HE mass bias in The Three Hundred clusters

Is it affected by mergers?

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Hydrostatic equilibrium

$$M_{HE,SZ}(< r) = -\frac{r^2}{G\rho(r)}\frac{dP_{therm}(r)}{dr}$$

$$\downarrow$$

$$b_{SZ} = \frac{M_{true} - M_{HE,SZ}}{M_{true}}$$

$$M_{HE,X}(< r) = -\frac{T(r)r}{\mu\, m_p\, \mathrm{G}}\left[\frac{d\log\rho(r)}{d\log r} + \frac{d\log T(r)}{d\log r}\right]$$

$$\downarrow$$

$$b_X = \frac{M_{true} - M_{HE,X}}{M_{true}}$$

$\boldsymbol{P_{therm}}$: thermal pressure
$\boldsymbol{\rho}$: electron density
μ: mean molecular weight
$\boldsymbol{m_p}$: proton mass
G: gravitational constant
$\boldsymbol{T}$: electron temperature

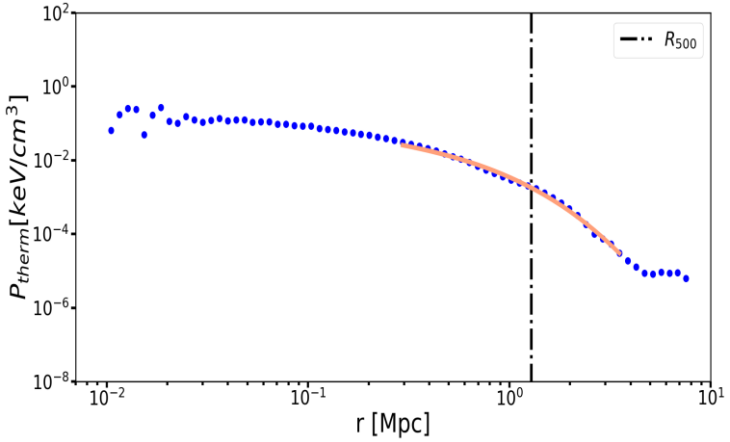
- Fit of the profiles with models from **[0.2 – 3]R_{500}**
  - Analytical derivative of the model
  - Goodness of the fits: Reduced $\chi^2 < 1$

Profiles computed with
- single halo model
- Centre as the minimum potential well

