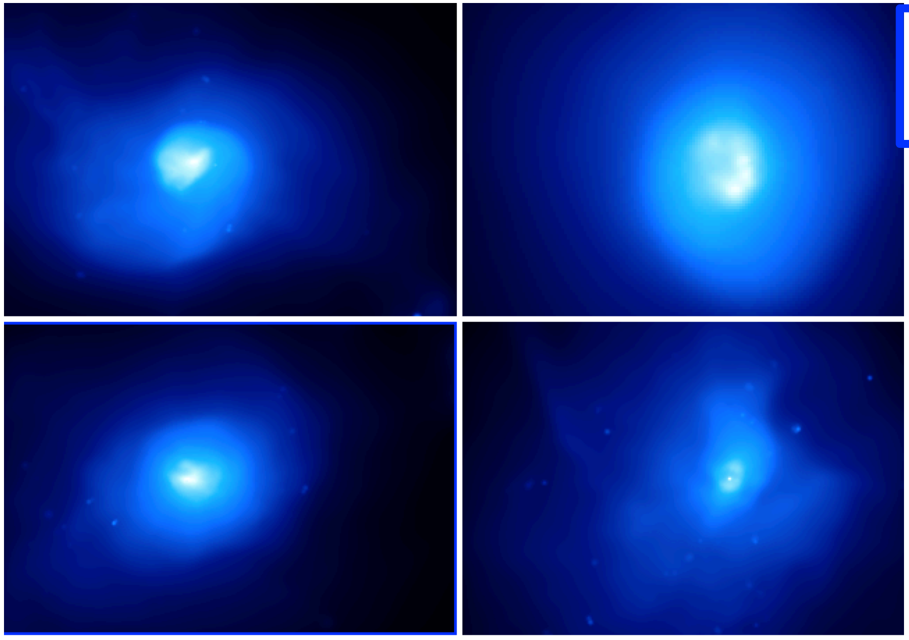
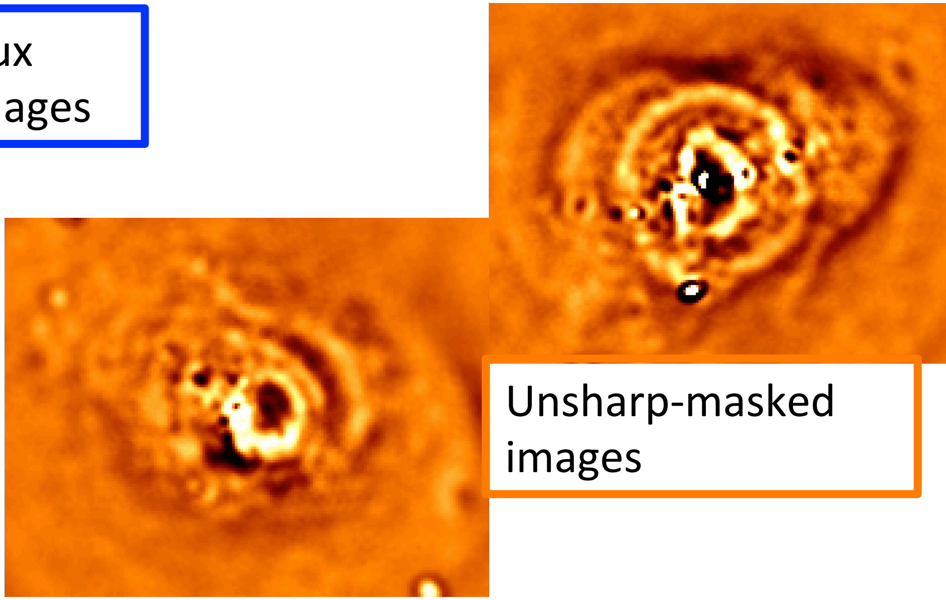


Flux images



Unsharp-masked images

Baryonic properties evolution within Galaxy Clusters

Elena Rasia

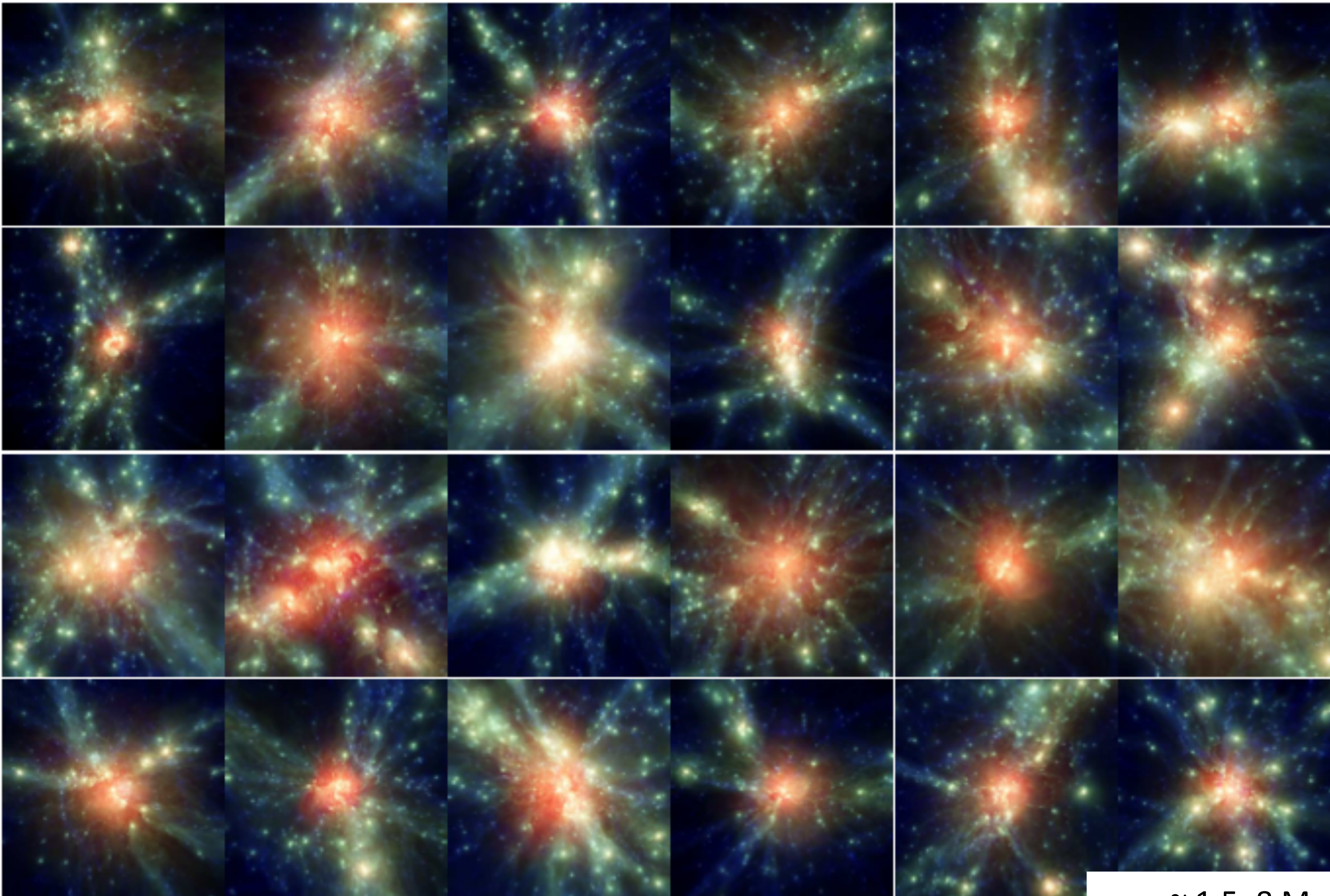
(INAF-oats, University of Michigan)

With:
Veronica Biffi
Nhut Truong
Susana Planelles
Dunja Fabjan

Acknowledgments:

24 massive clusters + 5 groups

Initial conditions from Bonafede+12



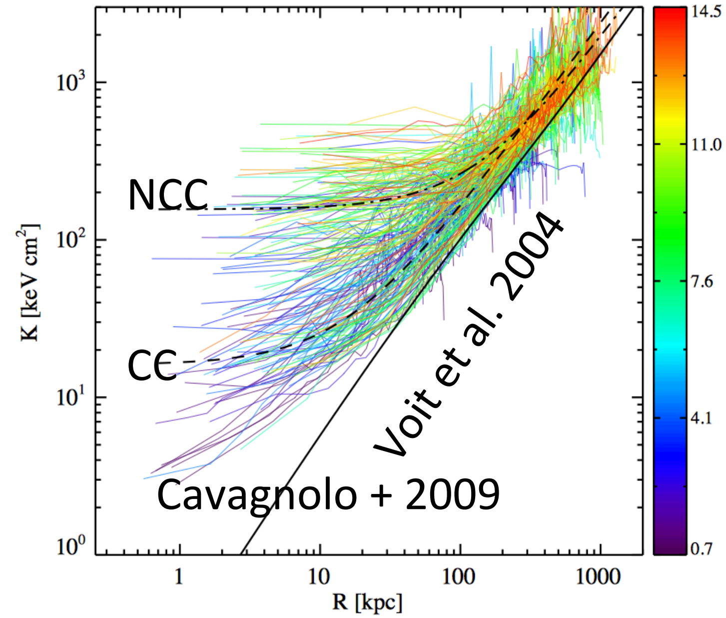
m_{DM} ~ 1.5e8 Ms/jh

Entropy @ z~0

$K=kT/n_e^{2/3}$

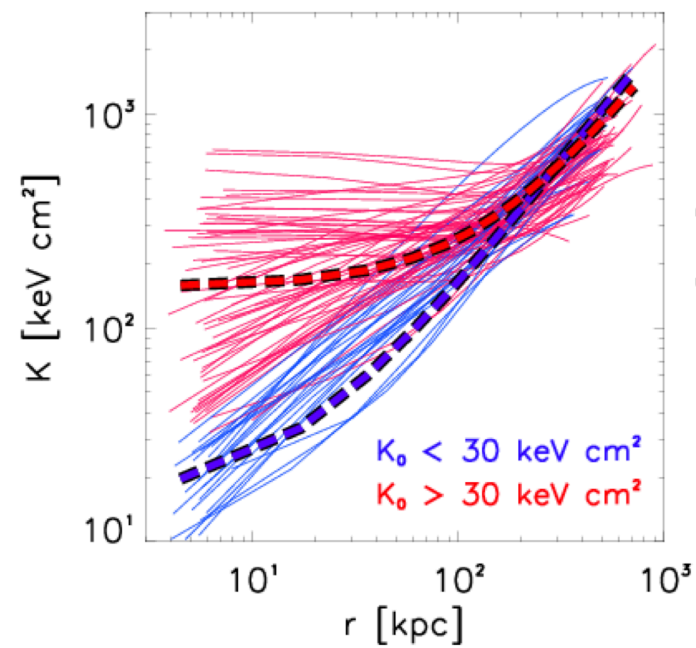
Gravity drives structure formation.

Simply gravity-only models do not explain the observed gas profiles from the core to the outskirts.



Delicate balance between heating and cooling is in place.

Entropy quantifies the history of the energy deposited in the intra-cluster medium.

