The Role of AGN Feedback in Strong Lensing Predictions

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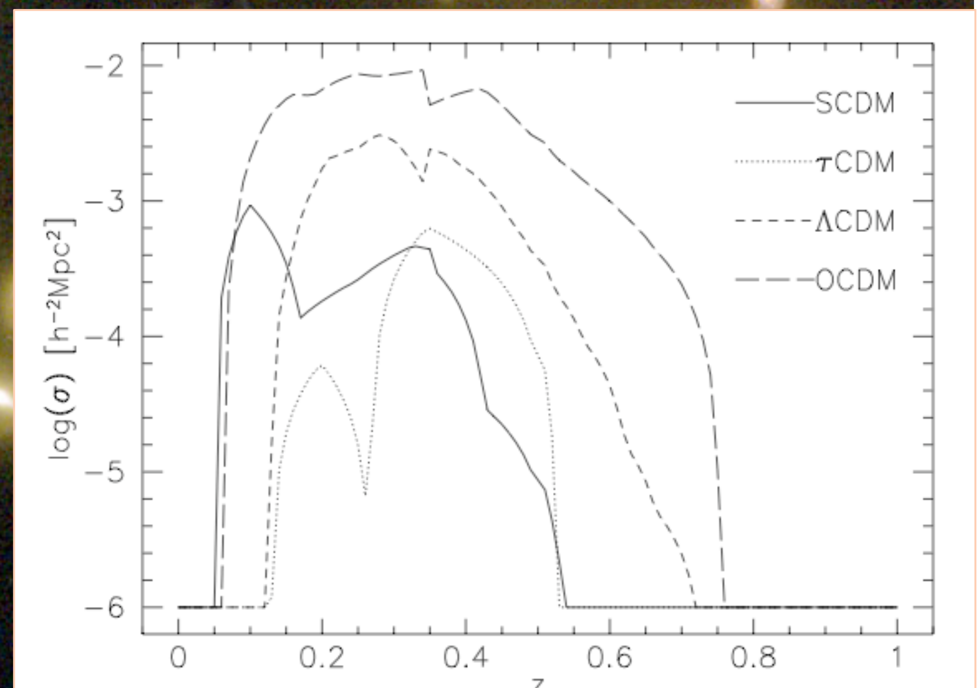
Giant Arcs

