Osservatorio Astronomico di Bologna
Istituto Nazionale di Astrofisica

UMBC
AN HONORS UNIVERSITY IN MARYLAND

X-ray surveys

High-z Black Holes (to be) revealed

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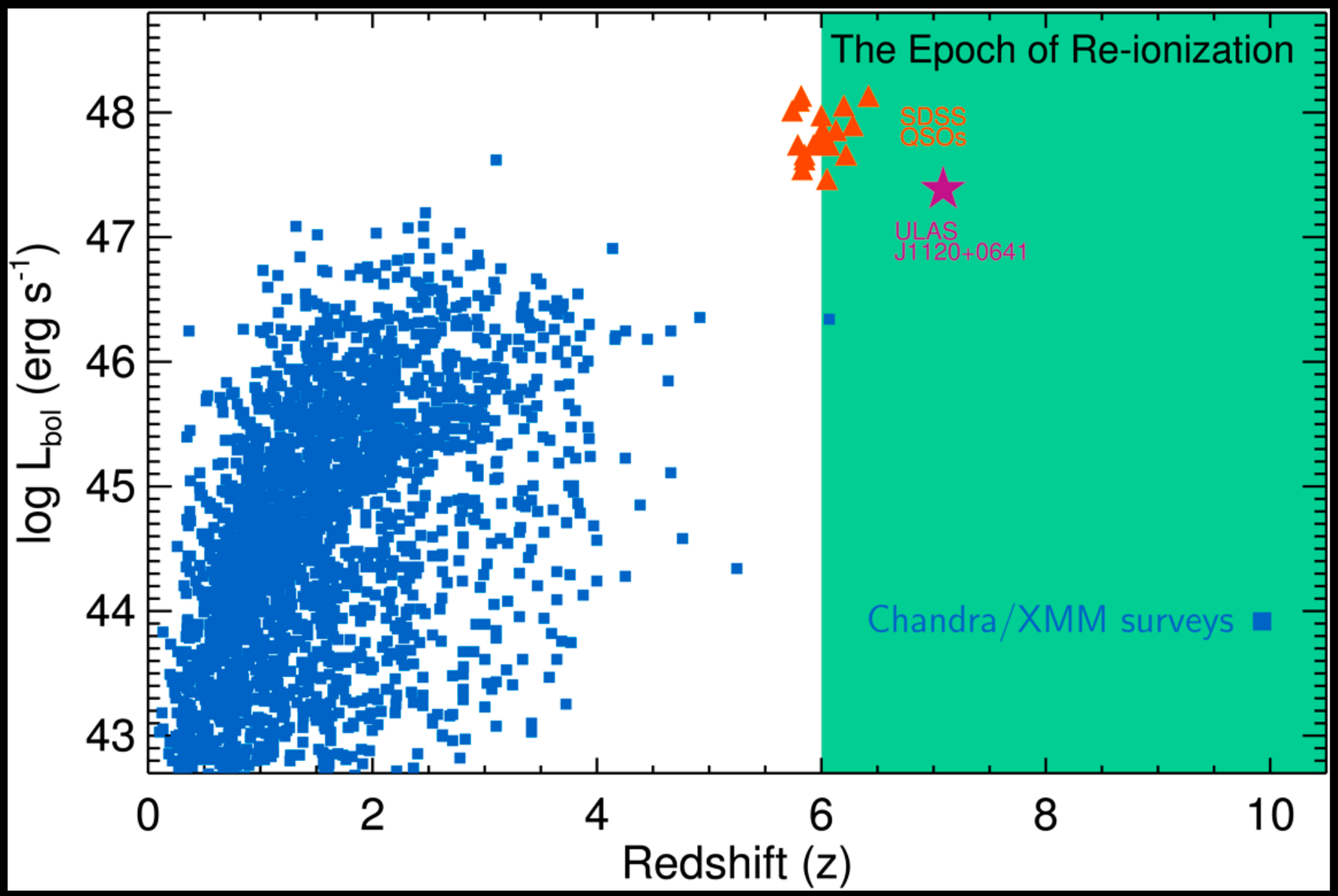
Scientific Drivers

How and when do the seeds of the first BHs form ?

What physical processes drive the initial growth of massive BH in the early Universe?

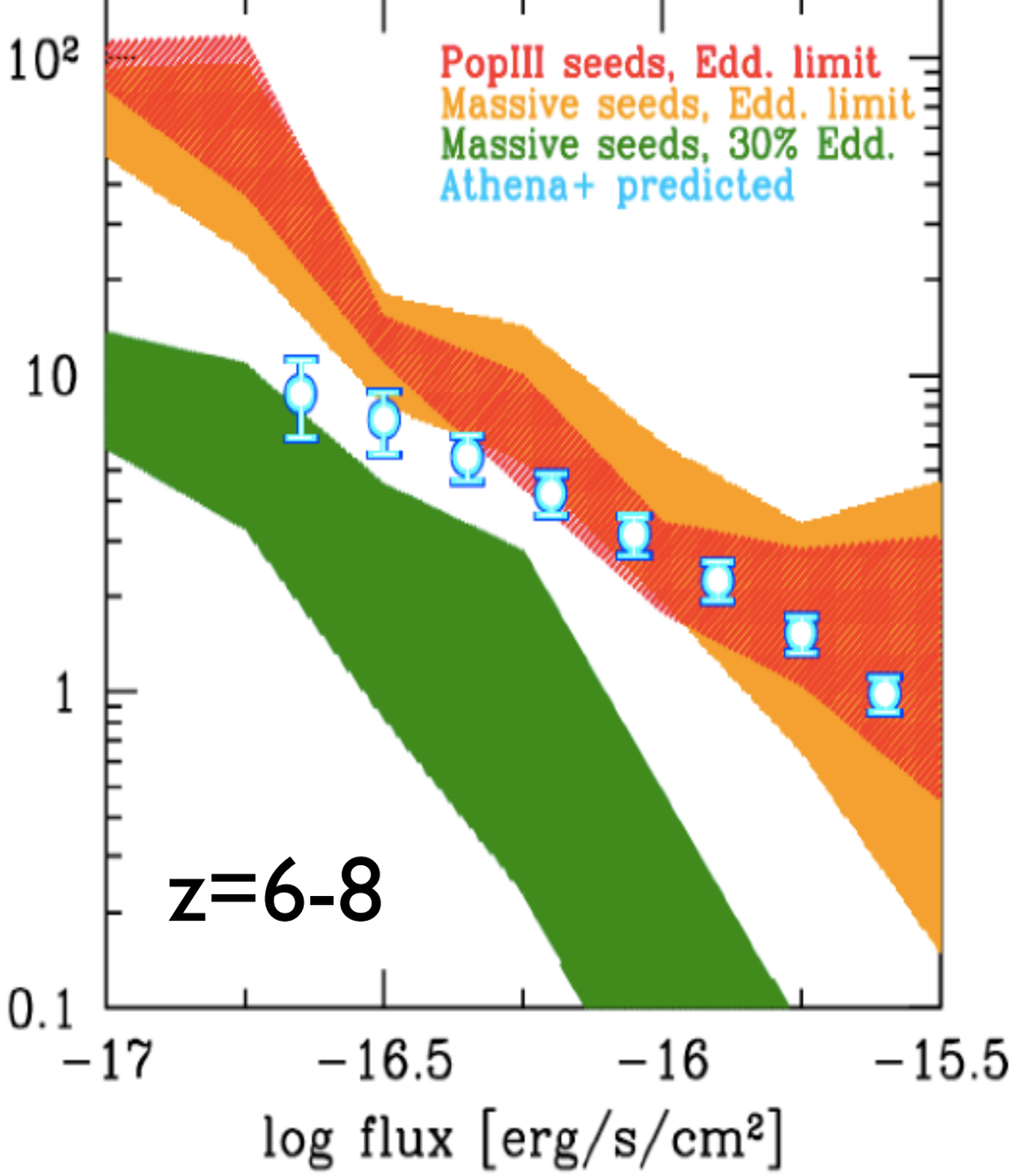
How to search early BHs seeds?

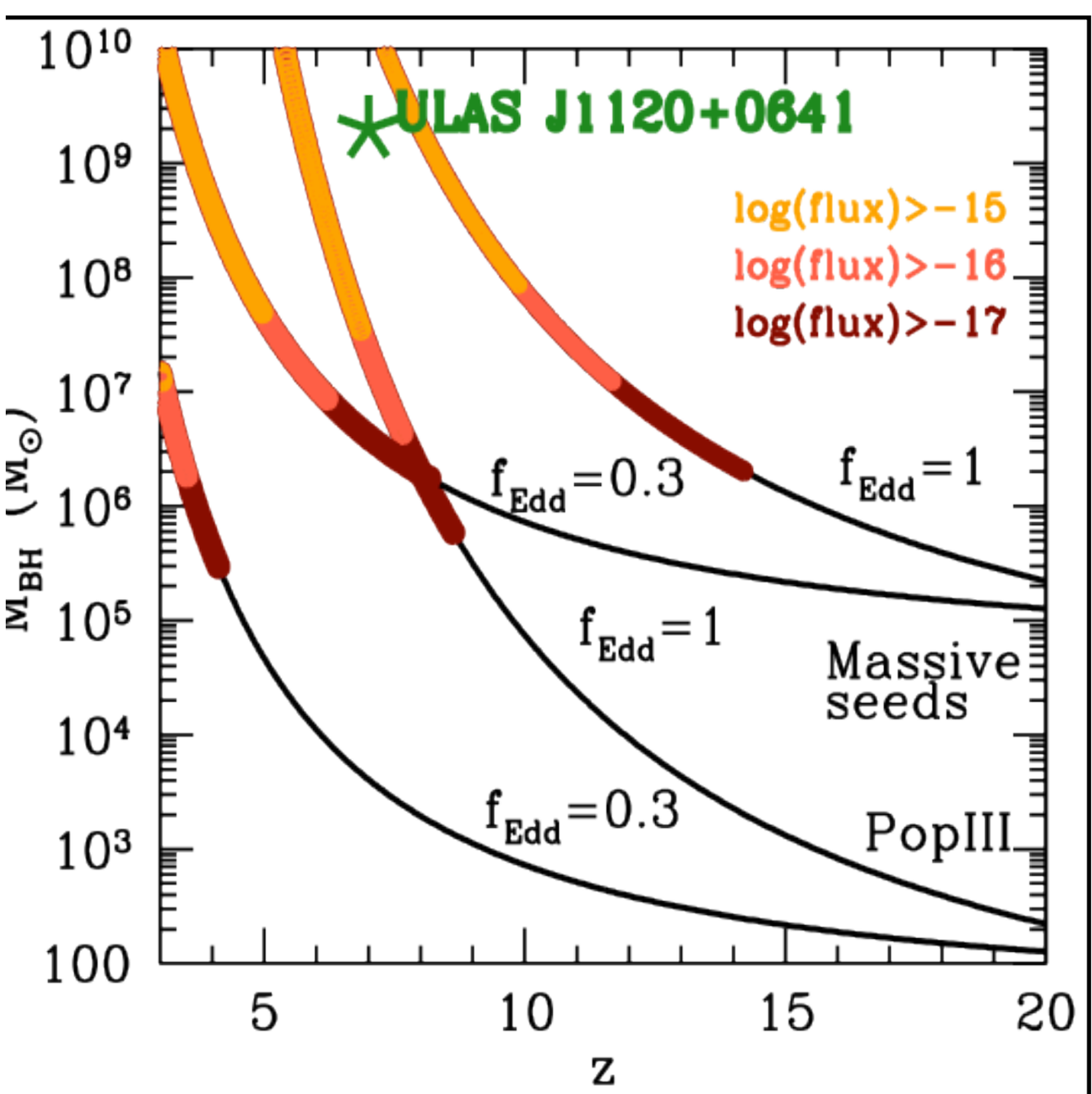
Probing black hole and galaxy growth during the epoch of re-ionization



