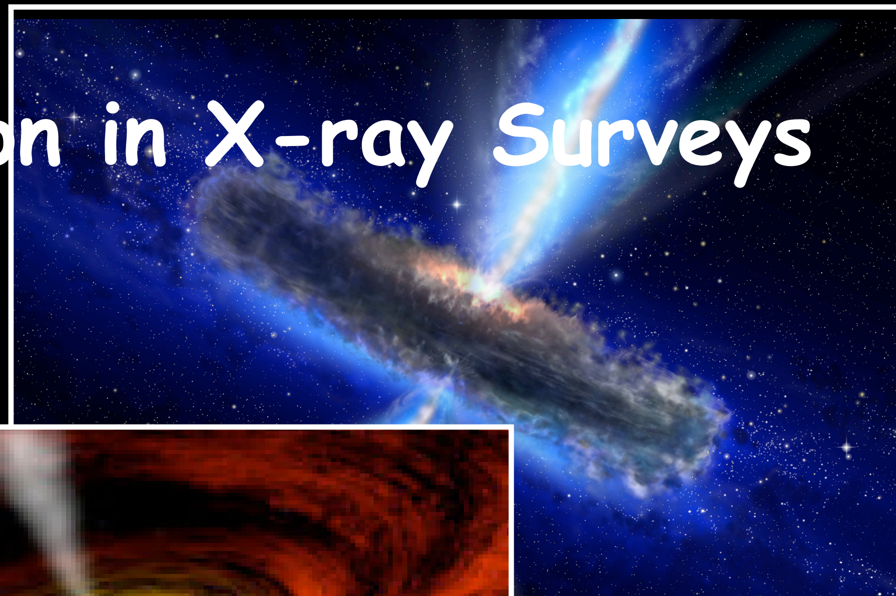
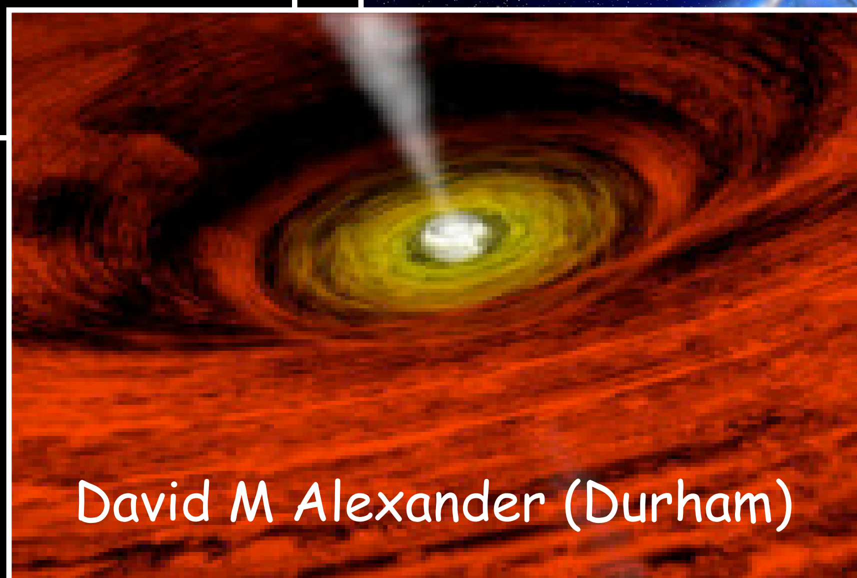
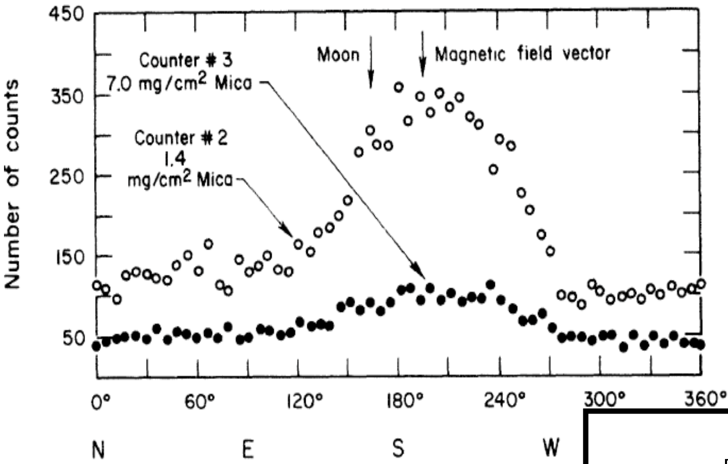
AGN Identification in X-ray Surveys





David M Alexander (Durham)

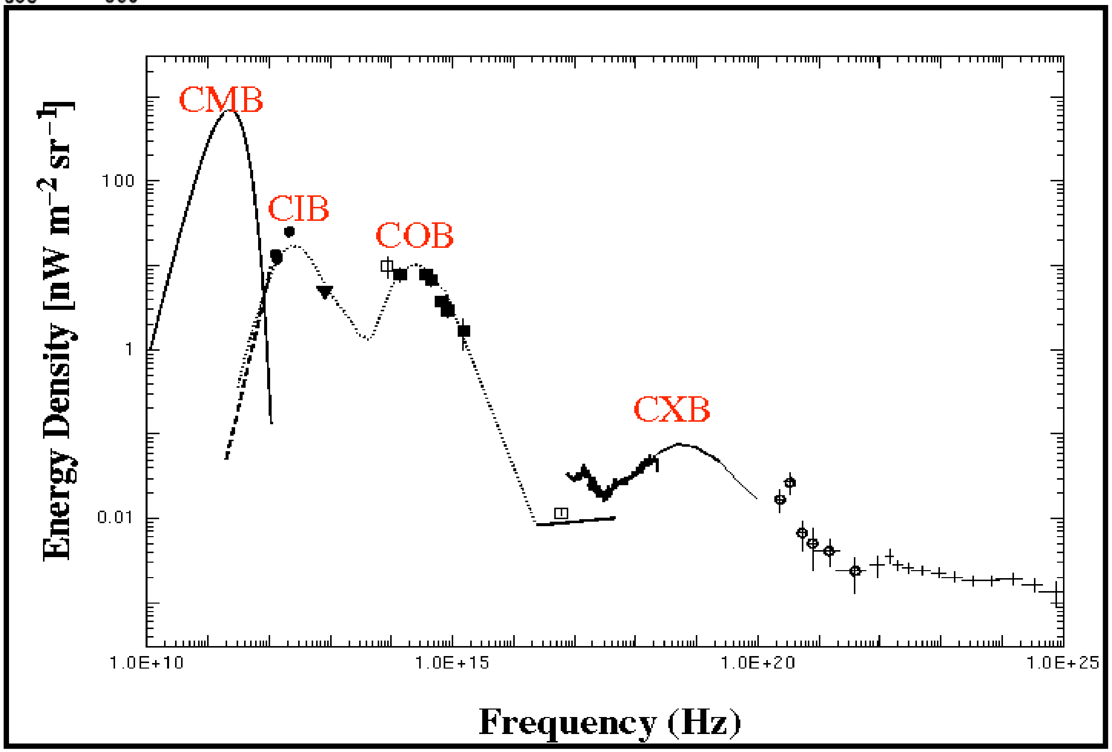
First X-ray Survey



Giacconi et al. (1962)

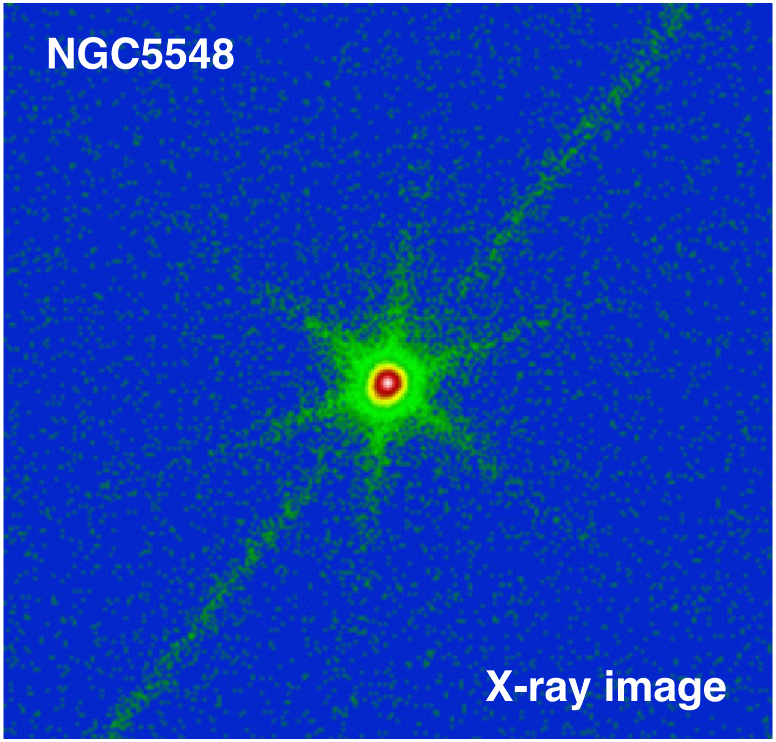
FIG. 1. Number of counts versus azimuth

Discovered X-ray background (CXB), first cosmic background discovered

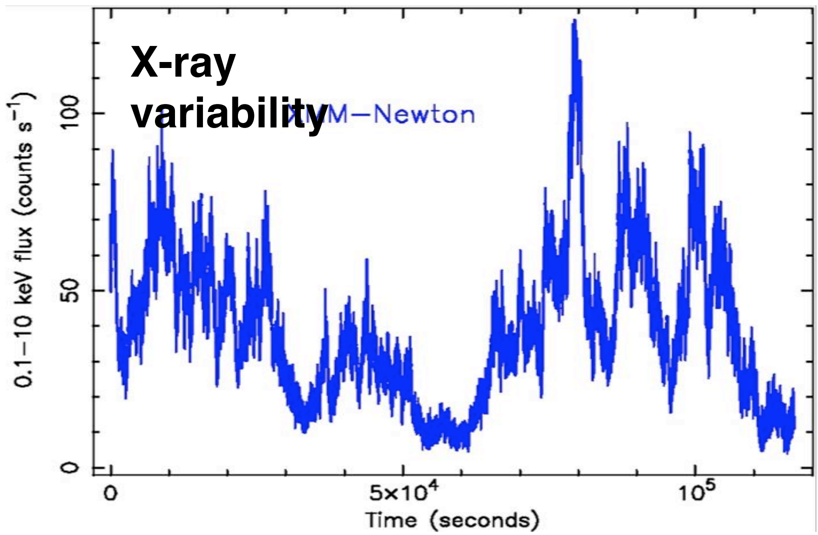


For a long time it was uncertain what dominated the CXB

AGNs are strong X-ray emitters



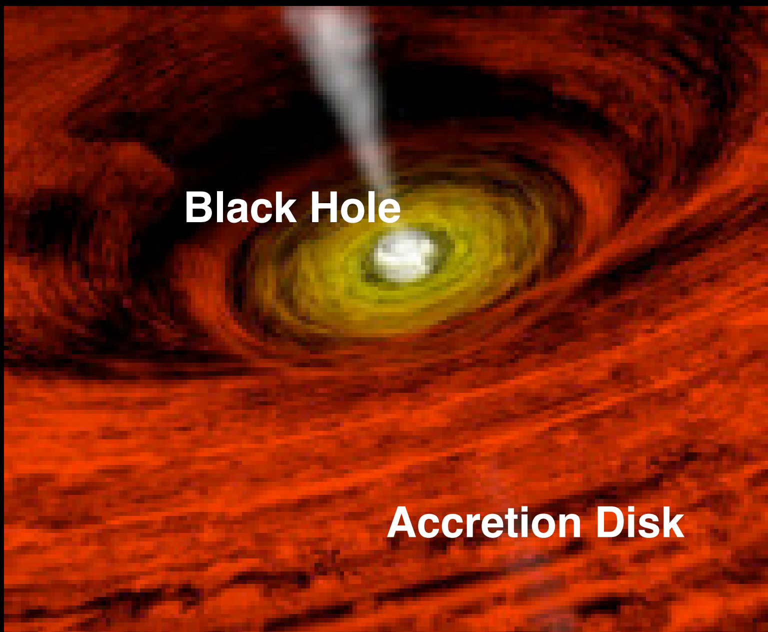
It is now confirmed that AGNs dominate the CXB

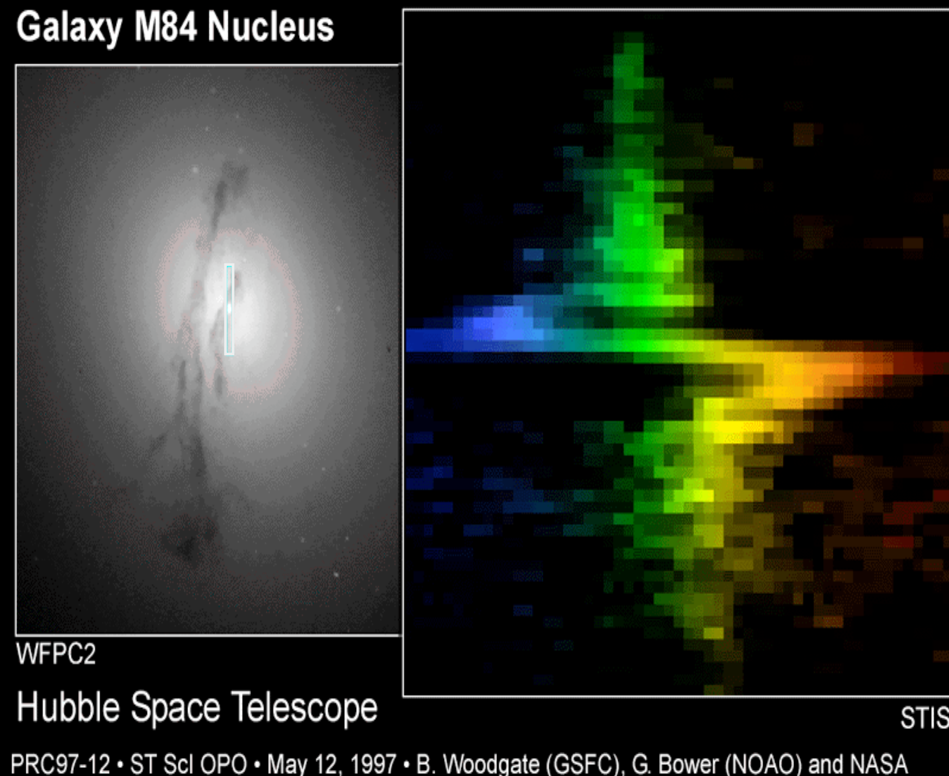


Rapid X-ray variabilty of nearby AGNs show the central regions are being probed: a measure of the on-going accretion

