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Deep Surveys

Andrea Comastri

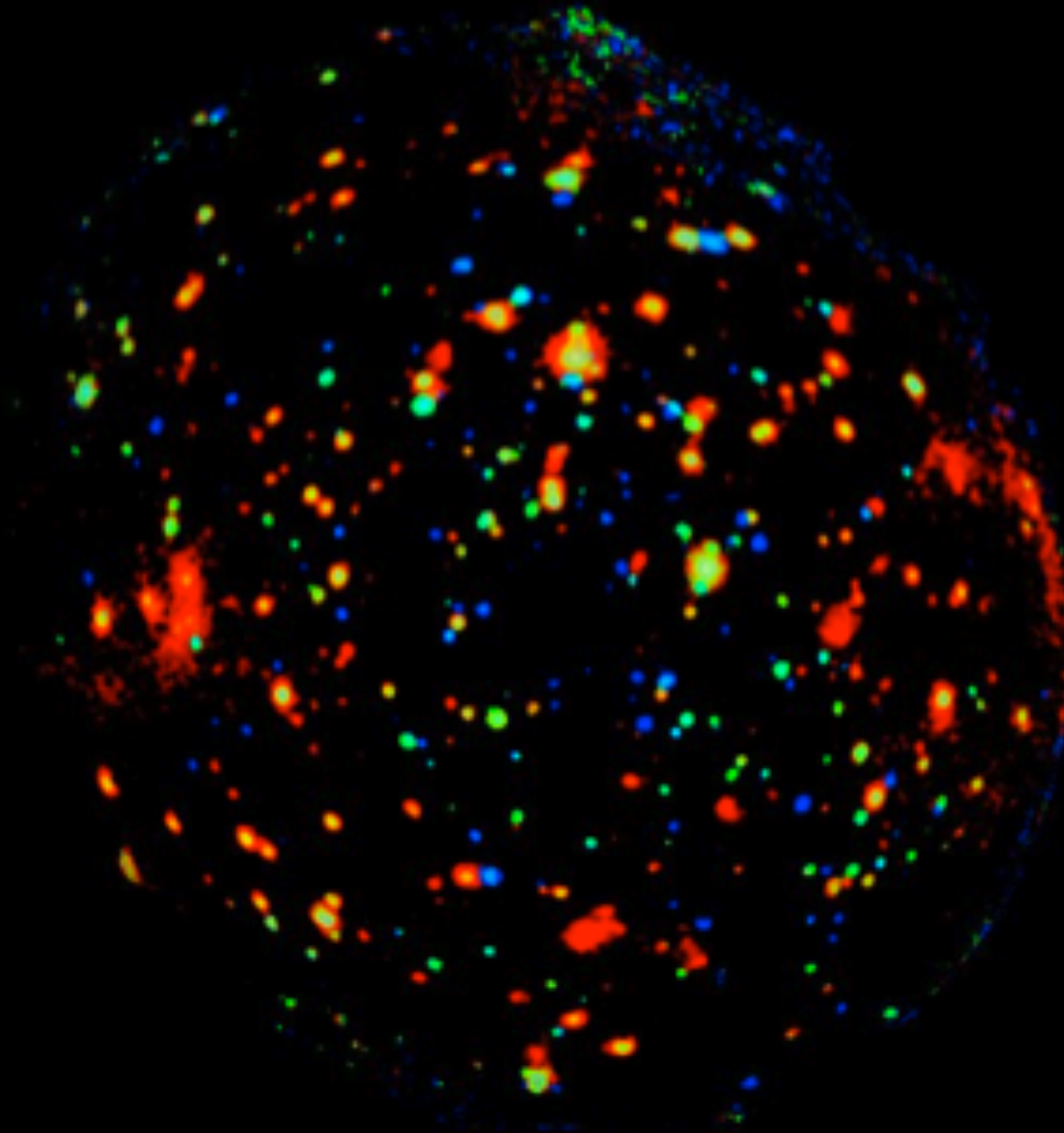
INAF-Osservatorio Astronomico di Bologna



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~3 Ms XMM image of the Chandra Deep Field South

~0.3 deg²



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

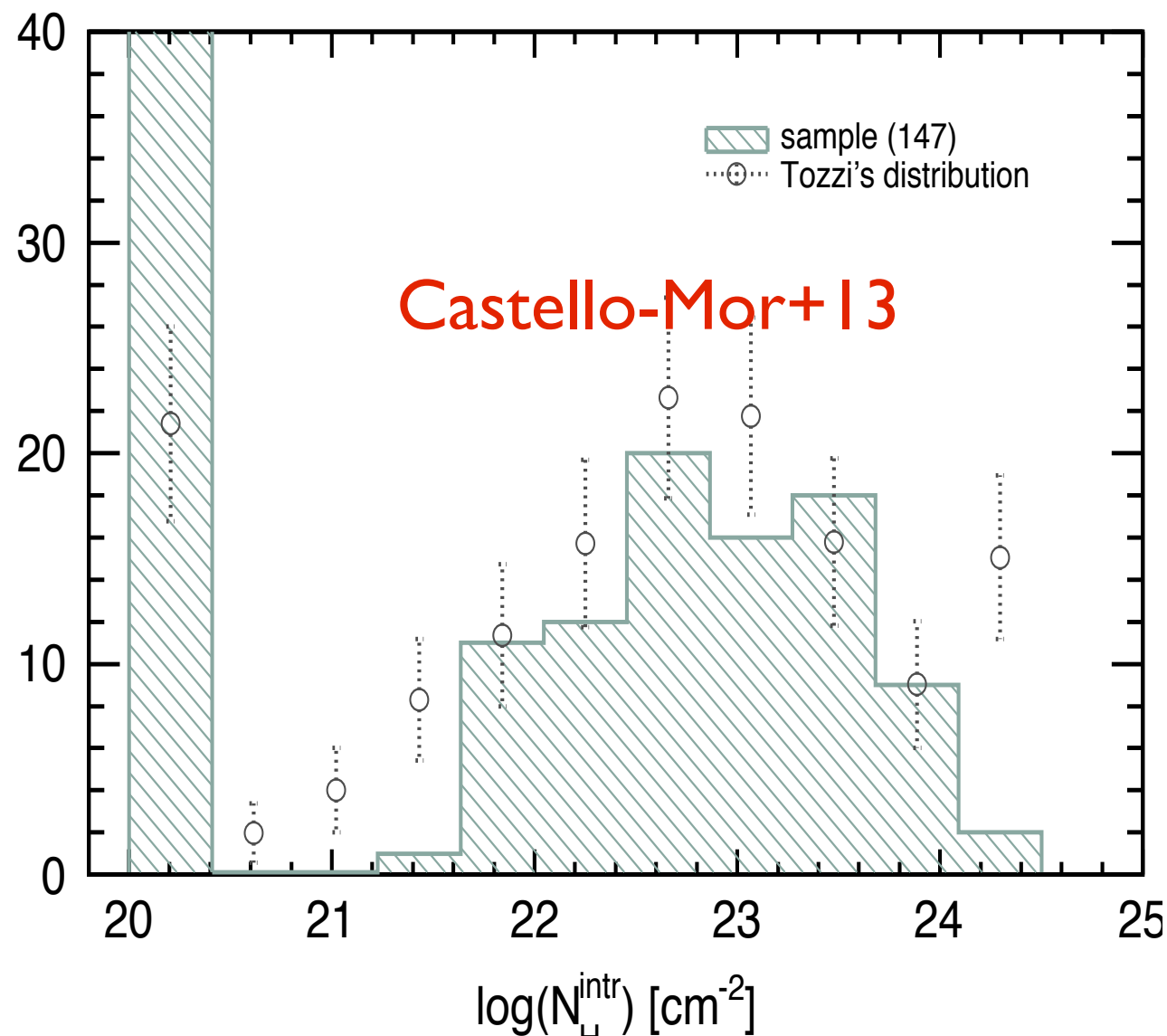
Variability

...

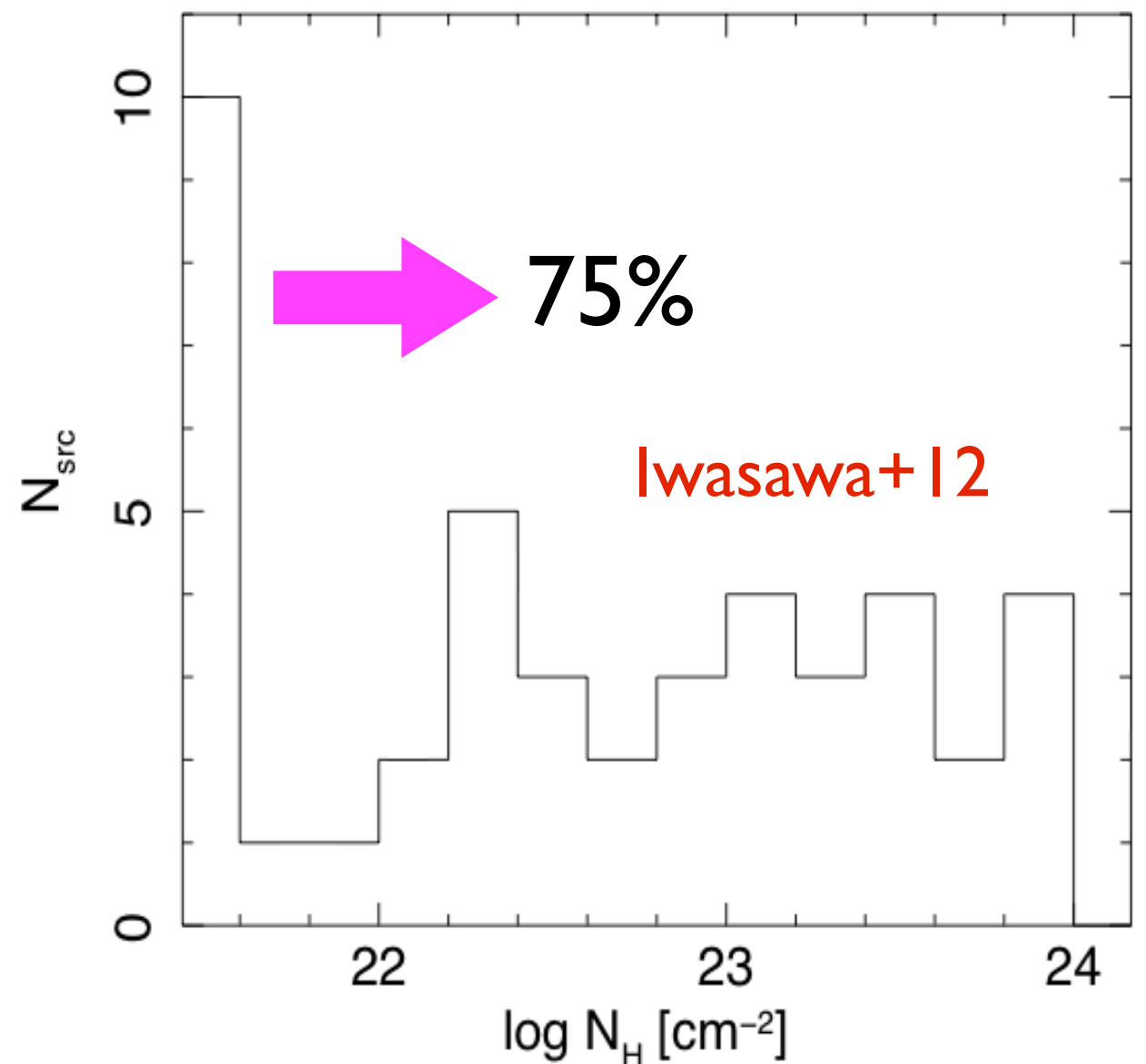
The X-ray sample(s)