Wide field NIR surveys are probing the bright, massive tail of the LF/MF

Need X-rays to get obscured and dominant population

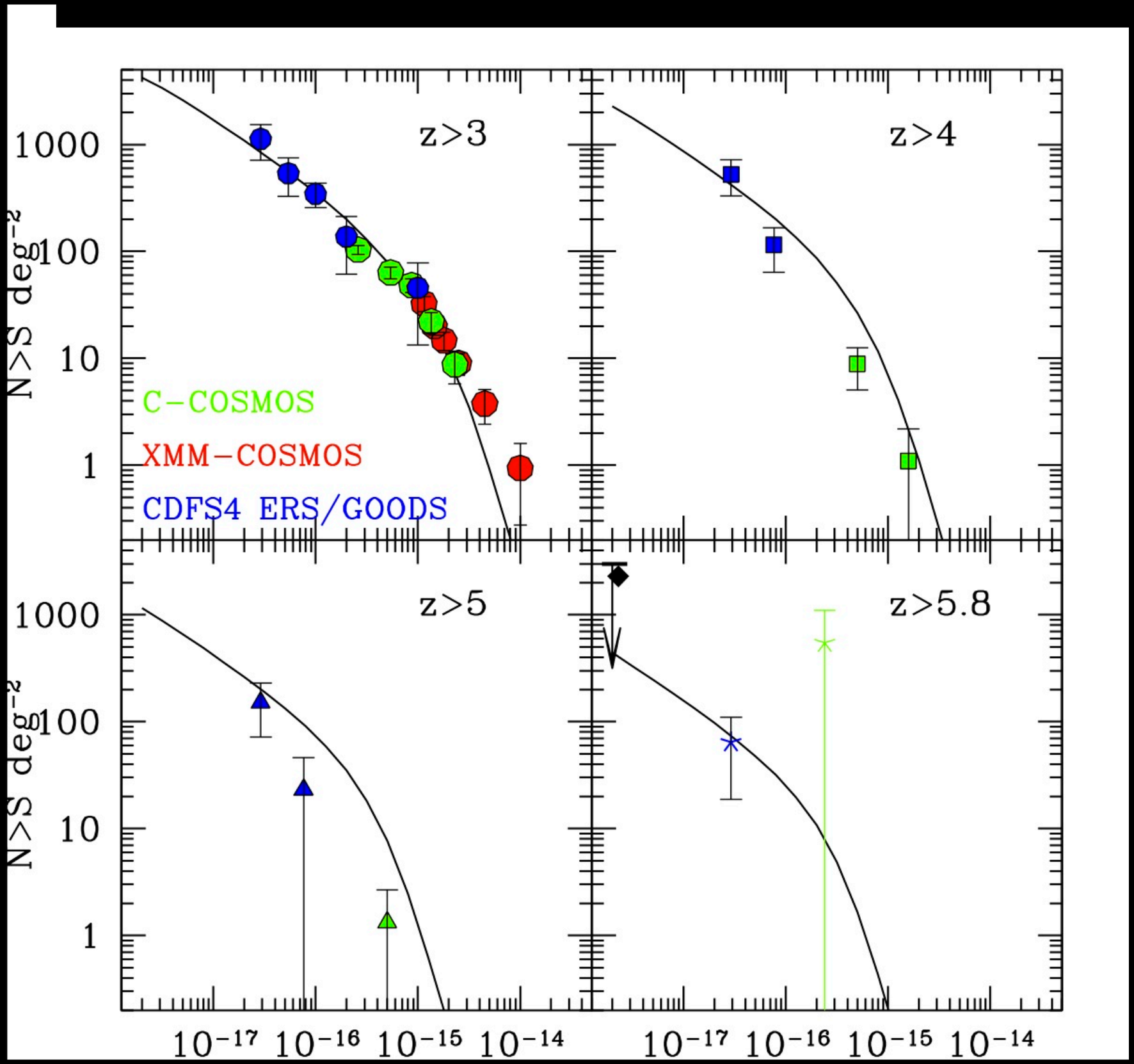




credit: M. Volonteri

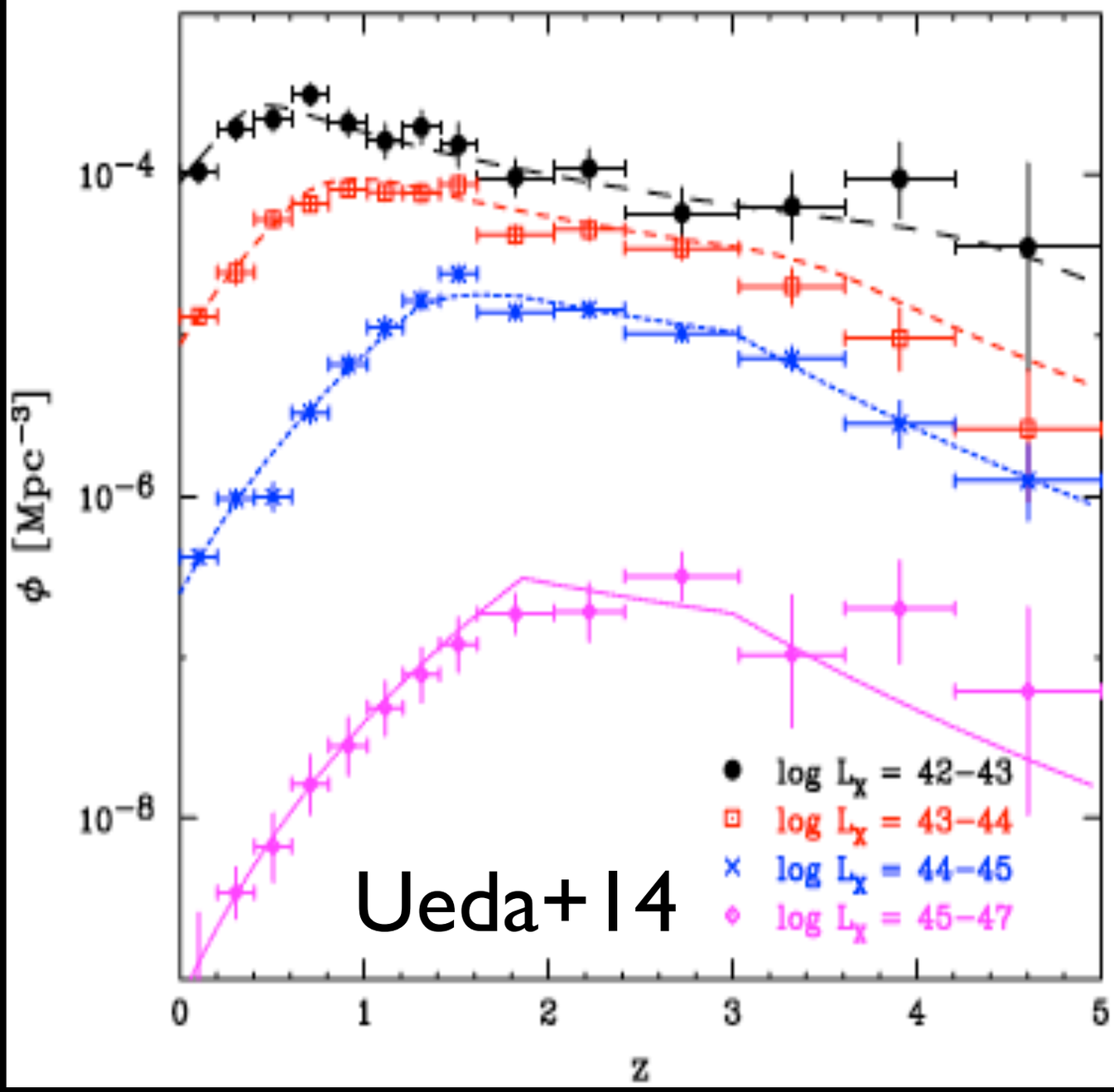
$\log L_{2\text{-}10\ keV} \sim 43$ - 43.5 need tens of square degrees to achieve a statistic good enough for XLF/Clustering studies

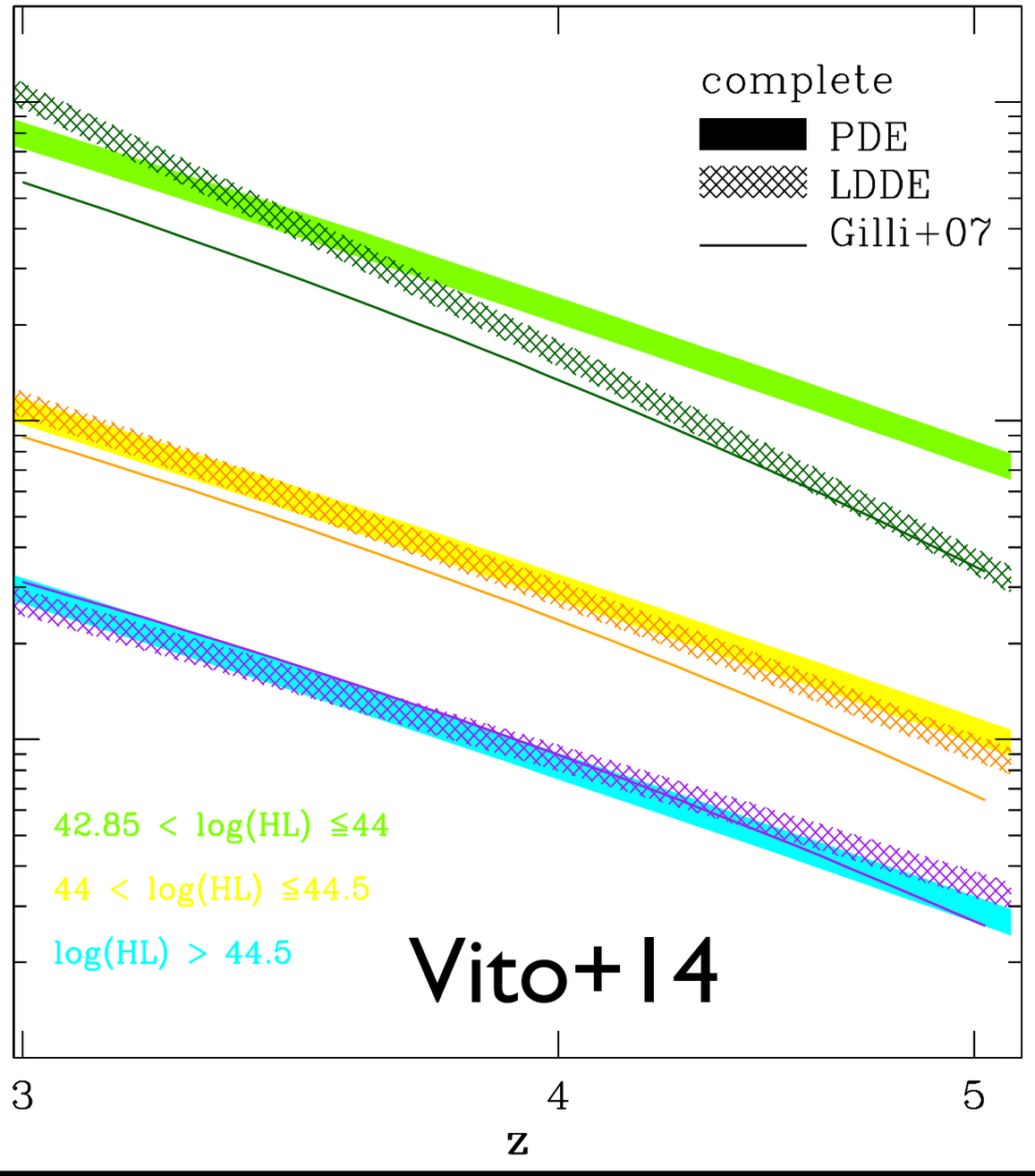
Source Counts II



At z > 4 and higher the number of X-ray "detected" AGN is very low (Vito+14)

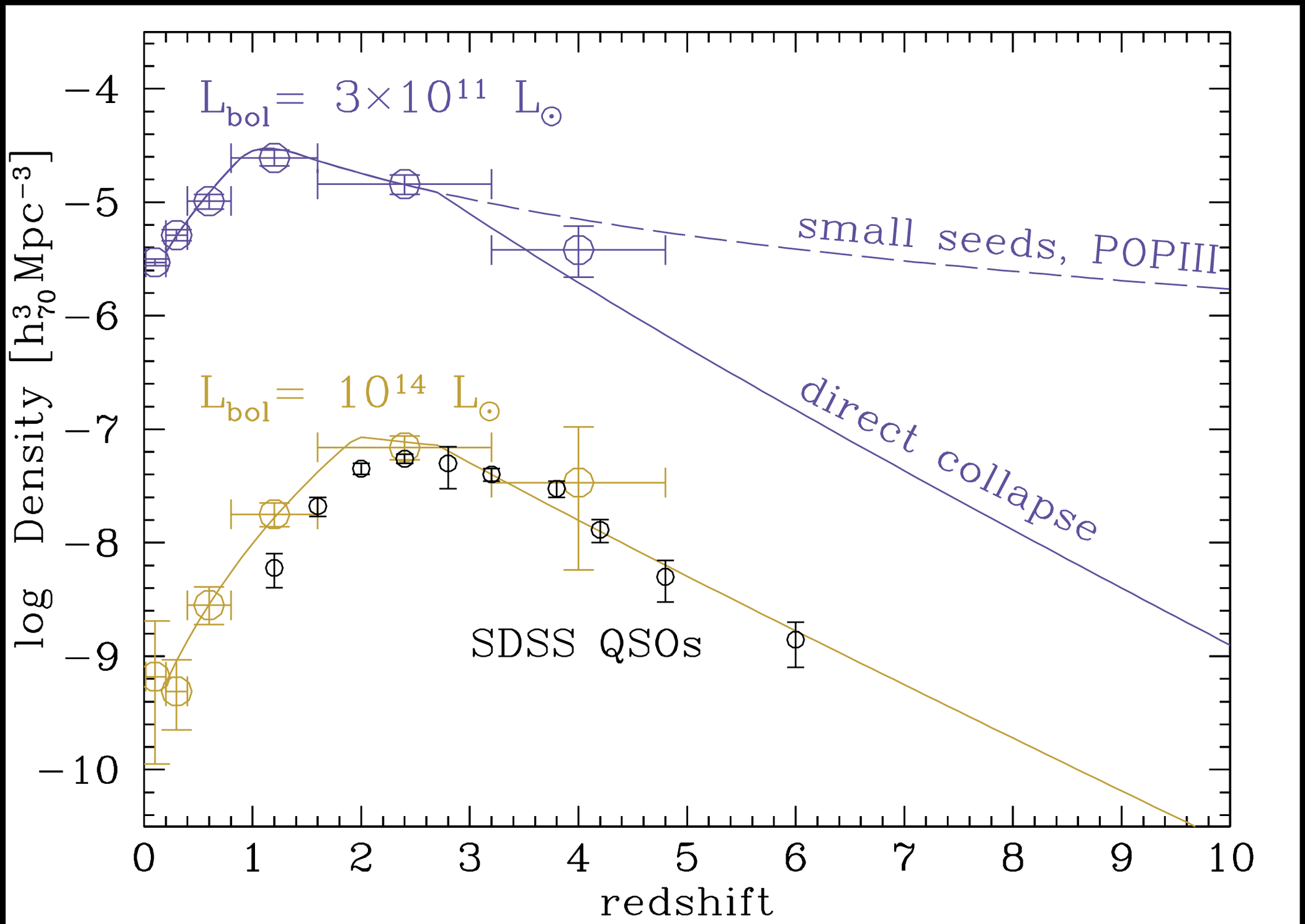
Luminosity Function





Downsizing= peak shifts towards low-z at low L

Anti-downsizing=flattening of the low L slope at high-z



Big circles are for soft X-ray selected AGN Hasinger et al. (2005), small circles are for SDSS QSOs (Richards et al. 2006) assuming the bolometric corrections of Marconi et al (2004).

