

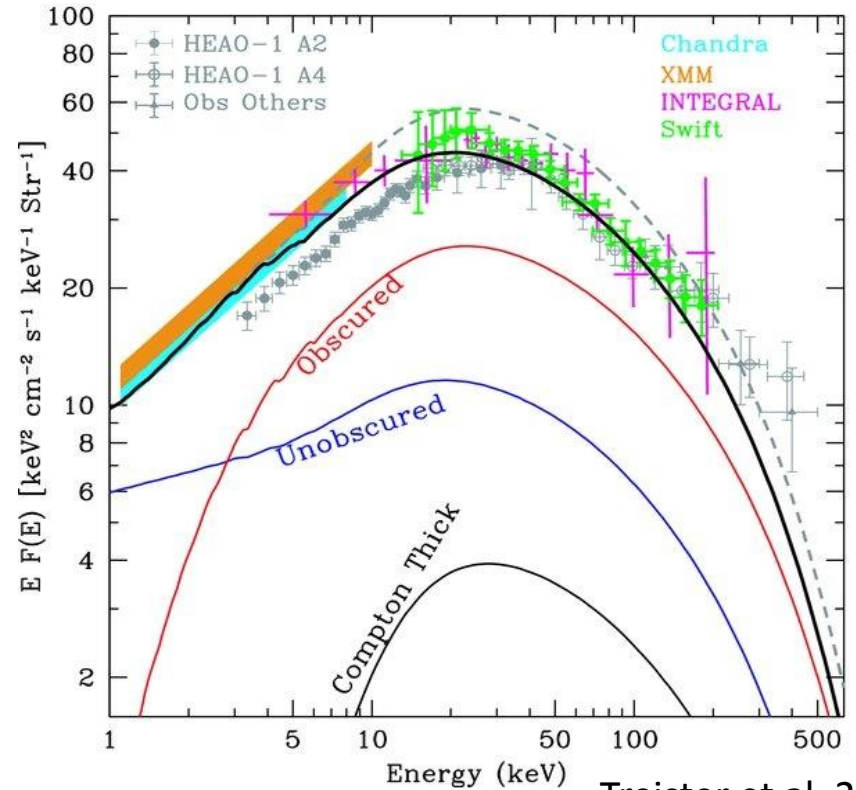
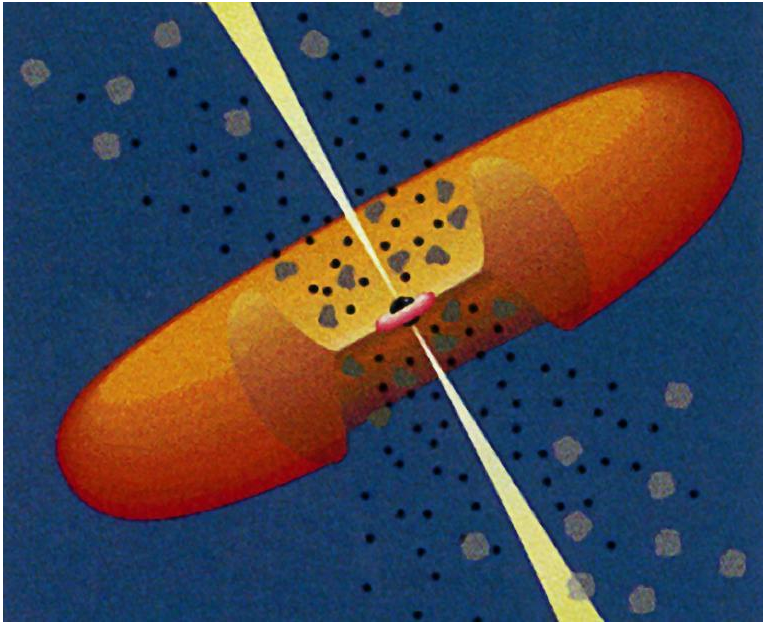
Does the obscured AGN fraction really depend on luminosity?

The background of the slide is a dark, star-filled space. In the upper left, a bright, glowing galaxy core is shown, with a central point of intense light representing an active galactic nucleus (AGN). A bright, white beam of light originates from this core and extends diagonally towards the lower right. In the lower right, a satellite is depicted in space, oriented towards the galaxy. The satellite has a blue body with various instruments and a large, rectangular solar panel array extending upwards. The overall scene suggests a satellite observing or studying the AGN.