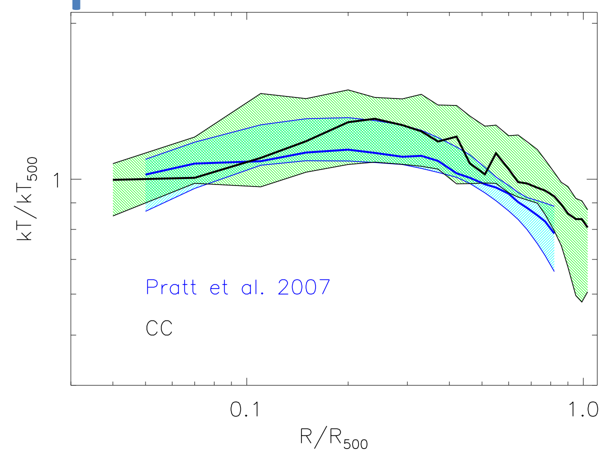


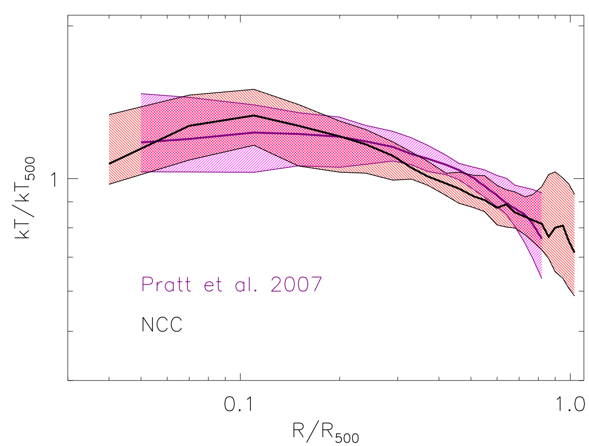
McDonald, SPT+ 2014

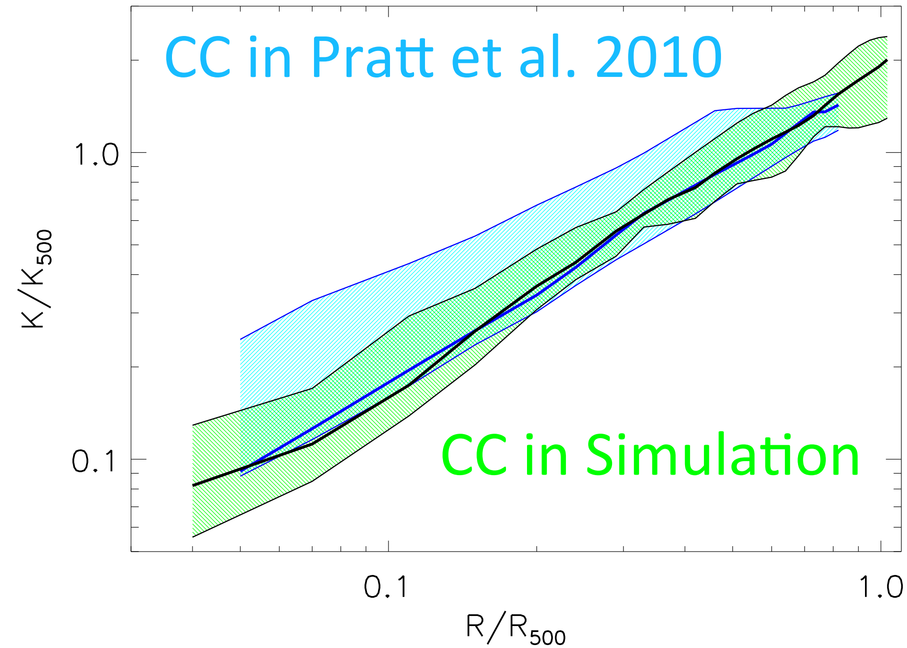
CC defined in Molendi & Pizzolato '01

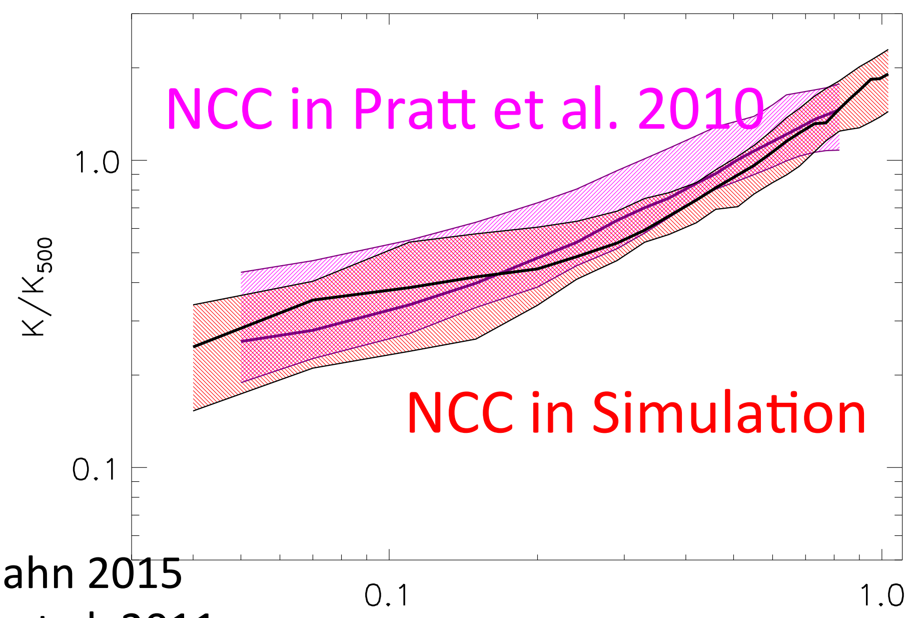
Entropy @ z~0
$K = kT/n_e^{2/3}$

Temperature Profiles







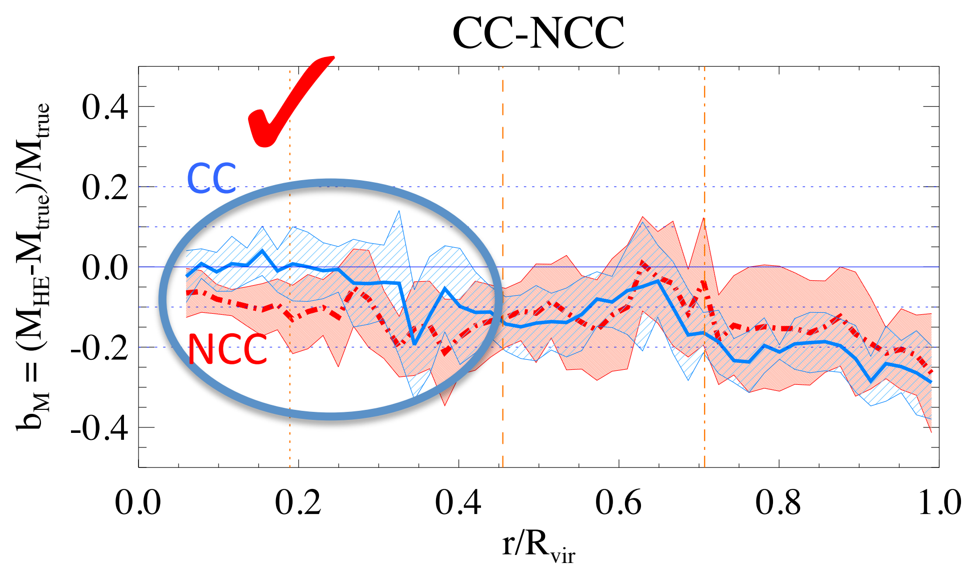


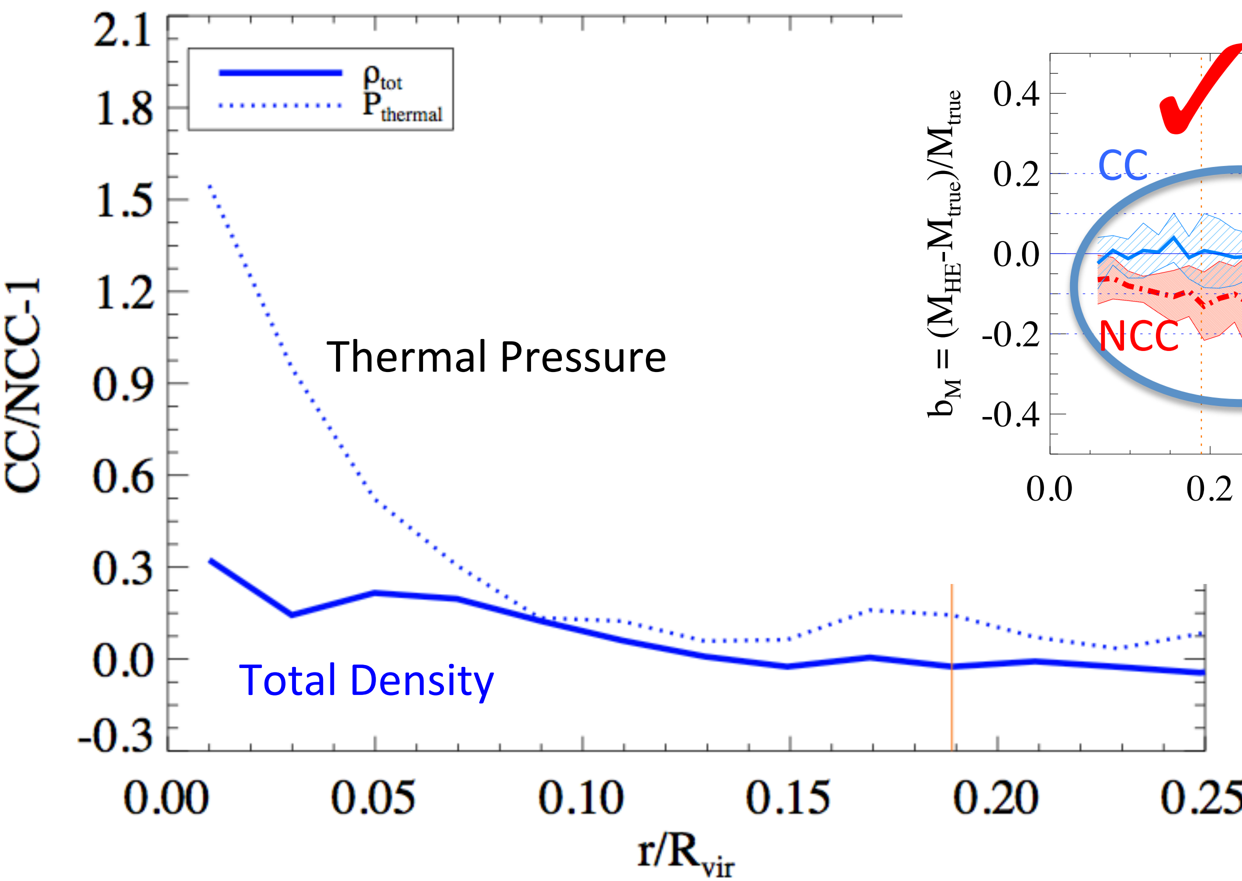
See also Hahn 2015
Valdarnini et al. 2011

Rasia+2015

Pressure profile (CC vs NCC)

$$b_M = (M_{\rm HE} - M_{\rm true})/M_{\rm true}$$





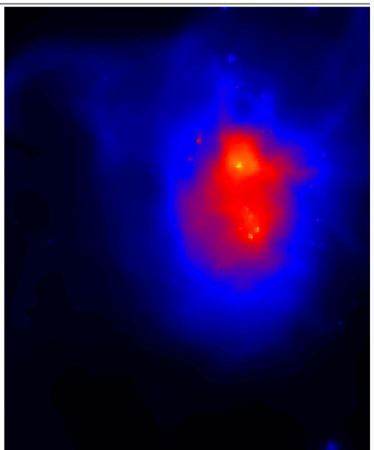
Veronica Biffi's talk tomorrow

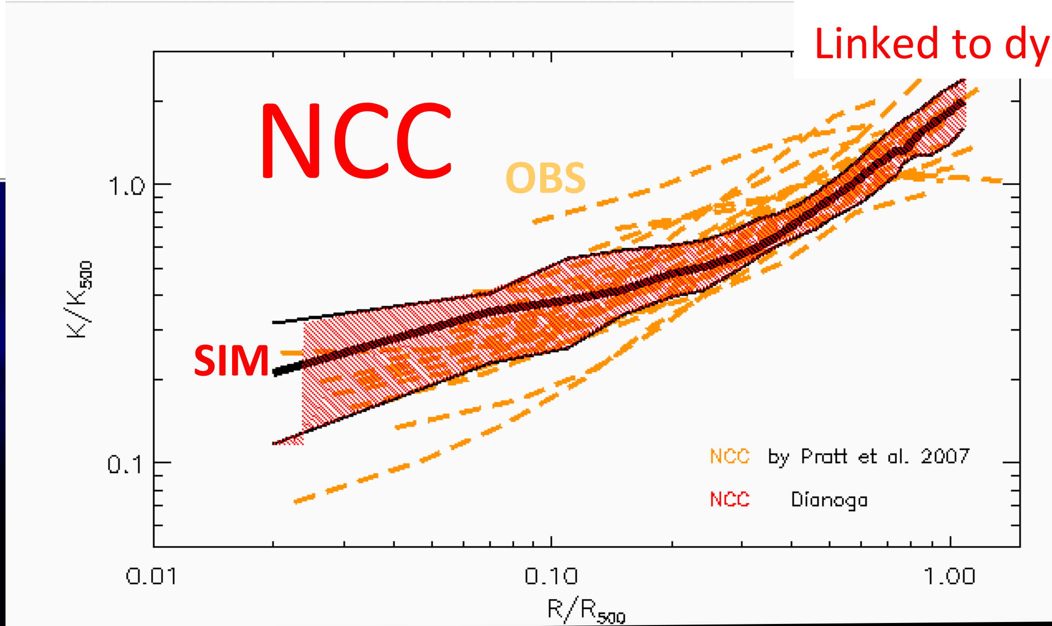
Accepted ApJ

Biffi+ 2016 (reply to Referee)