Power House and Ubiquity of AGN activity

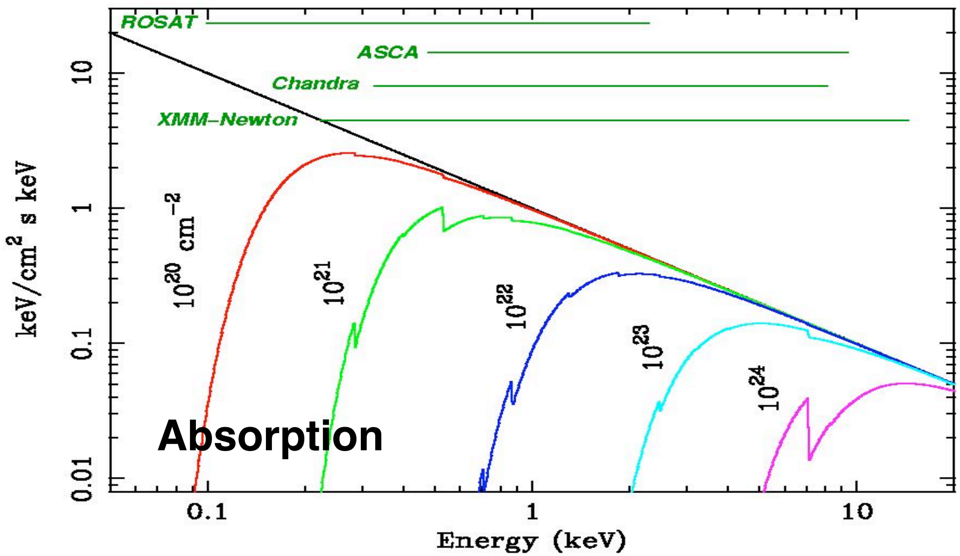
Accreting black-hole:
power-house of an AGN





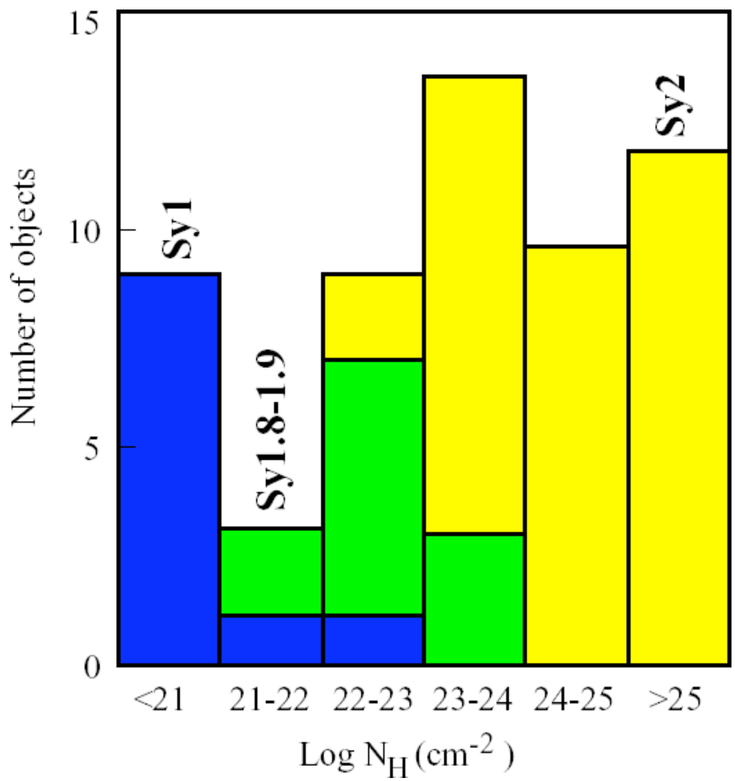
All massive galaxies appear to host a massive black hole
=> all galaxies have undergone luminous AGN activity in the past

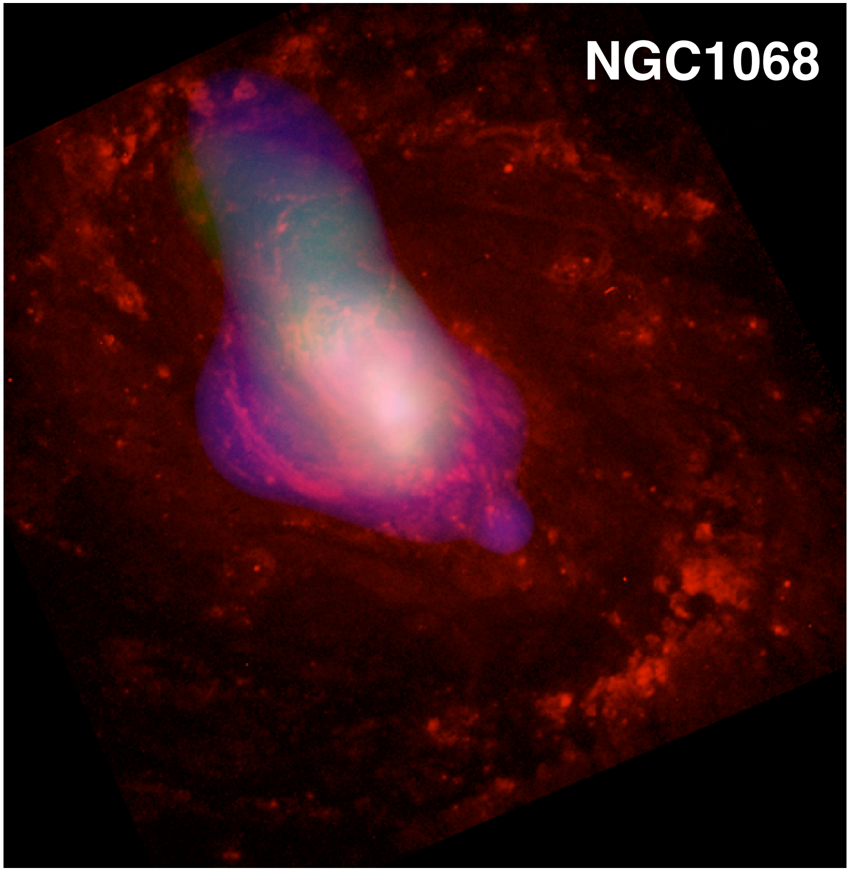
X-rays: Probing Heavy Absorption



X-rays can probe heavily obscured objects, particularly at hard energies (>2 keV)

X-ray Observations of Nearby AGN





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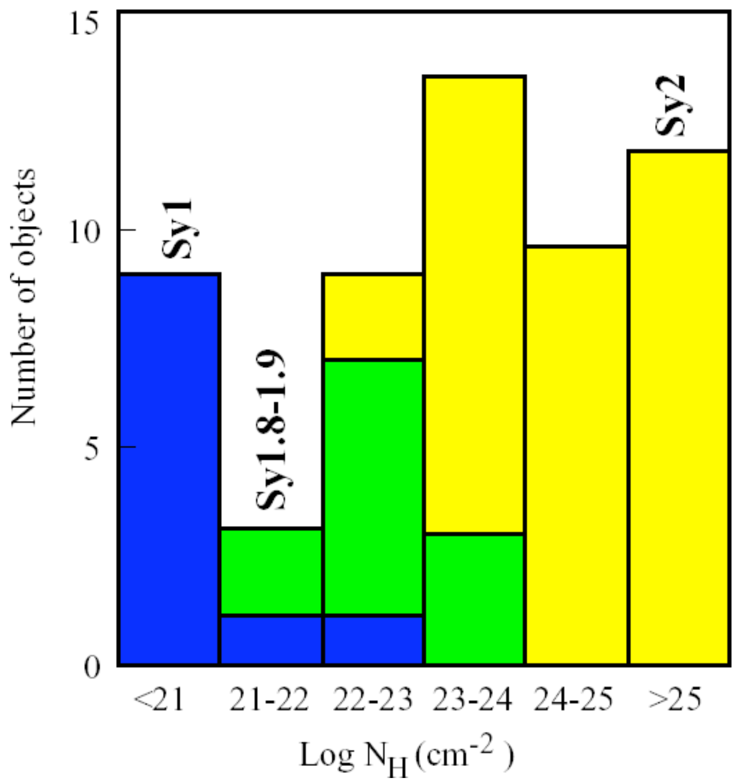
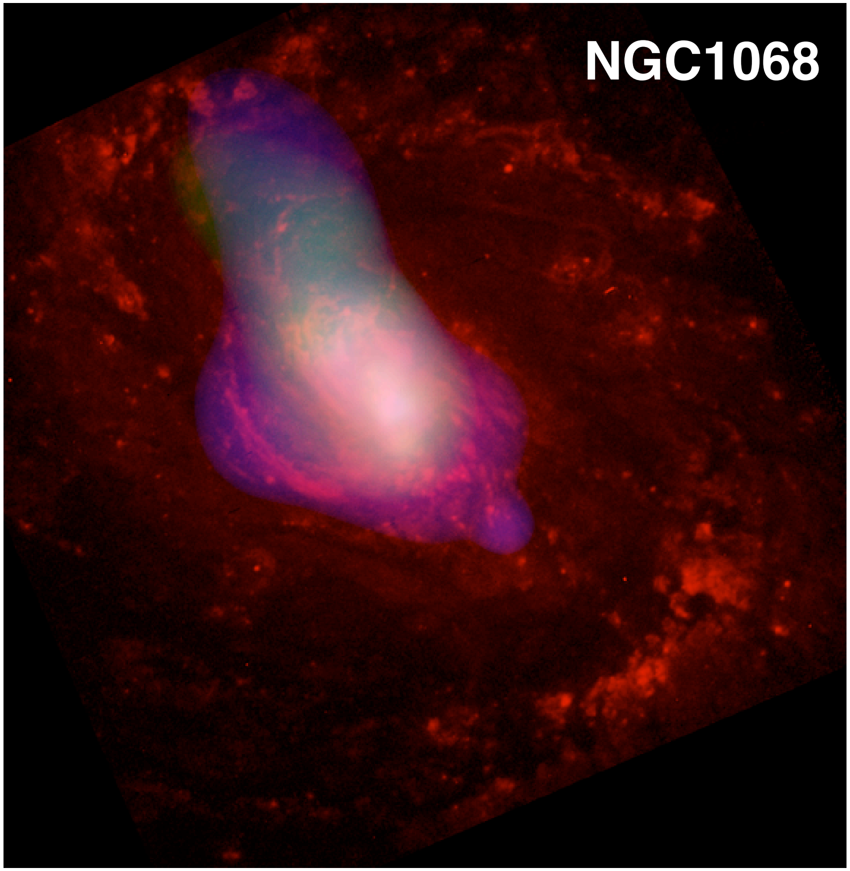
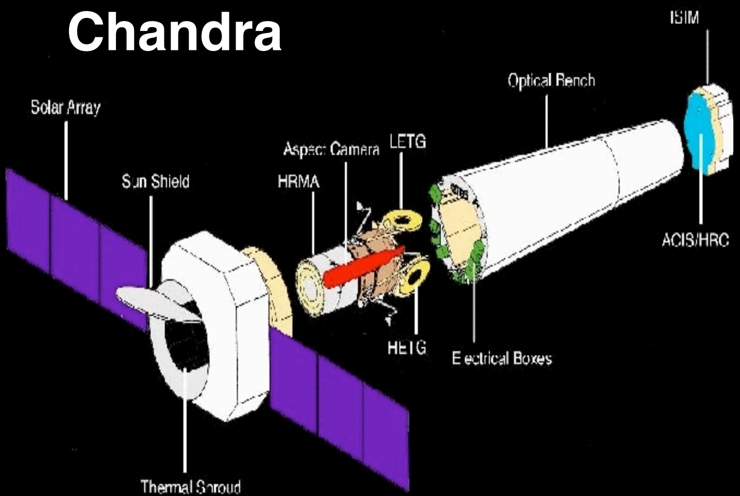




Majority of AGNs are obscured and perhaps half are Compton thick, where a large fraction of the emission is probably not direct (from scattering and reflection components; e.g., NGC1068)

