Metals in the intercluster medium

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Outline

Metals in intracluster medium

Aims of IXO observations

Recent results of metal observations

- Evolution of Fe abundance
- Abundance pattern of the ICM
- Metal mass to light ratios

Simulated spectra with IXO

Metals in the Intracluster medium

O, Ne, Mg

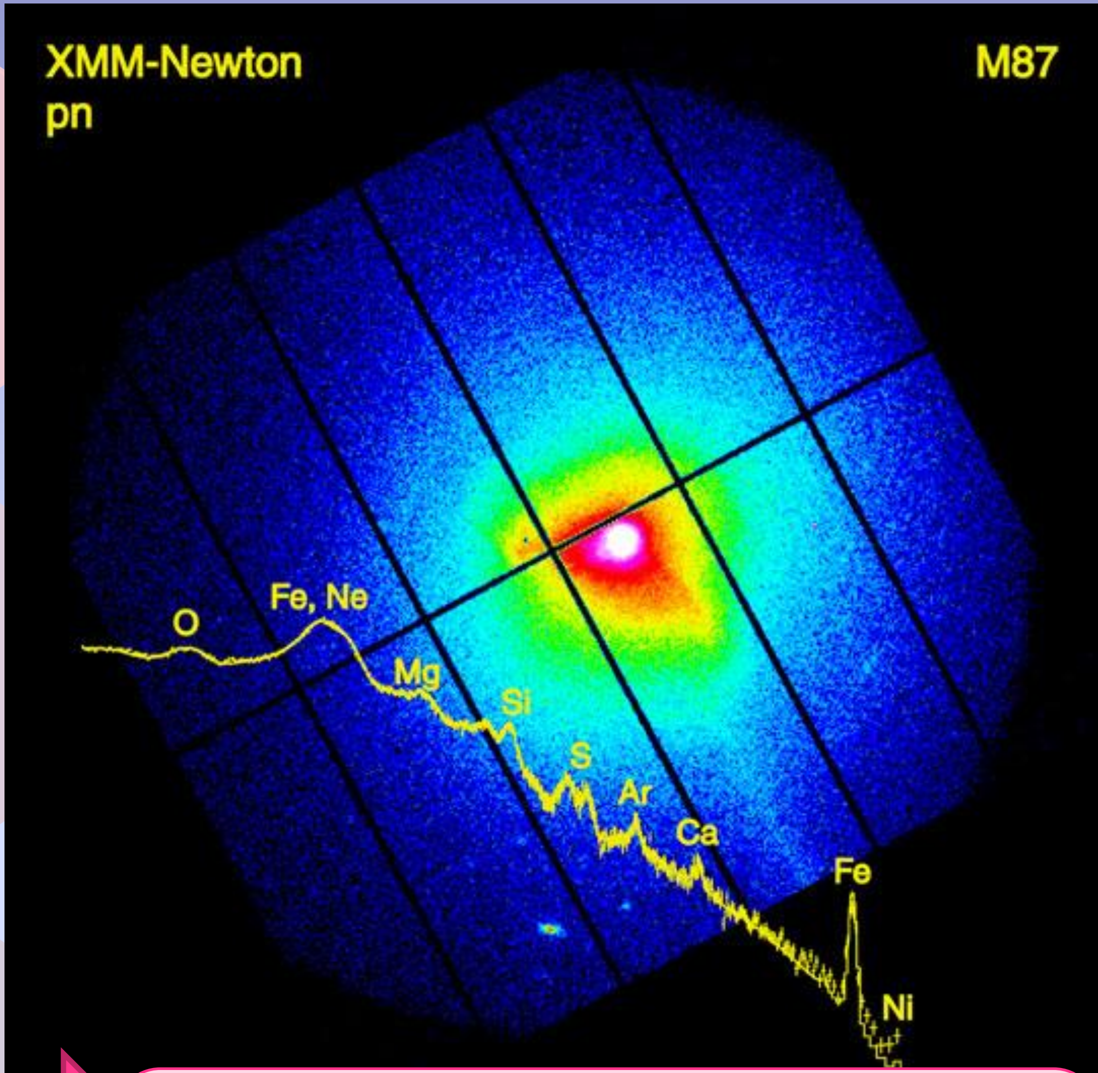
- From SN II
- Star formation history in clusters

Si, S, Ar,Ca,Fe,Ni

- From SN Ia and SN II
- History of SN Ia

C,N

- From intermediate mass stars
- History of these stars

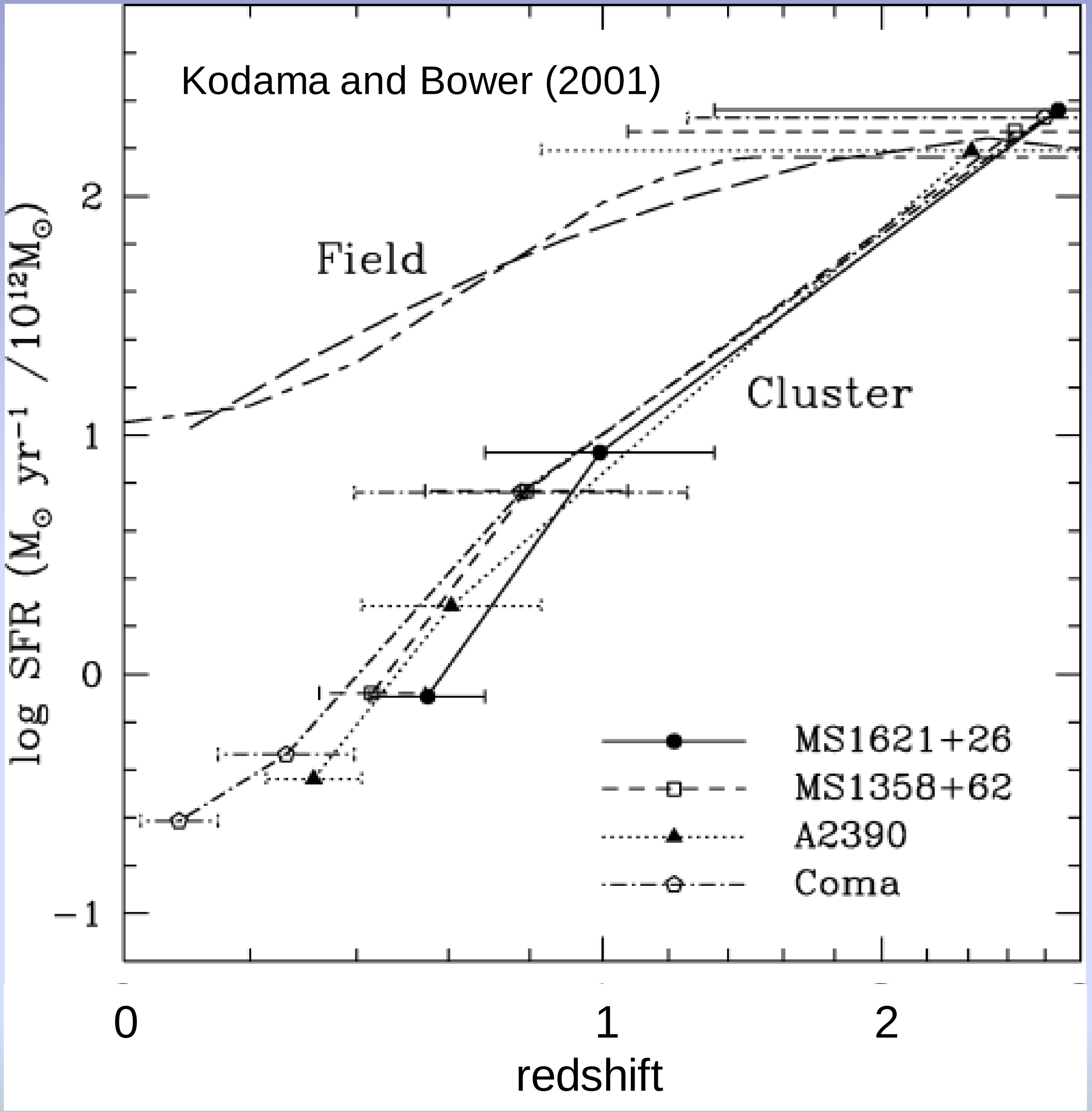


Star formation history in clusters

Star formation history in the Universe

Recent star formation rate in units of stellar mass in clusters are smaller than that in the field

History of O, Ne and Mg abundance of ICM?



