HSCサーヴェイと多波長観測プロジェクトとのシナジー

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「銀河団の物理」ワークショップ

2013/Dec/28

DM

Mass Distribution ?

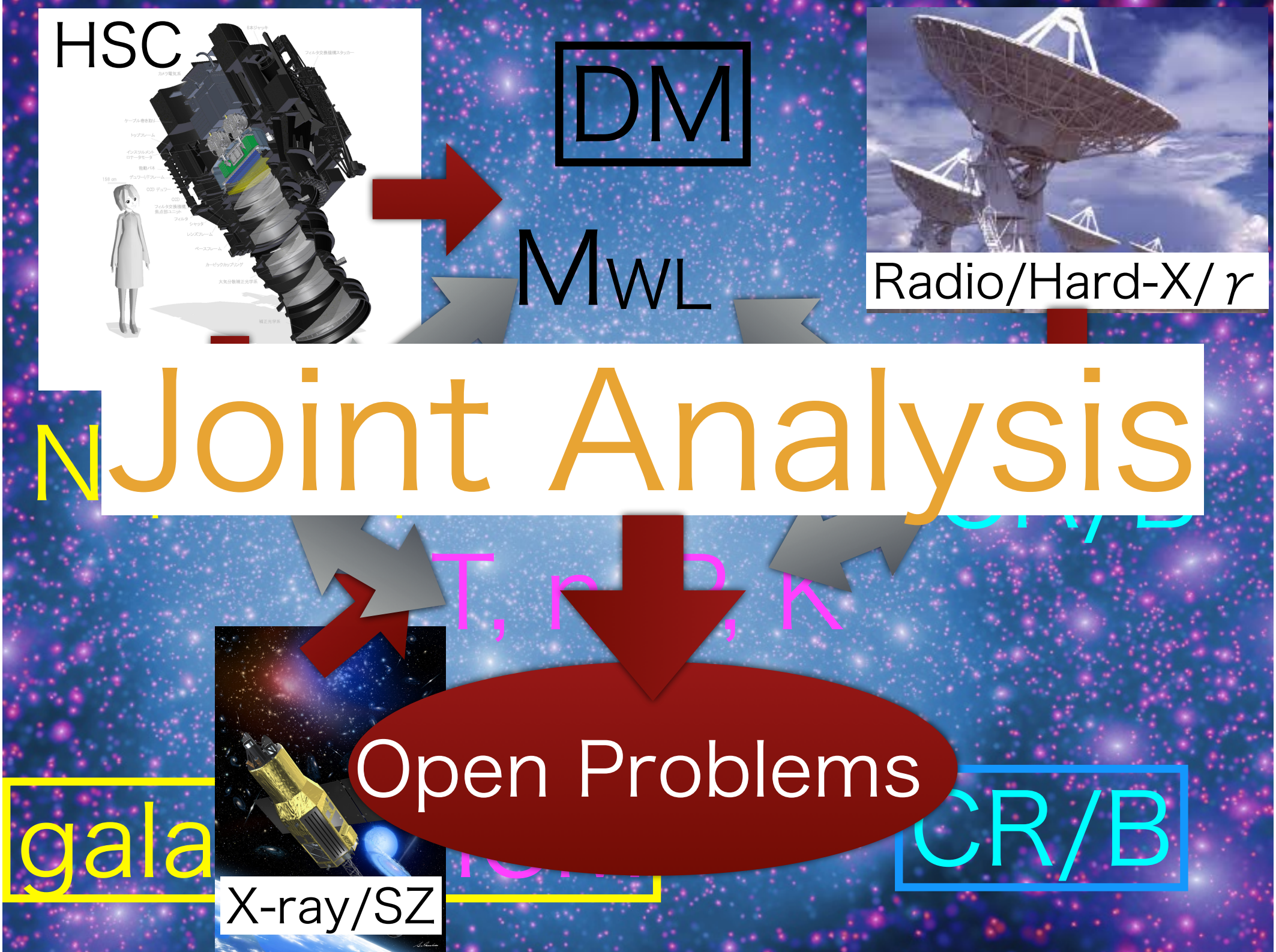
Dynamical state of ICM?

Co-evolution ?

Acceleration of CR ?

galaxies/ICM

CR/B


HSC
DM
MWL
Radio/Hard-X/γ
Joint Analysis
T, n, P, κ
Open Problems
gala
X-ray/SZ
CR/B

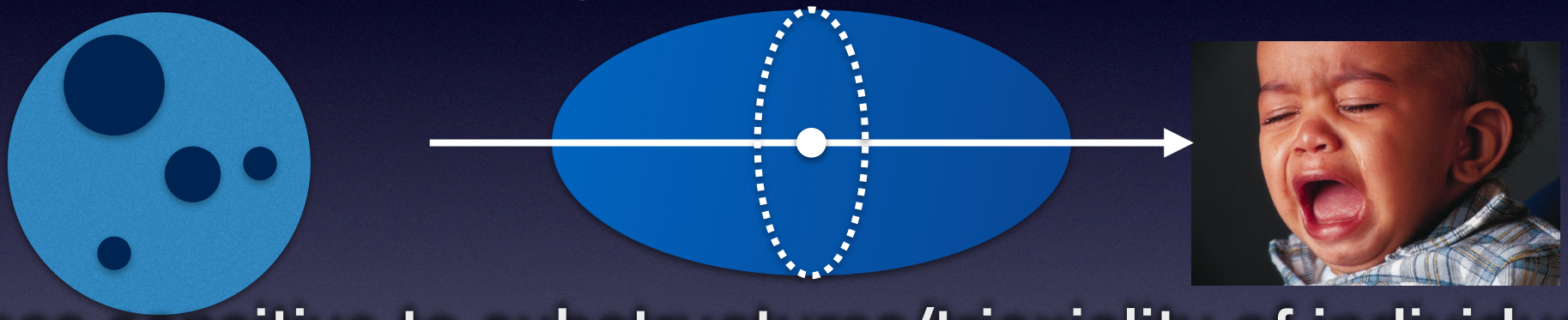
HSC Cluster WL(1400deg^2)

1: WL analysis for individual clusters

$M_{200}>5\times10^{14}M_{sun}/h$: $z<0.6$ scatter=0.2

theoretically expected number of clusters~170

2: Stacked WL analysis



Less sensitive to substructures/triaxiality of individual cluster thanks to random distribution.

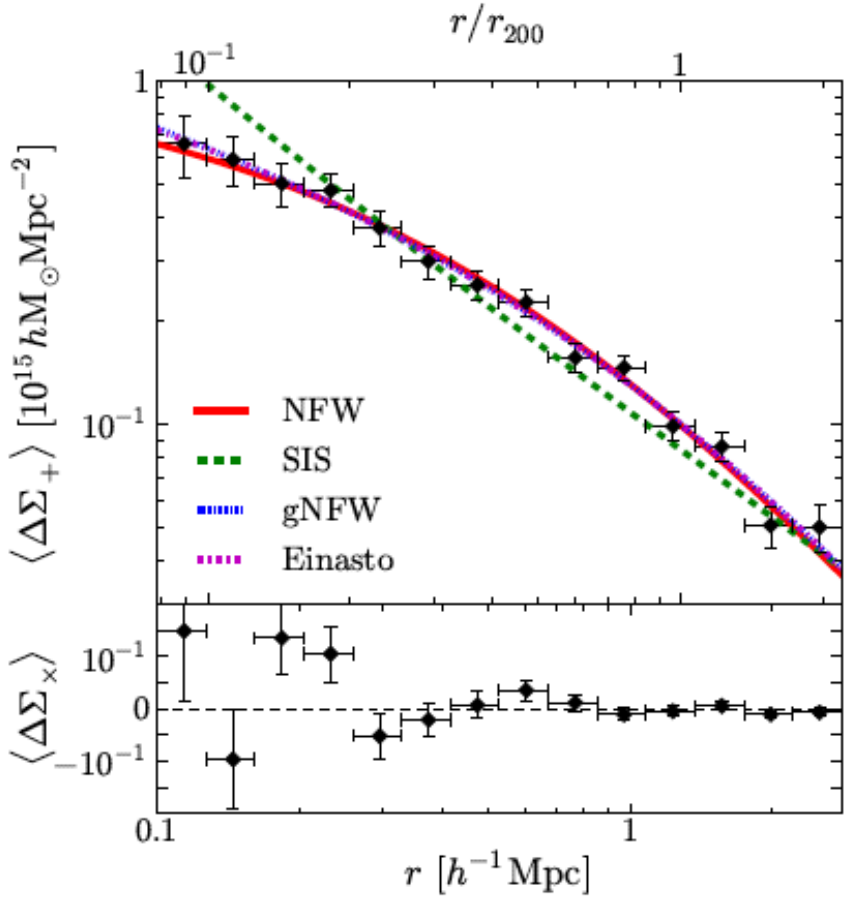
$M_{200}>10^{13}M_{sun}/h$: $z<0.6$ #clusters~190,000