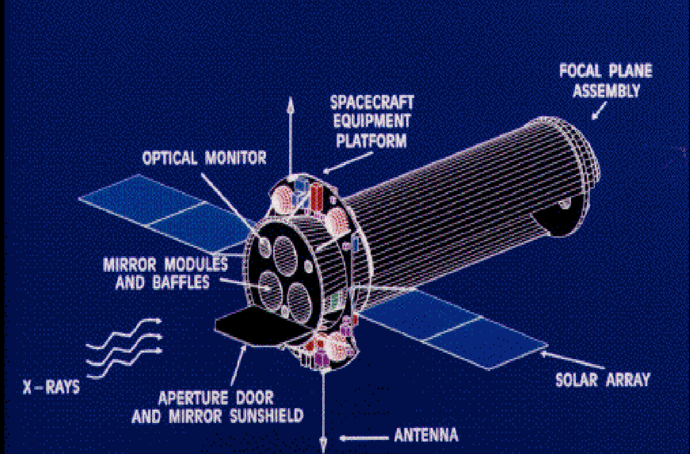
Most Sensitive Current Facilities

Chandra



0.3-8.0 keV, 0."5 resolution

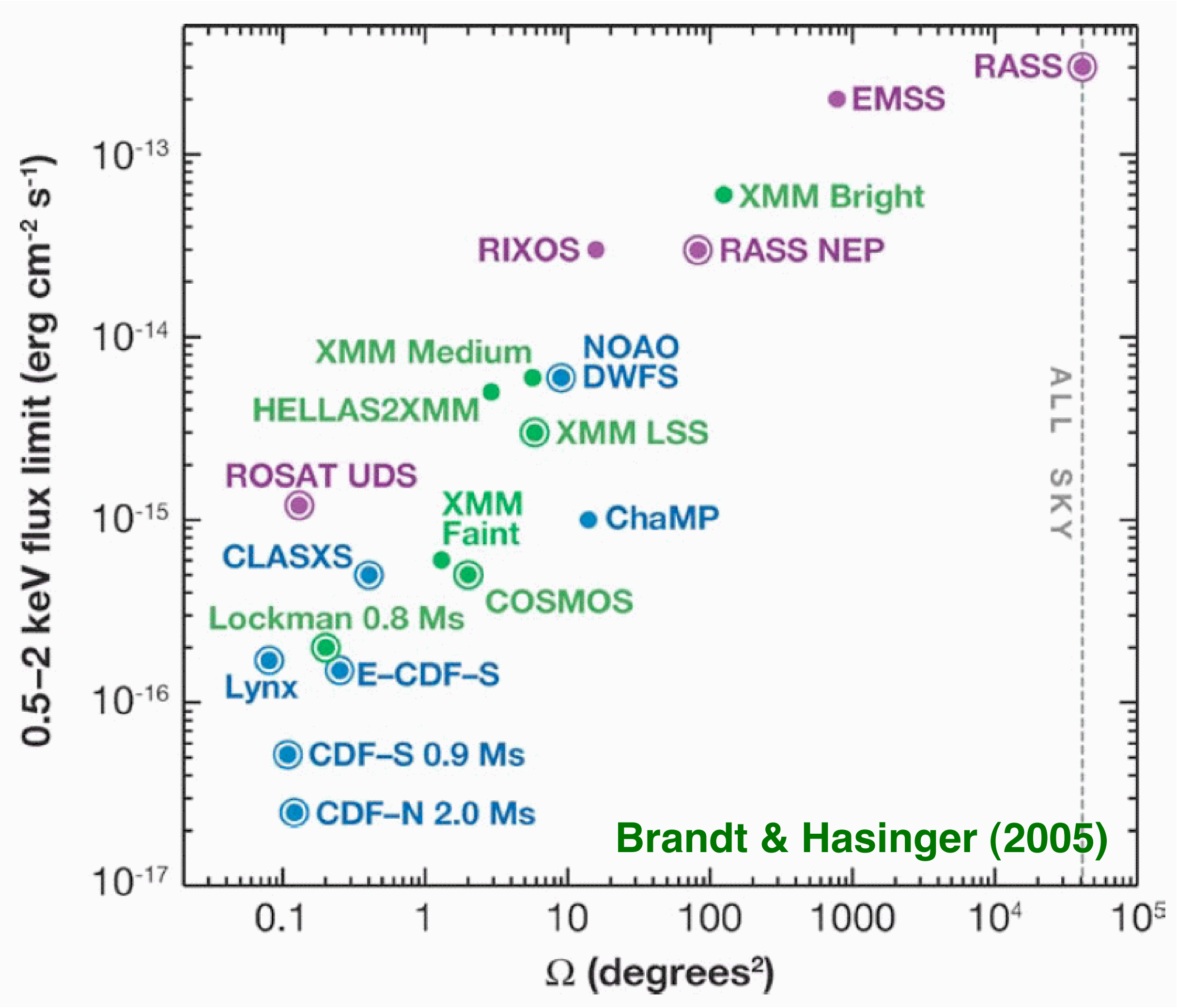
XMM-Newton



0.1-12 keV, 5" resolution

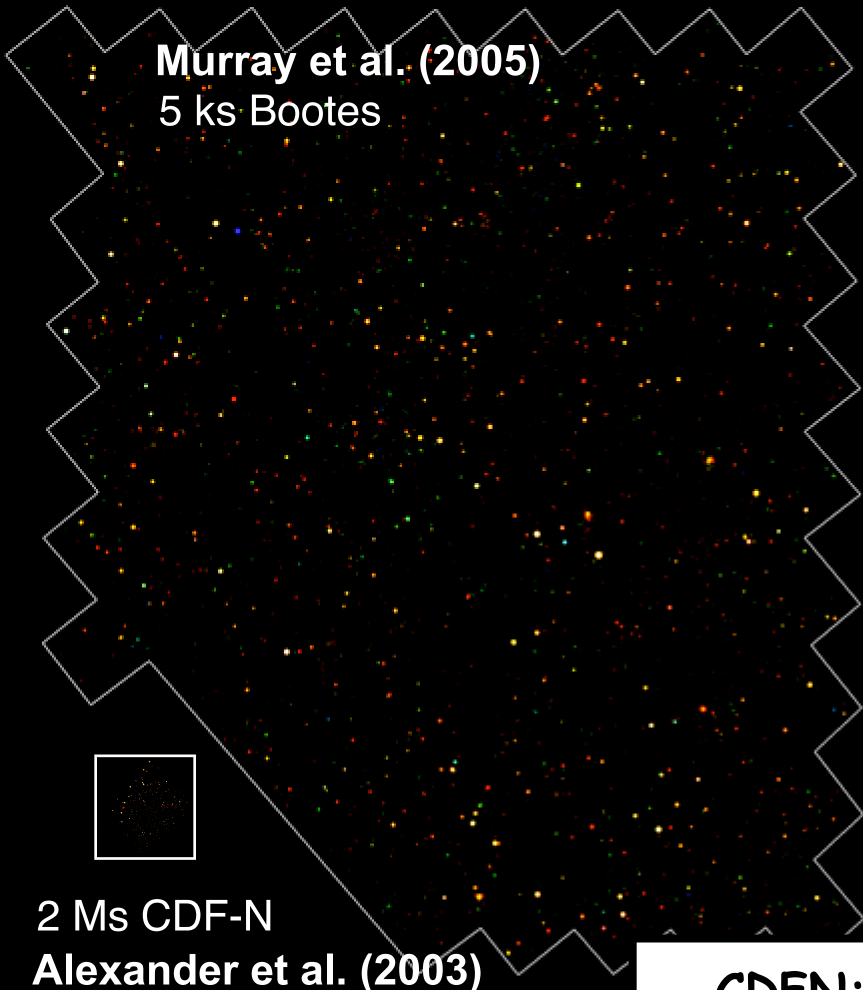
Most sensitive X-ray observatories (launched 1999) provide 1-2 orders of magnitude improvement at hard X-rays over previous observatories and with better spatial resolution

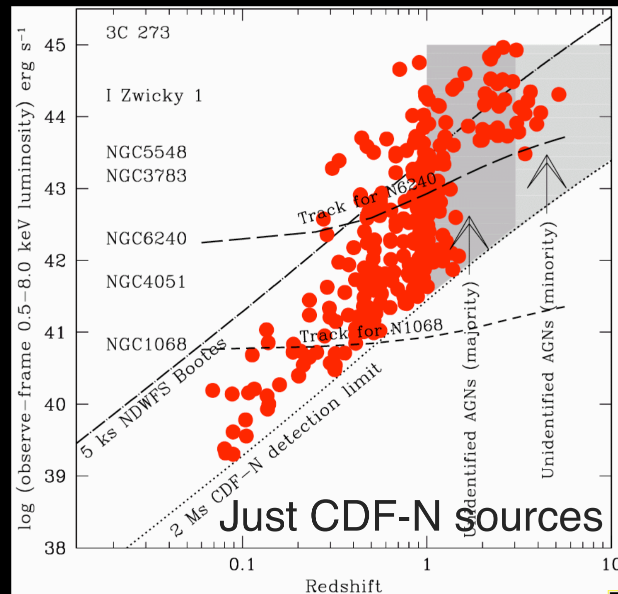
Blank-Field X-ray surveys



Broad exploration of available parameter space

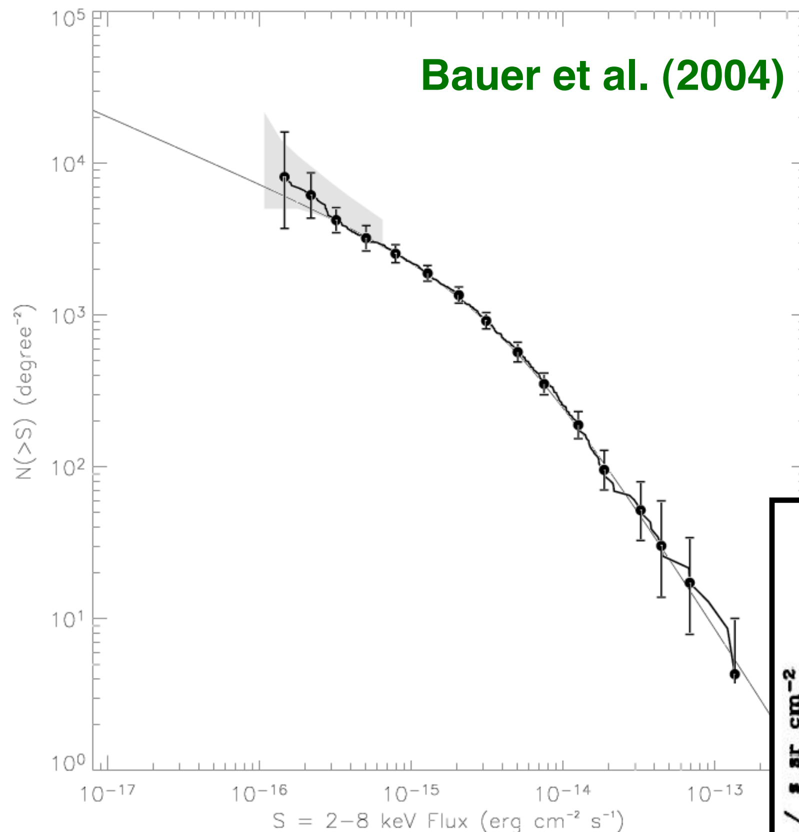
Wide and Deep: complementary parameter space



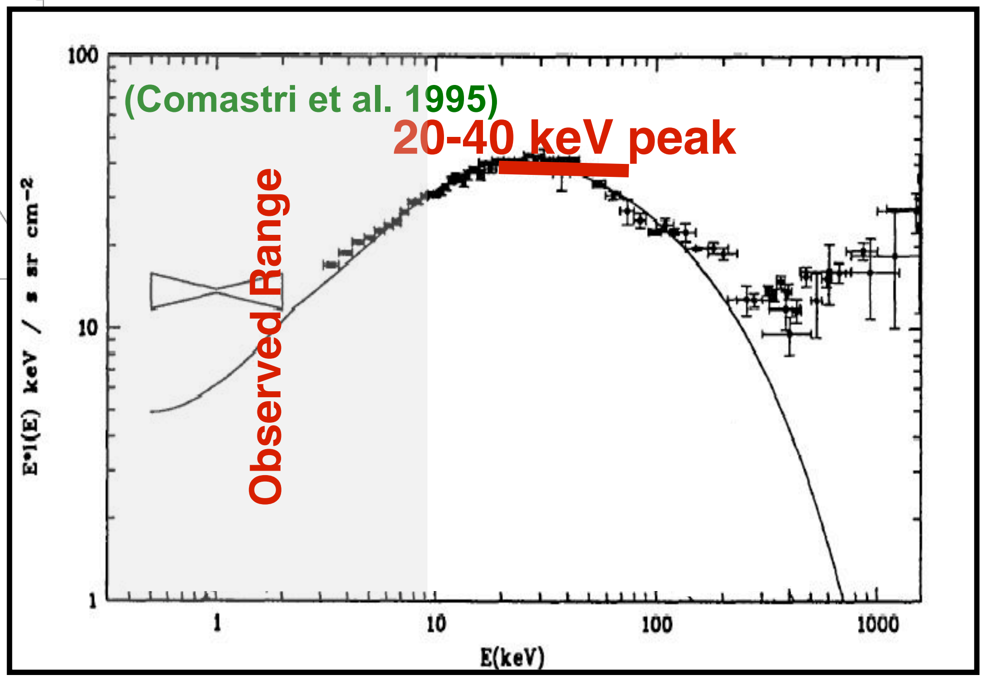


CDFN: L_X~3x10^{40} erg/s at z~0.5; L_X~10^{42} erg/s at z~2 (almost 100x deeper than Bootes but 100x larger)

LogN-LogS and X-ray Background



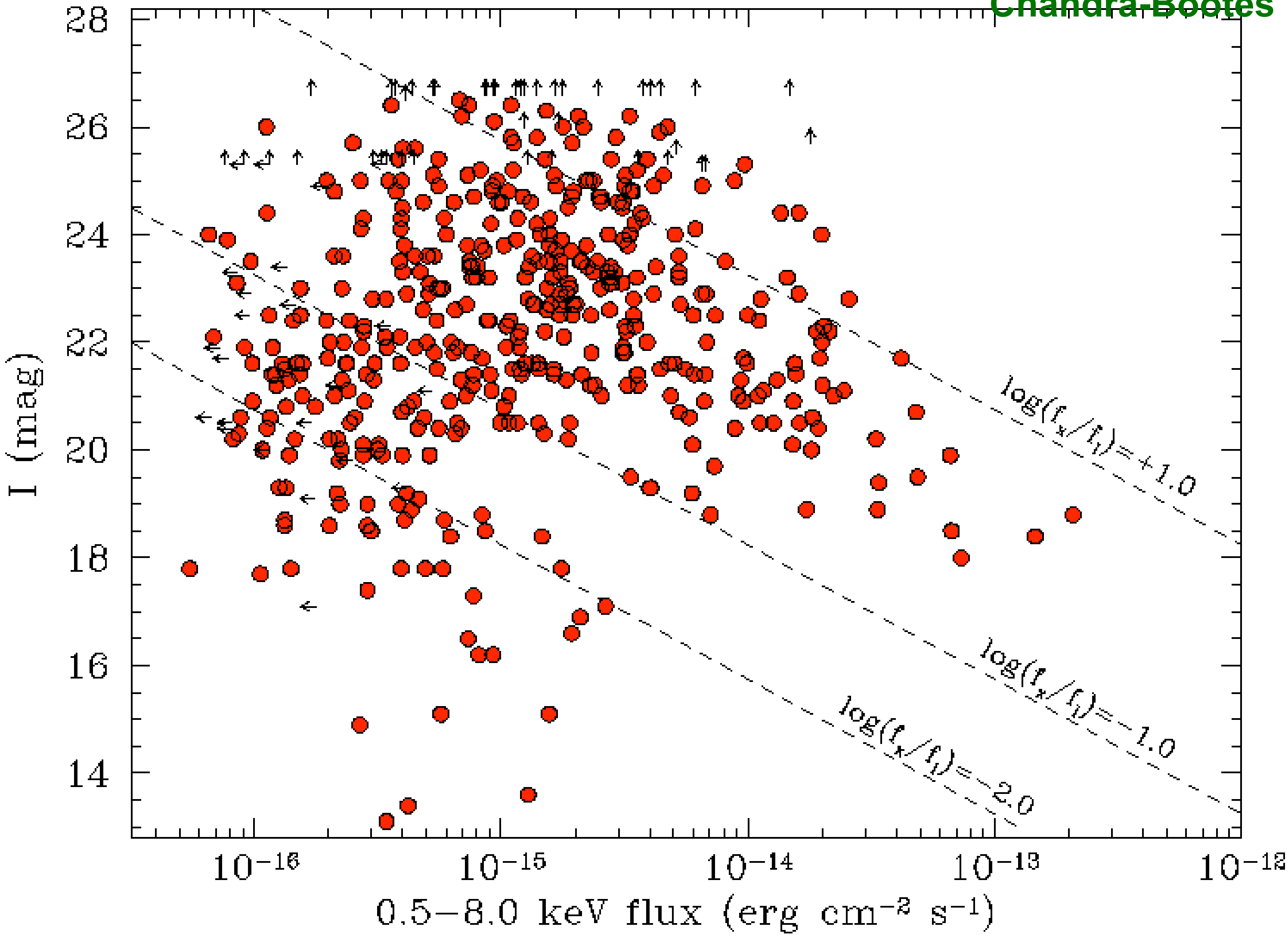
Deepest X-ray surveys find AGN source densities up to ~7200 deg^{-2}



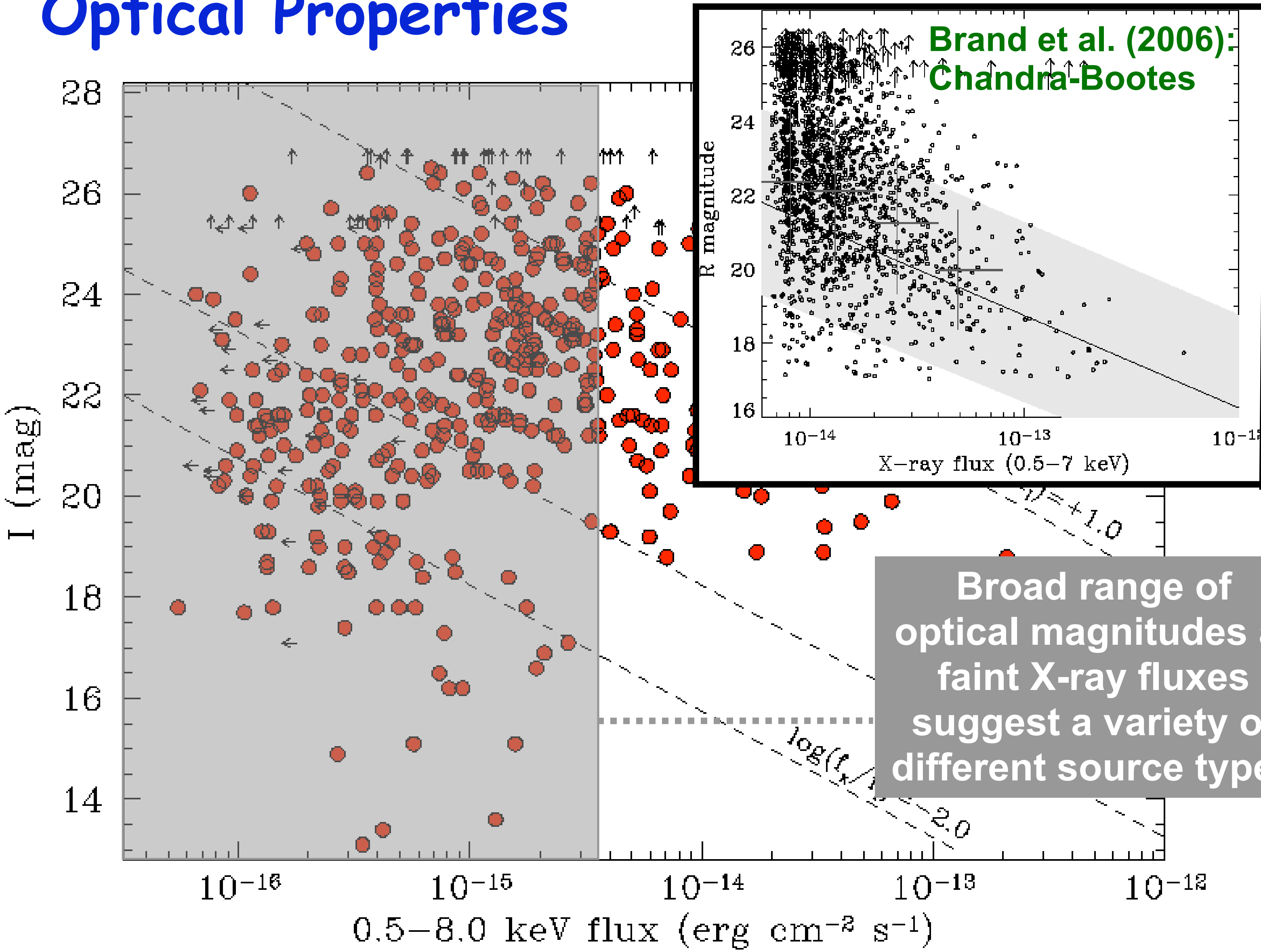
Large CXB fraction resolved (almost all at <6 keV) but not known how much at the peak of the CXB (at 20-40 keV)