Some numbers

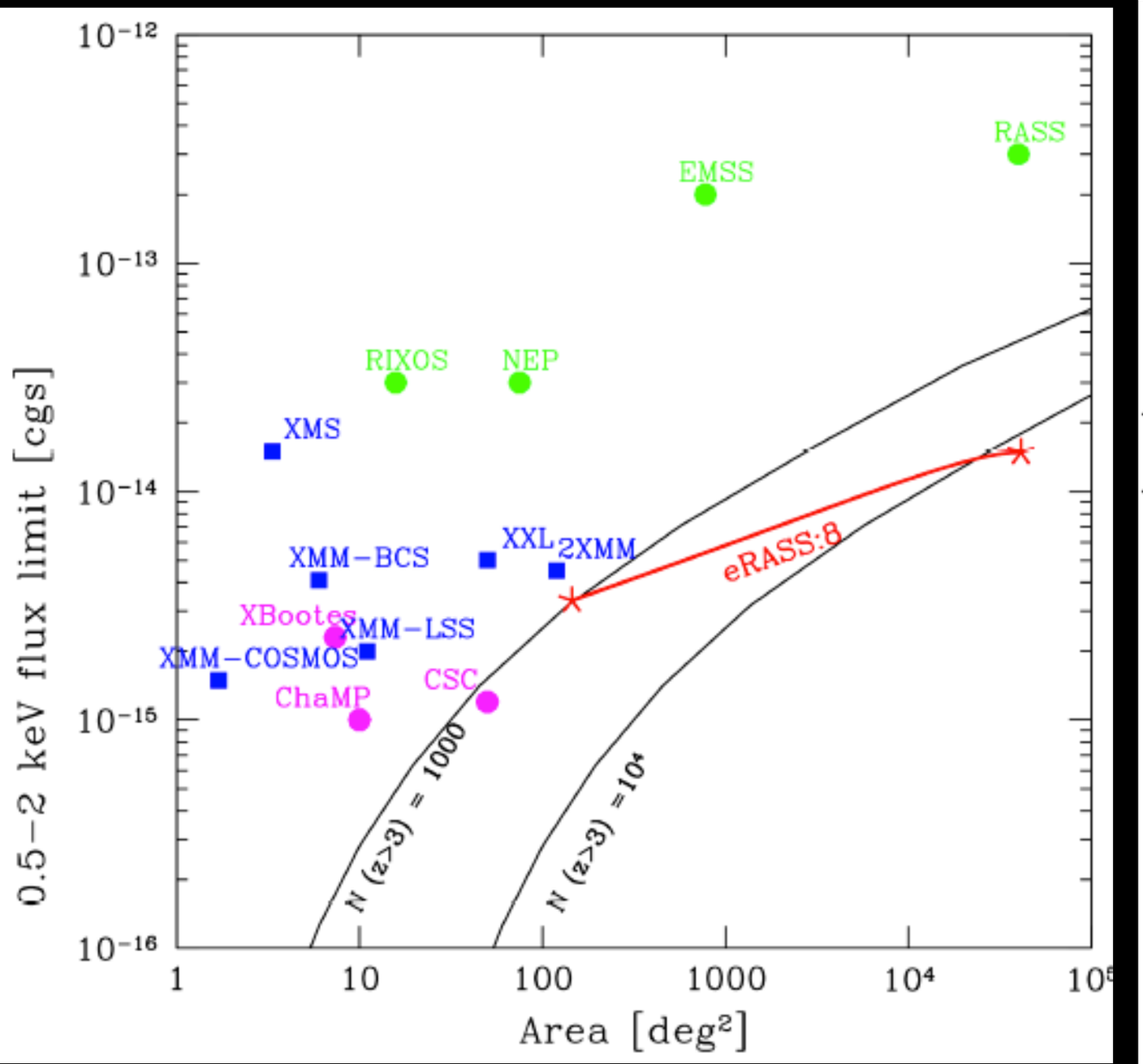
Present: CDFS 4 Msec, CDFN 2 Msec, EGS 3Msec,
COSMOS 1.8Msec
Coming Soon: CDFS 3 (Tot 7 Msec) COSMOS 2.8 (Tot 4.5)
XMM XXL & Stripe 82 (50 + 25 sq degrees high-L)

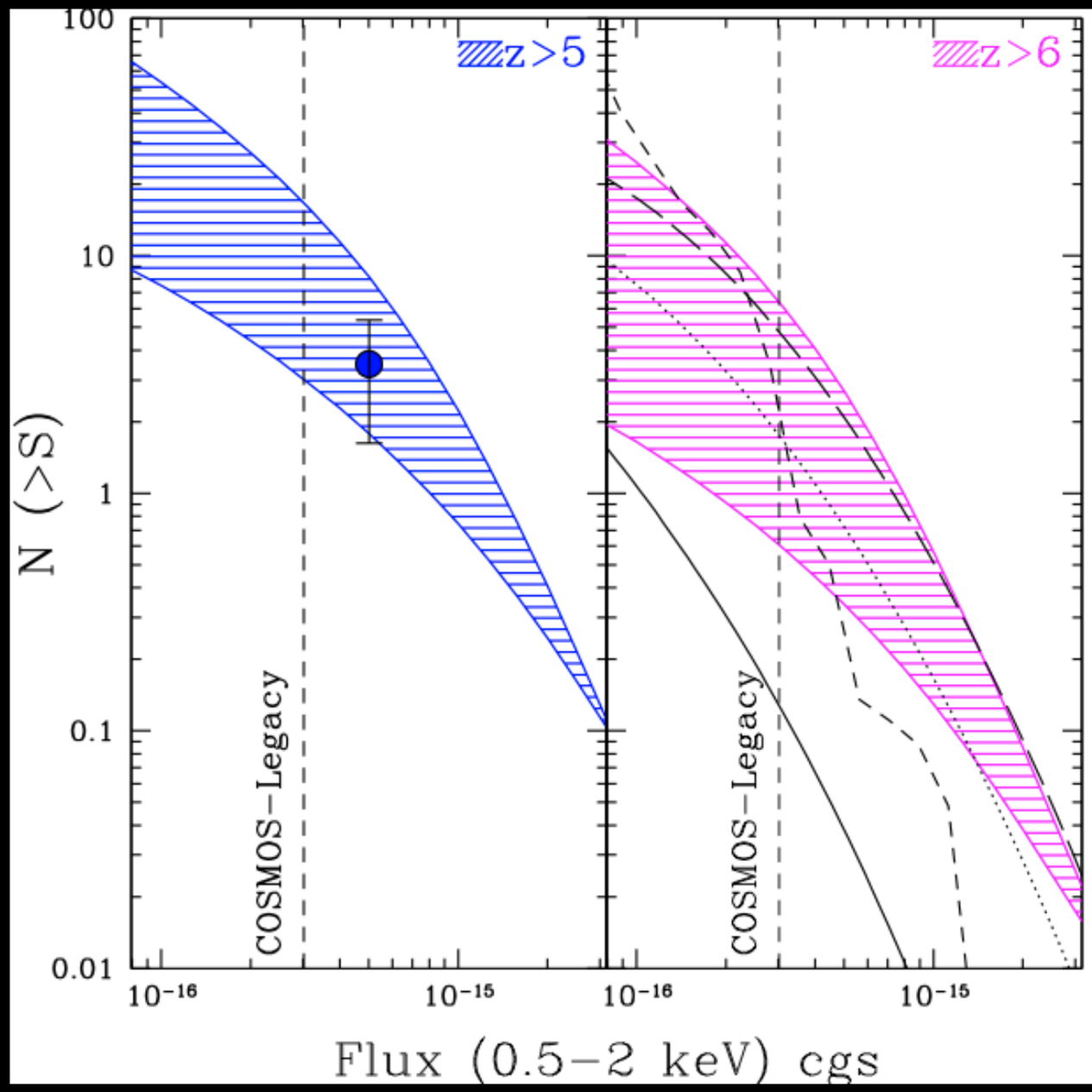
Some 20-30 Msec of Chandra & XMM

N	z
250	>3
30-40	4-5
10-15	5-6
3-5	>6 (no spec-z)

Further Chandra & XMM surveys?
May be some fine tuning of depth vs area
plus extensive use of priors is needed (ASTRODEEP)

“Near” future X-ray surveys

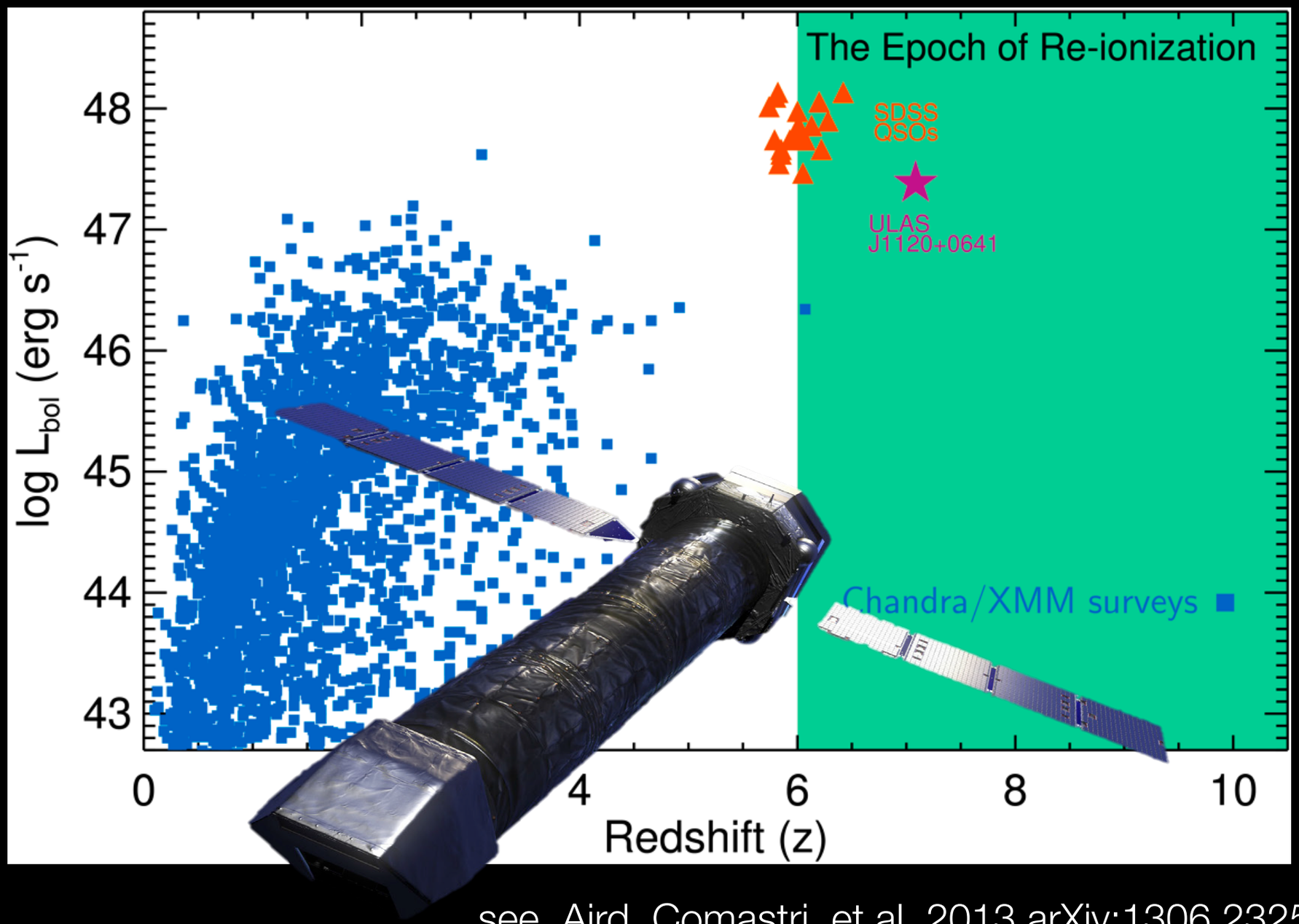




Identification of z>3 and z>6 QSOs among the few million eROSITA AGN is not trivial at all!
~ 40 z>6 bright QSO expected

High-z (> 6) predictions are uncertain
COSMOS Legacy Survey (PI F. Civano) is expected to give a first hint

Probing black hole and galaxy growth during the epoch of re-ionization



see Aird, Comastri, et al. 2013 arXiv:1306.2325
Nandra, Barret, et al. 2013 arXIv:1306.2307
http://www.the-athena-x-ray-observatory.eu/

