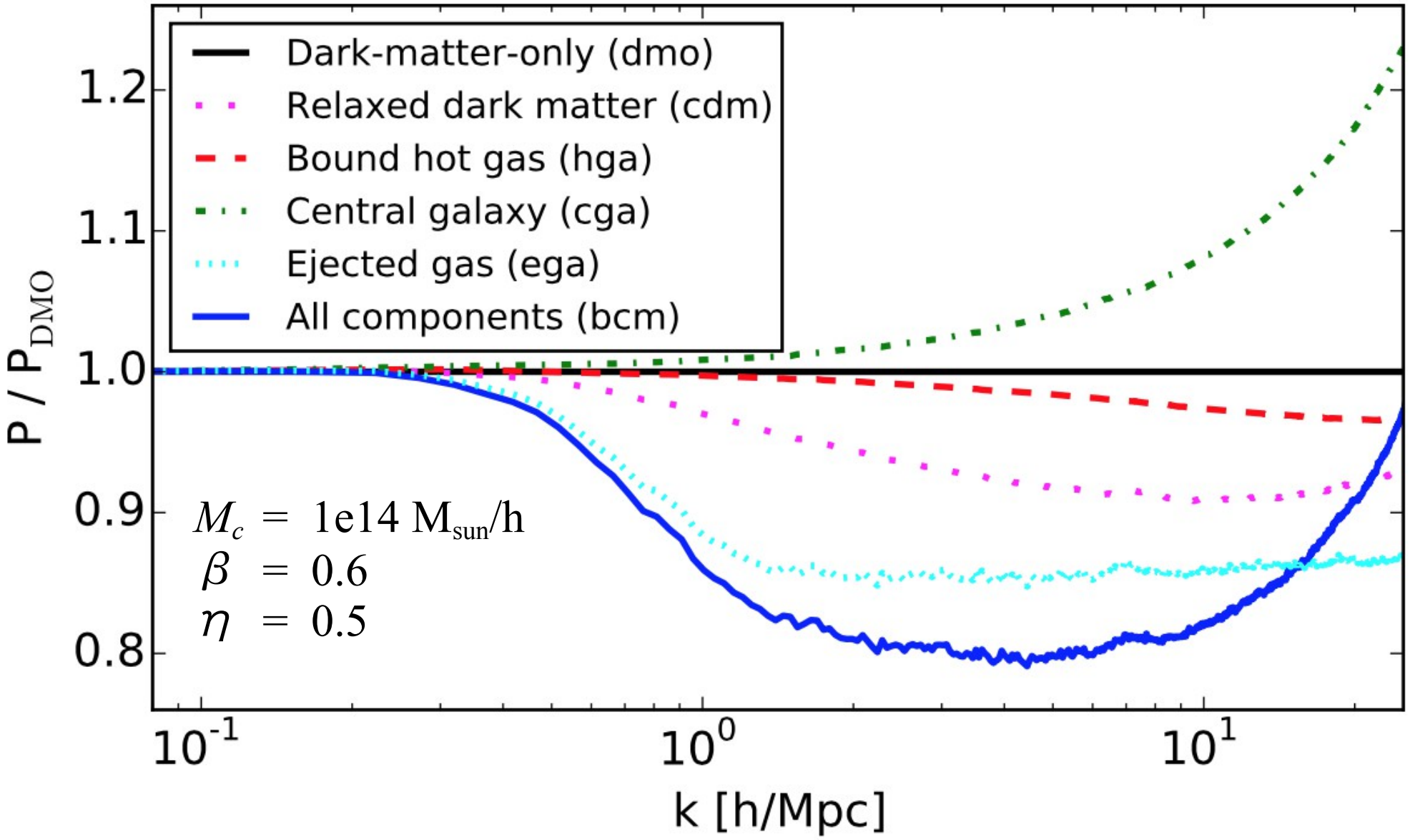
