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

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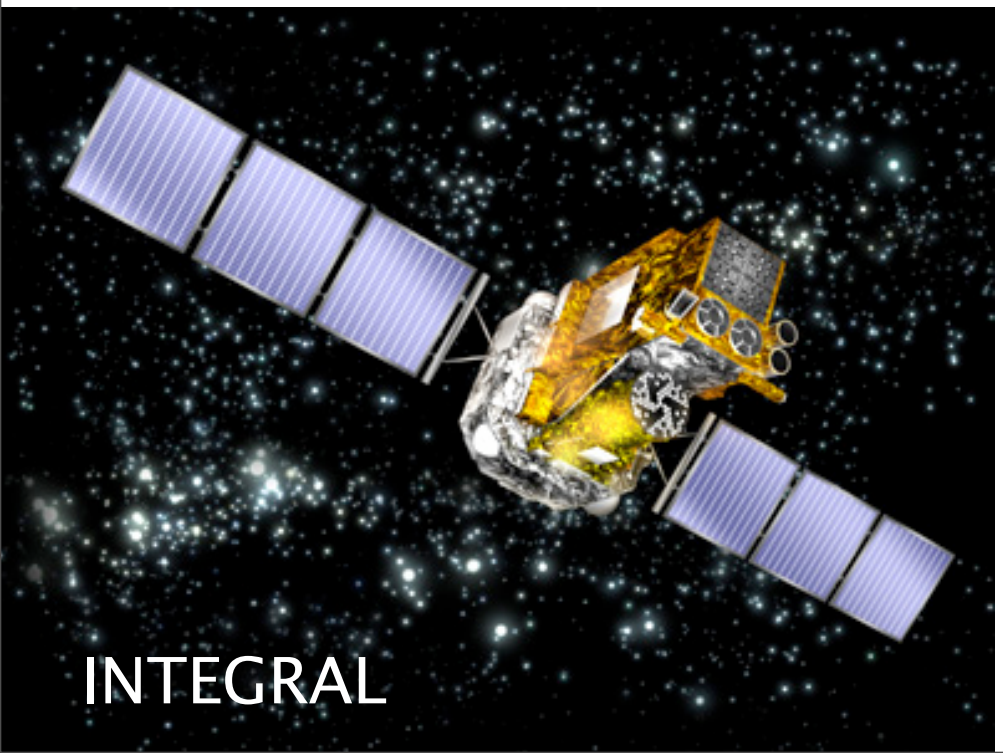
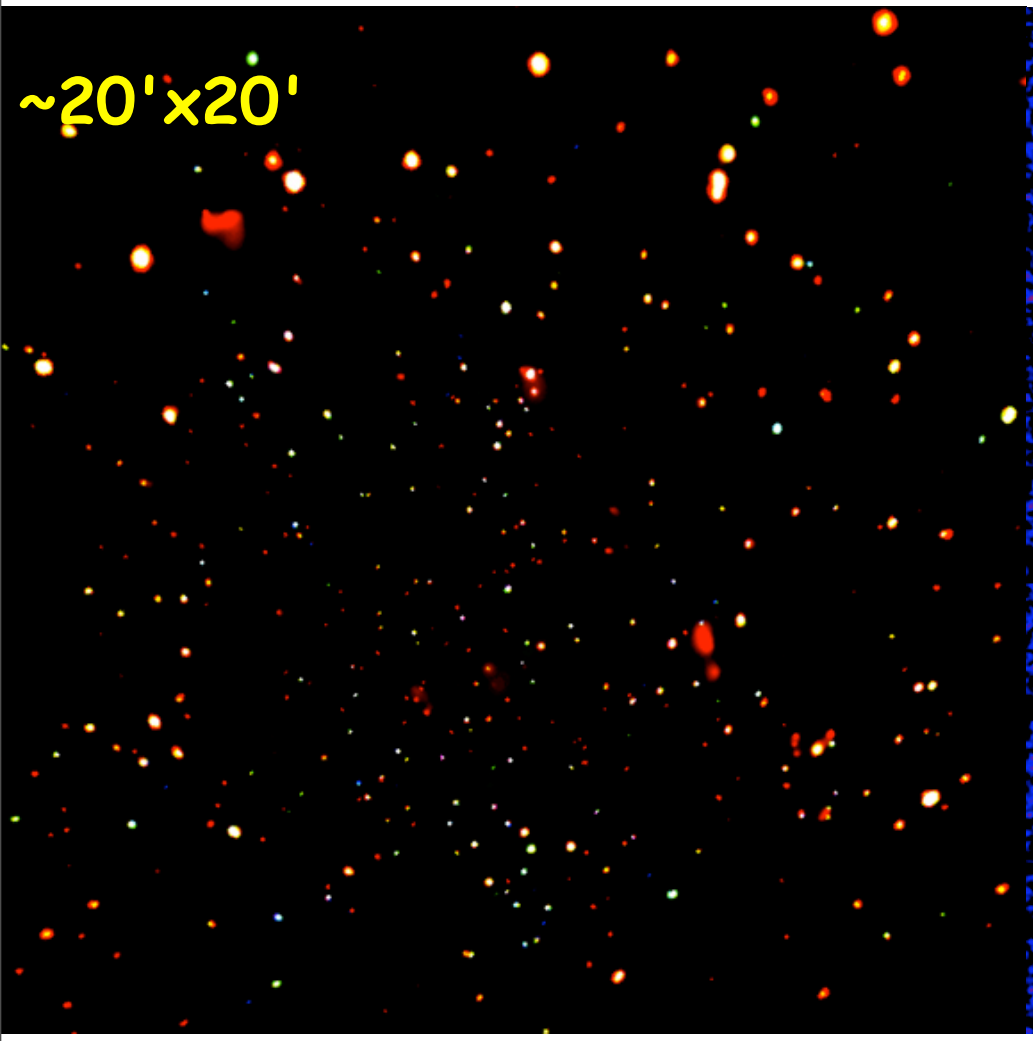
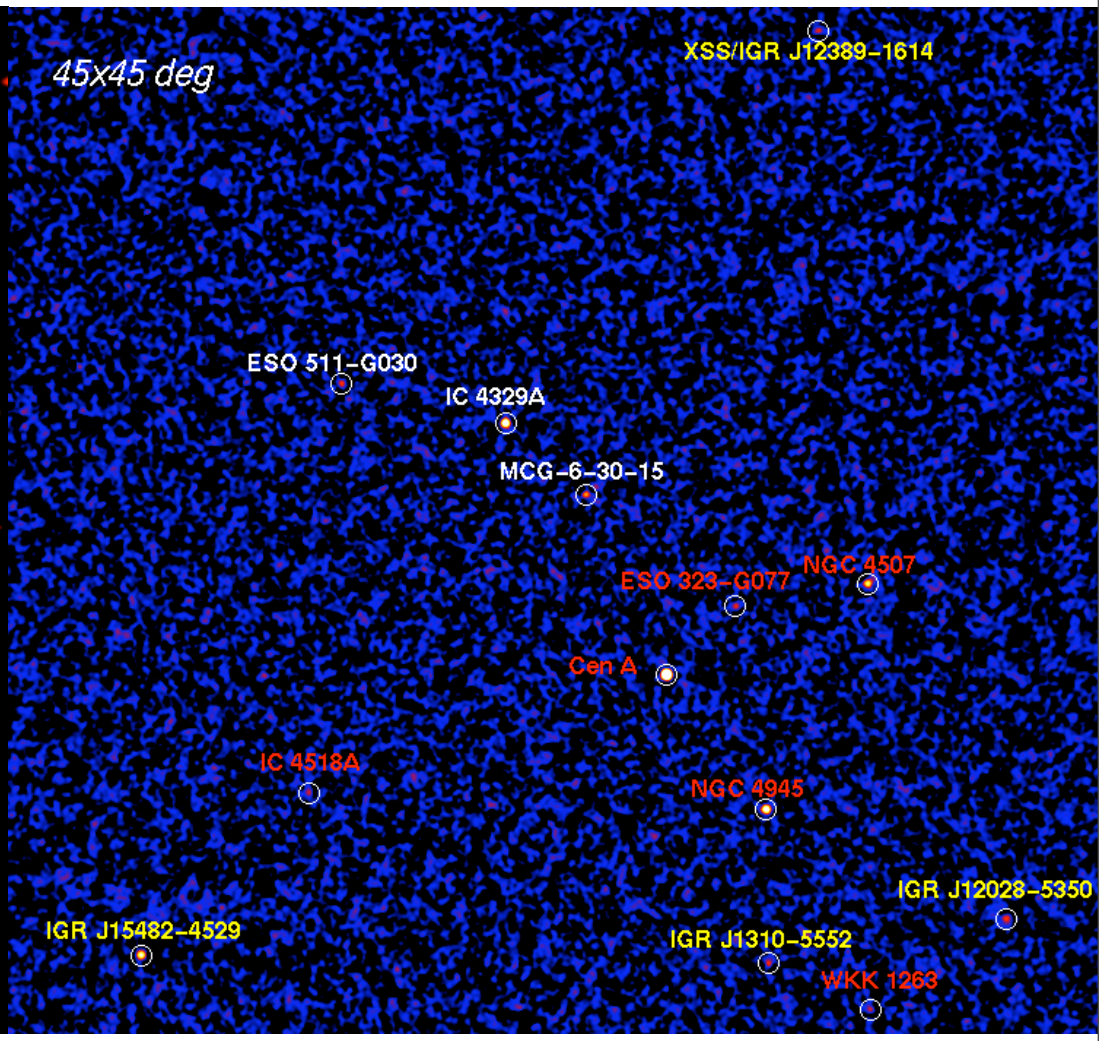