Aims of IXO observations

Large effective area

Small field of view

Good energy resolution

Redshift evolution of metals in ICM

Abundance pattern

- C, N, O, Ne, Mg, Si, S, Ar, Ca, Fe, Ni
- Chemical evolution in clusters

Up to virial radius

- Metal supply from cD galaxies are important at central regions
- Gas mass is larger at outer regions

from groups to clusters

- Groups are building blocks of clusters

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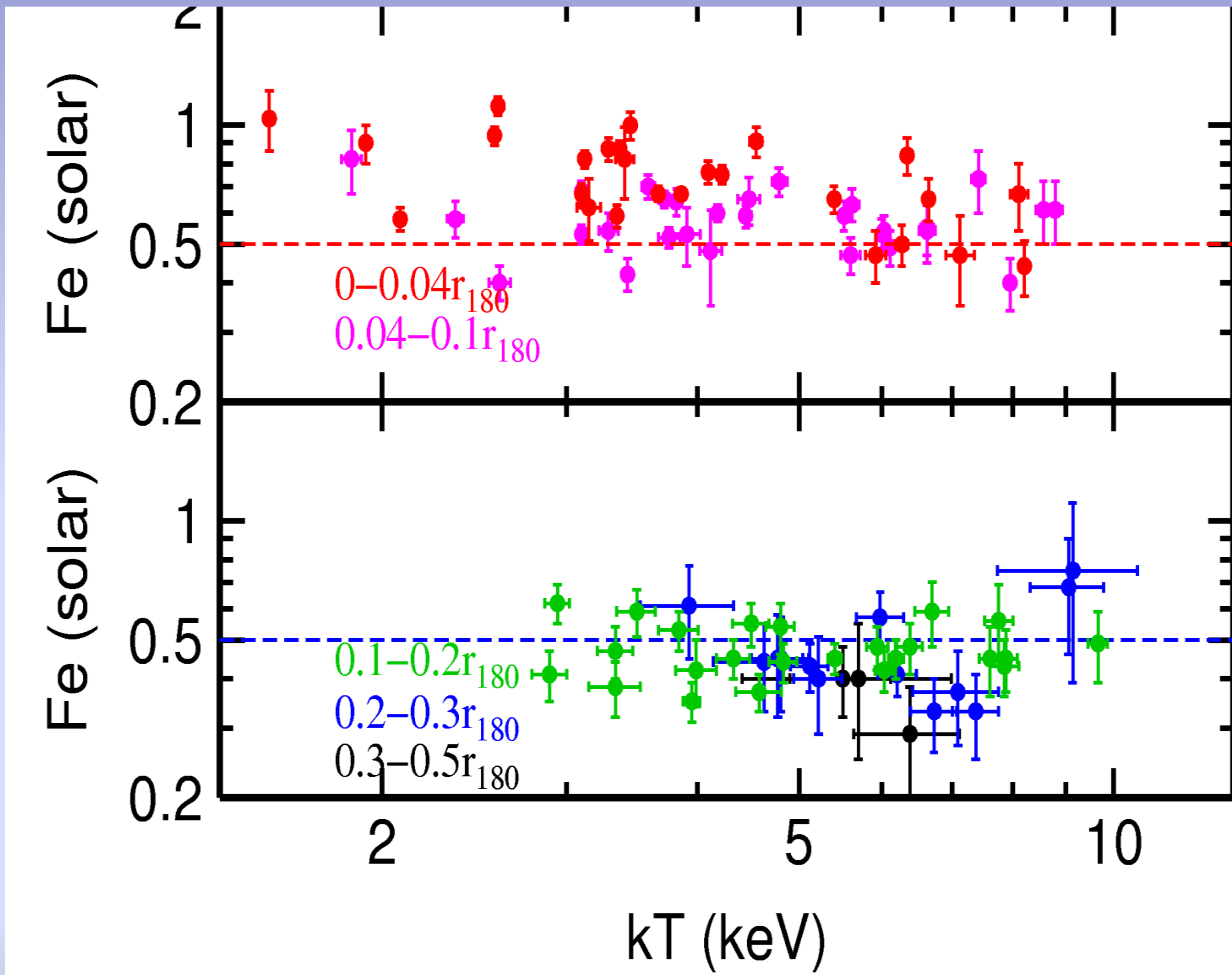
Fe abundance of ICM of nearby clusters observed with XMM

＜0. 1r_{180}

- large scatter
- Difference in metal suply from cD galaxies

0.1-0.5 r_{180}

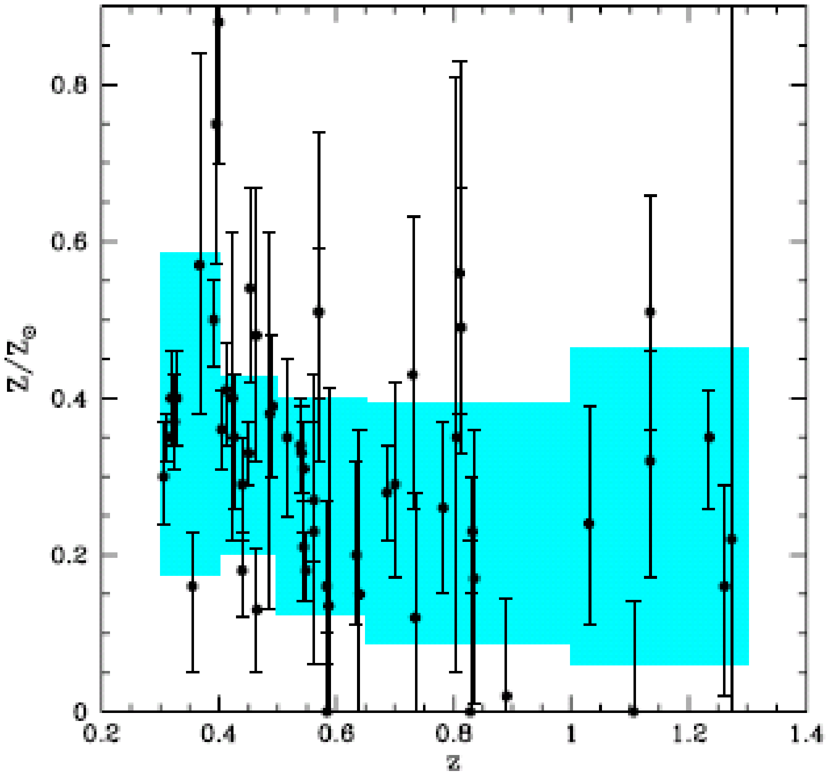
- ～0.5 solar
- Universal Fe abundance and chemical evolution

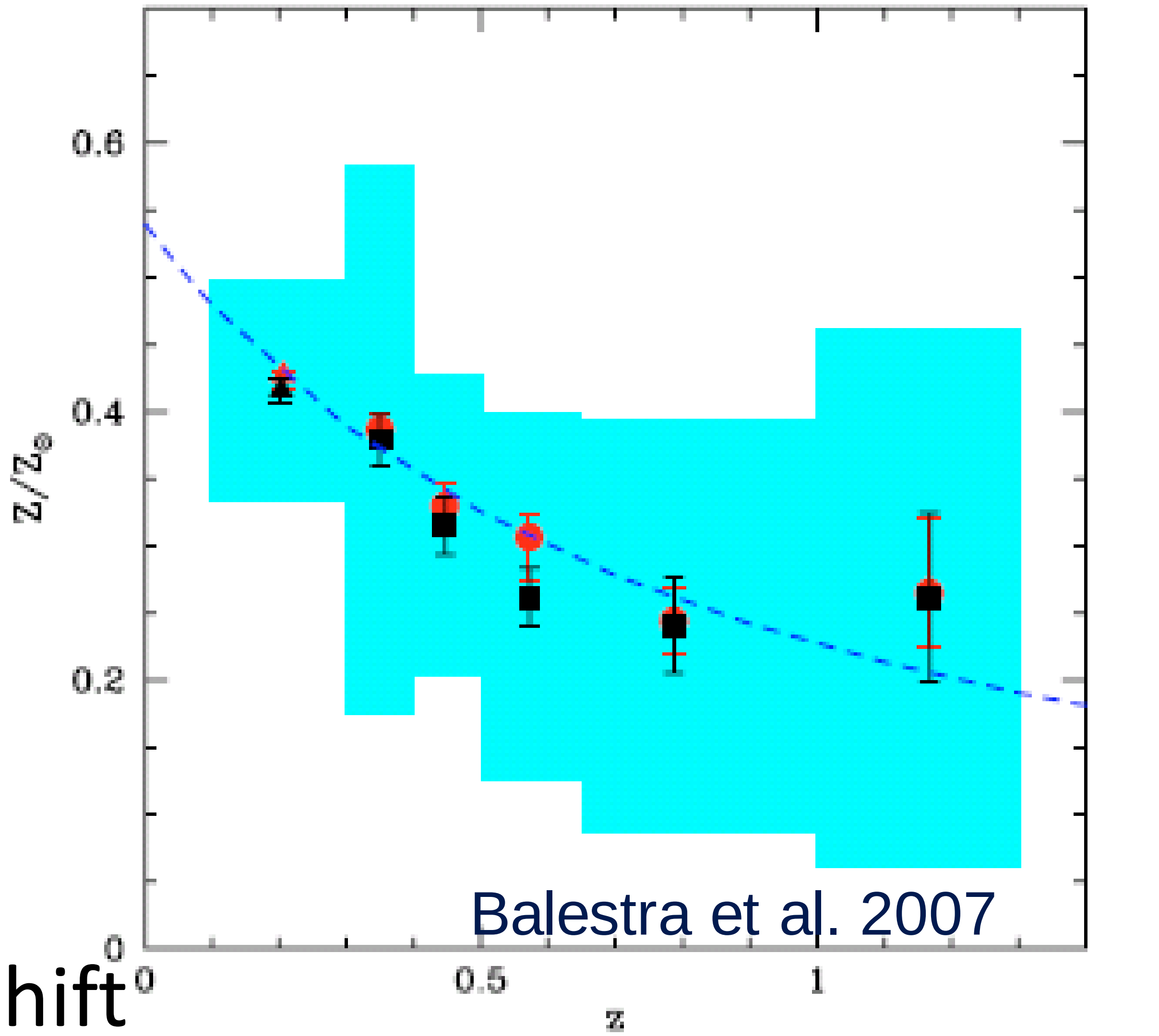


New solar abundance from Loddars (2003)

