

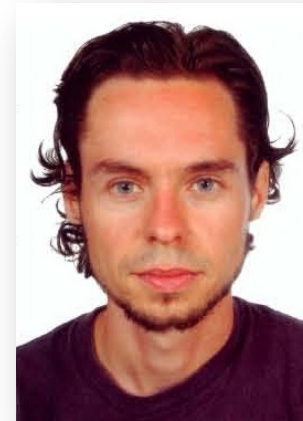
# Brightness fluctuations of unresolved CXB

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MPA, Garching

Alex Kolodzig

Gert Huetsi

Rashid Sunyaev



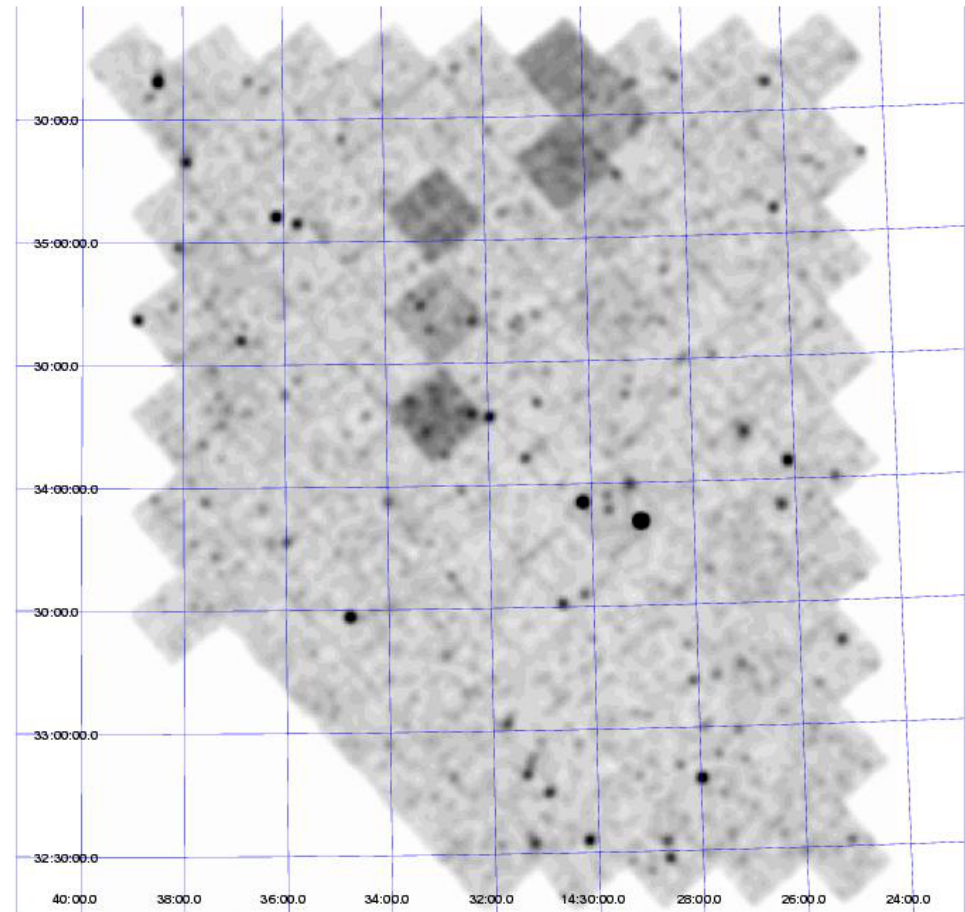
Alex Kolodzig  
KIAA, Beijing  
(former MPA)

# XBOOTES field

- 9.3 deg<sup>2</sup>
- 126 observations
- 5 ksec per field
- flux limit of  $\sim 10^{-14}$
- $\sim 50\%$  CXB resolved
- $\sim 3300$  sources
- $\sim 43$  extended sources

