# Mocking Astrophysics

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Core Team:

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## Mocking Astrophysics Aims

- Started in 2010.
- The ultimate plan is to provide testing and validation of mock skies.
- The production of a large mock-sky suitable for modern surveys.
- Understood and control the various steps required.
- Aim to complete a full end-to-end pipeline by the end of 2016.

## Areas of Concern

- Cosmological initial conditions generators
- Production simulation codes
- Post processing
  - Halo & subhalo finding
  - Merger tree building
- Generating mock galaxy catalogues
  - Semi-analytic models
  - Halo occupation distribution models
  - Full physics hydrodynamical models
- Lightcone generation
- Mock observing

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## Past Workshops

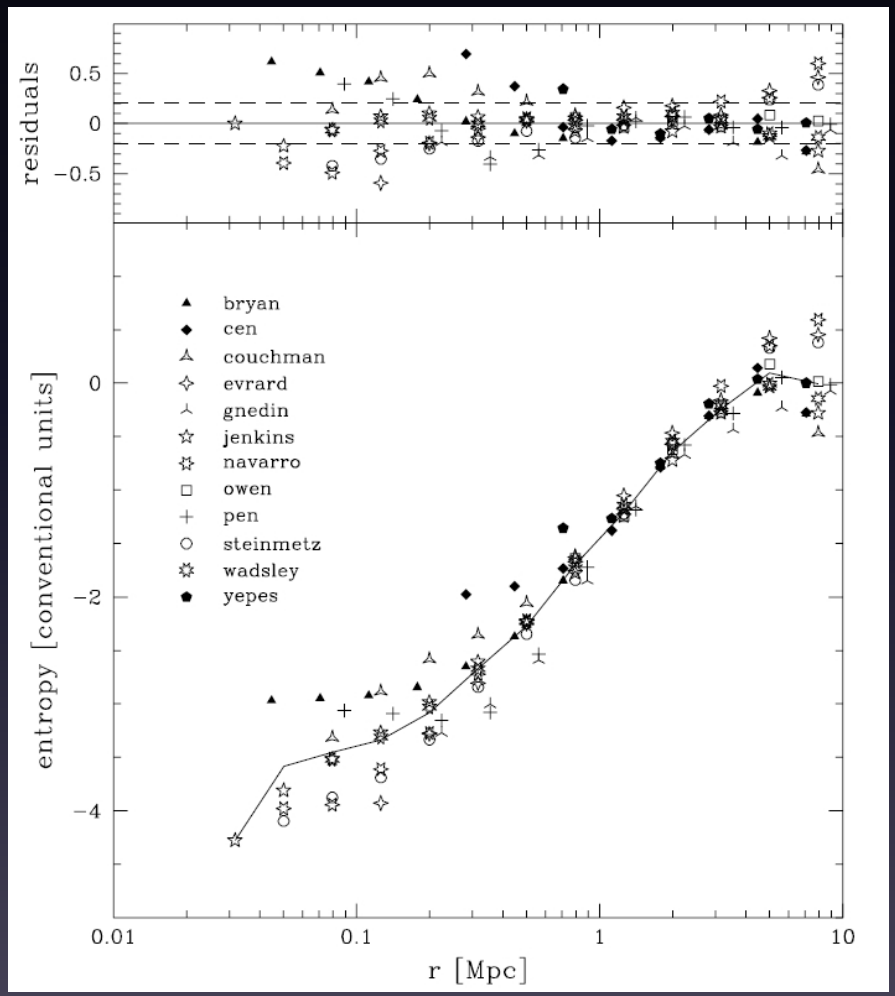
- Haloes Going MAD (2010)
- SubHaloes Going Notts (2012)
- Sussing Merger Trees (2013)
- Halo Mass Recovery Comparison (2013)
- nIFTy Cosmology (2014)
  - nIFTy Clusters
  - nIFTy Galaxies
  - nIFTy Observations
- Perth Clusters (2015)
- Cosmic CARNage (2015)

## Future Workshops

- Yonsei SAM (Seoul, July 2016)
- Comparison Cape Town (Cape Town, July 2016)
- nIFTy Lightcones (Madrid, August 2016)

# nIFTy Cluster Comparison

- 16 years on from the Santa Barbara Cluster Comparison (Frenk et al. 1999)

