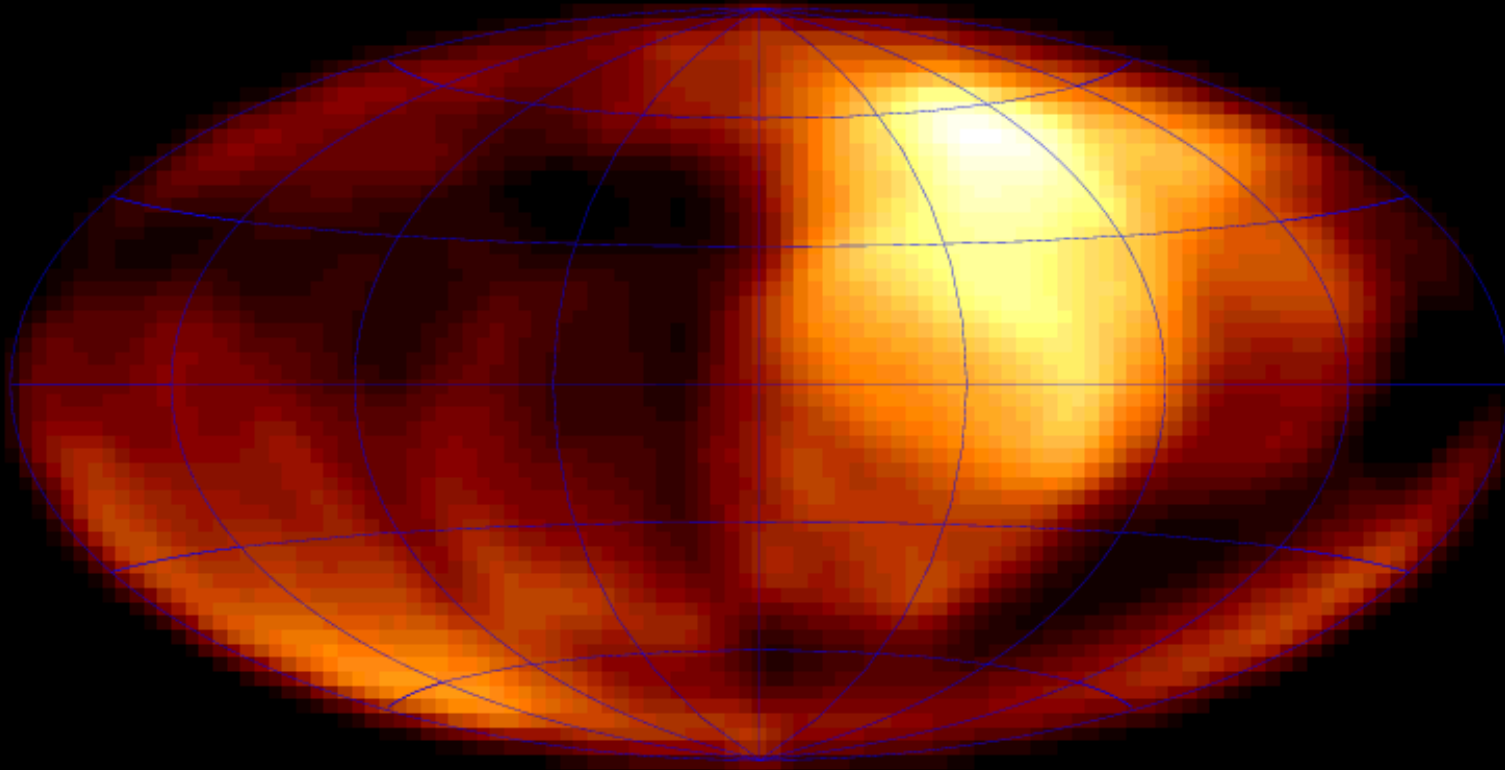


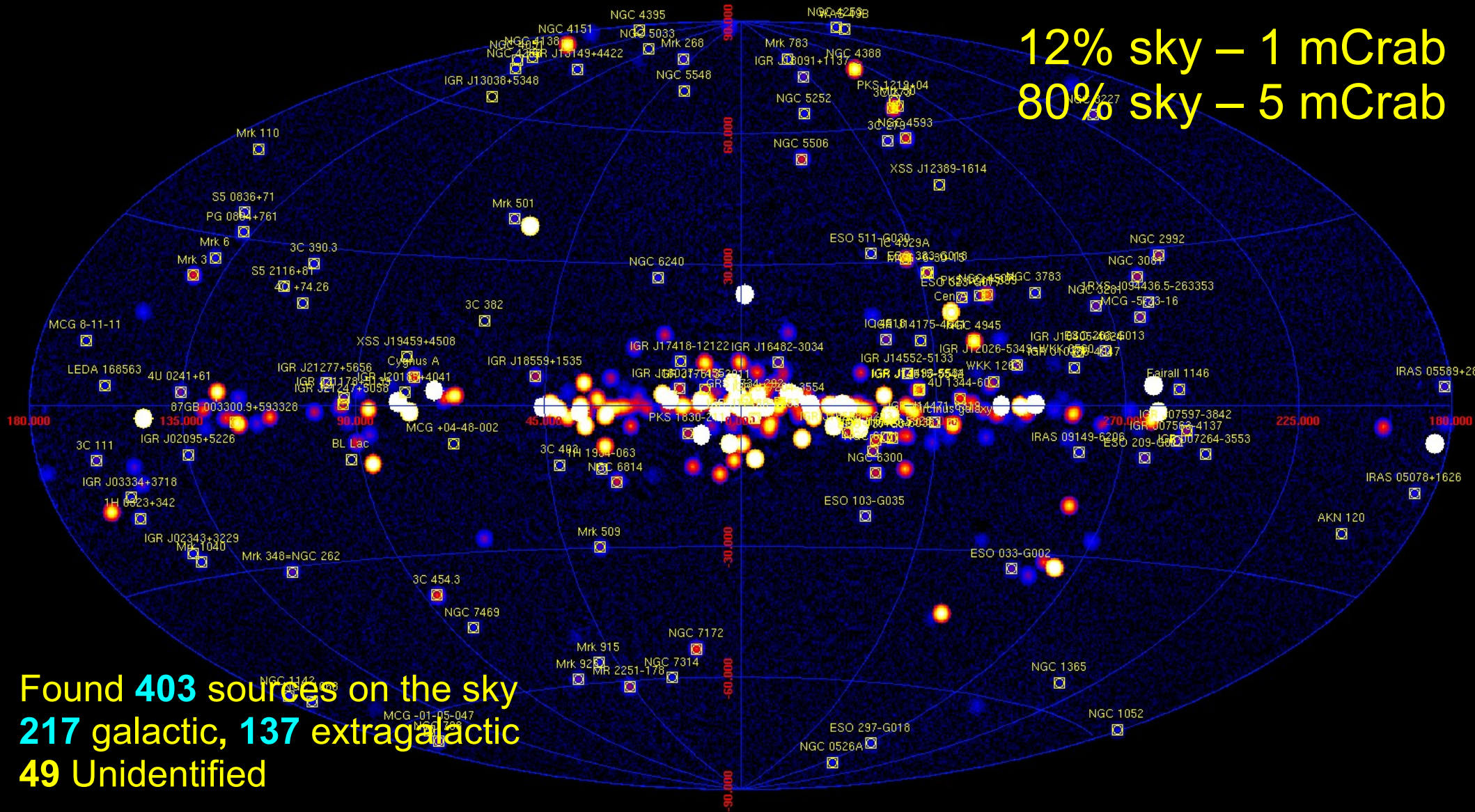
Large Scale Structure of the local Universe with INTEGRAL observatory