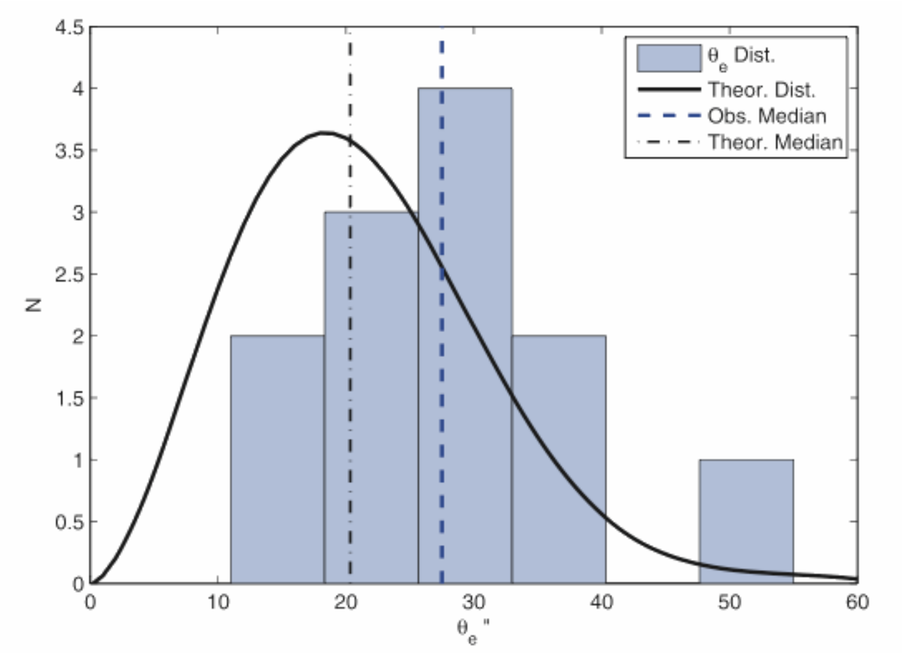
… and a niggling problem with LCDM

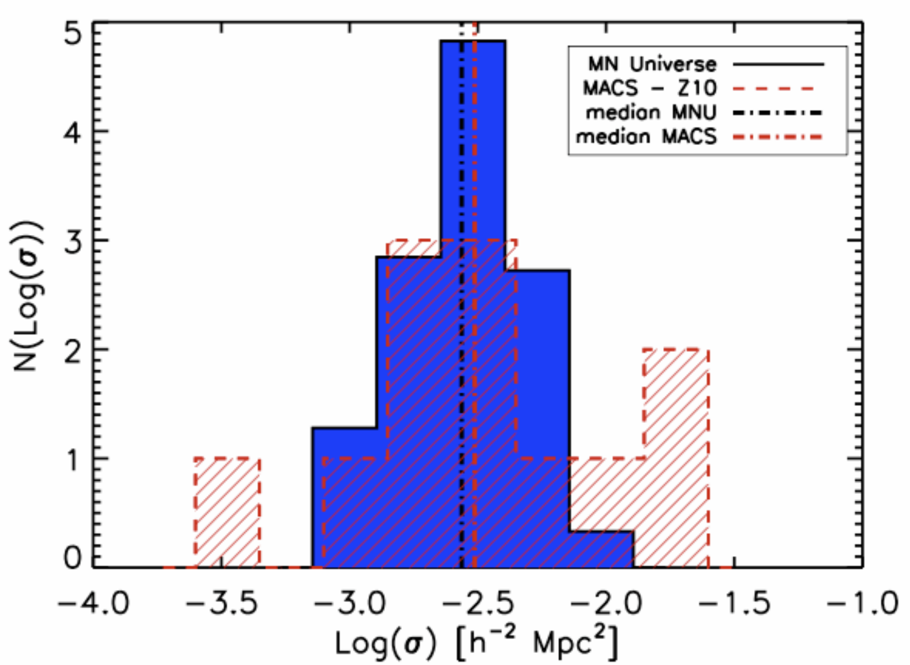


Bartelmann et al 1998

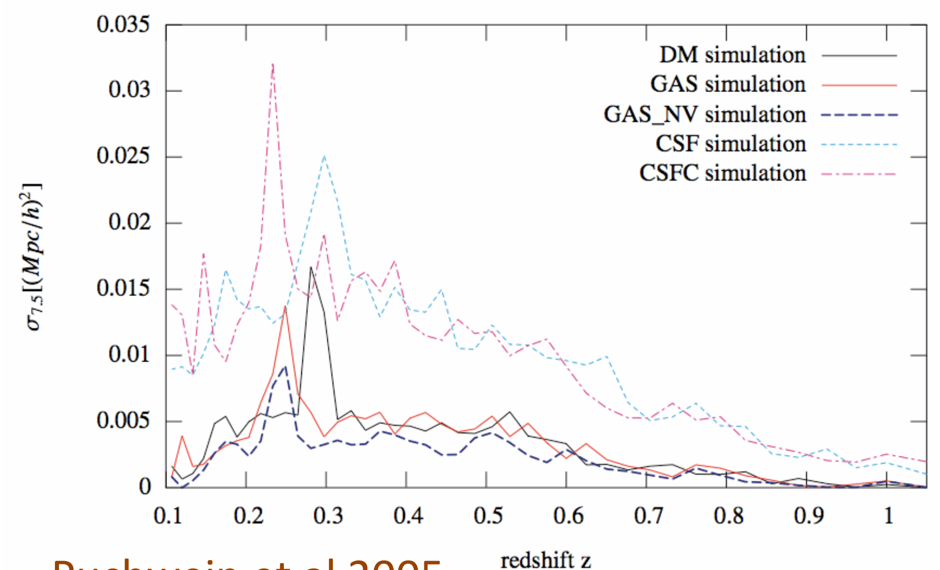
Previous tests

z>0.5 MACS clusters are stronger lenses than simulated clusters

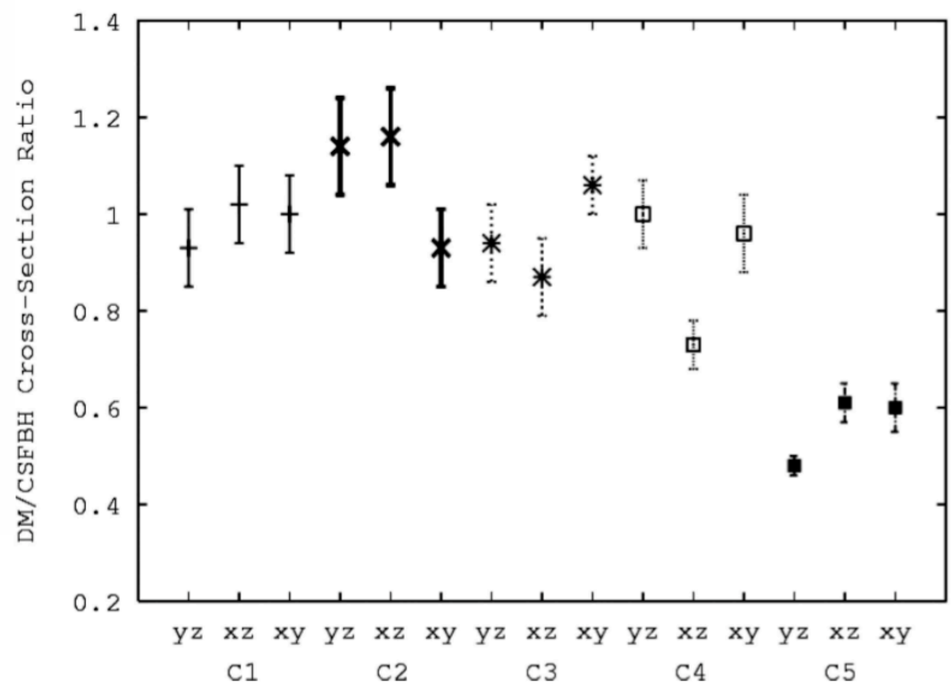




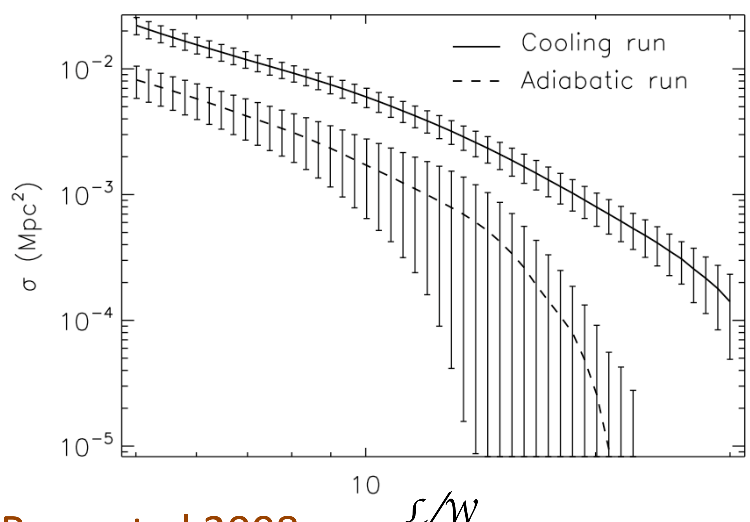
- Zitrin et al 2011
- Meneghetti et al 2010



Puchwein et al 2005



Mead et al 2010



Rozo et al 2008

Baryons in Simulations

The inclusion of baryonic processes have been shown to affect strong lensing predictions

New Simulation Set

Hear more in talks by Susana Planelles and Stefano Borgani

1024^3 DM particles in box with co-moving length 1 h^{-1} Gpc

$\Omega_{\rm M,0} = 0.24,\ \Omega_{\Lambda,0} = 0.76,\ \Omega_{\rm b,0} = 0.04,\ h = 0.72,\ \sigma_8 = 0.8$

SPH code GADGET-3 (Springel 2005)

