

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

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## **Acknowledgments to**

**A. Finoguenov (MPE / UMBC)**

H. Boehringer (MPE)

G.P. Smith (U of Birmingham)

N. Okabe (U of Tohoku)

A. Babul (U of Victoria)

A. Mahdavi (U of Victoria)

T.H. Reiprich (U of Bonn)

J.-P. Kneib (OAMP)

R. Kneissl (MPIR)

H. Dahle (OAMP)

A.E. Evrard (U of Michigan)

G.W. Pratt (MPE)

A. Vikhlinin (CfA)

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

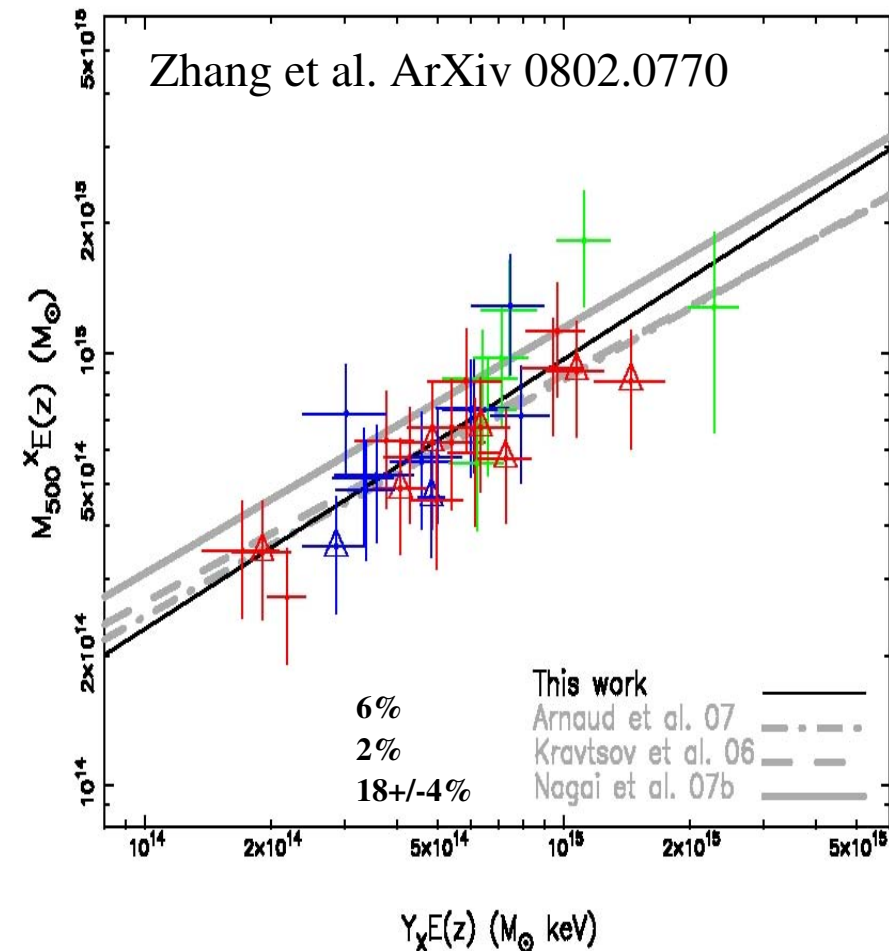
$N(>M,z) \sim 10,000 \Rightarrow \Delta M/M \sim 0.6\% \Rightarrow w=1\%$  in Vikhlinin07

