

Sub-grid physics impact on galaxy cluster simulations

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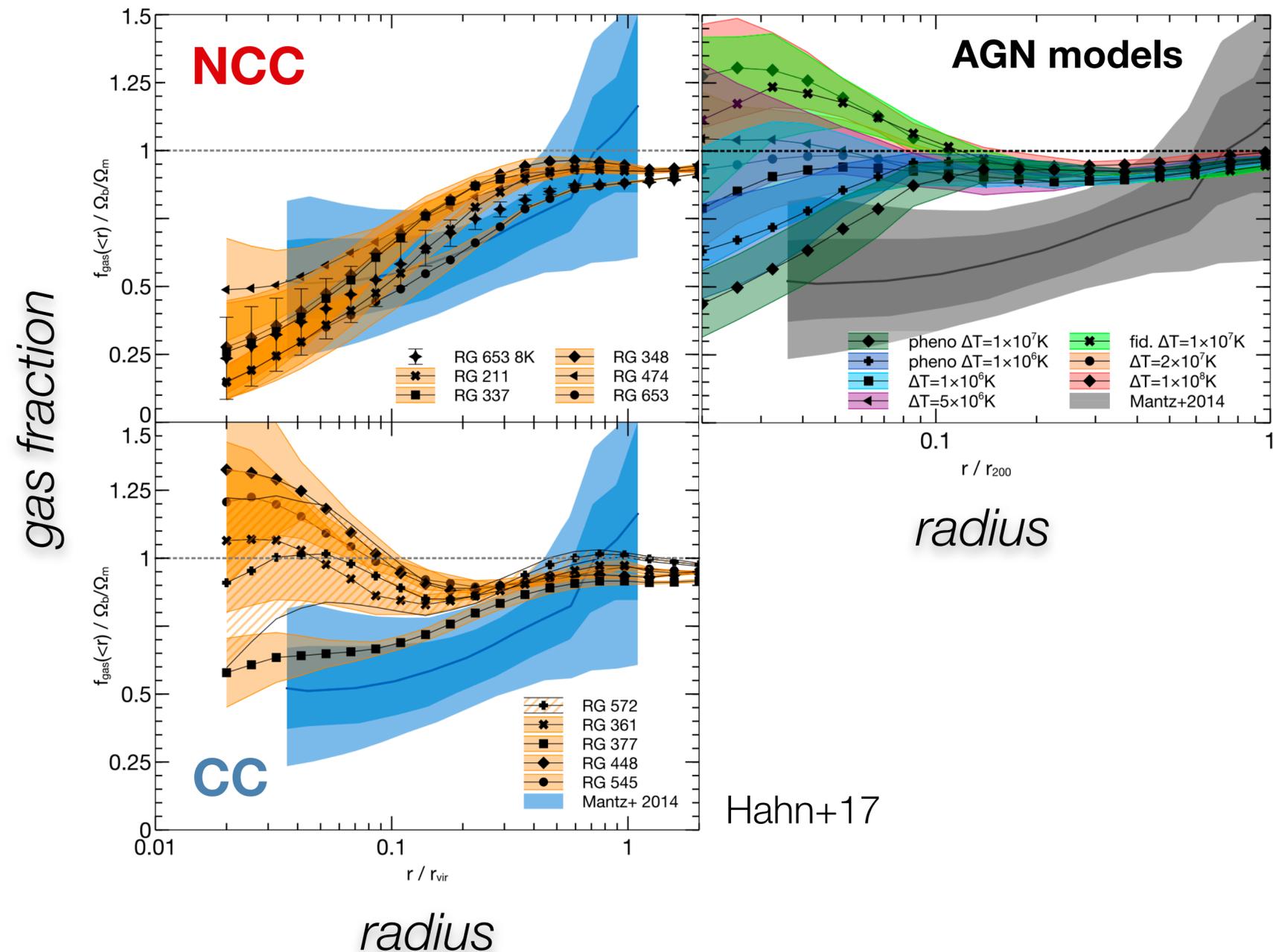
Atelier Amas France 2020

