



# Deep X-ray Spectroscopy of obscured AGN in the Chandra Deep Field South

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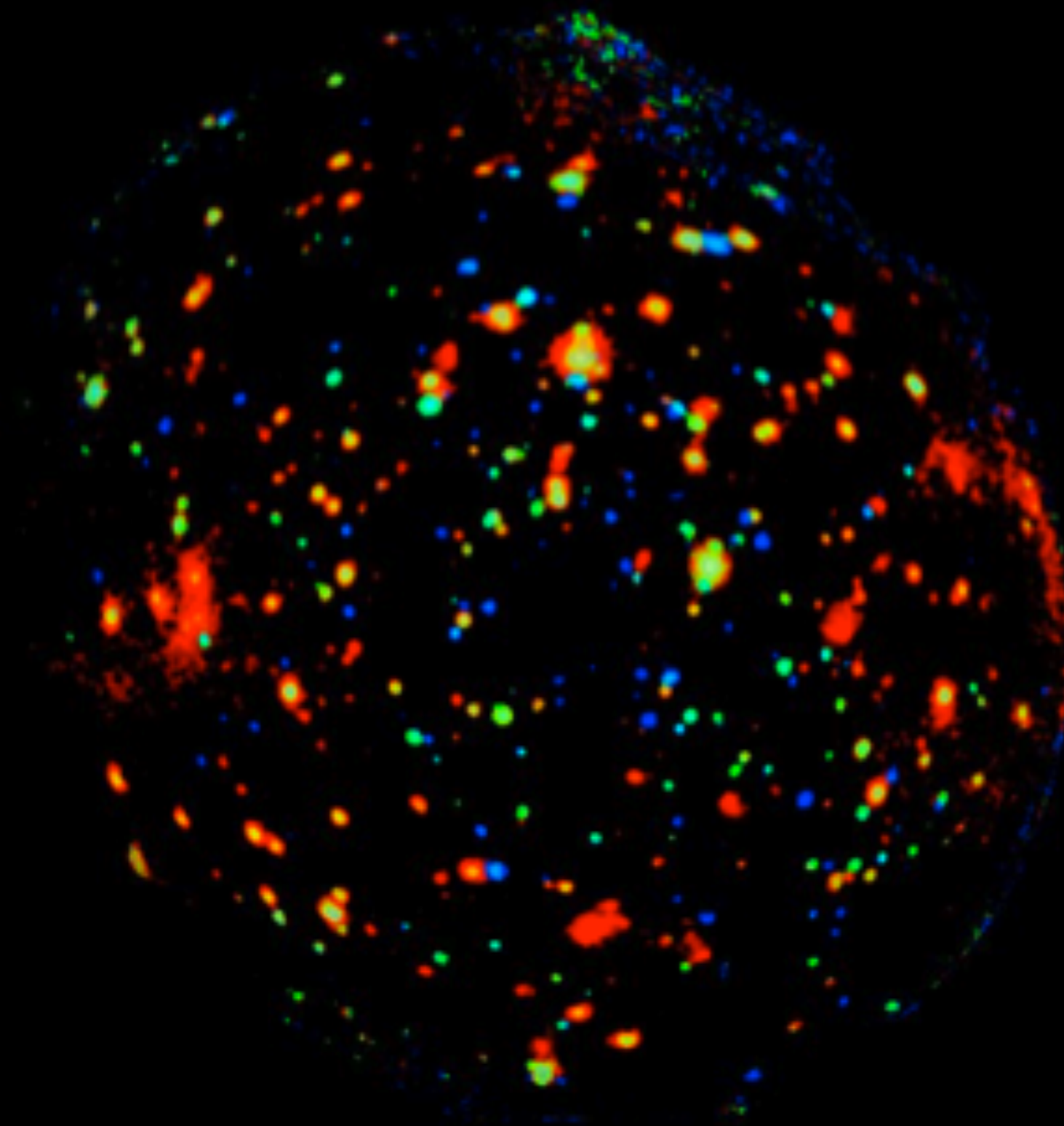
Kazushi Iwasawa

P.Ranalli, C.Vignali, N.Cappelluti, R.Gilli, G. Lanzuisi, F.J. Carrera, M. Brusa, F. Vito, I. Georgantopoulos, E.Rovilos, F.Fiore, F.Civano, W.N. Brandt, P.Tozzi, X.Barcons, S.Puccetti, S.Falocco, M. Paolillo, N.Castello-Mor, ...



# ~3 Ms XMM image of the Chandra Deep Field South

~0.3 deg<sup>2</sup>



## Goals:

Resolve the XRB in  
the 5-10 keV band

Fine spectroscopy  
of distant heavily  
obscured AGN

red = 0.4 - 1 keV  
green = 1 - 2 keV  
blue = 2 - 8 keV

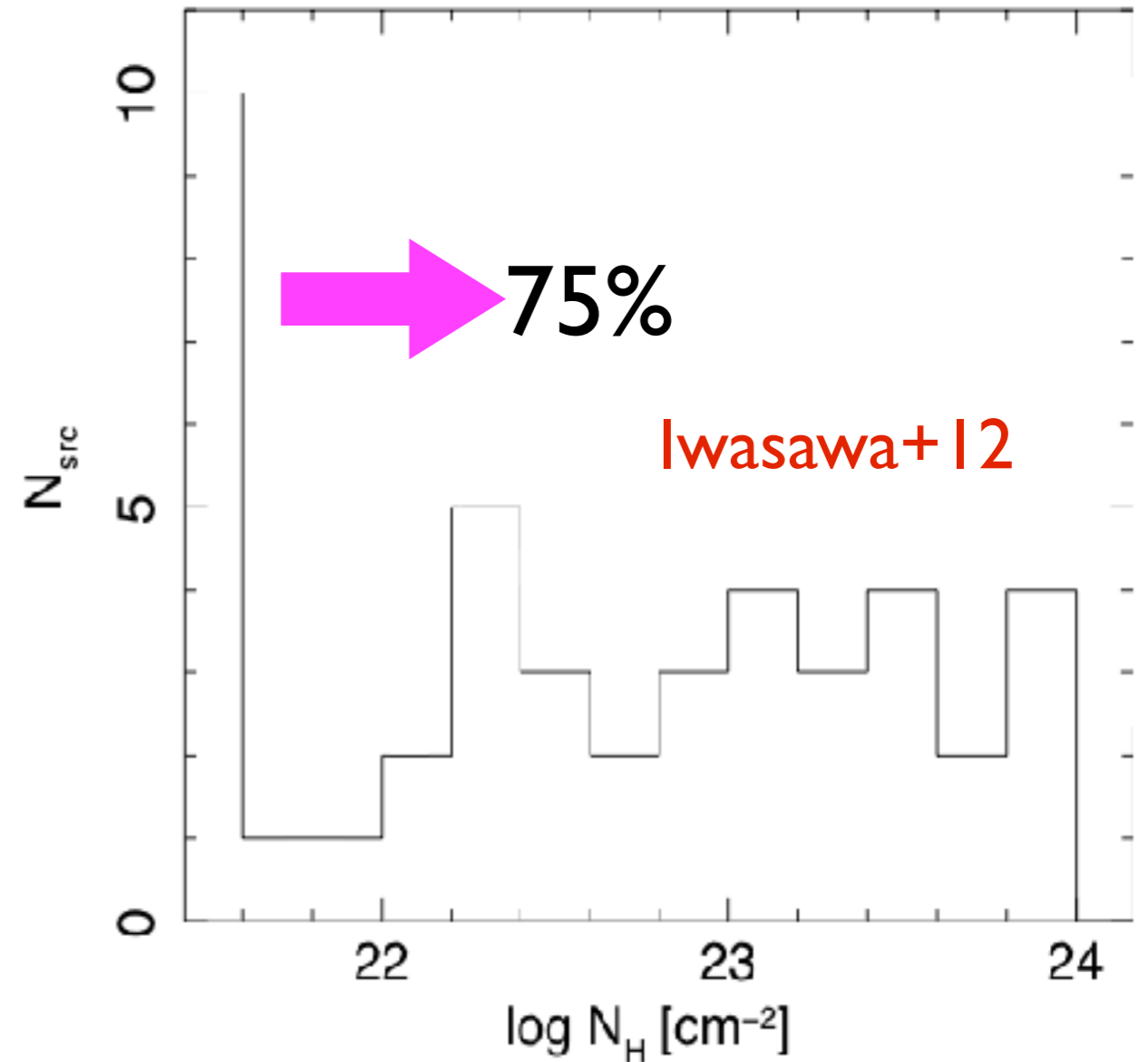
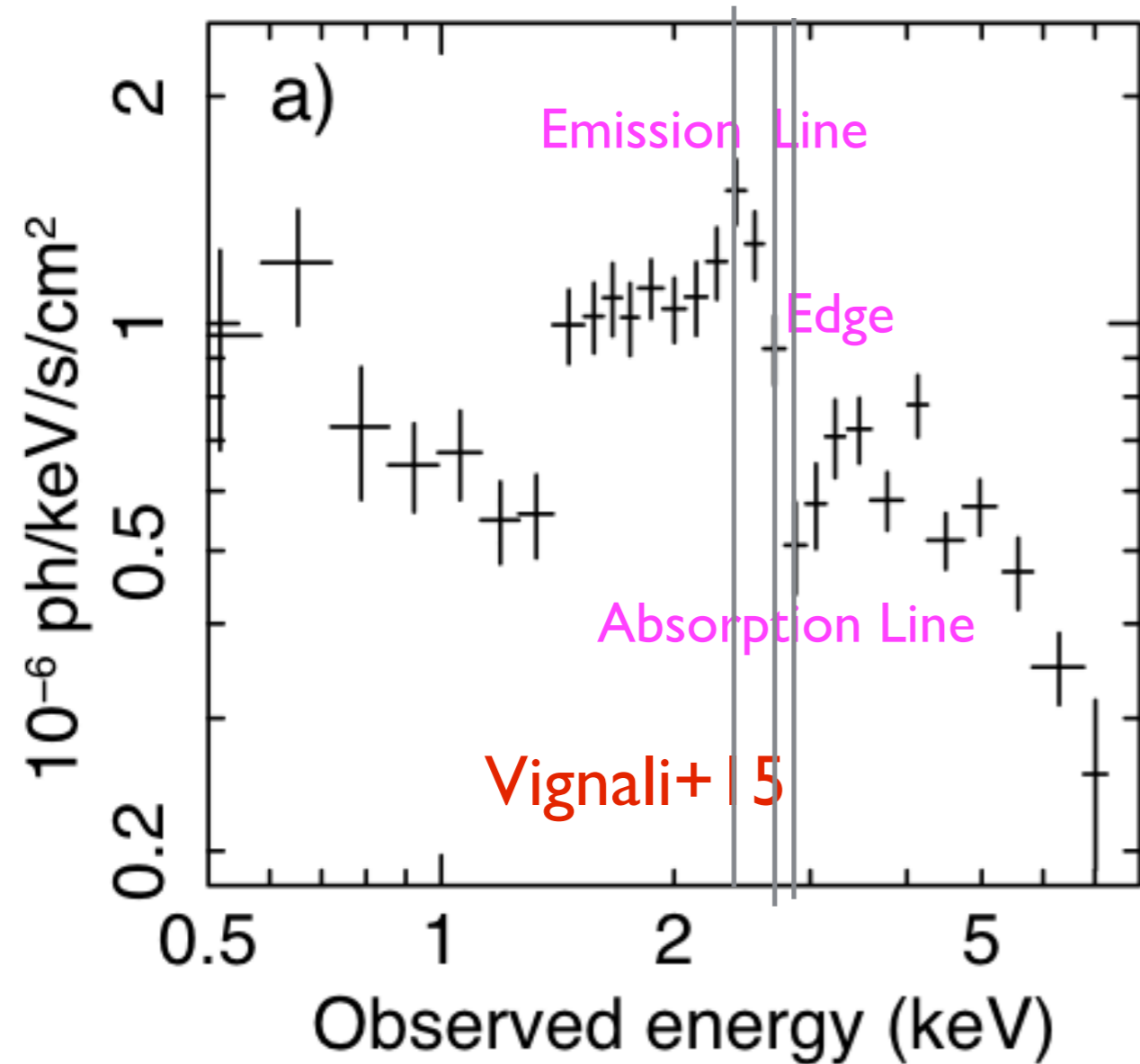
# Results & Credits