## 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:

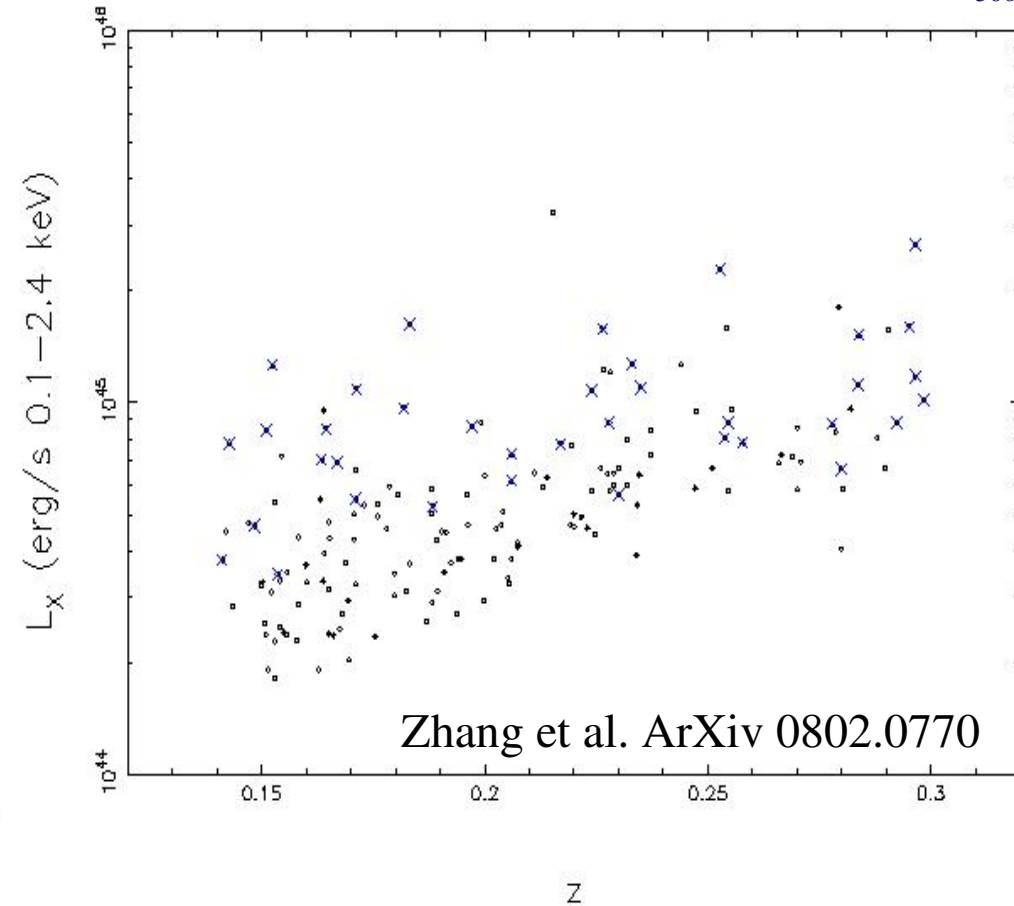
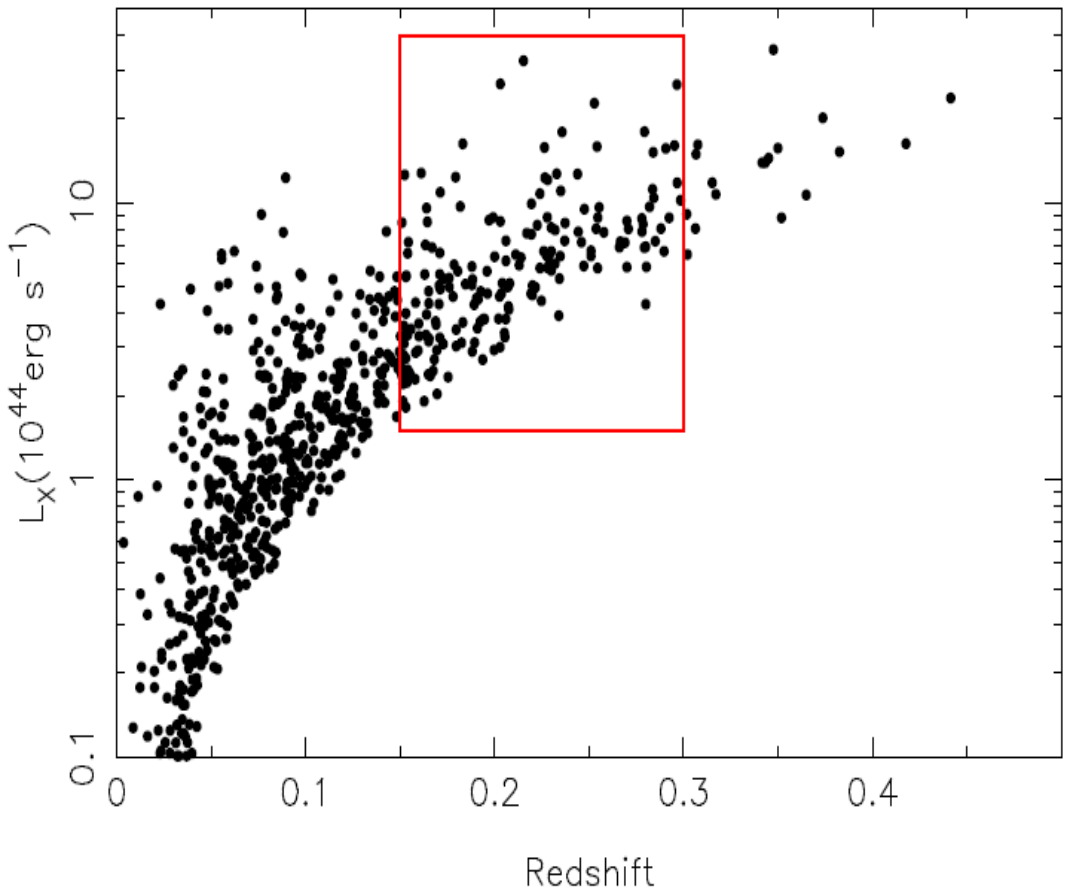
19 having published WL masses