Resolving the cosmic X-ray background





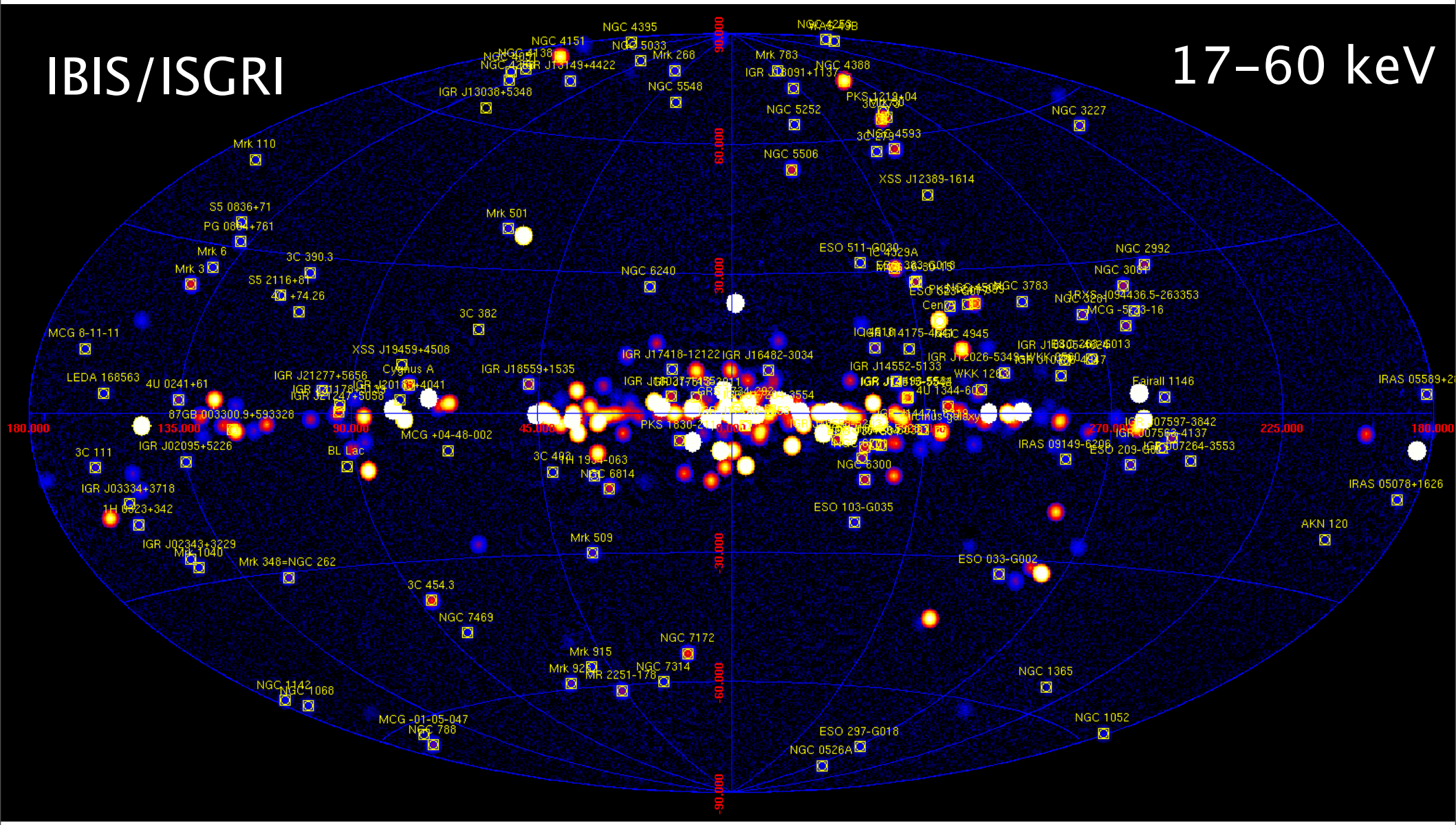
Chandra Deep Field-North

~90% of the CXB below 2 keV is resolved

INTEGRAL Cen-Shapley region

~3% of the CXB at 17-60 keV is resolved

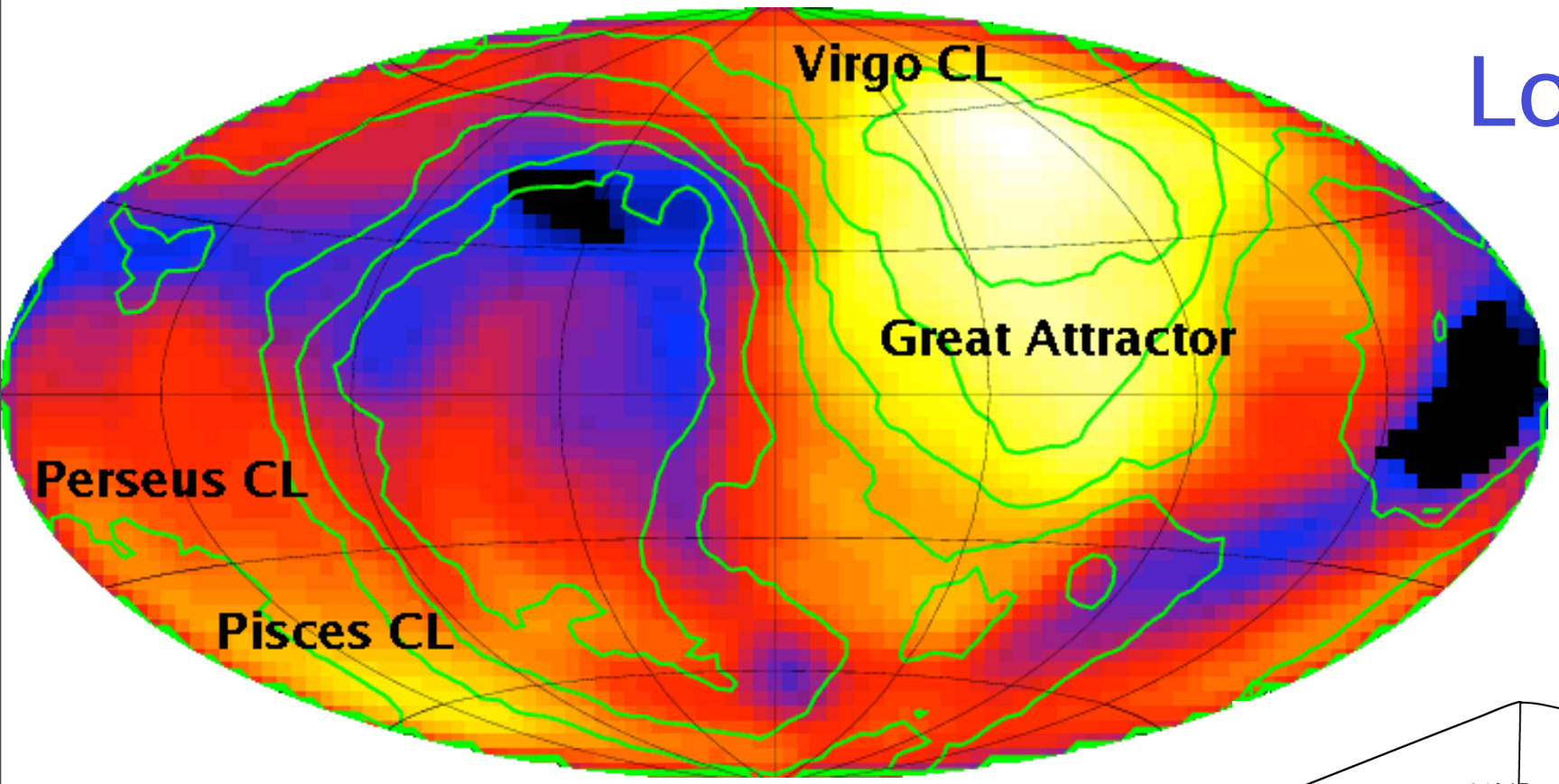
INTEGRAL All-Sky Survey



As of August 2006
>400 sources

Krivonos et al. 2007, Sazonov et al. 2007

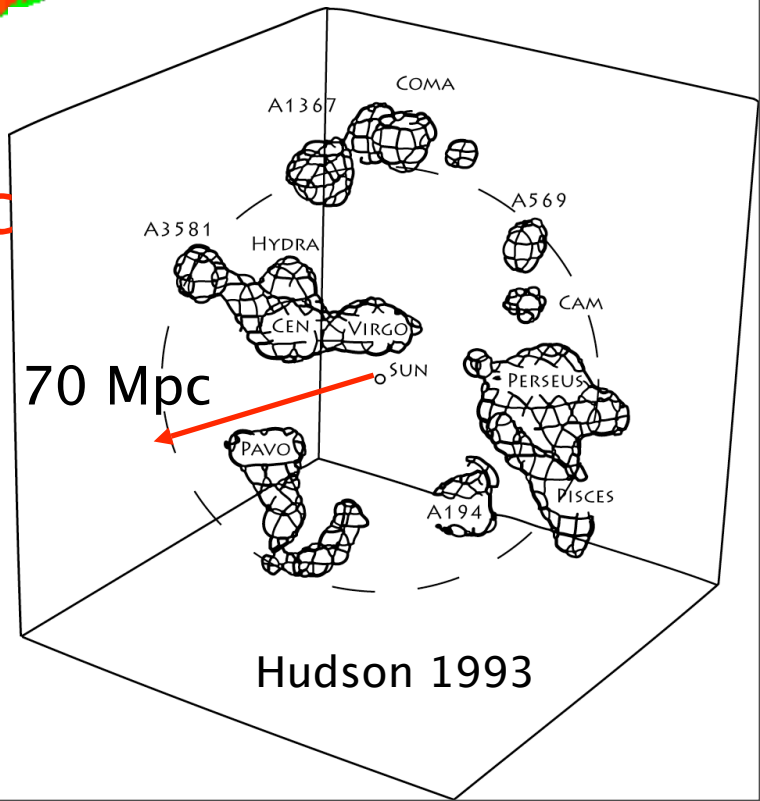
Local LSS

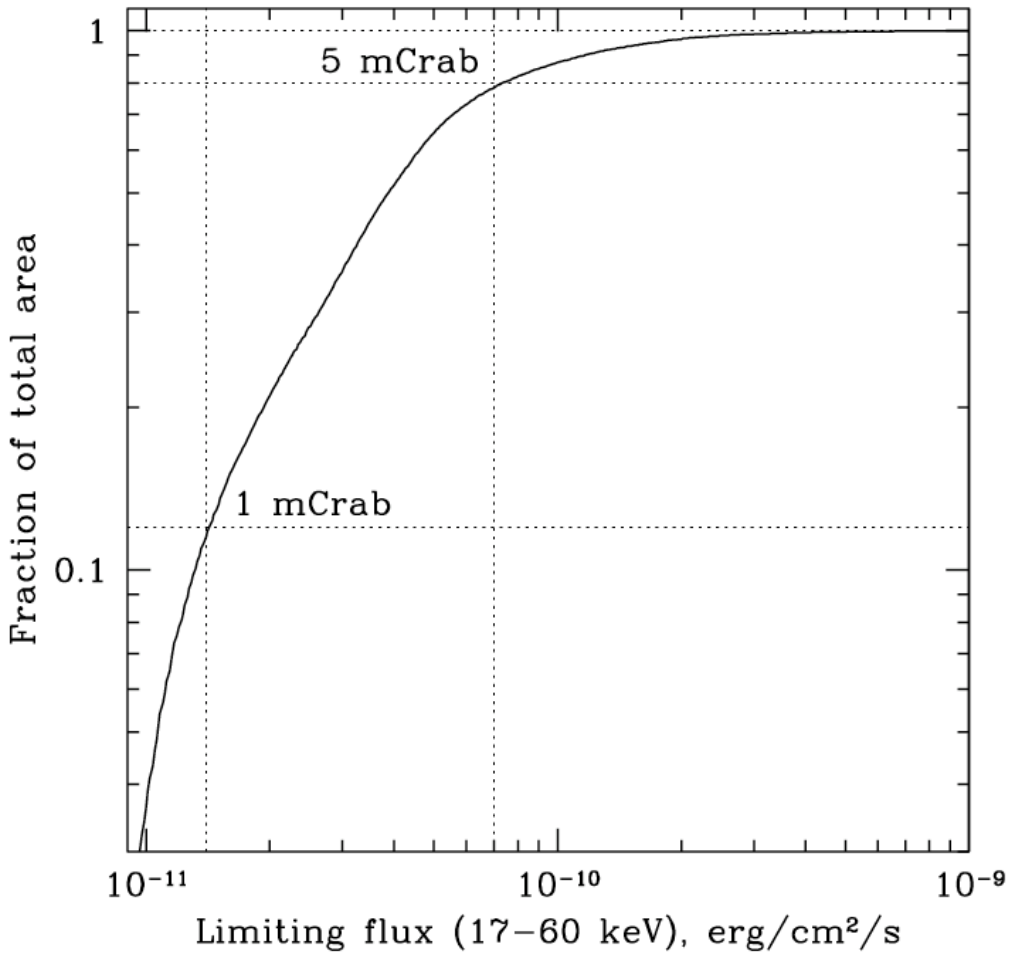


AGN number density within 70 Mpc
(averaged over a 45 deg cone)

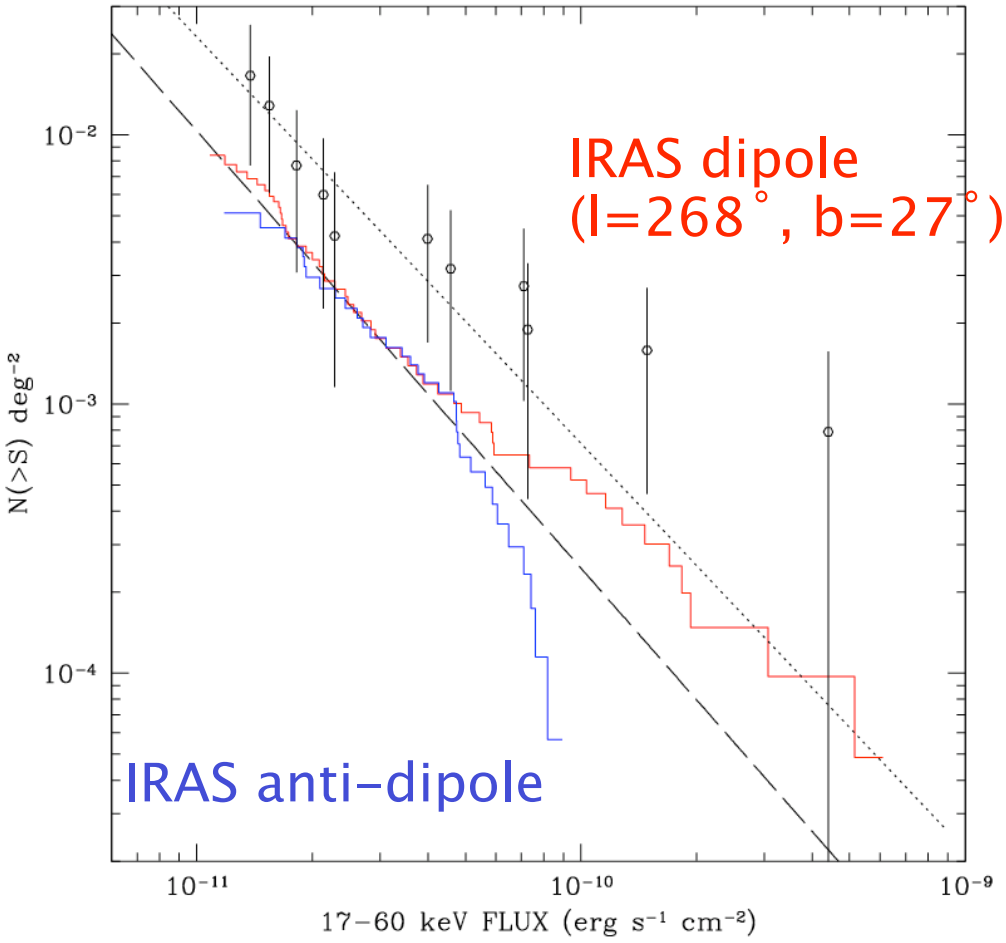
color map – INTEGRAL AGN

contours– IRAS PSCz galaxies





AGN counts



80% of the sky: <5 mCrab

12% of the sky: <1 mCrab

1 mCrab = 1.4 10^{-11} erg/cm²/s

Sensitivity is limited by photon statistics only, except for the GC region

AGN catalog

All sky:

93 AGN (84 Seyferts, 9 blazars) detected on average map

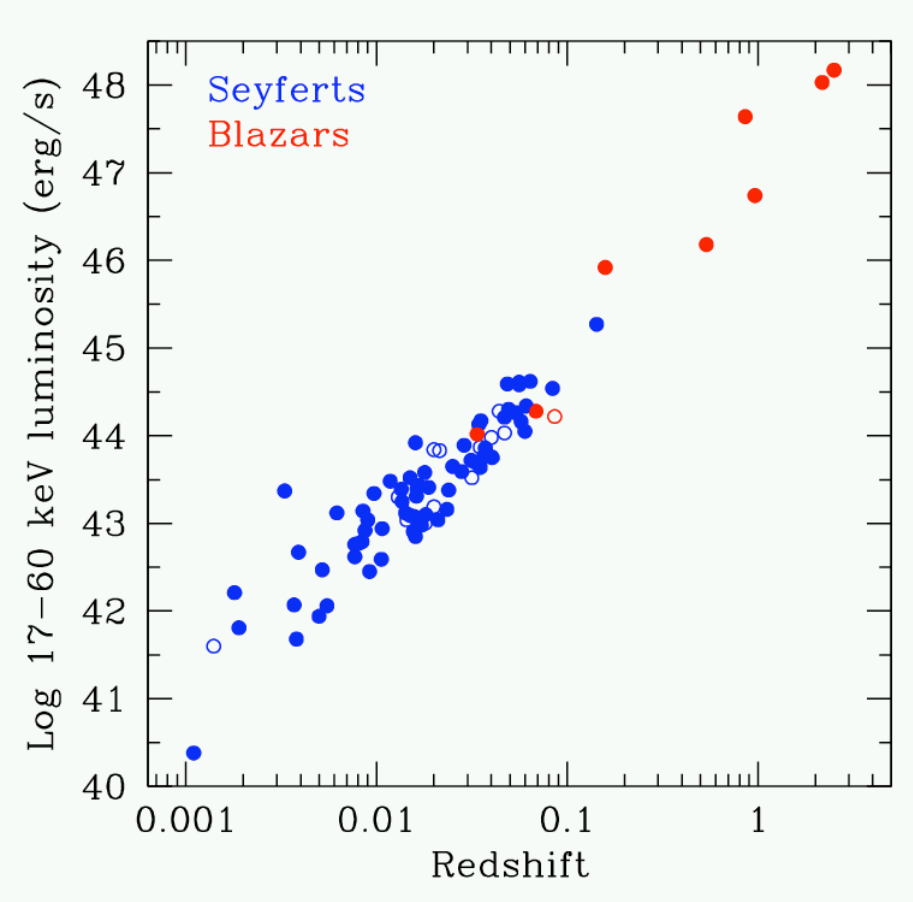
+37 AGN detected in single observations

+40 unidentified sources

|b|>5°:

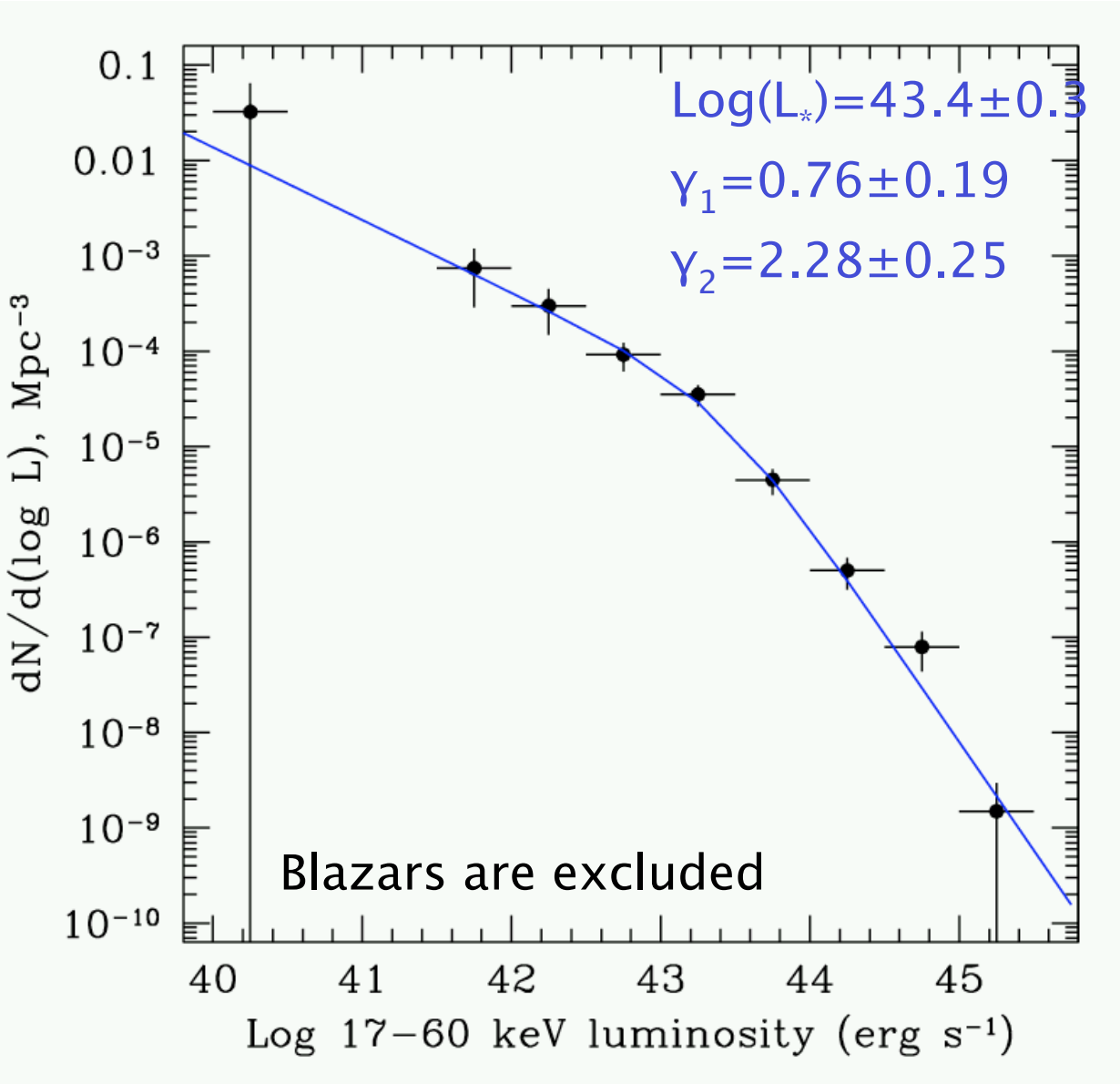
74 AGN (68 Seyferts, 8 blazars) detected on average map

+ 7 unidentified sources



The non-blazar sample is local (z<0.1)

Hard X-ray luminosity function



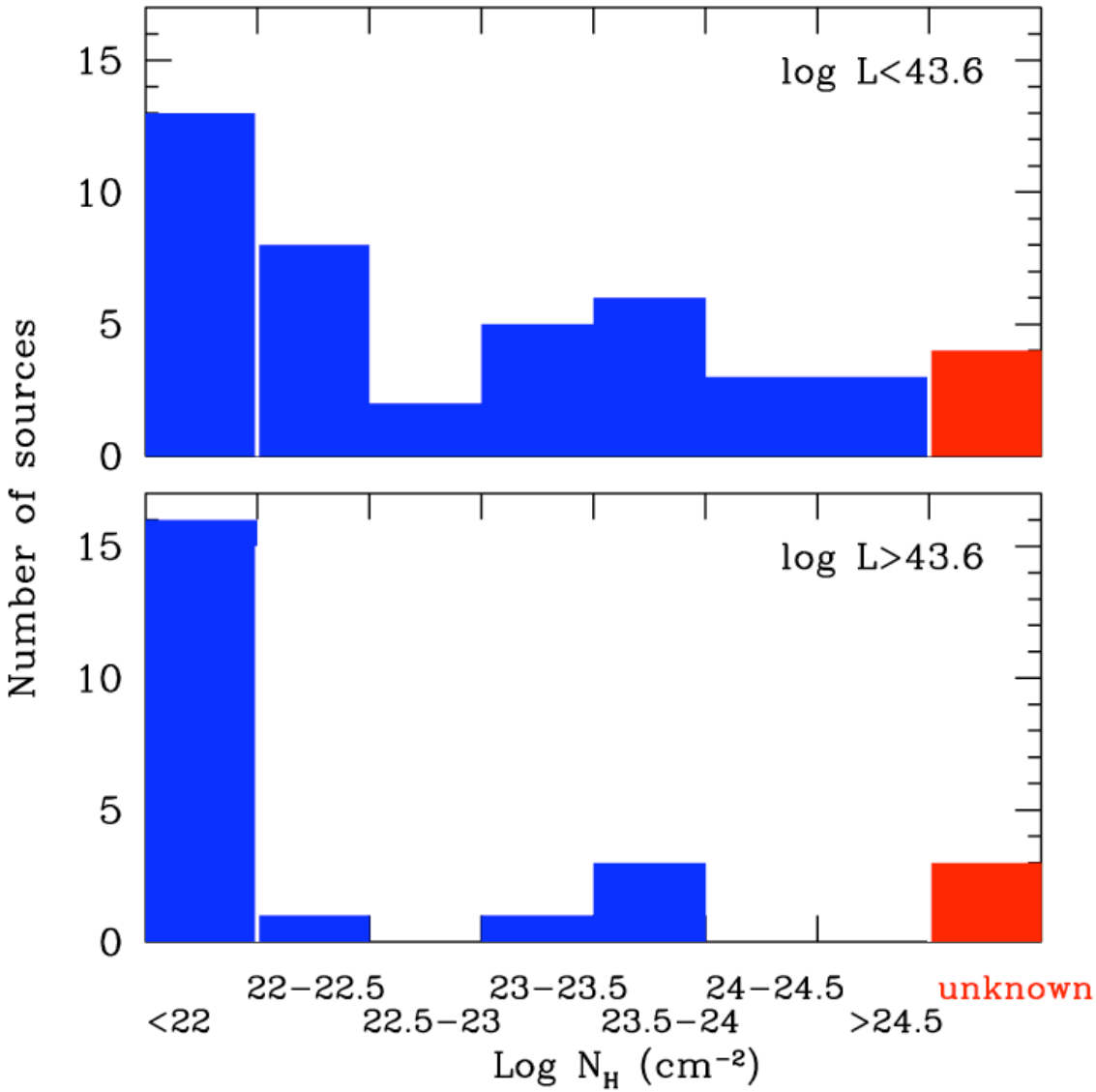
AGN number density:

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

AGN luminosity density:

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

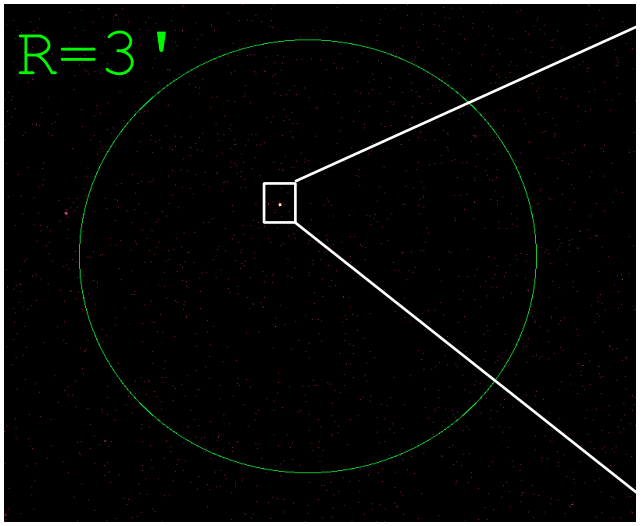
Distribution of absorption column densities

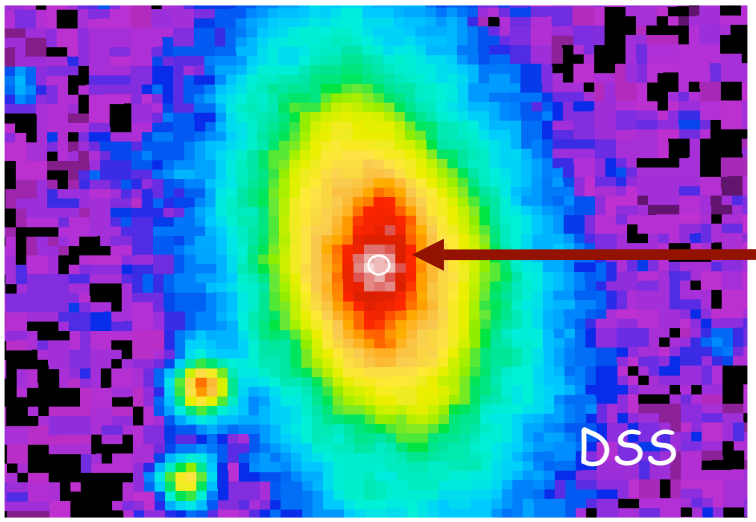


- Fraction of absorbed AGN
  drops from 65–70% at low
  L to 20–30% at high L

- Only 15–20% are Compton
  thick – all at low L

No selection bias!





