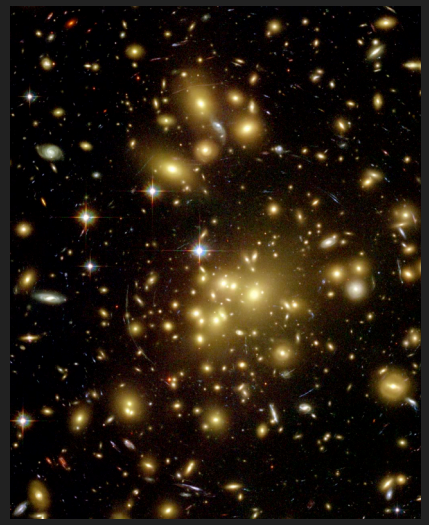


Dark Cosmology Centre

Resolving the discrepancy between lensing and X-ray mass estimates of the complex galaxy cluster Abell 1689

UniverseNet School, Sep 22, 2008
Signe Riemer-Sørensen

Collaborators: D. Paraficz (DARK), D.D.M. Ferreira (DARK), K. Pedersen (DARK), M. Limousin (DARK, Tarbes), H. Dahle (Oslo)
Submitted to ApJ

Abell 1689

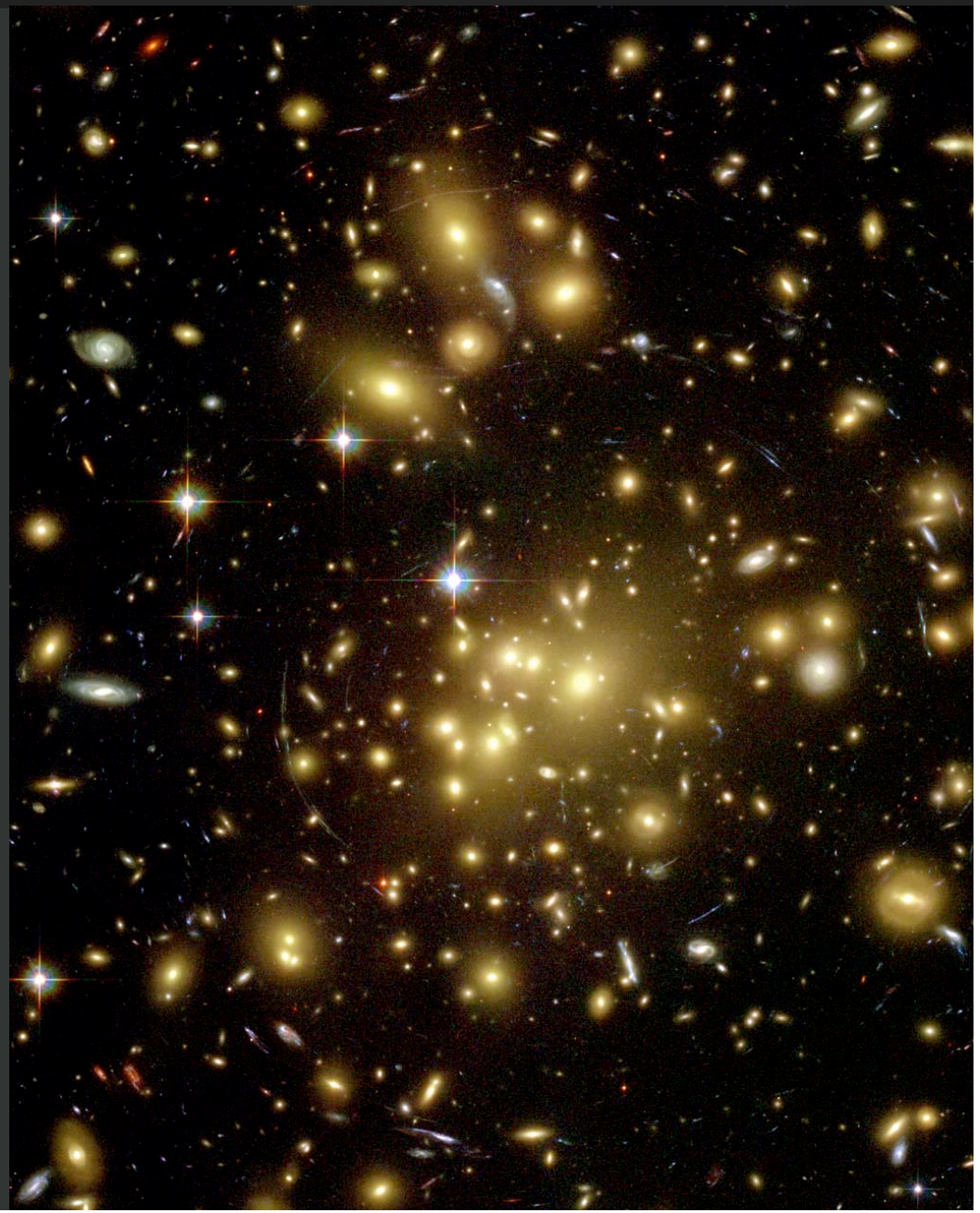
Dark Cosmology Centre

Cluster of galaxies

Known for gravitationally lensed systems

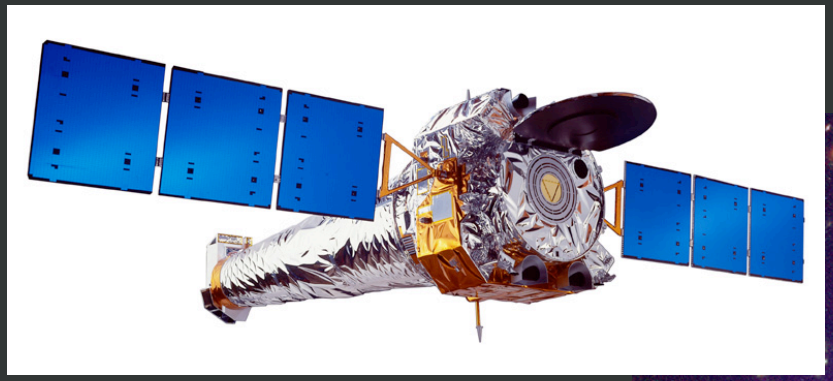
Cluster composition (general):
Few percent galaxies
~ 20% Hot X-ray gas
~ 80% Dark matter

Redshift, $z \sim 0.183$
$M_{200} = 10^{15} M_{\odot}$
(Limousin et al. 2006)