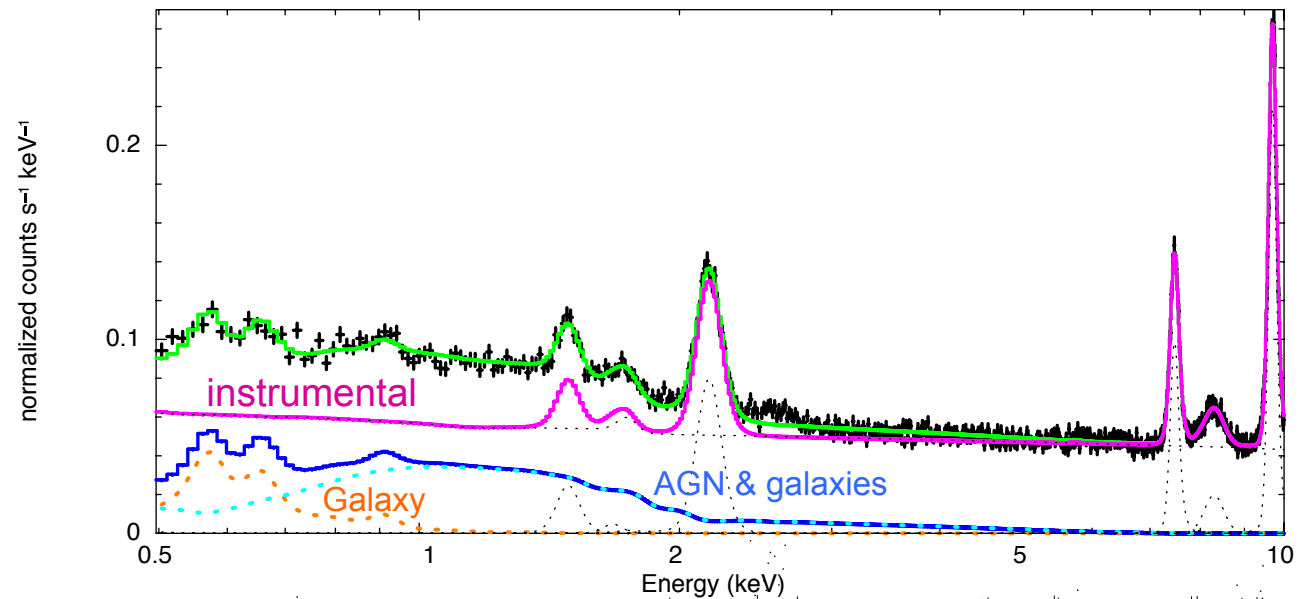
Murray et al., 2005

Kenter et al, 2006



# Unresolved CXB in XBOOTES

## Spectrum:



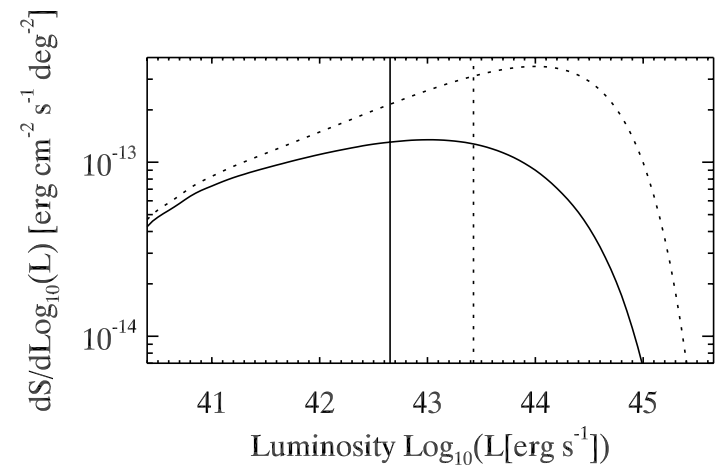
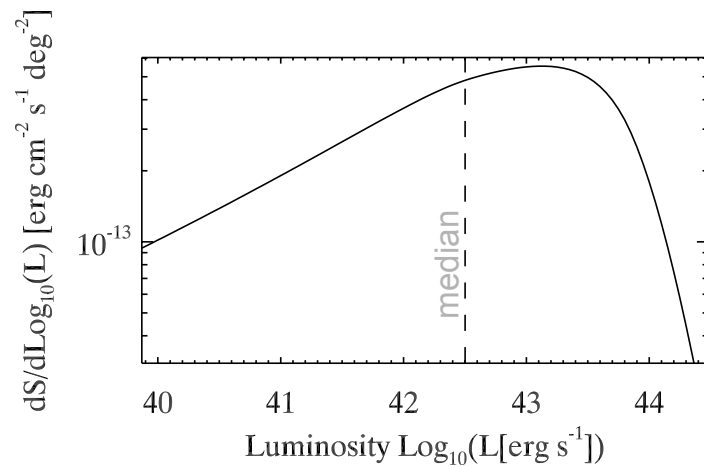
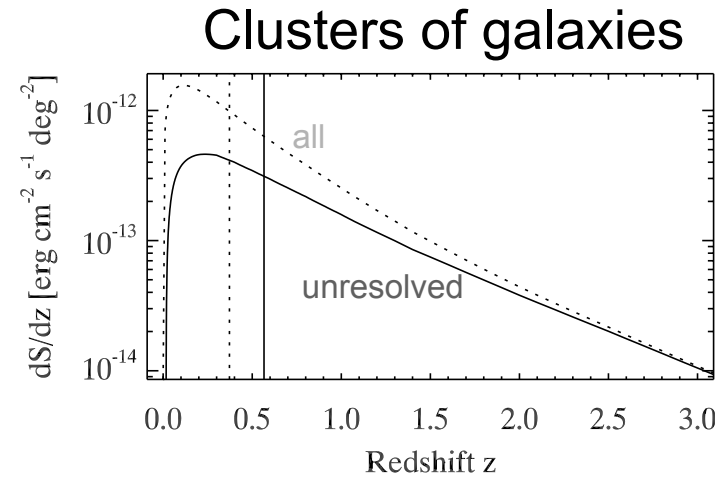
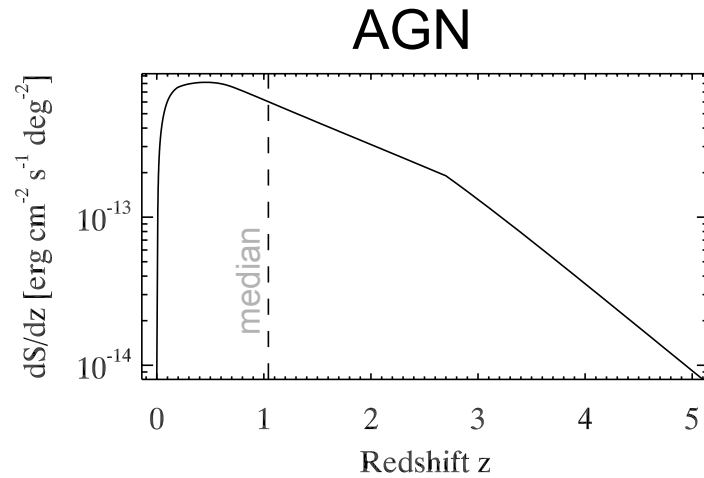
## Flux budget:

based on:

