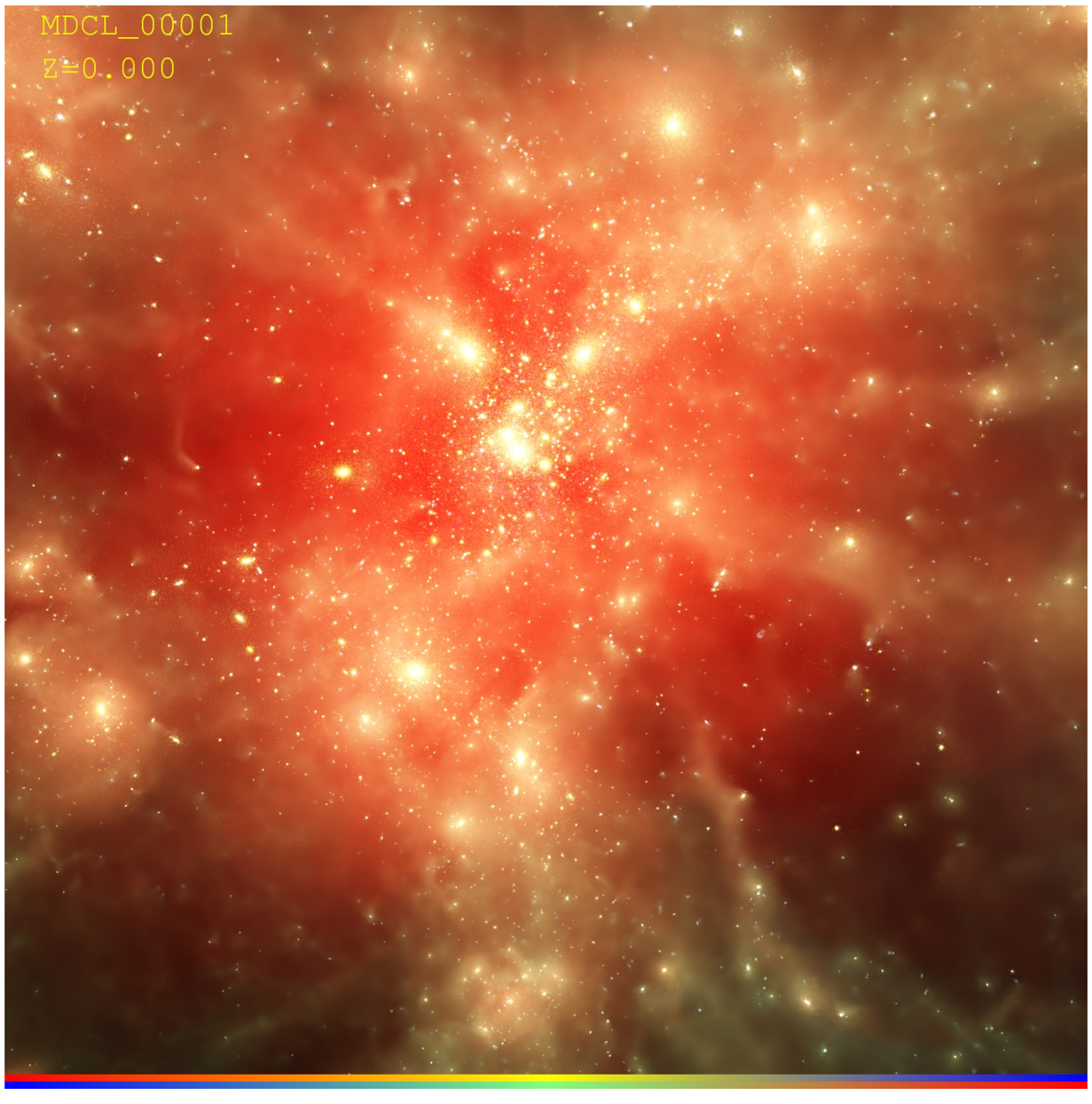
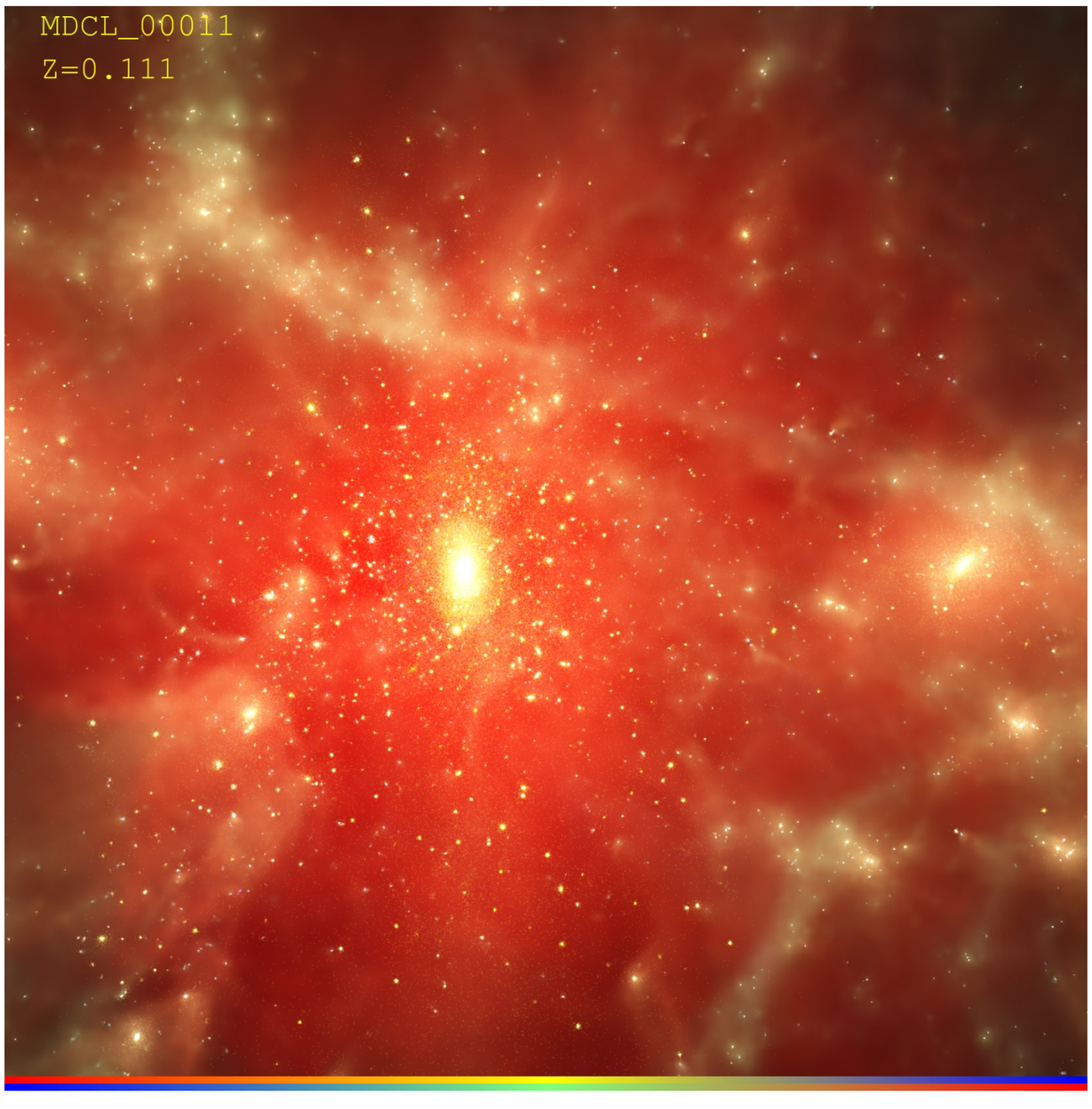
The impact of complex baryonic processes on simulated galaxy clusters



