Deep Surveys

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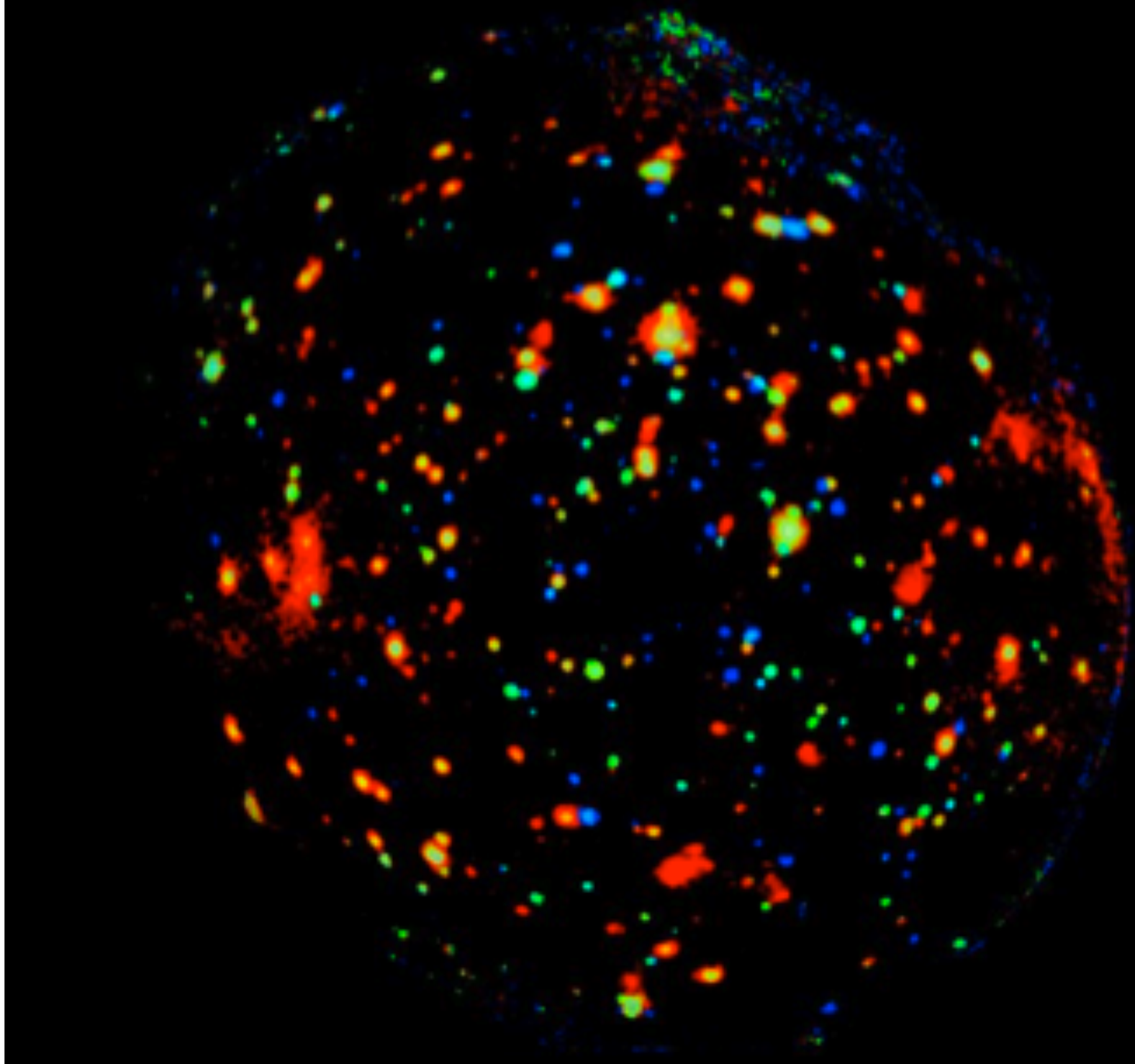
~3 Ms XMM image of the Chandra Deep Field South



~0.3 deg^2

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

XMM-CDFS deep survey science goals

About 60% of the hard 5-10 keV XRB was resolved
Ranalli+13

Unfortunately the background level was higher than expected

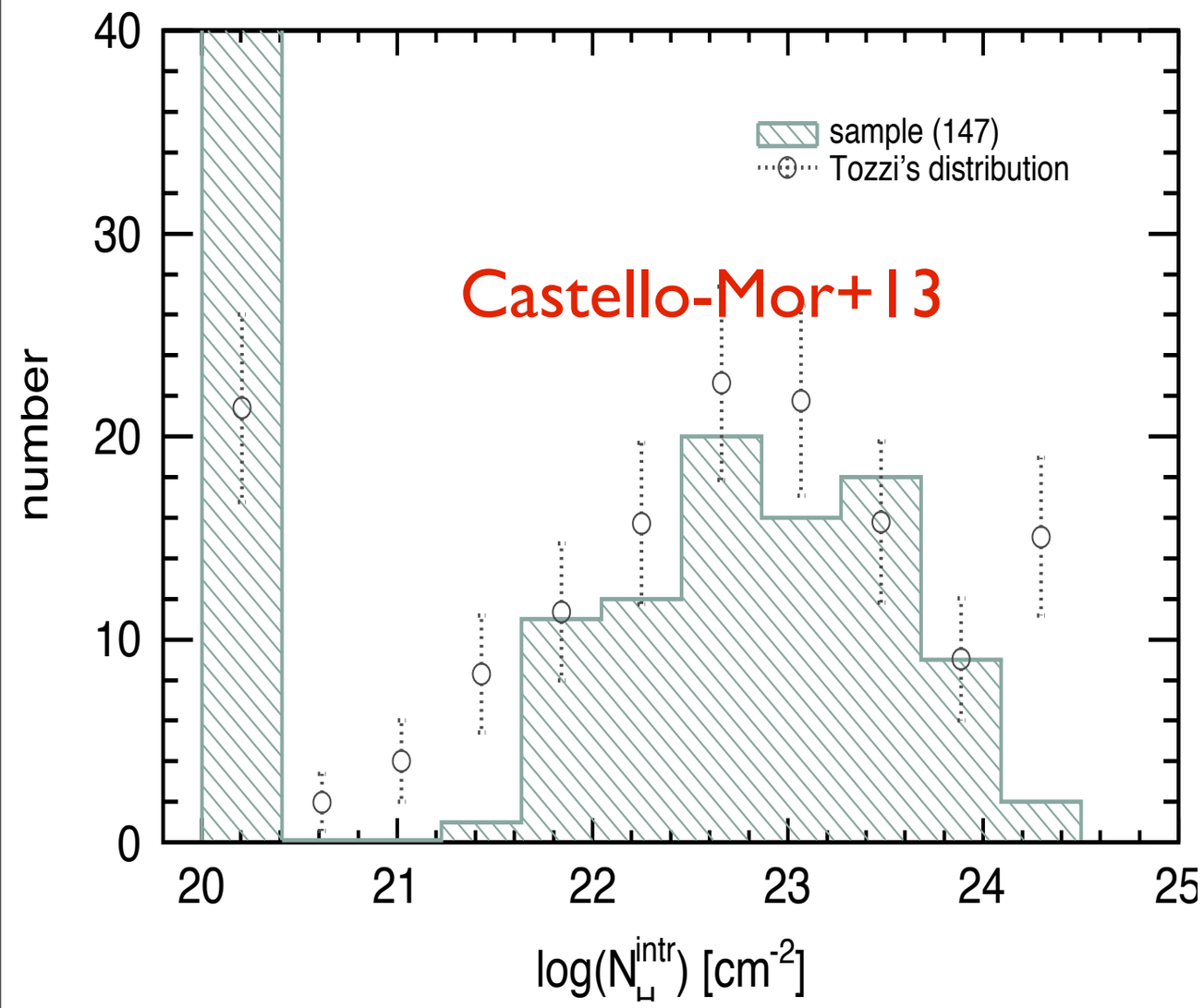
AGN "fine" spectroscopy beyond the local Universe
evolution, feedback, ...

