Statistics of local hard X-ray selected AGN: clues for the CXB and unification model

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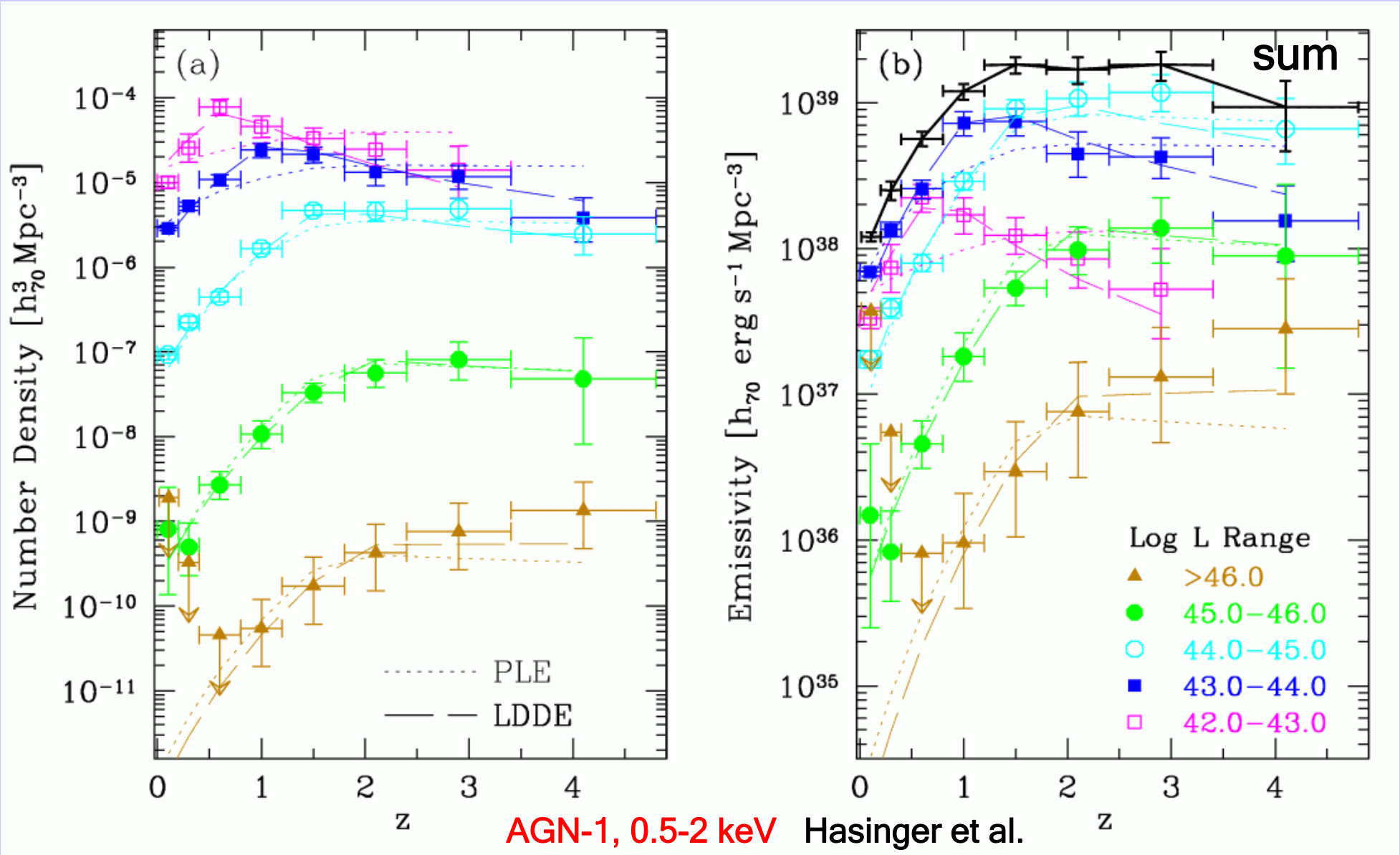
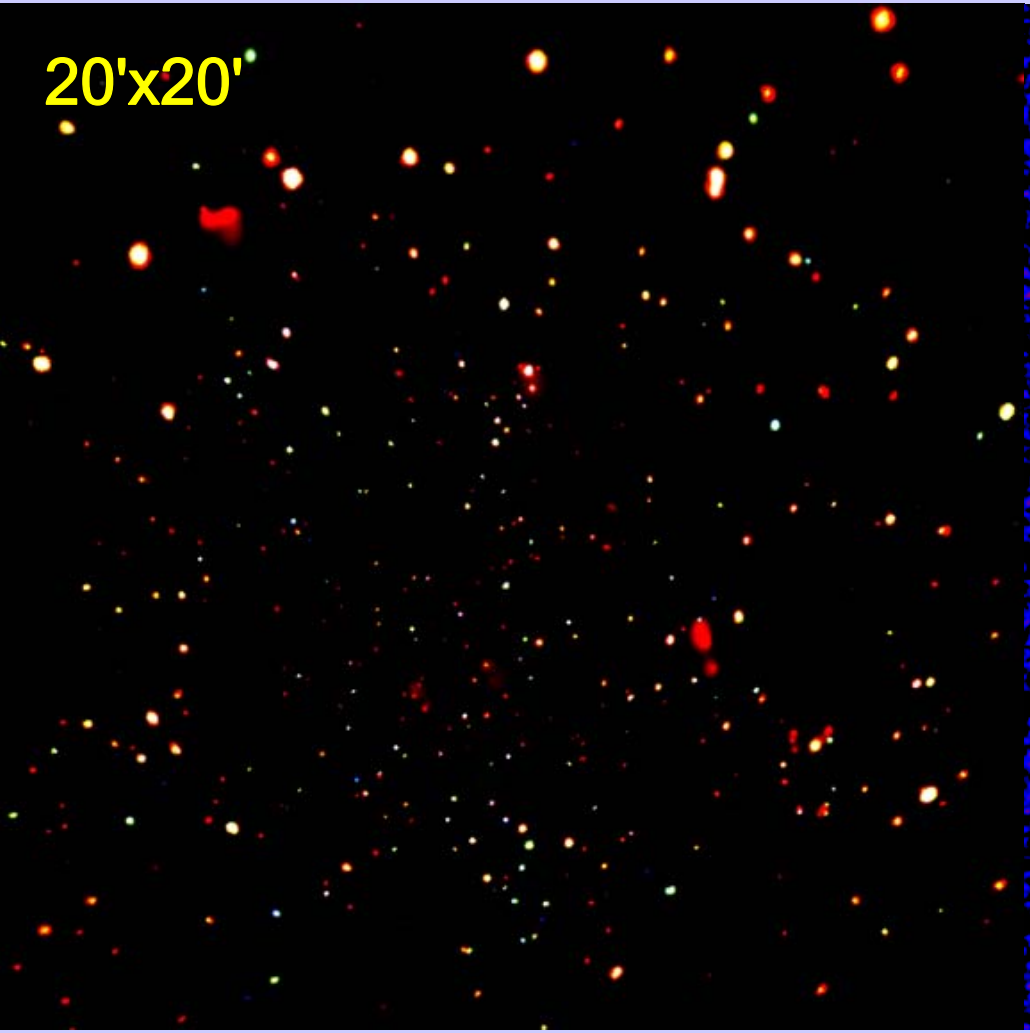
History of black hole growth: first giants, then dwarves

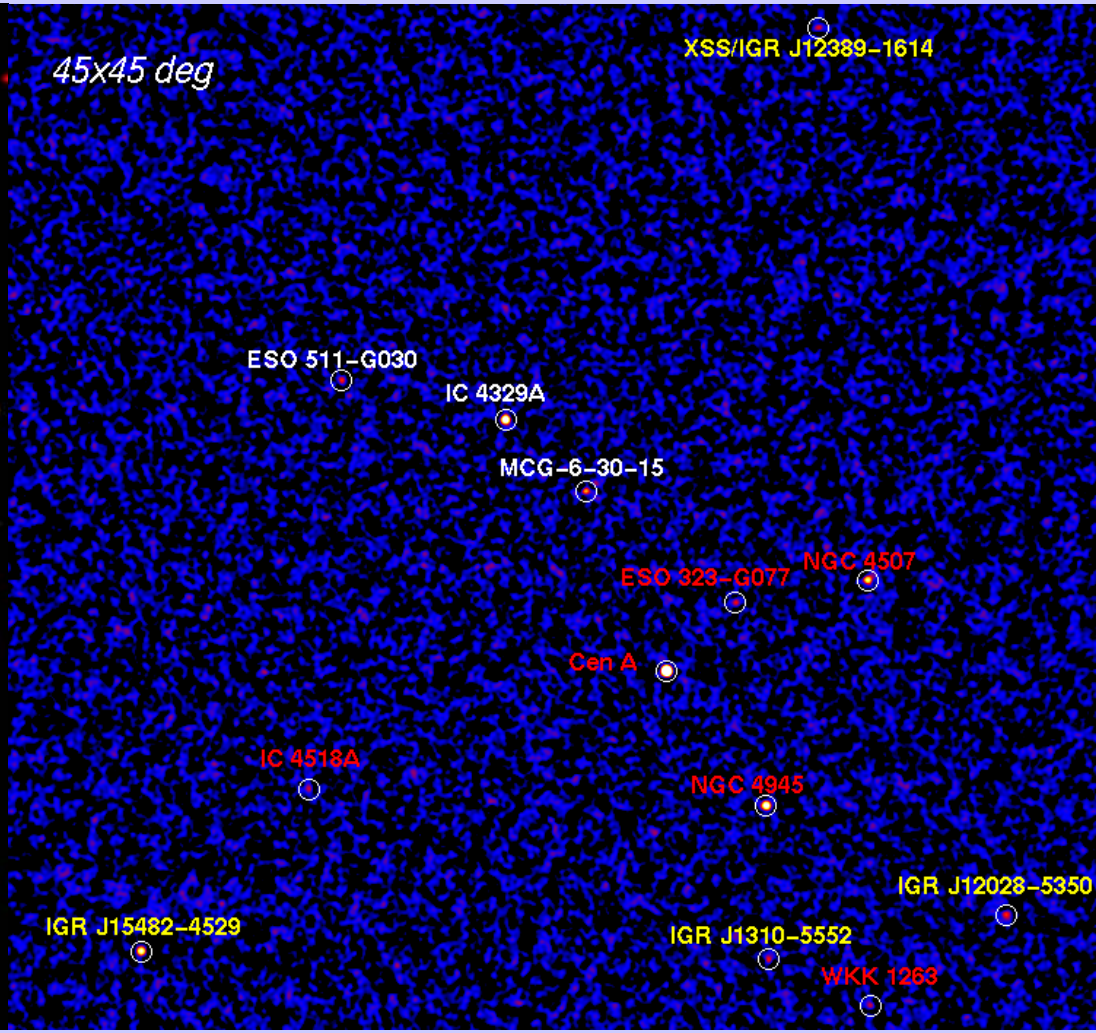


AGN-1, 0.5-2 keV Hasinger et al.

