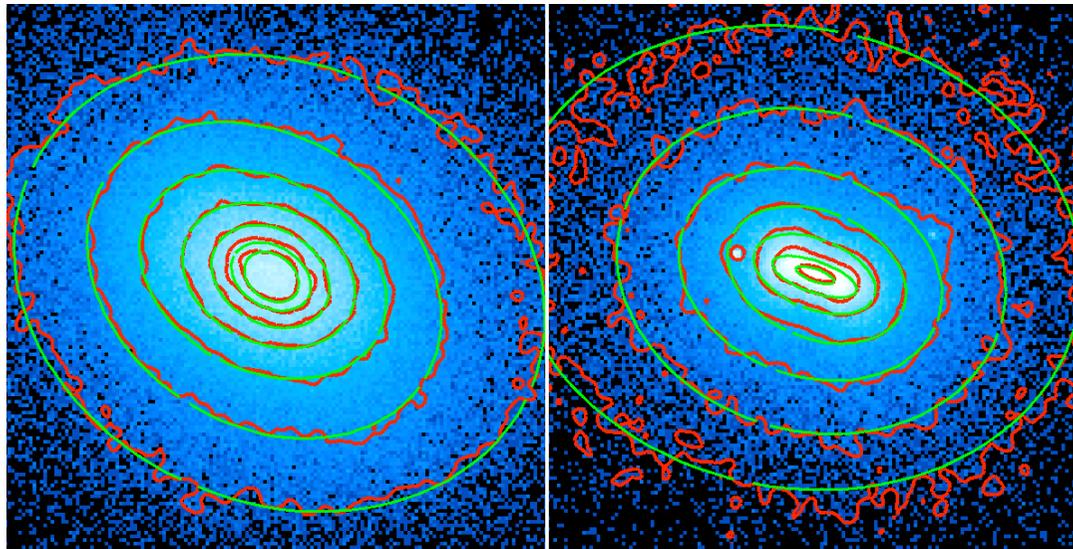


Gas Shape as a Probe of Dissipation in the Intracluster Medium



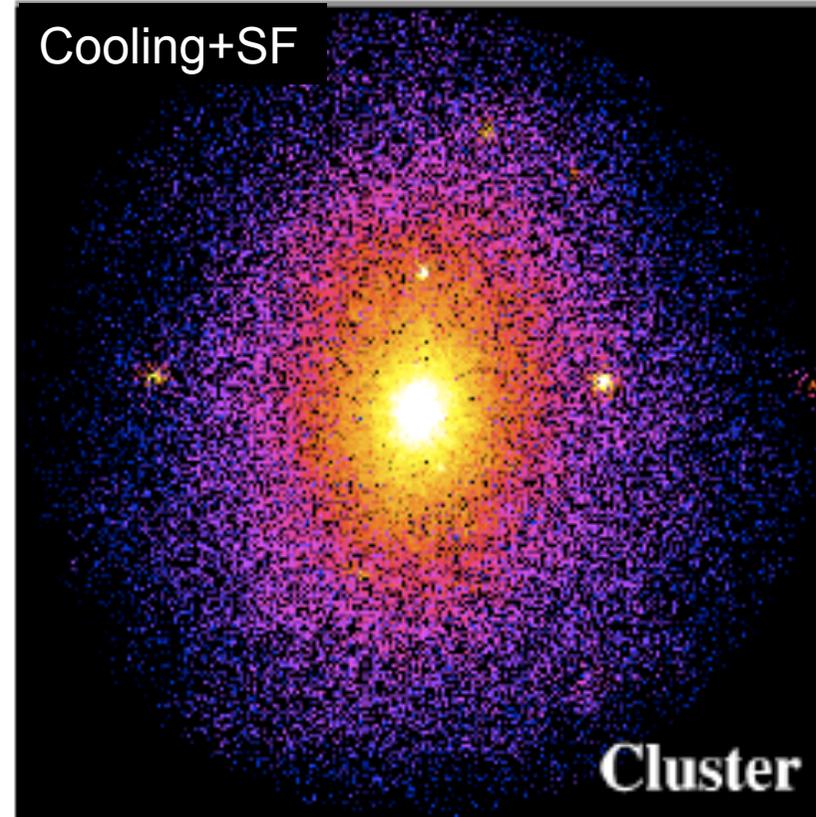
