Do Mass Estimates agree with the True Mass: LoCuSS & HIFLUGCS

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Zhang et al. 08, A&A, 482, 451 - LoCuSS
Zhang et al. A&A, to be submitted - HIFLUGCS

Large unbiased samples: LoCuSS vs. HIFLUGCS

1. Credible cluster cosmology experiments require calibrated measure on the
   SHAPE, **SCATTER** and **EVOLUTION**
   of the mass-observable scaling relations based on
   LARGE STATISTICAL SAMPLES
   of galaxy clusters that are
   UNBIASED WITH RESPECT TO CLUSTER MORPHOLOGY.
2. Elimination of systematic uncertainties from this calibration demands on

mass estimate calibration

i.e. independent technique,
X-ray + lensing

LoCuSS (PI: G.P. Smith)
~100 luminous clusters @ z~0.2
with XMM: 44 reduced, 3 coming

cluster dynamical state check

i.e. X-ray

HIFLUGCS (PI: T.H. Reiprich)
64 luminous clusters @ z~0
with XMM: 63 reduced

37 LoCuSS: X-ray scaling relations e.g. M-Y_X

1. Empirical self-similarity

e.g. Kravtsov et al. 07, Arnaud et al. 07

Zhang et al. 08, A&A, 482, 451 (37 LoCuSS clusters@z~0.2)

