Mass-to-Light-Ratios of the galaxy clusters and groups observed with Suzaku

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Introduction

Solar abundance table
= Lodders 2003

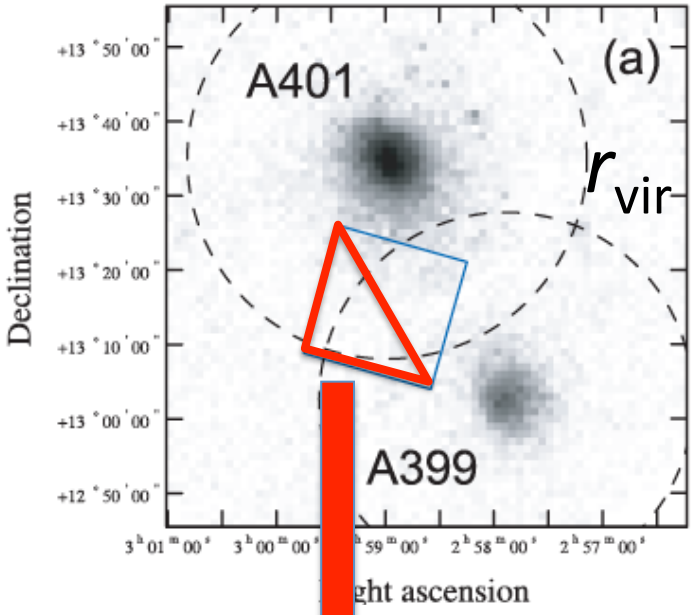
Thanks to the low background level, *Suzaku* enables us to detect the ICM emission out to the virial radius.

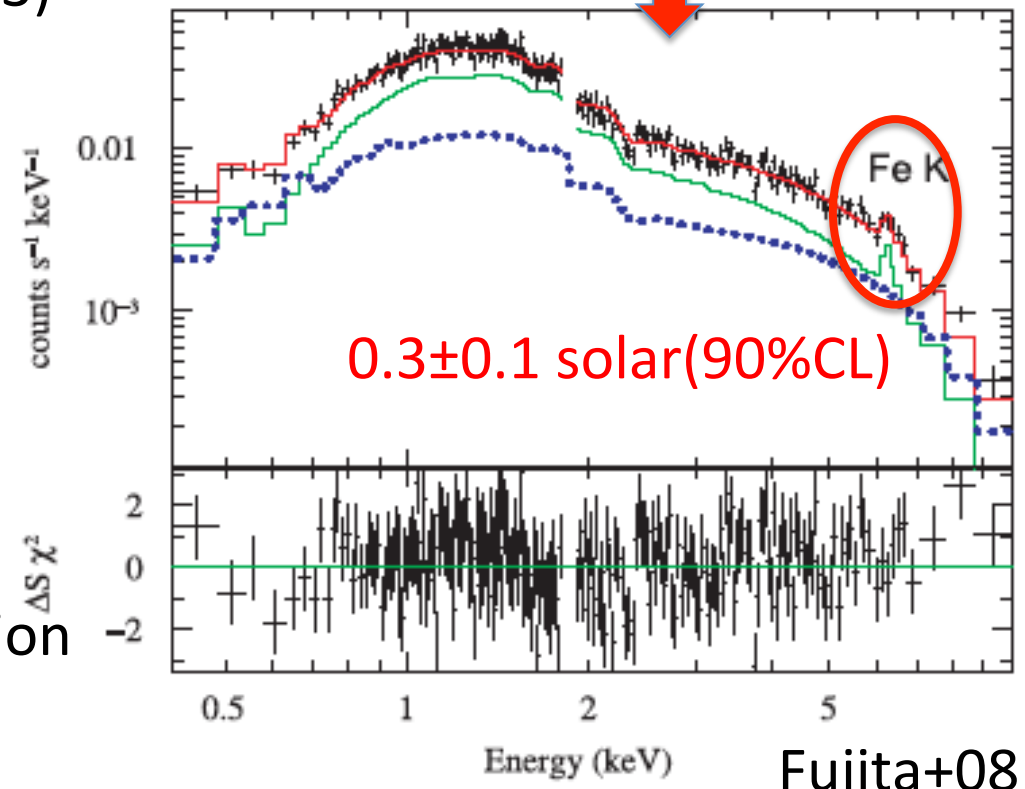
➡ The Fe abundances beyond r_{500} are about 0.2-0.3 solar (e.g., Fujita+08, Werner+13)

Purpose

We analyzed 13 clusters and groups observed with *Suzaku* beyond r_{500}, and derived the total gas and Fe mass in the ICM