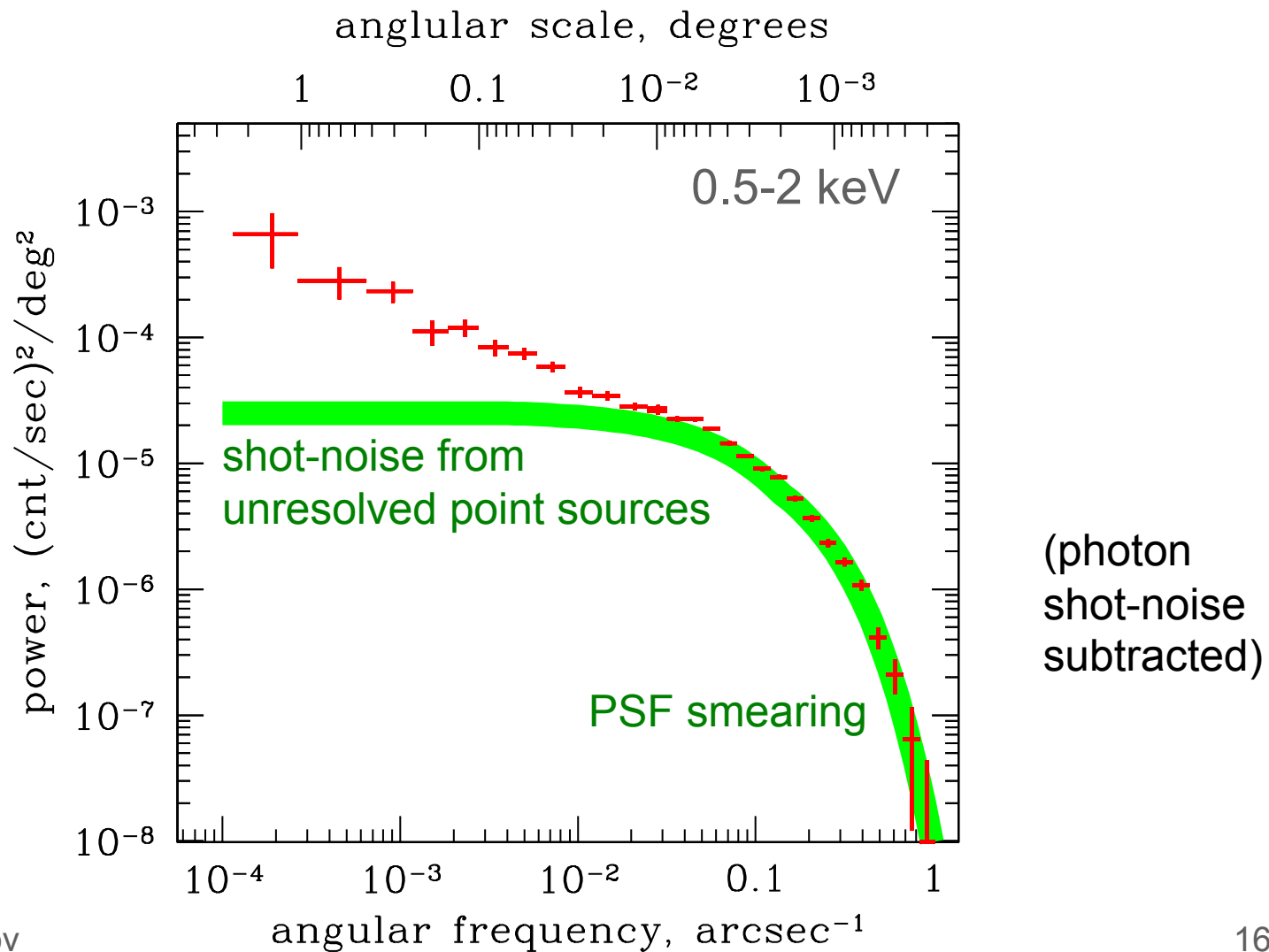
logN-logS of Lehmer+ 2012  
and Finoguenov+ 2007, 2015  
and XLF of Ebeling+ 1997

	flux 0.5-2 keV	CXB fraction
AGN	1.5	33%
galaxies	1.4	29%
clusters	0.7	15%
<b>Total</b>	<b>3.6</b>	<b>77%</b>

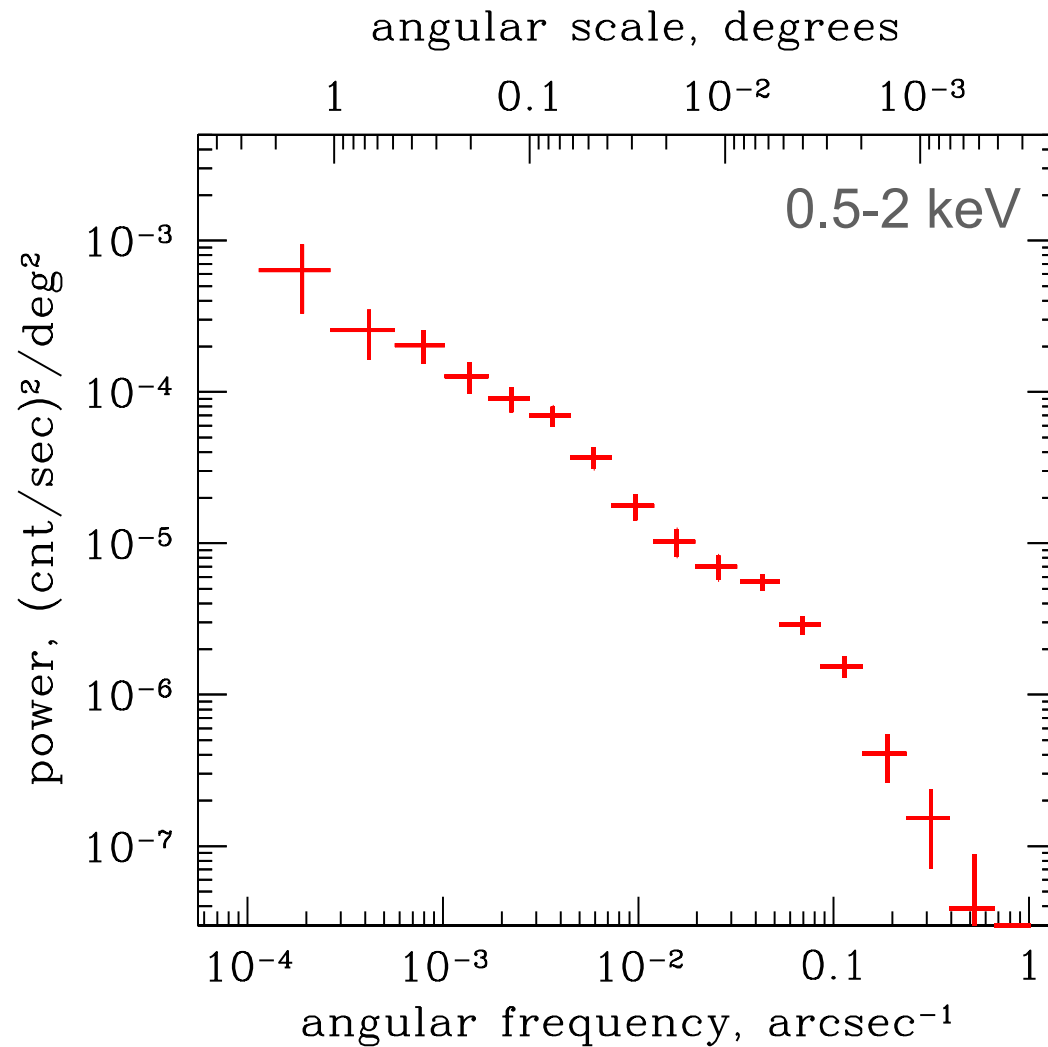
# Redshift and $L_x$ distributions of unresolved AGN and clusters of galaxies



