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Searching for high-z AGN with Chandra and with future facilities

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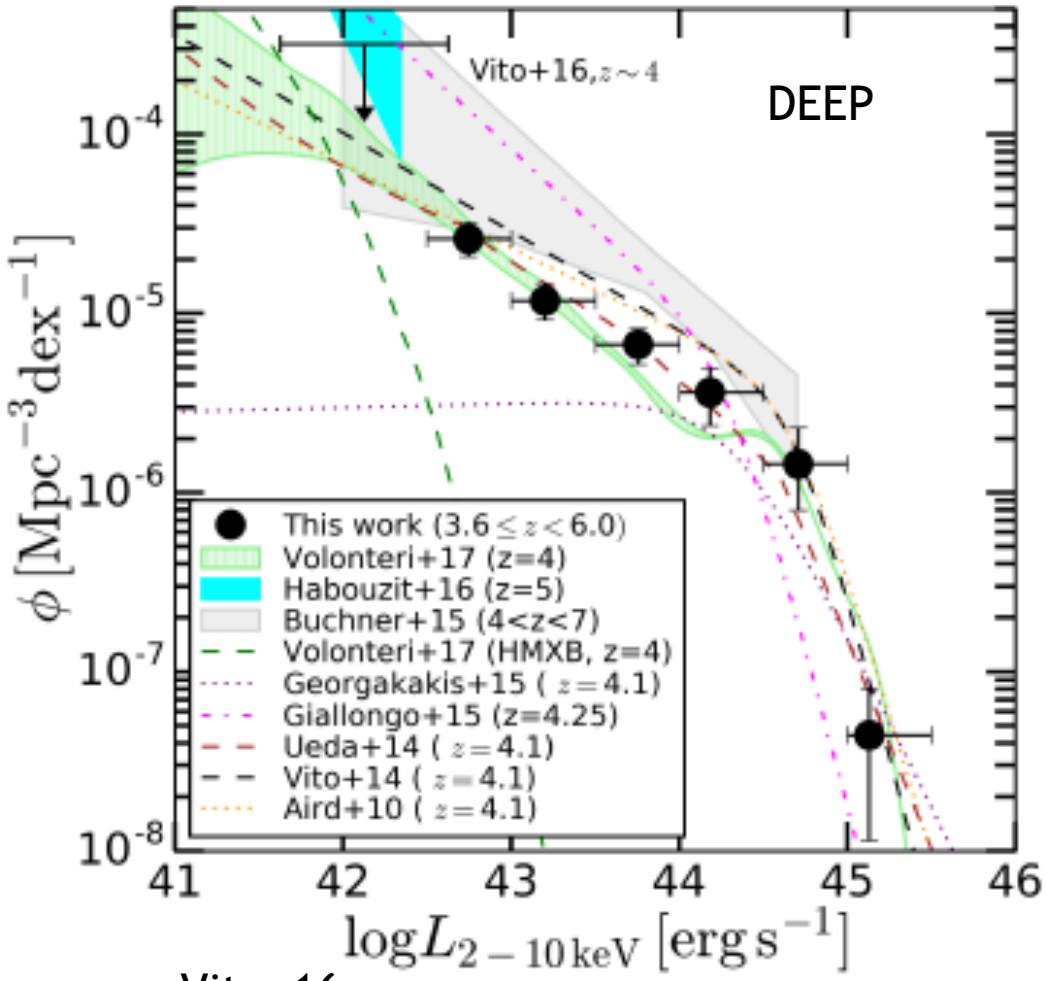
Questions for the next decade(s) in AGN demographics

- How did the first SMBHs form and grow so rapidly in the early Universe?
- What is the complete census of growing SMBHs from cosmic dawn ($z \sim 6$) to the peak formation epoch ($z \sim 2$) and beyond?
- How does SMBH accretion influence the growth of galaxies and large-scale structures?

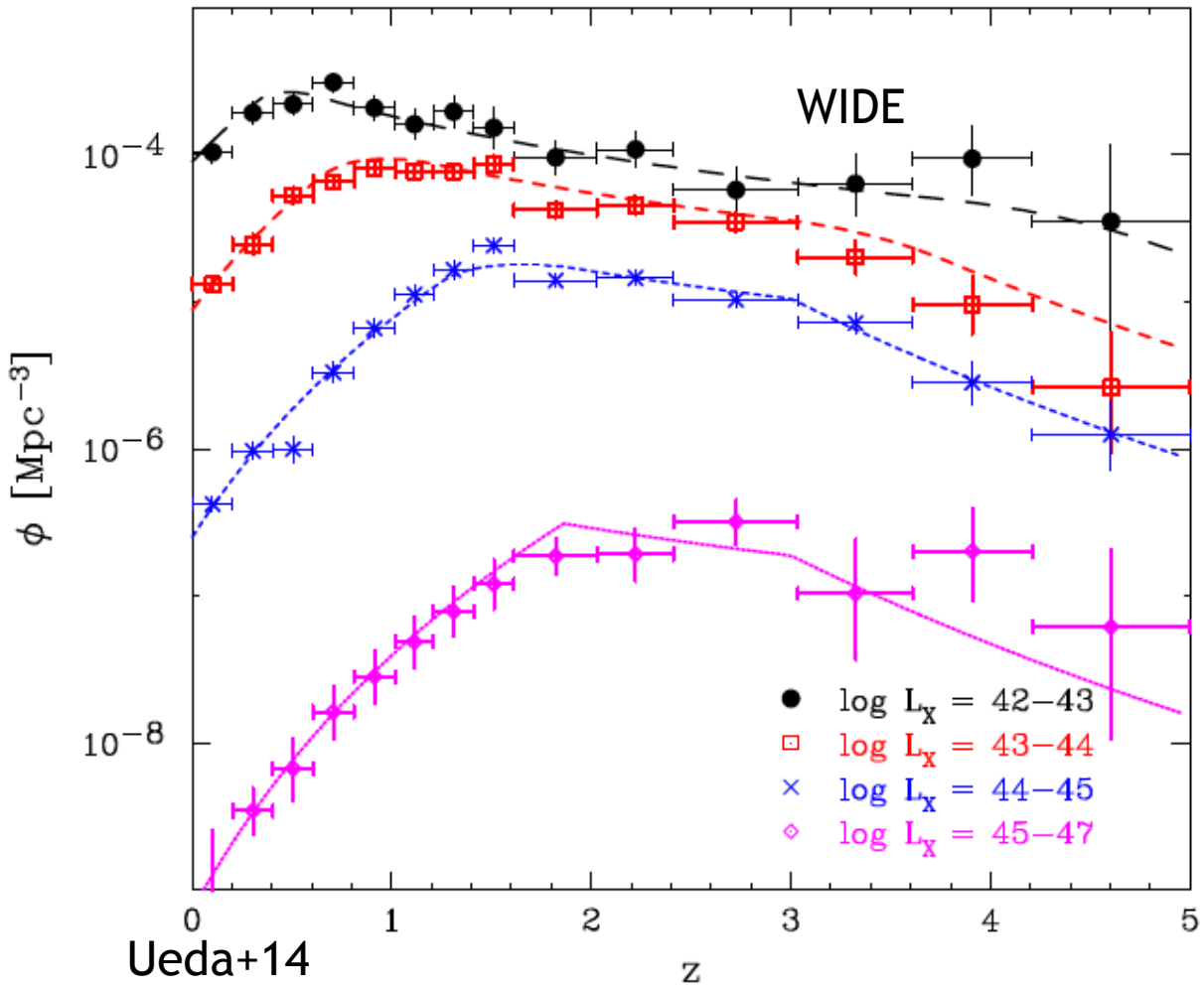
Civano, Cappelluti, Hickox and Canning+19