29 Lagrangian regions around massive z=0 clusters re-simulated at improved resolution (Tormen et al 2005)

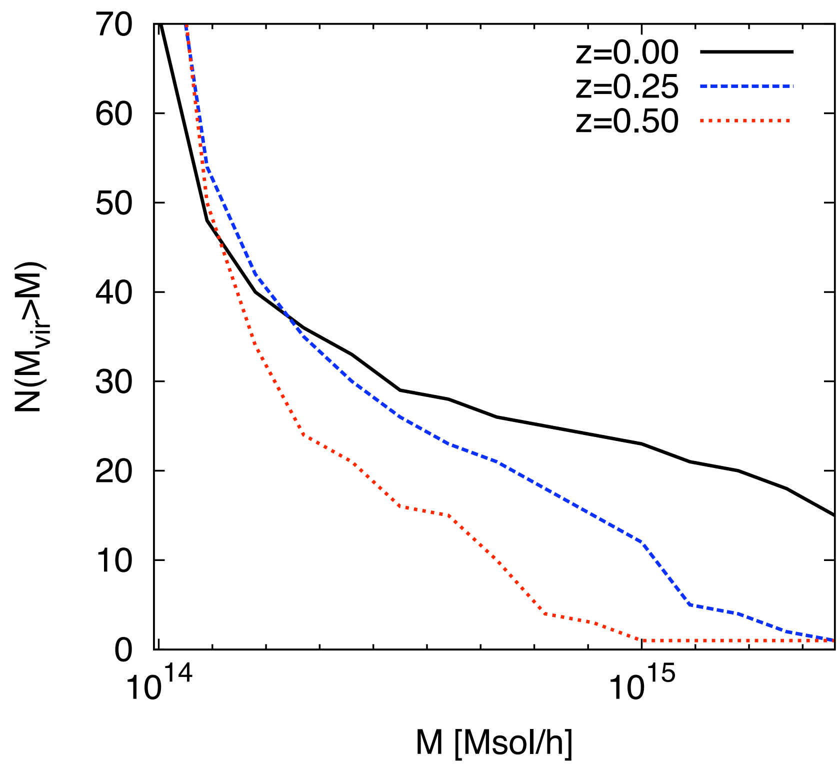
$m_{\rm DM} \approx 8.5 \times 10^8 h^{-1} M_\odot$

$m_{\rm gas} \approx 1.5 \times 10^8 h^{-1} M_\odot$ if applicable

4 flavours of simulations with the same clusters: one of these includes **AGN FEEDBACK**

17 of 42 clusters relaxed at z=0.25

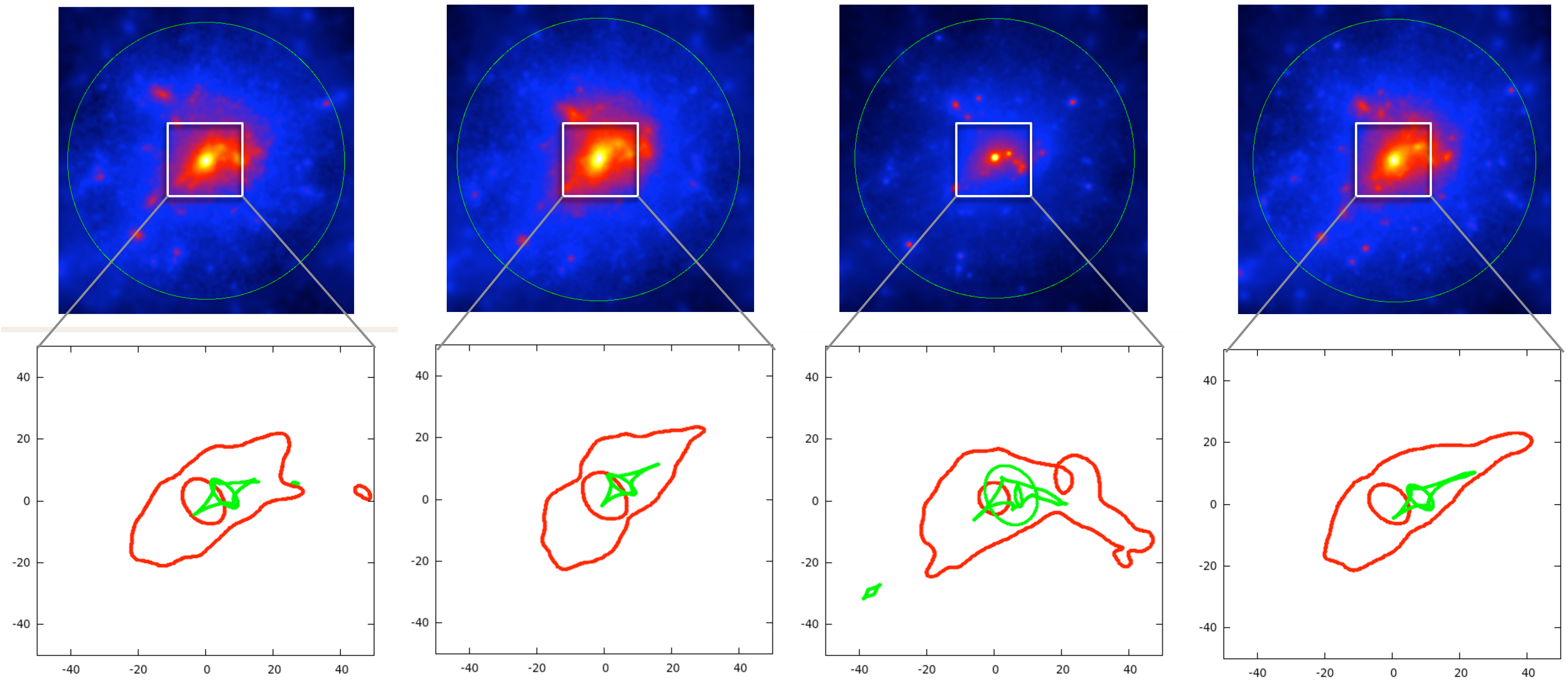
14 of 34 clusters relaxed at z=0.5



Glossary

Simulation	description
DM	Dark matter only
NR	DM+gas: Non-radiative gas
CSF	DM+gas: UV heating, Metallicity-dependent gas cooling, star formation, chemical evolution, stellar feedback
AGN	As above + AGN feedback (Springel et al 2005; Sijacki et al 2007)