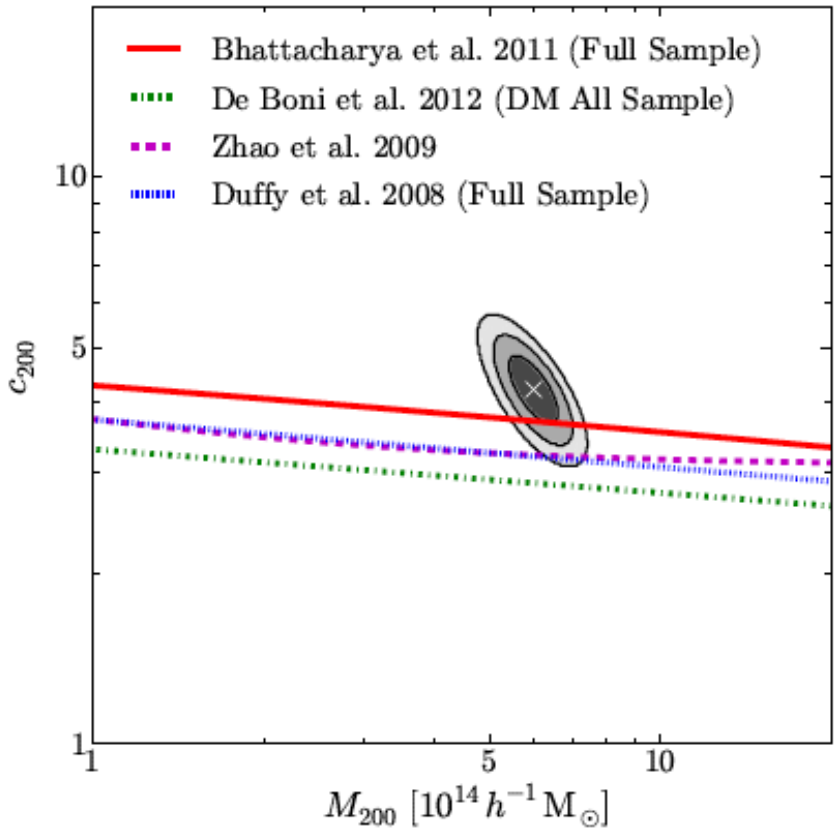
$M_{200}>5\times10^{13}M_{sun}/h$: $z<0.4$ #clusters~10,000

HSC survey will discover less massive clusters/ groups and high-z clusters http://risa.stanford.edu/cluster/

Stacked WL

50 clusters : Okabe+13





Powerful to understand average properties of cluster mass distribution for statistically well-defined, unbiased sample.

1: $M_{H.E.}$ vs M_{WL}

Test Hydrostatic Equilibrium

X-ray : Hydrostatic Equilibrium Assumption

WL : no assumption of dynamical state

Mass scatter from substructures/triaxiality

Stacked Lens recovers an average of mass.

1:Radial profile of $M_{H.E.}/M_{WL}$

(Zhang+10; Mahdavi+13)

1)r<r500 : eROSITA (XMM/Chandra)

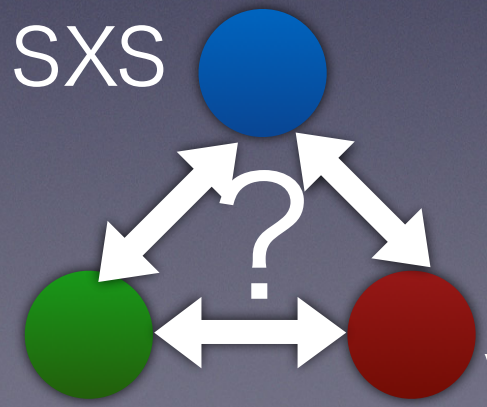
Systematic Study for HSC clusters

2)r<rvir : Astro-H

Systematic Study for subsample of HSC clusters

2:Direct Measurement of turbulence by Astro-H/SXS

SXS : core of very luminous X-ray clusters.