Sergey Sazonov

Space Research Institute, Moscow

Motivation

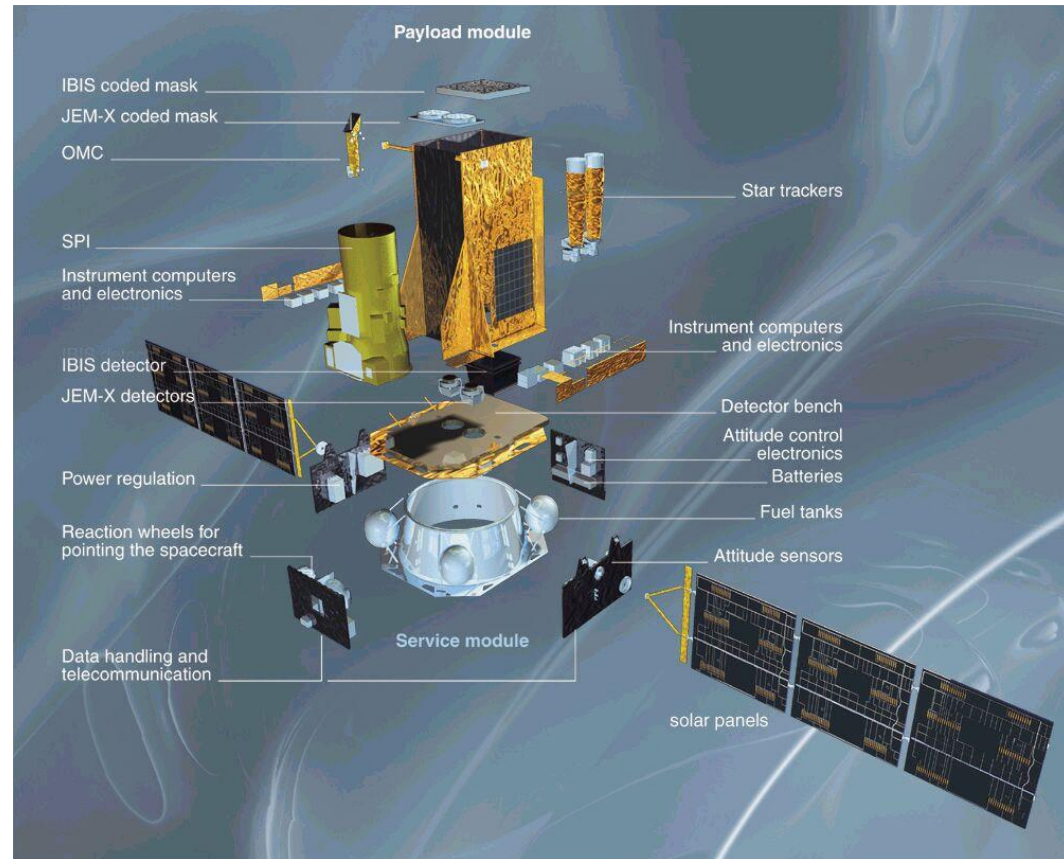


Treister et al. 2009

- **What is the TORUS?**
- **How is it affected by the central source?**
- **Are there many obscured AGN?**
- **History of SMBH growth**

INTernational Gamma-Ray Laboratory

- ❑ Launched October 17, 2002 by a Russian Proton
- ❑ In a high 3-day orbit
- ❑ ESA payload
- ❑ Continues to operate flawlessly



