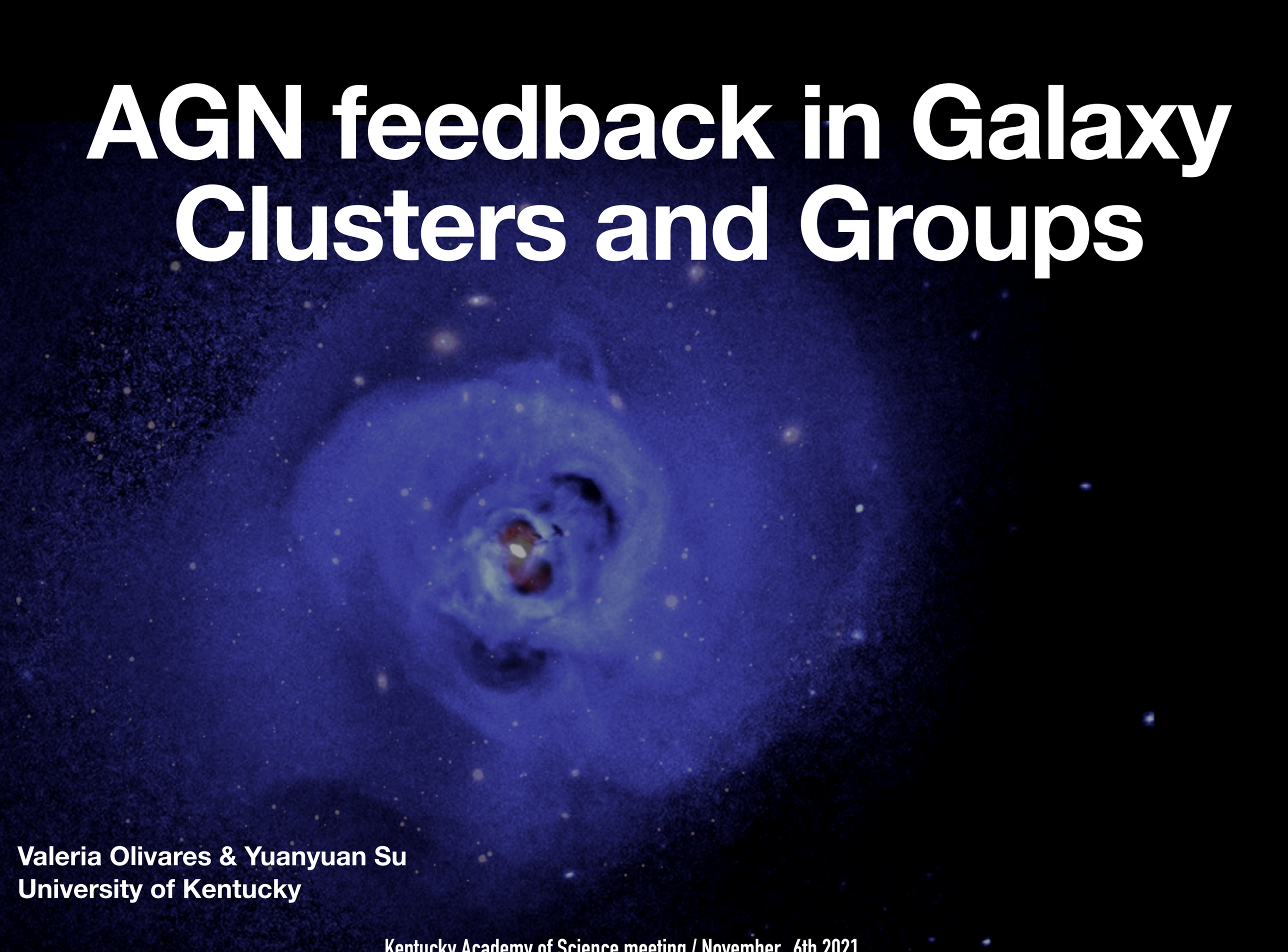
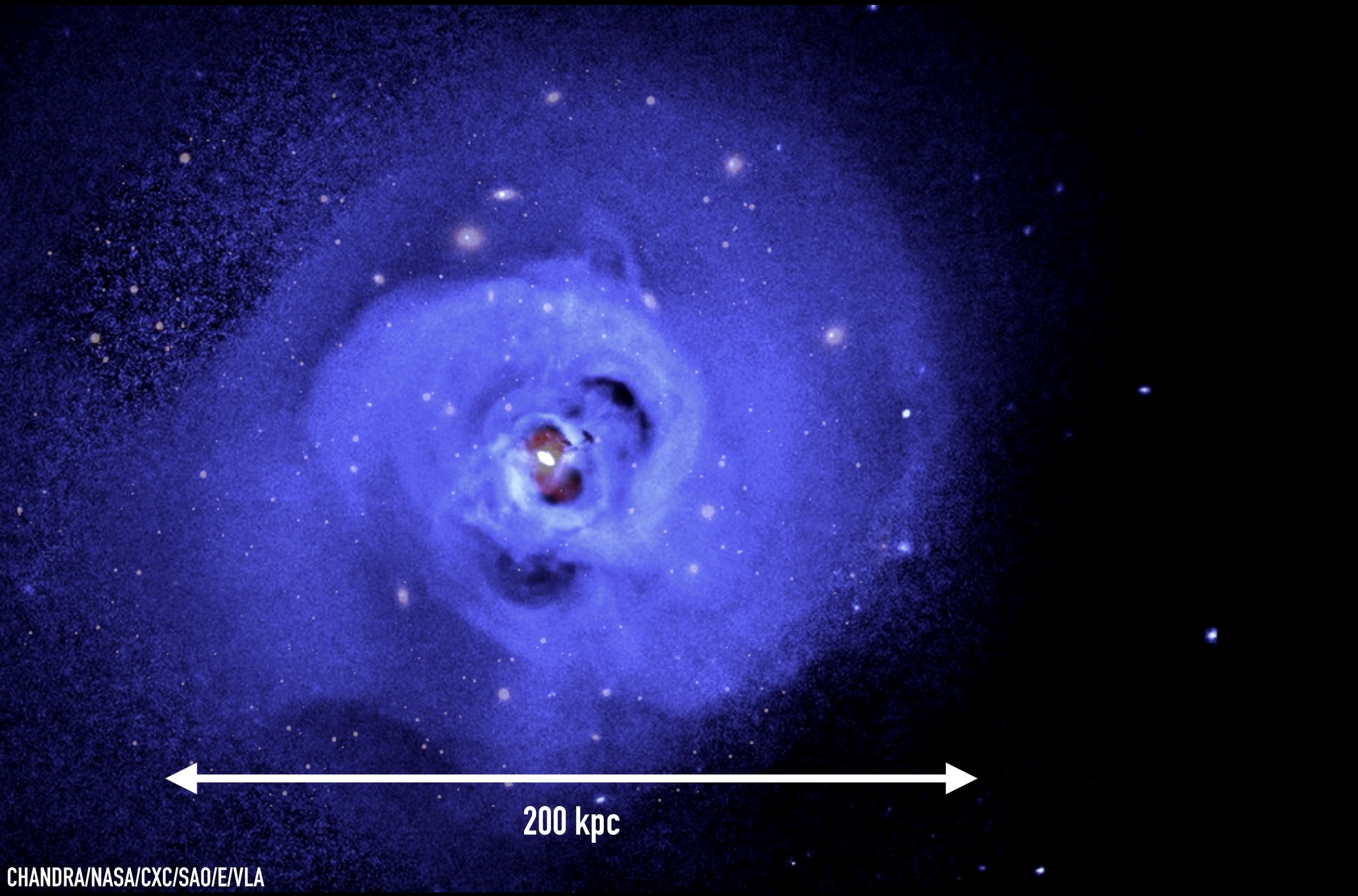
AGN feedback in Galaxy Clusters and Groups



Valeria Olivares & Yuanyuan Su
University of Kentucky

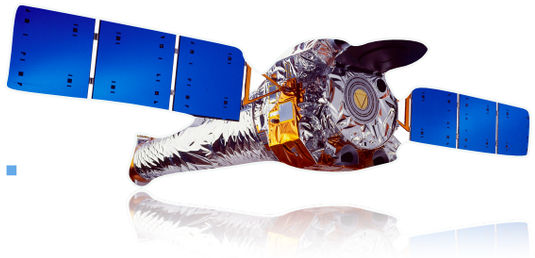
Kentucky Academy of Science meeting / November, 6th 2021

PERSEUS GALAXY CLUSTER



CHANDRA/NASA/CXC/SAO/E/VLA

AGN Feedback in Planck Selected Clusters

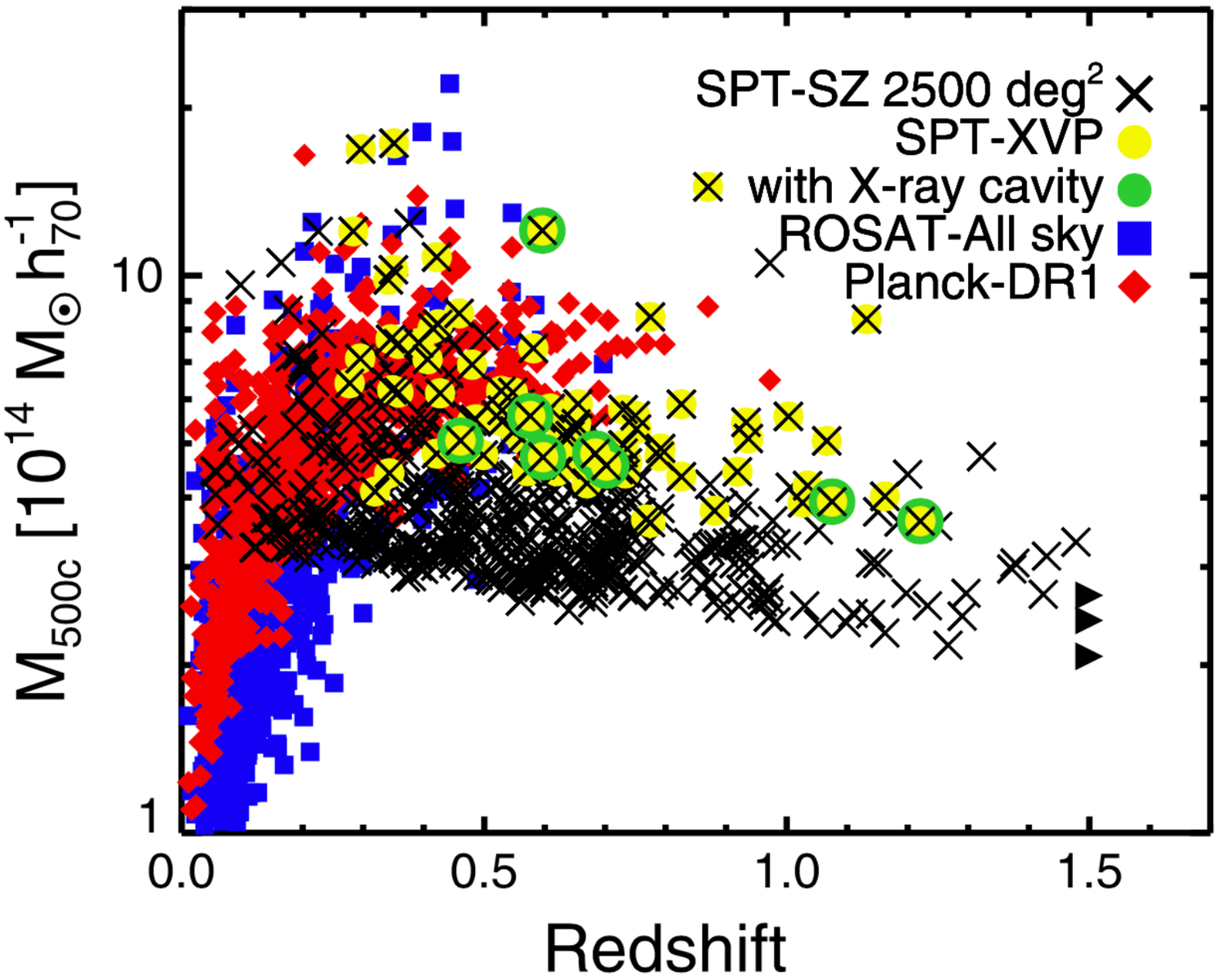


Planck Sample

Redshift: $z < 0.35$

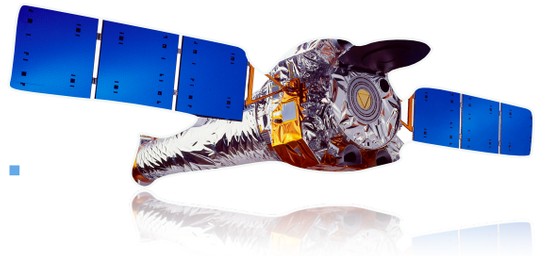
M_{500}: $7 \times 10^{13}\ M_\odot$ — $2 \times 10^{15}\ M_\odot$

173 clusters: 69 CC + 104 NCC
(Andrade et al. 2017)