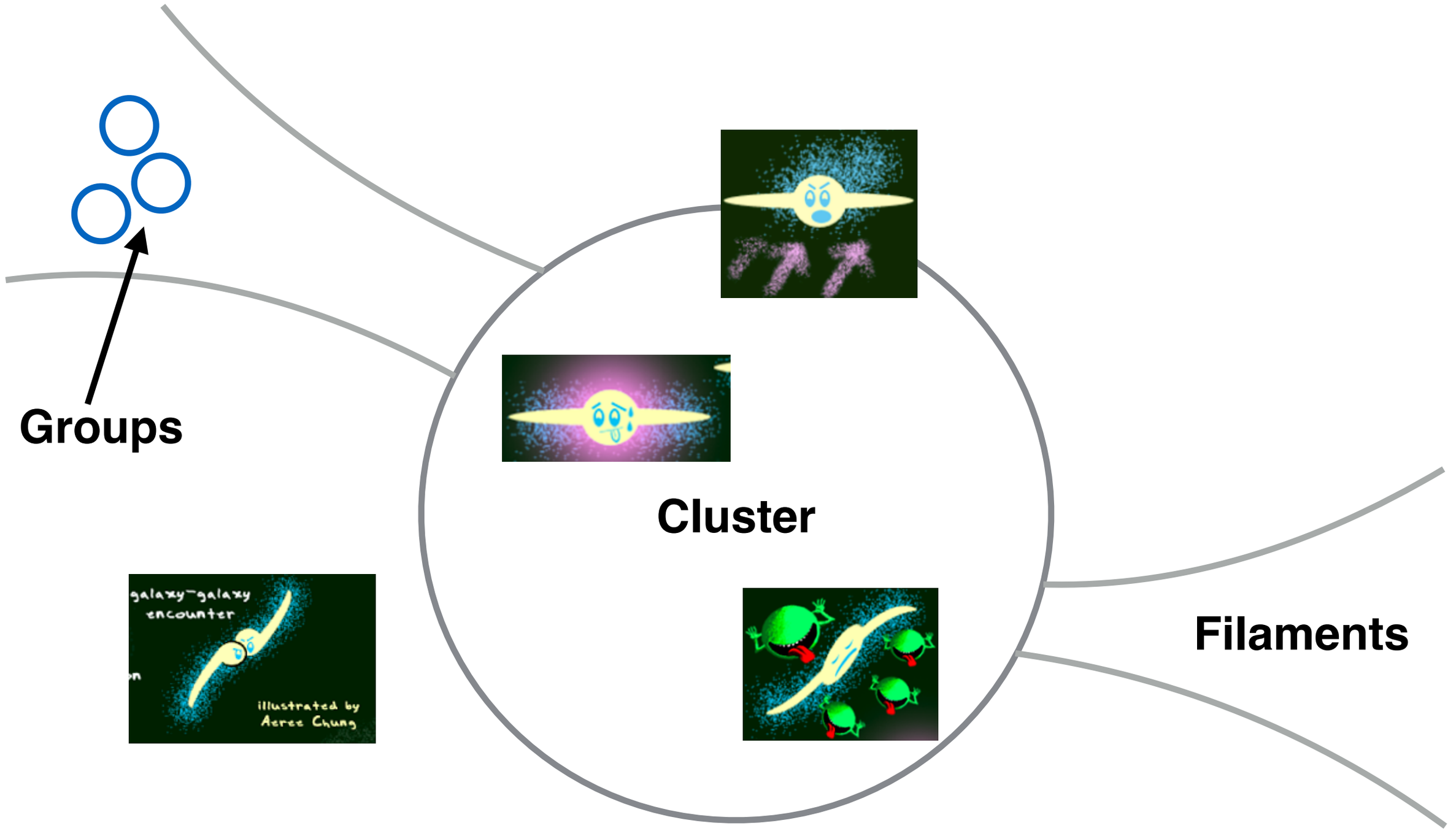


Jake Arthur, Frazer Pearce, Meghan Gray & nIFTy collaboration

Overview

- **Galaxy evolution** in clusters and need for **simulations**.
- The problems with galaxy cluster simulations.
- **nIFTy cluster comparison** most recent work.
- Future prospects: **TheThreeHundred** project
- Conclusions

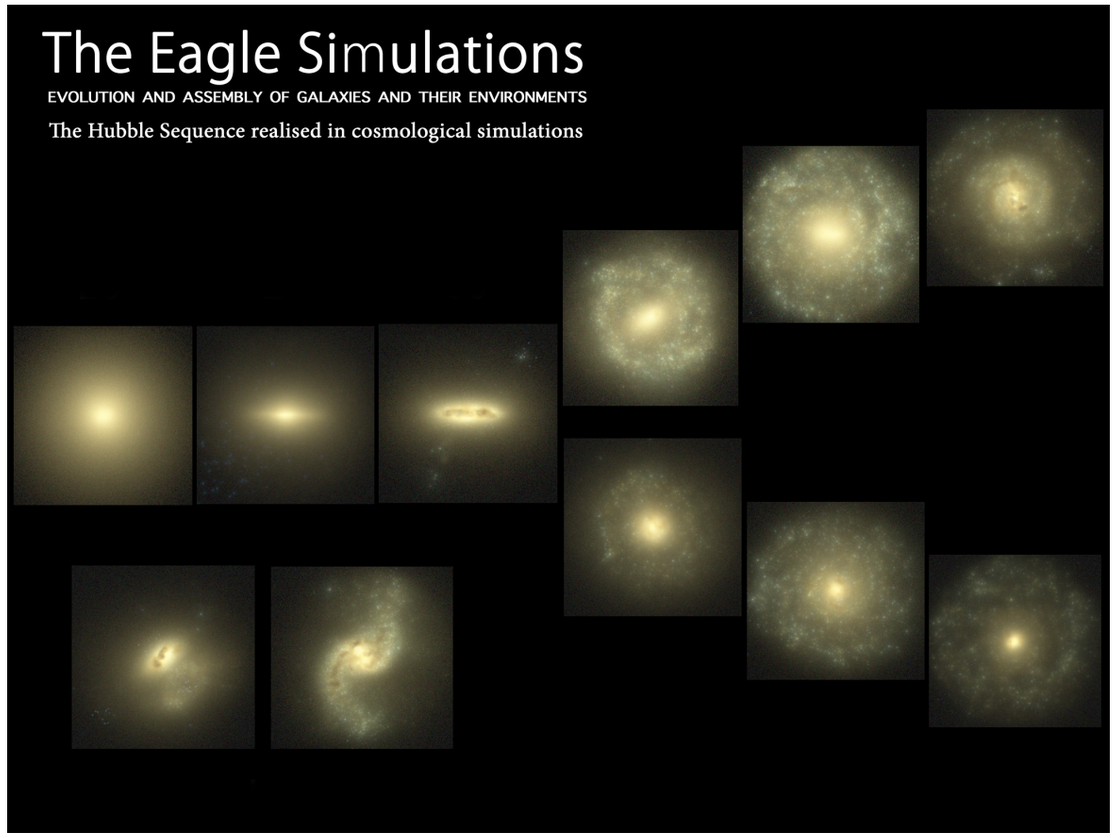
Galaxy evolution in clusters



Modelling messy baryonic processes

Need to model **cooling** and **feedback** with **subgrid** physics

Specifically: Gas cooling/heating, Star formation, Stellar feedback, BH growth, AGN feedback



EAGLE - Schaye (2015)

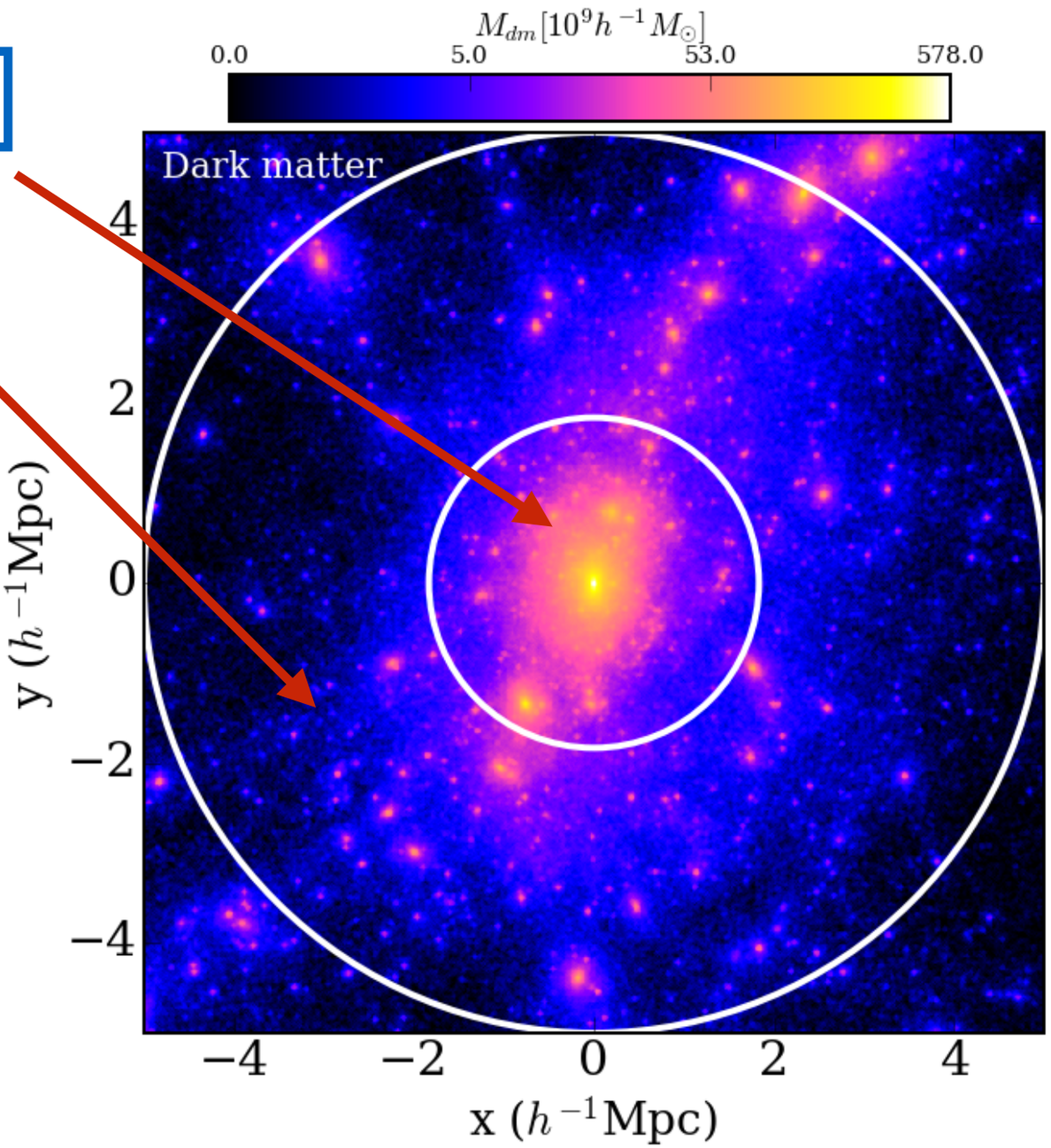
ILLUSTRIS - Genel (2014)

nIFTy cluster comparison

10 state-of-the-art codes simulate cluster from same initial conditions.