https://arxiv.org/pdf/1903.11091.pdf

State of art of X-ray Luminosity Functions



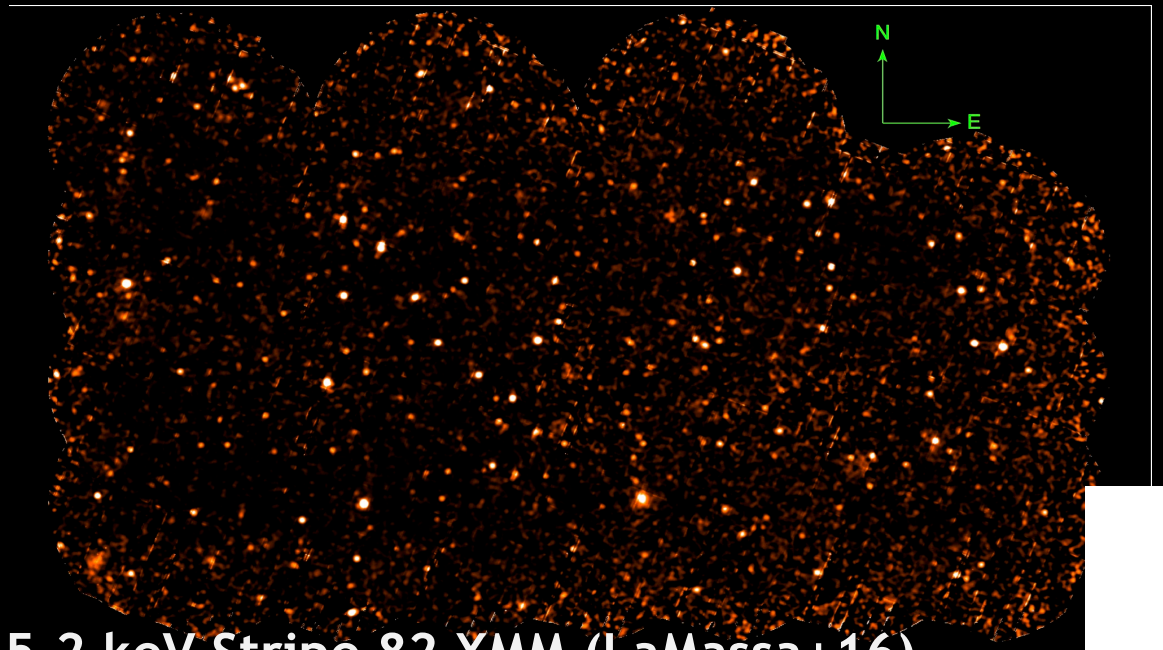
Vito+16



Ueda+14

- Still a lot to learn from the X-ray side mostly at the bright end

Finding Early BH: large volumes



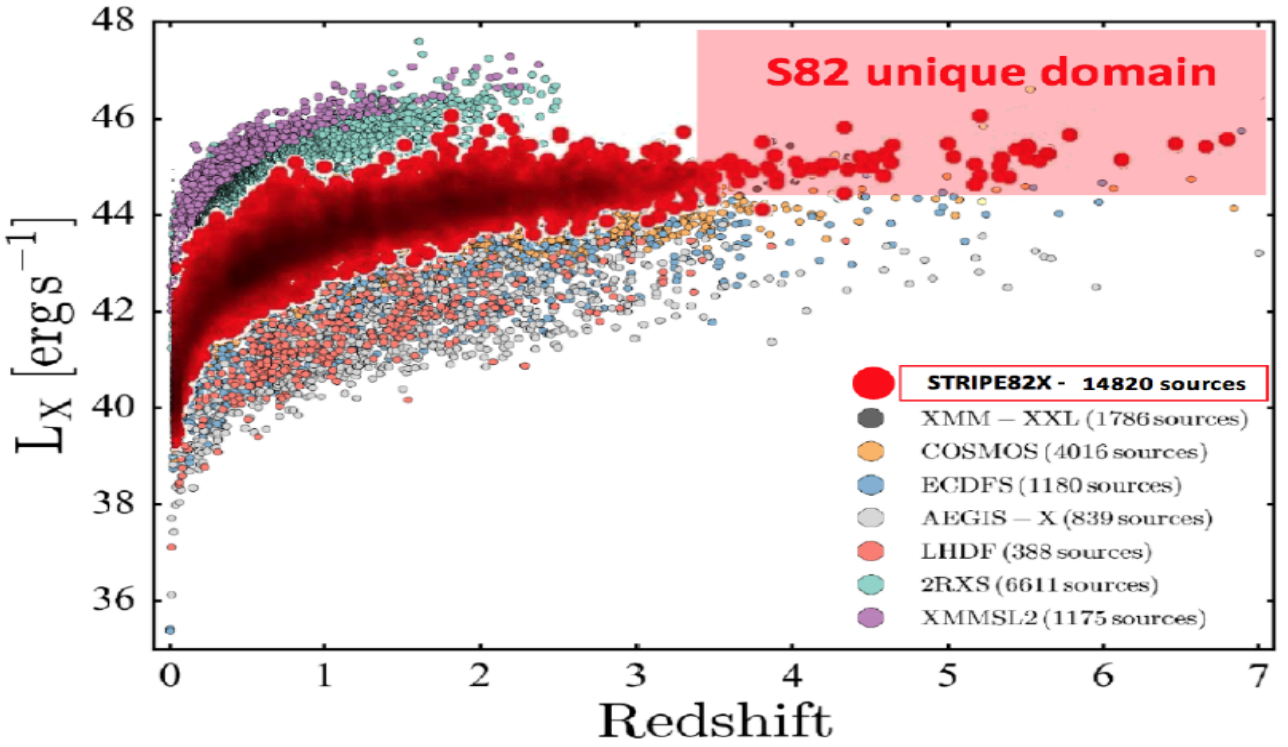
0.5-2 keV Stripe 82 XMM (LaMassa+16)

