

Resolving the hidden connections between black holes, galaxies, and halos with *Chandra* and *Lynx*

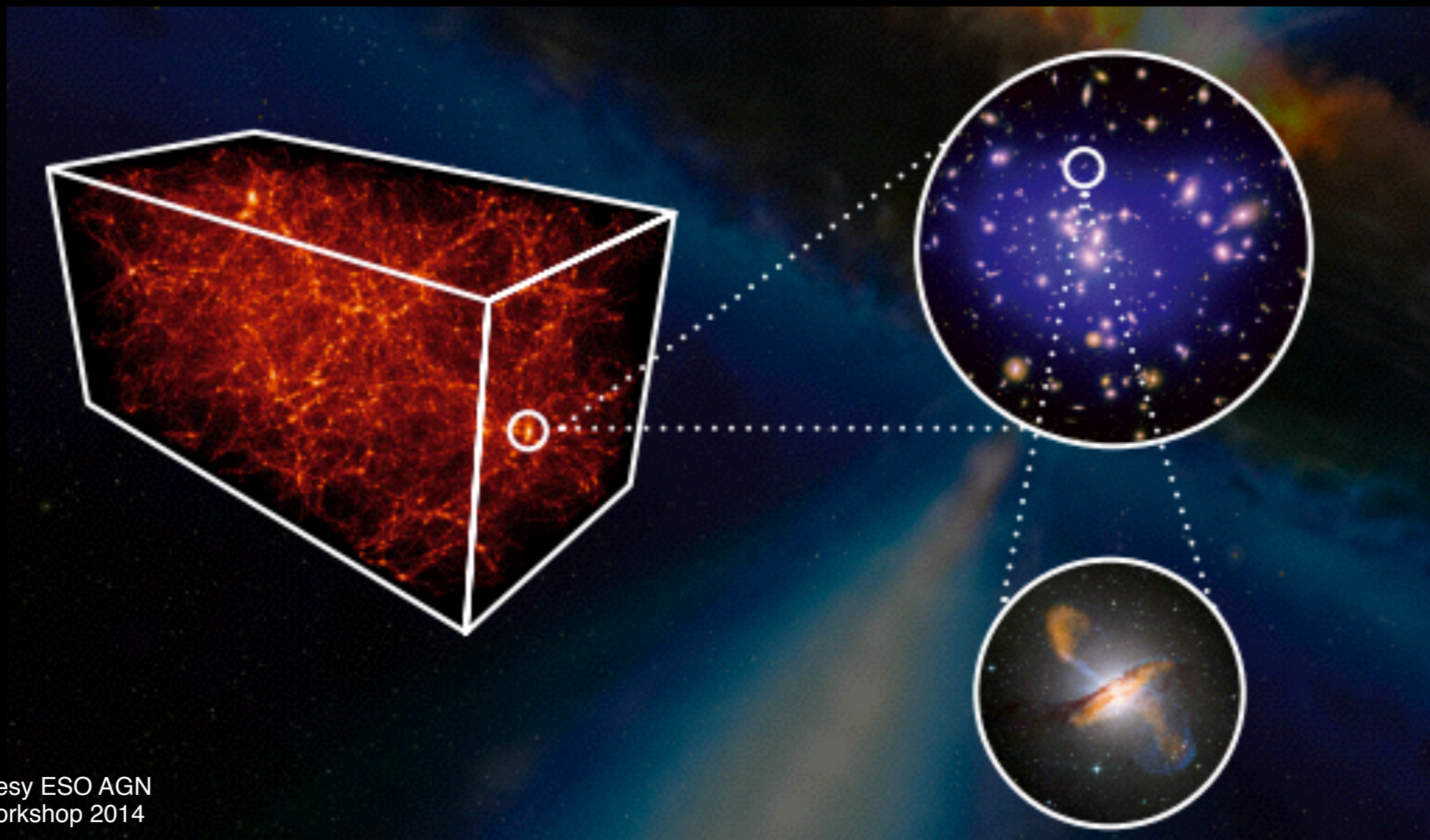


Image courtesy ESO AGN
clustering workshop 2014

Ryan C. Hickox

From *Chandra* to *Lynx*

8 August 2017



Dartmouth



Lynx



AGN and LSS SWG



Sloan Digital Sky Survey

Miguel A Aragon (JHU), Mark Subbarao (Adler P.), Alex Szalay (JHU)

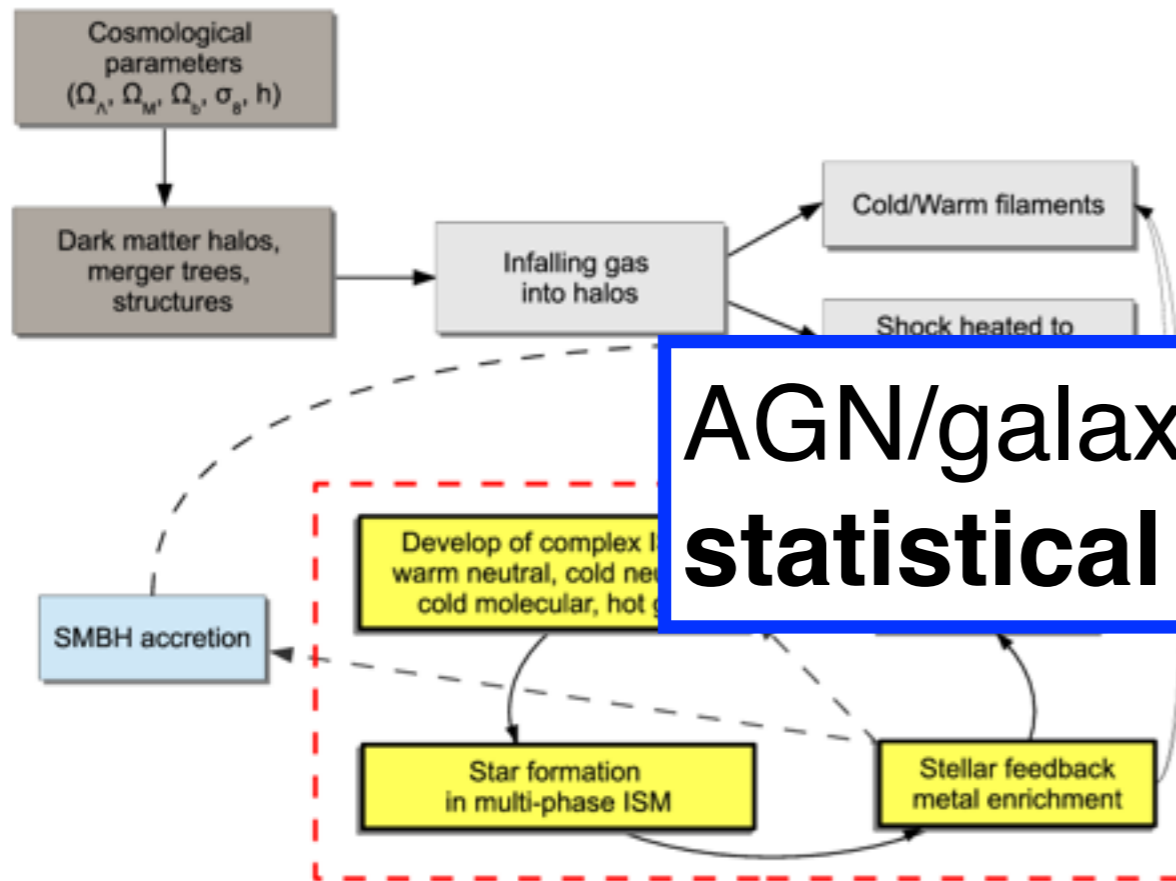


Time since the Big Bang: 5.7 billion years

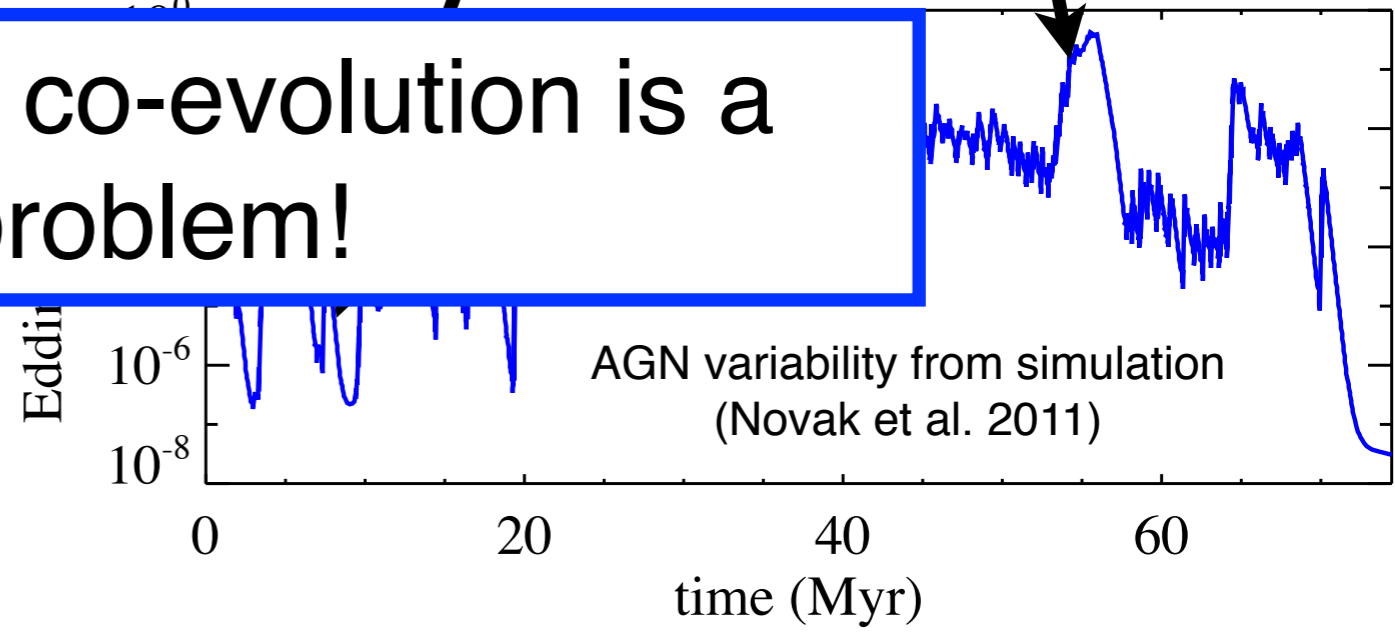
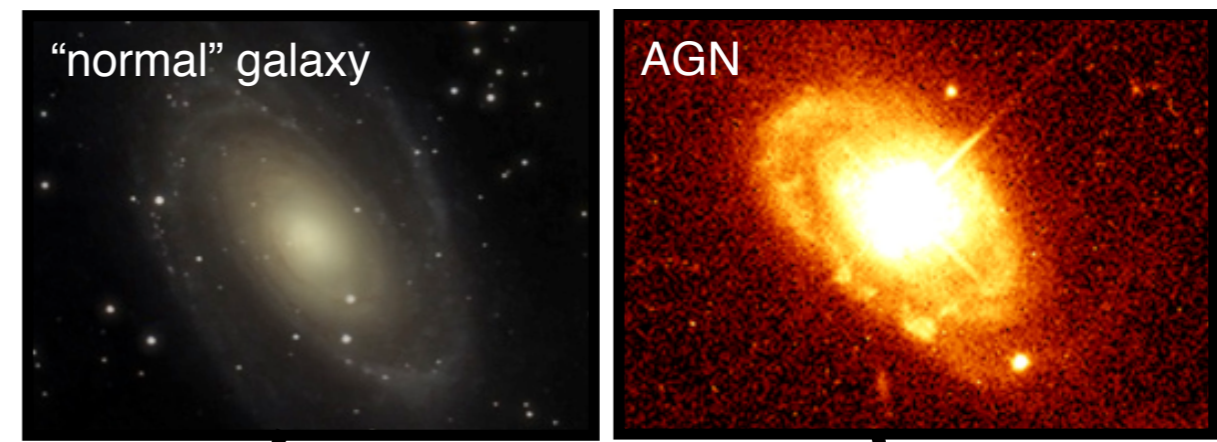
ILLUSTRIS

Galaxy formation is **complicated** and **takes a long time**

AGN **flicker** rapidly!



AGN/galaxy co-evolution is a **statistical** problem!