To make a full census of AGN we need deep, pencil beam surveys + large area (ideally all sky) surveys

Resolving the cosmic X-ray background





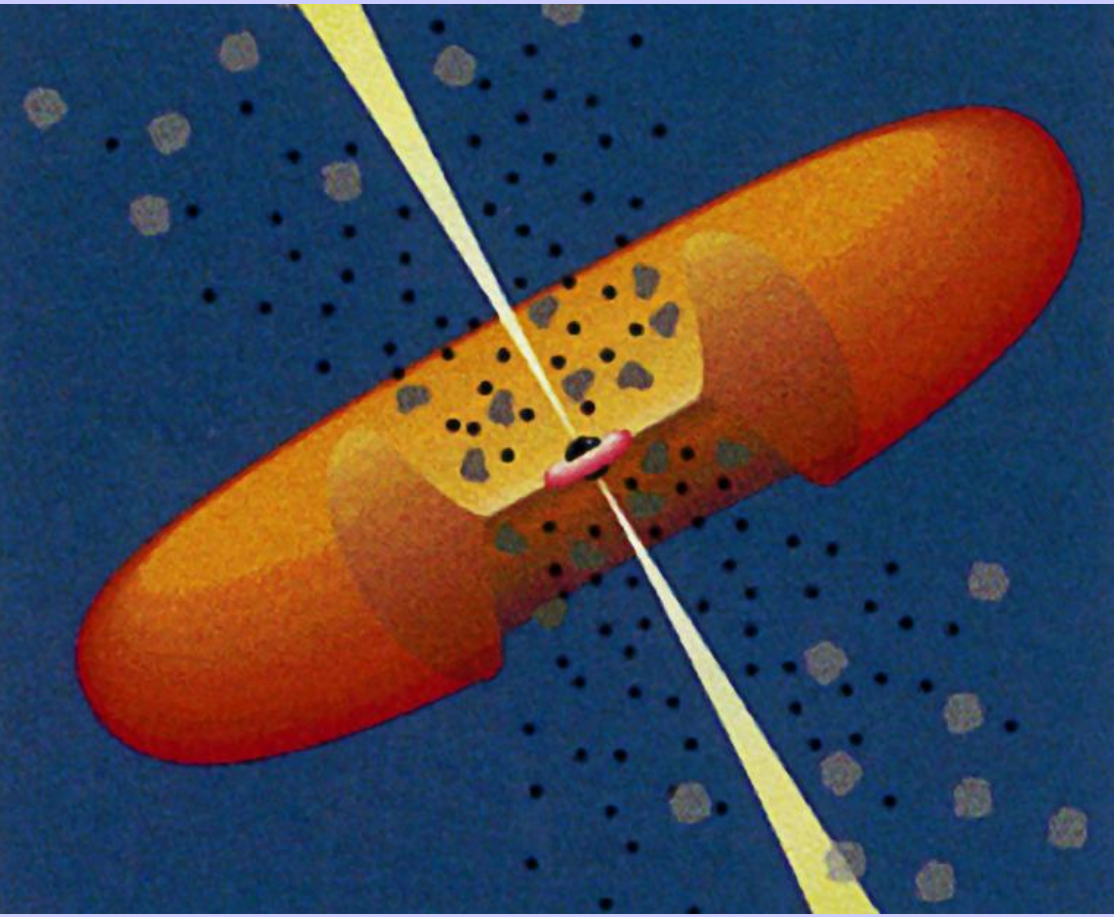
Chandra Deep Field North

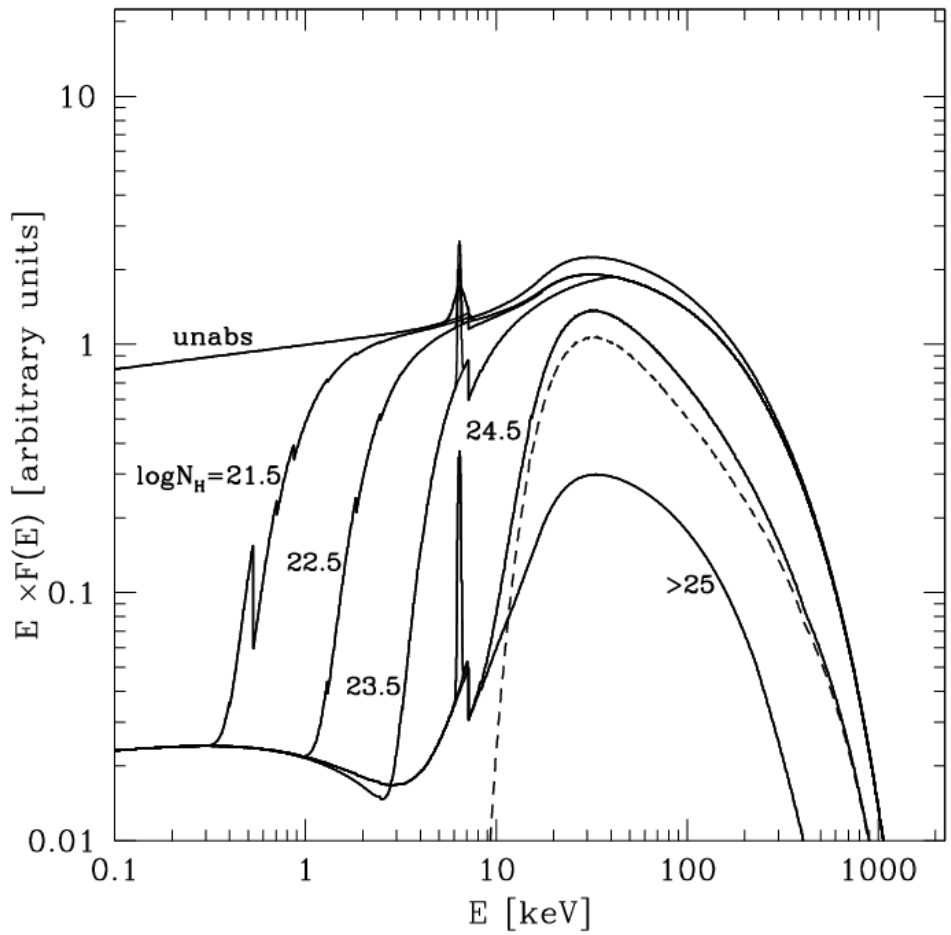
>80% of the CXB below few keV is resolved into distant quasars

INTEGRAL Cen-Shapley region

~1% of the CXB at 17-60 keV is resolved into nearby AGN

Obscured AGN

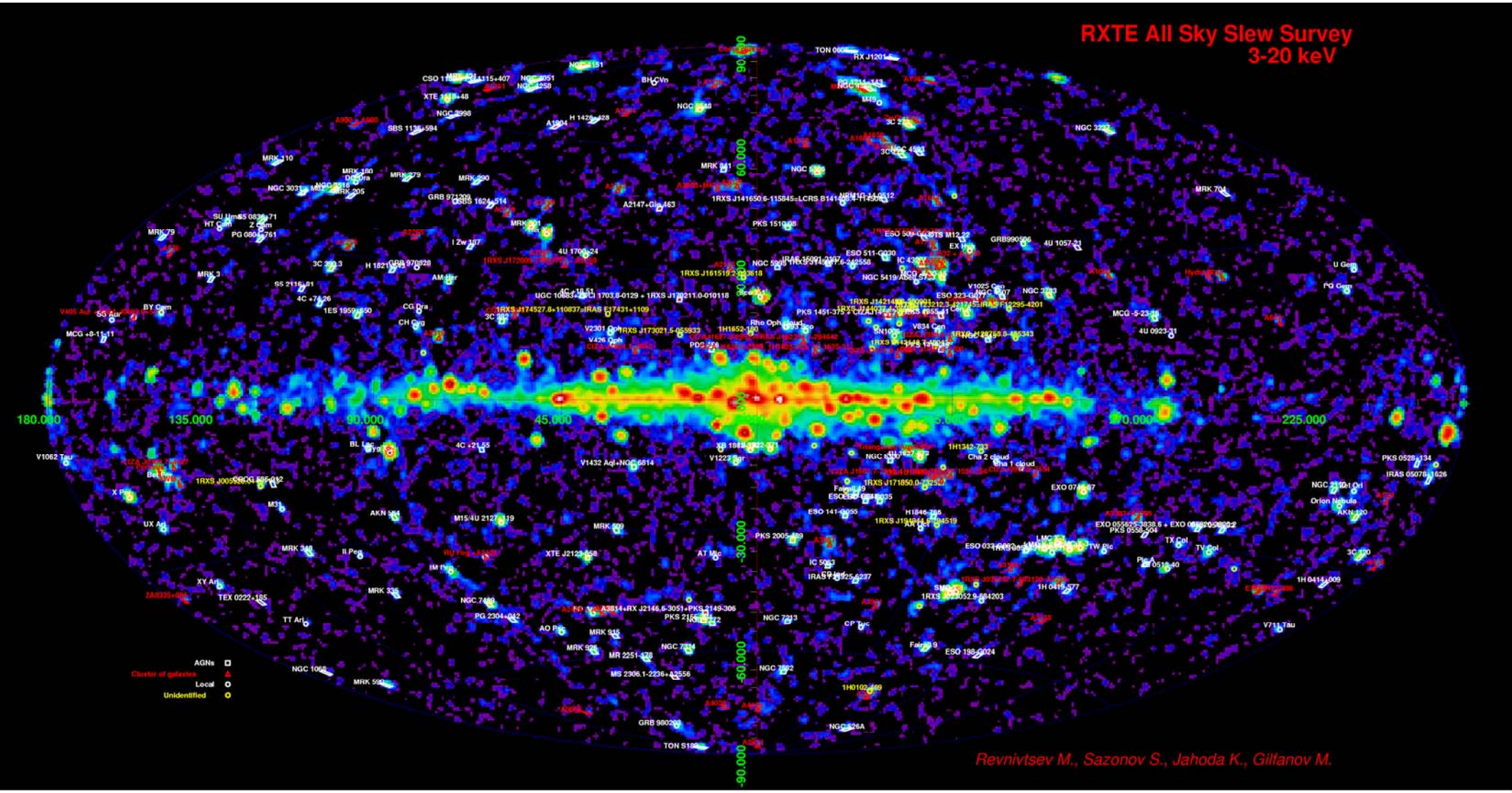




- Soft X-ray surveys (< 2 keV) only find unobscured AGN (N_H>10^{22})
- X-ray surveys (< 8 keV) miss heavily obscured AGN (N_H>10^{23-24})