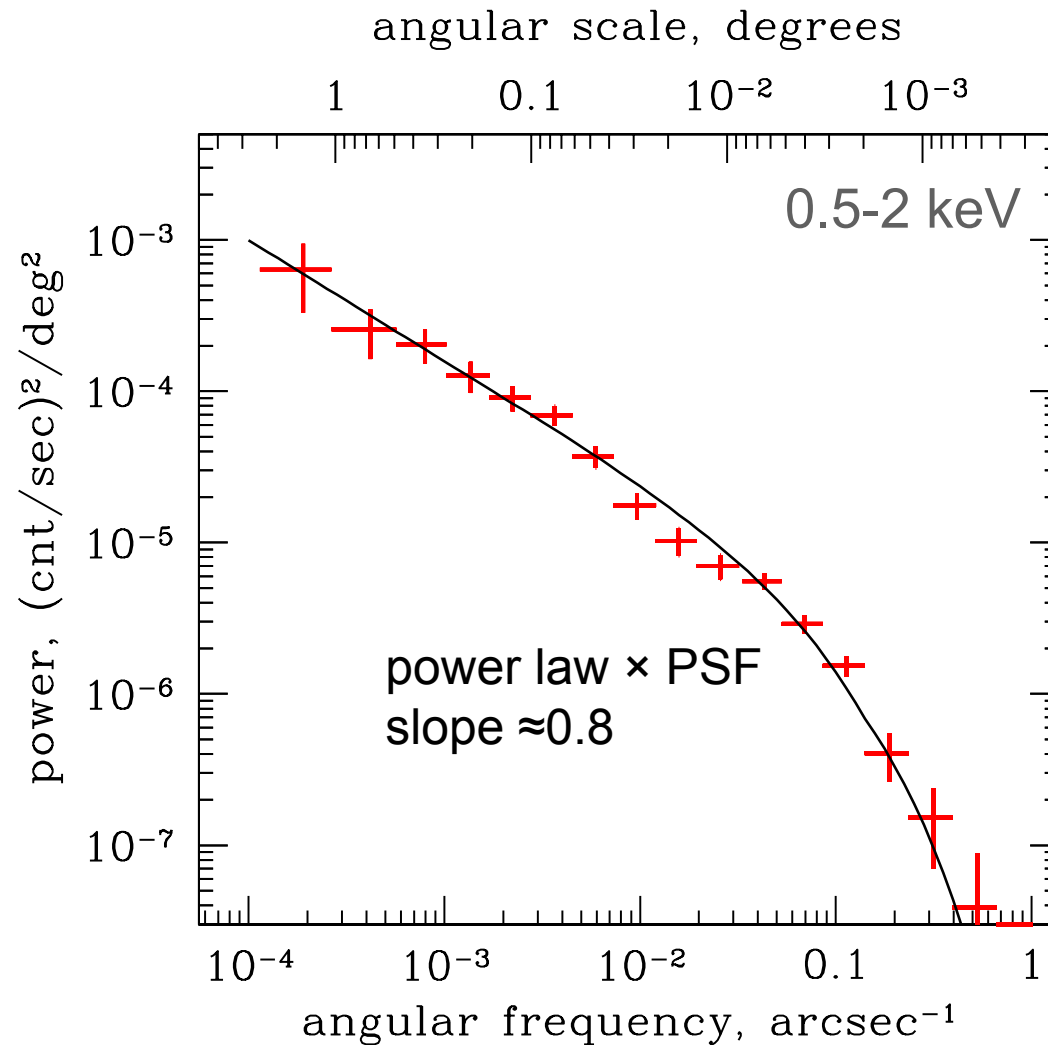
# Power spectrum of fluctuations of unresolved CXB



# ...shot noise of unresolved point sources subtracted

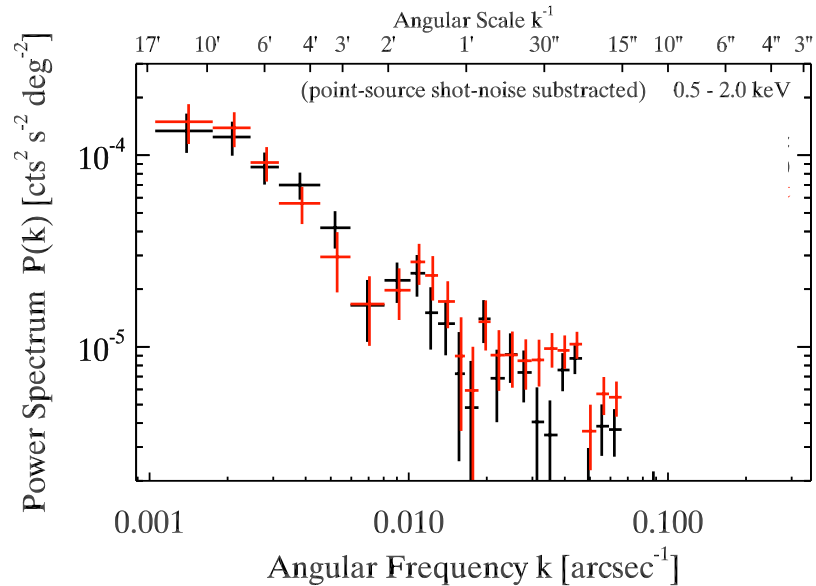
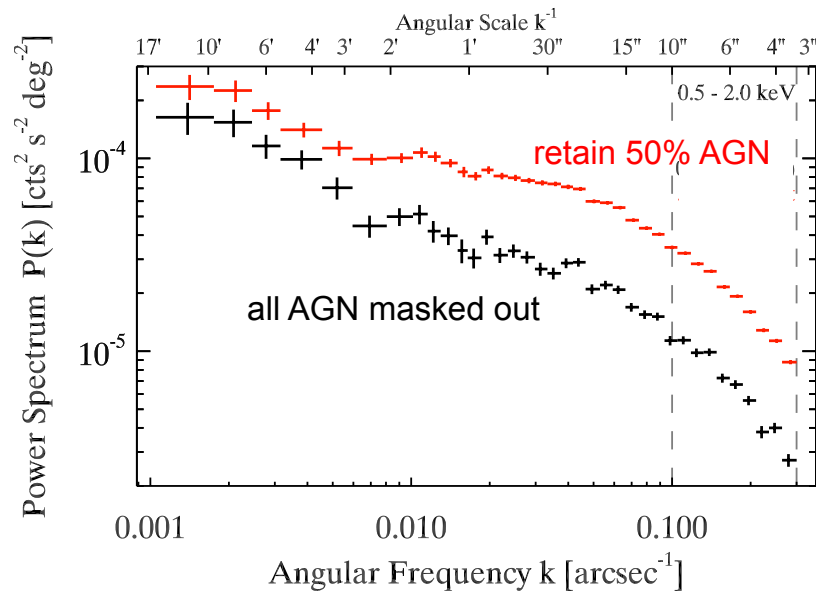