Matsushita in prep

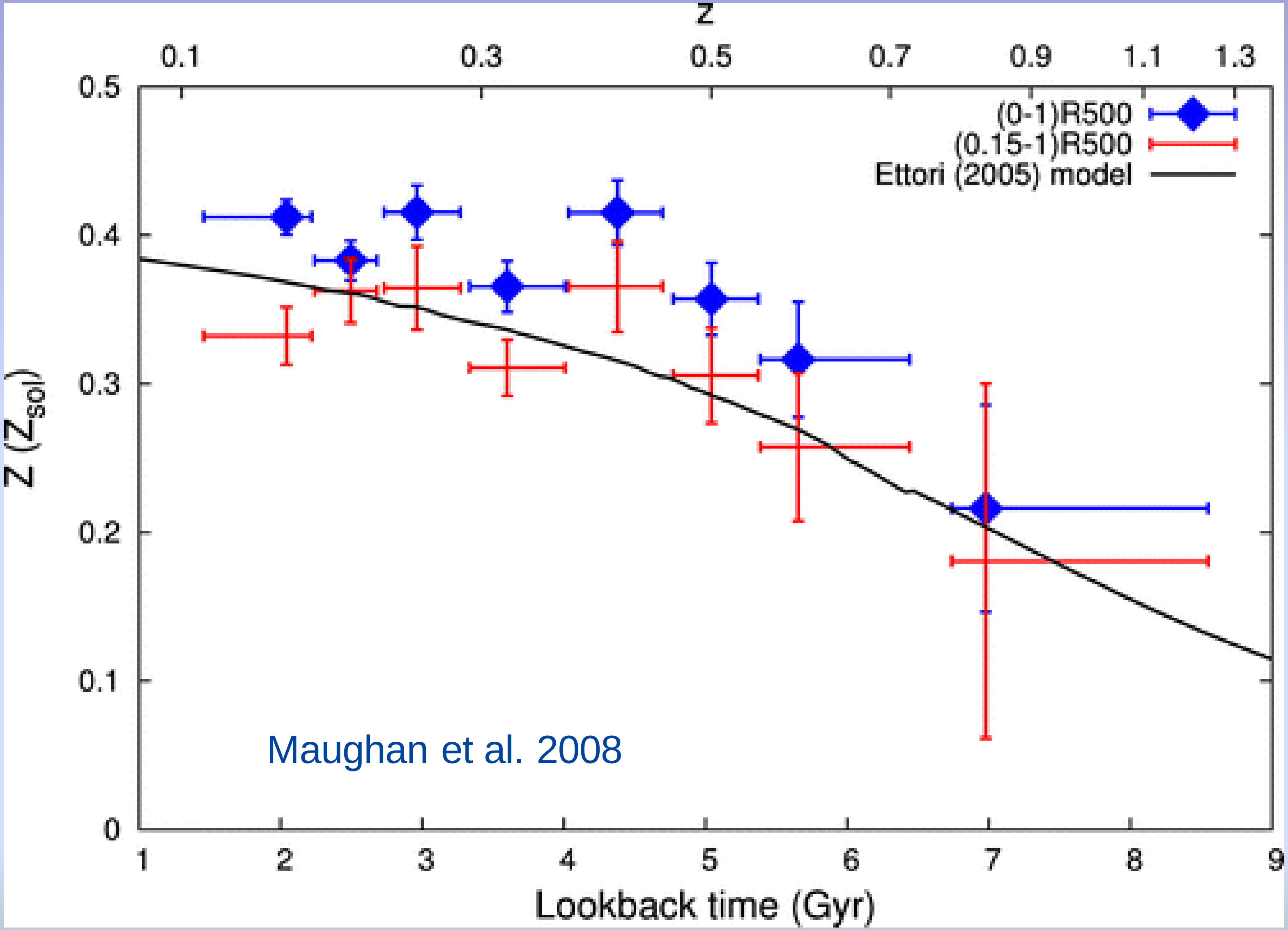
Evolution of Fe abundance





- Within 0.15-0.3r_{180}
- Decrease of Fe abundance with redshift

Evolution of Fe abundance of ICM



Observation of history of SN Ia rate with IXO

Evolution of Fe abundance of hot ISM in elliptical galaxies ➡ **Evolution of SN Ia rate**

- X-ray luminous elliptical galaxies at center of groups
  - Hot gas is dominated by stellar mass loss from elliptical galaxy
  - Observable $z<0.5$ with IXO

Fe abundance of hot ISM

= stellar Fe abundance + contribution from SN Ia

$\propto$ (SN Ia rate)/(stellar mass loss rate)

Fe abundance with IXO

To high redshift, up to virial radius

Evolution of metals < 0.1r180

- evolution of cooling core
- metal supply from cD galaxies

Evolution of metals > 0.1r180

- Universal metal supply from cluster galaxies?
- how about groups of galaxies

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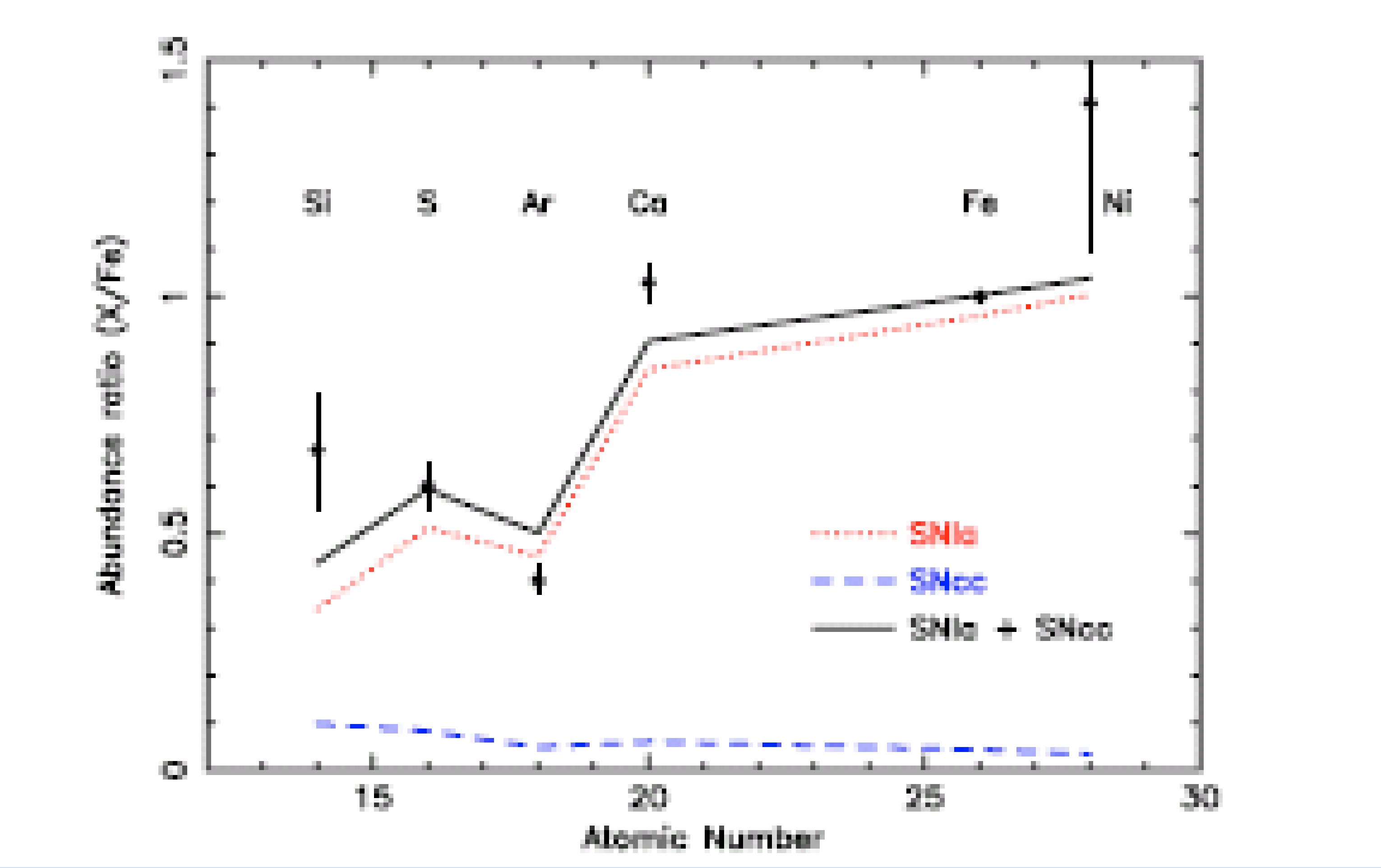
Abundance pattern observed with XMM (de Plaa et al. 2007)



Si/Fe ratio in ejecta of SN Ia depends on models.
We need O, Ne and Mg measurements.

