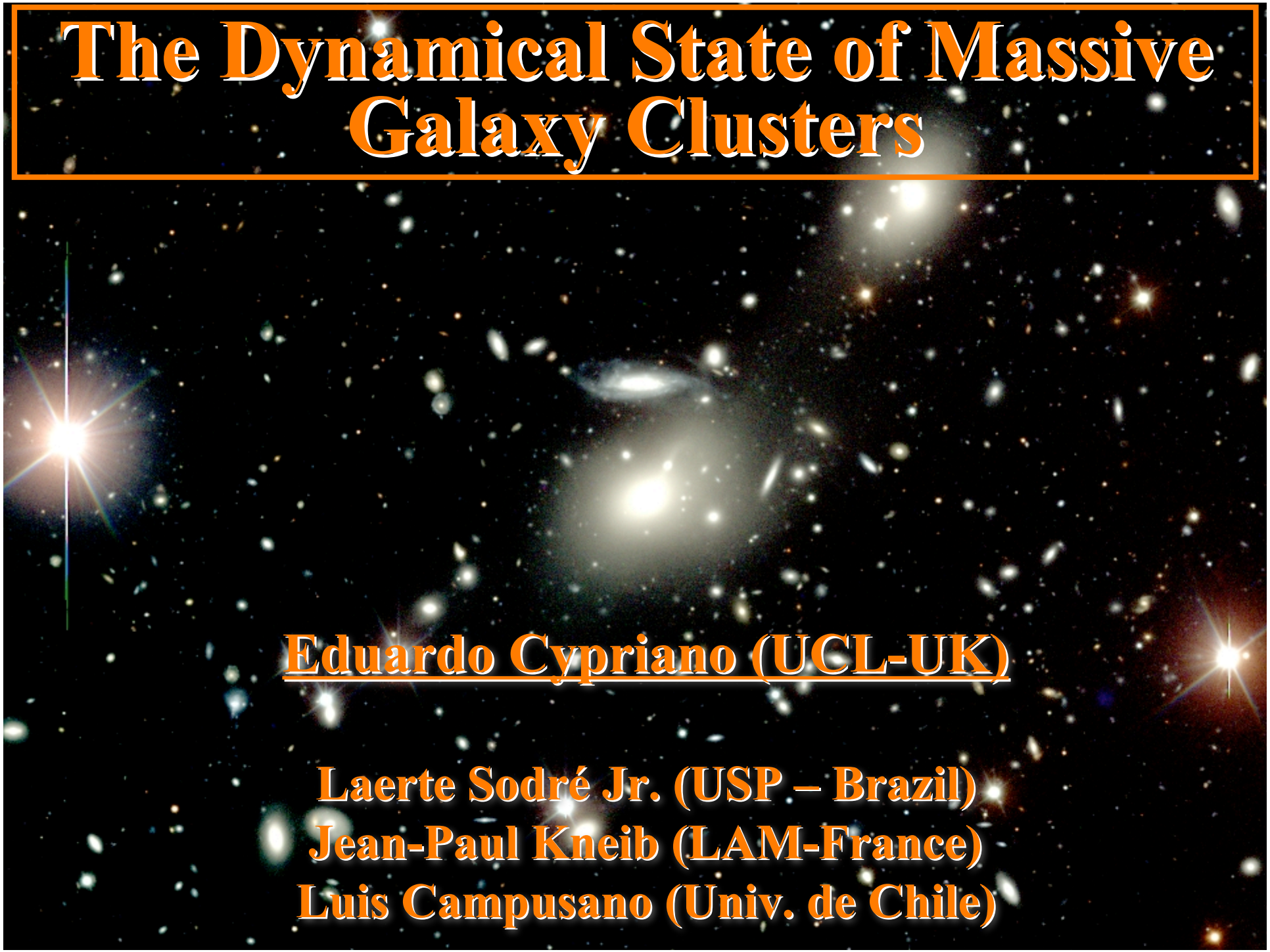
The Dynamical State of Massive Galaxy Clusters



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Clusters as cosmological probes ?

- Depends strongly on a well calibrated and tight Mass × Observable relation
- Widely available observables (T_X L_X S-Z) depend on the dynamical state of the cluster
- Comparison with weak-lensing allows the diagnose whether the cluster is relaxed or not

Weak Lensing Data

FORS1@VLT (FoV: 6.8'×6.8')

Queue mode: seeing ≤ 0.6"

24 Abell clusters (0.05<z<0.30)

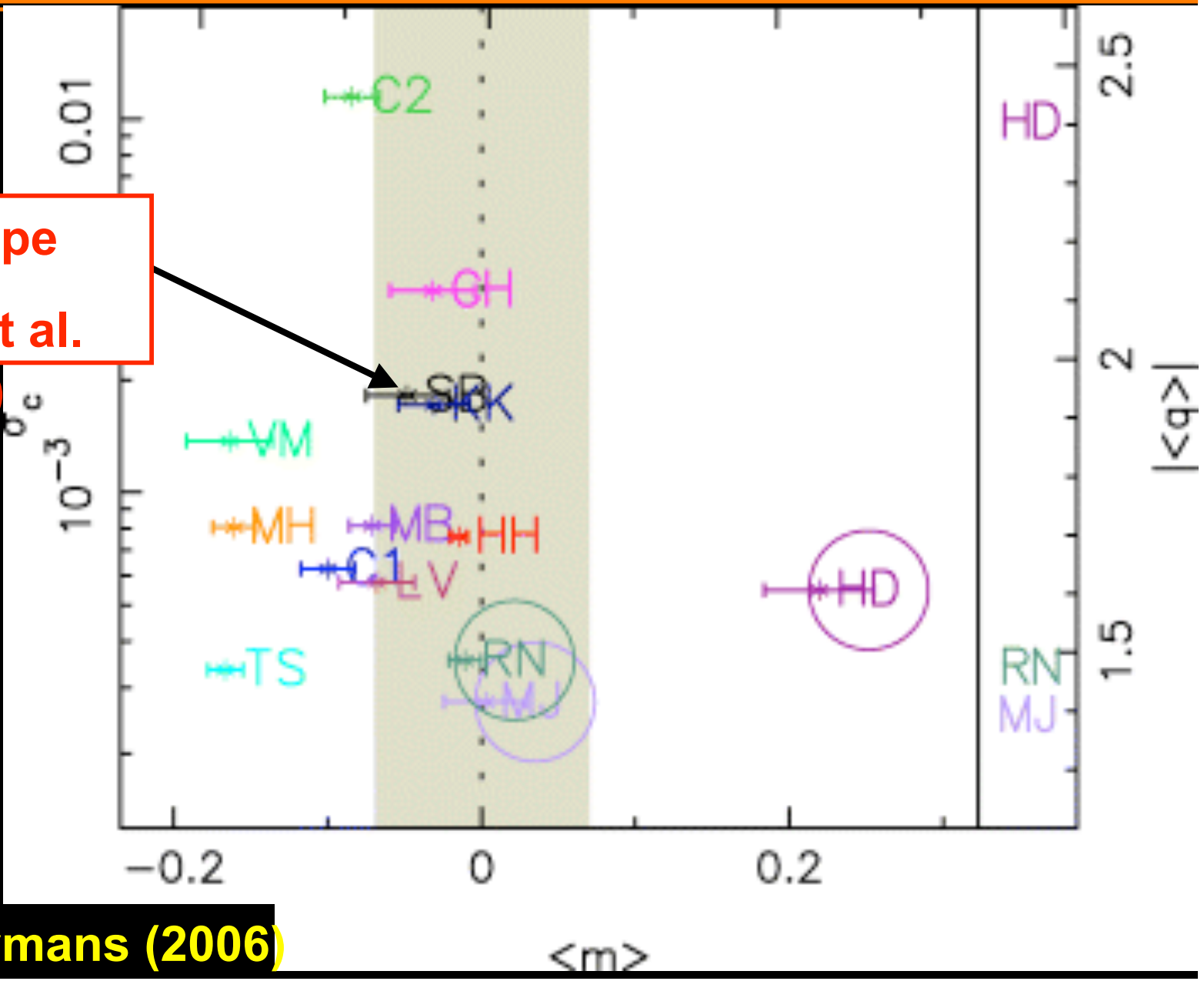
$L_X > 5 \times 10^{44}$ erg s^{-1} (XBAC's Ebeling 1996)