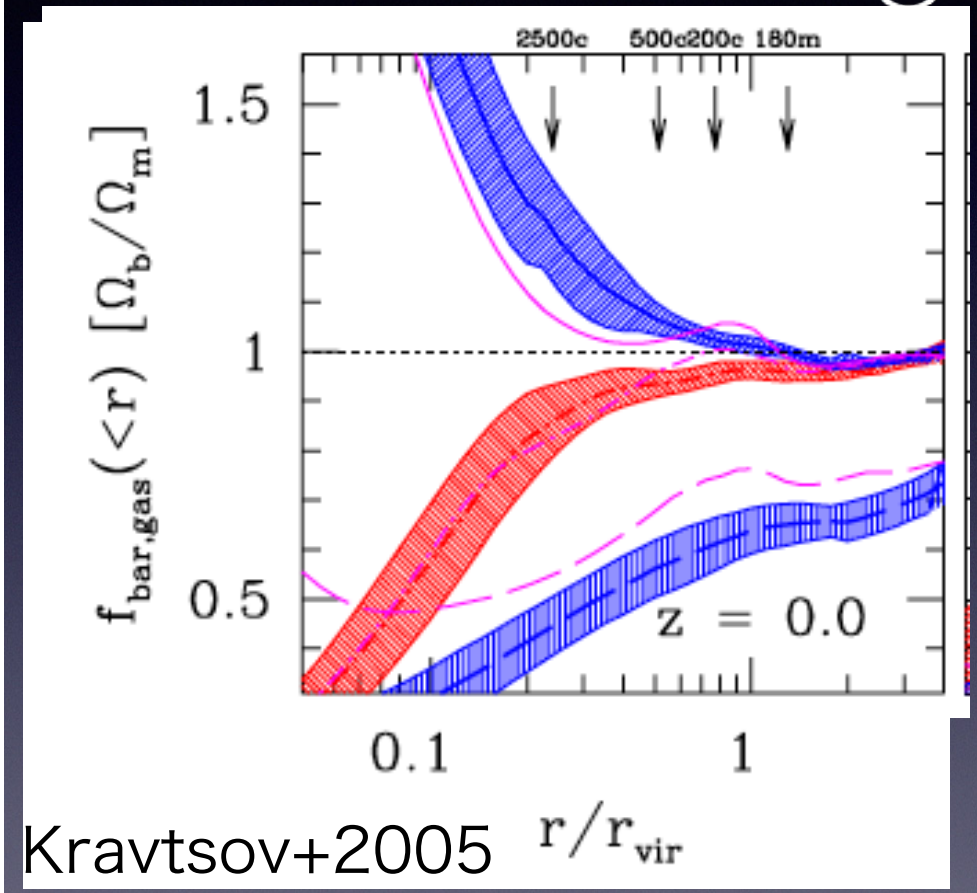
Well-known X-ray clusters

or

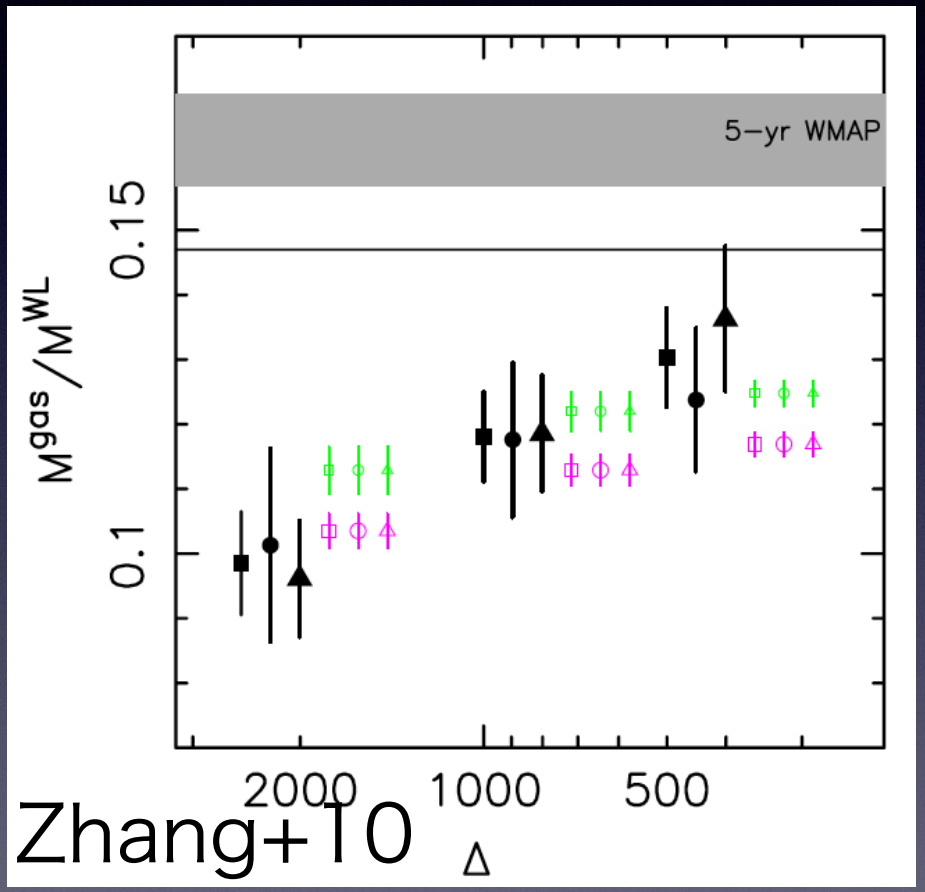
Well-known clusters in the survey region

2:baryon fraction

$$f_b = f_* + f_{\rm gas} \qquad f_* = \frac{M_*}{M_{\rm WL}} \qquad f_{\rm gas} = \frac{M_{\rm gas}}{M_{\rm WL}}$$



Kravtsov+2005



Zhang+10

$$\Omega_b/\Omega_m({\rm WMAP}) = 0.1659 \pm 0.0172$$
$$\Omega_b/\Omega_m({\rm Planck}) = 0.1434 \pm 0.0094$$

3: Pressure Profiles

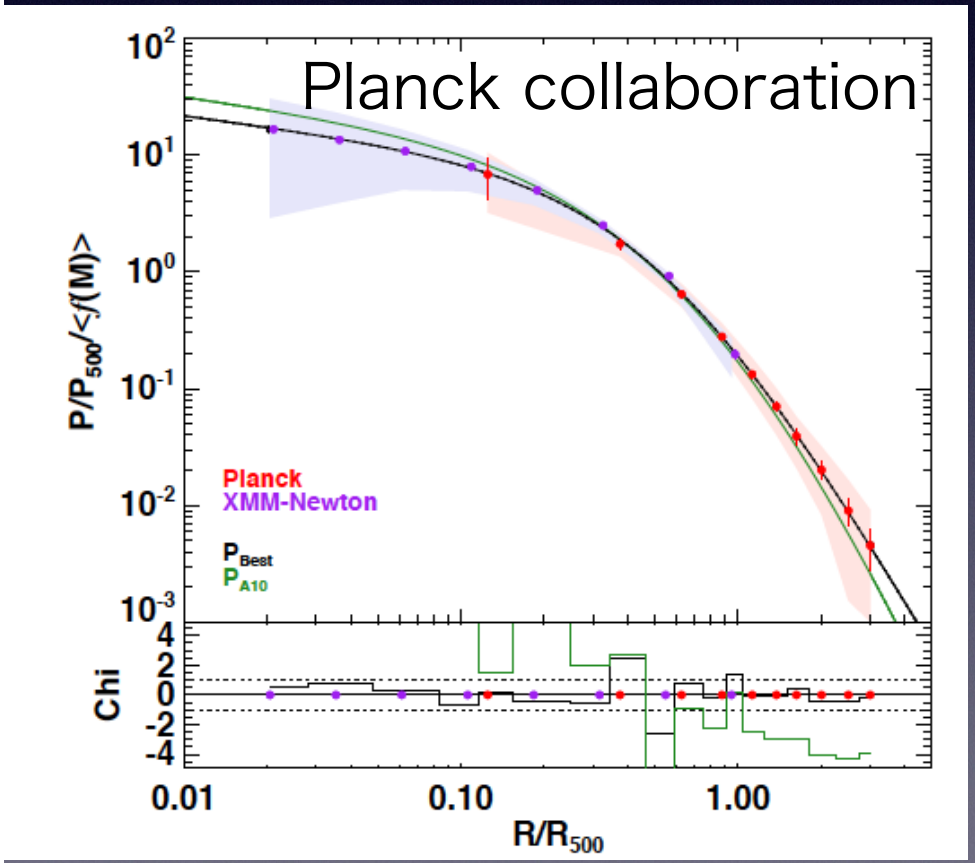
$P_{\rm X}(r) = nk_BT_e$ $P_{\rm SZ}(r)$ $P_{\rm WL}(r)$