Power et al. (2015)

Hickox et al. (2014), see also Schawinski et al. (2015)

XBoötes (5-10 ks)

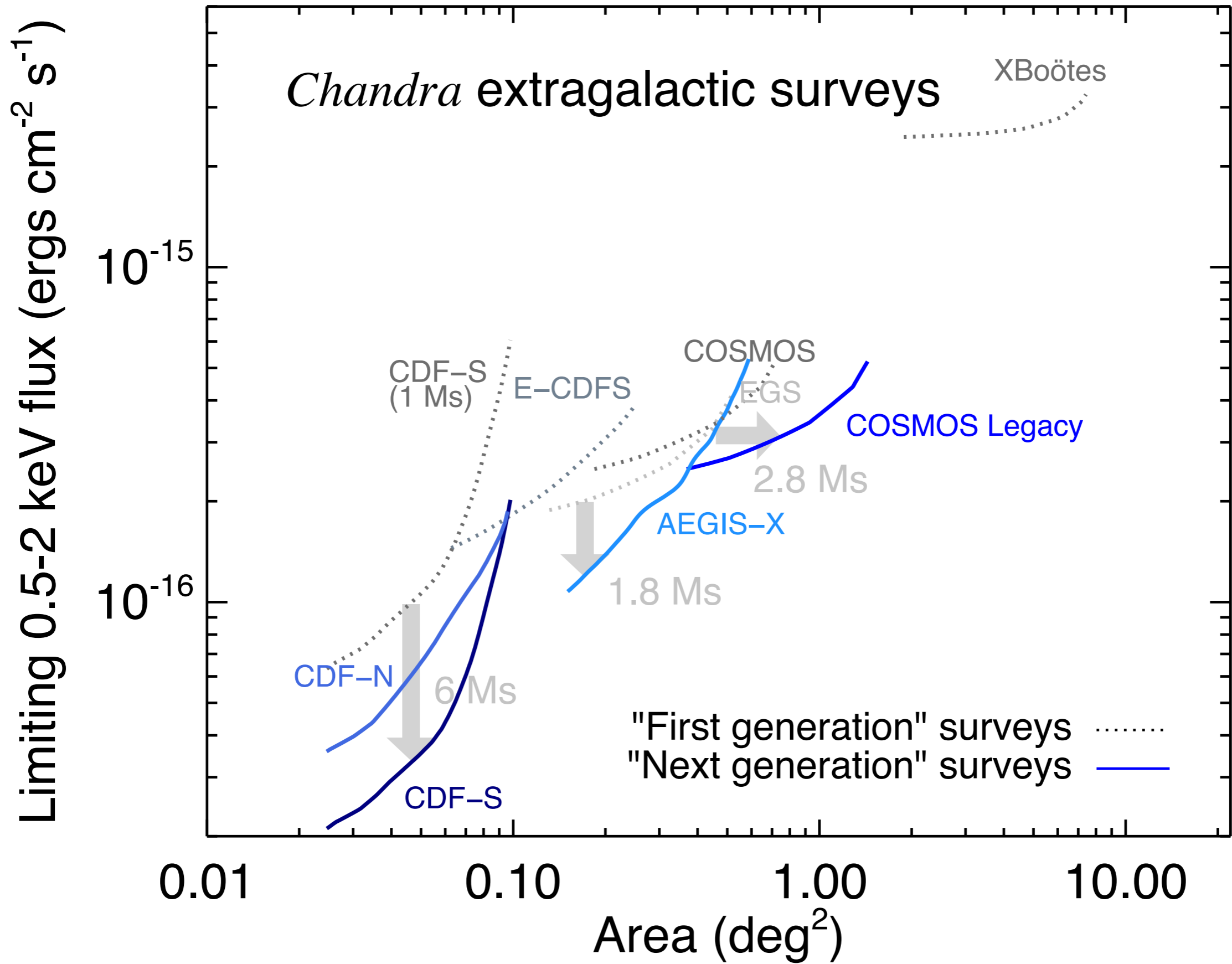
AEGIS (200 ks)

CDF-N (2 Ms)

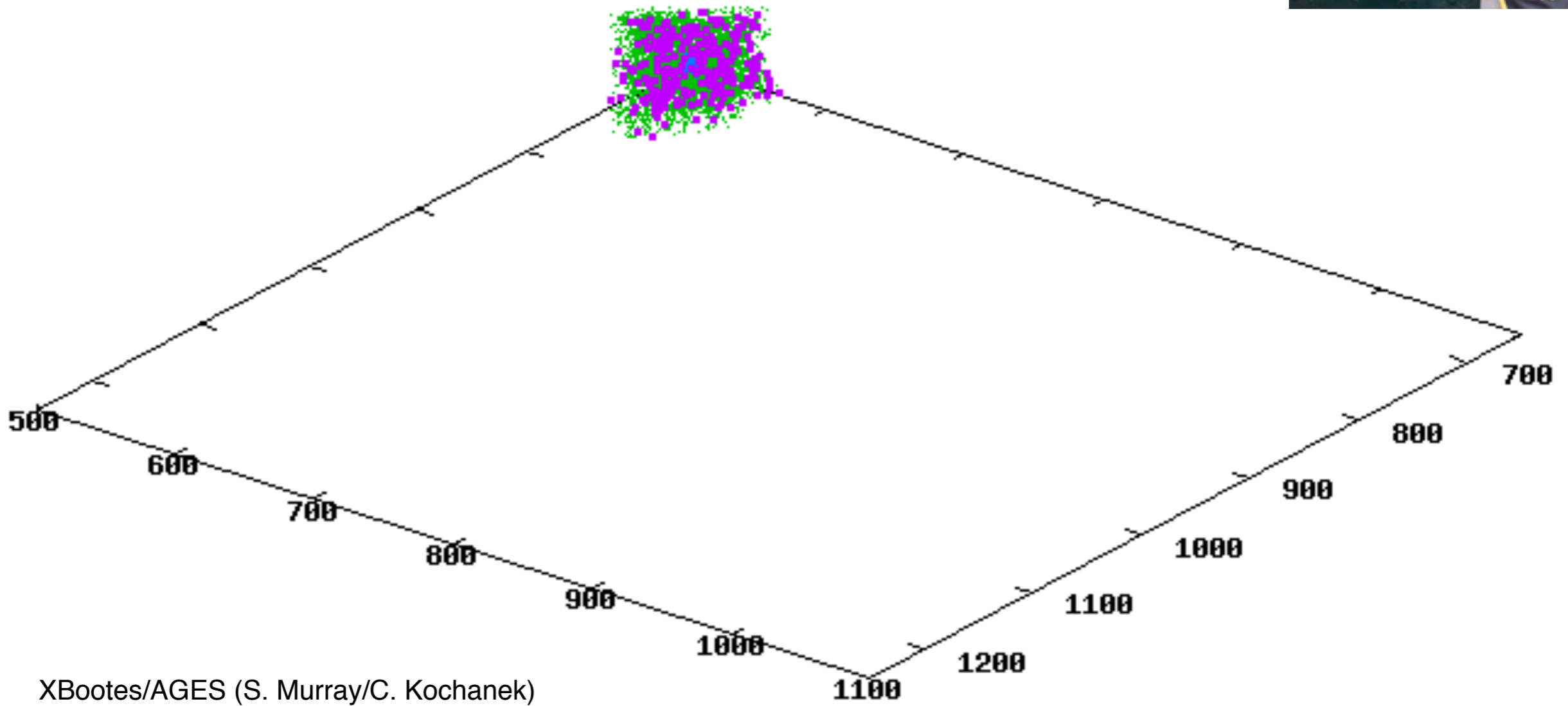
C-COSMOS
(160-200 ks)

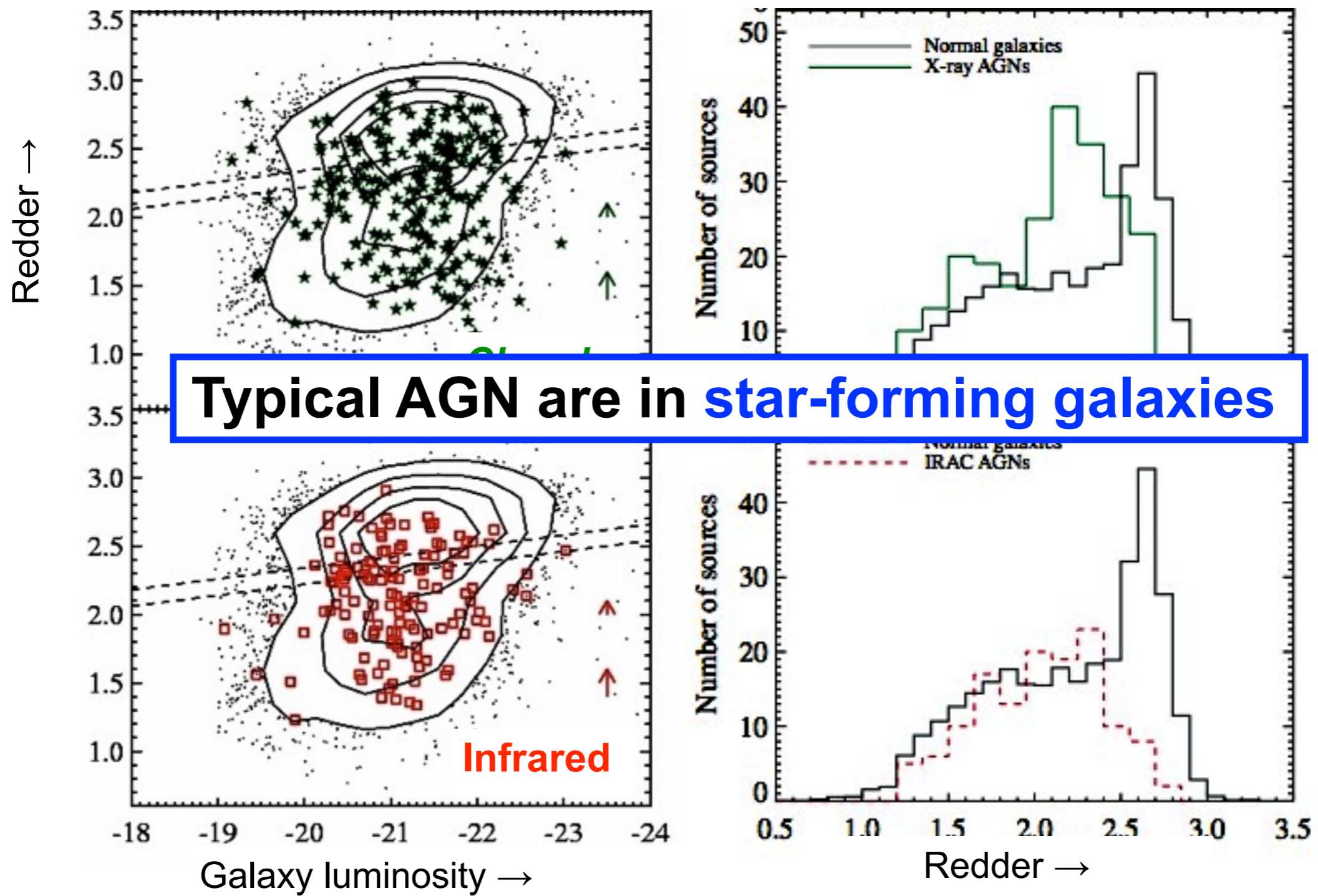


SHOWN FOR SCALE



- galaxies
- *Chandra* AGN

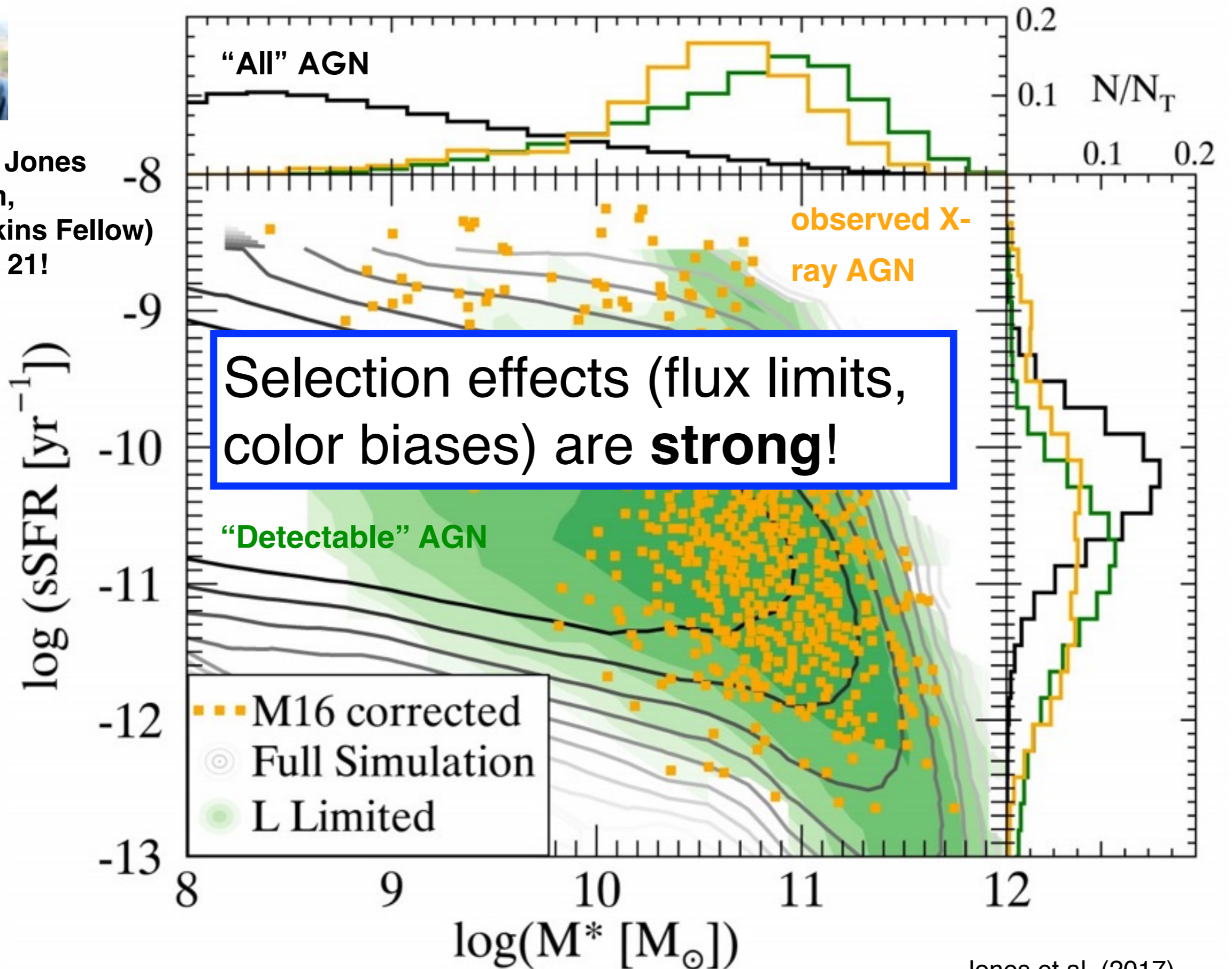




Hickox et al. (2009)