O mass to light ratio in the Universe

Half of metals in the solar system : O.

- Chemical evolution of the Universe
- ≒history of synthesis of O

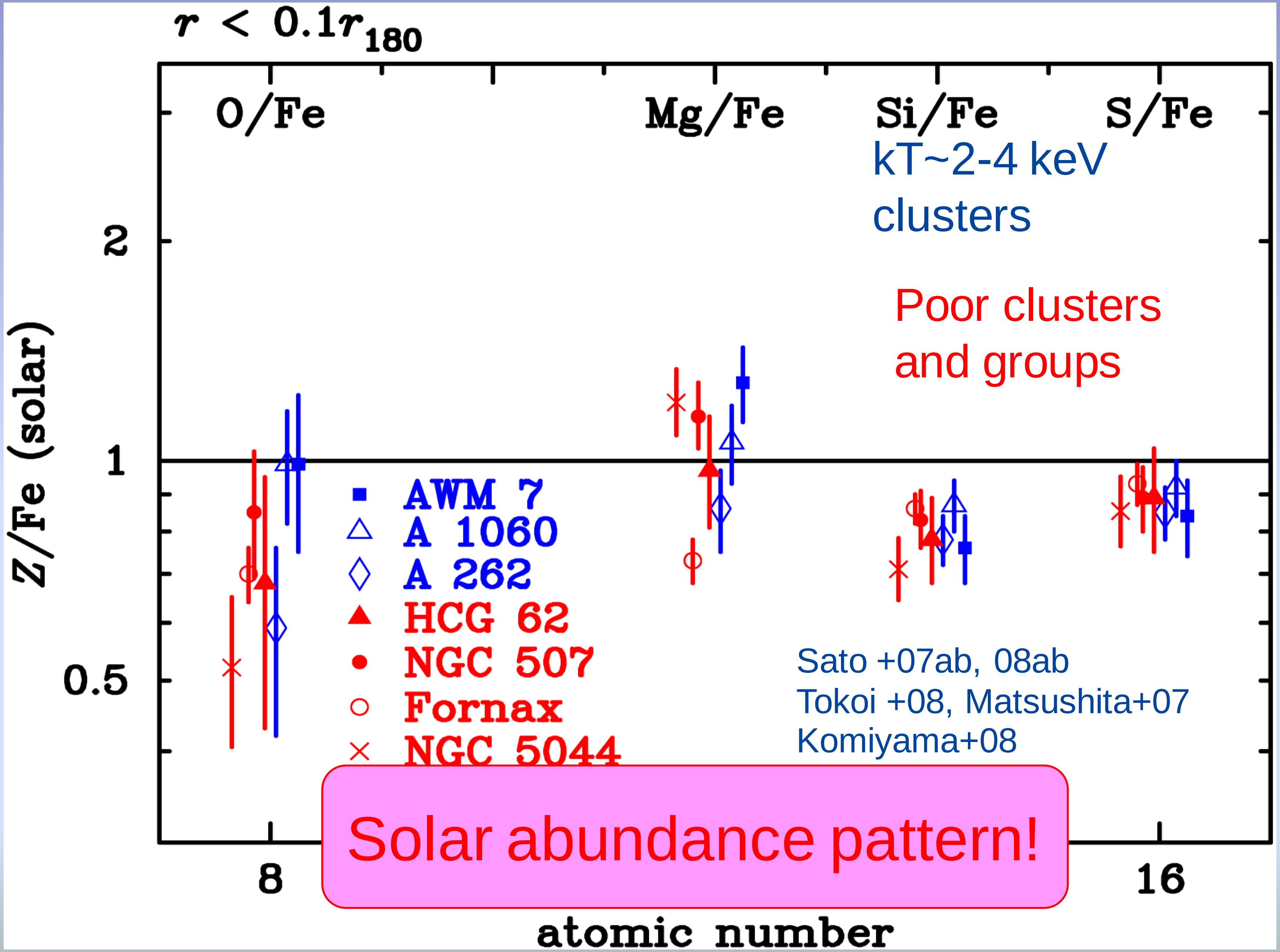
O is synthesized by SN II

- O mass reflects total amount of massive stars in the past

O mass to light ratio in the Universe

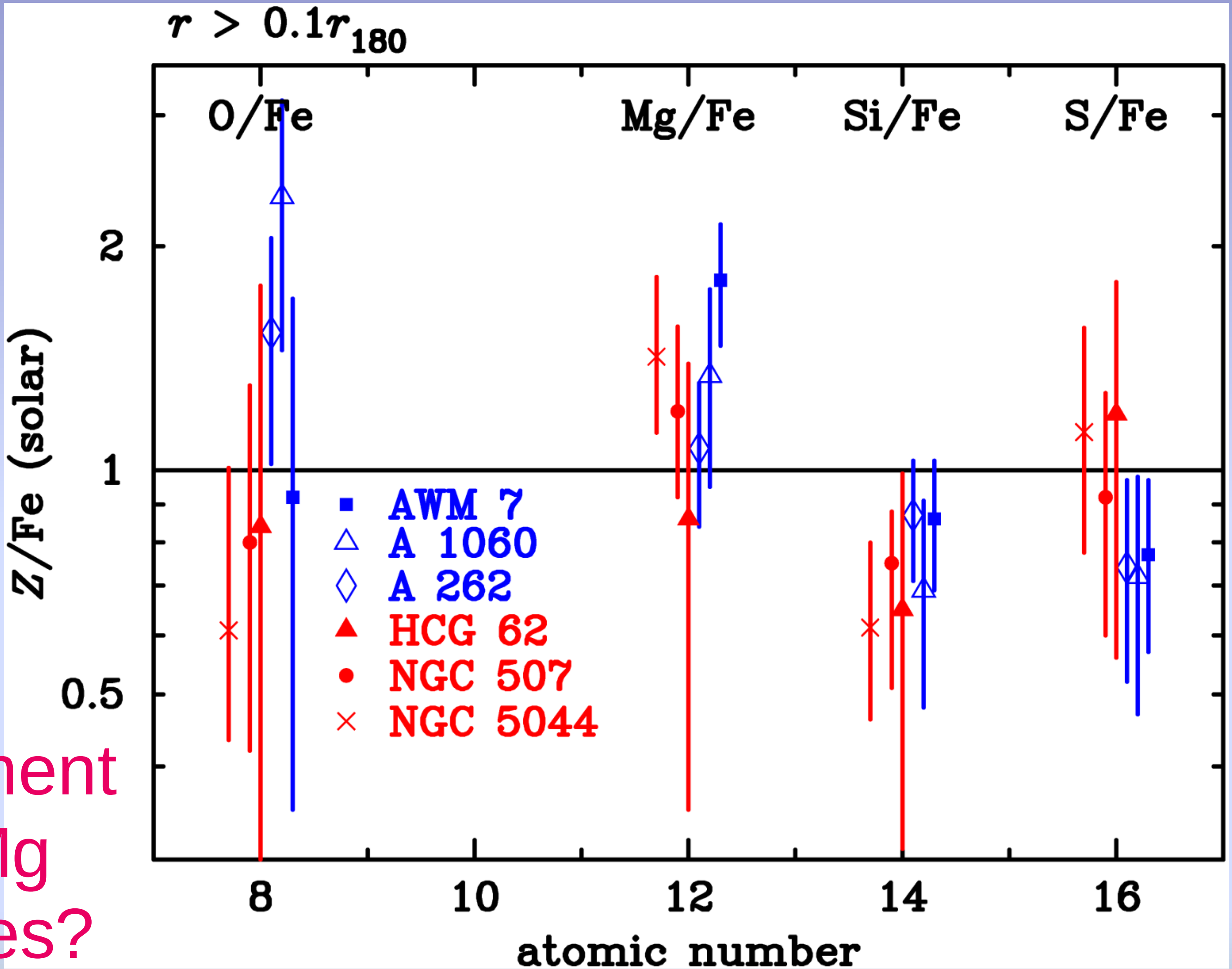
- Galaxies, groups, clusters of galaxies and WHIM
- Initial mass function vs. environment
- Feedback from SN II

O and Mg in ICM observed with Suzaku



New solar abundance by Loddars (2003)