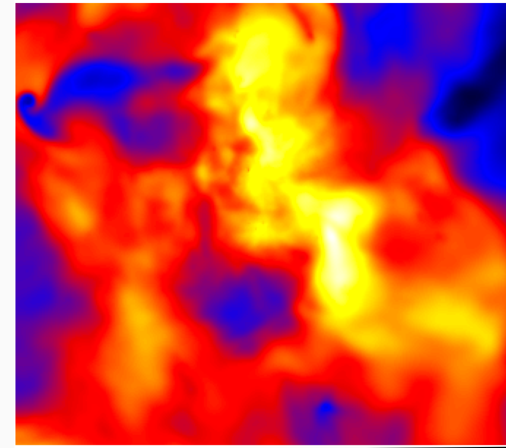
Linked to dynamically active systems

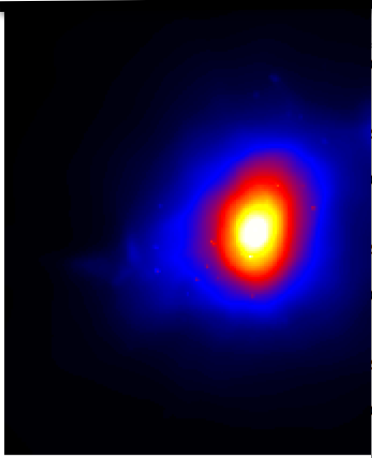
Flux Maps

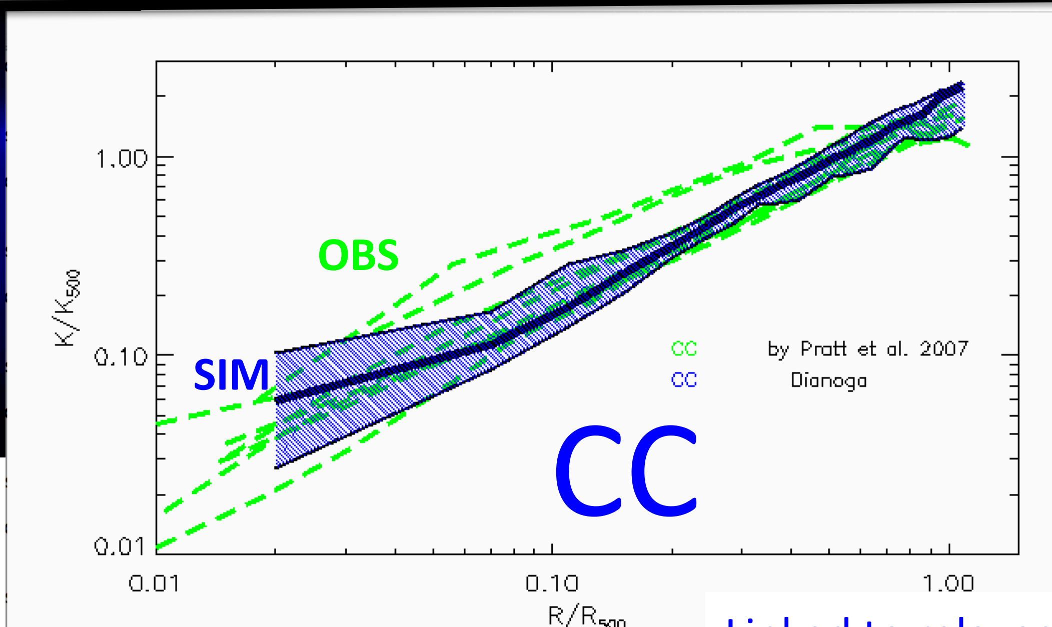


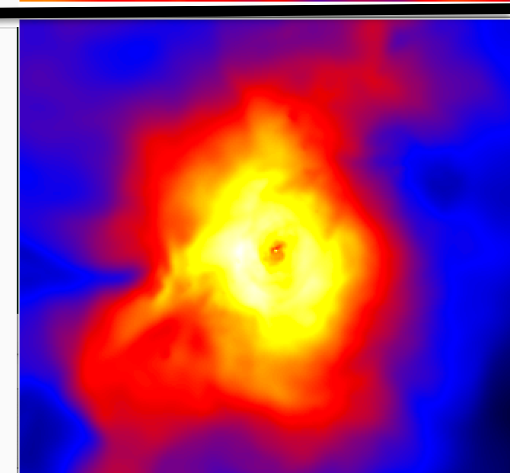


Temperature Maps









Flux Maps

Temperature Maps

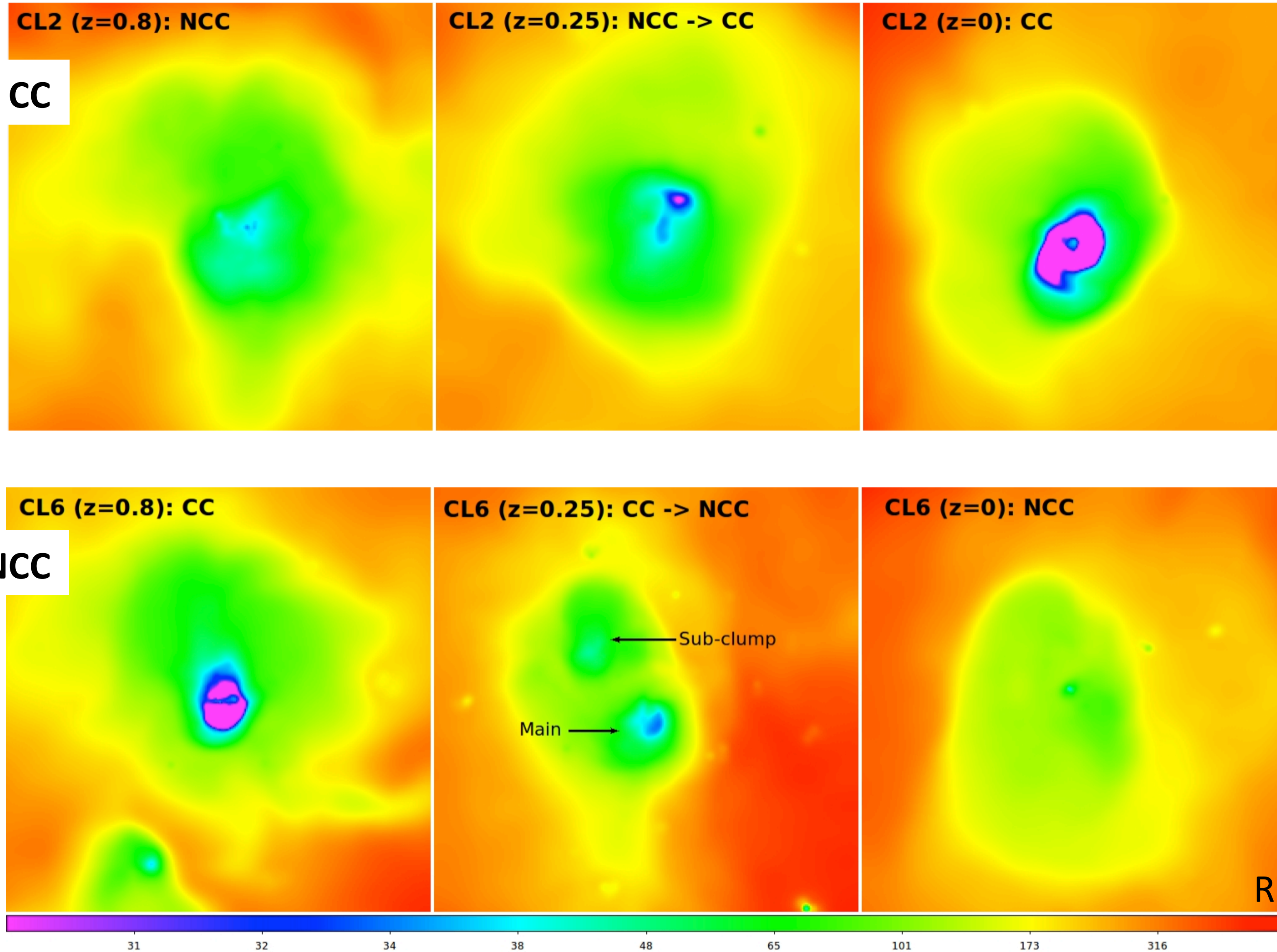
Linked to relaxed and regular objects

Passage between the two classes

Pseudo-Entropy Maps

NCC -> CC

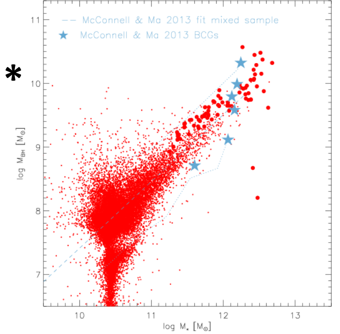
CC -> NCC



Rasia+2015

Stellar Properties

M_{BH} vs. M_*



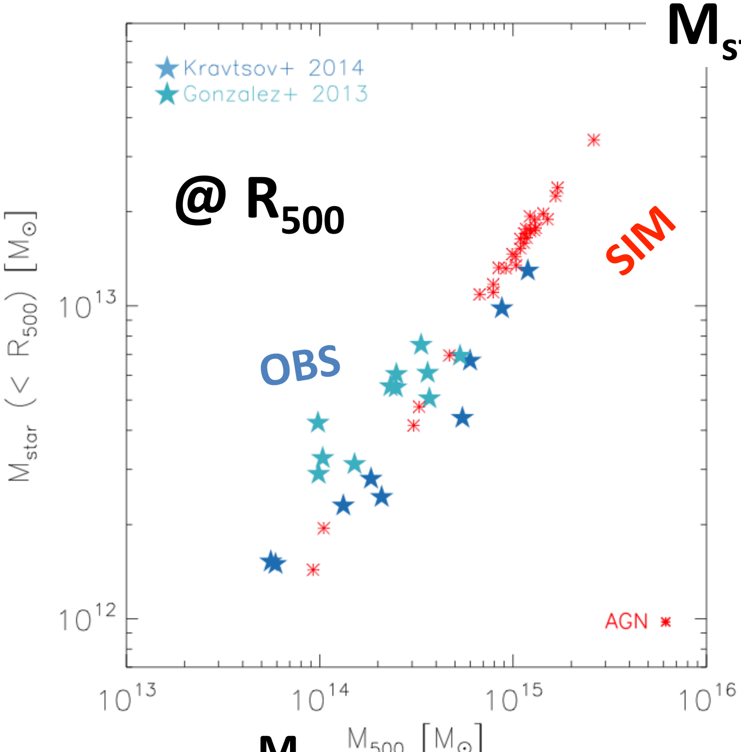
M_{BH}-M_* relation to calibrate feedback parameters. Observat
McConnell & Ma 2013.