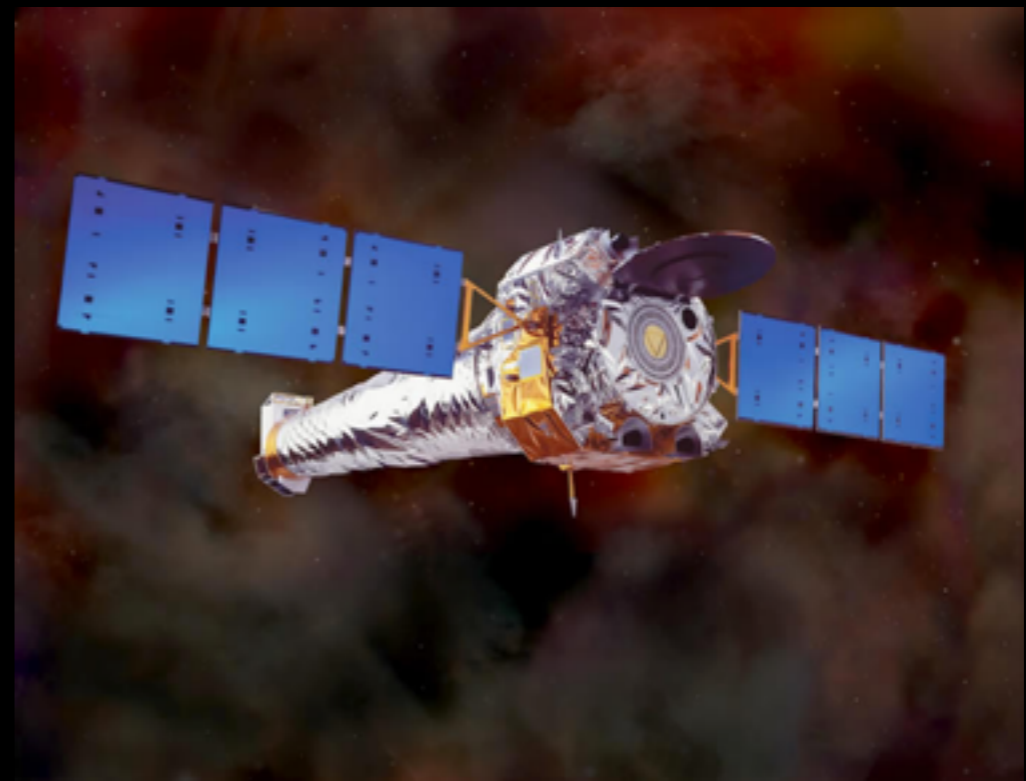
Mackenzie Jones
(Dartmouth,
NASA Jenkins Fellow)
See poster 21!

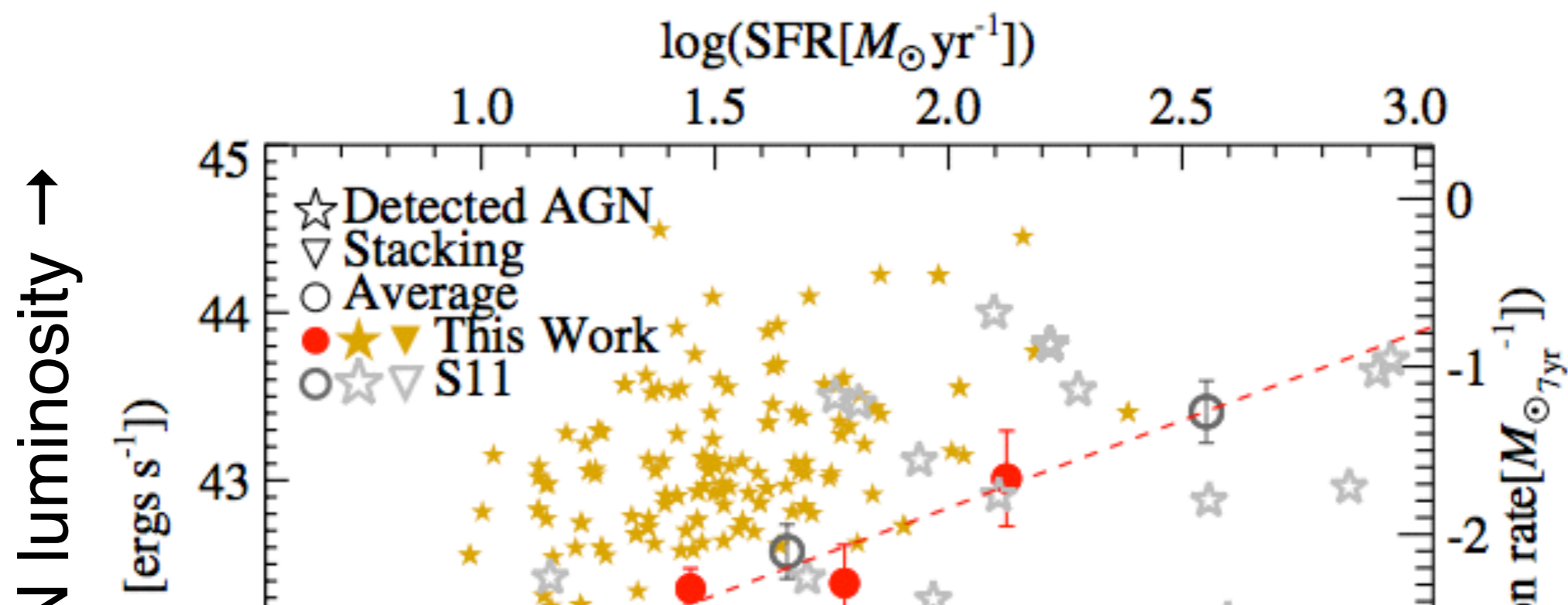


To fully account for selection effects, the optimal telescope has:

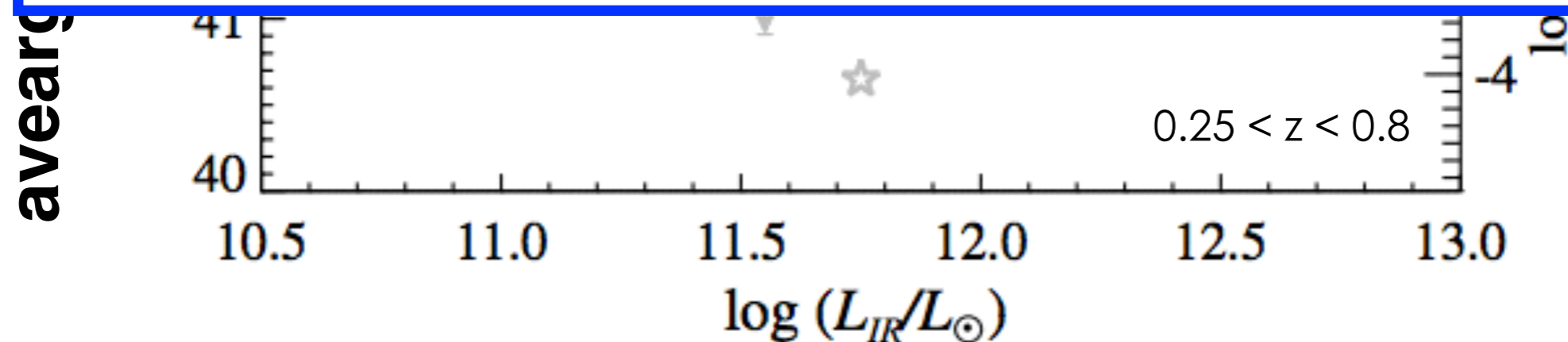
- (1) High throughput**
- (2) Low, well controlled backgrounds (and thus well characterized sensitivity)**
- (3) Little source confusion (for counterpart matching and X-ray stacking)**

High angular resolution!





Average AGN luminosity is correlated with **star formation rate**



observed IR luminosity →

Chen et al. (2013)

Do galaxy **bars** influence average BH accretion rates?