- Catalogues: **Ranalli+13 (X-ray); Antonucci+15 (Optical-monitor); Iwasawa+17 (Spectral)**
- Fine spectroscopy of obscured AGN at the redshift peak of AGN evolution  $z \sim 1-3$ : **AC+11, Iwasawa+12, Georgantopoulos+13, Falocco+13. Castello-Mor+13**
- Peculiar/interesting objects: **Vignali+15; Iwasawa+15; Corral+16**
- Groups/Clusters: **Finoguenov+15**
- 5-10 keV survey: **Fotopoulou+16**
- Variability: **Falocco+17**
- Iron Line properties: **Baronchelli+ in prep**

# Selected Results

PID 352 ~700 ksec

46 sources @  $z > 1.7$



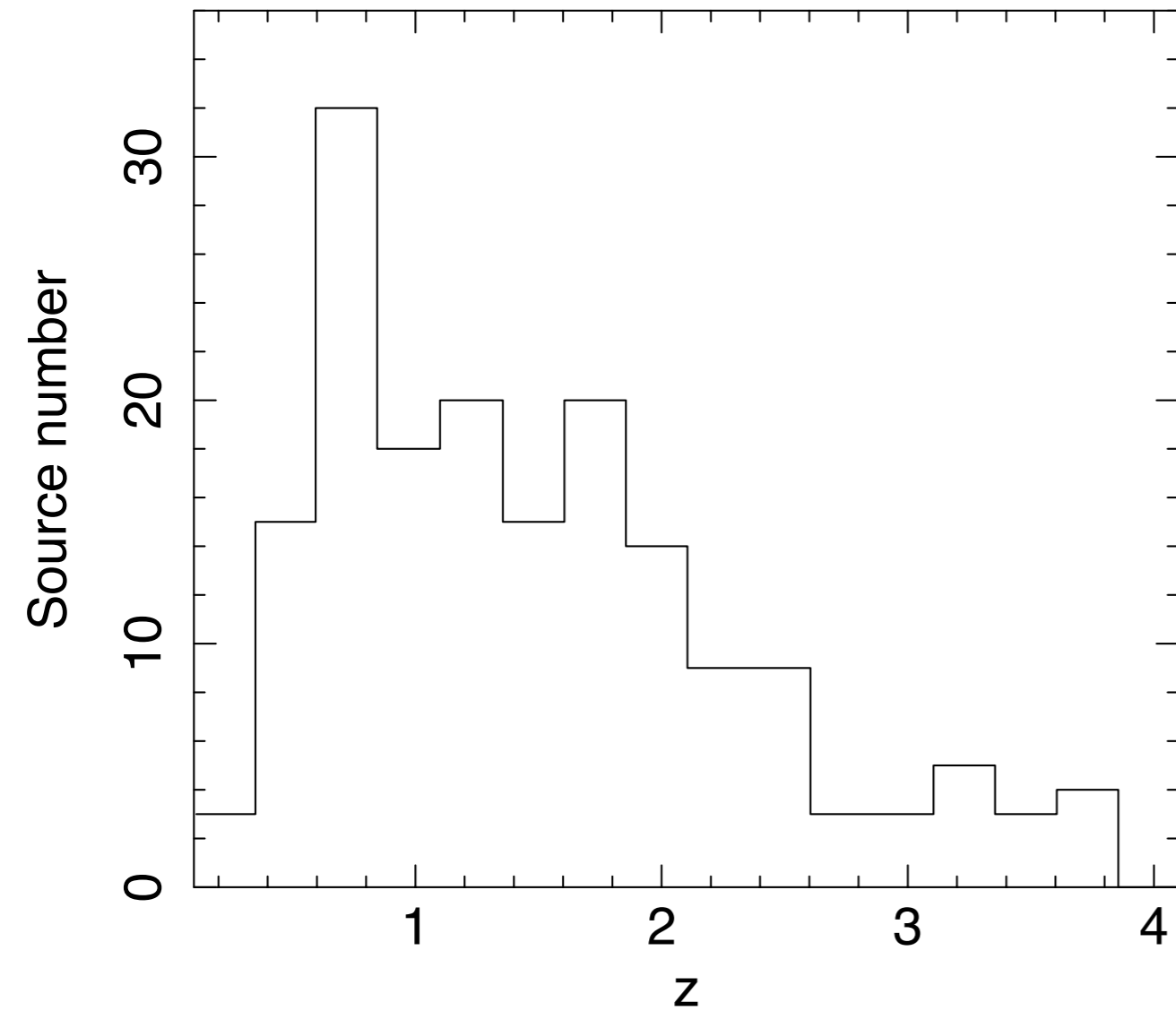
X-ray redshift from emission line + edge  $z \sim 1.6$   
Resonant FeXXV-XXVI absorption

$v_{\text{outflow}} \sim 0.14c$

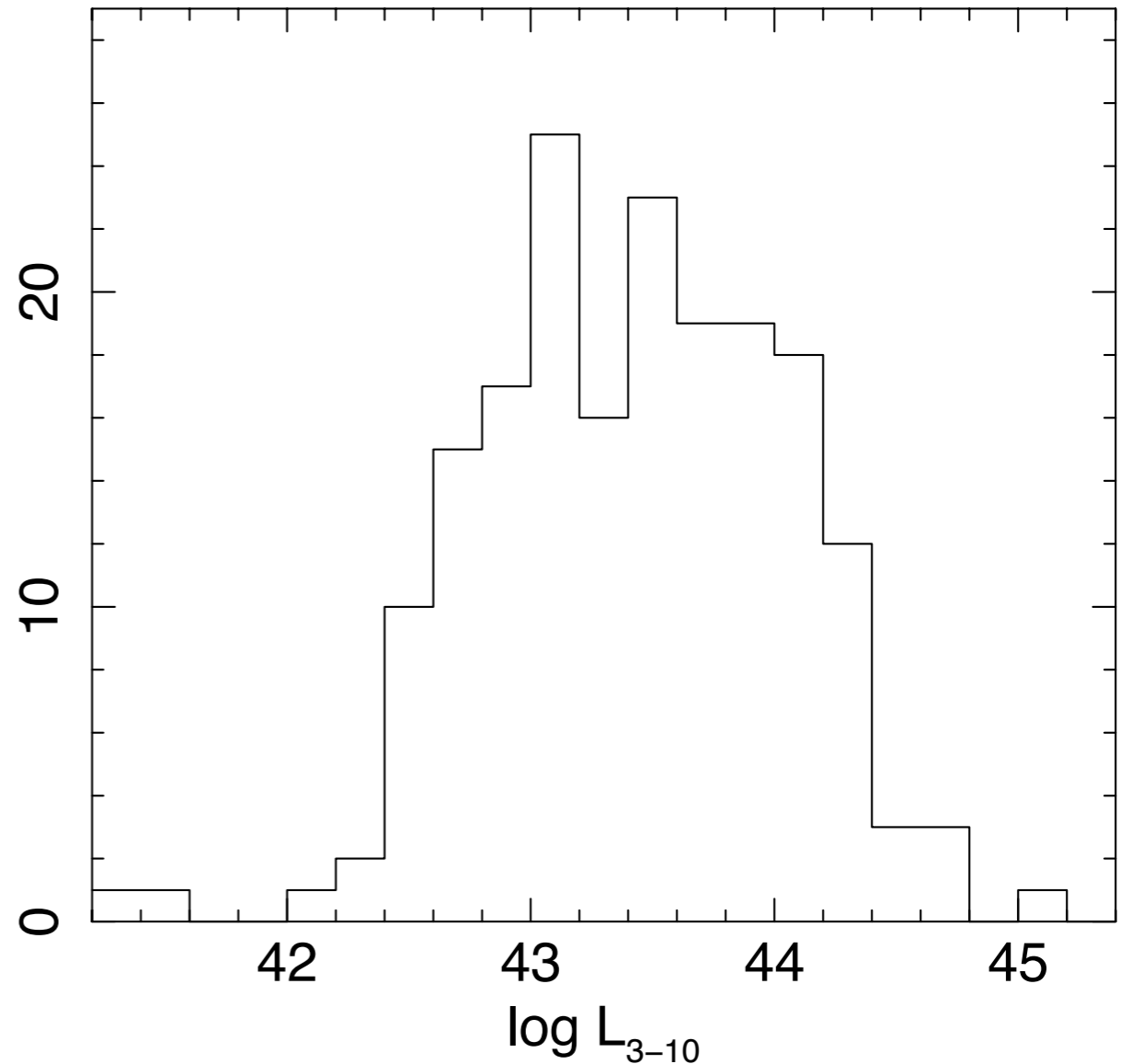
The obscured fraction increases toward high- $z$  for luminous ( $> 10^{44}$  erg s<sup>-1</sup>) AGN (cfr. ~20-30% at  $z \sim 0$  Burlon+11)