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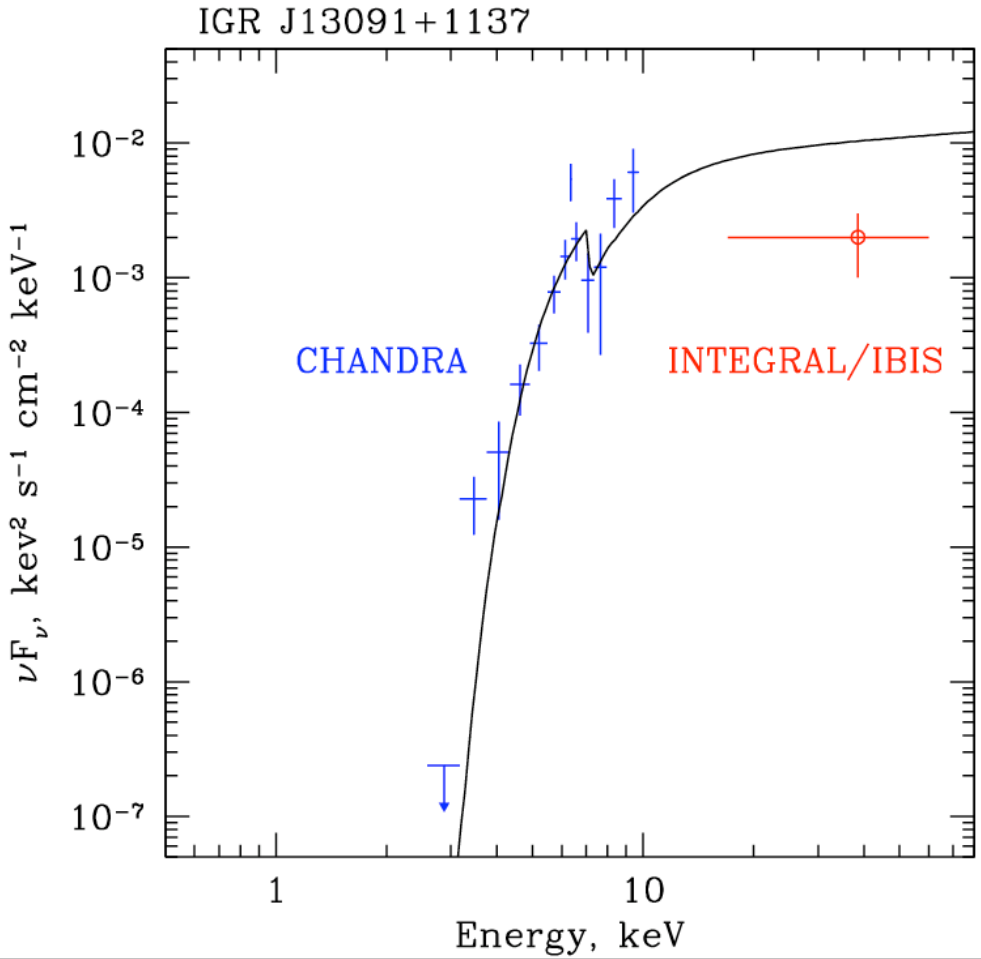
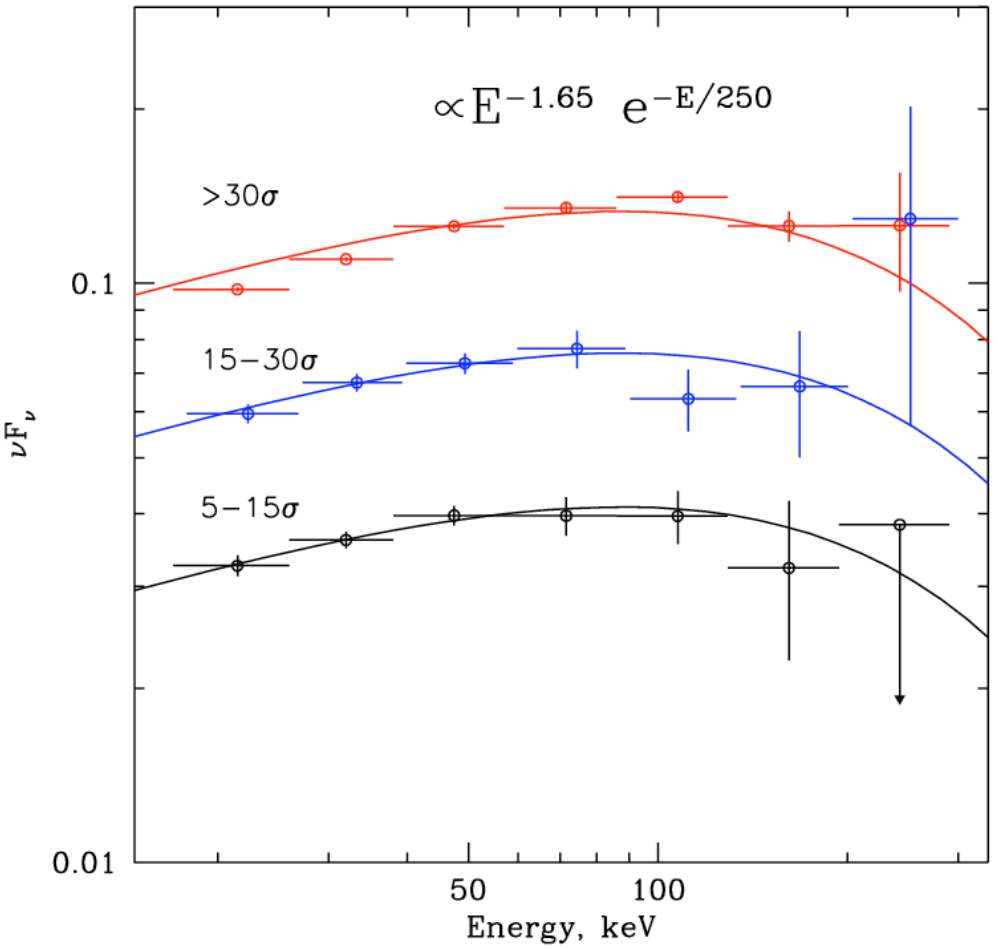
IGR J13091+1137 = NGC 4992