**R.Krivosos, M.Revnitsev, A.Lutovinov
S.Sazonov, E.Churazov, R.Sunyaev
IKI, Moscow / MPA, Garching**

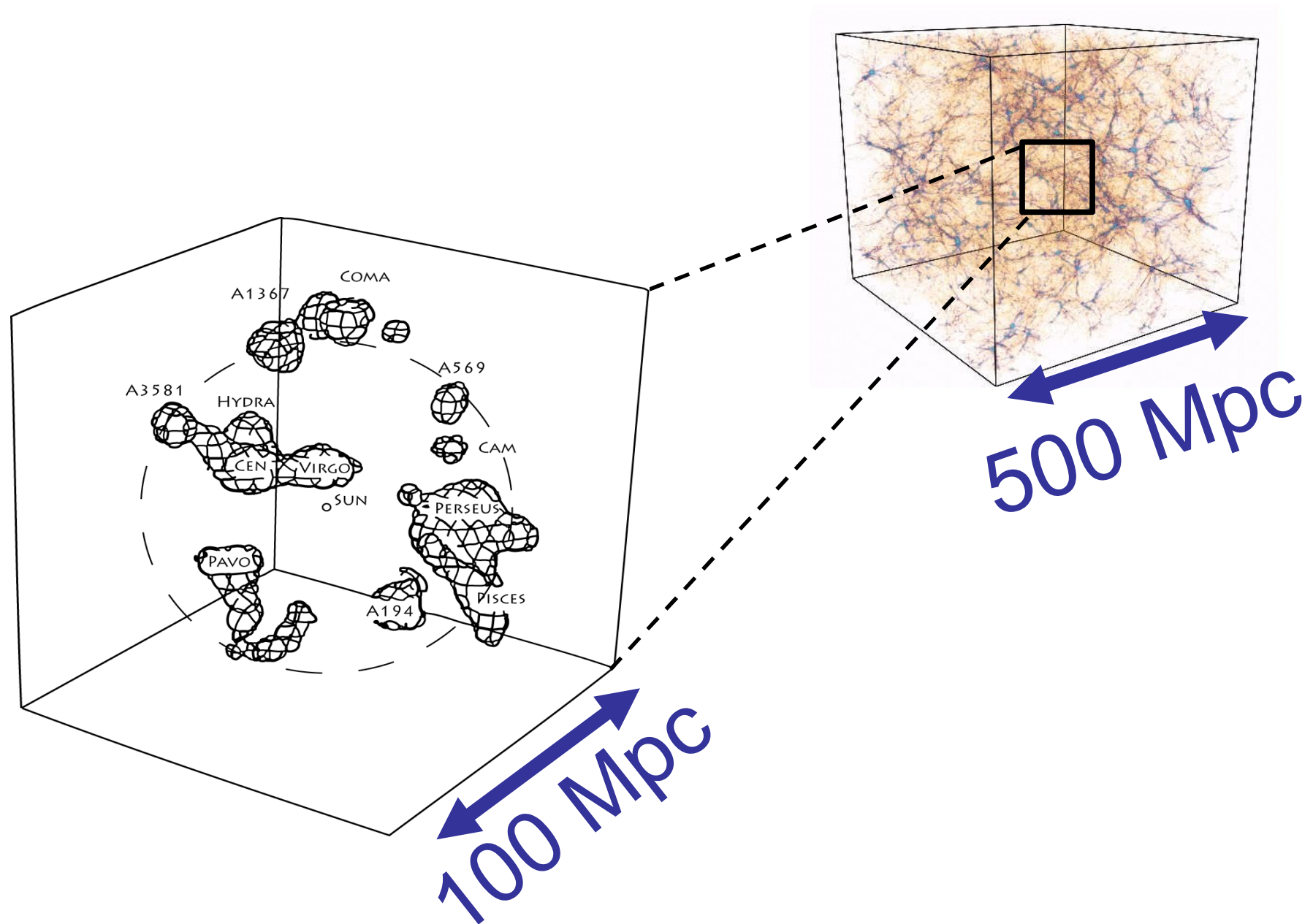
All-sky survey 17-60 keV (Krivonos et al. 2007)

12% sky – 1 mCrab
80% sky – 5 mCrab

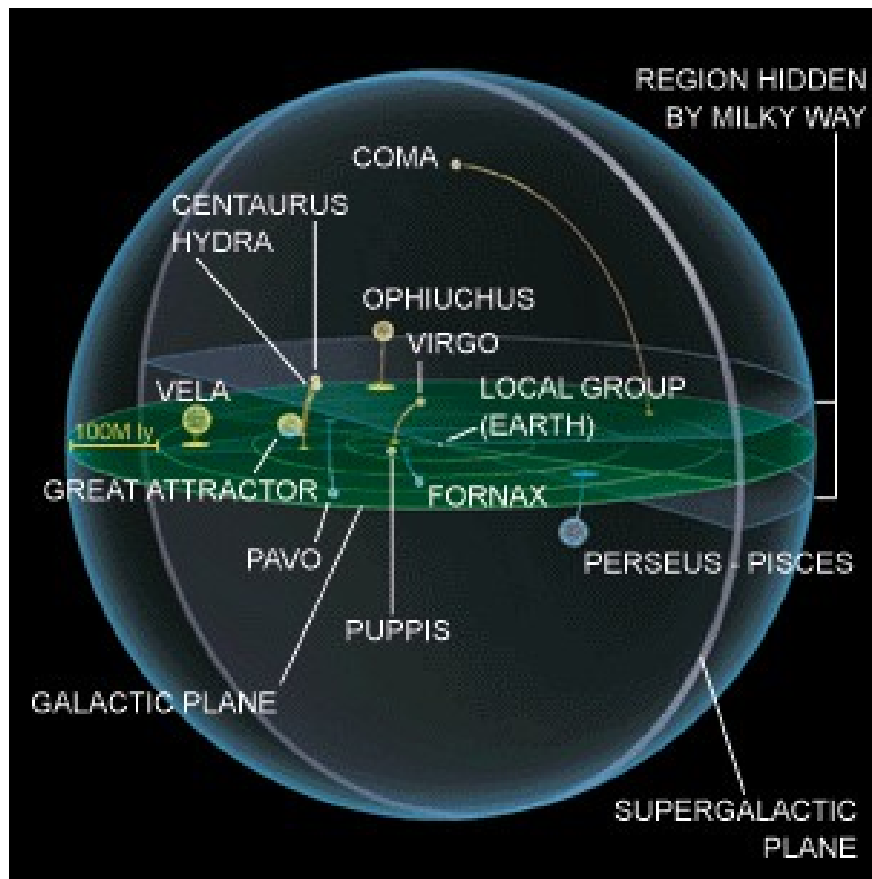


Effective “depth” of the survey 200-300 Mpc for a source with typical luminosity 10^{43} erg/s

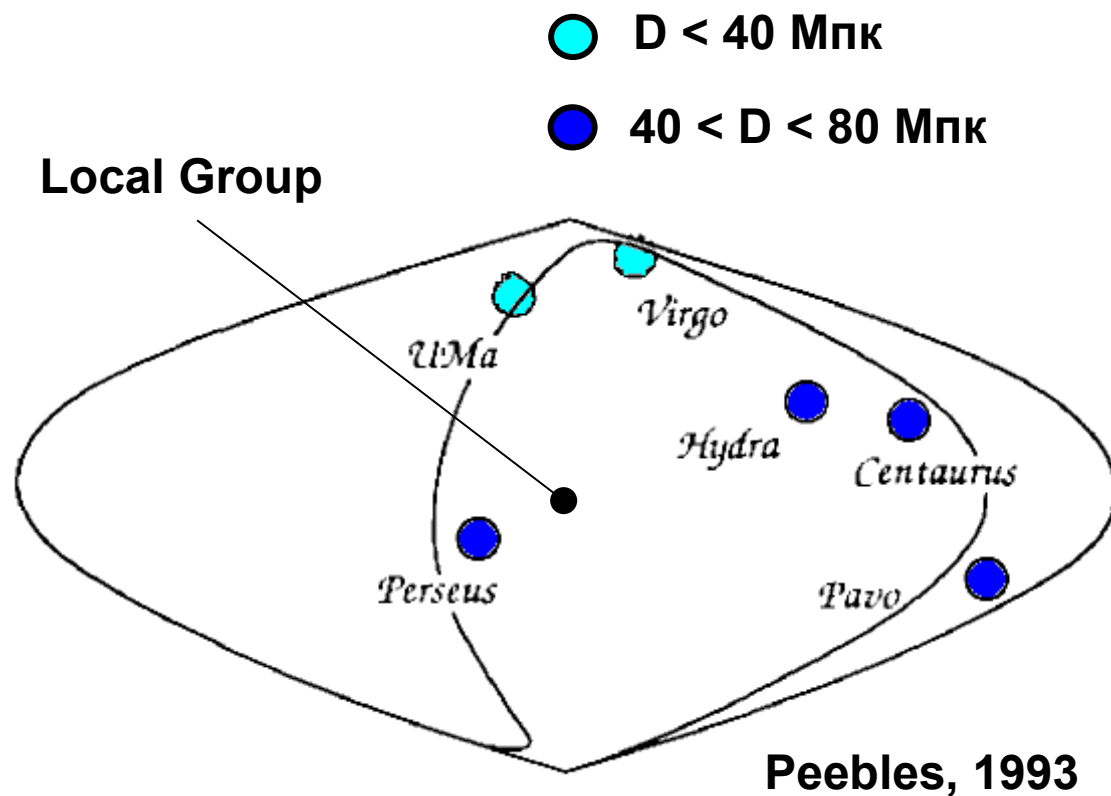
Large Scale Structure of the Local Universe