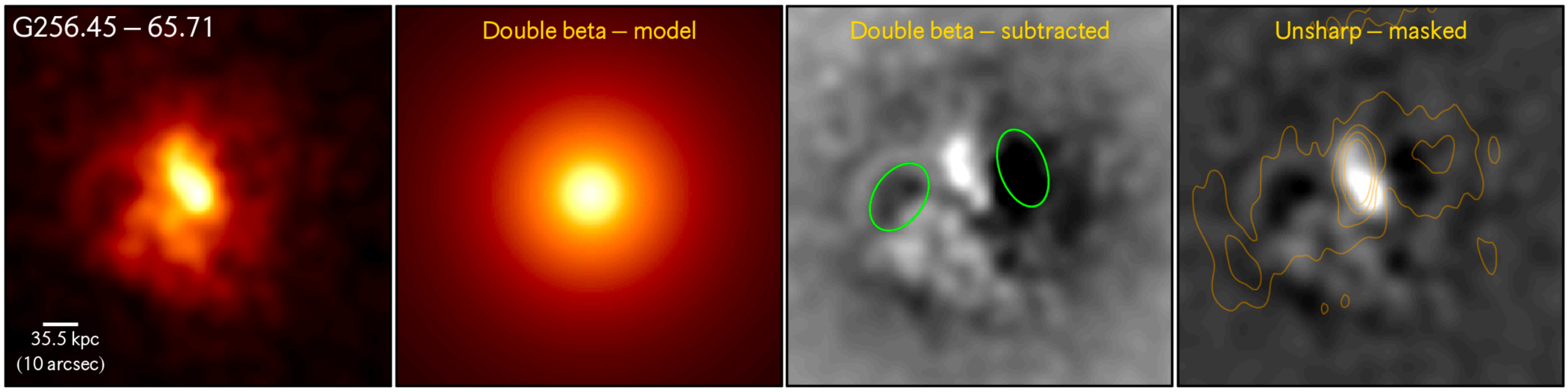
(Hlavacek-Larrondo et al. 2015)

AGN Feedback in Planck Selected Clusters



Looking for X-ray cavities

- 0.5 - 2.0 keV image
- Elliptical double beta model
- Unsharp masked



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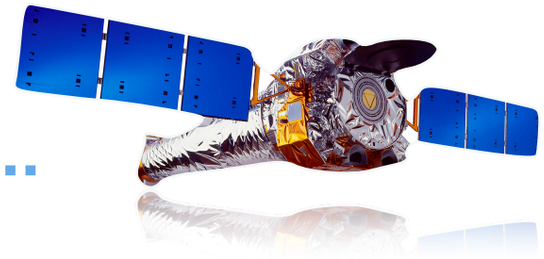
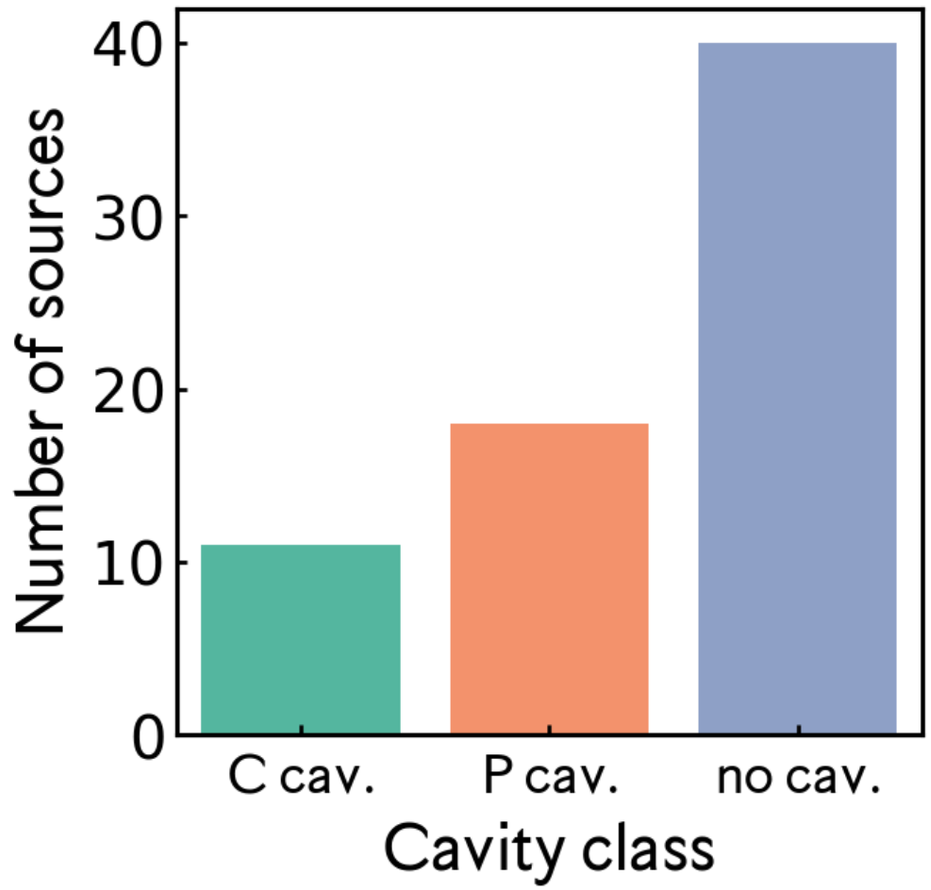


Detection of cavities

- 11 CC clusters with clear cavities
- 17 CC clusters with potential cavities
- 1 NCC cluster with potential cavities



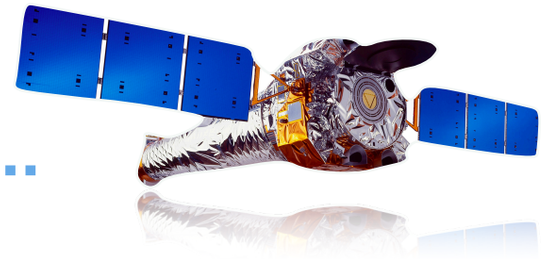
Detection fraction

Total detection fraction (CC+NCC): 17%

Detection fraction of the CC sub-sample: 40% (local galaxy clusters 20%—50%, Dong et al. 2010)

Detection fraction including all clusters and and consider detection only clusters that have $Cav_{size>10kpc}$: 8%, close to the high-z SPT sample (7%, $0.3 \leqslant z \leqslant 1.2$, Hlavacek-Larrondo et al. 2015)

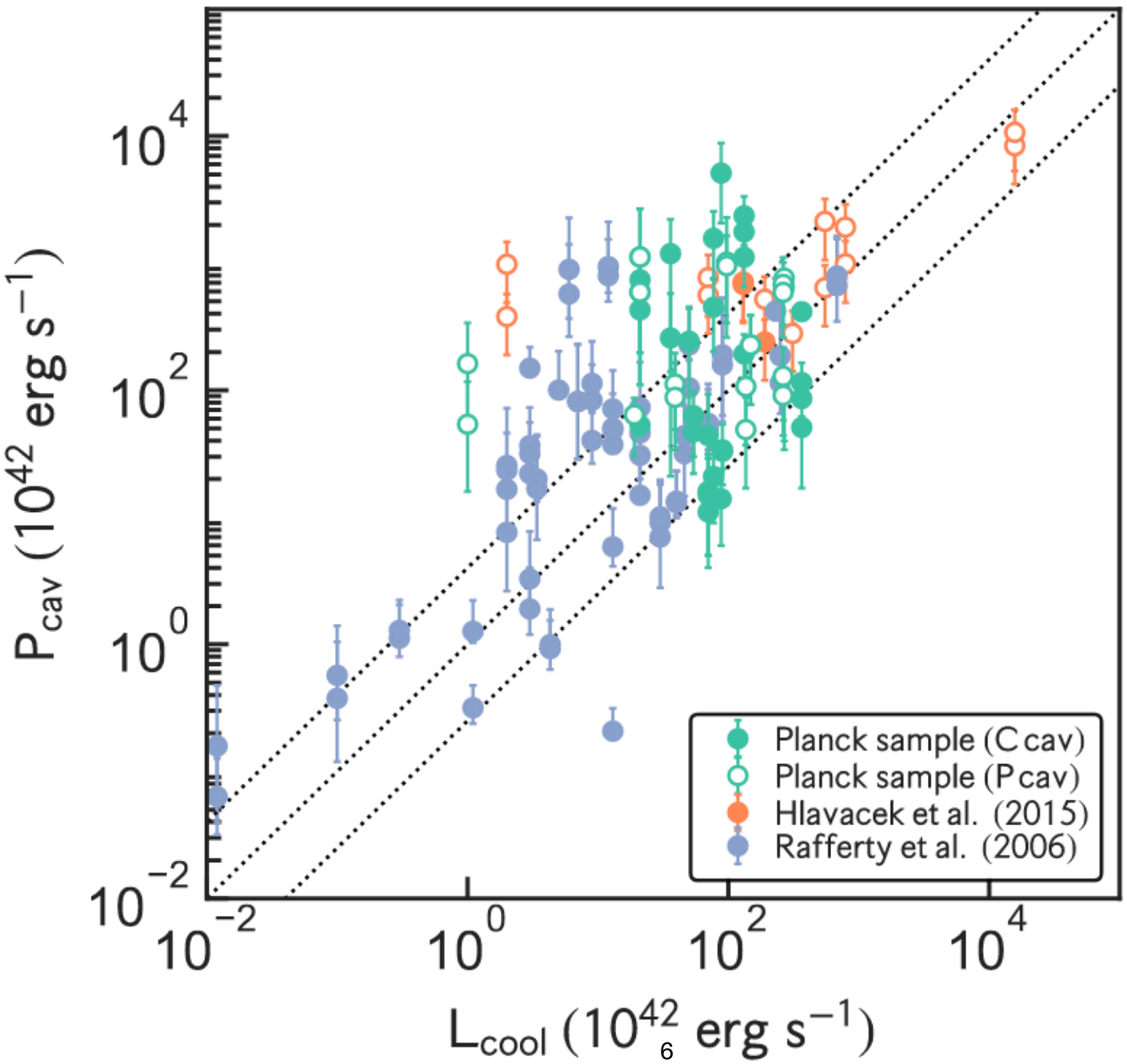
AGN Feedback in Planck Selected Clusters