2. No additional evolution beyond LSS growth

e.g. 37 LoCuSS@z~0.2, agree within

2% with Kravtsov et al. 07 @z~0

6% with Arnaud et al. 07@z~0

3. No pronounced bi-modality

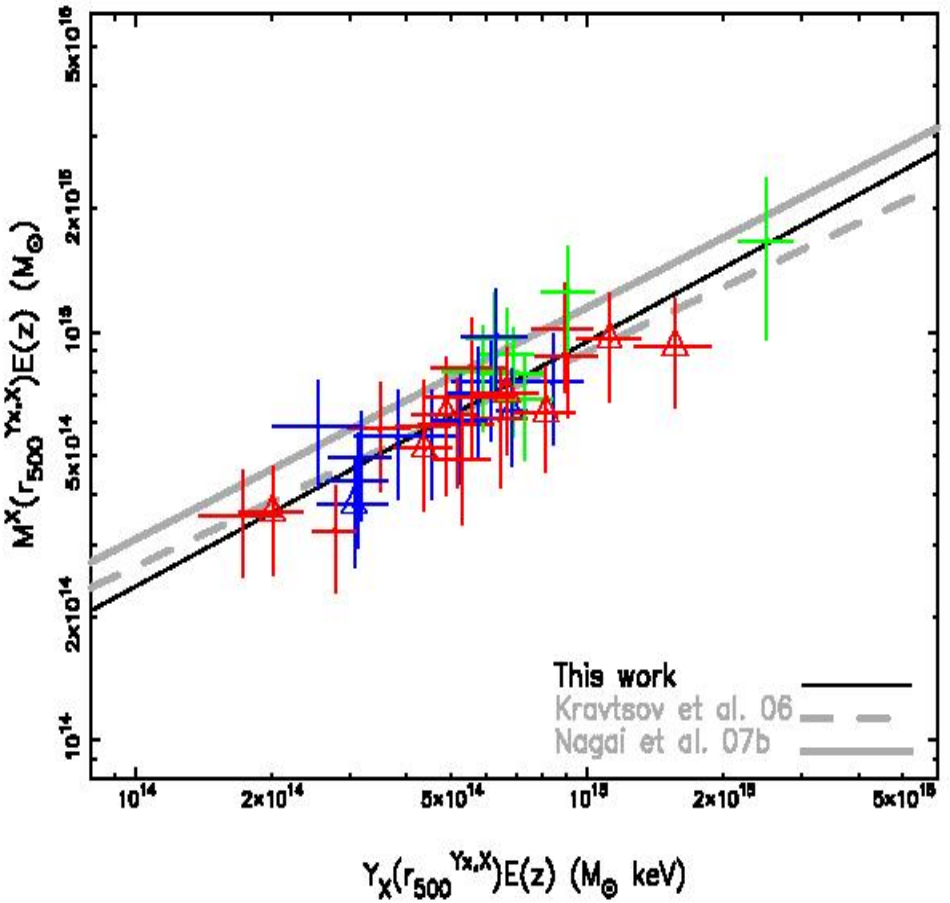
e.g. 5% segregation between

37 LoCuSS clusters and the non-CC subsample

4. Low scatter

e.g. 8% in Vikhlinin et al. 07 and Arnaud et al. 07

13% for 37 LoCuSS clusters



19 LoCuSS: weak lensing and X-ray vs. simulations

Observed mass based scaling is 15-20% lower than simulations

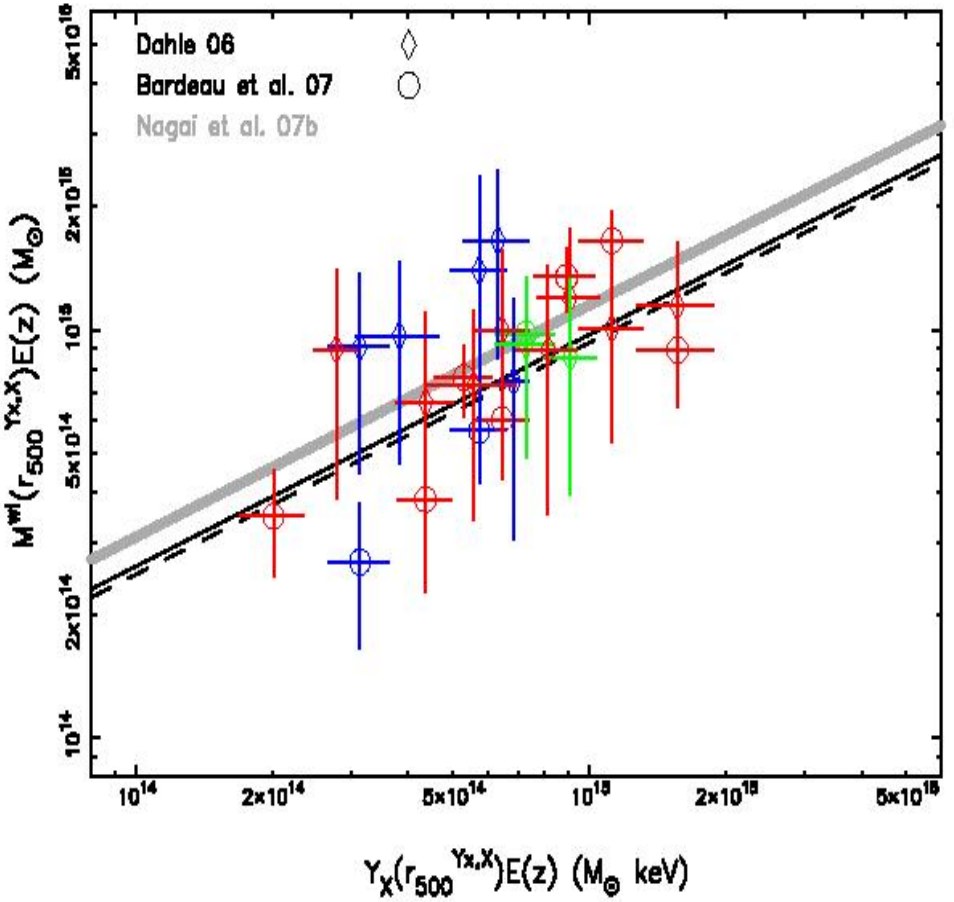
e.g. Zhang et al. 08, 24+/-3% for X-ray mass based M-Y_X,

18+/-8% for weak lensing mass based M-Y_X

Understanding this mass bias from the point of view of simulations?

Issues in X-ray and lensing mass measurements?

Why 2* larger scatter in the lensing based scaling (lensing based 24% vs. X-ray based 13%)?