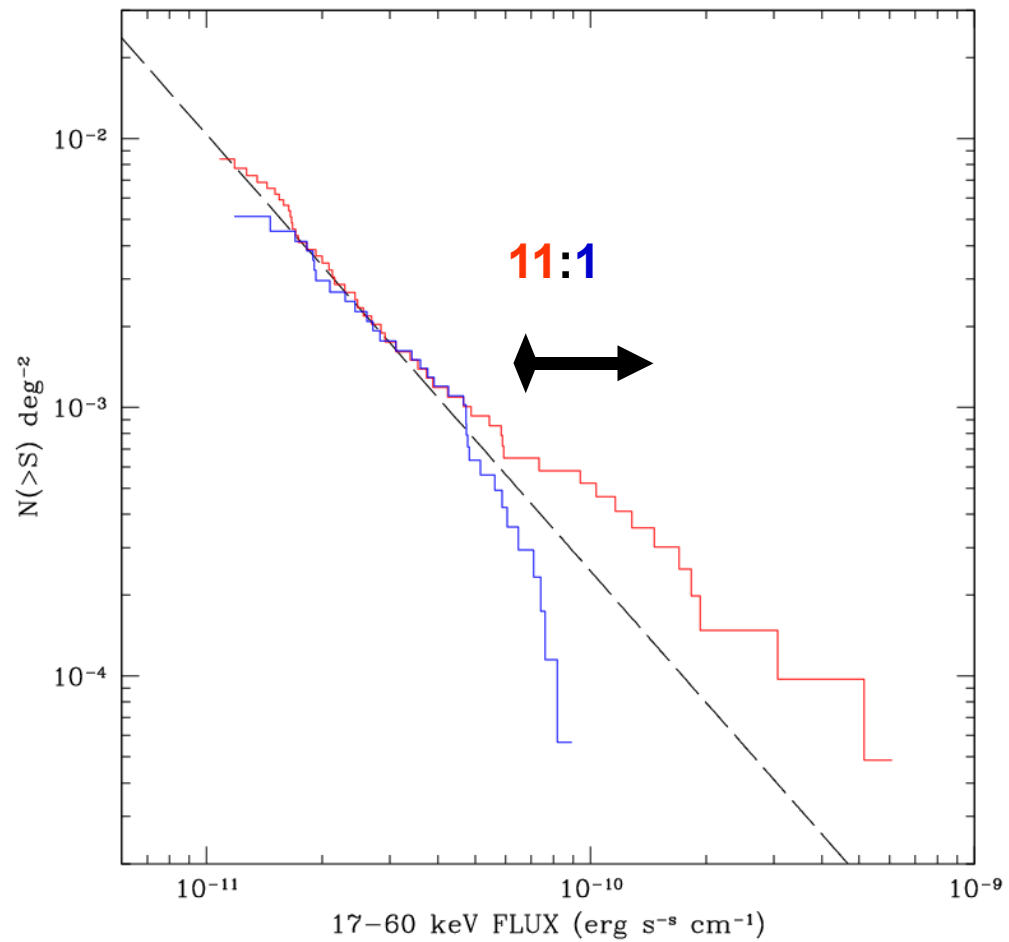
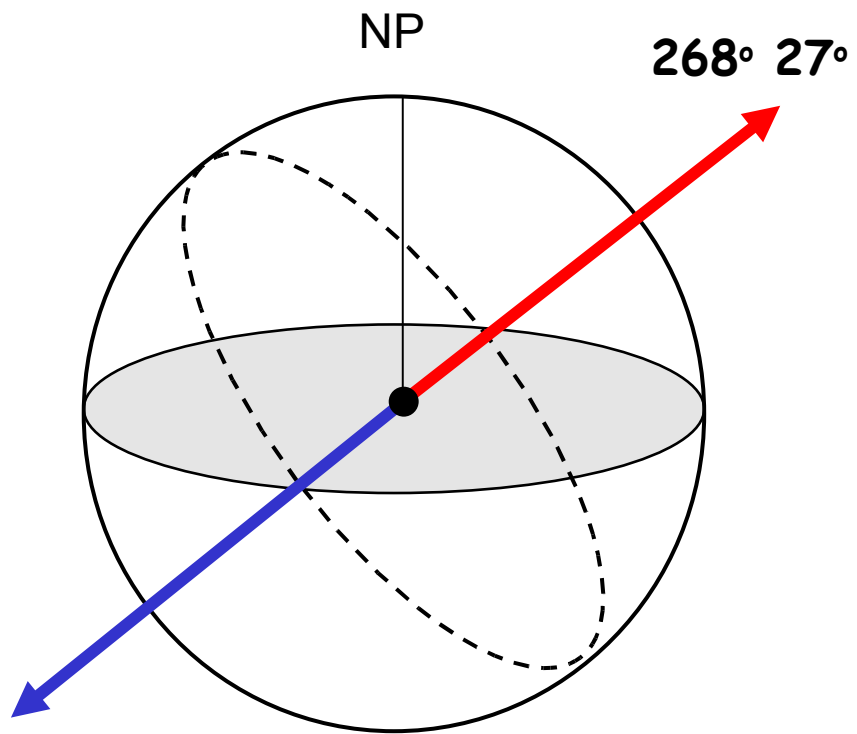
Large Scale Structure of the Local Universe



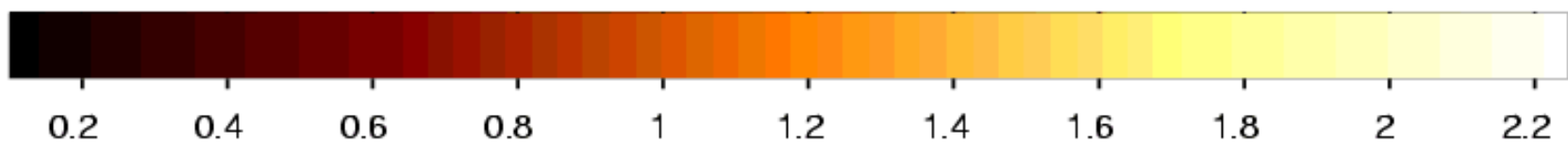
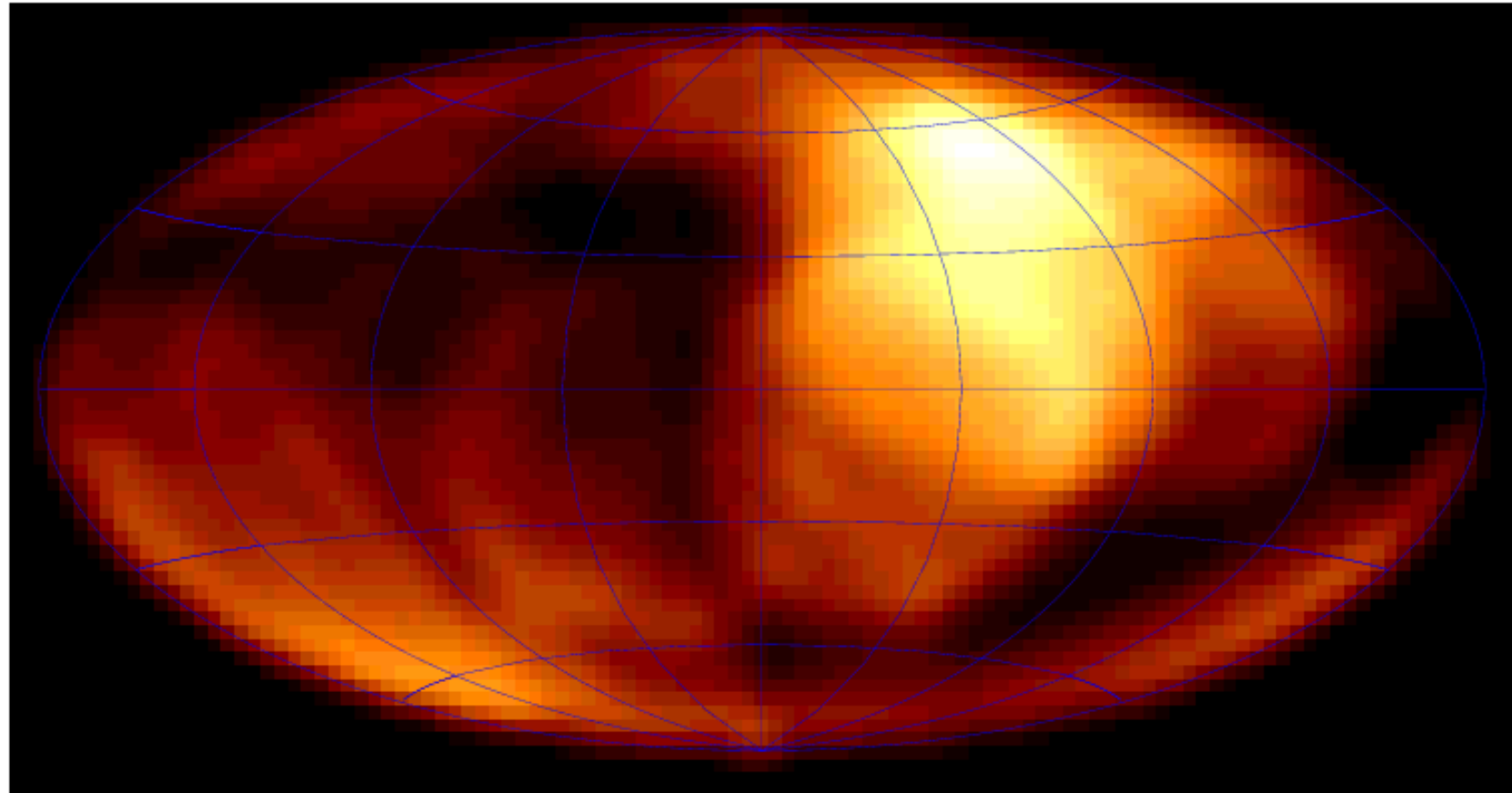
Kraan-Korteweg & Lahav, Sci. Am. 1998