# Spectral Atlas

180 sources hard X-ray selected  $F(2-10 \text{ keV}) > 2 \times 10^{-15}$



$$\langle z \rangle \sim 1.22$$

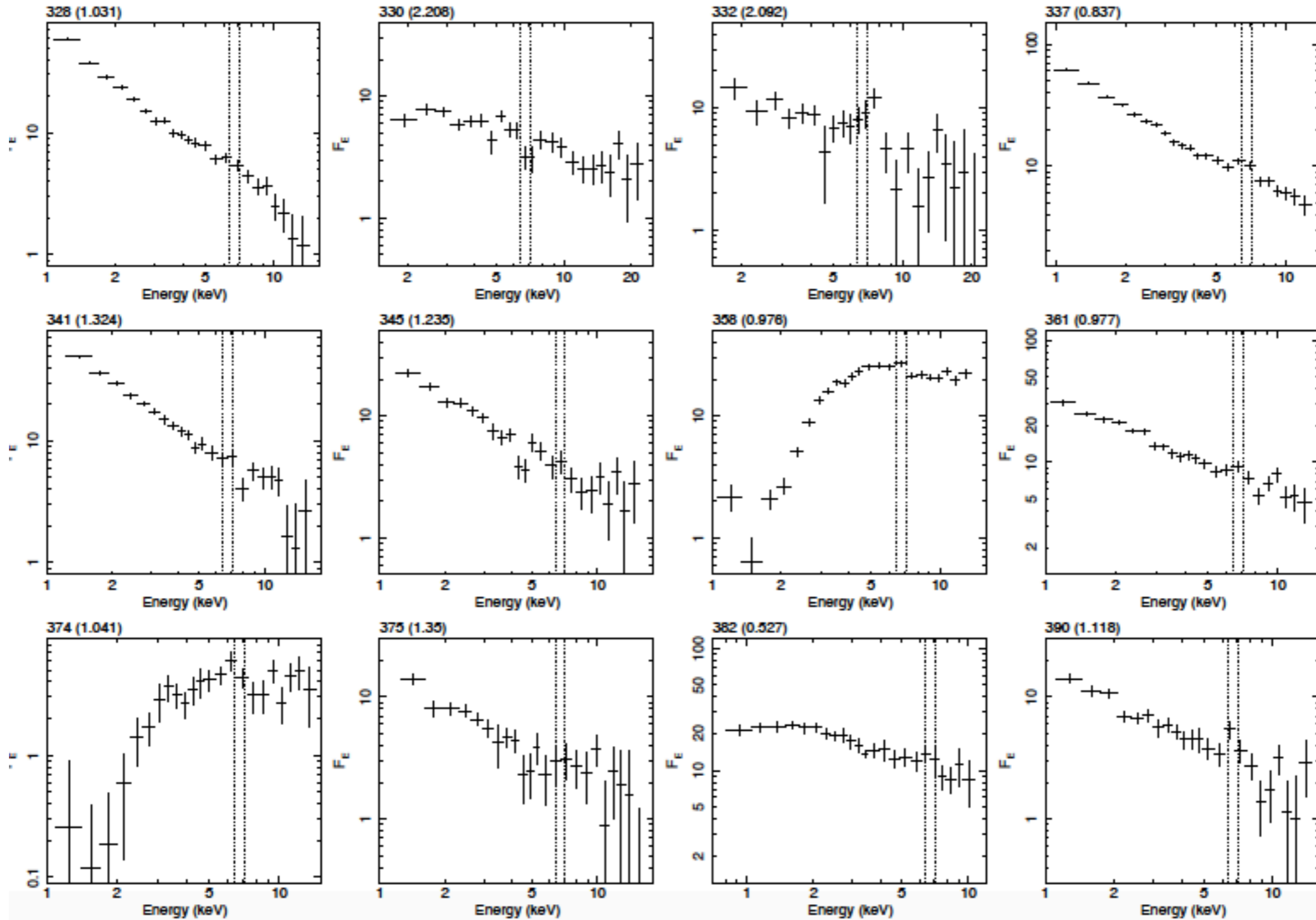


$$\langle \log L \rangle \sim 43.6$$

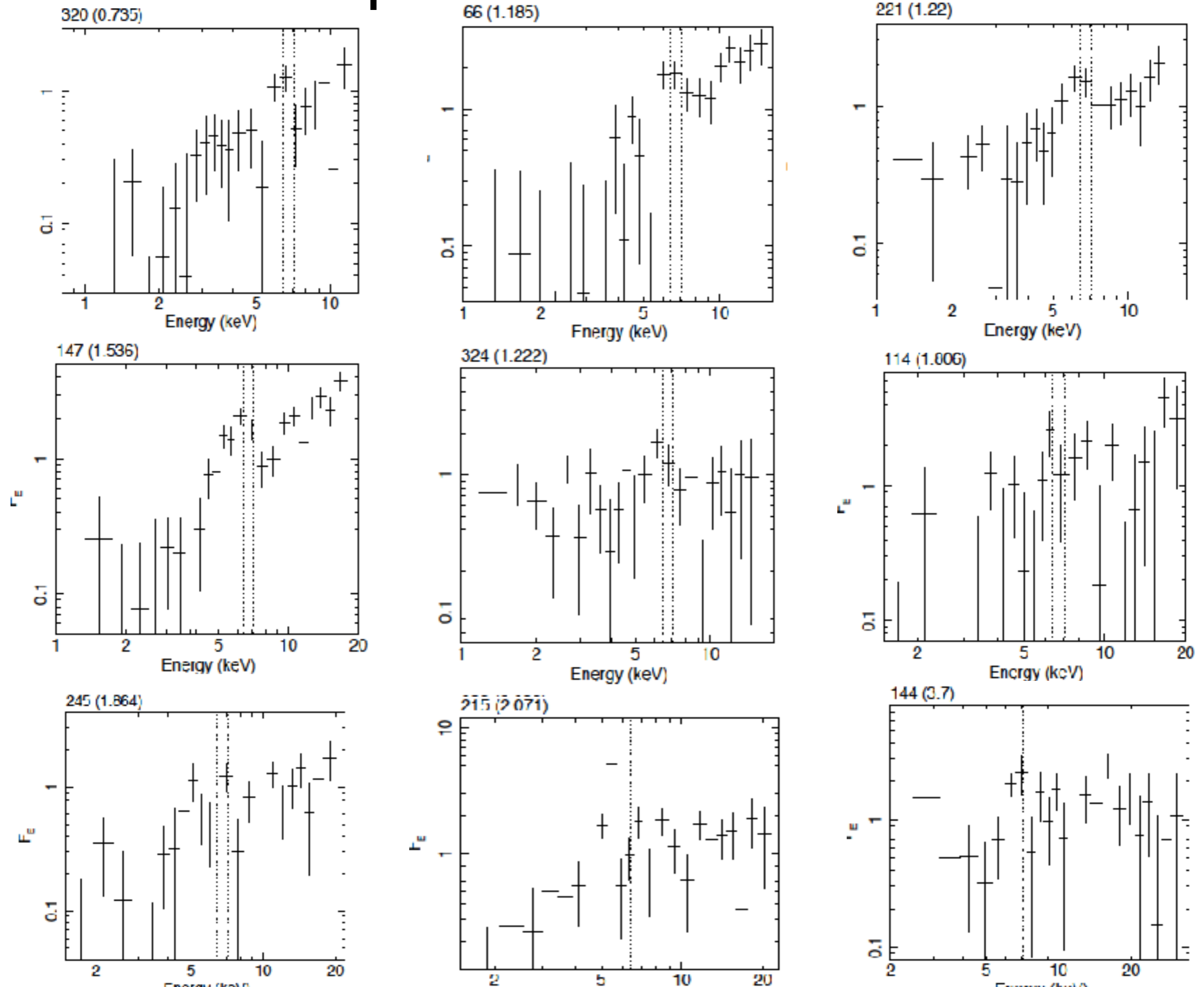
Redshifts and luminosities responsible of the bulk of the XRB  
... not the energy range