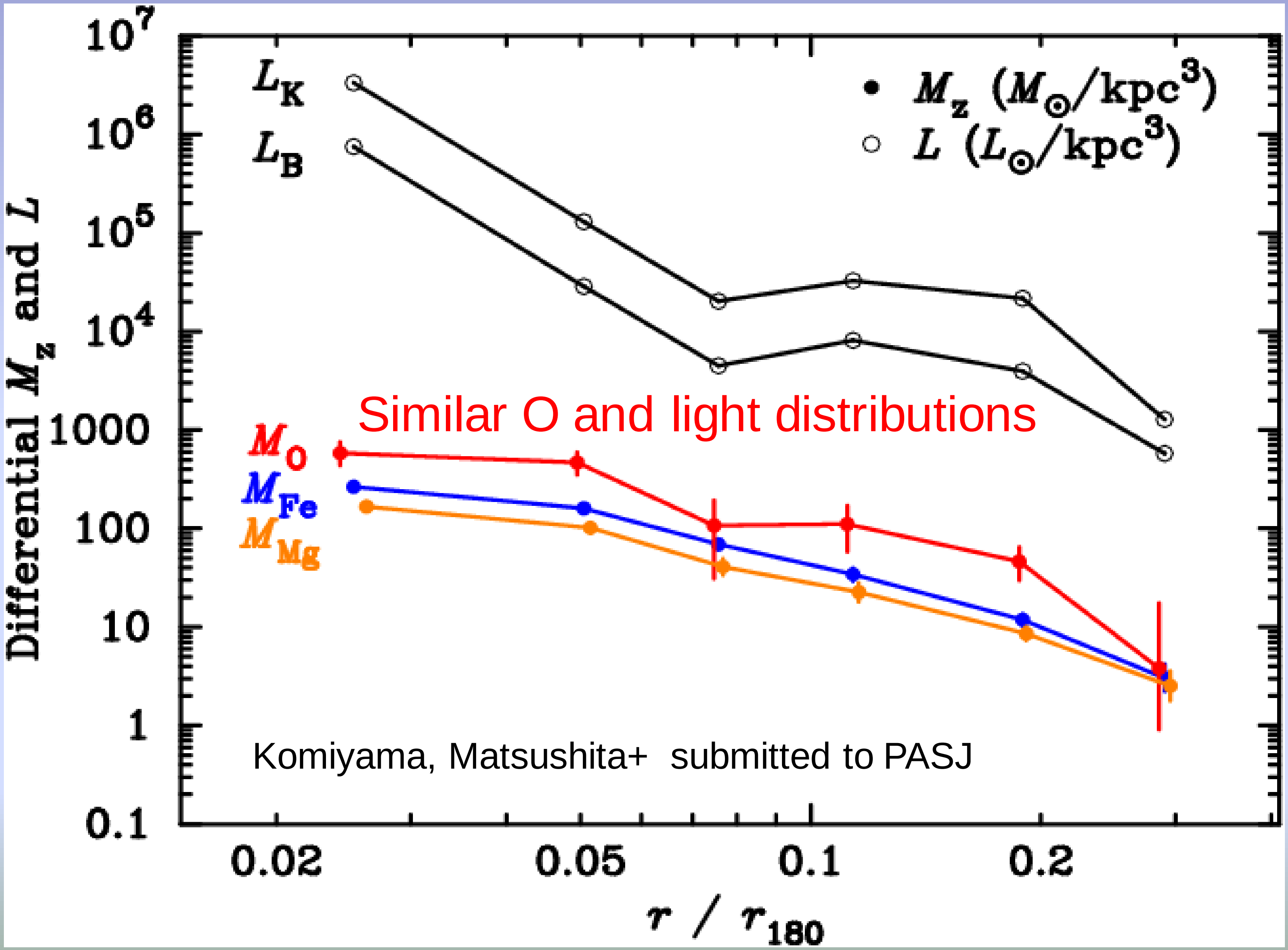
Abundance pattern at 0.1-0.3 r_{180}



Enhancement of O and Mg abundances?

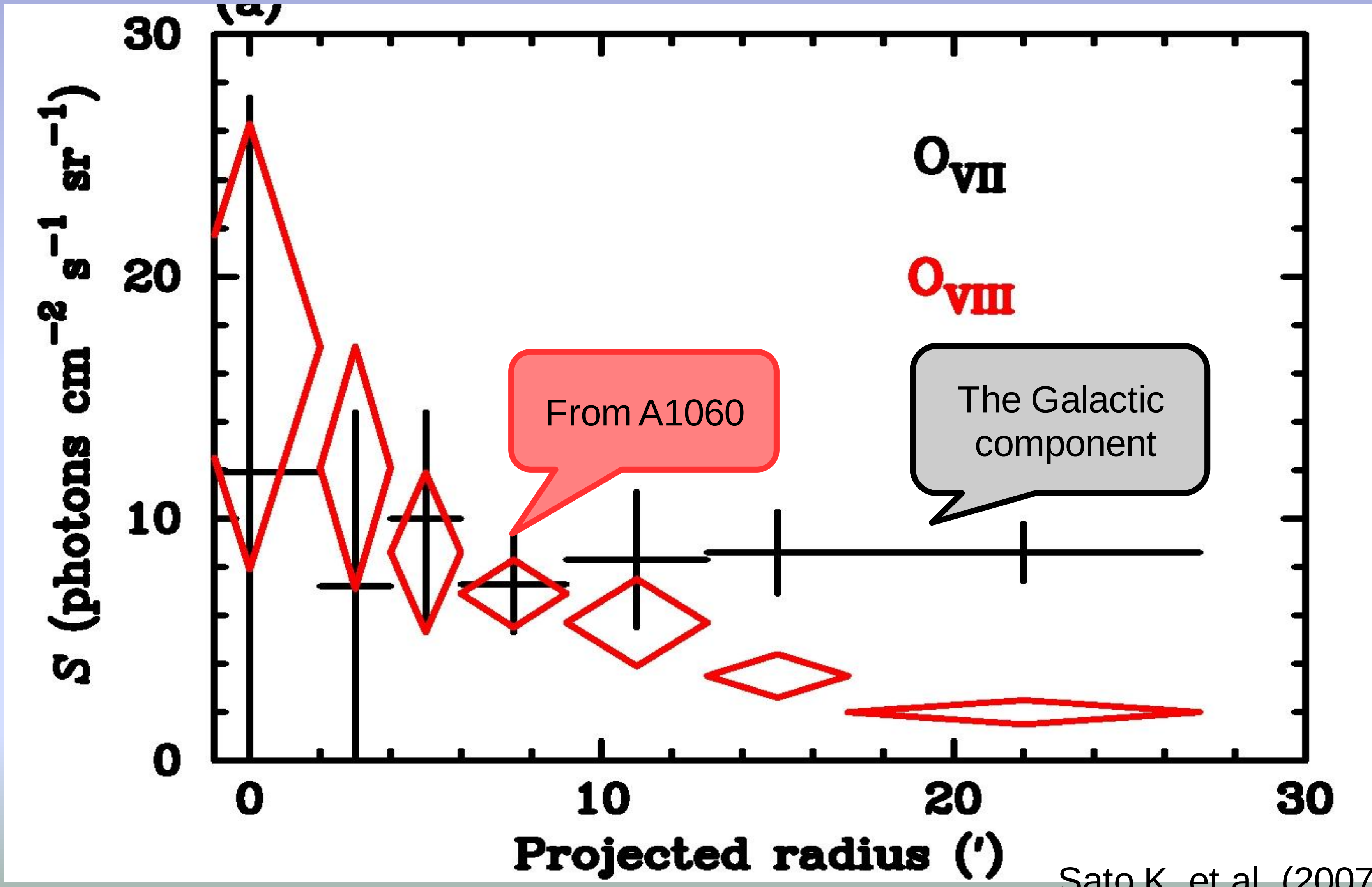
Are metals synthesized by SN II more extended ?