# ...shot noise of unresolved point sources subtracted



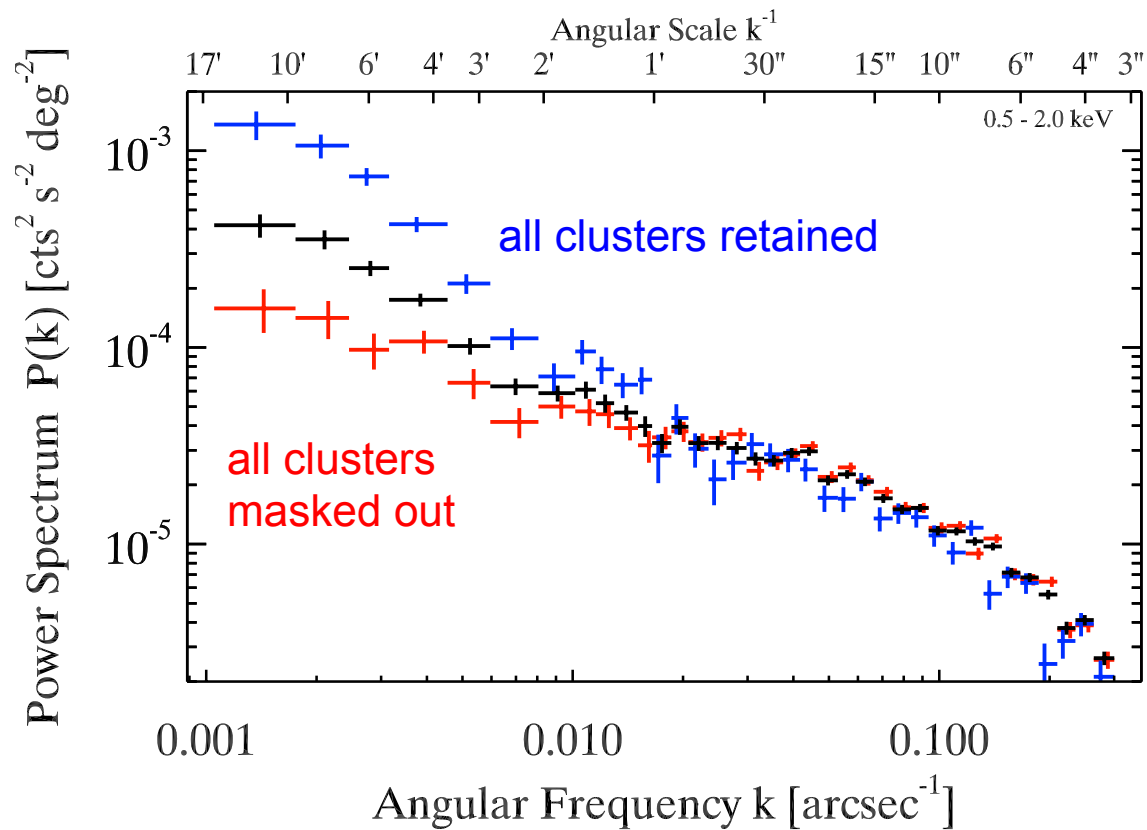


# Search for a similar signal in resolved sources: Retain AGN



shot-noise of unresolved  
sources subtracted

# Search for a similar signal in resolved sources: Retain clusters of galaxies



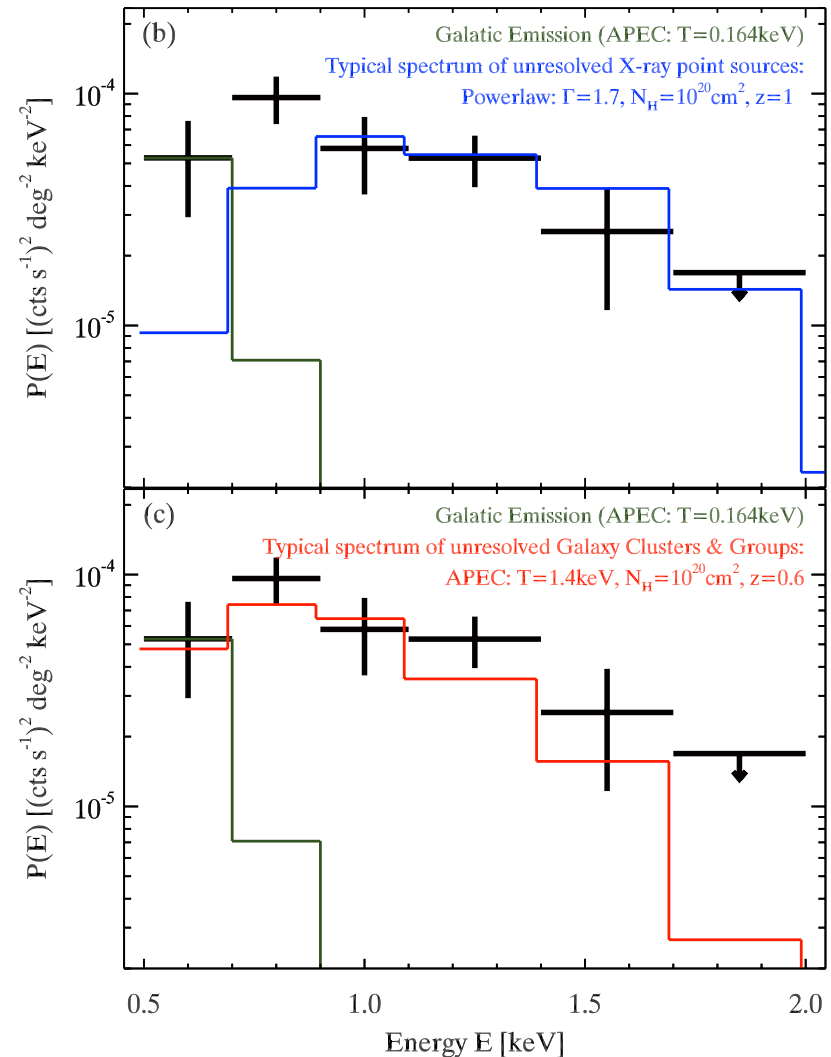
**(most of) the observed  
correlation signal appears  
to be caused by clusters of  
galaxies**