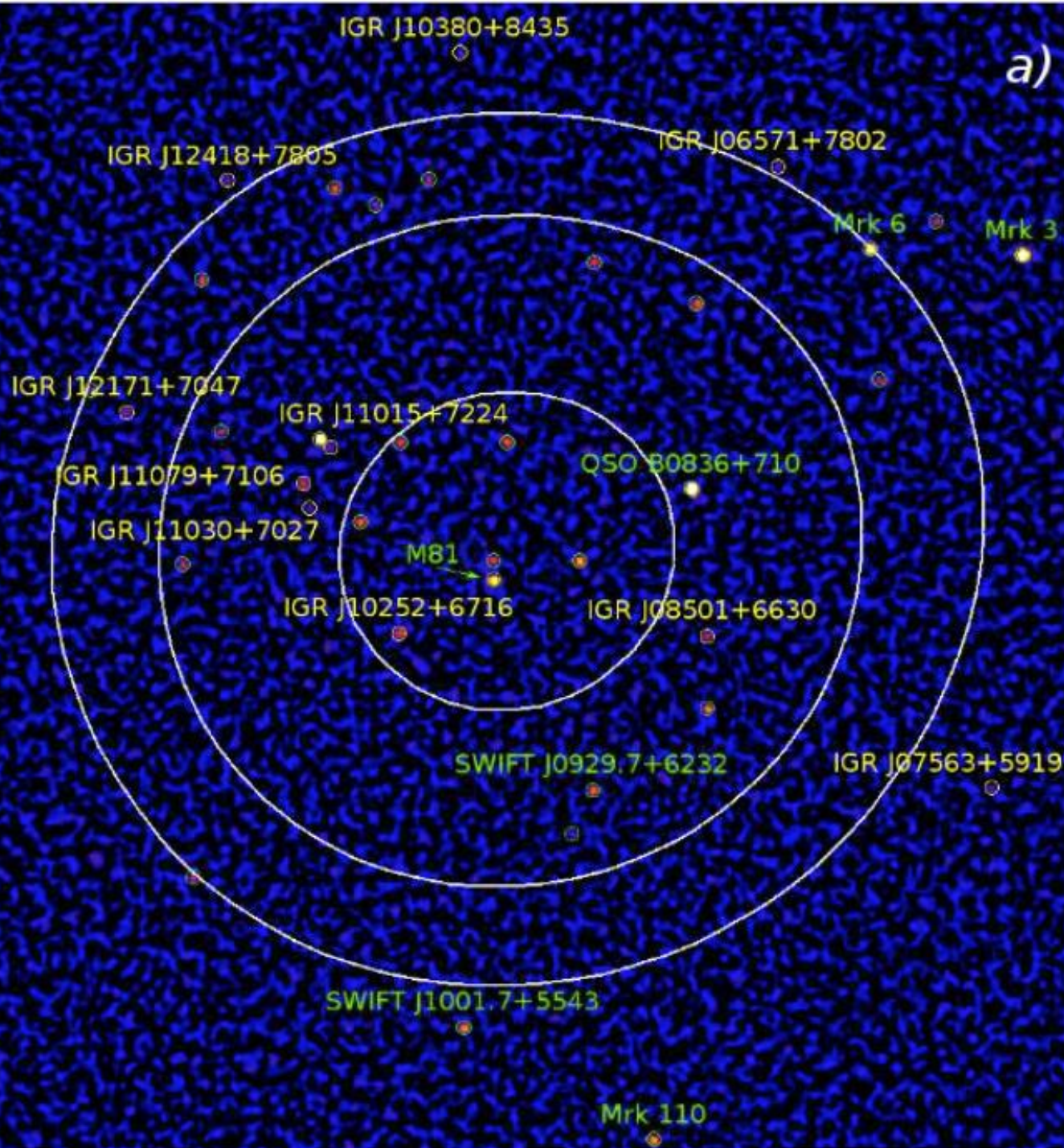
IBIS/ISGRI detector

Effective energy band: 15-300 keV

Geometrical area: 2600 cm²

Field of view: 28°x28°, 9°x9° fully coded

Angular resolution: 12 arcmin

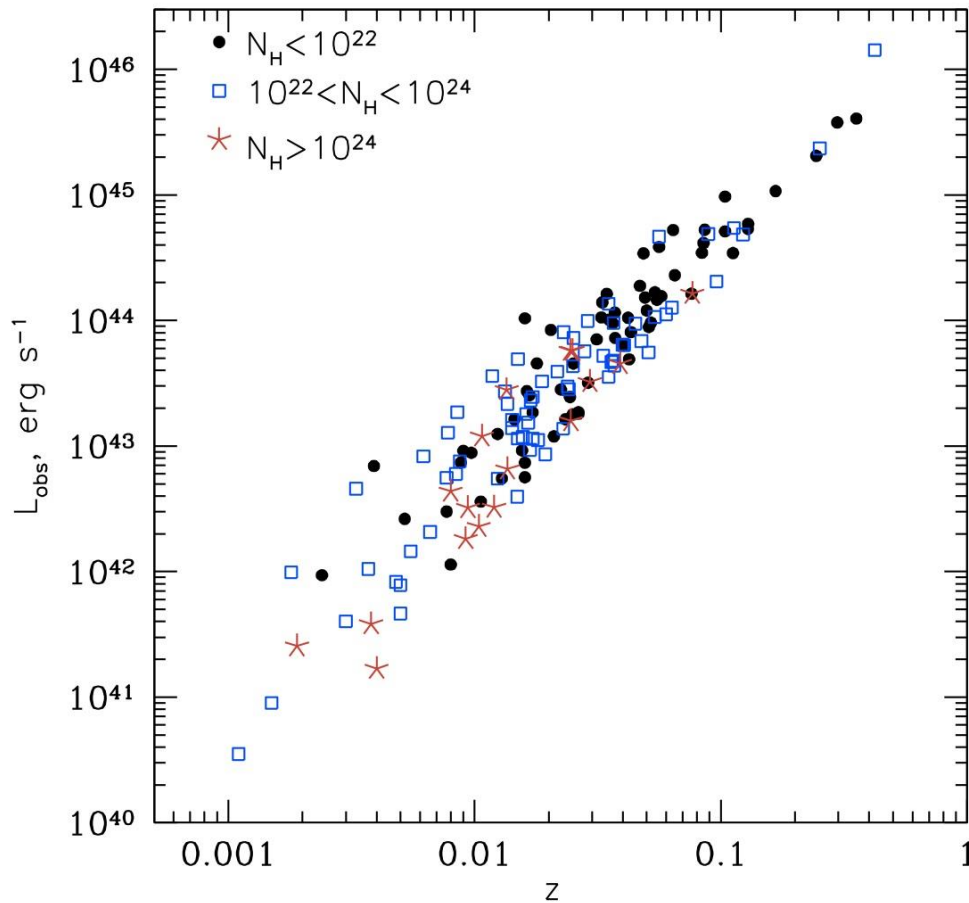
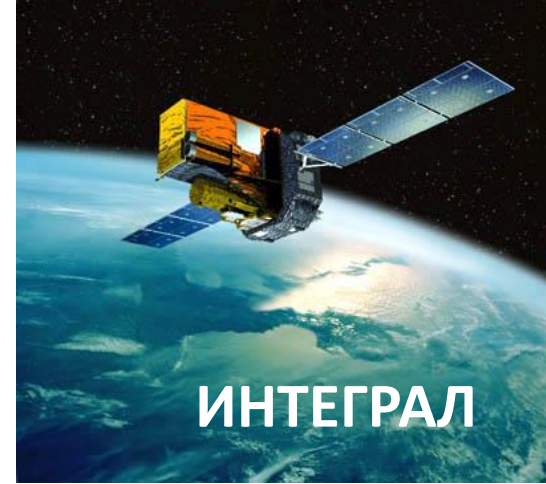