Imaging: V R I (330 s each)

Shape measurments

Im2Shape

(Bridle et al. 2001)

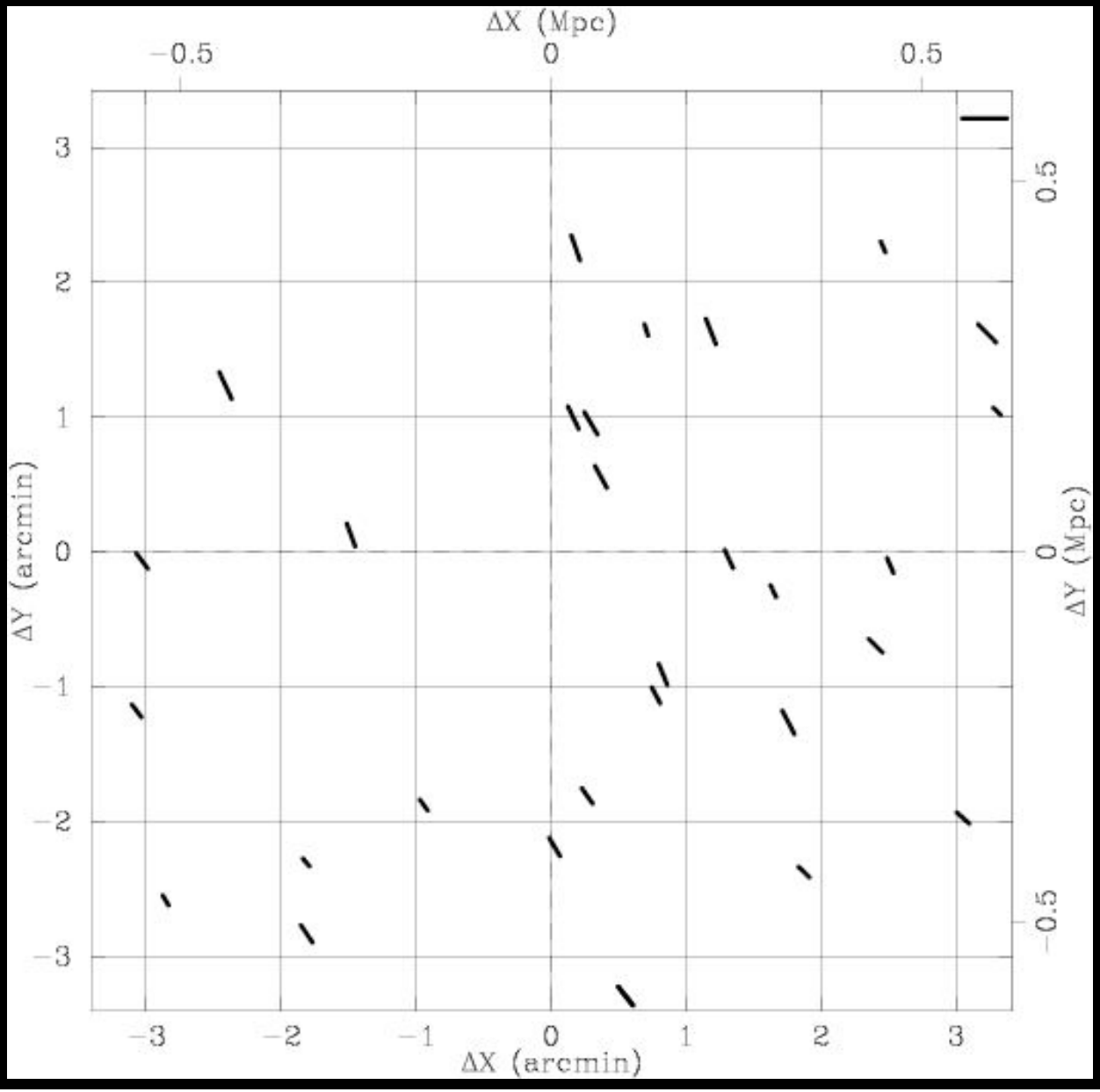


STEP 1: Heymans (2006)

Shape measurments - Stars

Seeing ~ 0.6”