Same view; different physics

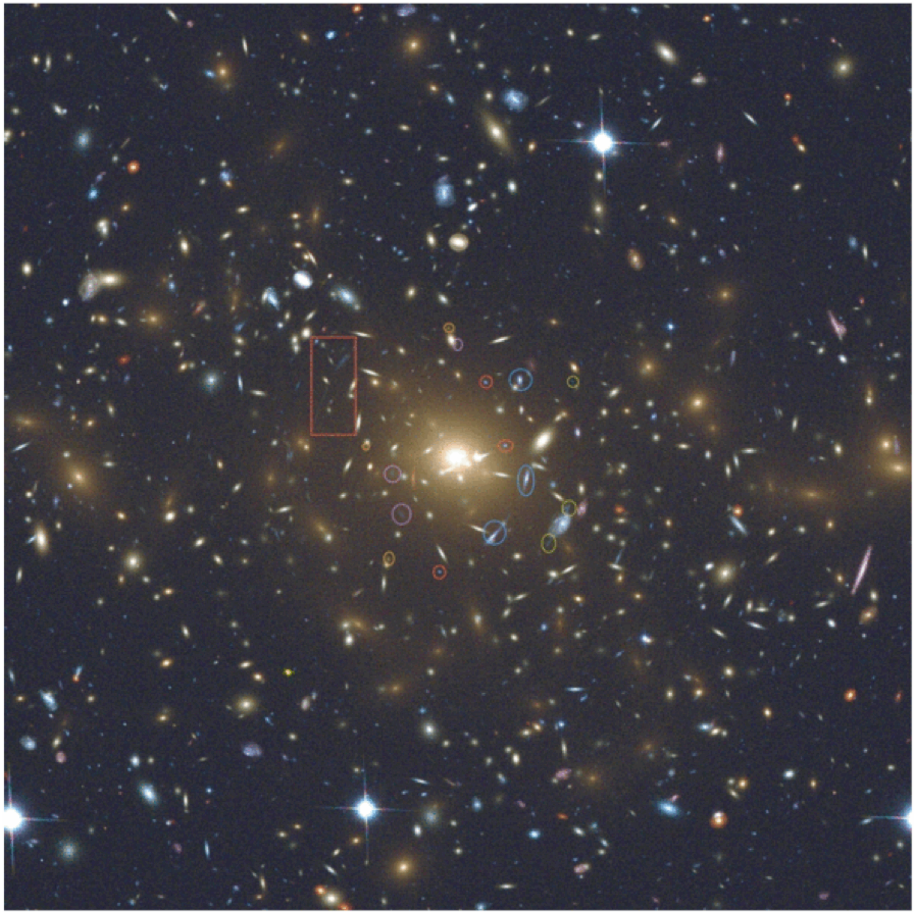


DM NR CSF AGN

Measuring Giant Arc Cross Section

1. Project lensing mass
2. Map deflection angles on a grid
3. Distribute sources at z_s
4. Produce images
5. Identify giant arcs
(L/W>7.5)
6. Measure cross section σ for a source to produce atleast one arc

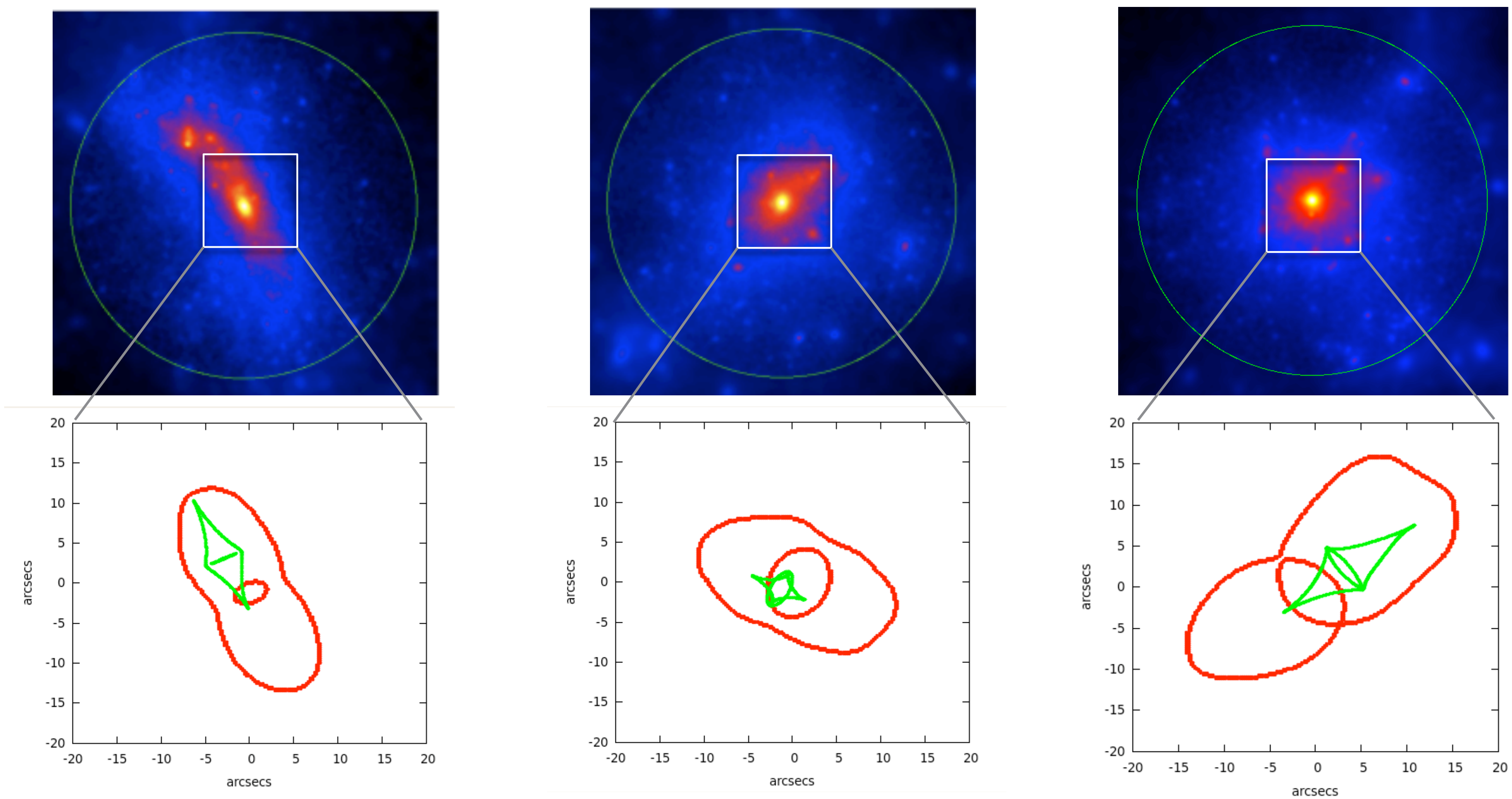
	z=0.25	z=0.5
FOV $(Mpc/h)^2$	3 x 3	3 x 3
Resolution (arcsecs)	0.5	0.2