# Spectral Atlas

Rest frame spectra with widely different spectral quality



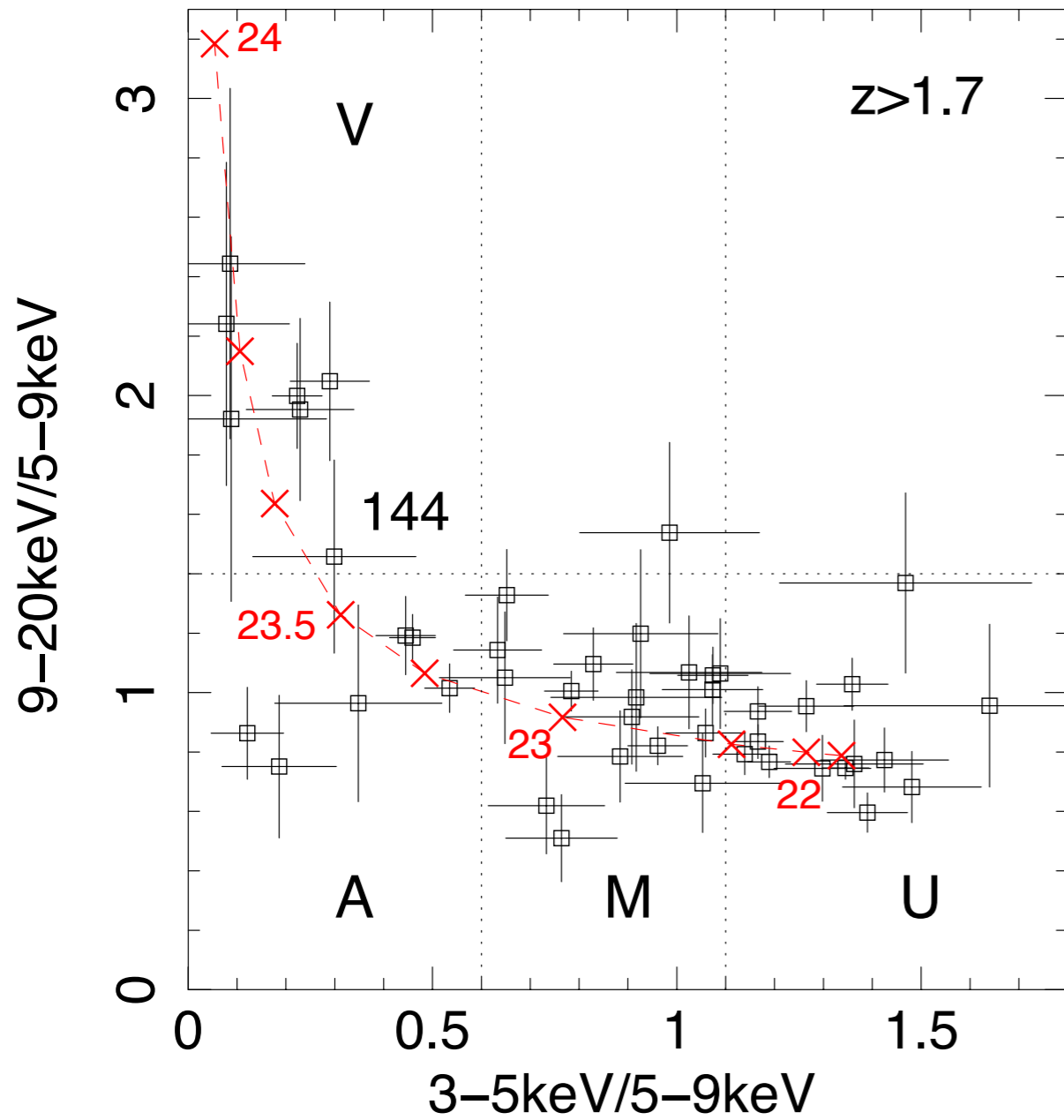
# Compton thick candidates



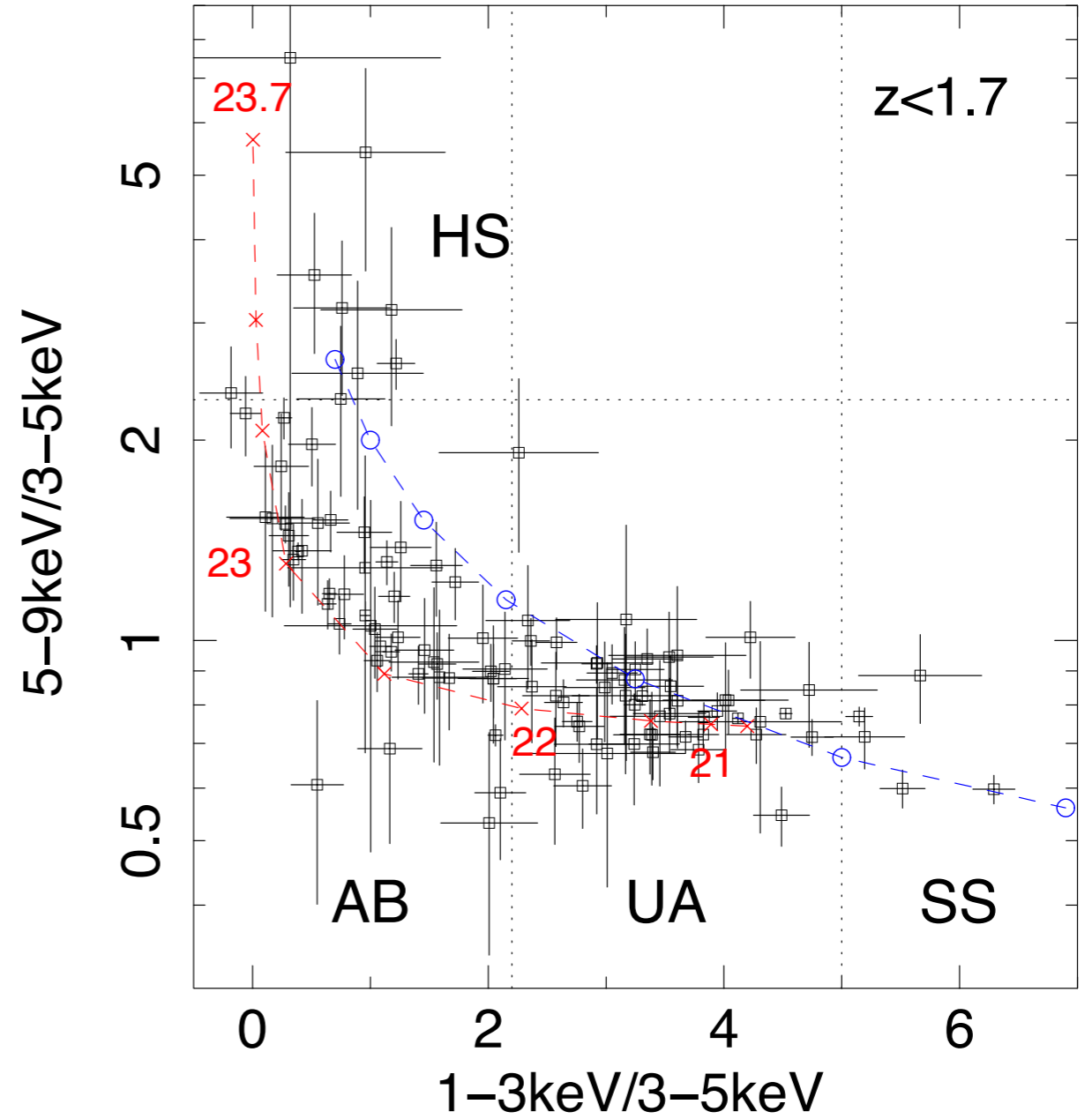


# X-ray Colors

Rest frame bands

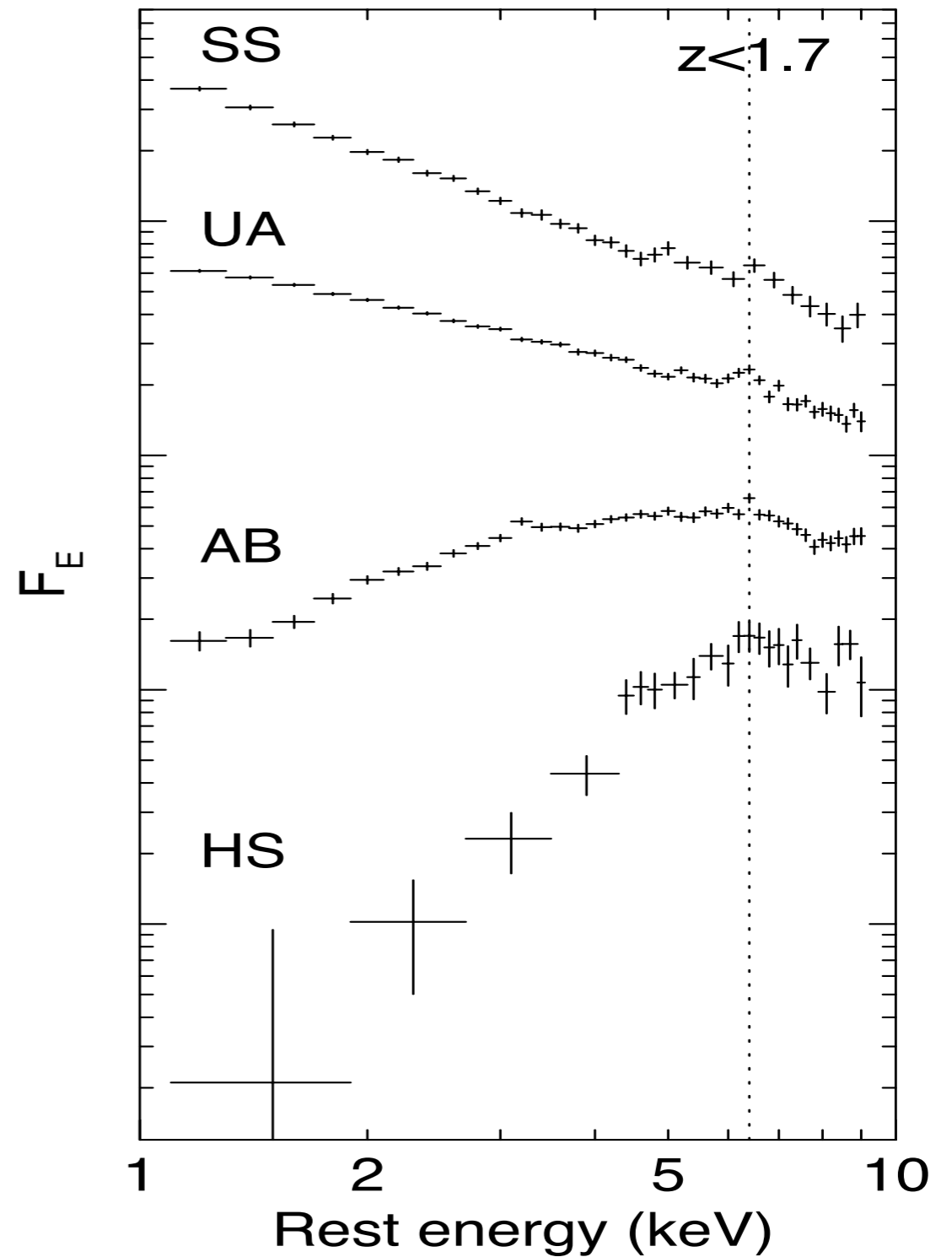
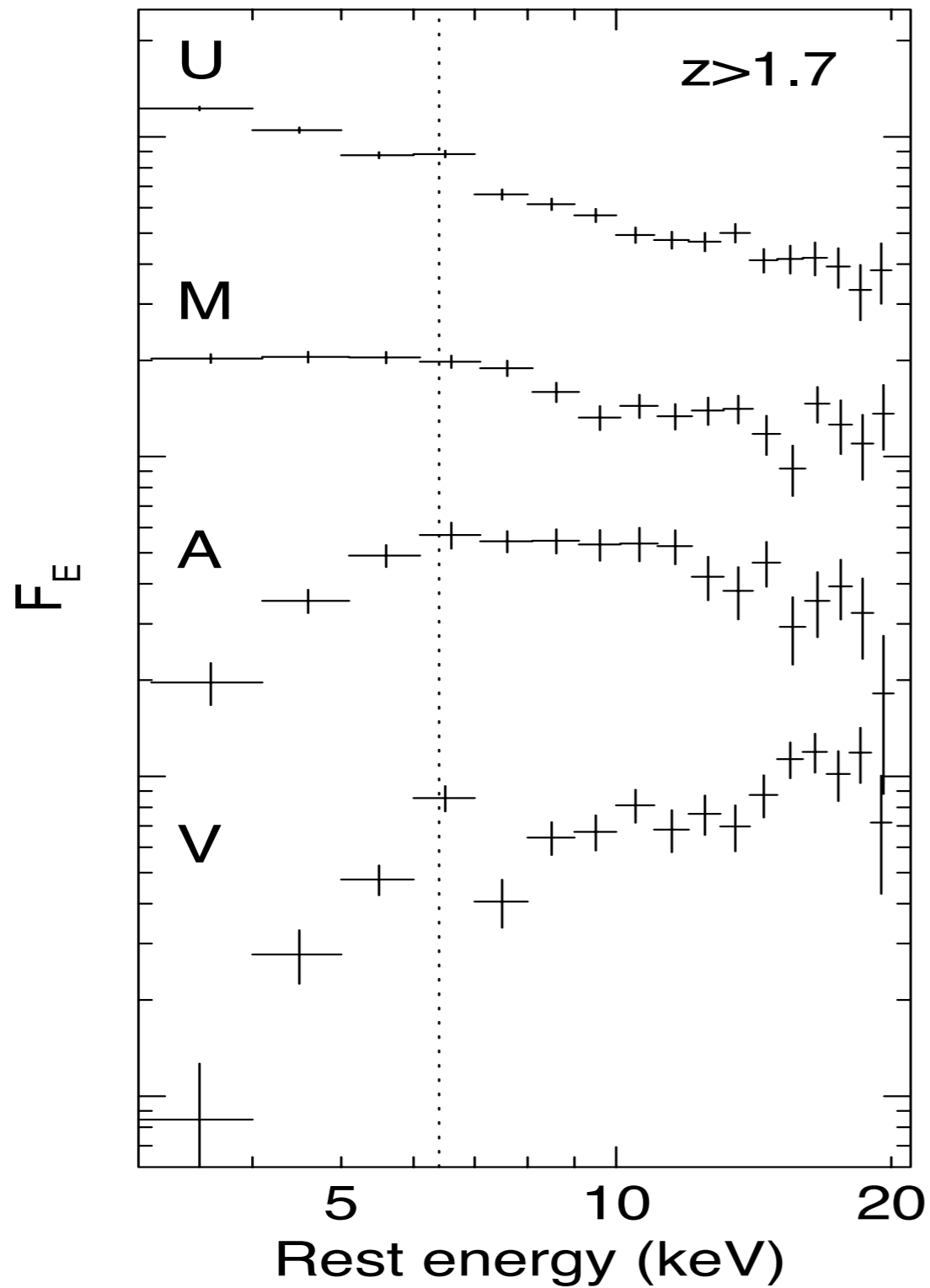