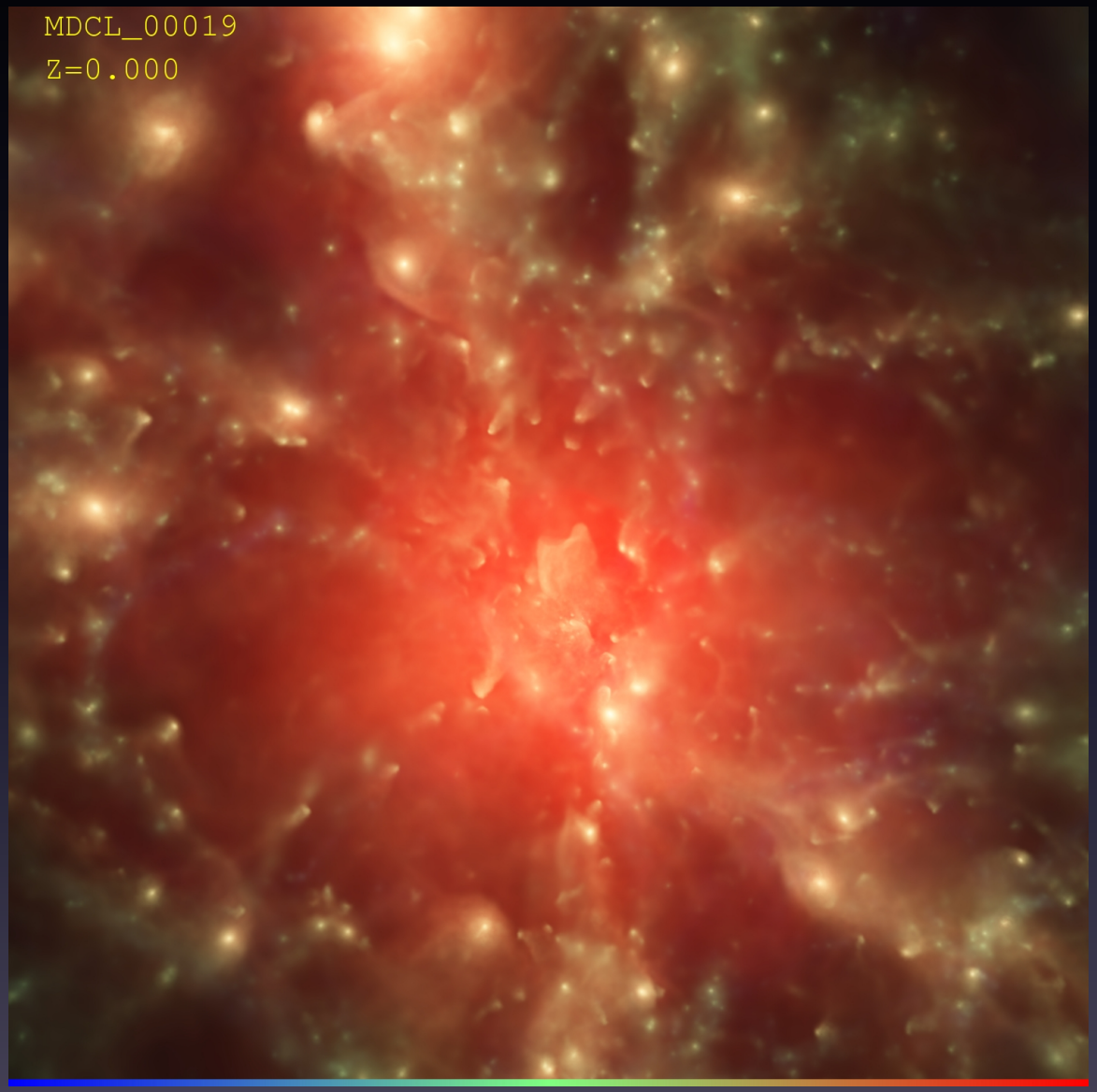



Frenk et al. 1999

## nIFTy Cluster Comparison

- 10 Different Hydrodynamical codes
  - including RAMSES, 2 incarnations of AREPO and 7 of GADGET
- 3 Runs:
  - Dark Matter Only
  - Non-Radiative
  - Full Physics

# nIFTy Cluster Comparison




MUSIC Database

## nIFTy Cluster

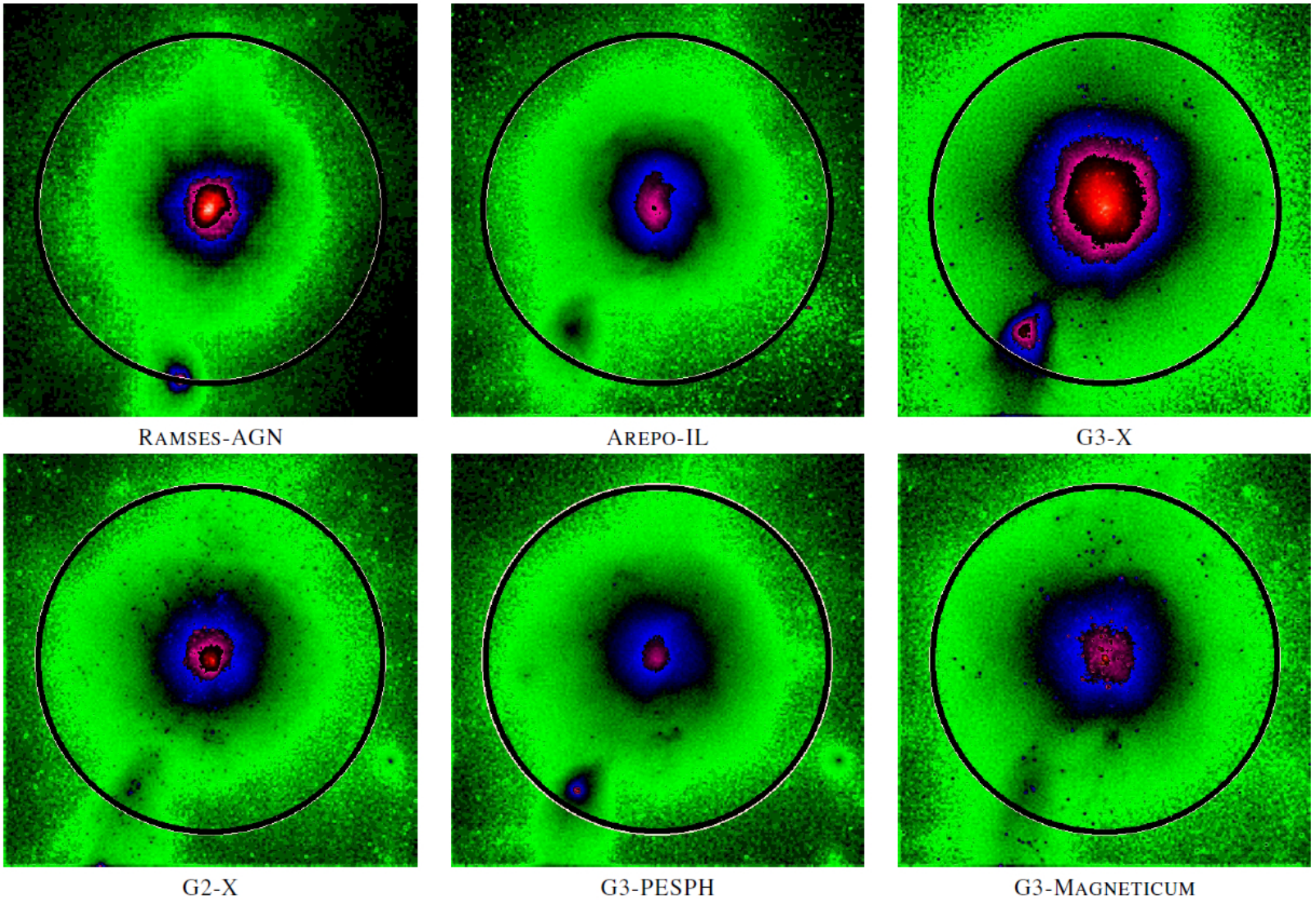
- $M_{200} \simeq 1.1 \times 10^{15} h^{-1} M_{\odot}$
- $R_{200} \simeq 1.69$ Mpc at $z$ = 0
- Selected from the MUSIC-2 Sample (Sembolini et al. 2013)
- Zoomed simulation:
  - $m_{DM} = 9.01 \times 10^{8} h^{-1} M_{\odot}$
  - $m_{gas} = 1.9 \times 10^{8} h^{-1} M_{\odot}$

## nIFTy Cluster

Various Projects:

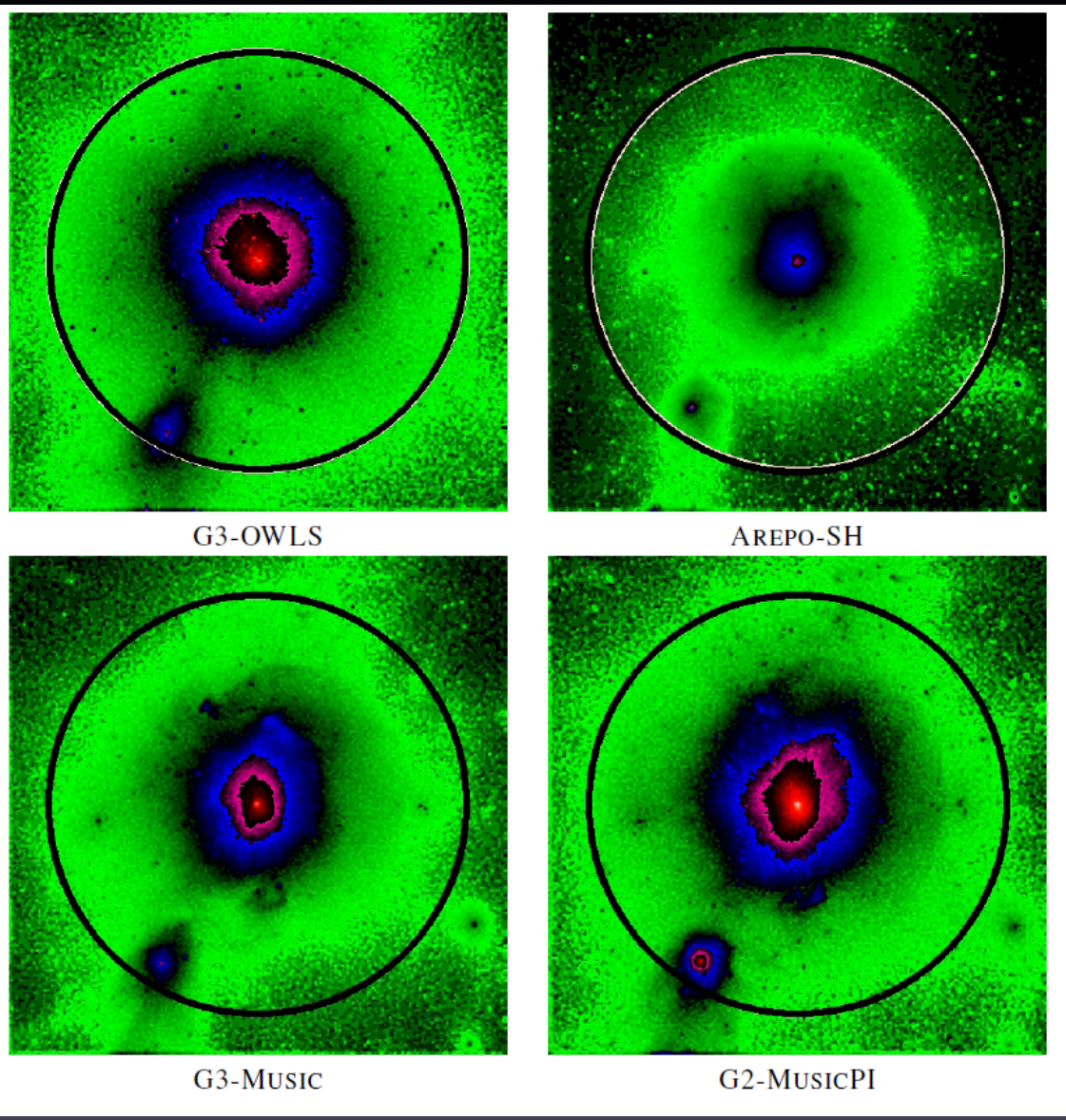
- Dark Matter and Non-radiative comparison
- Baryonic Effects
- Substructure