We need hard X-ray surveys (> 10 keV) to study obscured AGN

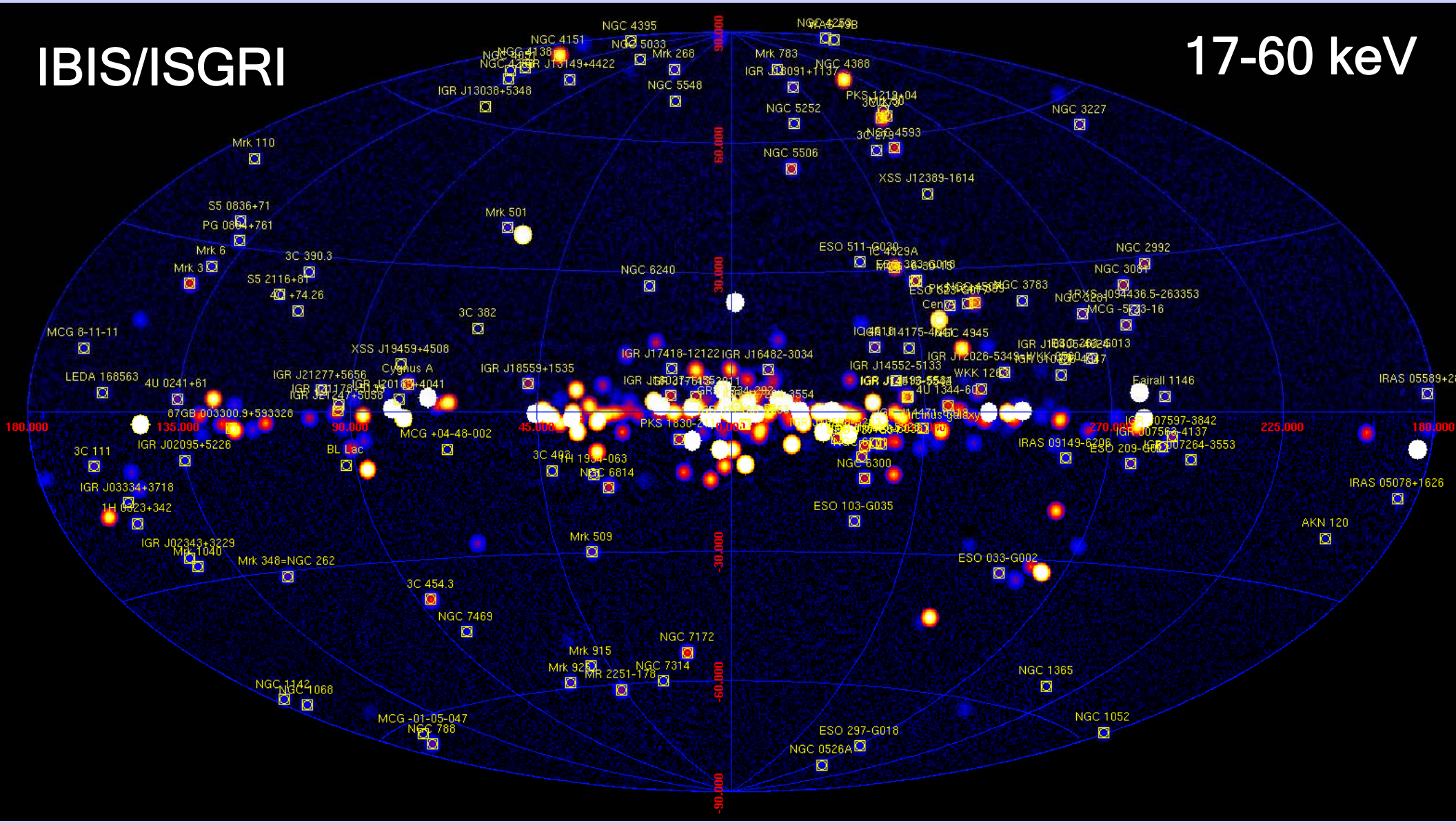
RXTE 3-20 keV Slew Survey



294 sources at |b|>10˚,
including 103 AGN

Revnivtsev et al. 2004
Sazonov, Revnivtsev 2004

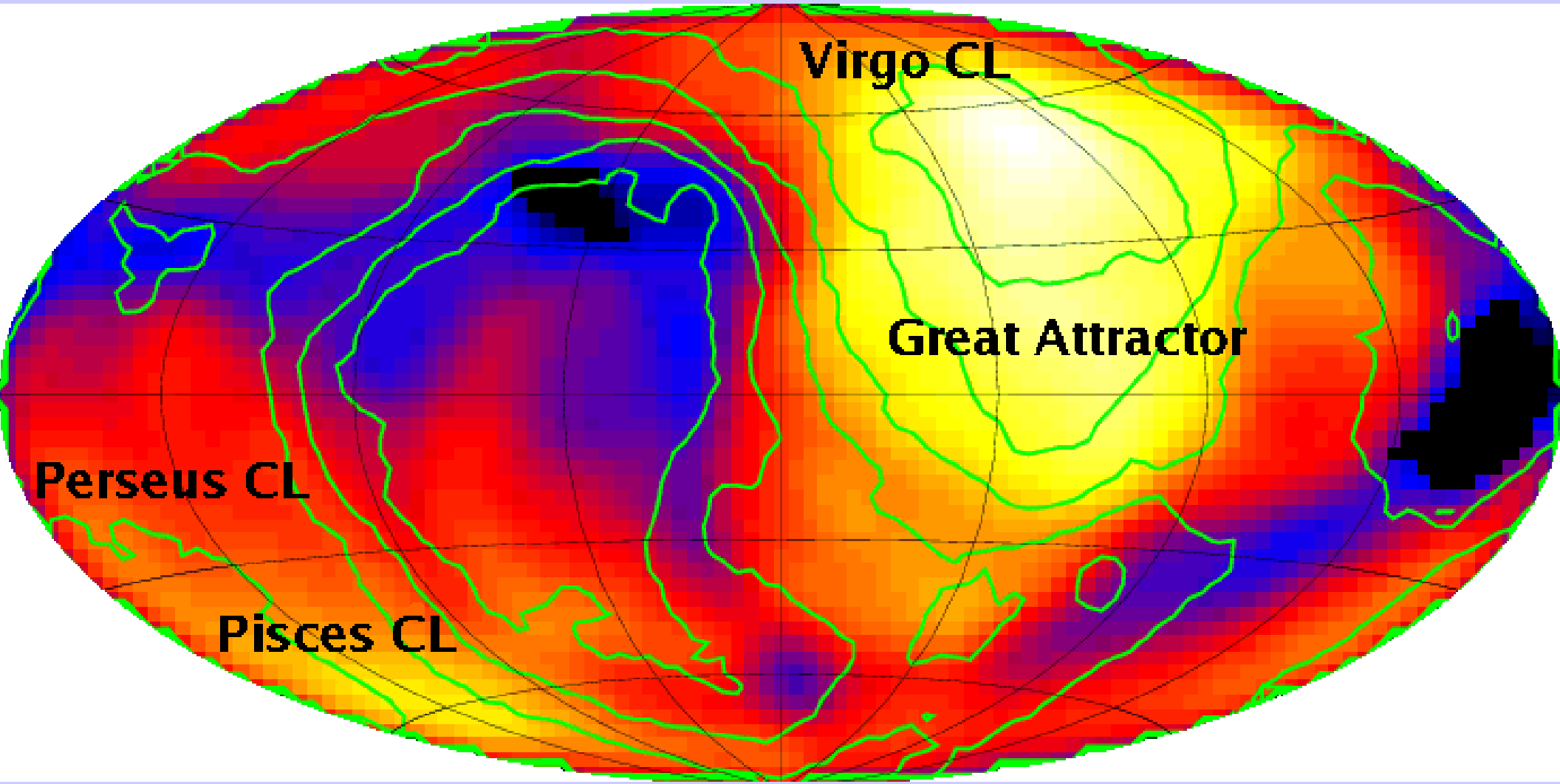
INTEGRAL All-Sky Survey



>400 sources,
including >131 AGN

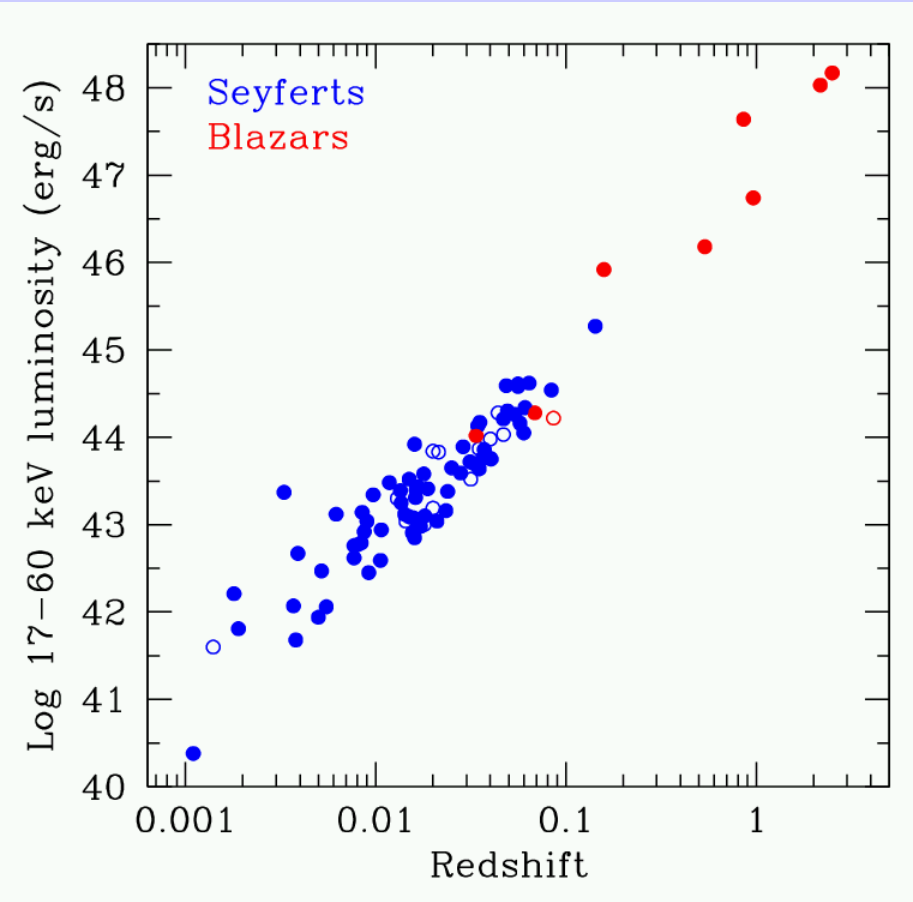
Krivonos et al. 2007

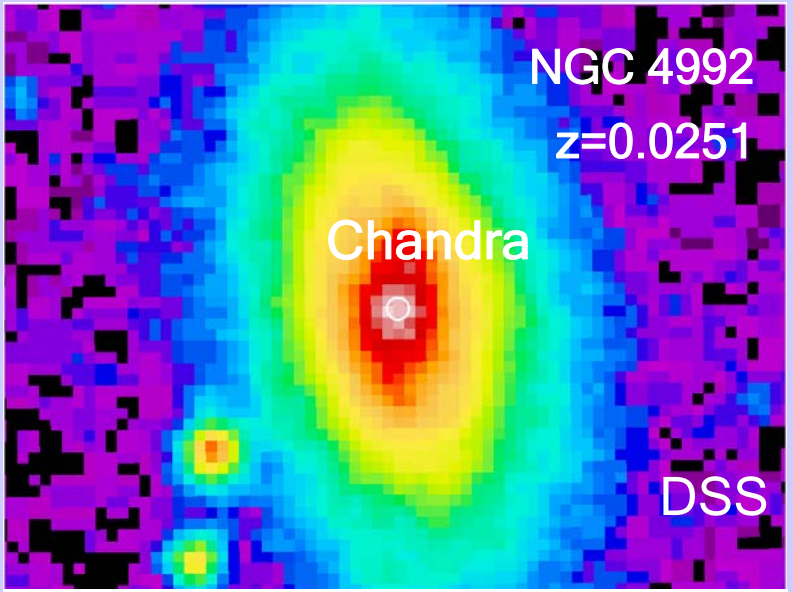
Local large scale structure

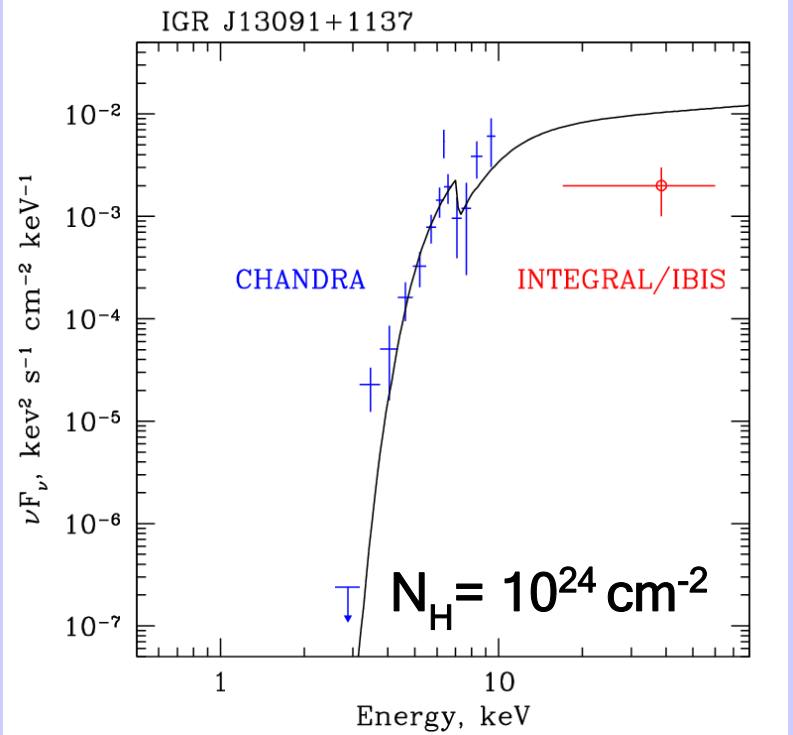


AGN number density within 70 Mpc (averaged over a 45 deg cone)
color map – *INTEGRAL* AGN, contours - *IRAS* galaxies

IBIS/ISGRI AGN catalog







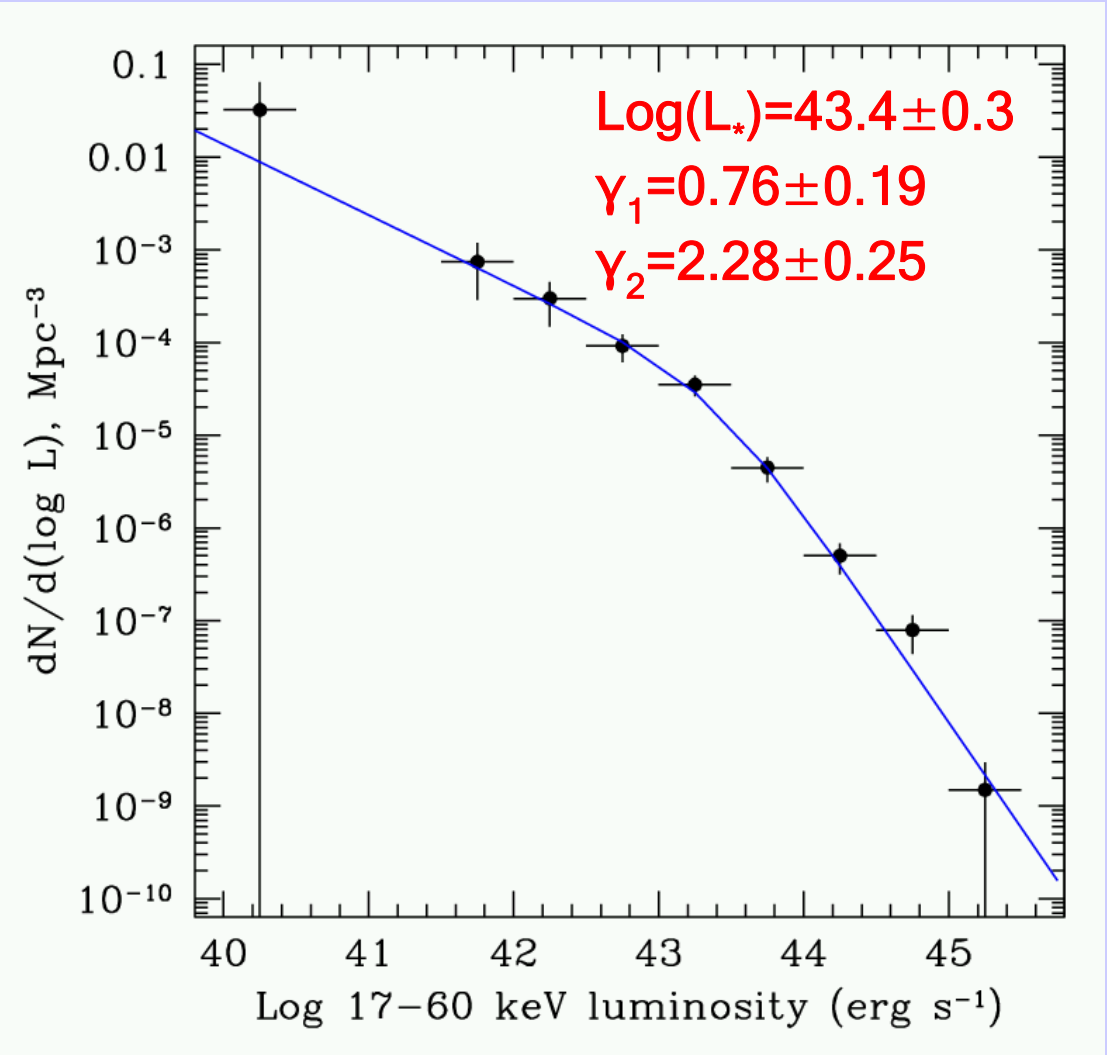