**35 deg x 35 deg
field around M81**

**Peak exposure
~10 Msec**

**Mereminsky et al.,
in prep.**

AGN in the local Universe: *INTEGRAL* all-sky hard X-ray survey



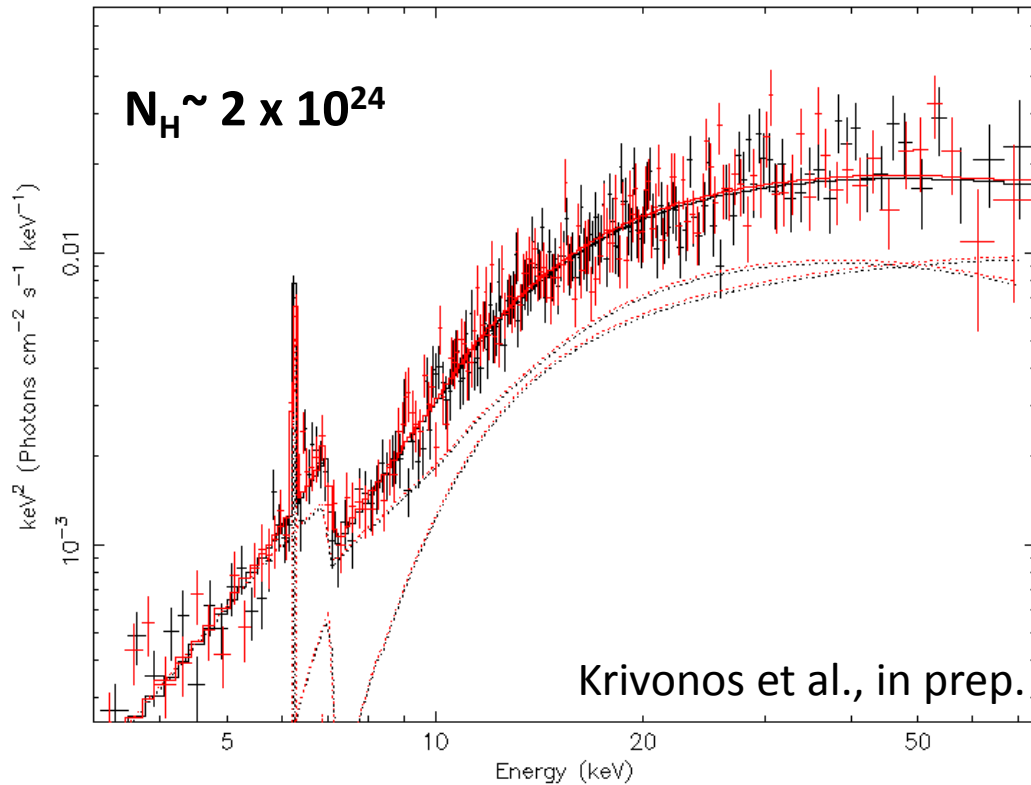
7-yr (2002-2009) catalog:
151 non-blazar AGN at $|b| > 5^\circ$