# Gas Density



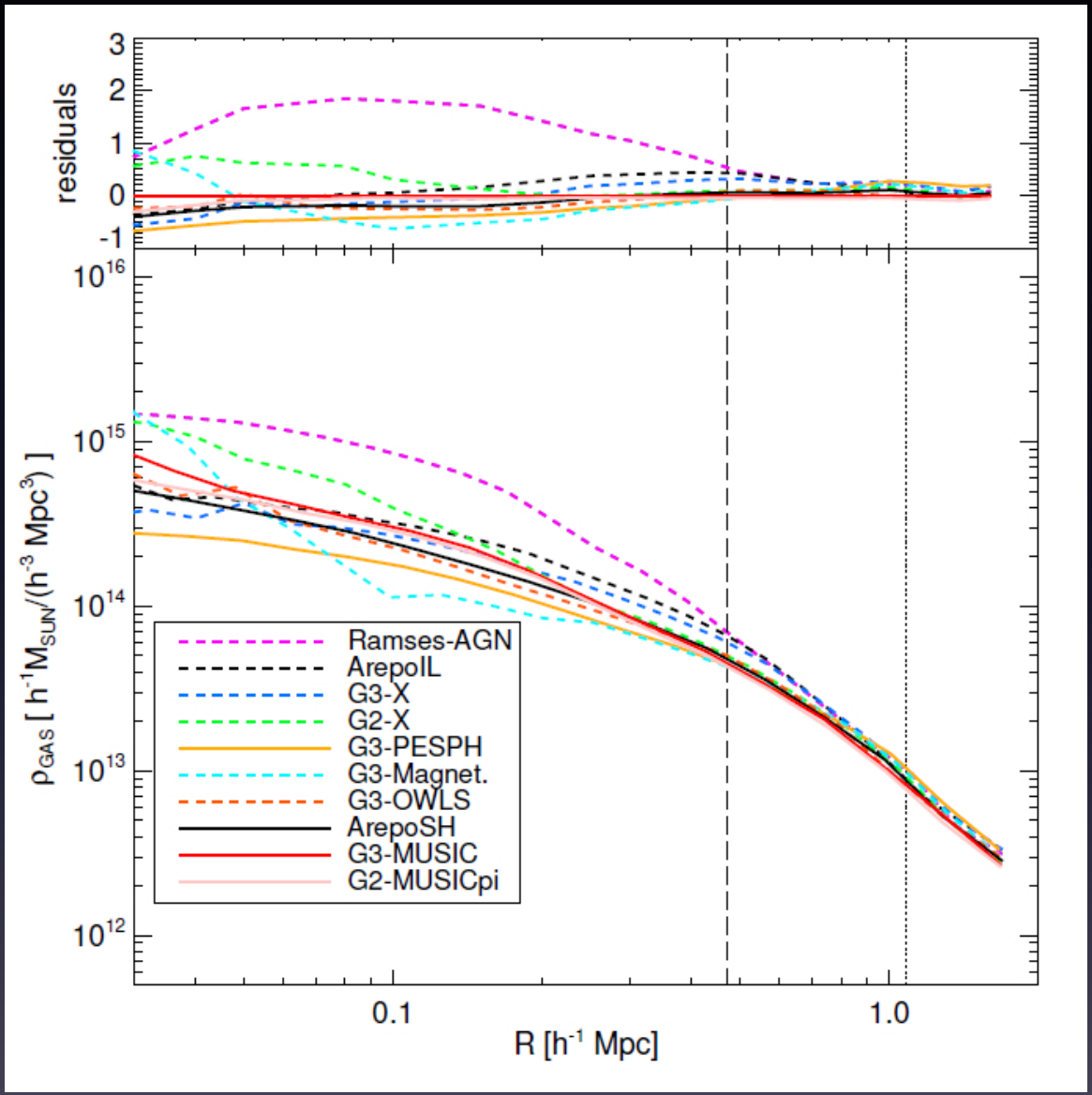

Sembolini et al. 2015

# Gas Density



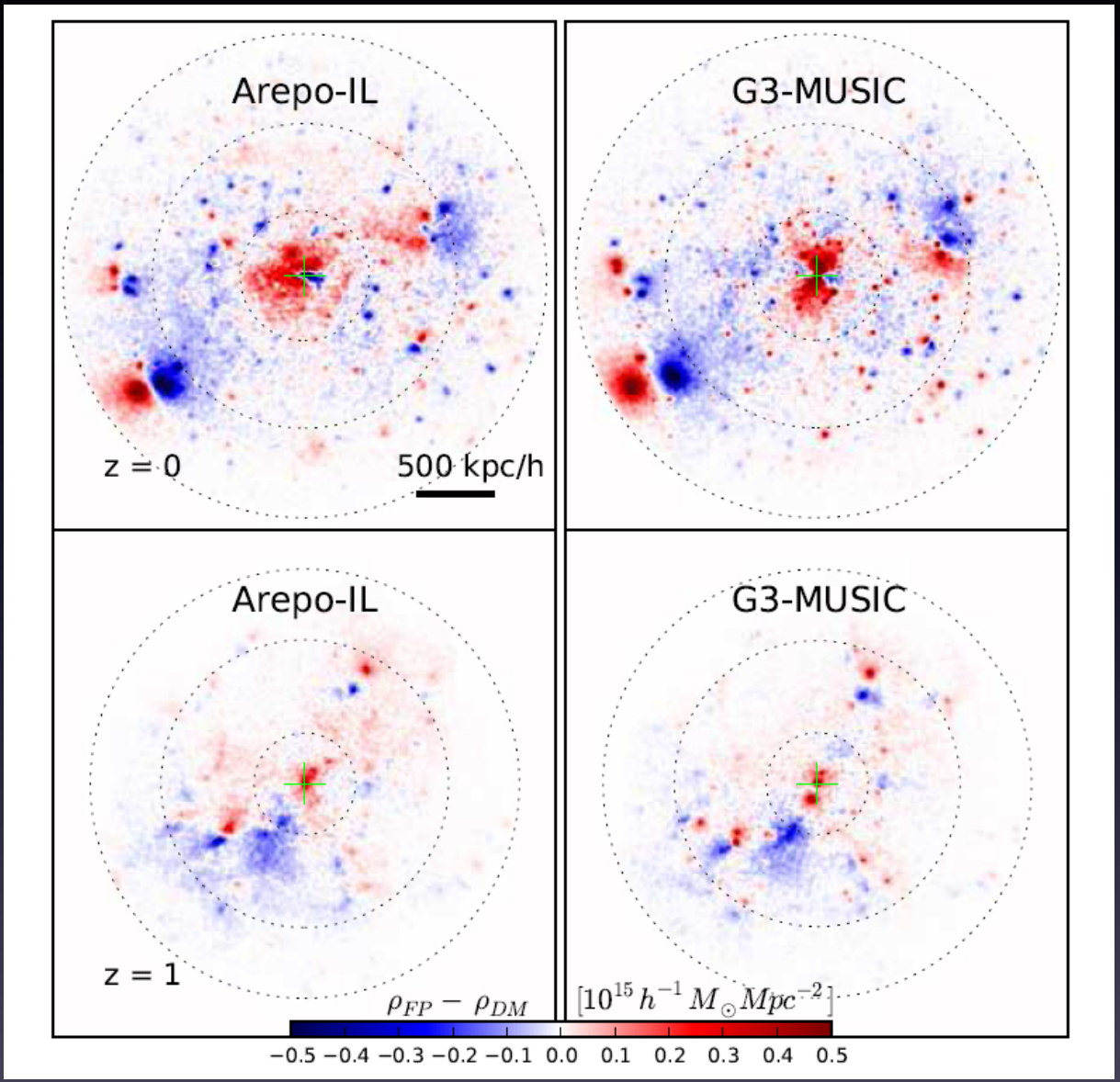

Sembolini et al. 2015

# Radial Gas Density



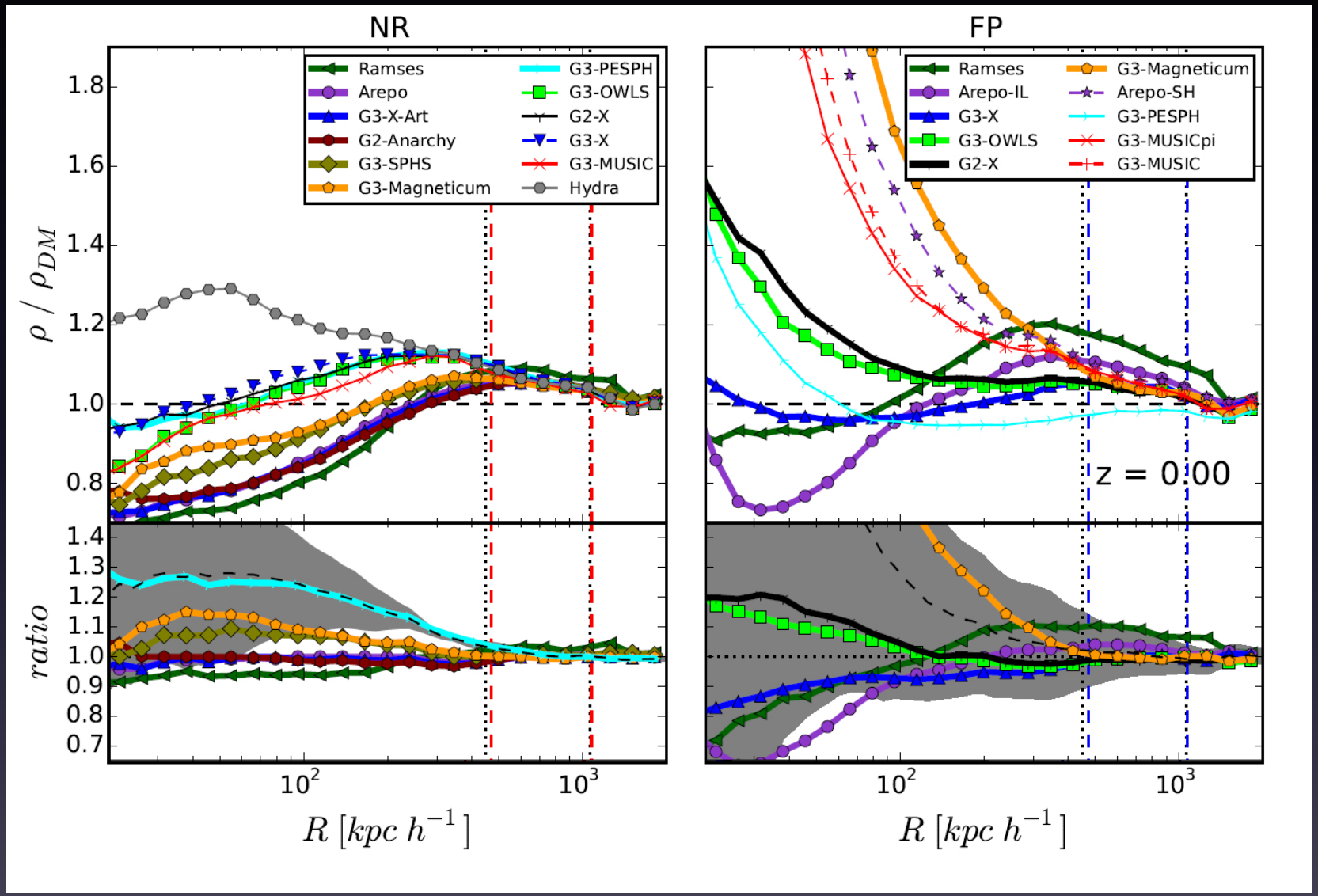

Sembolini et al submitted

# Baryonic Effects



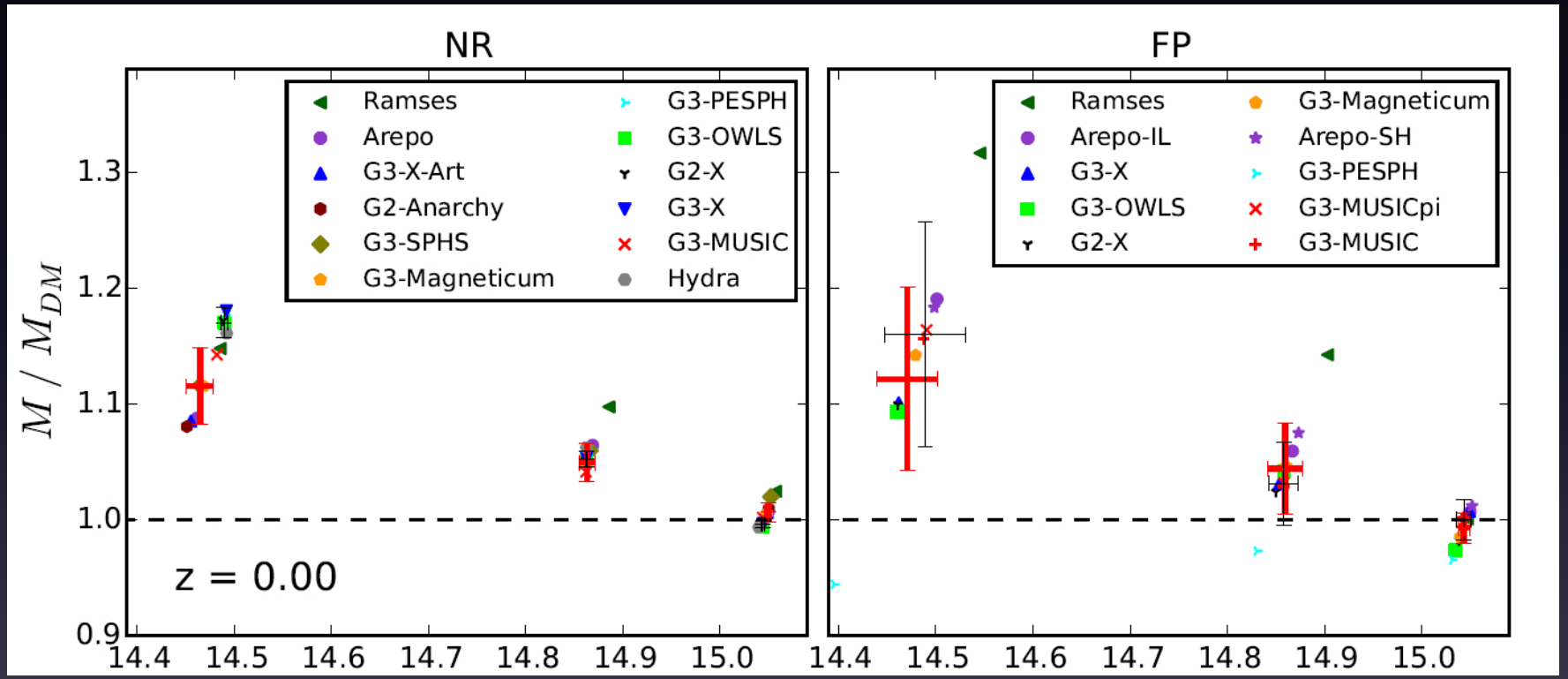

Cui et al. submitted