Luminosity and metal density profiles of NGC 5044 group



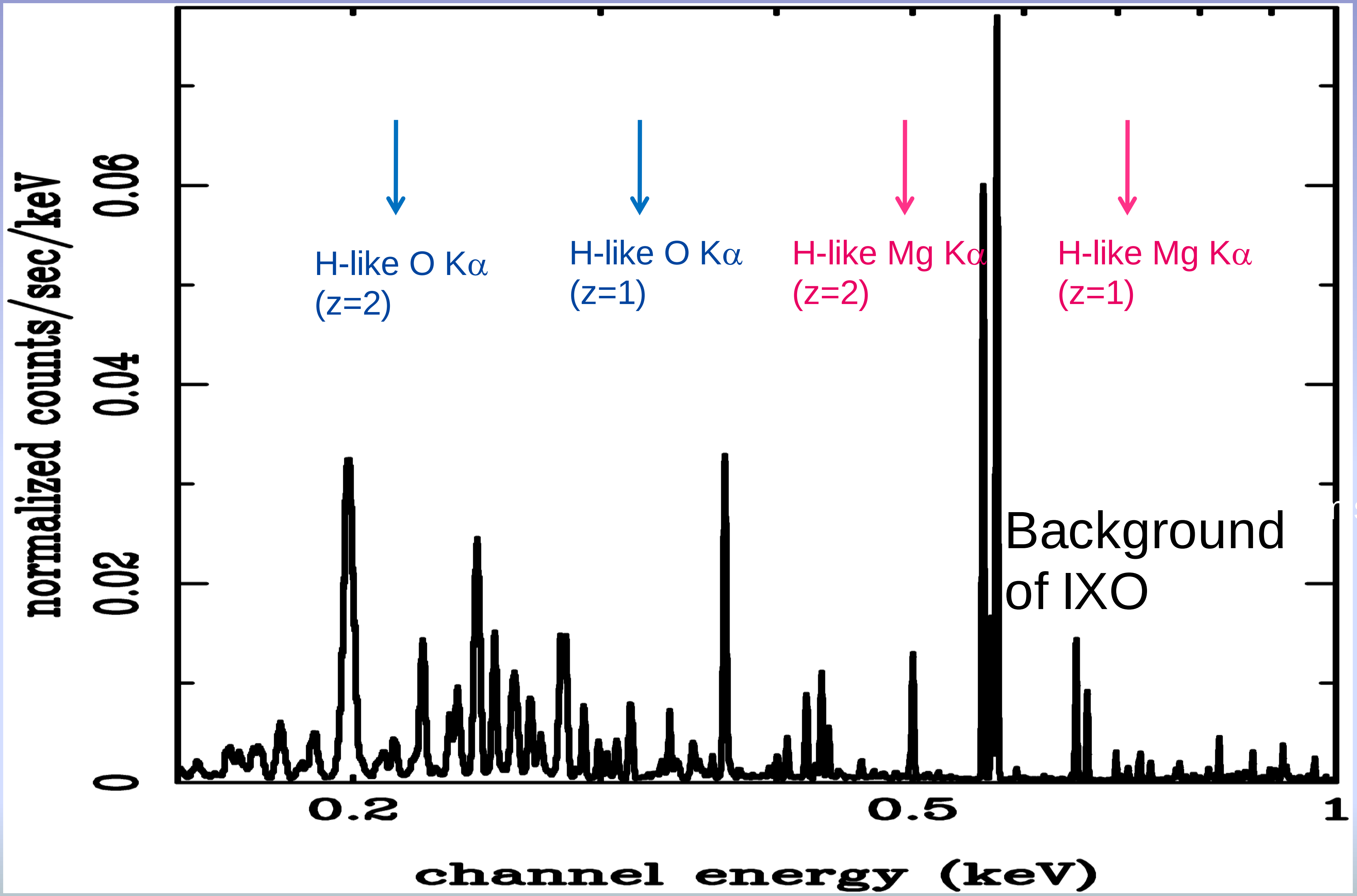
The effect of the Galactic component

Surface brightness of OVII, OVII lines of A1060 observed with Suzaku



Sato K. et al. (2007)

Effect of the Galactic emission with IXO

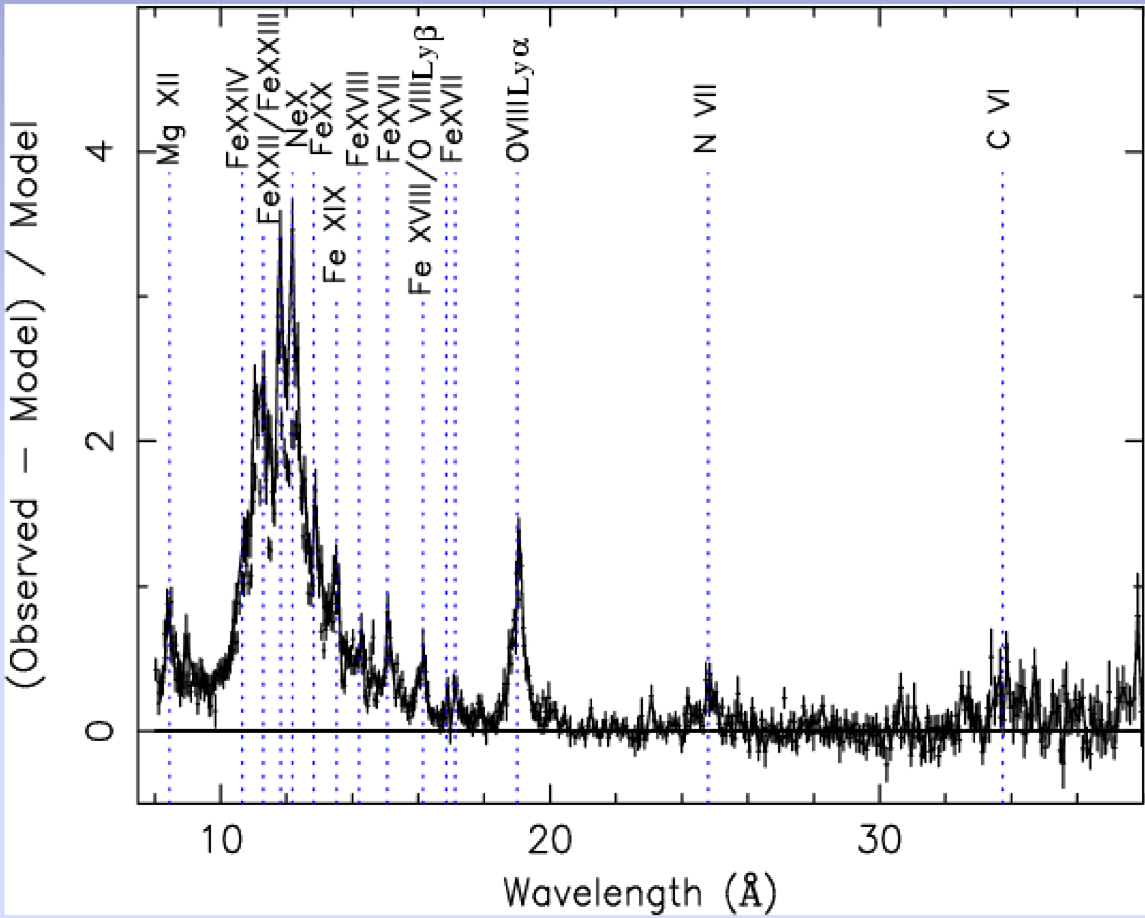


C and N evolution

CN come from intermediate mass stars

Star formation history of intermediate mass stars

RGS observation of M 87 (Werner et al. 2006)



Present knowledge of history of intermediate mass stars is very small

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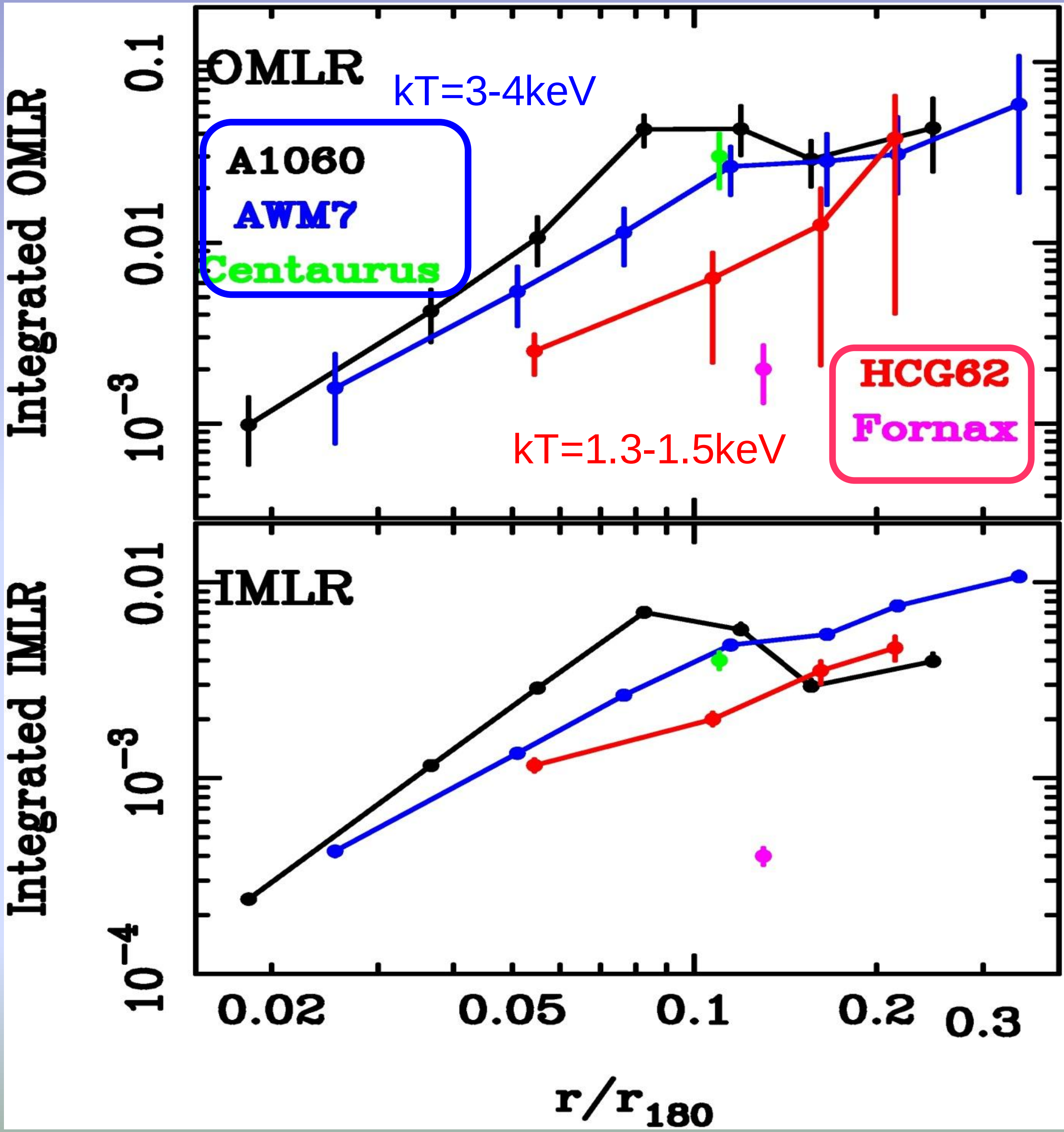
O and Fe mass to light ratios (OMLR&IMLR)