X-ray thermal pressure

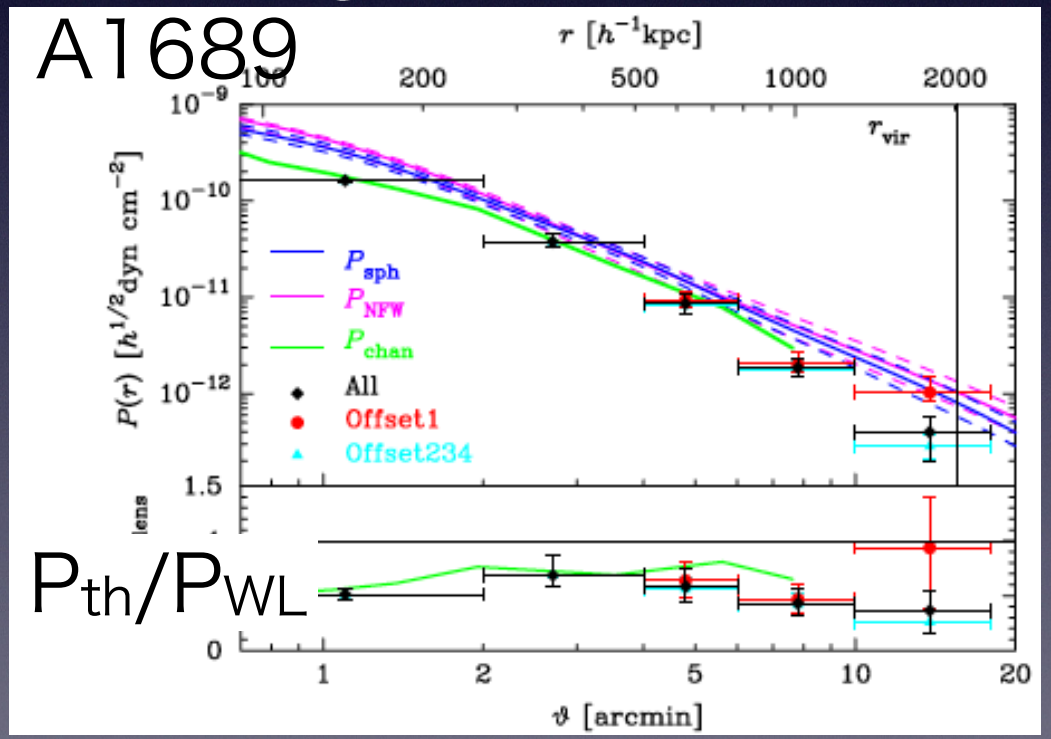
SZ

WL total pressure

$$\frac{1}{\rho_g}\frac{dP_{\rm WL}}{dr} = -\frac{GM_{\rm WL}}{r^2}$$



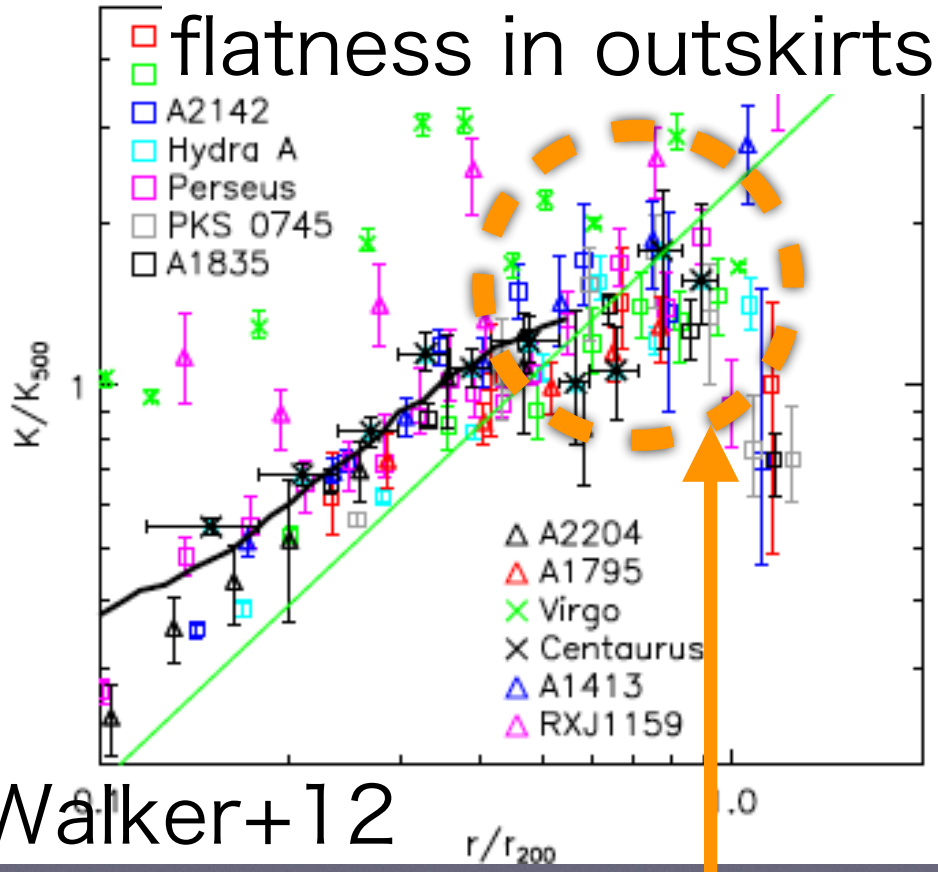
A1689



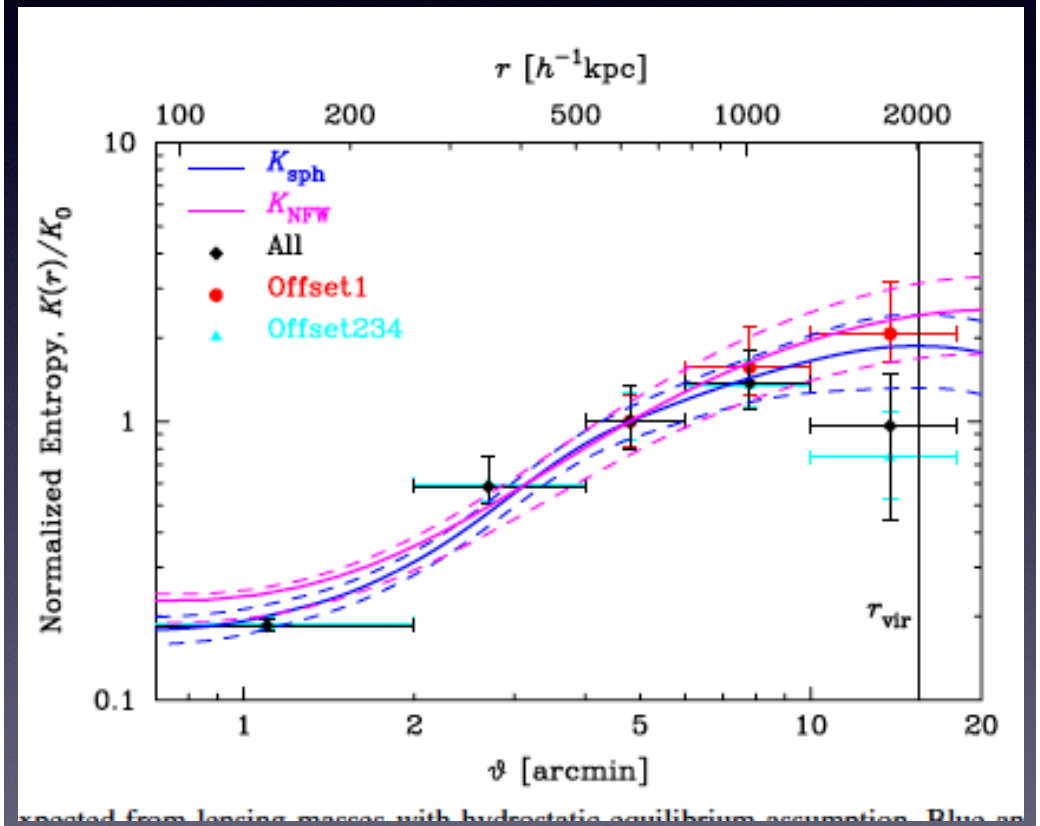
Kawaharada+10

4: Entropy Profiles

$$K = k_B T n^{-2/3} \qquad K_{\rm WL} = P_{\rm WL} n^{-5/3}$$



Walker+12

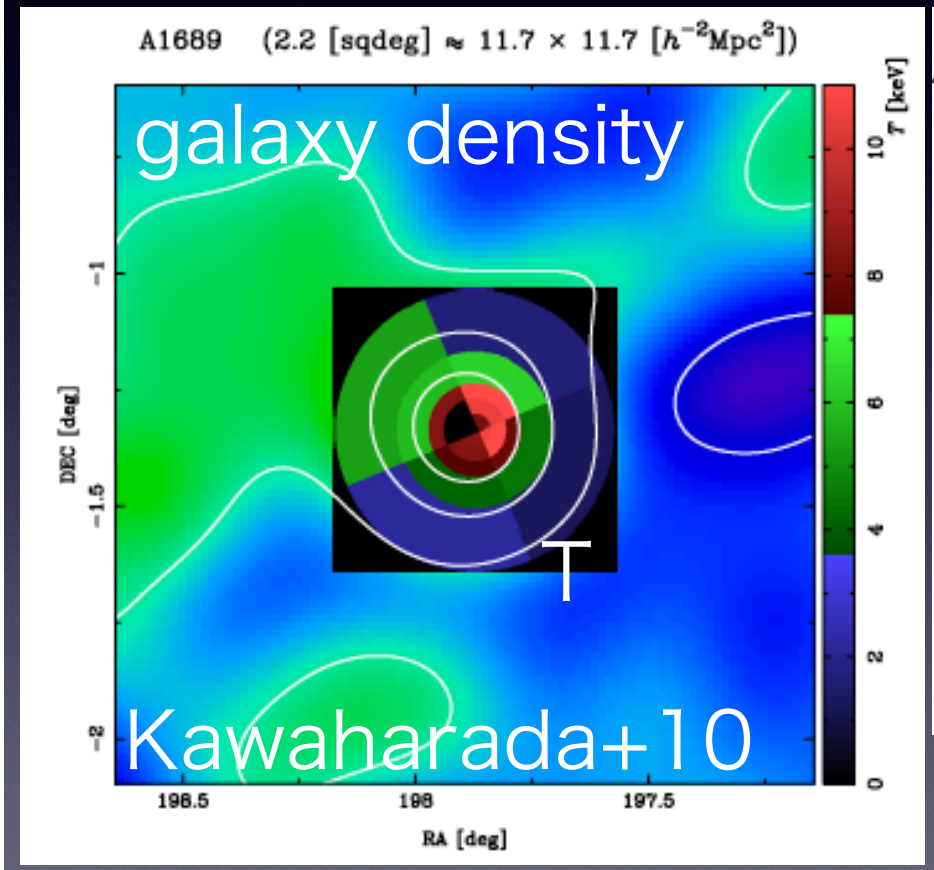


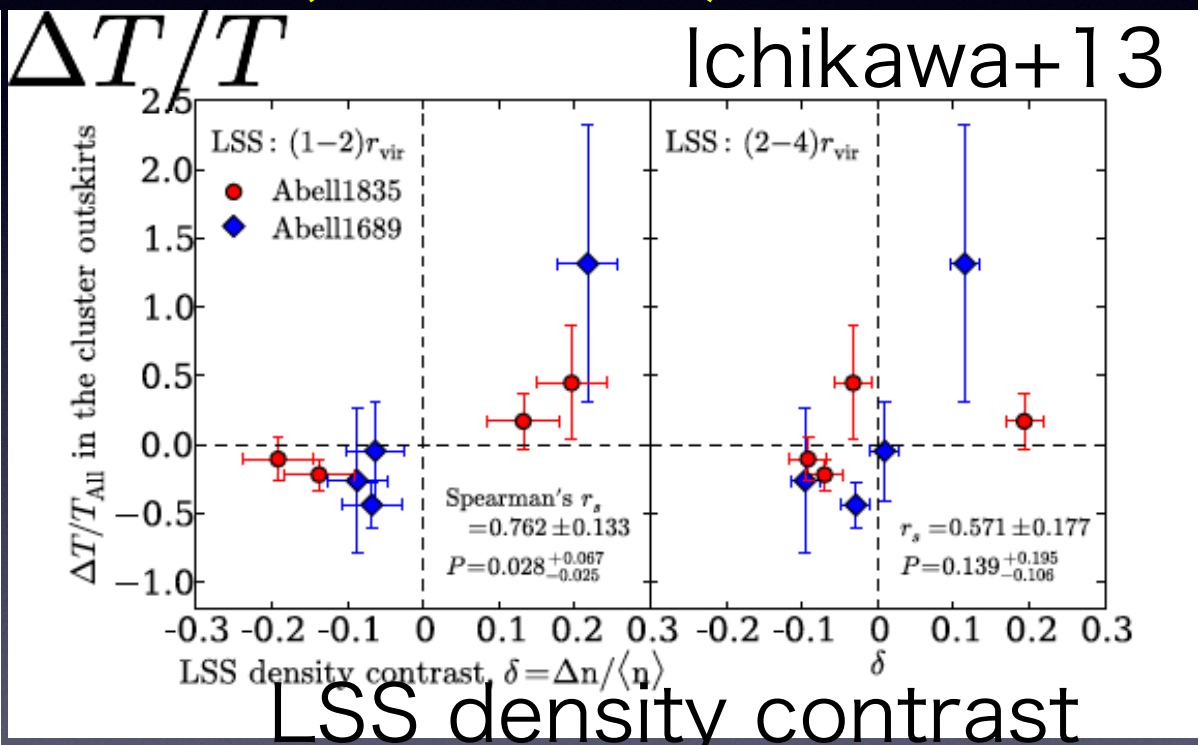
Kawaharada+10

flatness of entropy

5 : Correlation between cluster outskirts and large-scale structure

Outskirts temperatures and galaxy densities in large - scale structure are correlated (2 clusters).





HSC survey will provide us with the information galaxy distribution.