Athena

Europe's Next Generation X-ray Observatory
ESA mission since June 27, 2014

- $2m^2$ collecting area
- Wide Field Imager with 40x40 arcmin field-of-view
- 5" PSF over large fraction of field-of-view
- L2 mission (2028 launch)

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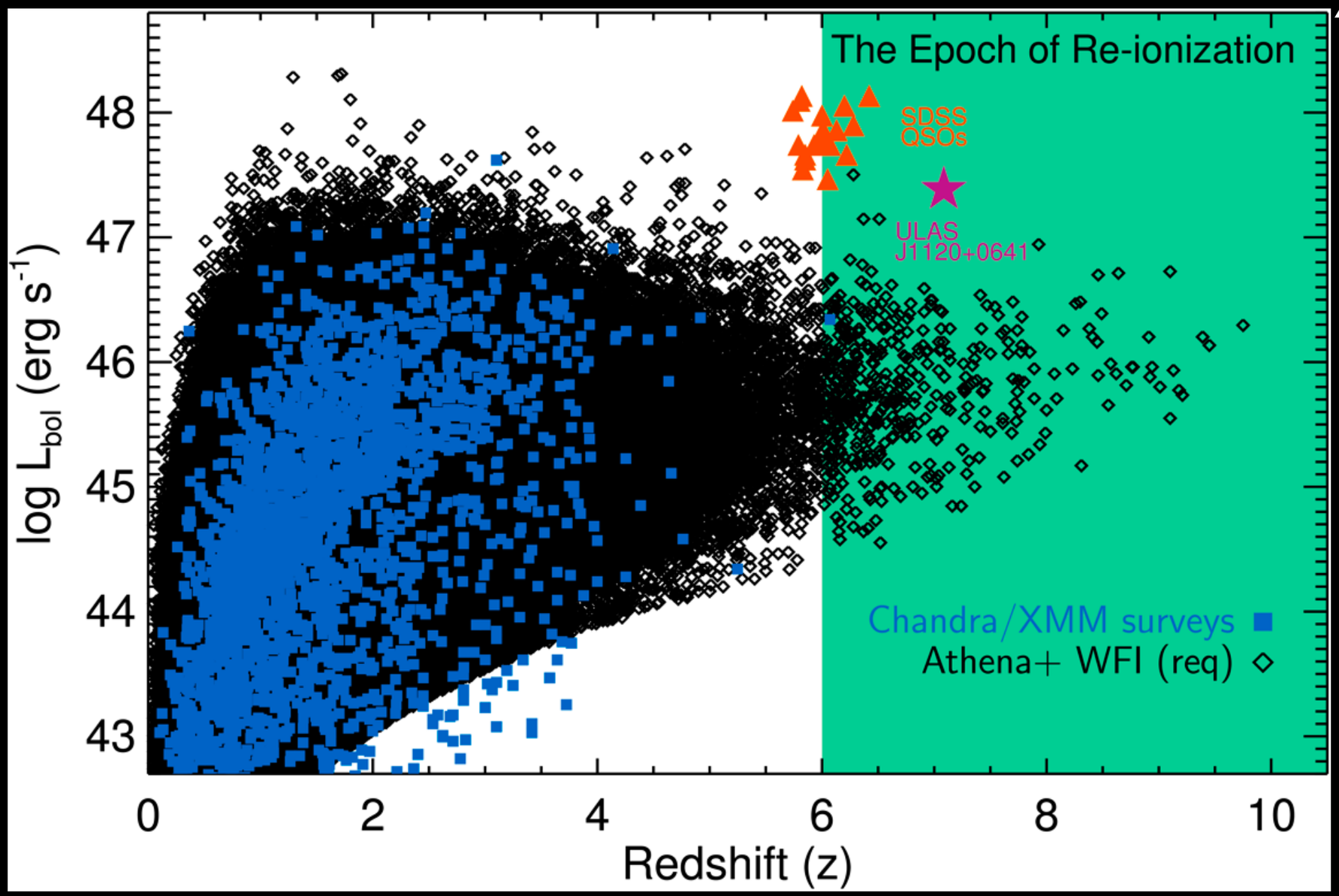

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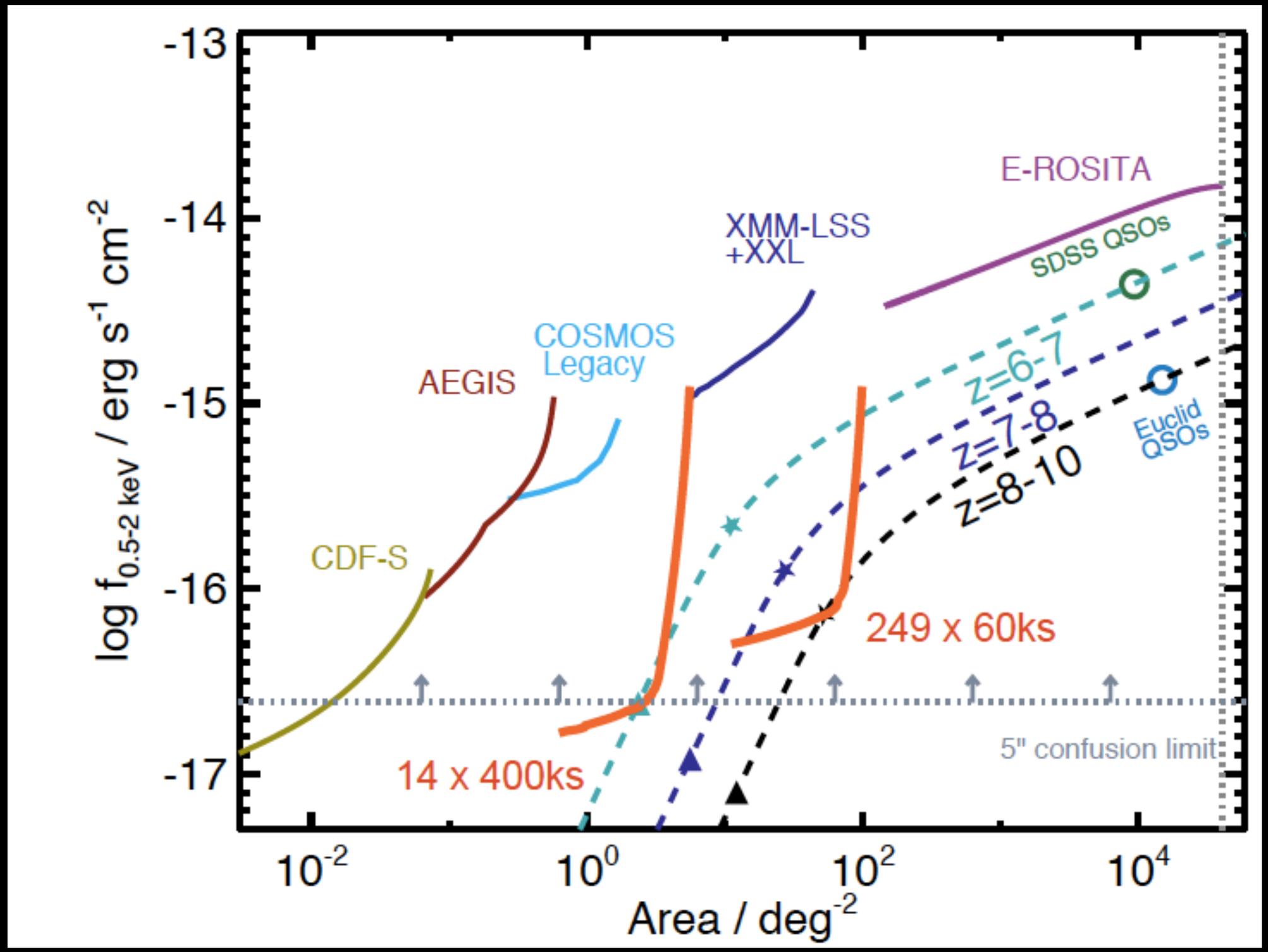
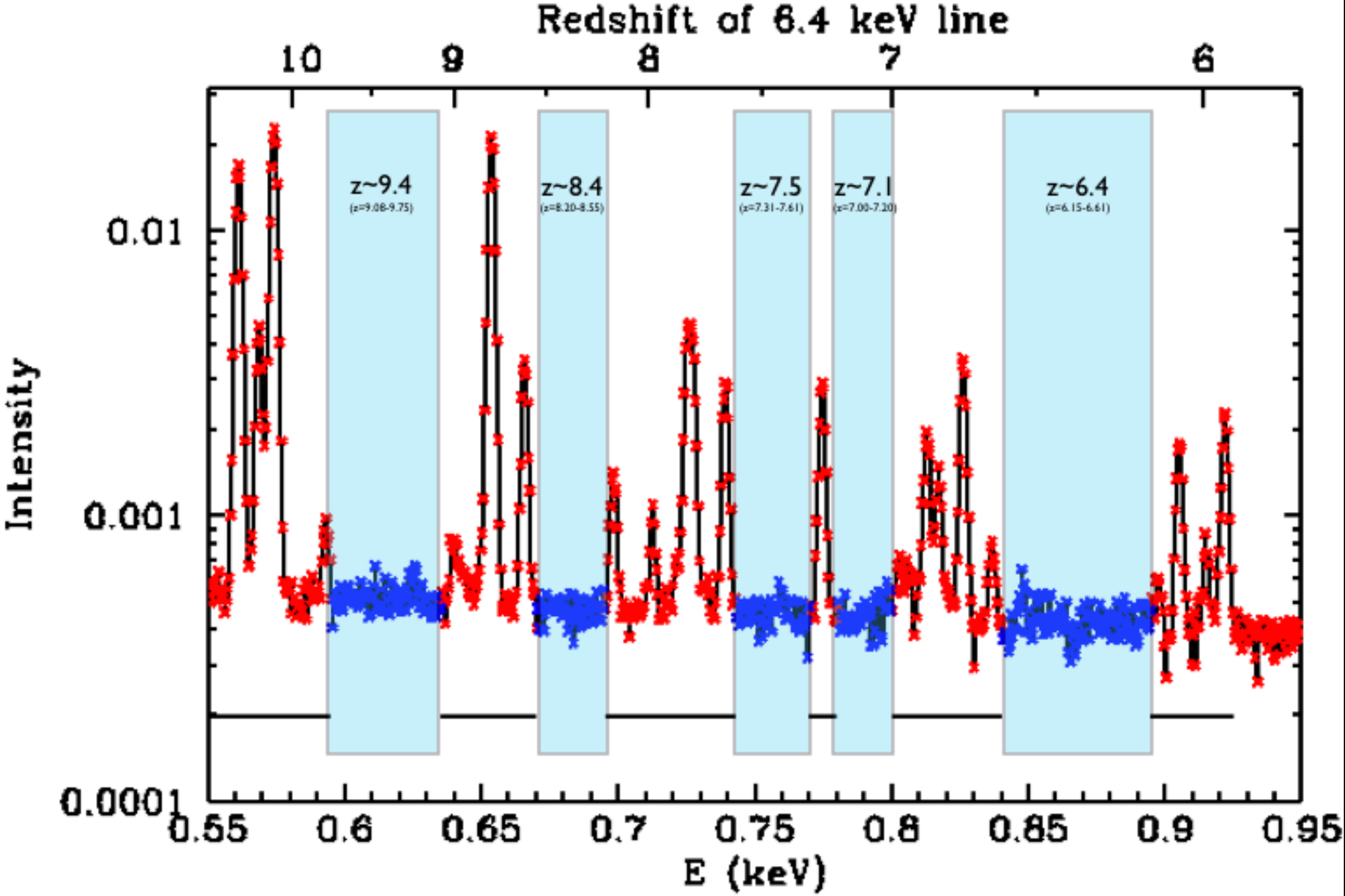
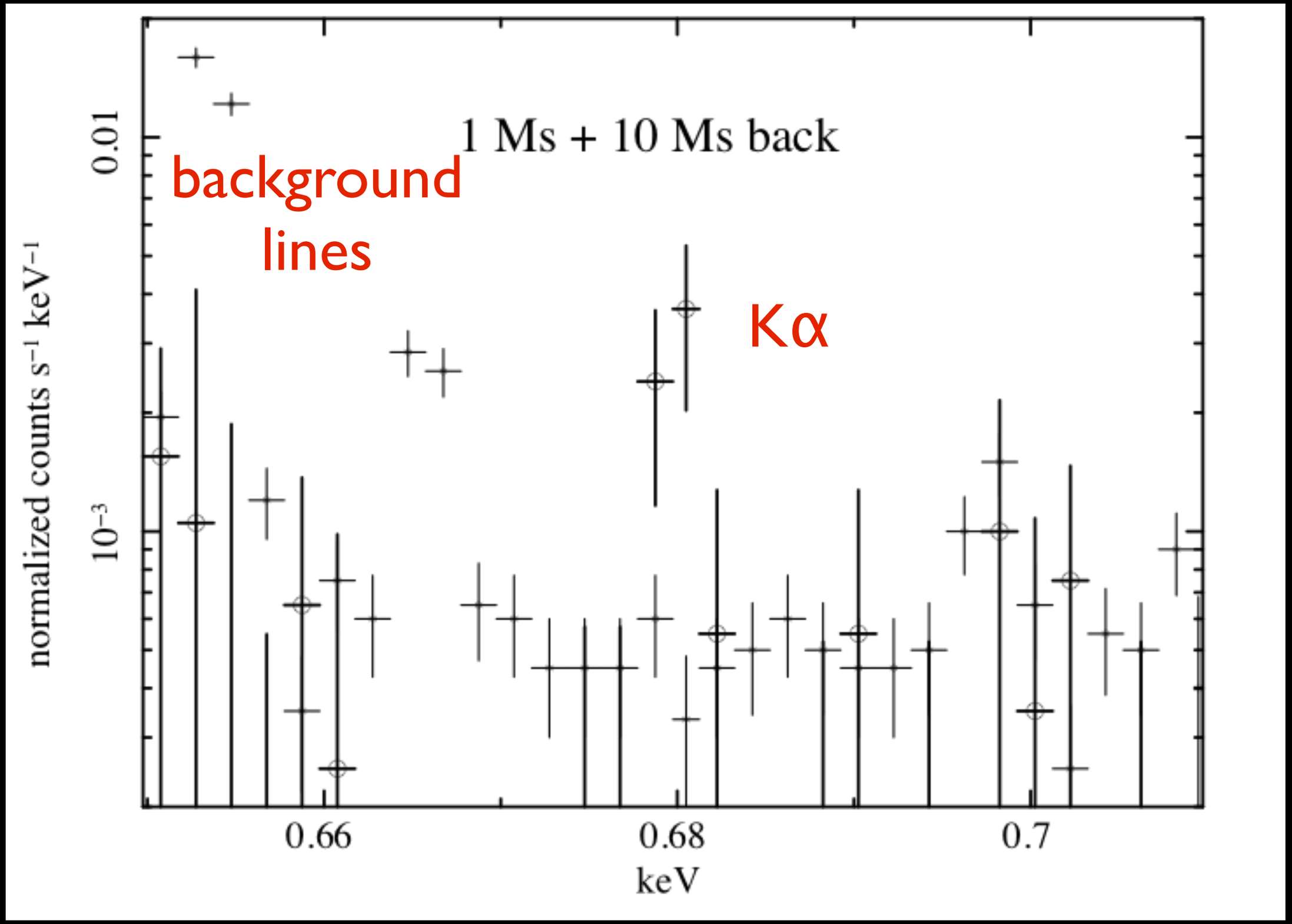