CL0068, z = 0.4

Fit of the radial profiles: models

gNFW

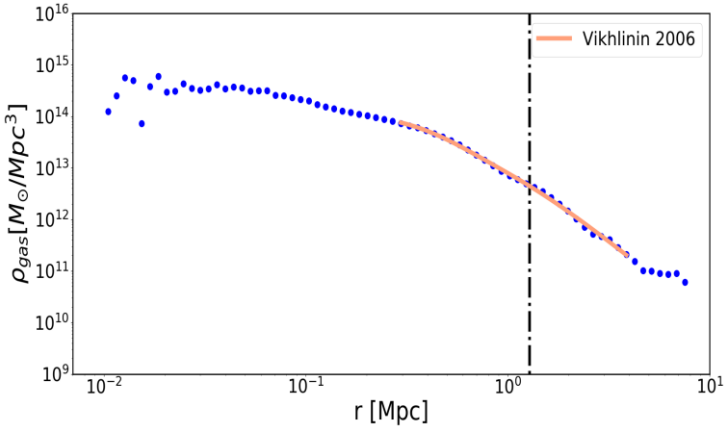


Gas pressure

$$\mathrm{P(r)} = \frac{P_0}{x^c(1 + x^a)^{\frac{b-c}{a}}}$$

$$x = \frac{r}{R_{500}}$$

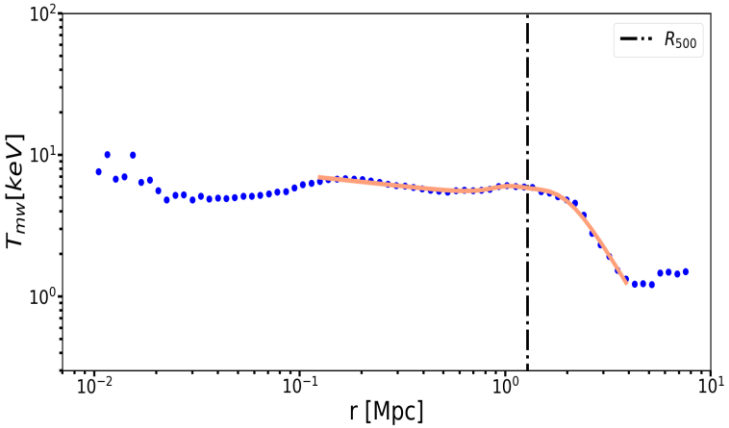
Vikhlinin



Gas density

$$\rho(r) = \rho_0 \frac{\left(\frac{r}{r_c}\right)^{-a}}{\left(\frac{r}{r_c}\right)^{-a}\left(1+\left(\frac{r}{r_c}\right)^2\right)^{\frac{\left(3b-\frac{a}{2}\right)}{2}}\left(1+\left(\frac{r}{r_s}\right)^c\right)^{\frac{e}{2c}}} + \frac{\rho_{0,2}}{\left(1+\left(\frac{r}{r_{c.2}}\right)^2\right)^{\frac{3b_2}{2}}}$$