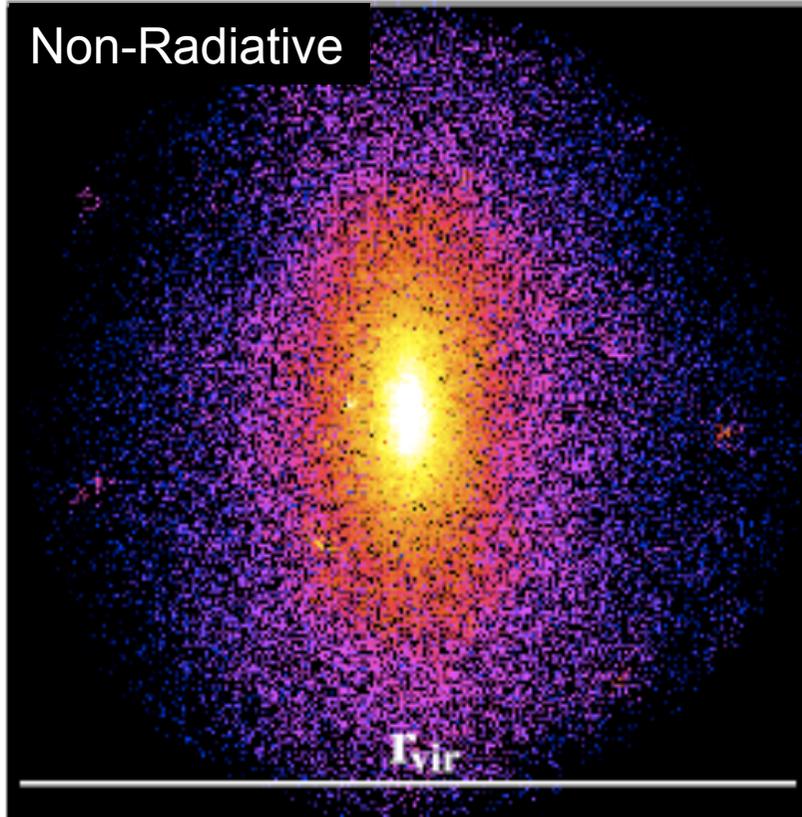
Erwin Lau (UChicago)

Andrey Kravtsov (KICP, UChicago),

Daisuke Nagai (Yale),

Andrew Zentner (Pittsburgh), Alexey Vikhlinin (CfA)