11 December 2020



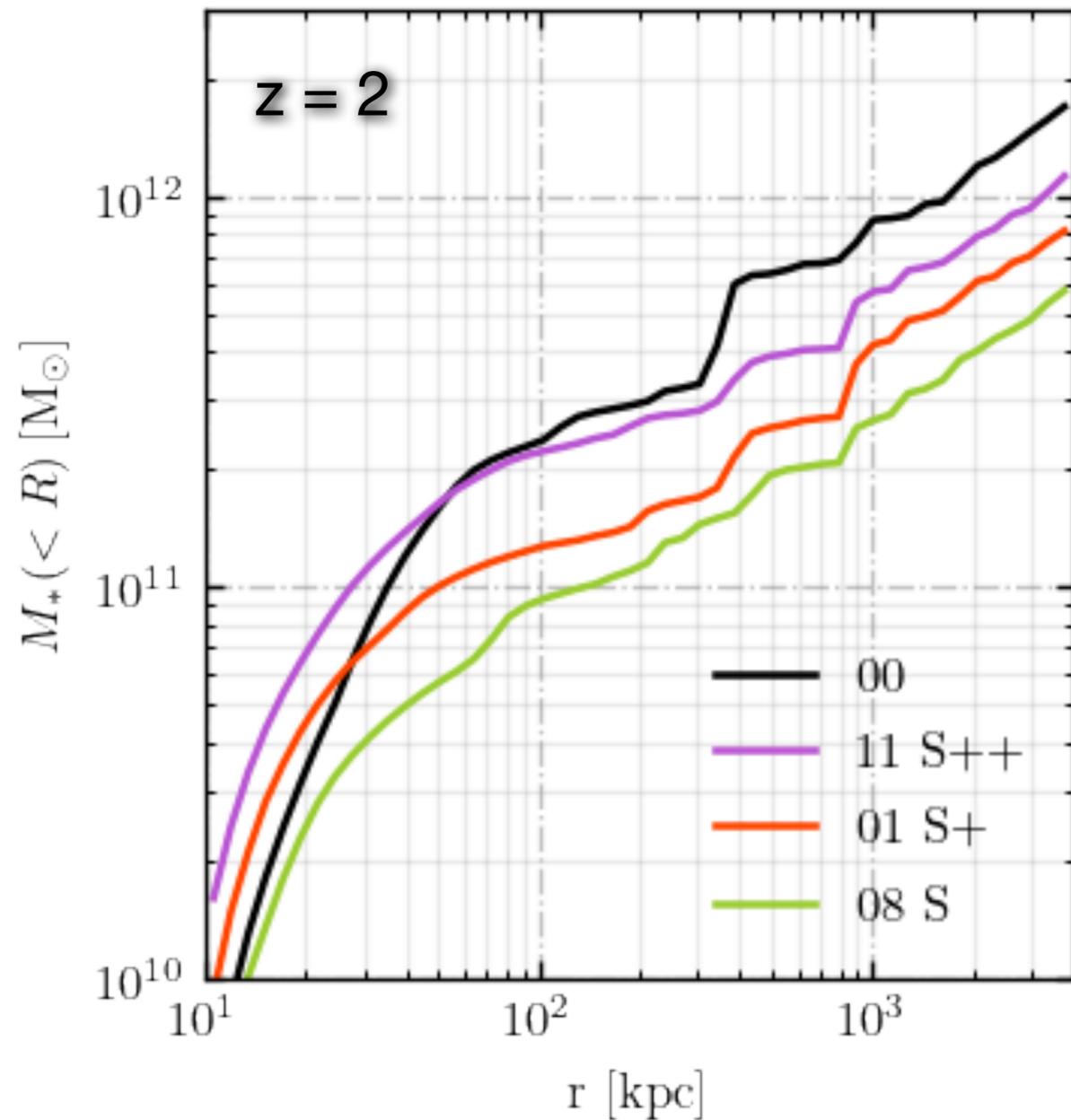
Starting point : Rhapsody-G simulation suite

10 massive clusters - Different assembly histories



- **Cool Core** > **Non Cool Core**
 - Transition : Major mergers
- **Shortcomings**
 - Massive galaxies
 - Gas rich clusters (too X-ray bright)
 - Thermal AGN feedback \leftrightarrow f_{gas}
Le Brun+14
- No clear effect of **AGN feedback** :
 - on thermodynamics of CCs
 - outside the core