➡ To study the slope of stellar Initial-Mass-Function of the cluster galaxies





Fujita+08

The Galactic emissions

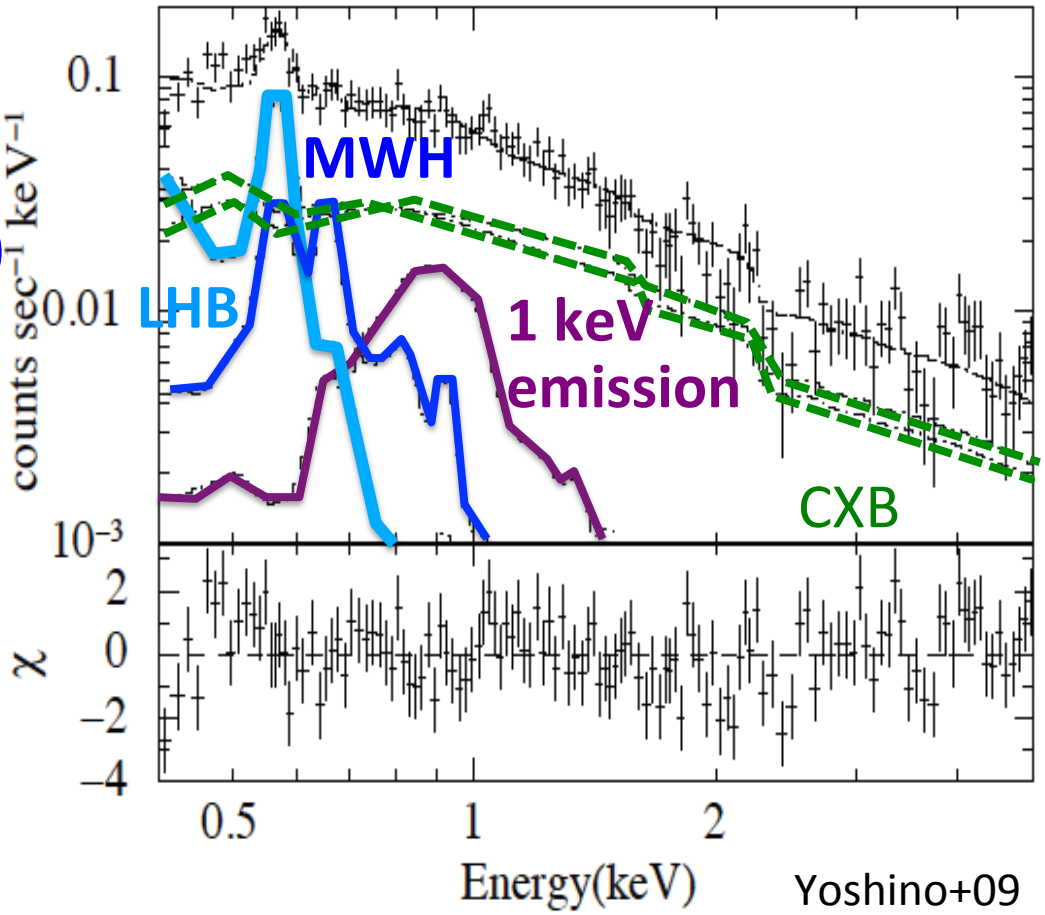
Since the X-ray emissions from the outskirts are faint,
the background and foreground estimation is vitally important.

Foreground emissions

= **Local Hot Bubble(0.1 keV)**
+ **Milky Way Halo(0.2-0.4keV)**

Yoshino+09

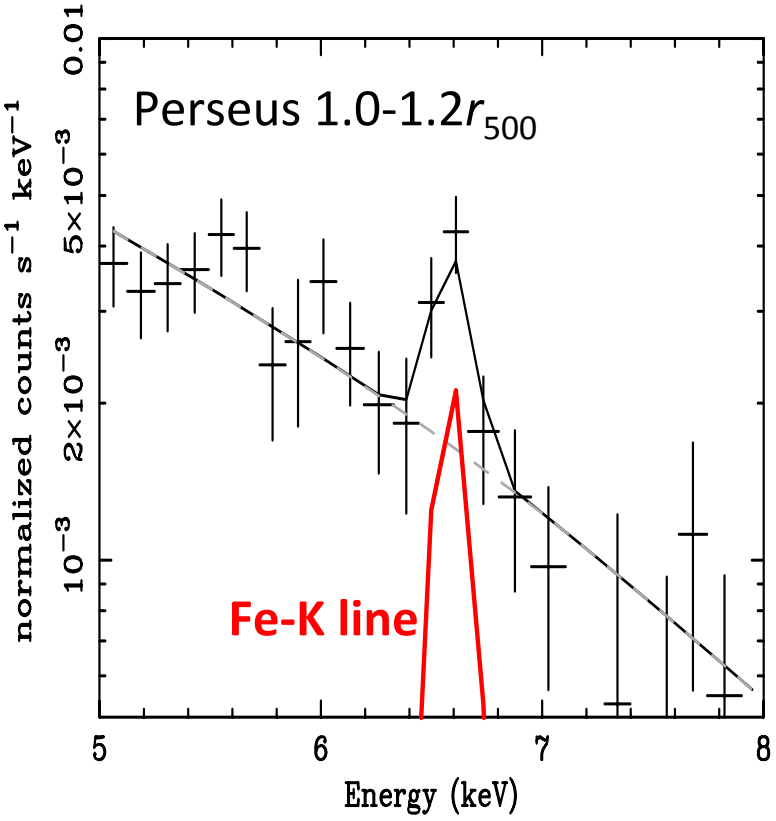
0.5~1 keV component possibly come from our Galaxy sometimes appears in the blank-sky observations with *Suzaku*