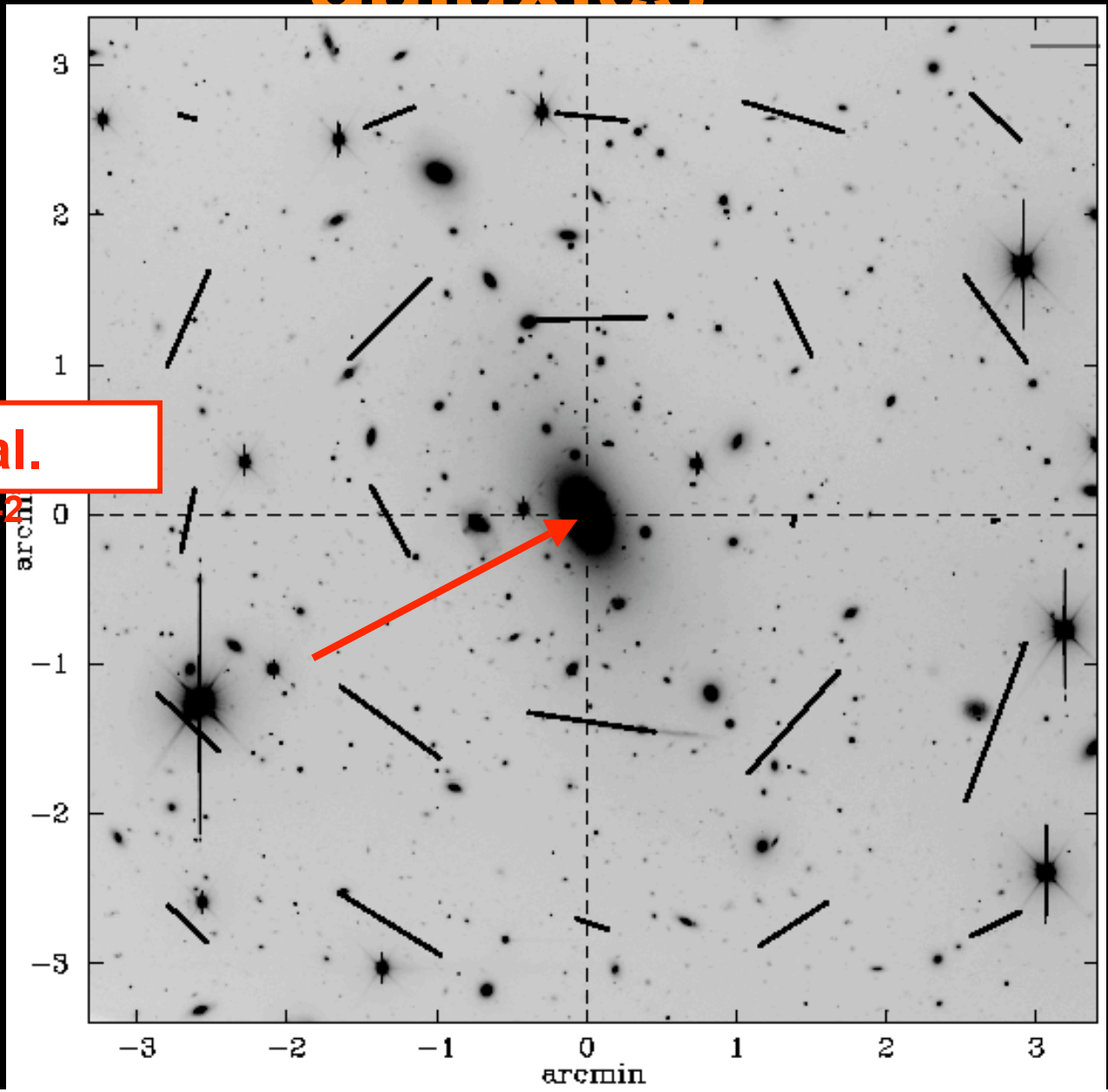
Ellip. ~ 3%



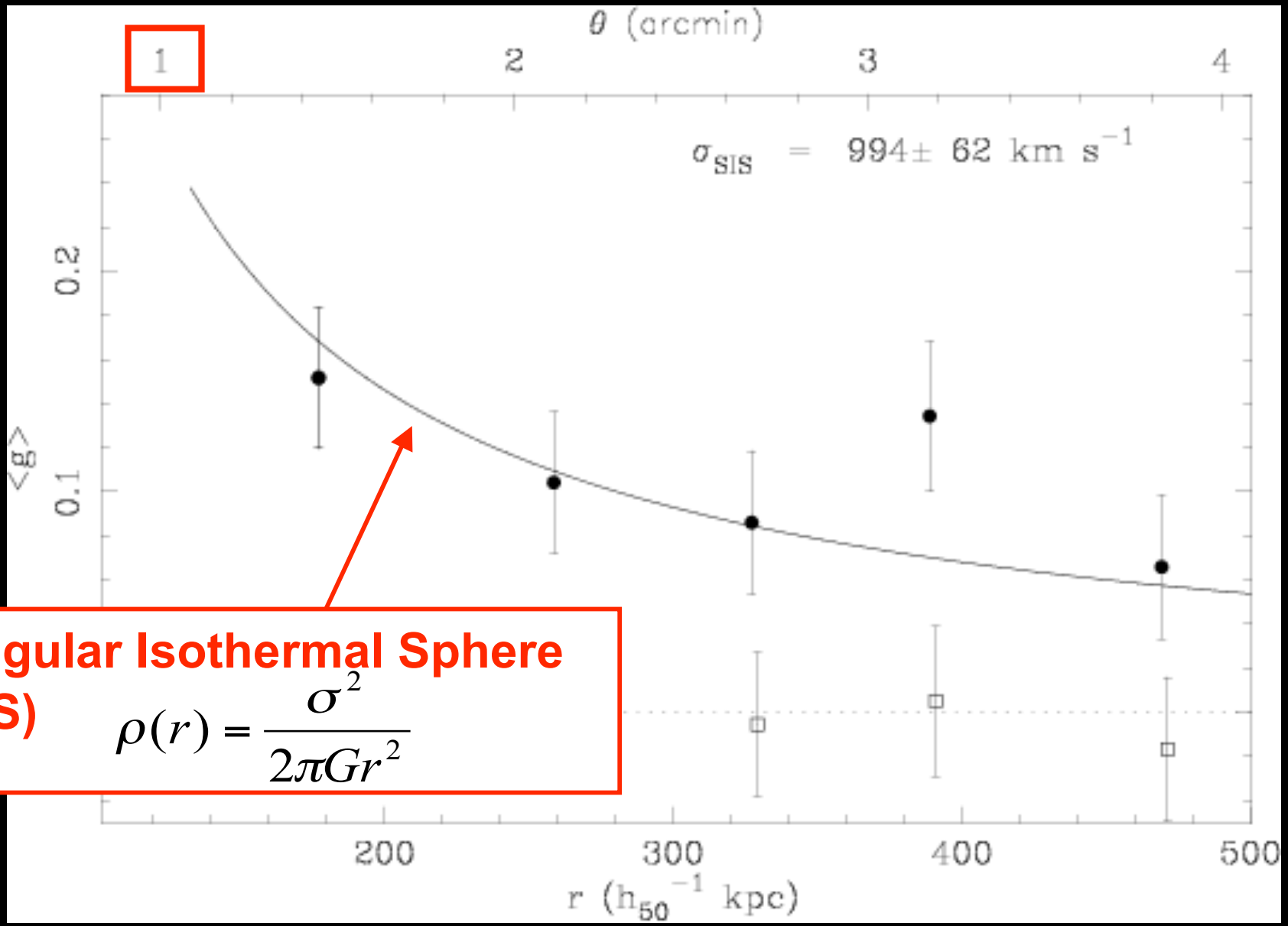
Shape measurments – Faint galaxies

$M_R > -16$

10-15 gal. arcmin^{-2}



Shear Radial Profile



Singular Isothermal Sphere (SIS)