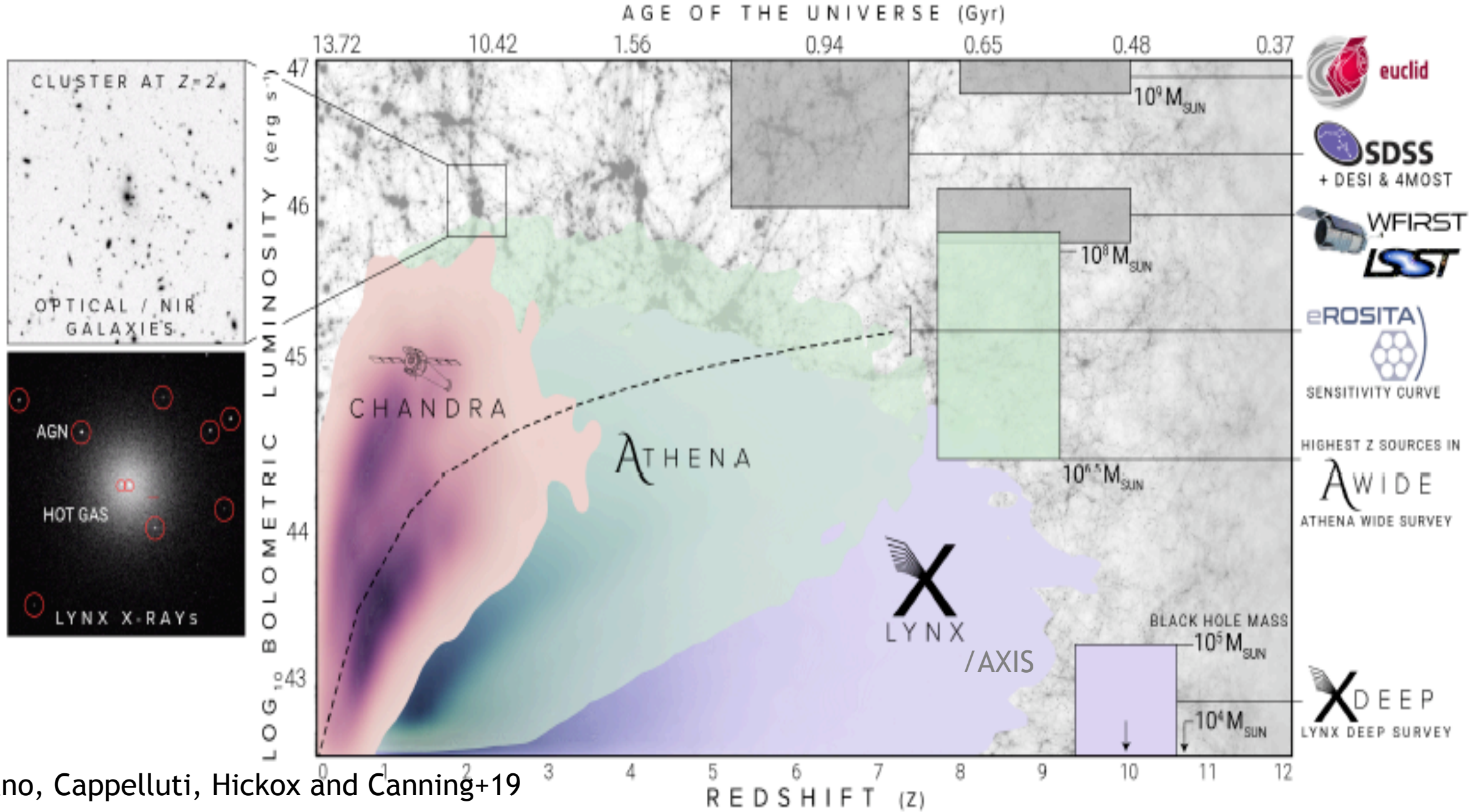
Wide field surveys are needed to Sample the high-L part of the XLF