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

180 sources $> 1.8 \times 10^{-15}$ cgs

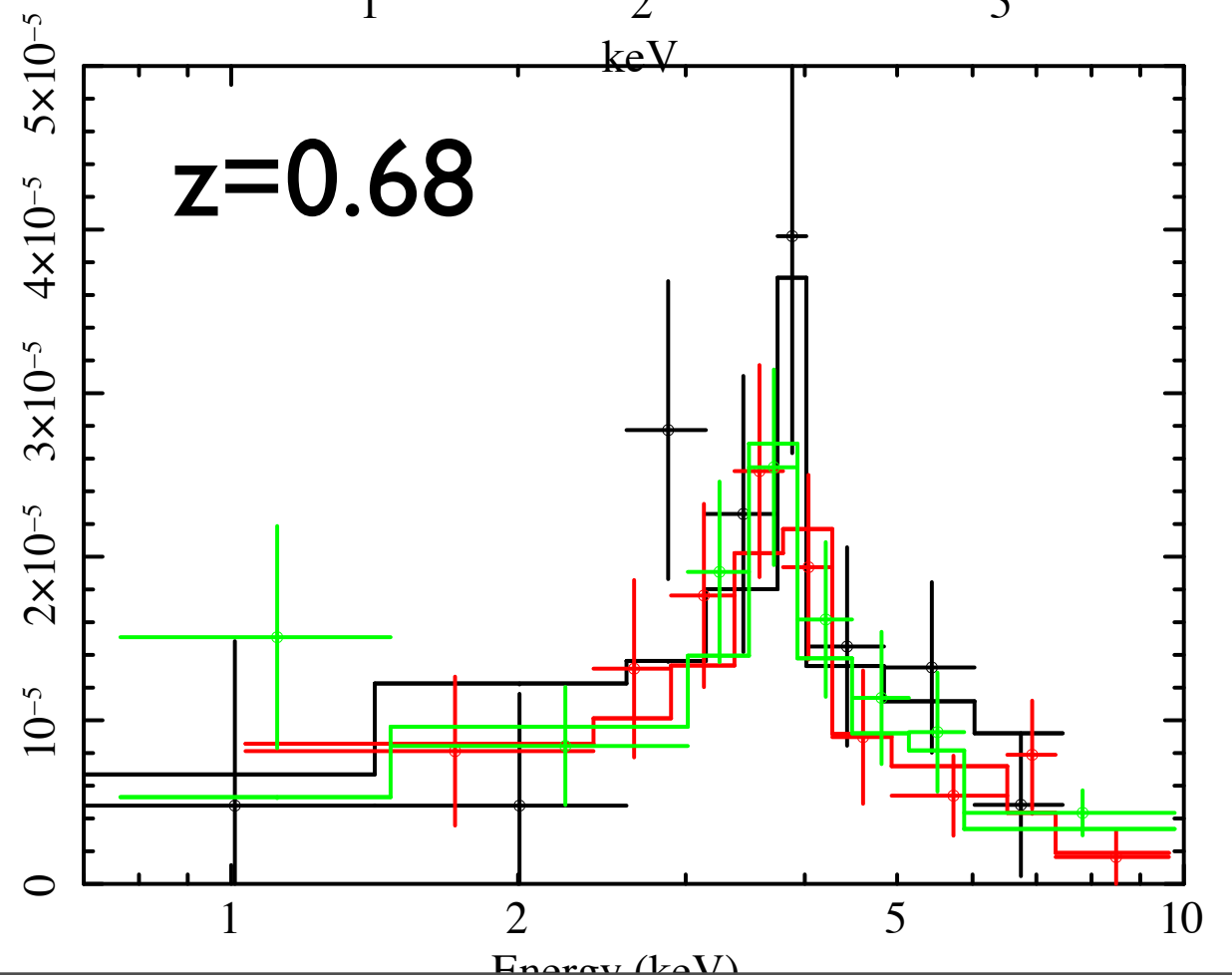