19 LoCuSS: non-thermal pressure support constraint

Non-thermal pressure support of ~10%

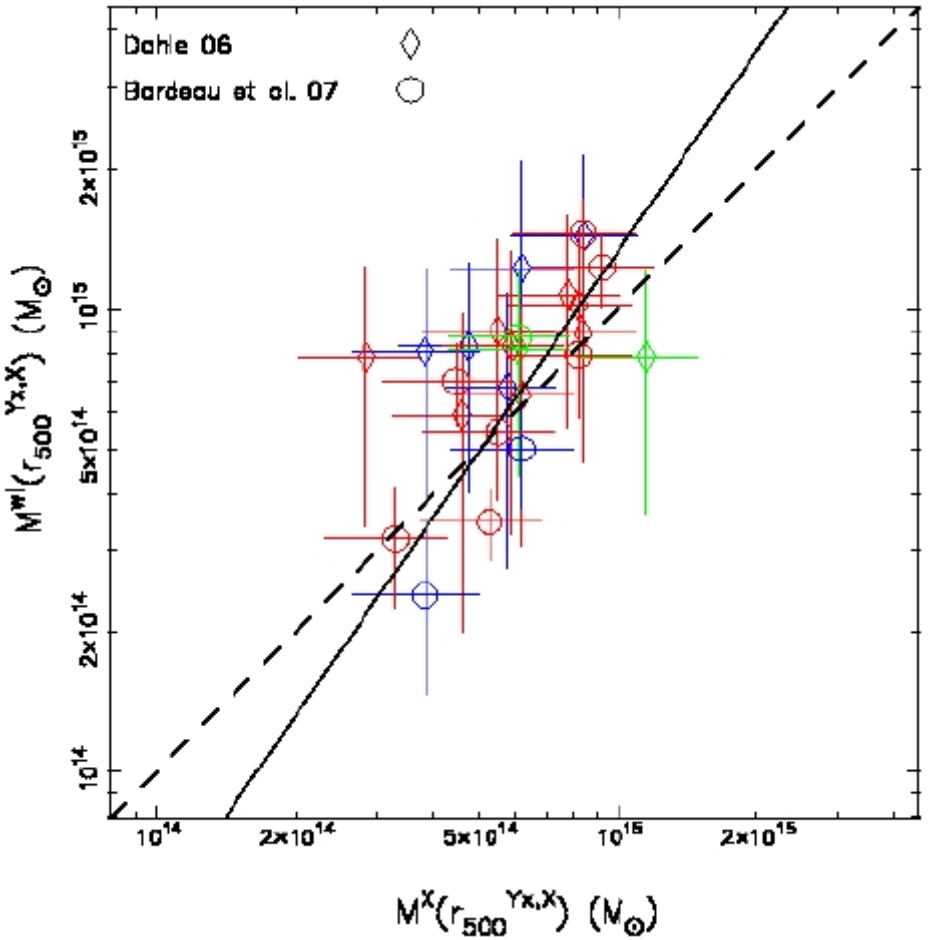
e.g. Mahdavi et al. 08 X-ray-to-lensing 0.78+/-0.09@r500 (=lensing-to-X-ray 1.28)

Zhang et al. 08 lensing-to-X-ray 1.09+/-0.08@r500

How much?

Cluster population dependent?

How to better quantify cluster population?