Krivonos 2010

Compton thick AGN

NGC 6240

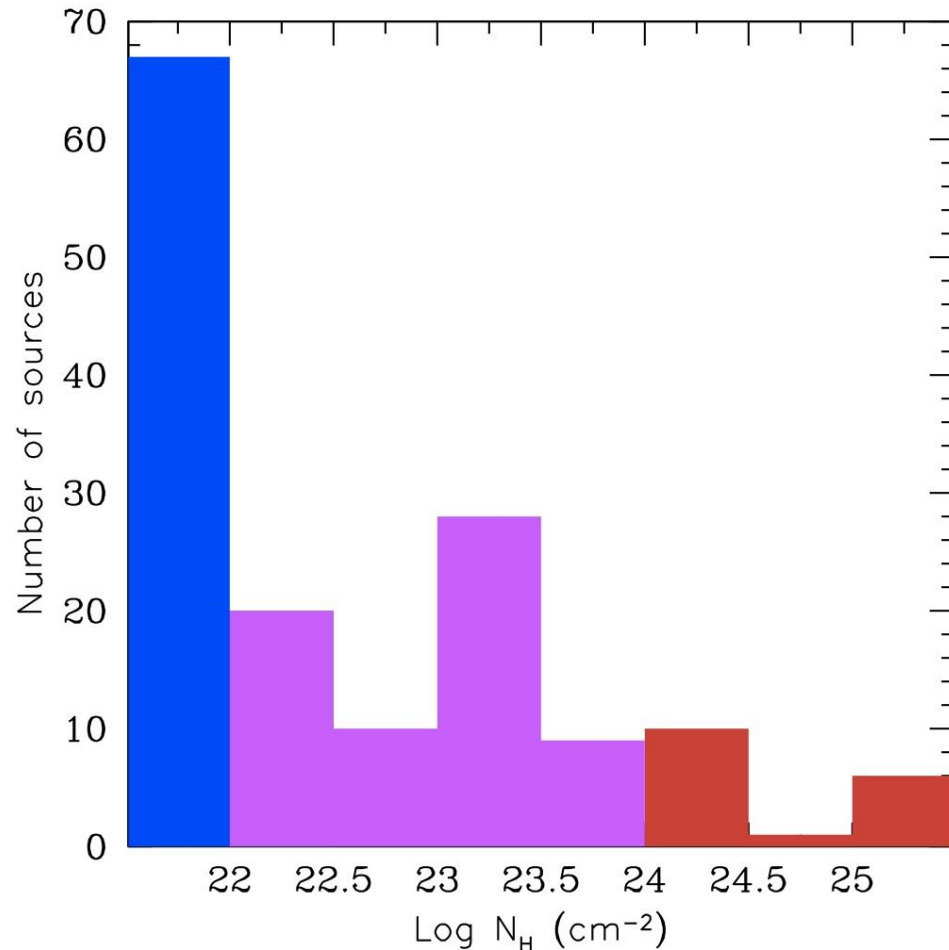
Unfolded Spectrum



Using high-quality X-ray data, one can estimate N_{H} or show that $N_{\text{H}} > 10^{25}$ (reflection-dominated)

Our INTEGRAL sample contains 17 such objects (out of 151), most of them now with good spectral data (*NuSTAR*)

Distribution of X-ray absorption columns



44%

unabsorbed (N_H < 10²²)