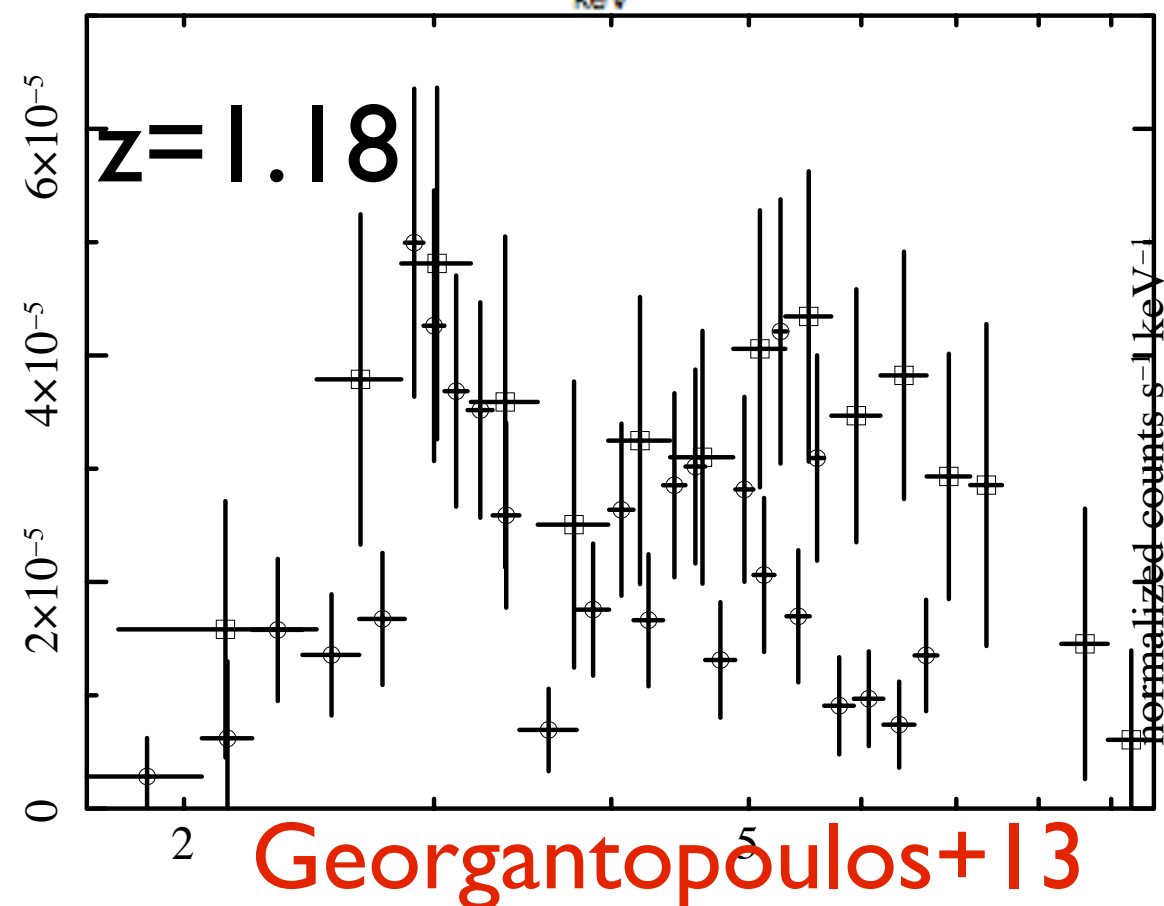
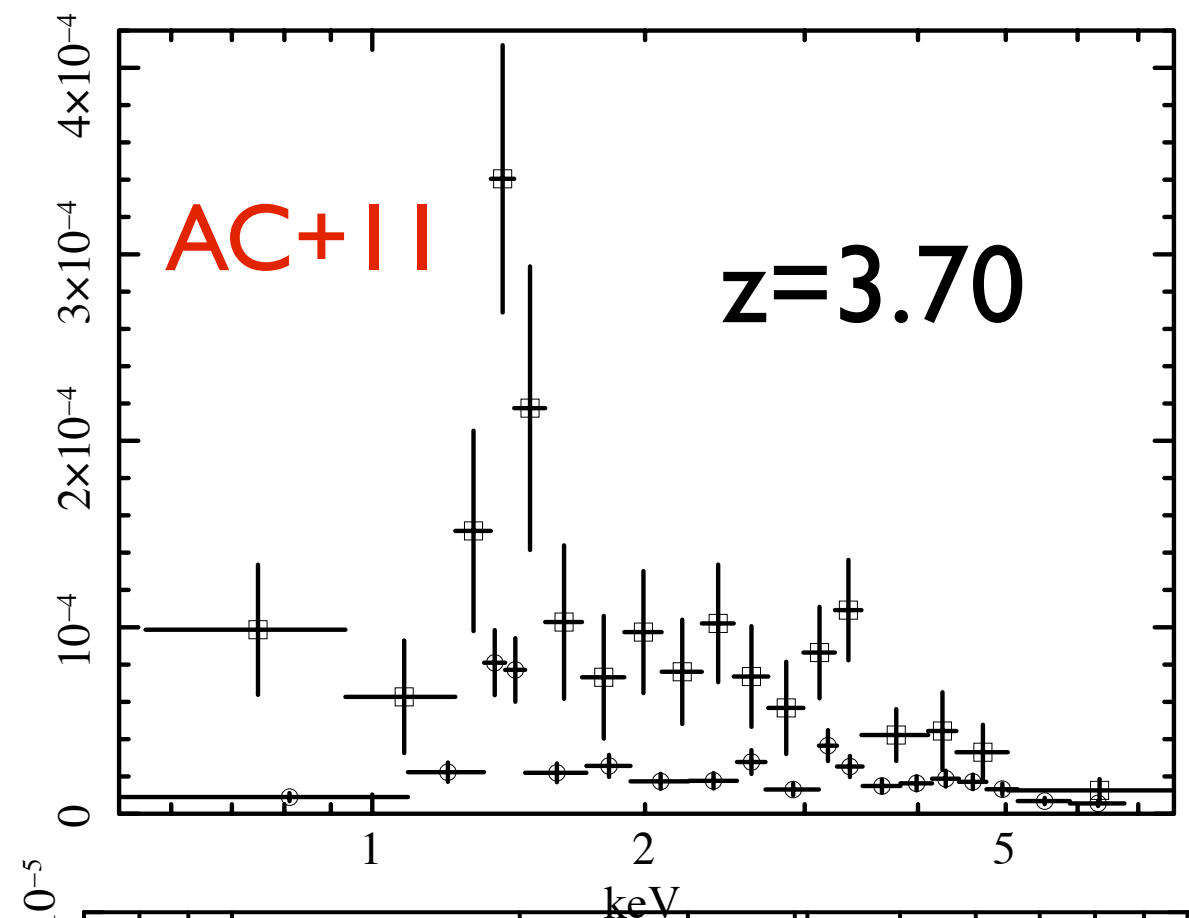
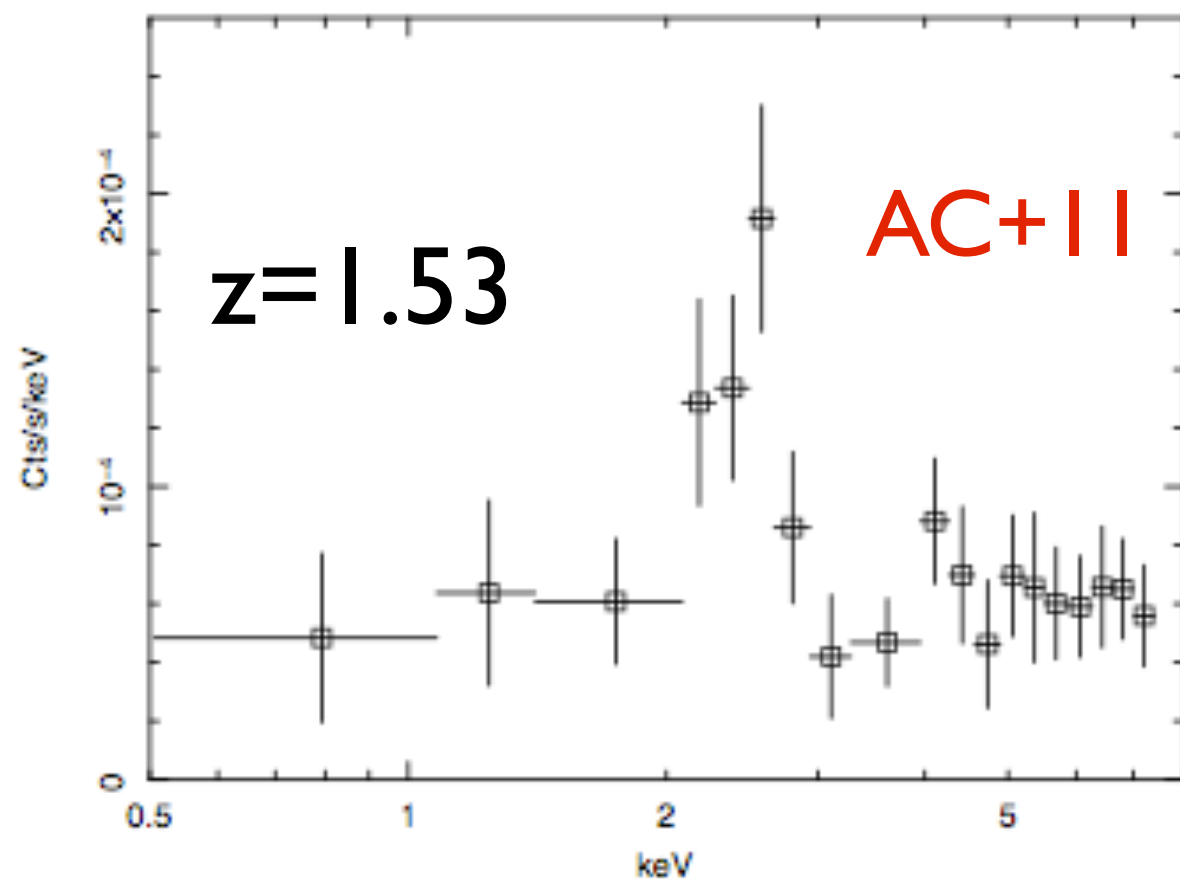