Black hole formation



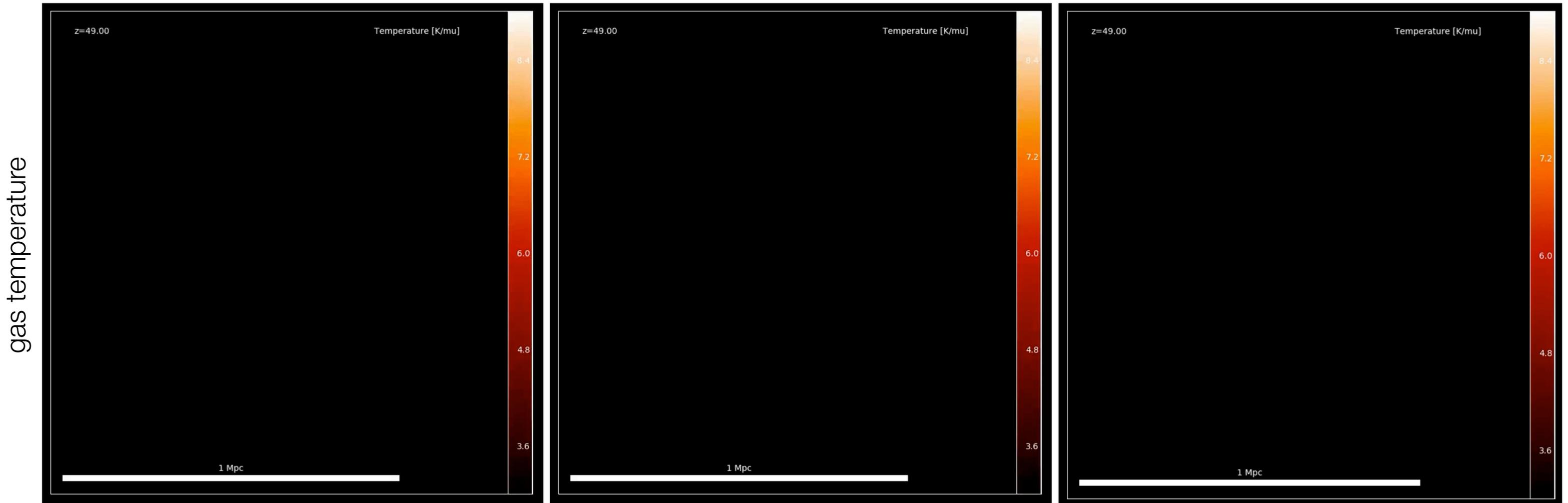
← • Fewer & More massive BHs

← • More & Less massive BHs

> *Control on star formation
In the proto-cluster*

Decaying black hole orbits