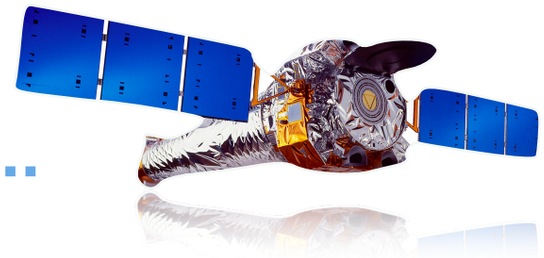
Calorimeters

$t_{cav} \sim 10^7 - 10^8$ yr

$P_{cav} = E_{cav}/t_{cav} \sim 10^{42} - 10^{44}$ erg/s

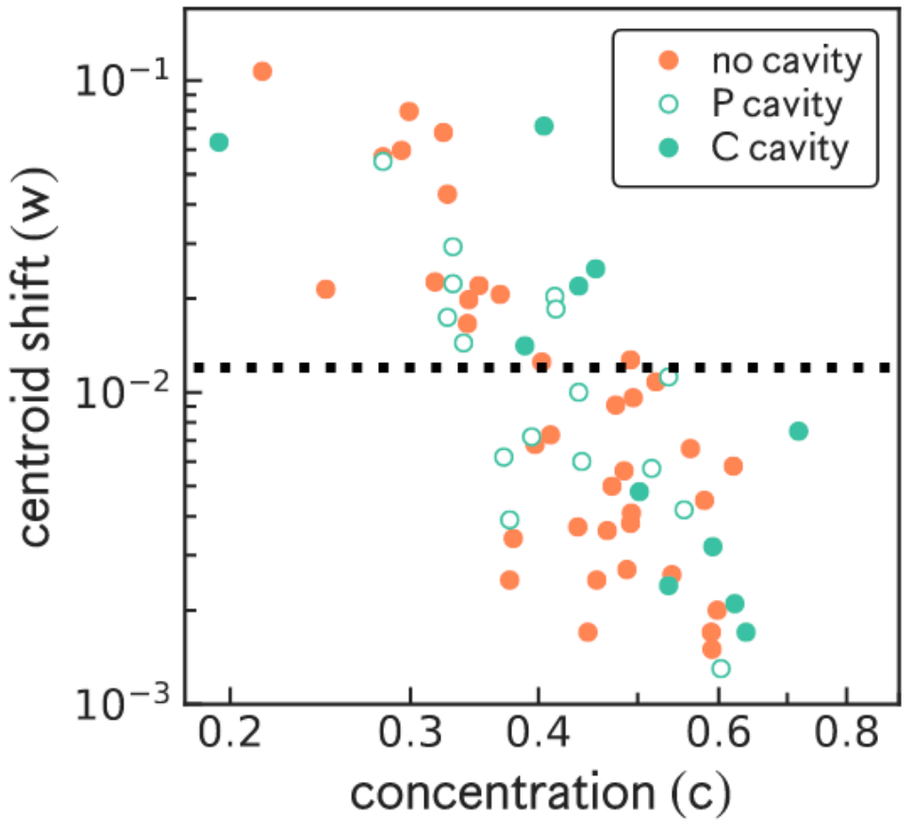


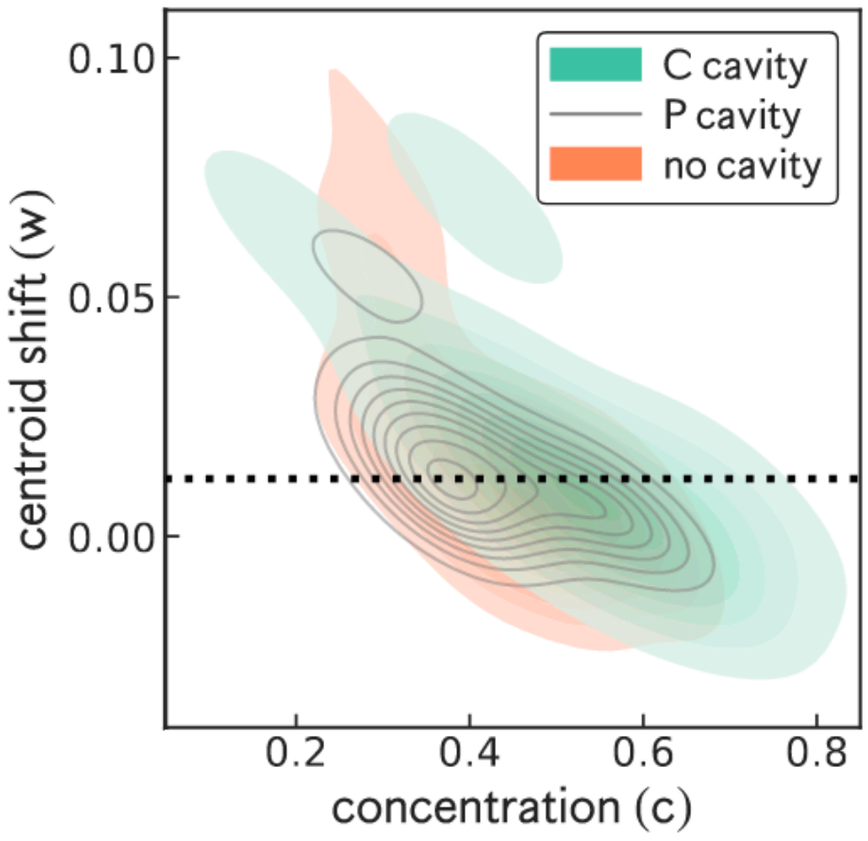
AGN Feedback in Planck Selected Clusters



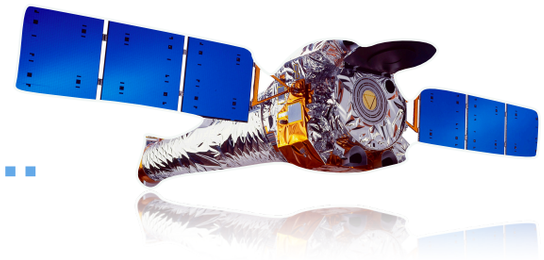
ICM effect on the X-ray cavities

Cavities are found in clusters with various dynamical states (e.g., relaxed, mergers, or sloshing)





AGN Feedback in Planck Selected Clusters



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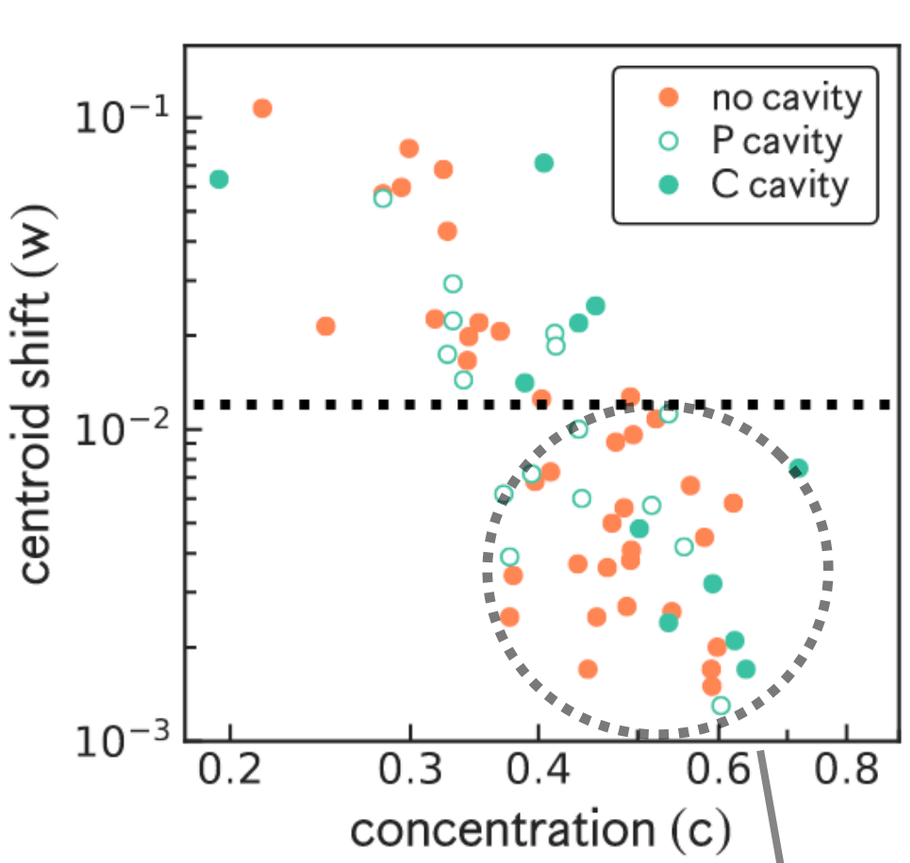

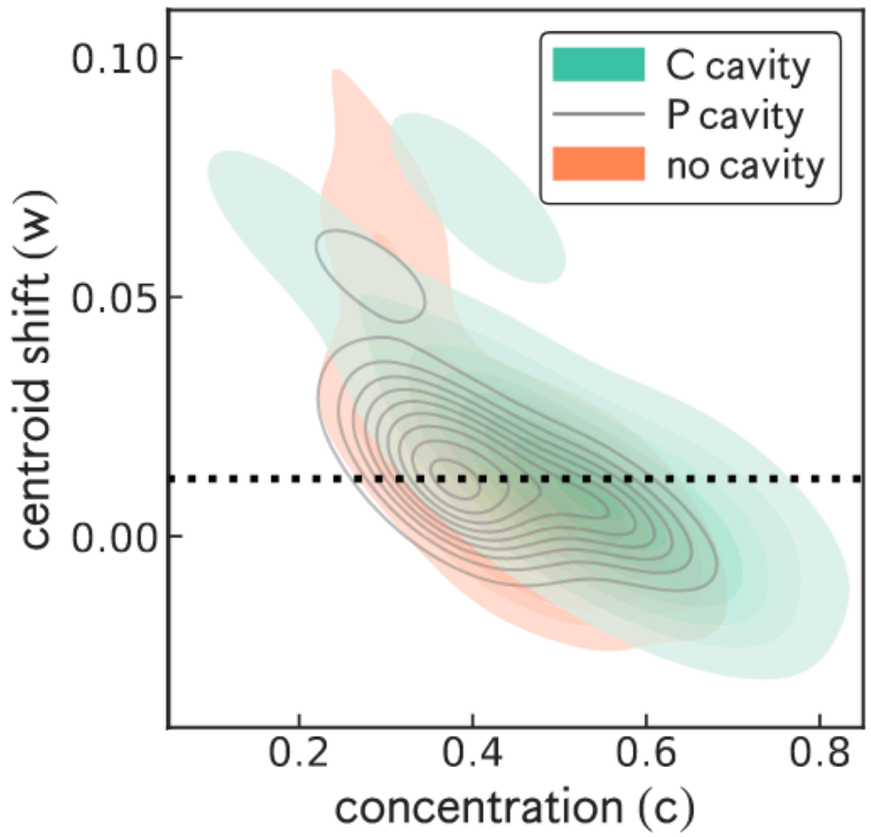

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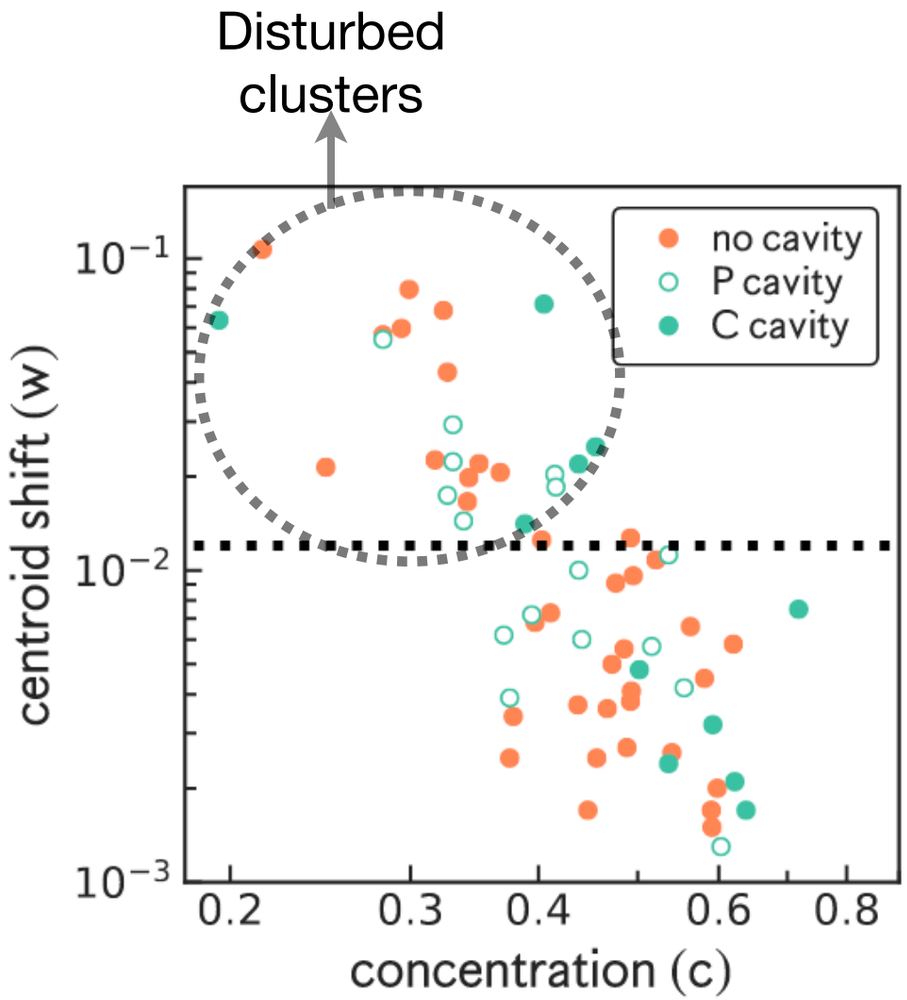
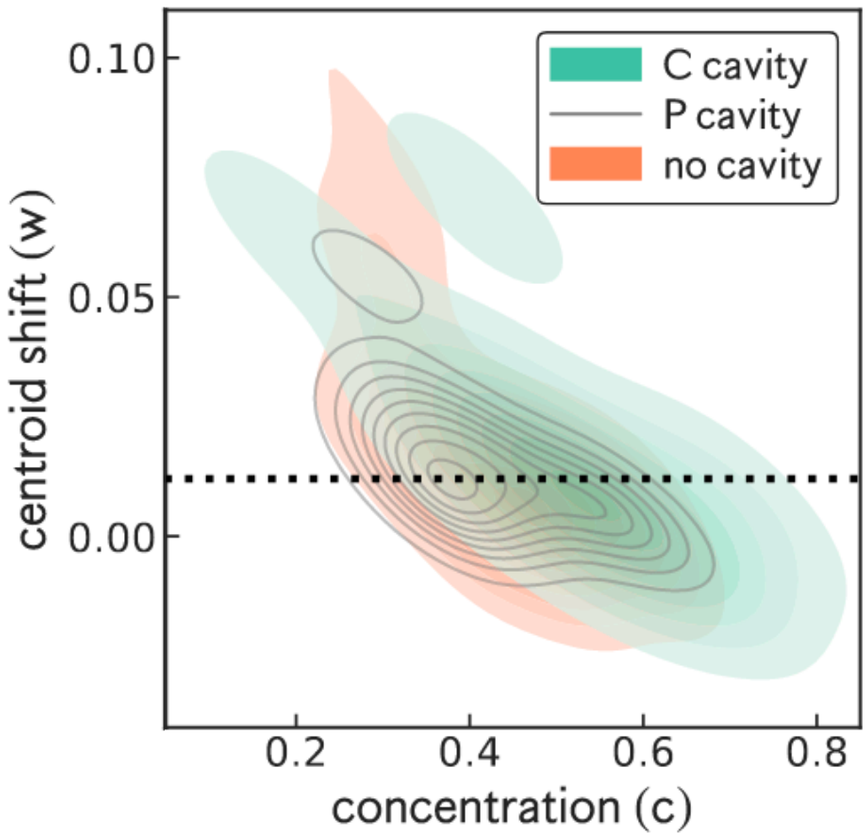
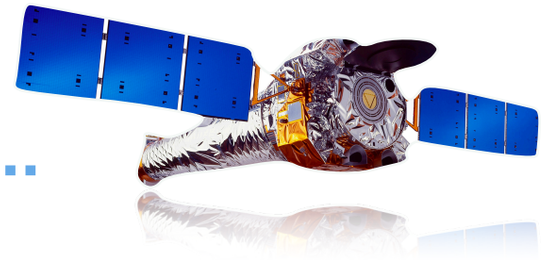