For sources missed in Optical/ NIR sources

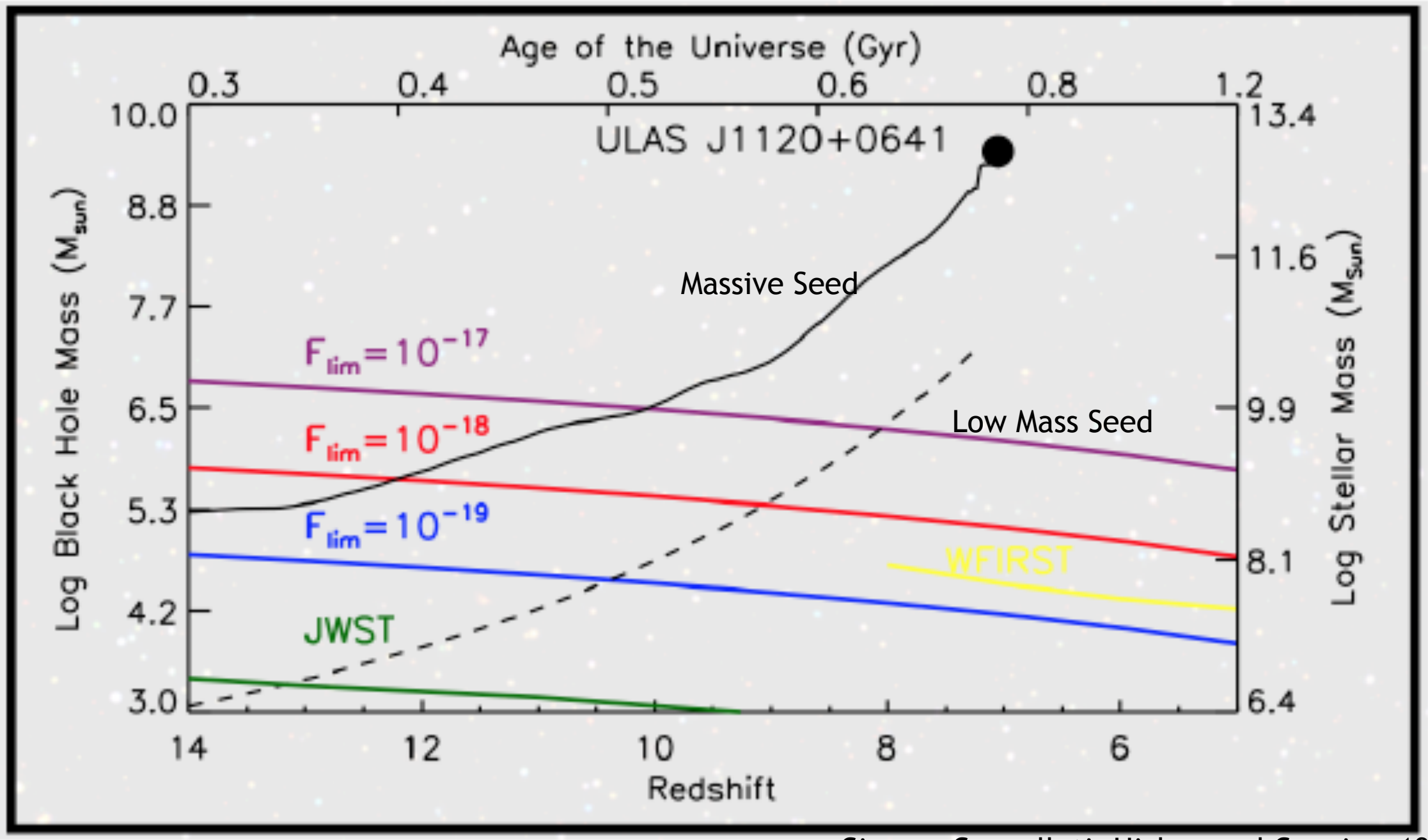
Chandra and XMM-Newton can still fill the gap between eROSITA and pencil beam surveys with