Census of highly obscured and Compton thick AGN
Iron line properties
Variability
...

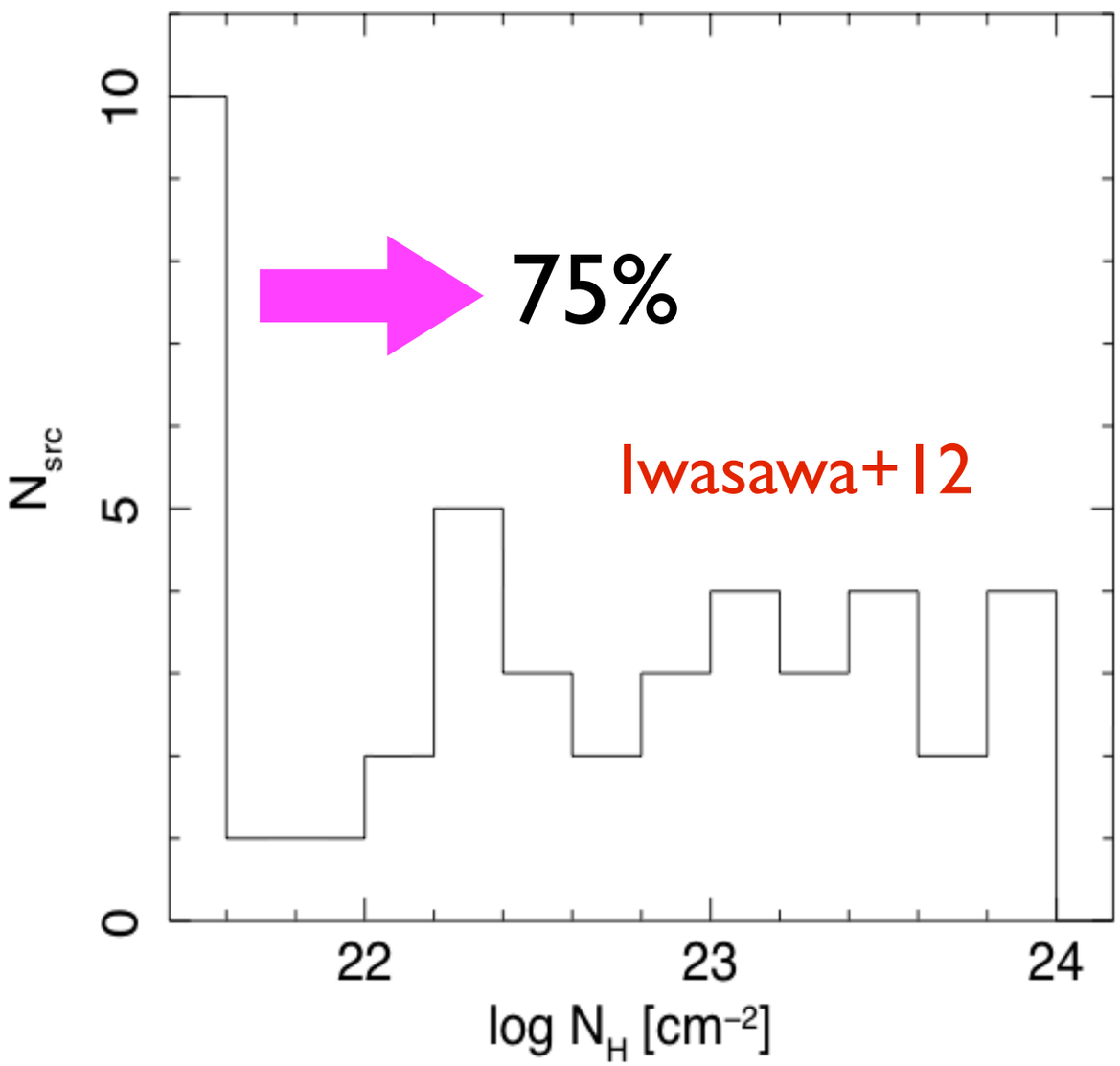
The X-ray sample(s)