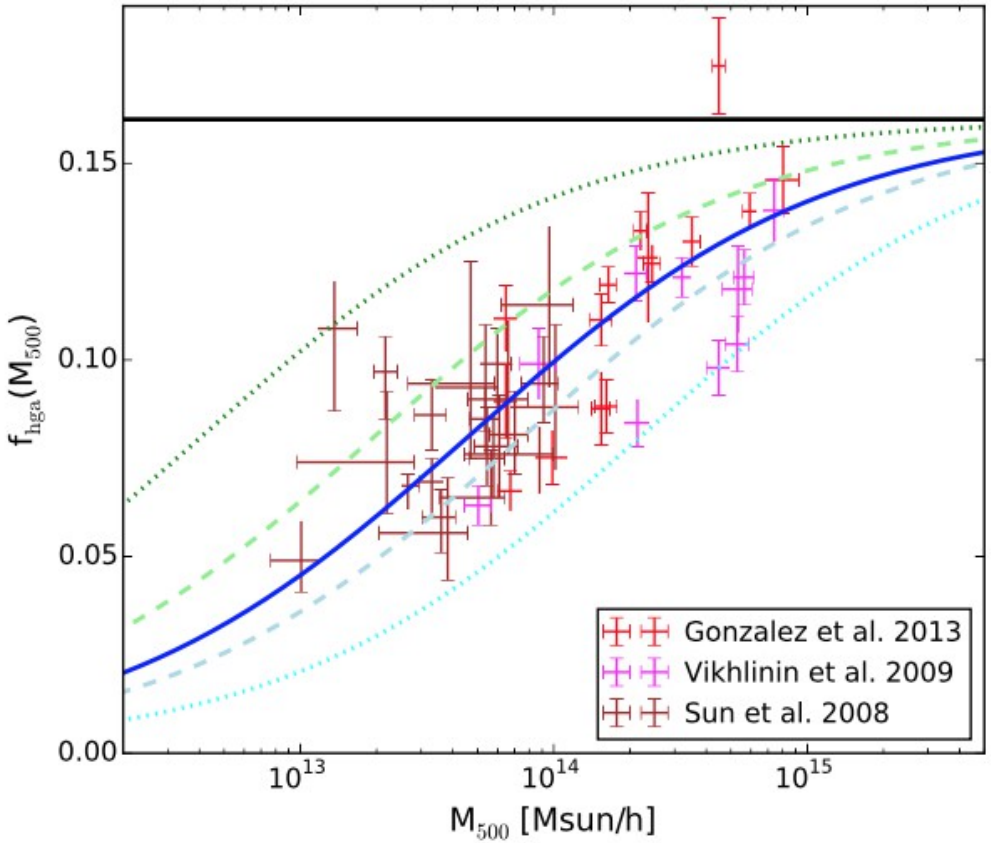
Fiducial values for model parameters :