All sky:

94 AGN (86 Seyferts, 8 blazars)
+37 AGN detected in single observations
+40 unidentified sources

|b|>5°:

76 AGN (68 Seyferts, 8 blazars)
+ 7 unidentified sources

Hard X-ray luminosity function



Sazonov et al. 2007

AGN number density:

$n(L>10^{41})=$
$(1.4\pm0.6)\ 10^{-3}\ \mathrm{Mpc}^{-3}$

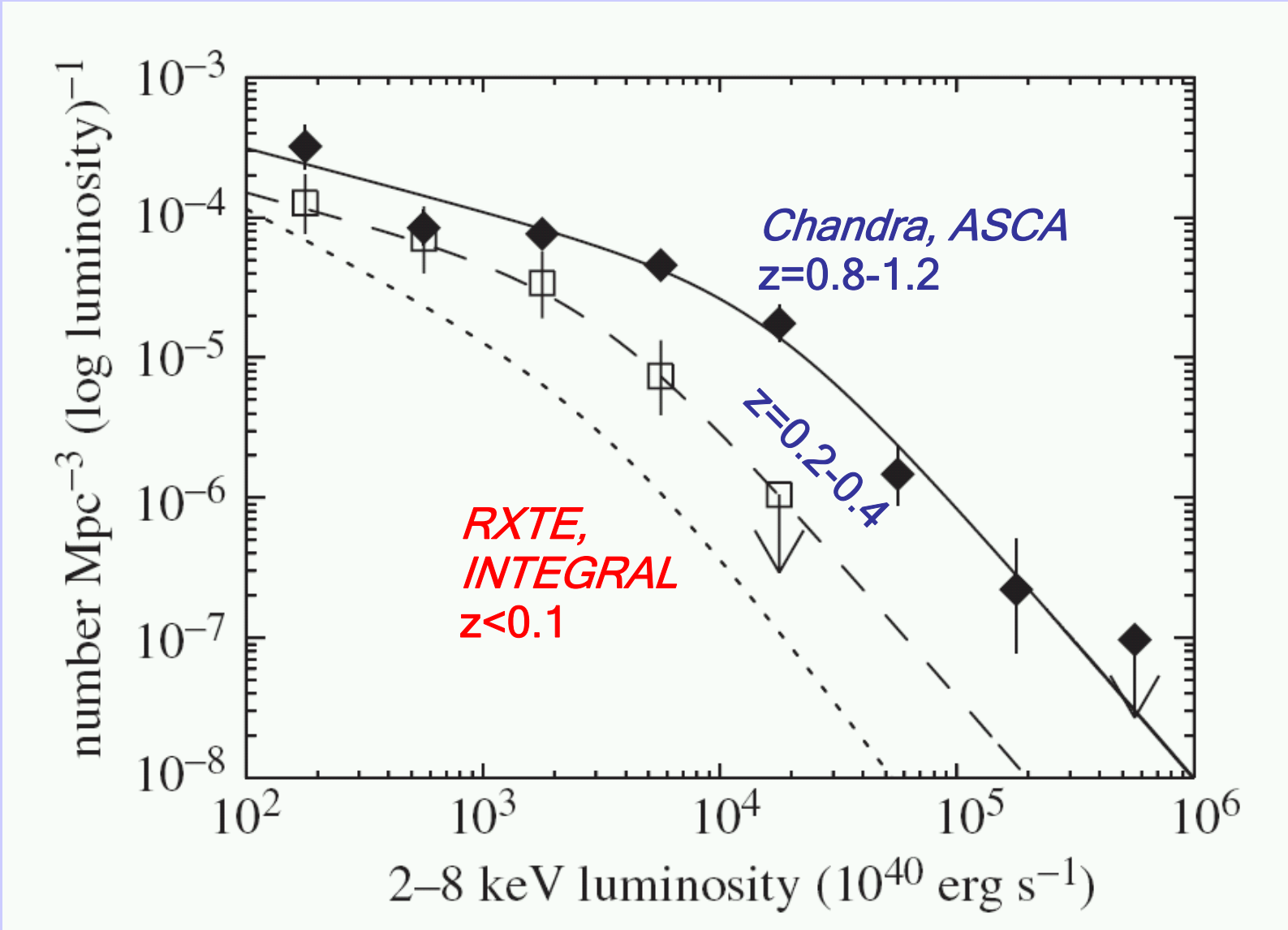
AGN luminosity density:

$\epsilon_{17\text{-}60\ \mathrm{keV}}\ (L>10^{41})=$
$(12.4\pm1.5)\ 10^{38}\ \mathrm{erg/s/Mpc}^3$

In satisfactory agreement with:

- Beckmann et al. 2006 (*INTEGRAL*)
- *RXTE* Slew Survey 3-20 keV LF (Sazonov & Revnivtsev 2004)
- *HEAO-1* 2-10 keV LF (Shinozaki et al. 2006)
- *Swift* (J. Tueller's talk)