50-100 deg^2 surveys like e.g the SDSS Stripe 82



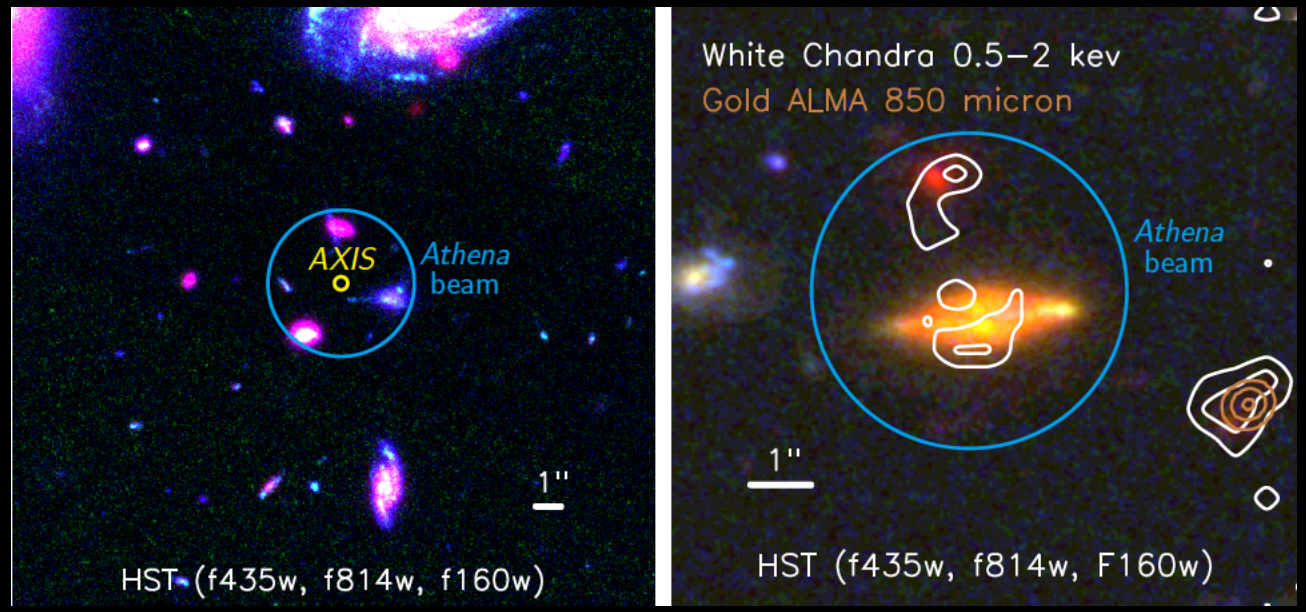


Civano, Cappelluti, Hickox and Canning+19



Civano, Cappelluti, Hickox and Canning+19

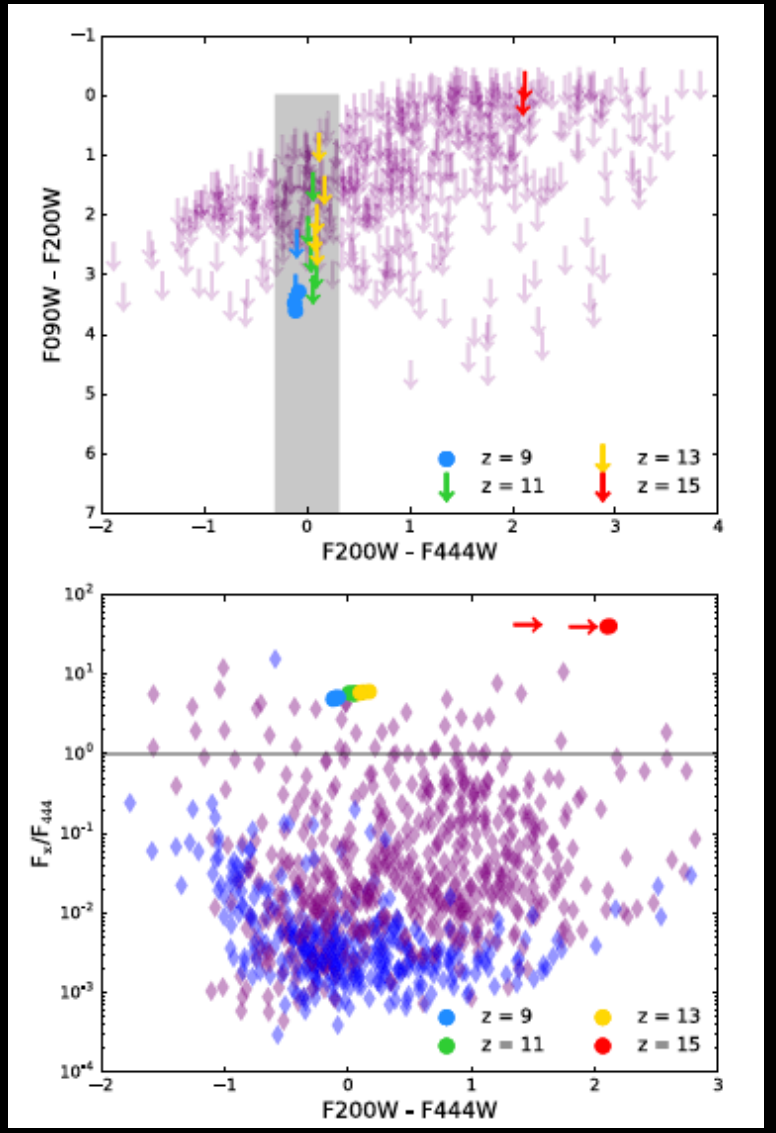
Challenge: Finding the needle in the haystack



Need high angular resolution

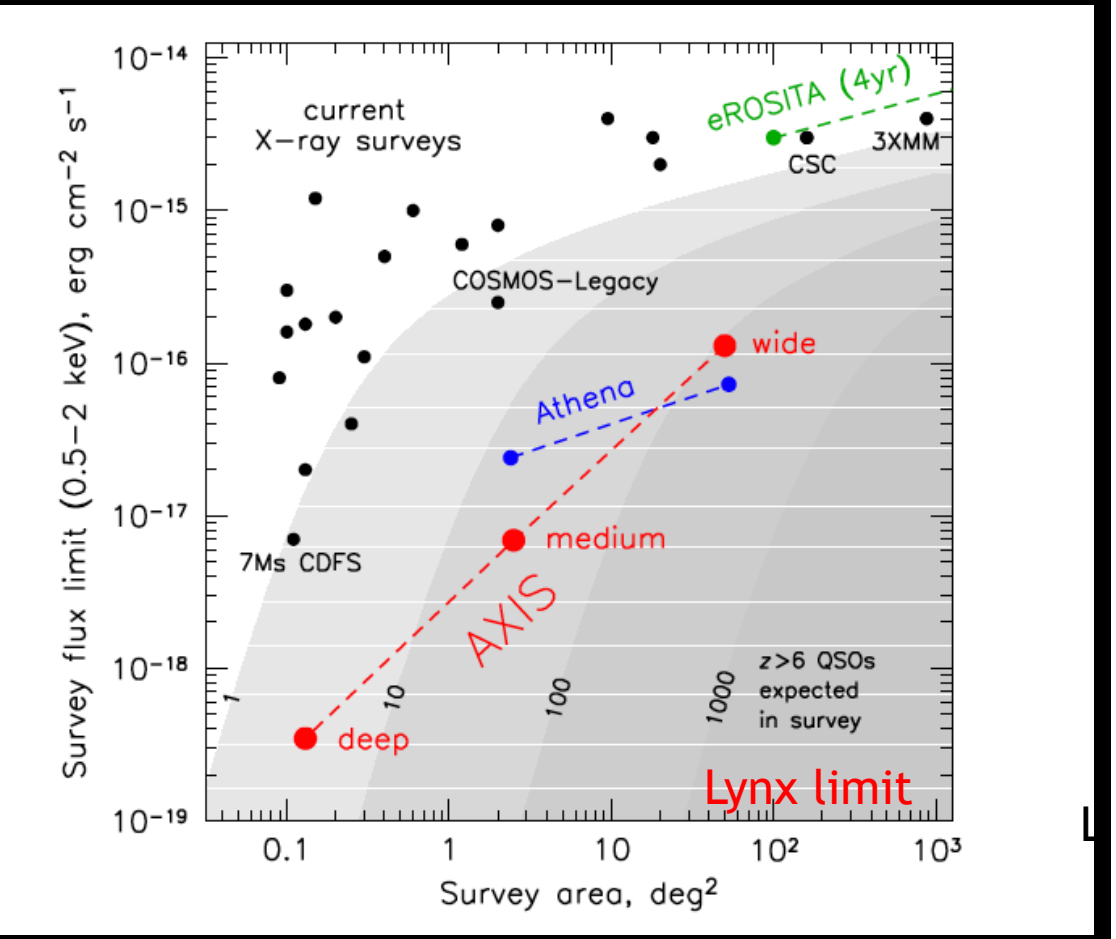
$-0.3 \lesssim$F200W-F444W$\lesssim 0$ and F090W-F200W$\gtrsim -0.2$
UV continuum slopes $\beta < -2$ and $-1.5 <$IRX< 0.