SkyLens (Meneghetti et al 2008)

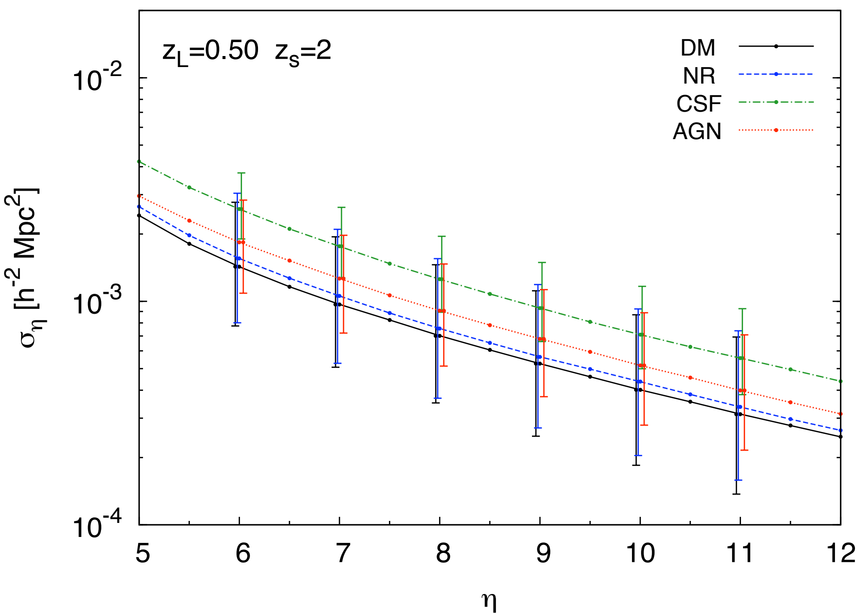
Same cluster; different points of view

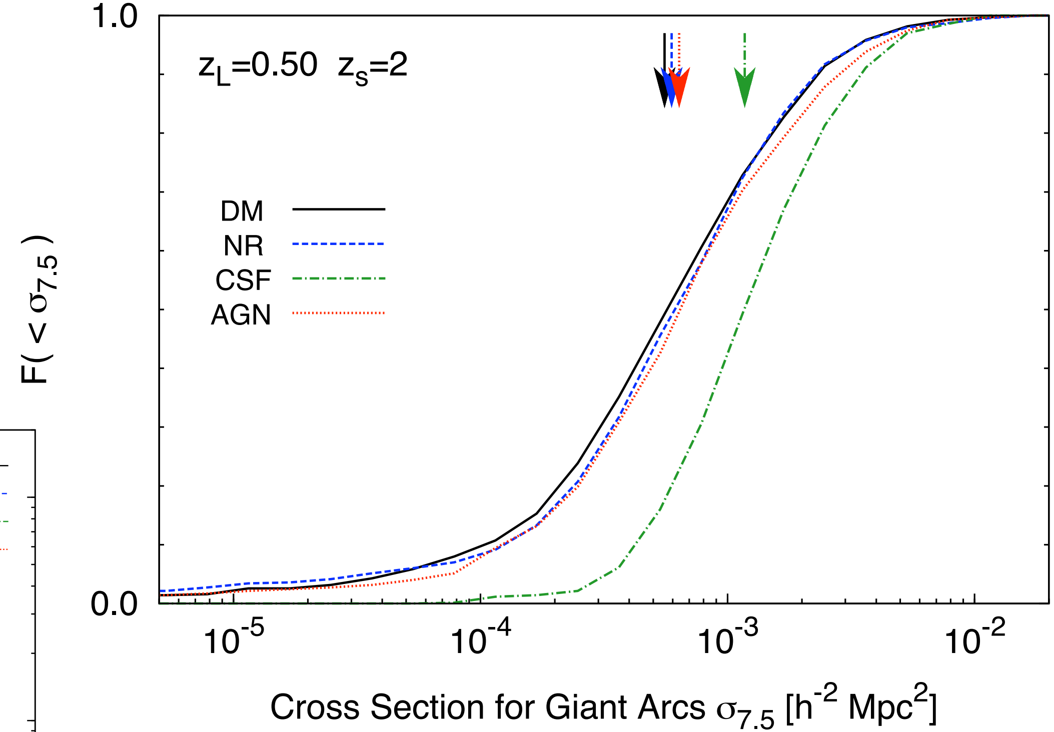
Different lines of sight produce very different caustics



We analyse 50 lines of sight through each cluster

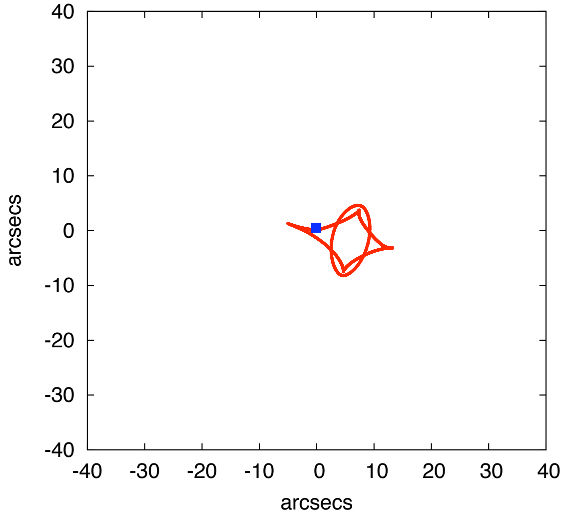
CSF ("cooling") simulations predict stronger lenses BUT AGN feedback reduces SL efficiency of clusters to levels similar to DM counterparts