$$\rho(r) = \frac{\sigma^2}{2\pi G r^2}$$

Shear Radial Profile

$$g = \gamma/(1-\kappa)$$

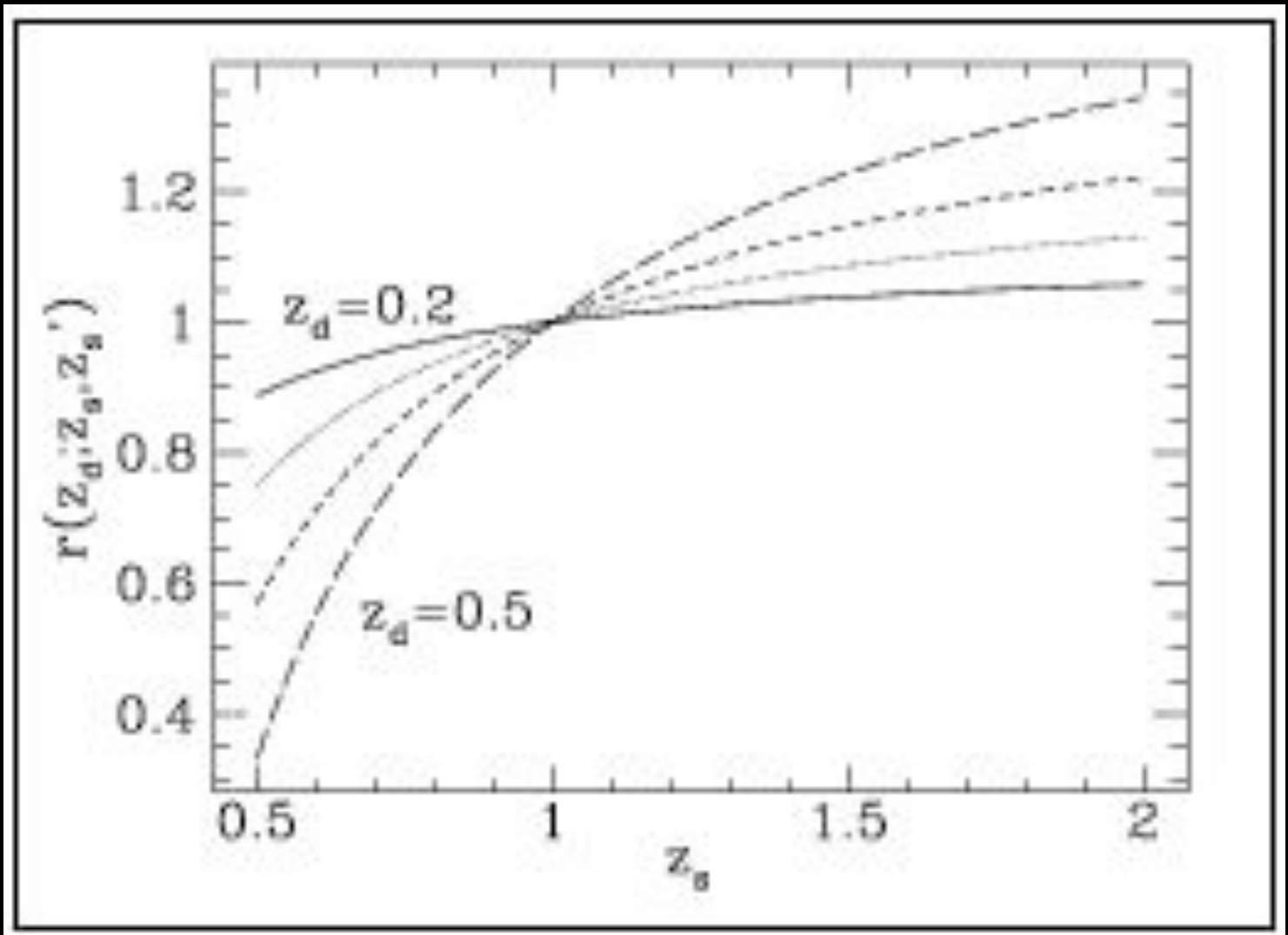
Singular Isothermal Sphere (SIS)