AGN Feedback in Planck Selected Clusters



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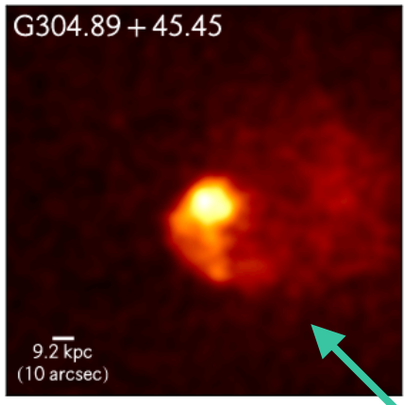
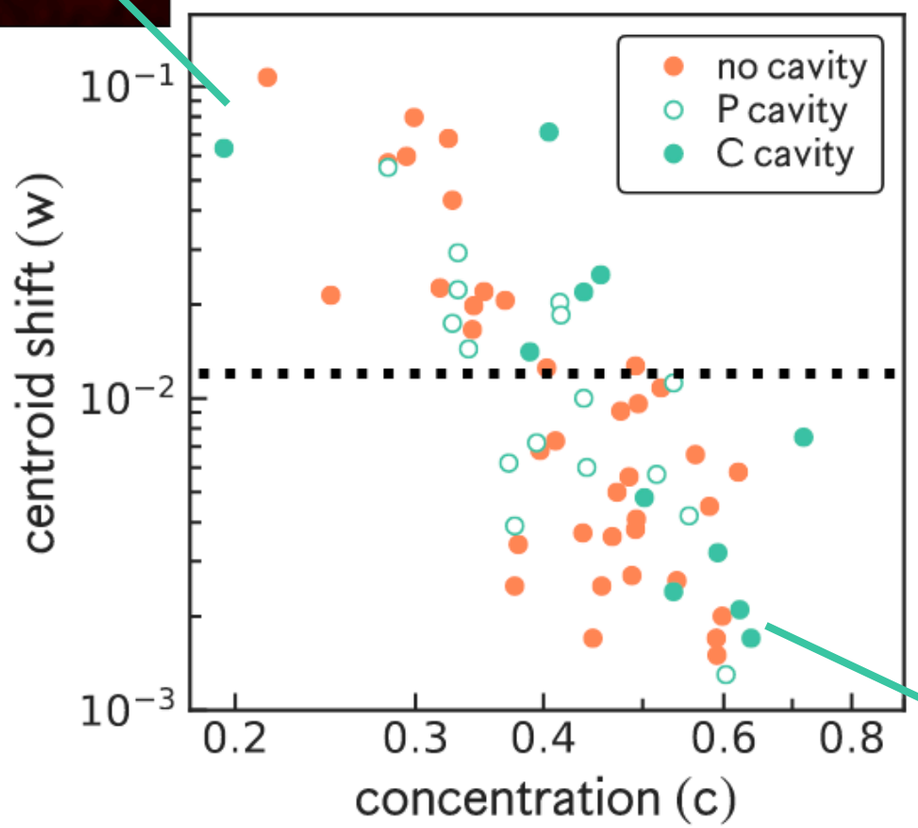
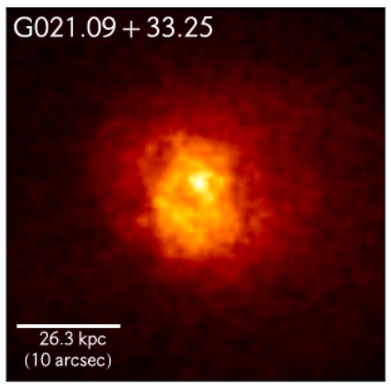
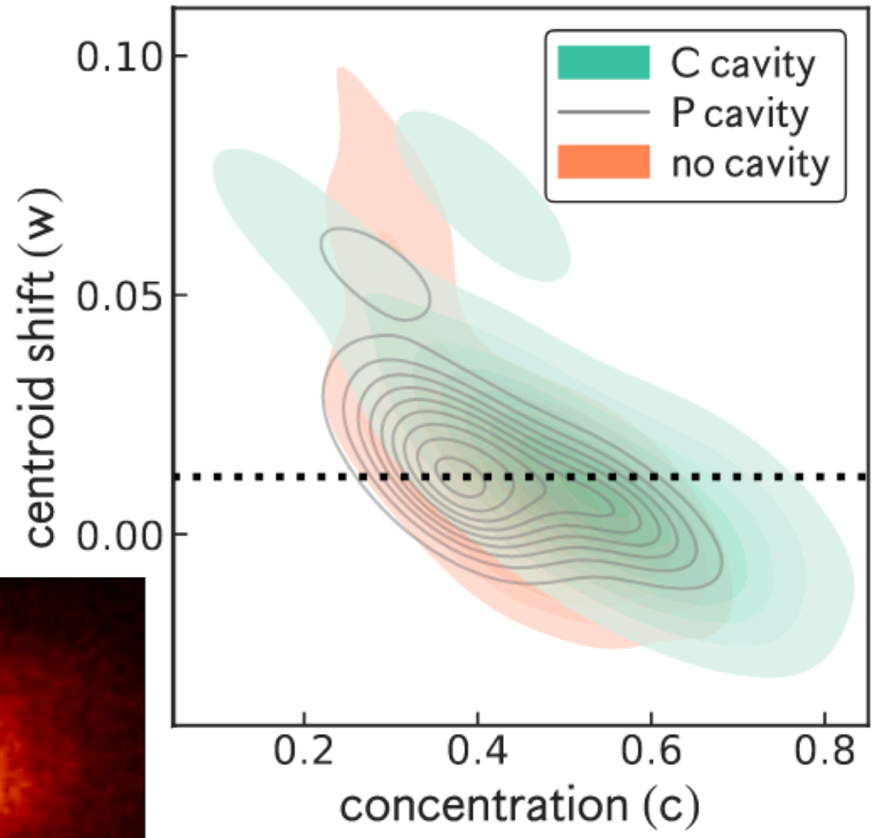






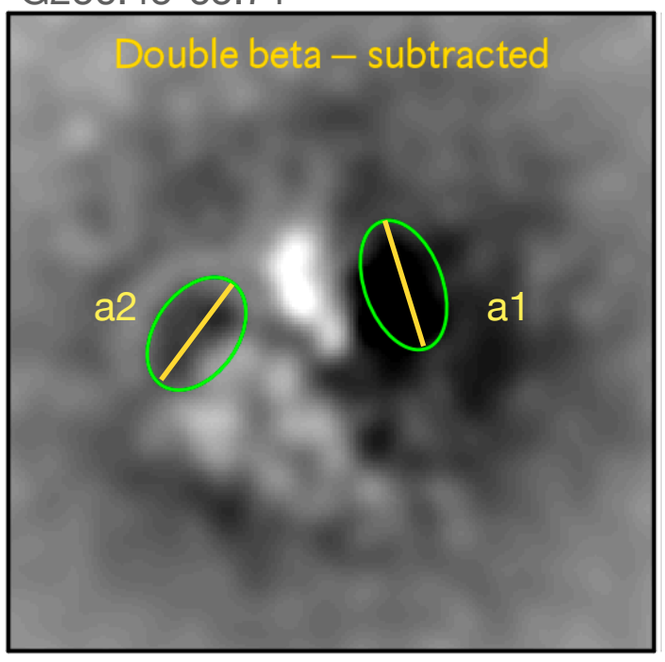


AGN Feedback in Planck Selected Clusters

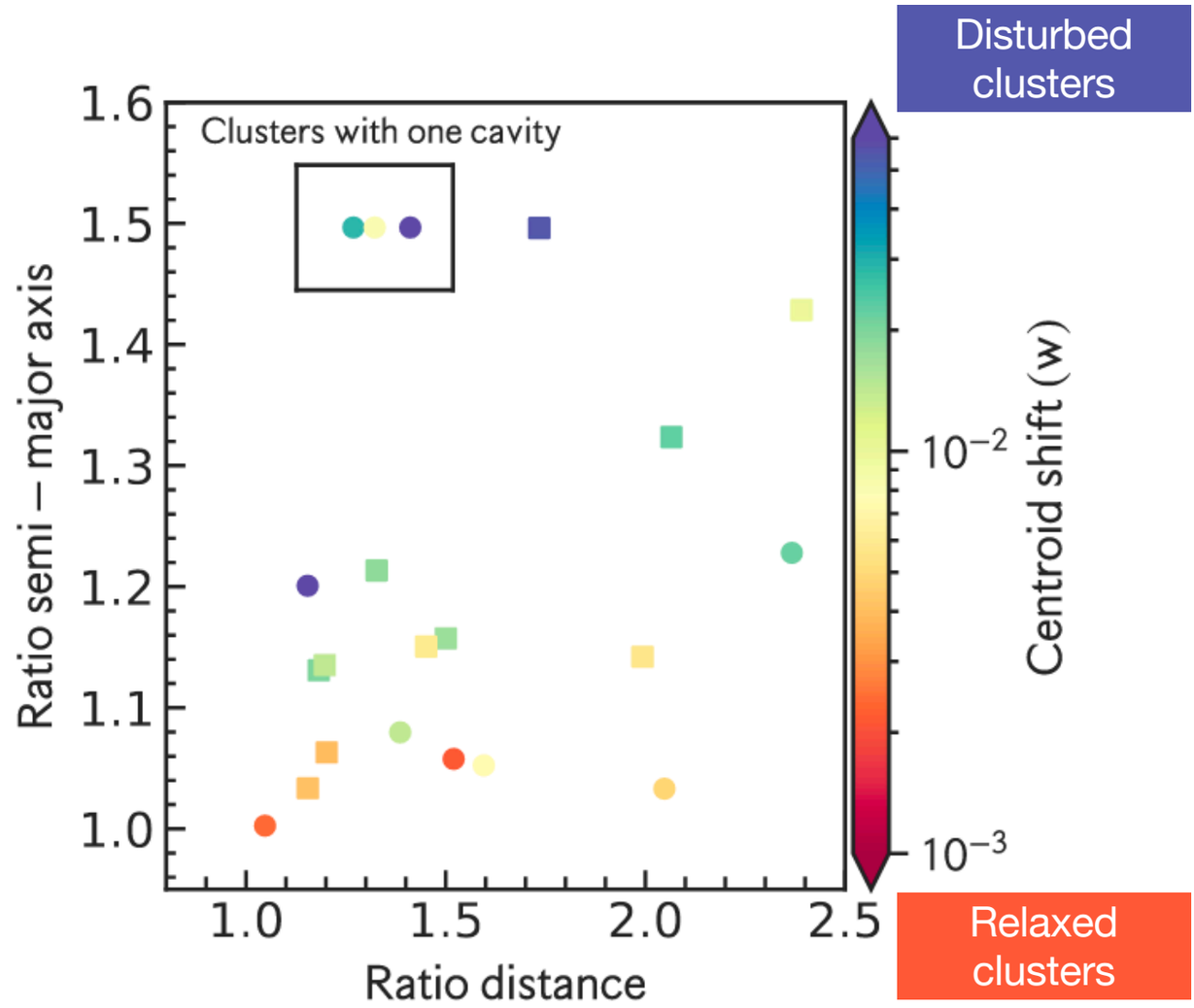
ICM effect on the X-ray cavities

Disturbed clusters show asymmetric cavities - ICM weather? (Simulations by Mendygral et al. 2012)