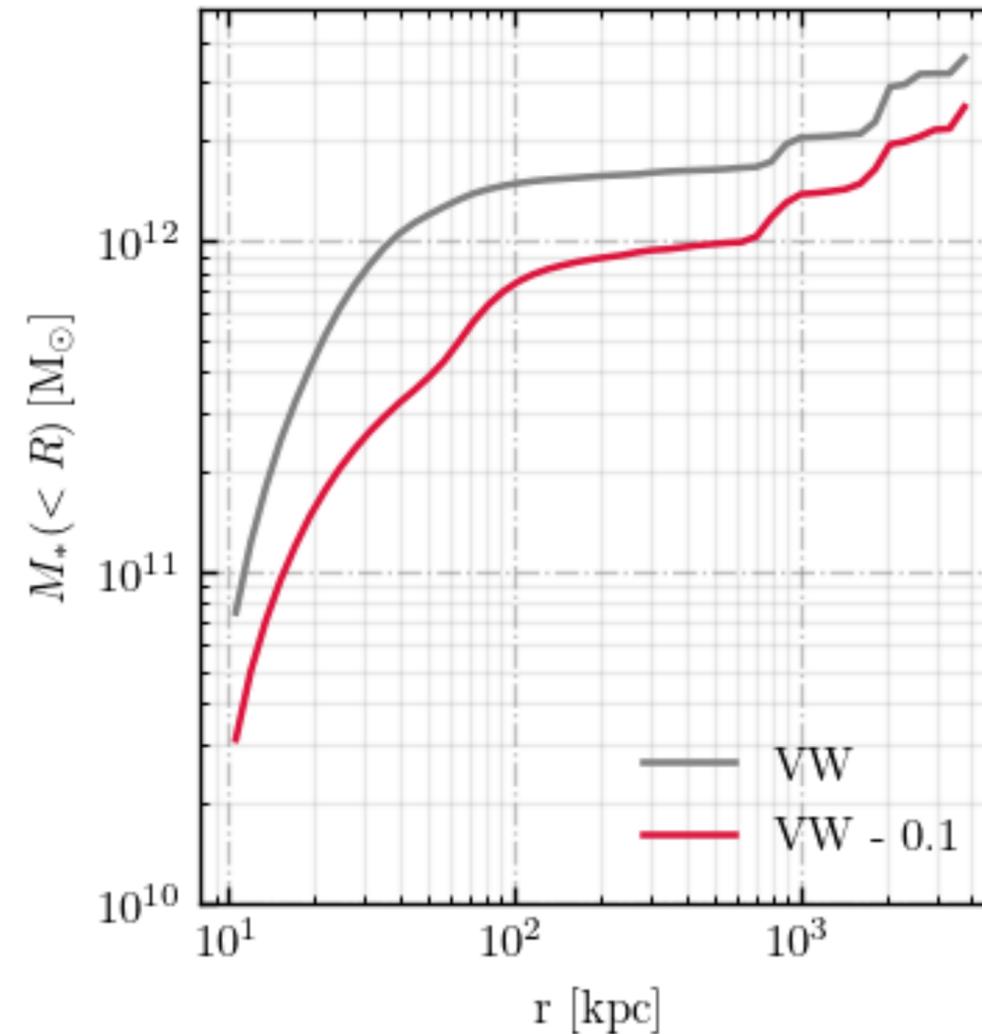
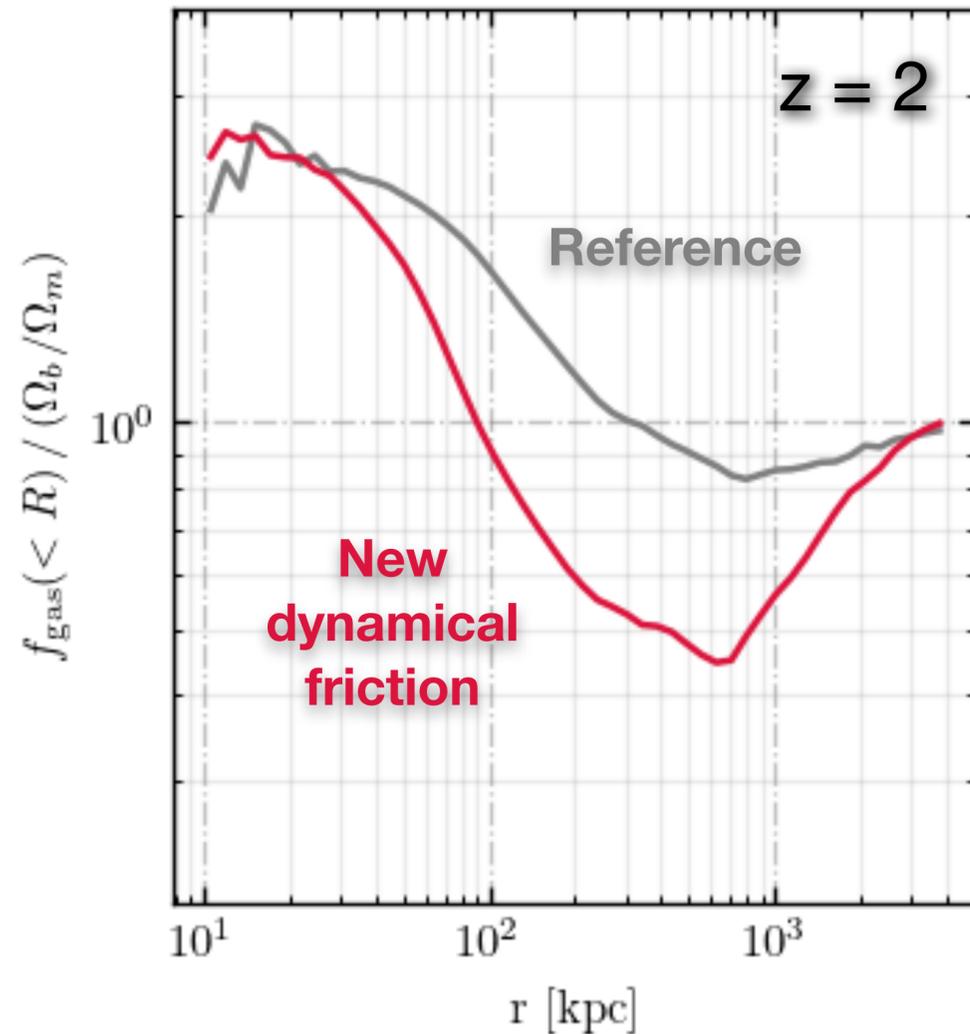
- Unresolved BH dynamics
 - Friction : Gas + Nuclear Star Cluster
- Dynamical friction models
 - Horizon, Illustris-TNG, Eagle, ...