n, T, P, K vs LSS / redshift evolution ??

Outskirts problem

Temperature/entropy in outskirts is lower than expected by shock-heating model.

Interpretations

gas clumsiness (Nagai+11)

kinetic energy of ion (Kawharada+10)

ion temperature (Hoshino+10)

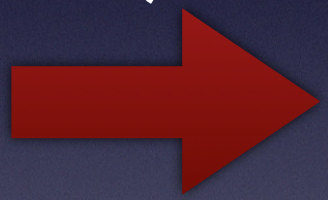
Current our approaches

1: WL/SL (Suprime-Cam)

2:Galaxy information (SDSS/2MASS)

3:Cross check with Suzaku/XMM/Chandra/ROSAT

4: Planck SZ



New Era

HSC/WL

HSC

Astro-H/eROSITA‥

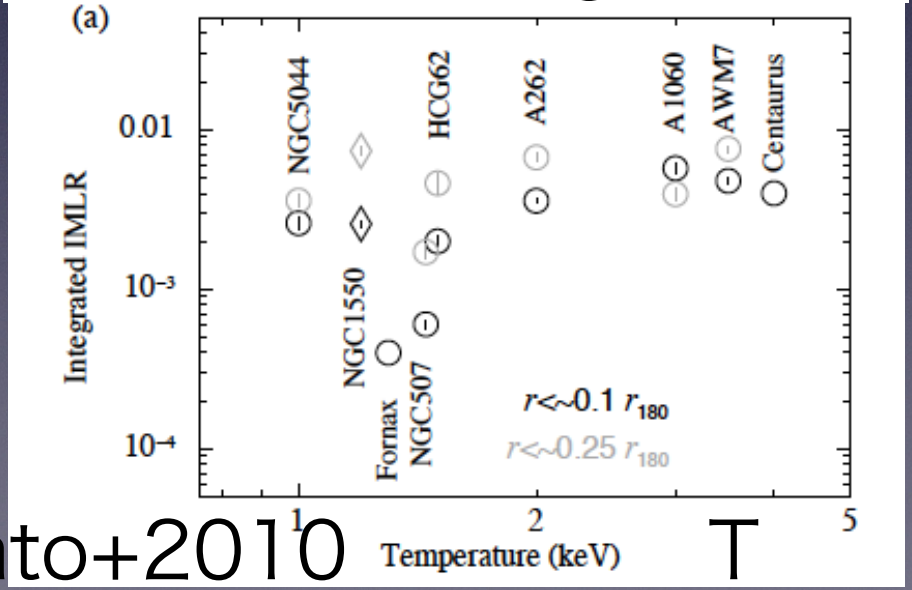
ACT/ALMA

6 : Metal Abundance

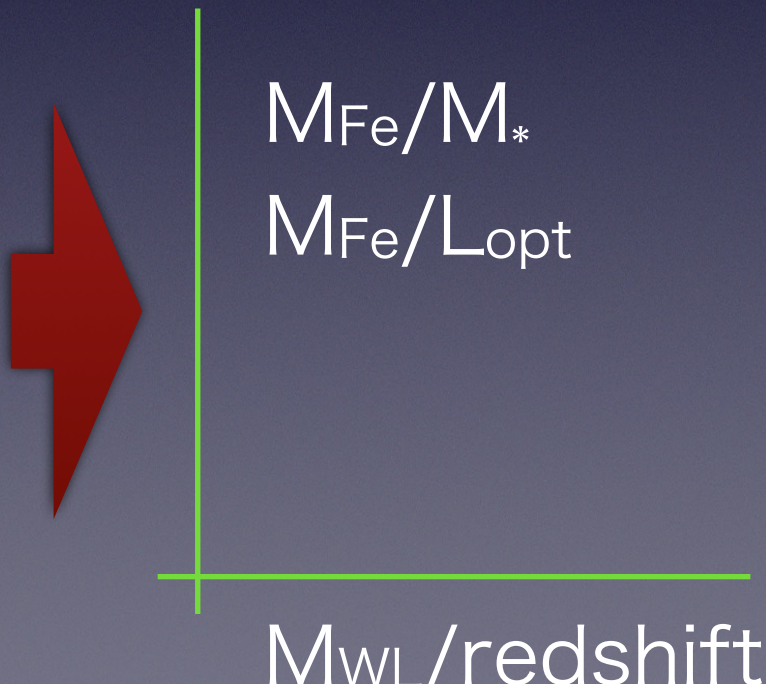
Fossil records of chemical evolution seeded by the stellar initial mass function (IMF) and star formation history (SFH).