"2-10 keV selected" flux limited, widely different spectral quality

180 sources > 1.8 x 10^{-15} cgs

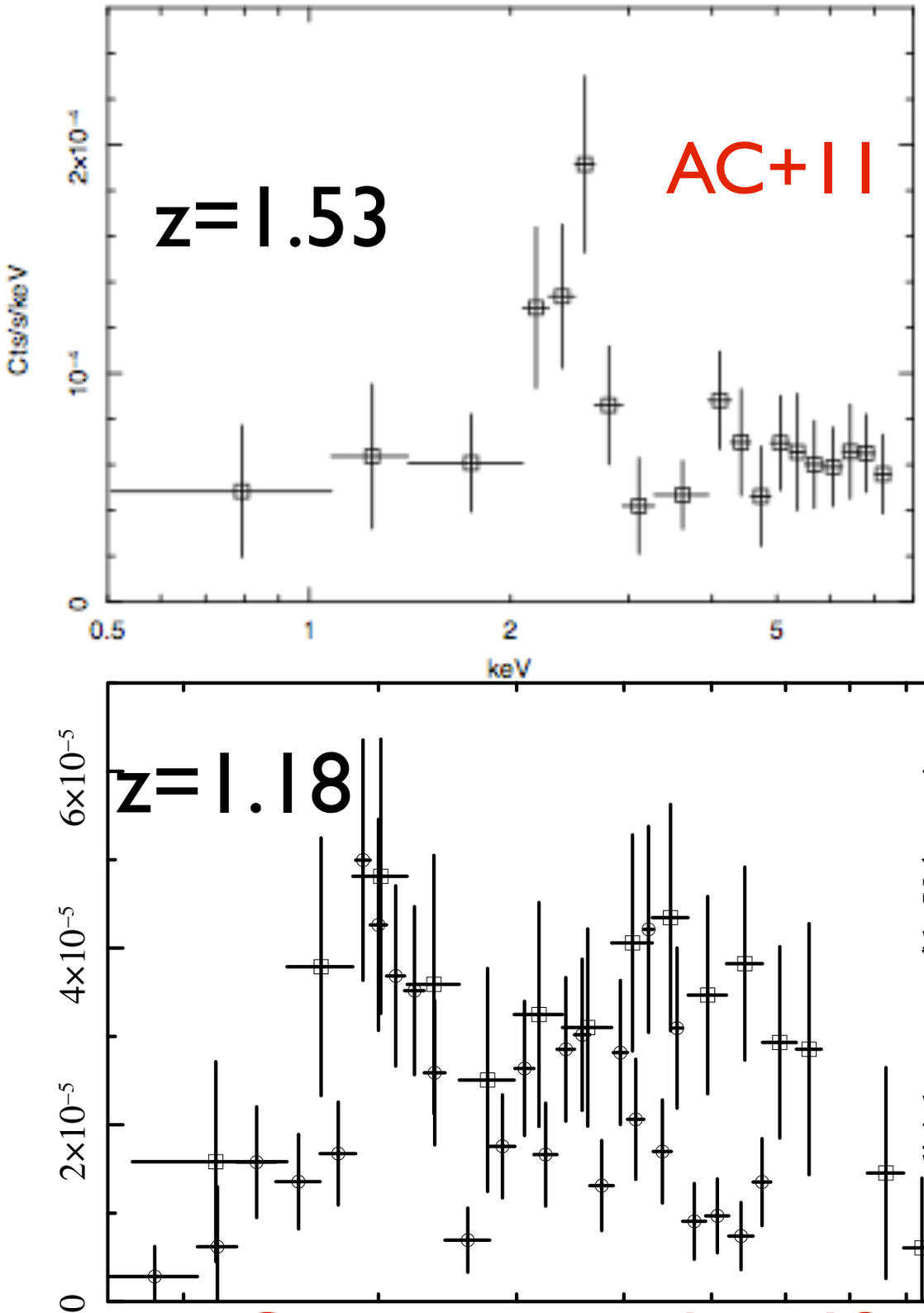


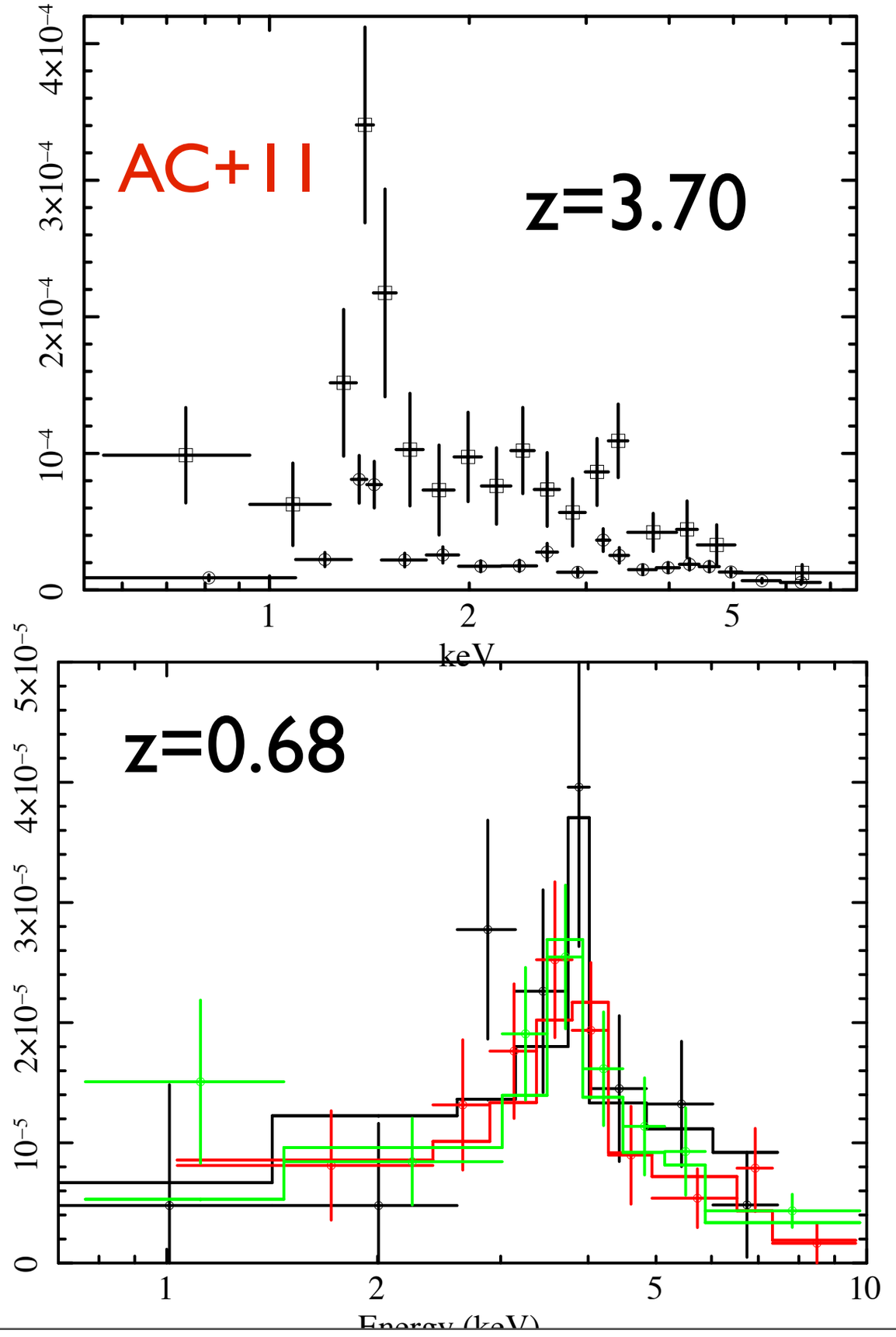
46 sources @ z >1.7



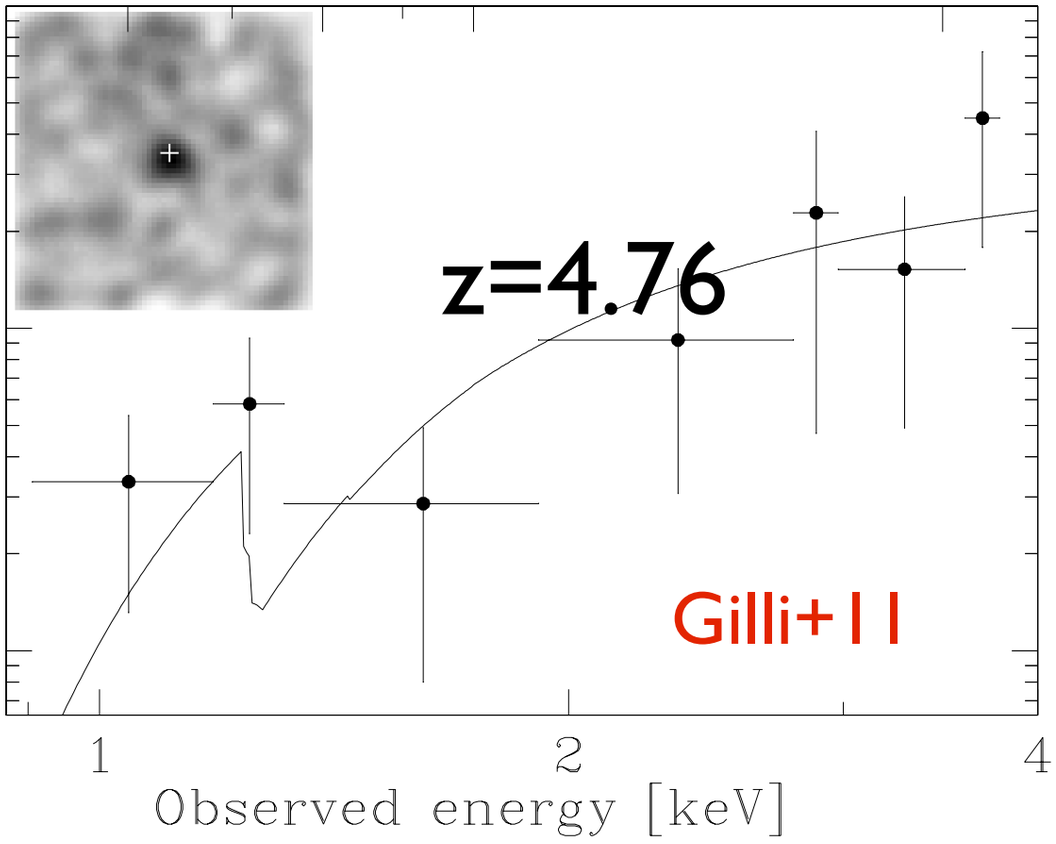
The obscured fraction increases toward high-z for luminous (> 10^{44} erg s^{-1}) AGN (cfr. ~20-30% at z~0 Burlon+11