||

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

+

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



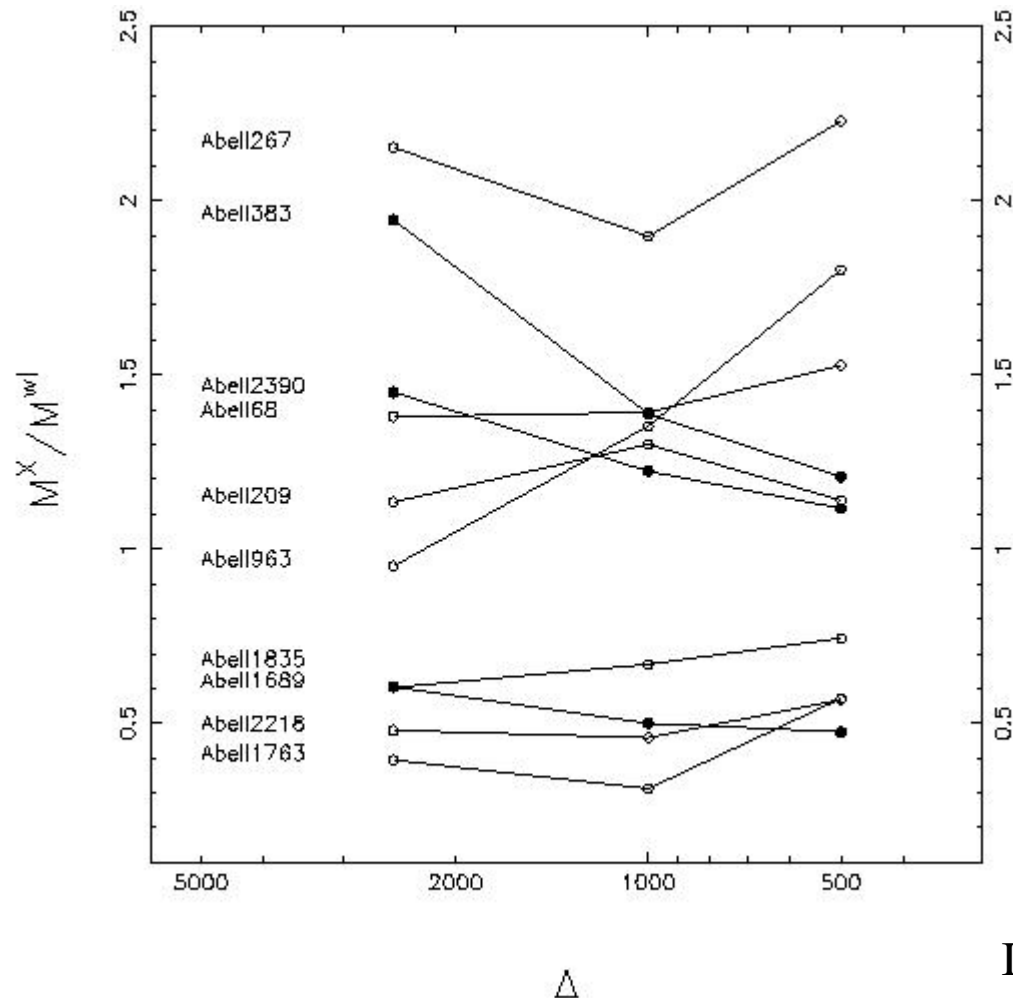
# How: X-ray vs. weak lensing mass ratios