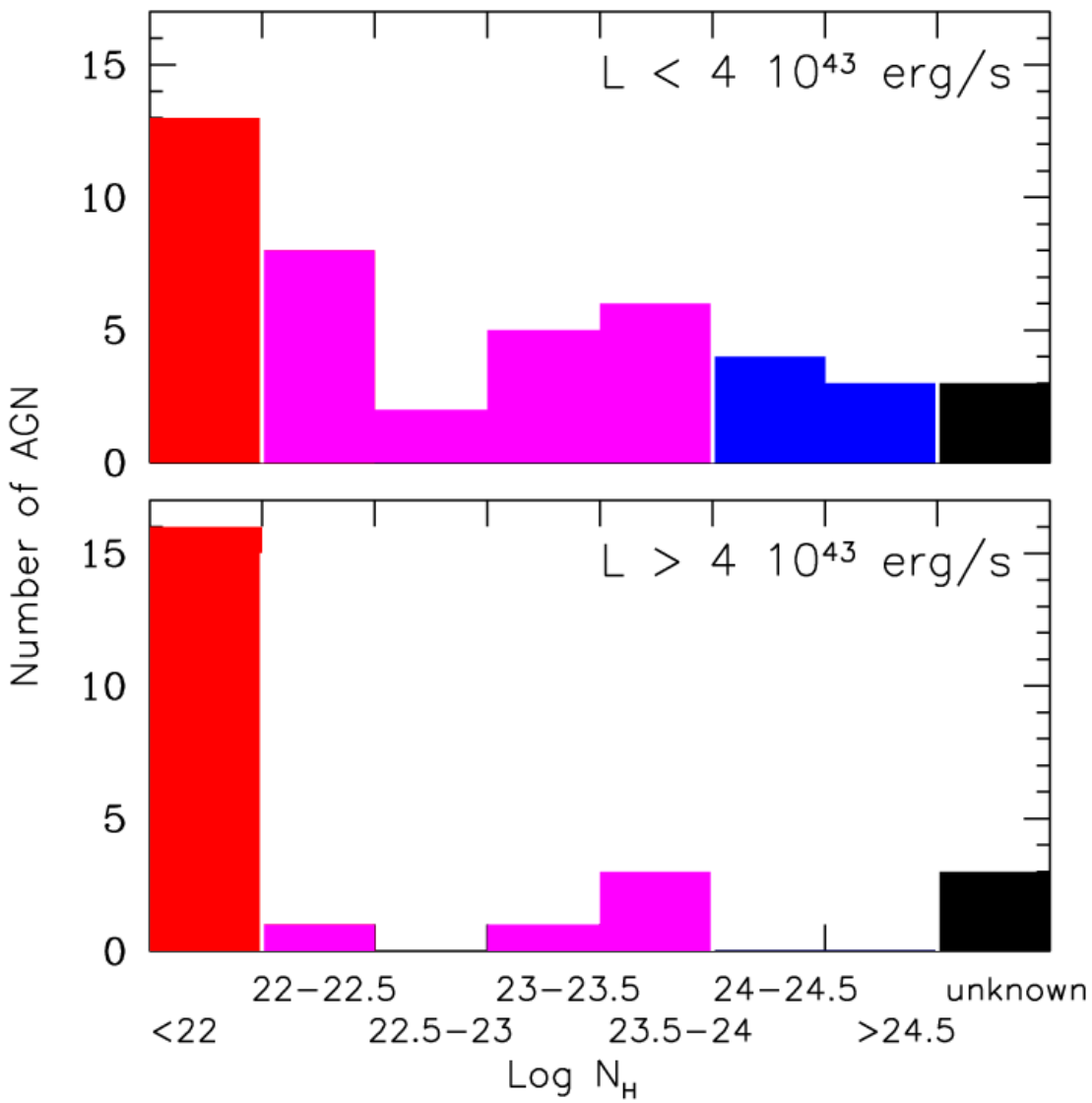
AGN downsizing continues at z~0



Barger et al. 2005

$L_* \sim (1+z)^3$ (z<1)

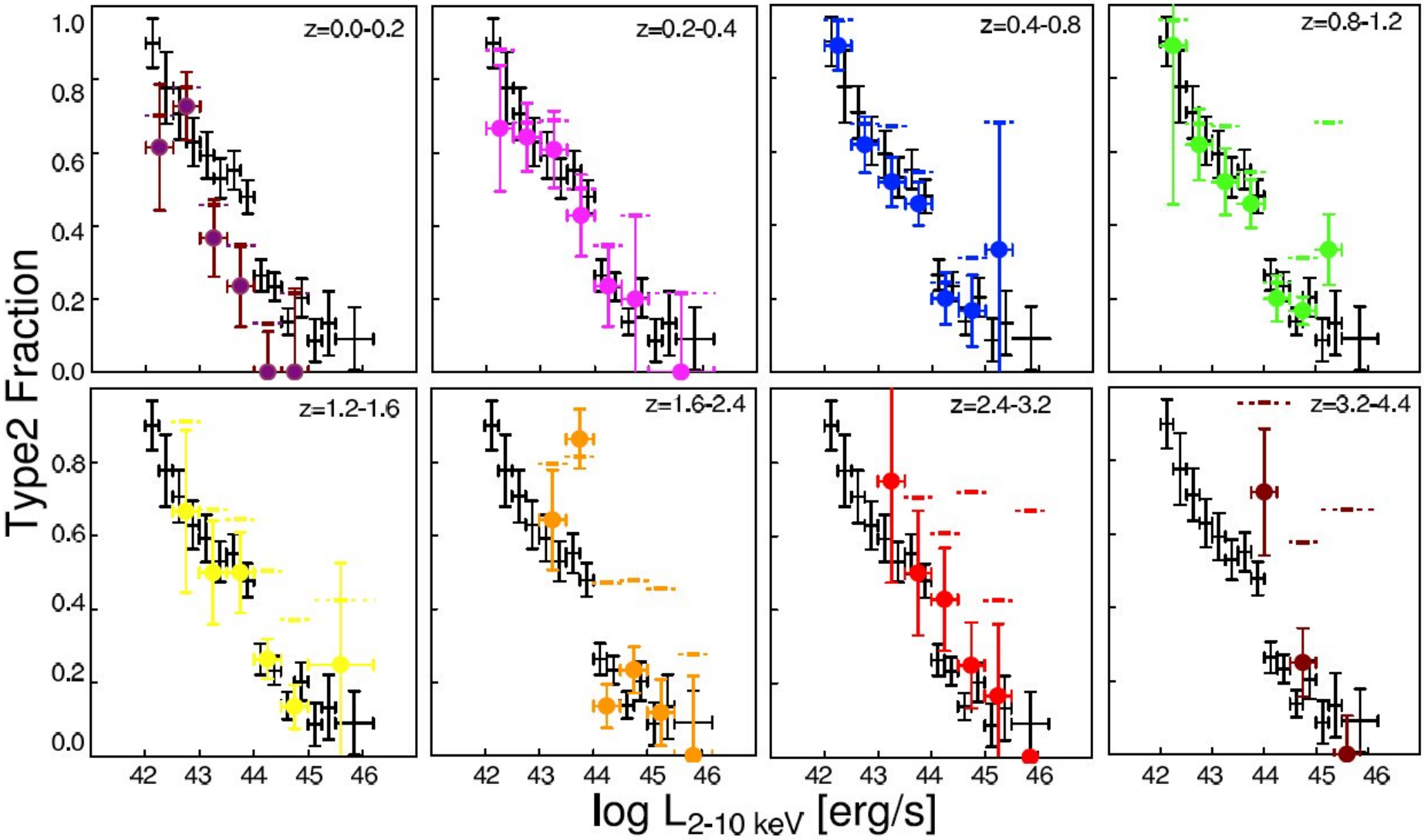
Obscured vs. unobscured AGN



- Fraction of obscured AGN decreases from 65-70% at low L to 20-30% at high L
- Only 15-20% of AGN are Compton thick - all at low L
  - Similar results reported by Bassani et al. 2006
  - Same luminosity trend seen by *RXTE* (Sazonov & Revnivtsev 2004) and *Swift* (Markwardt et al. 2005)

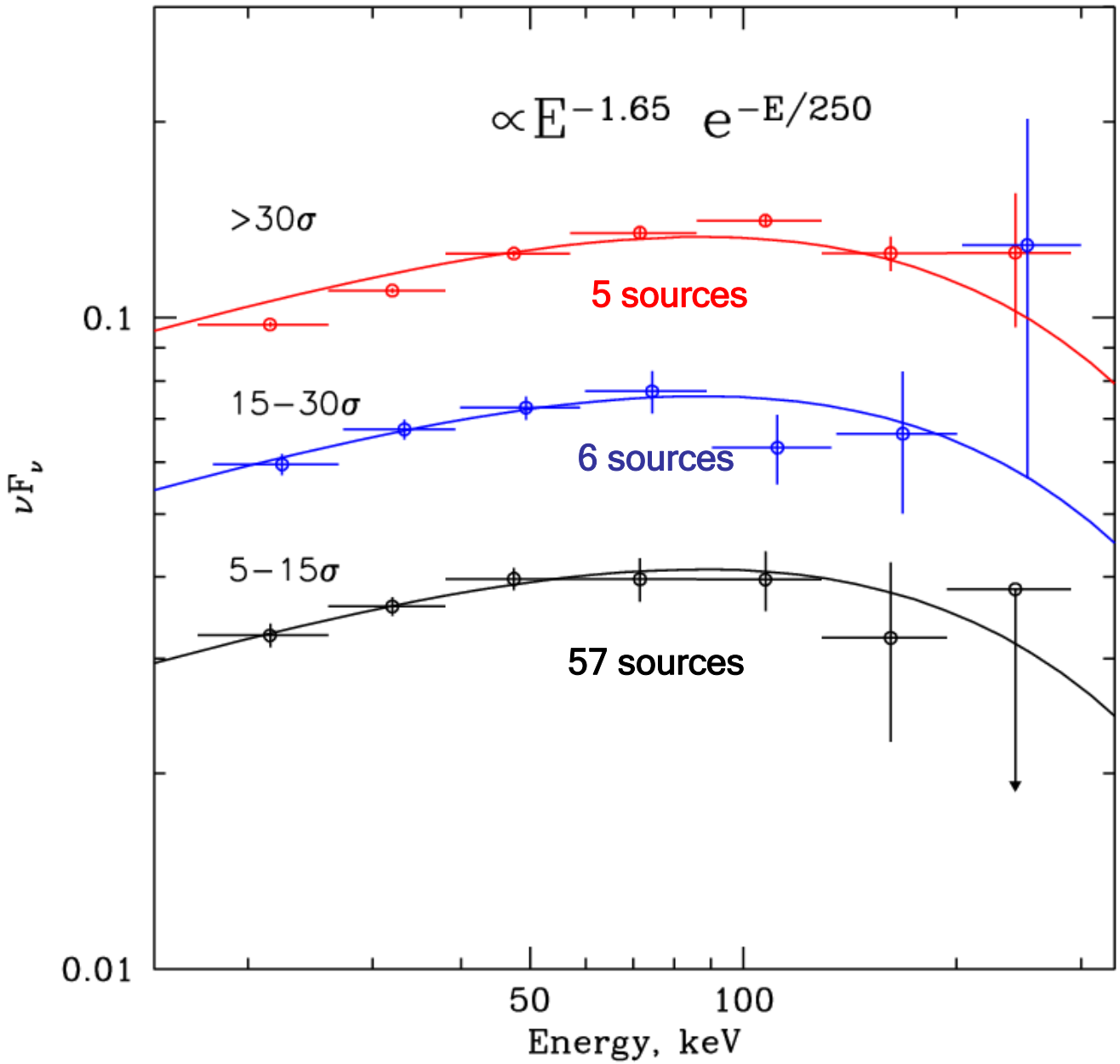
Simplest AGN unification does not work!