Effects of Dissipation on Halo Shapes

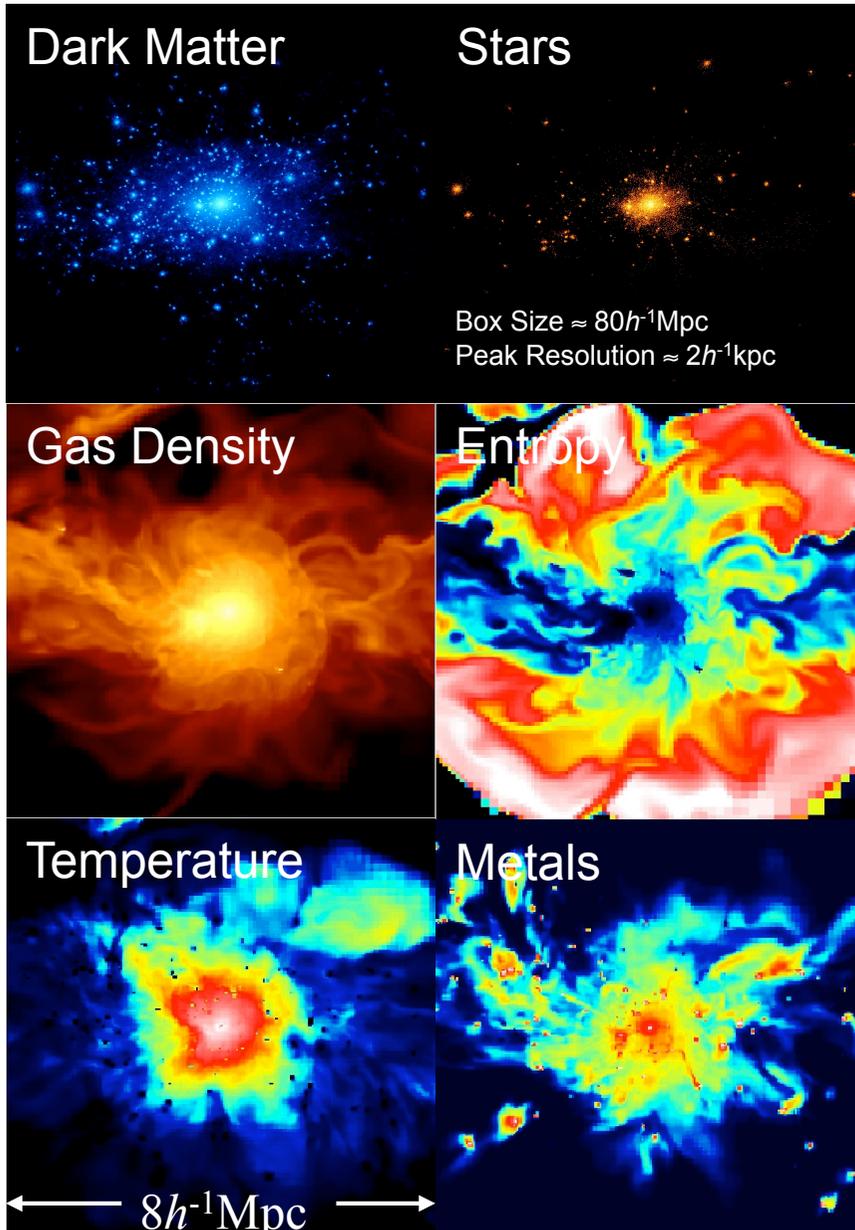


Kazantzidis et al (2004)

Dark matter halo more spherical due to baryon condensation

e.g., Katz & Gunn (1991), Evrard et al (1994), Dubinski (1994), Springel et al (2004), Hayashi et al (2007), Tissera et al (2009)