Vikhlinin

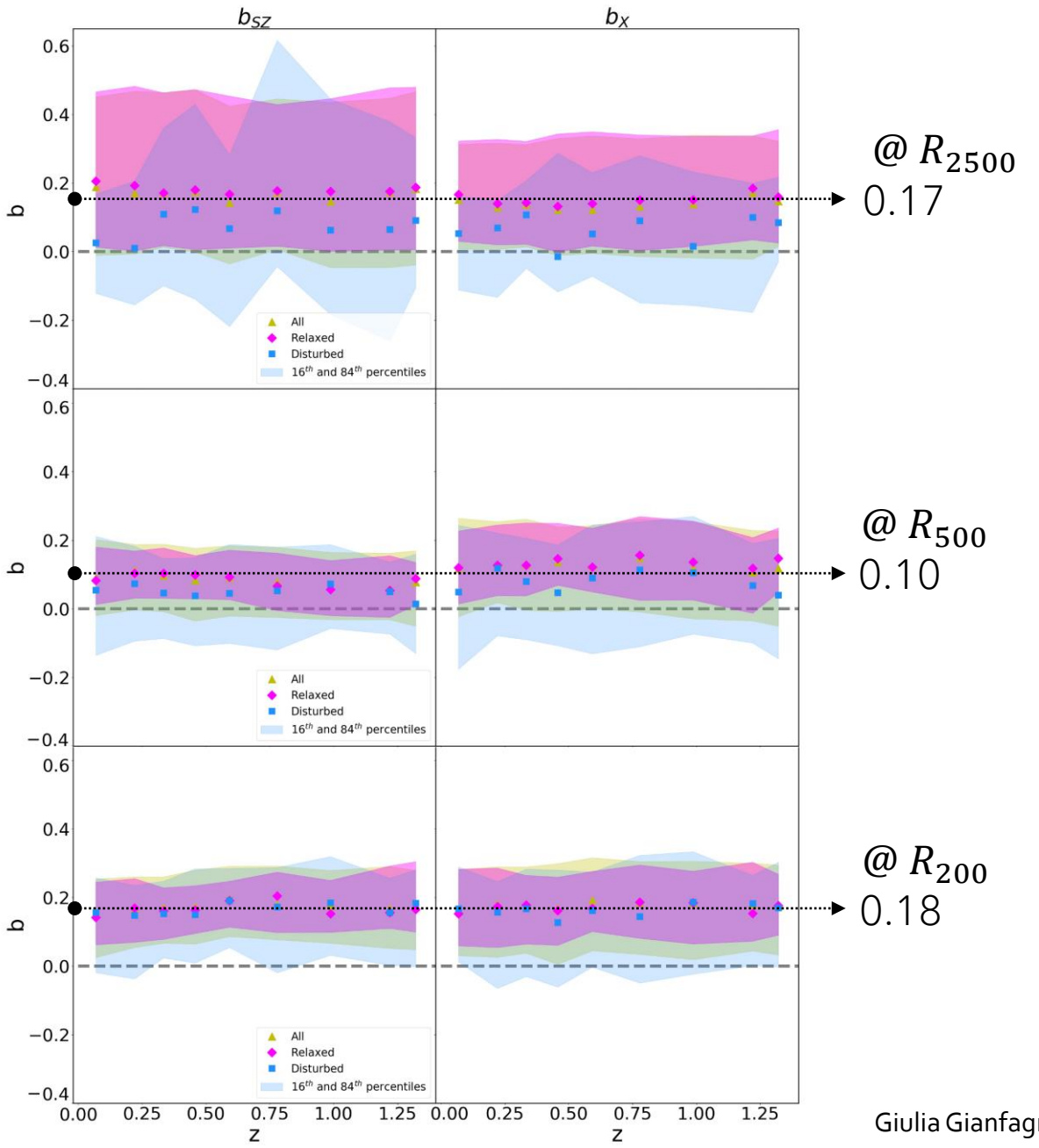


Mass-weighted temperature:

$$T(r) = T_0 \frac{(x + \frac{T_{min}}{T_0})}{(x+1)} \frac{\left(\frac{r}{r_t}\right)^{-a}}{\left(1+\left(\frac{r}{r_t}\right)^b\right)^{c/b}}$$

$$x = \left(\frac{r}{r_{cool}}\right)^{a_{cool}}$$

HE mass bias



$@\ R_{2500}$ 0.17

$@\ R_{500}$ 0.10

$@\ R_{200}$ 0.18

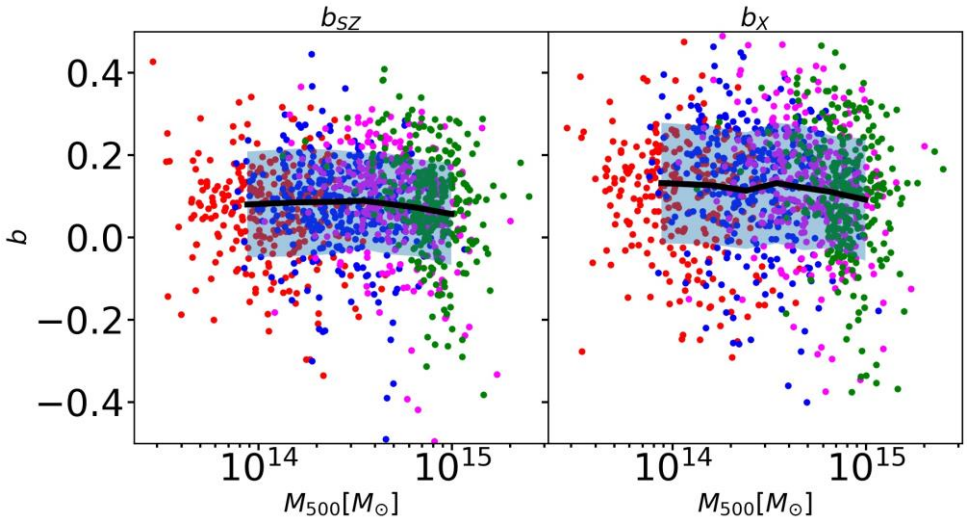
» No dependence with *z;*
» The disturbed clusters have the largest scatter;
» $@\ R_{2500}$ the scatter of all the classes is the largest.