G256.45-65.71



$R_a = a_1 / a_2$



$R_D = D_1 / D_2$

AGN Feedback in Planck Selected Clusters

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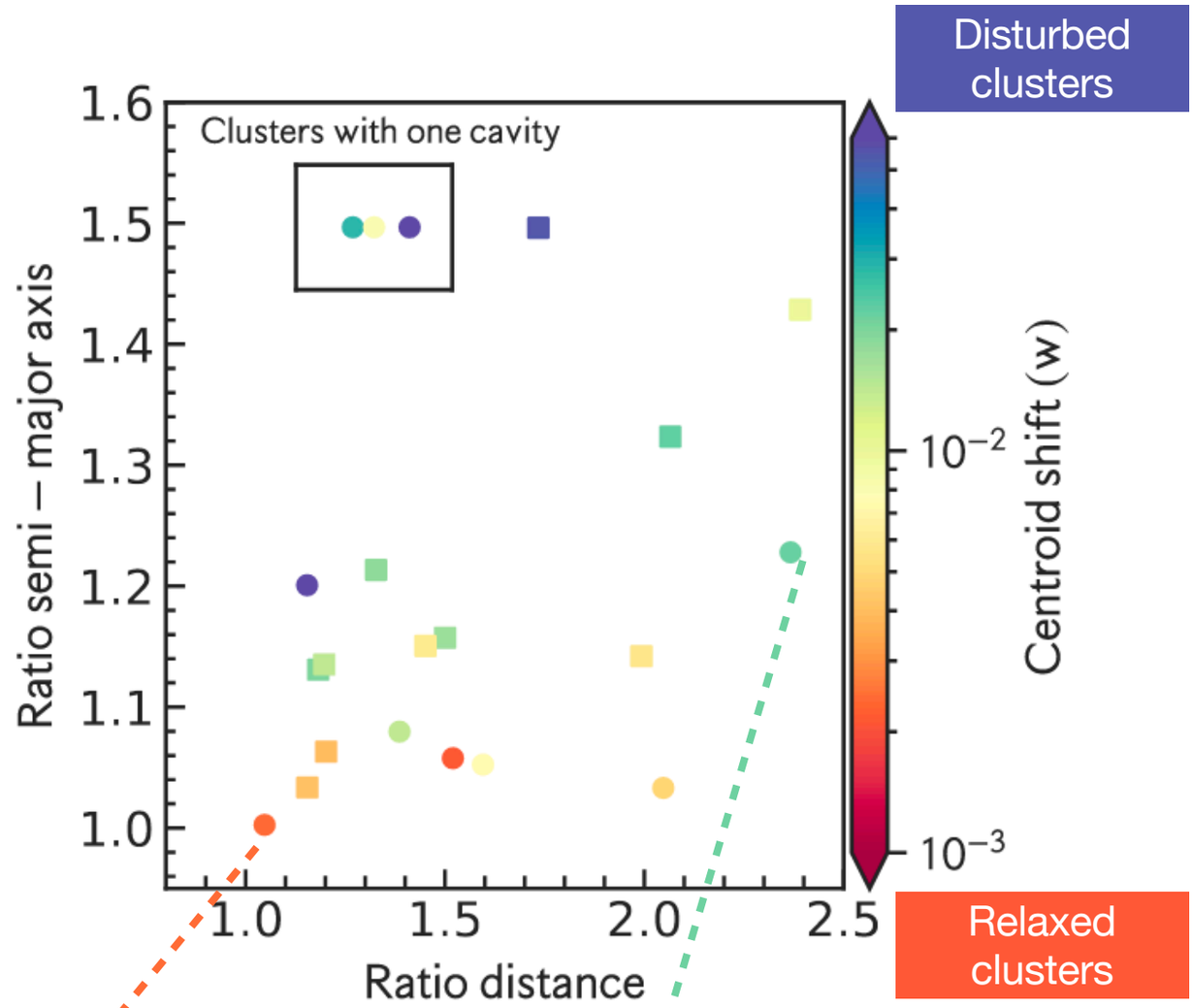

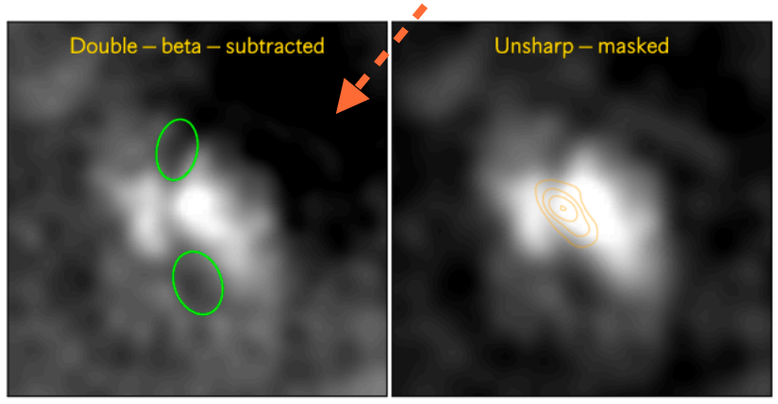

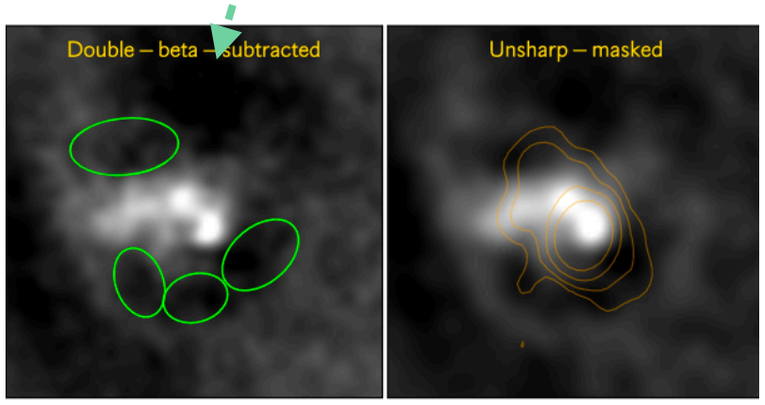

AGN Feedback in Planck Selected Clusters

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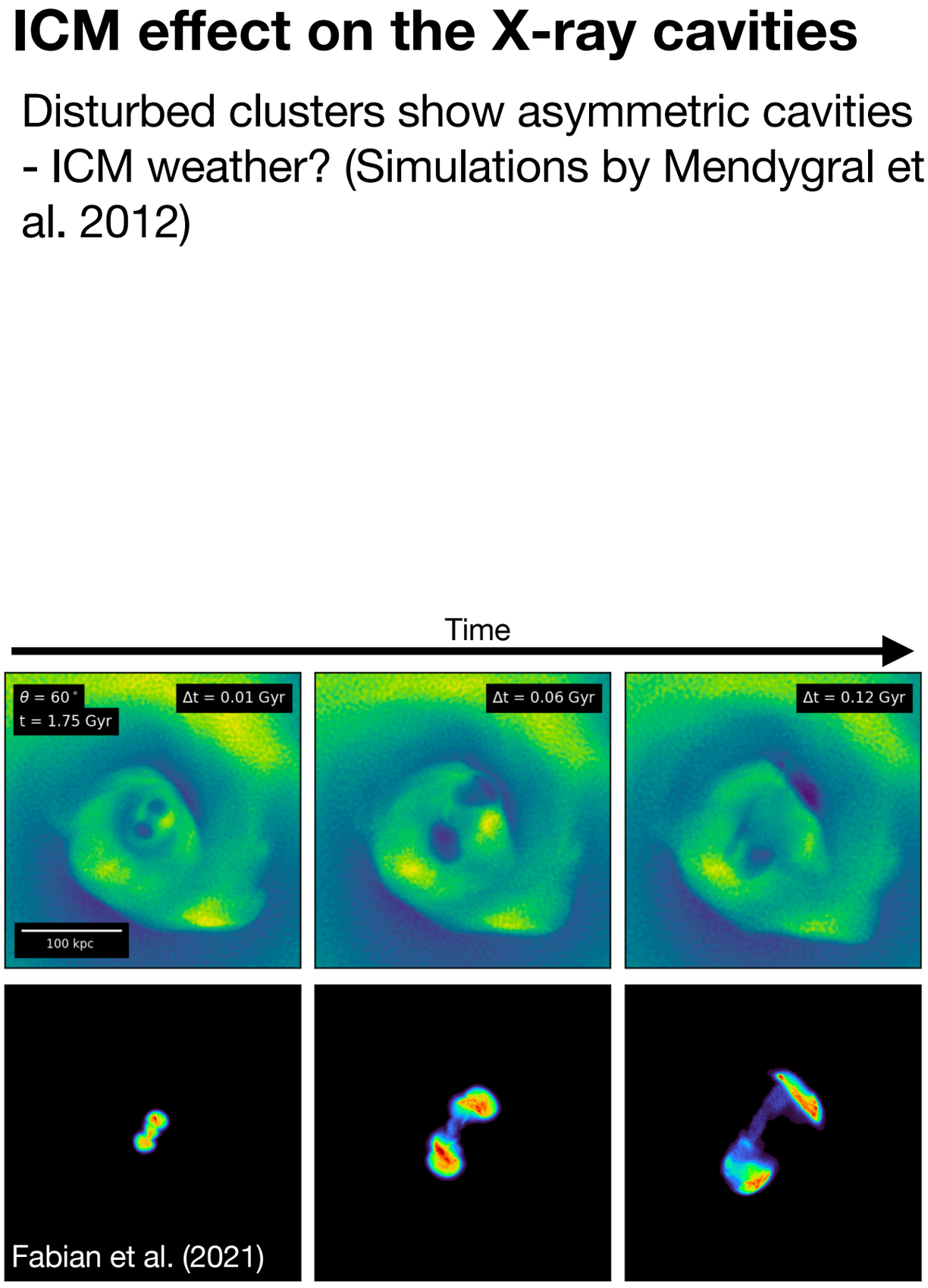
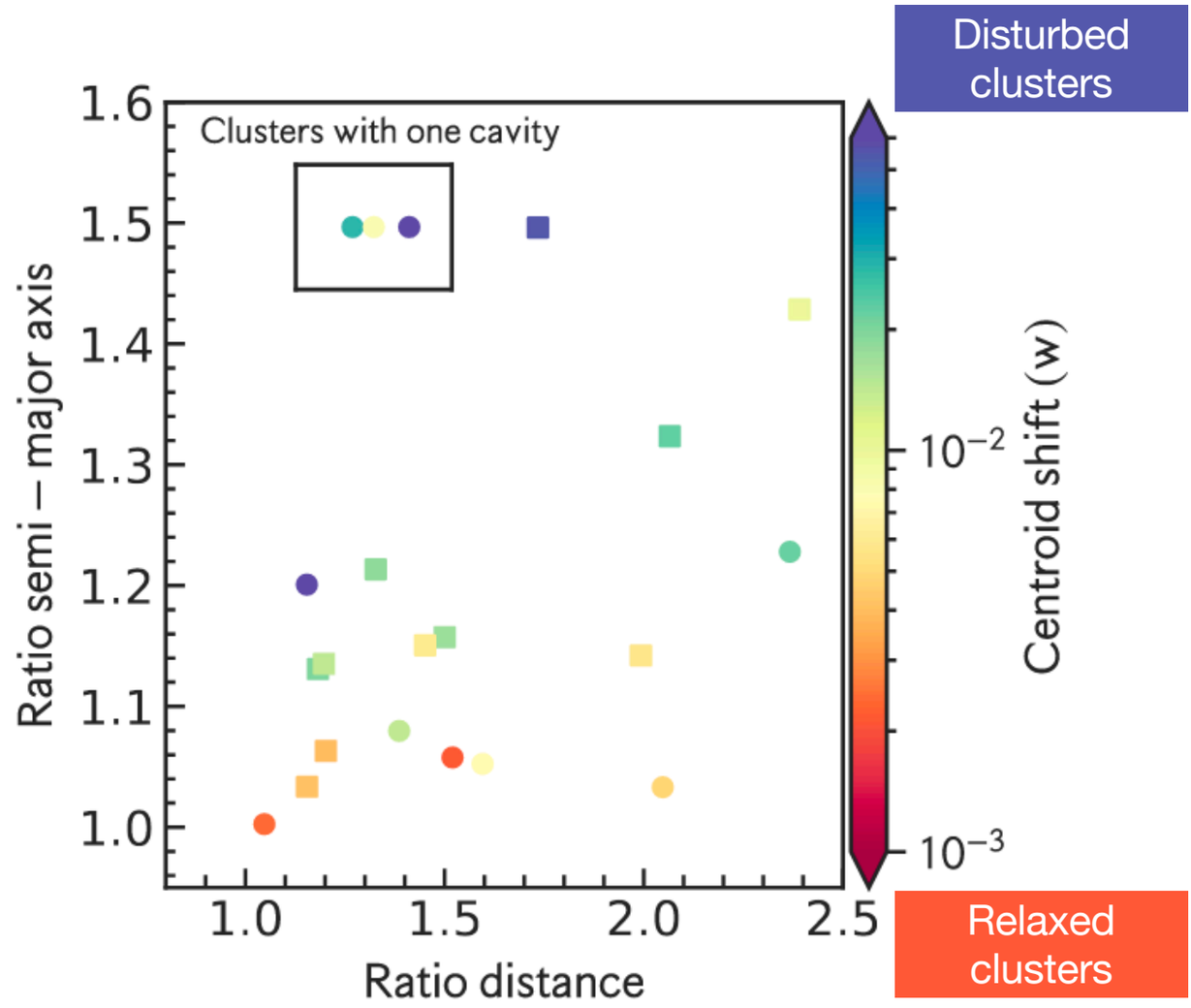
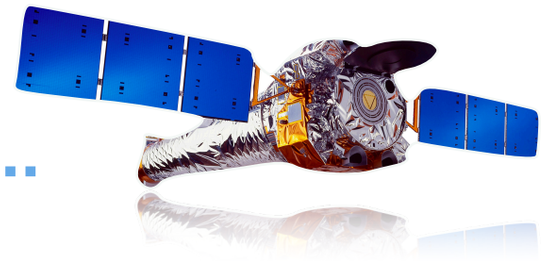