7,6,19,14

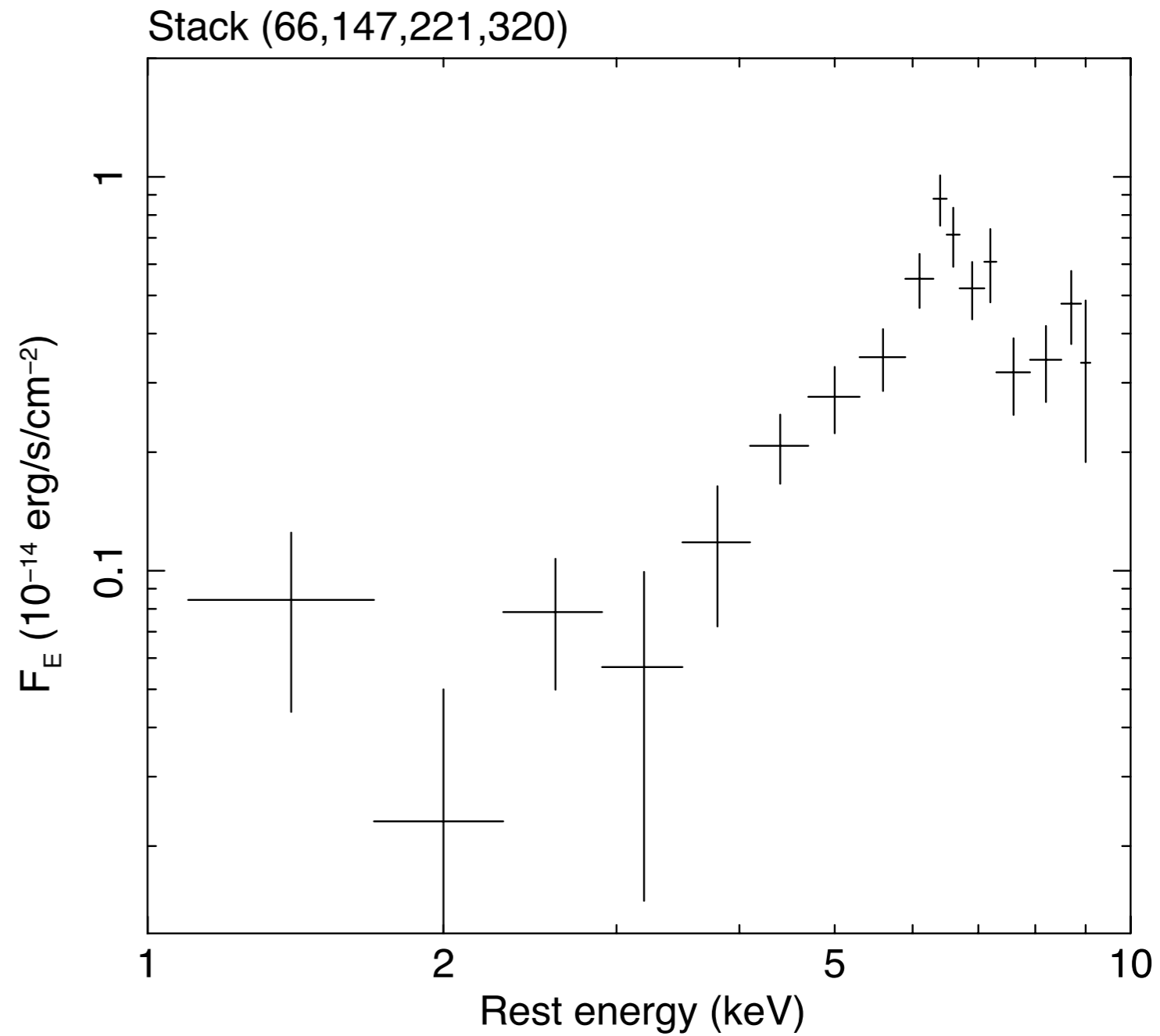
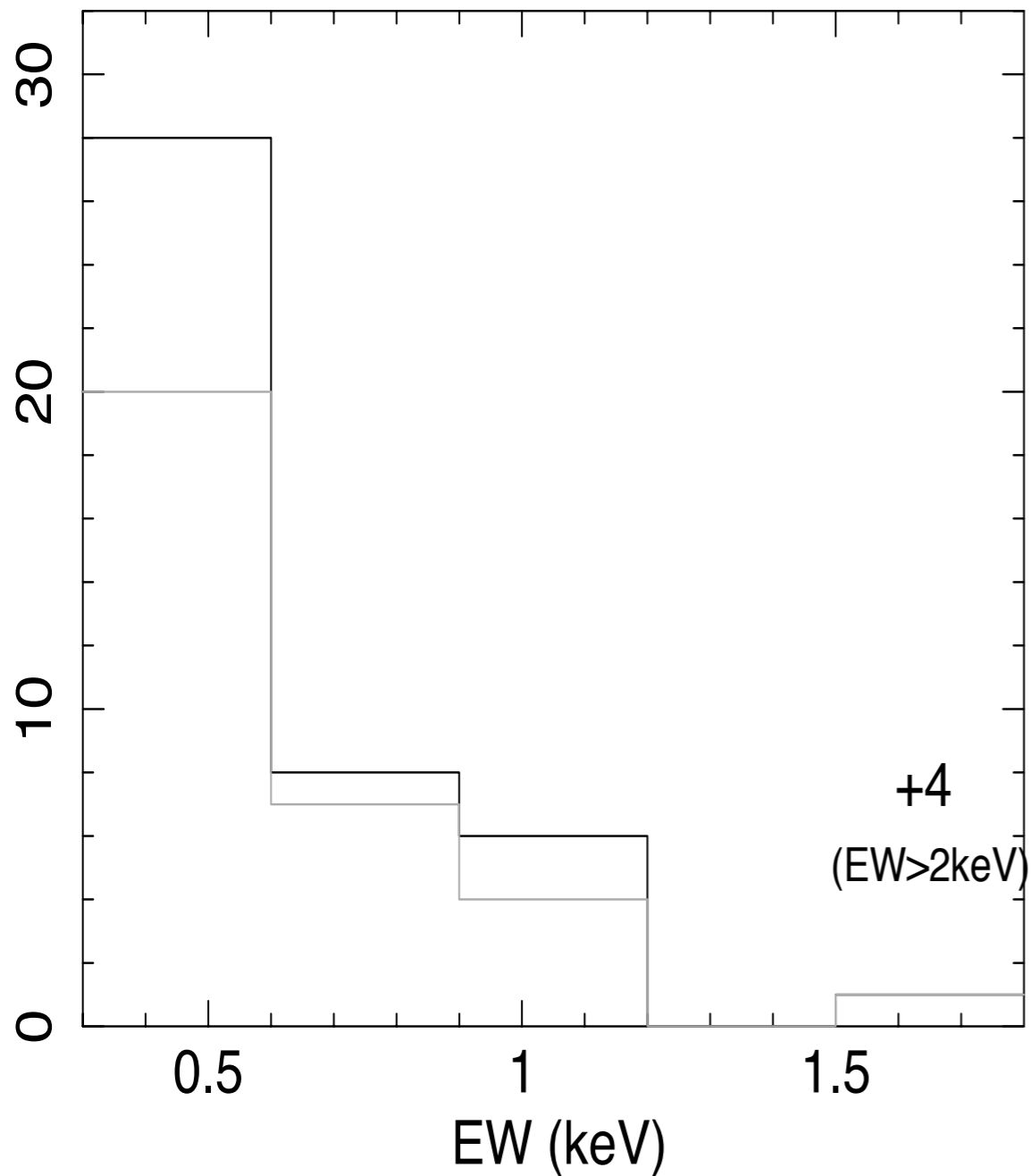