10 z>6 logLx ~ 43 & 10 z>8 logLx~44

~ 400 AGN at z > 6 (need > 25 Msec)


Redshift of 6.4 keV line
10
9
8
7
6
z~9.4
(z=9.08-9.75)
z~8.4
(z=8.20-8.55)
z~7.5
(z=7.31-7.61)
z~7.1
(z=7.00-7.20)
z~6.4
(z=6.15-6.61)
0.01
0.001
0.0001
Intensity
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
E (keV)



L_X ~ 6 x 10^{42} z=8.41 EQW ~ 1 keV

Perspectives

Chandra and XMM surveys will “marginally” improve the current statistic unless a major (> 20 Msec) further time investment is made (note that Chandra XVP is over ...)

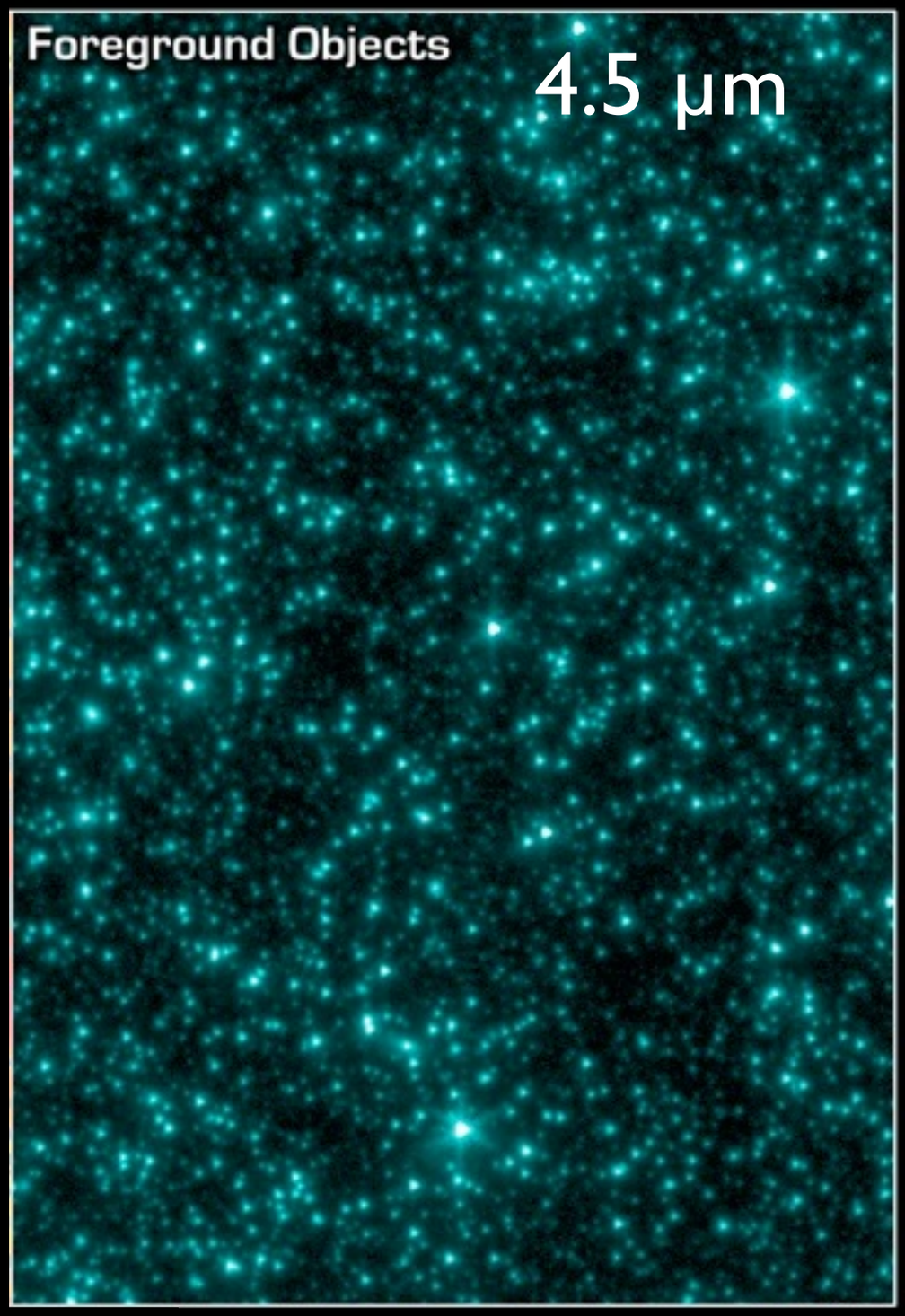
eROSITA will sample the ultra bright tail at z > 6

ASTRO-H and NuSTAR do not have high-z survey capabilities

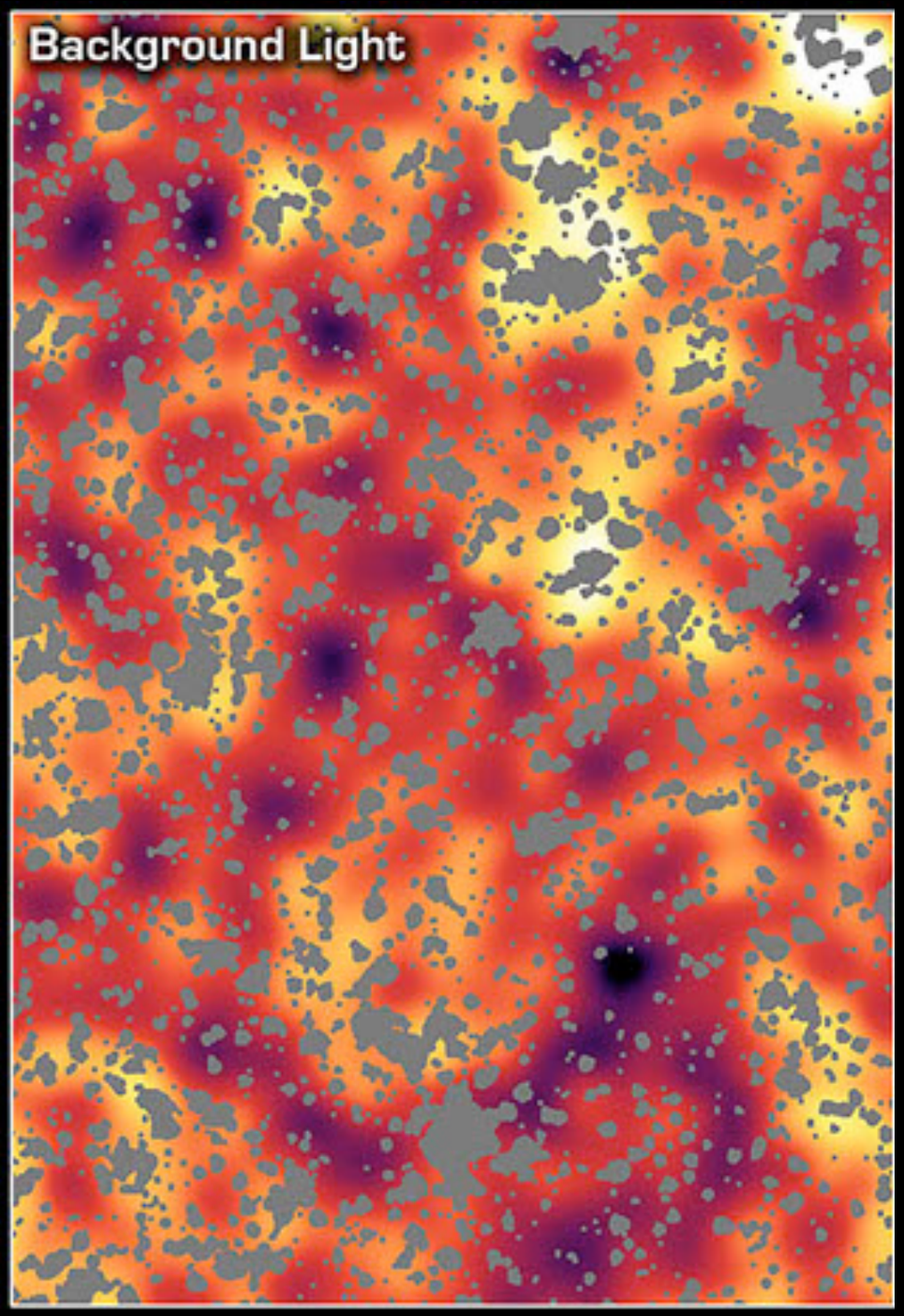
ATHENA WILL BE COMPETITIVE AND COMPLEMENT LONGER WAVELENGTH FACILITIES IN 2030

- **WFI** with 5 (goal 3) arcsec PSF HEW on axis and stable out to 20-25 arc min radius off-axis plus a significant time investment (> 30 Ms) and fine tuning on the band to minimize the background
- **XIFU** would nicely complement high-z science following-up JWST/E-ELT drop outs

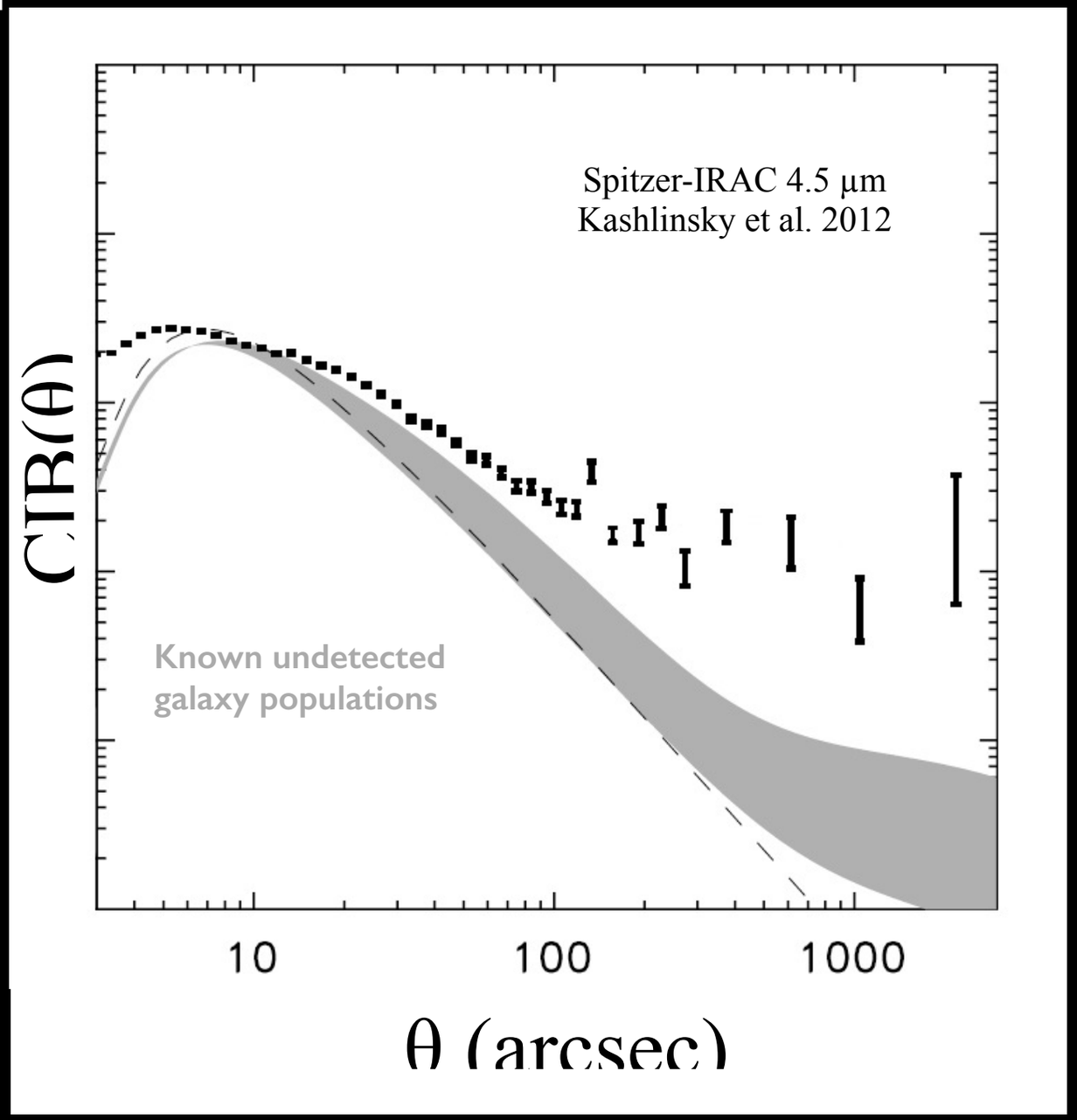
Can we obtain some information before Athena?