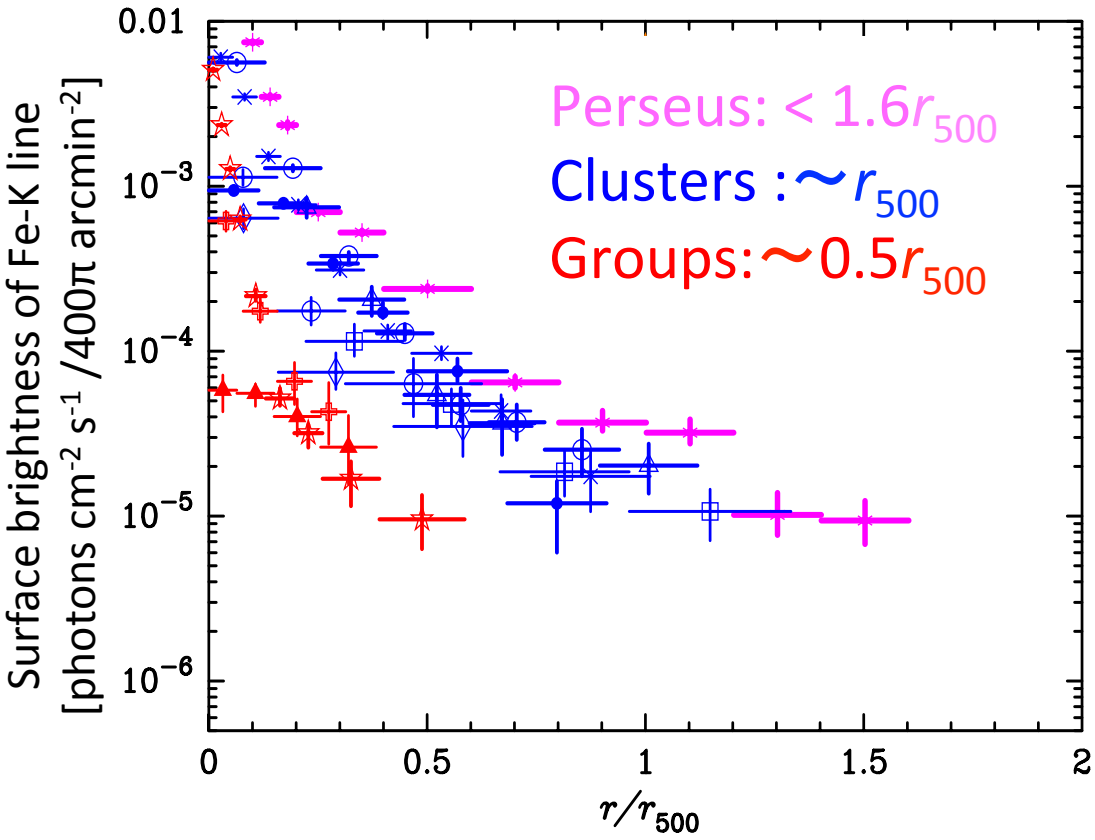


We included the systematic uncertainties of the Galactic emissions

Radial profiles of Fe-K lines

We investigated the Fe-K line surface brightness profiles.





- Fe abundances of clusters derived from Fe-K line (>0.2 r_{500}) are 0.2-0.3 solar
- Fe abundances of groups <r_{500} are also 0.2-0.3 solar

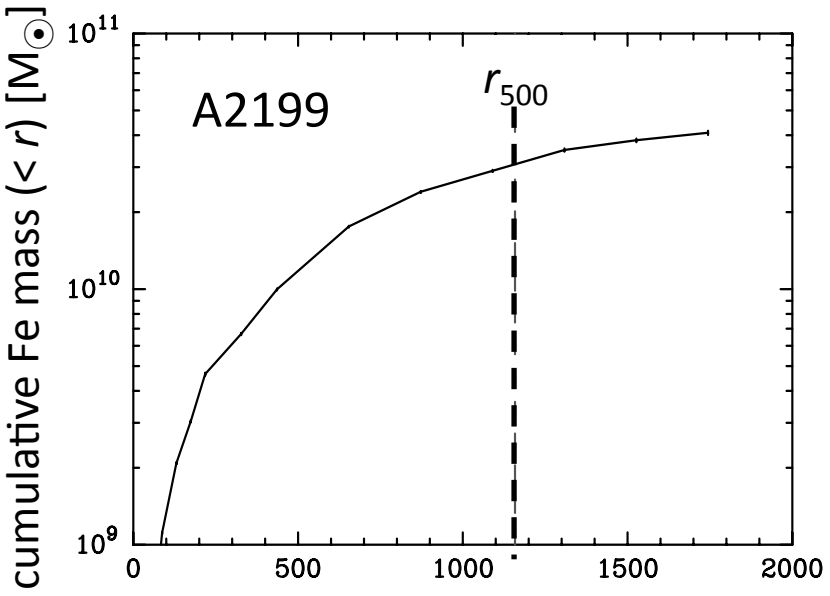
Iron-Mass-to-Light-Ratios (IMLRs)

The metals had been synthesized in the stars of the member galaxies

$$M_{Fe}/L_K = \frac{\textbf{Cumulative Fe mass in the ICM (< } r\textbf{)}}{\textbf{Cumulative } K\textbf{-band luminosities (< } r\textbf{)}}$$