X-ray observations

Dark Cosmology Centre

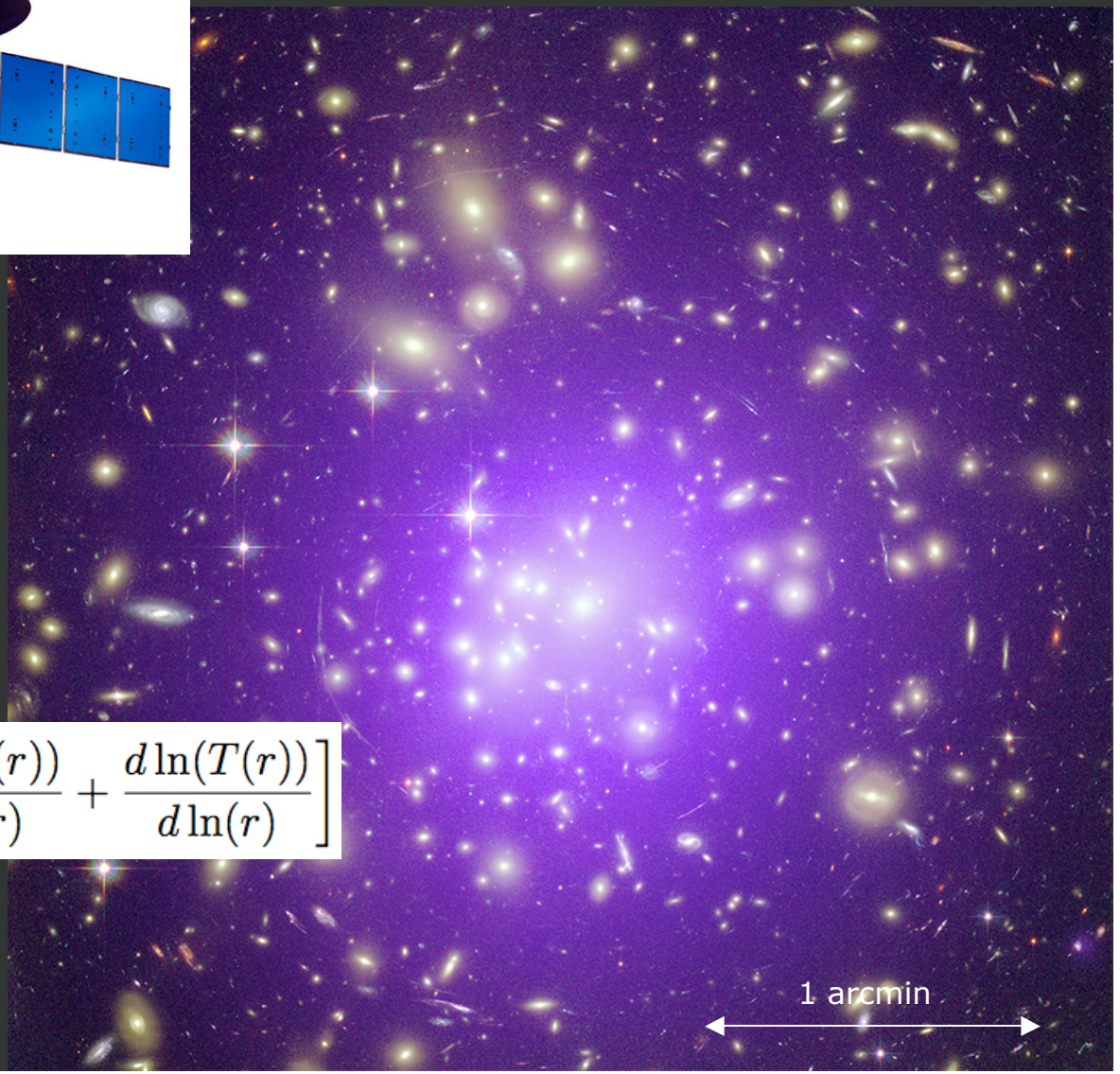


Chandra X-ray telescope

~ 40ks older observations
~ 150ks new observations

Hydrostatic equilibrium
and spherical symmetry

$$M(<r) = -\frac{T(r)}{G\mu m_p} r \left[\frac{d\ln(\rho_g(r))}{d\ln(r)} + \frac{d\ln(T(r))}{d\ln(r)} \right]$$