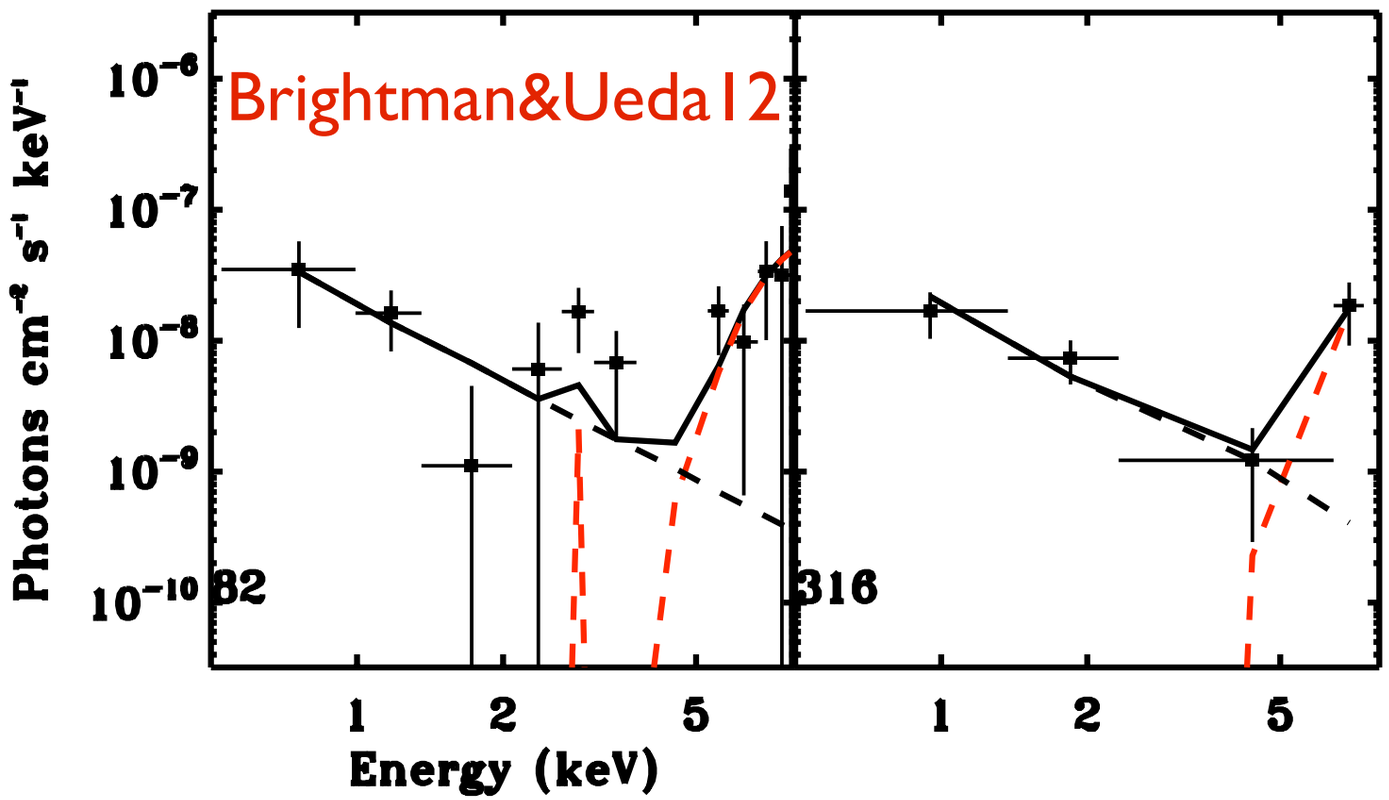
Distant Compton thick in the CDFS

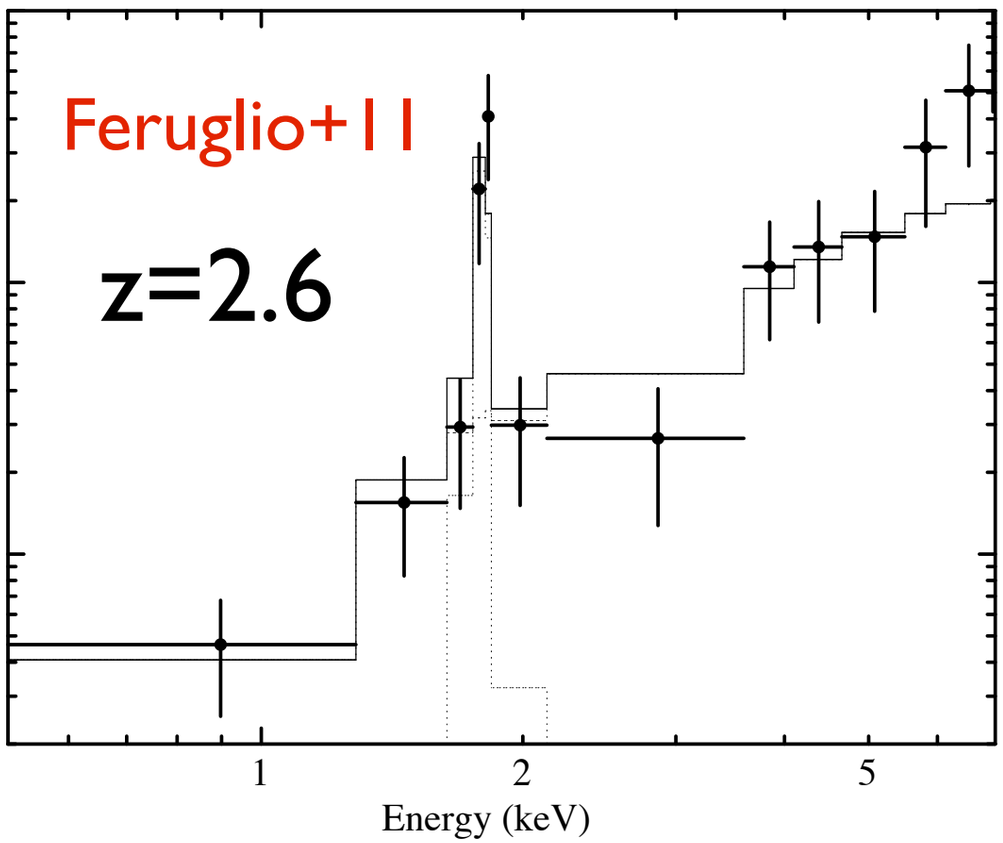




Chandra Results







Chandra is/will reach higher redshifts especially with the 7 Ms

Spectral Quality is not good enough for accurate N_H measurements in the Compton thick regime