Similar trends are seen at higher redshifts



Mueller & Hasinger 2007

Average hard X-ray SED of local AGN

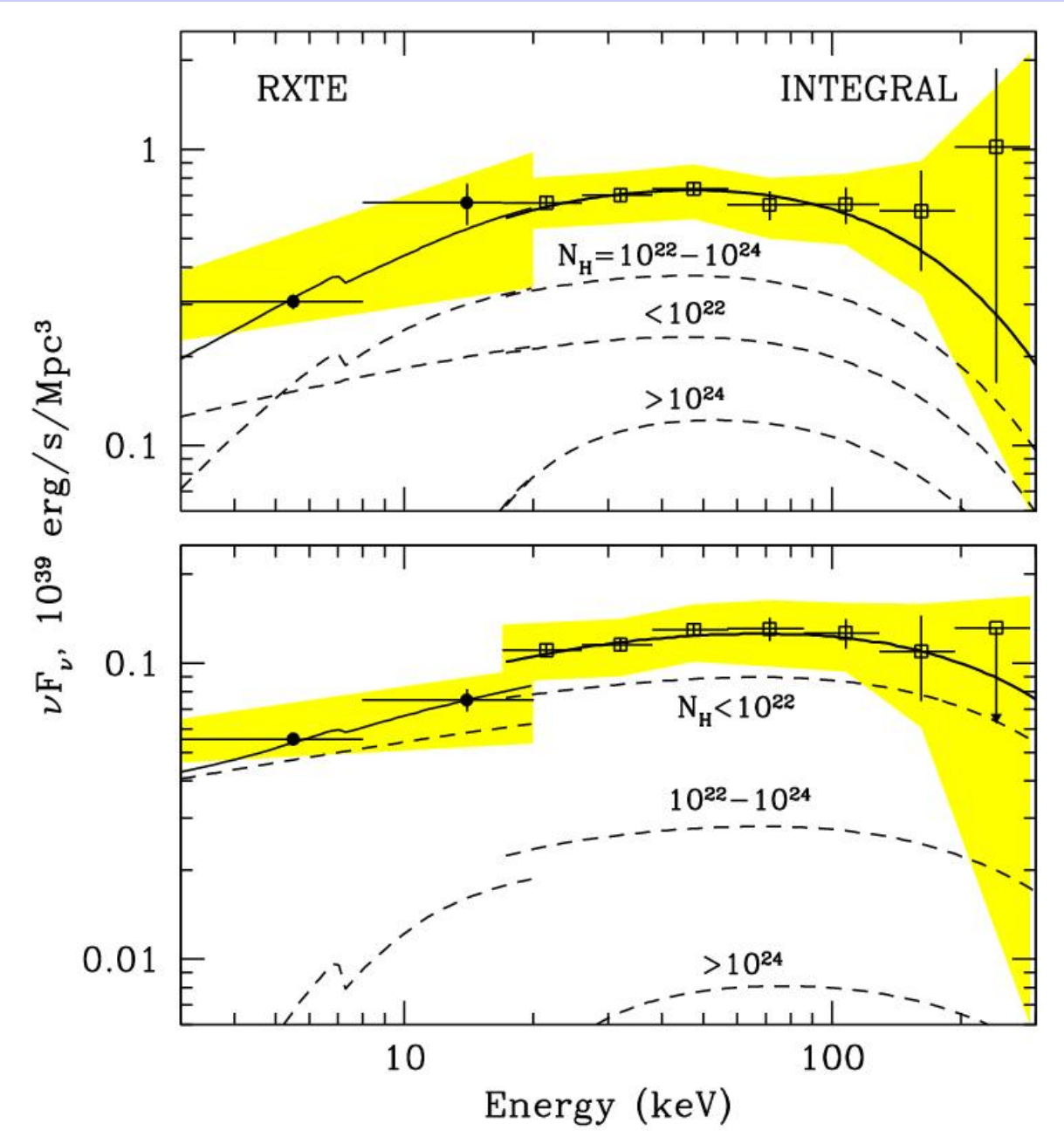


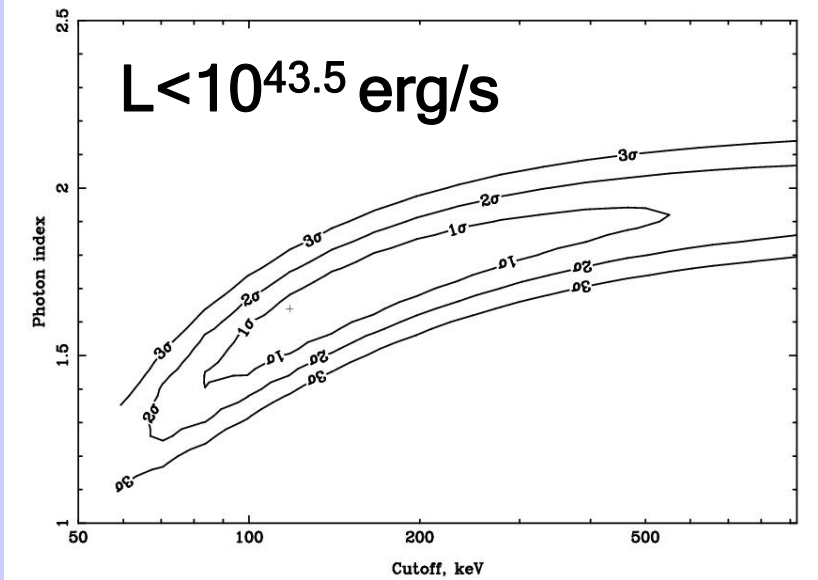
Simple stacking:

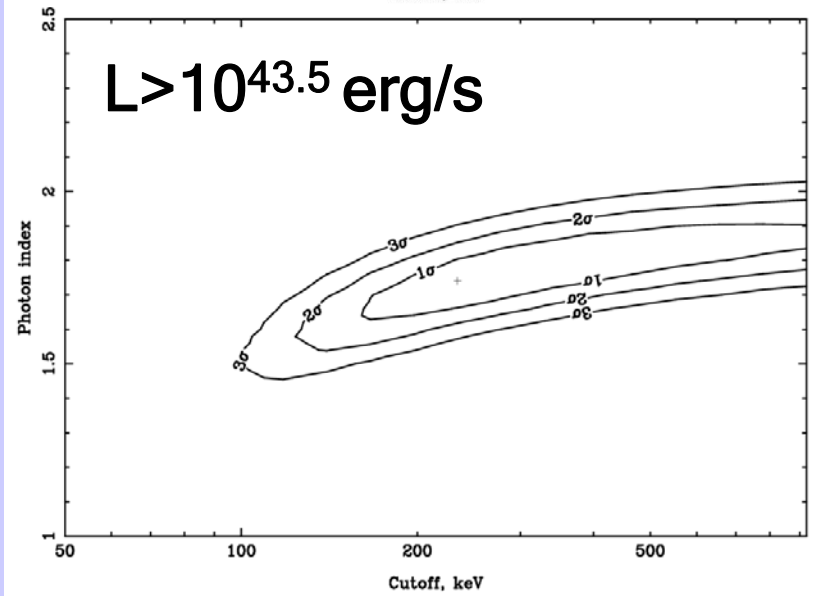
$S=\Sigma f_i$

High-energy cutoffs have also detected in *INTEGRAL* spectra of individual AGN (e.g. Molina et al. 2006)

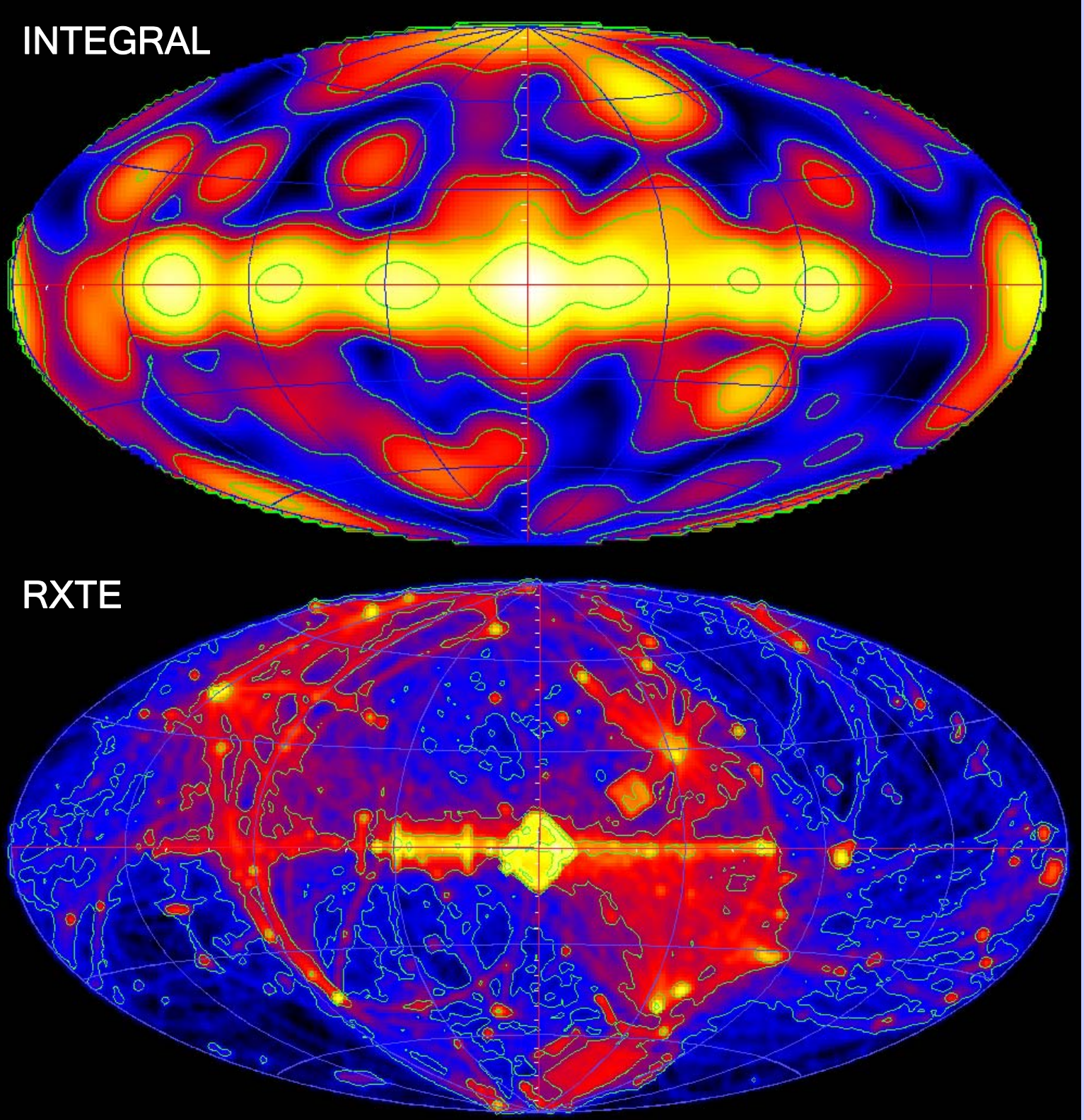
Space density weighted sum: $S=\Sigma L_i / V_{max,i}$