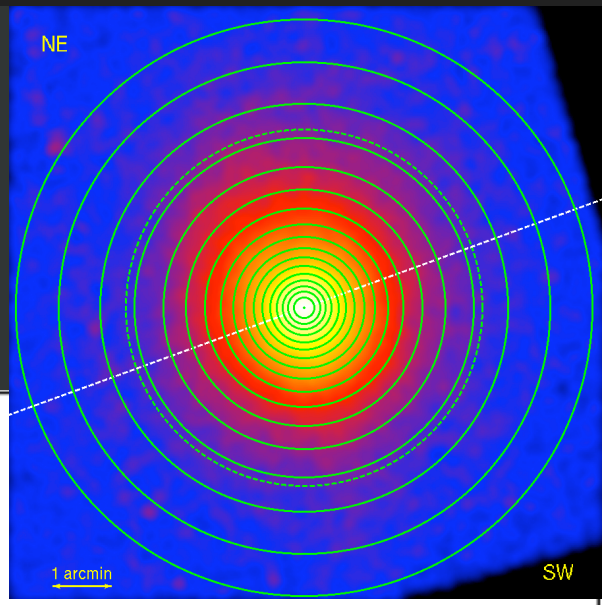


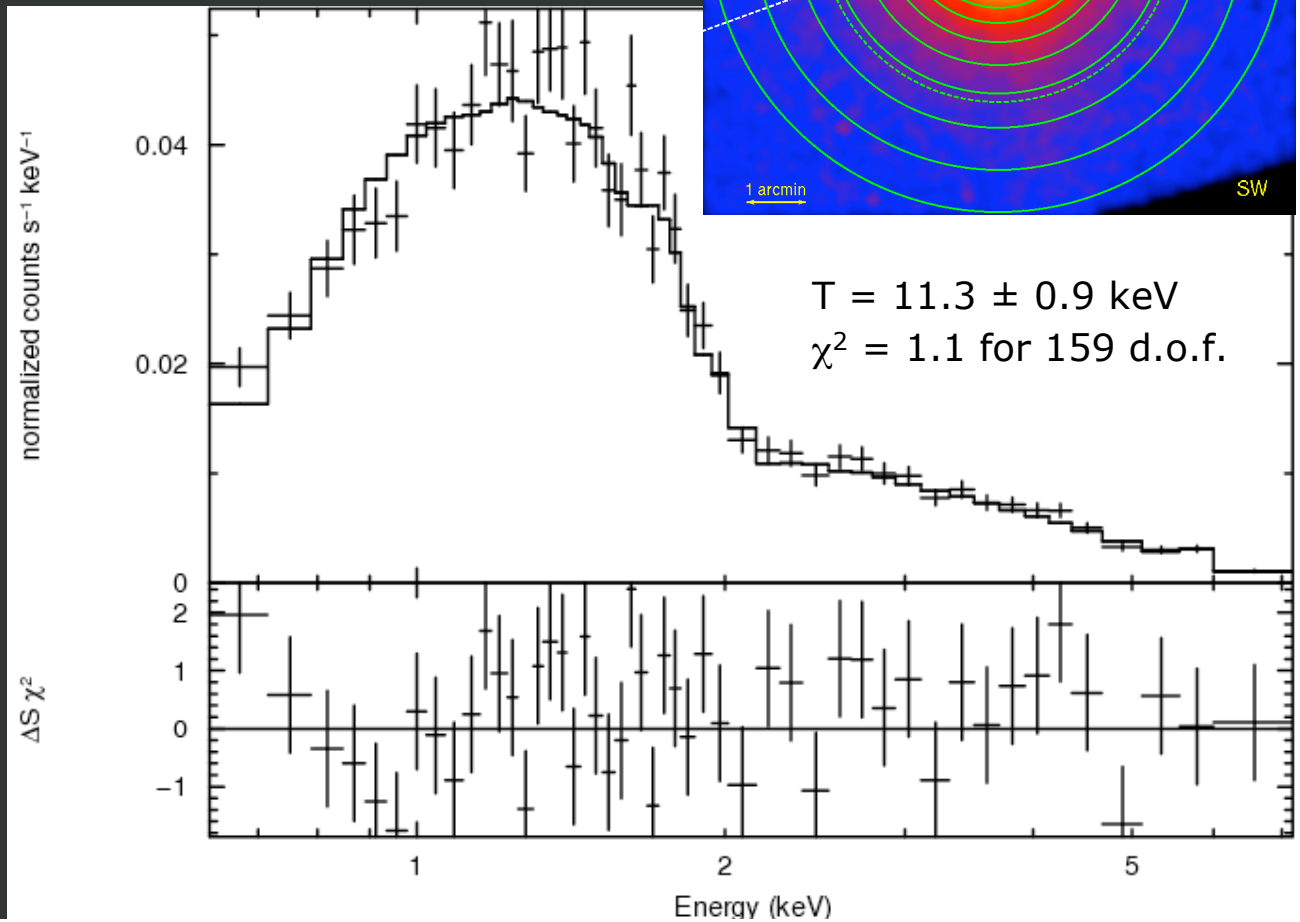
Spectral fitting

Dark Cosmology Centre

Temperature determined by fitting MEKAL model in radial bins

Overall temperature within 3 arcmin is 10.5 ± 0.1 keV (typic of clusters)





T = 11.3 ± 0.9 keV
χ^2 = 1.1 for 159 d.o.f.

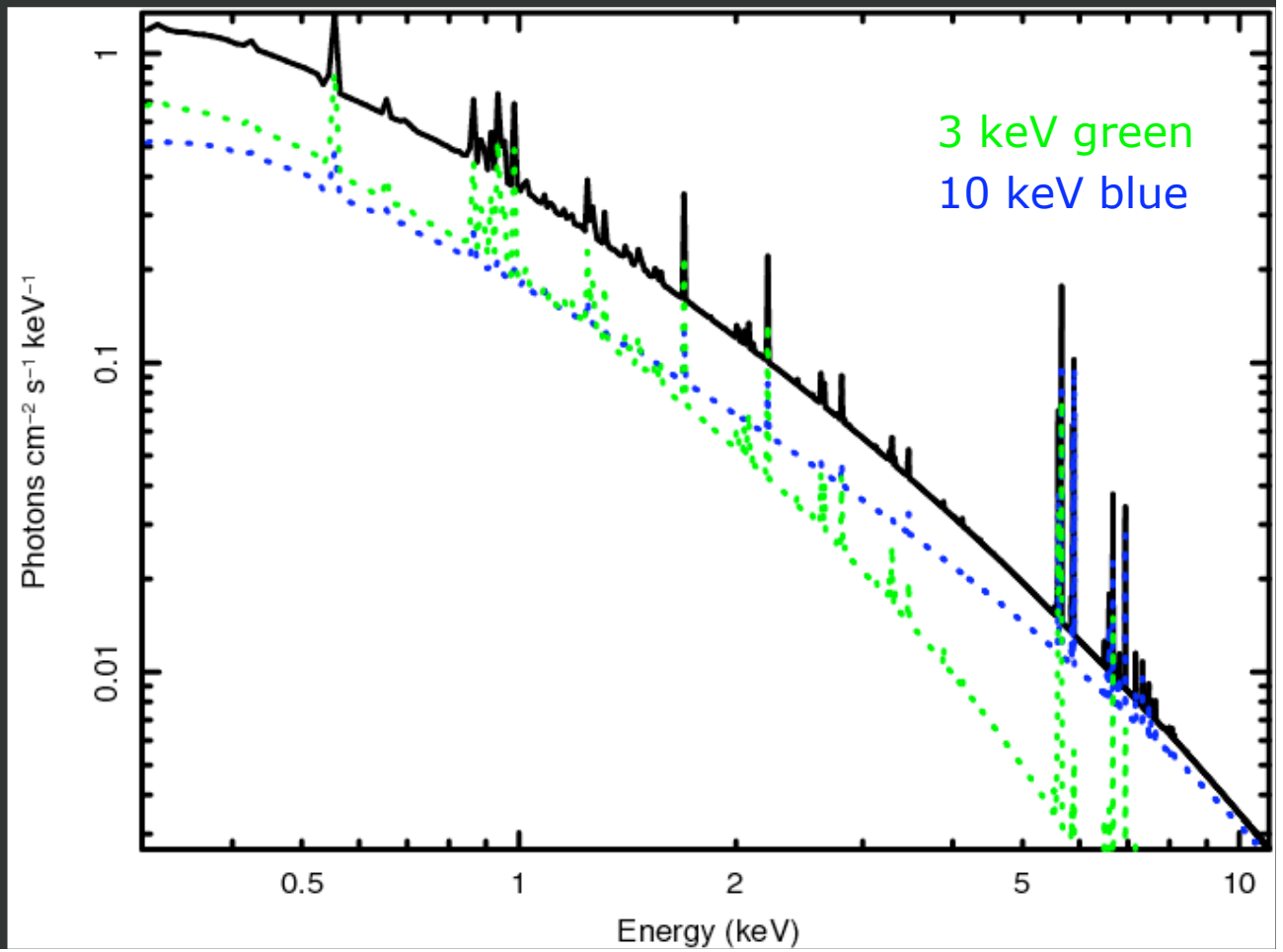
Hardness ratio

Dark Cosmology Centre

Temperature depends on mass (hydrostatic equilibrium)