M_{*BCG}-M_{500} in agreement with observations (Kravtsov+14)

Total stellar mass also close to observations (Gonzalez+13, Kravtsov+14)

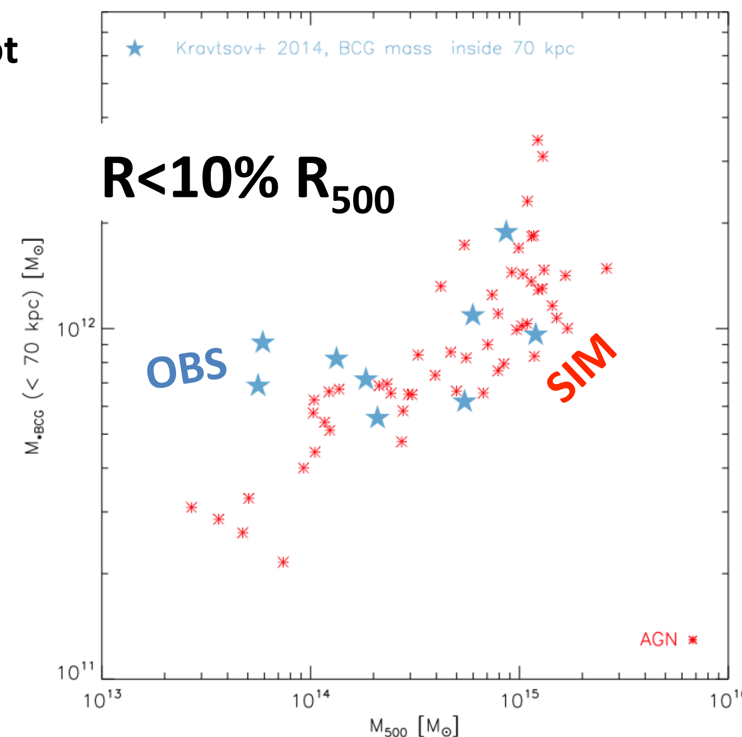
M_{star} vs. M_{tot}

M_{star}



M_{tot}

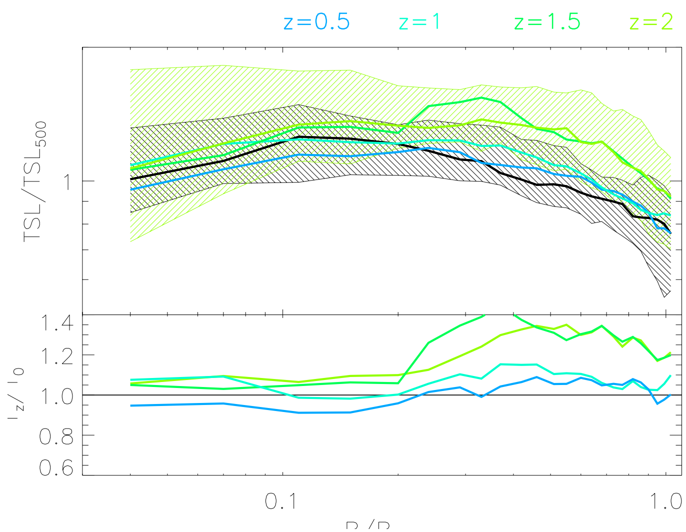
central M_{star}



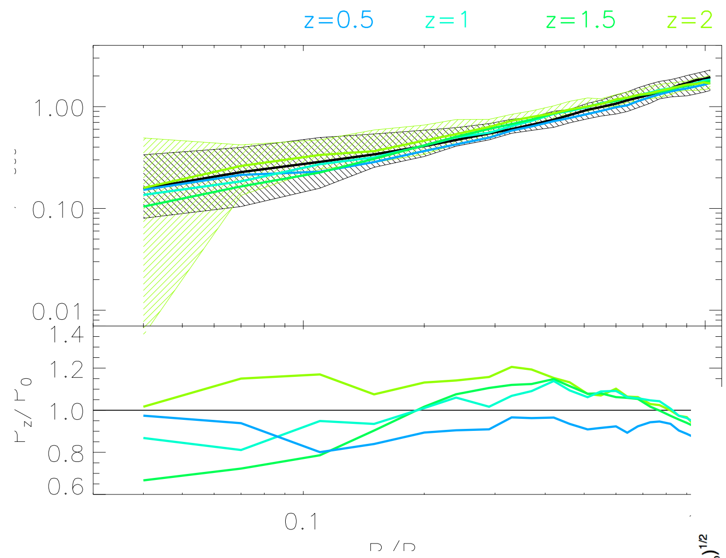
M_{tot}

In prep

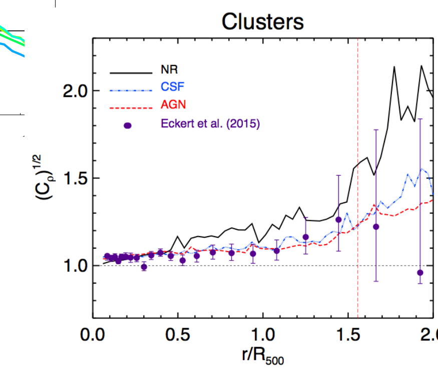
TEMPERATURE



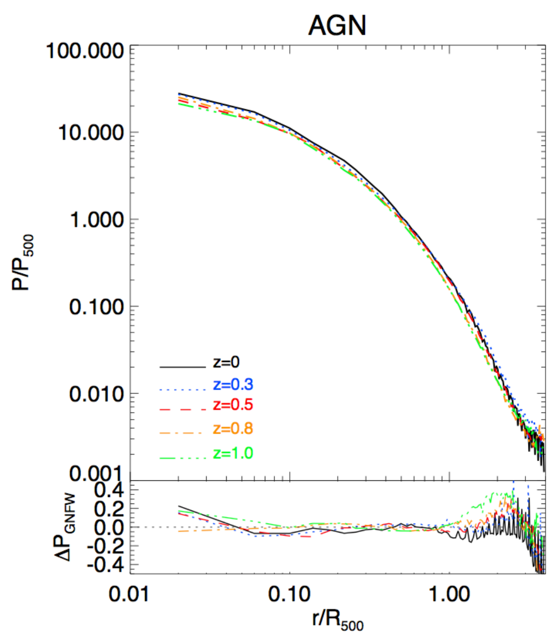
ENTROPY



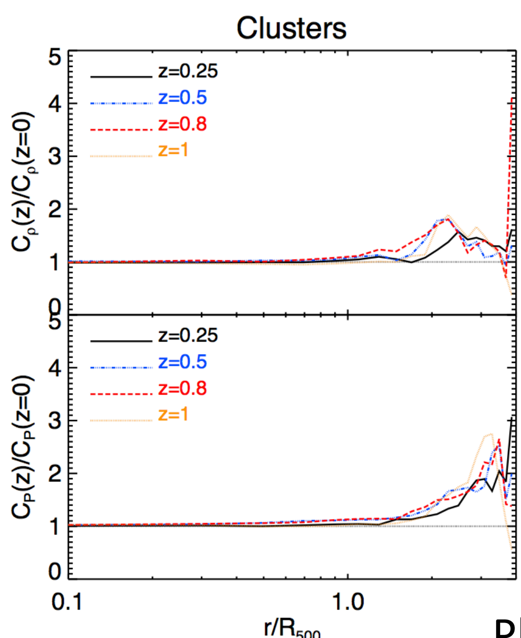
CLUMPING FACTOR @Z=0



PRESSURE



CLUMPING FACTOR



$$C_\rho(r) \equiv \frac{\langle \rho^2 \rangle}{\langle \rho \rangle^2} = \frac{\sum_i^N m_i \rho_i}{\left(\sum_i^N m_i\right)^2} V_{shell}$$

$$C_P(r) \equiv \frac{\langle P^2 \rangle}{\langle P \rangle^2} = \frac{\sum_i^N m_i \rho_i T_i^2}{\left(\sum_i^N m_i T_i\right)^2} V_{shell} \,,$$

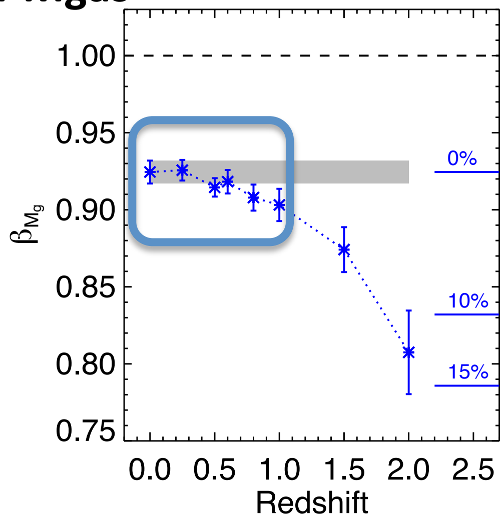
Planelles et al. 2016 (sub.)