AGN surface density contrast



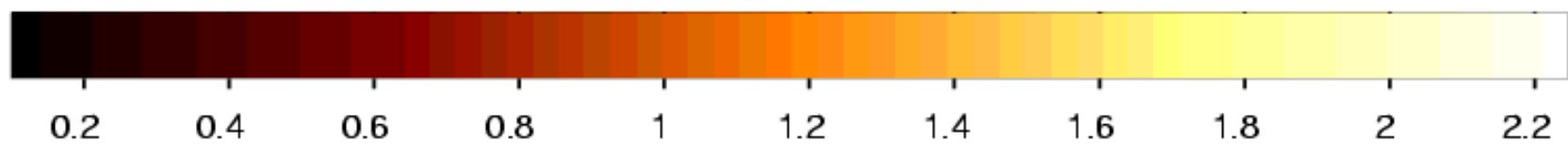
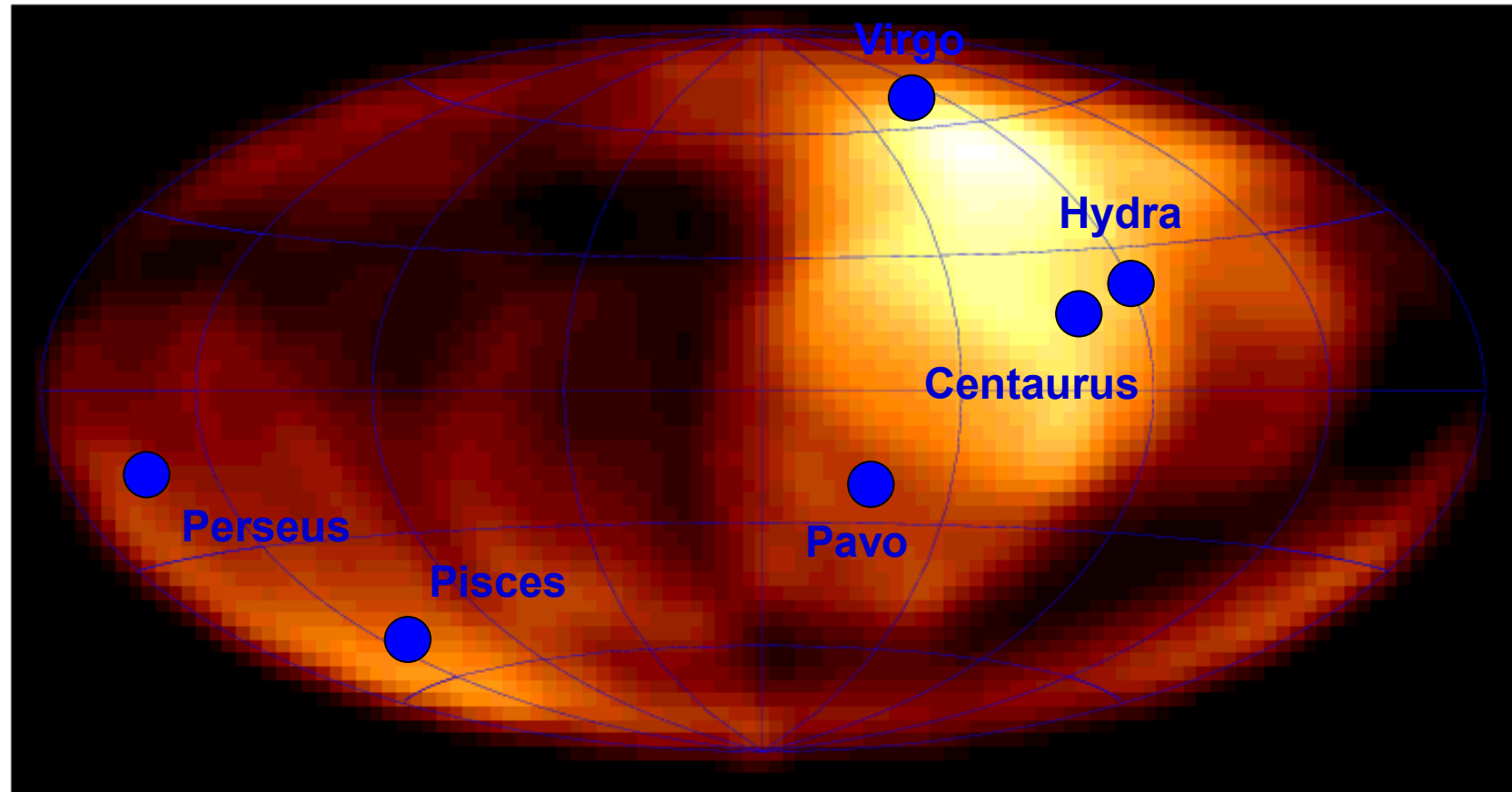
AGN volume density ($D < 70$ Mpc)



40 AGNs

$n = 1.4 \times 10^{-3} / \text{Mpc}^3, L > 10^{41} \text{ erg/s}$

AGN volume density ($D < 70$ Mpc)



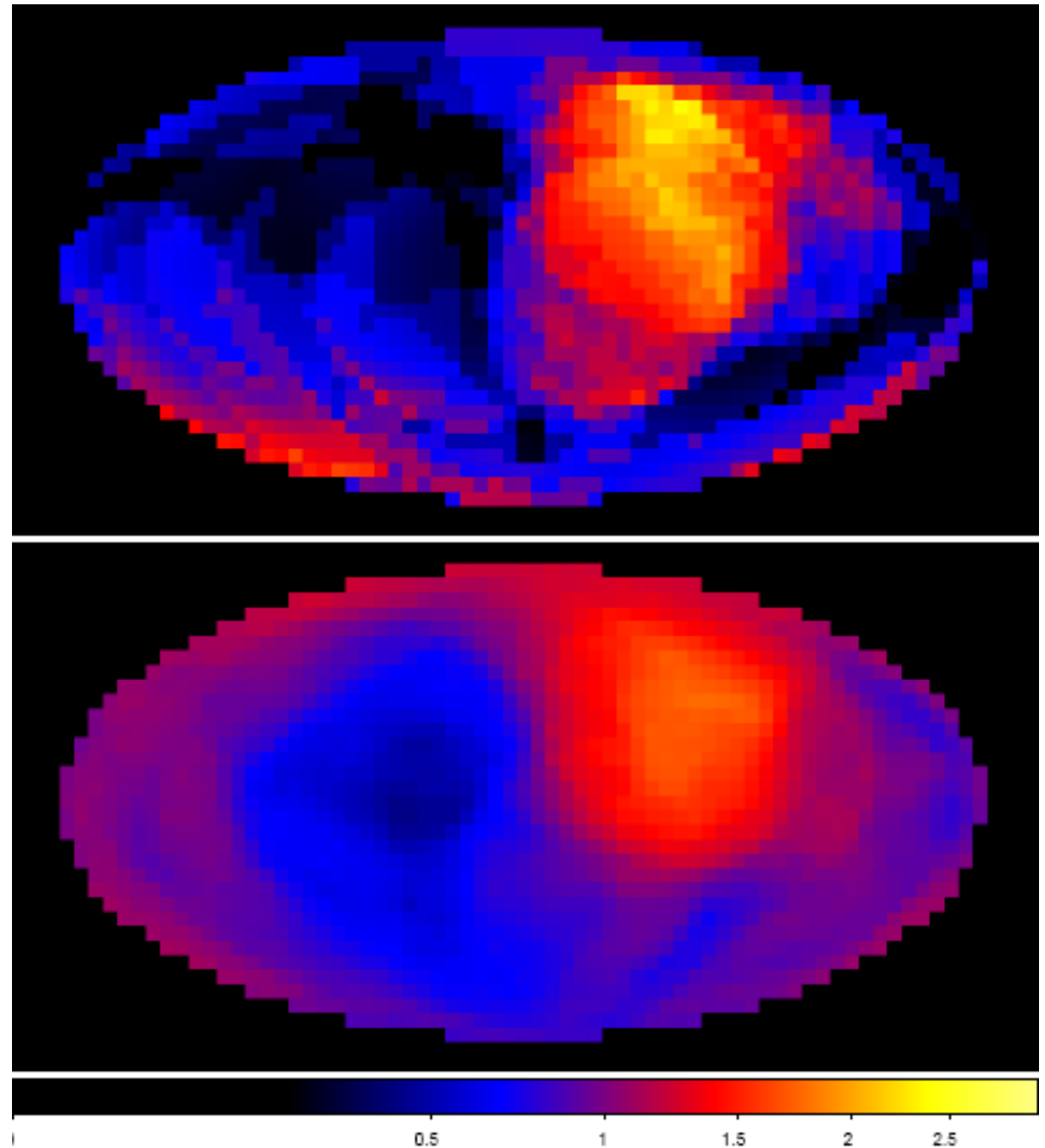
40 AGNs

$n = 1.4 \times 10^{-3} / \text{Mpc}^3, L > 10^{41} \text{ erg/s}$

Volume density excess of nearby (<70 Mpc)

40 AGNs:
(*INTEGRAL* survey)

~5,000 IR galaxies:
(*IRAS PSCz* survey)