# Accumulative Density Profile




Cui et al. submitted

# Halo Masses ($M_{2500}, M_{500}, M_{200}$)



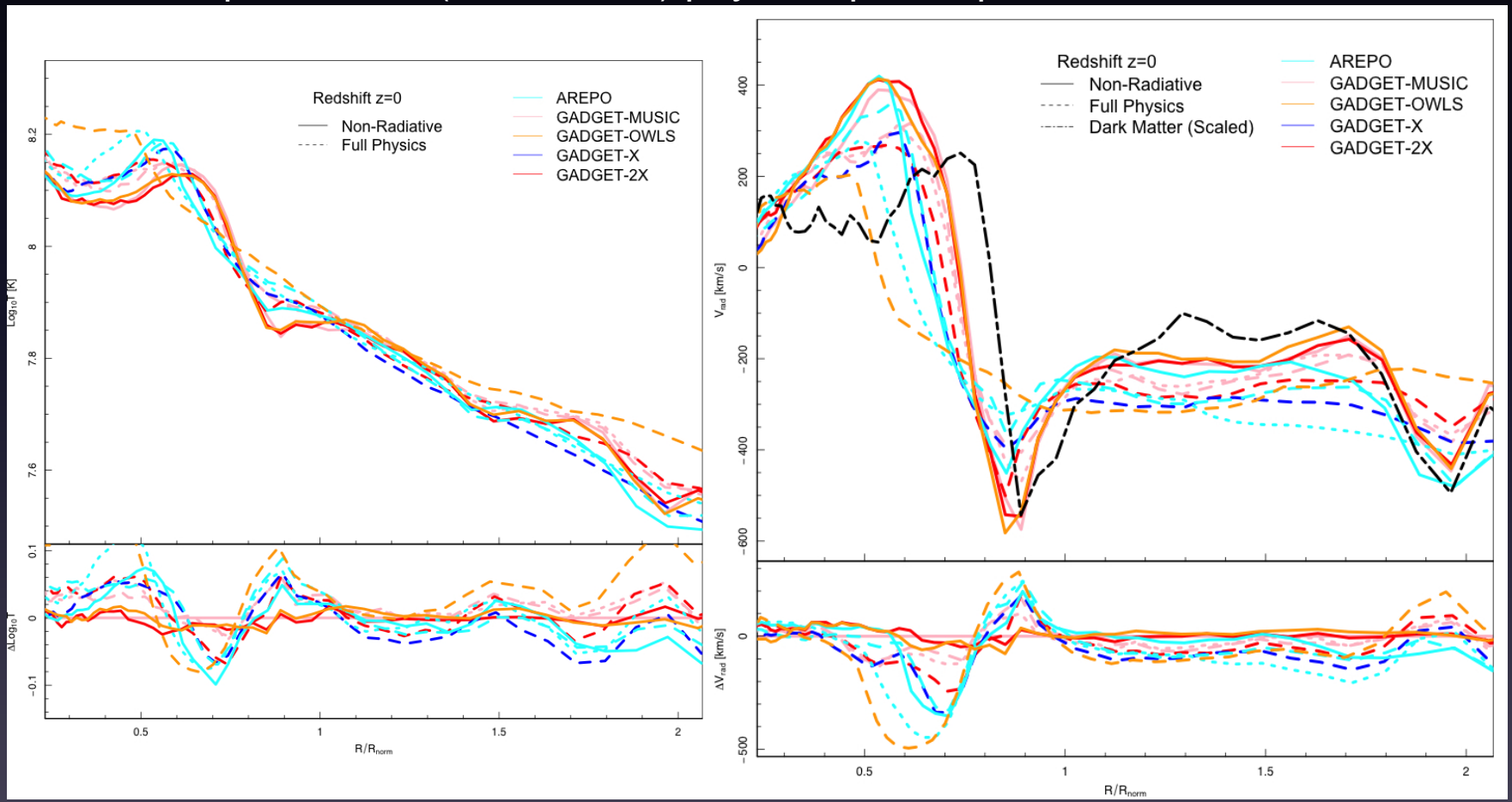

Cui et al. submitted

## Baryonic Effects

- Most disagreement in the total density profile in the cluster center
- The cluster environment differences seen between codes in the non-adiabatic