Comparisons

ID210	us	T06	C11	B12	I12	G13	
30	heavily	–	–	–	heavily	–	FLAT
44	unabsorbed	CThick	–	heavily	–	–	< 5 x 10-15
48	moderately	–	–	–	–	heavily	Moderate
64	heavily	–	–	–	heavily	–	
66	heavily	–	–	–	–	secure-CThick	
106	moderately	CThick	–	heavily	–	–	< 5 x 10-15
114	heavily	–	–	–	heavily	–	< 5 x 10-15
144	heavily	CThick	CThick	heavily	heavily	secure-CThick	< 5 x 10-15
147	heavily	CThick	CThick	heavily	–	secure-CThick	
155	moderately	CThick	–	heavily	–	< 5 x 10-15	Reflection Dominated
180	heavily	–	–	–	heavily	heavily	
214	heavily	–	–	–	–	heavily	NuSTAR Heavily
222	unabsorbed	–	–	–	–	heavily	FLAT
245	heavily	–	–	–	heavily	heavily	< 5 x 10-15
289	moderately	–	–	–	–	heavily	Reflection Dominated
324	unabsorbed	–	–	–	–	secure-CThick	

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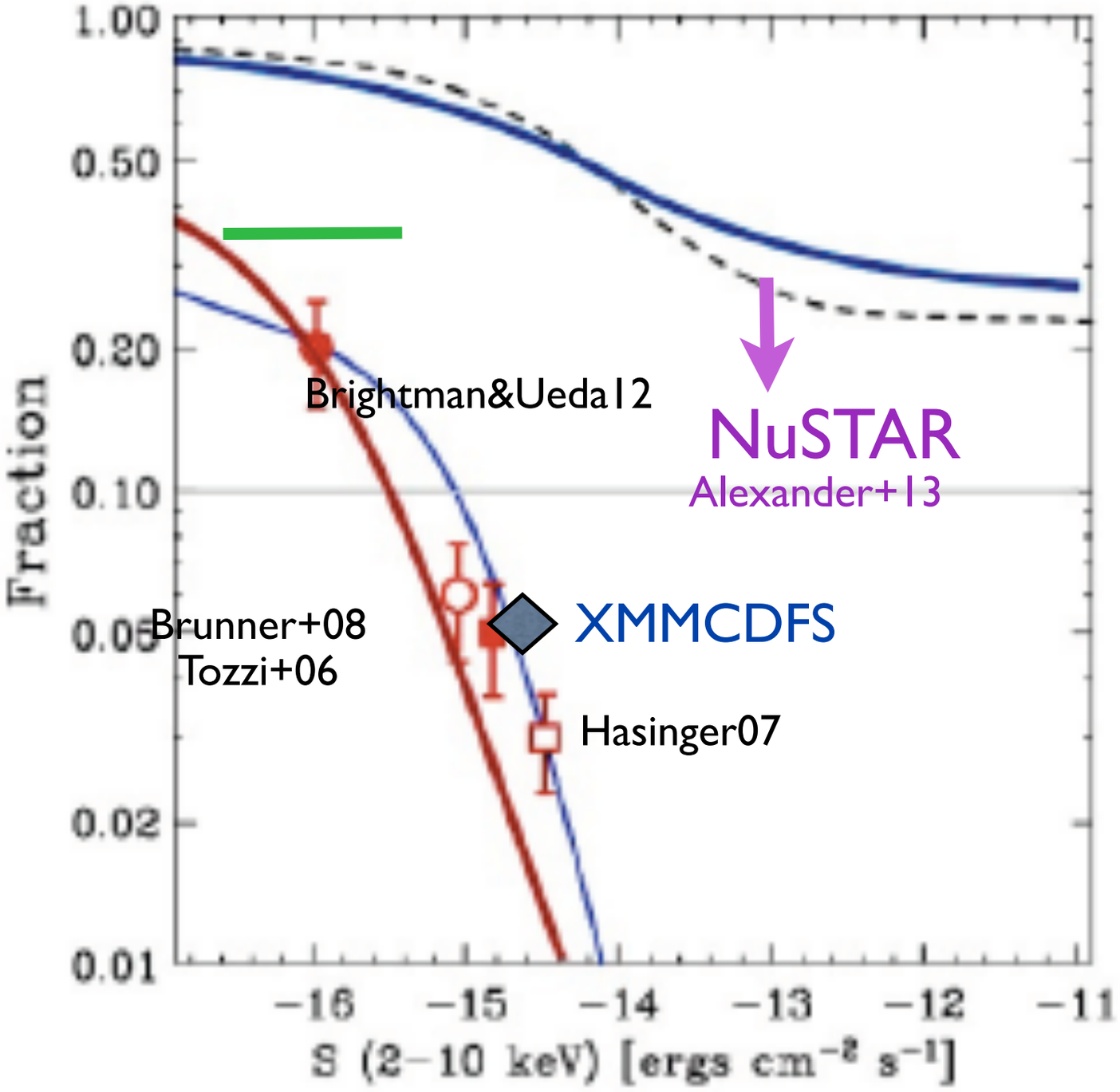
Reflection Dominated

Compton thick Fraction



Ueda+14, GCH07, Buchner+15

At the limiting fluxes of the XMM and Chandra spectral surveys the number of Compton Thick (CT) AGN is in fairly good agreement with the XRB model expectations.

Looking forward for NuSTAR deep surveys spectral analysis (Zappacosta+;Del Moro+ in preparation) to understand the evolution of the CT obscuring gas and implications for models

XMM deep X-ray spectrum

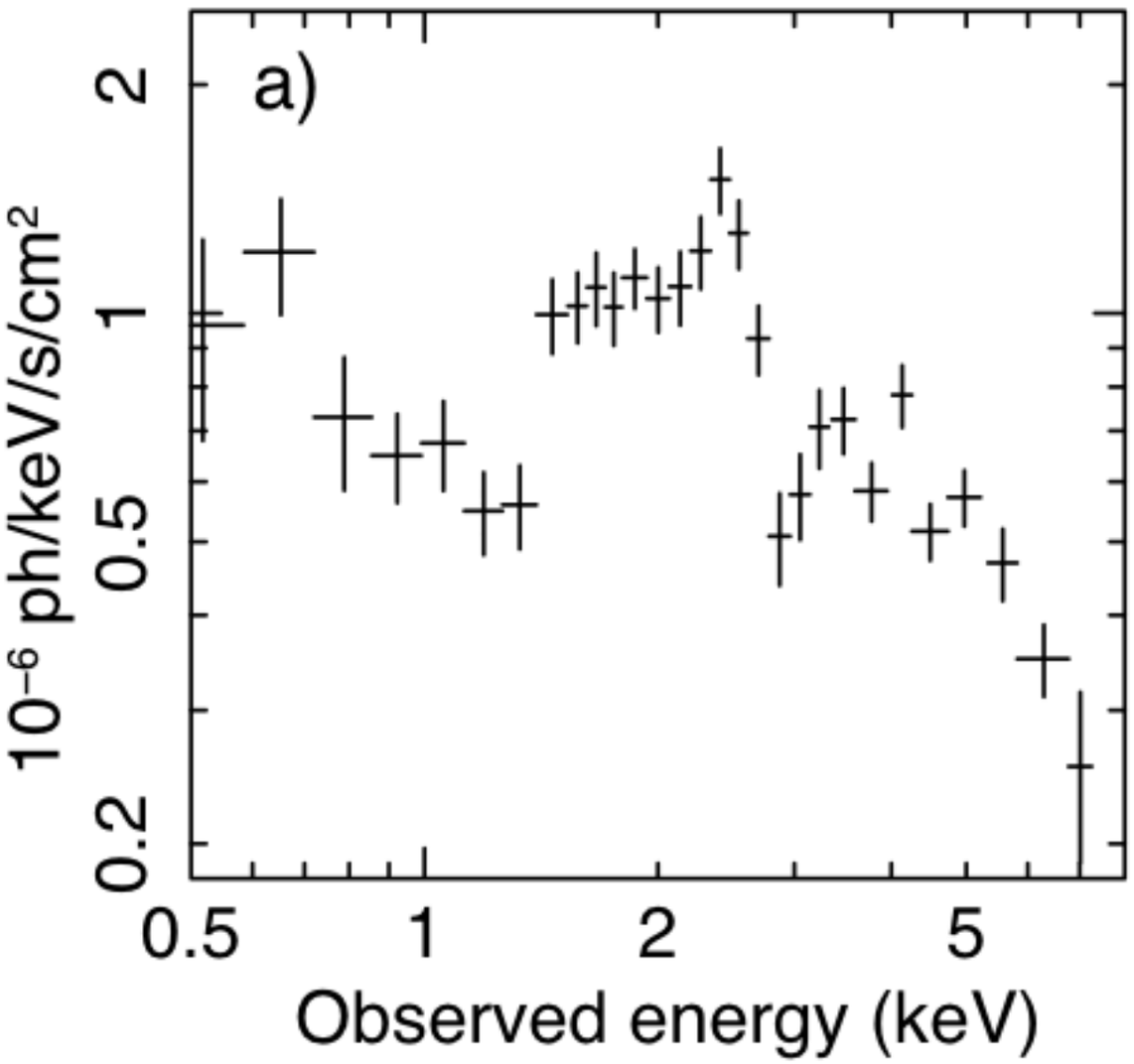
$F_X \sim 3 \times 10^{-14}$ $L_X \sim 2 \times 10^{44}$ $N_H \sim 2\text{-}3 \times 10^{23}\,cm^{-2}$