$$\kappa = \gamma = \frac{1}{2}\frac{\theta_E}{\theta}$$

$$\theta_E = 4\pi\frac{\sigma^2_{SIS}}{c^2}\frac{D_{ls}}{D_s}$$

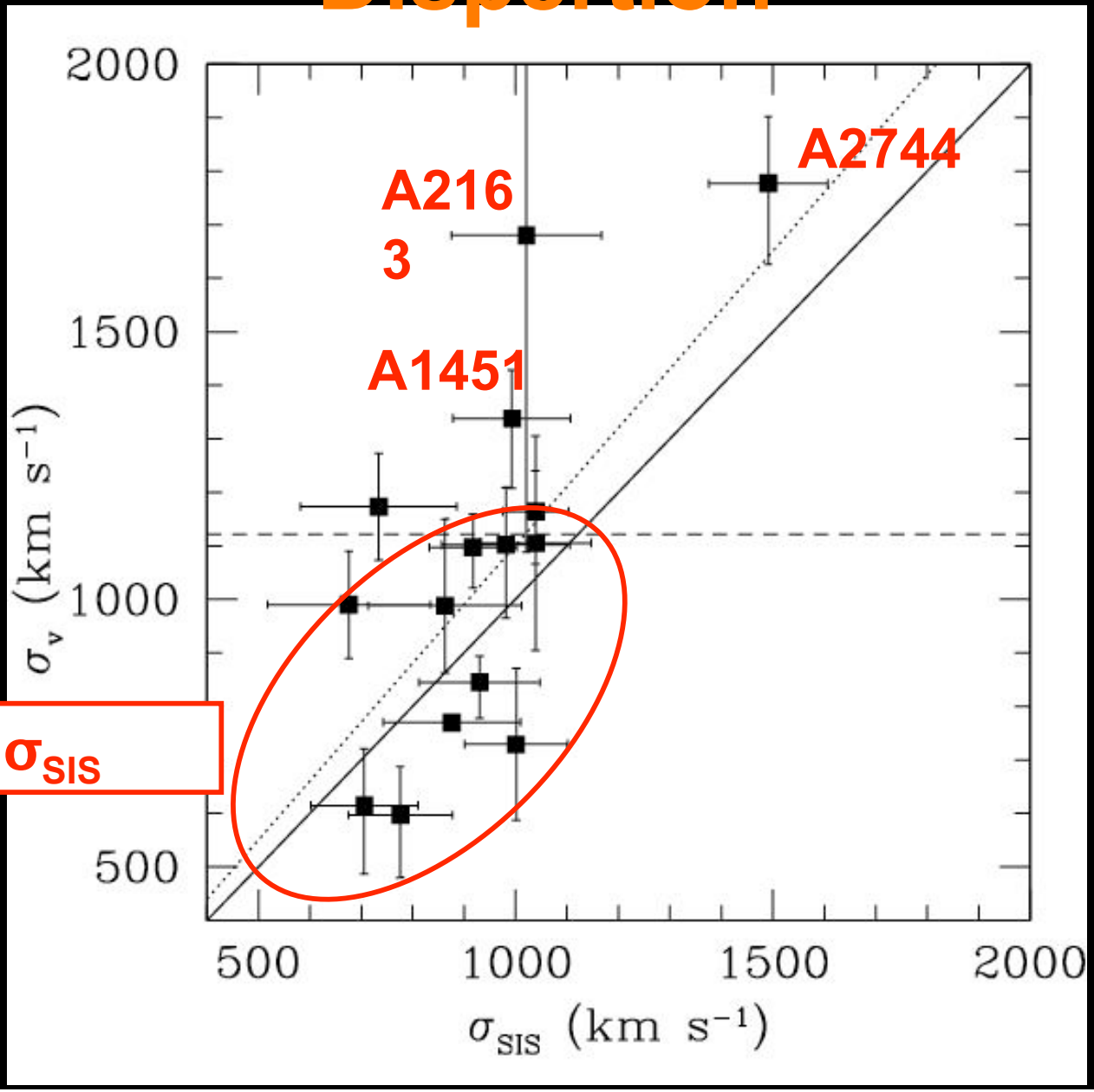
<D_{ls}/D_s> estimated using HDF redshift distribution. Same bright limit and median magnitude

Shear Radial Profile



Bartelmann (1995)