Inefficient BH accretion

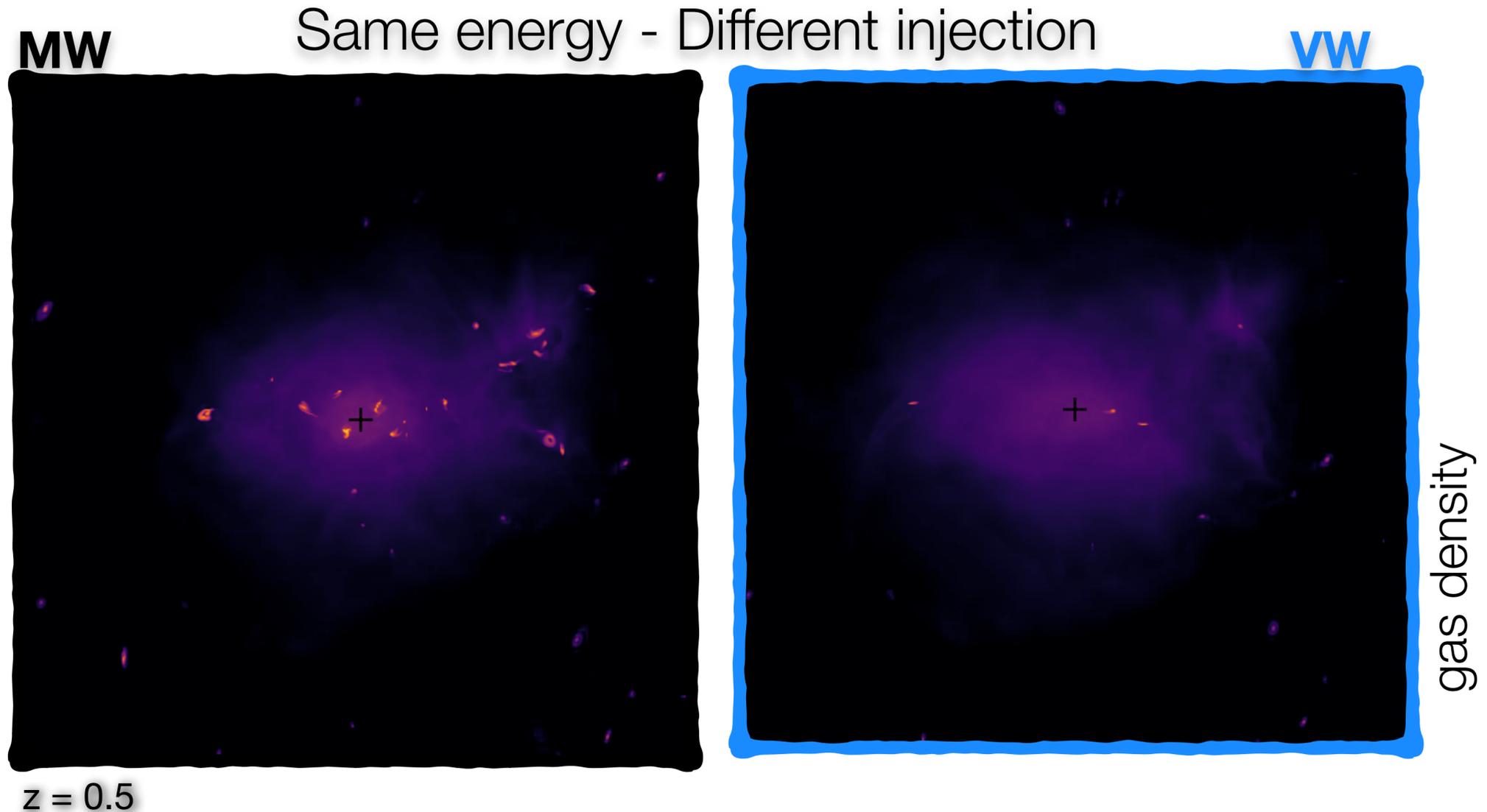
Decaying black hole orbits

- Unresolved BH dynamics
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Delivering AGN feedback

- Mass Weighted (MW)
 - Accretion region
 - BH starvation
- Volume Weighted (VW)
 - Homogenous
 - Heating at larger radii
- More efficient
 - $CC > NCC$

