Scaling relations of the LoCuSS sample of galaxy clusters: X-ray & lensing observations vs simulations

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Credits: Zhang et al. ArXiv 0802.0770 and some results in preparation

Outline

1. Why shall we study the cluster mass

2. How to understand the cluster mass

strategy

sampling

mass comparison

scaling calibration-- X-ray & weak lensing vs. simulations

3. What is the current knowledge of the cluster mass

Why: precision cluster cosmology – mass systematics

Positive results

segregation for LoCuSS: 5%

normalization for LoCuSS: 2% with Kravtsov+07; 6% with Arnaud+07

low scatter: 8% in Vikhlinin+07, Arnaud+07

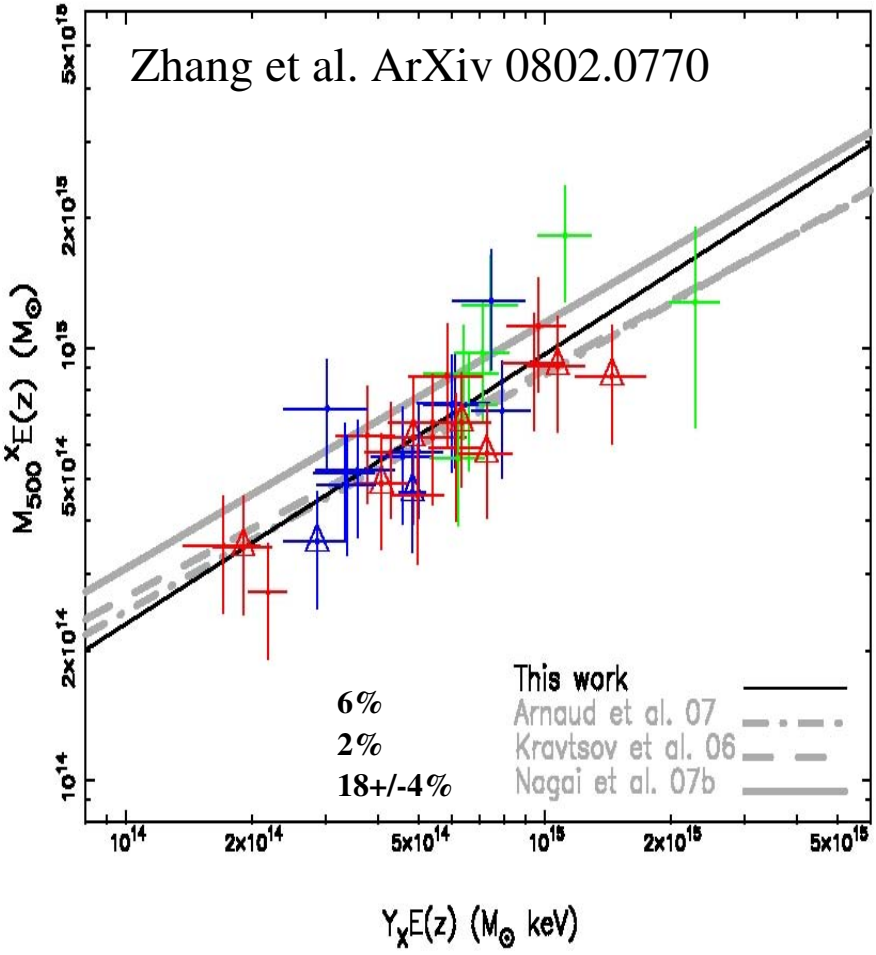
N(>M,z) ~ 10,000 => ΔM/M~0.6% => w=1% in Vikhlinin07

Problems

deviation: 15-20% between obs. & simu.

non-thermal pressure: 10% e.g. Nagai+07

large scatter in wl mass based scaling: Smith+05



How: strategy to study the cluster mass

Direct: X-ray vs. lensing mass ratios

at the same overdensity

at the same radius

Indirect: M-Y calibration between

X-ray mass based vs. weak lensing mass based relations

at the same overdensity

at the same radius

observations and simulations

How: sampling

LoCuSS (Local Cluster Substructure Survey, Smith et al.**)**

a) X-ray selected from RASS (homogeneous)

b) z cut

=> ~100 clusters (sampling atypical ones)

a morphology-representative sample

"x" — 37 in XMM archive:

19 having published WL masses

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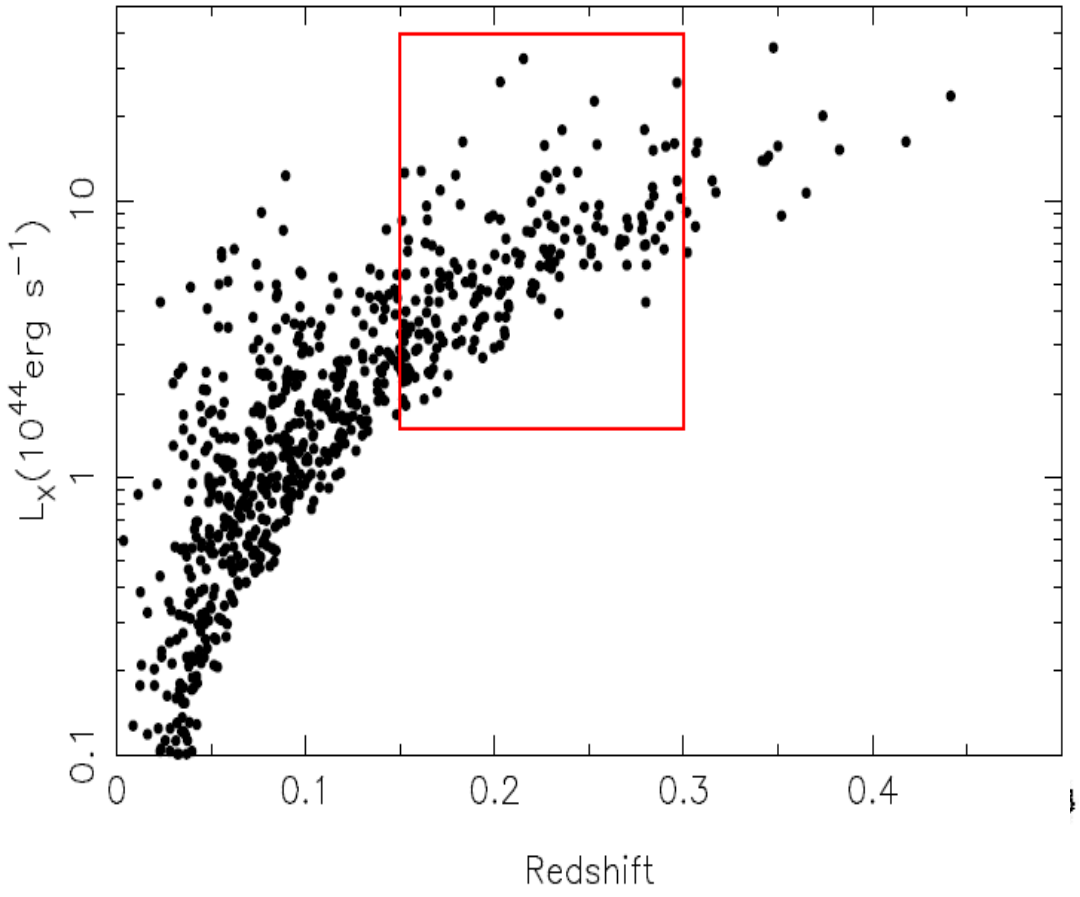