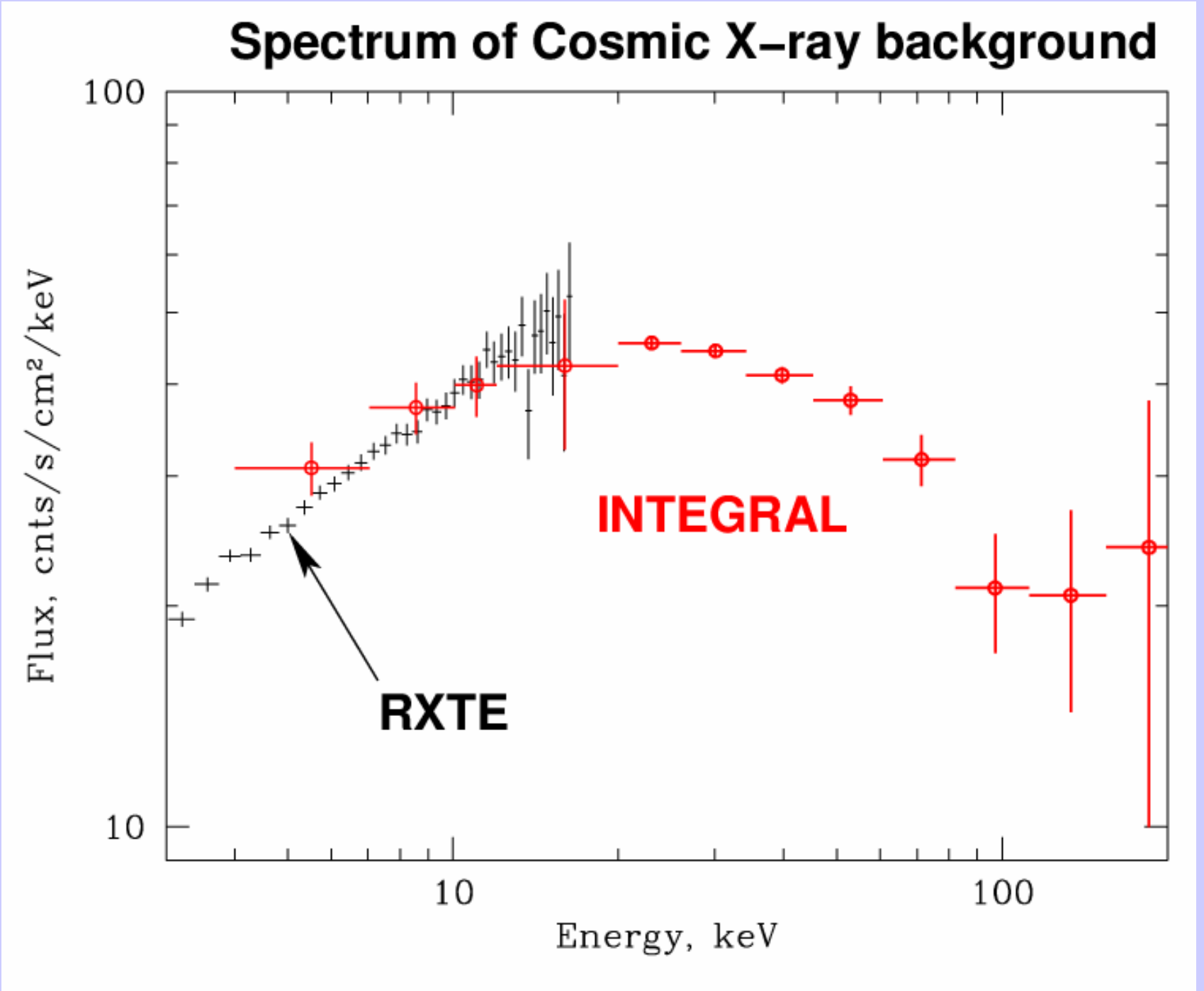


Model: $\Sigma\, f(N_H)\, E^{-\Gamma}\, e^{-E/Ecut}$



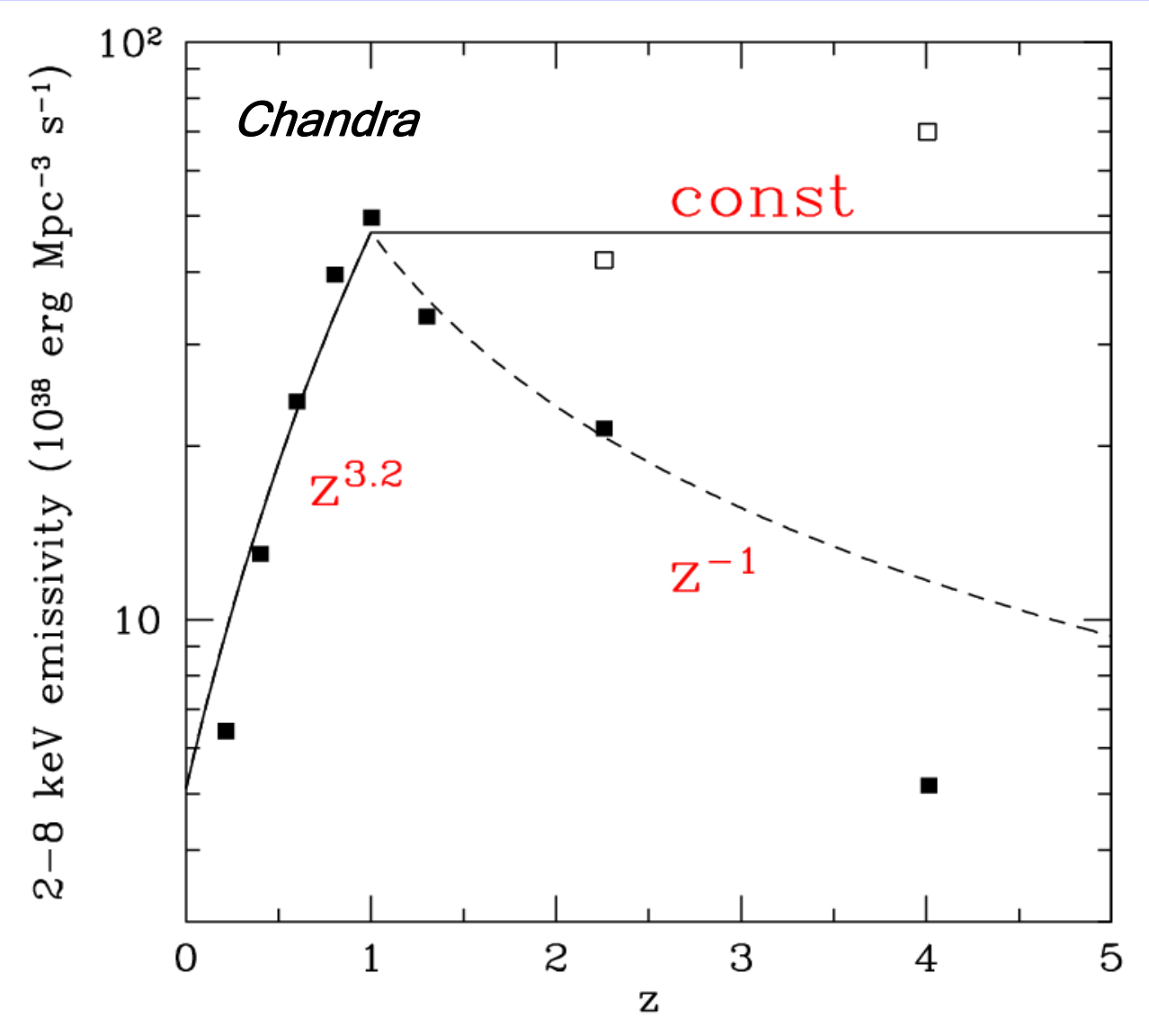
within ~100 Mpc *INTEGRAL* sees a factor of 1.2 denser Universe than *RXTE*

This is taken into account in our analysis



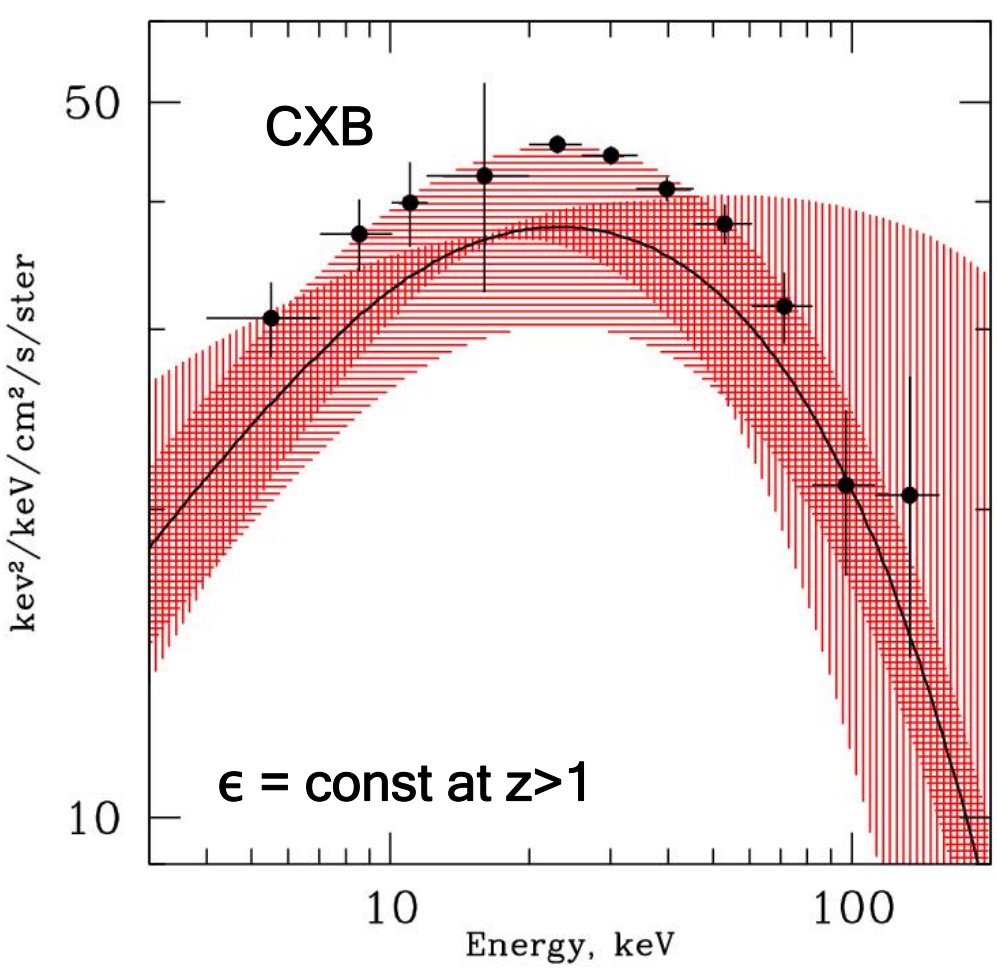
Revnivtsev et al. 2003, Churazov et al. 2007