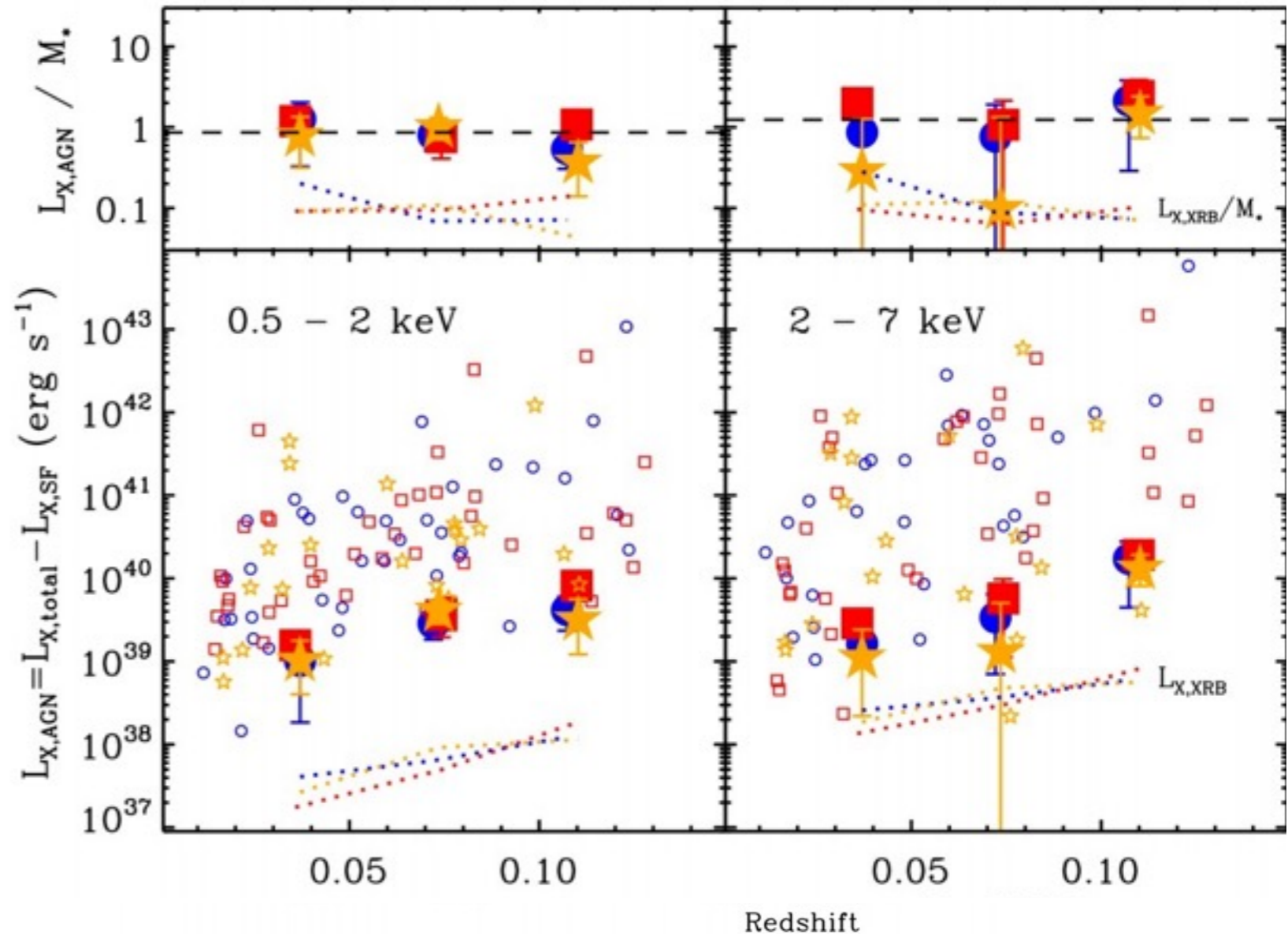
Bars



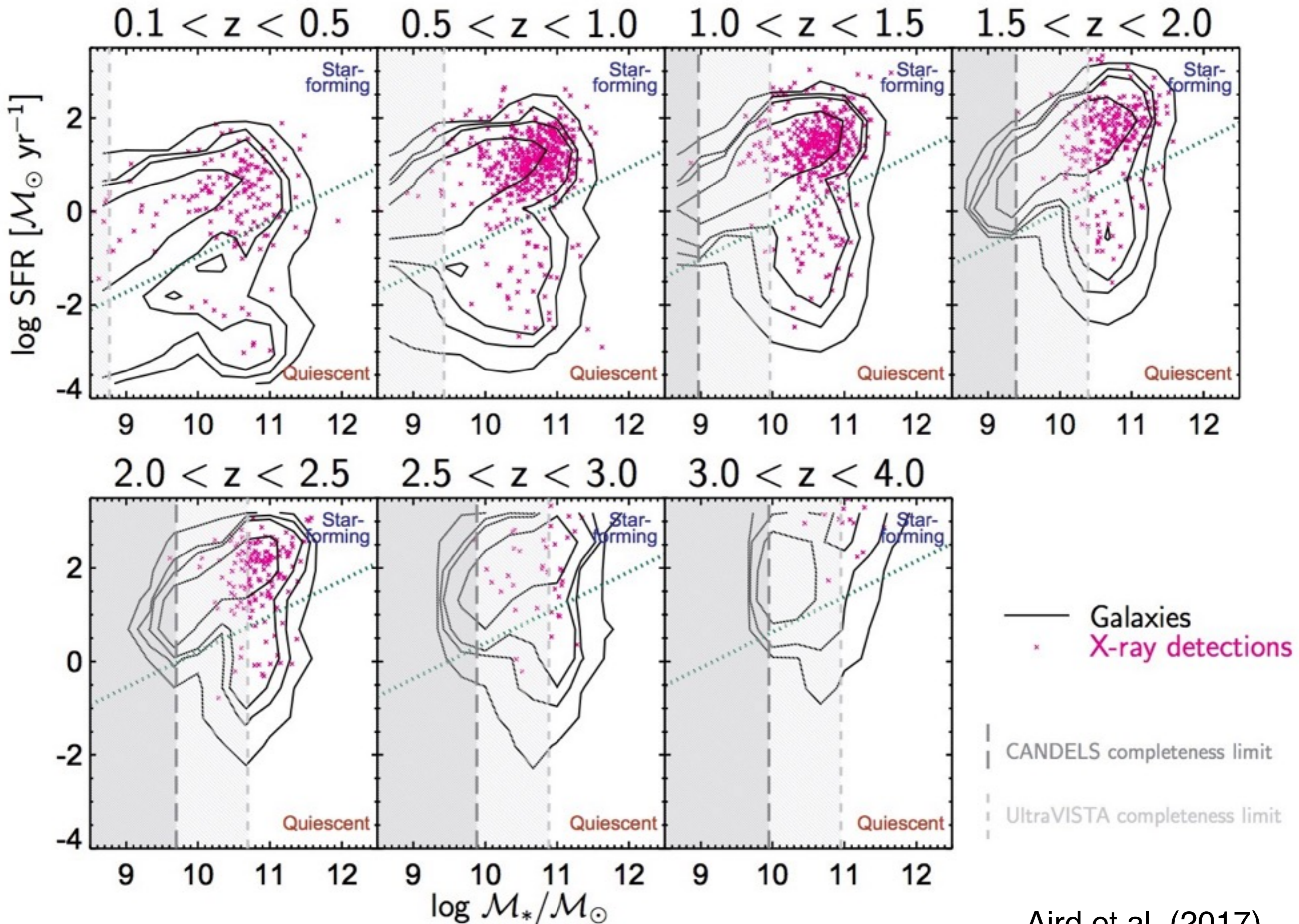
Ambiguous



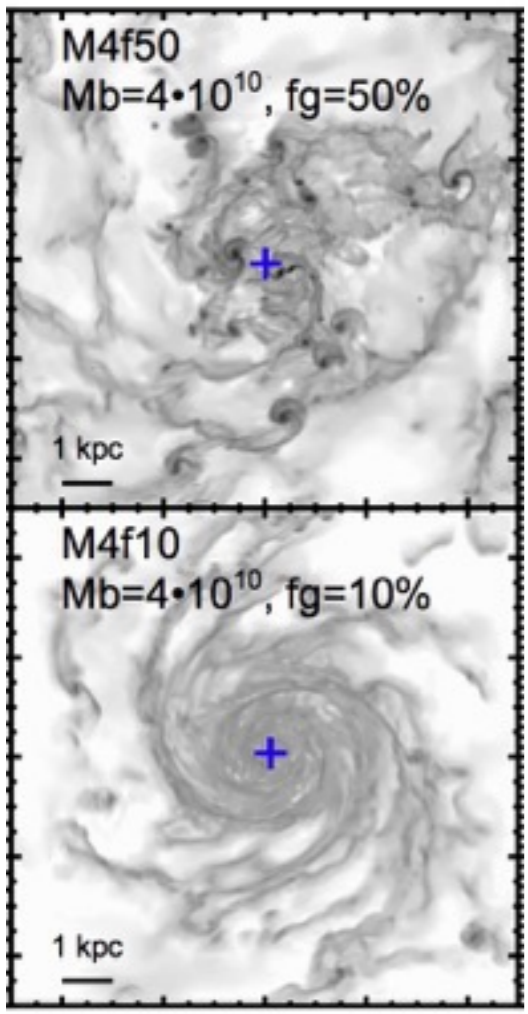
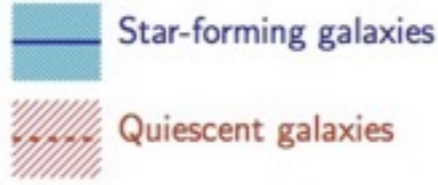
No bars



No clear effect of bars on average accretion

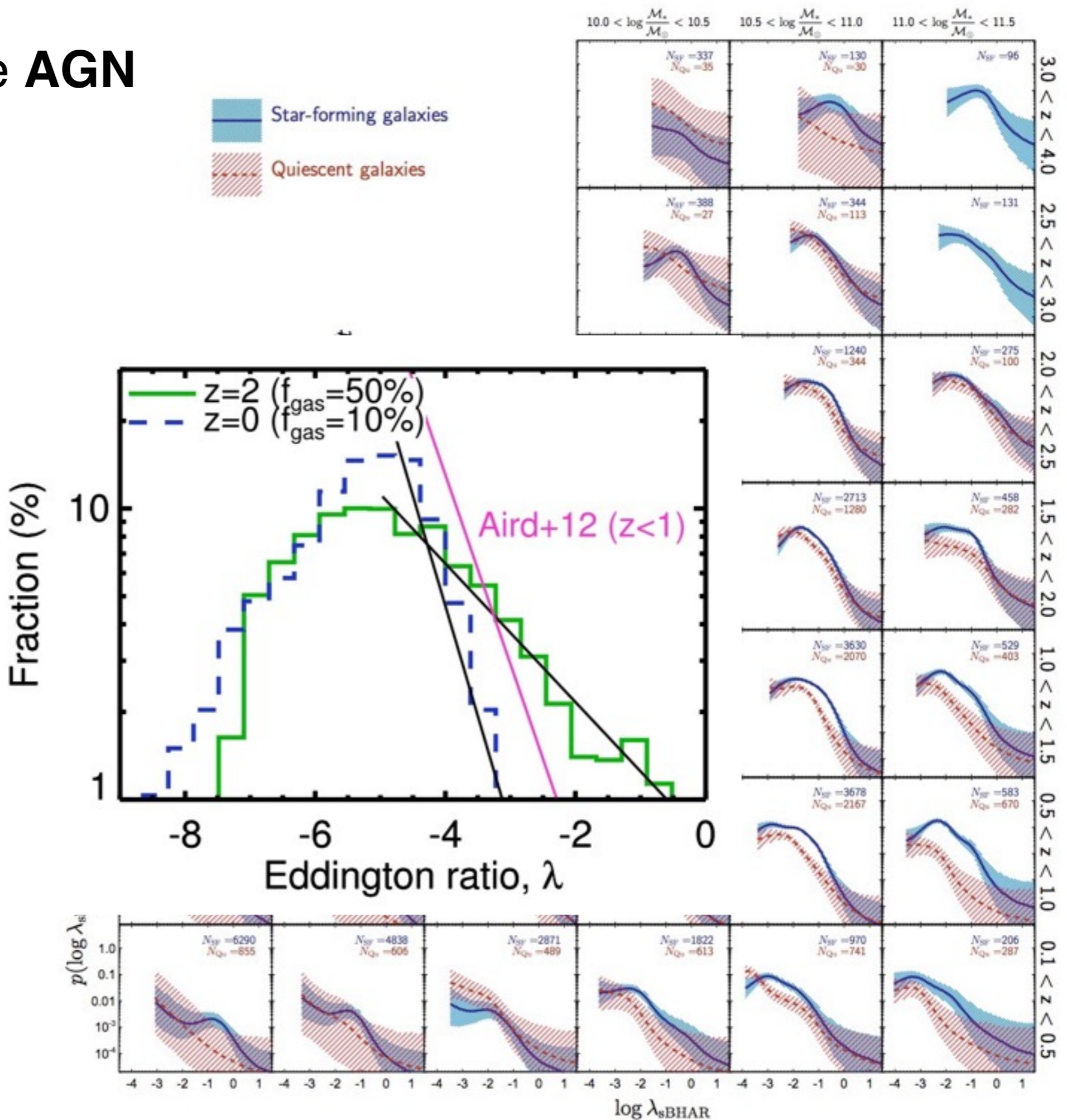


Evolution of the AGN accretion rate distribution



Gabor & Bournaud (2013)

Aird et al. (2017)

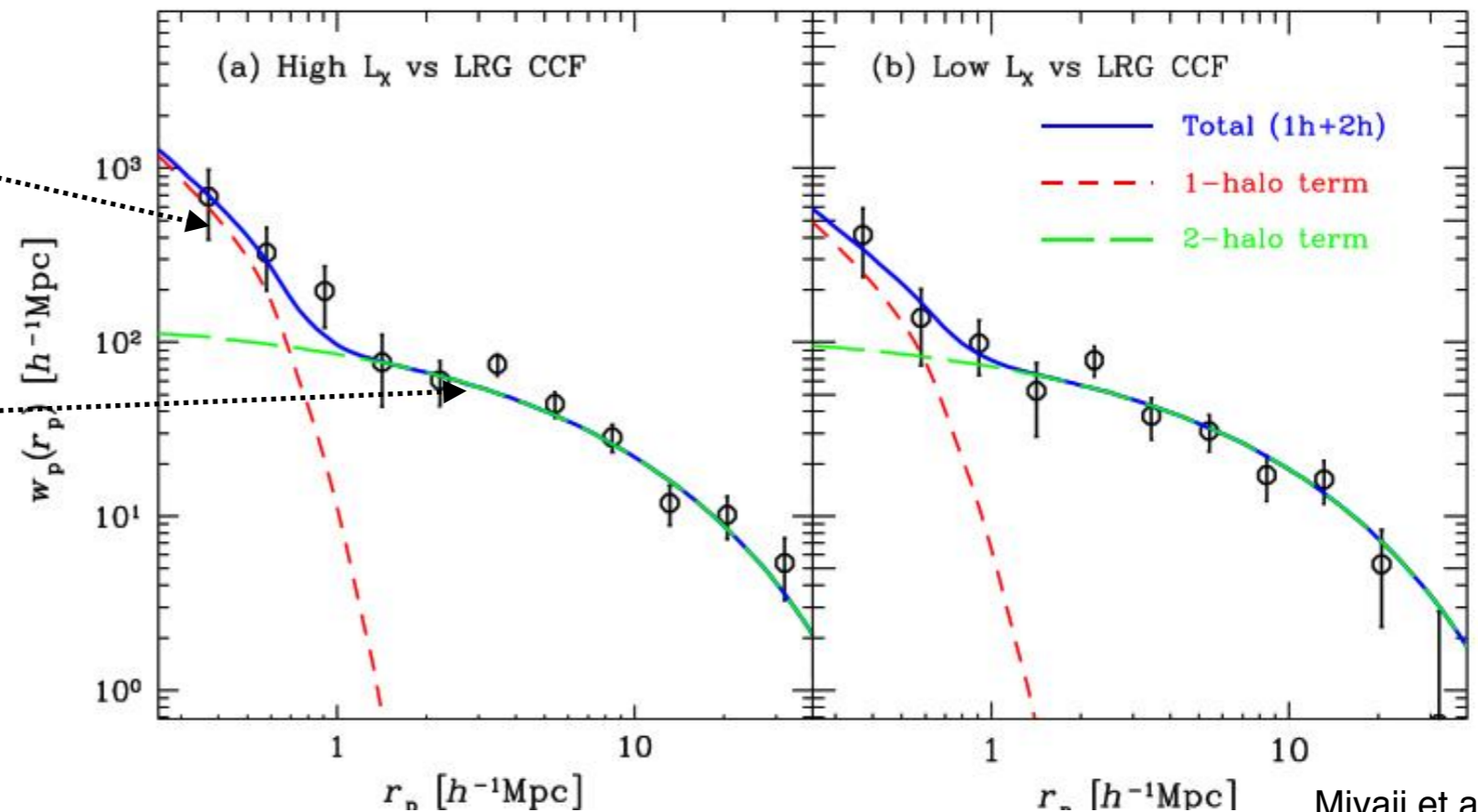
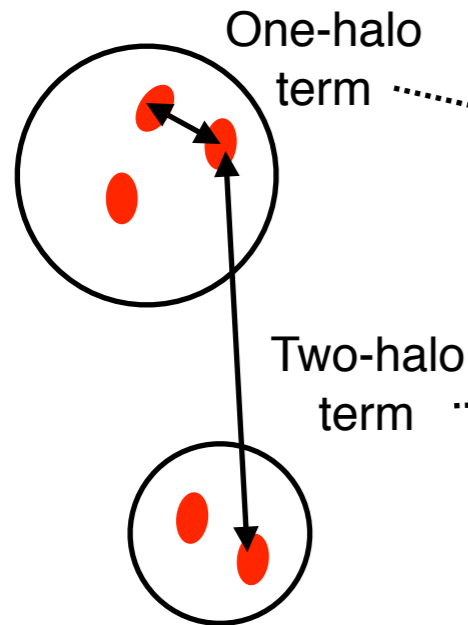