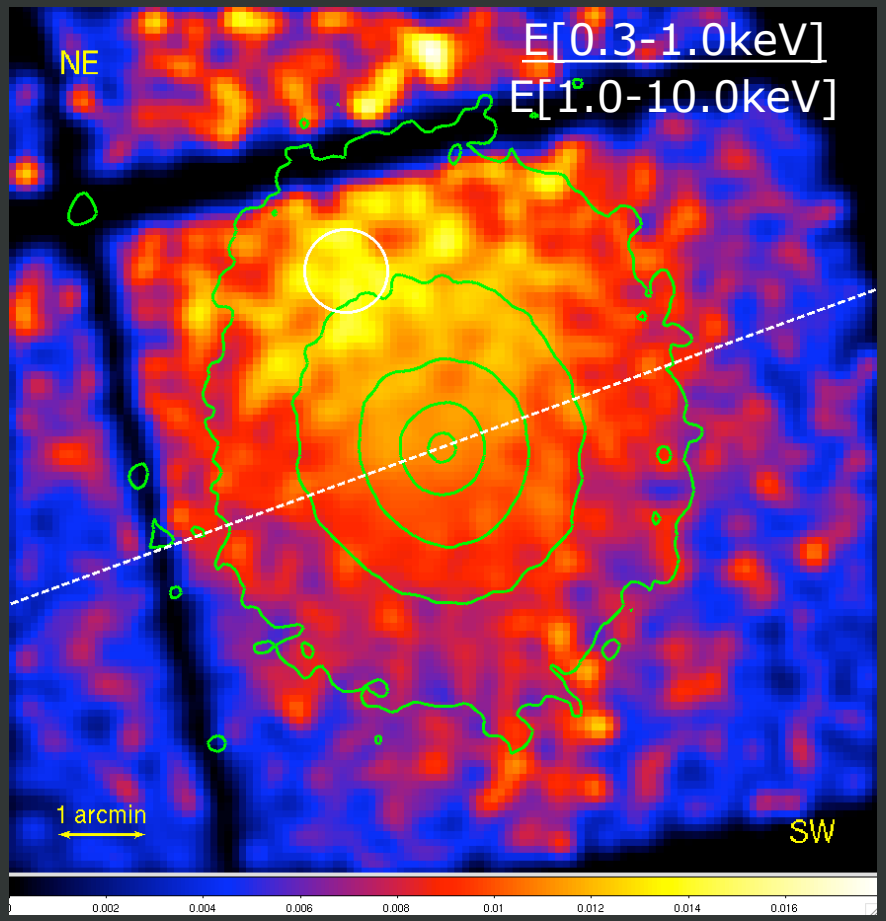
Low energy photons divided by high energy photons

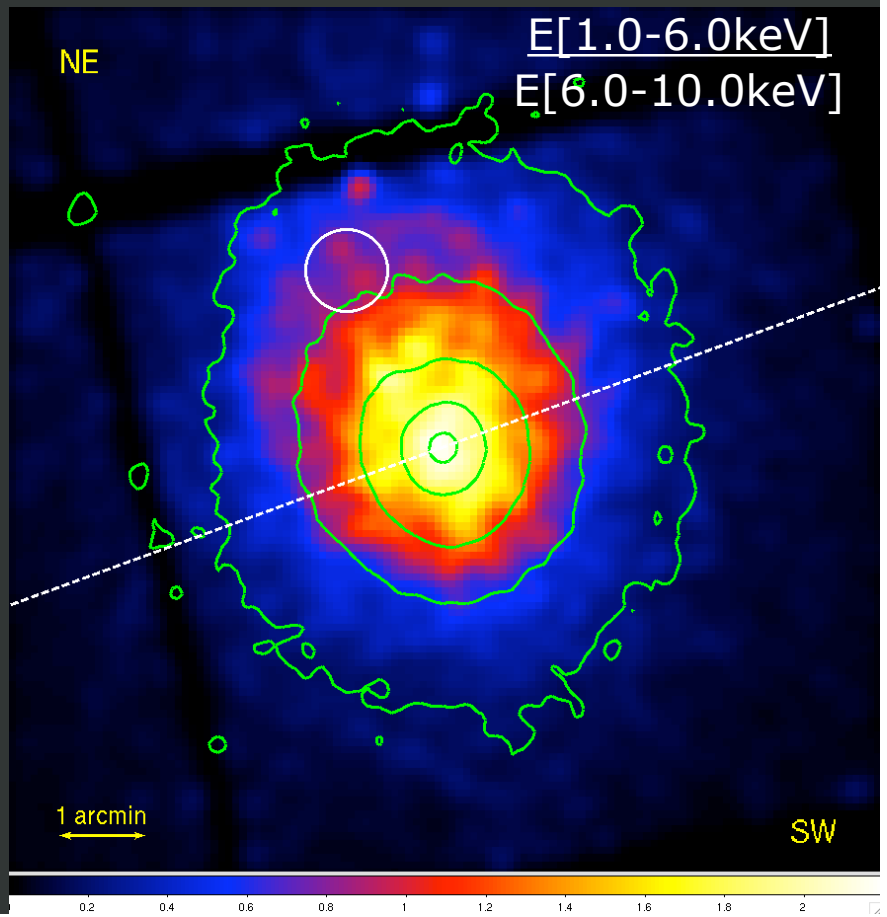
Proportional to temperature ratios



Temperature structure

Dark Cosmology Centre





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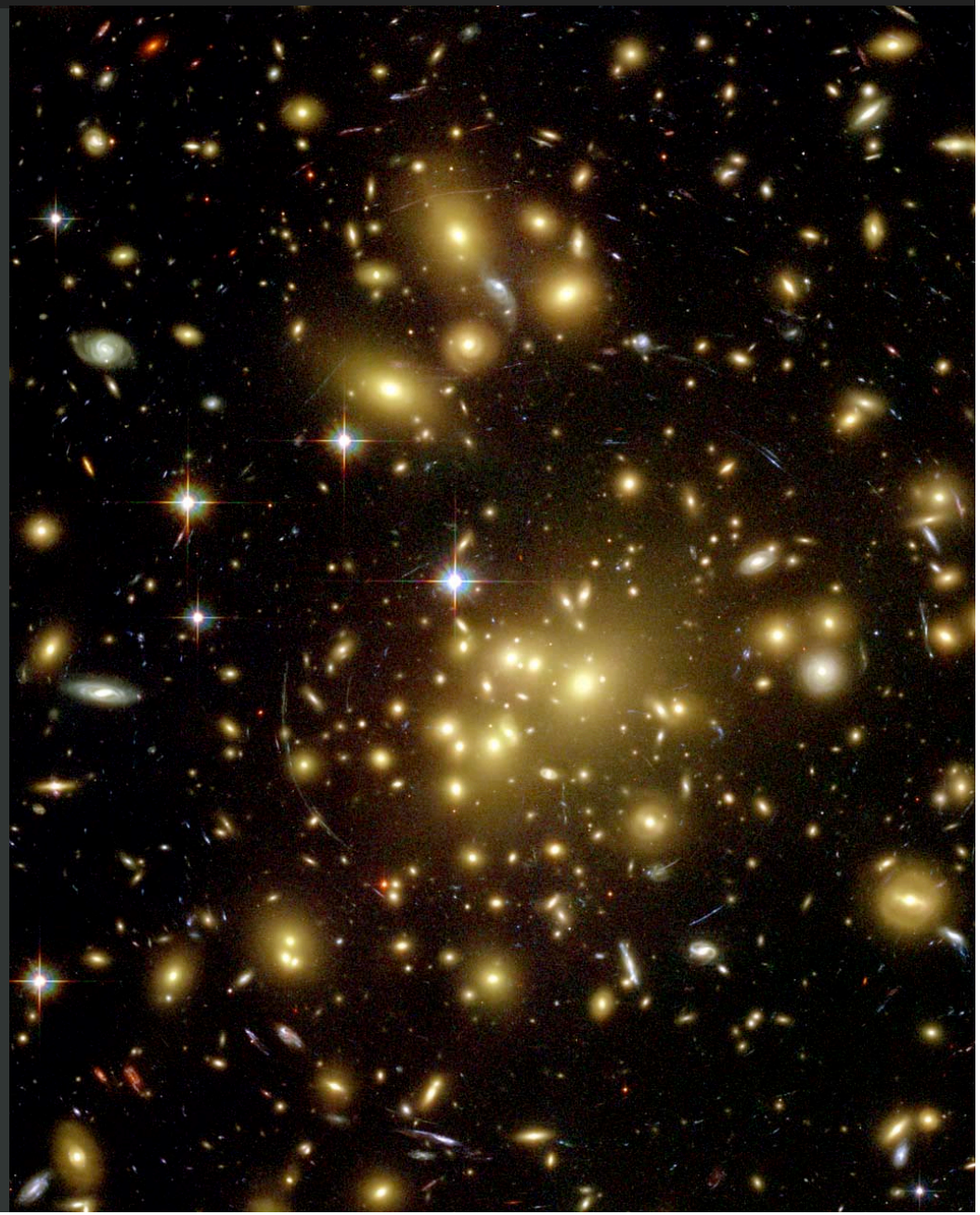
Optical image again