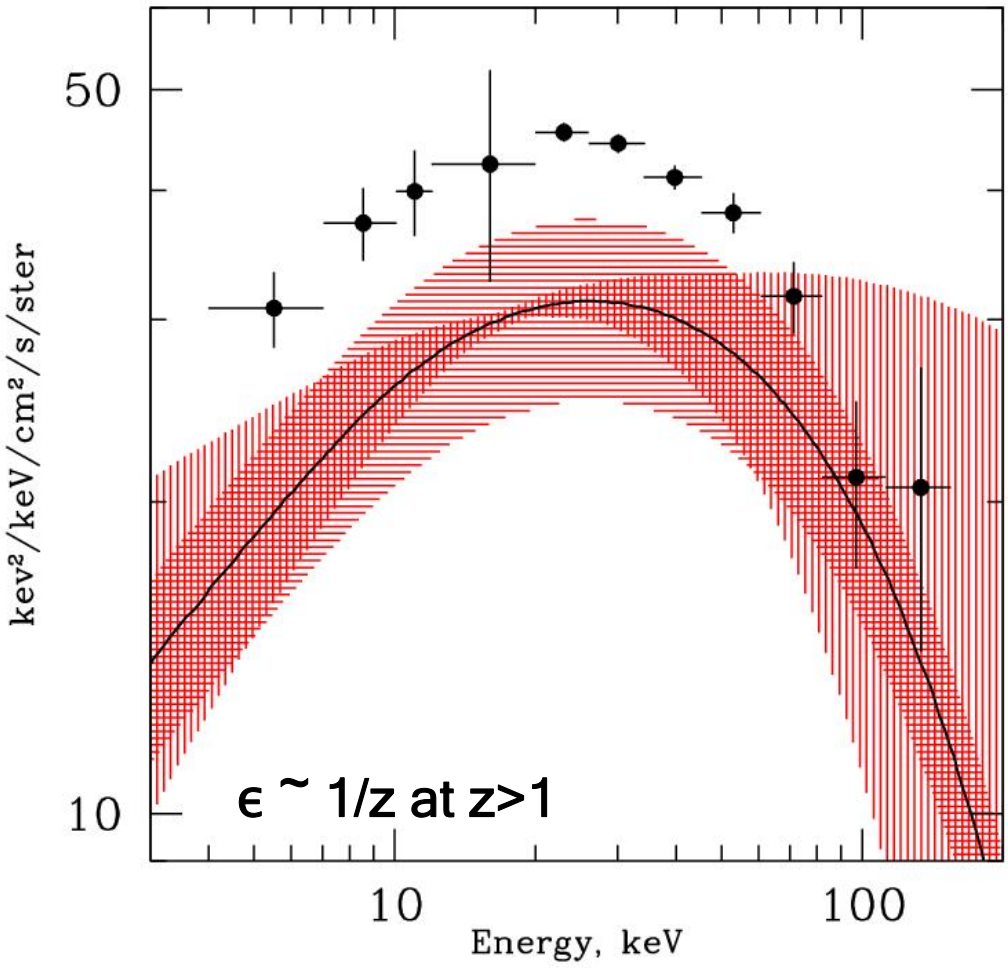
Evolution of AGN X-ray luminosity density



Barger et al. 2005

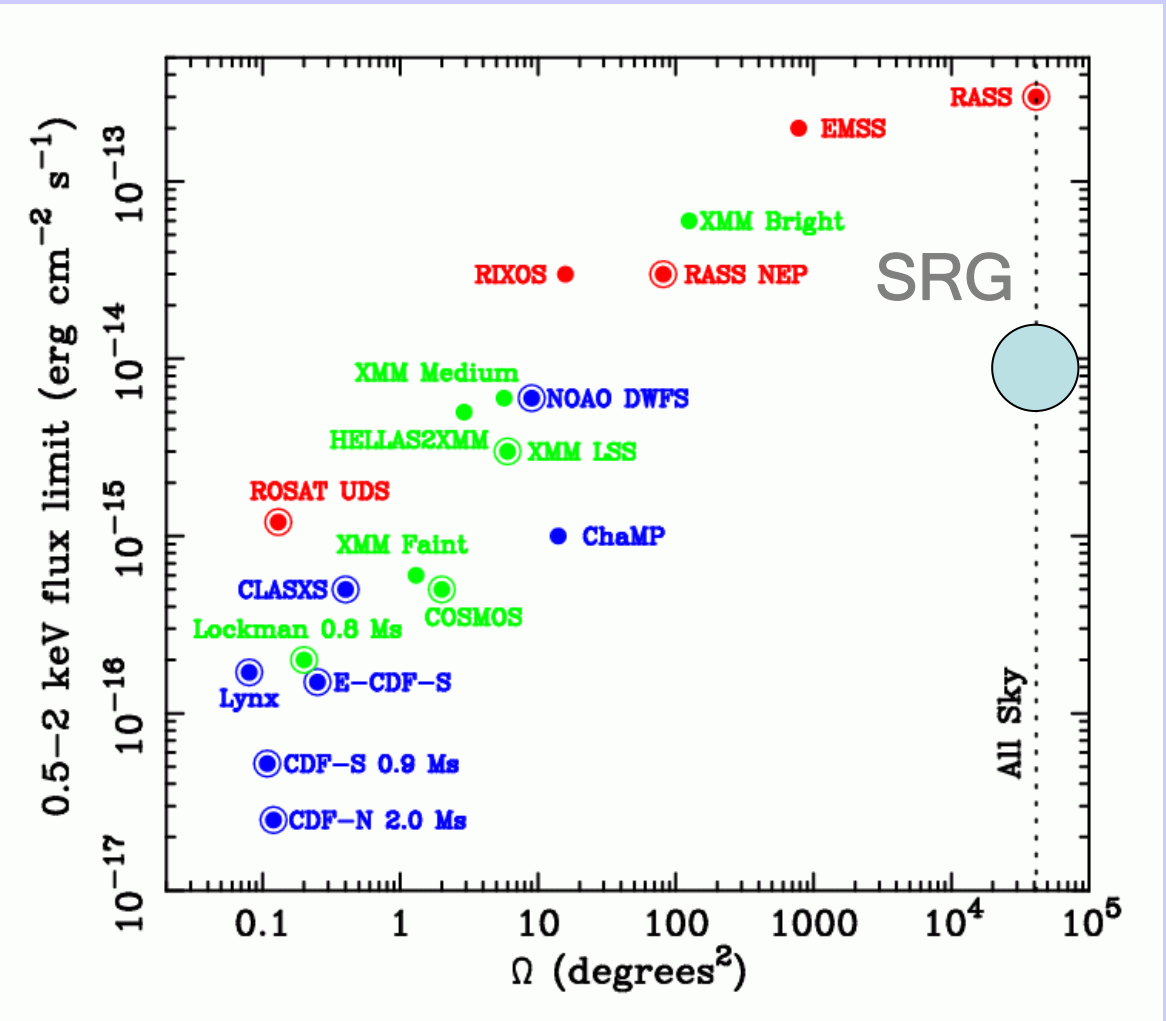
Let's convolve average local AGN SED with z-dependence





Consistent with the cosmic X-ray background spectrum!
(within the large uncertainties)

Future: S*pectrum-X-Gamma* / eROSITA
from thousands to millions AGN



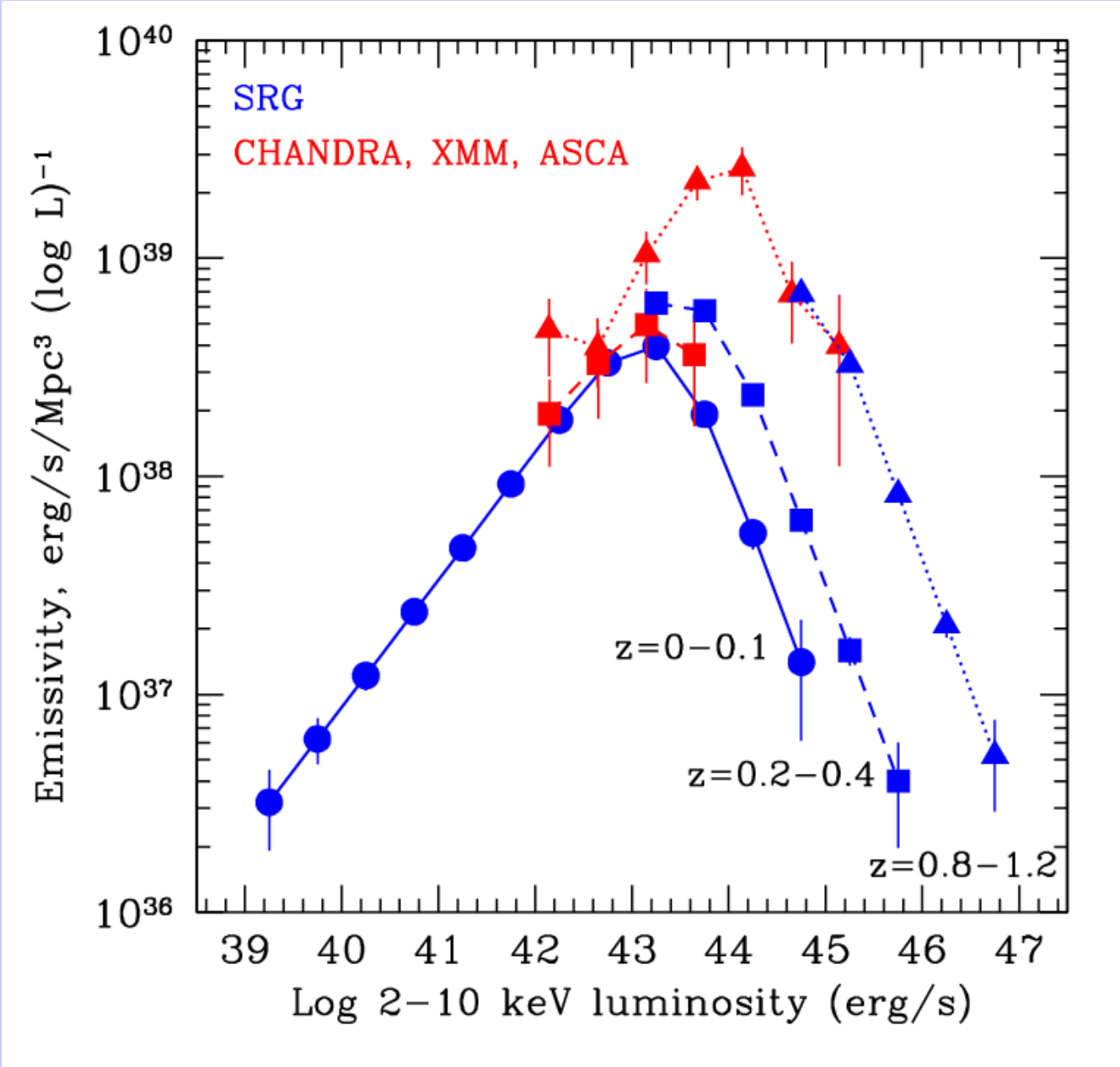
Sensitivity of 4-year all-sky survey will be:

$9\ 10^{-15}$ erg/s/cm^2 in 0.5-2 keV

$2\ 10^{-13}$ erg/s/cm^2 in 2-10 keV

2 orders of magnitude better than previous all-sky surveys (*ROSAT, RXTE*)

Spectrum-X-Gamma survey + deep surveys = a full census of nearby AGN and distant quasars



Conclusions

- Local ratio of obscured to unabscured AGN drops from 2:1 at low luminosities to 1:3 at high luminosities and the same trend is seen at higher redshifts. Does this mean that AGN feedback on the torus is important or something else?

- Observed fraction of Compton-thick AGN is significant but not large (15-20%), but we do not know yet the fraction of extremely thick objects ($N_H > 10^{25}$ cm^{-2}) - infrared surveys are key

- Average properties of local AGN – hard X-ray luminosity density, column density distribution, and high-energy cutoff - are all consistent (within large uncertainties) with the CXB if these properties are propagated from z=0 to z~2

- The census of AGN is still far from being complete. *INTEGRAL* and *Swift* will continue improving the statistics. Exciting prospects for future X-ray and hard X-ray missions (Spectrum-X-Gamma, Simbol-X …). Wait for surprizes!