runs are washed away in full physics runs, even between codes with very different feedback physics.
- see Cui et al. submitted.

# Shocks around Clusters

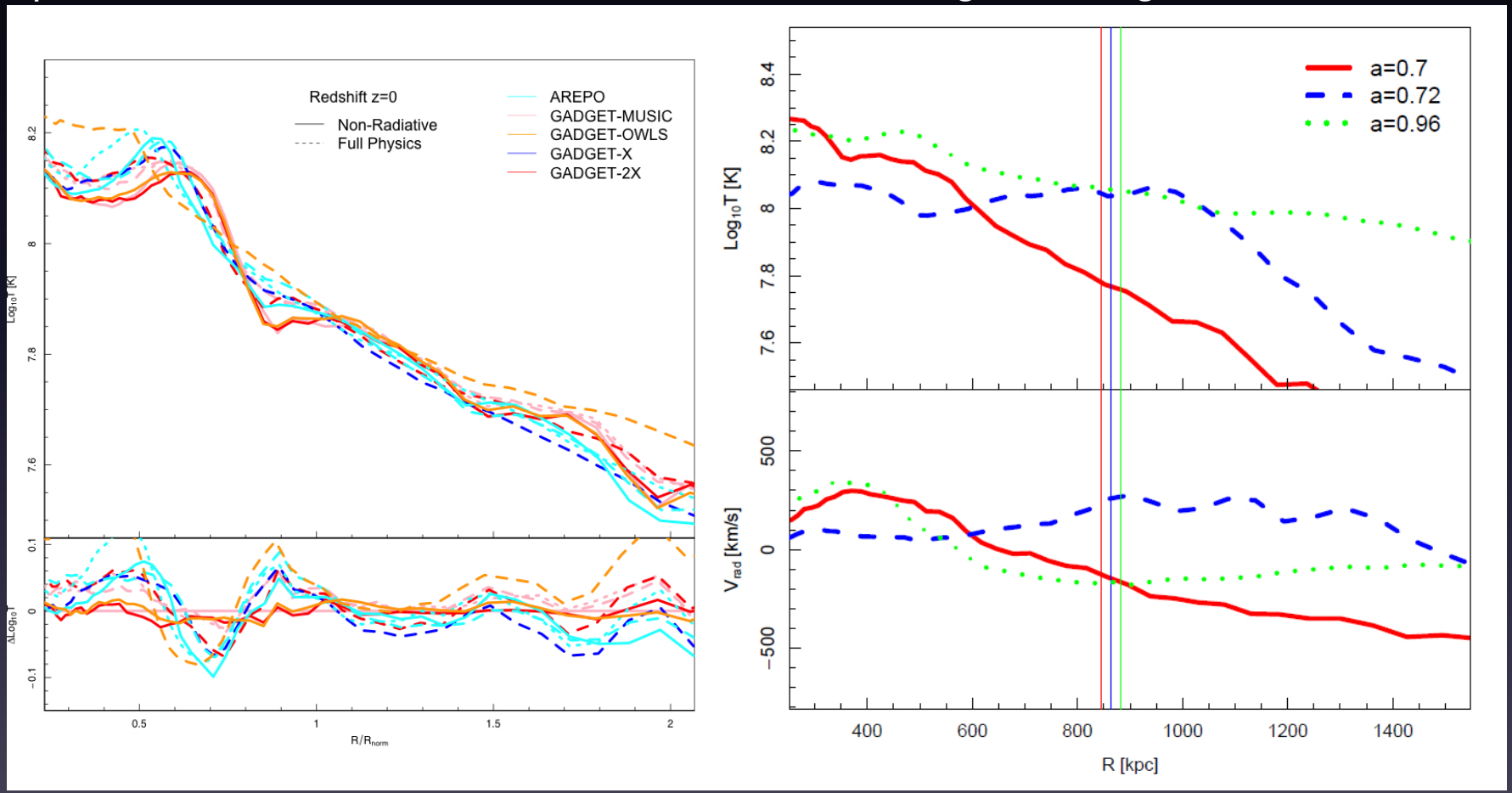
nIFTy cluster comparison - properties of cluster outskirts robust prediction of codes, independent of (reasonable) physical prescriptions