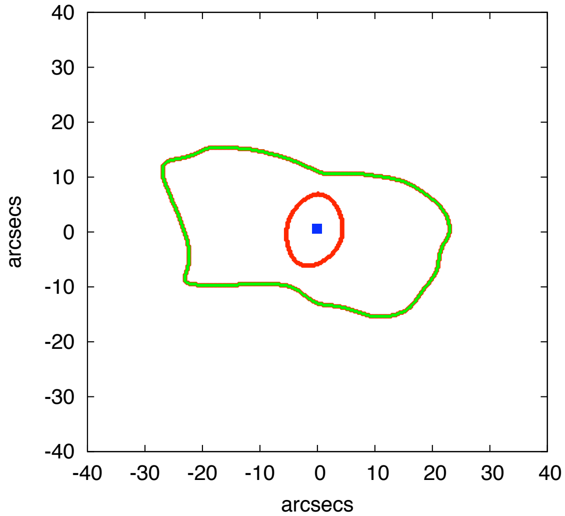


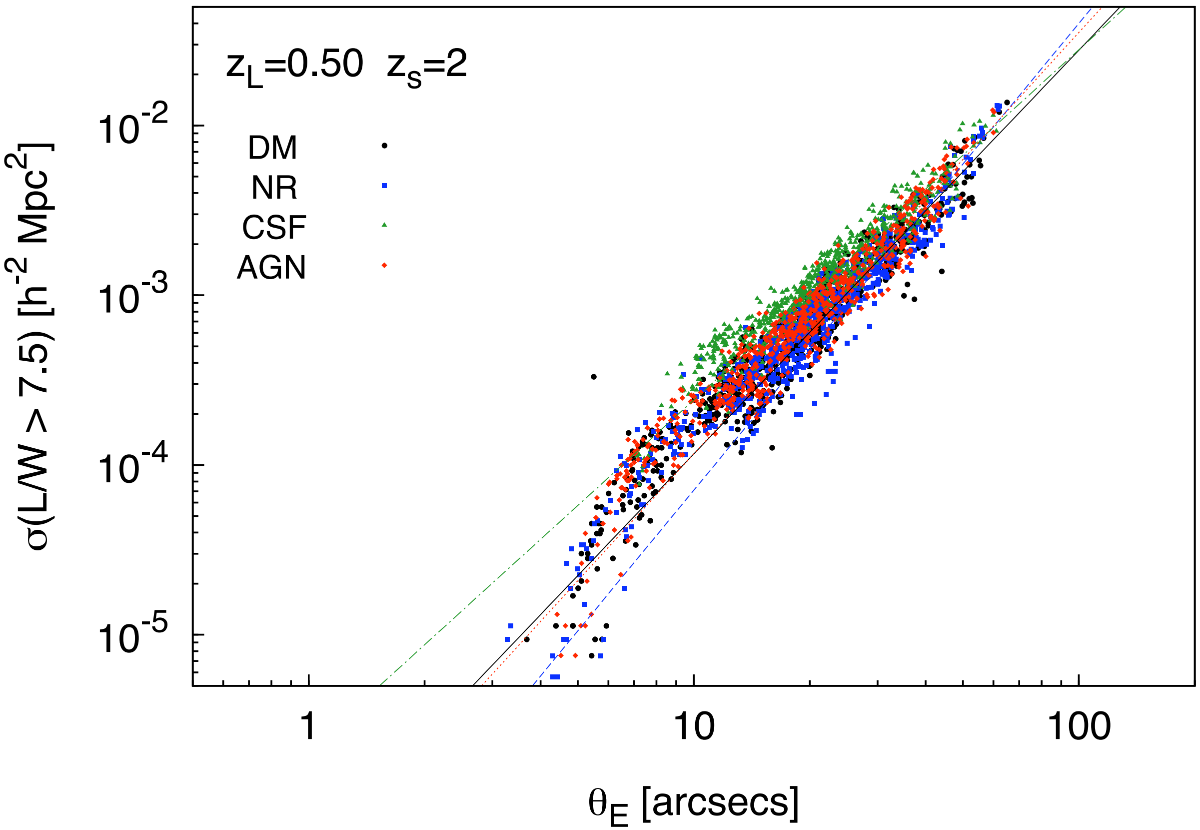


Cross Section for Giant Arcs

L/W threshold of 7.5 used, but qualitative results are not sensitive to this choice