Spitzer Space Telescope • IRAC



After removing foreground sources the CIB revealed an unexpected pattern of the fluctuations



Known Properties

Large scale excess:

- **IRAC m>25**
- **No correlation with <1 *μ*m**

Large scale excess:

- **Consistent with population in high-z structures**

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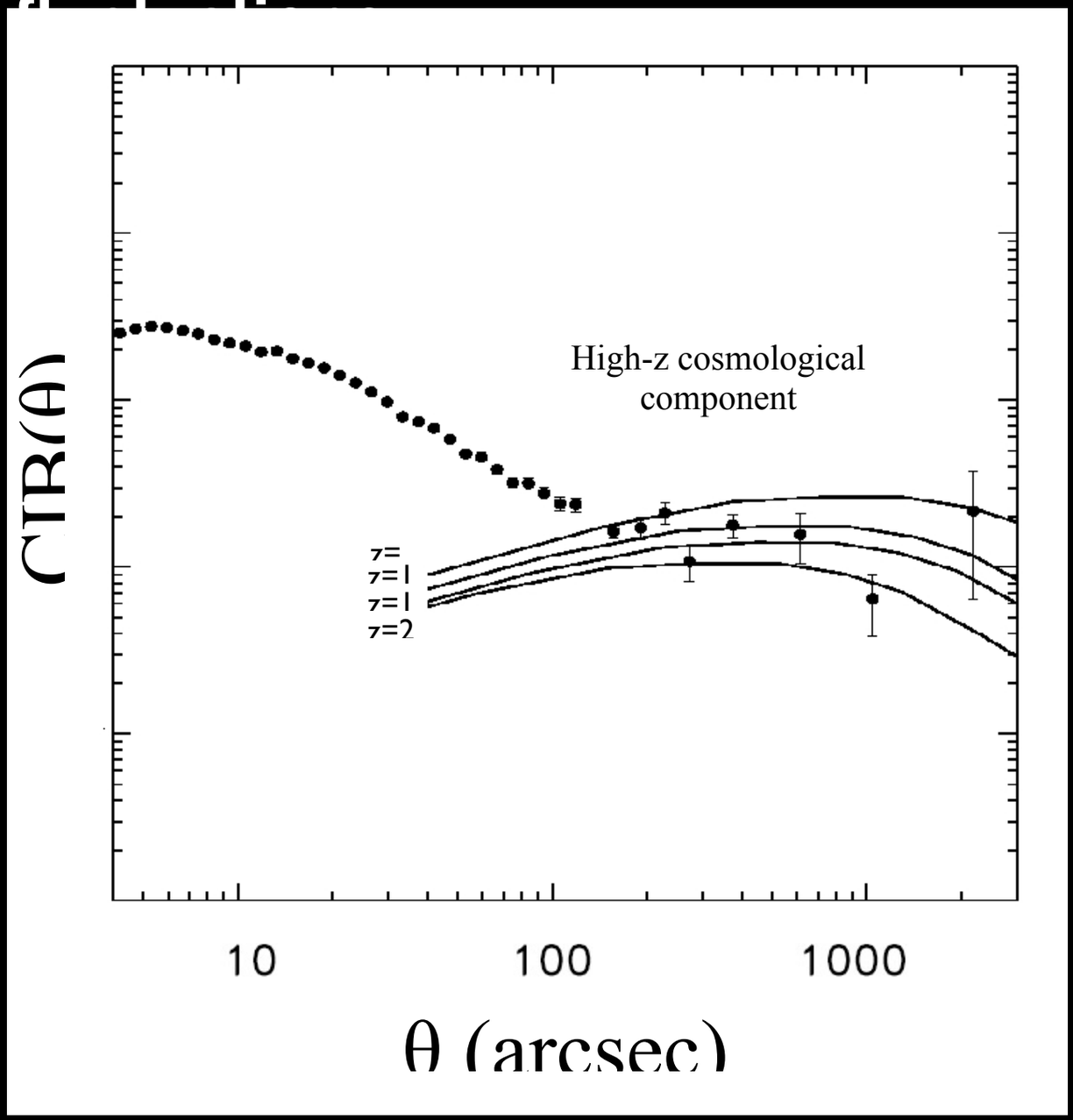


Known Properties

Large scale excess:

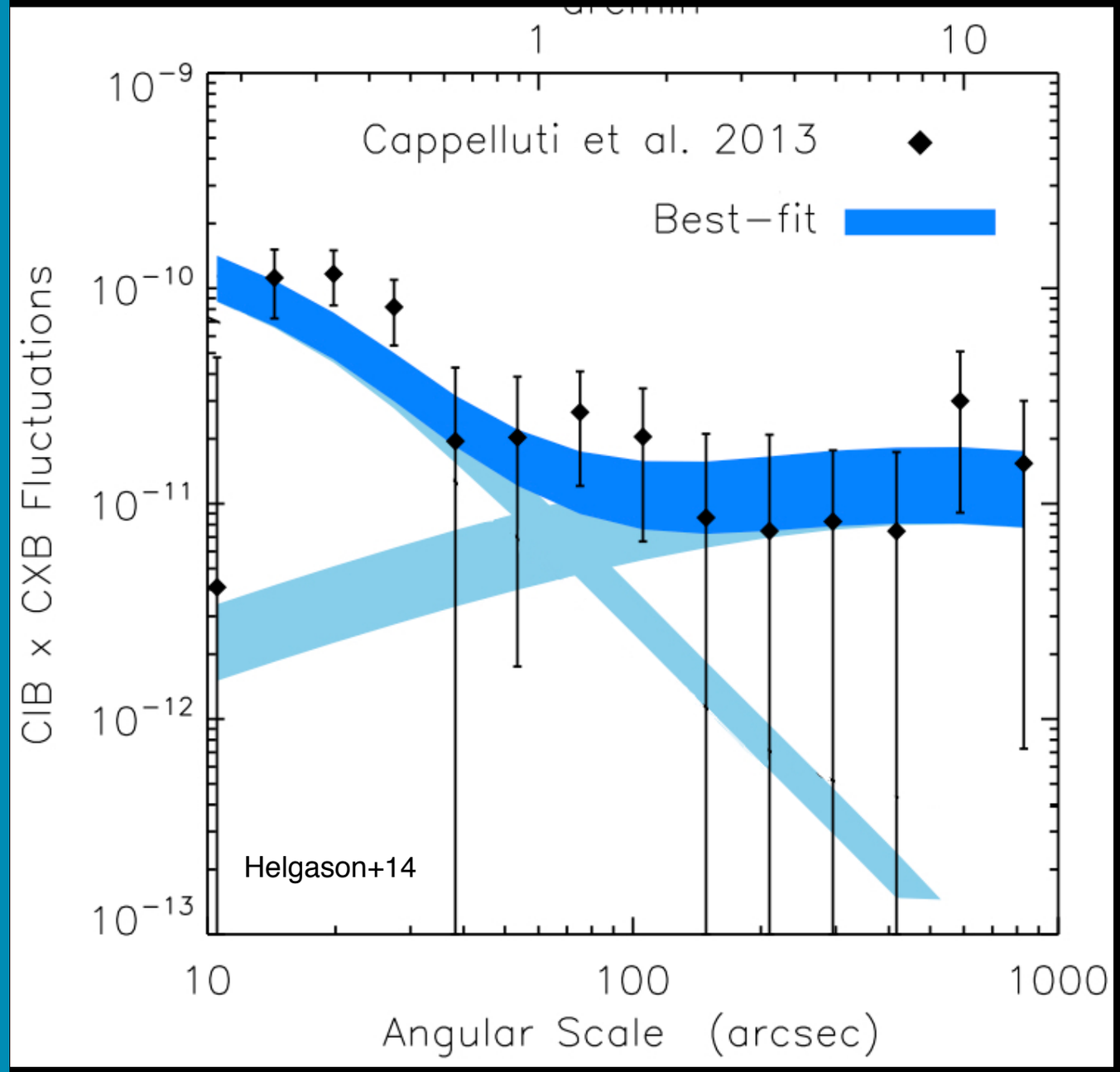
- IRAC m>25
- No correlation with <1 μm
- Optical m>28

Large scale excess:

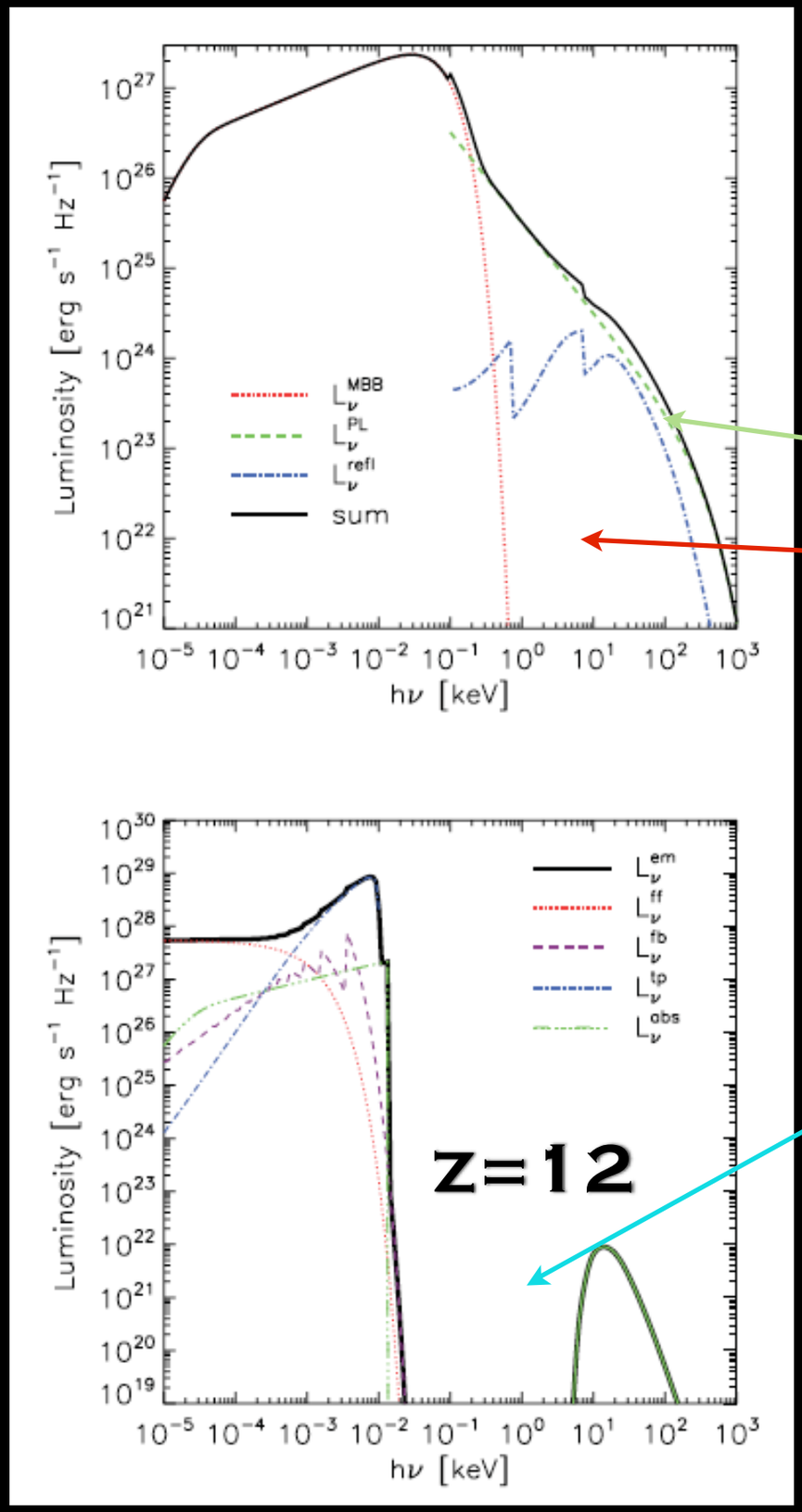
- Consistent with population in high-z structures