Dark Cosmology Centre



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Mass map from gravitational lensing

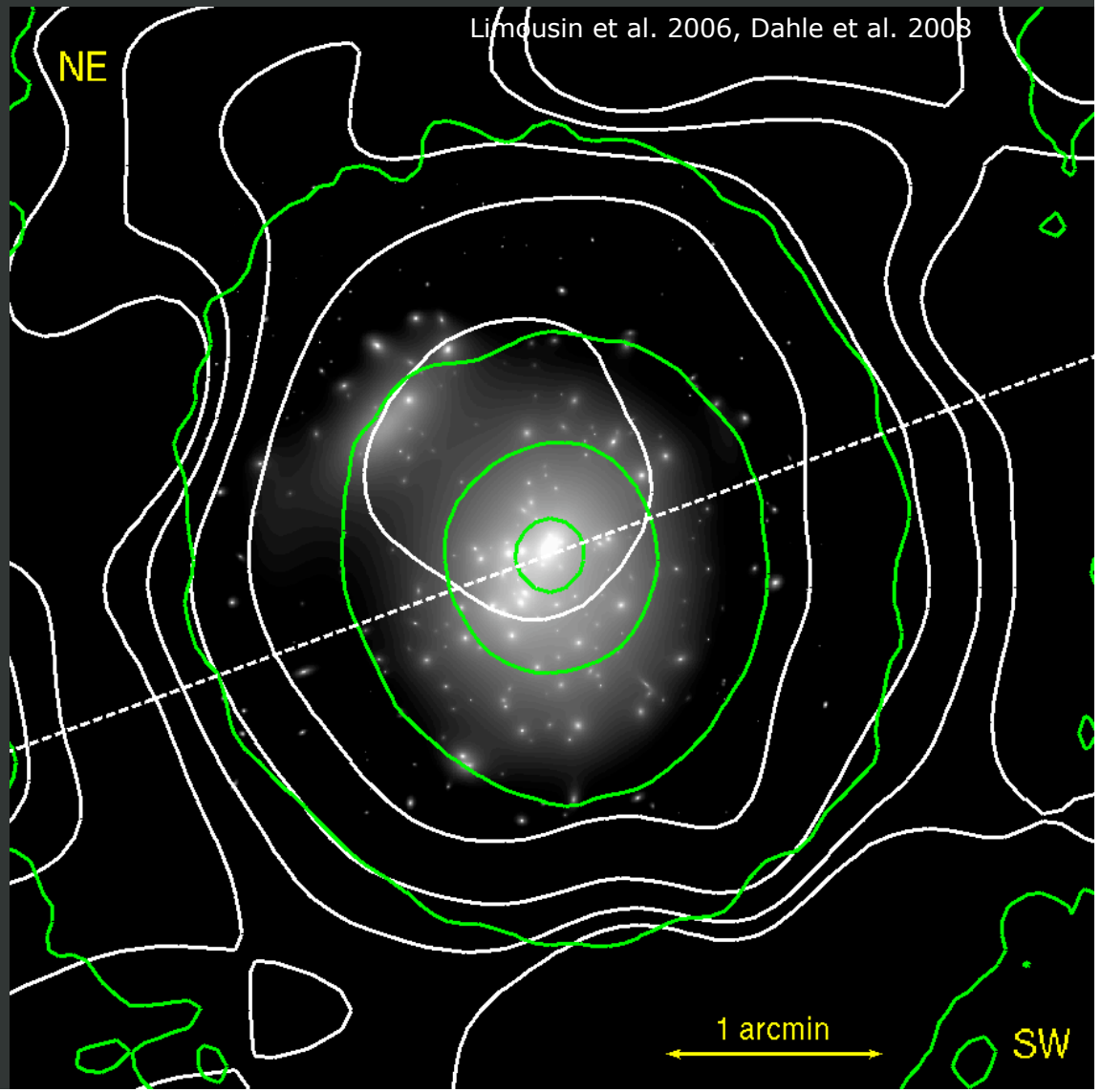
Dark Cosmology Centre

Strong gravitational lensing
Limousin et al. 2006

Weak gravitational lensing (white contours)