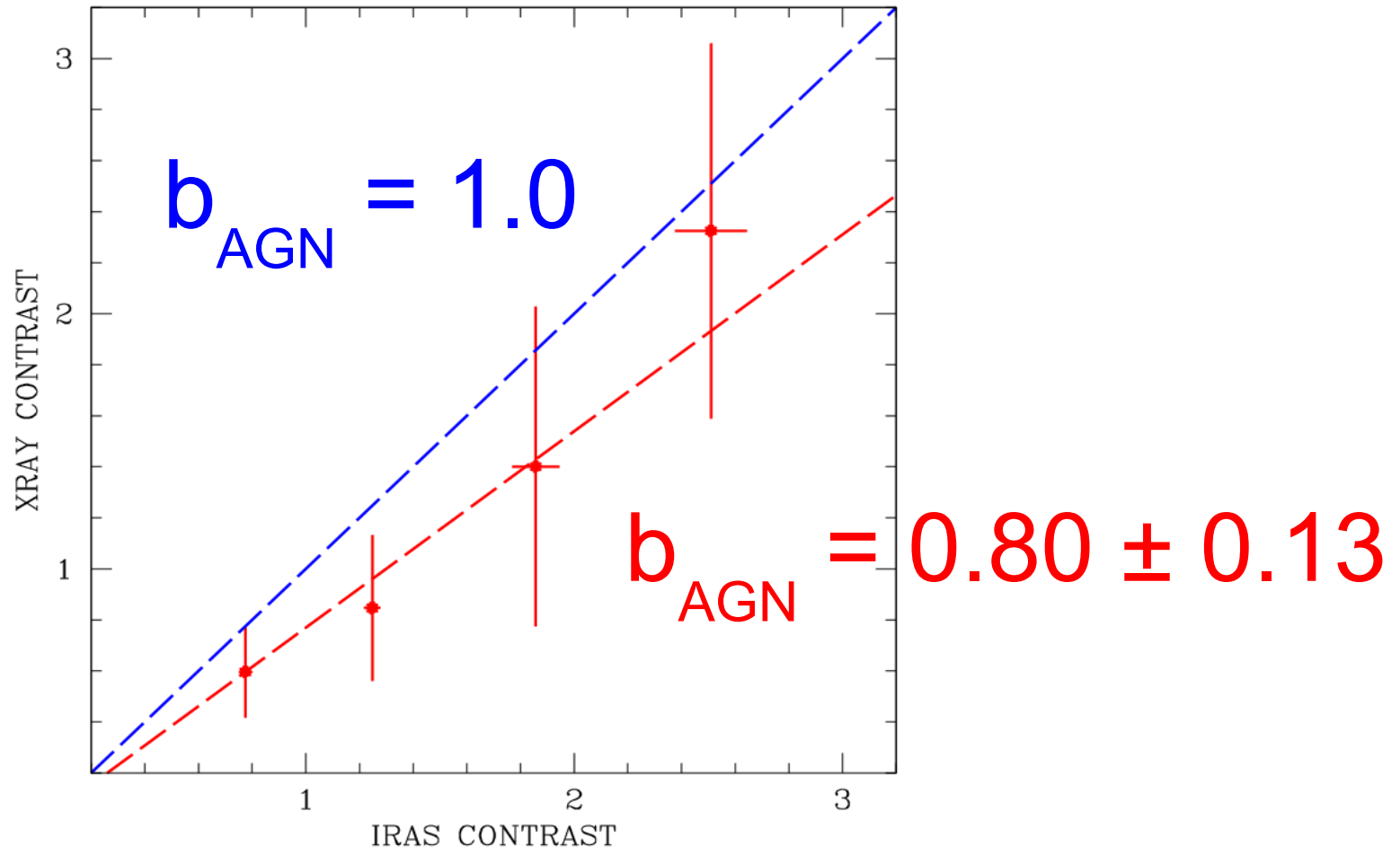
X-Ray AGN bias factor

$$b = \delta\rho_{\text{AGN}} / \langle \rho_{\text{AGN}} \rangle : \delta\rho_{\text{m}} / \langle \rho_{\text{m}} \rangle$$

We use IRAS PSCz survey as matter tracer ($b_{\text{IR}} \approx 1$)



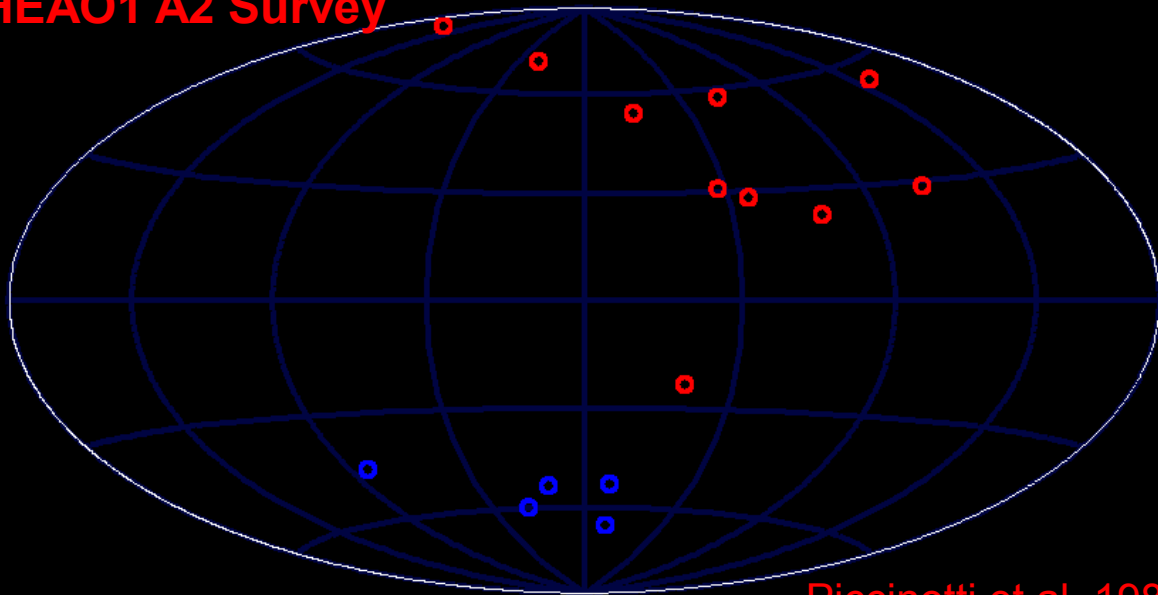
X-Ray AGN bias factor



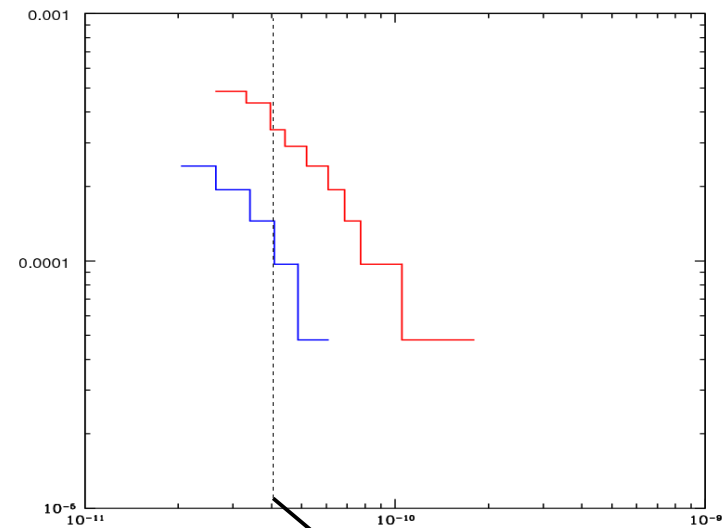
- => AGNs – good matter tracers on 10-70 Mpc scale
- => SMBH activity independent from density of galaxies