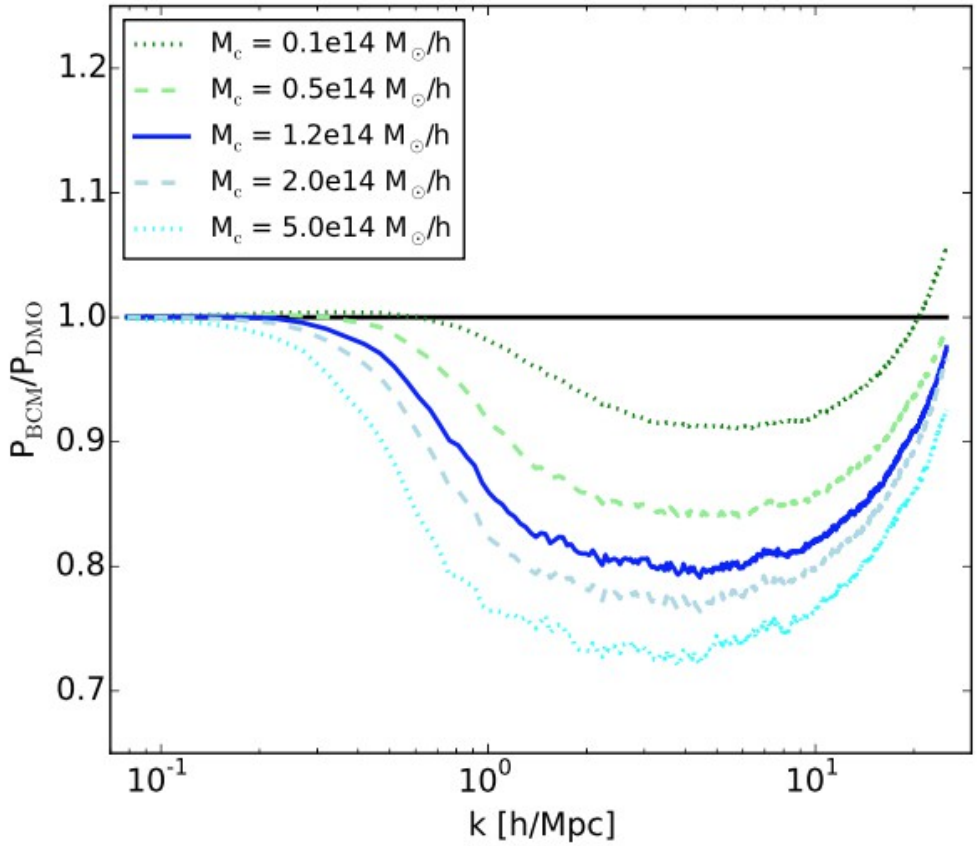


Power suppression with two parameters

Power suppression with two parameters

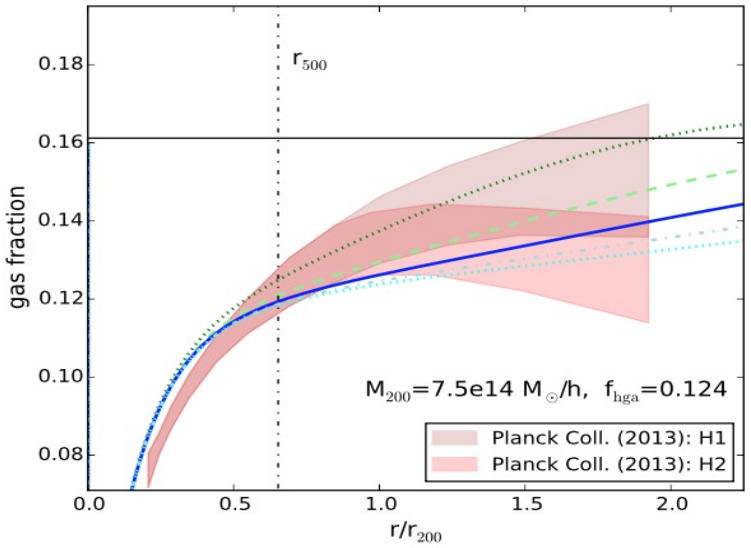
First parameter: varying ejected gas fraction