46 sources @ $z > 1.7$

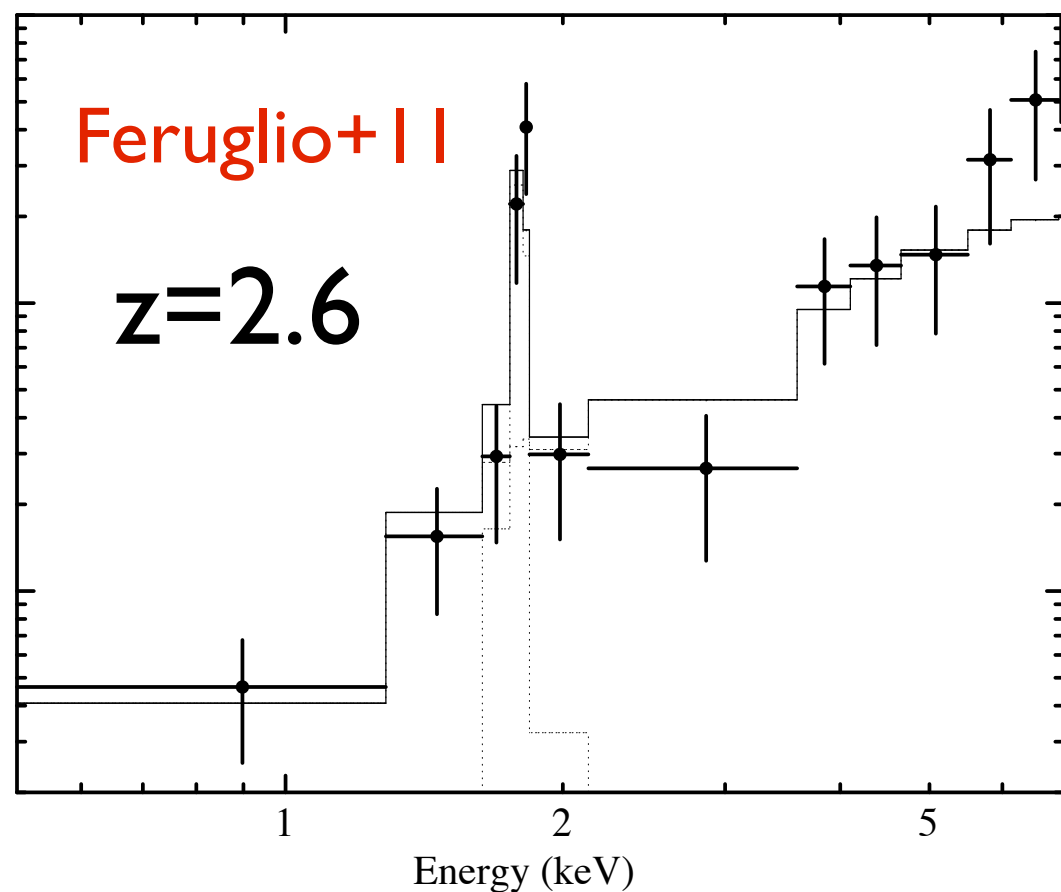
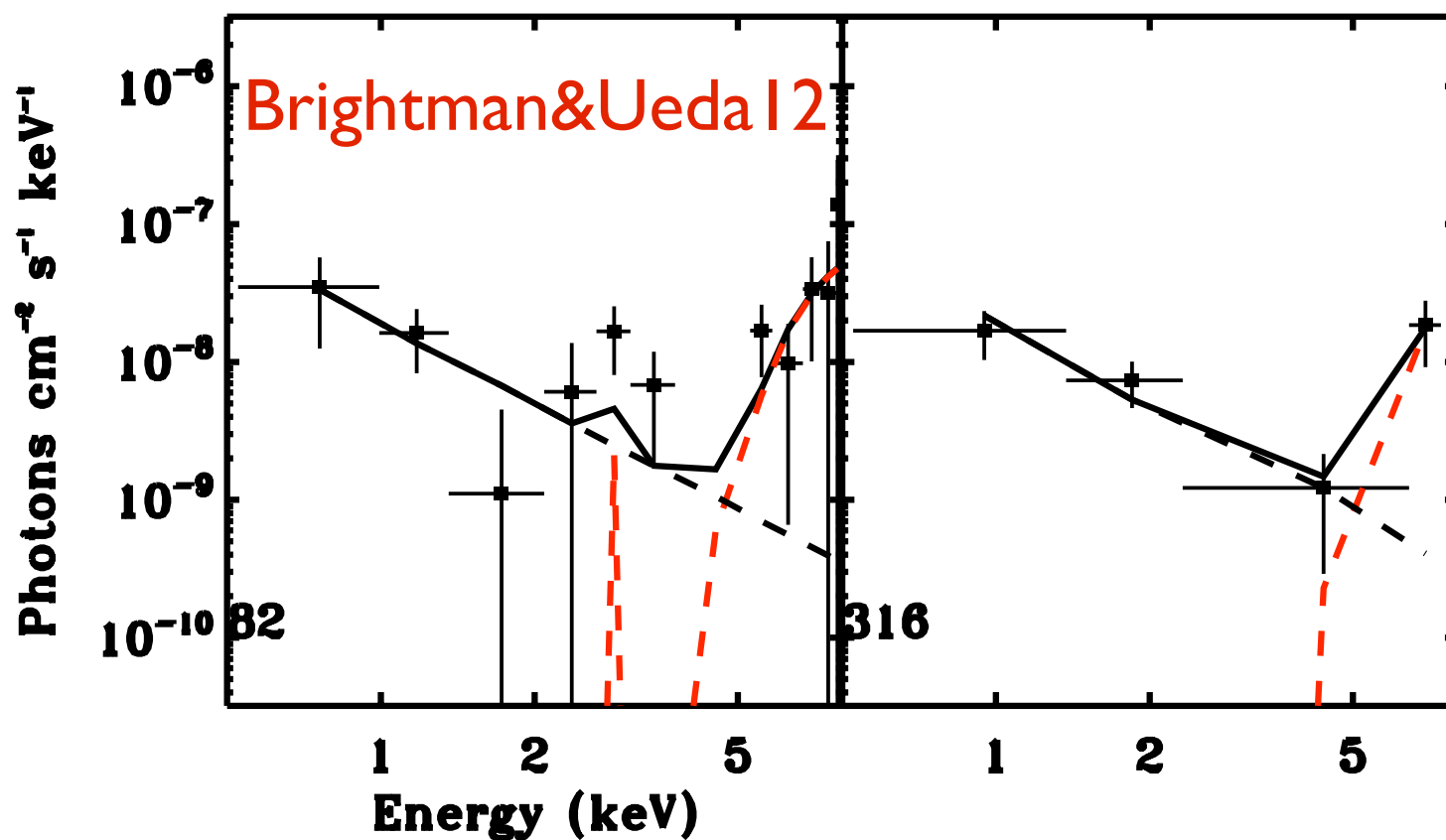
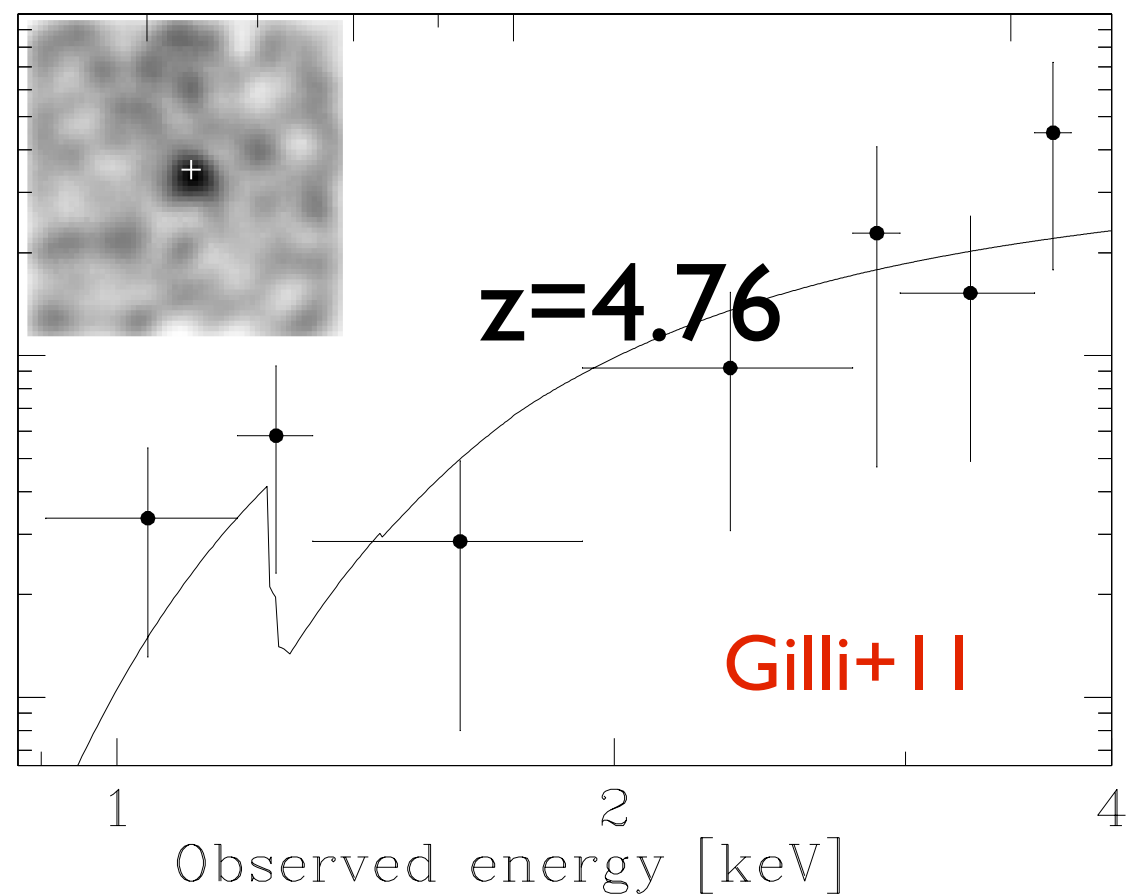


The obscured fraction increases toward high- z for luminous ($> 10^{44}$ erg s⁻¹) AGN (cfr. ~20-30% at $z \sim 0$ Burlon+11)