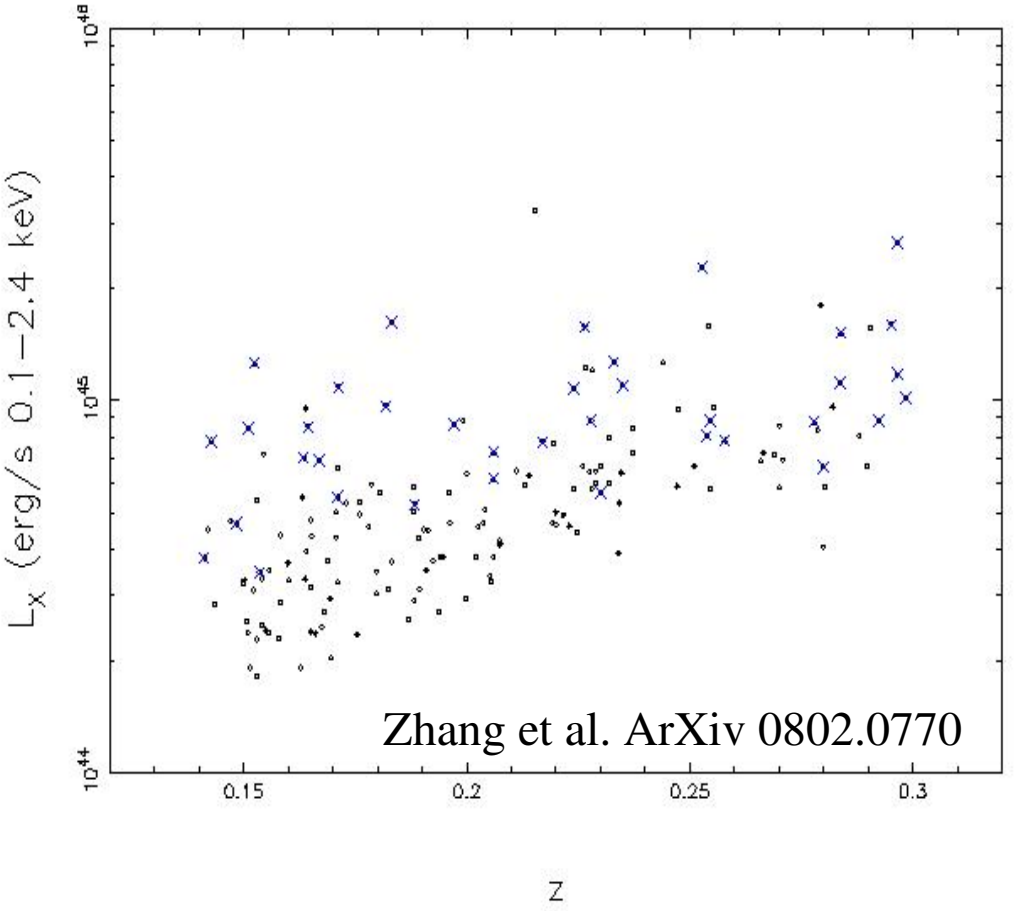
10 in Bardeau+07 (B07), CFHT12k, out to r_{200}