Historic remark: HEAO 1 / A2 survey

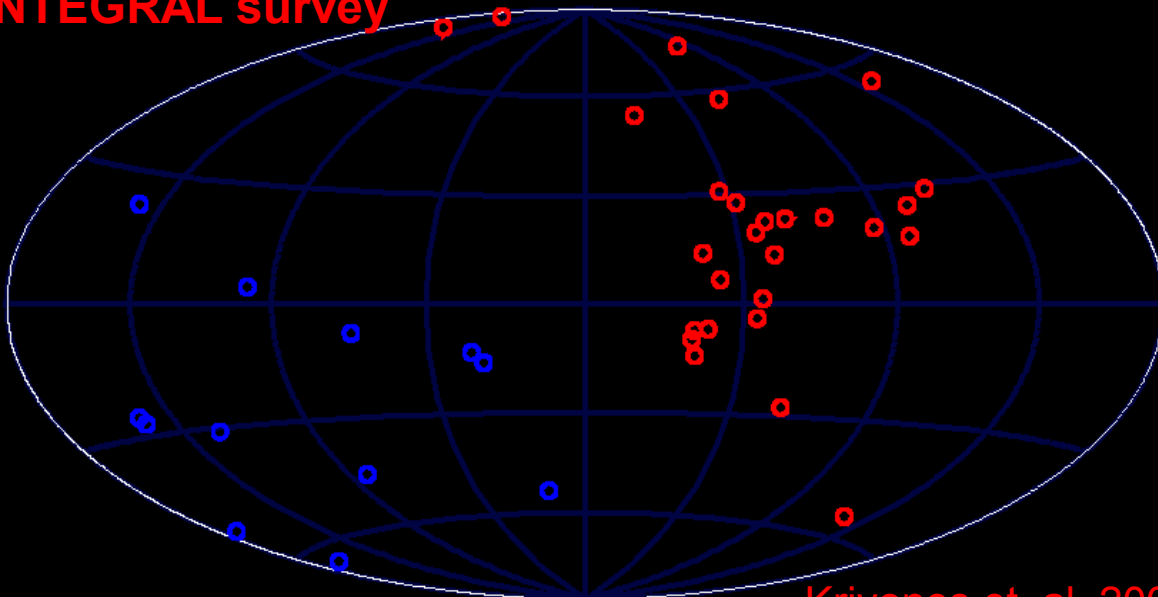
HEAO1 A2 Survey



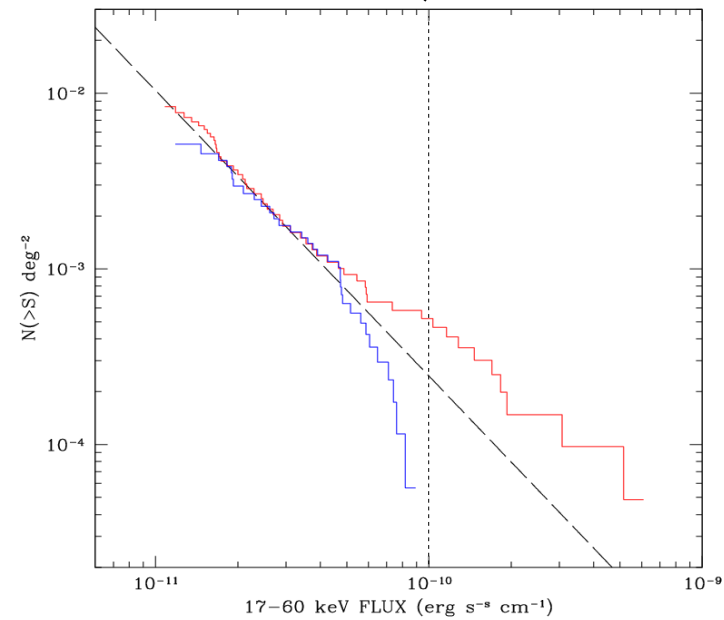
Piccinotti et al. 1982



INTEGRAL survey



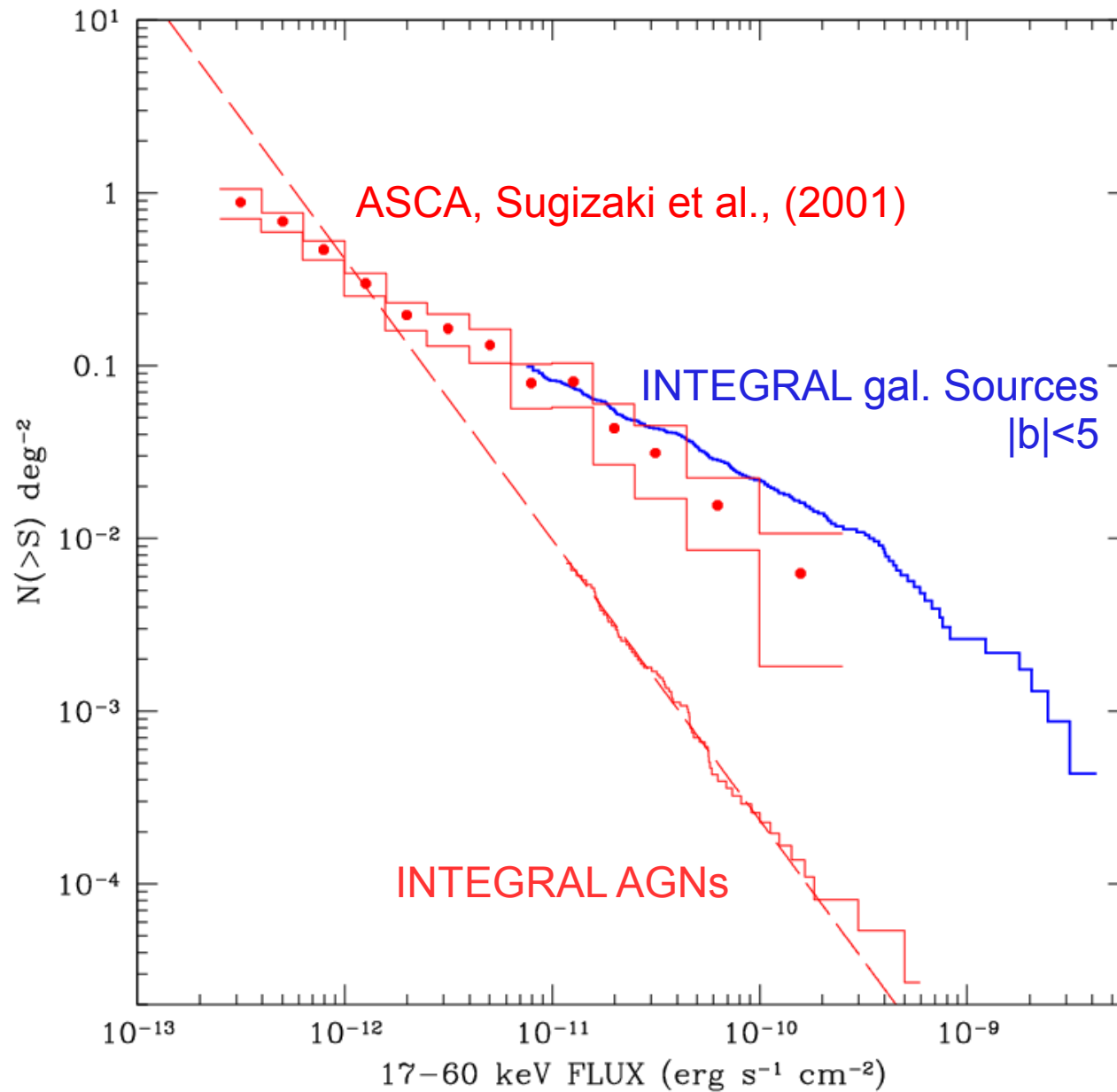
Krivonos et al. 2007



Summary

- => Already now INTEGRAL is able to probe Large Scale Structure of the local Universe
- => Density fluctuations of matter can be linearly translated into the density fluctuation of Hard X-ray emitting AGNs at zero redshift.
- => SMBH activity independent from density of galaxies on scales 10-70 Mpc

Galactic and extragalactic source counts



All-sky survey / 17-60 keV

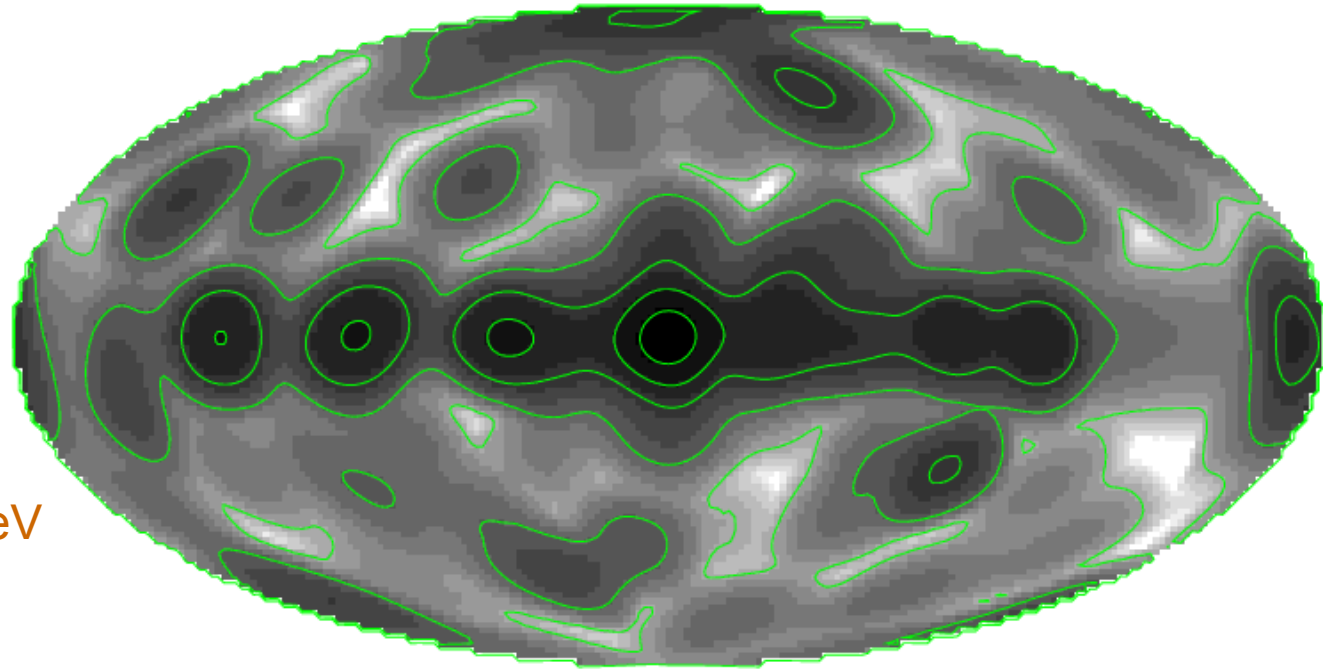
Coded-mask based telescope

IBIS:

- FOV 30x30 degrees.
- Angular resolution 12'

Detector **ISGRI:**

- Survey energy range 17-60 keV



Survey Sensitivity:

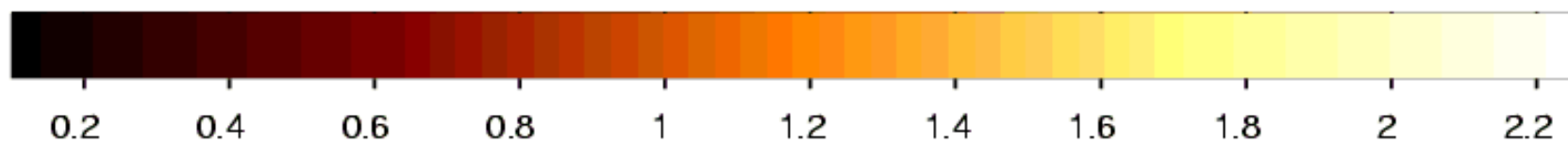
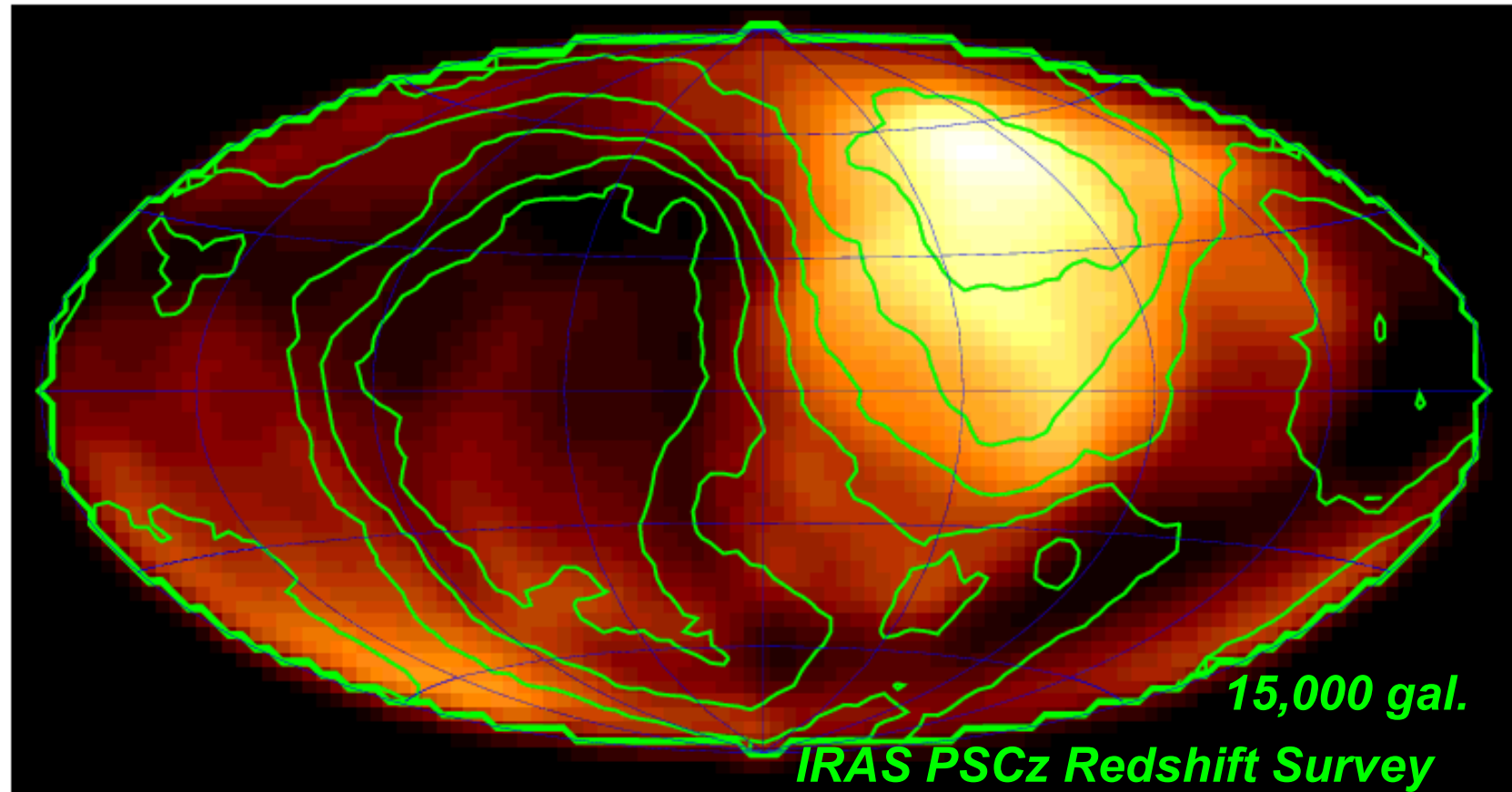
12% sky – 1 mCrab

80% sky – 5 mCrab

Effective “depth” of the survey 300-400 Mpc for a source with typical luminosity 10^{43} erg/s

$$1 \text{ mCrab} = 1.4 \times 10^{-11} \text{ erg/s/cm}^2$$

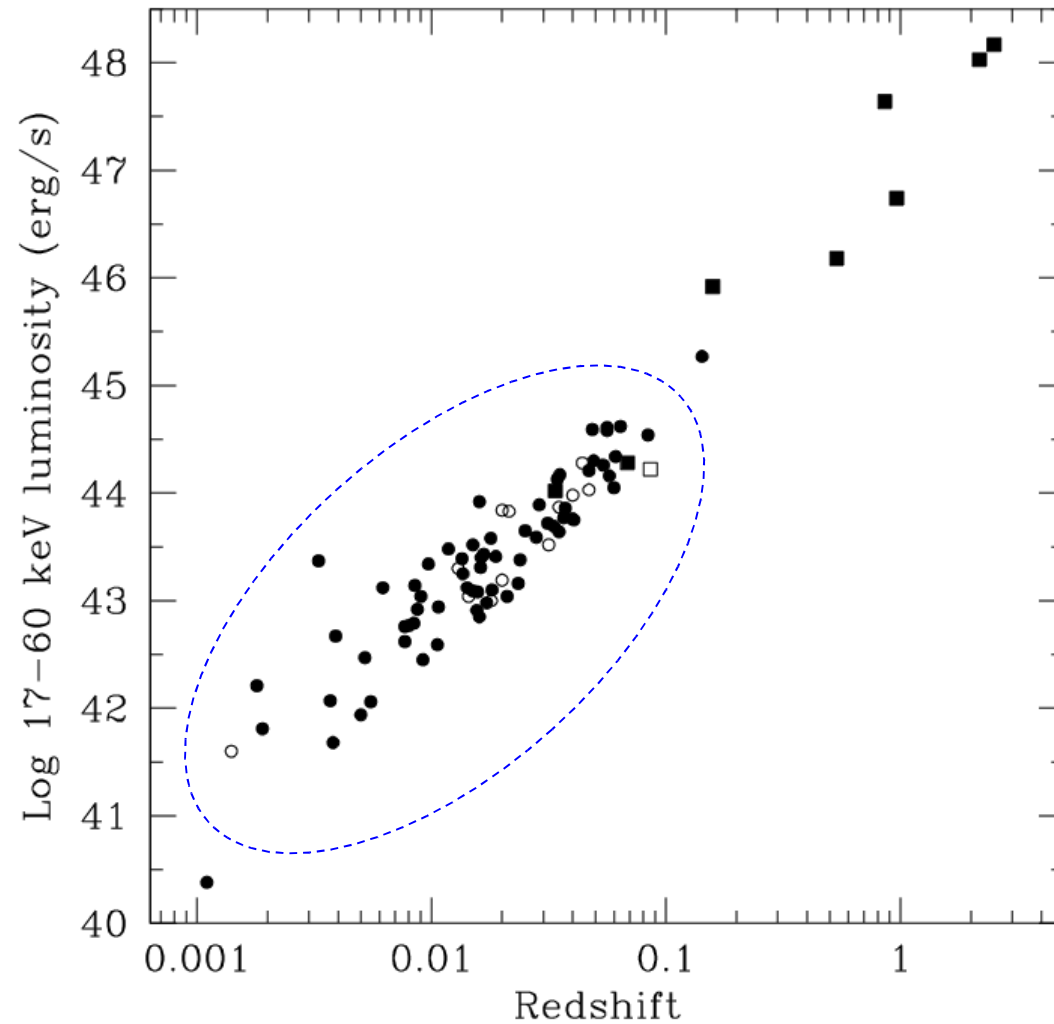
AGN volume density ($D < 70$ Mpc)