AGN Feedback in Planck Selected Clusters



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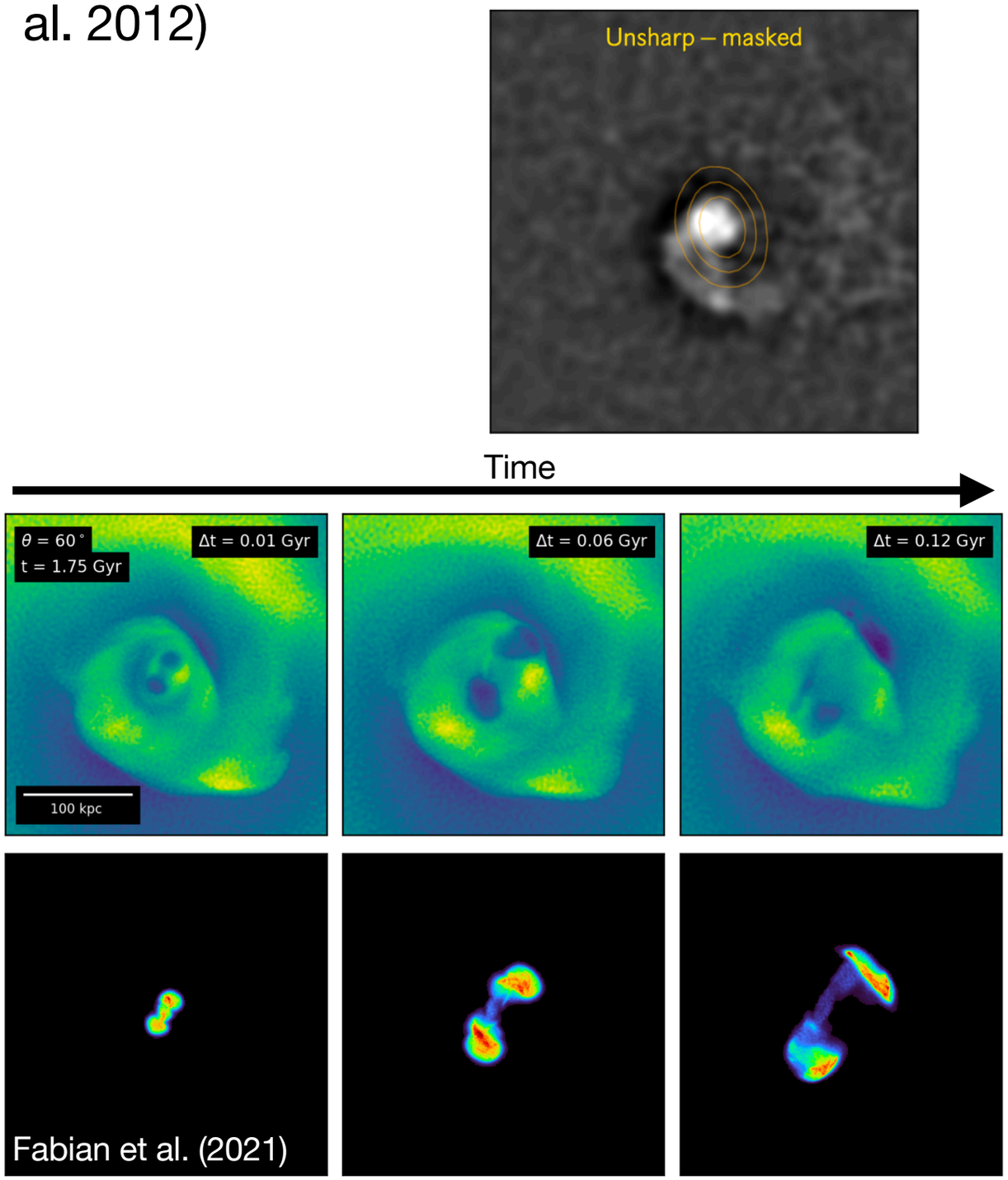
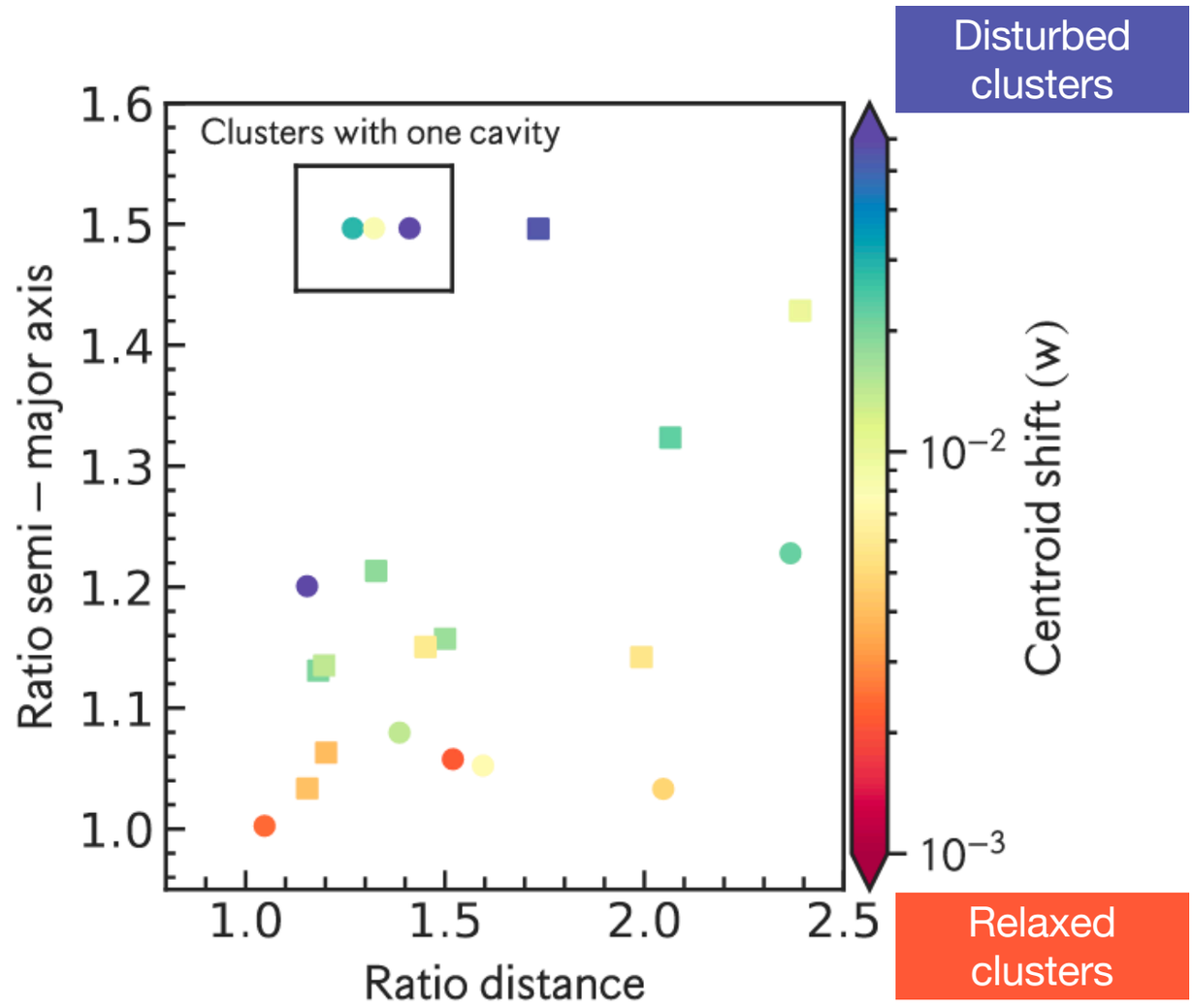
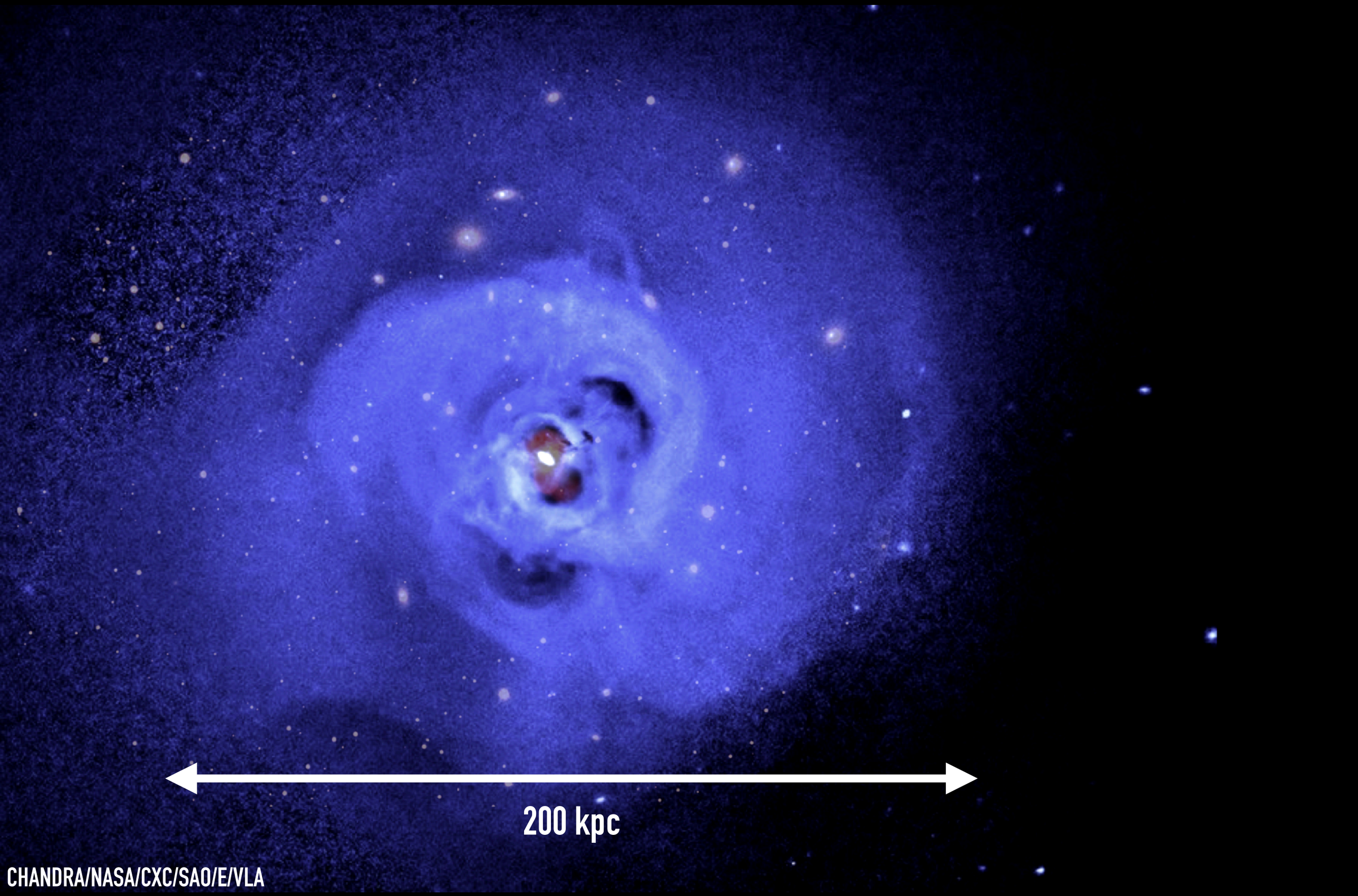