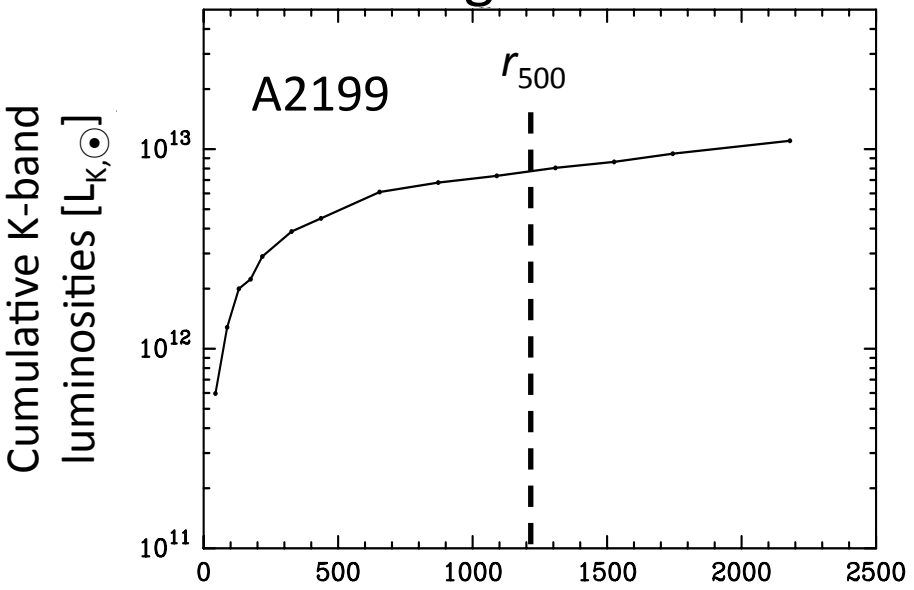
Suzaku

Cumulative Fe mass in the ICM



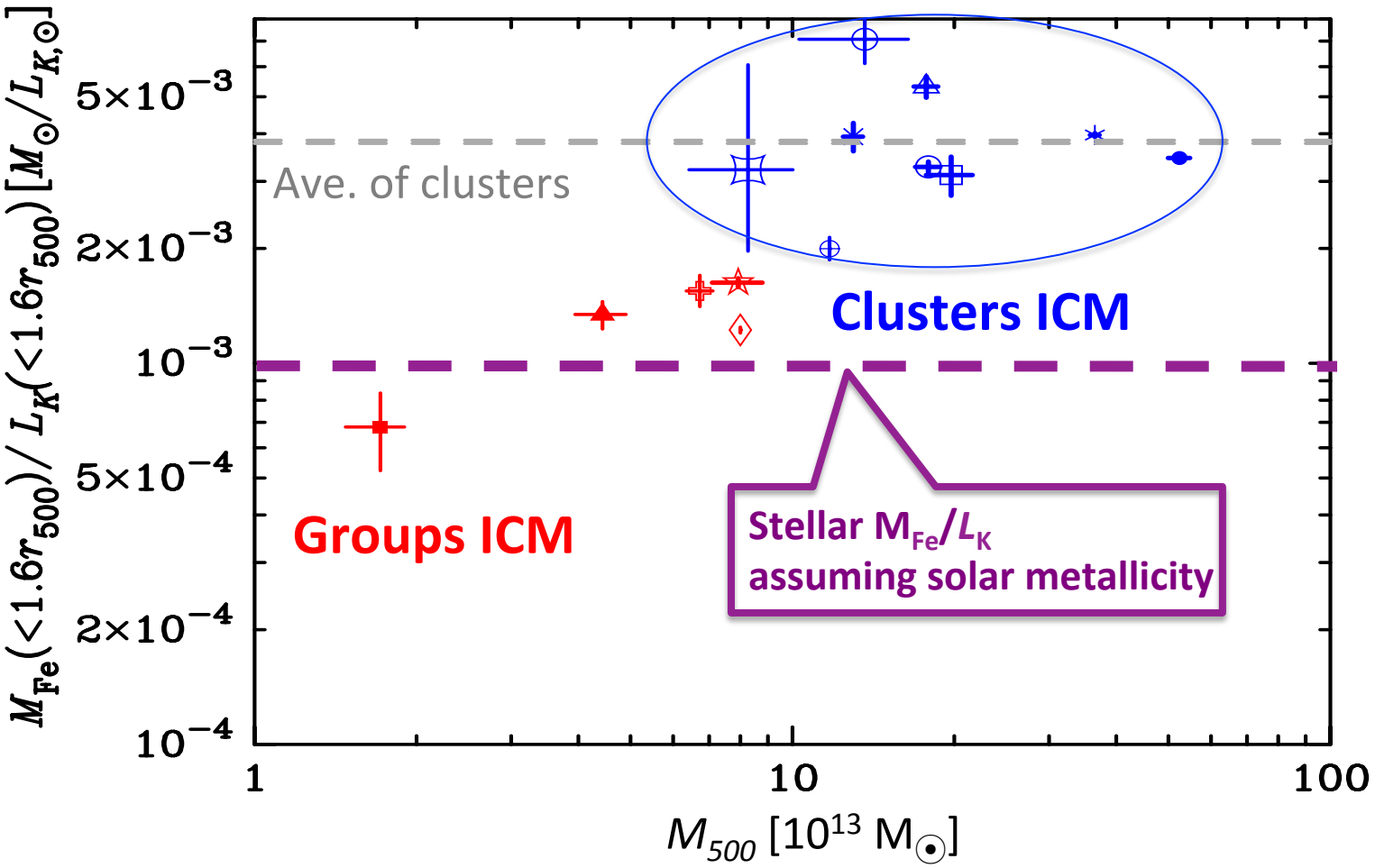
2MASS

Cumulative *K*-band luminosities of the member galaxies



From the Fe masses and luminosities profiles, we calculated the M_{Fe}/L_K of the clusters and groups at the virial radius

M_{Fe}/L_K at 1.6 r_{500} as a function of M_{500}.

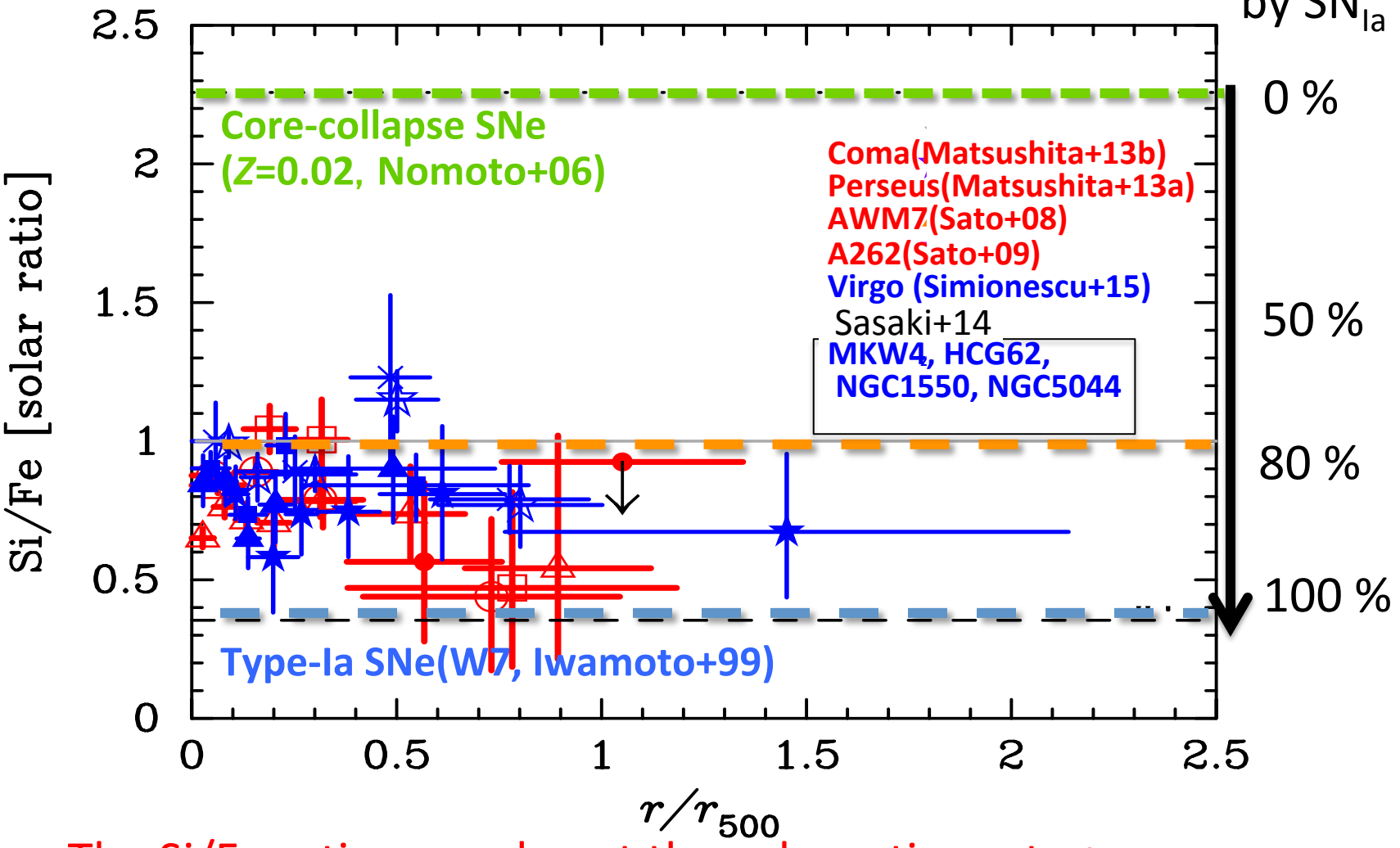


- Most amount of Fe are in the ICM.
- M_{Fe}/L_K of the clusters does not depend on the M_{500}.