In the plot:
Median values
16° and 84° percentile

See also *Gianfagna et al, 2021*

Other HE bias correlations

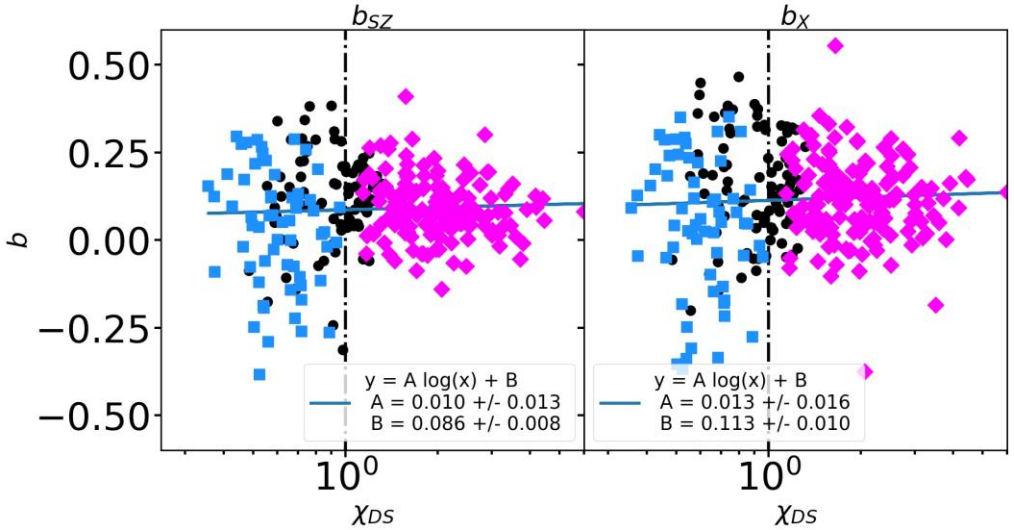
Mass



z = 1.32
z = 0.78
z = 0.33
z = 0.069

No dependence on the mass.

Dynamical state



De Luca et al, 2021
+ Federico's talk

$$\chi_{DS} = \sqrt{\frac{2}{\left(\frac{\Delta_r}{0.1}\right)^2 + \left(\frac{f_s}{0.1}\right)^2}}$$

Disturbed clusters have the widest scatter.