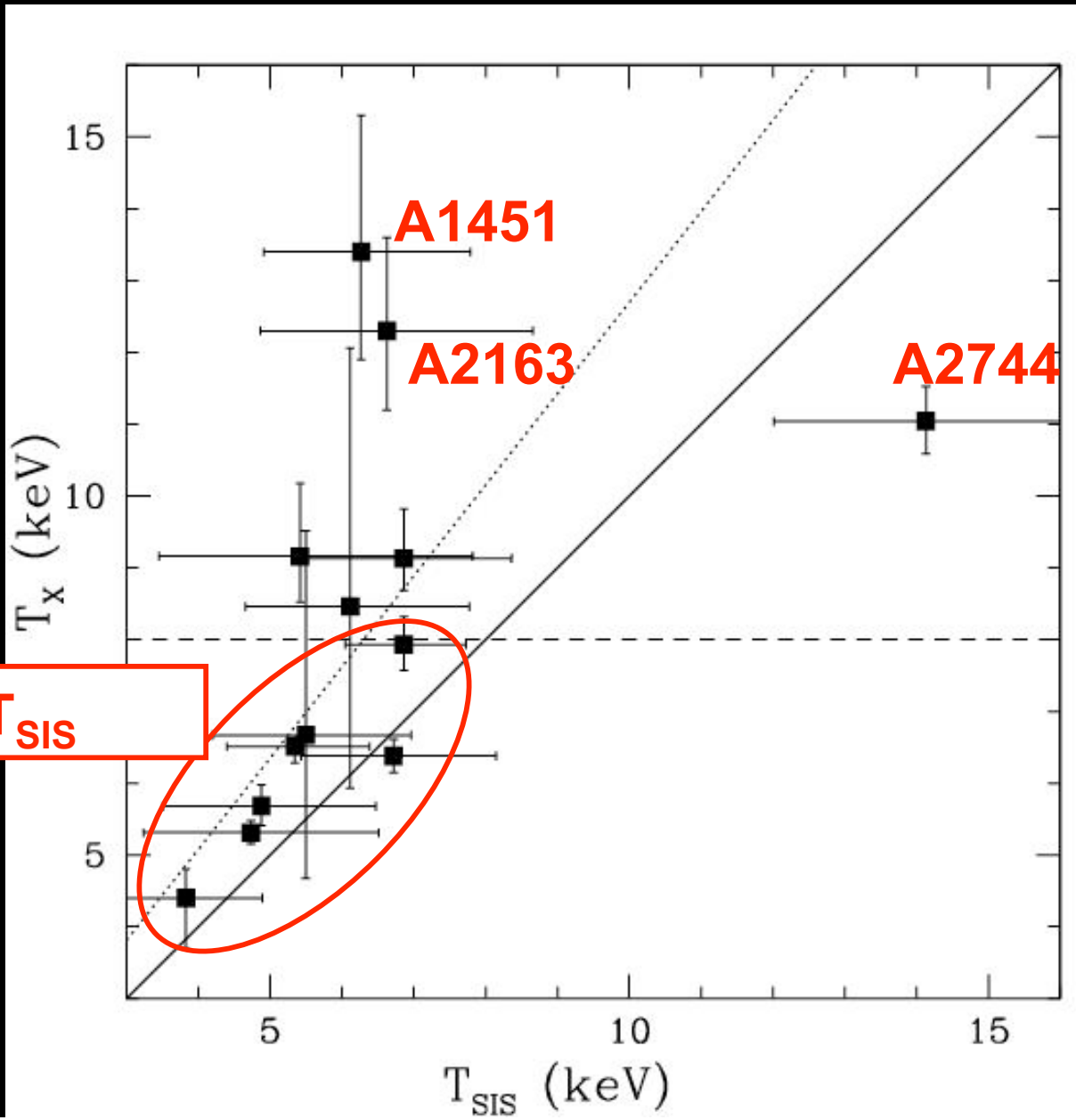
Comparison with the Velocity Dispertion



$\sigma_v \sim \sigma_{SIS}$

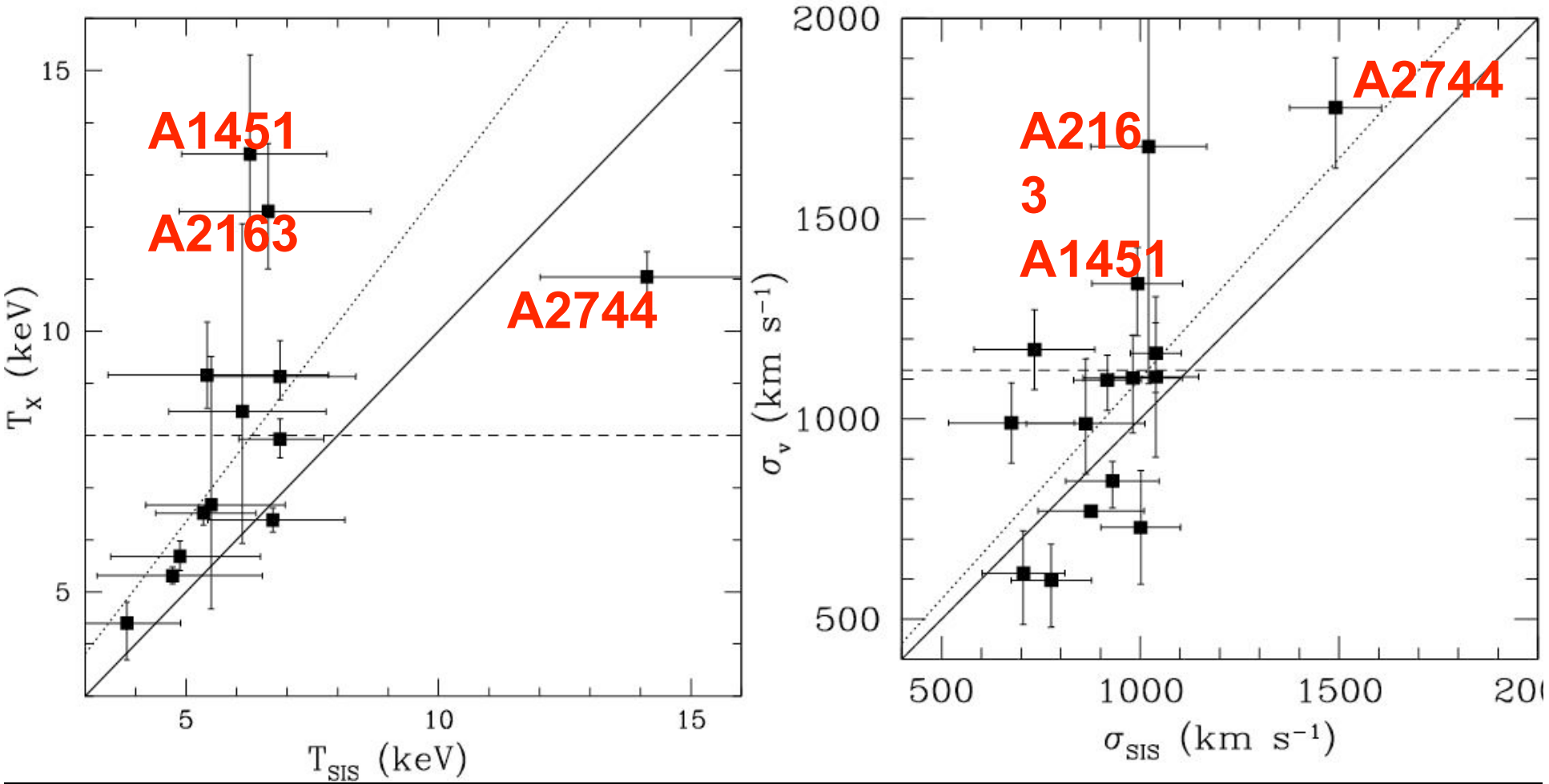
Comparison with X-Rays

$$\sigma_{SIS}^2 = \frac{kT_{SIS}}{\mu\, m_p}$$



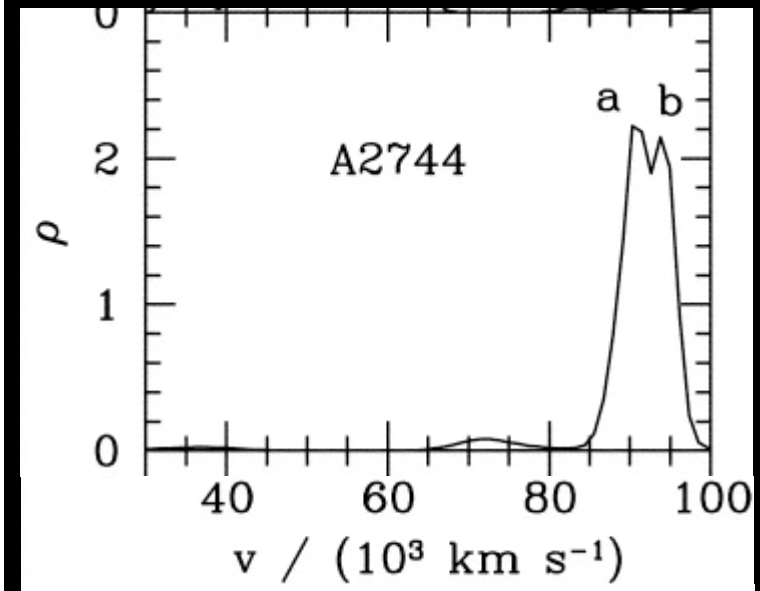
$T_X \sim T_{SIS}$

Comparison with X-rays and dynamics



The dynamical state of the clusters

A2744 – Virial mass> Lensing > X-rays



Girardi & Mezzetti (2001)