Cluster Simulations with ART



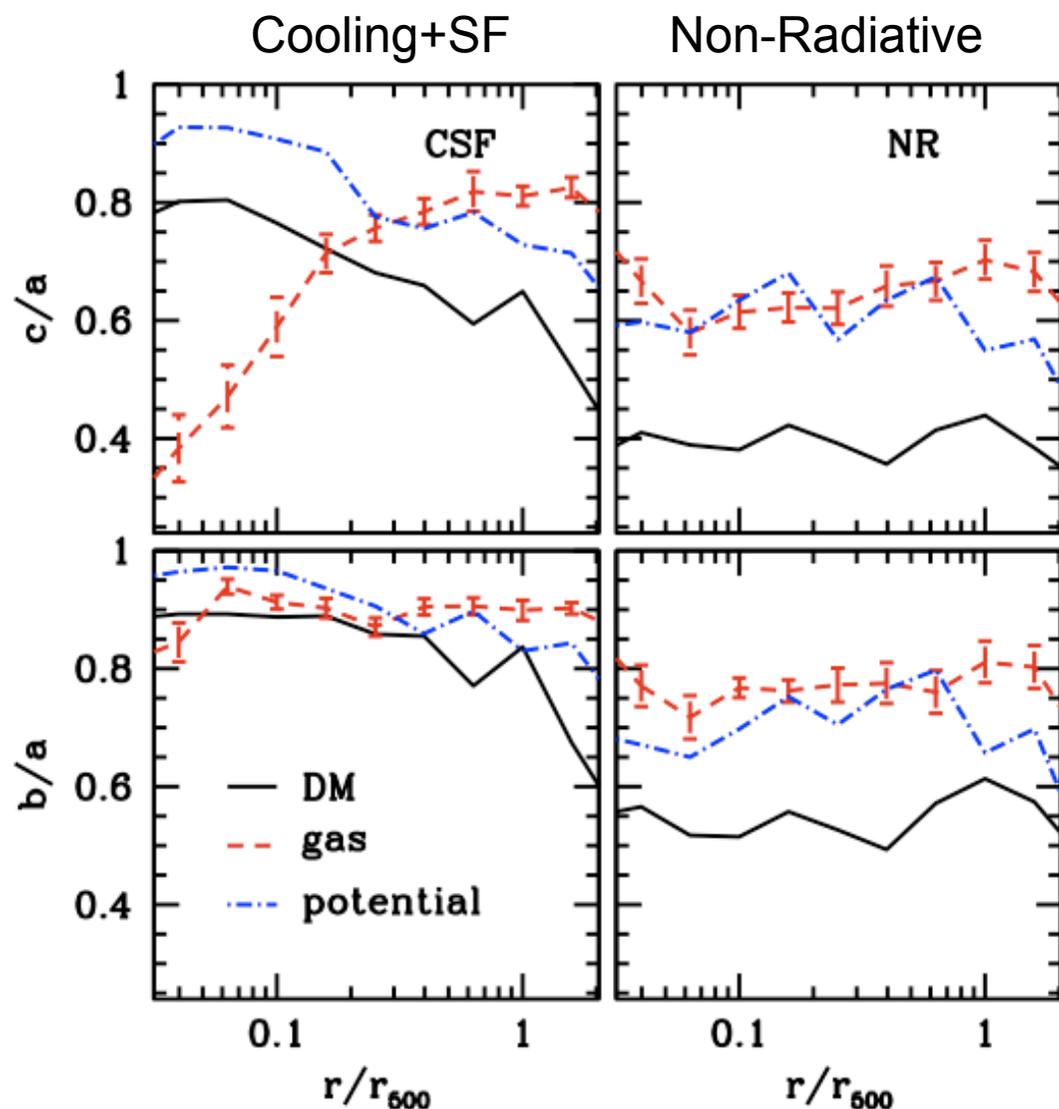
N-body+Gasdynamics with ART code

- Collisionless dynamics of DM and stars
- Gasdynamics: Eulerian Adaptive Mesh Refinement
- Radiative cooling and heating of gas:
metallicity dependent net cooling/heating rates
- Star Formation using the Kennicutt (1998) recipe
- Thermal stellar feedback
- Metal enrichment by SNIa
- No AGN feedback, thermal conduction, cosmic-rays, magnetic field, & physical viscosity

Cluster Simulations & Samples

- High-resolution allows us to actually simulate clusters of galaxies
- Study the effects of galaxy formation
 - ▶ Sample of 16 clusters in ΛCDM model
 - ▶ Two sets of runs with **cooling & SF (CSF)** and with **non-radiative (NR)** gasdynamics