The Three Hundred - Mergers

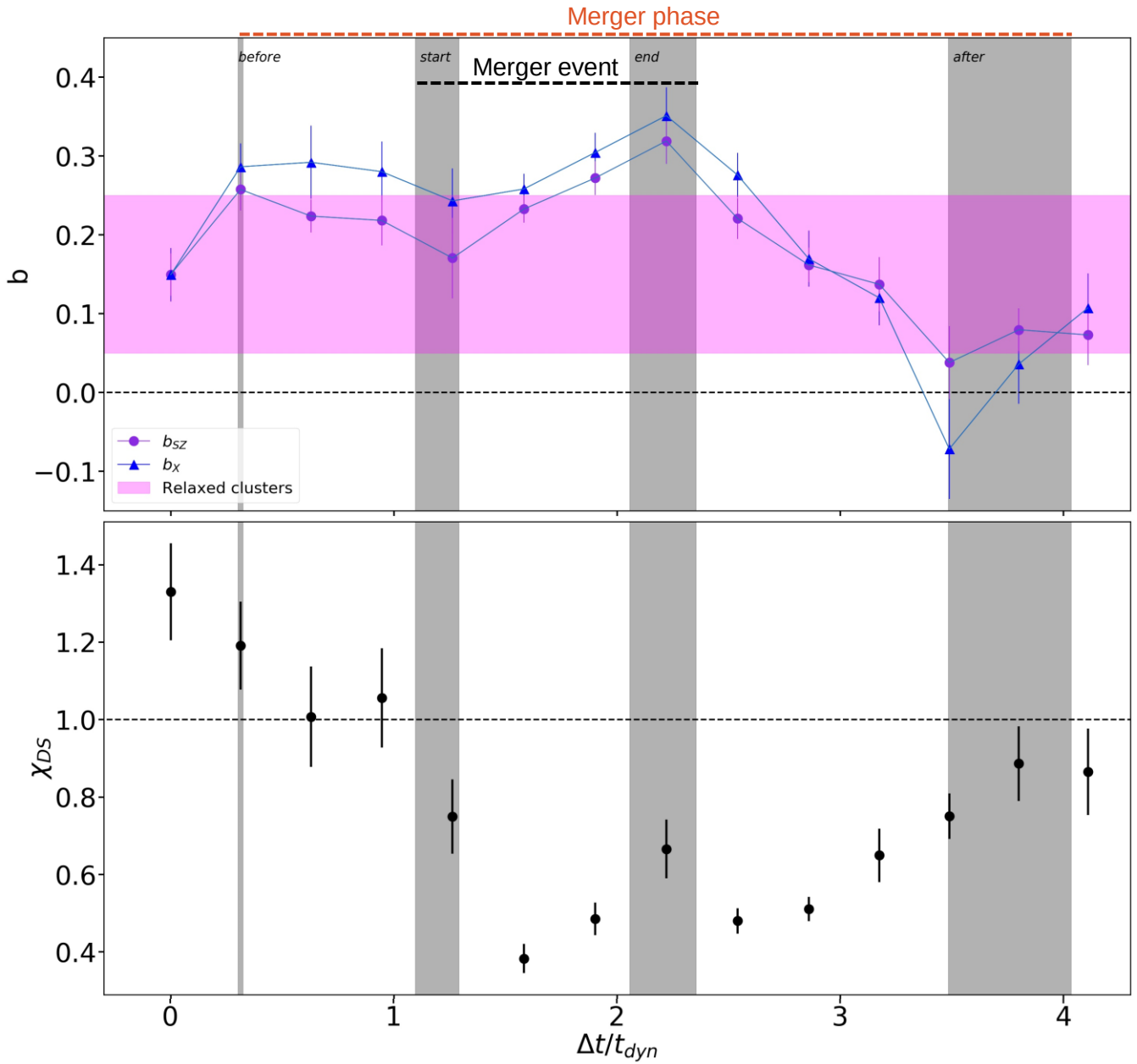
MERGER: finding a mass increase of 100 per cent happening within half the cluster's dynamical time [*Contreras et al* in preparation].

$$\frac{\Delta M}{\mathrm{M}} = \frac{\mathrm{M_f} - \mathrm{M_i}}{M_i} \geq 1 \quad \Longrightarrow$$

12 clusters

Merger phase

- z_{before}: the two objects start to influence each other. The main object is still in equilibrium;
- Merger event
  - z_{start}: the merger begins;
  - z_{end}: the merger disturbing effects end;
- z_{after}: the cluster returns to equilibrium.



Preliminary

Stacking of the profiles – R_{200}

- On the x axis:

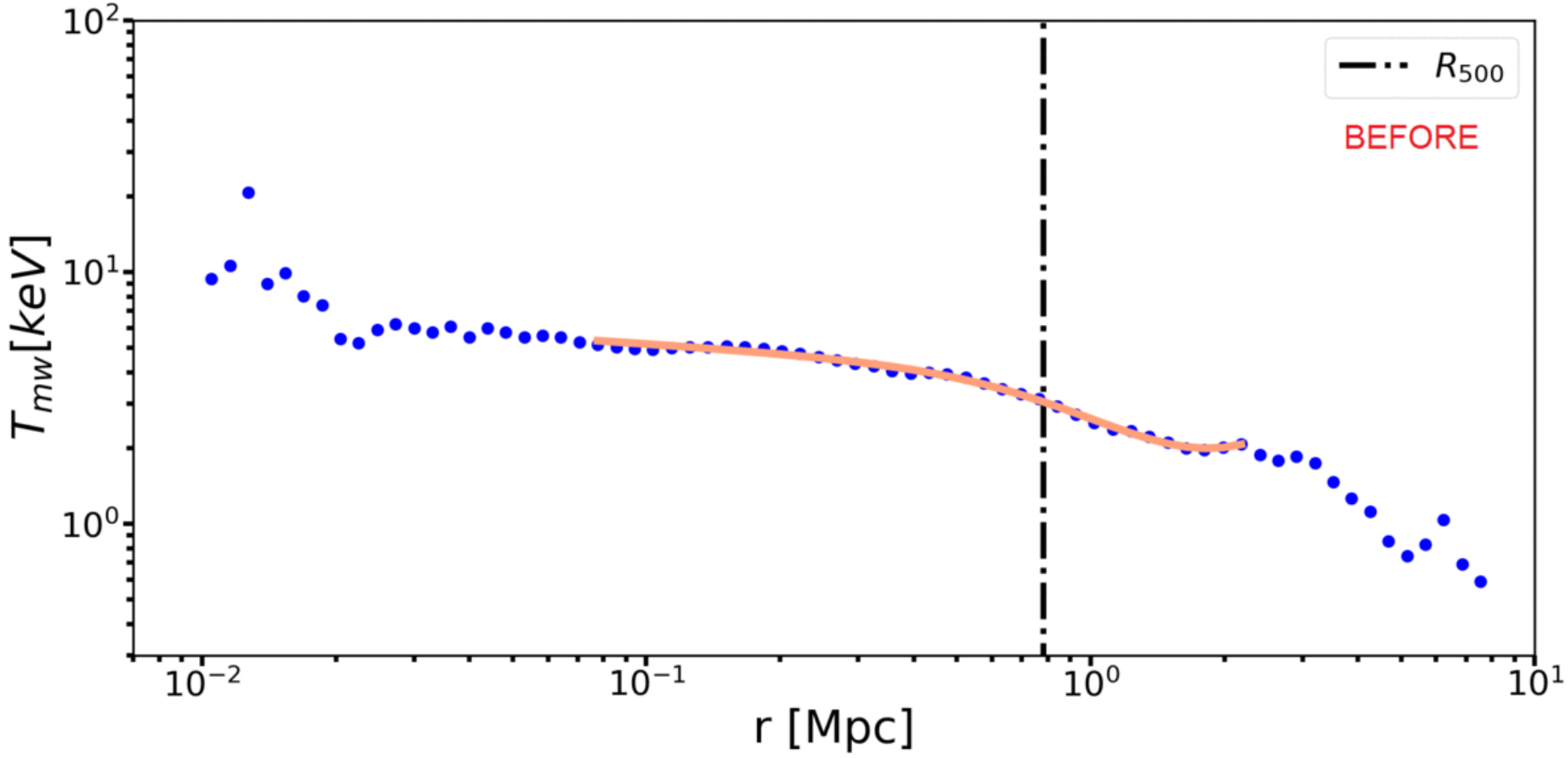
$$\frac{\Delta t}{t_{dyn}} = \frac{t_{(before-1)+i} - t_{(before-1)}}{t_{dyn}}$$

$$t_{dyn} = \left(\frac{3}{4\pi}\frac{1}{200 G \rho_{crit}}\right)^{1/2}$$ *Dynamical time*

At R_{500} the biases are similar.