Using M_{Fe}/L_K of the ICM and stars, and the Si/Fe ratios of the ICM (next slides), we constrain the stellar initial mass function of cluster galaxies

Radial profiles of Si/Fe ratios

Suzaku and XMM-Newton measured Si/Fe ratios up to ~r_{500}.



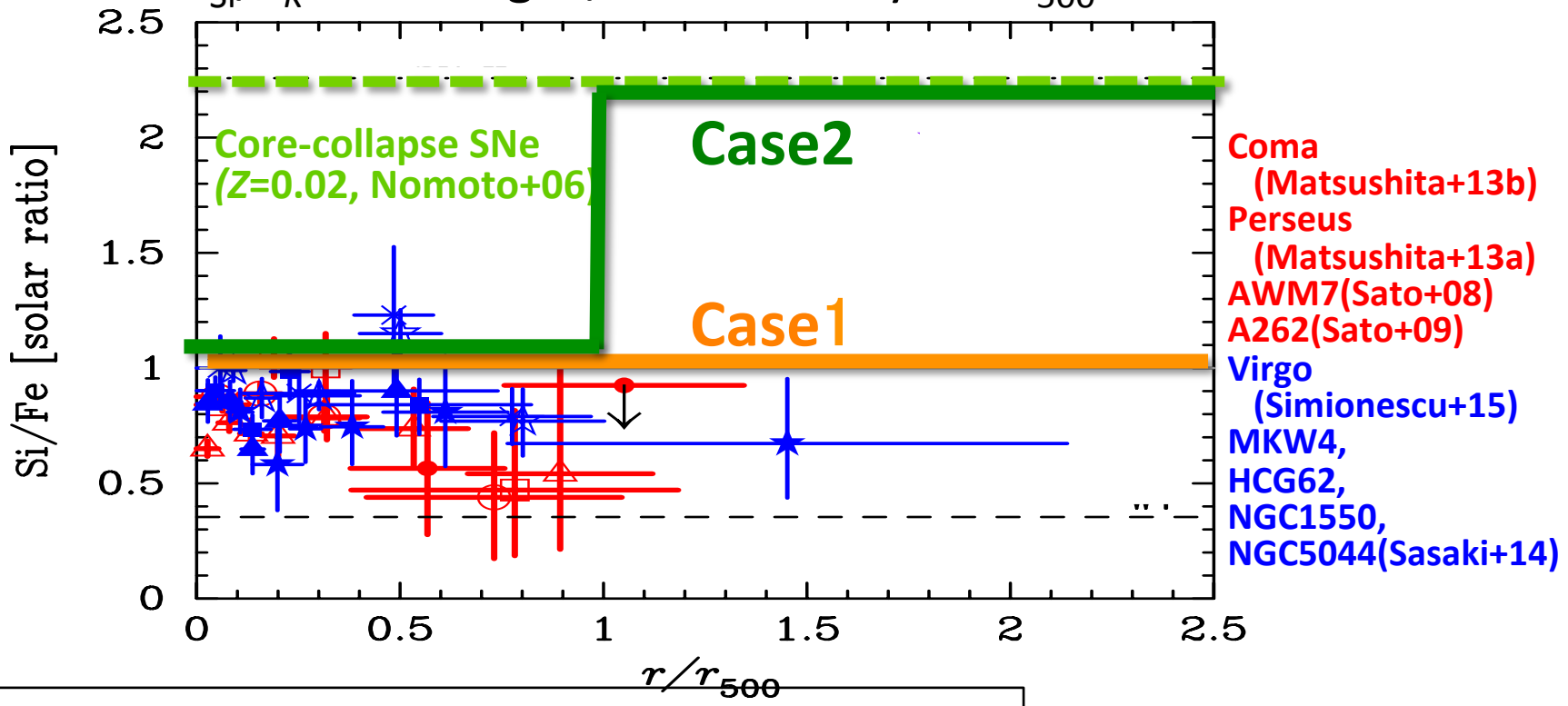
The Si/Fe ratios are almost the solar ratio up to ~r_{500}.

Estimation of total Silicon-Mass-to-Light-Ratios(M_{Si}/L_K)

Assuming Si/Fe ratio beyond r_{500}, we estimated the **"total (ICM+star)" M_{Si}/L_K** to reveal the IMF slope.