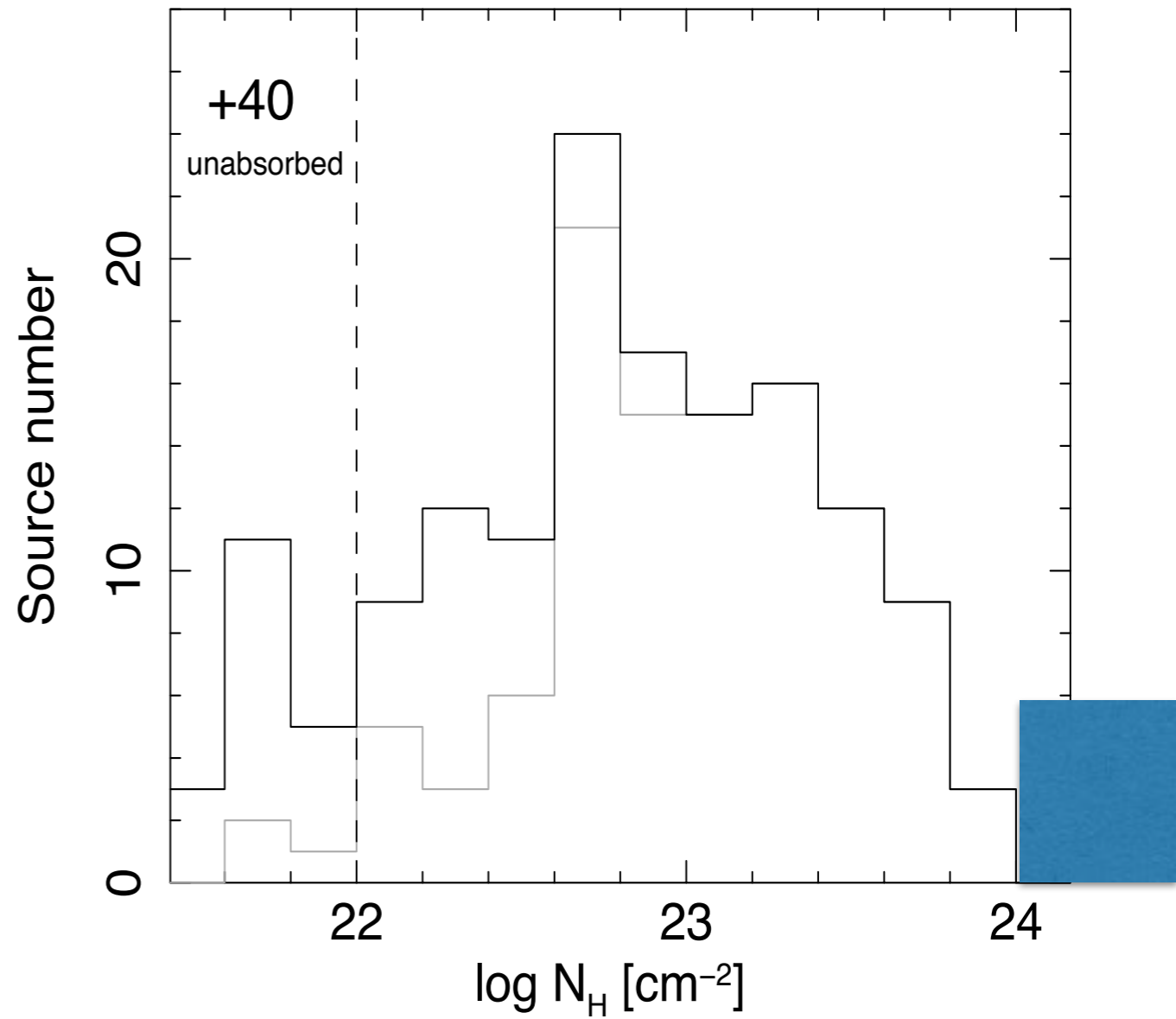
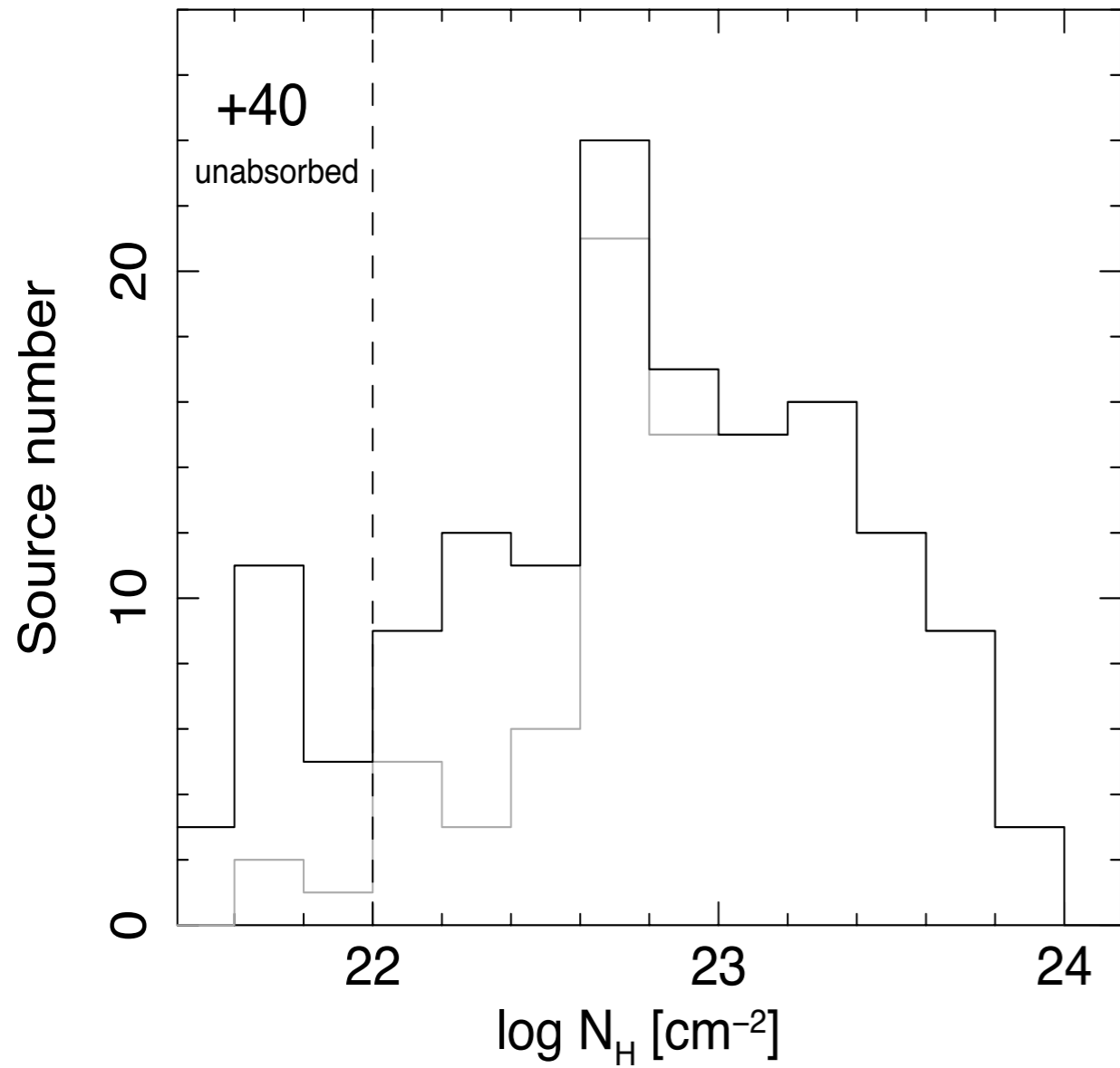
9,49,47,5