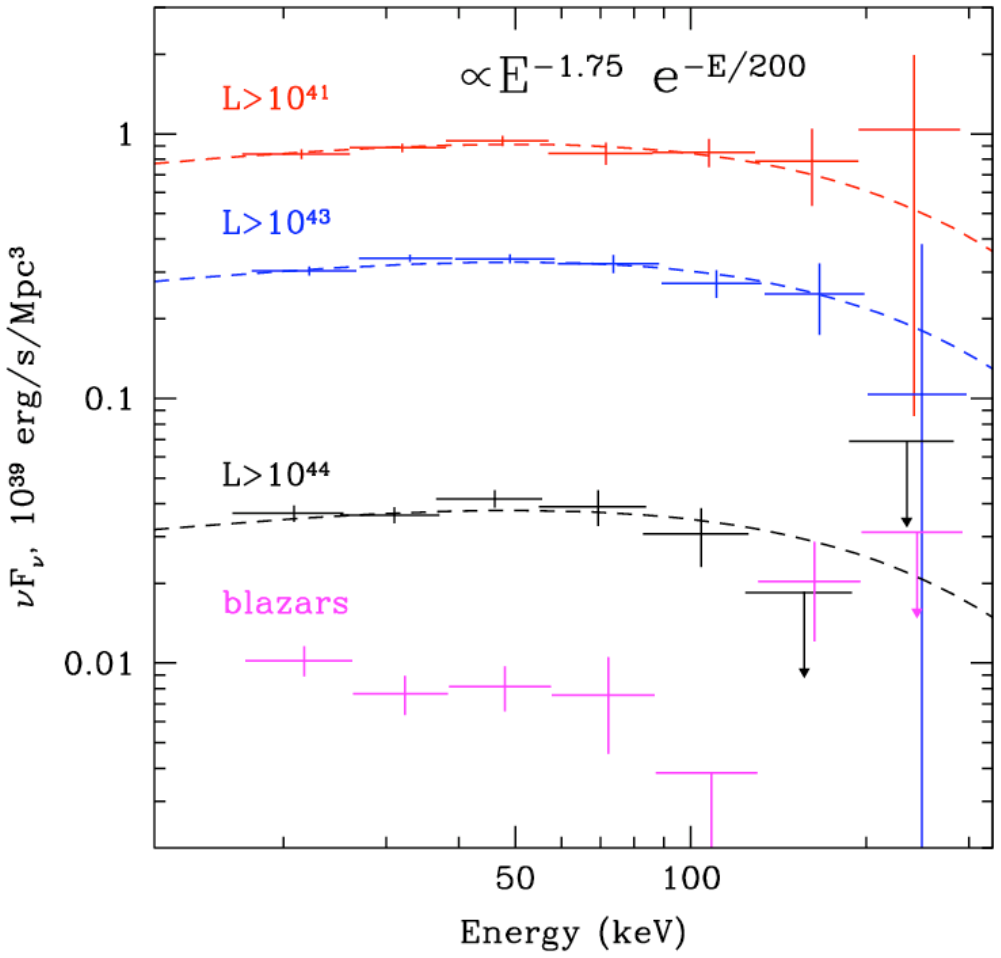
z=0.0251



$N_H=(9\pm1)\ 10^{23}\ cm^{-2}$

Average hard X-ray spectra of local AGN

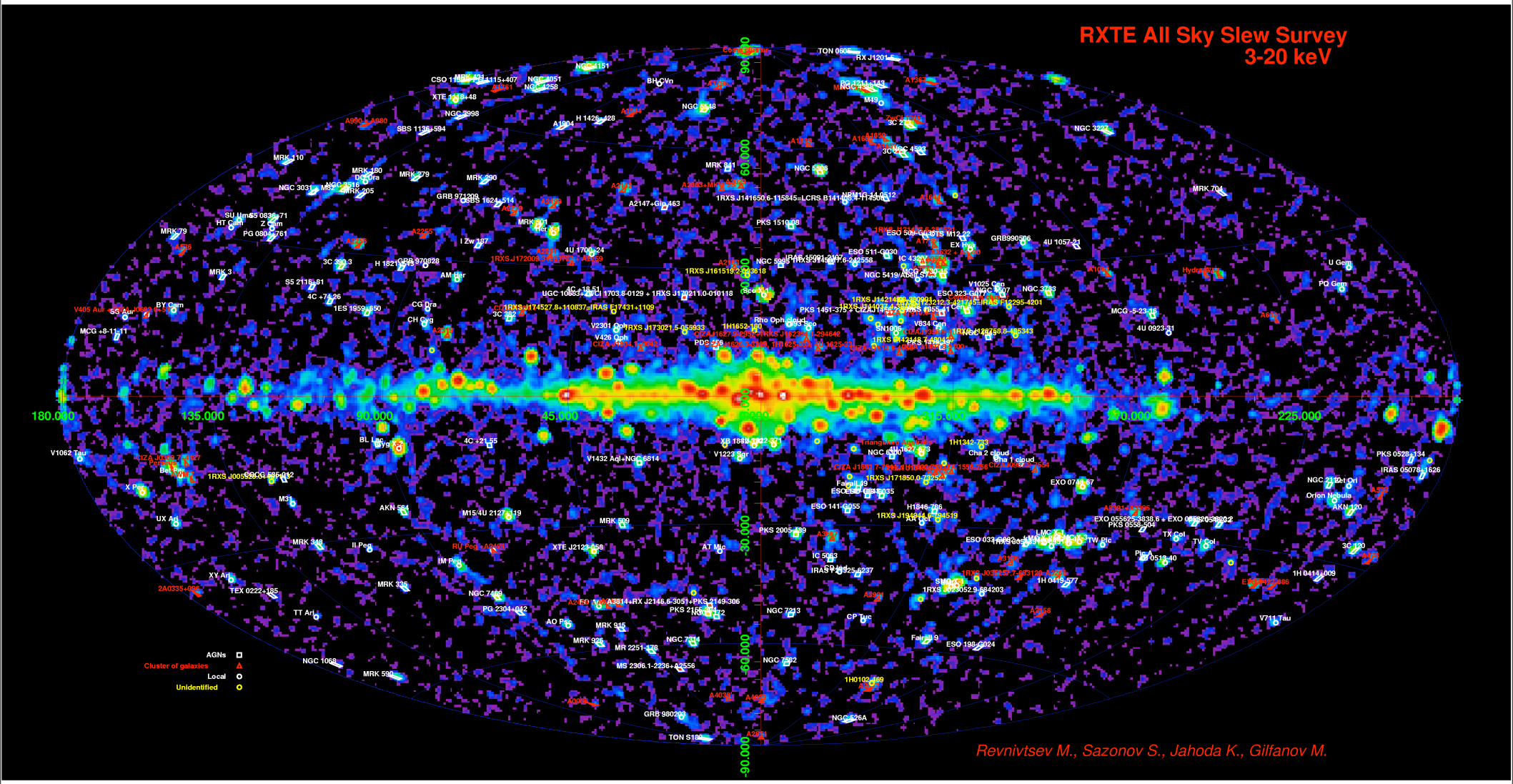




$S=\Sigma f_i$

$S=\Sigma L_i / V_{max,i}$

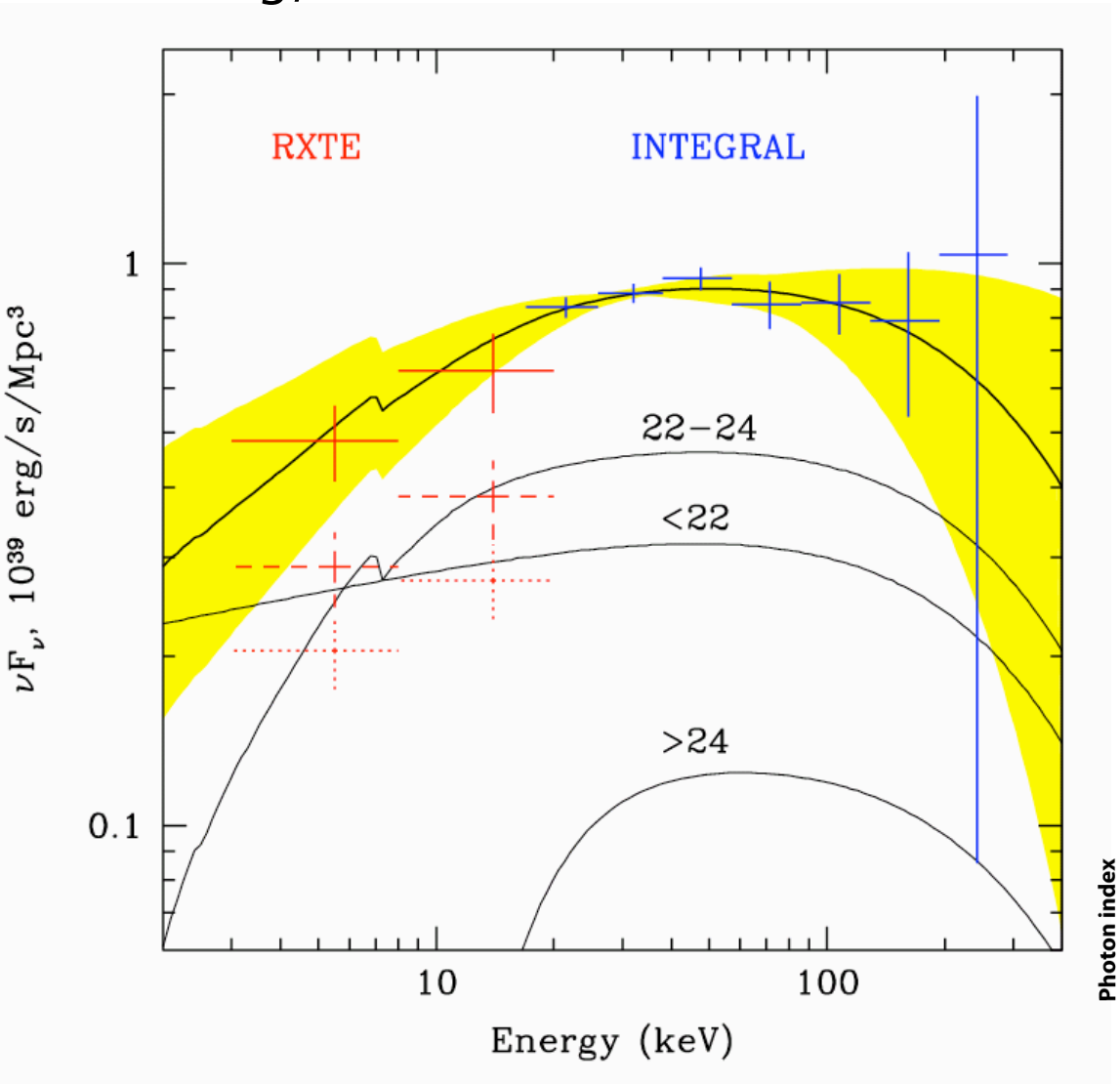
RXTE 3–20 keV Slew Survey



294 sources at $|b|>10^\circ$, including 103 AGN and 16 unidentified

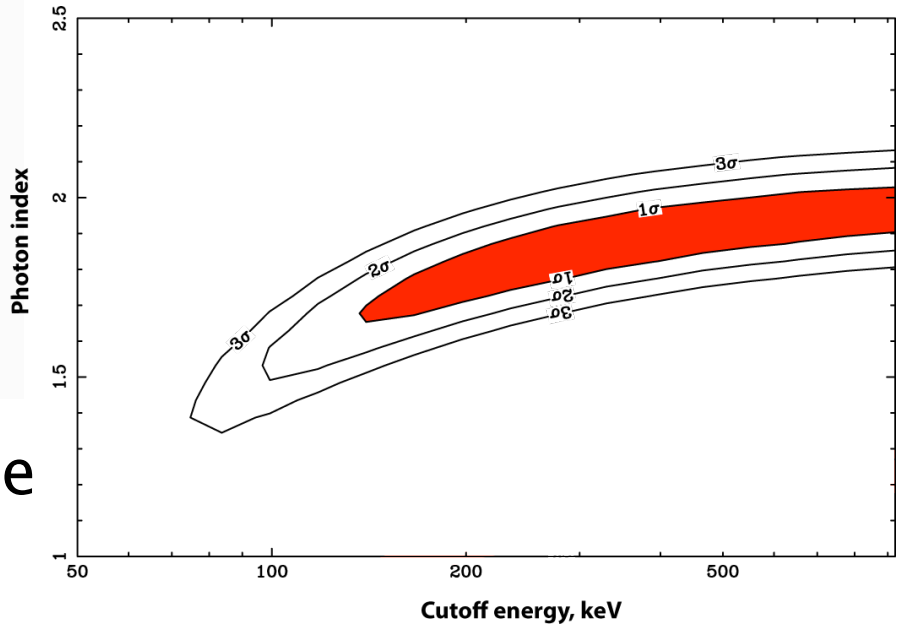
Revnivtsev et al. 2004;
Sazonov, Revnivtsev 2004

$L > 10^{41}$ erg/s



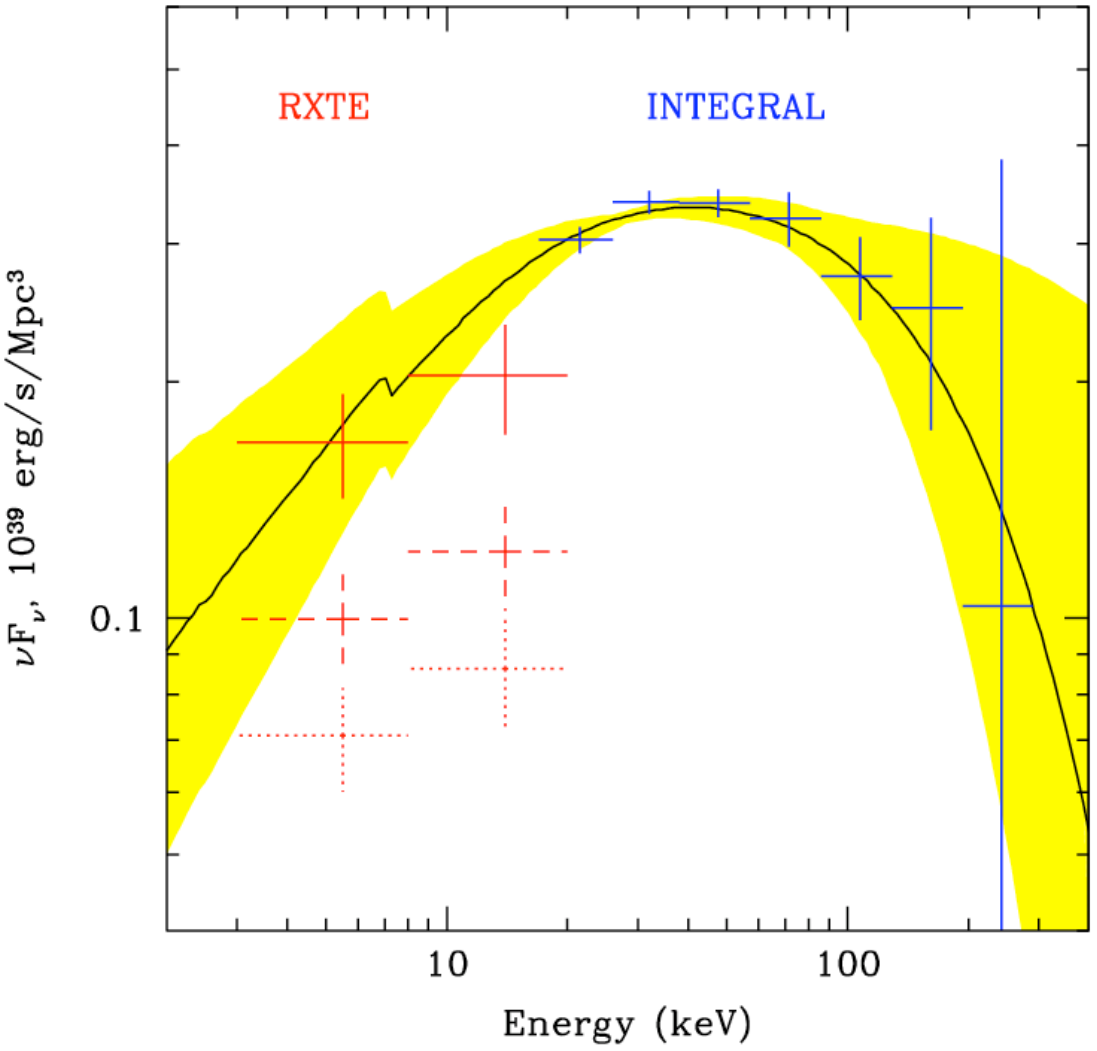
Model:
$f(N_H)\ E^{-\Gamma} \exp(-E/E_{cut})$

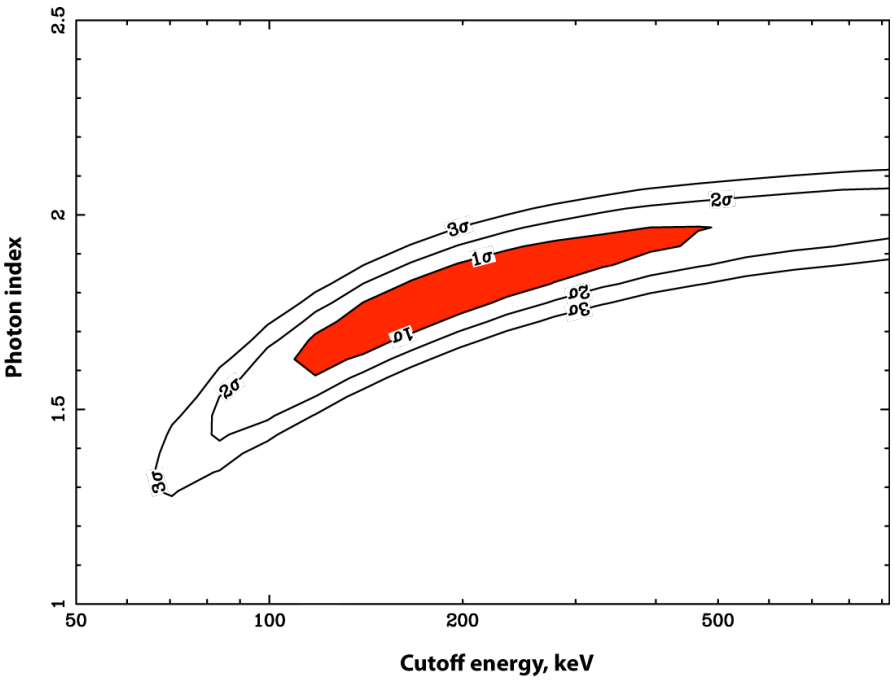
distribution of absorption columns is as measured with INTEGRAL

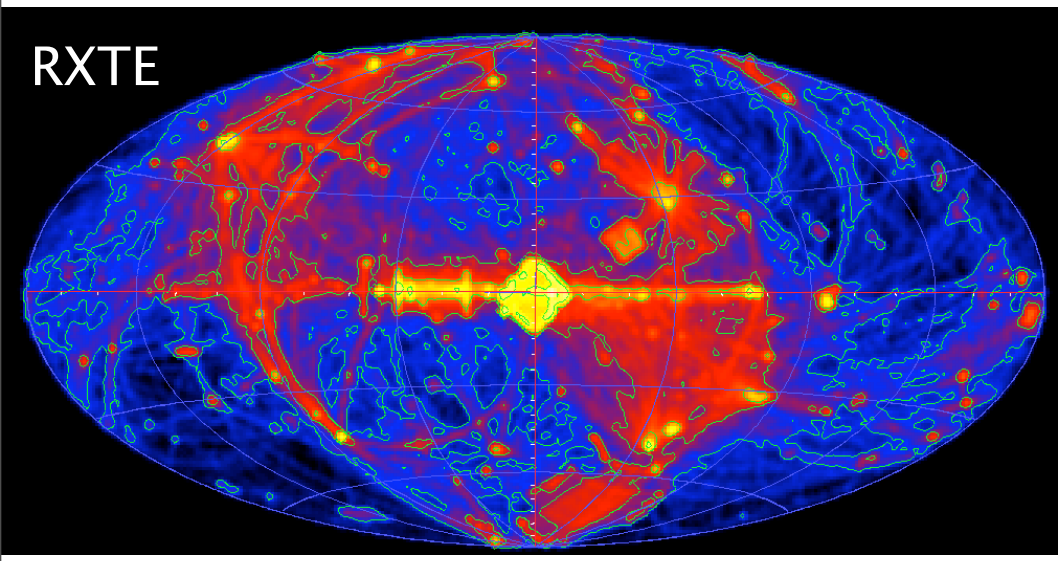


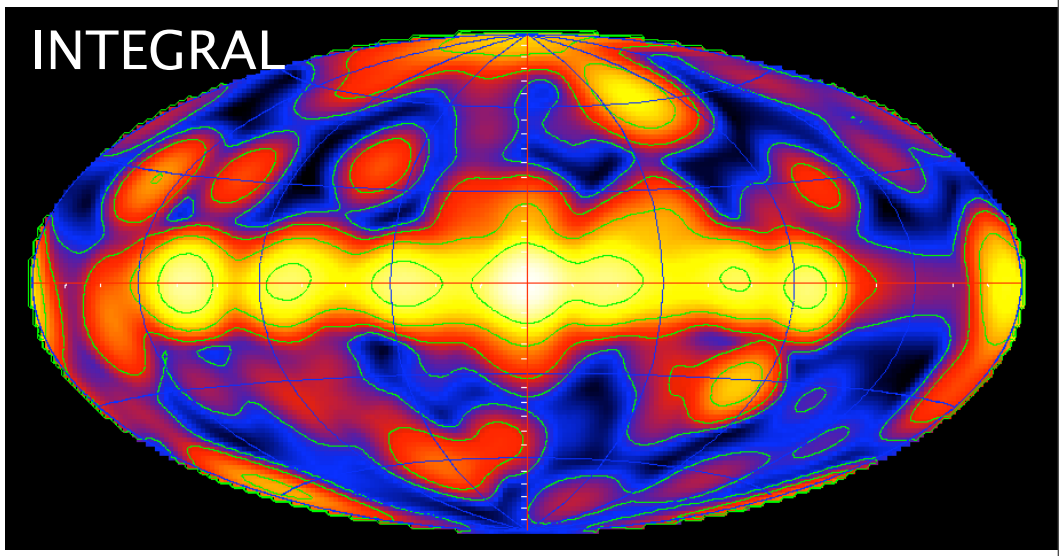
+ normalization uncertainty due finite number of sources ~20% for each sample