Summary of the LoCuSS results

1. The X-ray scaling relations

appear empirical self-similar showing

no additional evolution beyond the LSS growth in concordance cosmology

no significant bi-modality

2. The scatter of mass—observable relations

is 2*larger using weak lensing masses than using X-ray masses

3. The observed mass--observable relations

are lower than simulations by ~20%

with 2 significance based on weak lensing mass estimates

with 3 significance based on X-ray mass estimates

4. The average of the lensing-to-X-ray mass ratio

is 1.09+/-0.08,

indicates non-thermal pressure contribution of~10%

HIFLUGCS perspective

1. Profiles as the reference curves

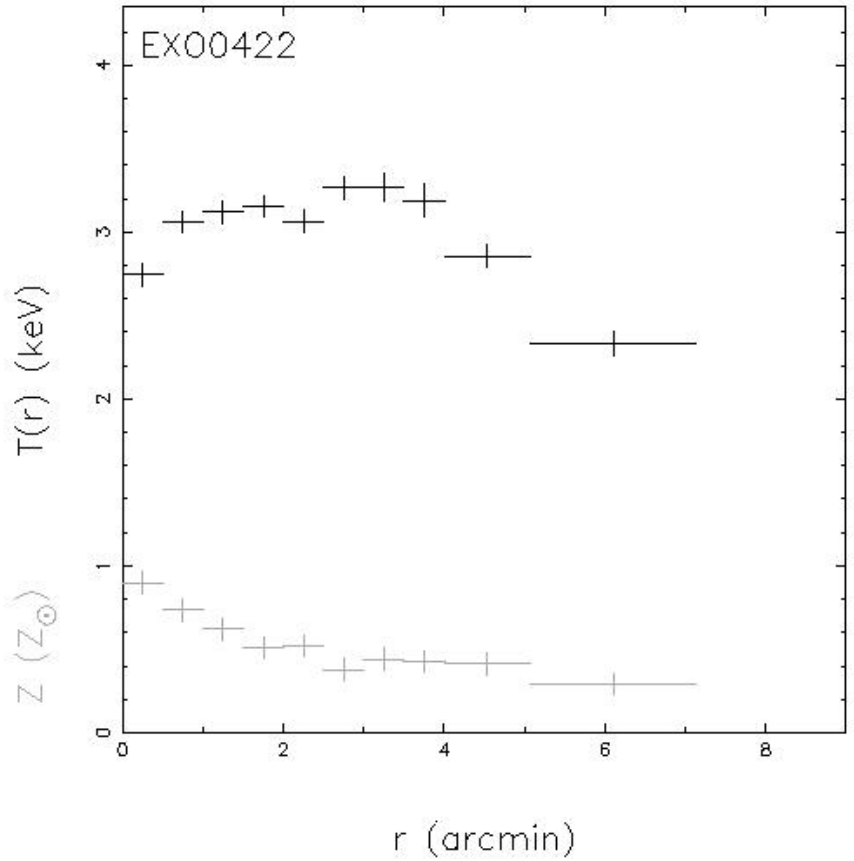
Zhang et al. in prep.

background subtraction follows Snowden et al. 08 with some complications

e.g. ROSAT PSPC pointed observations – CXB

pn data included in the reduction

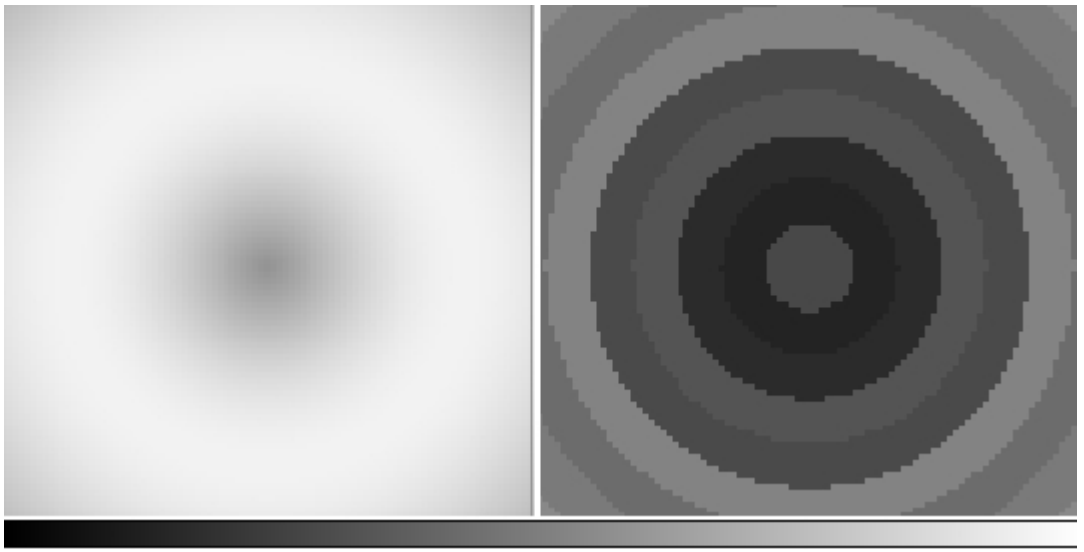
radial bins defined by S/N=270, 0.5-7.8keV



6'*6'