Dahle et al. 2008, new HST mosaic

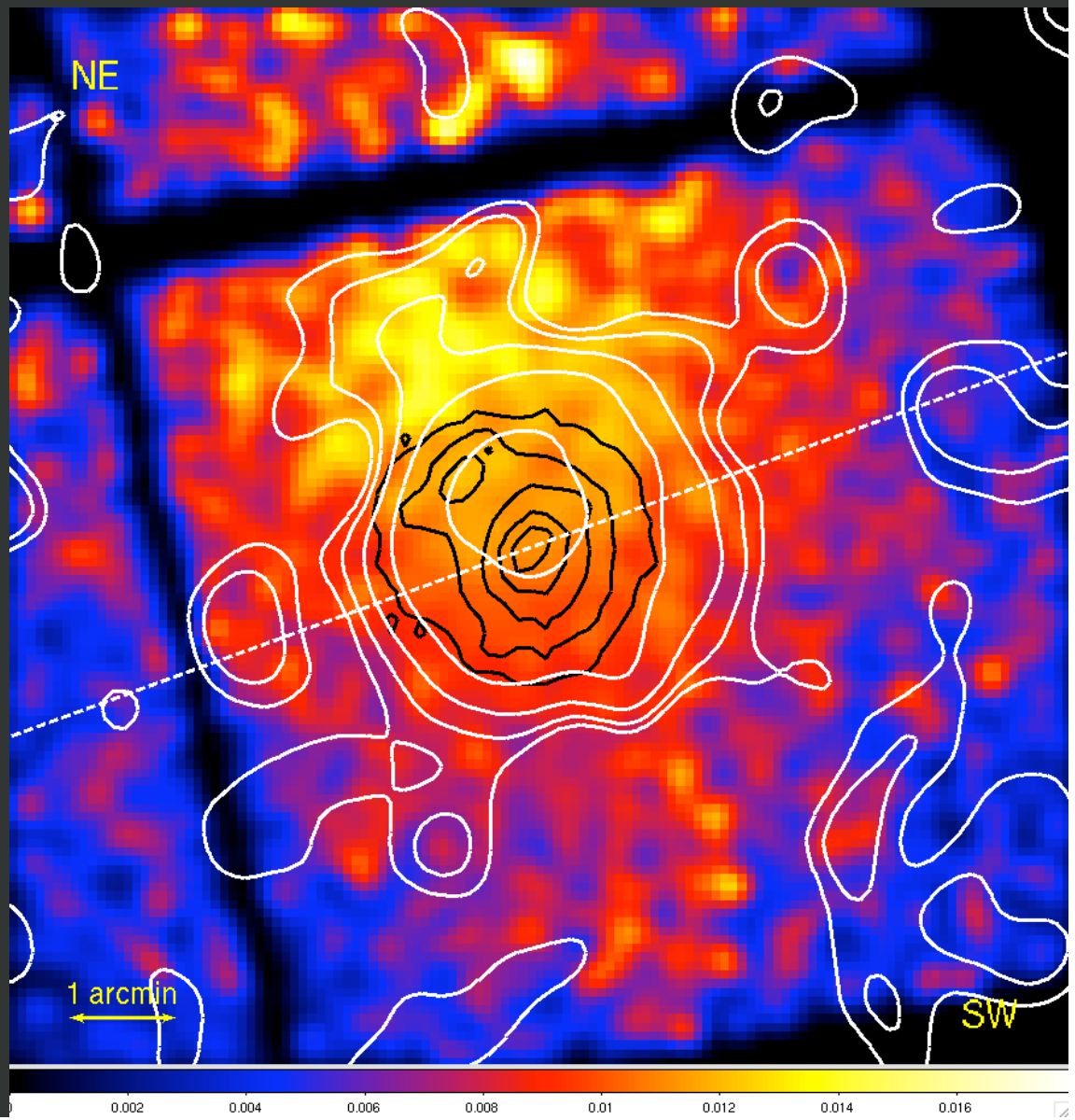
X-ray (green contours)

Distinct clumps



Comparing to X-rays

Dark Cosmology Centre



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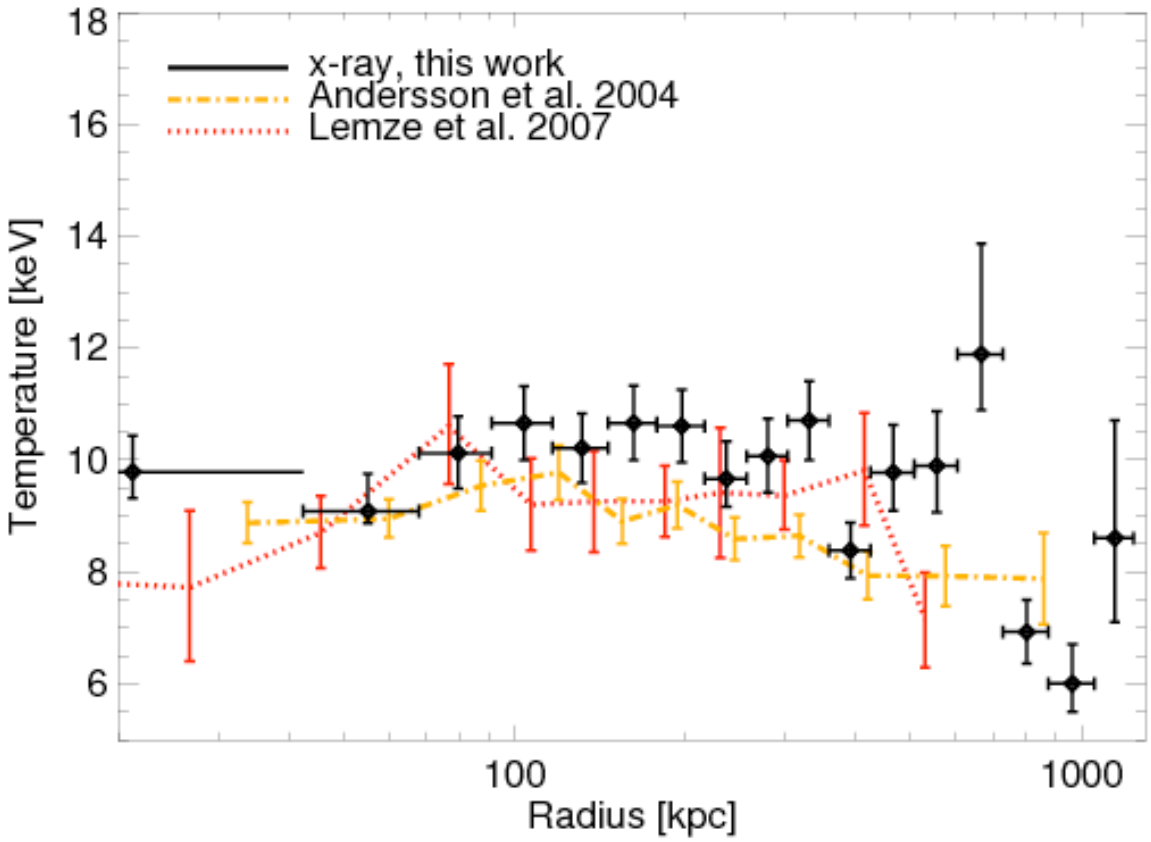
Temperature profile