Centre

Infall

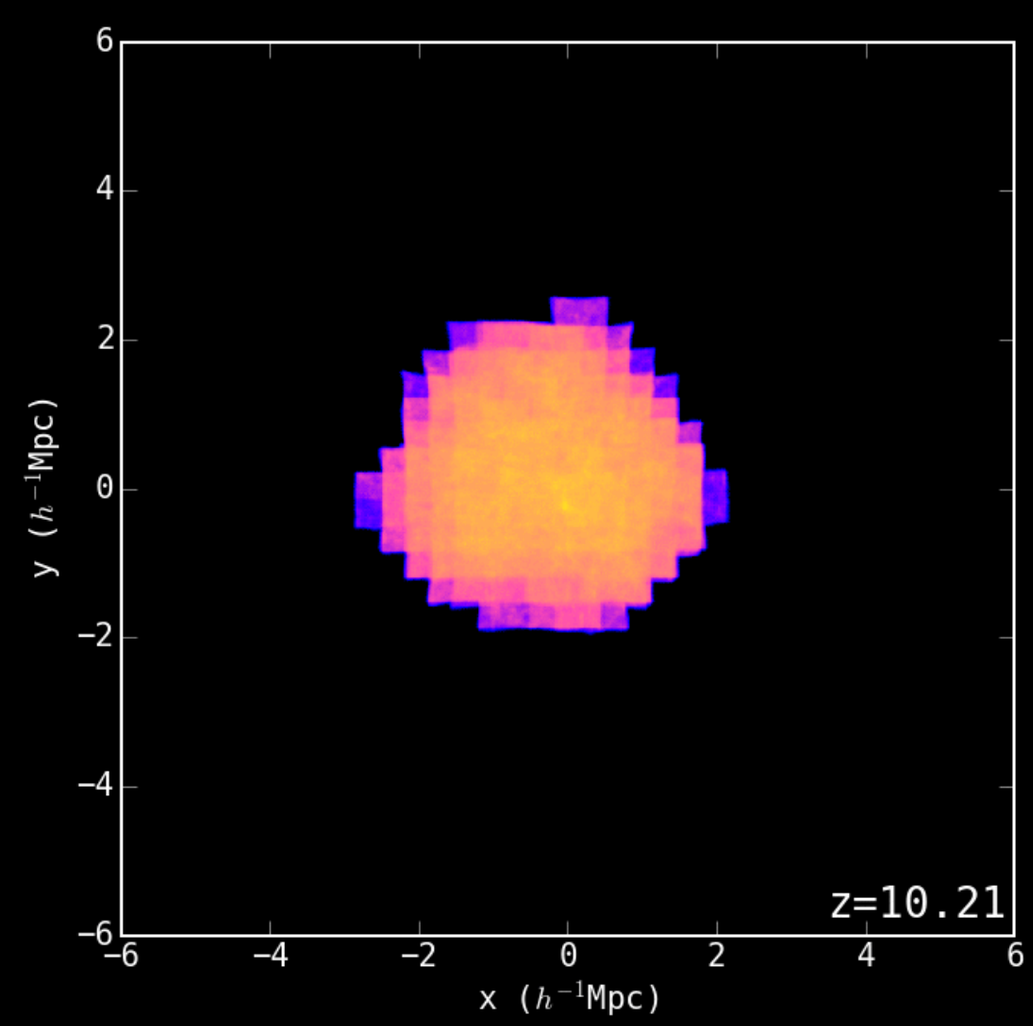


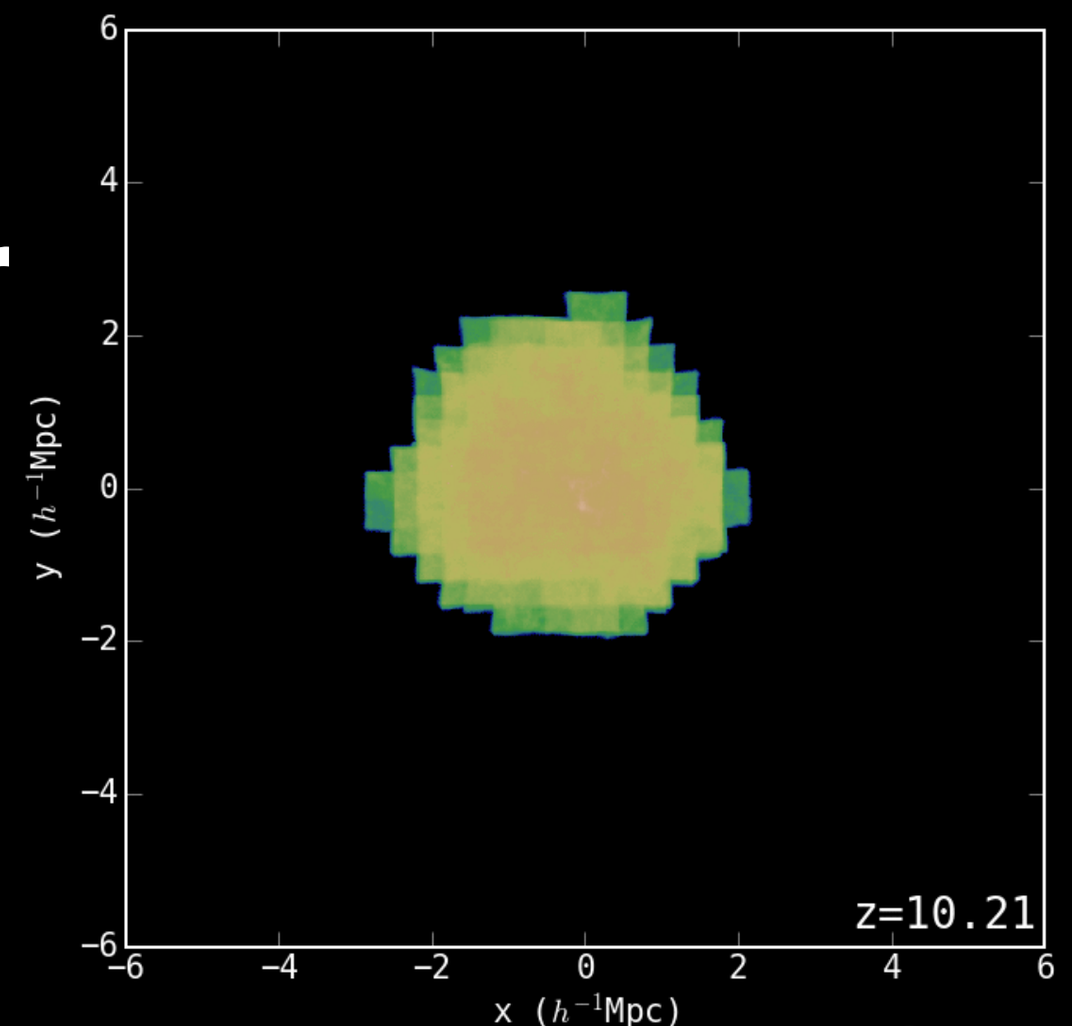
Code	Number of subhaloes			
	DM	NR	FP	Galaxies
G3-MUSIC	378	303	**428**	325
G3-MUSICPI	"	"	**435**	324
RAMSES	290	**174**	182	16
AREPO	360	**243**	294	76
AREPO-SH	"	"	**341**	220
G3-X-ART	381	356	388	262
G3-OWLS	383	327	**440**	307
G3-PESPH	371	328	**425**	273
G2-X	399	**294**	319	186
G3-MAGNETICUM	380	341	330	176

Elahi, et al. (2016)

Elahi (2016) shows large code-to-code scatter in galaxy populations **inside virial radius** of main cluster halo at **z=0**.