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

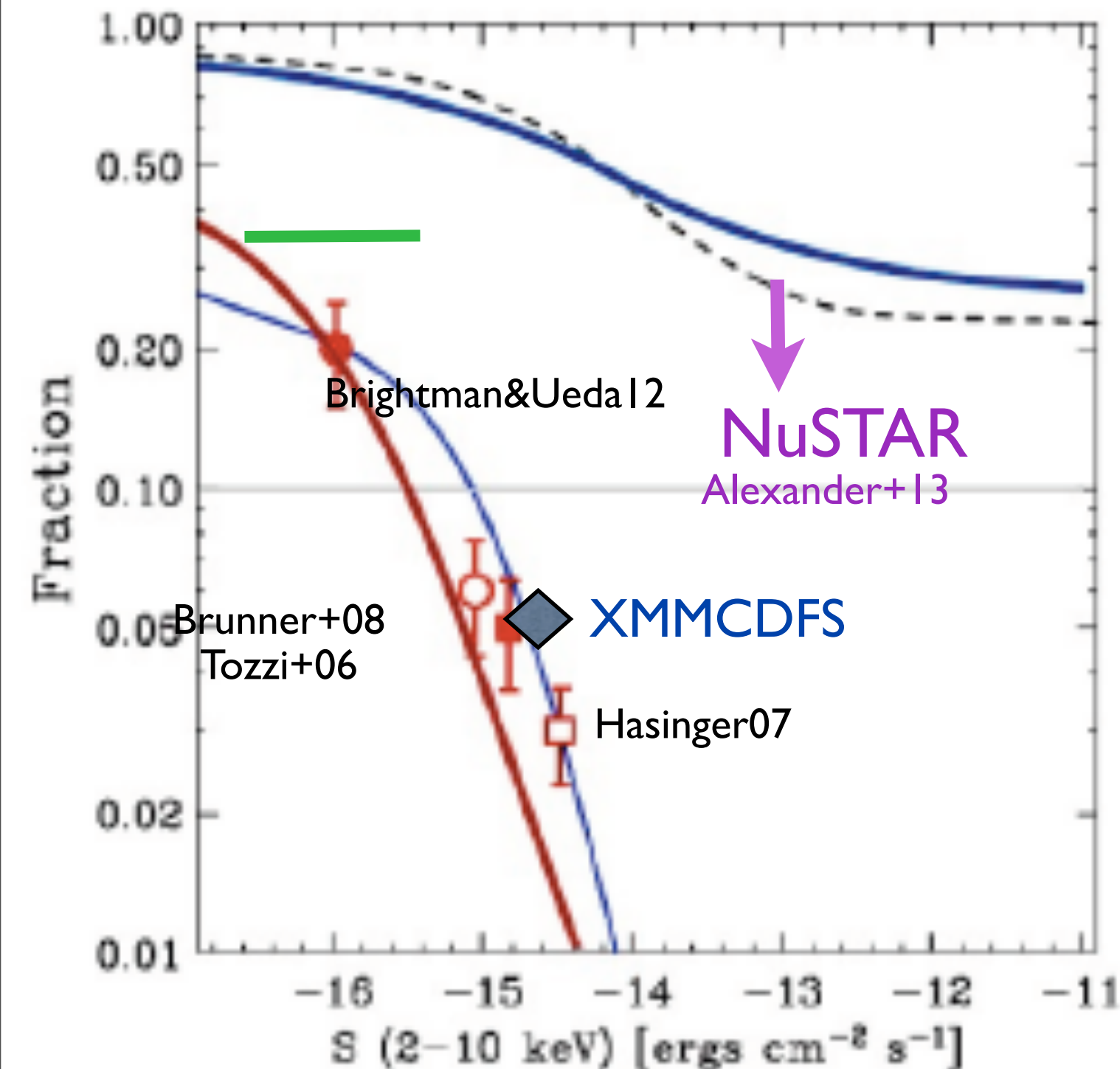
Comparisons

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

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Reflection Dominated

Compton thick Fraction



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

Ueda+ 14, GCH07, Buchner+ 15

XMM deep X-ray spectrum

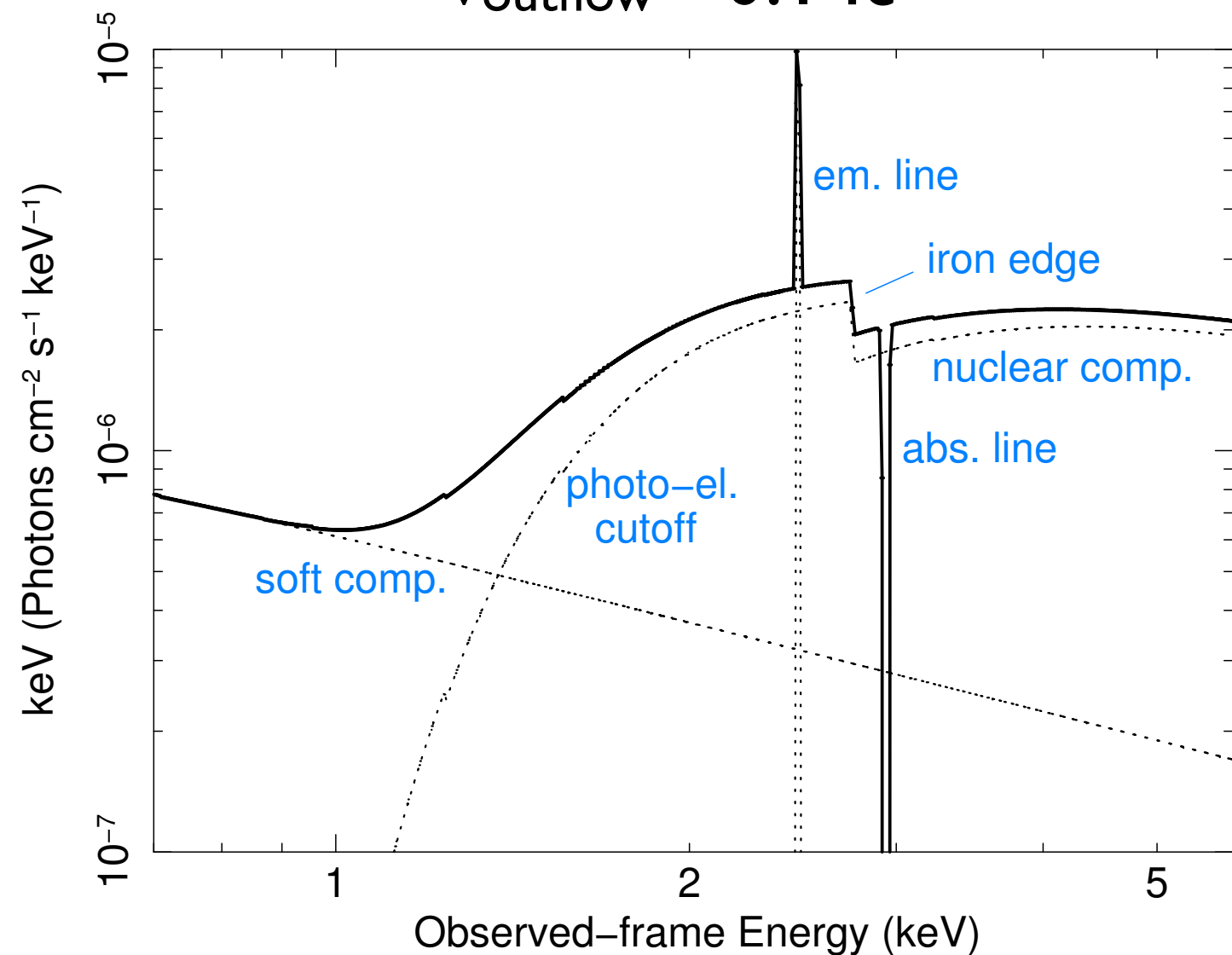
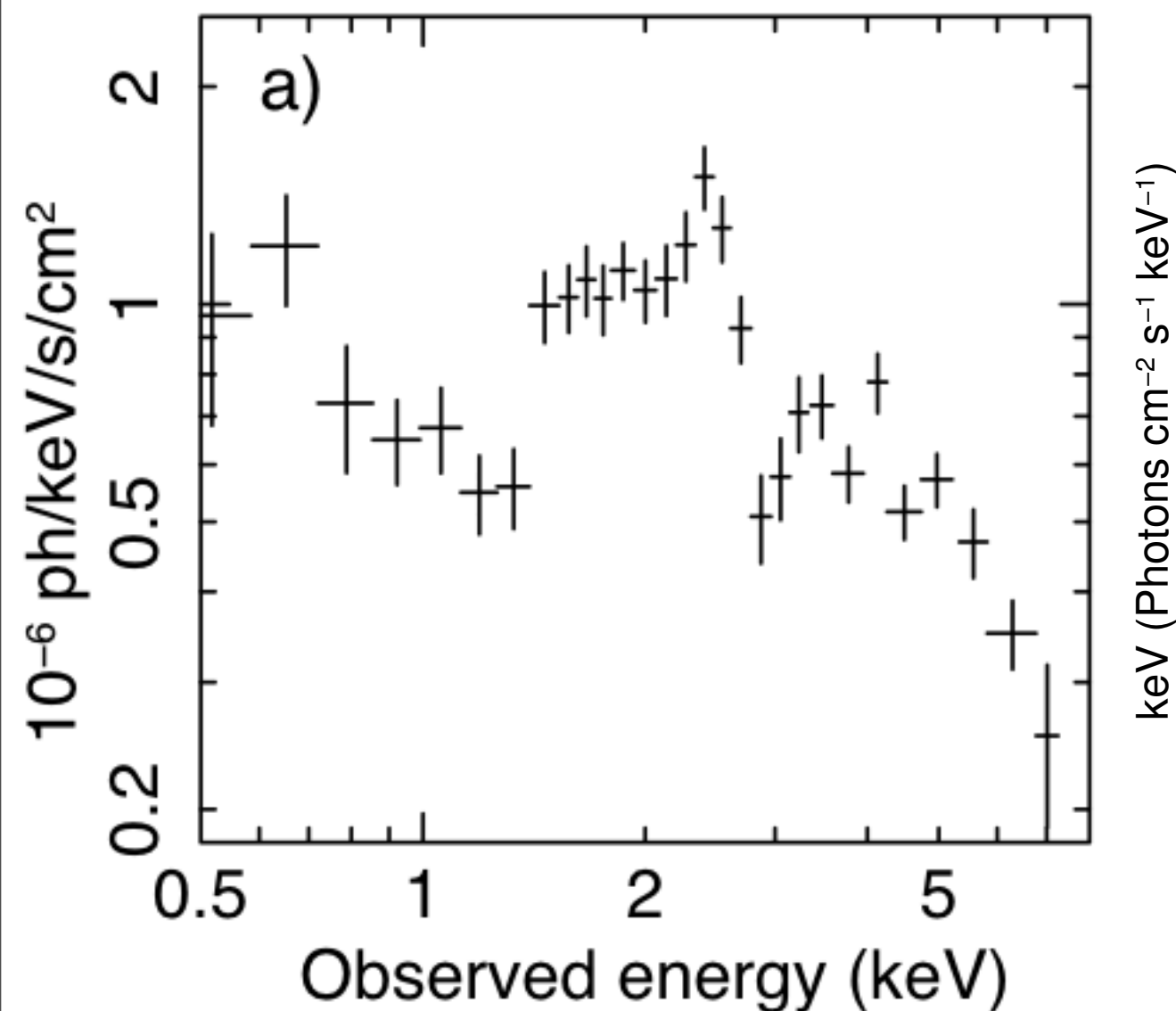
$$F_X \sim 3 \times 10^{-14} \quad L_X \sim 2 \times 10^{44} \quad N_H \sim 2-3 \times 10^{23} \text{ cm}^{-2}$$