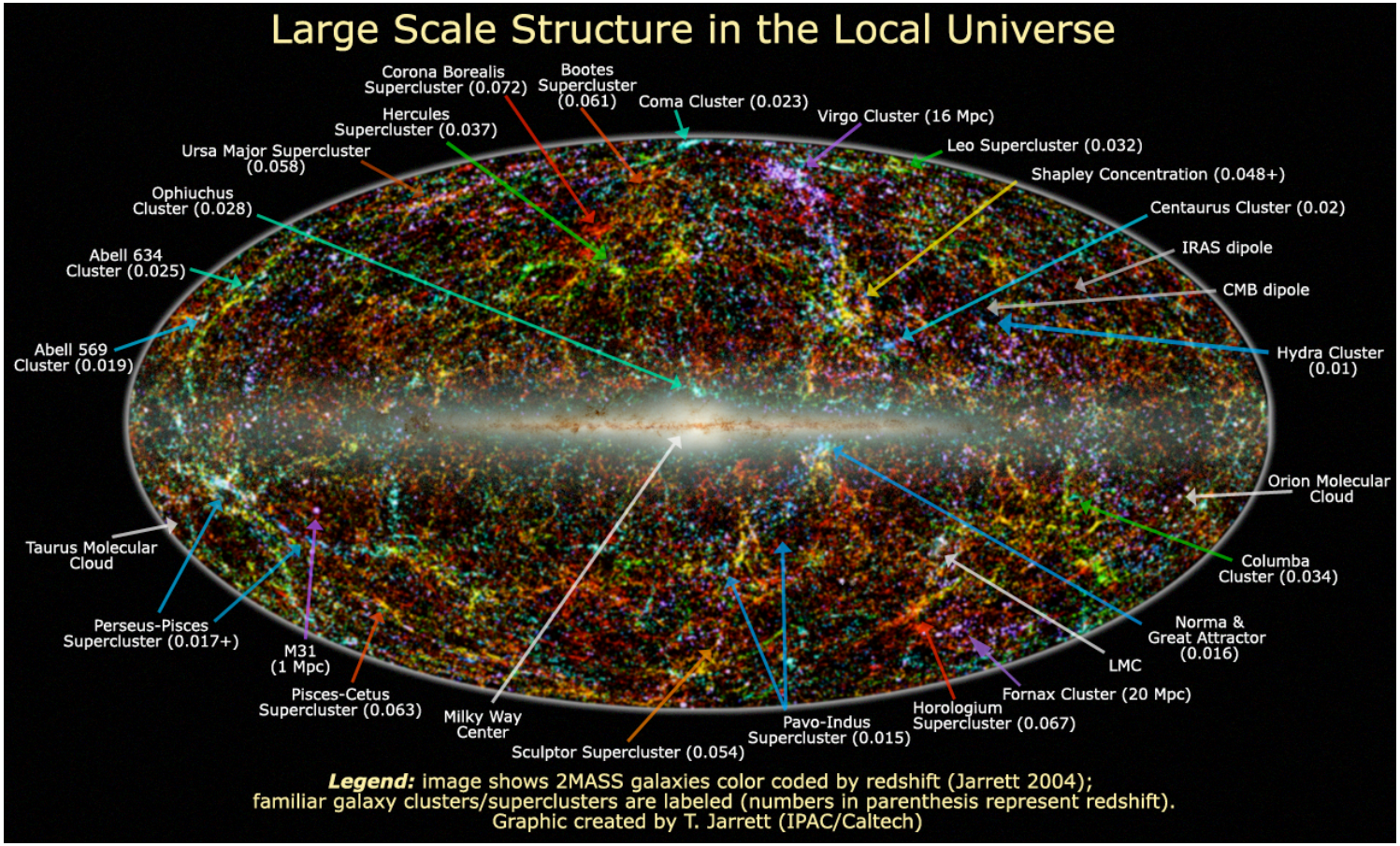
$L > 10^{43}$ erg/s


RXTE
INTEGRAL
νF_ν, 10^{39} erg/s/Mpc^3
0.1
10
100
Energy (keV)