# Stacked Spectra



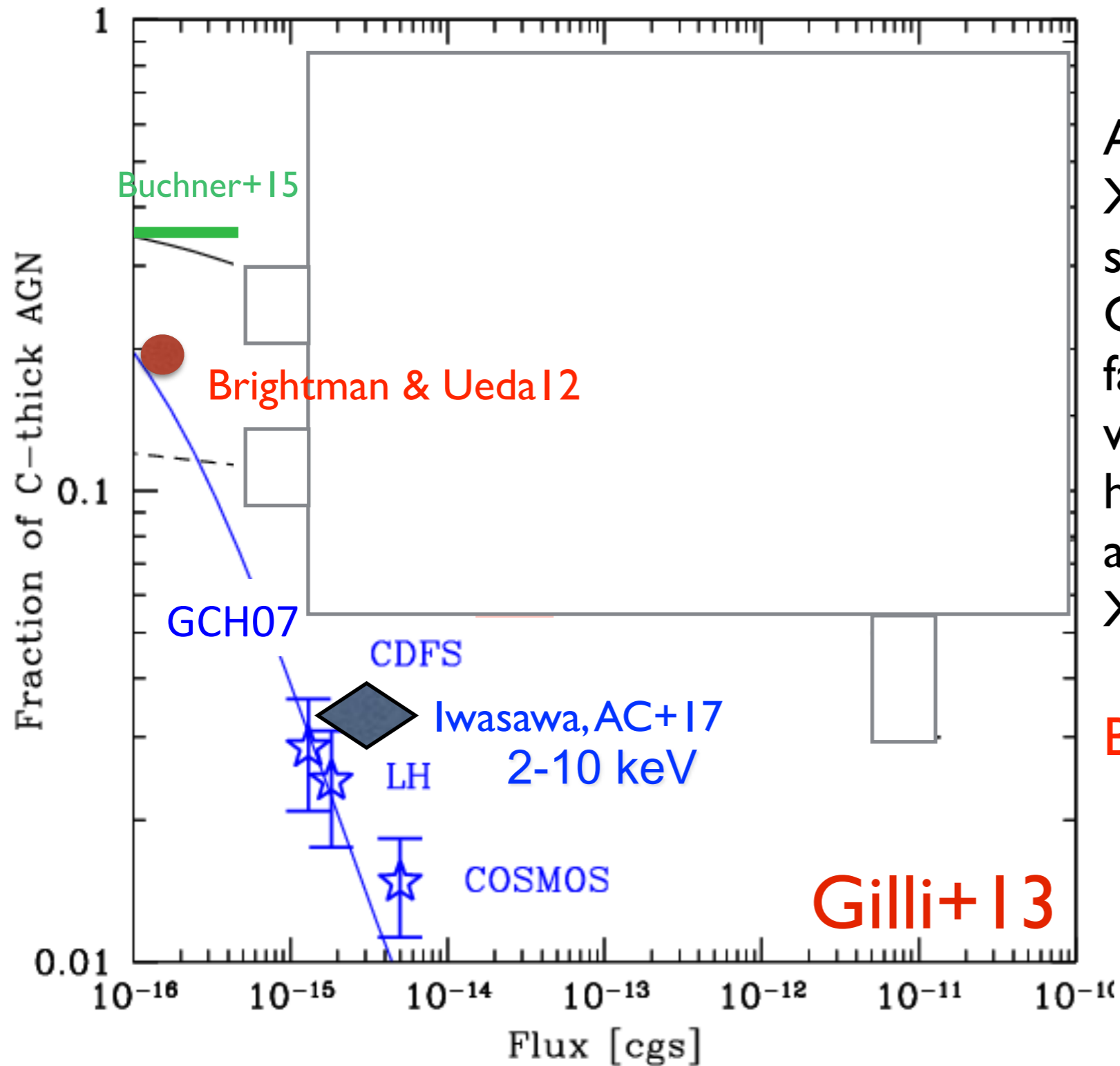
# Select Distant Compton thick in the CDFS