Optical Properties

Brand et al. (2006): Chandra-Bootes

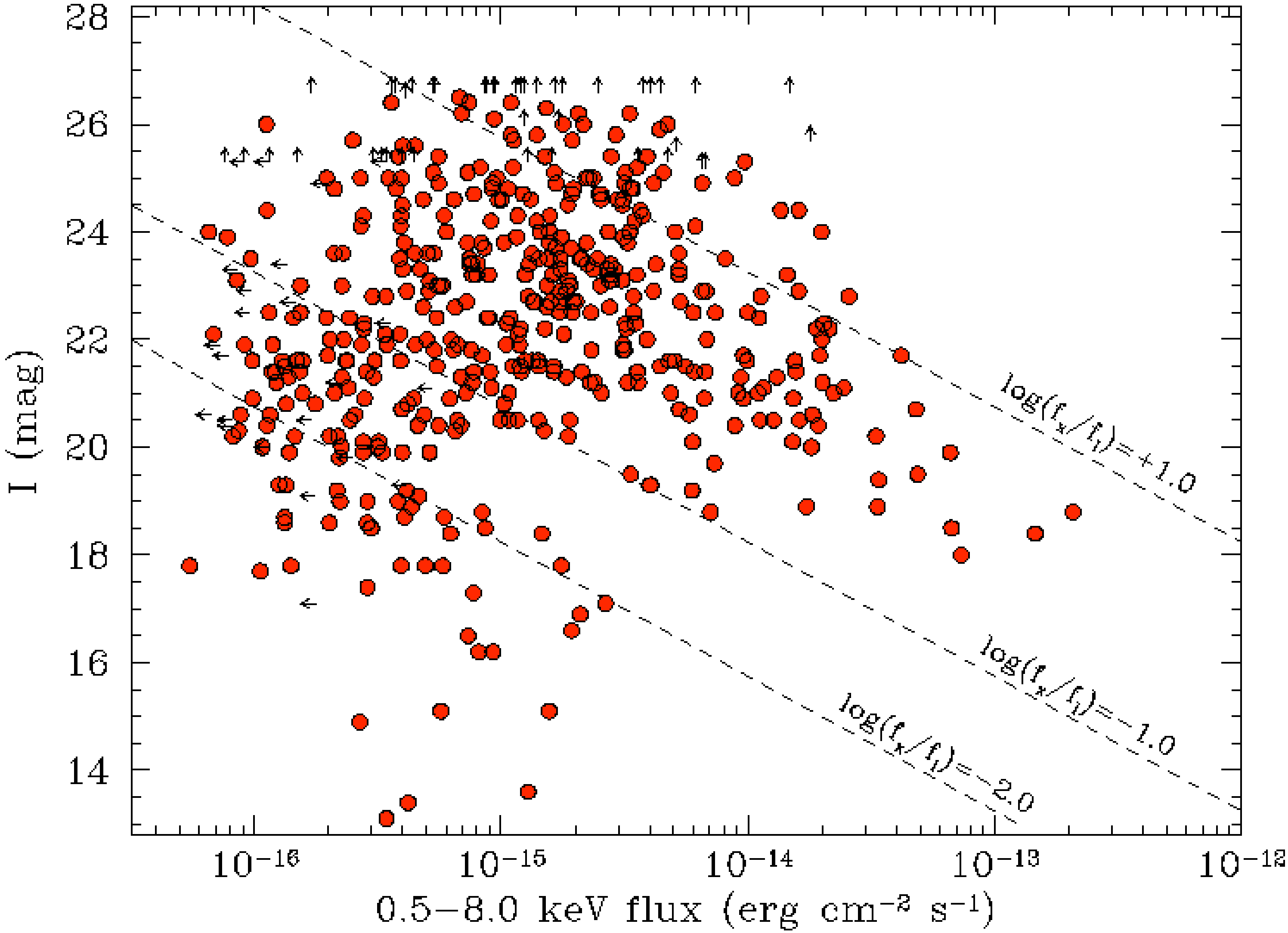


Optical Properties

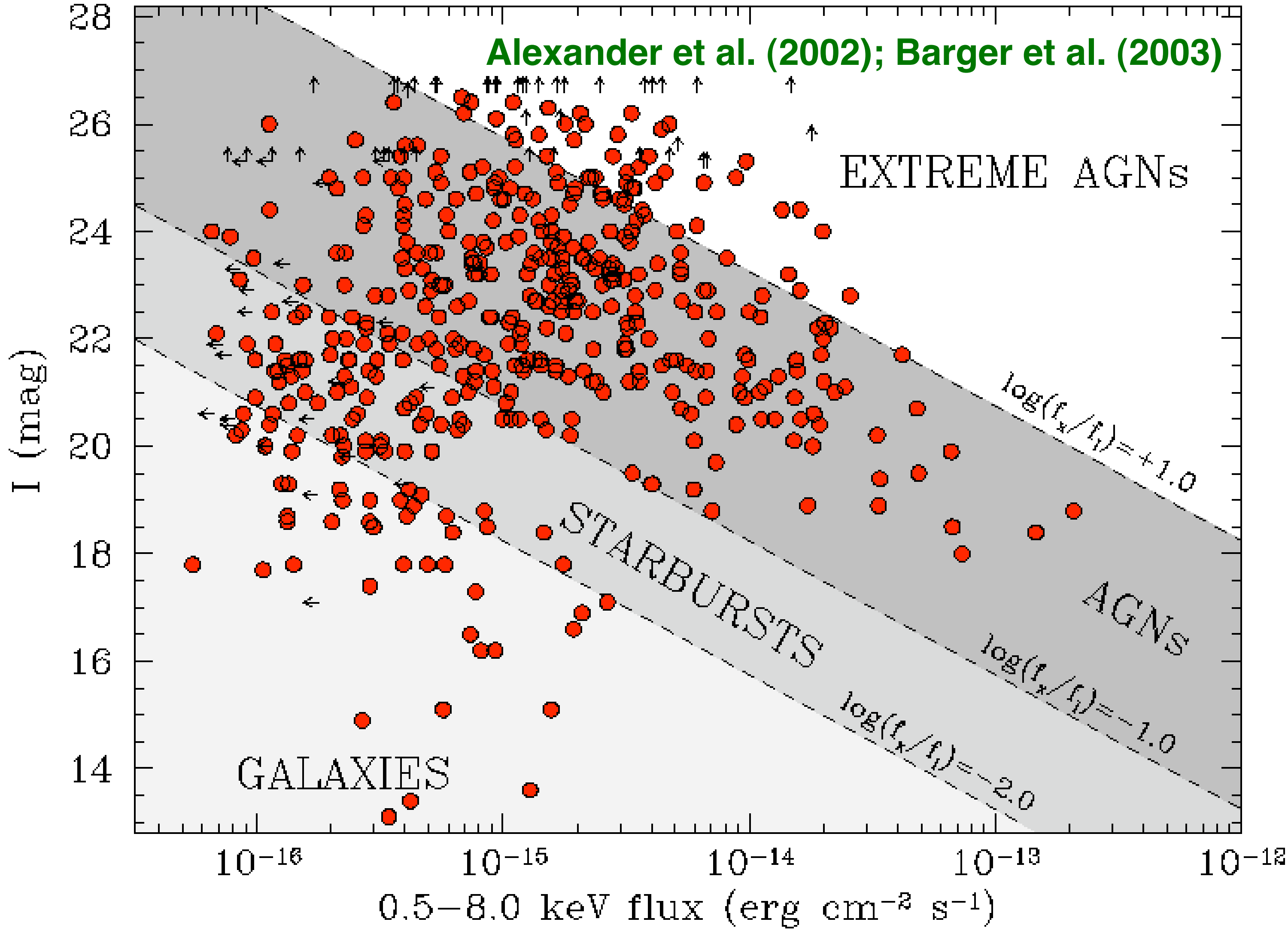


Broad range of optical magnitudes at faint X-ray fluxes suggest a variety of different source types

X-ray Source Diversity



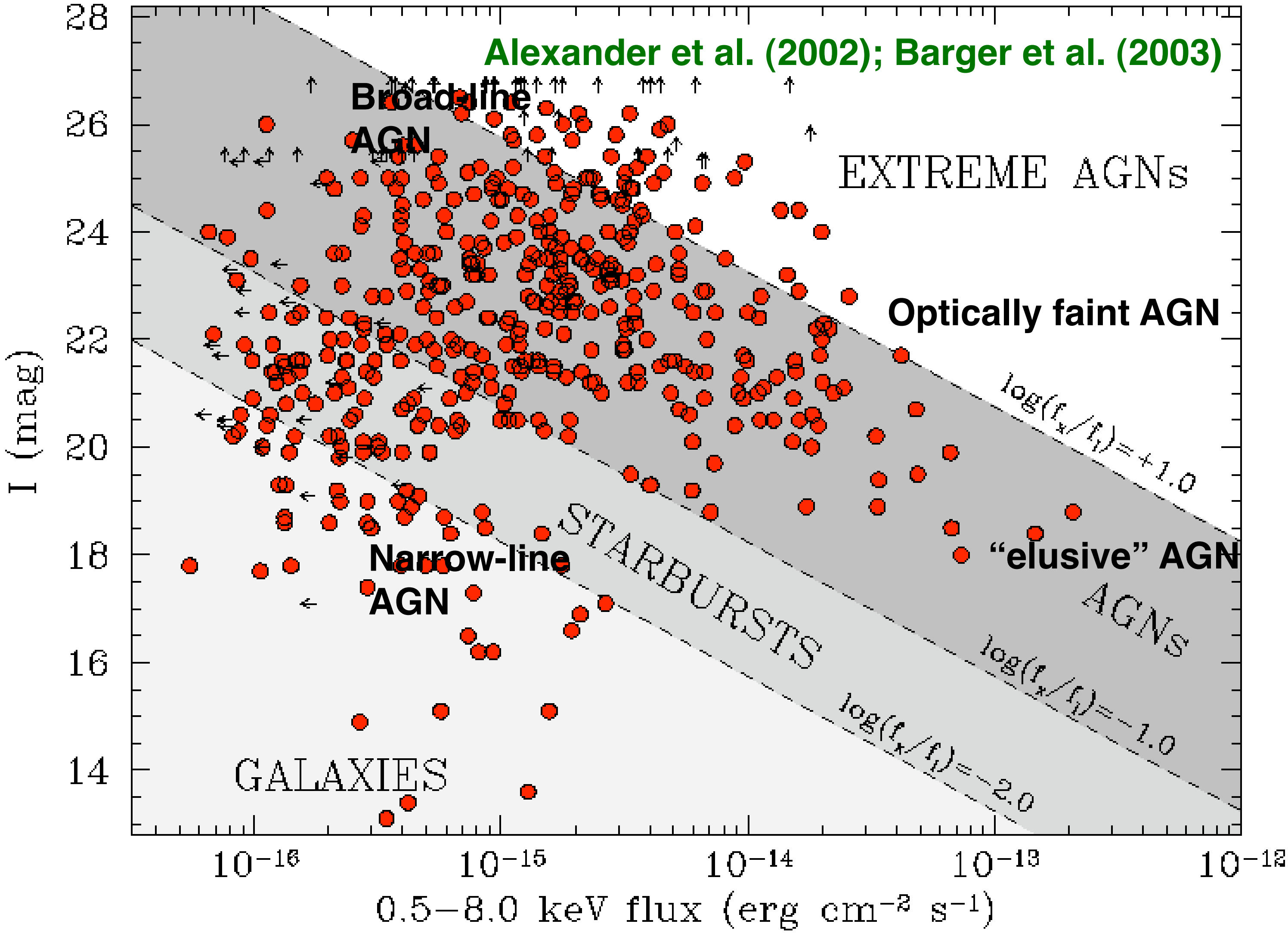
X-ray Source Diversity



As generally found in previous X-ray surveys (e.g., Stocke et al. 1991)

but 4 orders of magnitude fainter!