SR Evolution:-Slopes

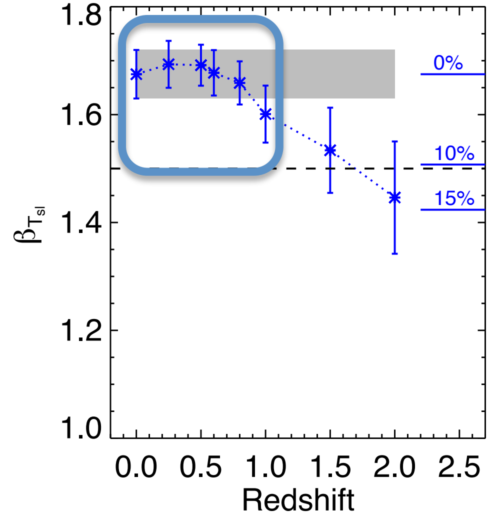
$$Y = C_0 \times E(z)^{\gamma} \times (X/X_0)^{\beta}$$

Slope

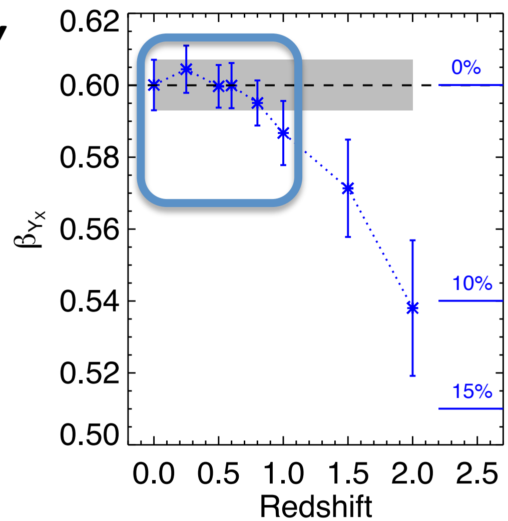
M-Mgas



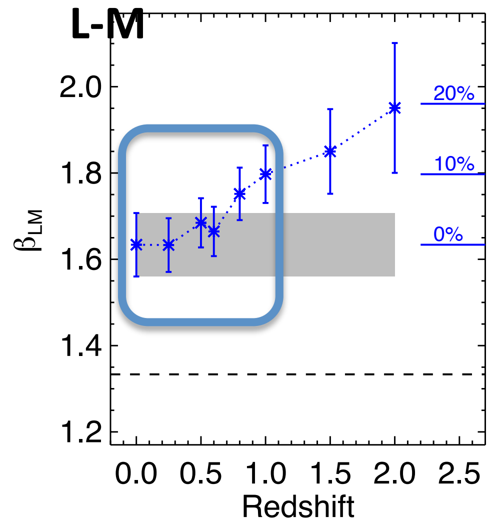
M-T



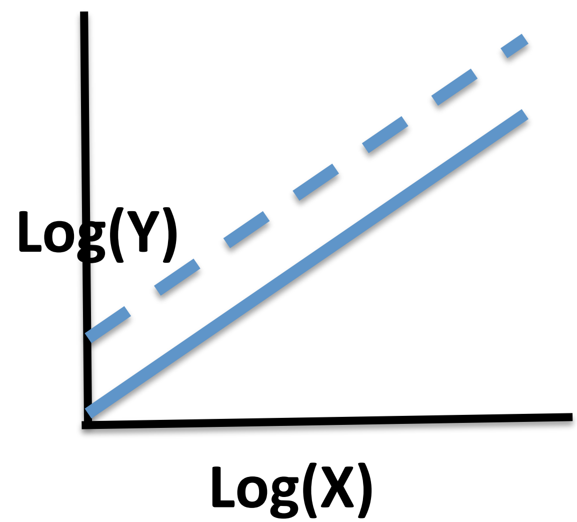
M-Y



L-M



- β_{Mg} changes due to the z=2 AGN intense activity that provide significant thermal energy to the gas that accretes at slower rate into the cluster potential well
- For the evolution in the normalization one needs to be sure that β is constant
- => cosmology can be done using objects with redshift between 0 ad 1



Troung+ 2016 to be submitted

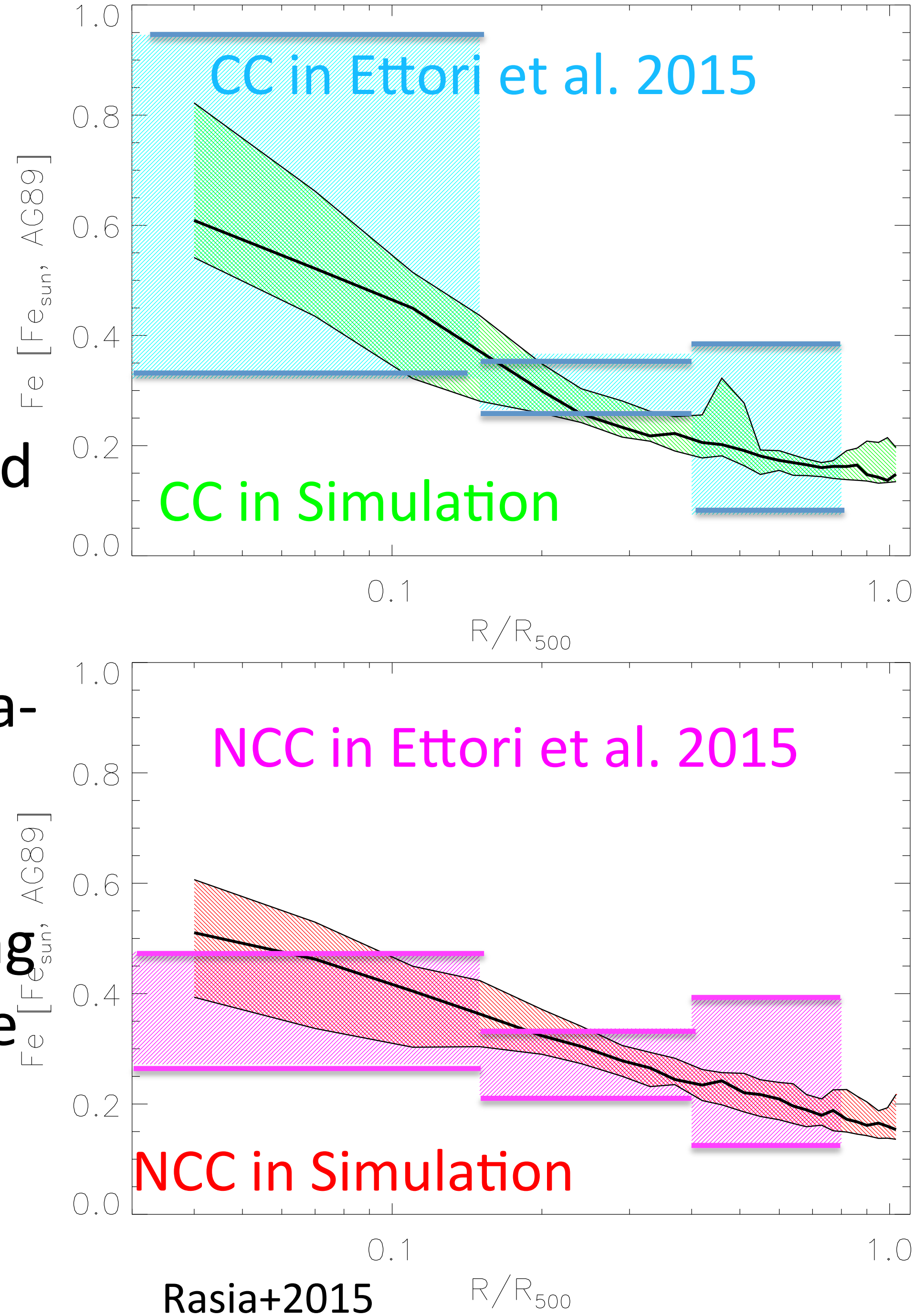
Iron Abundance at z~0

Process driving evolution of chemical enrichment:

- Initial Mass Function
- SNIa, SNcc, AGB yields (and evolution)

Metal diffusion into the intra-cluster medium:

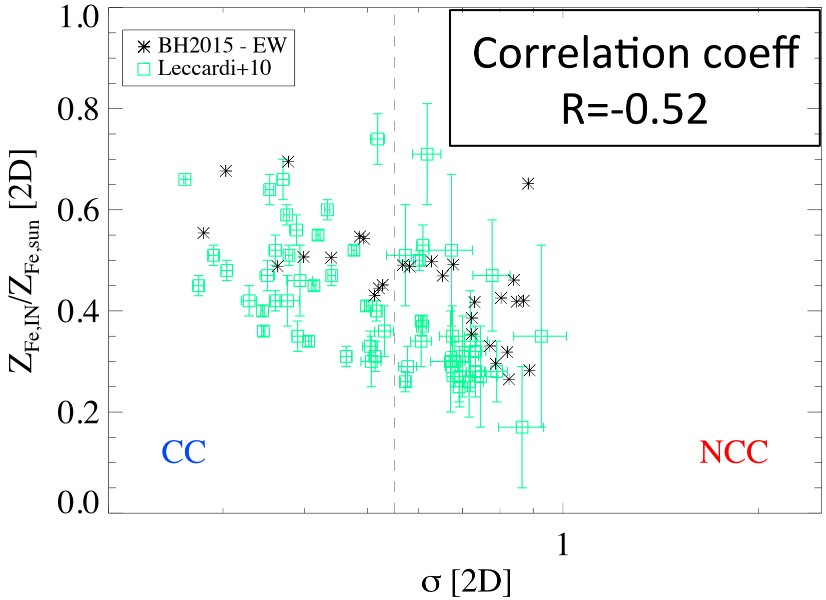
- Early superwinds
- Late ram pressure stripping
- Minor mergers in the core
- Uplift by AGN bubbles