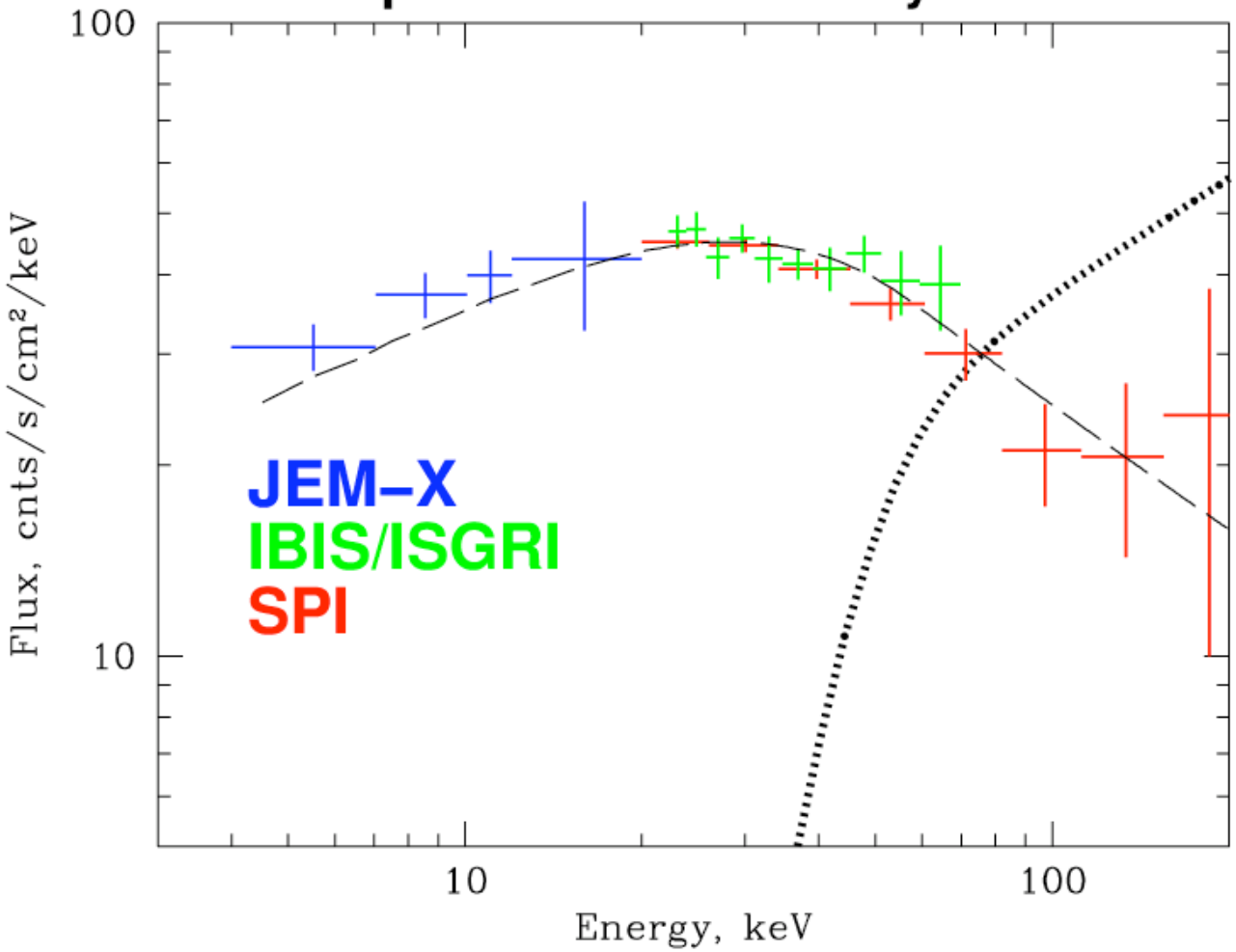

Photon index
2.5
2
1.5
1
50
100
200
500
Cutoff energy, keV
1σ
2σ
3σ

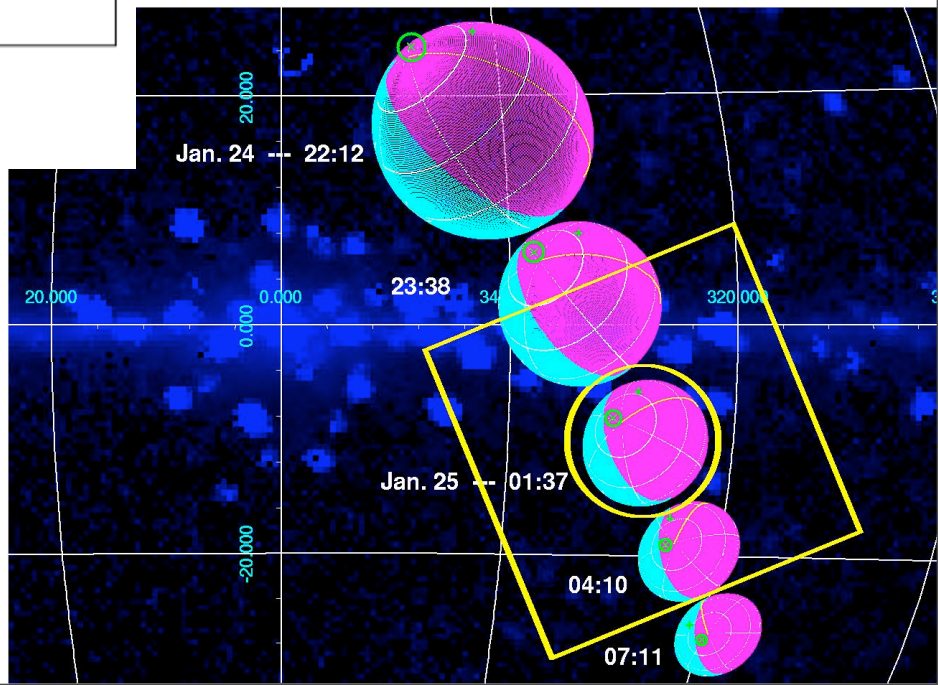

RXTE


INTEGRAL

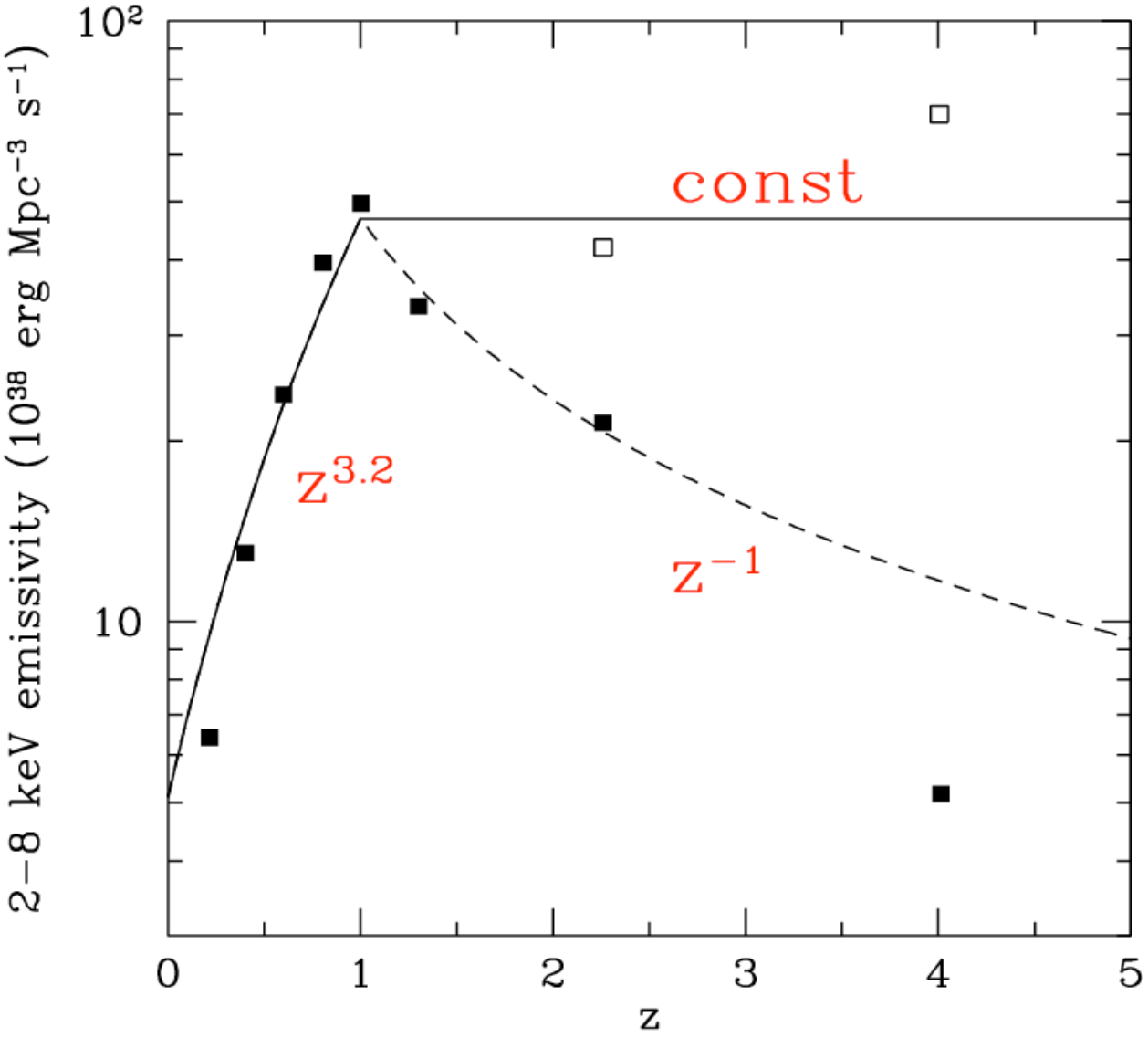

Large Scale Structure in the Local Universe
Corona Borealis Supercluster (0.072)
Bootes Supercluster (0.061)
Coma Cluster (0.023)
Virgo Cluster (16 Mpc)
Hercules Supercluster (0.037)
Ursa Major Supercluster (0.058)
Leo Supercluster (0.032)
Shapley Concentration (0.048+)
Ophiuchus Cluster (0.028)
Centaurus Cluster (0.02)
Abell 634 Cluster (0.025)
IRAS dipole
CMB dipole
Abell 569 Cluster (0.019)
Hydra Cluster (0.01)
Orion Molecular Cloud
Taurus Molecular Cloud
Columba Cluster (0.034)
Perseus-Pisces Supercluster (0.017+)
Norma & Great Attractor (0.016)
M31 (1 Mpc)
LMC
Pisces-Cetus Supercluster (0.063)
Fornax Cluster (20 Mpc)
Milky Way Center
Horologium Supercluster (0.067)
Pavo-Indus Supercluster (0.015)
Sculptor Supercluster (0.054)
Legend: image shows 2MASS galaxies color coded by redshift (Jarrett 2004);
familiar galaxy clusters/superclusters are labeled (numbers in parenthesis represent redshift).
Graphic created by T. Jarrett (IPAC/Caltech)

CXB spectrum measured by INTEGRAL





Redshift evolution of AGN X-ray luminosity density



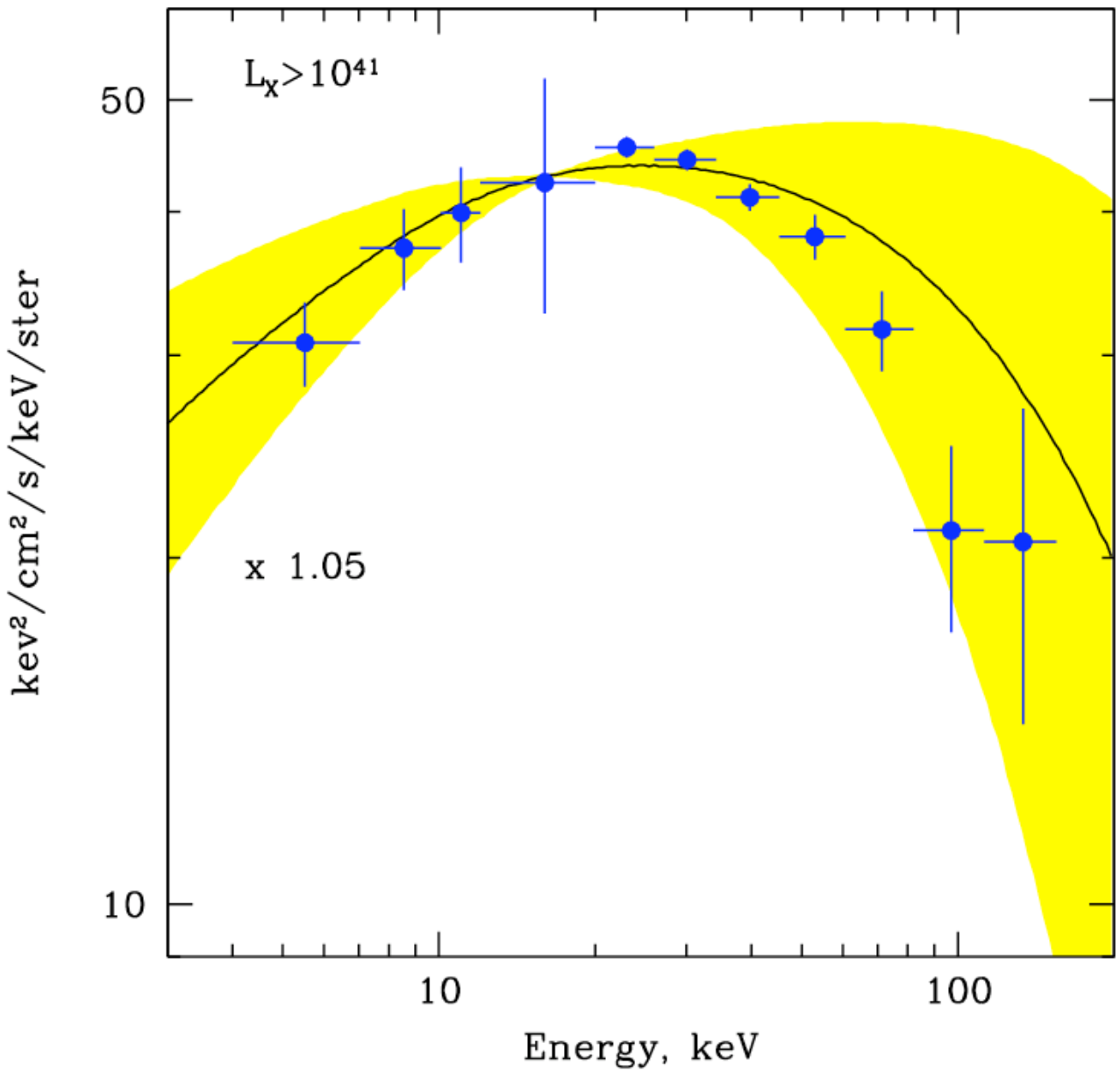
CHANDRA

Barger et al. 2005

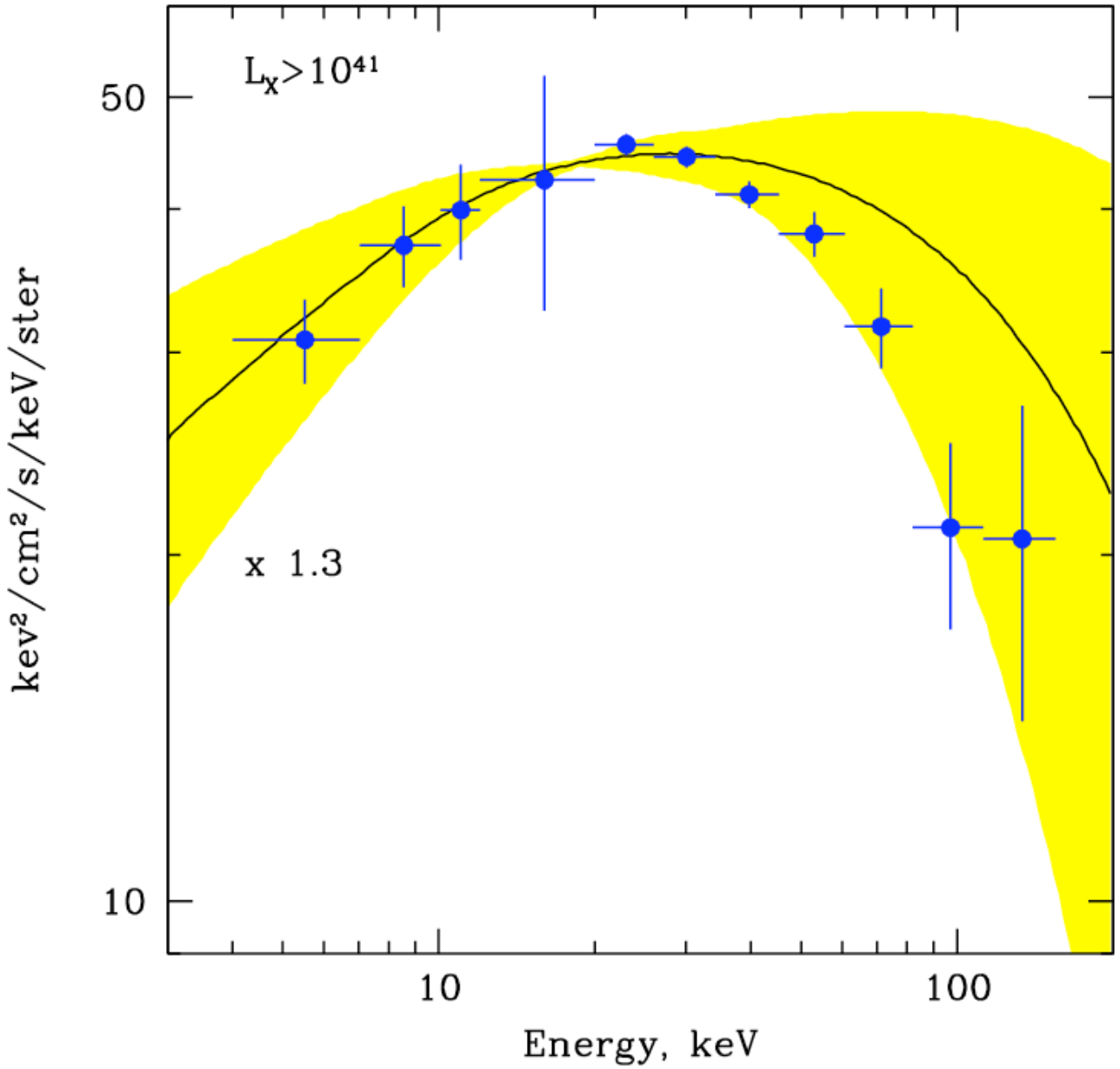
see also Ueda et al., Hasinger et al…

A typical quasar contributing to the CXB is at <z> ~ 1.5

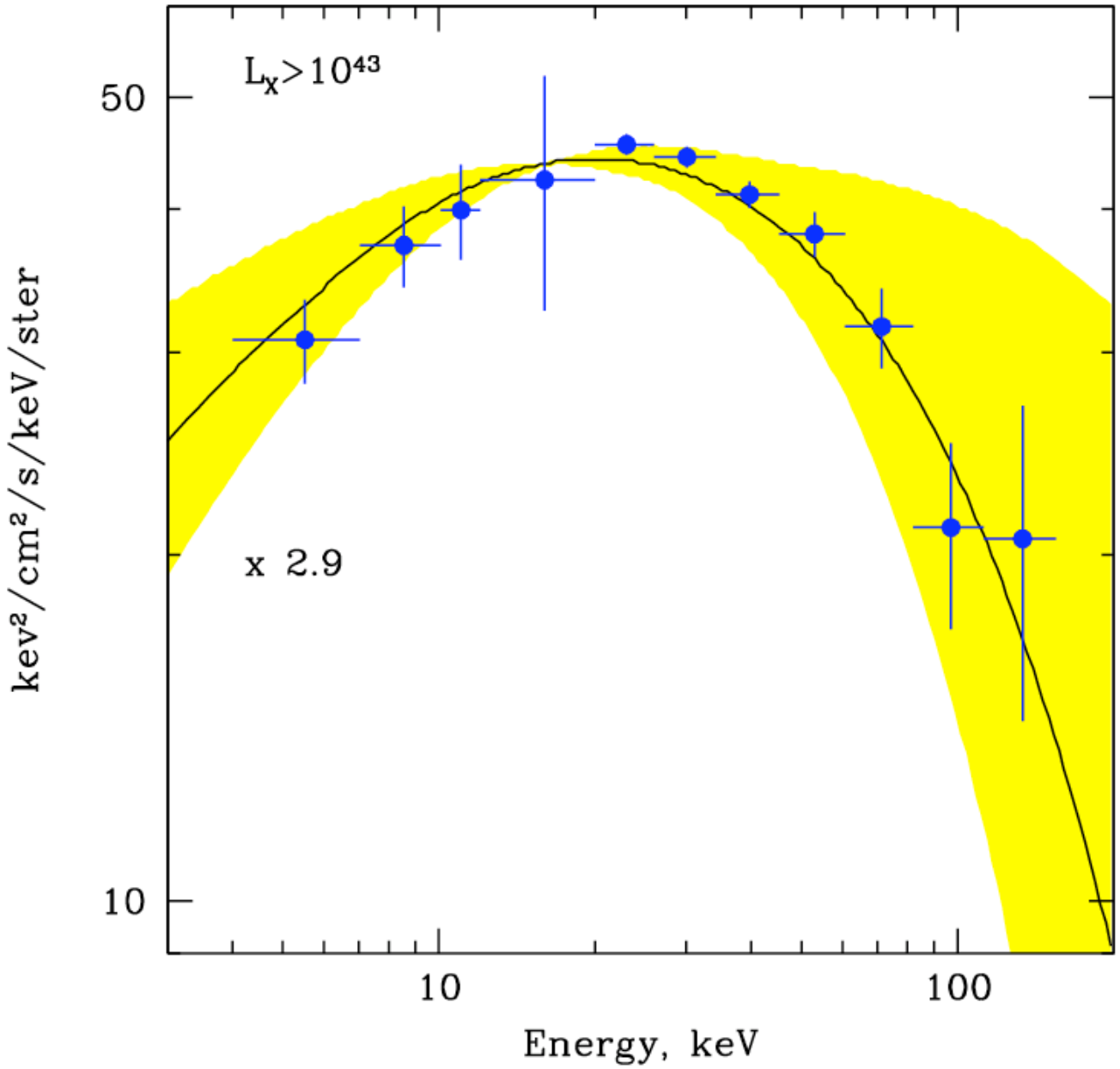
Convolve the average hard X-ray spectrum of local AGN with a redshift dependence of AGN luminosity density