PERSEUS GALAXY CLUSTER



CHANDRA/NASA/CXC/SAO/E/VLA

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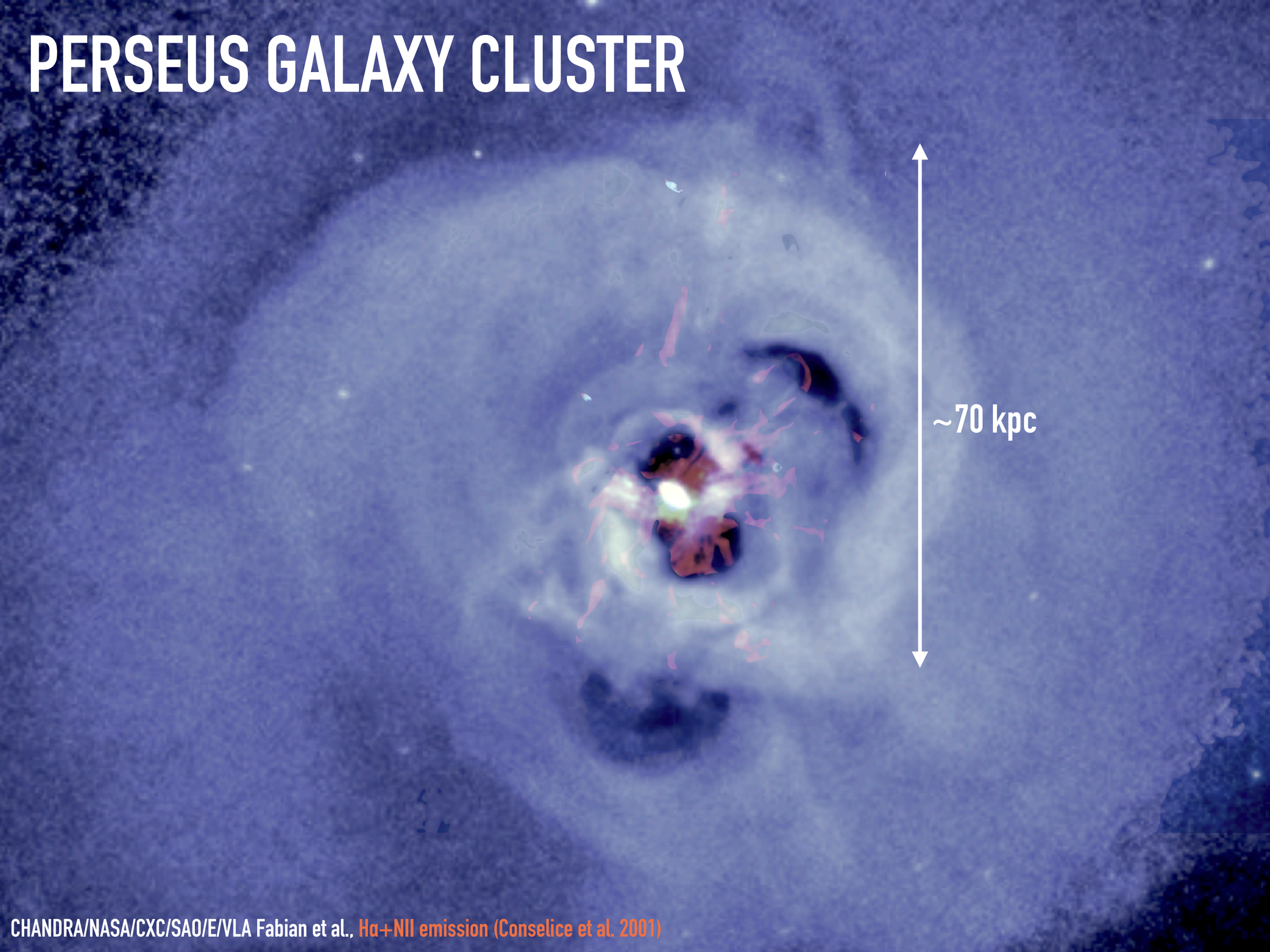
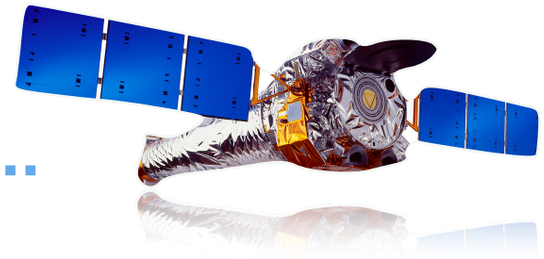
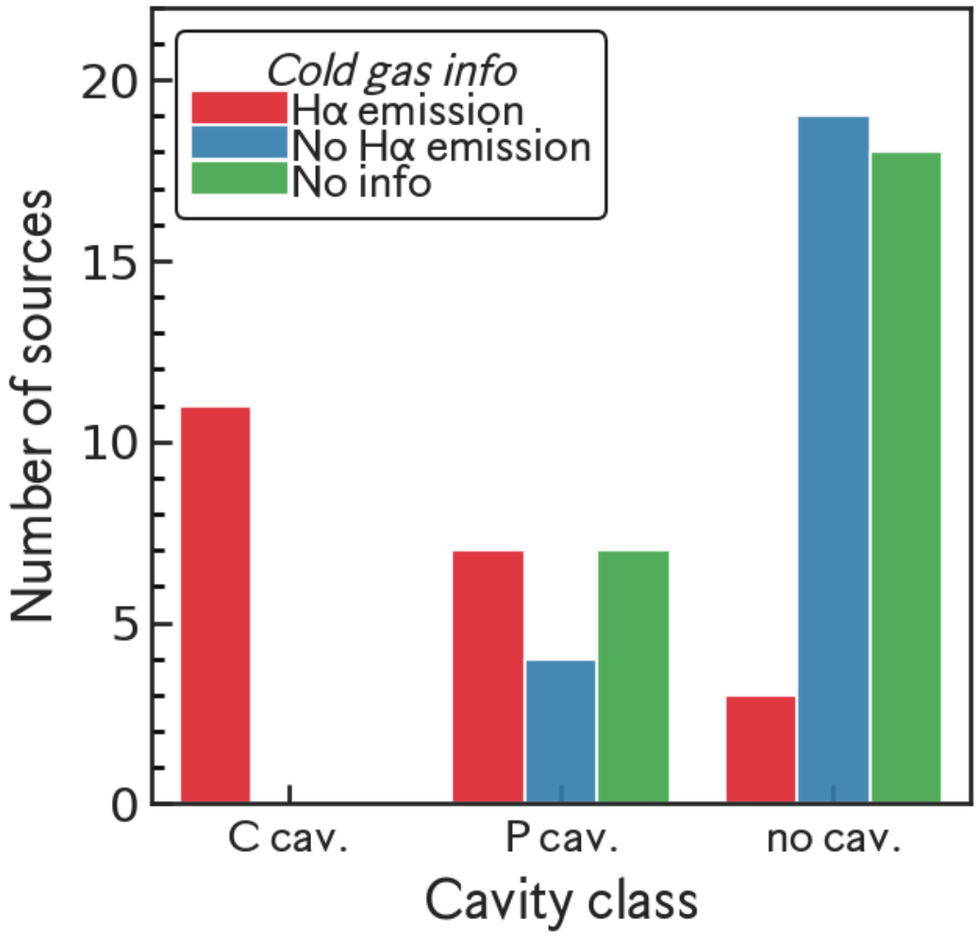


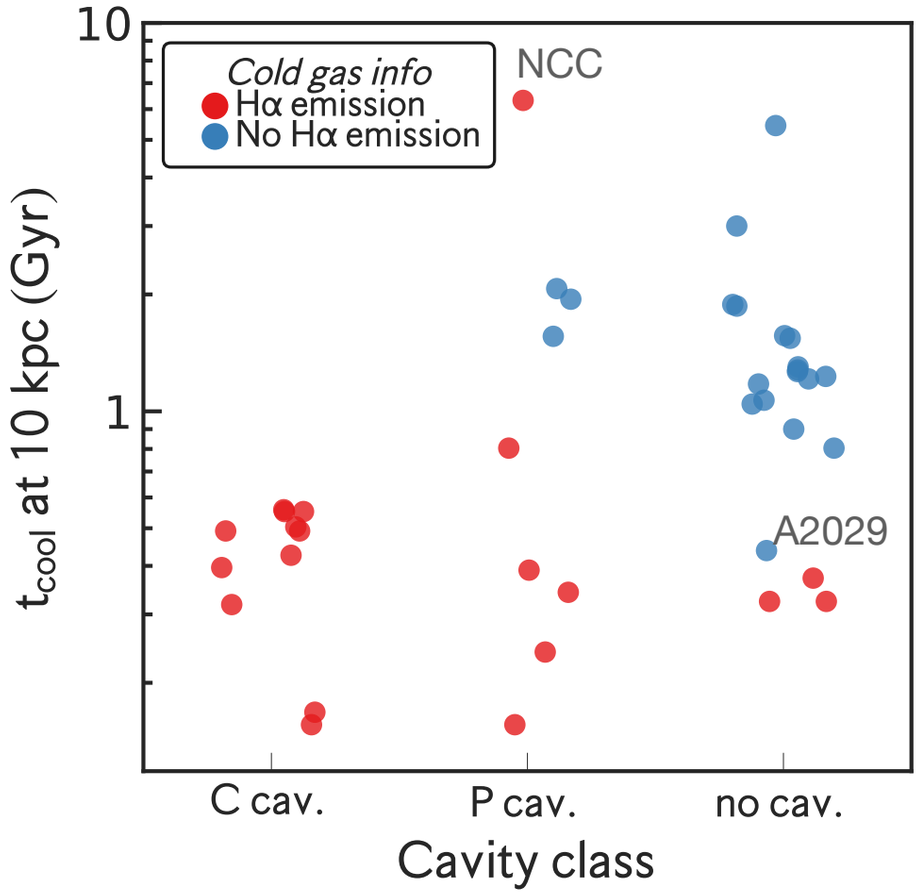
CHANDRA/NASA/CXC/SAO/E/VLA Fabian et al., Hα+NII emission (Conselice et al. 2001)

AGN Feedback in Planck Selected Clusters



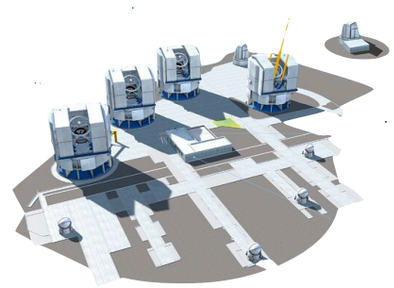
Are AGN bubbles crucial in the precipitation process?





- 11/11 clusters with “certain” cavities have cold gas
- 7/19 clusters with “potential” cavities have cold gas (including one NCC)
- 3/40 clusters without cavities have cold gas

AGN Feedback in Planck Selected Clusters



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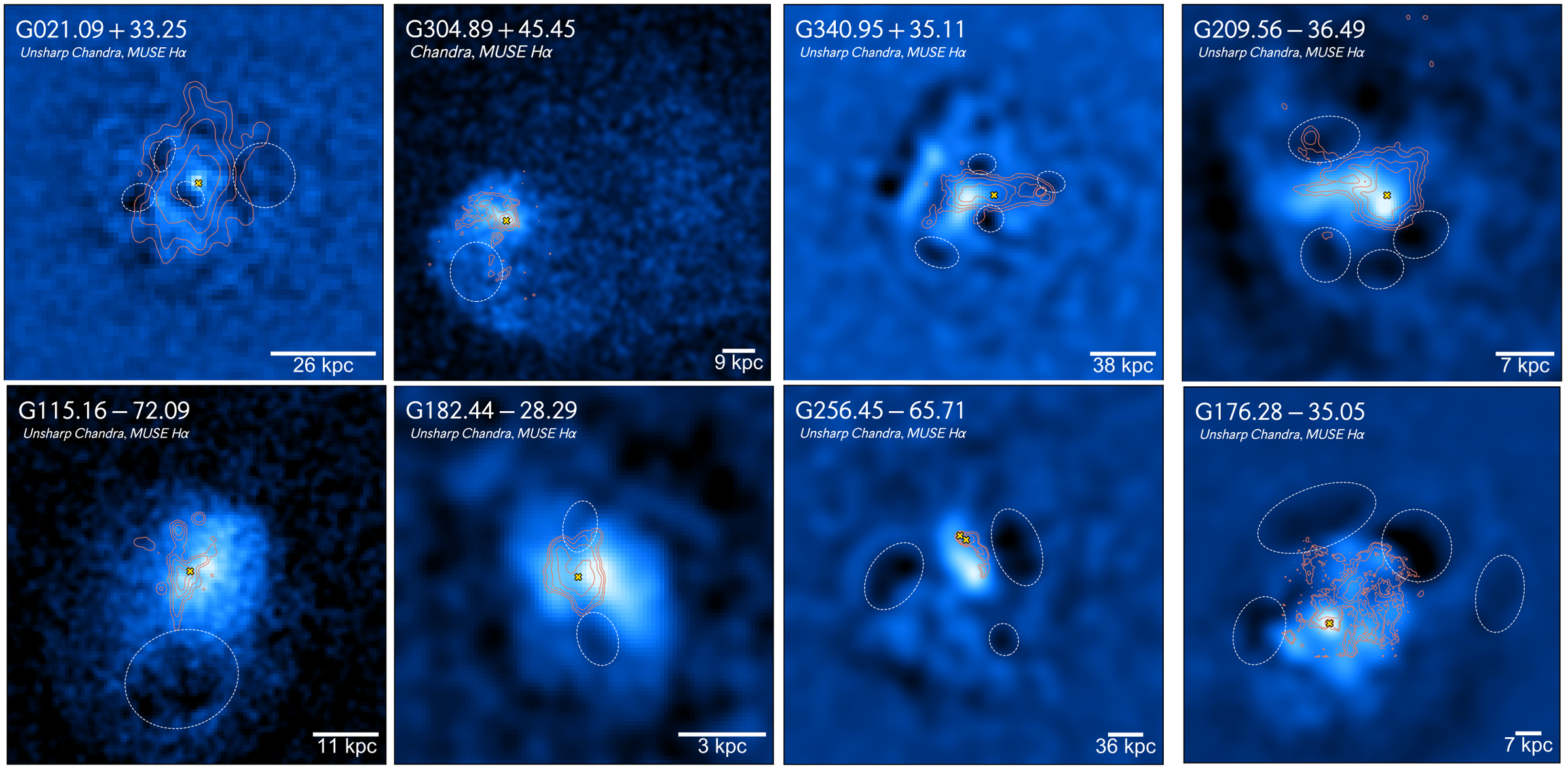
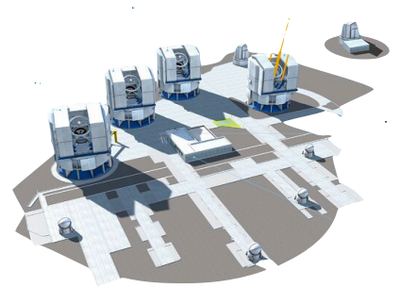


See also B. McNamara, H. Hu, Q. Yu talks!