Rasia+2015

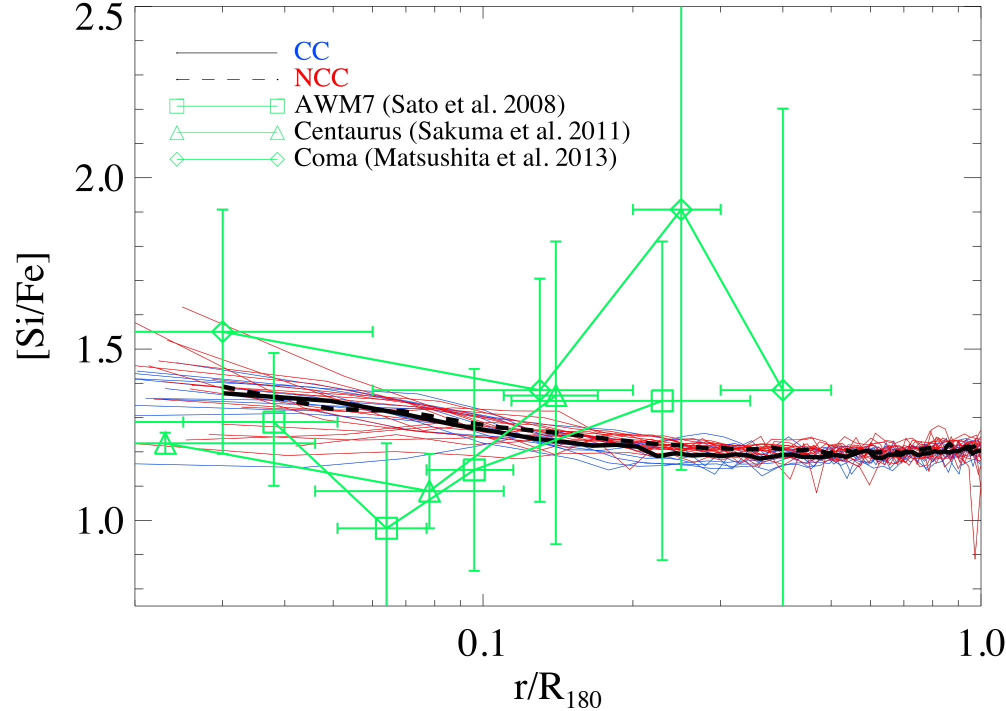
Metals

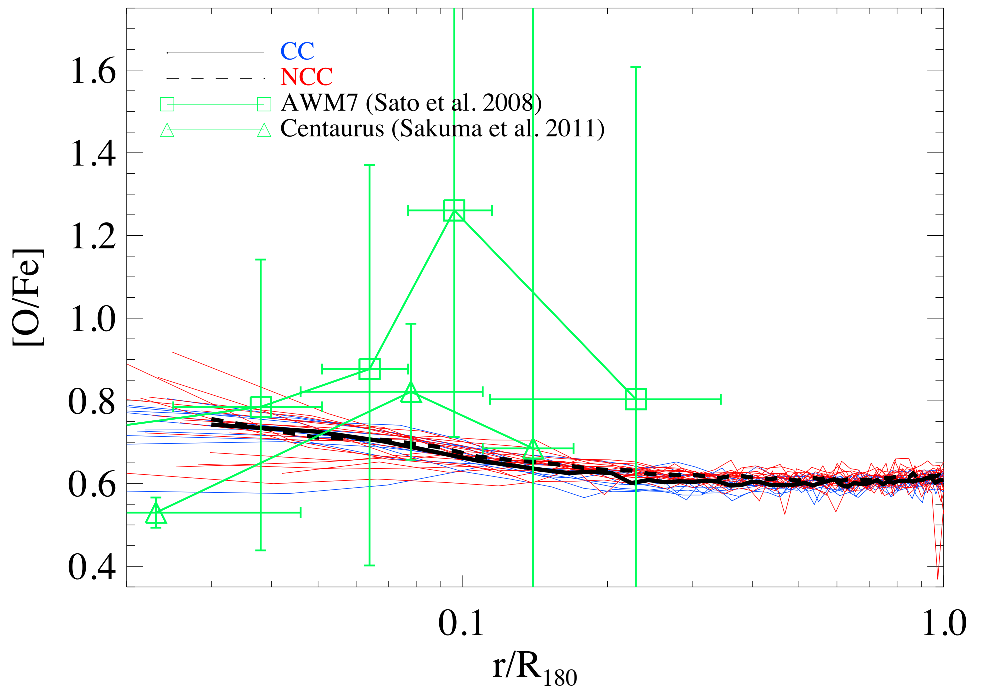
- metal/entropy relation in the core
- [α/Fe] ratio



Pseudo-entropy

In preparation





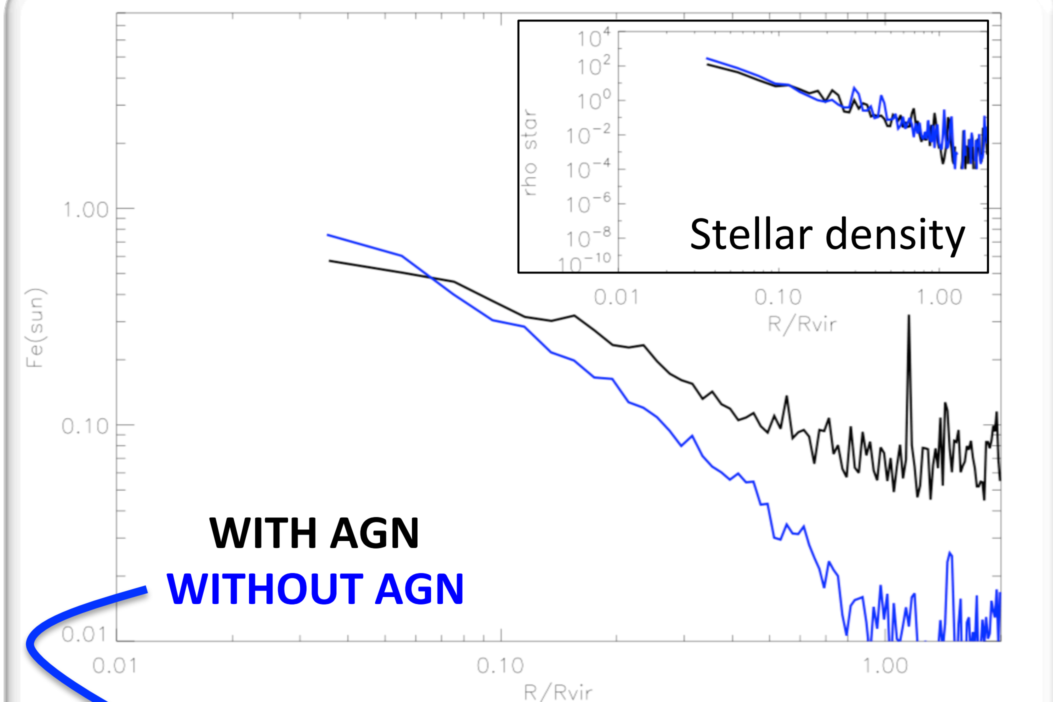
Where is the flatness of the ratio coming from?

The possible explanations:

1. Metals spread inside-out (AGN outflows + mergers)

2. Gas accreted is already enriched (High-z AGN expelled enriched gas that accretes in a second moment)

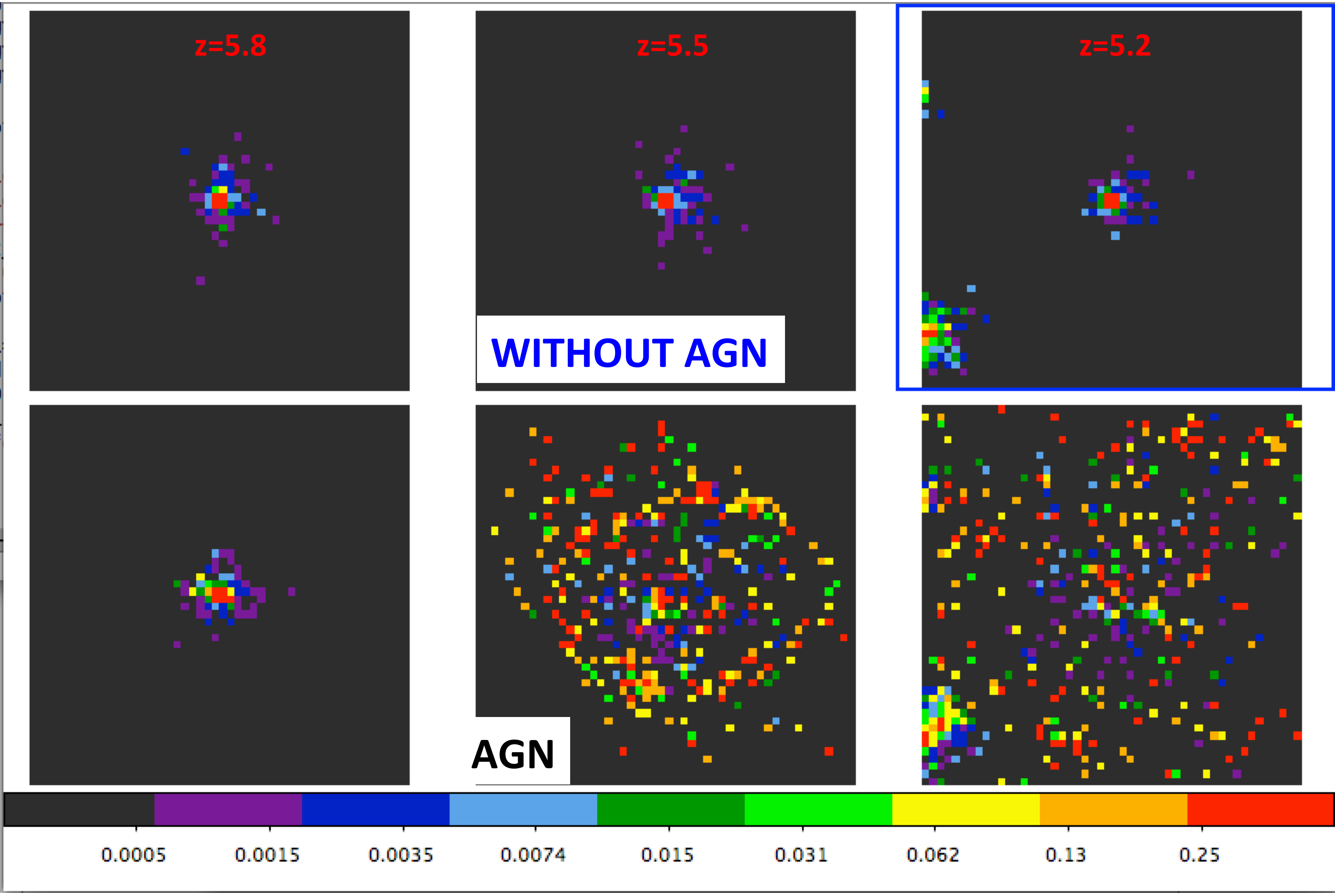
Iron radial Profile of 1 cluster @ z=2



Same cosmology
Same merging history
Still similar stellar profiles
Only difference in presence of AGN

In preparation

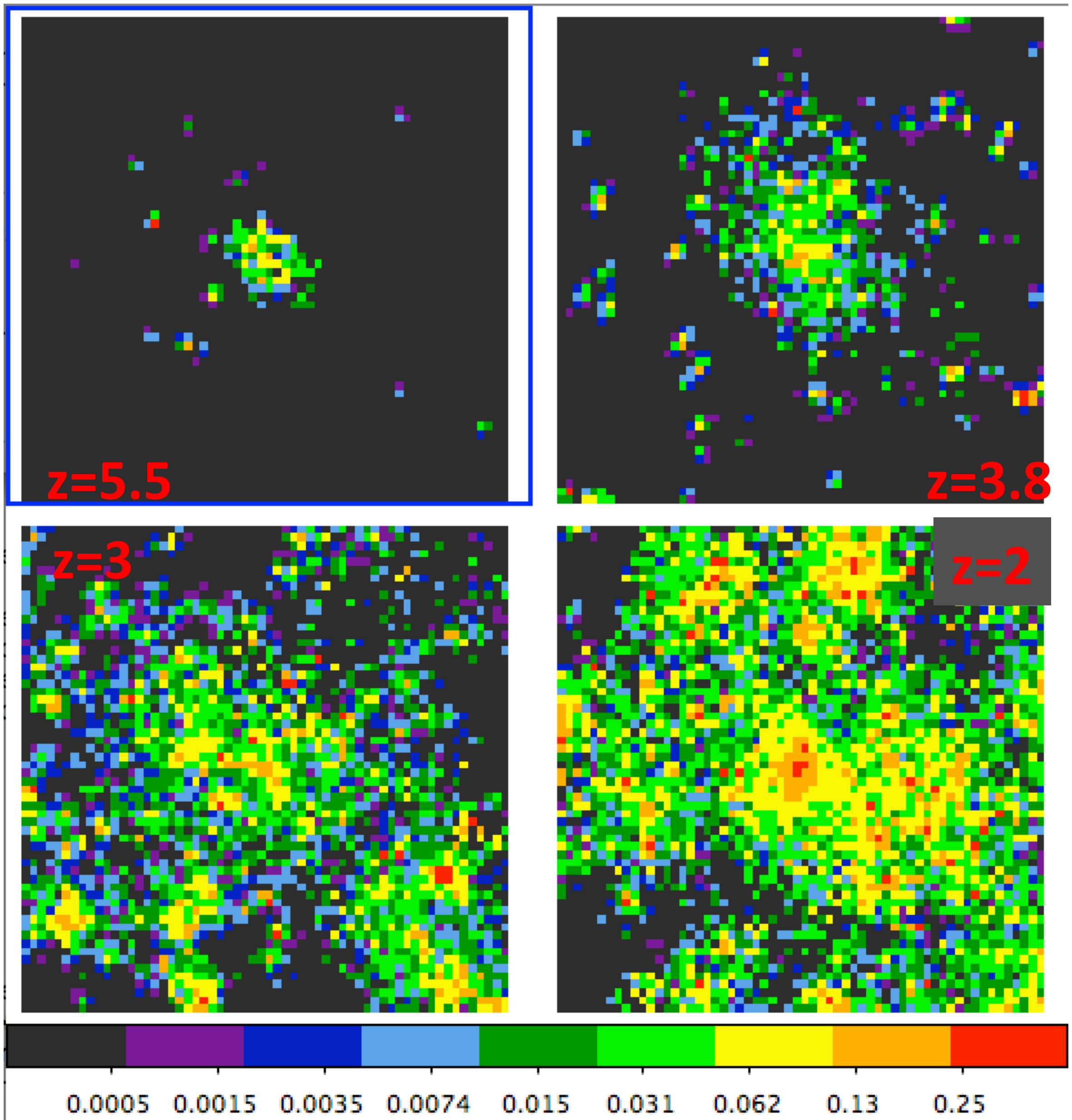
Iron Distribution



Iron Distribution

At larger scales (6 Mpc comoving)

Gas (metals) keep expanding up to z=3-4.
By z=2 the large scale medium is all enriched (also by other sources)



$$\dot{M}_{\rm B} = \frac{4\pi\alpha G^2 M_\bullet^2 \langle\rho\rangle}{(\langle c_{\rm s}\rangle^2 + \langle v\rangle^2)^{3/2}}$$

$$\dot{M}_\bullet = \min(\dot{M}_{\rm B,hot} + \dot{M}_{\rm B,cold}, \dot{M}_{\rm Edd})$$

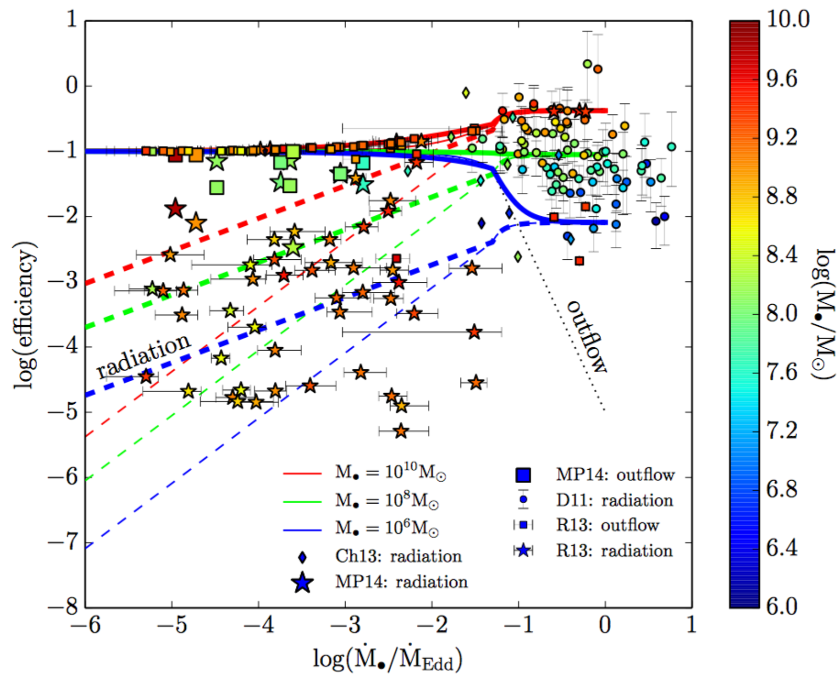
New BH accretion model

$$\dot{M}_{\rm Edd} = \frac{4\pi G M_\bullet m_{\rm p}}{\eta_{\rm Edd}\sigma_{\rm T} c}$$

It is the cold mode that drives BH accretion/ AGN feedback ("cold chaotic accretion" driven by thermal instabilities, Gaspari et al. 2013)

New AGN Feedback model

Separated radiation and outflow efficiencies



Steinborn et al. 2015

Summary

CC/NCC clusters are naturally formed in cosmological hydro-dynamical simulations with realistic thermo- and chemo-dynamical properties.

No significant evolution on the ICM quantities from $z=0$ to $z=1$ -> suitable redshift range to do cosmology by using ICM

Flatness of the Iron profile mostly due to the accretion of previously enriched material expelled by the AGN at $z>2-3$