The AGN halo occupation distribution

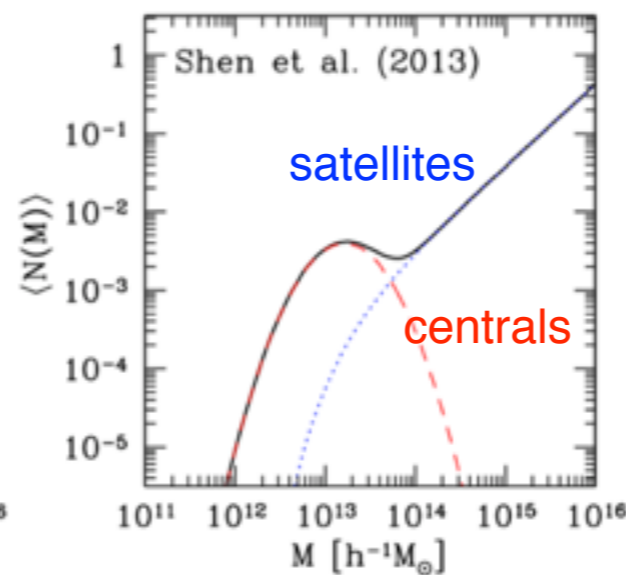
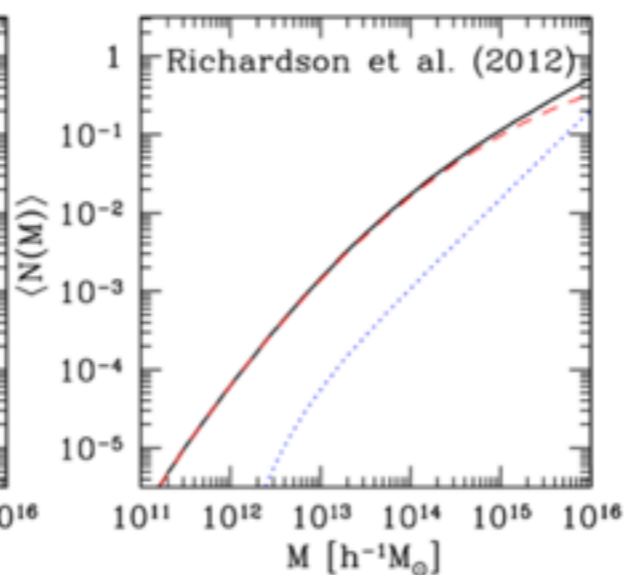
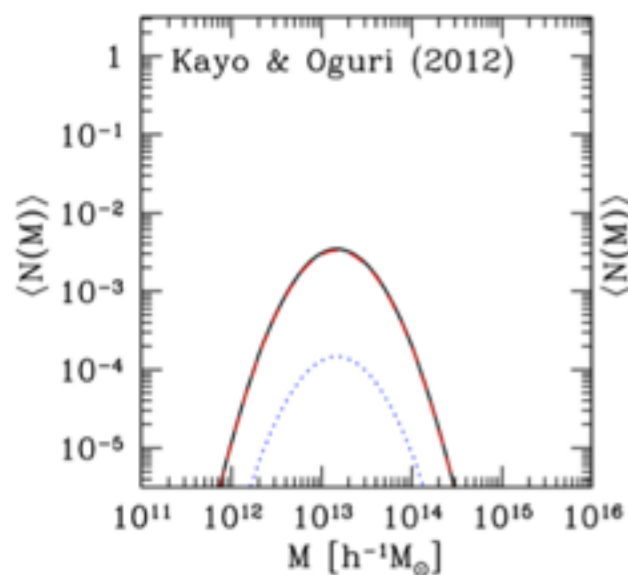
How likely is a DM halo to host an AGN as a function of **halo mass**?

Are AGN primarily in **central** or **satellite** halos?

The HOD formalism

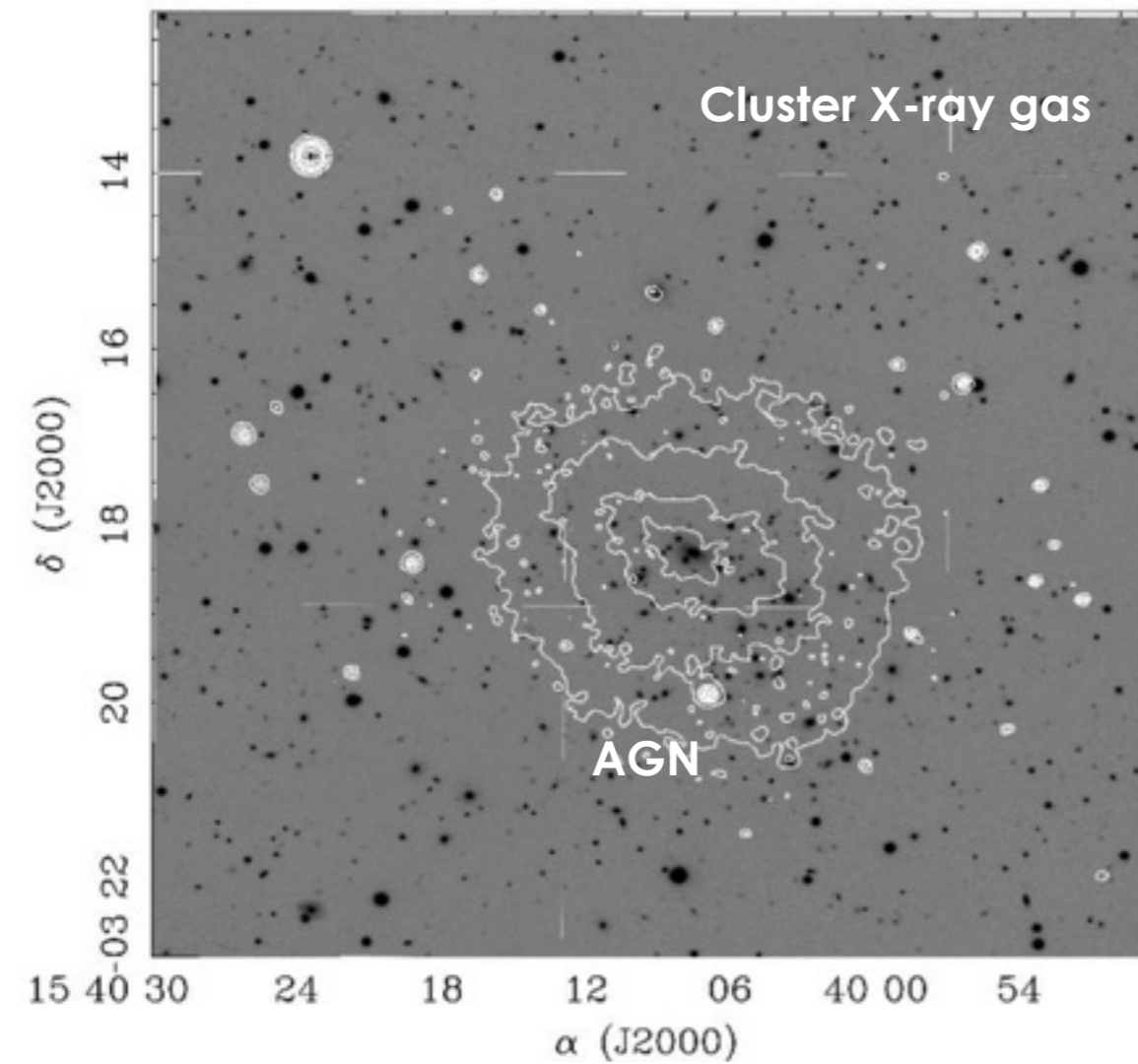


Miyaji et al. (2011)