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

Resonant FeXXV-XXVI absorption $\rightarrow$ outflow

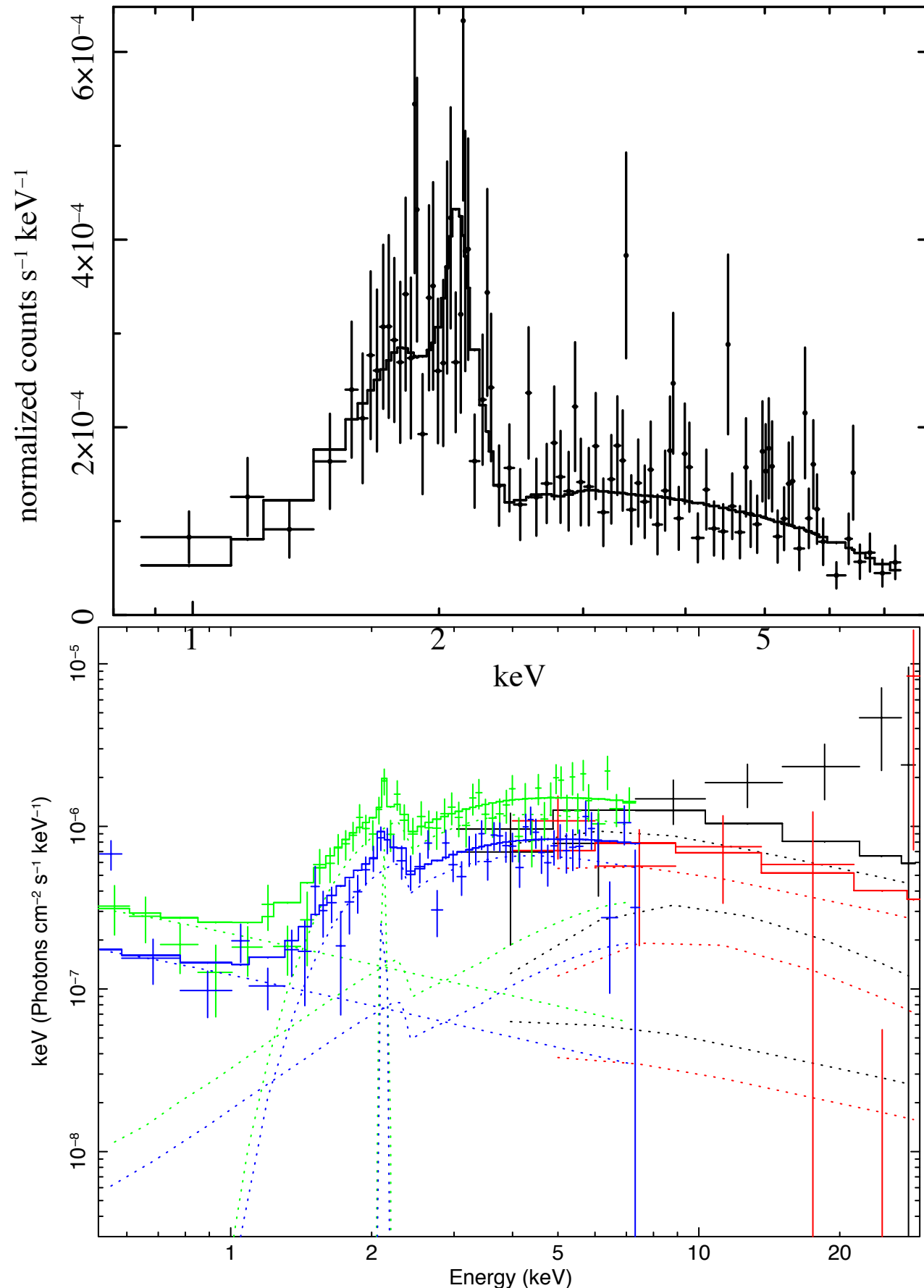
~ 700 ksec

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



Vignali+15

Redshift from the X-ray spectrum



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

$$z = 2.03 \pm 0.04$$

Georgantopoulos+13

$$F_X \sim 1.5 \times 10^{-14} \quad L_X \sim 4 \times 10^{44}$$

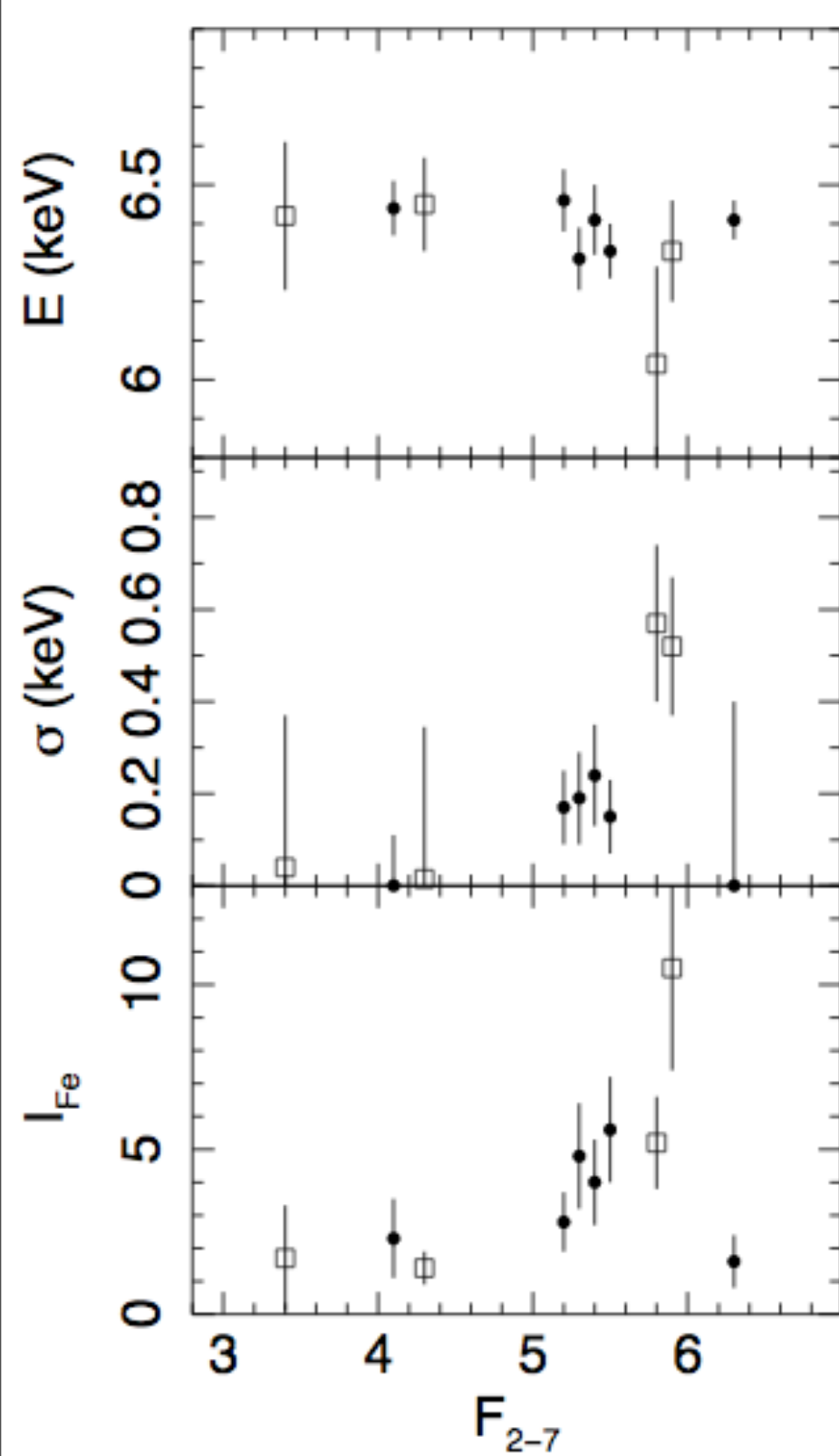
$$N_H \sim 5-6 \times 10^{23} \text{cm}^{-2}$$

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

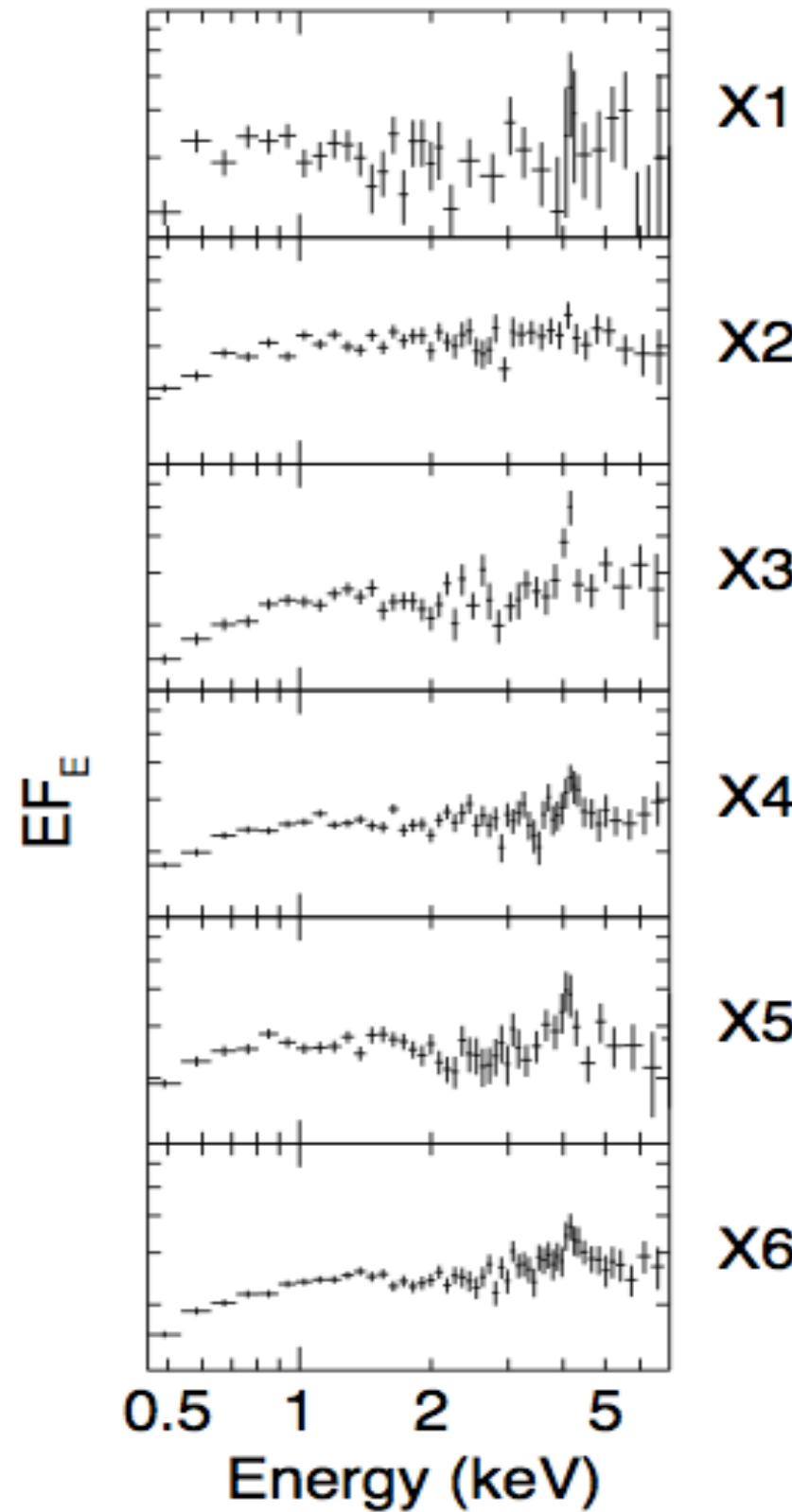
The most distant AGN
detected above 10 keV