M_{Si}/L_K in the ICM

Estimate M_{Si}/L_K assuming Si/Fe ratios beyond r_{500}

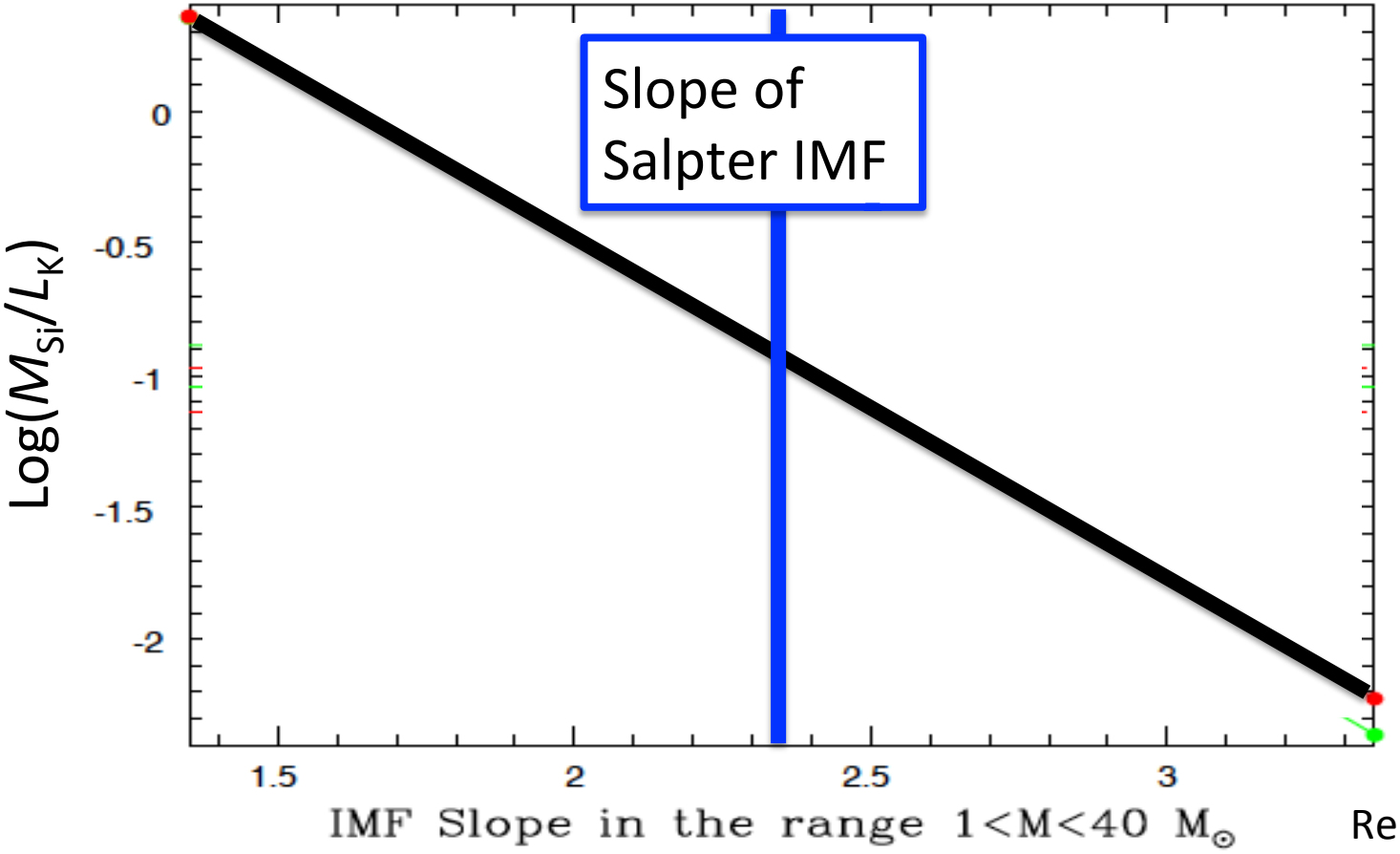


M_{Si}/L_K in the stars of the member galaxies

Assumed the solar metallicity

Slope of Initial mass function of the clusters

Renzini (2005) showed that M_{Si}/L_K is very sensitive to the slope of IMF of stars.



Renzini+05

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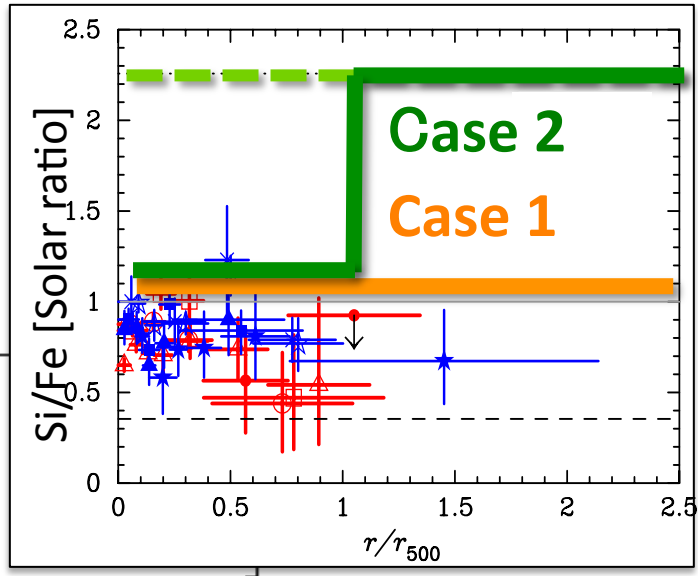
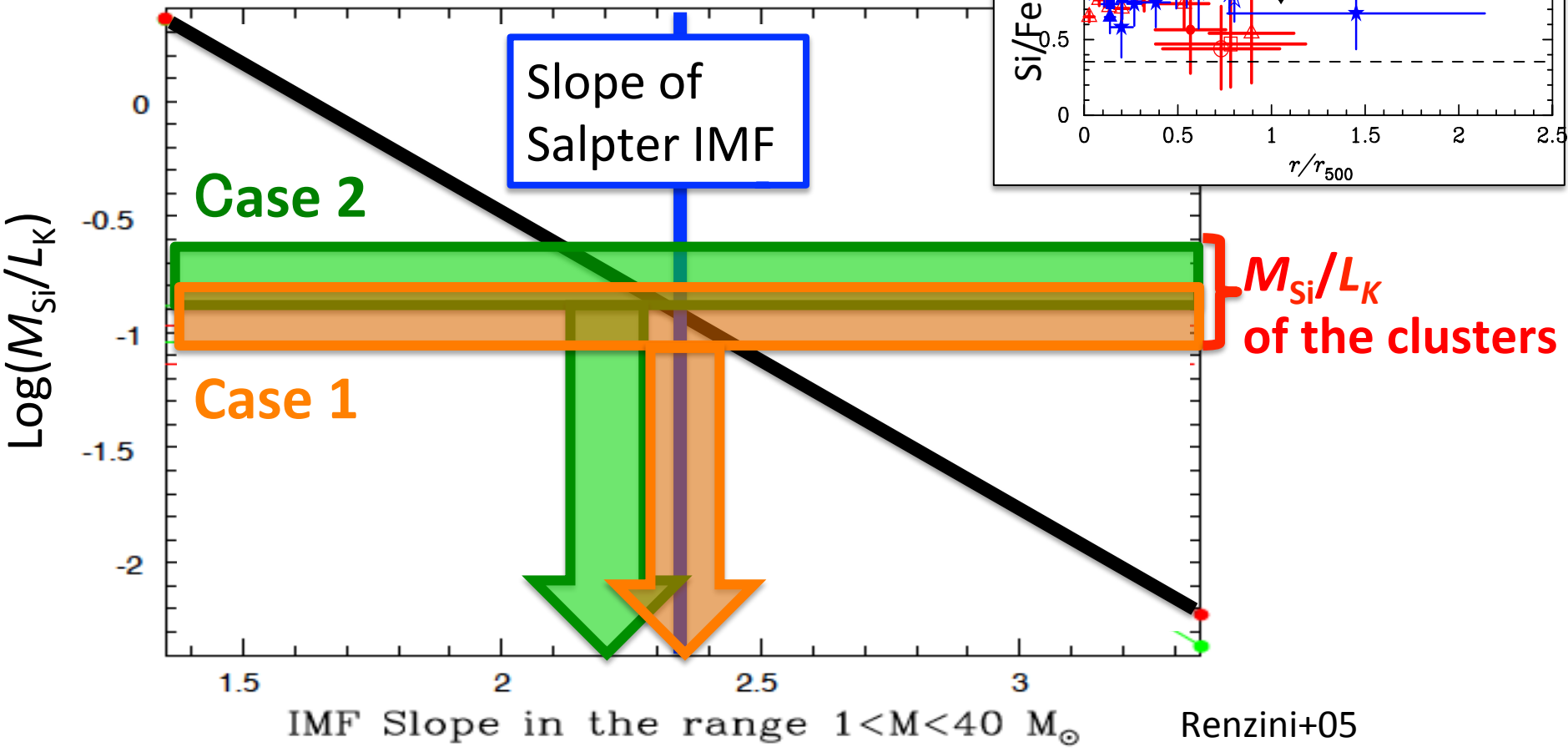