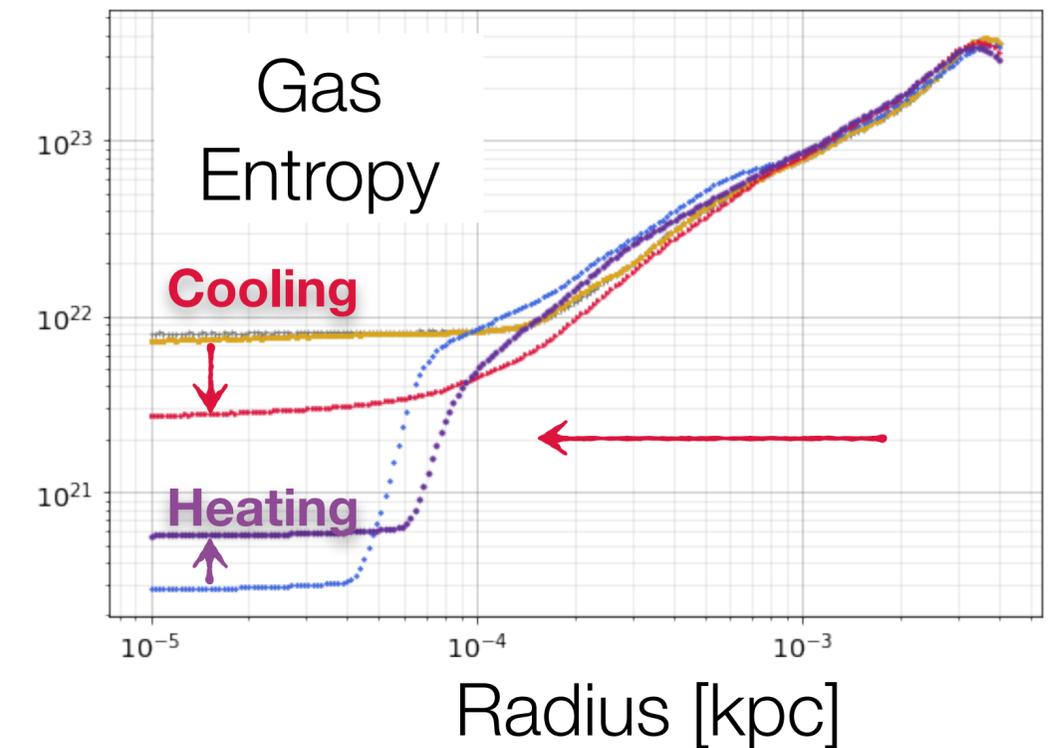
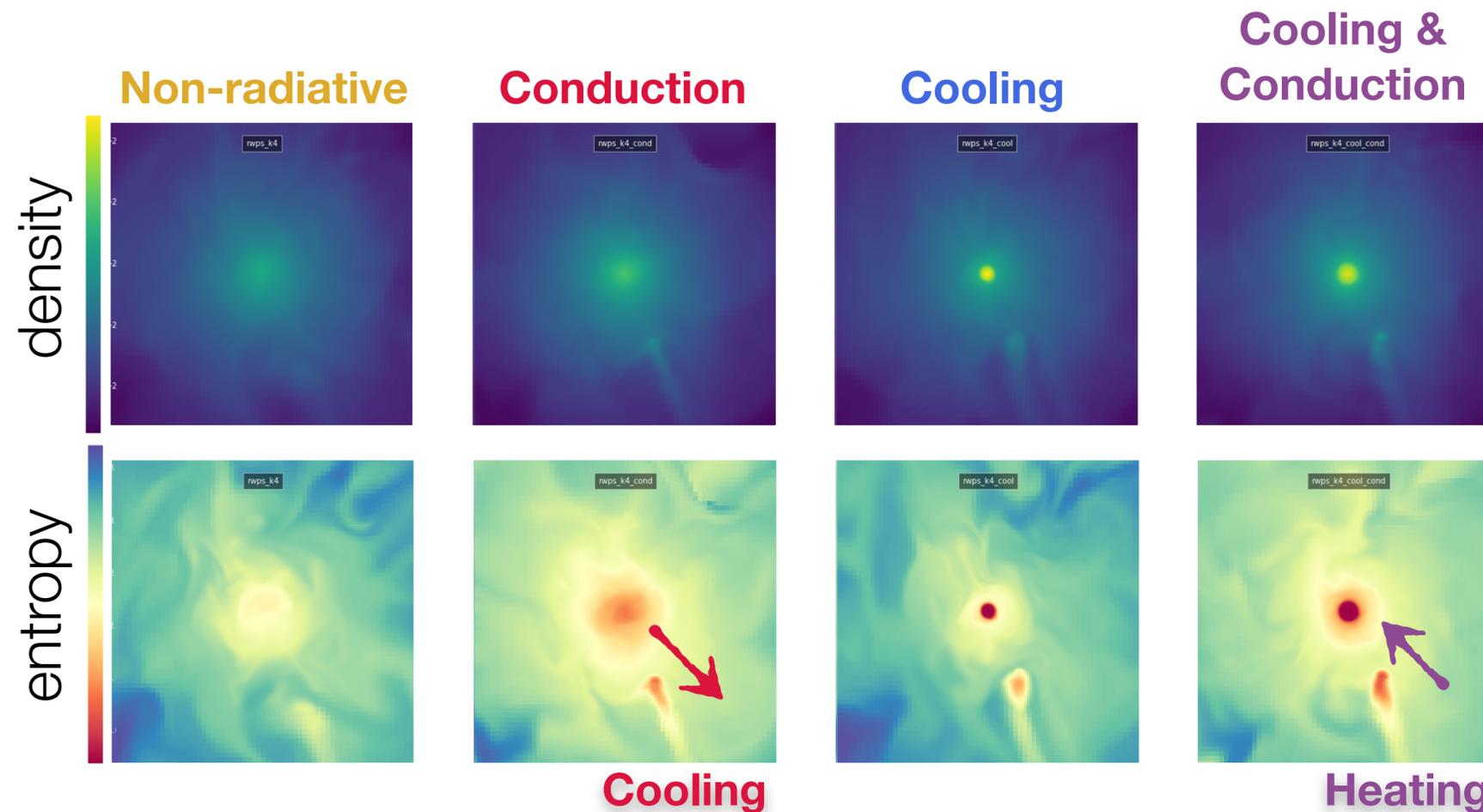


Less parameter-dependant ?