# Energy spectrum of fluctuations

The energy spectrum of CXB fluctuations is

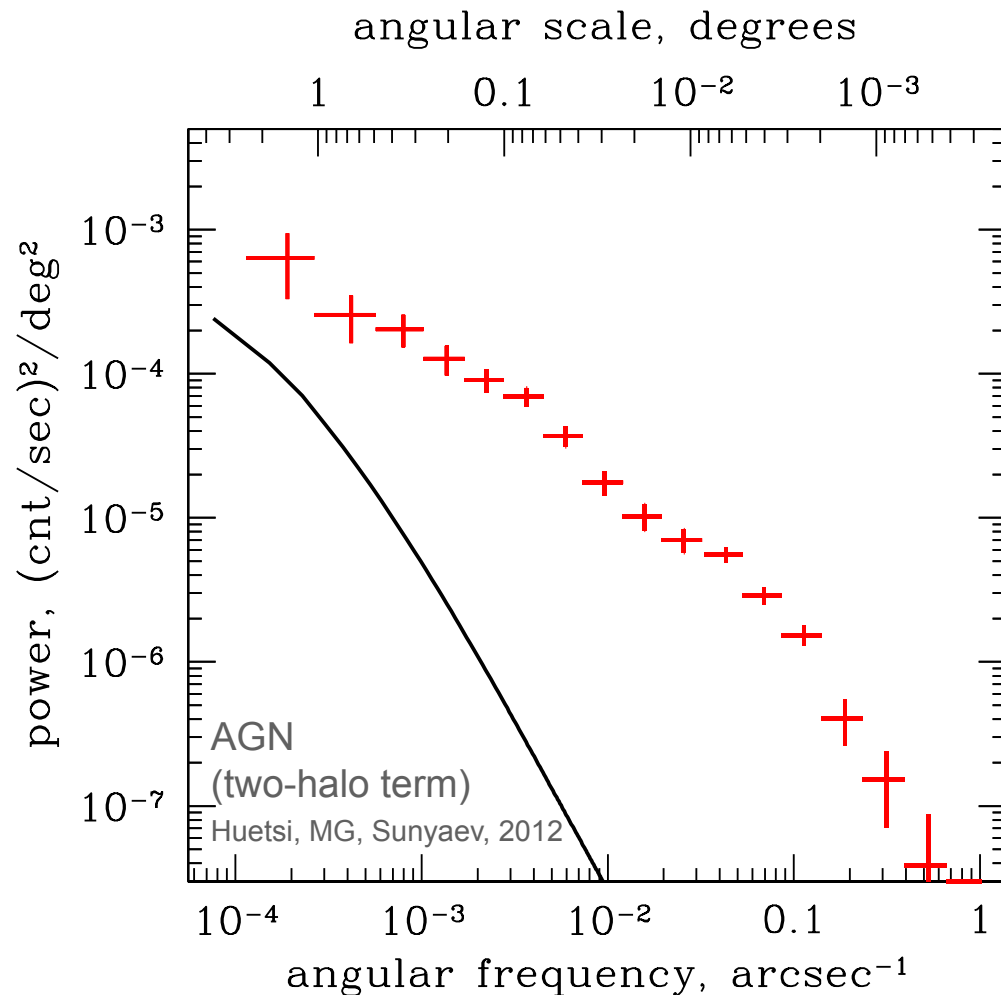
- inconsistent with the spectrum of AGN and normal galaxies
- consistent with the spectrum expected from clusters of galaxies

✧ Contamination from the Local Bubble is not significant.