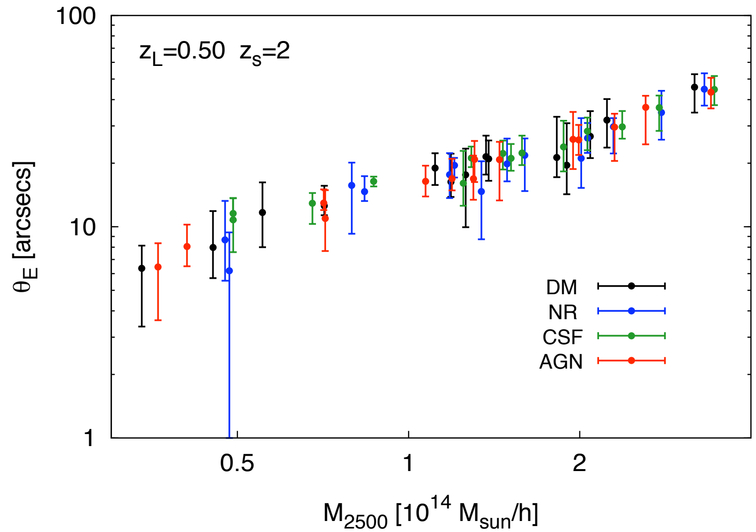


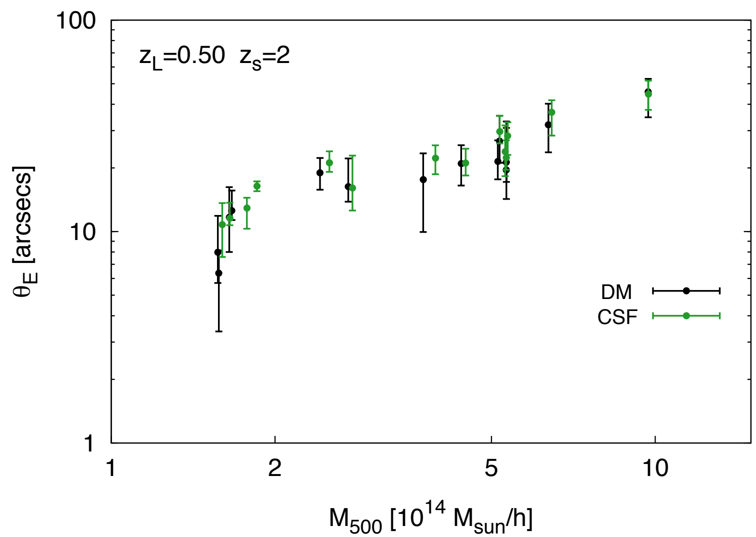


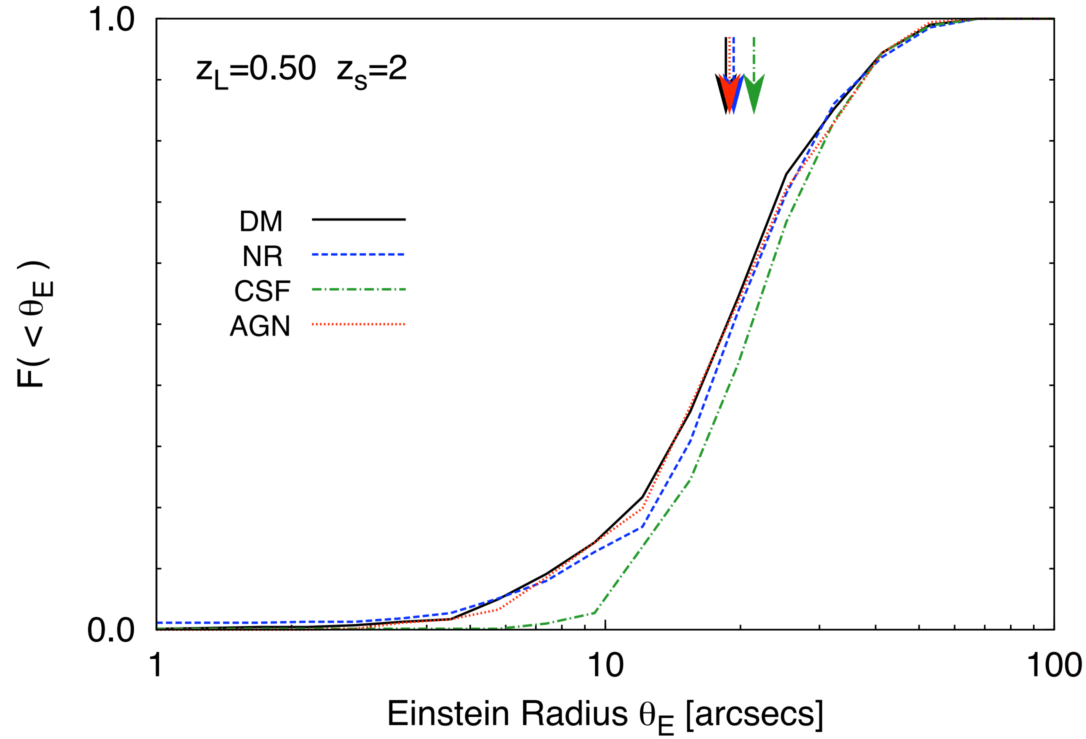


Einstein radius vs. Arc Cross Section

The two ways of characterising strong lensing are very strongly correlated. The Einstein radius is more robust choice for comparison with observational samples