A link between metal abundance and M_{WL}, redshift, M_*, L_{opt}, N_{opt}

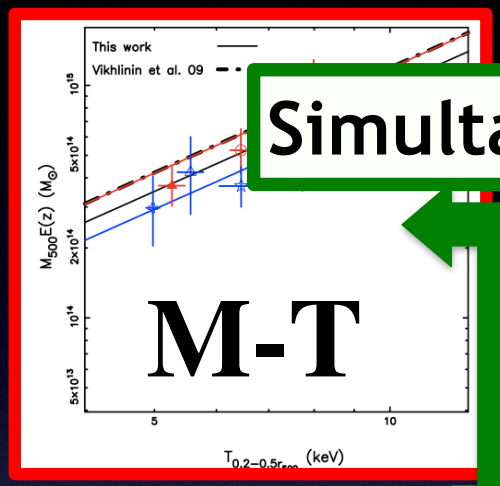
iron mass-to-light ratio

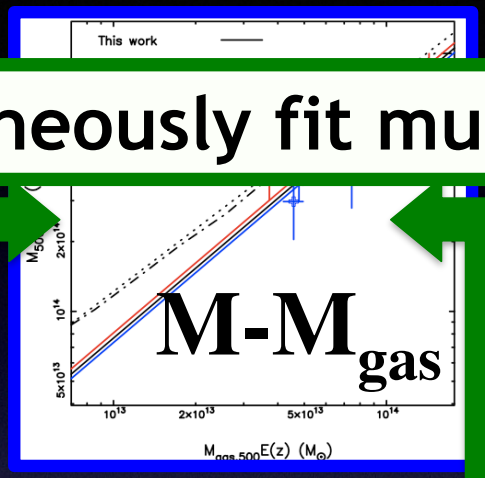


Sato+2010



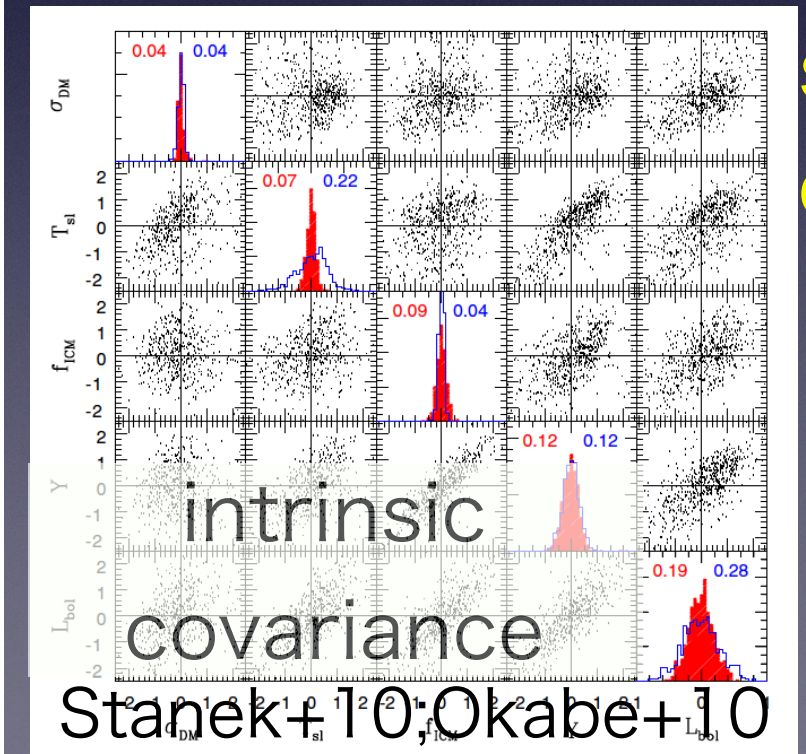
7: Multivariate scaling relation





Simultaneously fit multiple scaling relations

$$M_{\rm gas}, T_X, L_X, Y_{\rm SZ}, L_{\rm BCG}, L_{\rm opt}, N_{\rm gal}, M_*\cdots$$



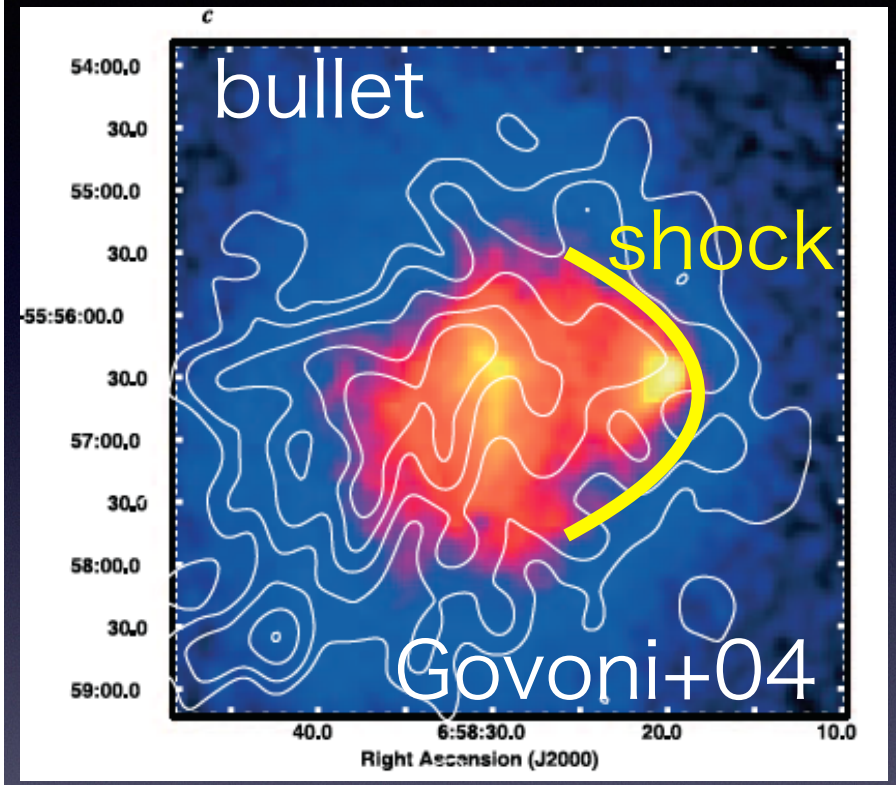
Stanek+10;Okabe+10

statistical study to understand co-evolution of baryon and DM

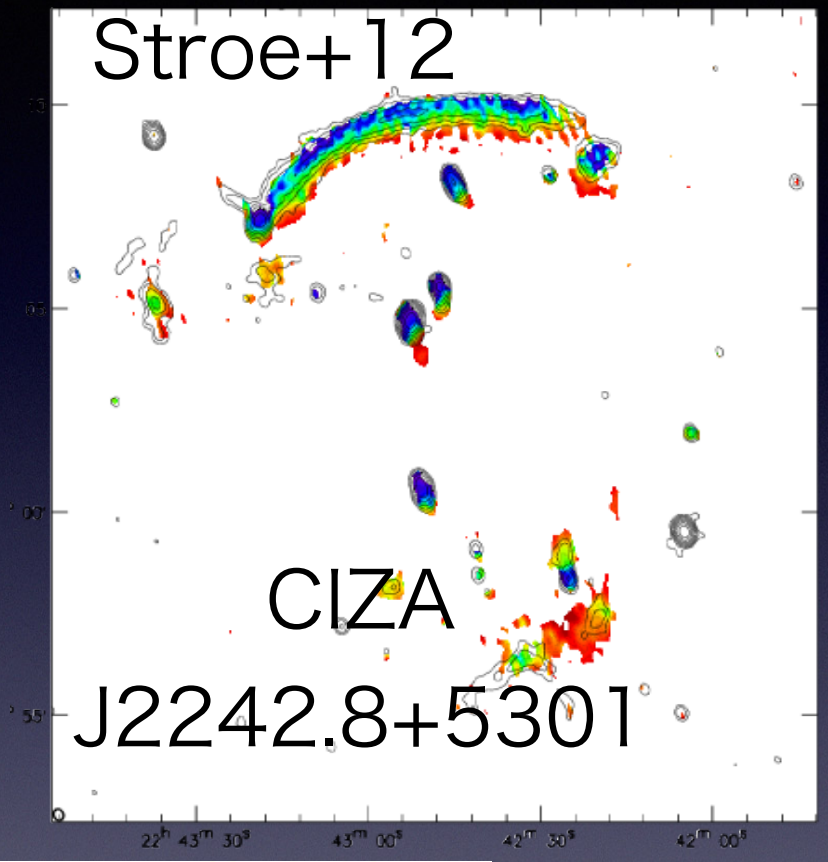
*Intrinsic covariance
*normalization
*CC/NCC;merger/non-merger?
*optical-, x-ray-, or SZ- selected?
*CPA-like mass proxy