Temperature profile CL0068

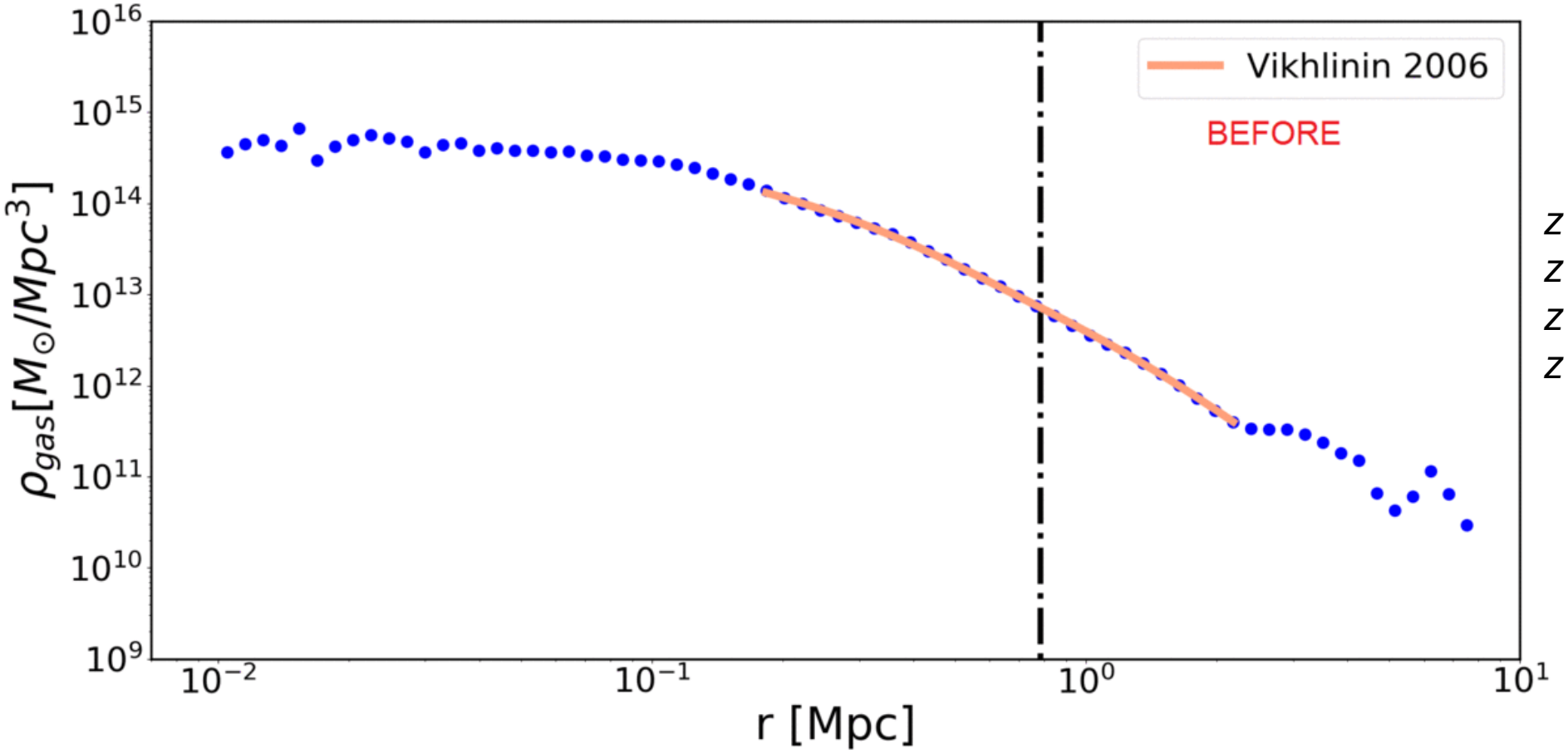
Preliminary



z = 0.8: BEFORE
z = 0.6: START
z = 0.5: END
z = 0.3: AFTER

Gas density profile CL0068

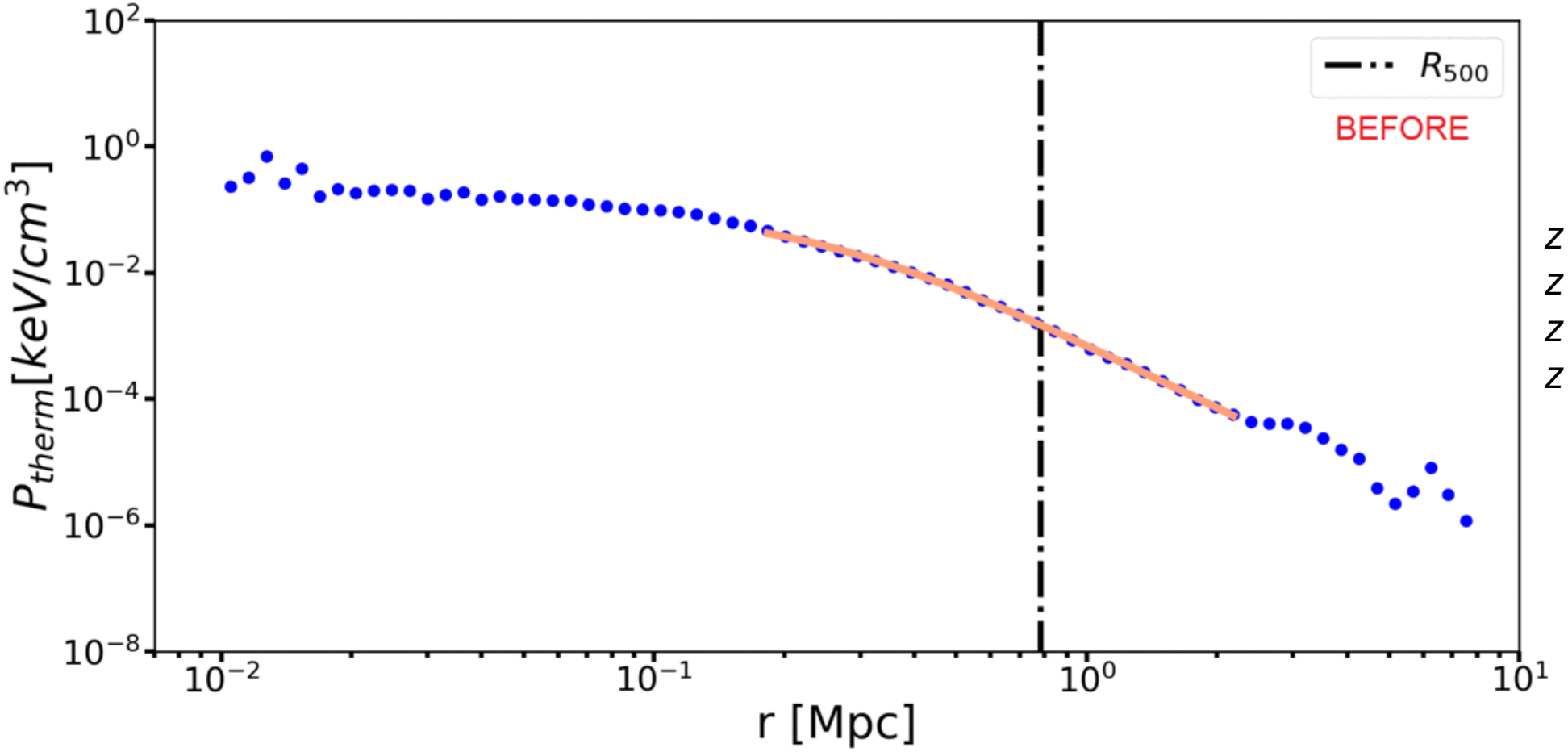
Preliminary



z = 0.8: BEFORE
z = 0.6: START
z = 0.5: END
z = 0.3: AFTER

Pressure profile CL0068

Preliminary



z = 0.8: BEFORE
z = 0.6: START
z = 0.5: END
z = 0.3: AFTER

Summary

- The HE mass bias is **influenced by the merger;**
- The value of the bias during the merger, especially after t_{start}, is not compatible with the average value of the relaxed clusters;
- The HE mass bias values during the mergers can be explained thanks to the dynamical state and the steepening of the radial profiles.

THANK YOU