The IMF slope of the clusters are close to the Salpeter IMF.

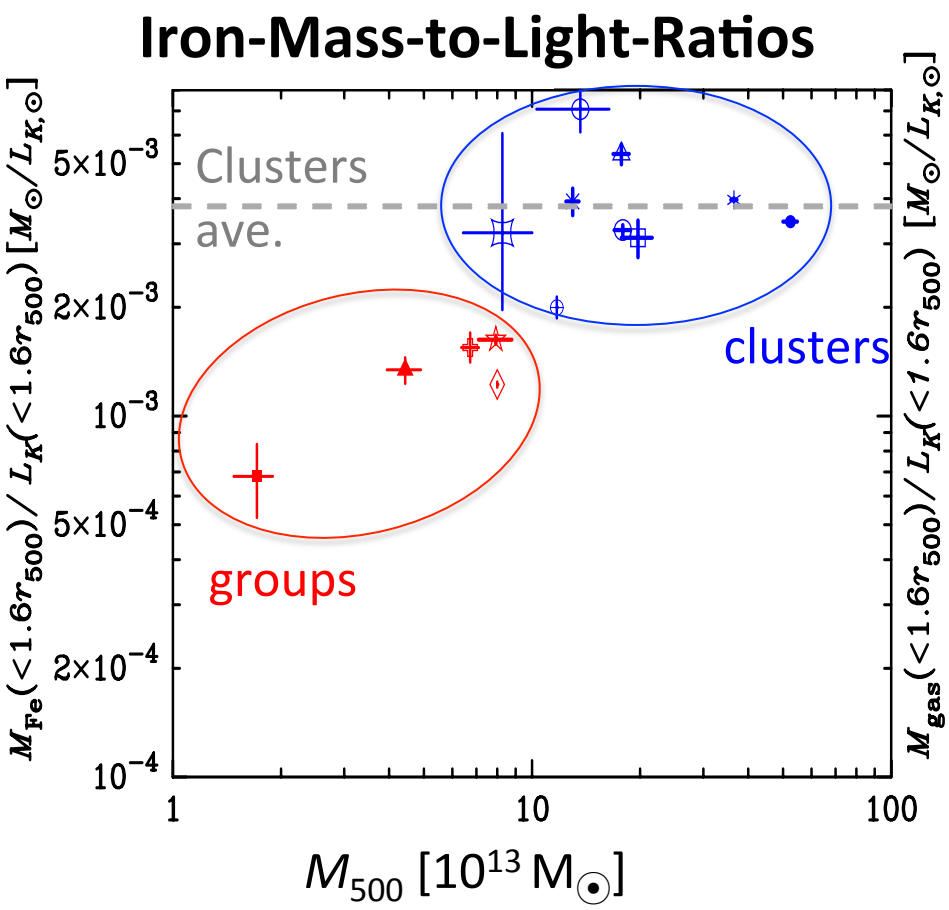
Summary

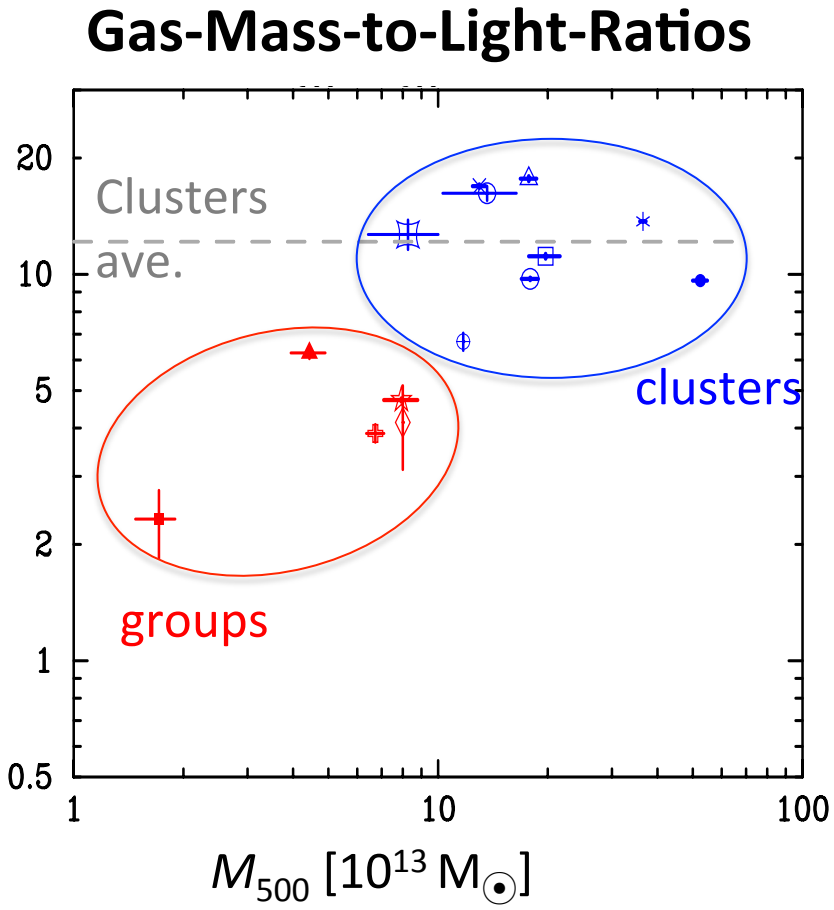
We analyzed 13 clusters and groups observed with Suzaku beyond r_{500}.

- We detected the Fe-K line up to ~r_{500} for the clusters, and ~0.5 r_{500} for the groups
- Fe abundances of clusters derived from Fe-K line (>0.2 r_{500}) are 0.2-0.3 solar
- Fe abundances of groups <r_{500} are also 0.2-0.3 solar
- $M_{Fe}(<1.6\ r_{500})/L_K(<1.6\ r_{500})$ in the ICM of the clusters are several times greater than that in the stars.
  ⇨ Most amount of Fe are in the ICM.