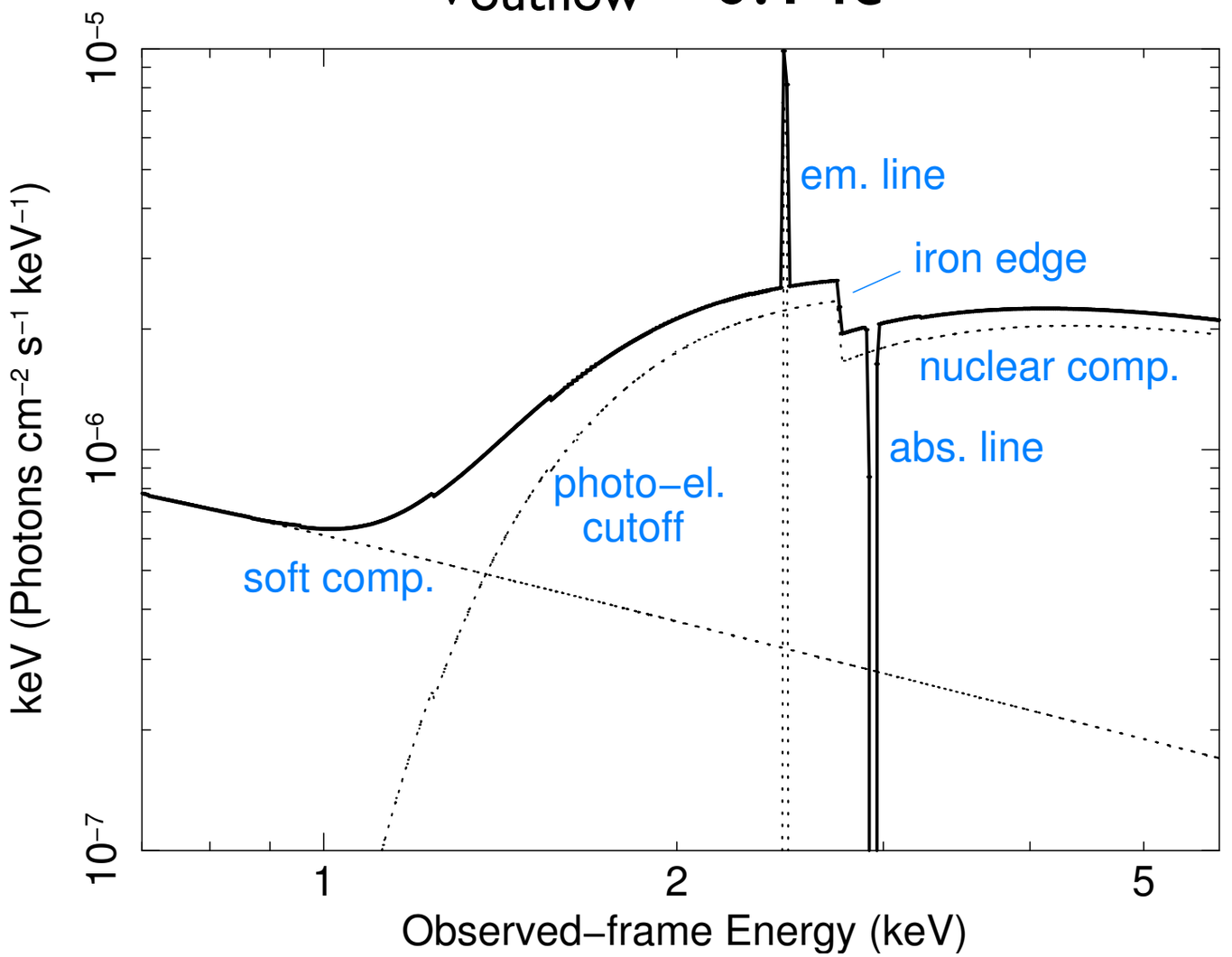
X-ray redshift from emission line + edge $z \sim 1.6$