Dark Cosmology Centre

SW part only

Assuming sphericity

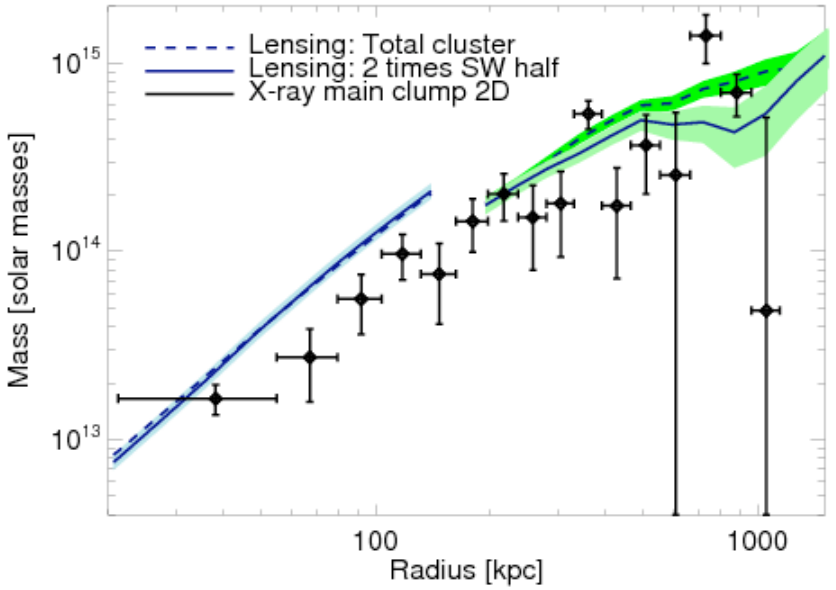


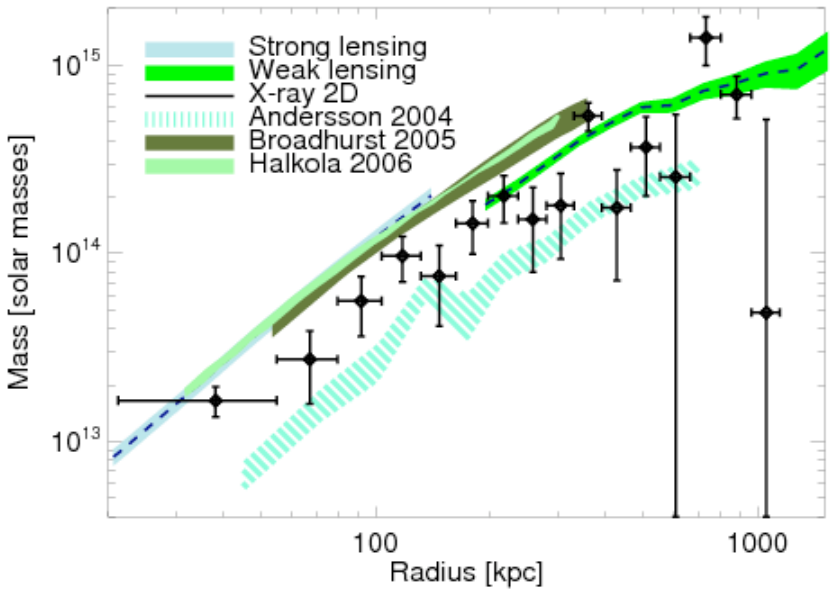
Mass profile

Dark Cosmology Centre

Assumes sphericity and hydrostatic equilibrium

Only SW clump



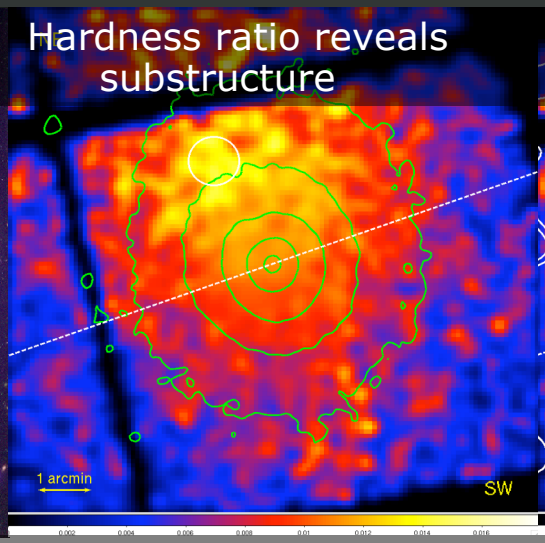


Summary

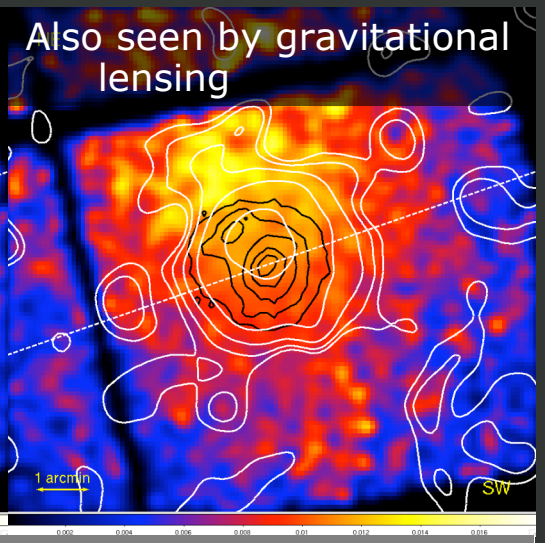
Dark Cosmology Centre

X-rays are nice and symmetric

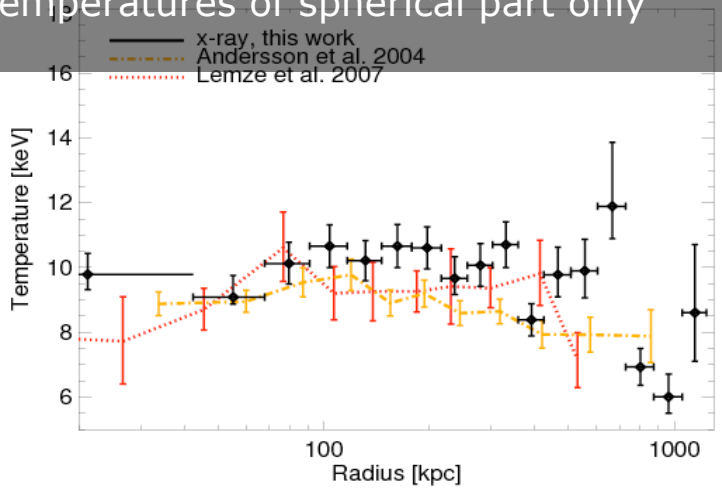
Hardness ratio reveals substructure



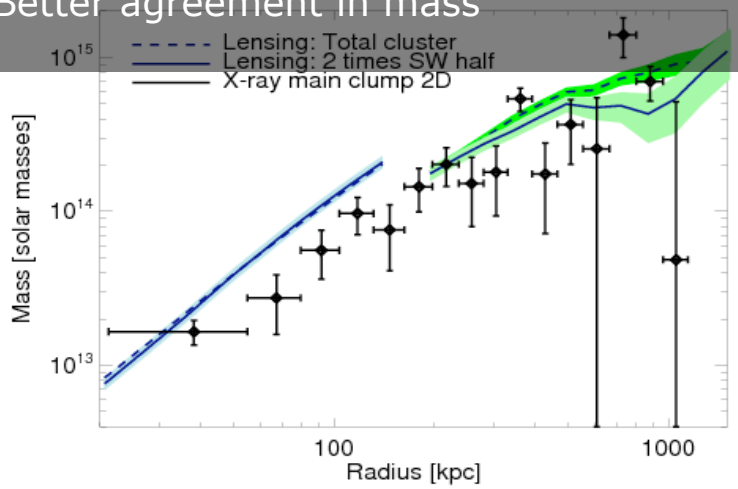
Also seen by gravitational lensing