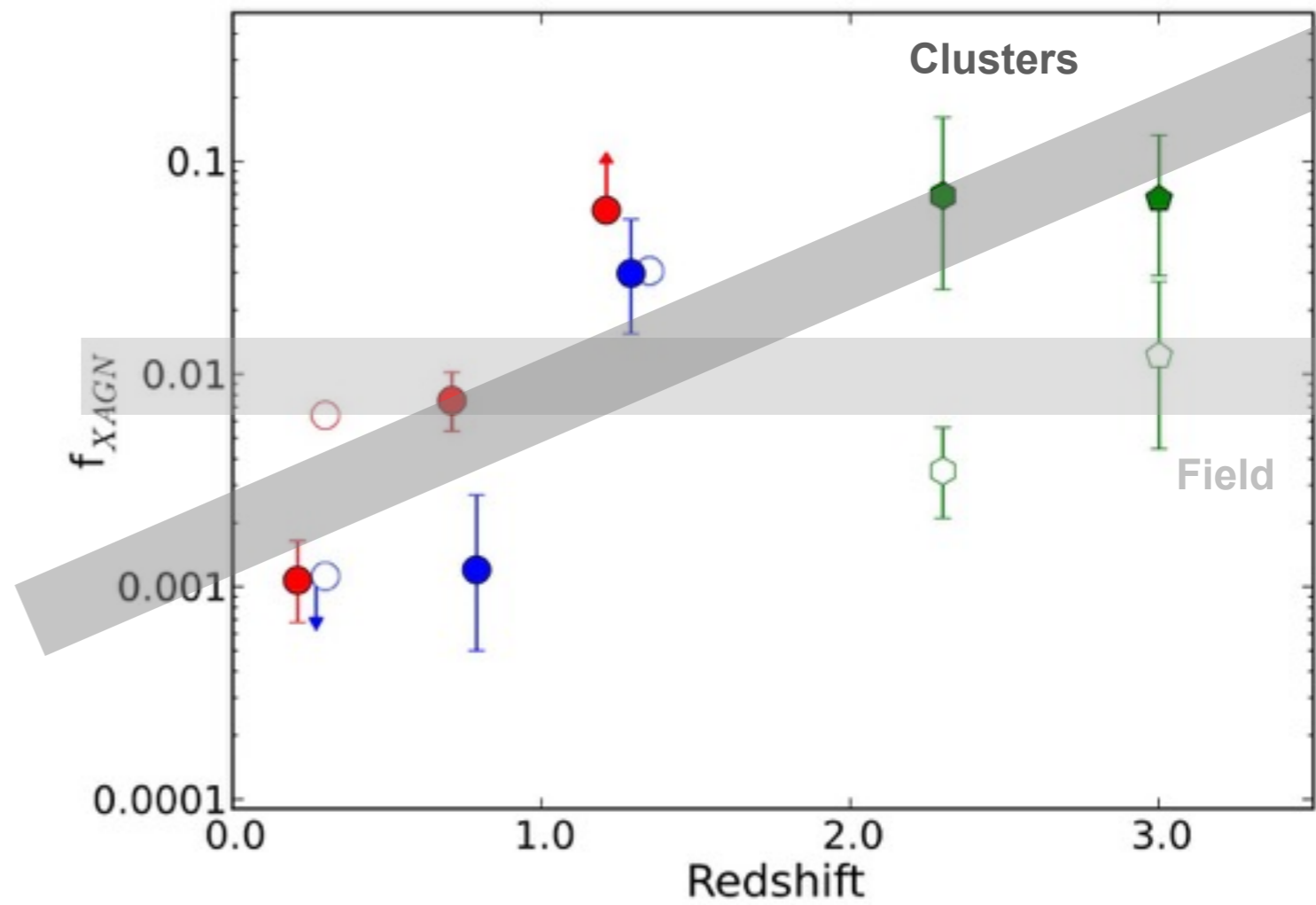


Credit: I. Kayo

Direct measures of AGN halo occupation in clusters

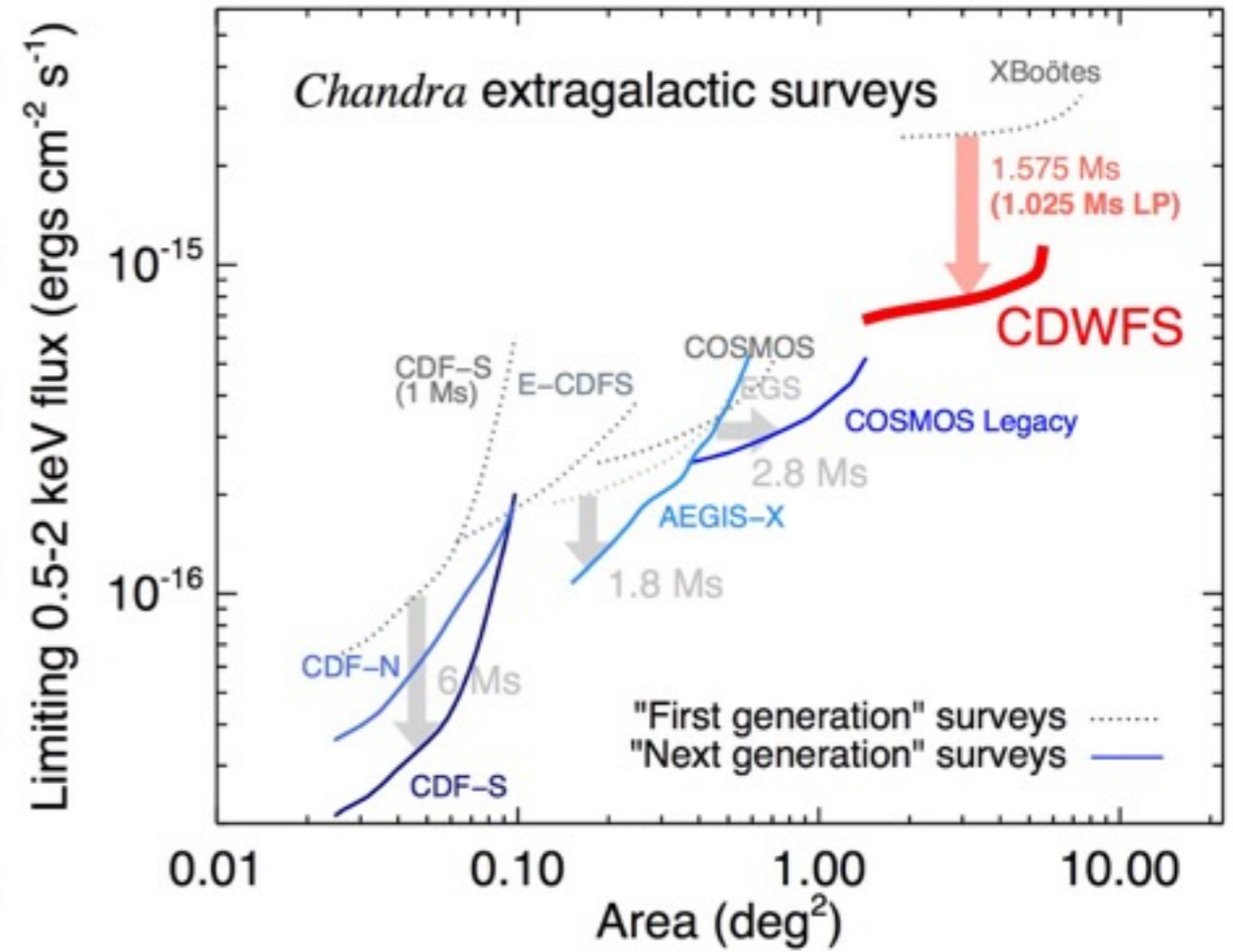
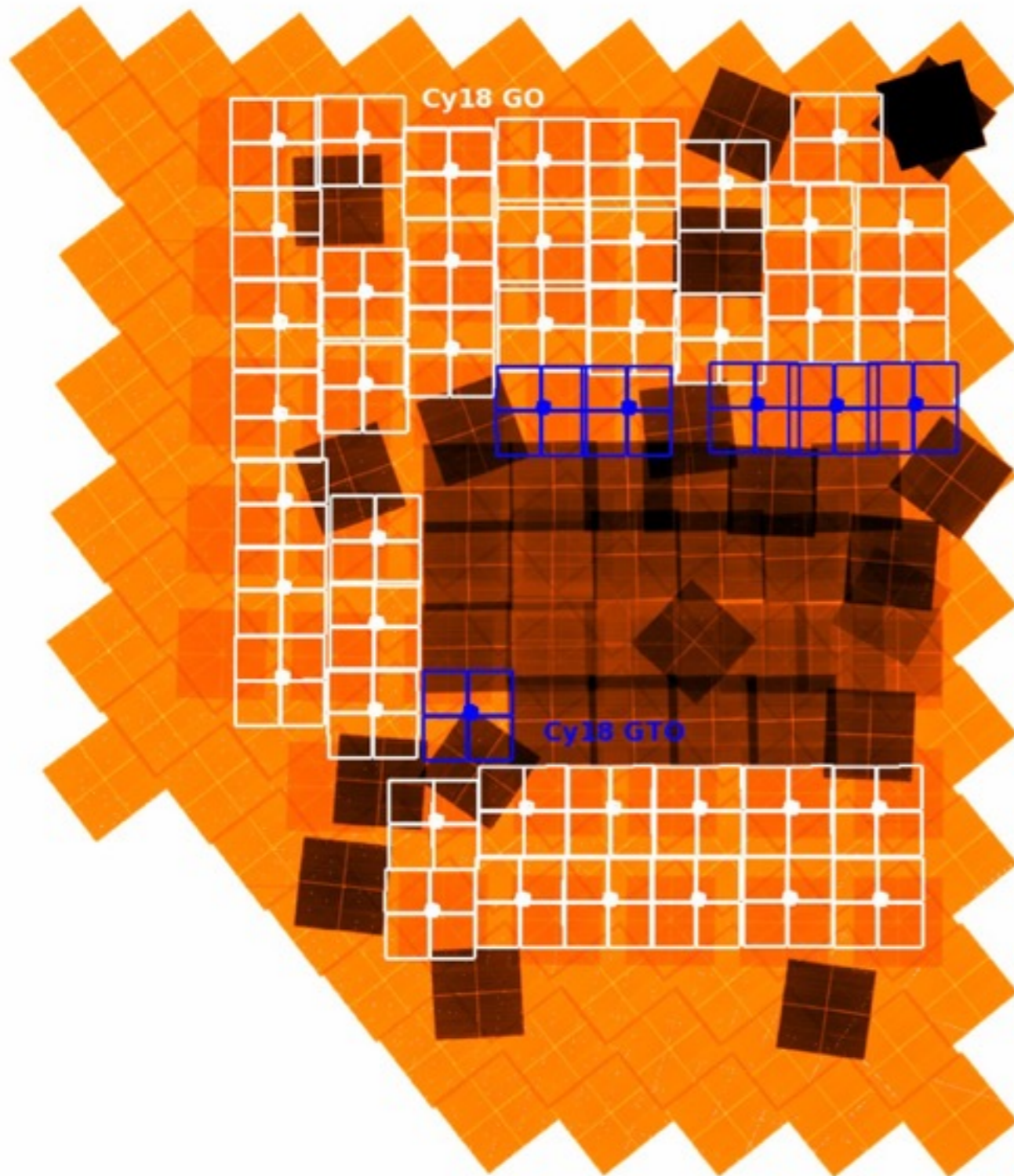


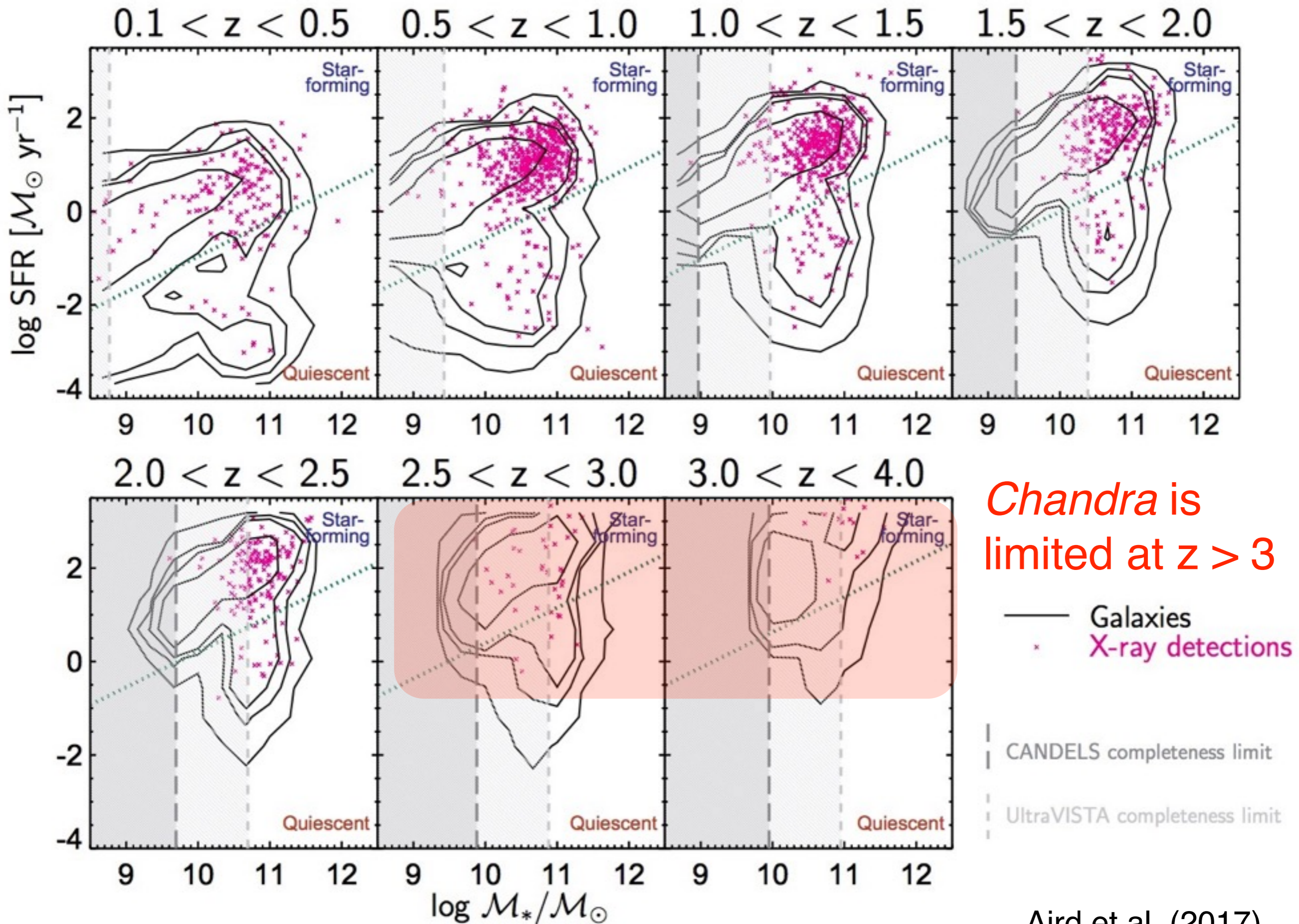
Martini et al. (2002)



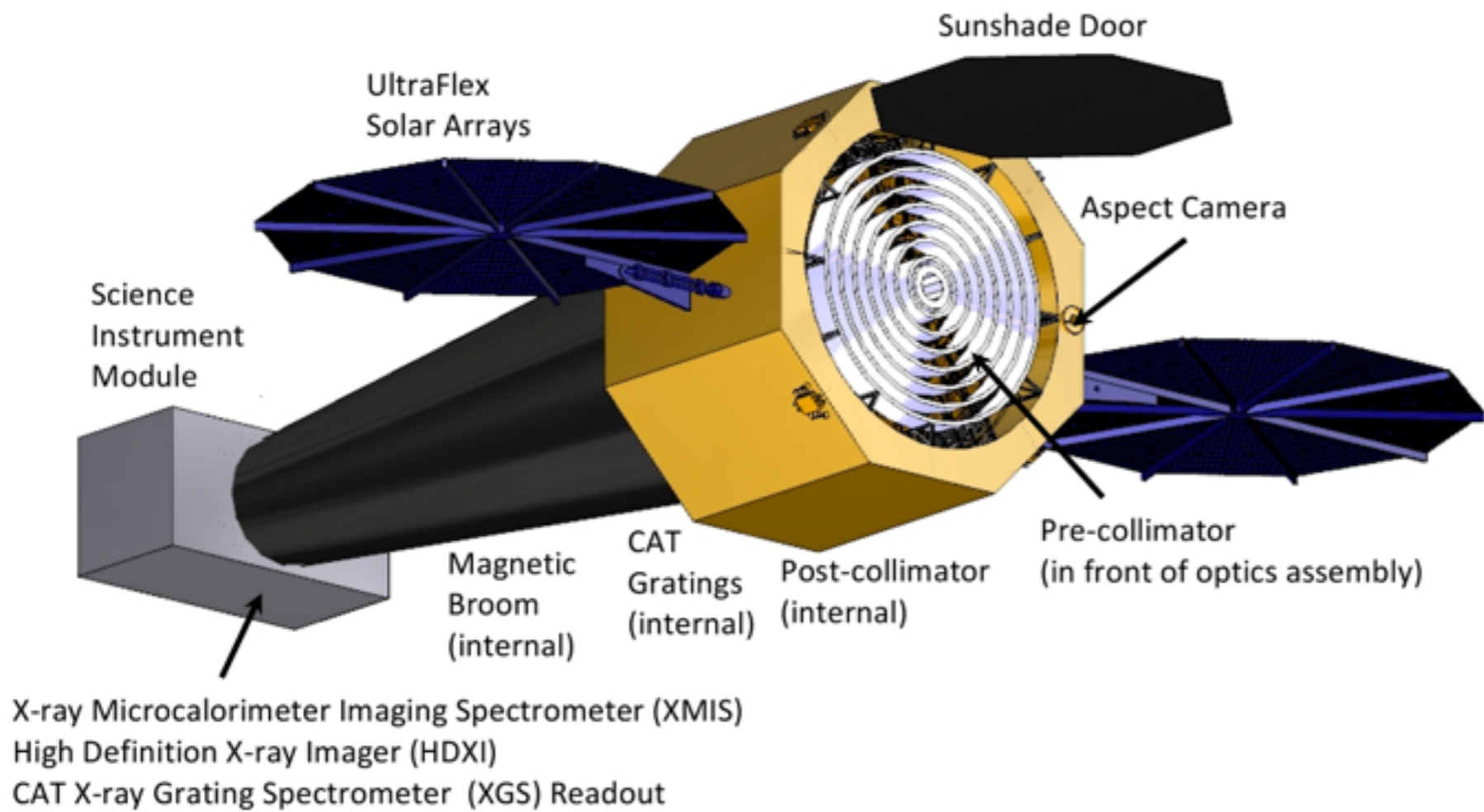
Martini et al. (2013)

The *Chandra* Deep Wide-Field Survey (1 Ms program in Cycle 18, PI: Hickox)