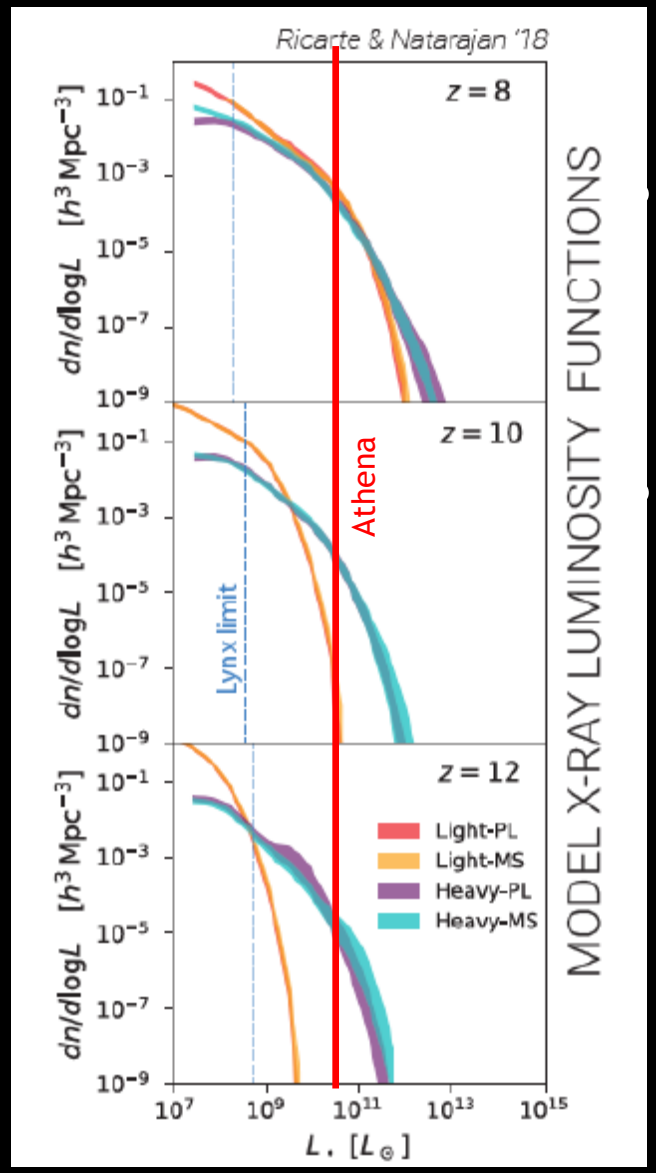
Valiante+18



Natarajan+17

How many "seeds" do we reasonably expect to see?





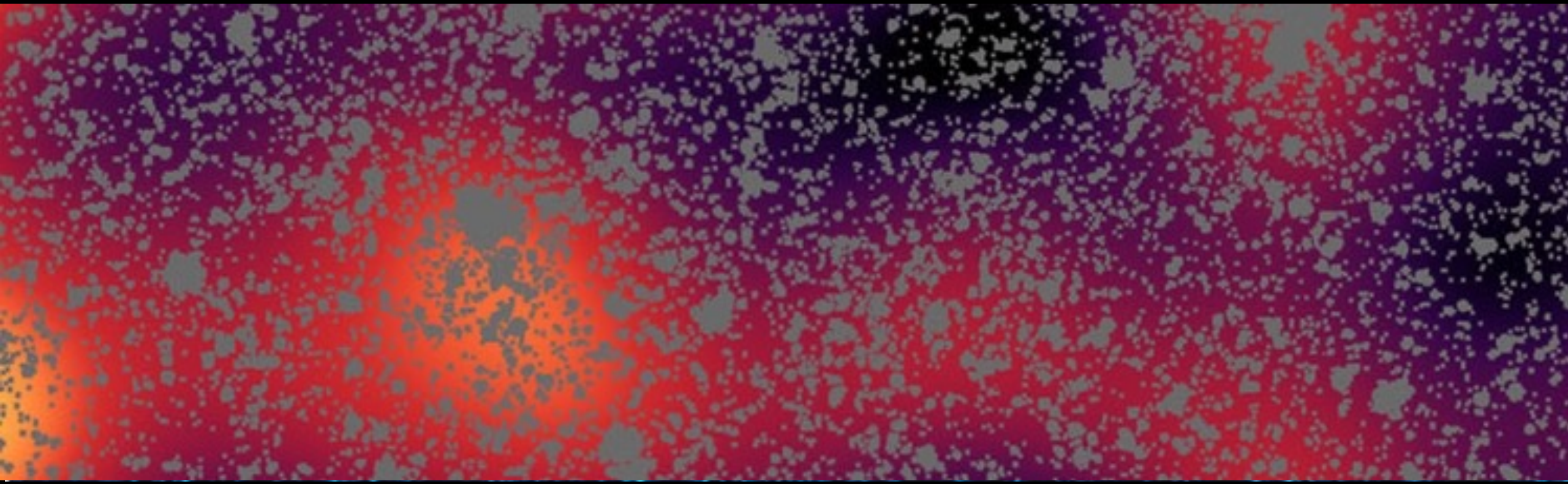
Literature has been proposing all the possible scenarios: from and handful with JWST to 5000 deg^{-2} with Athena

Realistic expectation: 1-10 detections with JWST (Natarajan+17,Pacucci +19) dozens/hundreds with Lynx/ AXIS (Heiman+19,Mushotzky+19)

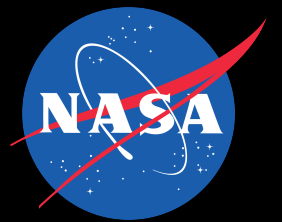
See AXIS WP, Mushotzky et al. (2019)