Power et al. in prep

# Shocks around Clusters

Evidence of accretion shocks and shocks associated with infalling subclumps - predictions for emission at radio continuum and higher energies...




Power et al. in prep

## The Next Workshop: Cape Town Clusters (11 -15 July 2016)

**www.uwcastro.org/compact**

Projects that have been initiated:

- Reconstructing the dynamical state and merging history of clusters from present-day observables.
- Synthetic observations of galaxy clusters at radio continuum, X-ray wavelengths.
- Tidal disruption of galaxies in clusters, the formation of intra-cluster light.
- The outskirts of clusters and the detection of missing baryons.
- The creation of lightcones and mock observables.

# Galaxy Formation Modeling for the SKA and its Pathfinders

Chris Power

Core Team:

Lagos, Obreschkow, Power, Robotham (ICRAR/UWA), Cunnama (UWC), Elahi (U Sydney), Gonzalez-Perez & Norberg (ICC Durham)

# WAVES Simulations I

Large N-body simulations coupled to GALFORM semi-analytical model.

- Mass resolution sufficient to resolve haloes of galaxies with stellar masses of $10^8 M_\odot$.
- Require at least 100 particles per halo.
- Haloes identified with Rockstar (Behroozi et al. 2013), merger trees constructed with consistent trees (Behroozi et al. 2013) from 200 outputs equally spaced in $log(a)$.

| Run | $L_{box}$ [Mpc/h] | $N_{side}$ | $m_{part,dm}$ [Msol/h] | $m_{halo,res}$ [Msol/h] |
|---|---|---|---|---|
| micro | 40 | 512 | 4.07e7 | 4.07e9 |
| mini | 210 | 512 | 5.9e9 | 5.9e11 |
| medium | 210 | 1024 | 7.37e8 | 7.37e10 |
| maxi | 210 | 2048 | 9.22e7 | 9.22e9 |
| ultra | 210 | 4096 | 1.15e7 | 1.15e9 |

# WAVES Simulations I

Large N-body simulations coupled to GALFORM semi-analytical model.

- Assumes Planck 2015 cosmological parameters.
- Simulations run at Pawsey Supercomputing Centre, models run at ICRAR.

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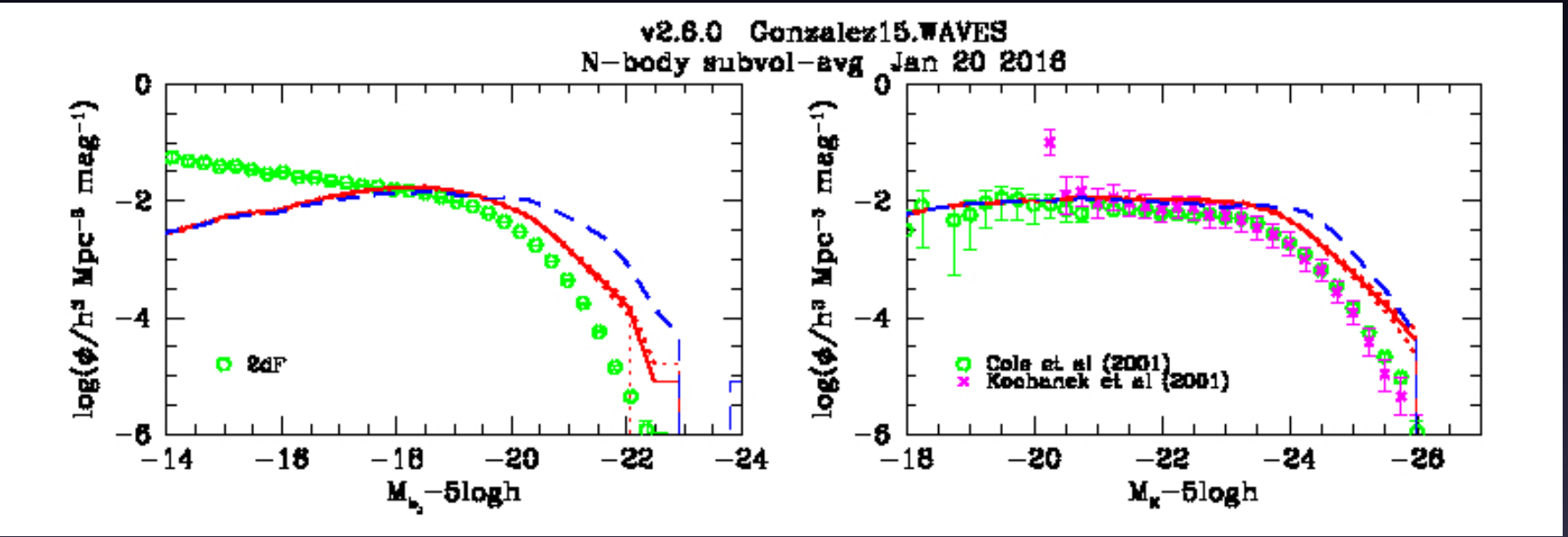
# WAVES Simulations II