Chandra is limited at $z > 3$



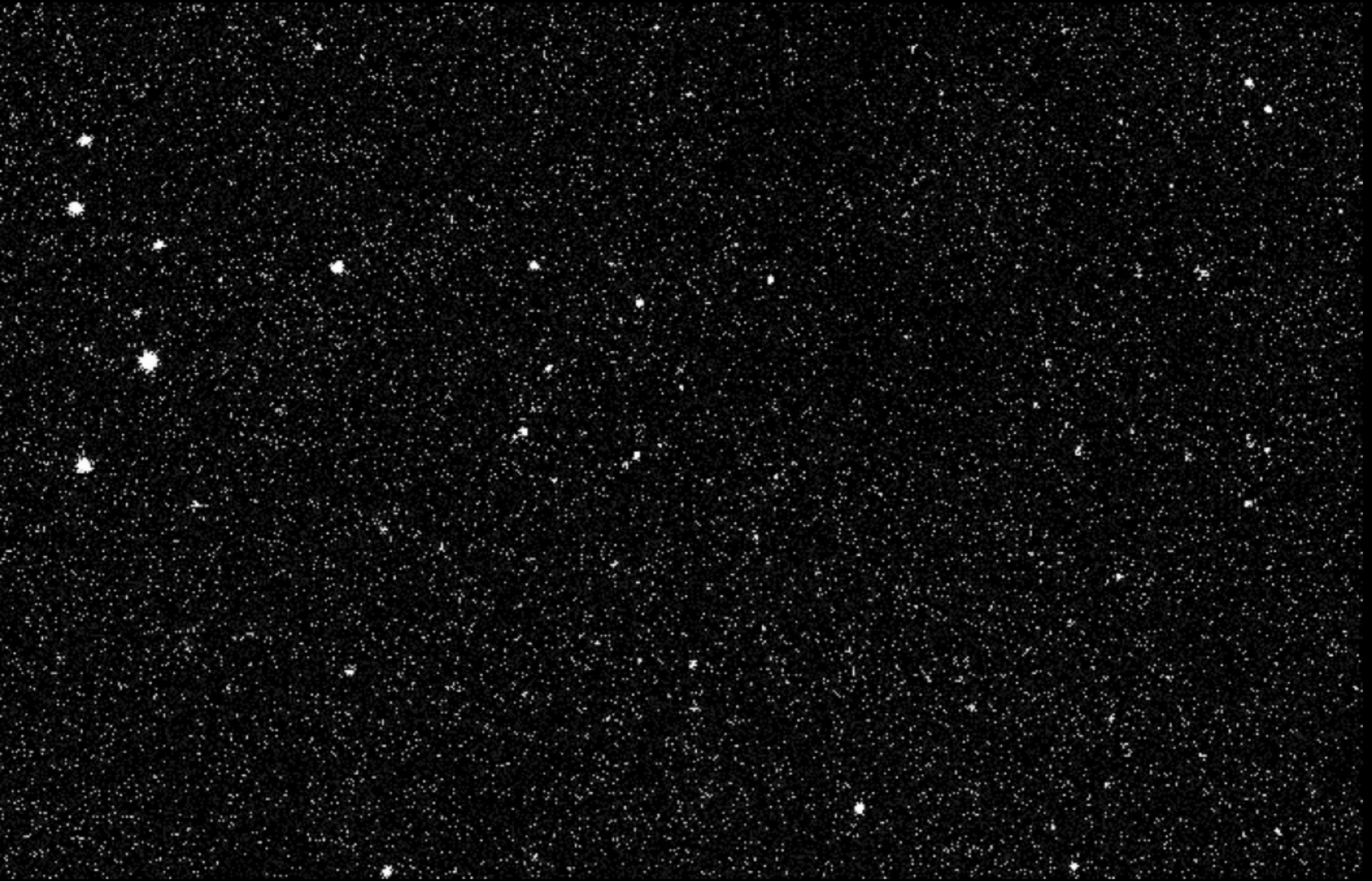
Lynx



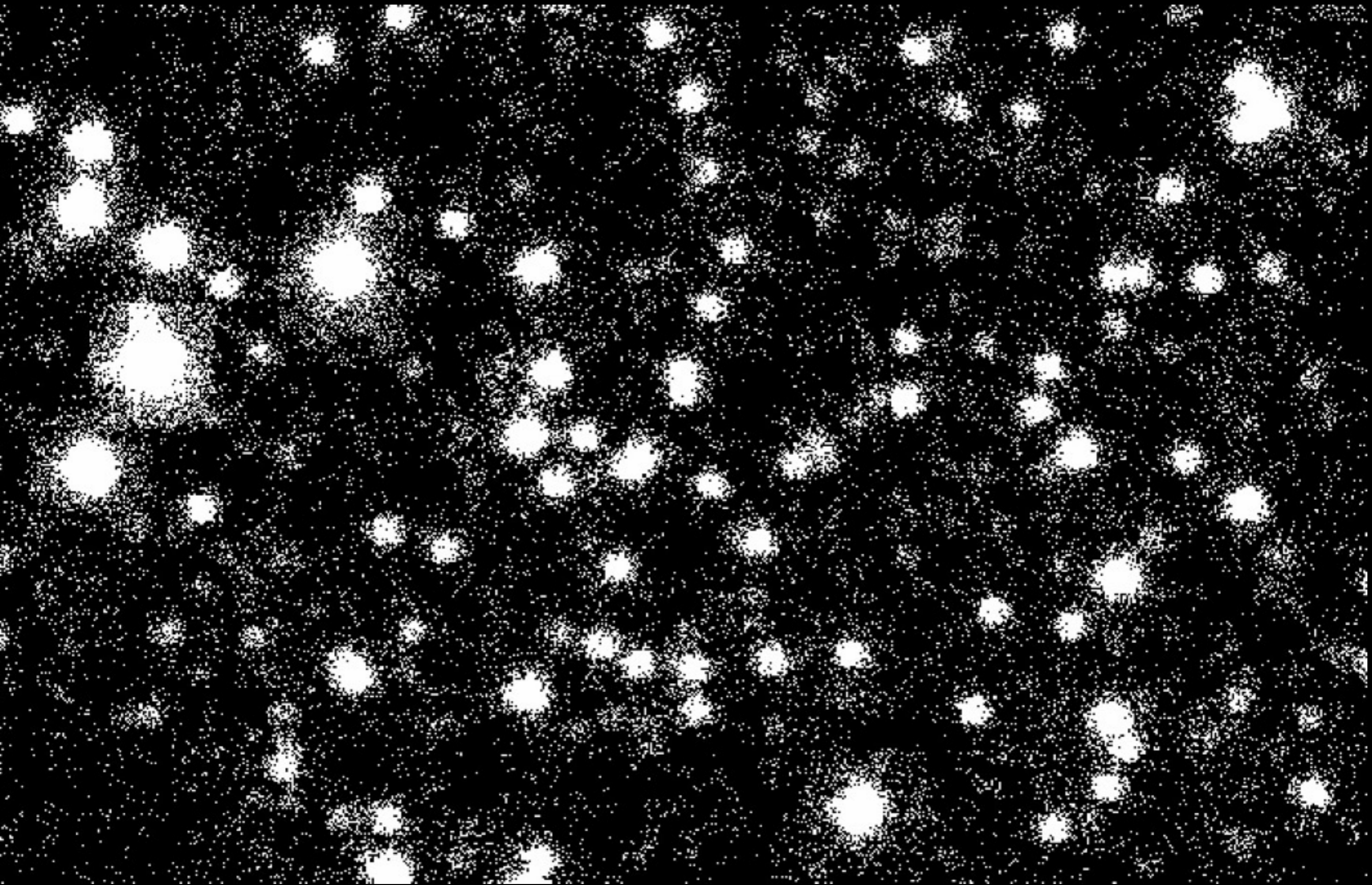
*Revealing the
invisible Universe*

www.wastro.msfc.nasa.gov/lynx/

Chandra (7 Ms, Luo et al. 2017)



Athena-like ($\sim 5''$ PSF, 1 Ms)



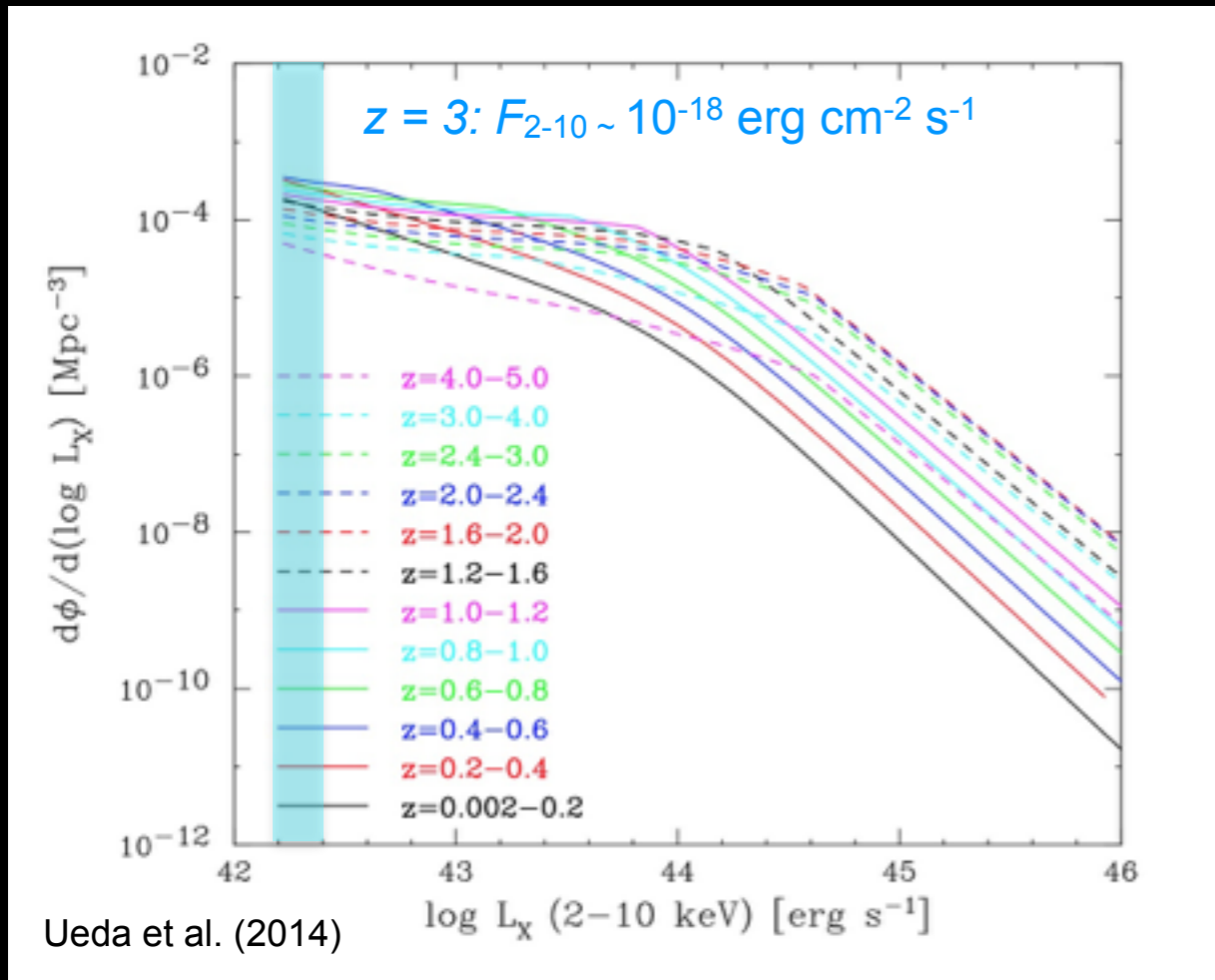
XRS HDXI (~1 Ms)