AGN Feedback in Planck Selected Clusters



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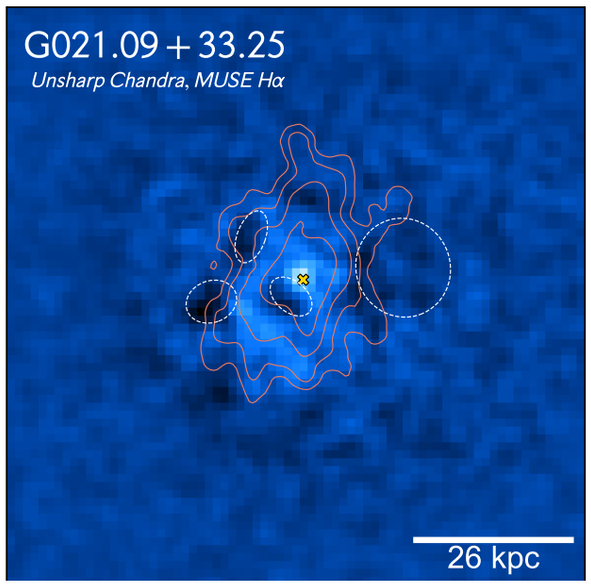
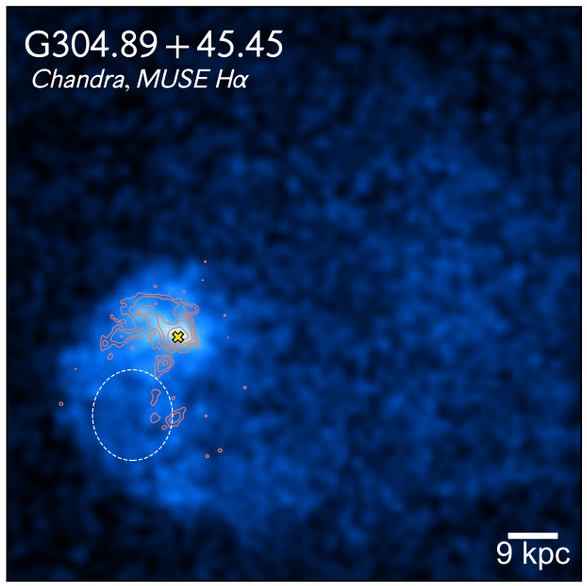
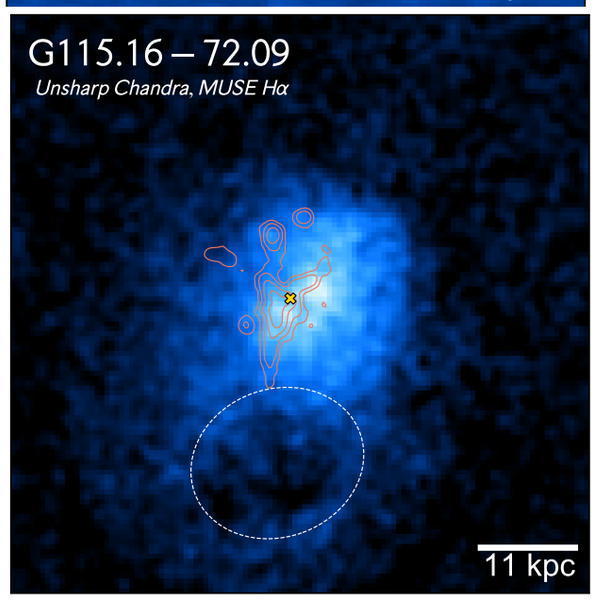
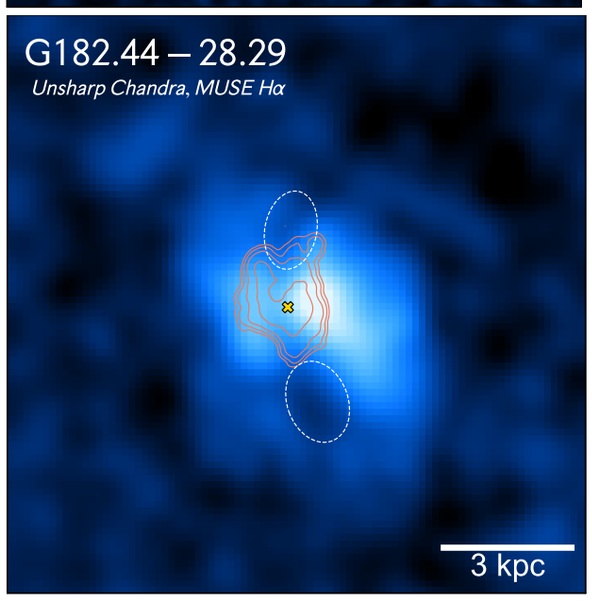
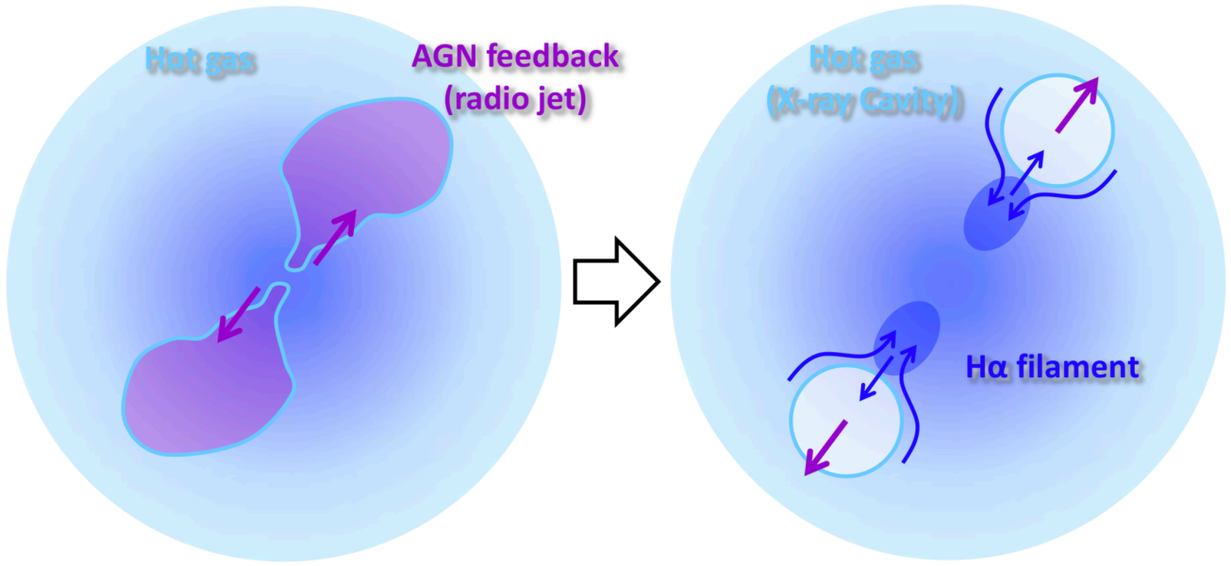








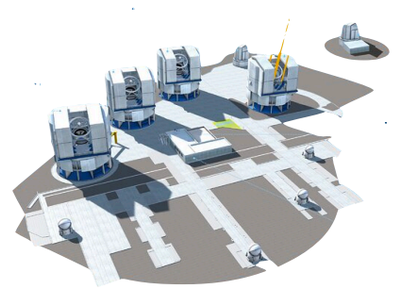
Uplifting mechanism likely the dominant mechanism of filament formation



In 9/15 clusters, filaments spatially correlate with the X-ray cavities

Revaz et al. (2008), Pope et al. (2010), Li et al. (2015, 2016, 2017), McNamara et al. (2016), Beckmann et al. (2019), Qiu et al. (2020, 2021)

AGN Feedback in Planck Selected Clusters



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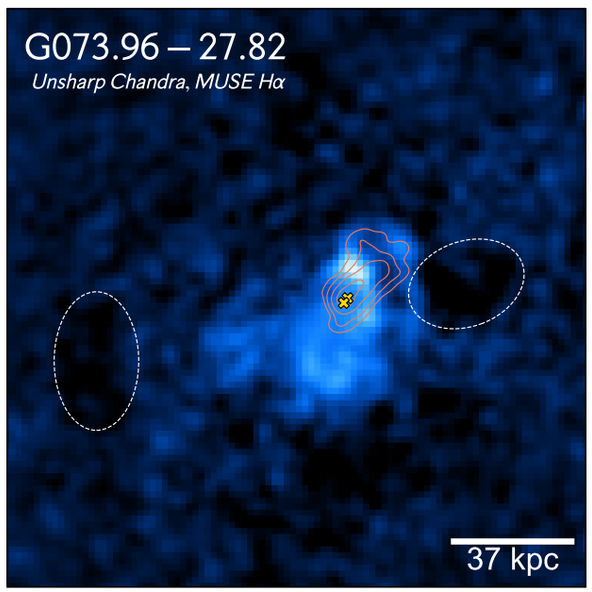

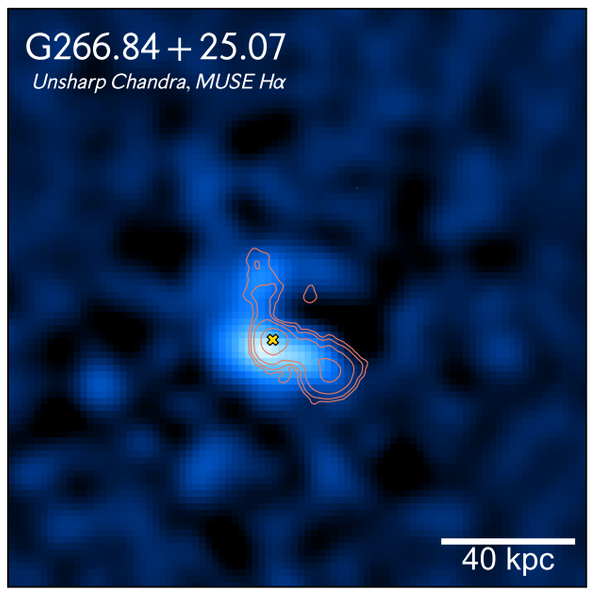

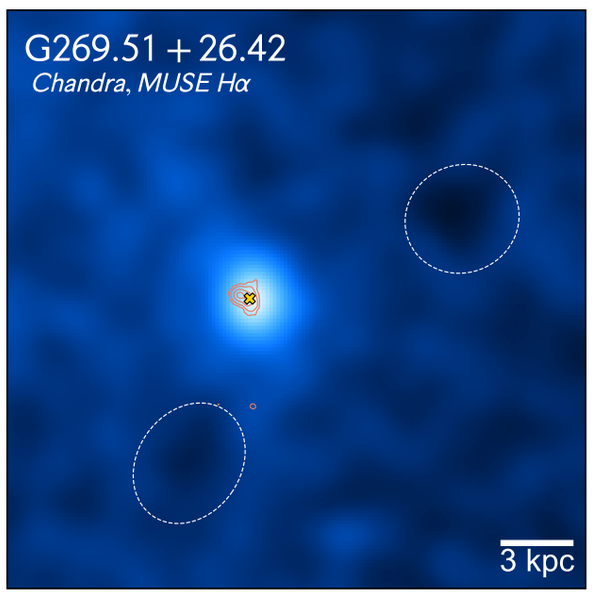

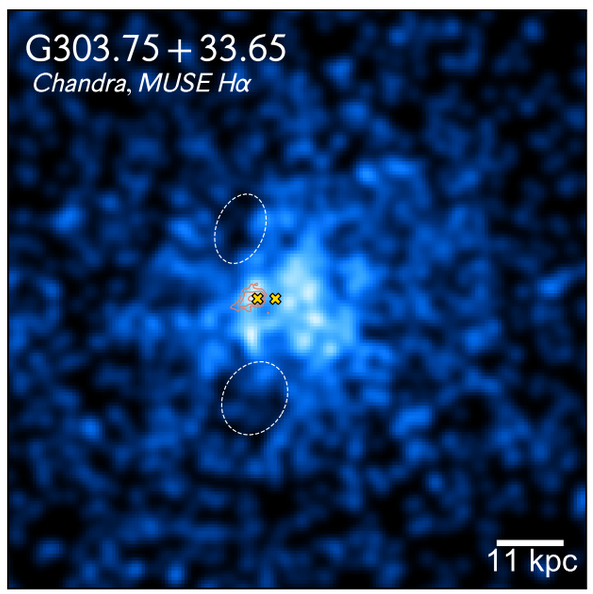

What about the rest of the cooling flow clusters?

- Another heating mechanism? (e.g. sloshing (Markevitch et al. 2001; Ritchie & Thomas 2002; ZuHone et al. 2010); cluster mergers (Roettiger et al. 1997; Gómez et al. 2002; ZuHone et al. 2010)
- Different timescales for dissipation of X-ray cavities and the Halpha filaments?
- A low number of counts?
- Projection effects?

Take home message

- The detection fraction of X-ray cavities is nearly the same across the cosmic time, suggesting an involution of the AGN feedback cycle.

- Cavities are located in a large variety of dynamical state clusters, from merging, sloshing to relaxed clusters.

- ICM weather may affect the distribution and morphology of the X-ray bubbles.

- AGN feedback plays an important role in cold gas precipitation by uplifting mechanisms and increasing the turbulence of the gas.

Thank you

NASA/STScI / SDSS J103842.59+484917.7