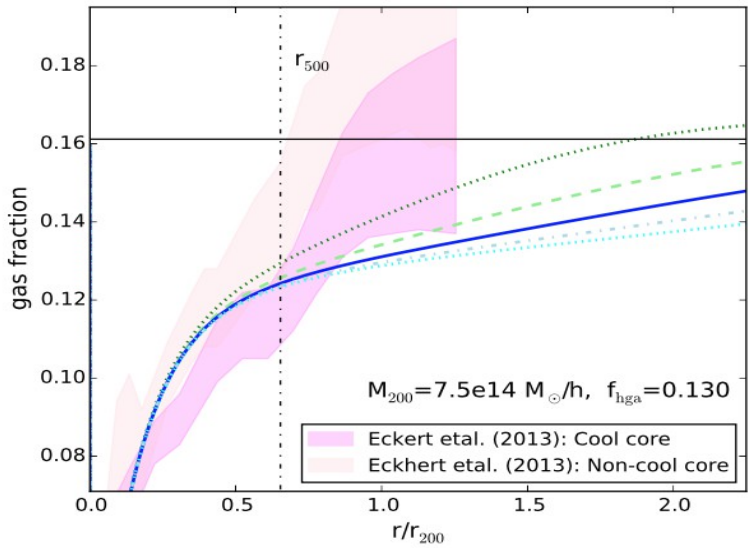


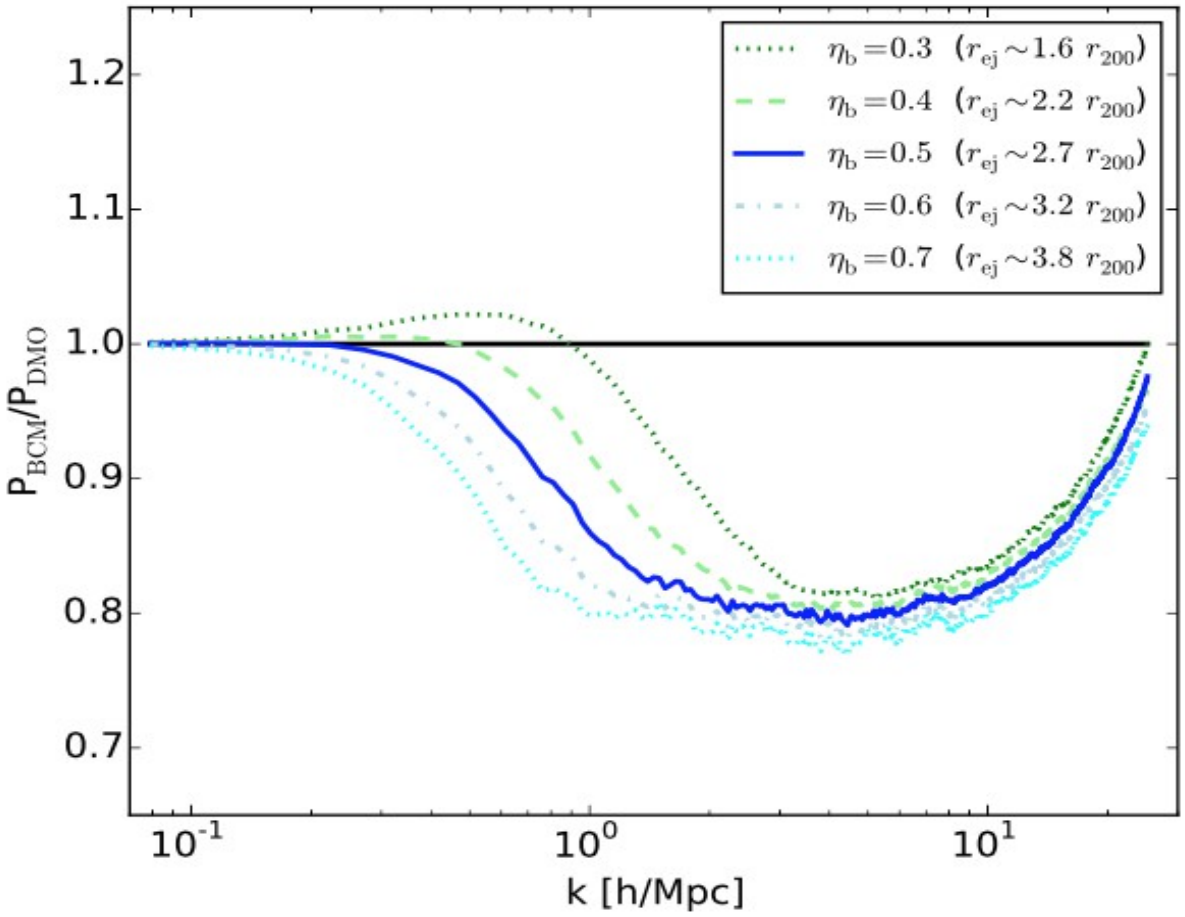


Power suppression with two parameters

Second parameter: varying ejected gas radius