B07 subsample

insignificant small scatter @ 1000

no clear trend between

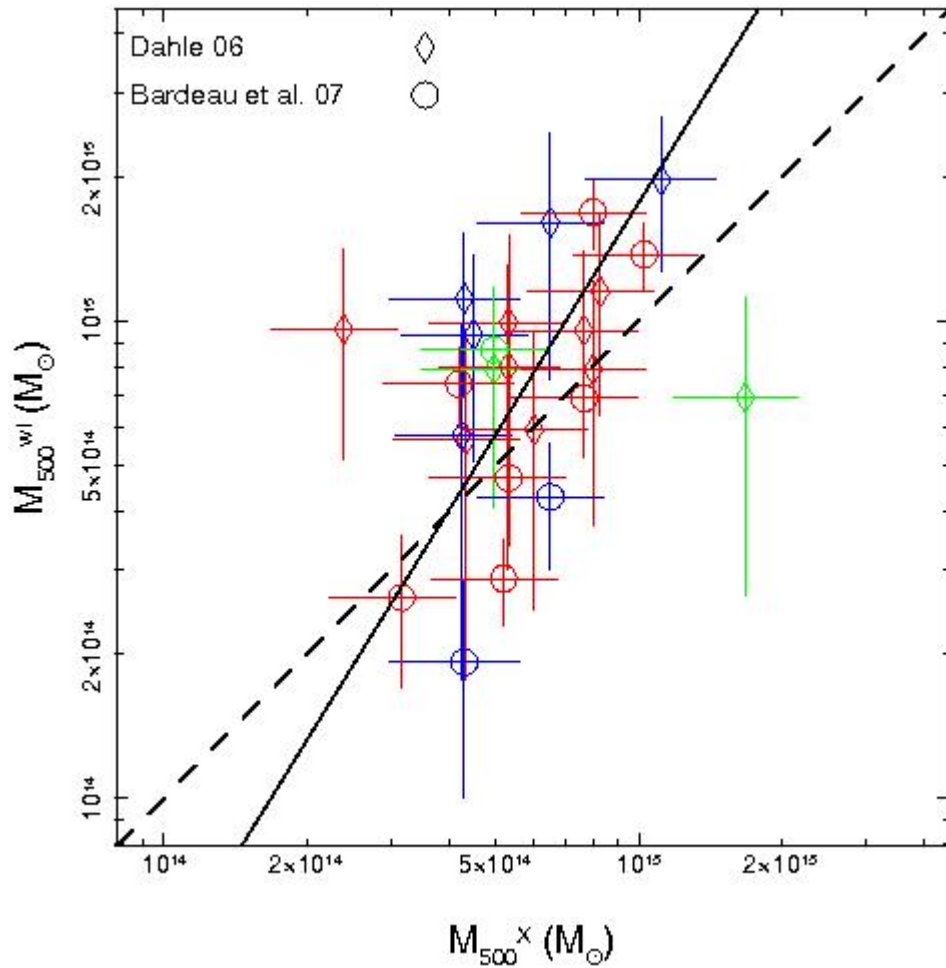
cool core vs. non-cool core



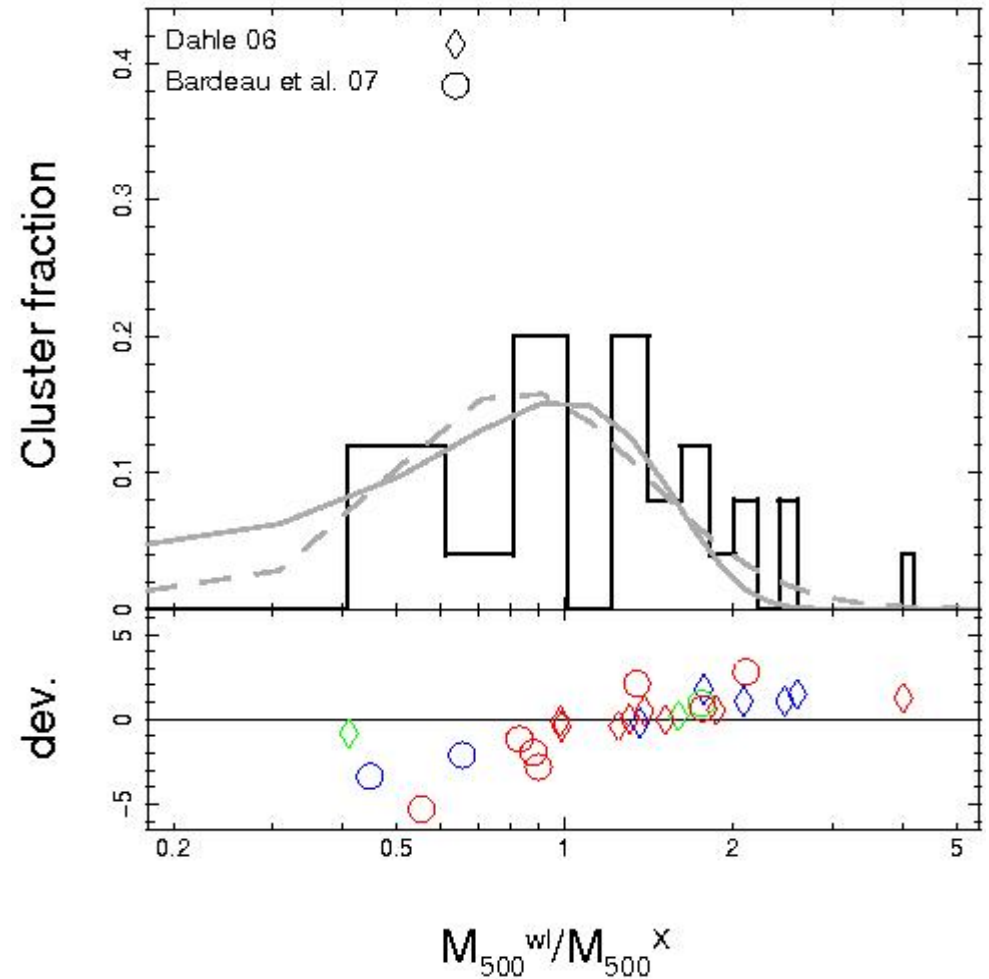
In prep.