Del Moro+14

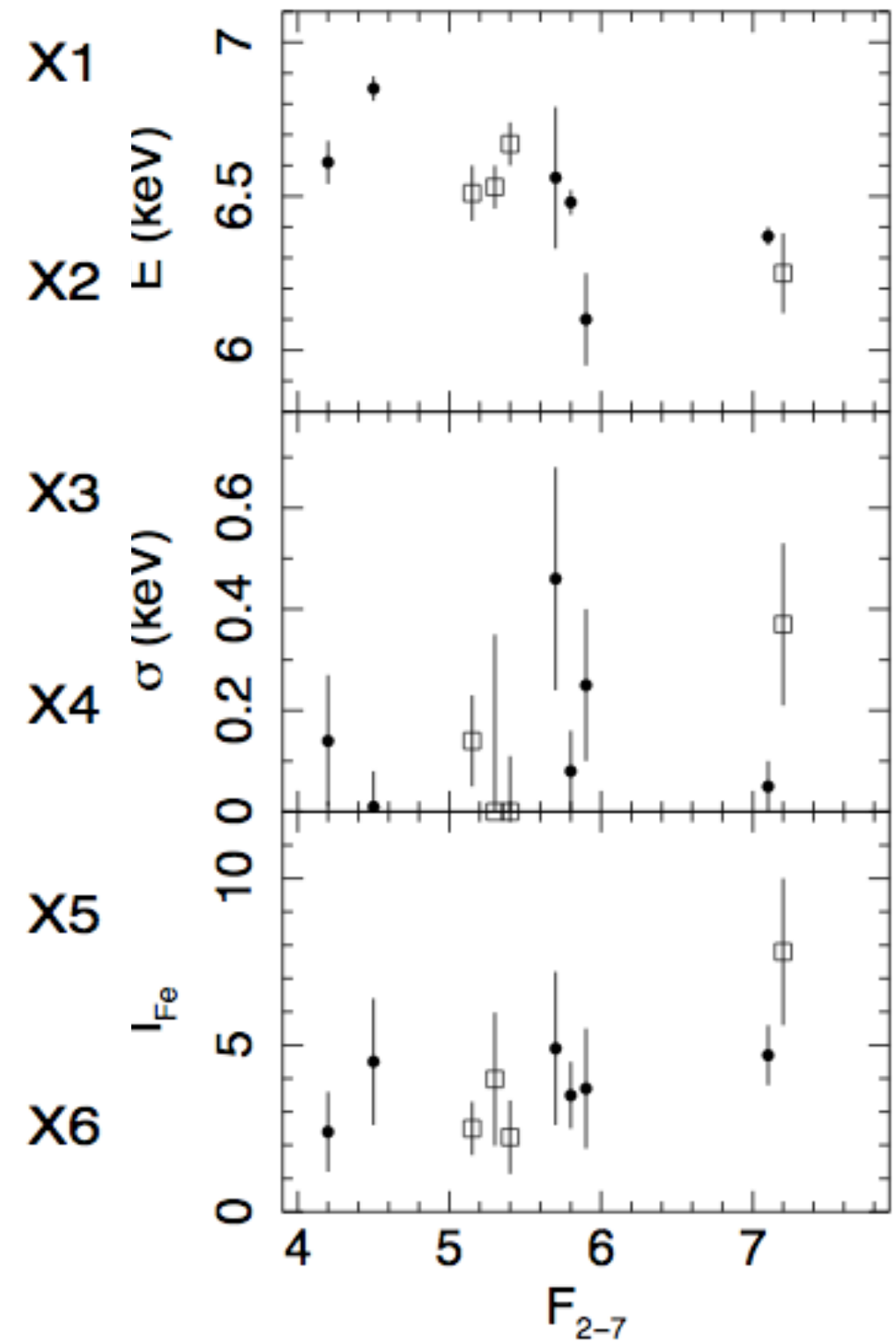
Brightest sources iron line variability



$z=0.544$

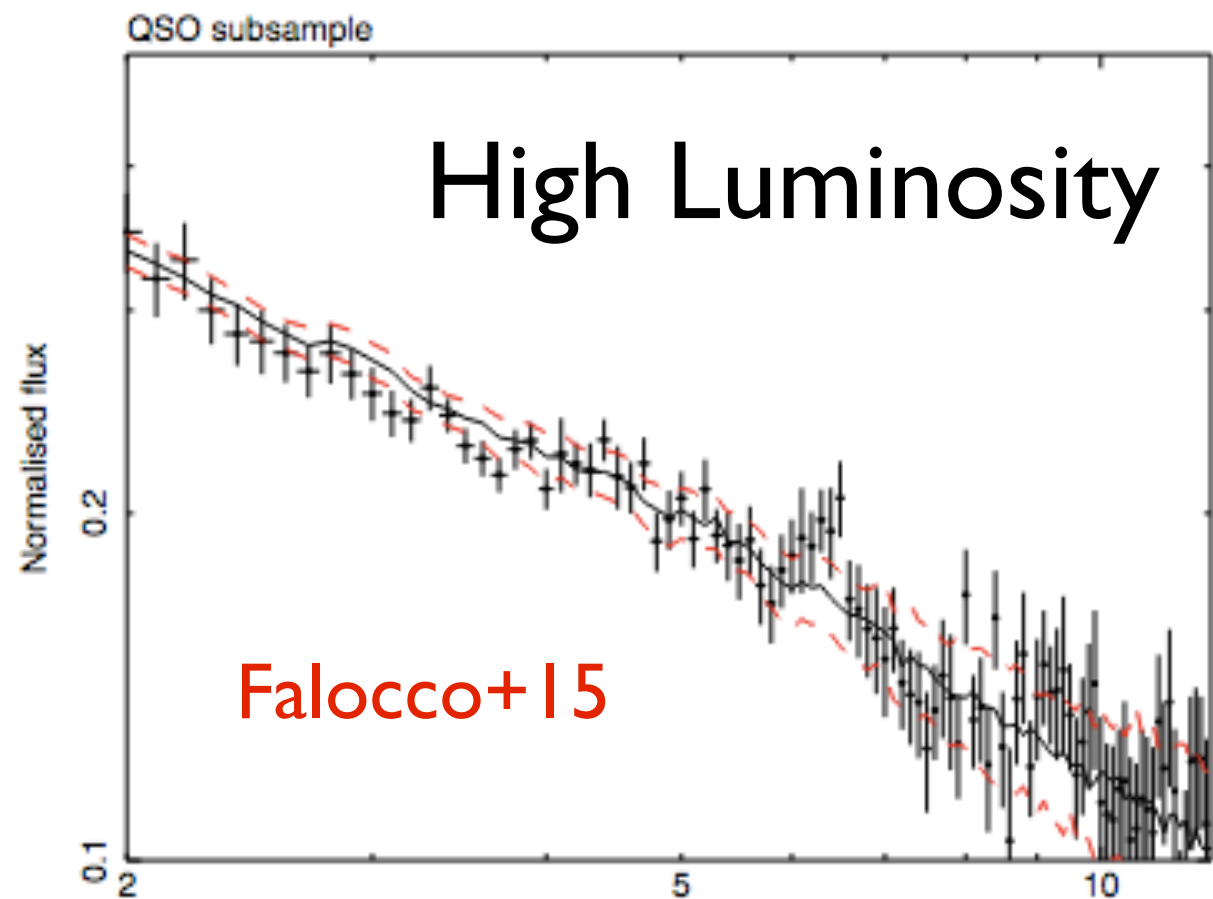
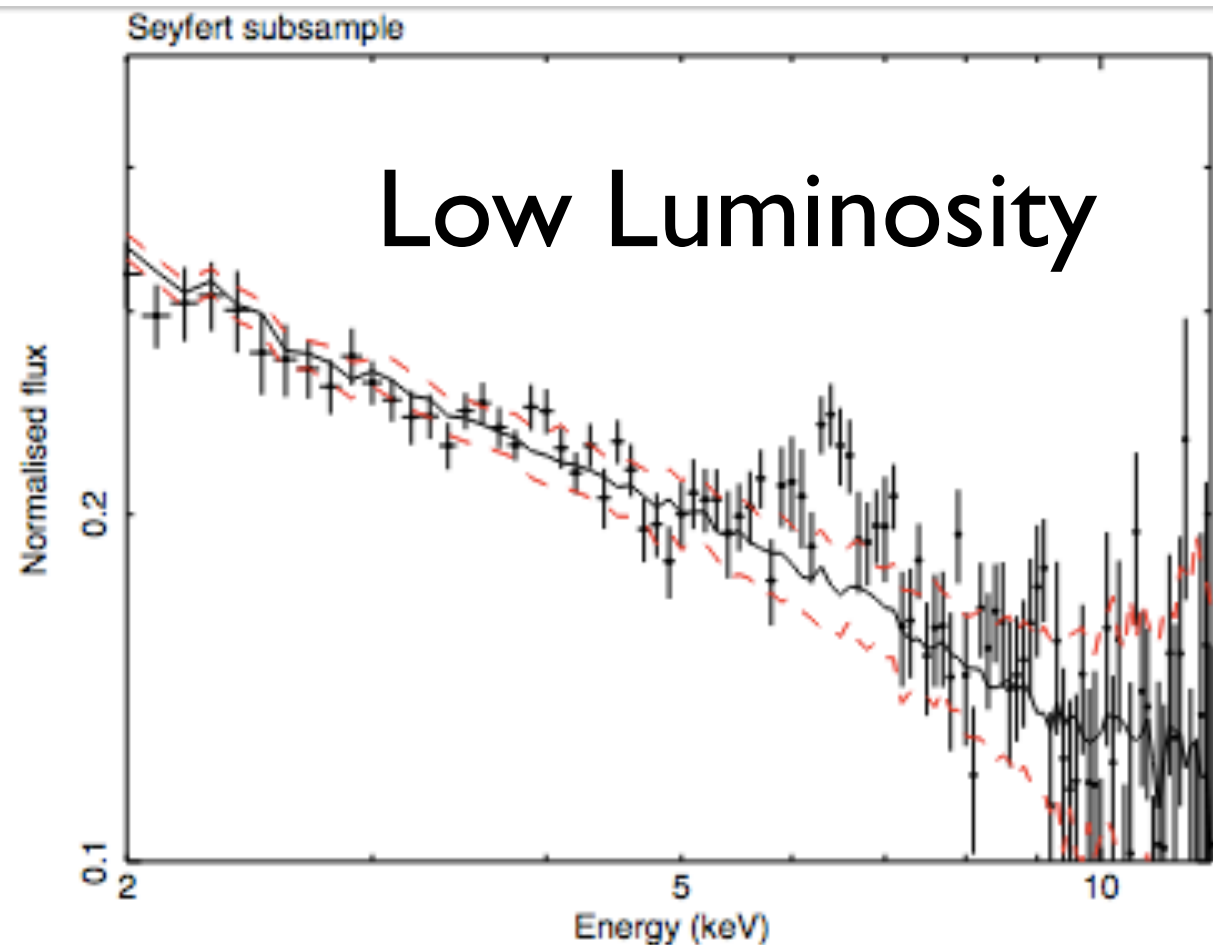