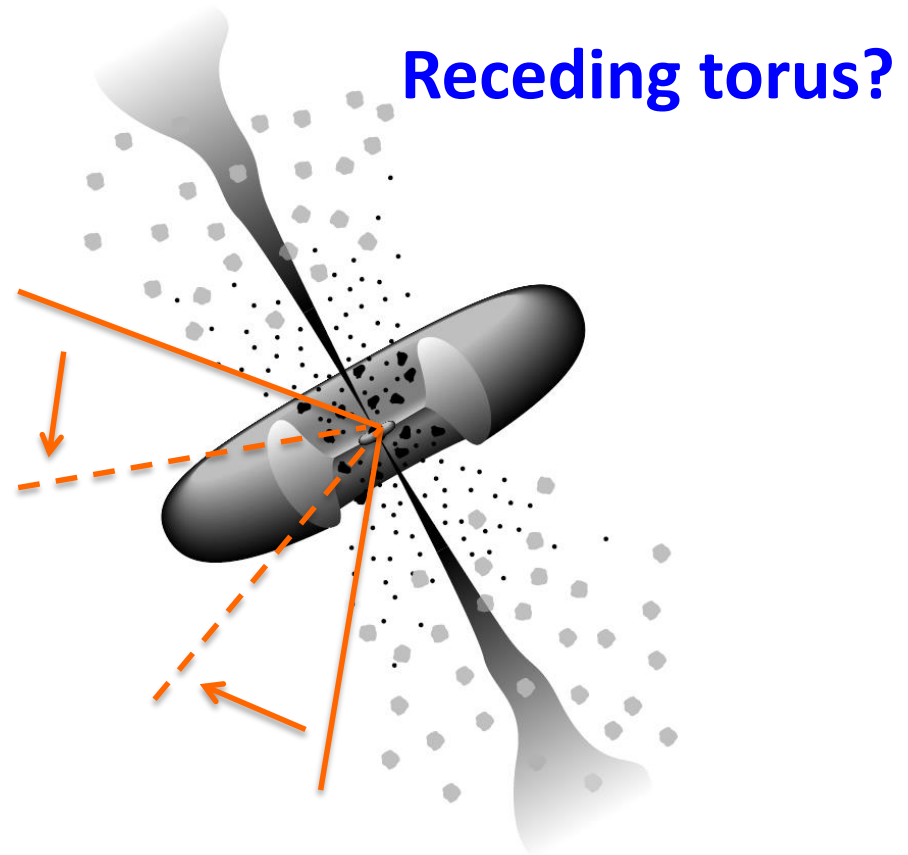
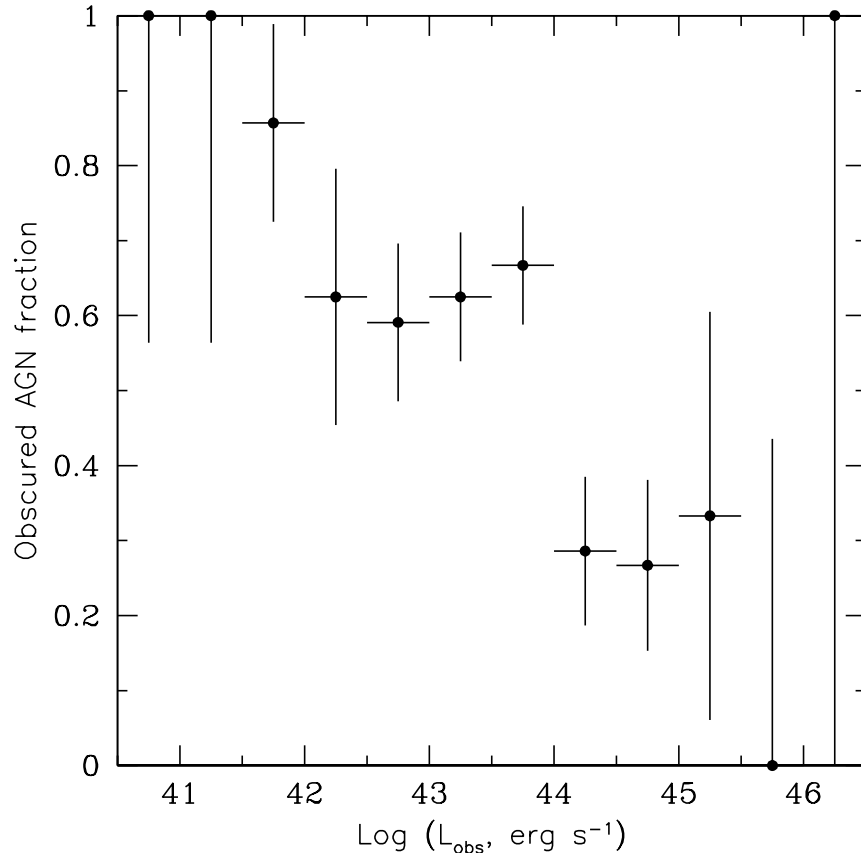
44%

weakly absorbed (10²² < N_H < 10²⁴)