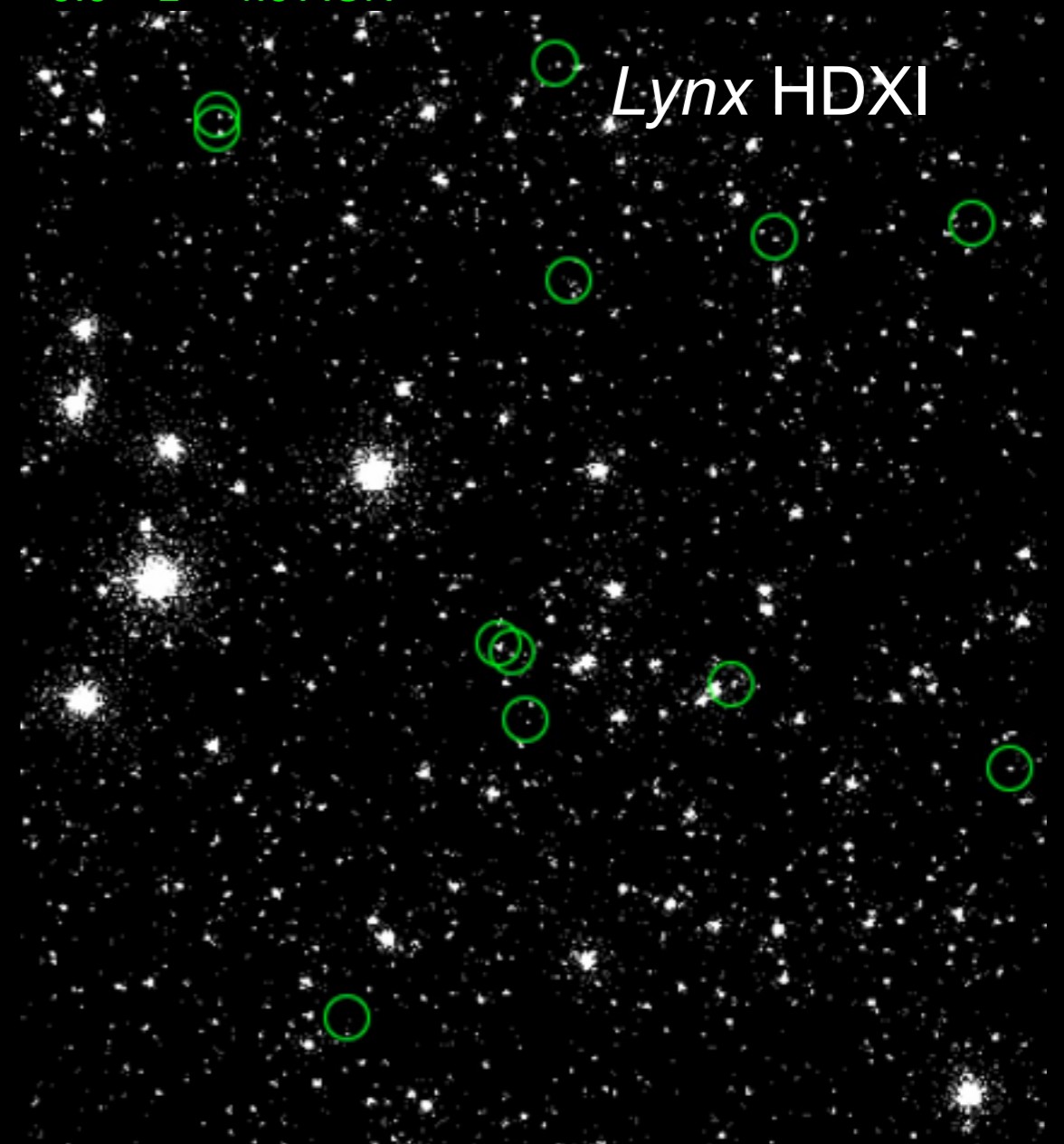


The power of *Lynx*

Sensitivity to faint sources



3.5 < z < 4.5 AGN

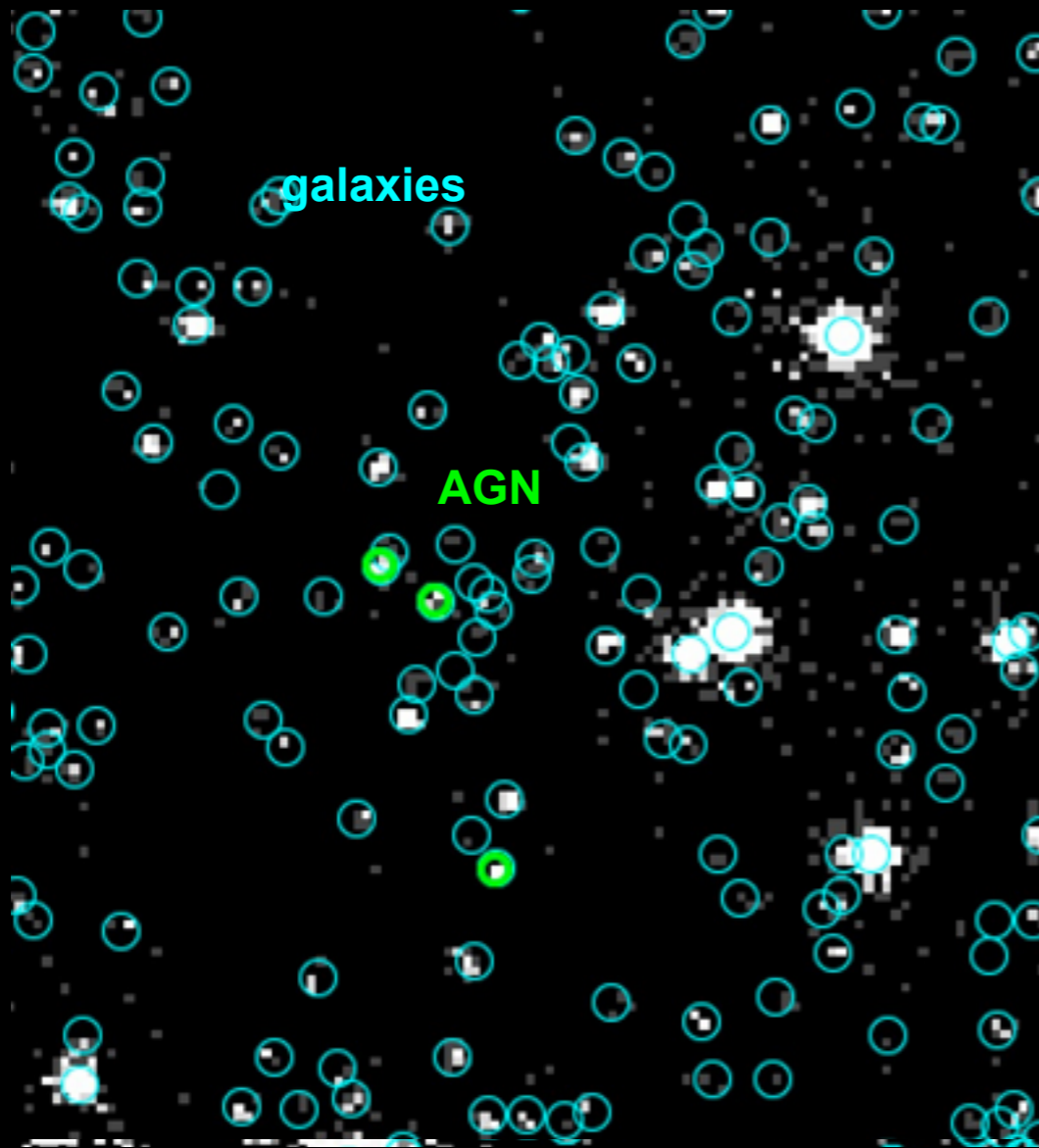


High throughput
minimal source confusion

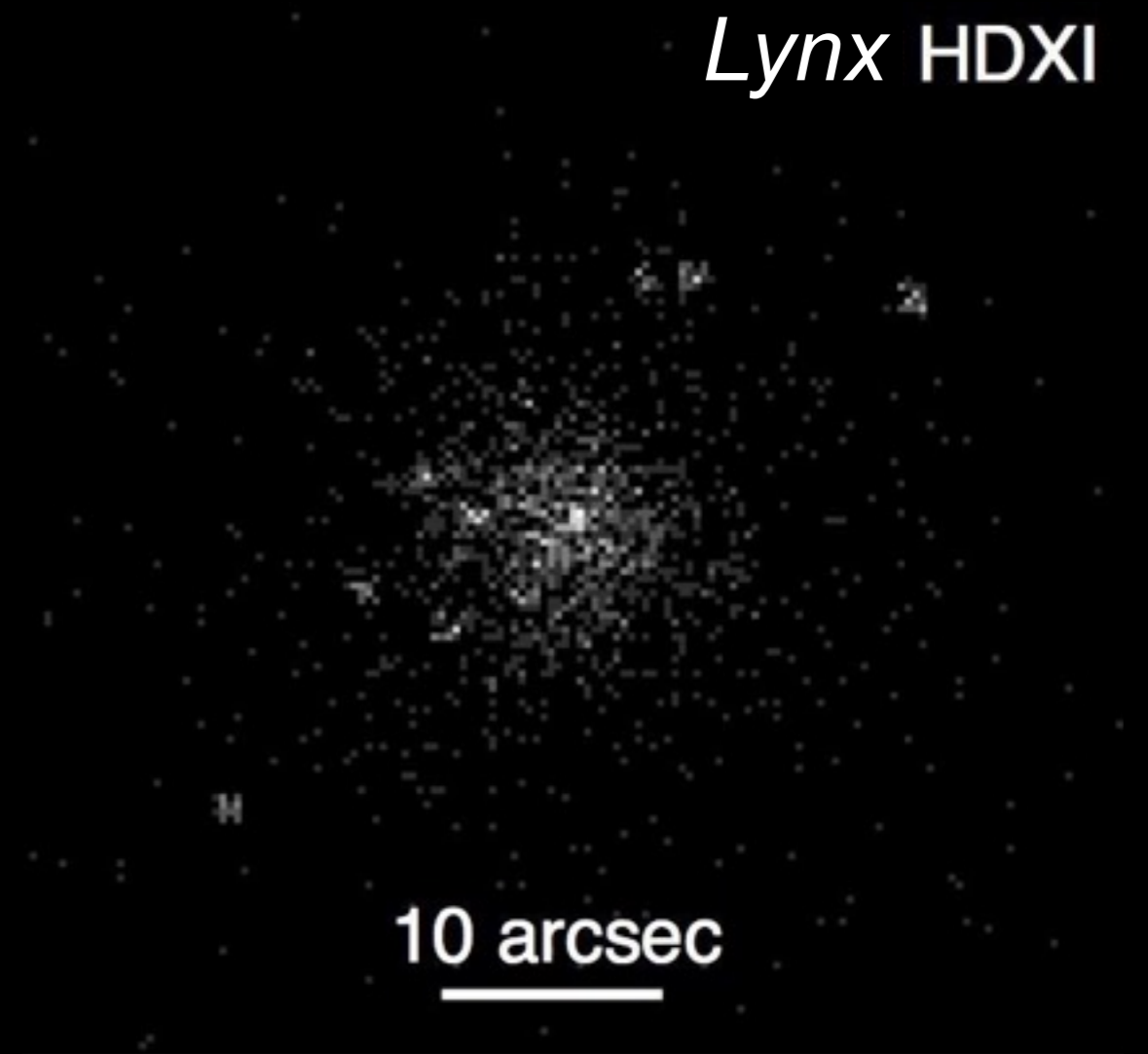


The power of *Lynx*

Exquisite angular resolution

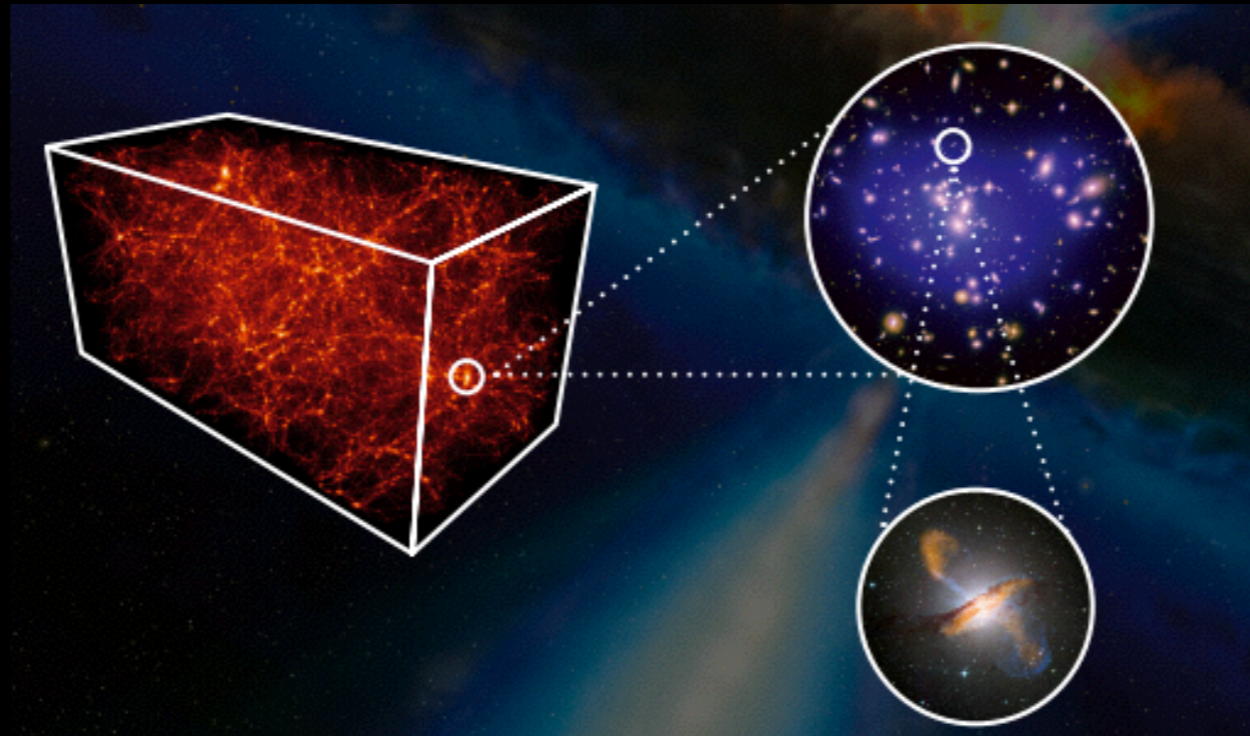


“Field” AGN



“Cluster” AGN

Take-home messages



Black hole - galaxy - halo co-evolution is a **statistical problem!**

Chandra has shown us that galaxy and BH growth are linked in a **broadly universal** (although complex) process, but can only probe to low accretion rates at $z < 3$.

Through high throughput and exquisite angular resolution, *Lynx* will push our studies of BH/galaxy co-evolution to the **epoch from the dawn to the peak of black hole** and galaxy formation

Physics and Astronomy at Dartmouth College



Dartmouth

Tenure-track faculty position open this year
If interested please feel free to come find
me at coffee!