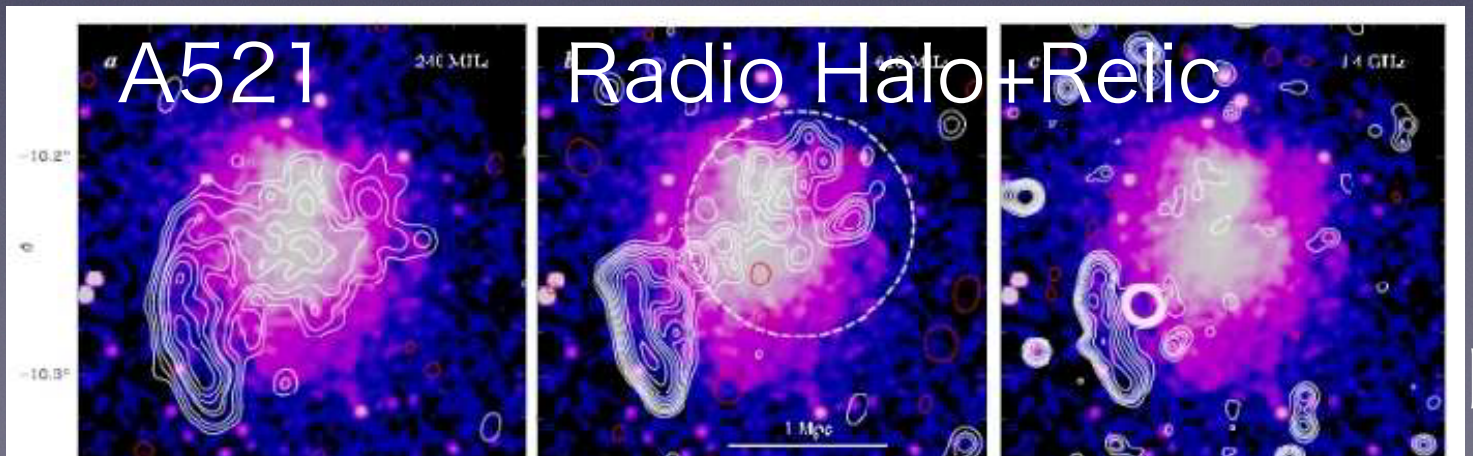
8:Non-thermal Physics

Radio Halo



Radio Relic





Brunetti+08

WL : Mass ratio

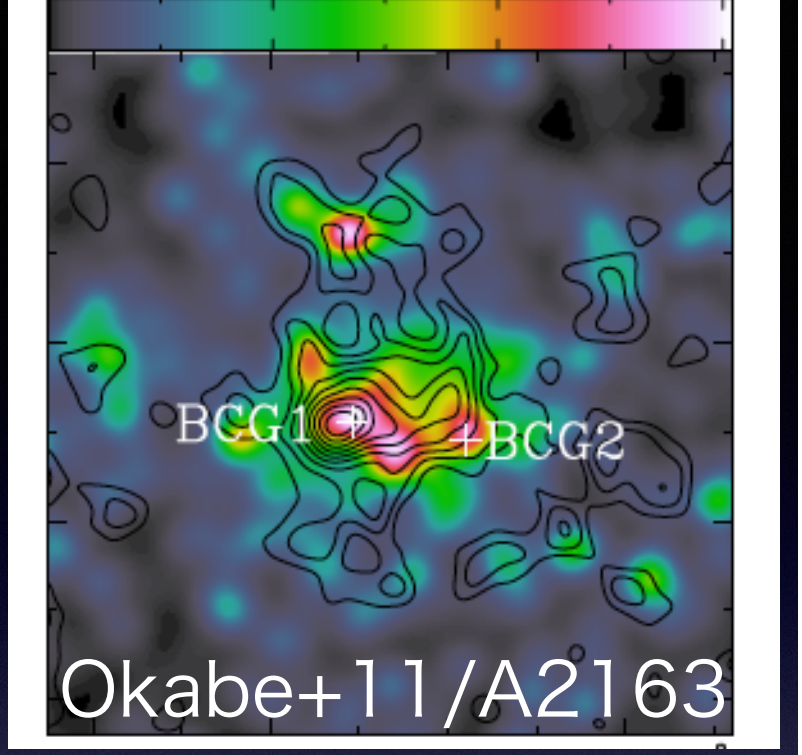
subhalo position

DM subhalo :