12%

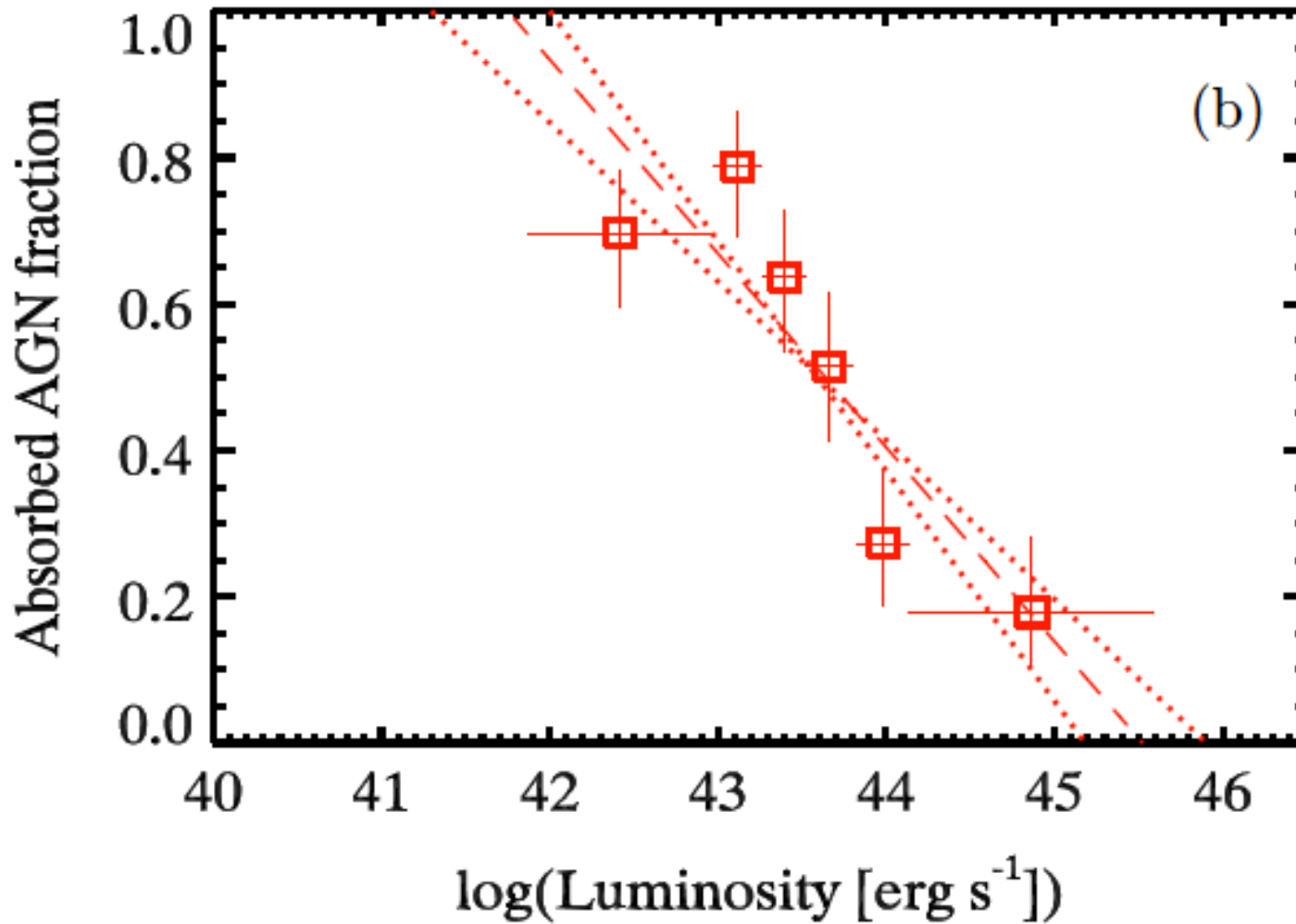
strongly absorbed (N_H > 10²⁴)