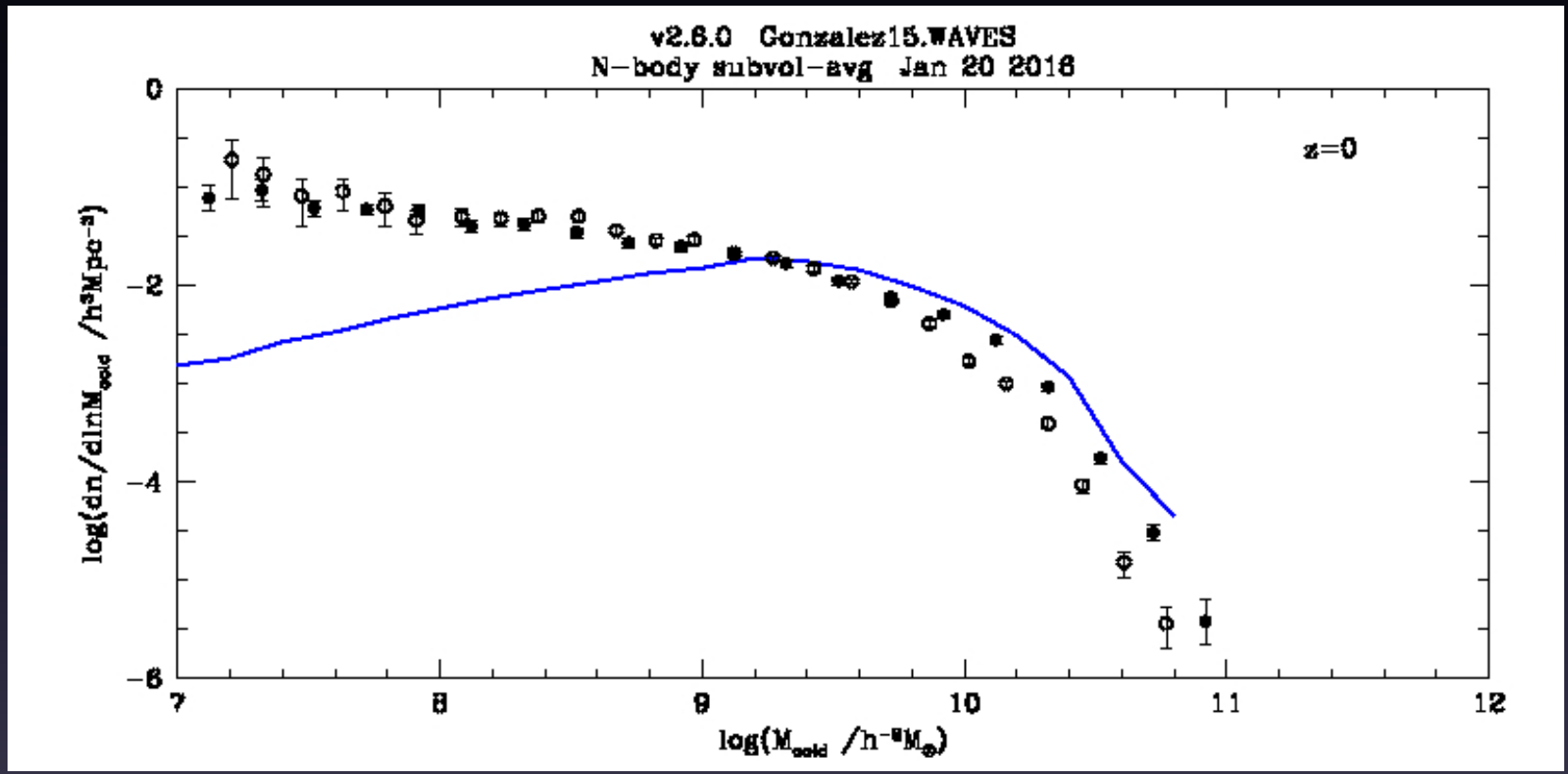
Gonzalez et al. 2015 GALFORM models, run at ICRAR on $512^3$ resolution WAVES volume




Blue lines - intrinsic luminosity
Red lines - after dust effects are included

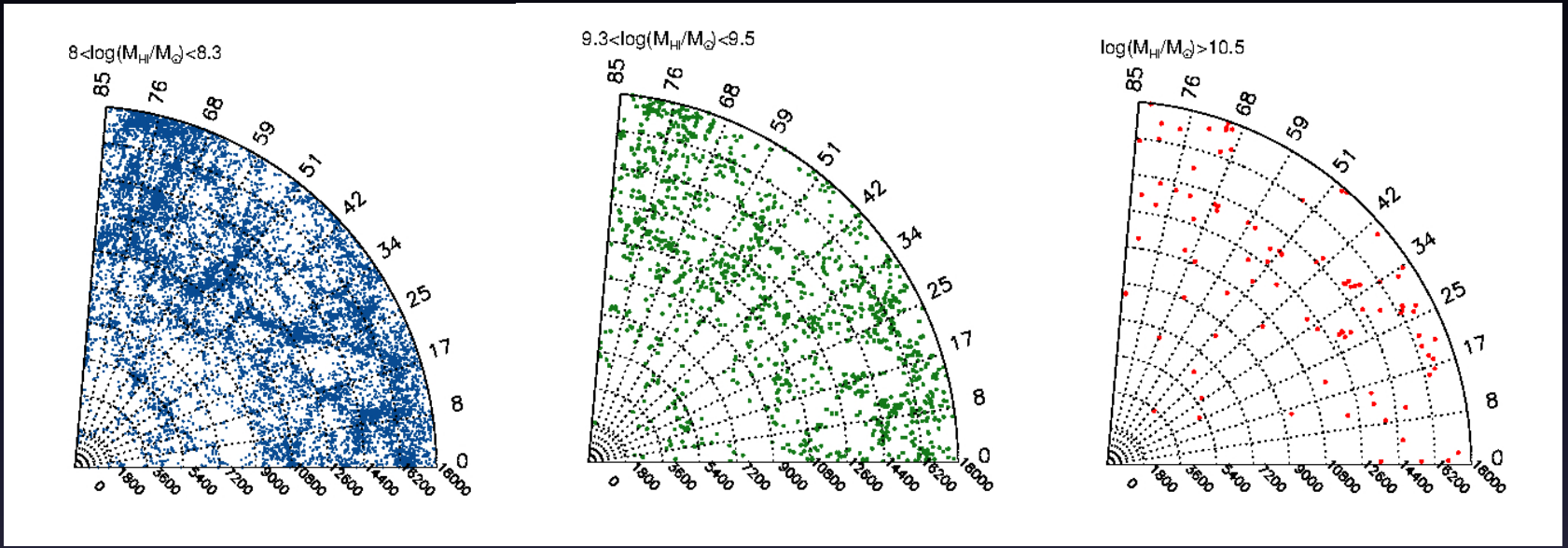
# Cold Gas Mass Function

- Dominated by HI




- Based on Lagos et al. (2012)
- explicitly separates HI and H2
- galaxies form stars only from the H2 component.

# HI Galaxies




- Busy building these catalogues
- Soon we will have HI absorption and radio continuum (from AGN and star formation).