OMLR
=O mass / stellar luminosity
IMLR
= Fe mass/stellar luminosity
stellar luminosity- B-band

The most important parameters to study necleosynthesis in galaxies

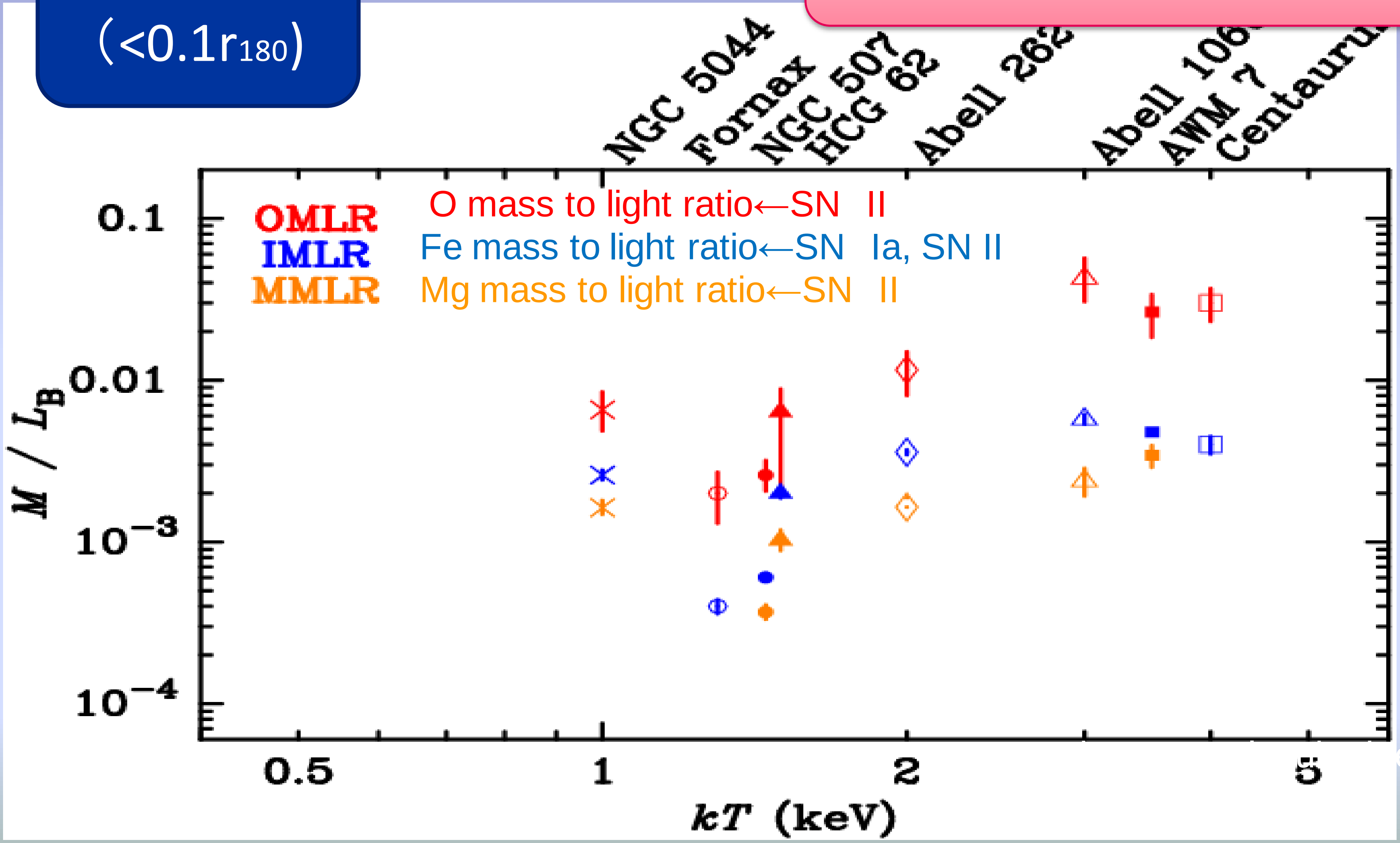
IMLR and OMLR increase with radius



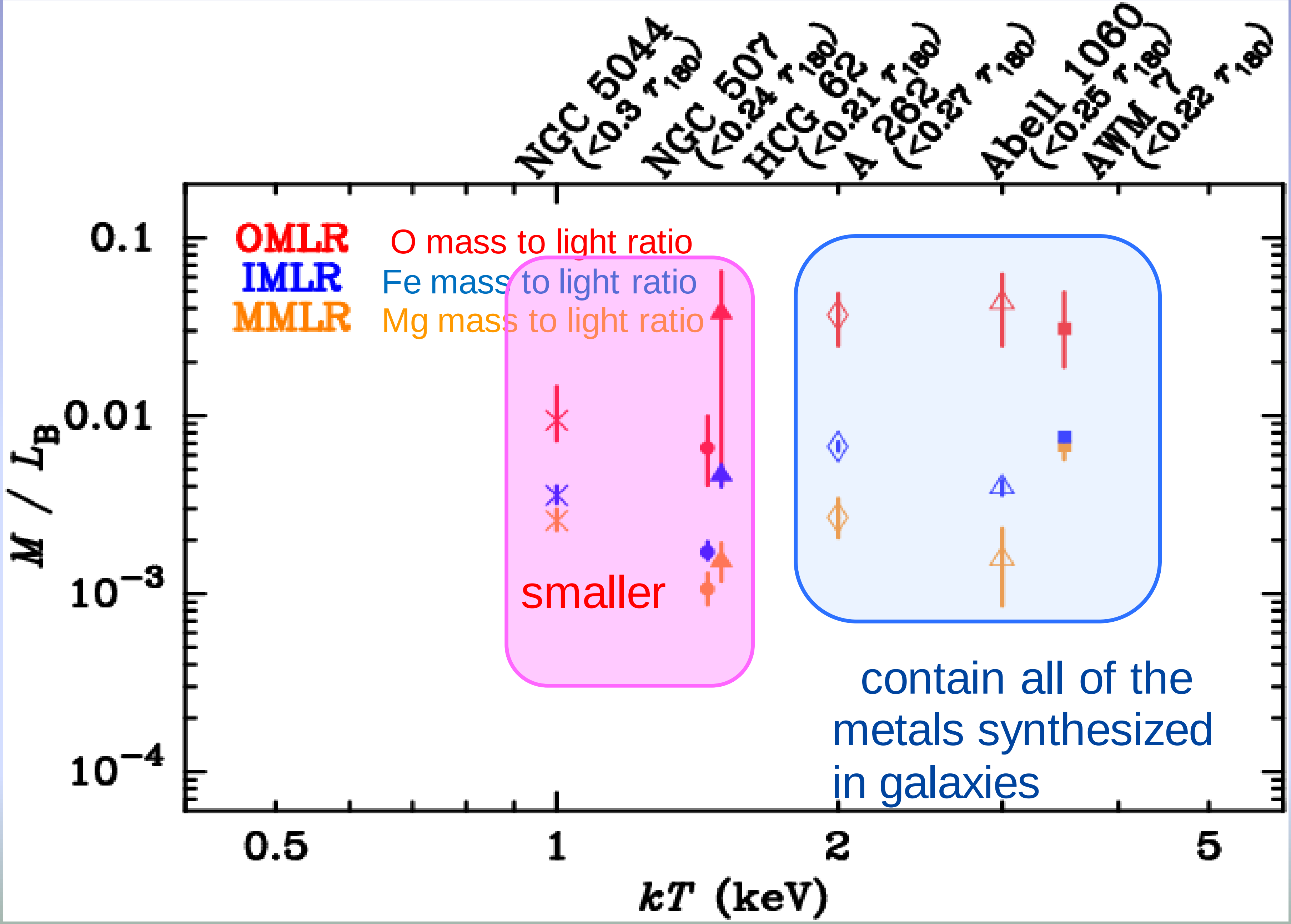
Metal mass to light ratio

Mainly low mass stars

Suzaku
(<0.1r_{180})