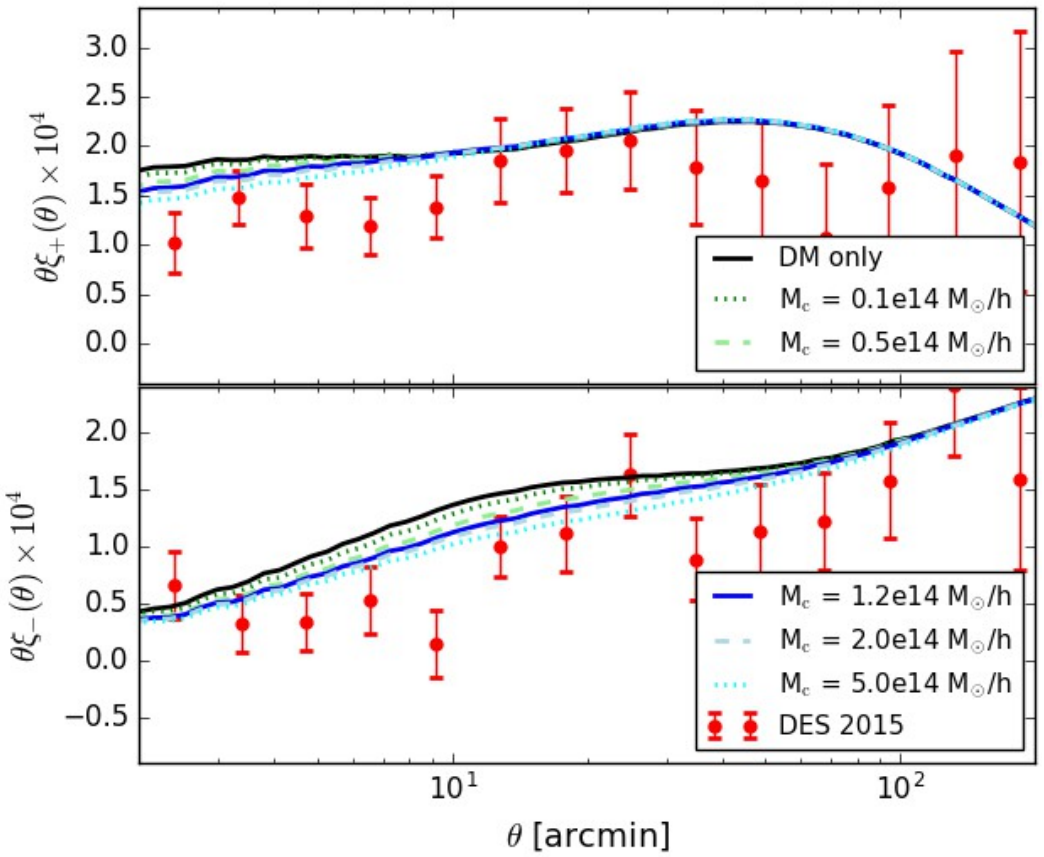




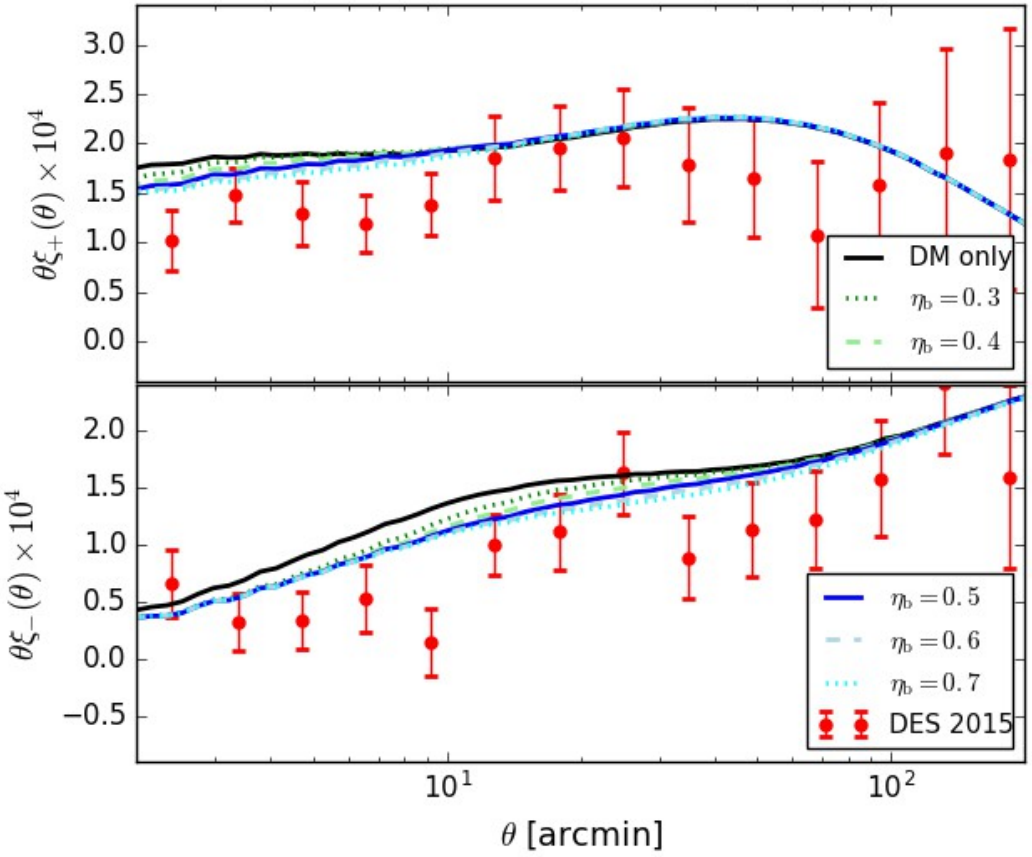


Weak lensing shear correlation (PRELIMINARY)