1.4-3.5keV

0-0.2keV



HIFLUGCS perspective

2. X-ray maps and their error maps

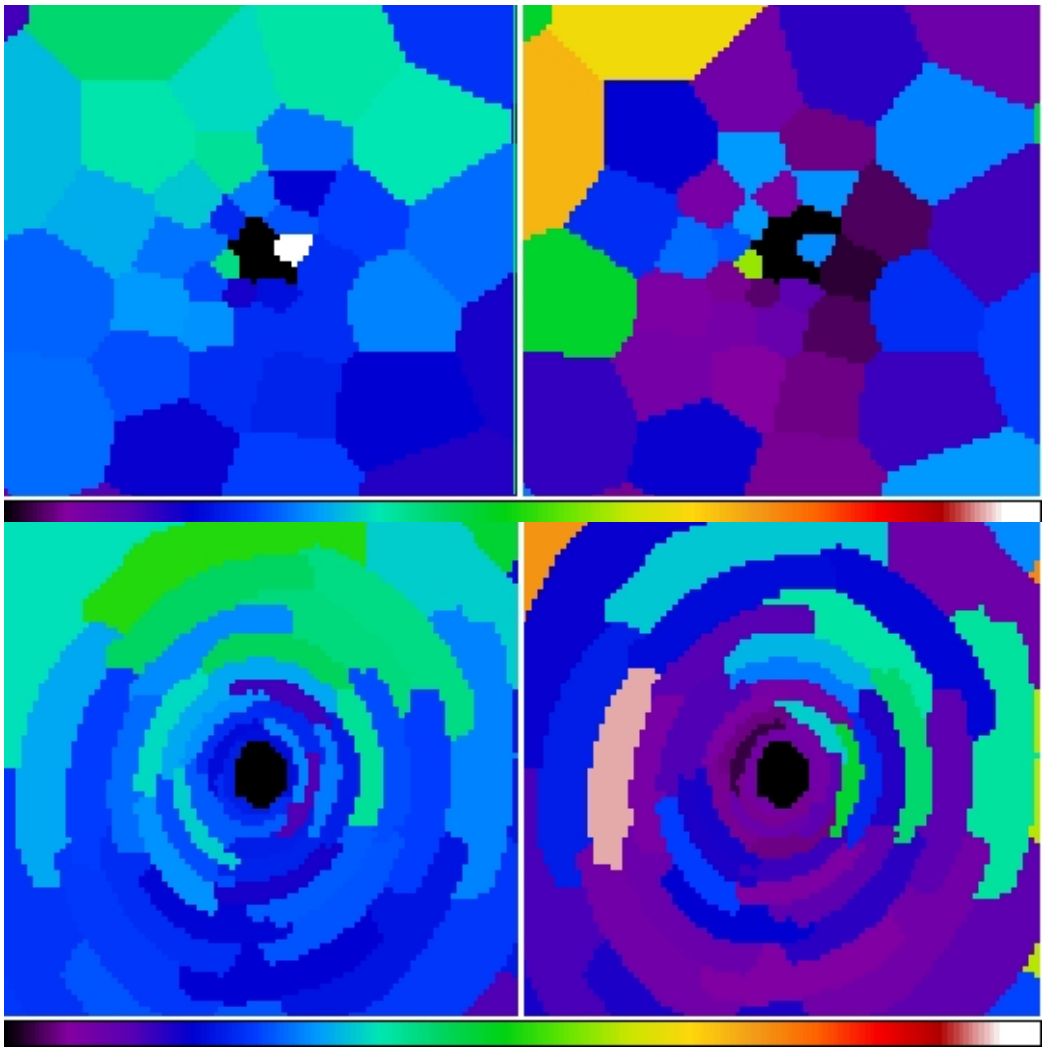
Zhang et al. in prep.

bins defined by S/N=60, 0.5-2.0keV

measurements by the spectral analysis in each bin

left: temperature 6'*6' 1.4-5keV

right: 1sigma error 6'*6' 0-0.5keV



Upper binning scheme cf, Cappellari+Copin03;

Lower binning scheme cf, Sanders 06.

6 HIFLUGCS: substructures

Average of the normalized fluctuations vs. the distance from the center

Zhang et al. in prep.

a. significant fluctuation measurements can be carried out to 0.2r500

b. <30% fluctuations within 0.4r500, in which relaxed clusters show <10% fluctuations

c. substructure vs. fluctuation

Conclusions:

1. X-ray mass and weak lensing mass based scaling relations are ideal to constrain the bias between mass estimates and the true mass.

2. Observed mass-scaling relations vs. simulation predictions can be used either to search the required physics in mass assembly histories, or to figure out the systematics and/or bias in mass estimates.

3. X-ray 2-D maps can characterize substructures, which can be
   a. taken into account to reduce the scatter of the scaling relations;
   b. compared with various substructure measurements, e.g. from lensing to understand the systematics in mass estimates.

Thank you!