# How: X-ray vs. weak lensing mass ratios

## Sample



## Dominant population



# How: X-ray vs. weak lensing mass ratios

## 1. Radius

$$Y_X(r) + M^X - Y_X \leftarrow$$

↓

-----||----- Till  $M^X - Y_X$  stops varying

↓

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

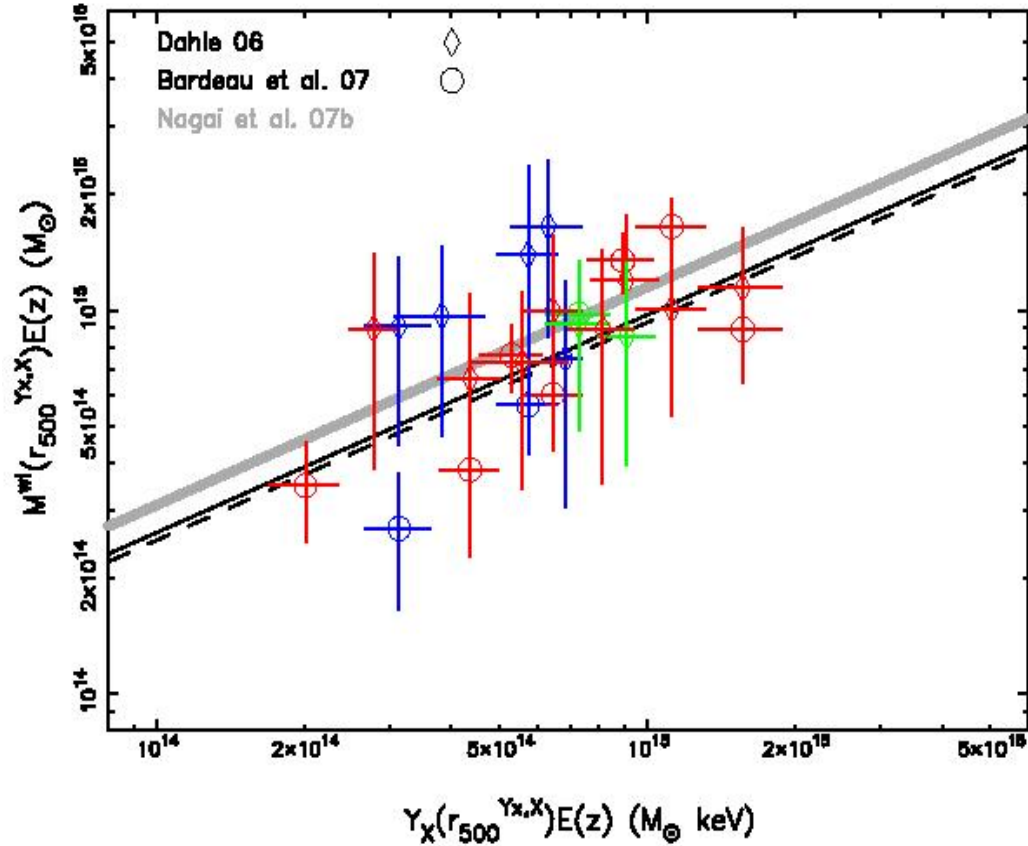
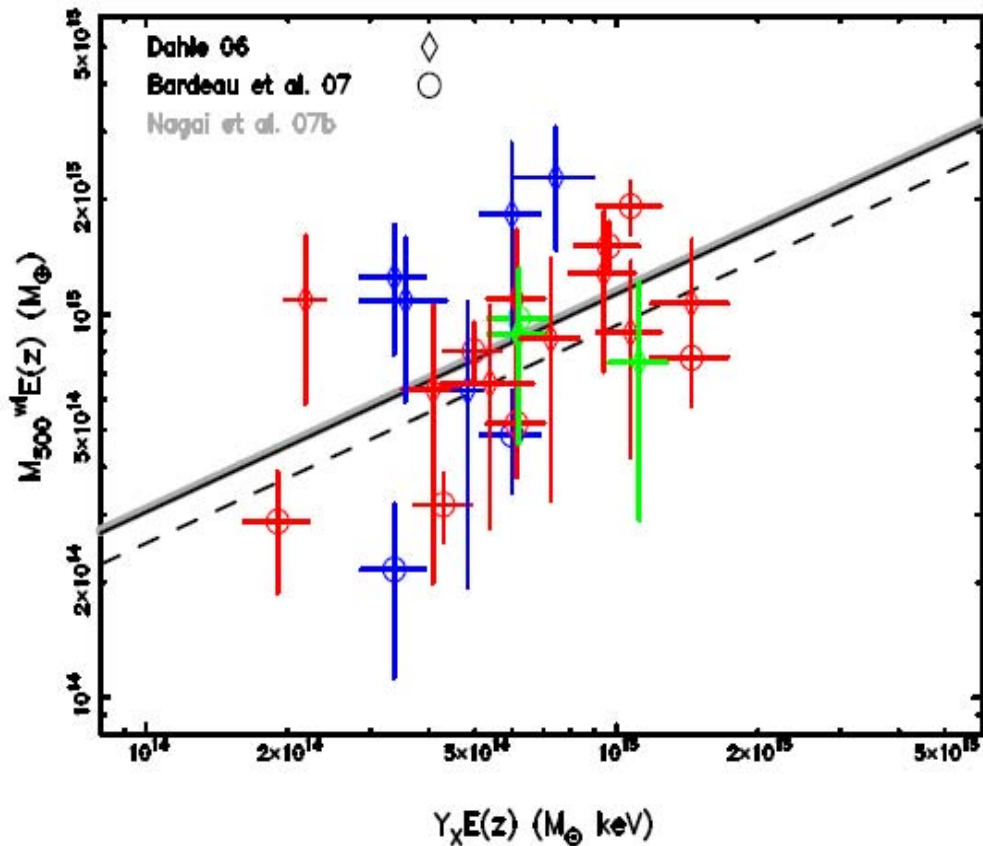
## 2. Results

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

# 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%	1+/-10%	24+/-3%	18+/-8%



# 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  $2\sigma$  significance based on lensing masses  
with  $3\sigma$  significance based on X-ray masses

# Tasks: deep understanding of the cluster mass

## 1. LoCuSS: ~100 clusters @ $z \sim 0.2$

HST vs. Subaru vs. Chandra vs. XMM

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

## 2. HIFLUGCS: 64 clusters @ $z \sim 0$

Chandra vs. XMM

63 clusters with  $\sim 2M_{\odot}$  clean data

X-ray 2-D maps vs. radial profiles

vs. simulated clusters