AGN Optical Spectral Diversity



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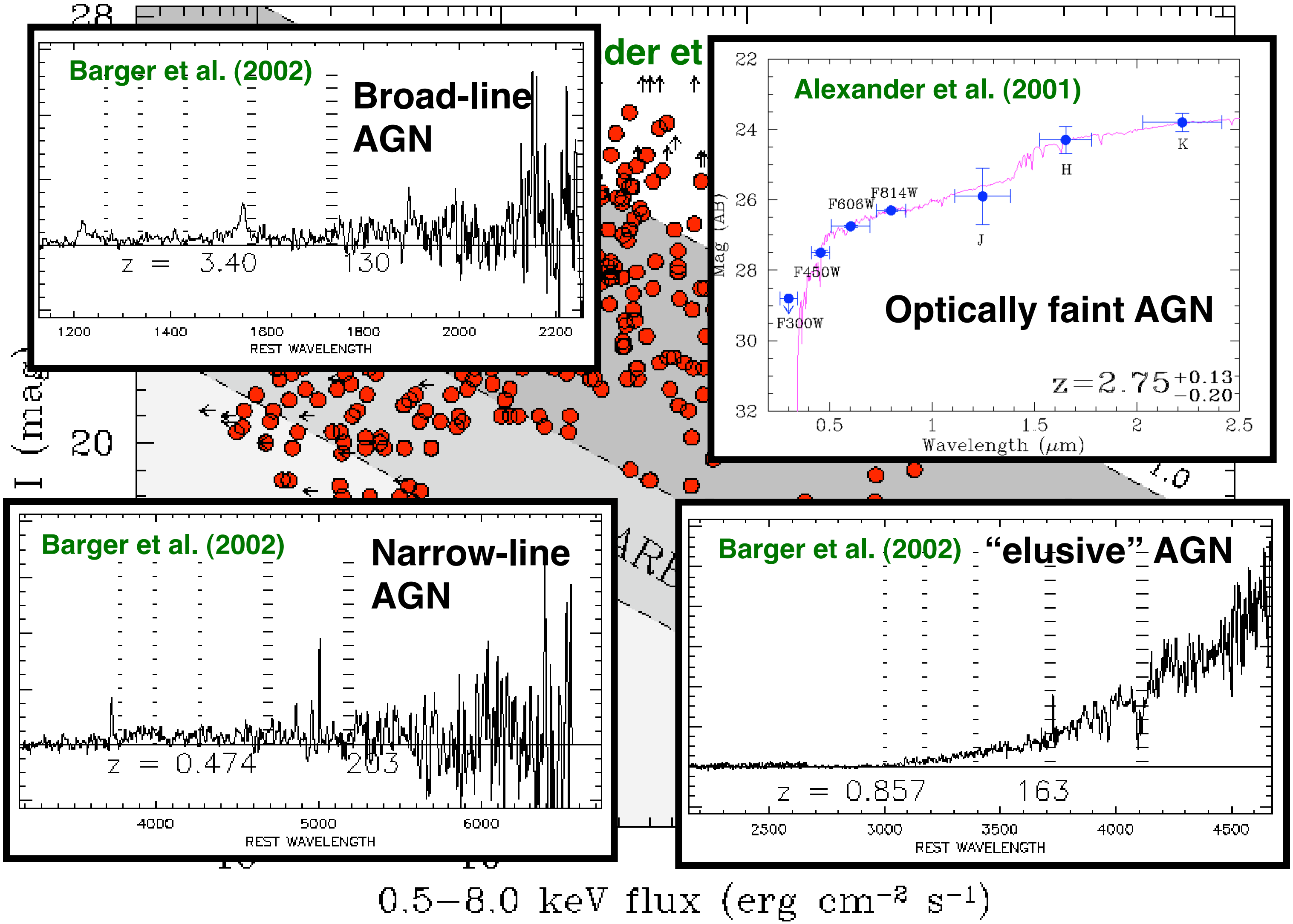
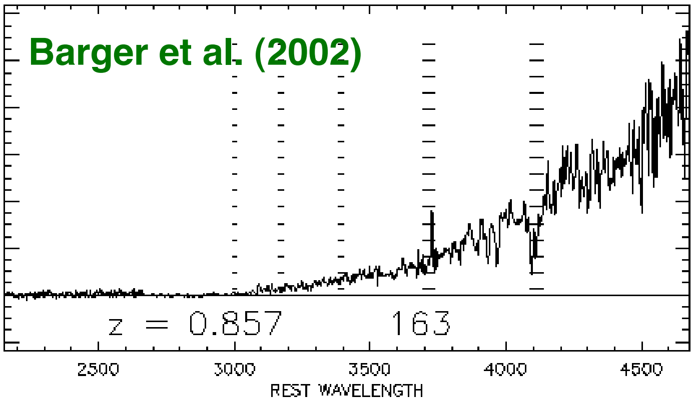
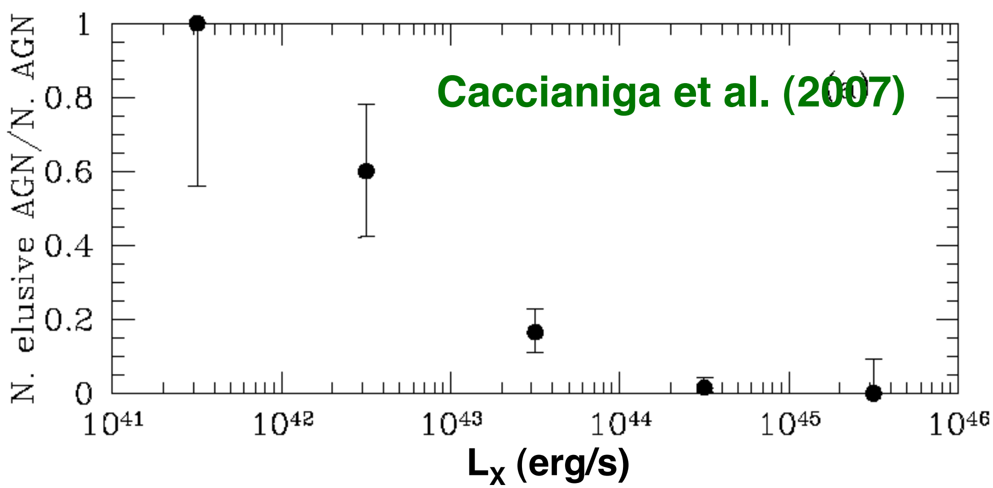


Troublesome Sources: "Elusive" AGN



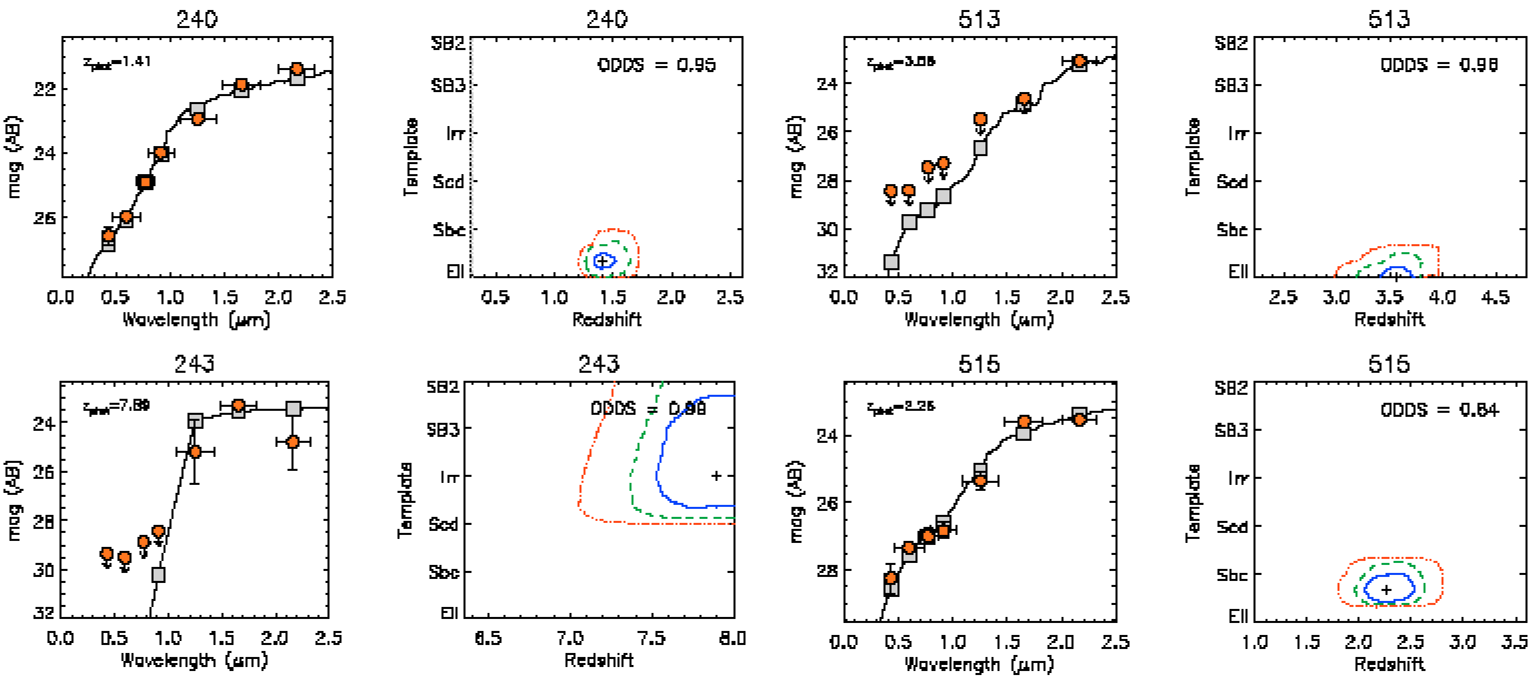
No clear optical evidence for AGN activity - challenging to identify as an AGN without X-ray observations

Lower luminosity AGNs tend to be "elusive": host-galaxy dilution (Caccianiga et al. 07)?



Rigby et al. (2006) also find galaxy inclination (host galaxy obscuration)

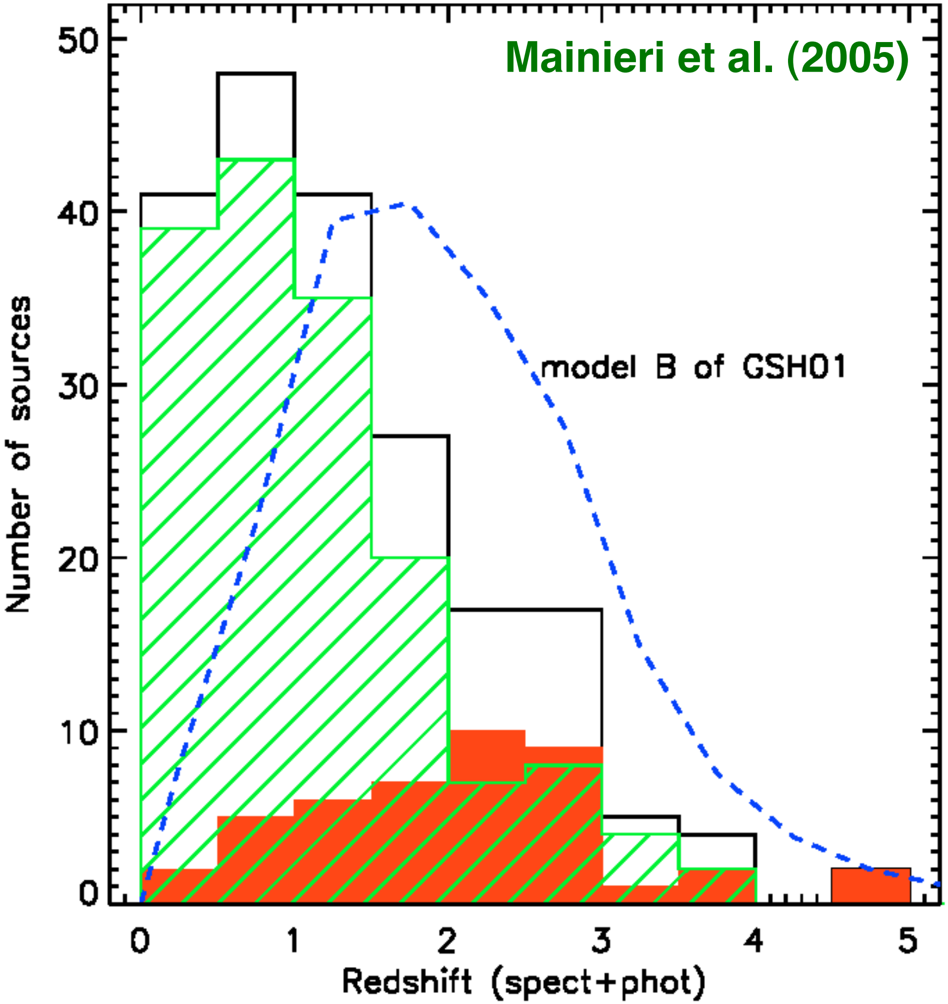
Troublesome Sources: Optically Faint AGN



Mainieri et al. (2005)

I>23-24 objects: challenging to identify with spectroscopy but photometric redshifts and multiwavelength properties suggest majority are z>1 moderate-luminosity AGN (e.g., Alexander et al. 2001; Mainieri et al. 2005)

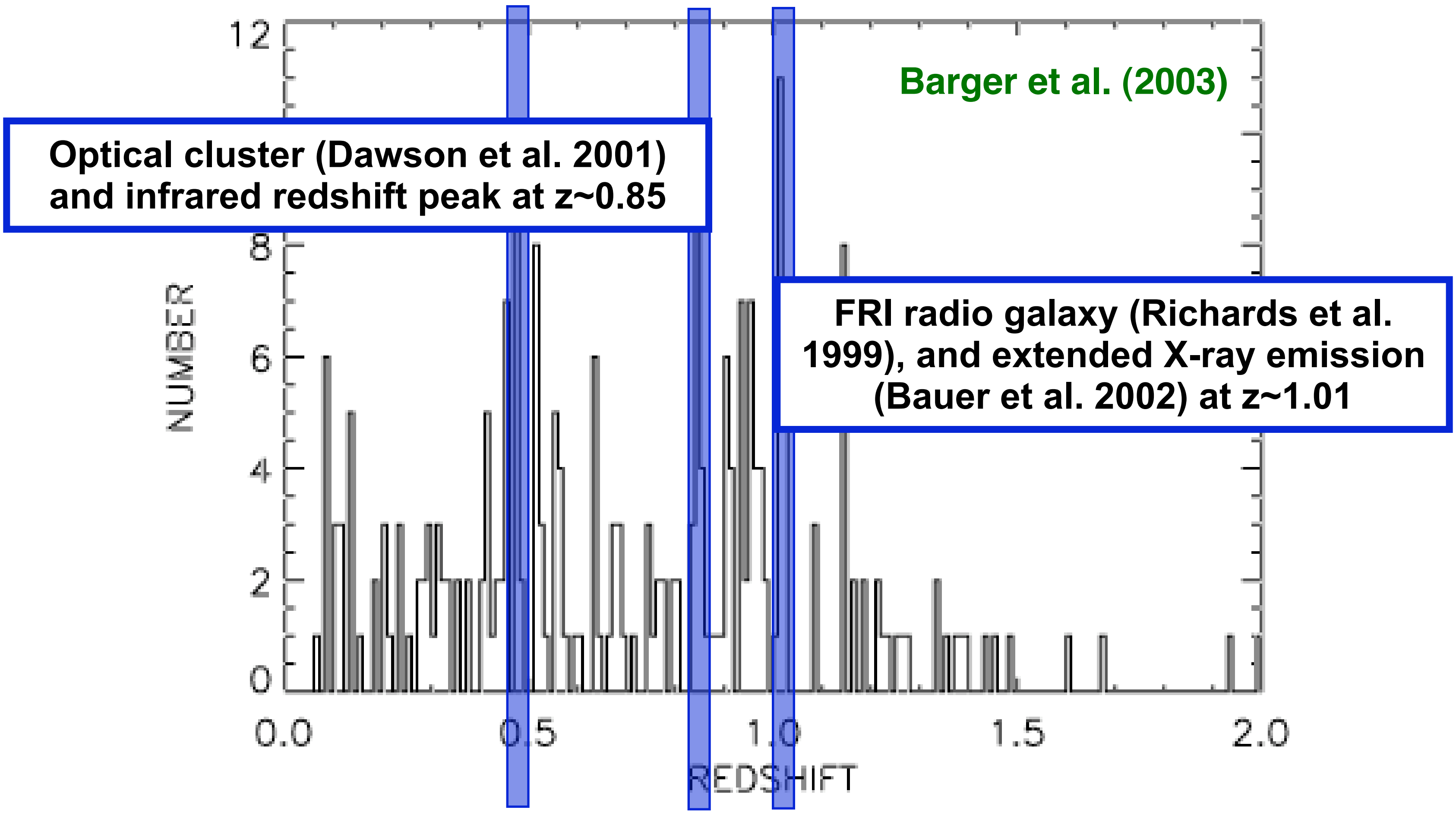
Redshift Distribution of AGNs in 1Ms CDF-S