$Øσ_{total}$ = 1777 km/s

$Øσ_{A}$ = 1121 km/s

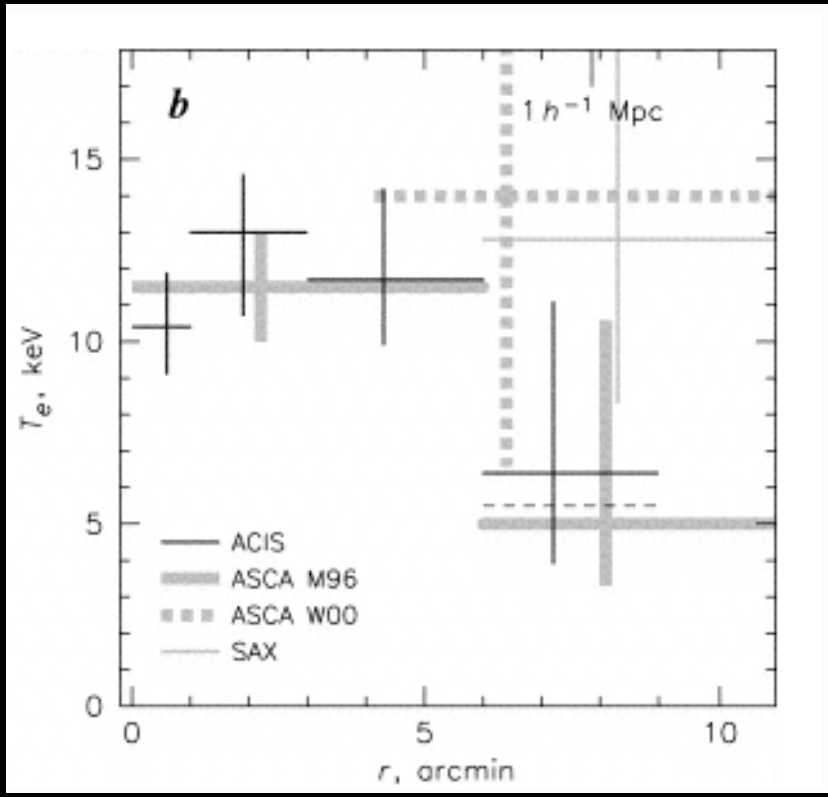
$Øσ_{B}$ = 682 km/s

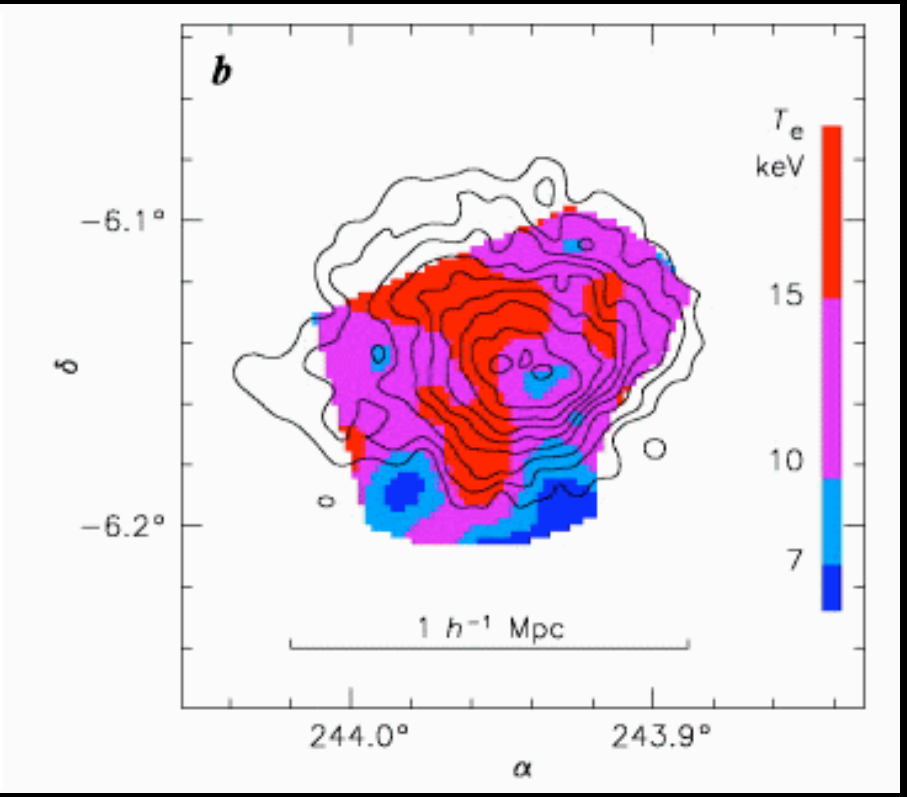
Interpretation: There are two structures along the line of sight

Chandra observations confirms fusion along the line of sight (Kempner & David 2004)

The dynamical state of the clusters

A2163 – "State of violent activity" (Markevitch & Vickhlinin 2001)





The dynamical state of the clusters

A1451 – "...establishing equilibrium after a merger event"

(Valtachanov et al. 2002)

The dynamical state of the clusters

Cluster with T_X > 8 keV (σ_v >1120 km/s) shows strong signs of dynamical activity (mergers)

Colder clusters appears to be nearly relaxed (lensing ≈ dynamical methods)

Conclusions

The hottest clusters tend to present dynamical activity

1 – Reliable masses for these clusters can be obtained through gravitational lensing (preferably in a non-parametric way)