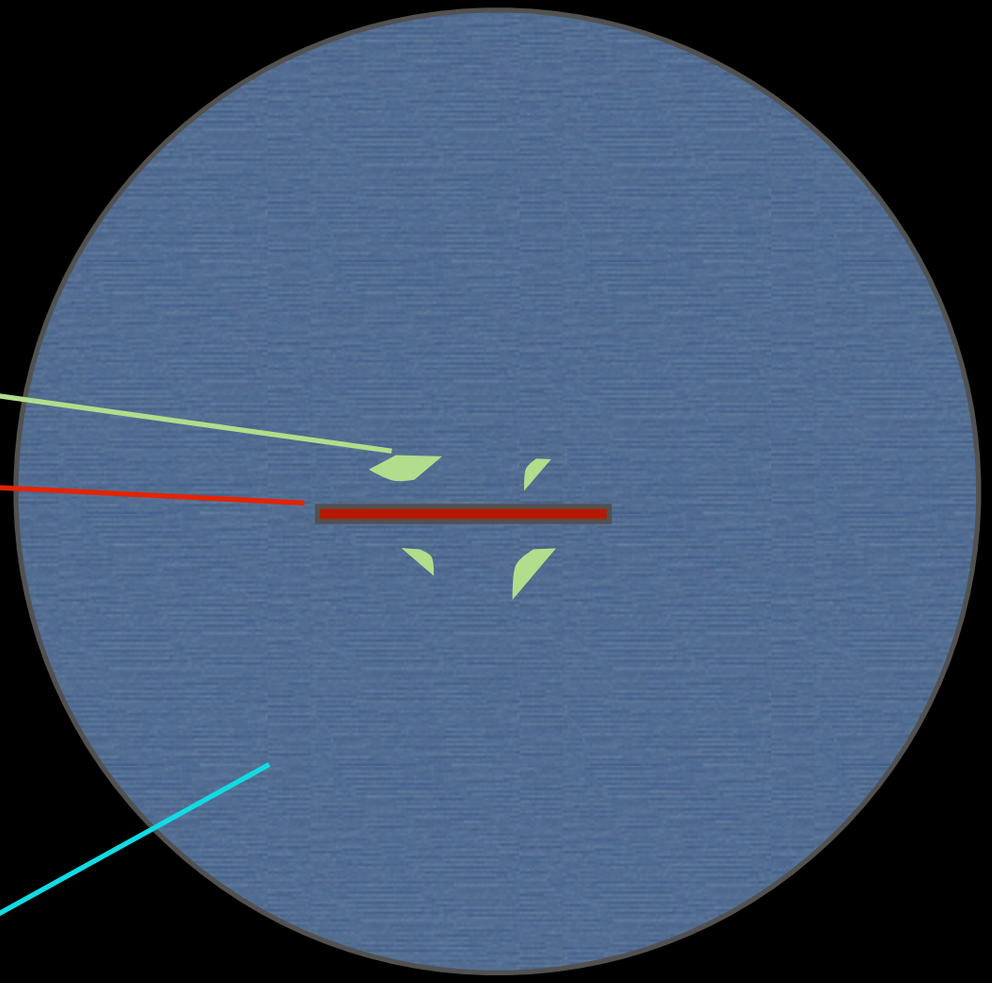
Large scale excess:

- Correlations with the CXB
- Significant BH population



DCBH could explain the observed cross correlation

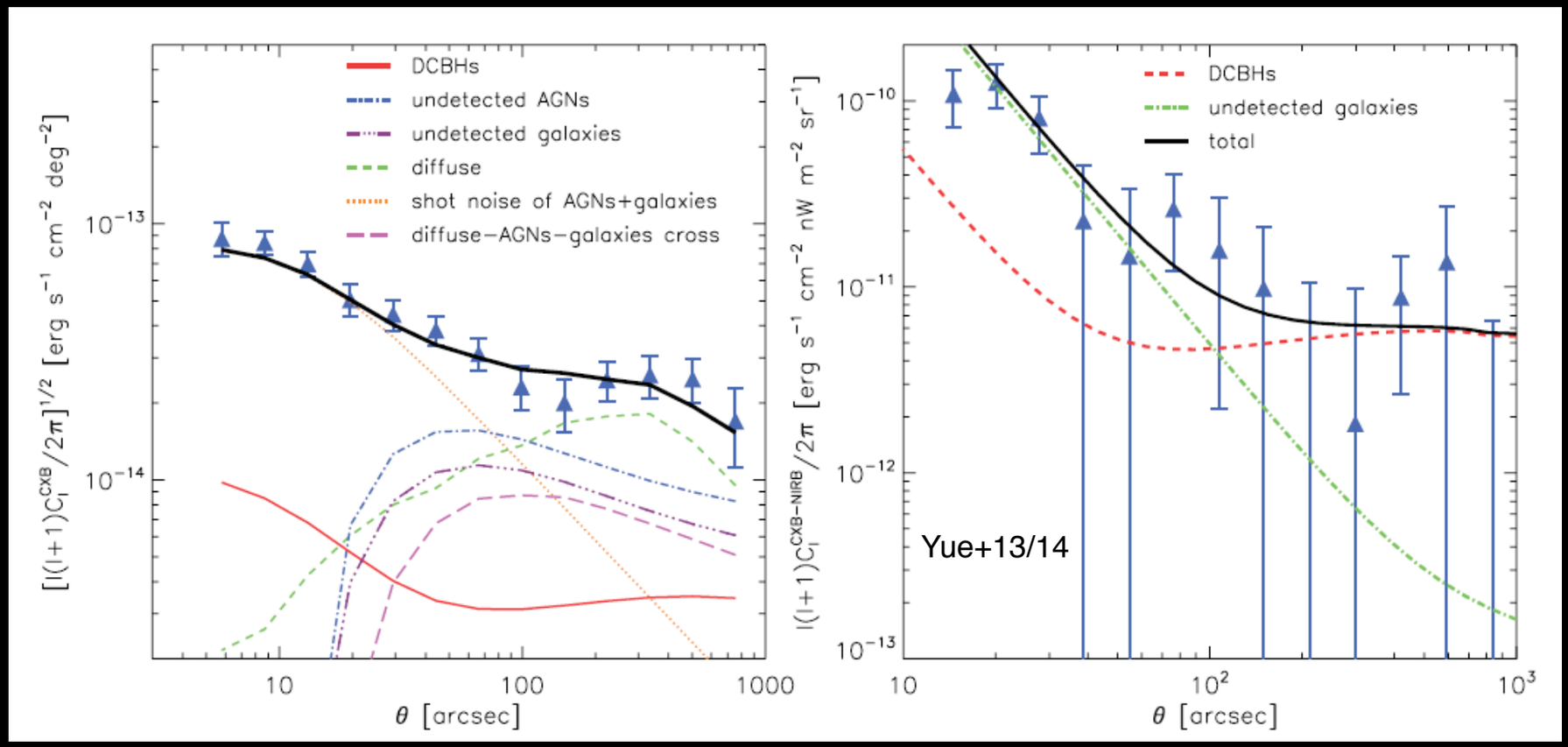




C-thick Absorption

Figure 1. Upper: the primary spectrum (solid) for a BH with $M_{BH} = 10^6\,M_\odot$ and its three components. Bottom: the emerging (thick solid line) quasar spectrum of above BH when $N_H = 1.5 \times 10^{25}\,cm^{-2}$ and the four components (thin lines).

DCBH from high-z

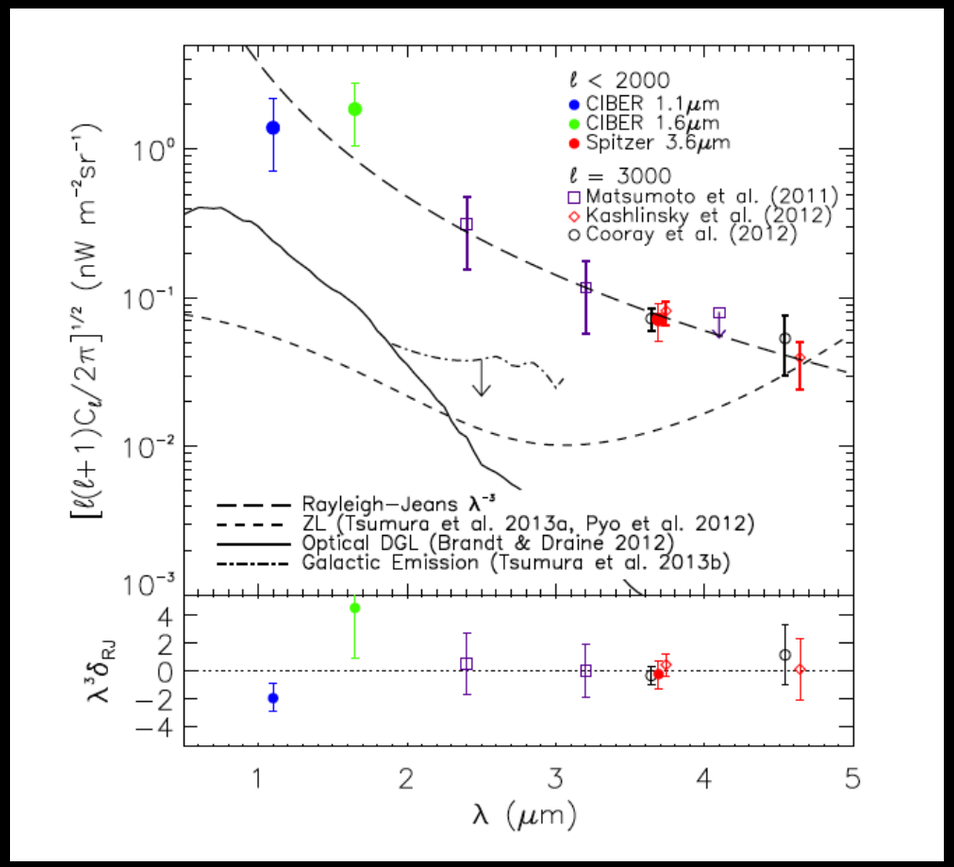


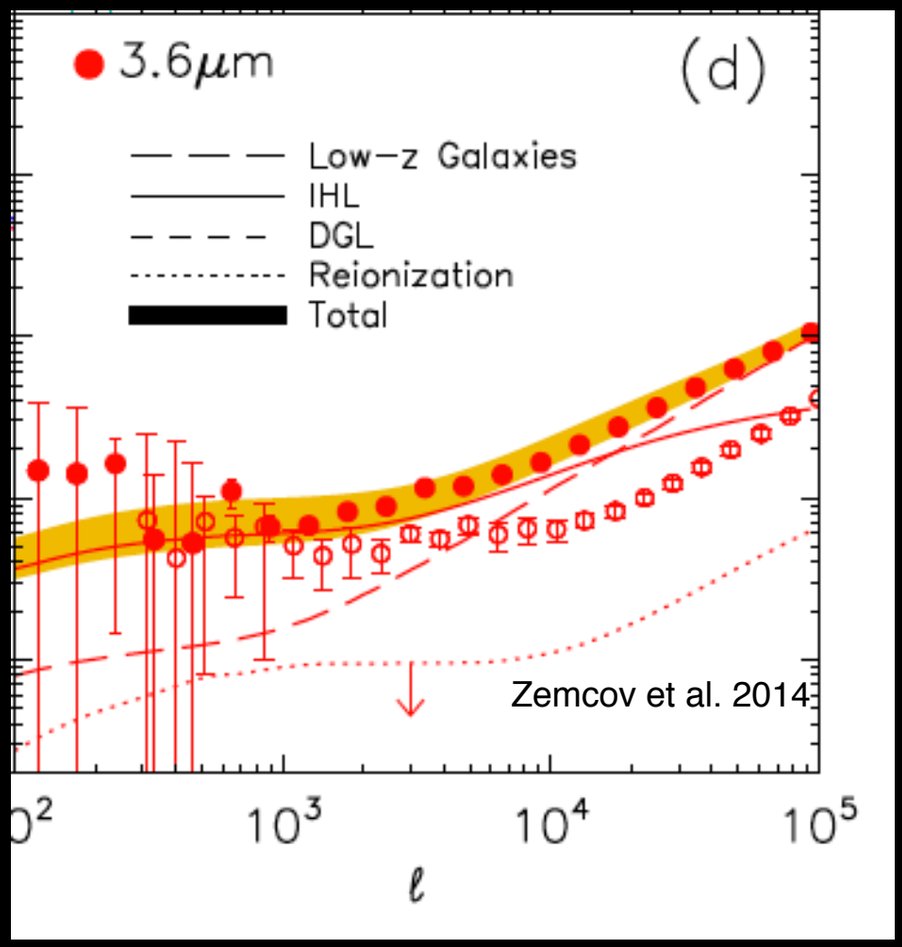
However if DCBH are responsible for these anisotropies, models predict a very high space density of a 10^6 M$_\odot$ SMBH @z~6

Meaning that we'd observe many of them of low mass halos in the local Universe

Intra Halo light?