+

15 in Dahle06 (D06), small field, out to $0.4r_{500}$





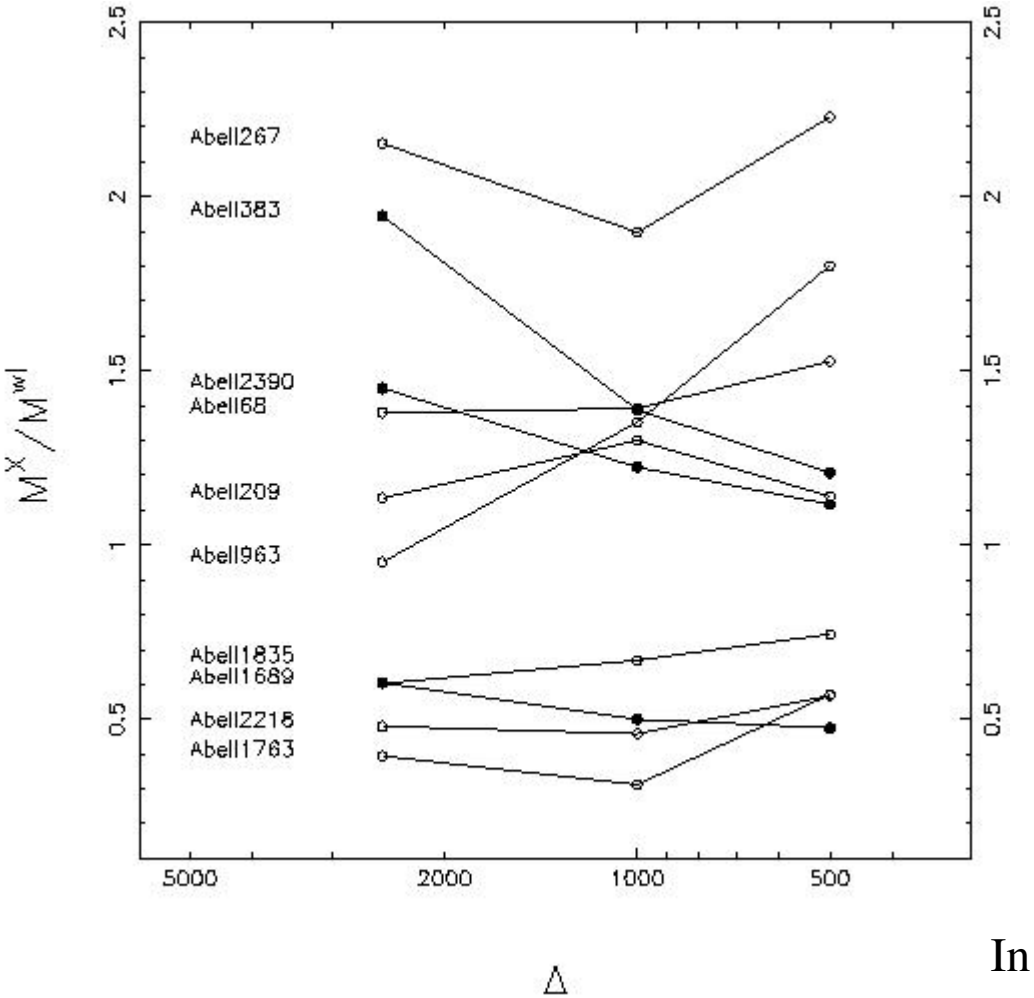
How: X-ray vs. weak lensing mass ratios

B07 subsample