Spectroscopic+ photometric redshifts

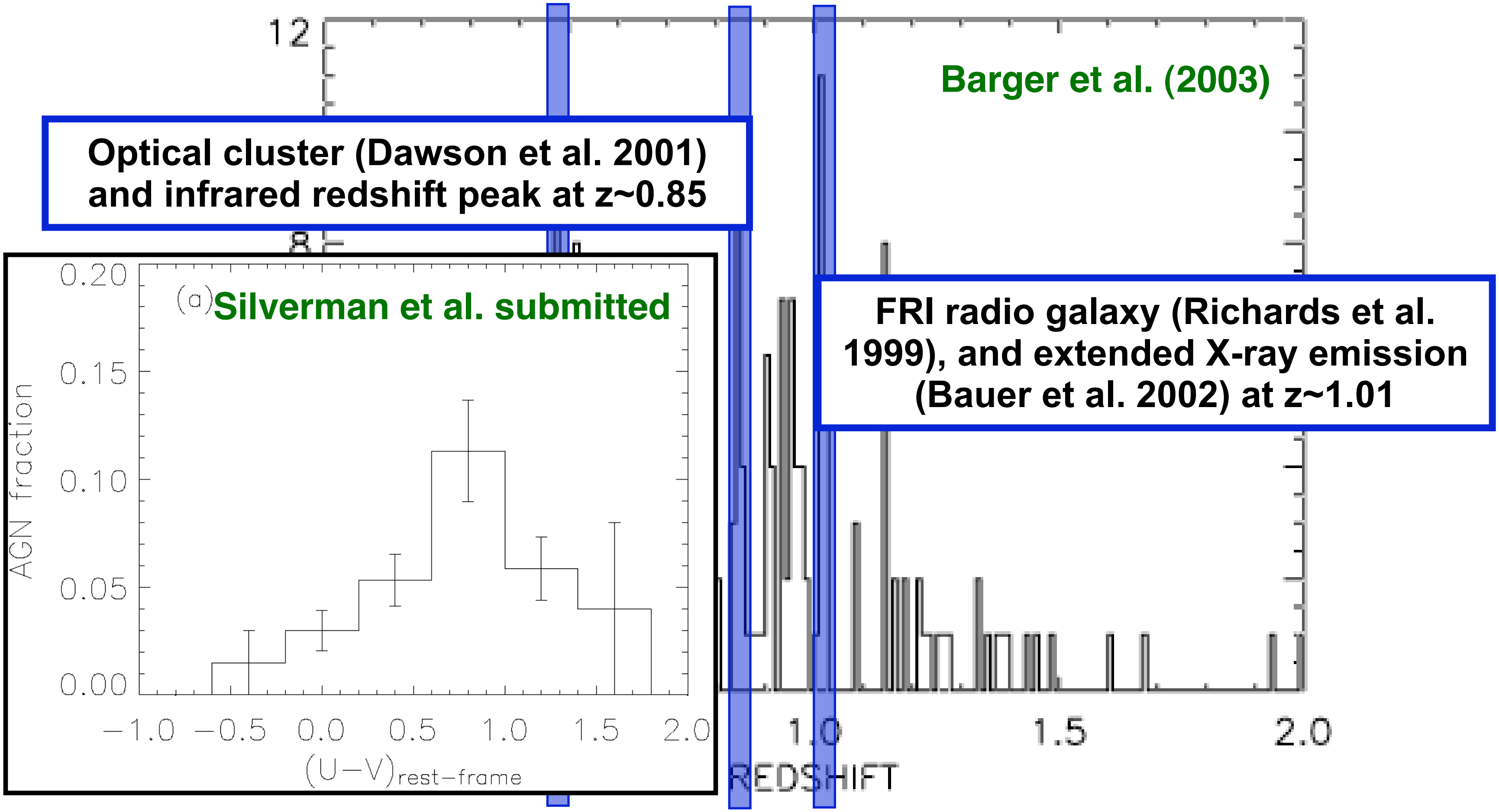
z<1 peak with high-z tail: possibility of some z>5 AGNs (X-ray sources without optical c/parts; EXOs) but unlikely to big large number. See Koekemoer talk

AGNs and Large-Scale Structure



AGN fraction in galaxies often enhanced in spikes (Silverman et al. submitted; see also Gilli et al. 2003): need to explore AGNs in across a range of environments

AGNs and Large-Scale Structure



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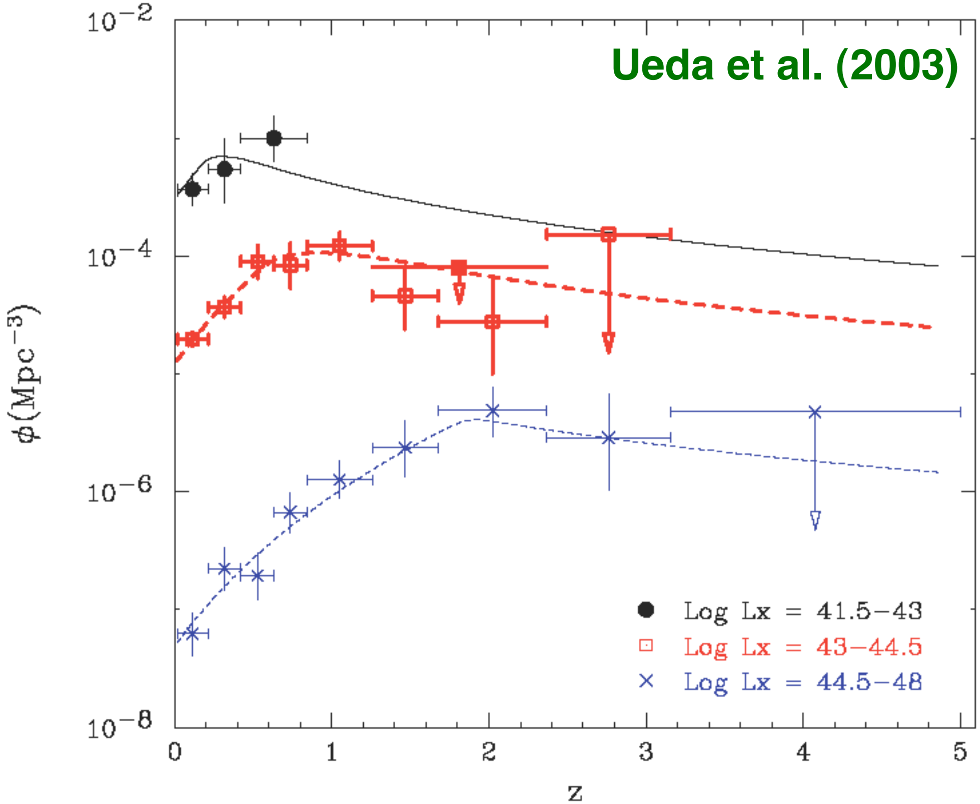
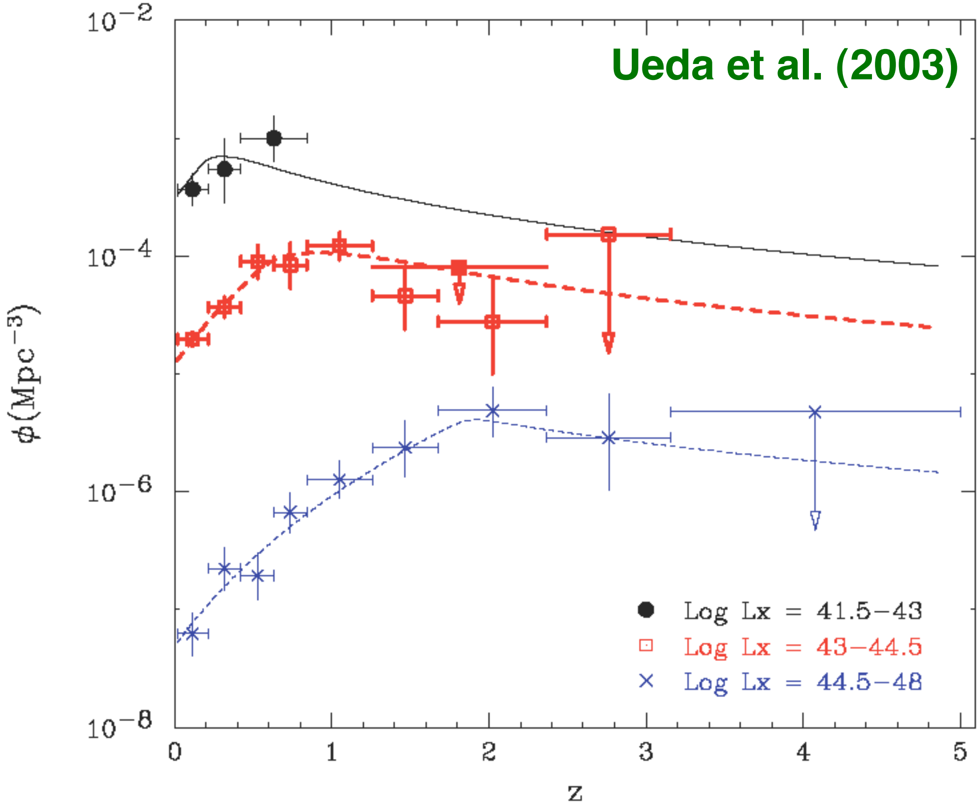
Cosmic Evolution of AGN activity



Source downsizing is also seen in galaxy populations and originally in AGNs f[illegible]m radio su[illegible]s

Strong evolution at z<1 (factor ~10) seems to be mirrored in the luminous IR galaxy population (e.g., Elbaz et al. 2002)

Cosmic Evolution of AGN activity



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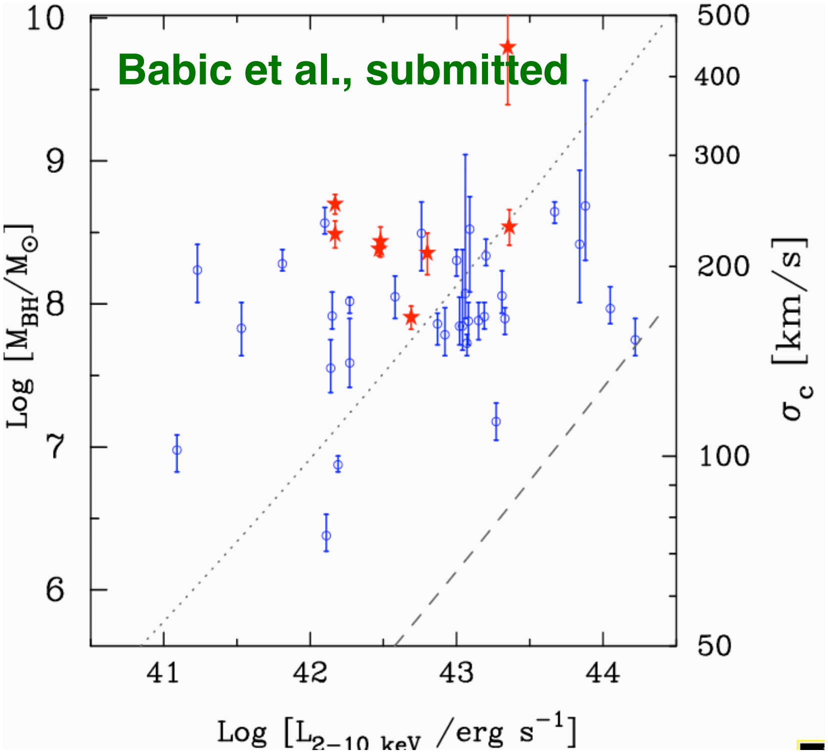
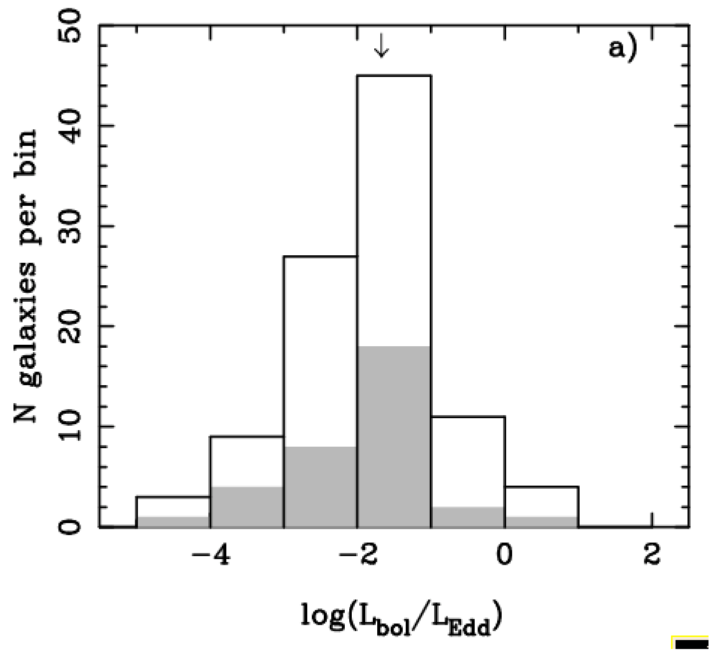
Moderate-luminosity AGN activity (i.e., Seyfert galaxies) peaks at lower redshifts than high-luminosity AGN activity (i.e., QSOs); see, e.g., Cowie et al. (2003); Fiore et al. (2003); Hasinger et al. (2004); Barger et al. (2005); La Franca et al. (2005)

Investigation of z<1 "AGN downsizing"

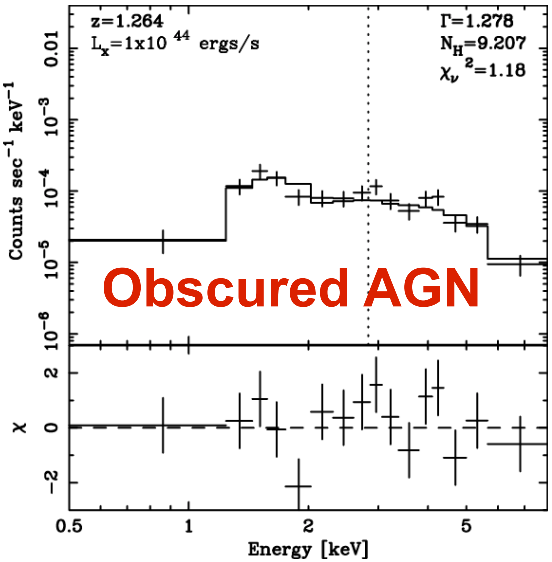


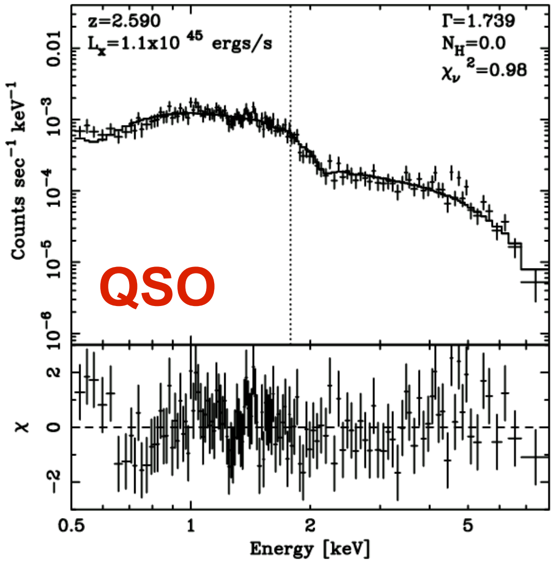
Calculate black-hole mass from K-band luminosity and stellar mass; average black-hole mass ~10^8 solar masses