- Cooray et al. 2012 propose IHL from star stripped during mergers
- Zemcov et al. 2014 suggest that SED of CIBER fluctuations is consistent with IHL



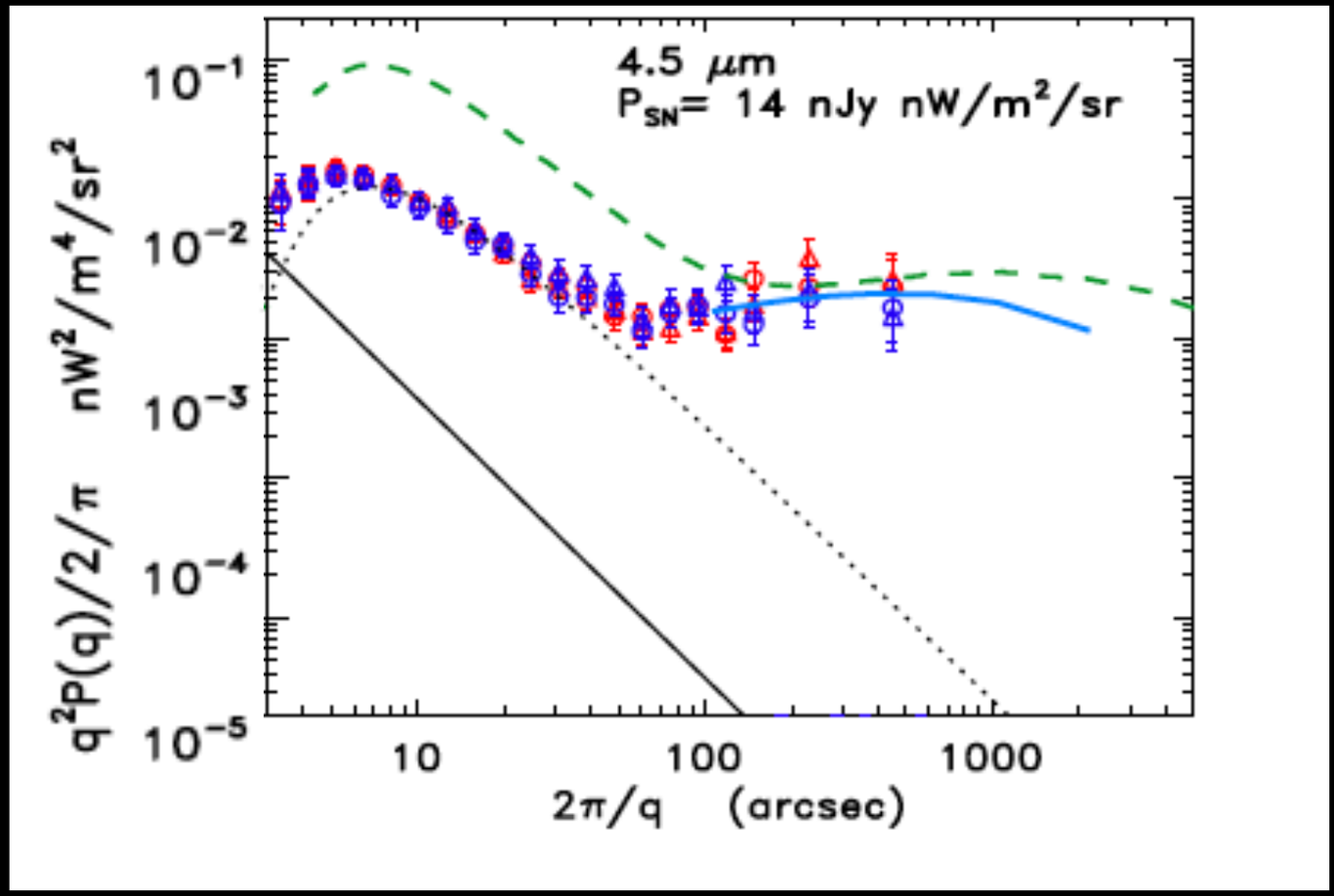


This interpretation also has several problems

Weak points of IHL

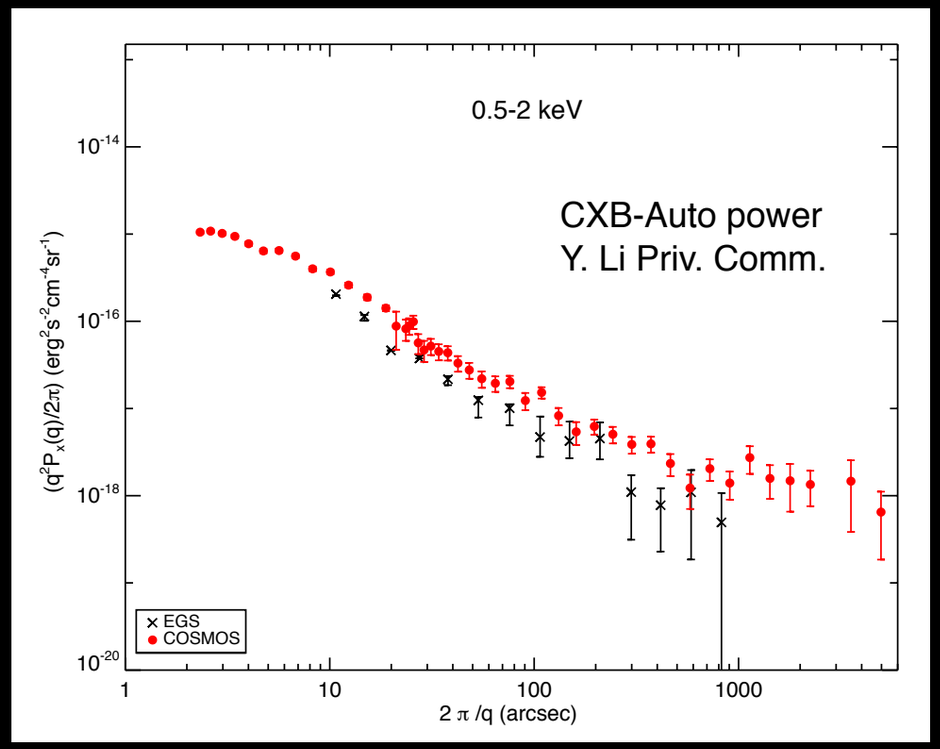
- Cannot account for CXB-CIB coherence at anywhere near the measured level (not discussed by C12, Z14)
- There is no correlation between IRAC CIB fluctuation and ACS sources to m>28 (points not discussed by C12, Z14)
- **The measured CIB power spectrum does not change with dilating the mask (not discussed by C12, Z14)**
- Also problems with going to lower shot-noise:

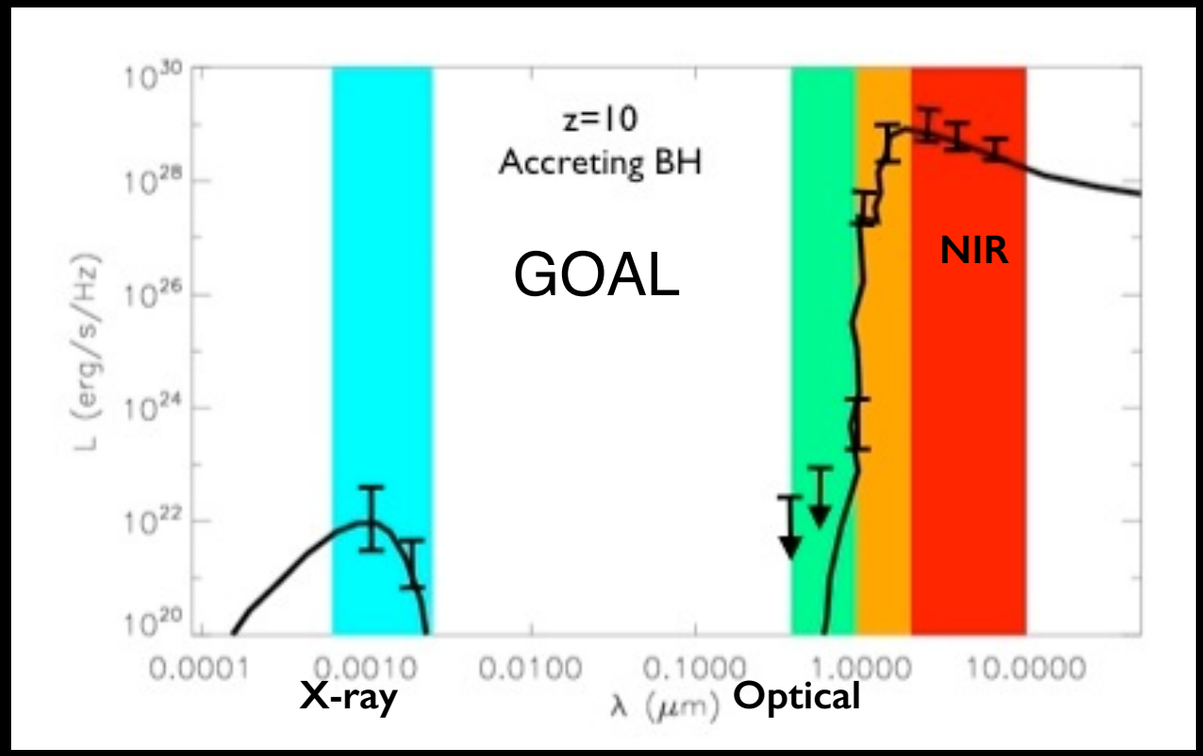
Cyber measurements sample too high fluxes for discarding the high-z interpretation



Next Steps

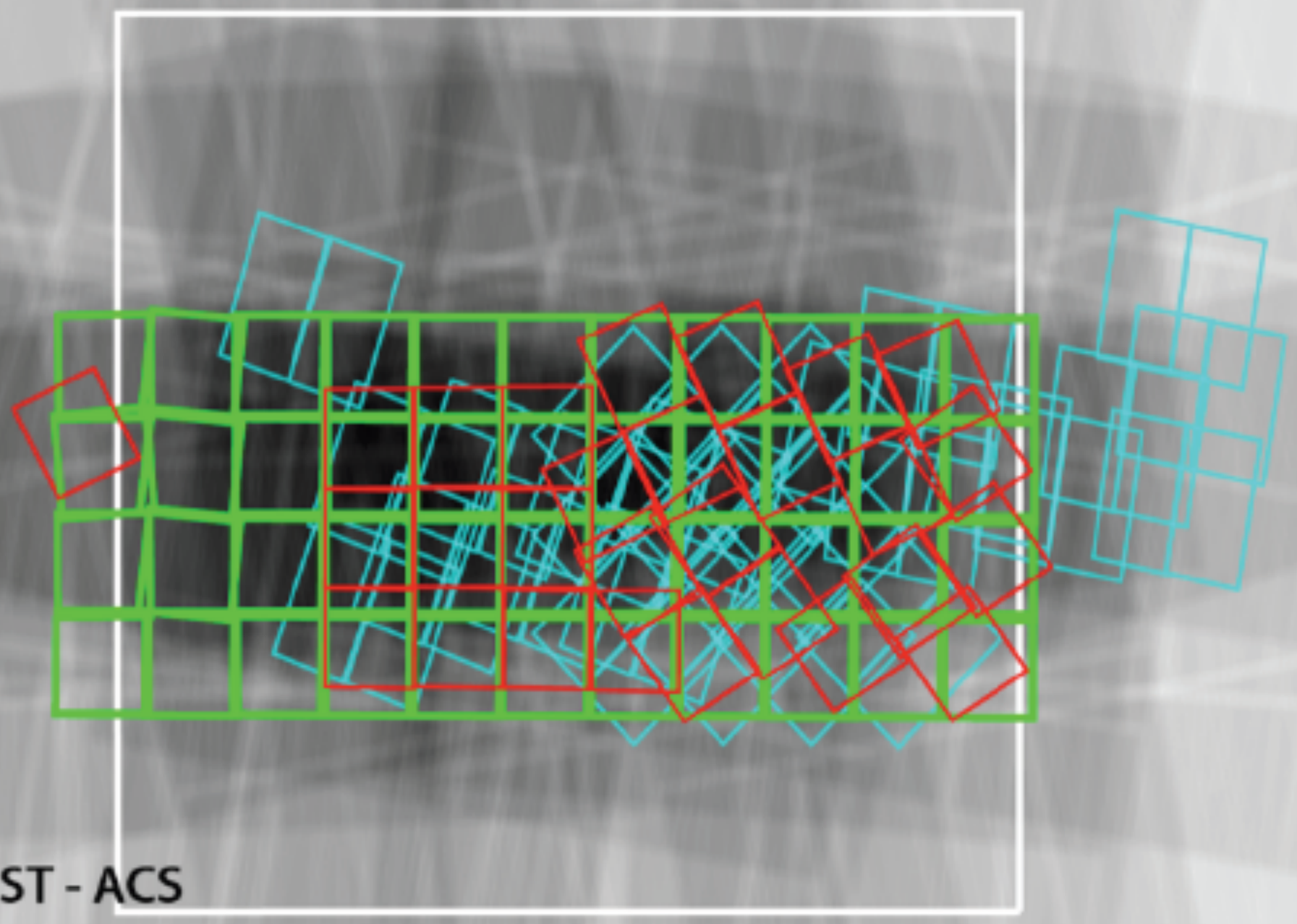
- The key point to disentangle the nature of these fluctuations is to obtain a broad band (IR to X-ray) SED of these EBL excess fluctuations
- Confirm the X-ray/IR correlations
- One Solution is using COSMOS Legacy data + Splash + Ancillary data (Depth?)





- Or Exploit the recently approved 1.3 Msec UDS Chandra XVP (PI G. Hasinger) +CANDELS and combine the results with EGS and COSMOS legacy

Chandra XVP on UDS
GH,DK,NC et al.



Summary

- There are pieces of evidence that large scale CIB fluctuations may arise from high-z
- CIB fluctuations correlate with CXB
- Models can explain the observations with DCBH
- We are likely accessing for the first time BH formation epoch with observational proxies
- IHL cannot explain X-ray/IR correlation
- Need of deep and wide field observation to construct the SED of the fluctuations
- Chandra has the potential to solve this problem