insignificant small scatter @1000

no clear trend between

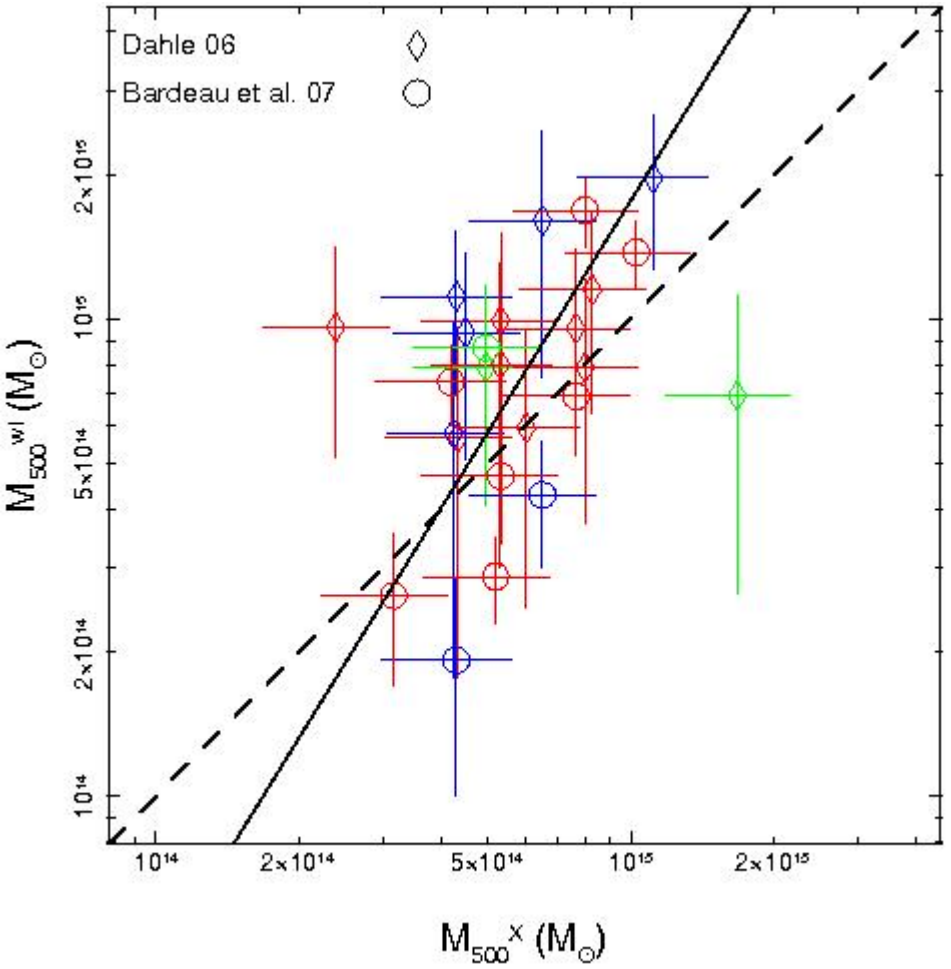
cool core vs. non-cool core



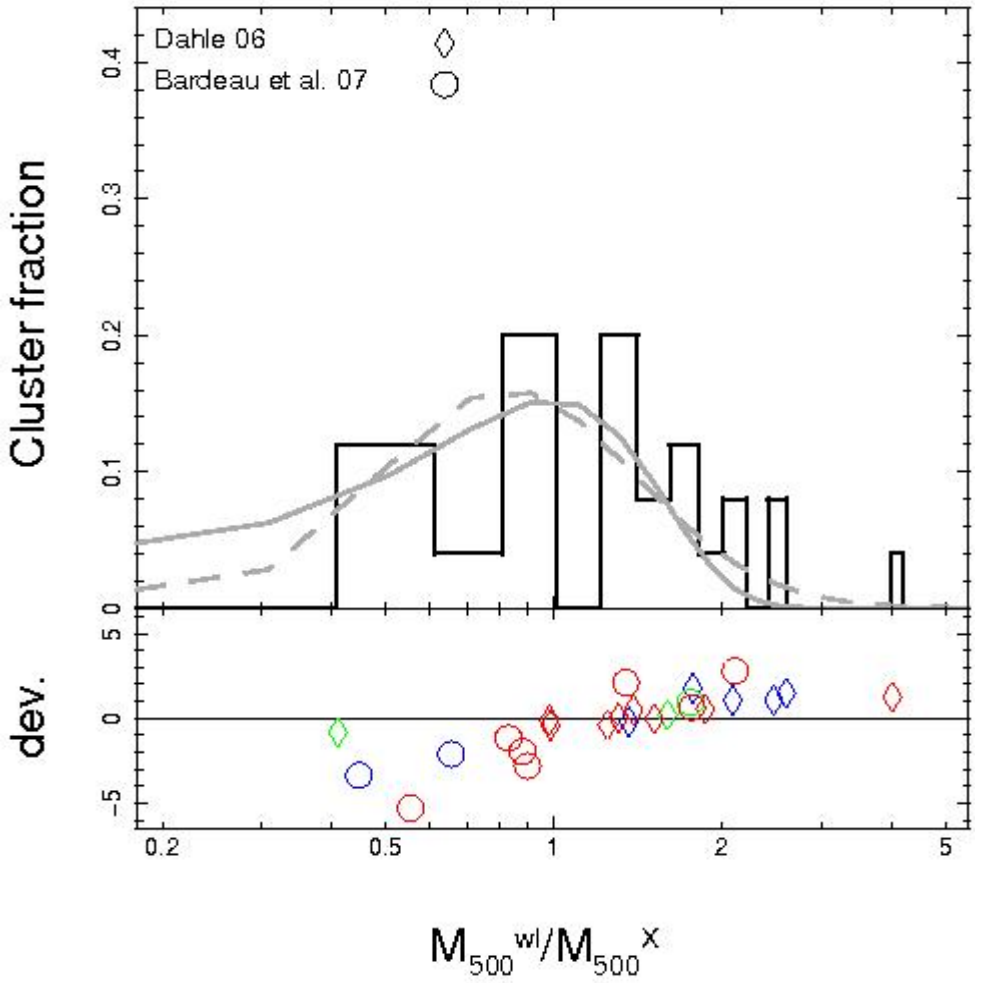
In prep.