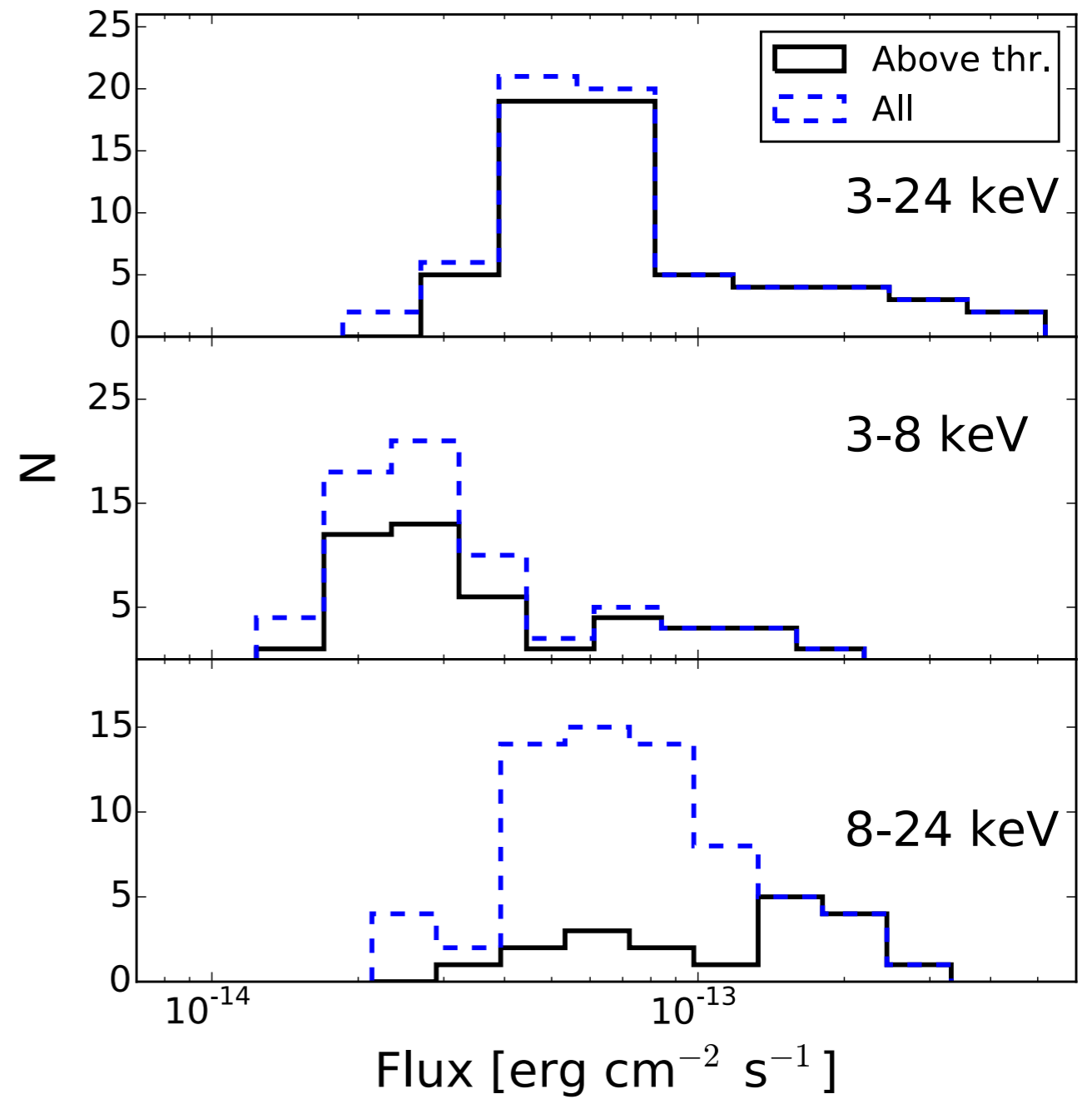
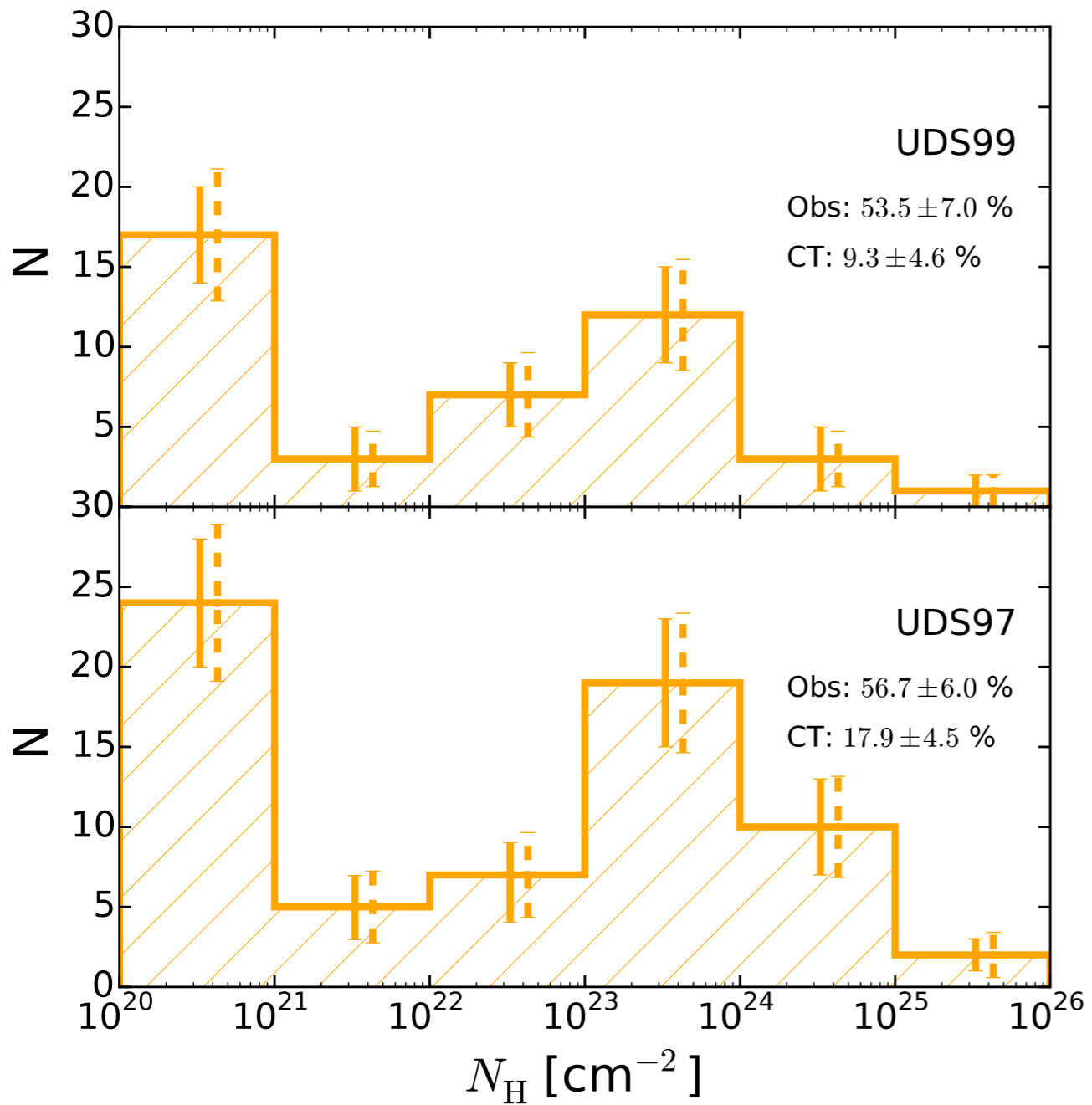
6 CT out of 180 in a flux limited ( $> 5 \times 10^{-15}$ ) Iwasawa+17

# Compton thick fraction



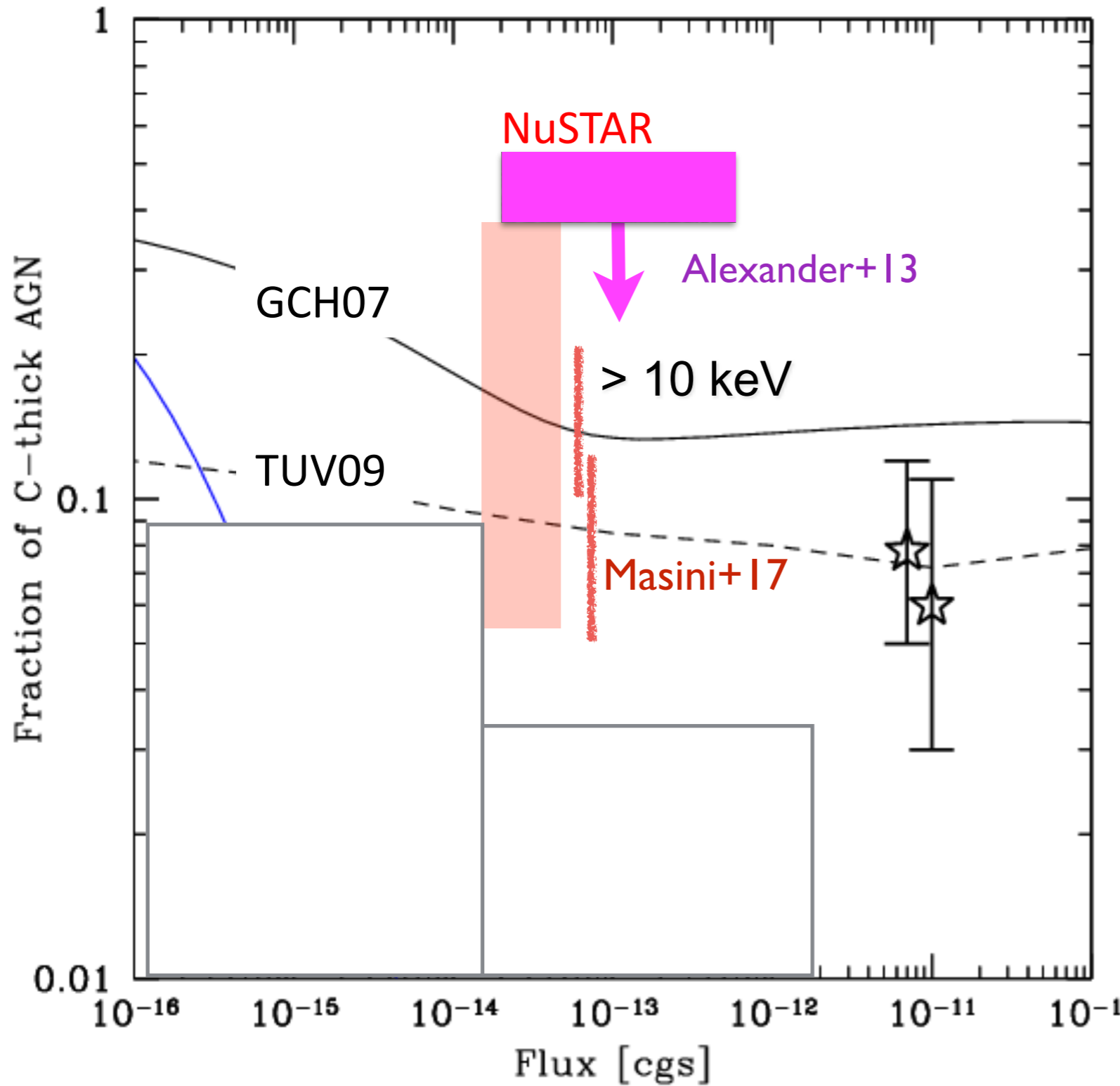
At the limiting fluxes of the XMM and deeper Chandra spectral surveys the number of Compton Thick (CT) AGN is in fairly good agreement with a sizeable population of heavily obscured nuclei accounting for the peak of the XRB

Buchner & Corral talks



UDS NuSTAR Deep Surveys **Masini+17**

# Compton thick Fraction



NuSTAR deep surveys

COSMOS Civano+15

ECDFS Mullaney+15

UDS Masini+17

Spectral analysis

Zappacosta+17

Del Moro+17

Talks at the conference !!!

X-rays are “sort of” complete  
CT candidates from Far-IR and  
other indirect methods?

# Lessons learned & Perspectives

Photon starved spectra remain an issue for many science goals

Evolution of obscuration — especially above  $10^{24} \text{ cm}^{-2}$  — and accretion physics beyond the local Universe ( $z \sim 1-3$ ), outflows/UFO  
Feedback at work ...

ATHENA will systematically address many of these science issues

Pushing even deeper is not rewarding especially after Chandra 7 Ms

Representative samples “obscured/UFO/molecular outflows/...”

ECDFS, UDS, COSMOS, XSERVS, XXL, Stripe82, ...

Multi-mission (XMM, NuSTAR, Chandra, Hitomi2, ...) X-ray and longer wavelengths follow up