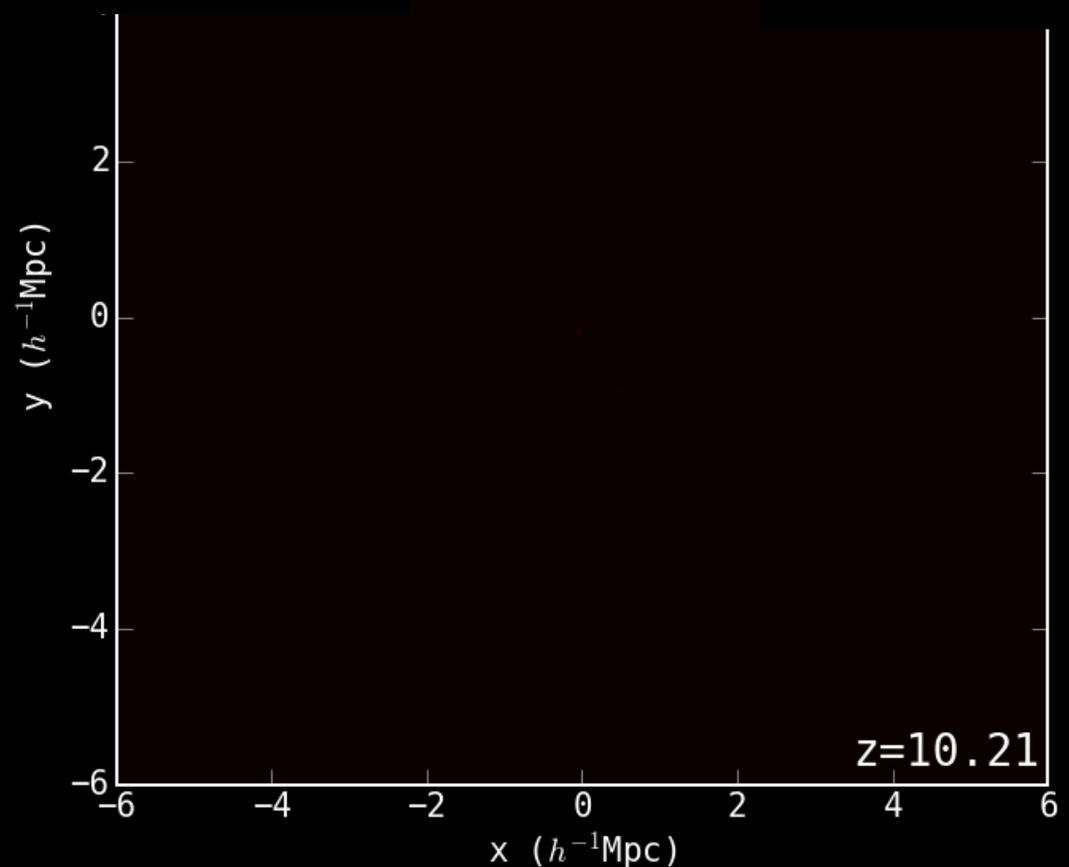
nIFTy cluster





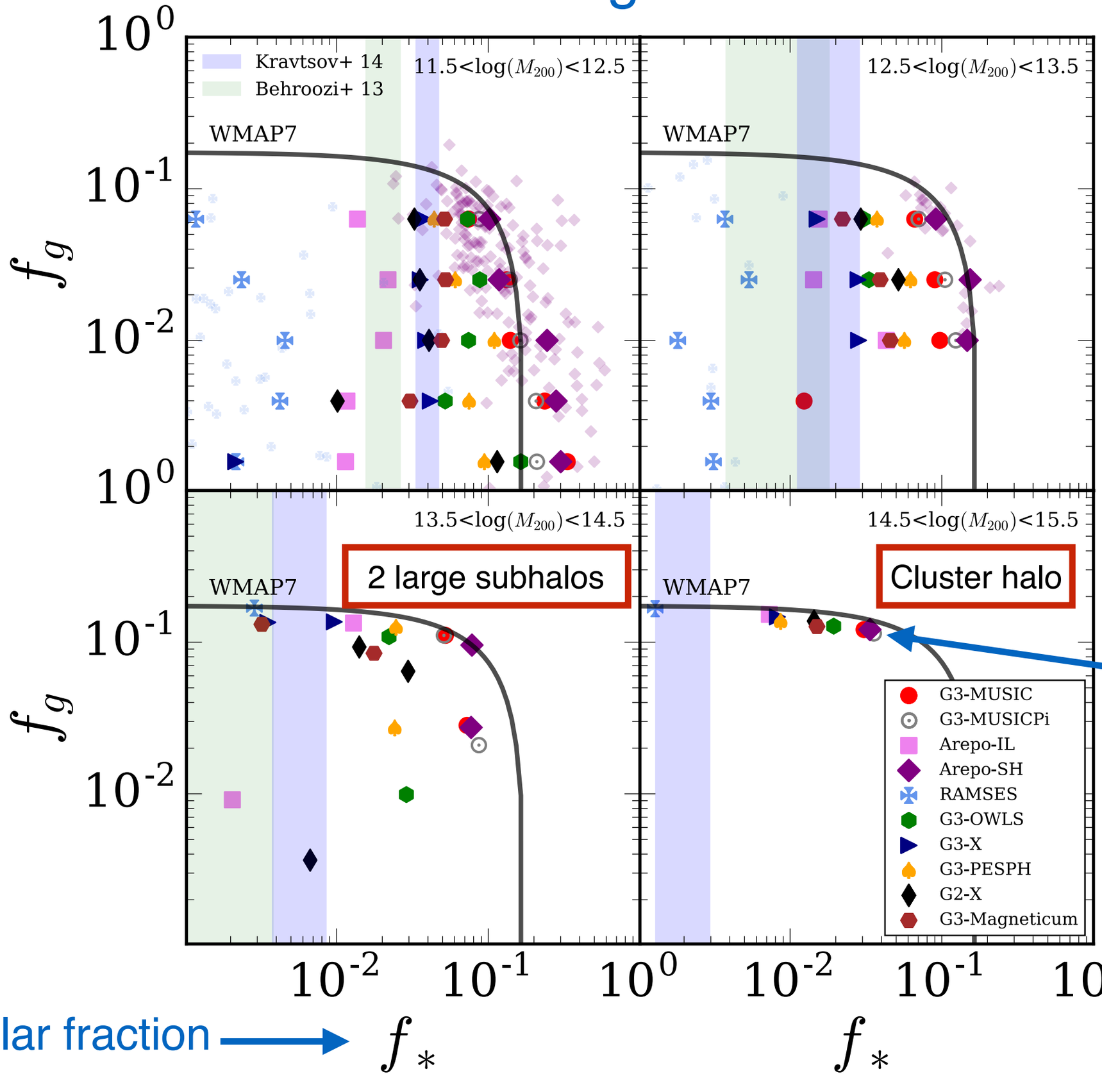
Dark matter

Gas



Galaxies

Codes cannot reproduce stellar fractions from halo abundance matching across all halo masses



Gas fraction

Stellar fraction

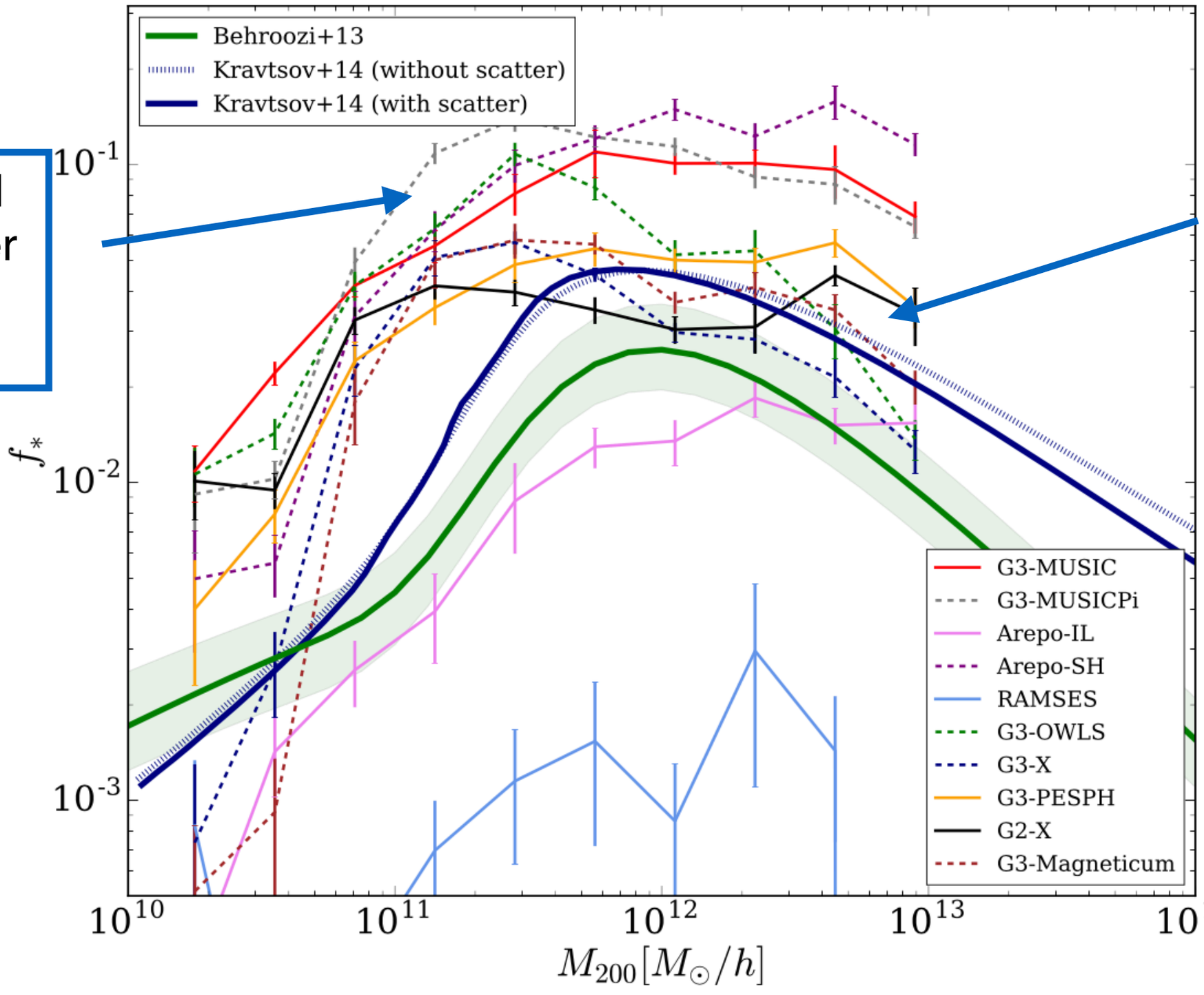
Code ordering in stellar fraction is preserved at all halo mass

Codes overcool in main halo compared to observations.

Arthur, et al. (2017)

Still large code-to-code scatter in stellar fraction between halos in infall region