collision-less/long lifetime

Constraint on Energy Release

merger time



cooling-time ⟷ acceleration time

magnetic field

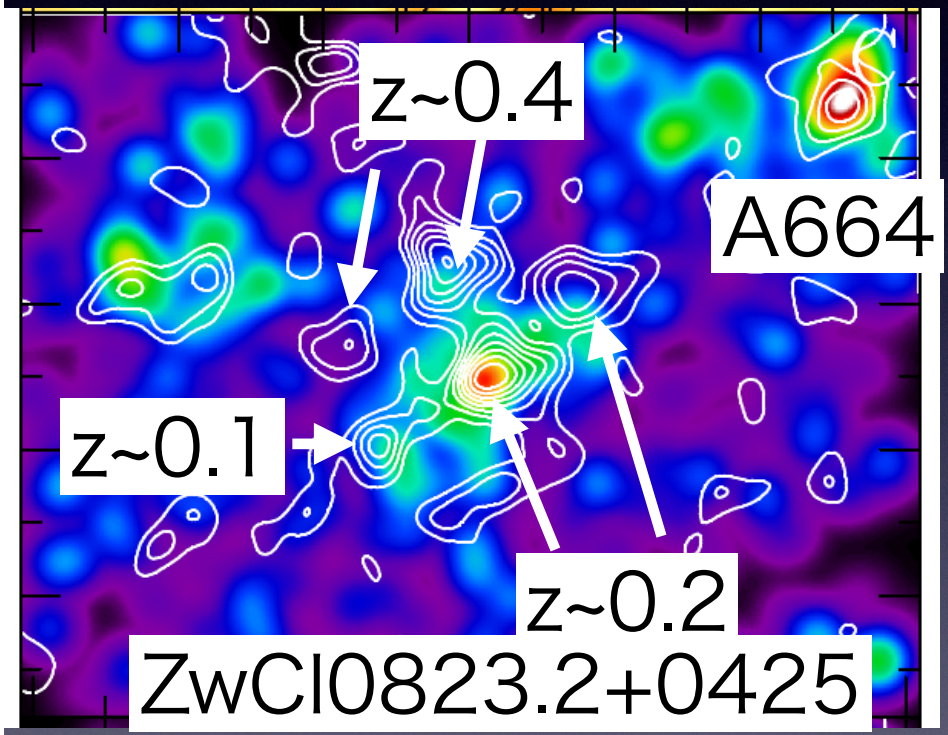
Astro-H/HXI +Radio

model

Follow-up X-ray Observation of WL-detected halos

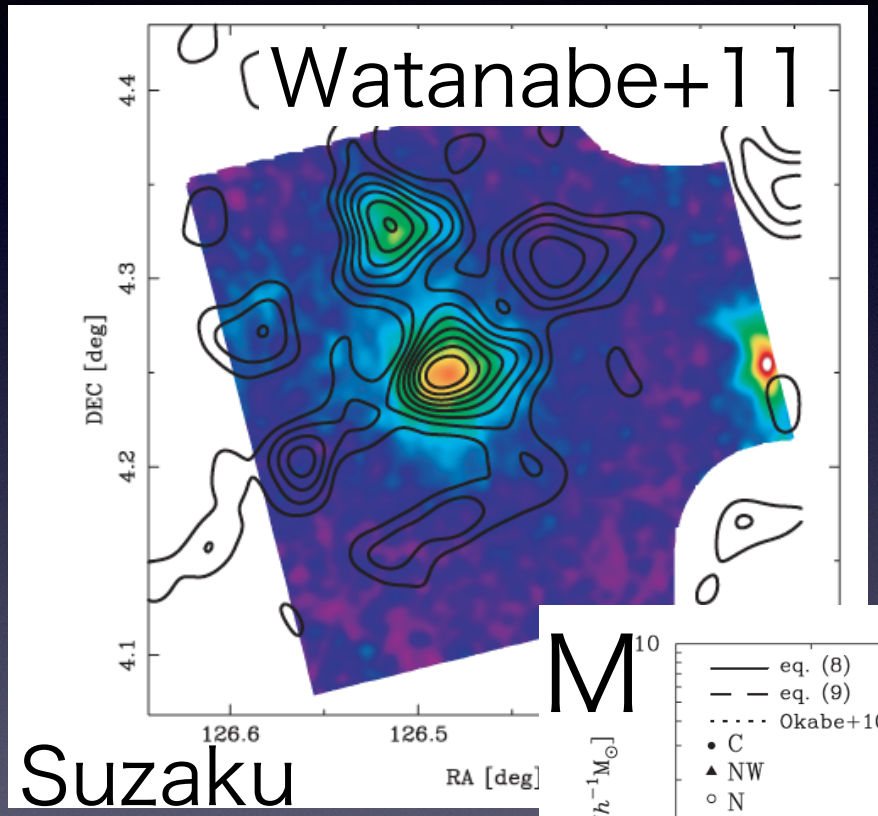
Lens : mass along the line-of-sight

$$S_X \propto n_e^2$$

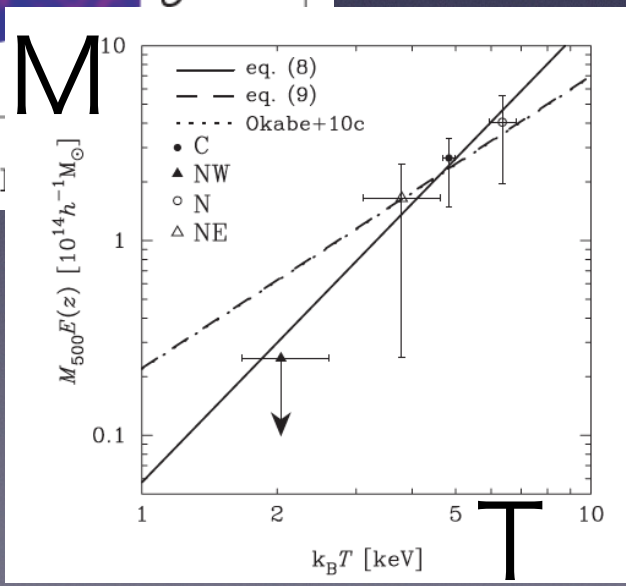


Galaxy distribution w/
mass contours

Okabe+10



Suzaku



Follow-up Observations by Astro-H/SXI

One pointing

$M_{200}>5\times10^{13}M_{sun}/h$: z<0.4 #clusters~10,000

10ksec / each cluster

Total exposure = 10000x10ksec/(6000 ksec/yr)

~17 yr

Out to virial radius

$M_{200}>5\times10^{14}M_{sun}/h$: z<0.3 #clusters~85

Total exposure = 85x200ksec/(6000 ksec/yr)

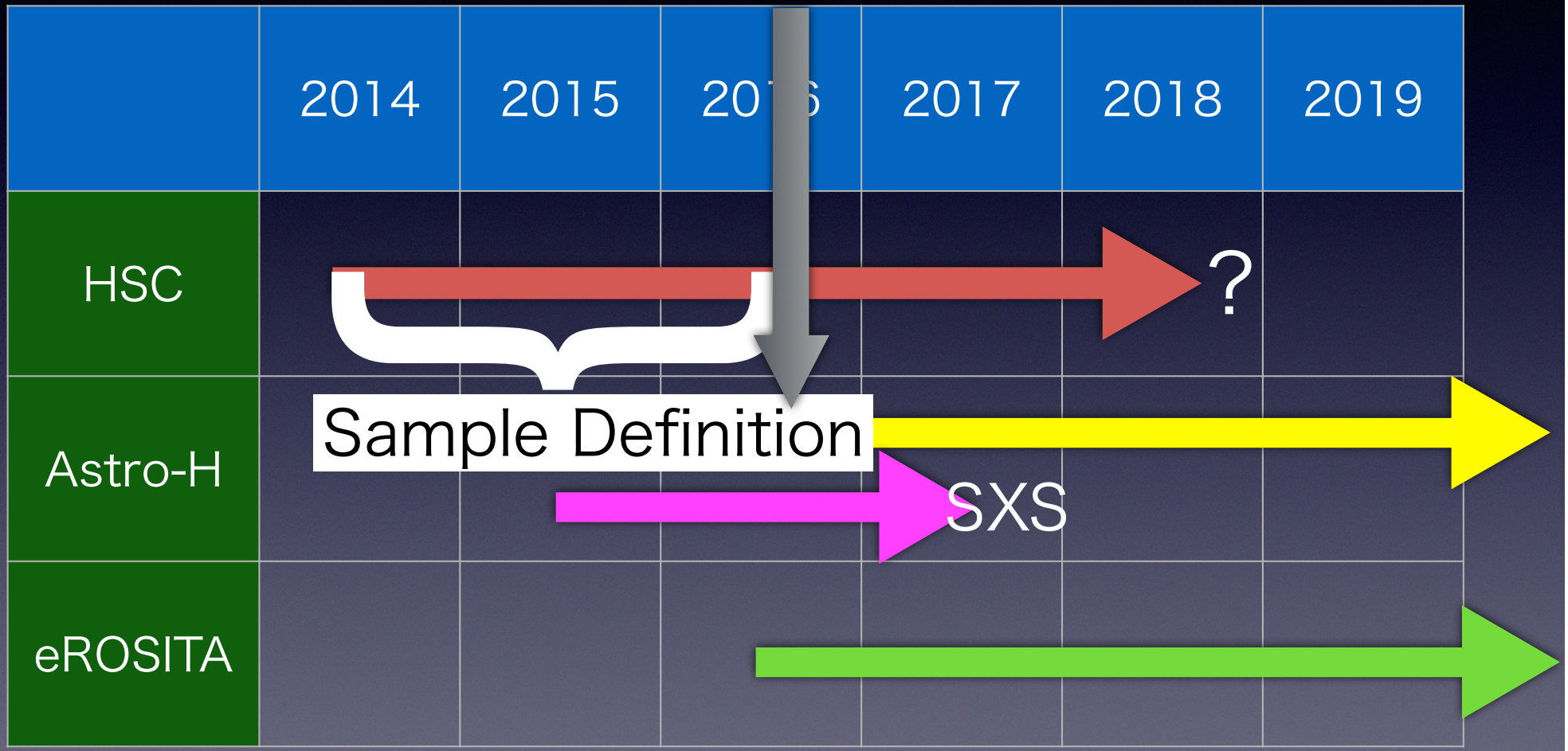
~3 yr

unrealistic……

NEED Sample Definition

Schedule

Proposal for follow-up SXI observation



Suzaku/S-Cam & Astro-H/HSC

Suzaku/Subaru collaboration for clusters started from 2007, published highly-cited papers, will publish high-quality papers.

No reason to stop here

Astro-H and HSC!!!