EBL fluctuations

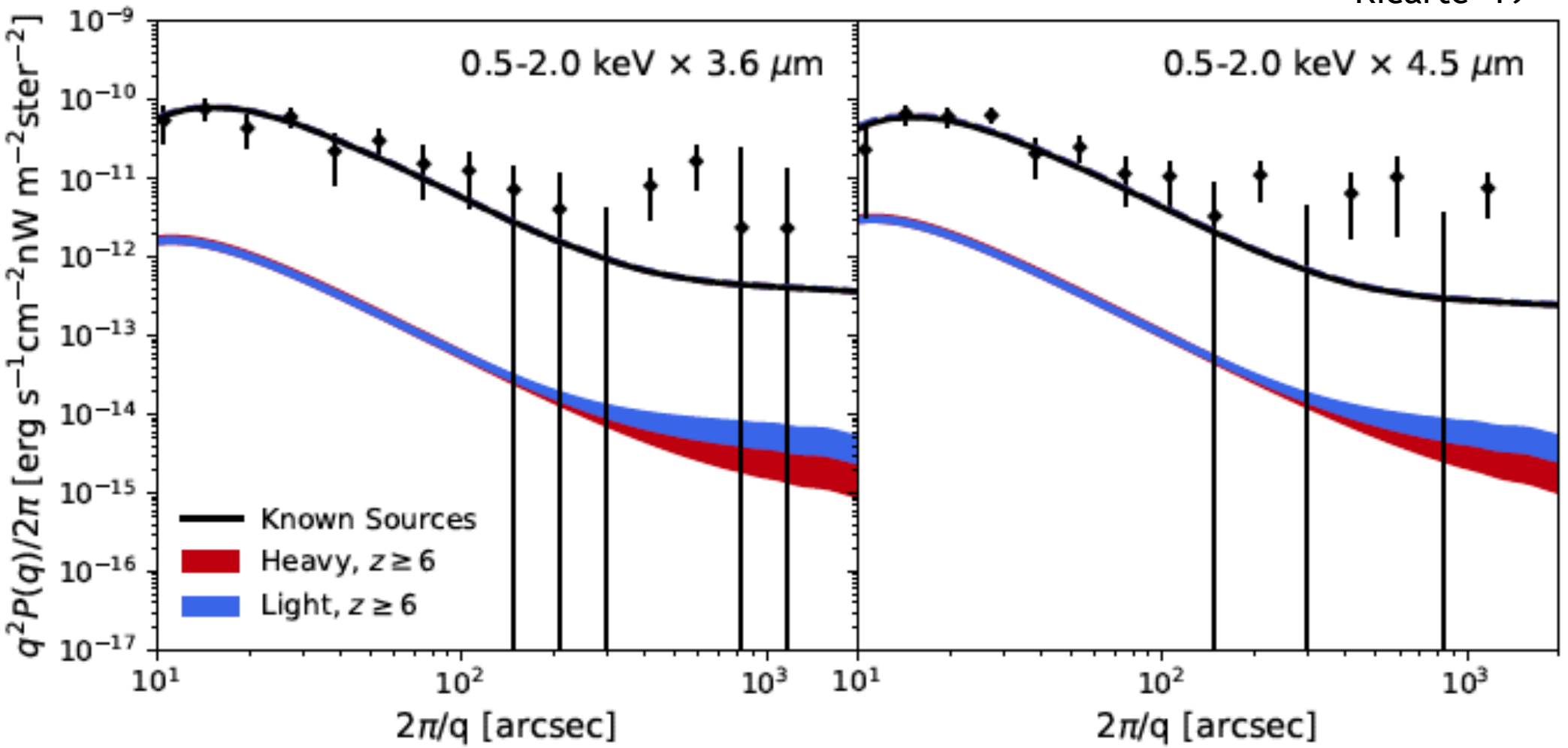
$\Delta F(q) = F(q) - \langle F(q) \rangle$



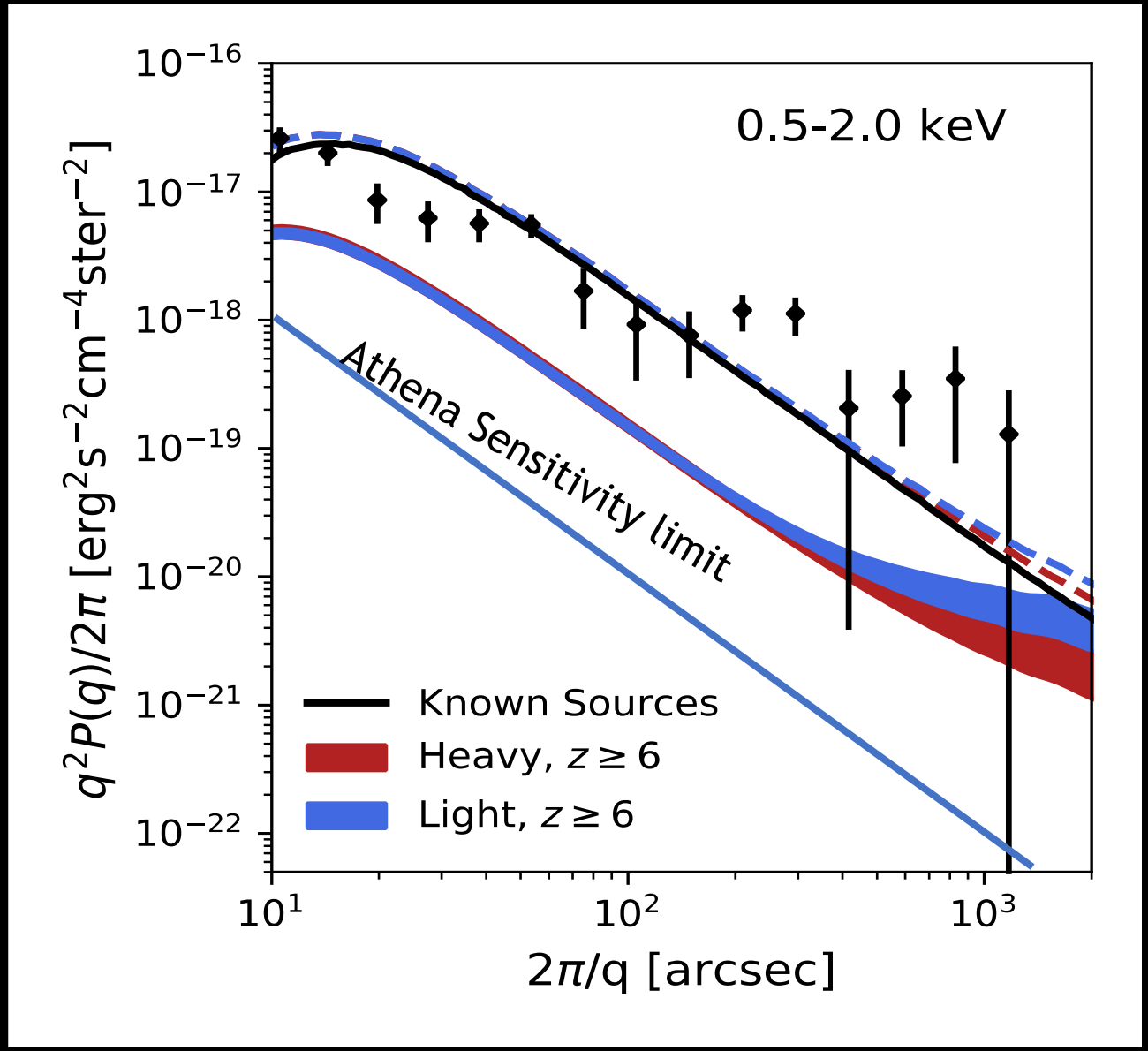
Using NASA Great Observatories
Spitzer and Chandra