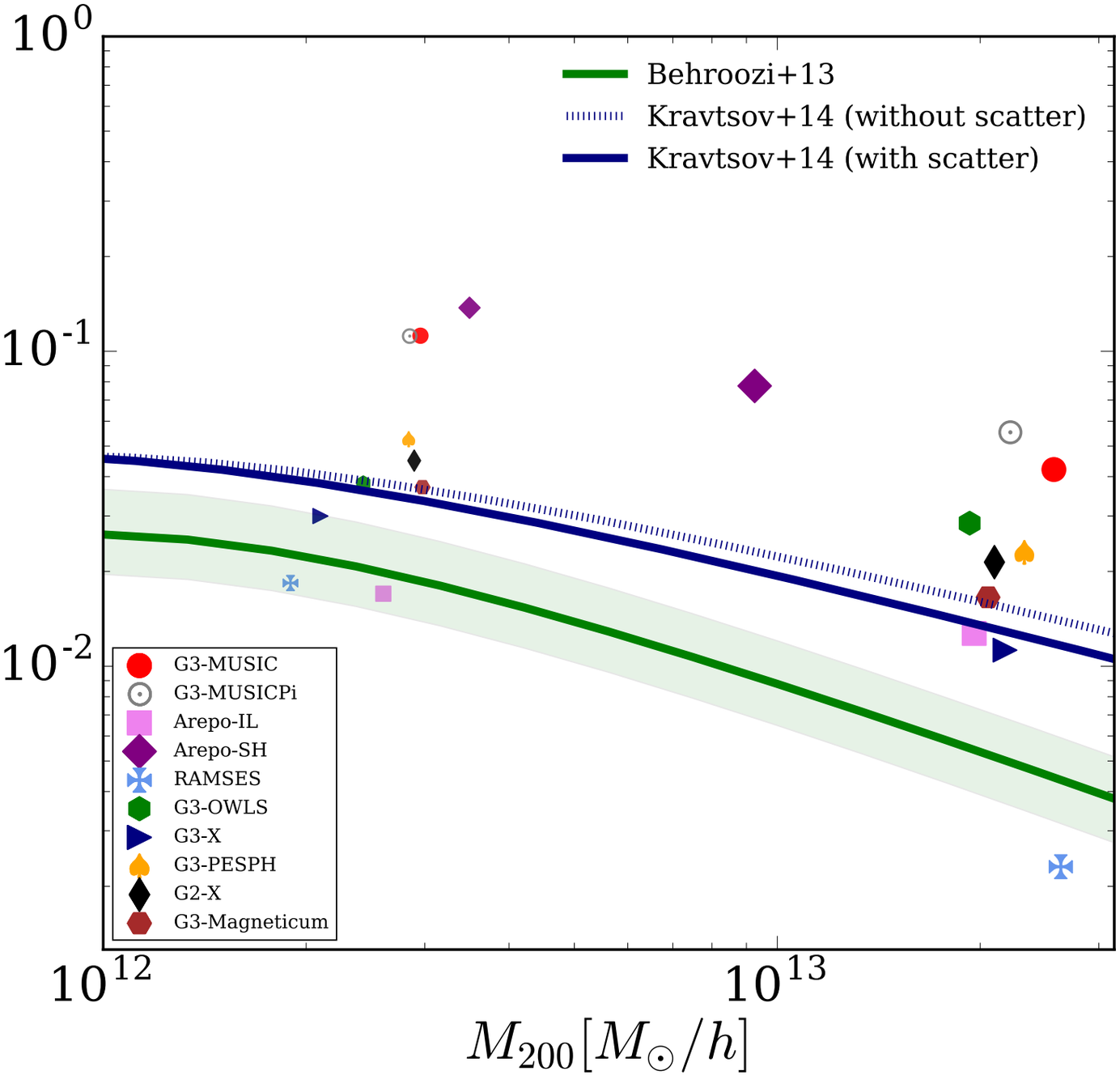
Non-AGN codes over produce stars

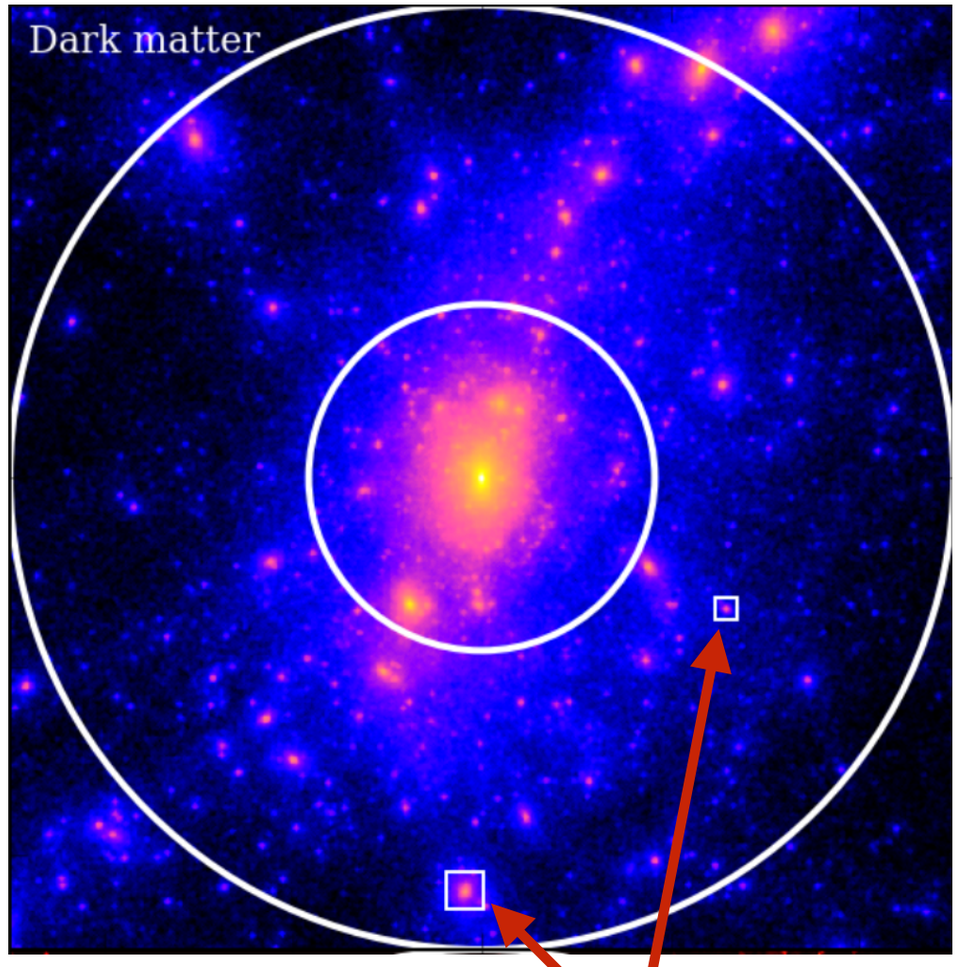


Some codes come close to observations between M_{200} ~ 10^{12} - 10^{13}

Arthur, et al. (2017)

Code-to-code scatter due to subgrid physics



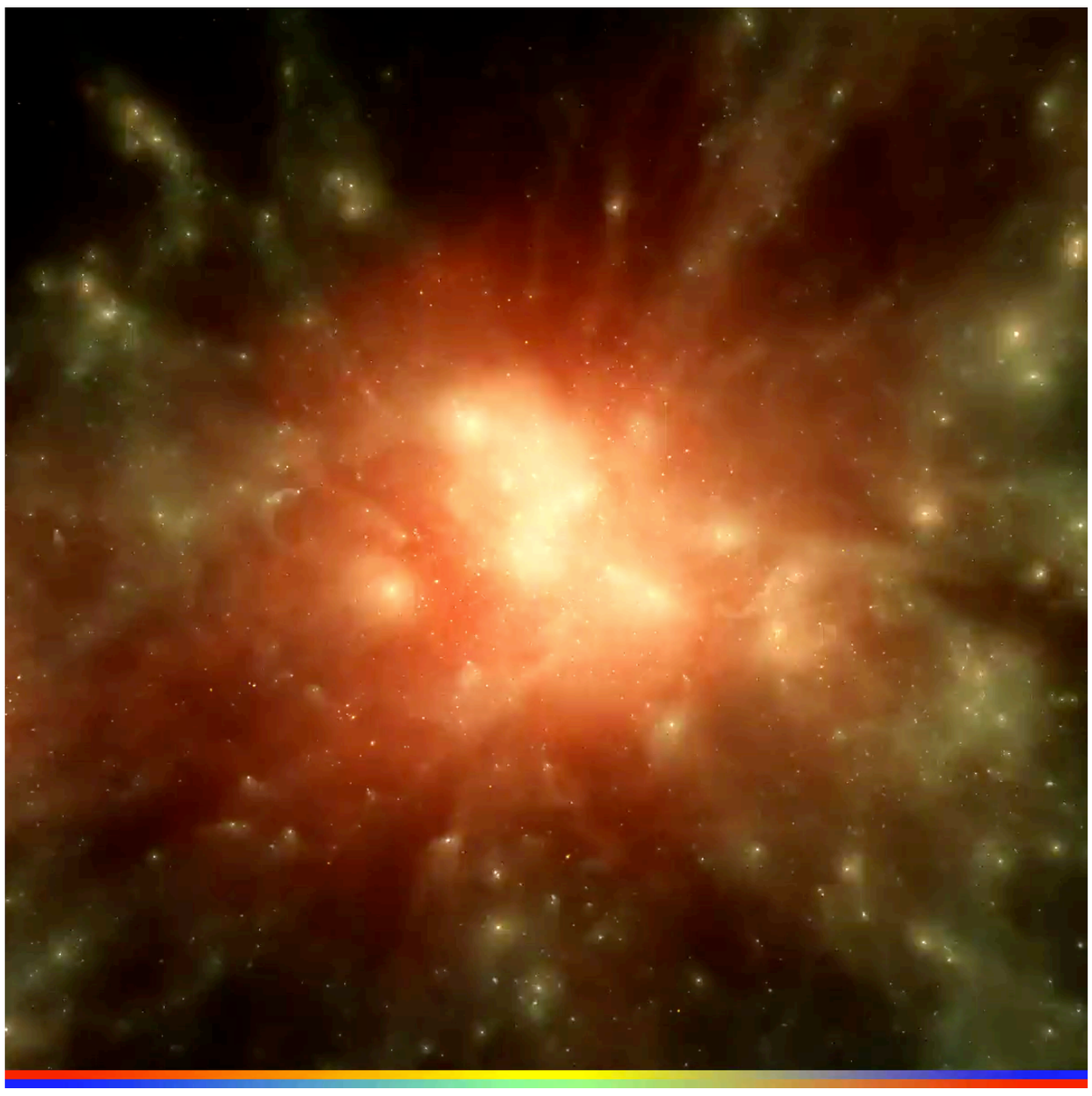


Isolated haloes in infall region

Arthur, et al. (2017)

What next for nIFTy?

The ThreeHundred Project



Courtesy: Gustavo Yepes

Data:

- 300 resimulated clusters.
- z ~ 17 -> 0, in 129 snapshots

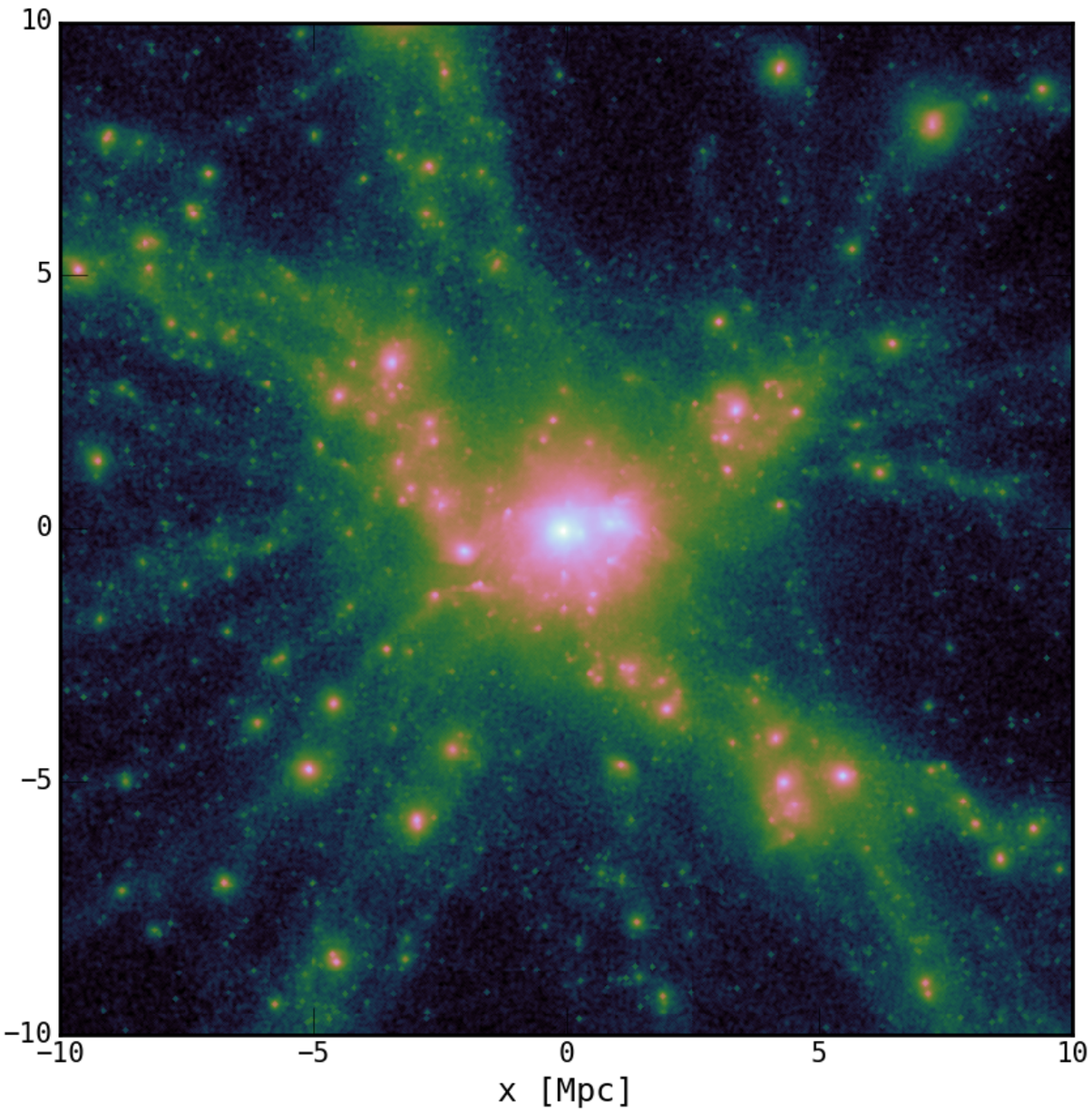
Projects:

- Preprocessing
- Close-pairs
- Gravitational lensing
- Dynamical substructure
- Many more!

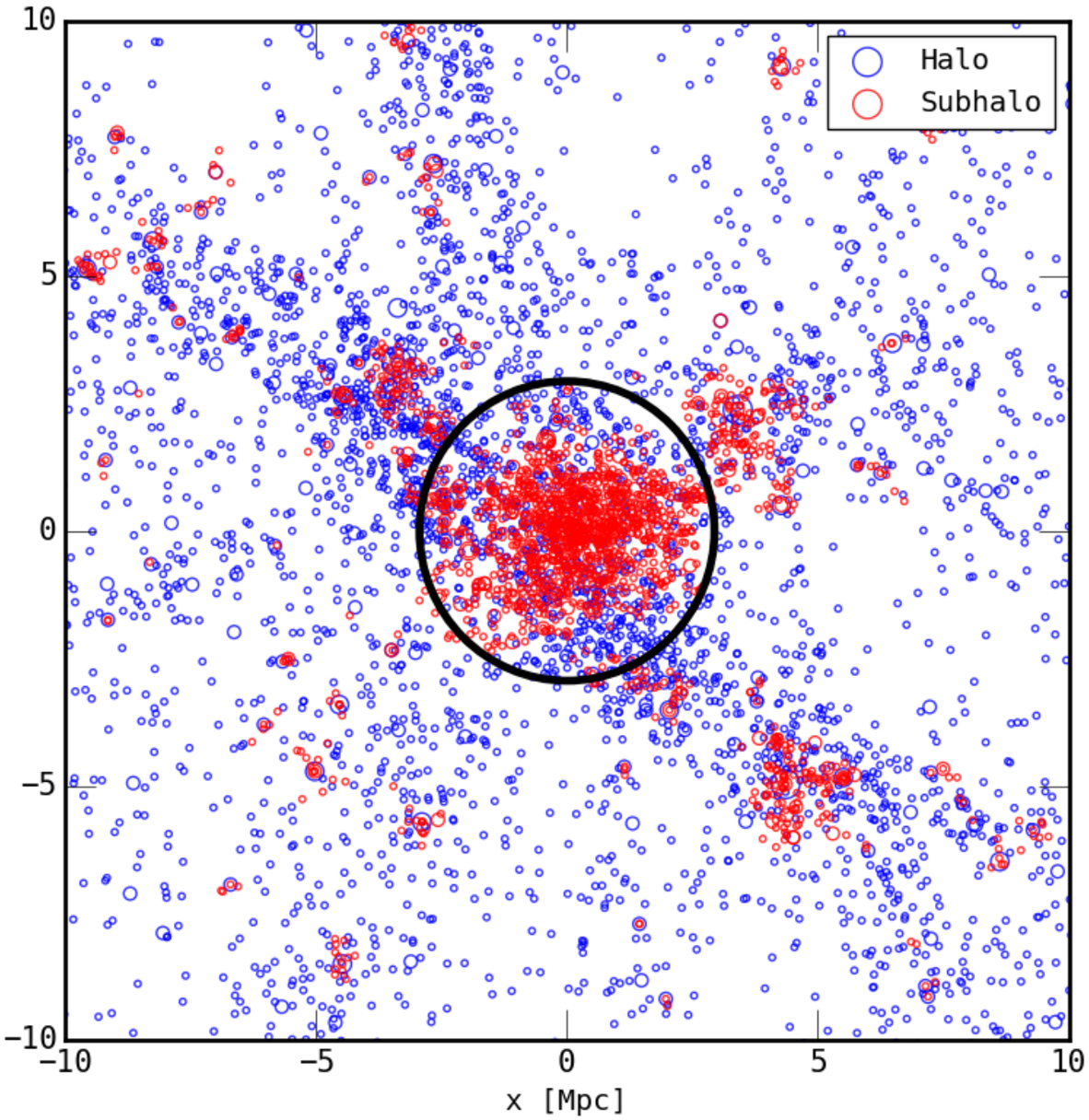
Preprocessing & defining environment

z=0

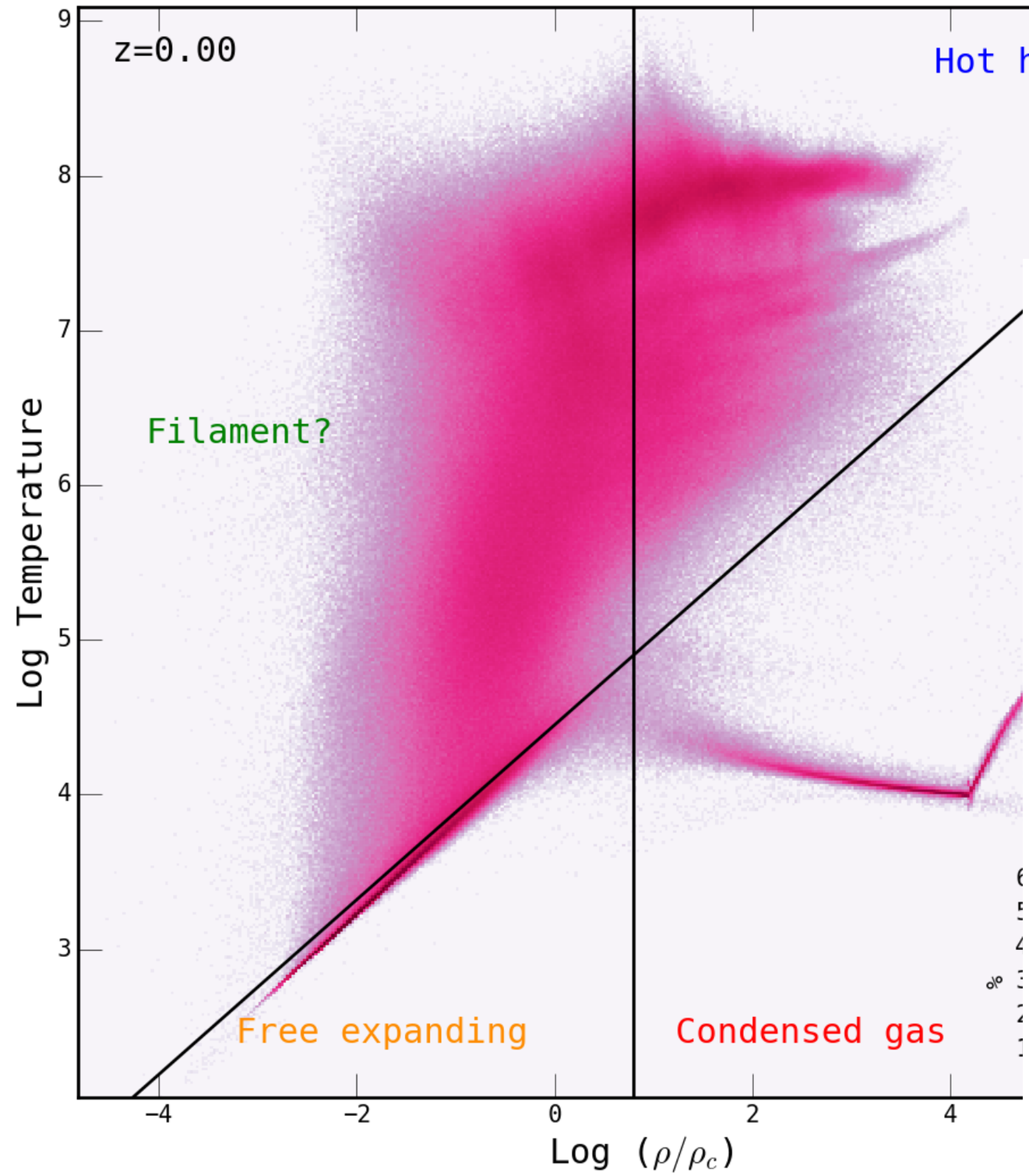
Gas particles

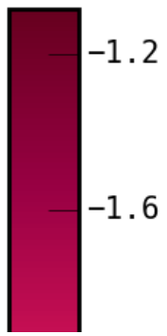


Halo catalogues

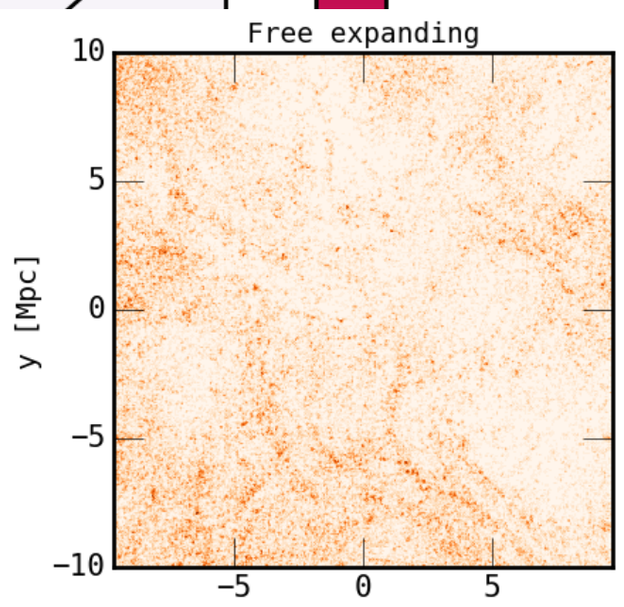


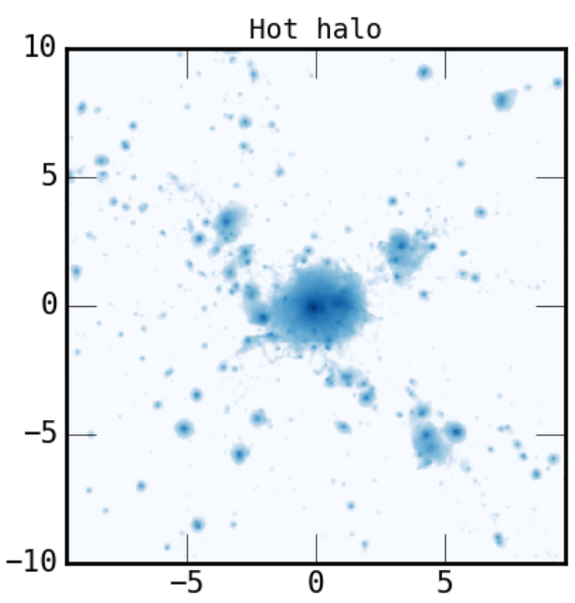
Finding gas environments with gas temperature and density