Temperatures of spherical part only



Better agreement in mass

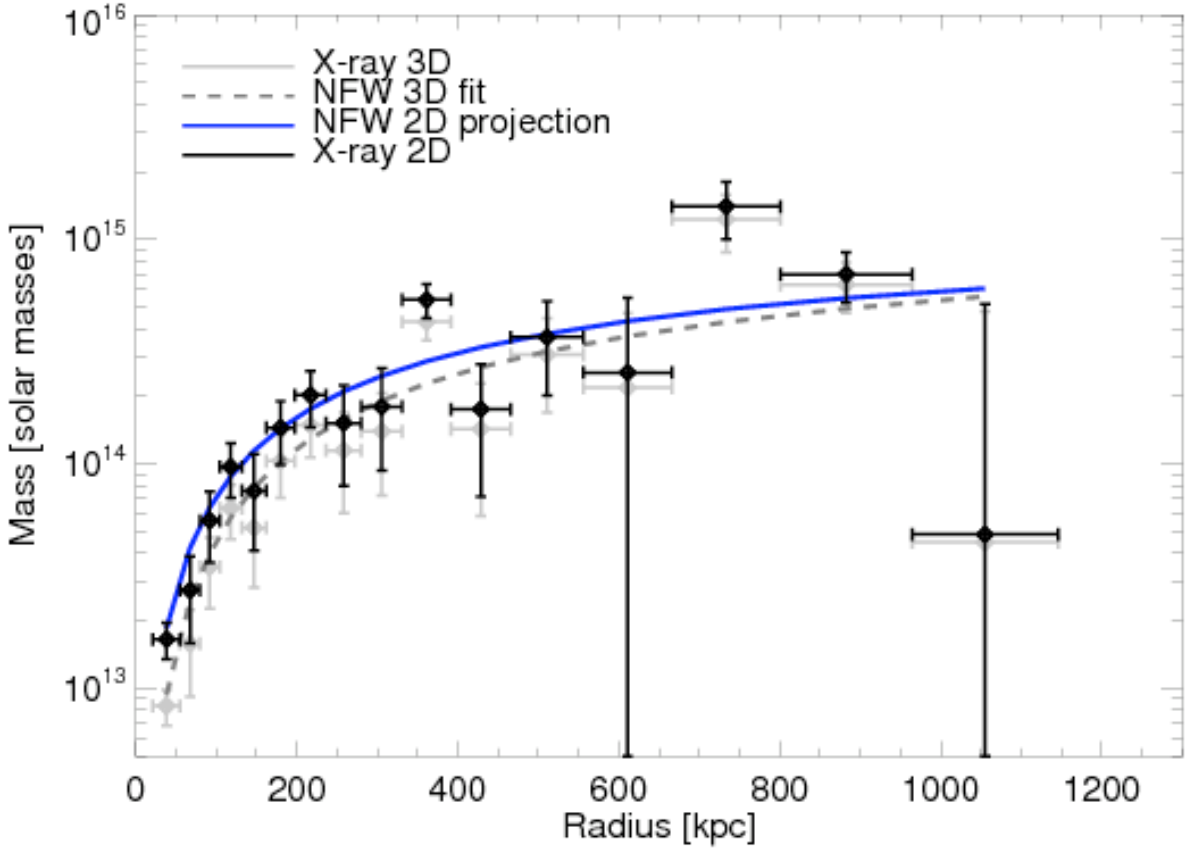


Projection

Dark Cosmology Centre

X-ray 3D mass profile obtained assuming sphericity and hydrostatic equilibrium

Projected as NFW



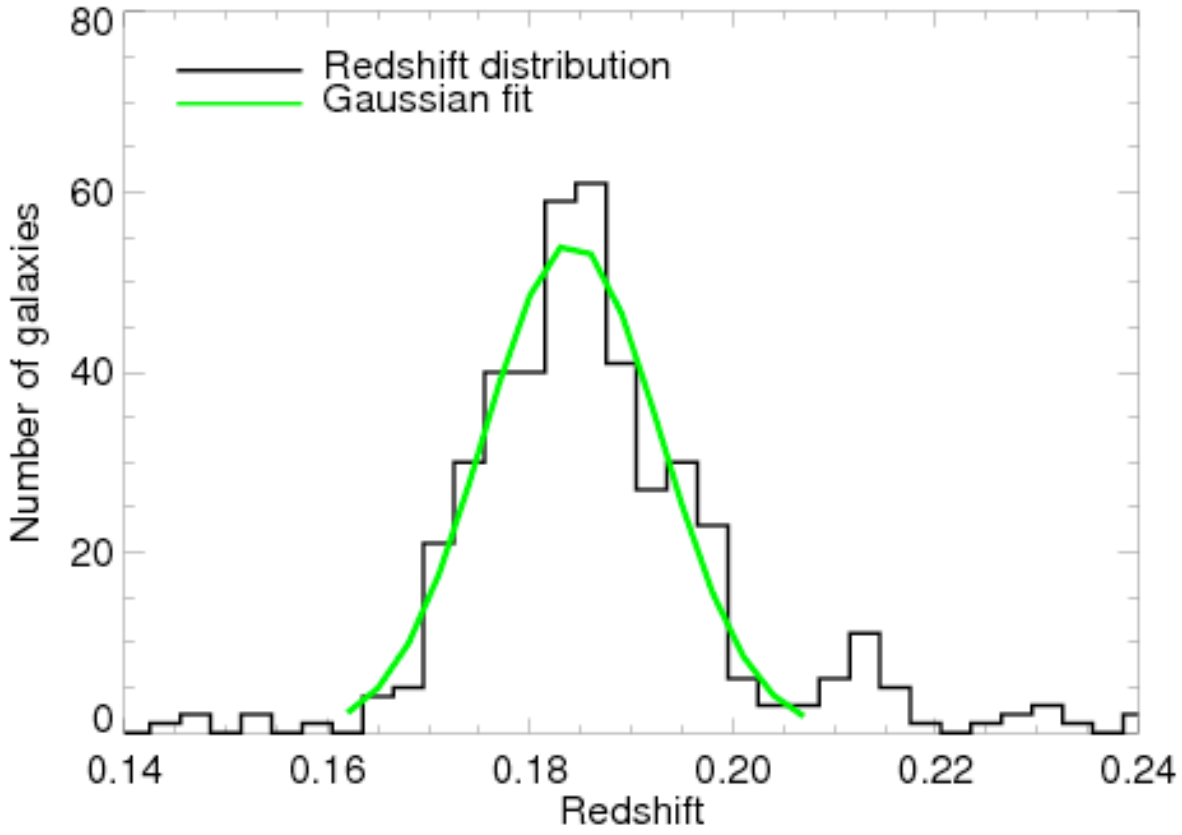
Galaxy distribution

Dark Cosmology Centre

Gaussian redshift distribution

Huge velocity dispersion if in equilibrium

Lokas et al. claims several clumps along the line of sight



Surface brightness profile

Dark Cosmology Centre

Follows beta-model (power-law model)