40 AGNs

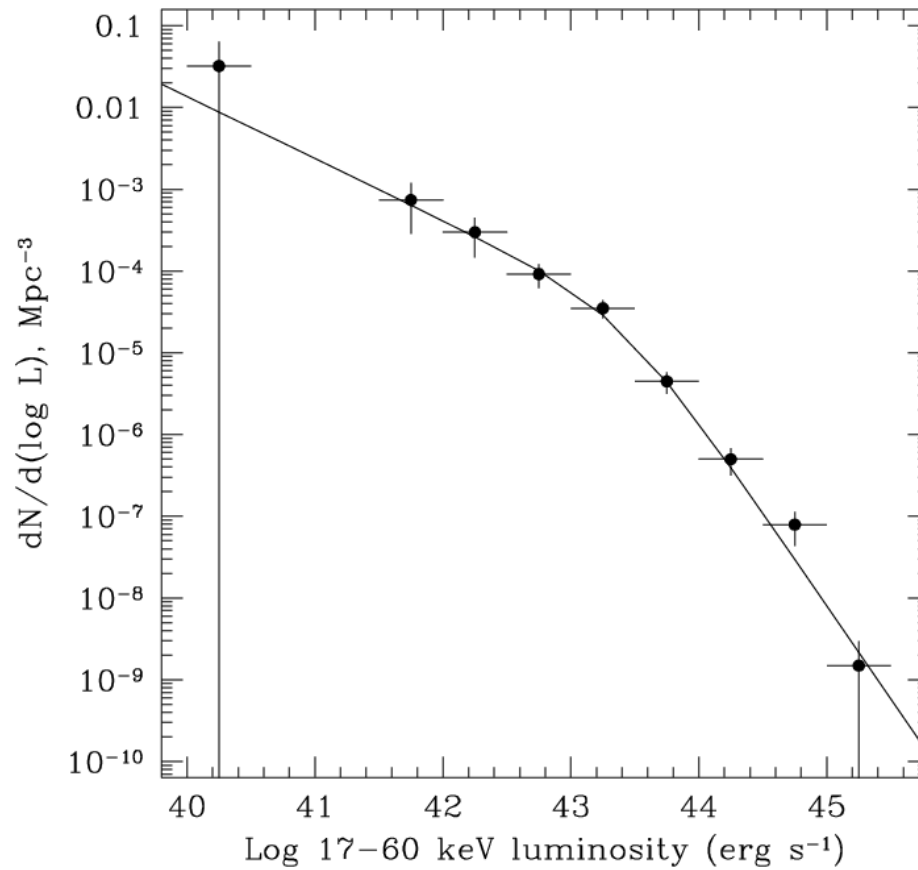
$$n = 1.4 \times 10^{-3} / \text{Mpc}^3, L > 10^{41} \text{ erg/s}$$

Nearby Active Galactic Nuclei ($|b| > 5$)



- 66 non-blazar AGNs
- 3 clusters of galaxies

Luminosity Function



Consistent with:

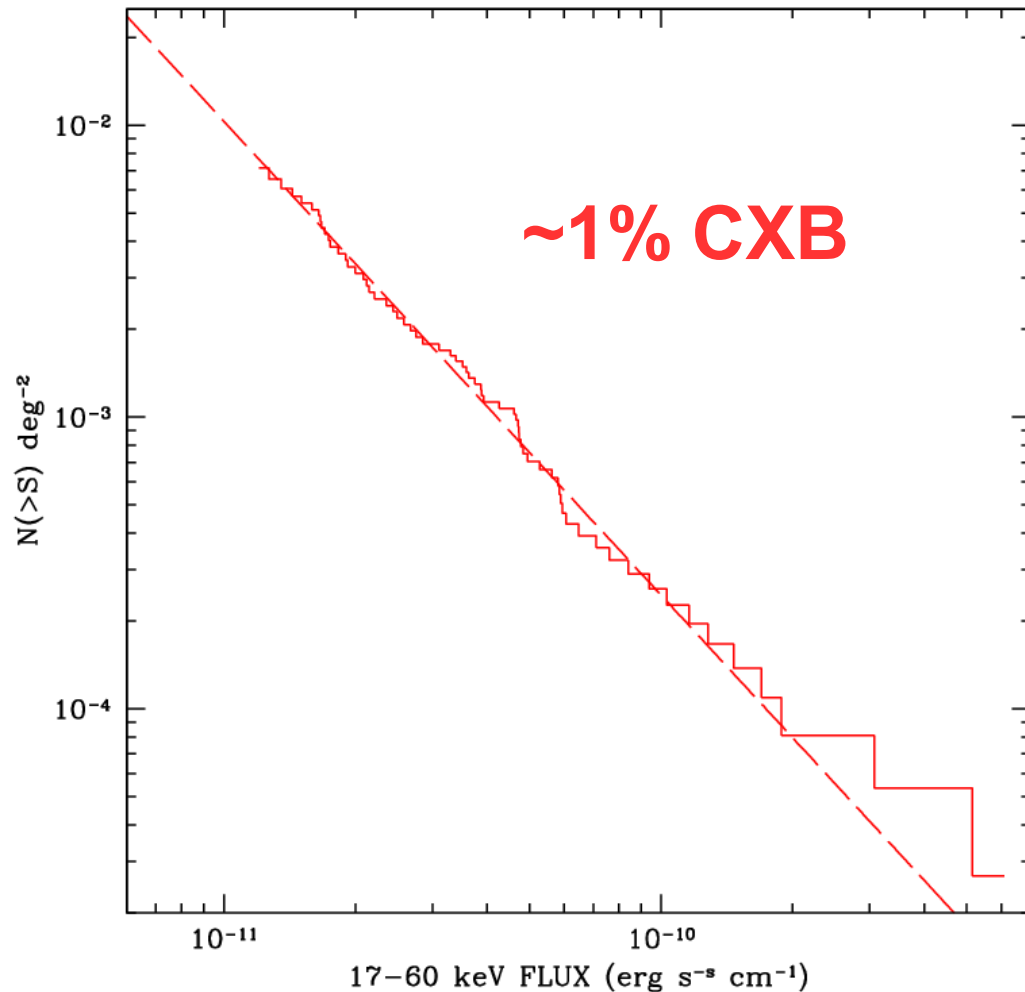
Beckmann et al. 2006 20-40 keV LF
(smaller INTEGRAL sample)

RXTE Slew Survey 3-20 keV LF
(Sazonov & Revnivtsev 2004)

HEAO-1 2-10 keV LF
(Shinozaki et al. 2006)

- 1) Volume density ($L > 10^{42}$) $2 \times 10^{-4} / \text{Mpc}^3$
- 2) Volume emissivity ($L > 10^{41}$) $12 \times 10^{38} \text{ erg/s} / \text{Mpc}^3$

Extragalactic source counts

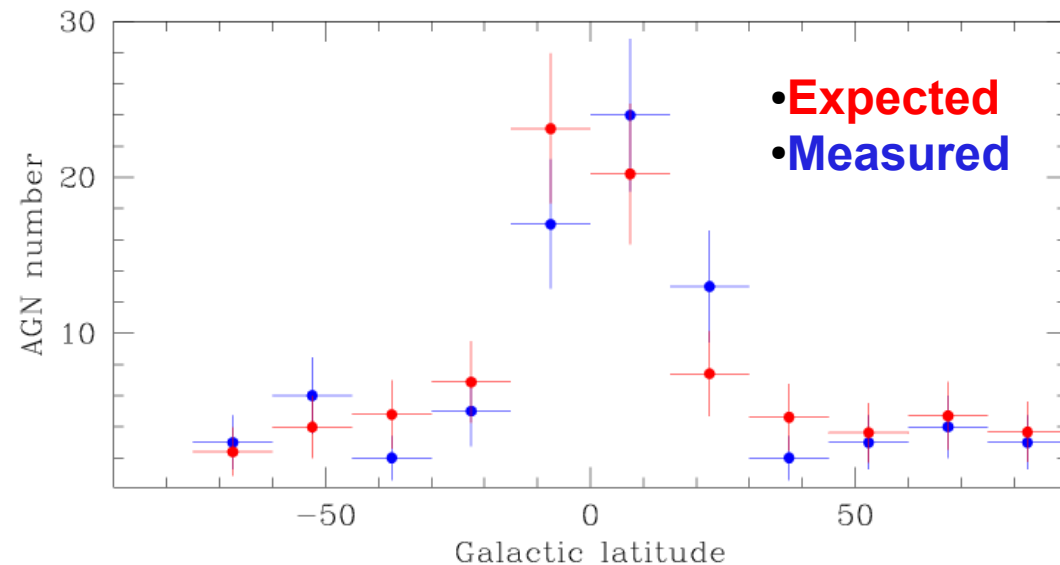


17-60 keV, $|b| > 5^\circ$, $z < 0.1$

$$N(F > 1 \text{ mCrab}) = M F^{-a}$$

$$a = 1.62 \pm 0.15$$

$$M = (5.7 \pm 0.7) 10^{-3} / \text{deg}^2$$



Most of the unidentified sources in the Galactic Plane should be of Galactic origin