Iwasawa+15



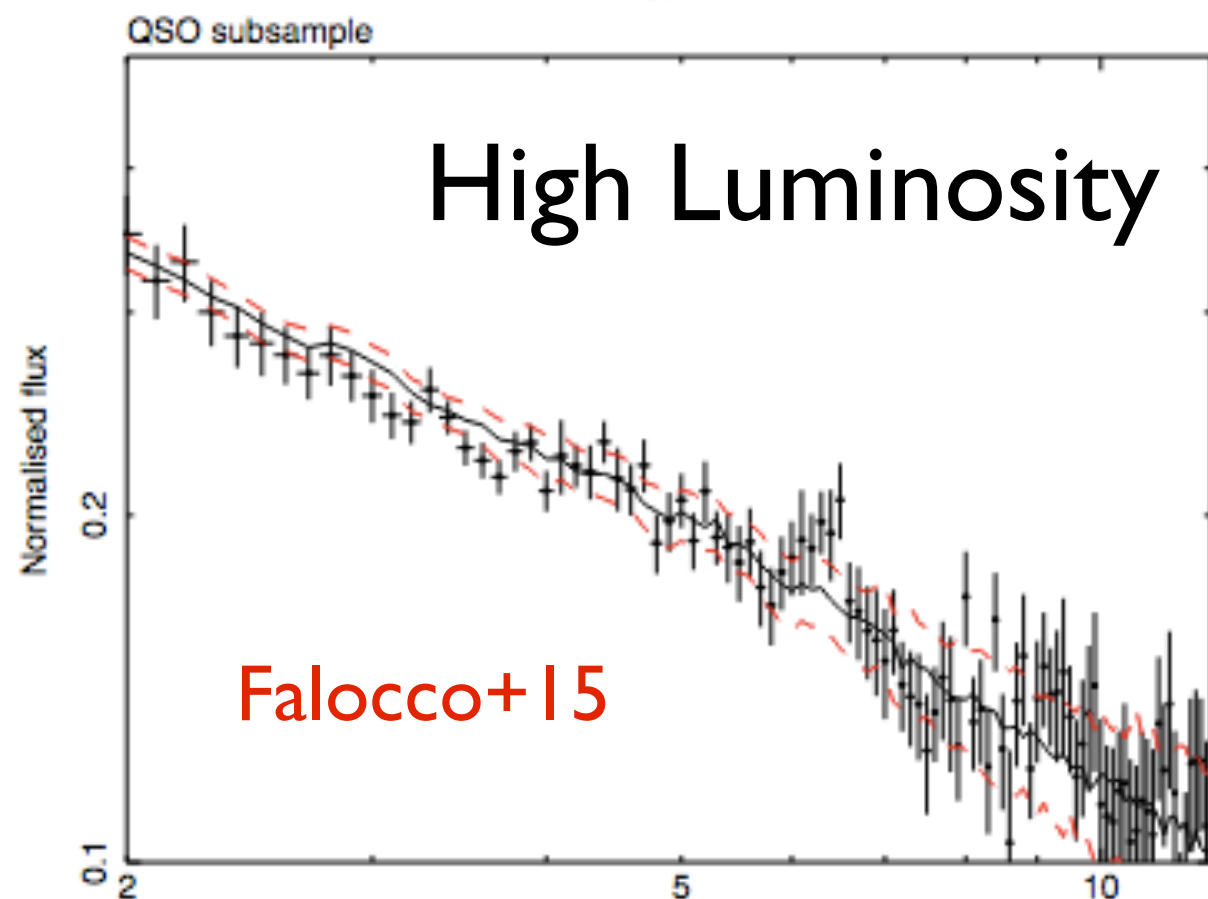
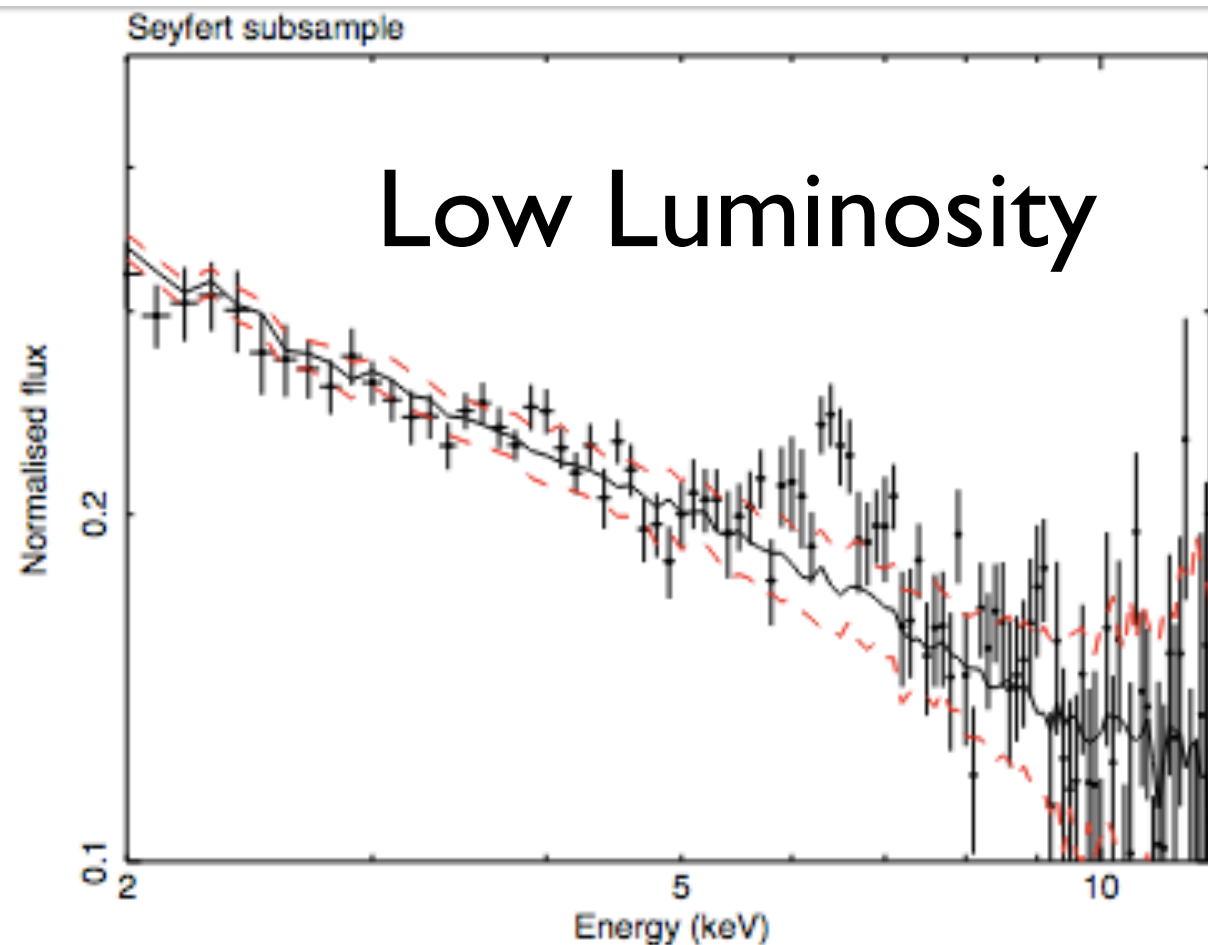
$z=0.742$

Iron line profile



“Tentative” evidence
of a broad component
cfr. Brusa+05
Chaudary+12
and many others

Iron line profile



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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&Walter 16, 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.