Resonant FeXXV-XXVI absorption → outflow

~700 ksec

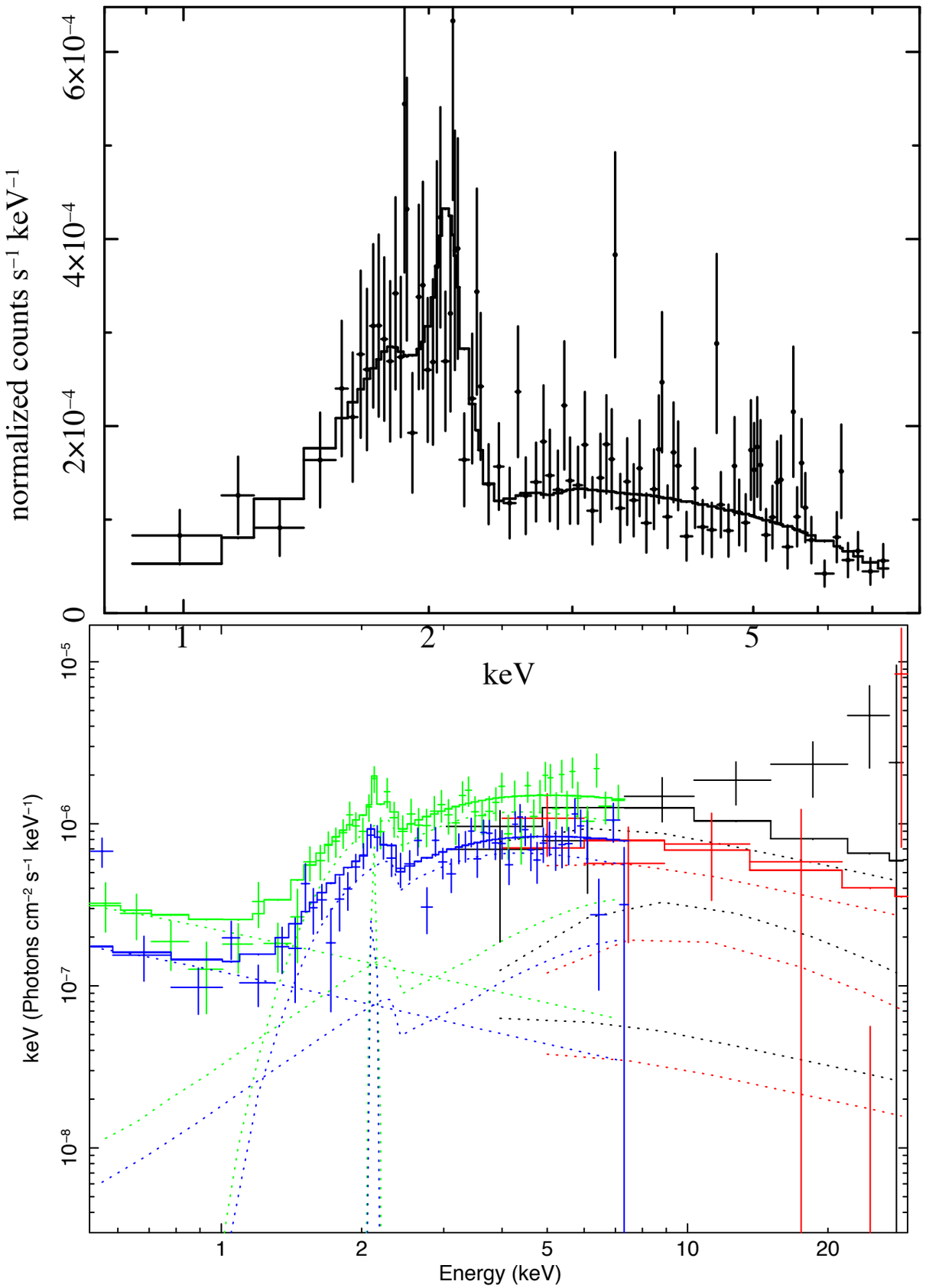
$v_{outflow} \sim 0.14c$





Vignali+15

Redshift from the X-ray spectrum



X-ray redshift from the Kalpha Iron Edge (7.11 keV)

z = 2.03+-0.04

Georgantopoulos+13

F_X ~ 1.5 x10^{-14} L_X ~ 4 x 10^{44}

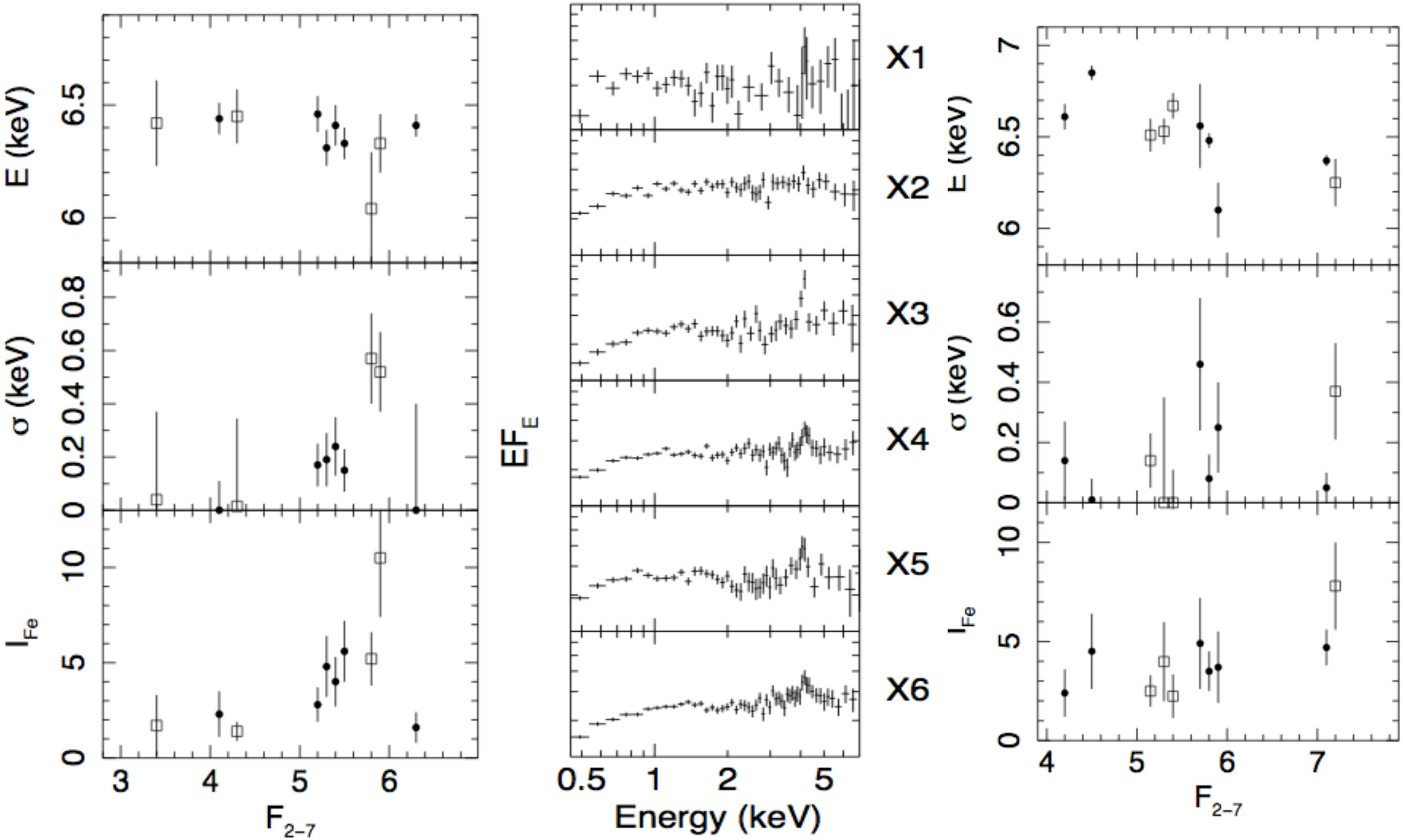
N_H~5-6×10^{23}cm^{-2}

Detected by NuSTAR in the 8-24 keV band (but not < 8 keV)