ϵ = const at $z > 1$



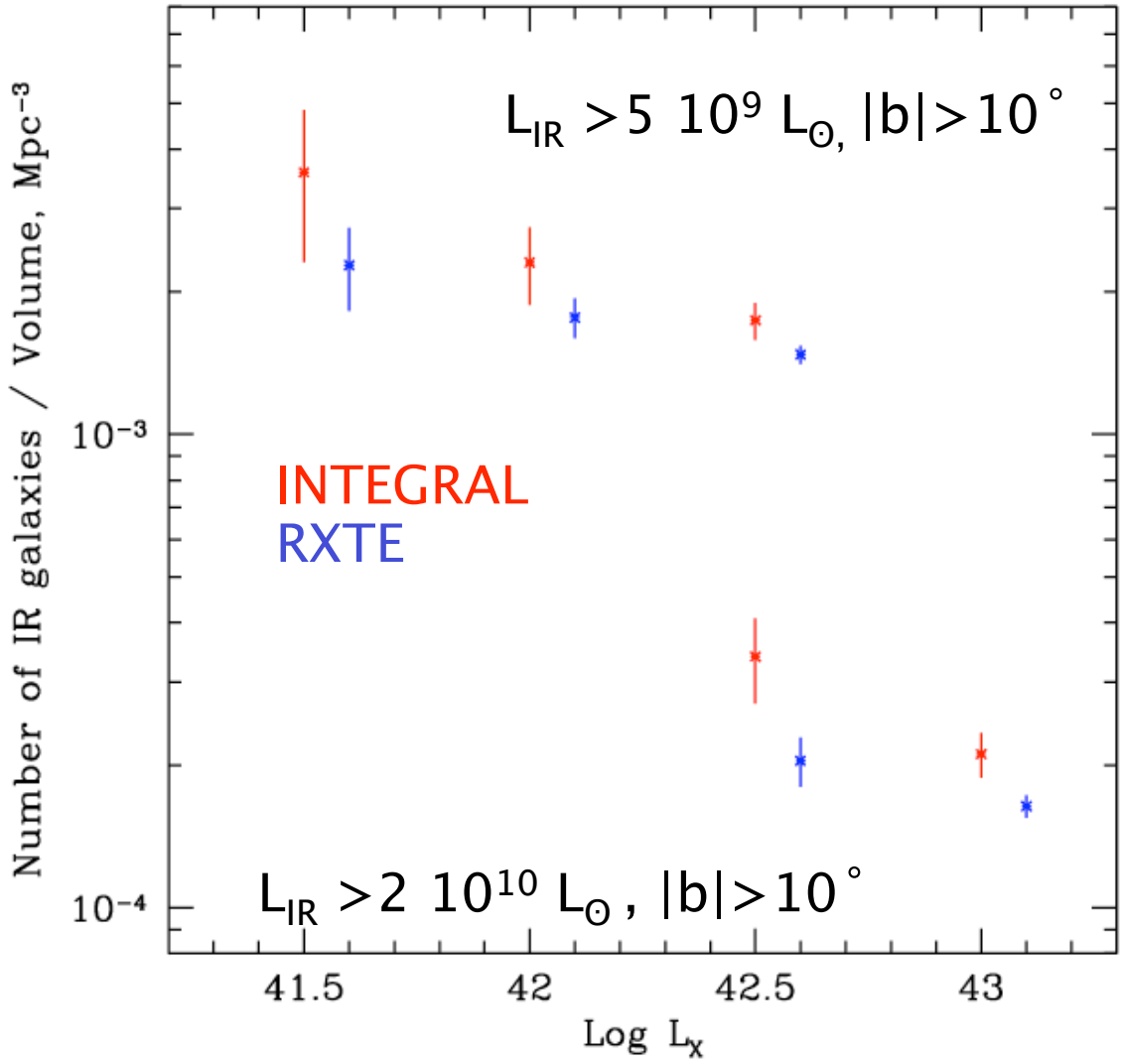
$\epsilon \sim 1/z$ at $z>1$


$L_x > 10^{43}$
x 2.9
50
10
10
100
Energy, keV
kev²/cm²/s/keV/ster

Conclusions

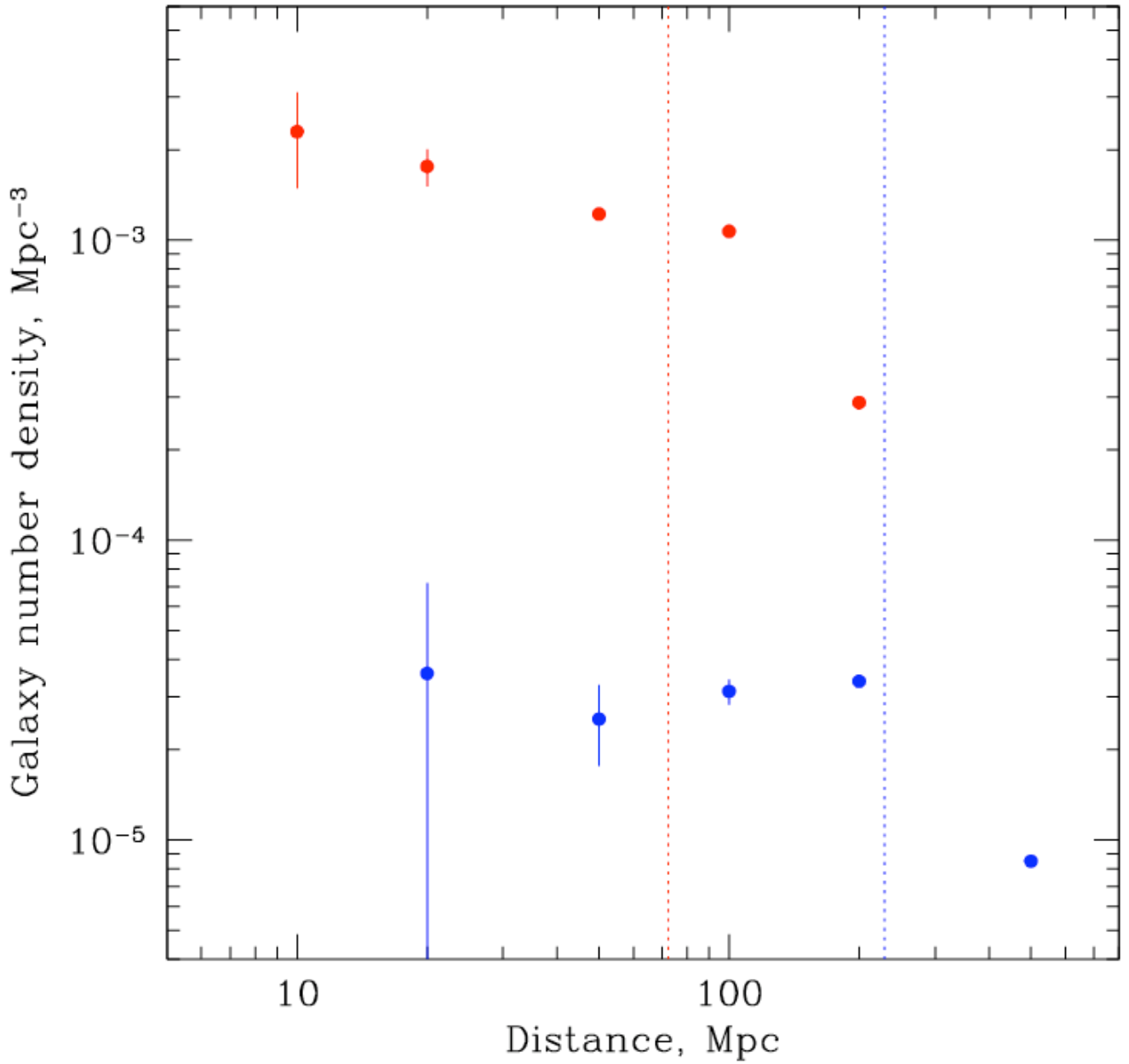
- Ratio of obscured to unabscured AGN drops from 2:1 at low luminosities to 1:3 at high luminosities
- Fraction of Compton-thick AGN is not large (15-20%)
- A possible scenario for the CXB: AGN have undergone downsizing since z ~ 1-1.5 but their spectral properties and N_H distribution have not changed significantly

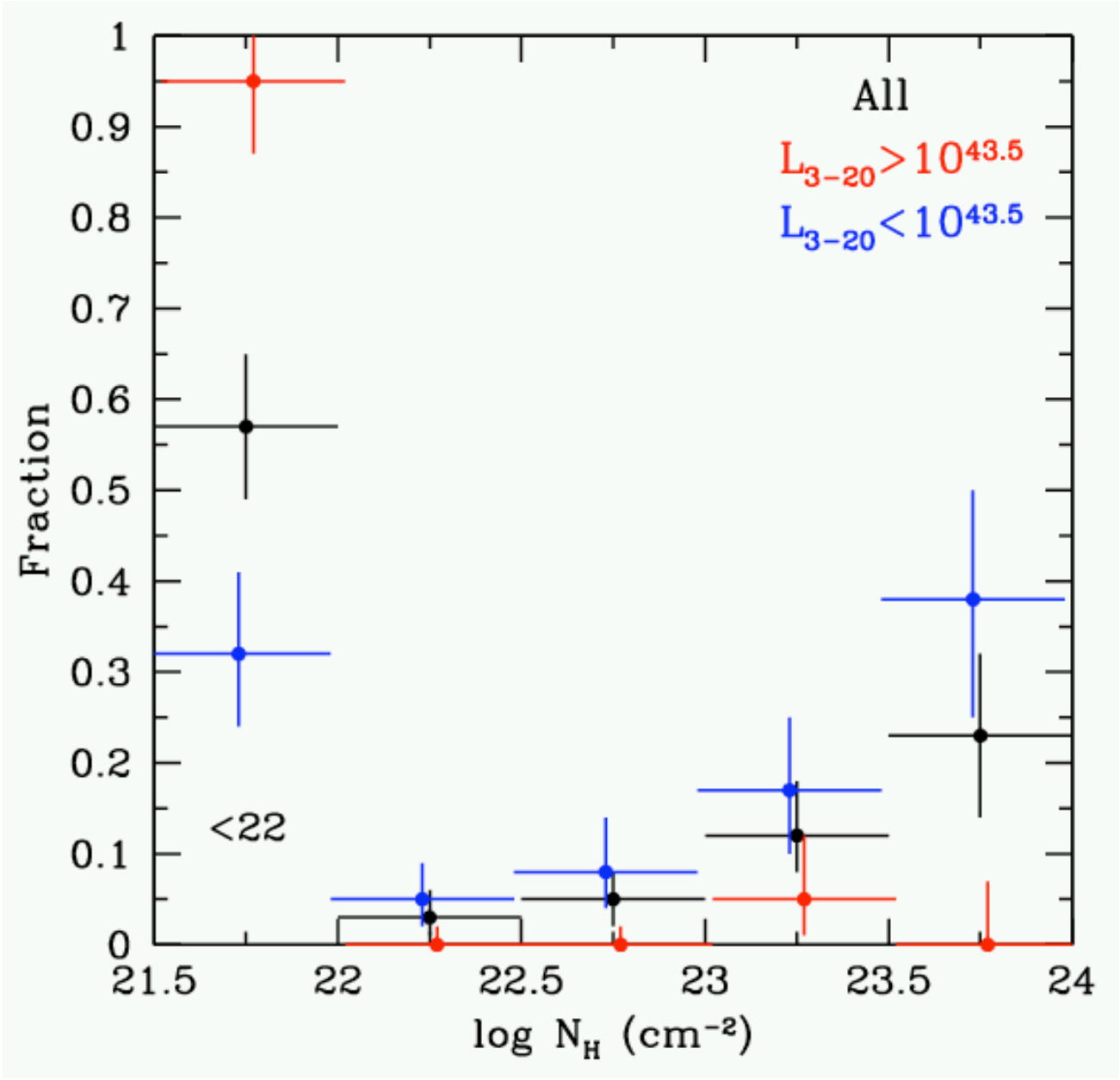
Distribution of exposure over the sky is important!



Average matter density is smaller for RXTE survey by a factor of 1.3–1.5

Based on IRAS PSCz catalog


Galaxy number density, Mpc^{-3}
10^{-3}
10^{-4}
10^{-5}
10
100
Distance, Mpc



RXTE Slew Survey (Sazonov & Revnivtsev 04)