# Comparison with LSS theories

## AGN



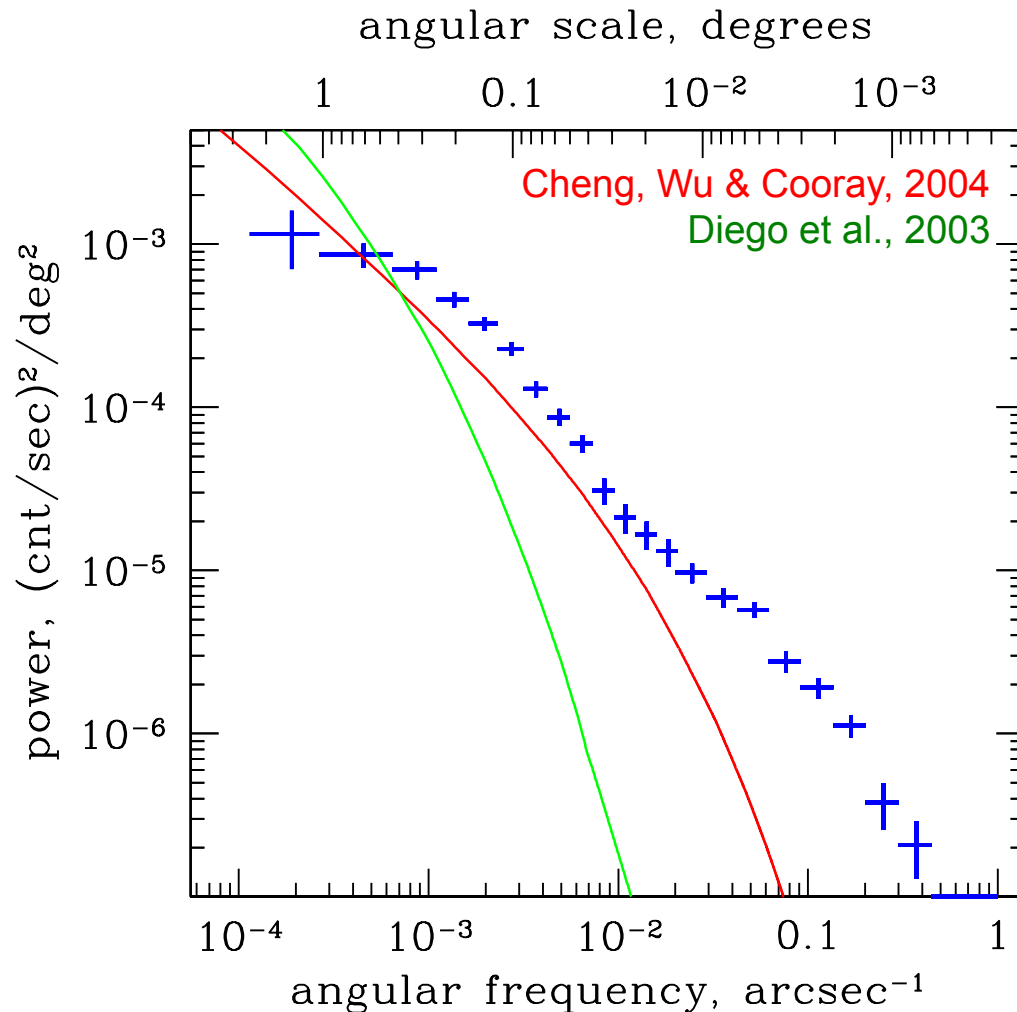
AGN two-halo term is by far insufficient to explain the observed signal

in agreement with experimental result!

shot-noise of unresolved AGN subtracted

# Comparison with LSS theories

## Clusters of galaxies



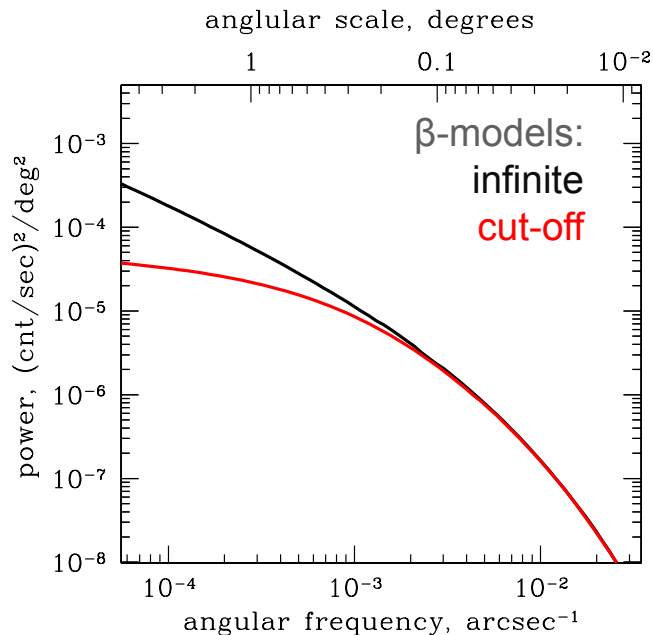
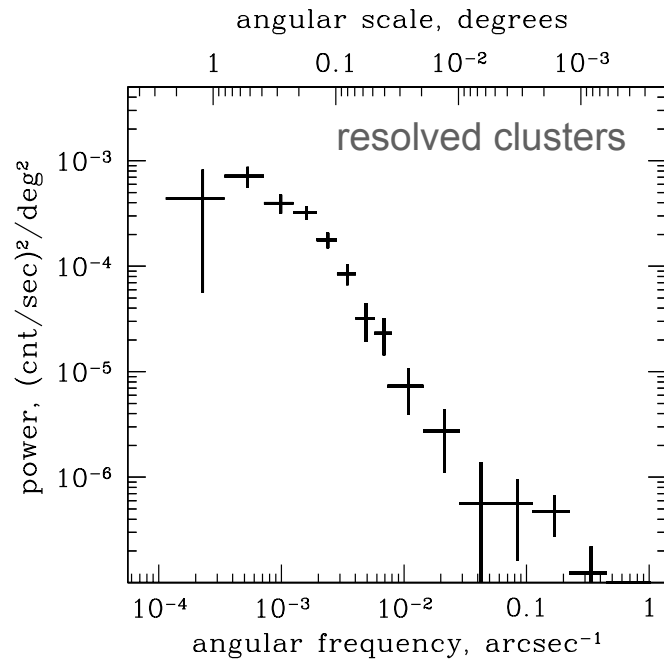
models – one halo term of clusters of galaxies (two-halo term insignificant)