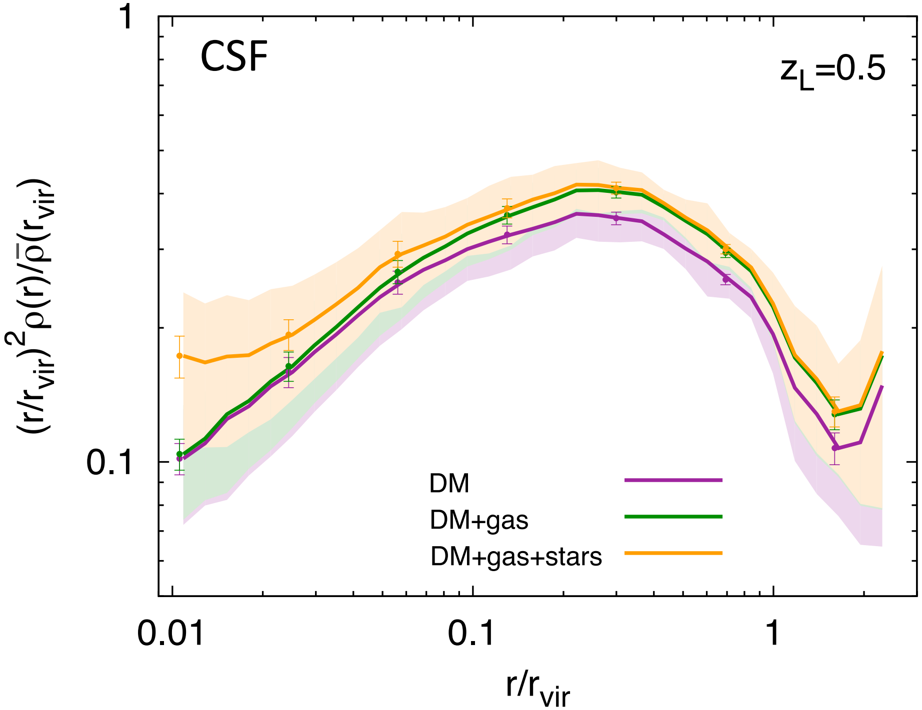
Einstein radius

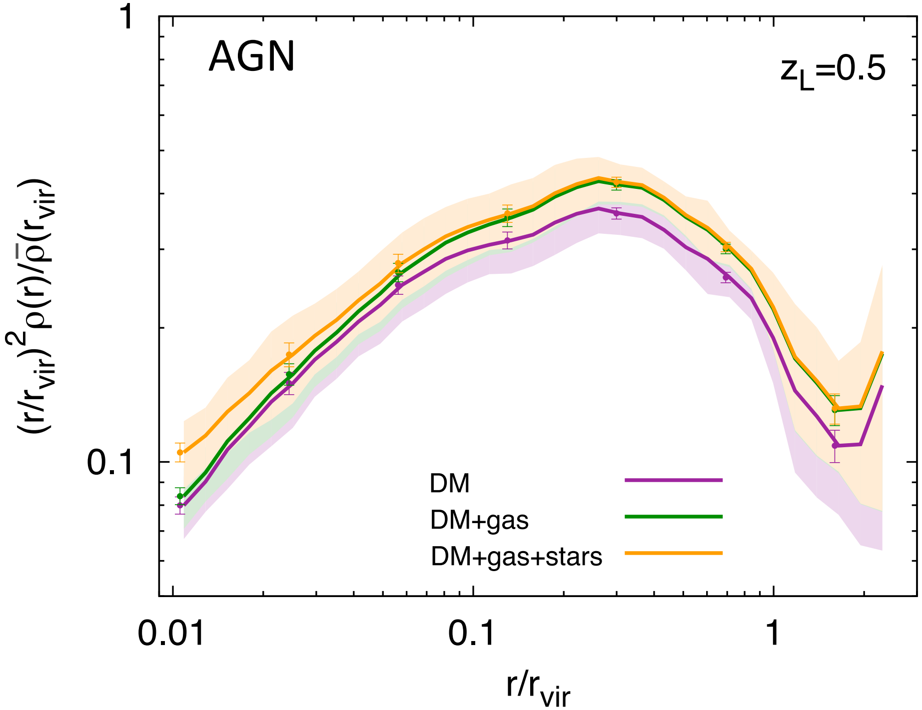
AGN predict similar Einstein radii to DM counterpart

Einstein radii are good proxies for mass at large overdensities

The distribution of stellar mass

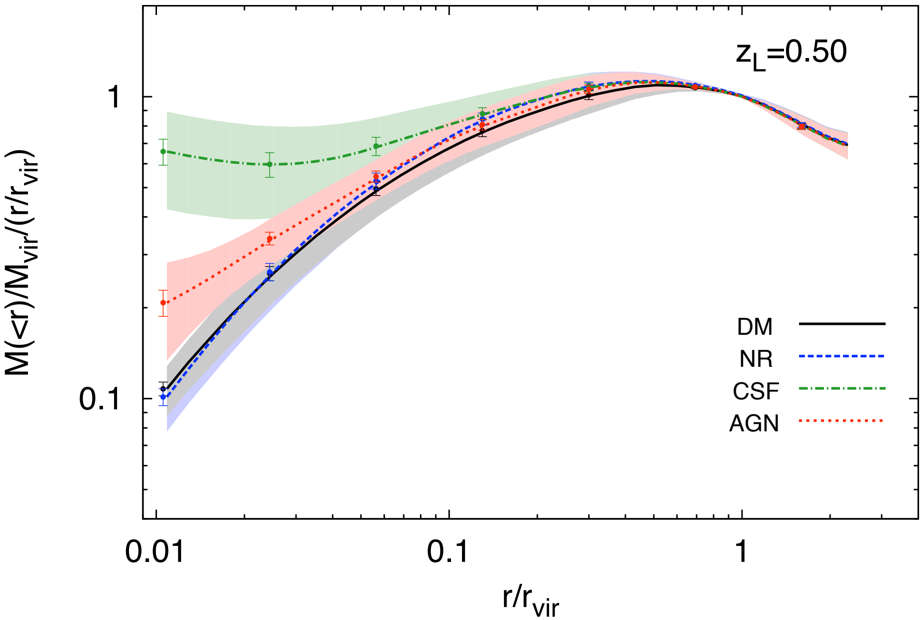
Stacked density profiles of relaxed clusters





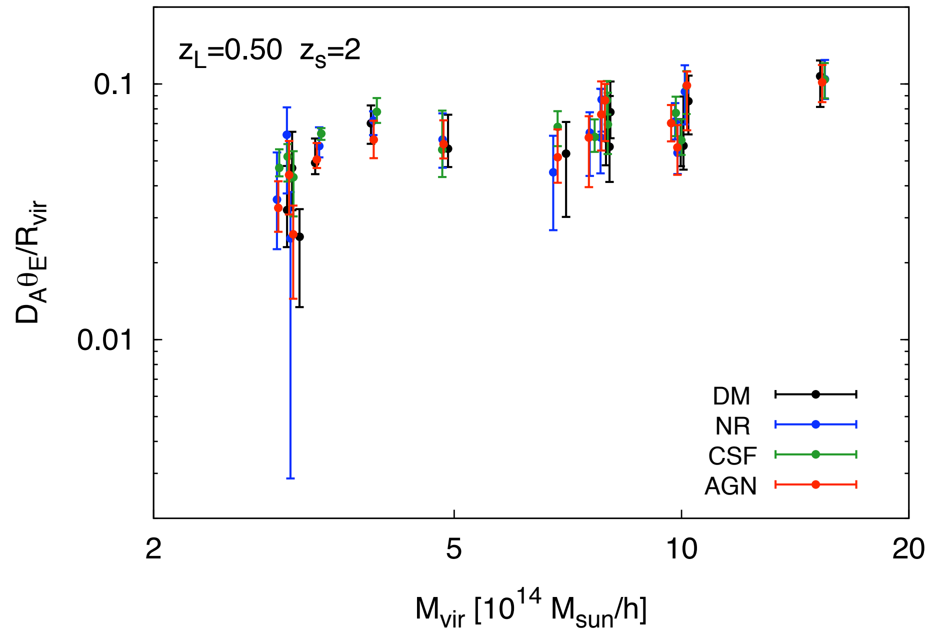
- Stellar mass dominates in the core
- Reduced stellar (and total) mass

Mass profiles and typical Einstein radii



- stacked cumulative profiles reveal central mass affected by baryonic physics…

- … but compare this to the scale of typical Einstein radii



Summary

- We inferred strong lensing properties of a large sample of simulated clusters at z=0.25 & z=0.5 under different physical processes incl. AGN feedback
- Baryons play an important role in strong lensing predictions, *BUT* AGN feedback returns lensing predictions to levels similar to DM-only simulations
- Einstein radius is more robust than the giant-arc cross-section for strong lensing comparisons; can avoid source z-distribution as a source of discrepancy
- MACS and CLASH provide ideal candidates for our future comparison study; it's important to compare like with like.