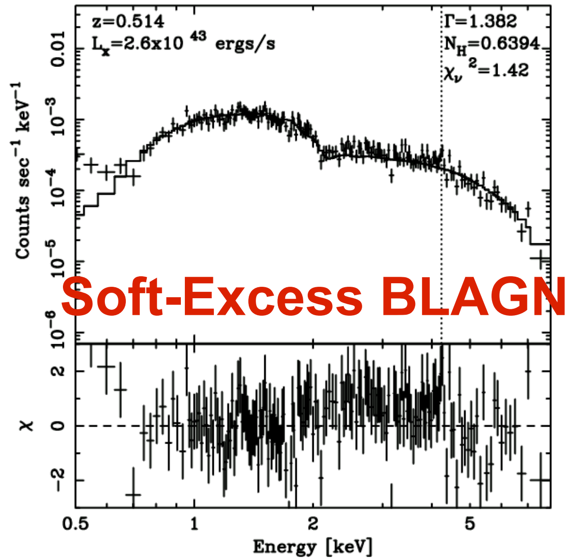


Lower luminosity sources appear to have lower Eddington ratios rather than having lower mass black holes (at least at z<1)

X-ray Spectra: Tracing X-ray Absorption

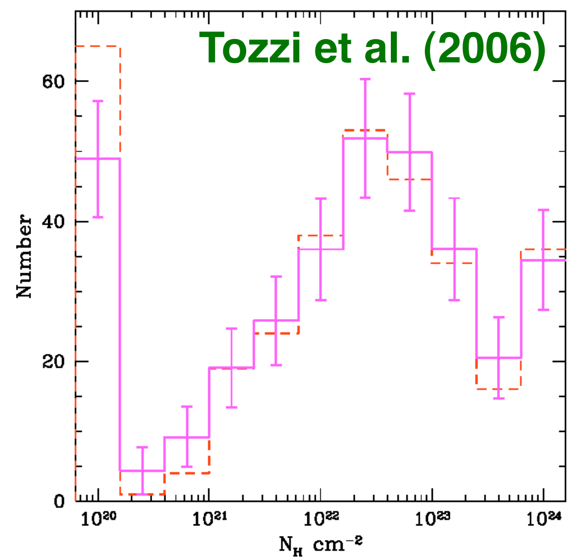




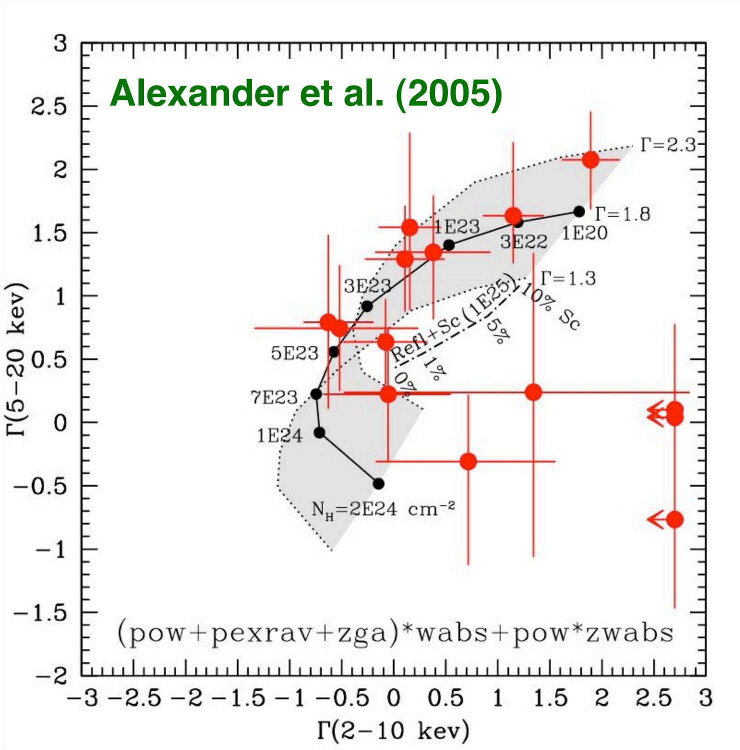


Bauer et al, in prep

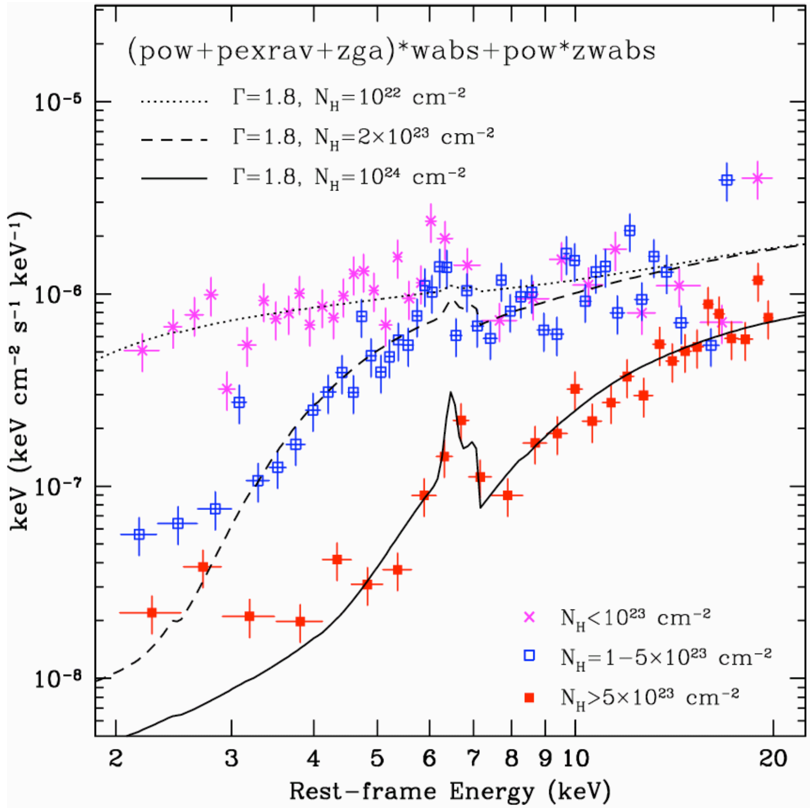
Variety of X-ray spectral types but majority of the X-ray detected AGN are absorbed



Going Deeper: Composite Faint Source Spectra

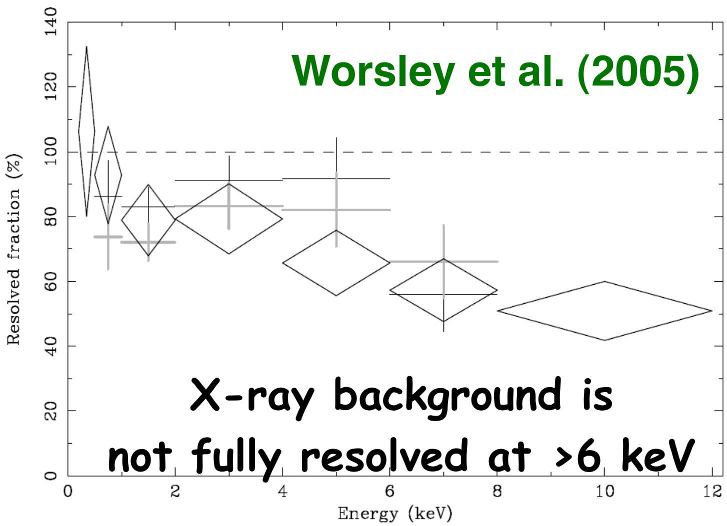


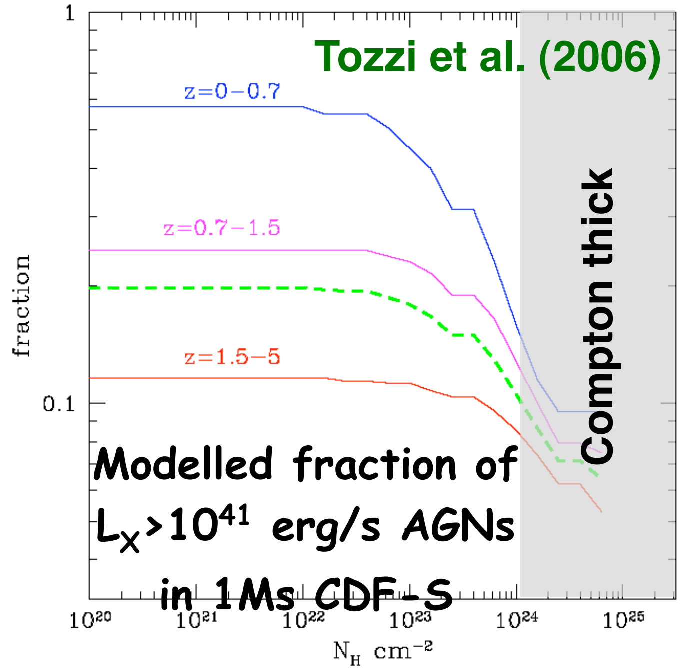
12Ms Composite Chandra spectra

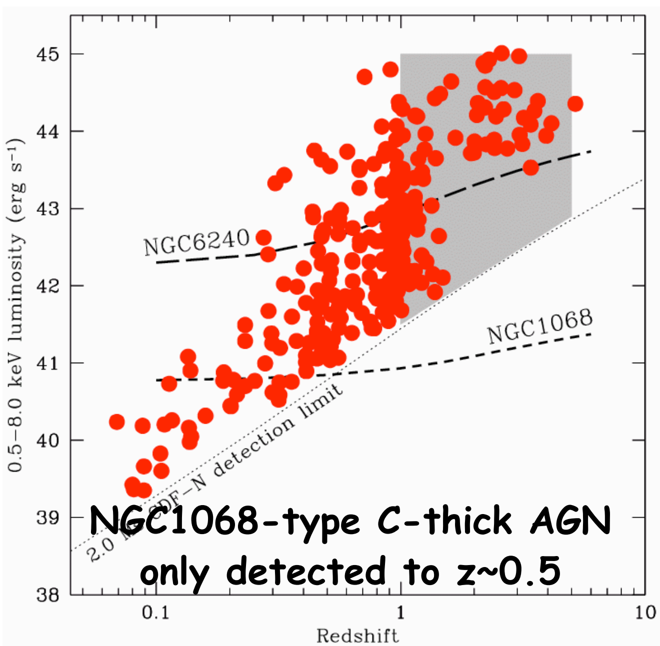


Can extend X-ray spectroscopy to fainter sources using X-ray stacking, if have spectroscopic redshifts

But many AGNs undetected in deepest X-ray surveys

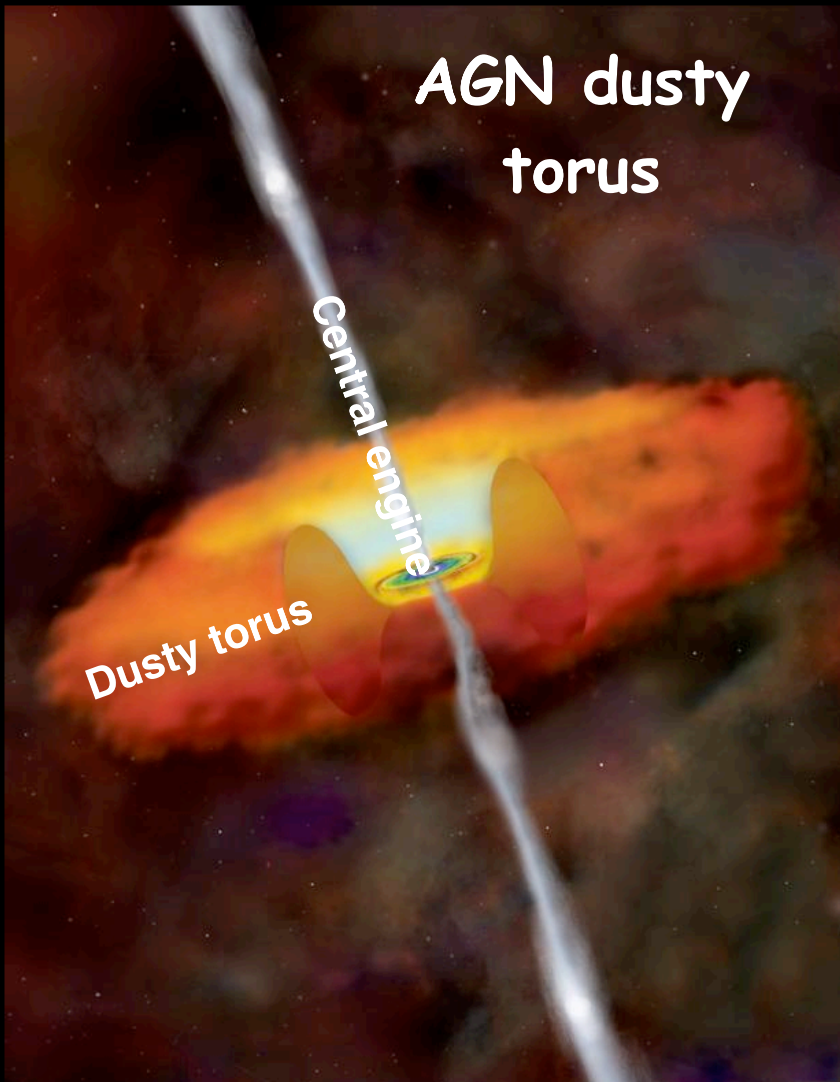






Many of these X-ray undetected sources likely to be luminous Compton-thick AGN

Searching for the X-ray unidentified AGNs



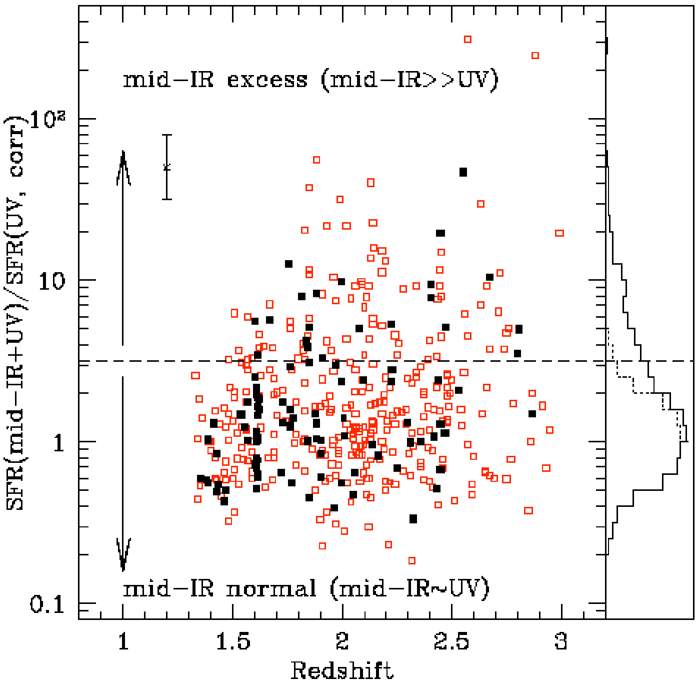
Stacking bright X-ray undetected Spitzer sources (f24>80uJy) we get a very hard signal (even in 6-8 keV)

Steffen et al. submitted

Mid-IR power-law sources and objects with a "radio excess" also find some X-ray undetected AGNs (Donley et al. 2005; Alonso-Herrero et al. 2006)

BUT WHERE IS THE LARGE PREDICTED C-THICK POPULATION?