models are inadequate or an additional signal is present in the data

resolved clusters of galaxies retained on the image

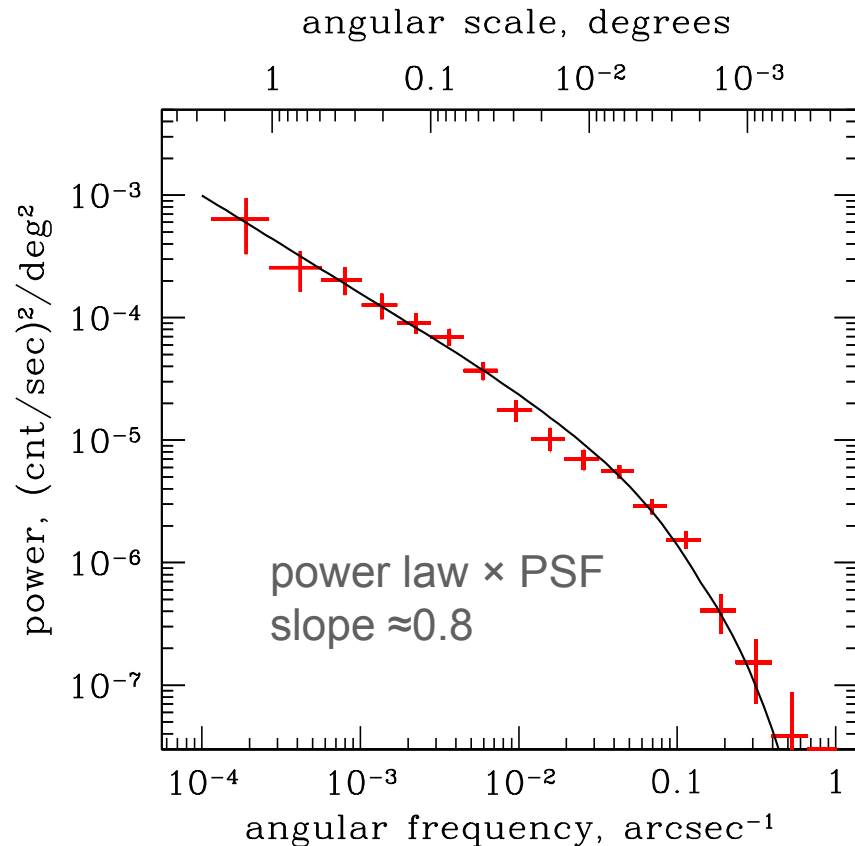
shot-noise of unresolved AGN subtracted

# Resolved clusters



- ✧ low frequency break at  $\sim 10$  arcmin
- ✧ power spectrum of a  $\beta$ -model is  $\sim e^{-a \cdot k}$  – does not have a low frequency break
- ✧ the break appears if there is a cut-off in the  $\beta$ -model density distribution at large radius
- ✧ the break characterizes properties of IGM at the  $\sim$ virial radius
- ✧ a tool to study IGM at large radii

# Fluctuations of unresolved CXB



- ✧ unresolved groups and clusters of galaxies in Xbootes:

$$\langle z \rangle \sim 0.2$$

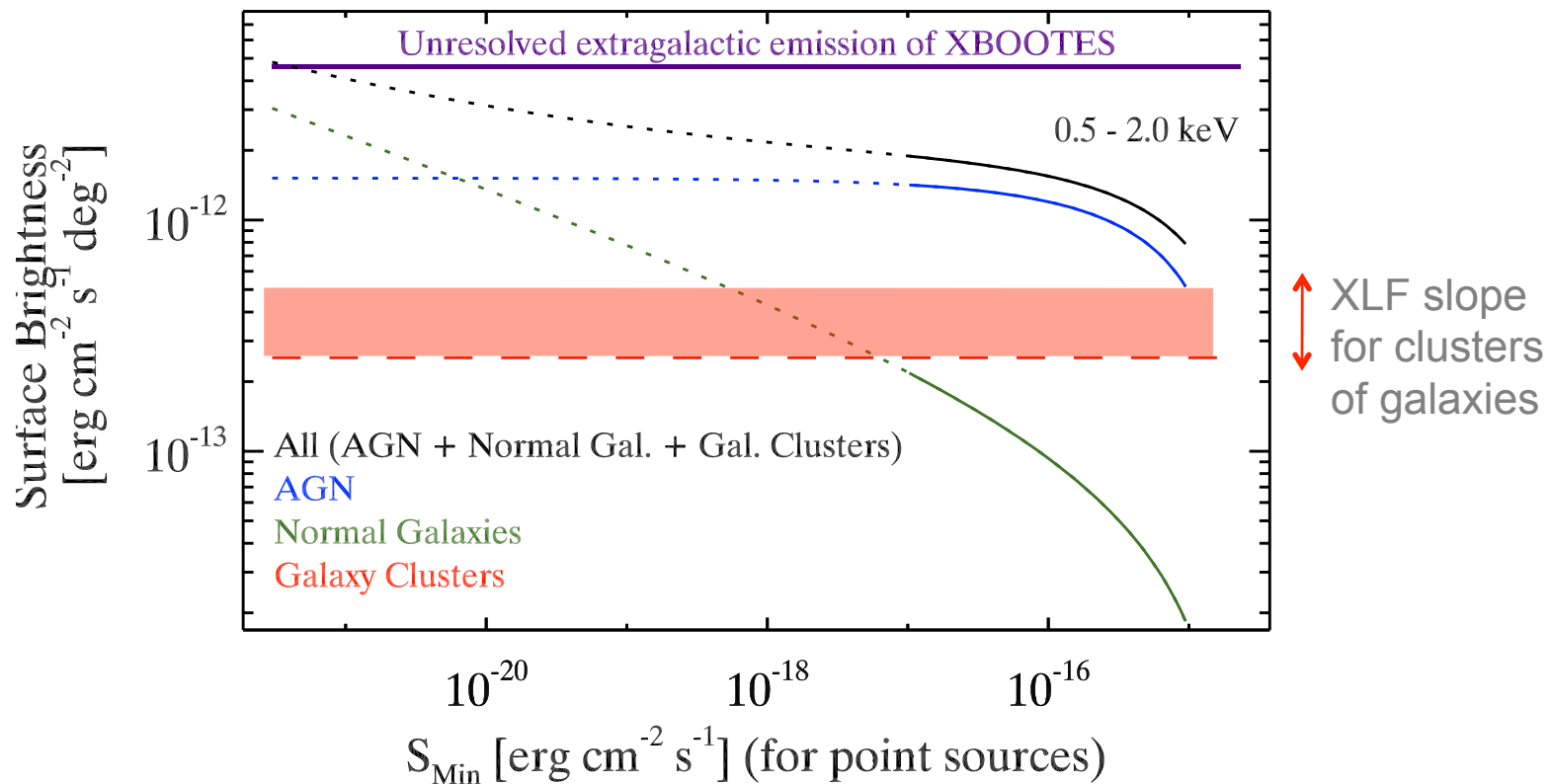
$$\langle M_{500} \rangle \sim 10^{13.5} M_{Sun}$$

- ✧ at  $z \sim 0.2$ , angular scales of  $0.1^\circ - 1^\circ$  correspond to  $\sim 1-10$  Mpc
- ✧ outskirts of clusters and groups of galaxies, IGM
- ✧ shape of PS - spatial structure of IGM  $\otimes$  redshift distribution
- ✧ normalization is proportional to the square of their volume density



*The End*

# Uncertainties in the flux budget of unresolved CXB



low limit for  $\log(N)$ - $\log(S)$  integration (AGN & galaxies)