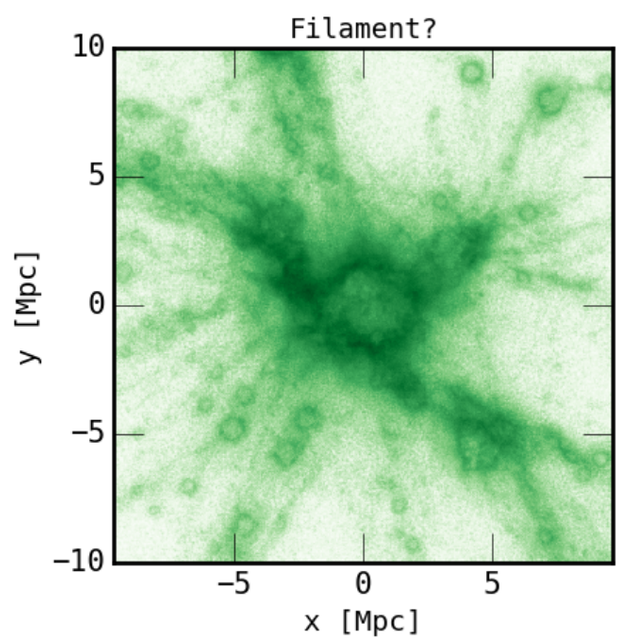


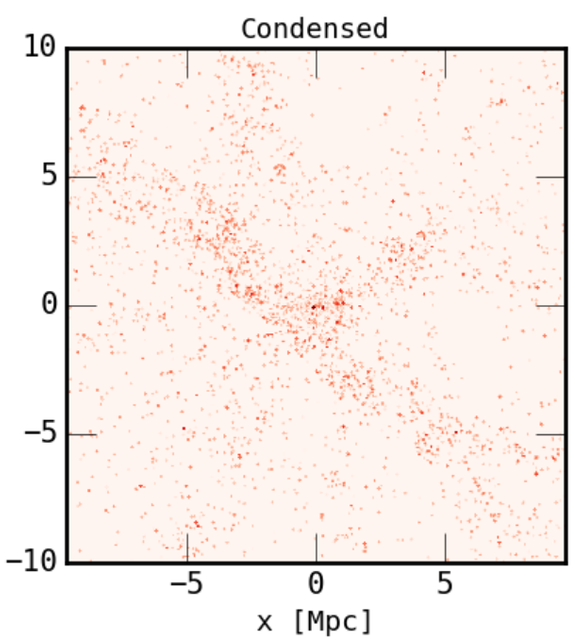


gas

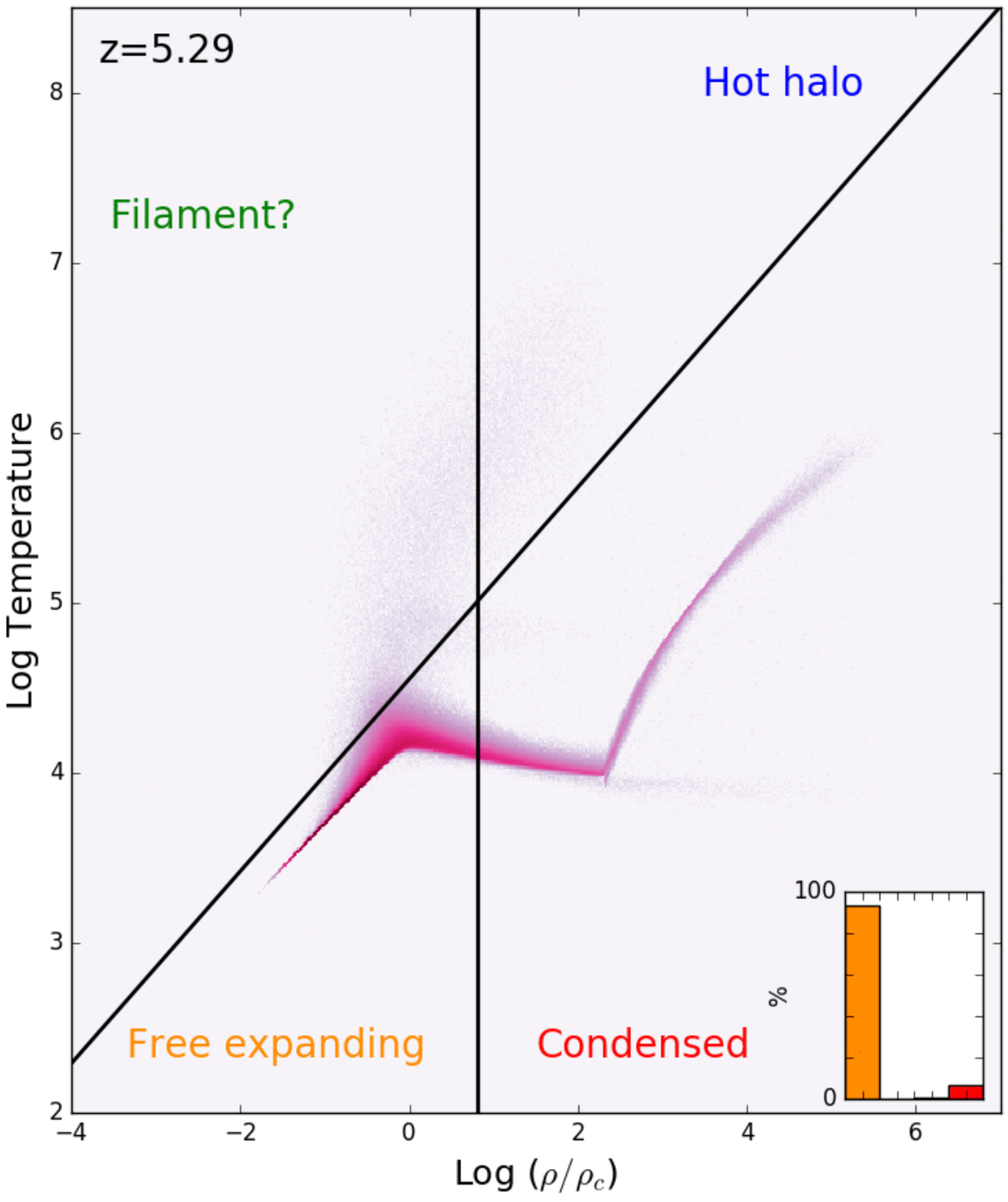


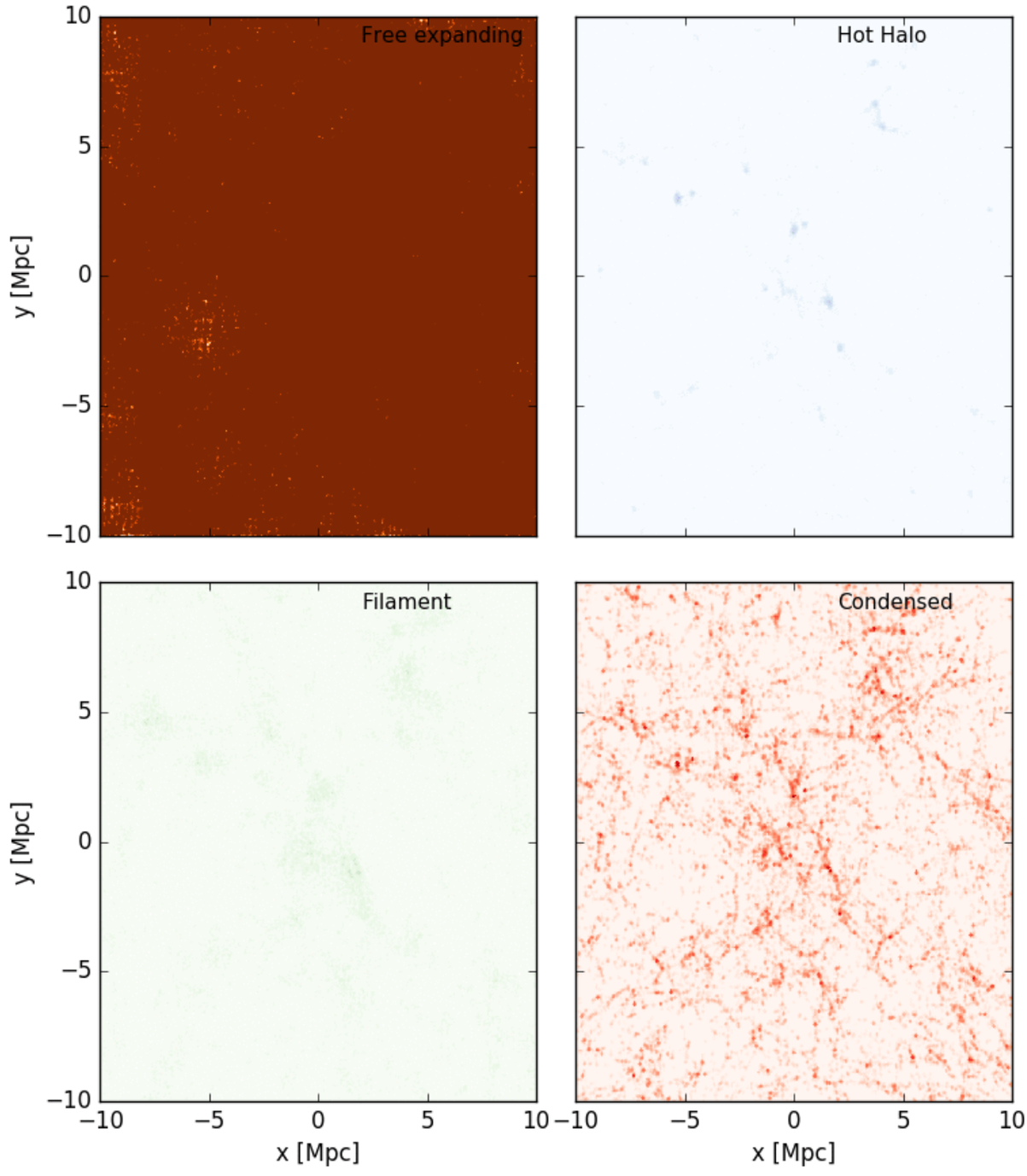






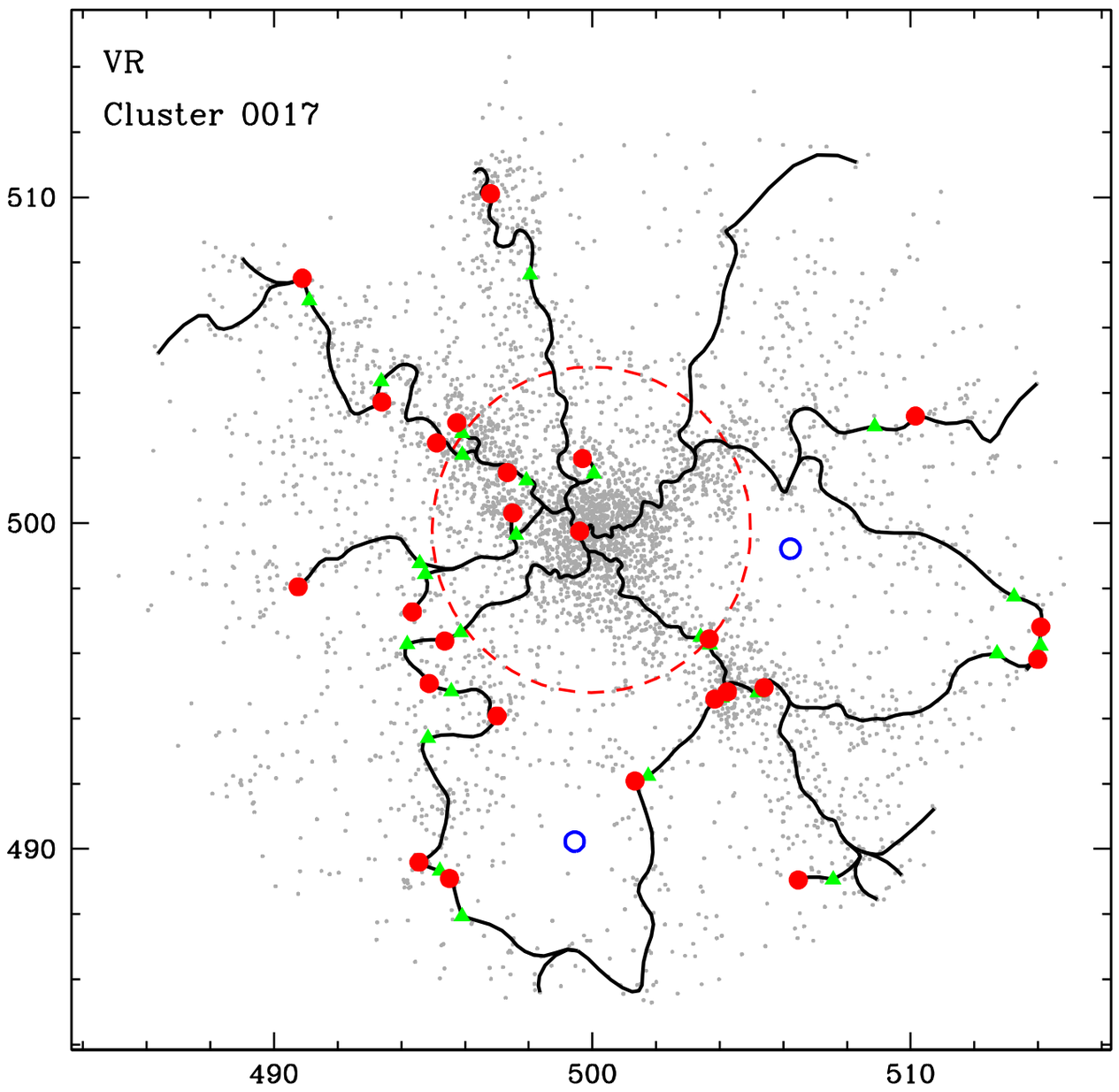
Cluster gas and environment evolution

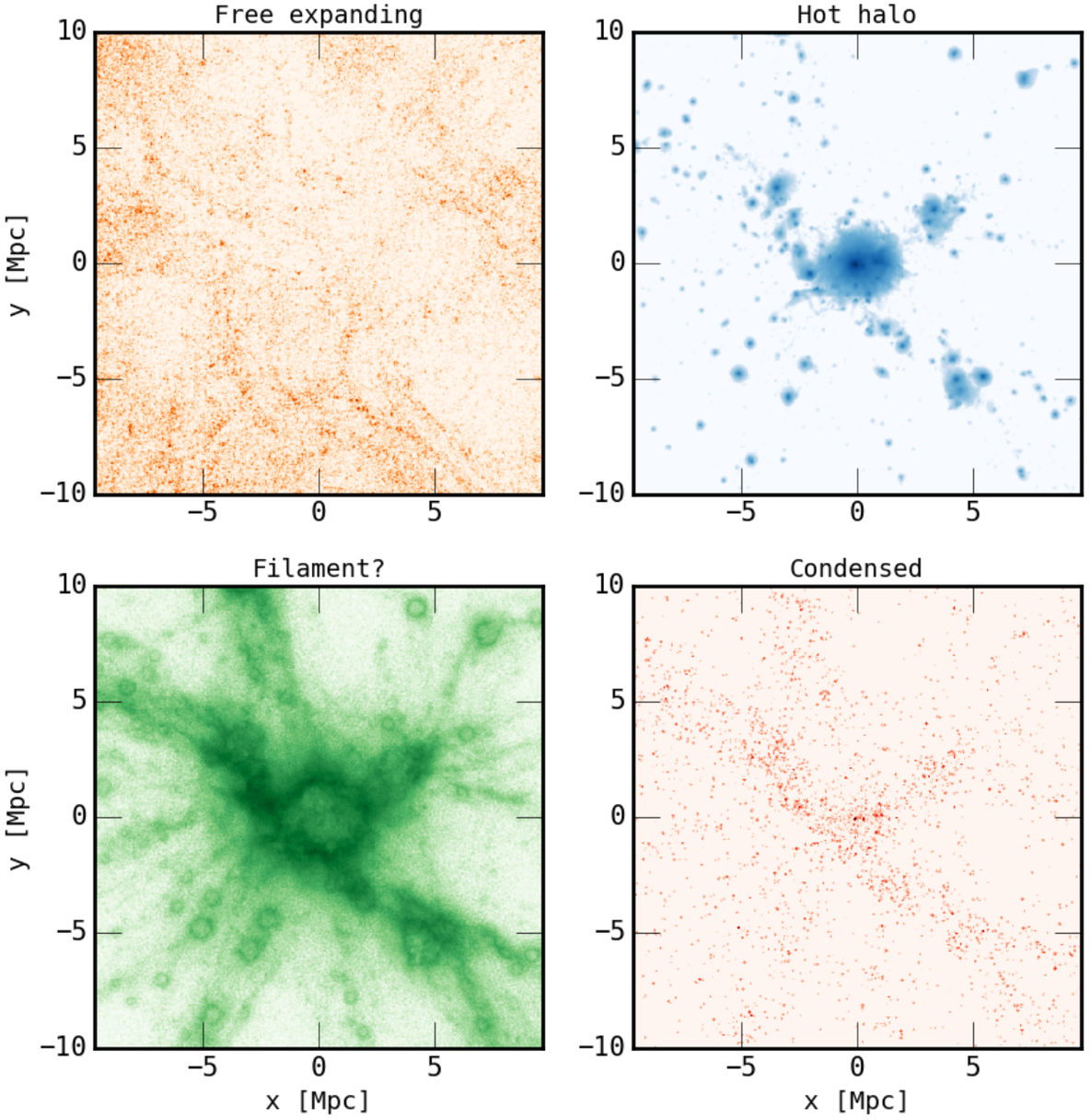




Refining filament finding technique with DisPerSE

- **DisPerSE** (Sousbie 2011,2013) is a topology structure finder in 2D & 3D. Uses critical points and integral lines to find filaments.





Courtesy: Meghan Gray, Charlotte Welker

Conclusions

- Simulations are useful for studying galaxy evolution in clusters, but some of their **results need to be checked** before use.

- nIFTy cluster comparison results:

    1. **Large code-to-code scatter** between codes in **stellar fraction** at all halo masses in both centre and infall.

    2. Codes **do not match trends** from halo abundance matching methods.

    3. Choices and calibration of **sub grid physics to blame**.

- Future prospects:

    1. The **ThreeHundred project**

    2. My interests - **preprocessing and environment** surrounding these clusters