How: X-ray vs. weak lensing mass ratios

Sample



Dominant population



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How: X-ray vs. weak lensing mass ratios

1. Radius

$Y_X(r) + M^X\text{-}Y_X$ ↖

↓ --------||-------- Till $M^X\text{-}Y_X$ stops varying

↓ ↖

$500\rho_c(z)V = M^{Yx}(r) \rightarrow r_{500}{}^{Yx} \rightarrow Y_X(r_{500}{}^{Yx}) \& M^X(r_{500}{}^{Yx}) \& M^{wl}(r_{500}{}^{Yx})$

2. Results

		mean	scatter	normalization
by overdensity:	$M^{wl}(r_{500})$ vs. $M^X(r_{500})$	0.99	0.51	28%
by radius:	$M^{wl}(r_{500}{}^{Yx,X})$ vs. $M^X(r_{500}{}^{Yx,X})$	1.16	0.42	9%

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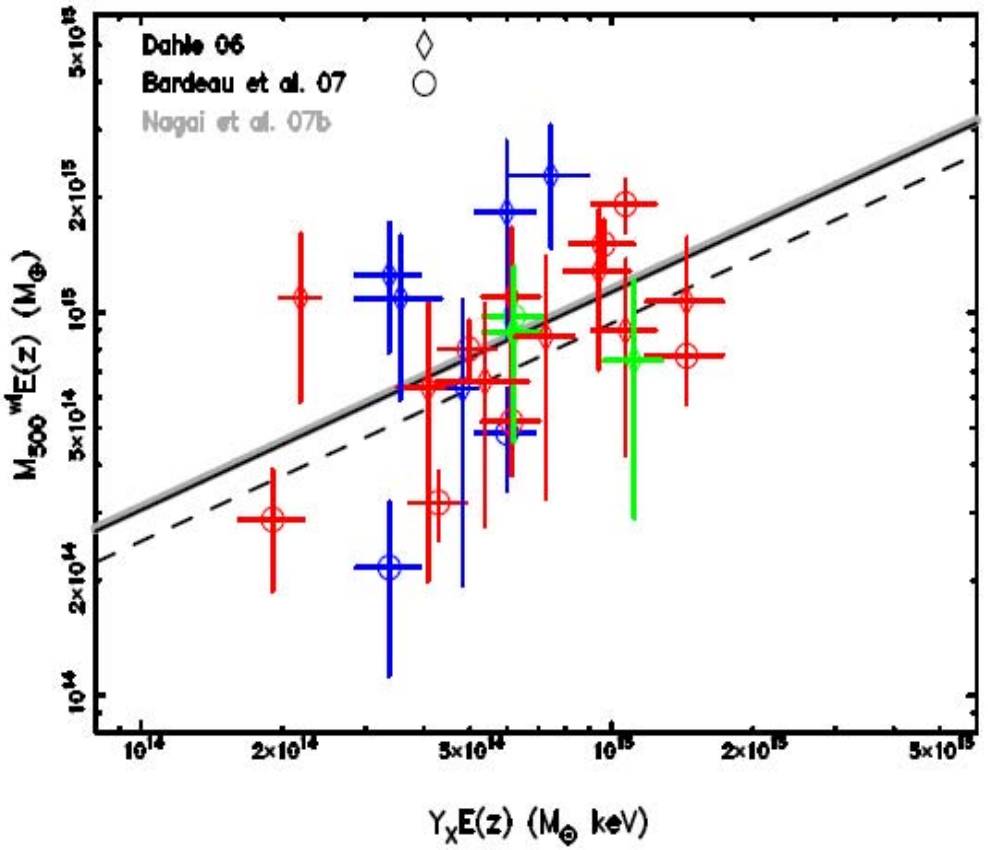
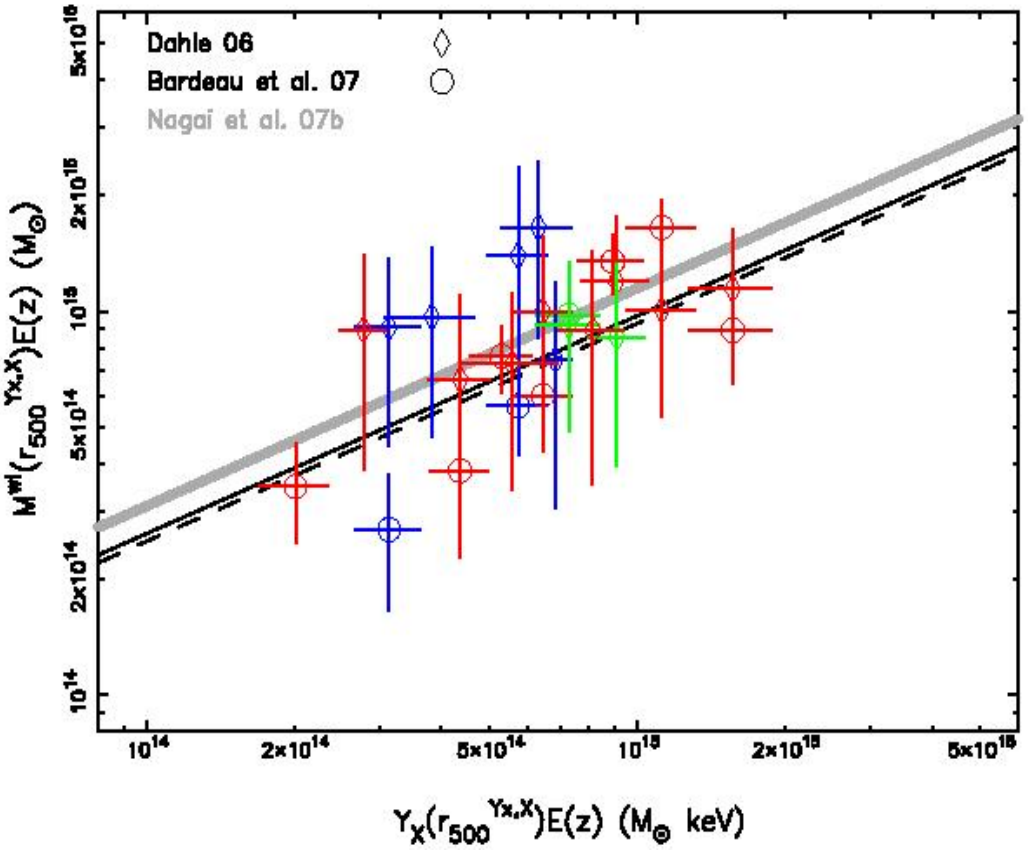
How: X-ray mass based vs. lensing mass based M-Y_X

Obs. vs. simu. with its slope fixed to 0.568 from simulations

	X-ray		lensing	X-ray		lensing
scatter	12%	vs.	24%	13%	vs.	22%
<simulations by	18+/-4%	vs.	1+/-10%	24+/-3%	vs.	18+/-8%





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Conclusions: knowledge of the cluster mass

1. The scatter of mass ratio does not depend on chosen over-density
does not show evident bi-modality
goes down @r_{500}^{Yx}

2. Mass ratio average indicates non-thermal pressure contribution <9%
mean indicates agreement between X-ray and lensing

3. The scatter of M-Y_X is 2*larger using lensing mass than using X-ray
goes down @r_{500}^{Yx}

4. The observed M-Y_X relations are lower than simulations by up to 24%
with 2σ significance based on lensing masses
with 3σ significance based on X-ray masses

Tasks: deep understanding of the cluster mass

1. LoCuSS: ~100 clusters @z~0.2

HST vs. Subaru vs. Chandra vs. XMM

cool core vs. non-cool core vs. merger vs. non-merge

2. HIFLUGCS: 64 clusters @z~0

Chandra vs. XMM

63 clusters with ~2Ms clean data

X-ray 2-D maps vs. radial profiles

vs. simulated clusters