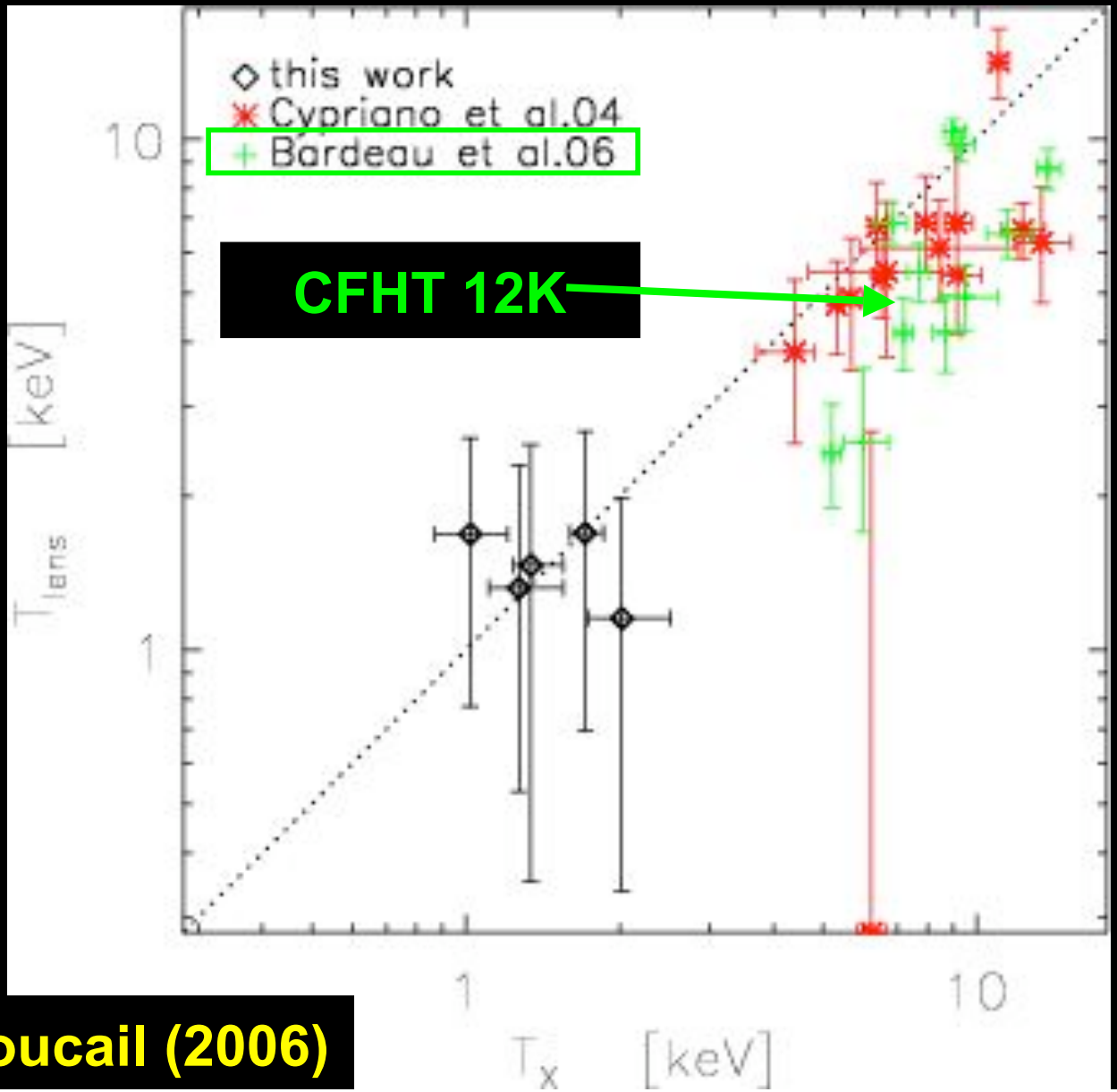
2 – Hot clusters are far from ideal to constrain $M \times T_X$ L_X SZ σ etc.

Comparison with X-Rays

Sehgal et al. (2008)

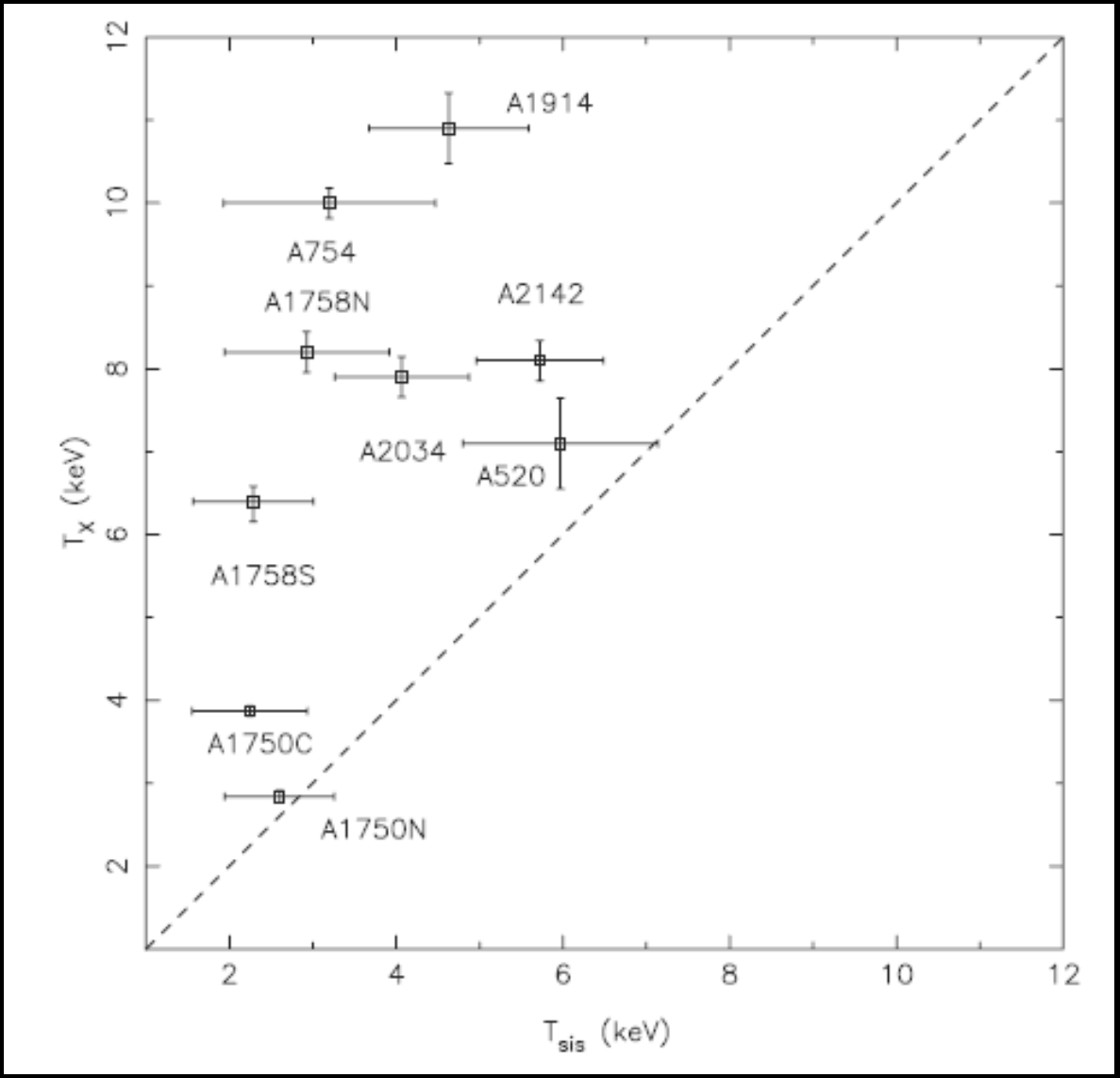
However, recent work based on hydrodynamic cluster simulations suggests X-ray mass estimates are biased low for unrelaxed clusters because only a portion of the kinetic energy of the merging system is converted into thermal energy of the intracluster medium, for even an advanced merger, while the mass of the merging system has already increased (e.g., Kravtsov et al. 2006).

Comparison with X-Rays



Gavazzi & Soucail (2006)

Comparison with X-Rays



Okabe & Umetsu (2008)