- $M_{Fe}(<1.6\ r_{500})/L_K(<1.6\ r_{500})$ of the clusters does not depend on M_{500}.

Assuming the solar Si/Fe ratios in the ICM and stars, the slope of IMF in the clusters are agree with the Salpter IMF

Iron-Mass-to-Light-Ratios and Gas-Mass-to-Light Ratios

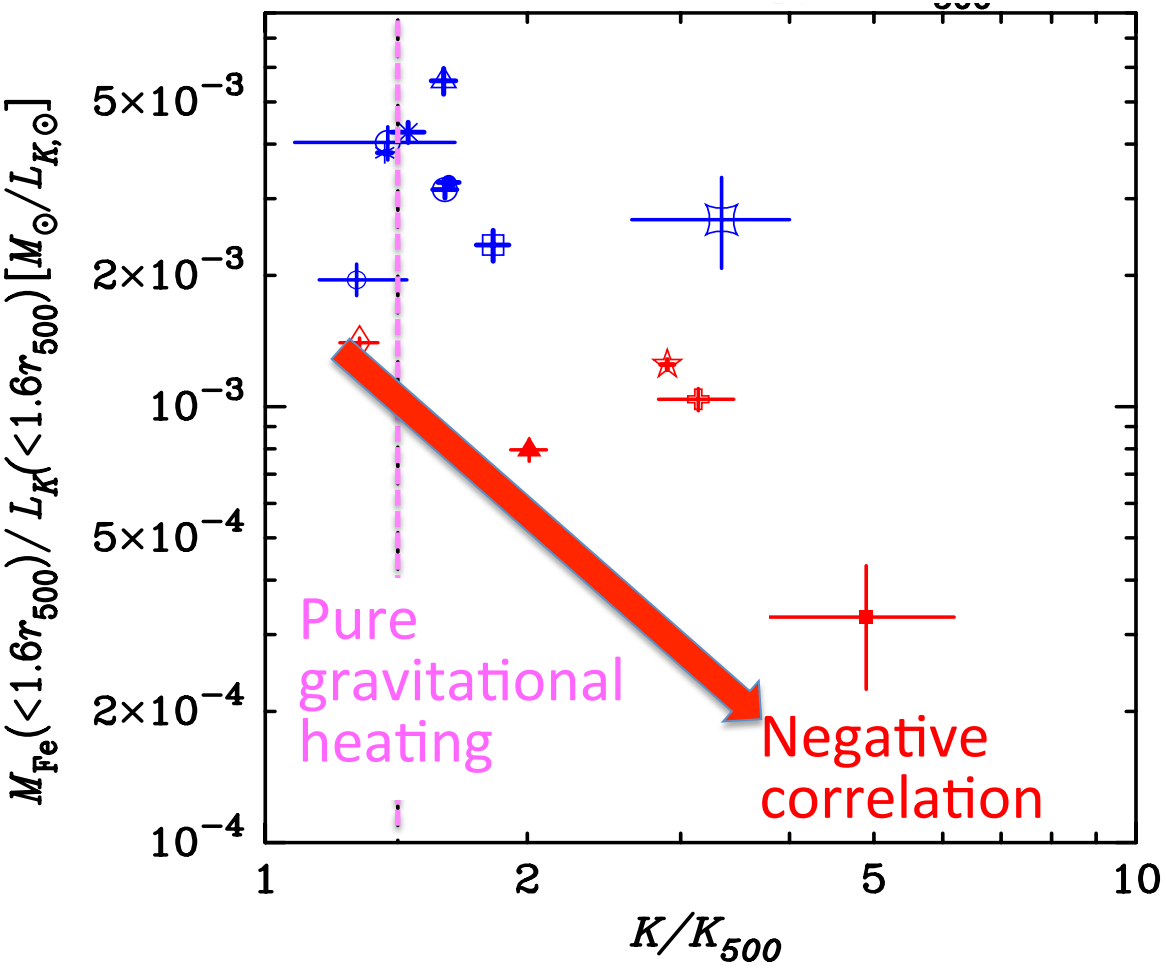




Poor systems have smaller IMLRs and GMLRs than these of the clusters.

The dependence of the IMLRs on entropy

The poor systems have smaller M_{Fe}/L_K than the clusters.



Non-gravitational energy input is more important in poorer systems

Poor systems would have shallower gas and metal distributions than stars