First param: ejected gas fraction

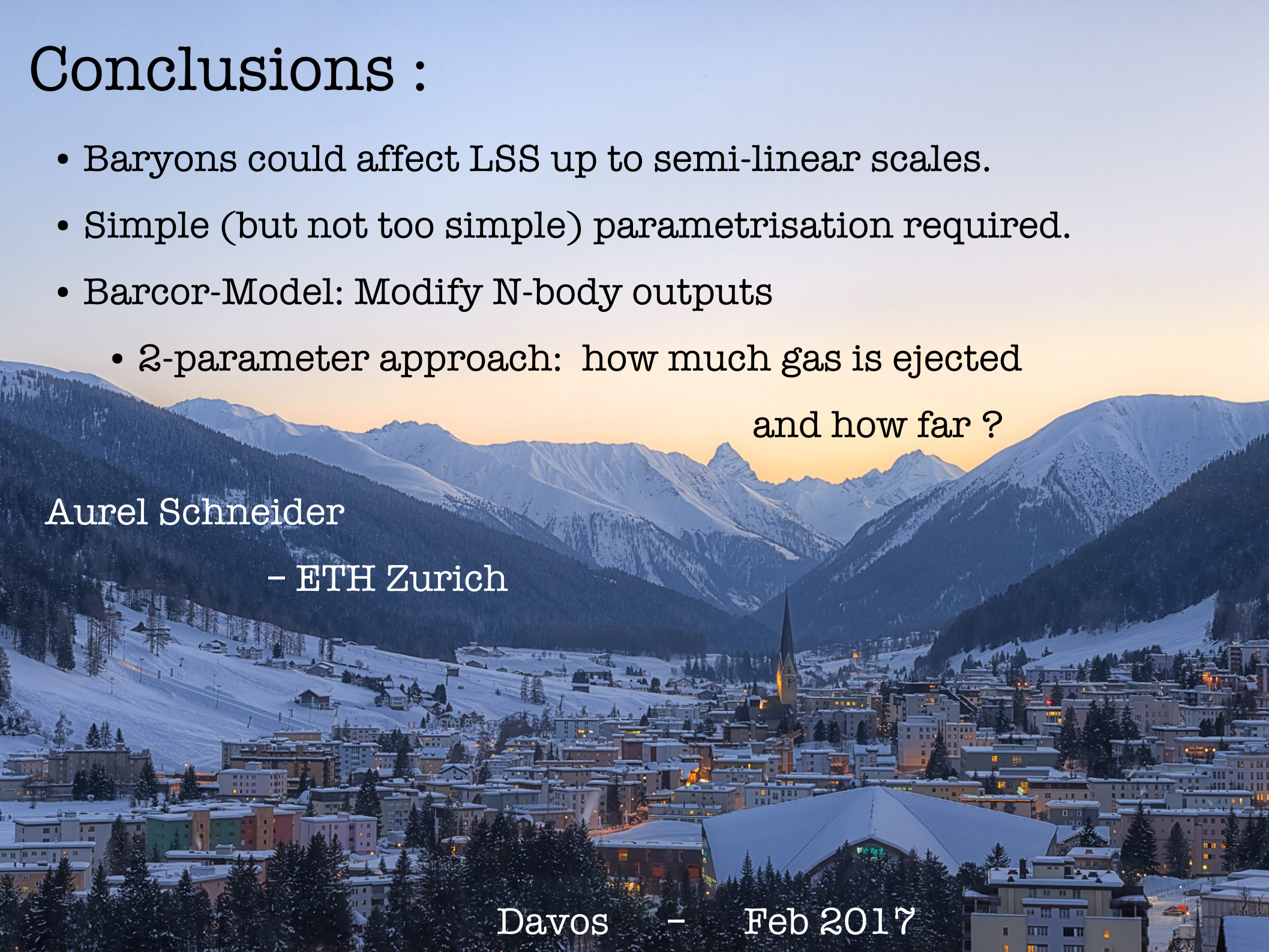


Second param: ejected gas radius



Conclusions :

- Baryons could affect LSS up to semi-linear scales.
- Simple (but not too simple) parametrisation required.
- Barcor-Model: Modify N-body outputs
  - 2-parameter approach: how much gas is ejected and how far ?



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