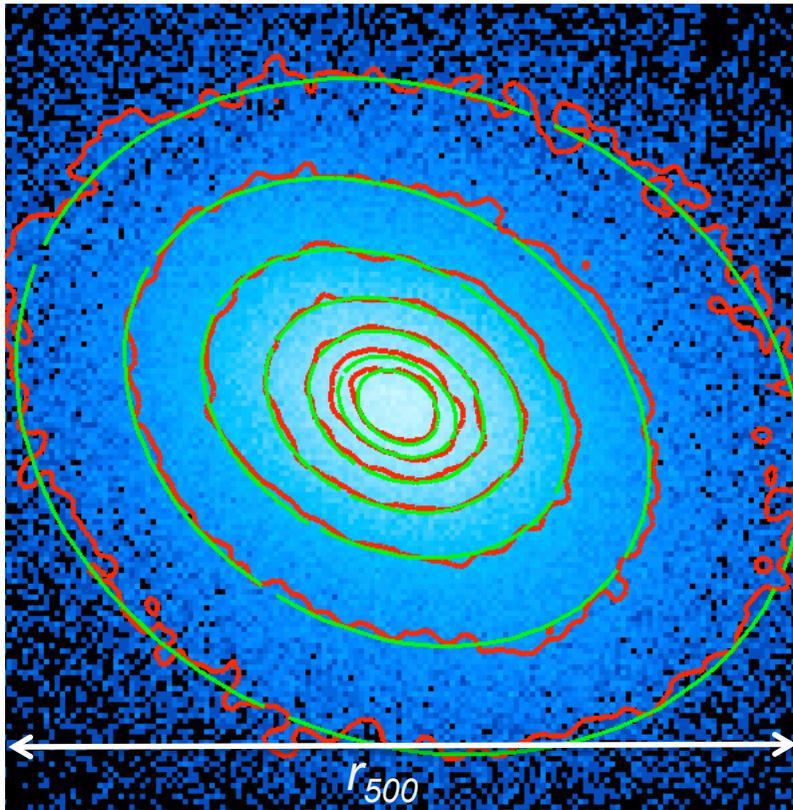
Effects of Dissipation on ICM Shape



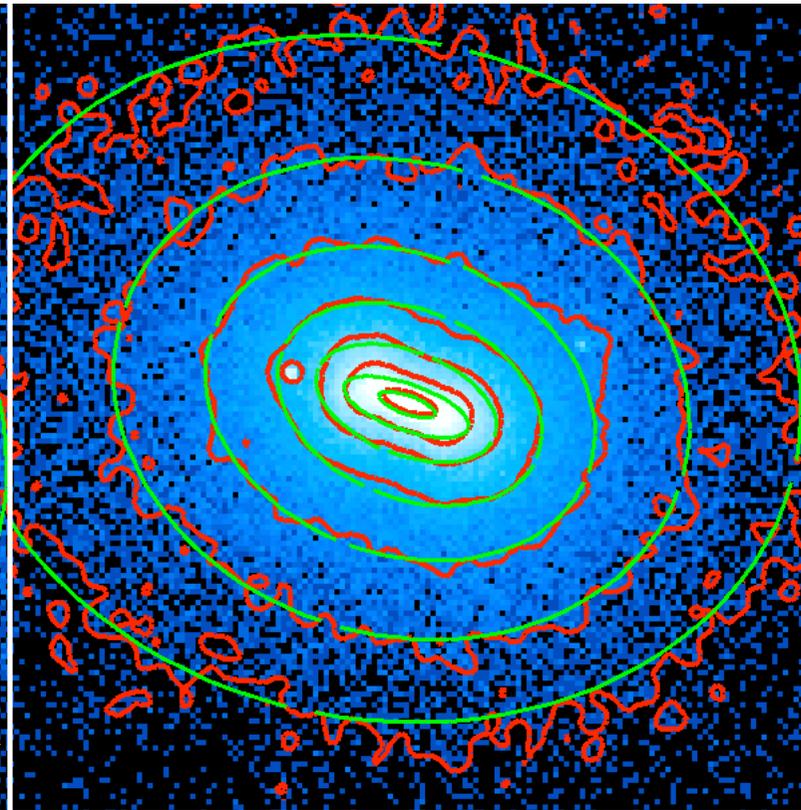
- Cooling: gas more spherical in the outer regions similar to DM
- Gas is more oblate in the inner region
- Gas shape follows isopotential surfaces outside core
(c.f., e.g. Buote & Tsai 94, 95, 96)