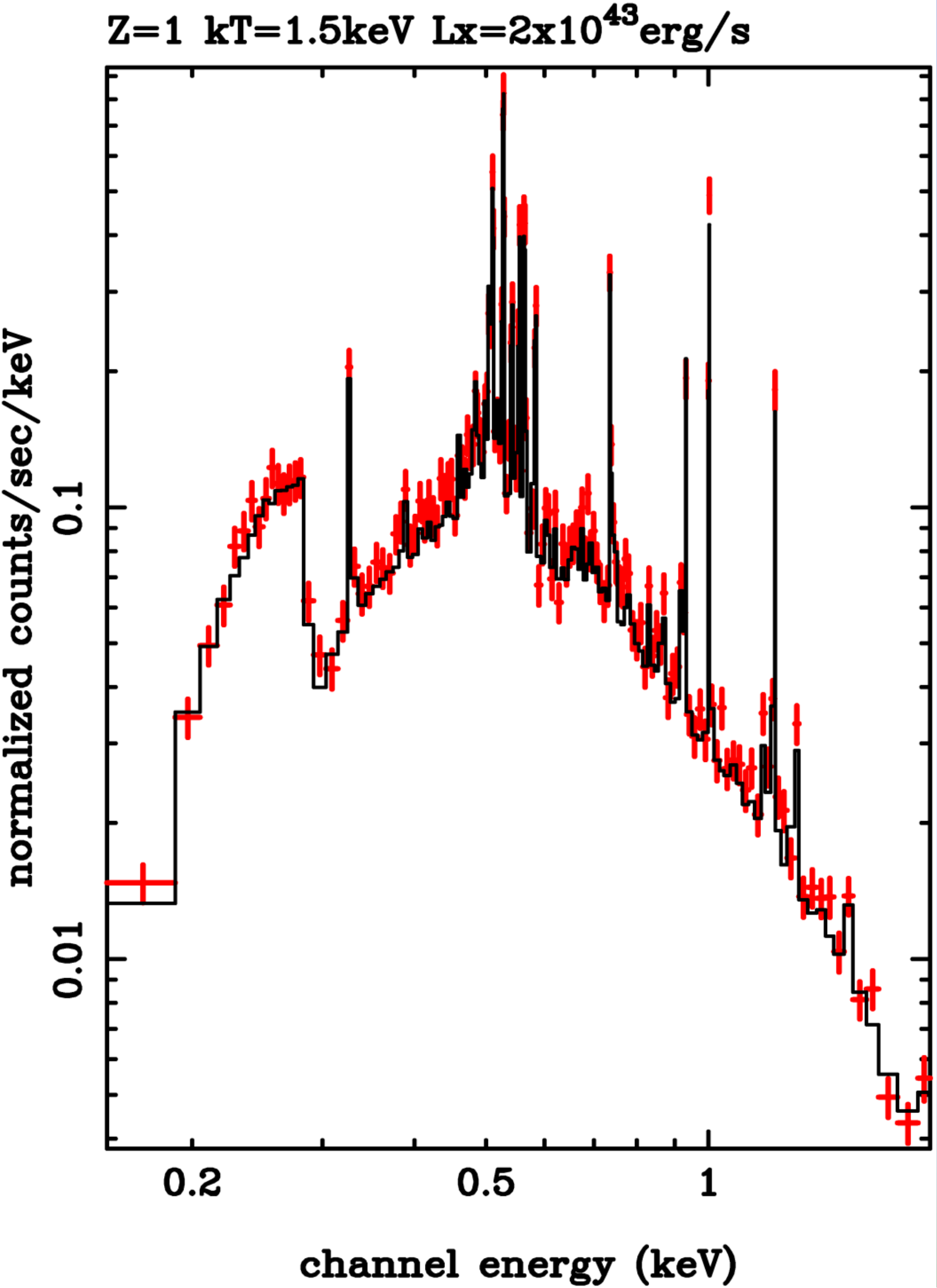
Metal mass to light ratio　(<〜$0.3r_{180}$)

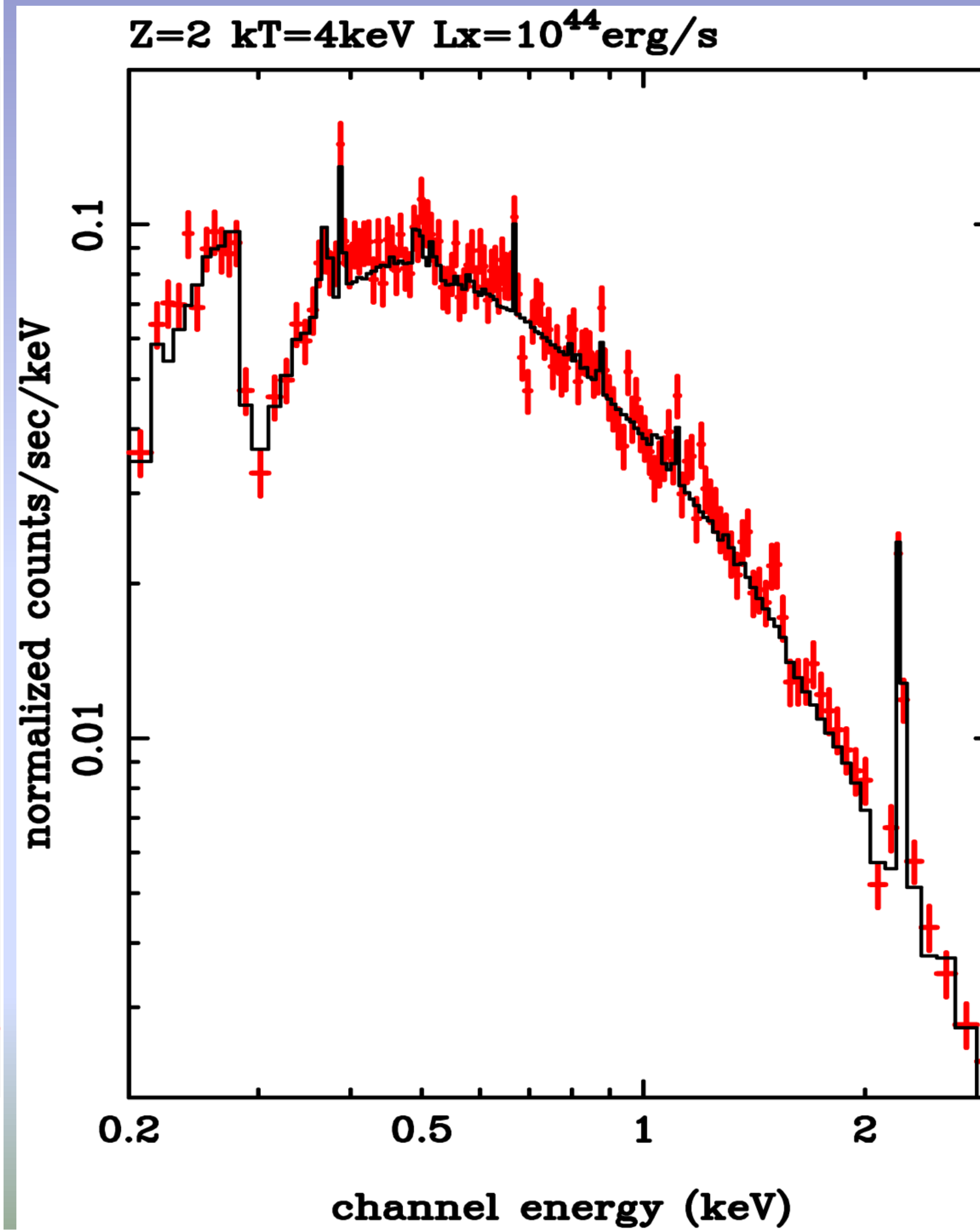


Small OMLR, IMLR in groups

- Gas mass/stellar luminosity of the groups are small
  - ICM in groups is more extended than those in rich clusters
    - Excess entropy and heating
  - Metal distribution may be used as a tracer of history of heating since timescales of metal enrichment and heating determine the metal distribution.
- metal enrichment -> preheating
  - Similar abundance and smaller metal mass-to-light ratios
- Preheating -> metal enrichment
  - Similar metal mass to light ratio
- Different timescales O and Fe synthesis

IXO Simulated spectra (200ks)





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