Adding anisotropic thermal conduction

Kannan+16 , Barnes+19

- Dubois & Commerçon 2016 > Latest RAMSES !
- Act as **Heating** & **Cooling** source
 - Alleviate burden of AGN heating

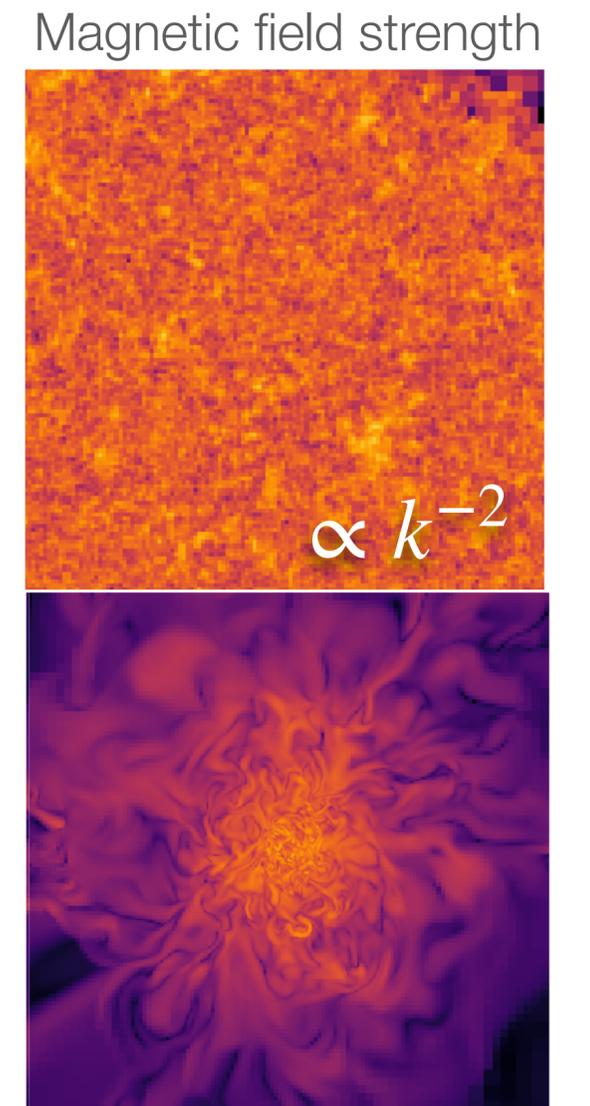
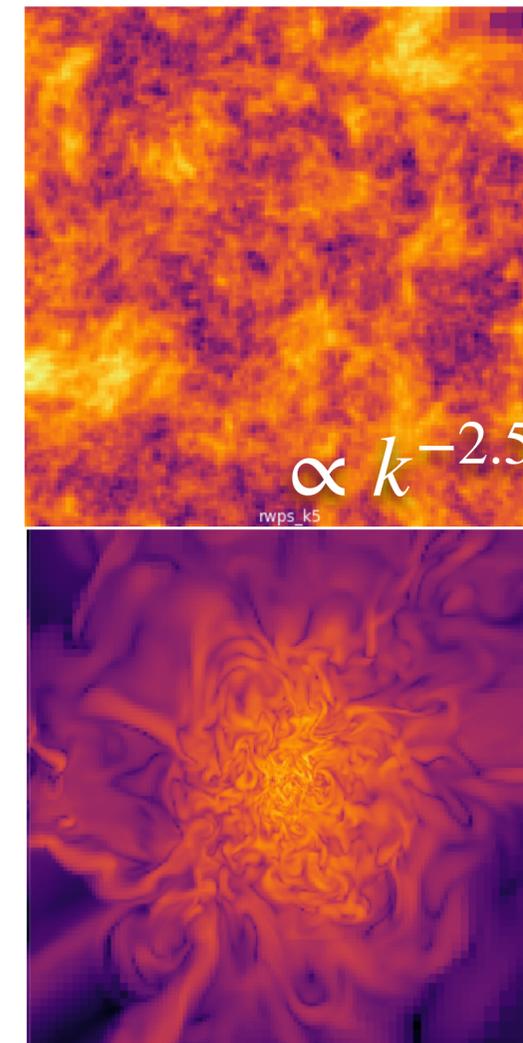
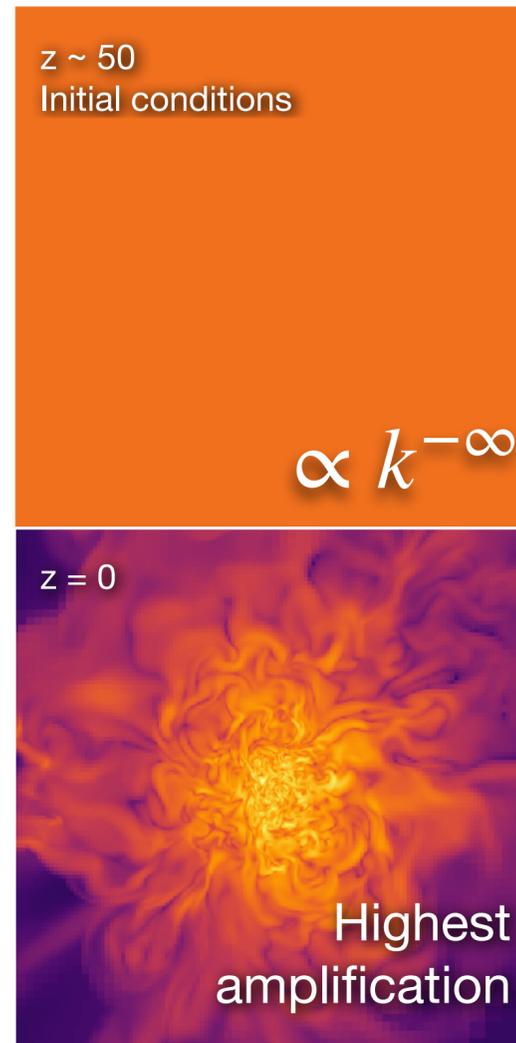
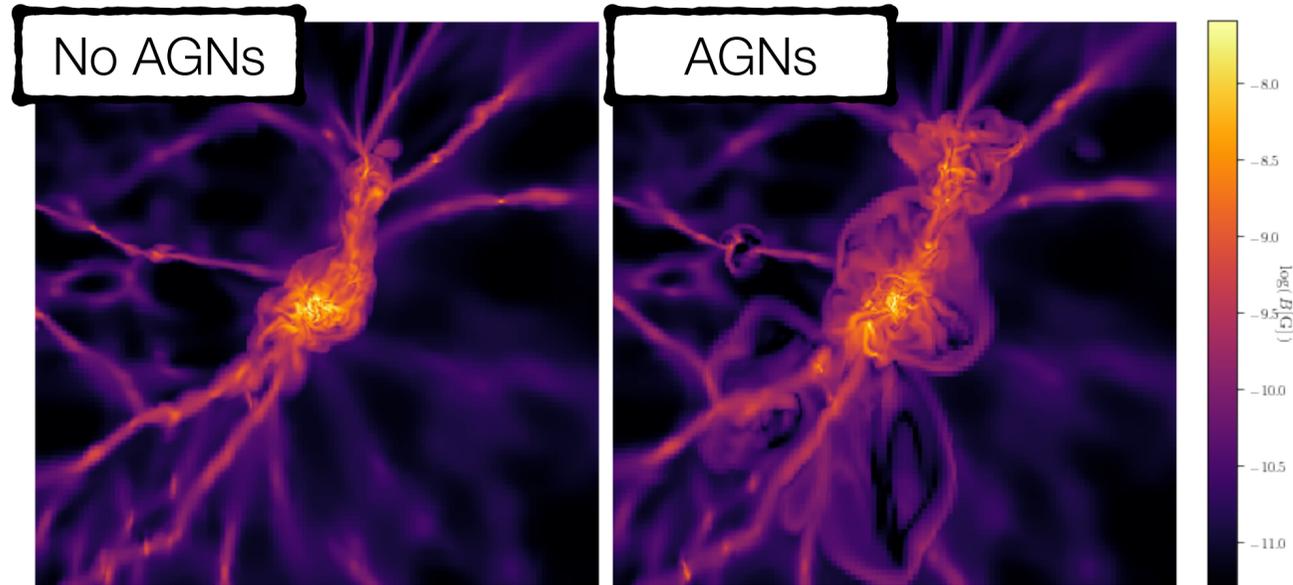


> *Self regulation*

Transport AGN energy
+ Regulate star formation ?

Amplification & Magnetic seed field topology

- **Topology** of seed field \leftrightarrow Amplification
 - Coherence length
- Role on conduction ?



Outlooks

- Intra-Cluster gas thermodynamics sensitive to sub-grid models
- Improvements :
 - BH formation & evolution modelling
 - Merging anisotropic thermal conduction with public RAMSES version
- Predictions for cosmology !
 - Rhapsody-G sample > Cosmic variance
 - Impacts on Observables