The most distant AGN detected above 10 keV

Del Moro+14

Brightest sources iron line variability

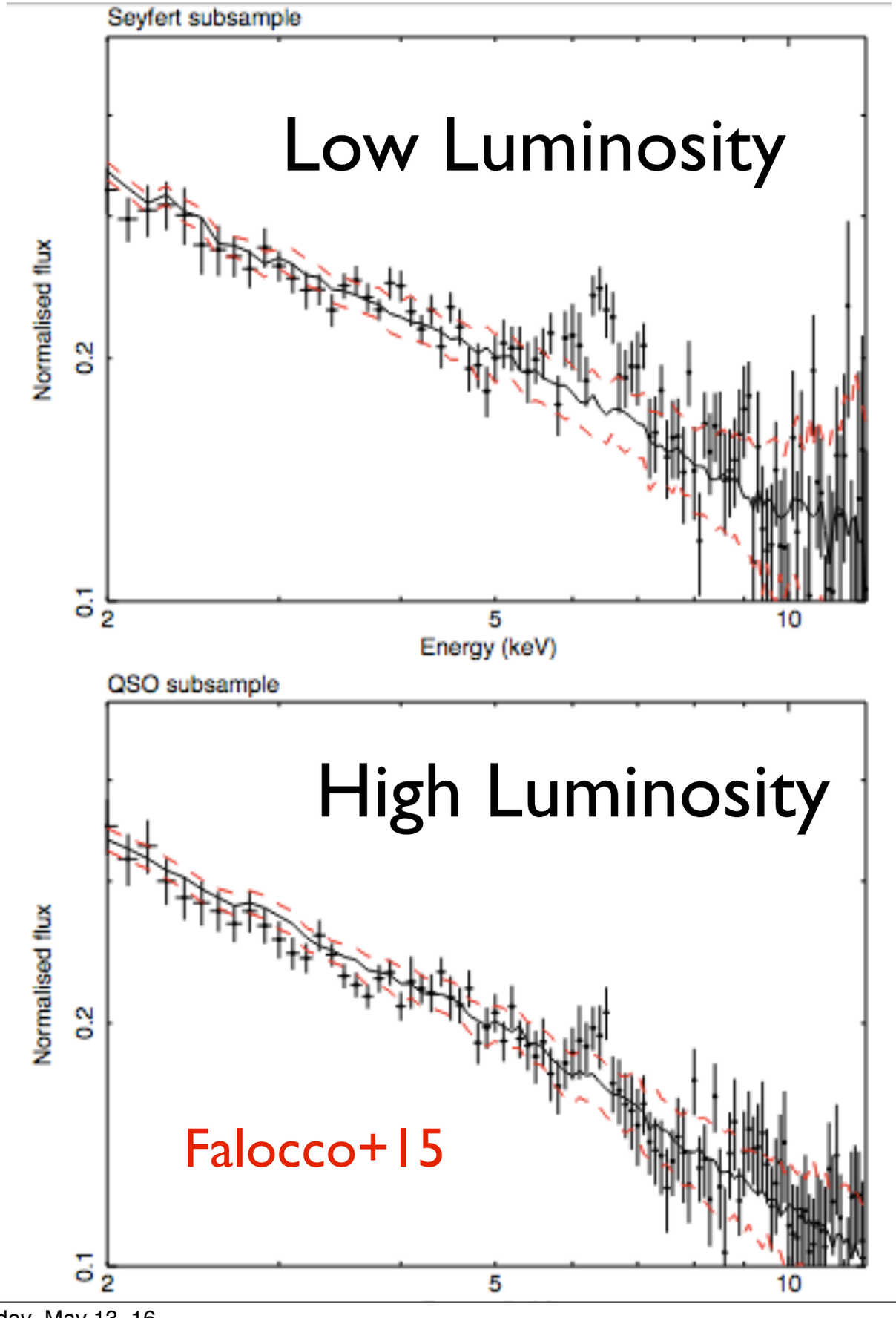


z=0.544

Iwasawa+15

z=0.742

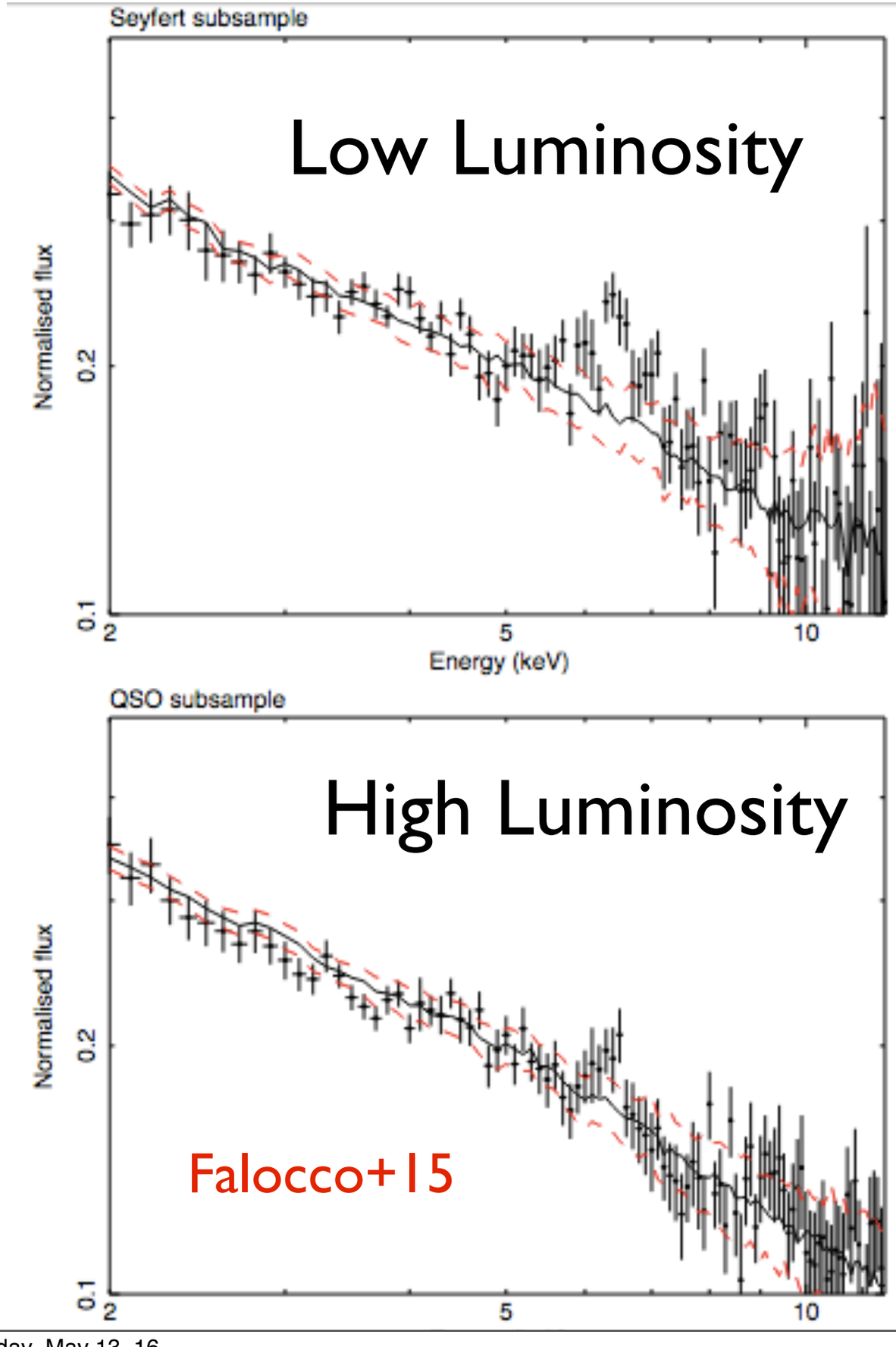
Iron line profile



"Tentative" evidence
of a broad component

cfr. Brusa+05
Chaudary+12
and many others

Iron line profile



"Tentative" evidence
of a broad component

cfr. Brusa+05
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and many others

Lessons learned & Perspectives

Pushing even deeper is not rewarding especially with 7 Ms Chandra

Good quality spectra are absolutely needed for many science goals

N_H distribution above 10^{24} cm^{-2}: relative fraction of reflection dominated vs XRB contributors and their volume emissivity/space density (cfr. Akylas+12;Fabian+16;Esposito&Walter16, XRB is mostly due to disk reflection rather than CT)

UFO/Outflows at high-z: feedback at work

Iron line, absorption and continuum variability

...

XMM 2016-2026

If I have 10 - 20 Ms

Identify a well defined sample of molecular outflows and UFO
only two examples (Tombesi+15;Feruglio+15)
and/or high-redshift interesting objects (cfr. Massimo Cappi review)

Large sample of "representative" heavily obscured AGN,

Iron line intensity and profile distribution beyond the local Universe

COSMOS, (Lanzuisi) XSERVS (Brandt), XXL(Pierre), Stripe82 (La Massa) are excellent starting points.