The cross-power is not explained by AGN seeds (POP III, DCBH)

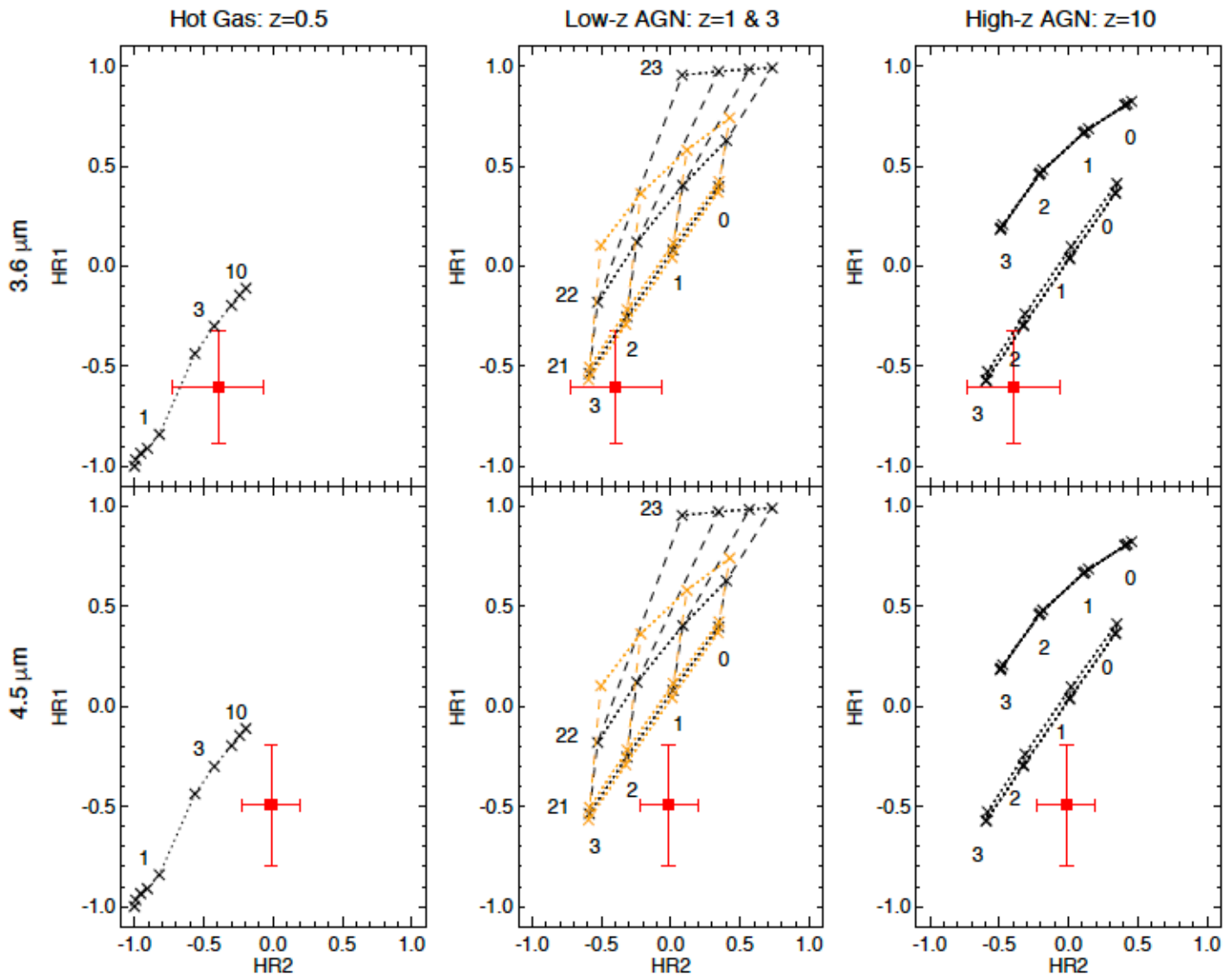


CXB fluctuations with Athena.



Athena Unresolved CXB will be dominated by early BHs, regardless of their nature

Colors of the X-ray fluctuations correlating with CIB



Colors seem to indicate unobscured accretion

Li+19

Scattering of MW disk source on dust?

$L_{X,MW}=2x10^{39}$ erg/s

IF we distribute it uniformly in a disk of radius 15 kpc

We get:

$$F_{\rm MW} \sim L_{\rm MW} \frac{1}{\pi(15\ {\rm kpc})^2} \frac{1}{4\pi} \sim 3\times10^{-8}\ {\rm erg\ s^{-1}\ cm^{-2}\ ster^{-1}}$$

Given a column density we get the reflected flux:

$$F_{\rm ref} = F_{\rm MW}(1 - e^{-N_H \sigma_T})$$

CXB vs CIB coherence requires a flux $F=2x10^{-10}$ erg/s/cm^2/sr

Implying an unrealistic NH>1e22 cm^{-2}

So to summarize our needs:

Wide fields surveys with Chandra and XMM-Newton

Large field of view sensitive to faint fluxes in the X-ray (Athena):

Background Fluctuations

High angular resolution (Lynx, AXIS):

Multi-wavelength facilities (JWST, WFIRST, LSST,E-ELT).