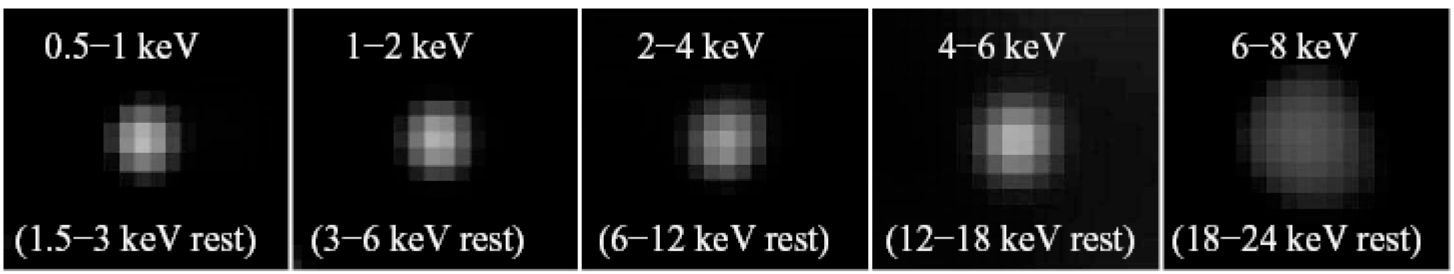
X-ray undetected mid-IR AGN in z~2 galaxies



Identified a population of z~2 X-ray undetected galaxies with mid-IR excess over that expected from SF: do they host obscured AGNs?

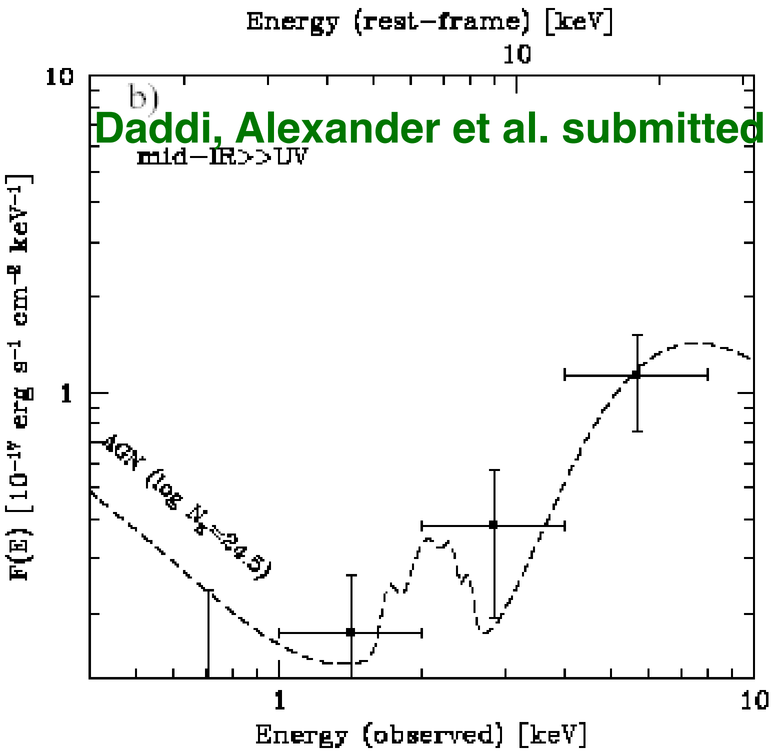
Daddi, Alexander et al. submitted

Stacked X-ray data of mid-IR excess in narrow bands

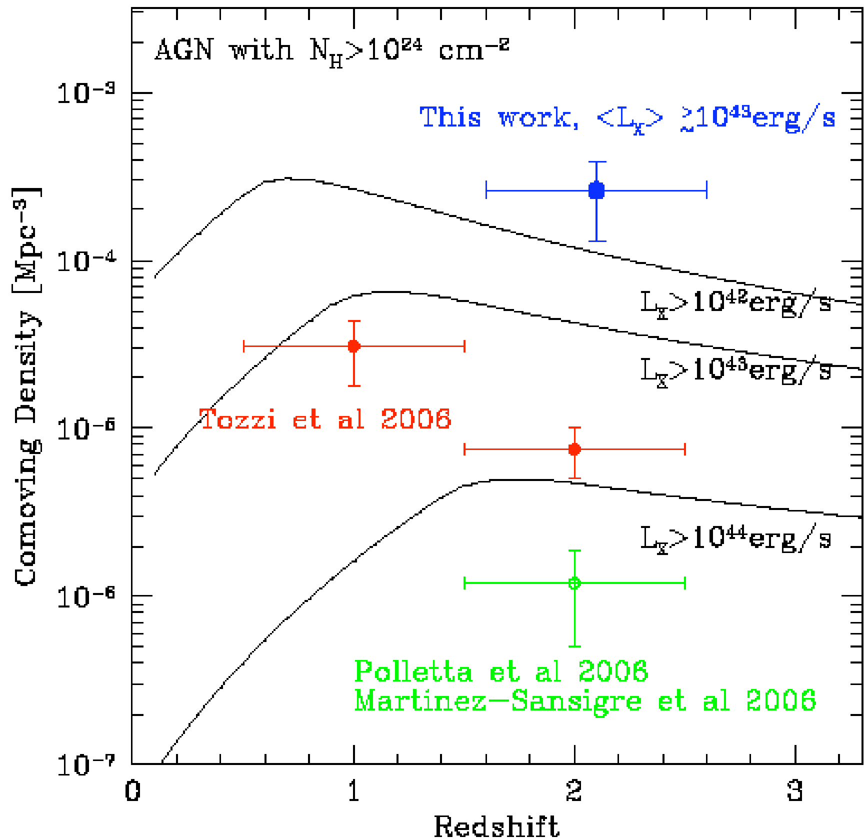


Very hard signal => obscured AGN activity (see also Fiore et al. submitted)

Properties suggest C-thick (or near C-thick) AGNs

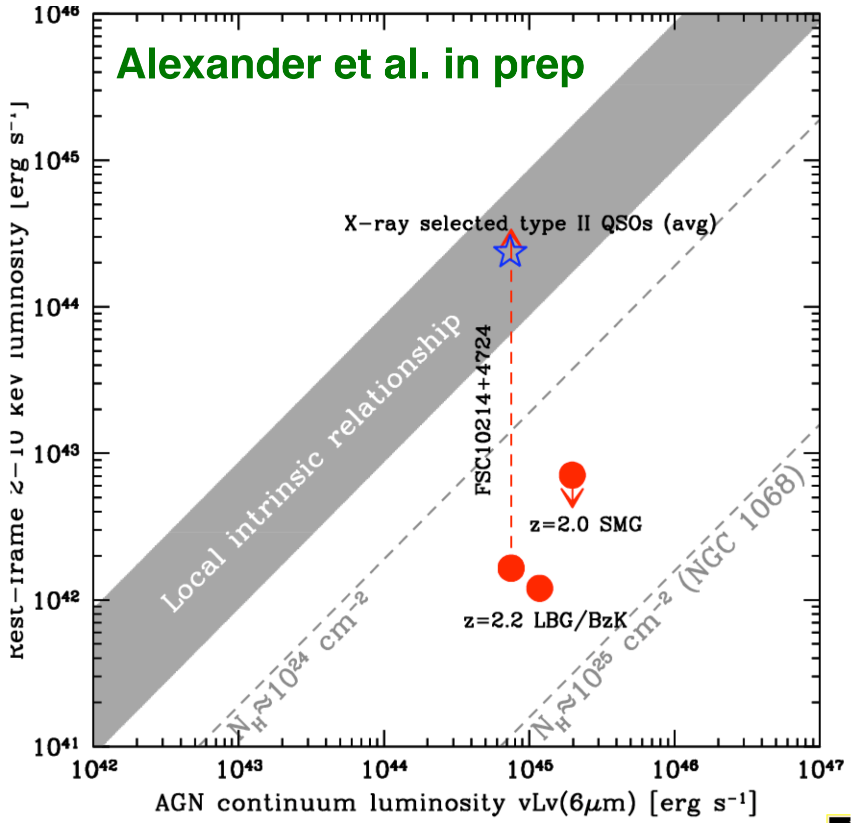


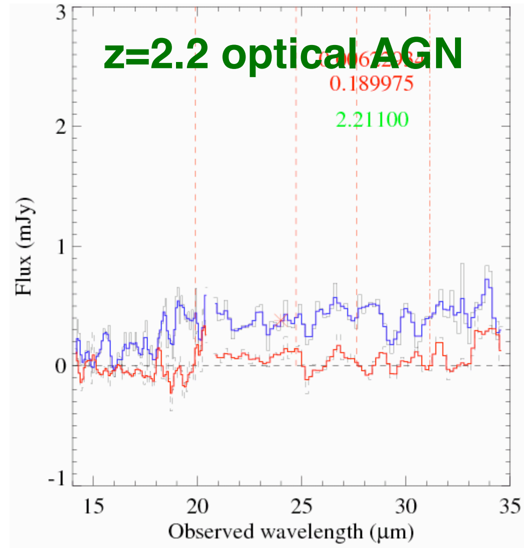
Similar to C-thick AGN of Gilli et al. (2007): has SF component removed

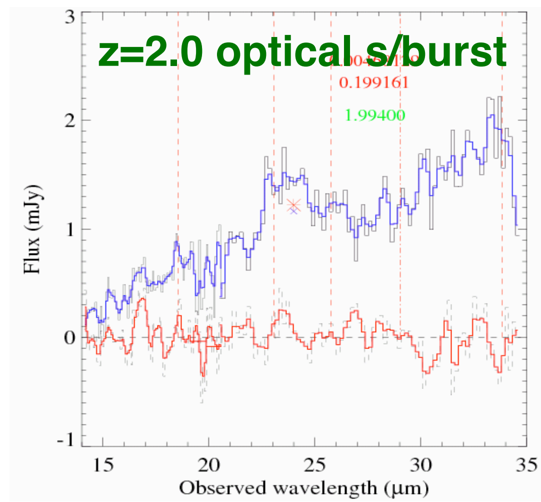


Large C-thick (or near C-thick) z~2 AGN population (up to ~3000 deg^{-2})!
Potentially as much black-hole growth as z~2 QSO population!

Power of MIR spectroscopy: ID'ing individual C-thick AGN at z~2



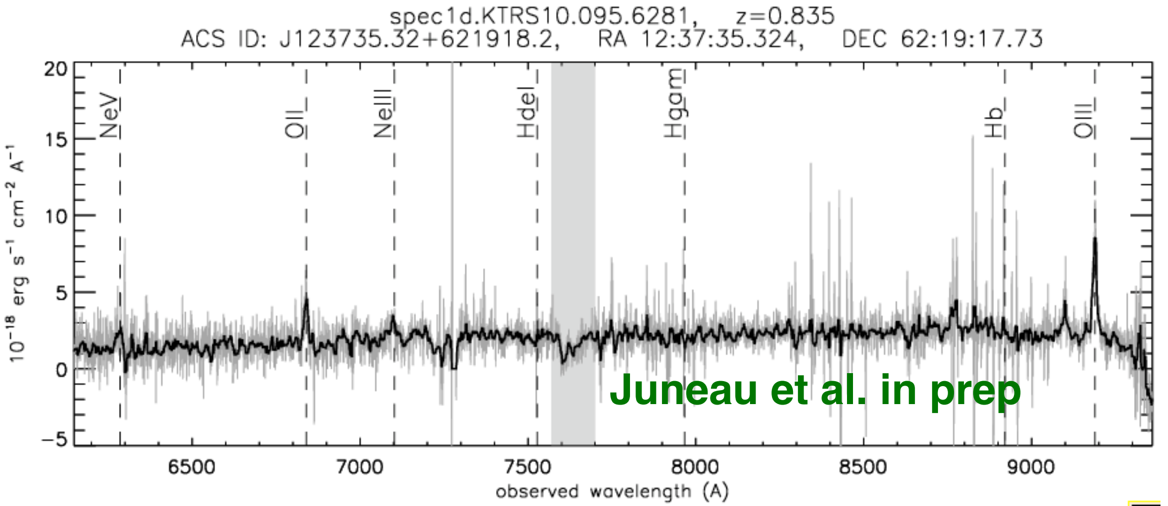


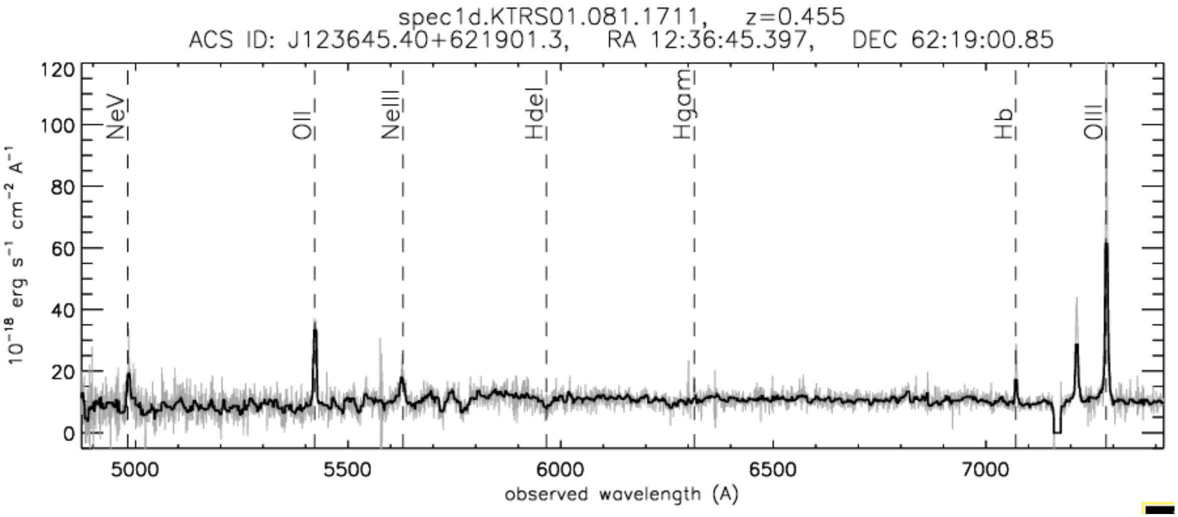


X-ray weak/undetected sources with strong IR power-law emission: luminous C-thick AGN (quasar luminosity)

Pope et al. in prep

And also identifying potential C-thick AGN at z~0.5-1





X-ray unidentified AGN in 2Ms CDF-N with clear AGN signatures in optical

Coming soon: Spitzer-IRS spectroscopy for sample of z~0.5-1 candidate C-thick AGN to confirm if actually C-thick

Summary

Summary

• X-rays: efficient AGN identification and almost absorption-independent probe of mass accretion

• X-ray surveys ID largest AGN source density (~7200 deg^{-2}):

⇒ Optical properties of sources are diverse, including objects without optical AGN signatures and faint, high-z obscured AGN

⇒ X-ray sources in deep fields predominantly at z~0.5-1 with high-z tail

⇒ AGN activity appears to be enhanced in redshift "spikes"

• Evolution of X-ray AGNs consistent with "downsizing": most luminous objects dominant at high-z, lower luminosity dominant at low-z:

⇒ First investigation suggests "downsizing" is due to decrease in Eddington ratio rather than black-hole mass

• Majority of AGNs are X-ray absorbed but clear evidence that many luminous AGNs remain undetected even in deepest X-ray survey:

⇒ Large (up to ~3000 deg^{-2}) candidate C-thick AGN population found at z~2 from X-ray stacking analyses: potentially as much black-hole growth as z~2 QSOs