Mock Chandra Maps

Non-Radiative

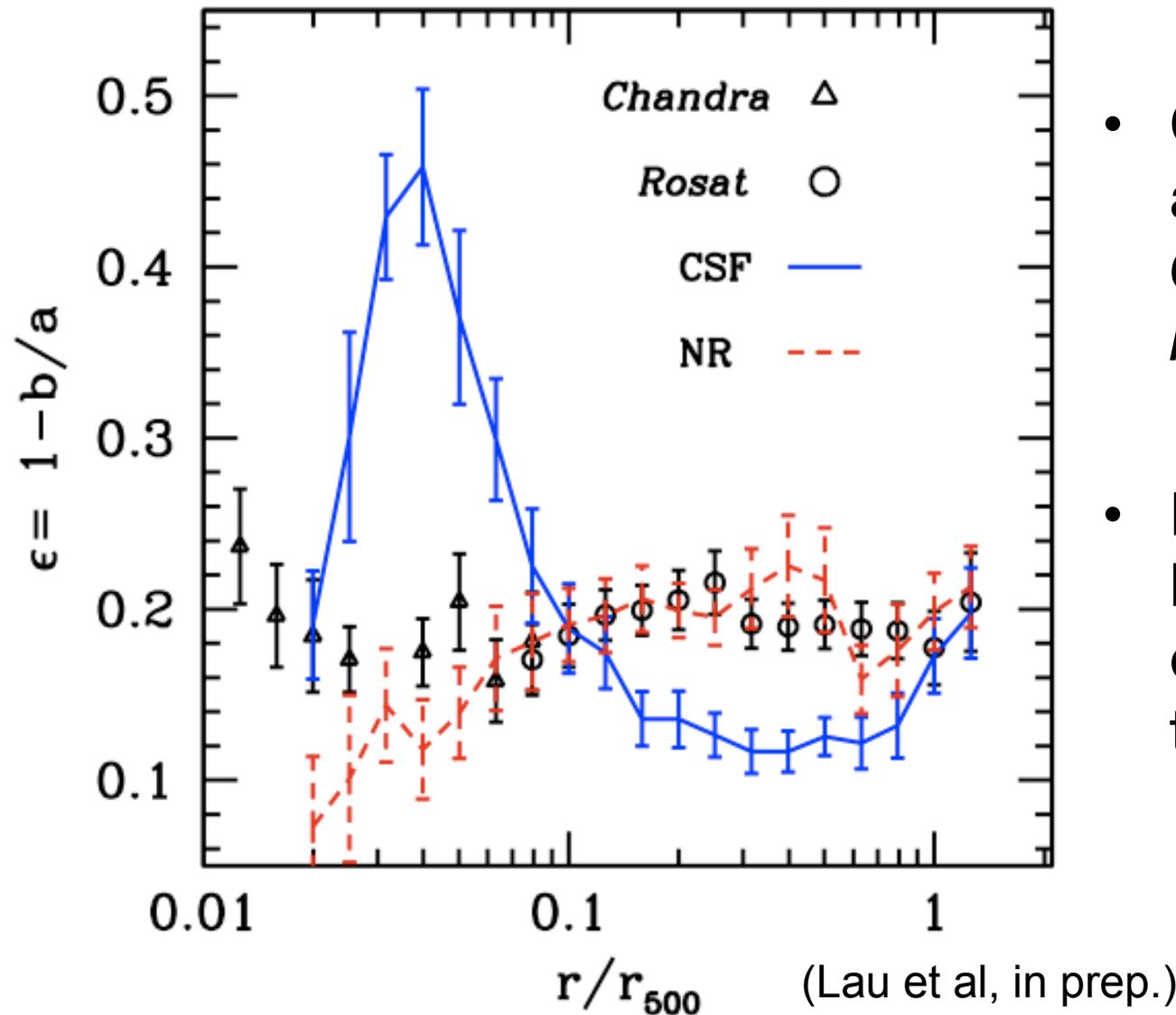


Cooling+SF



- Dissipation makes observable signature in X-ray map

Comparing Ellipticity Profiles

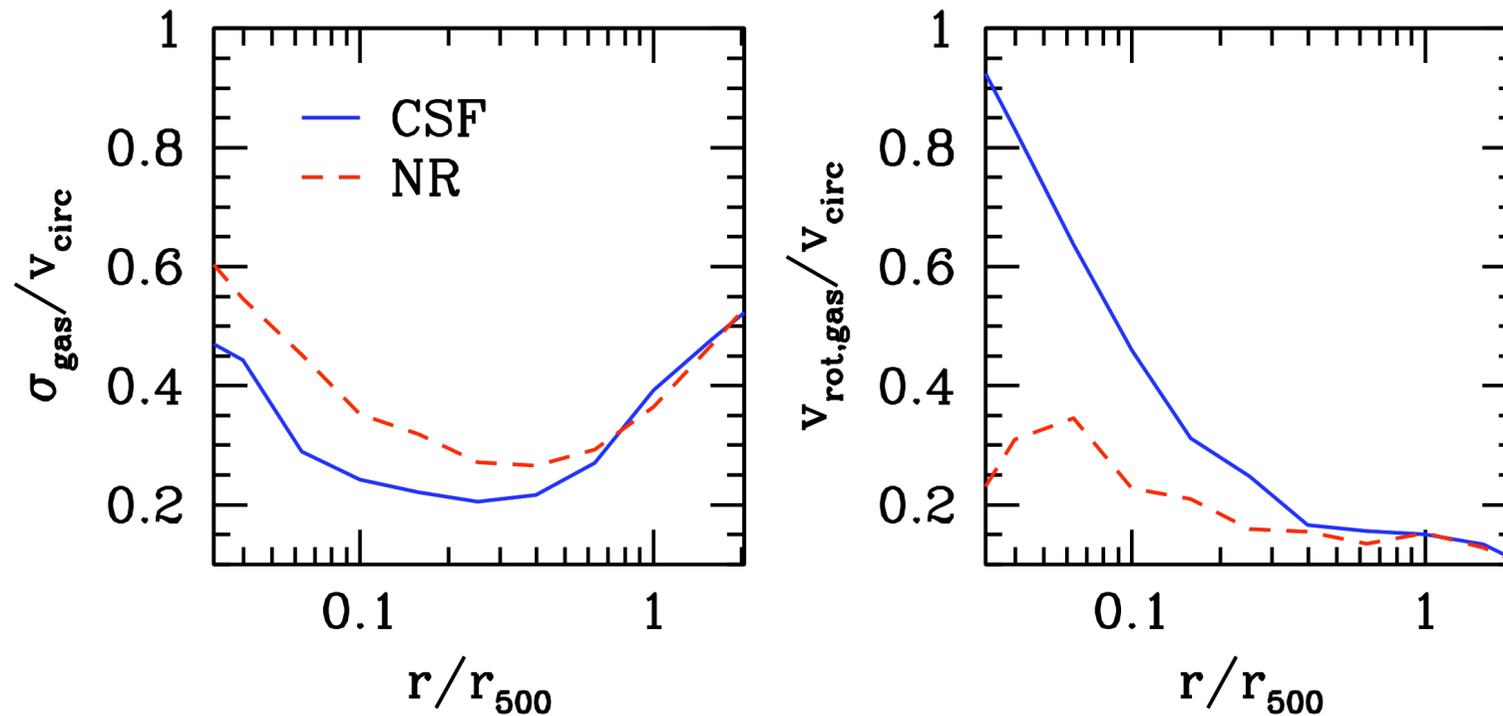


- Comparing against 25 $z < 0.1$ *Chandra* and *Rosat* Clusters
- NR ellipticities a better match to observations than CSF

Summary

- Dissipation makes gas:
 - more spherical outside core
 - more oblate inside core
- Mock X-ray ellipticity profiles are able to show above effects
- Comparison against observations shows “overcooling” in CSF clusters
- Ellipticity profile constrains cluster physics

Difference between shapes of gas and potential



Gas motions causes difference between shapes of gas and potential