Fraction of obscured ($N_{\text{H}} > 10^{22}$) AGN as a function of luminosity

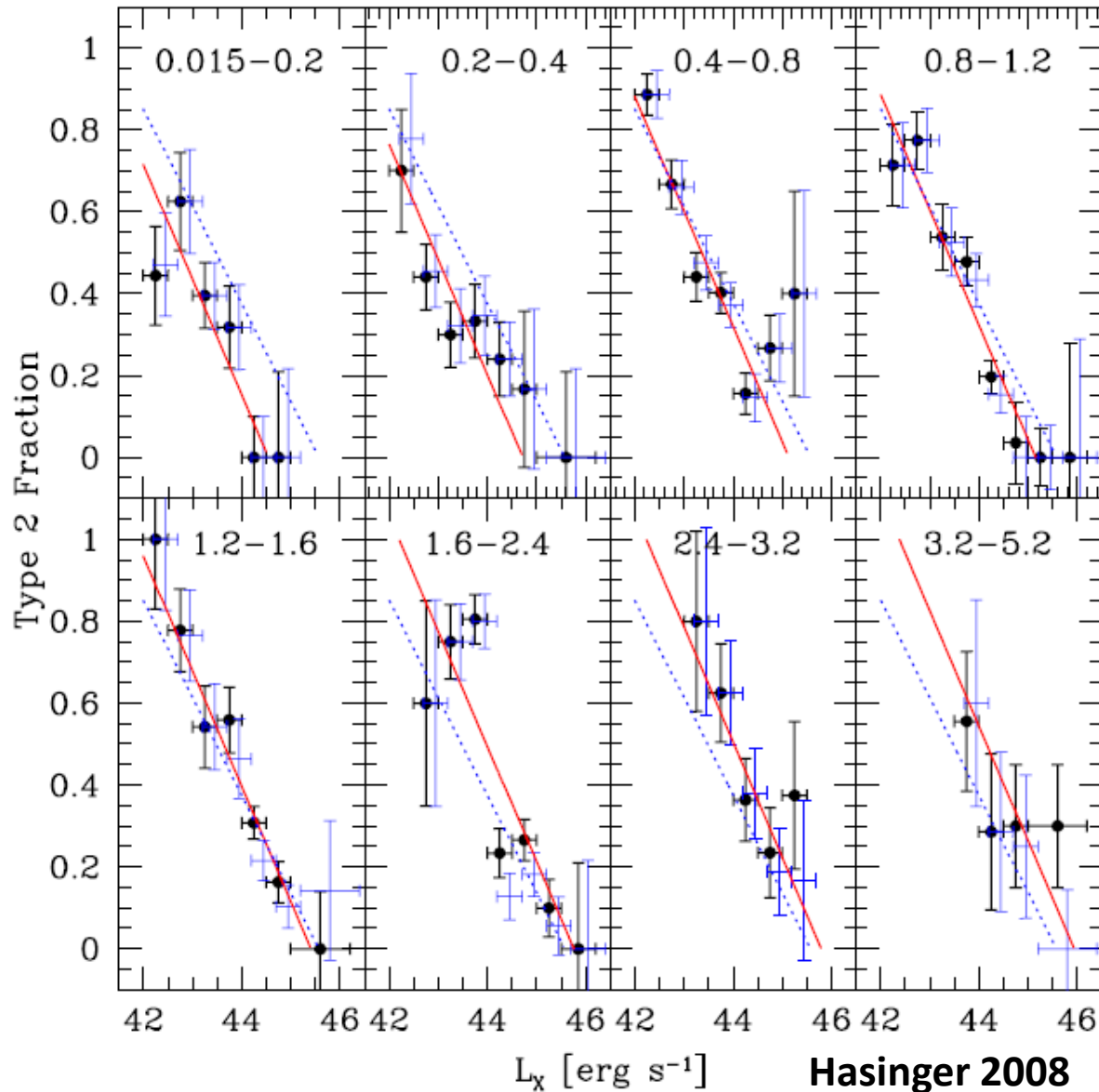


$$\Omega_{\text{Torus}}/4\pi \approx 1 - 0.25(\log L_{17-60 \text{ keV}} - 41.5)$$

The same is seen in the Swift/BAT hard X-ray survey



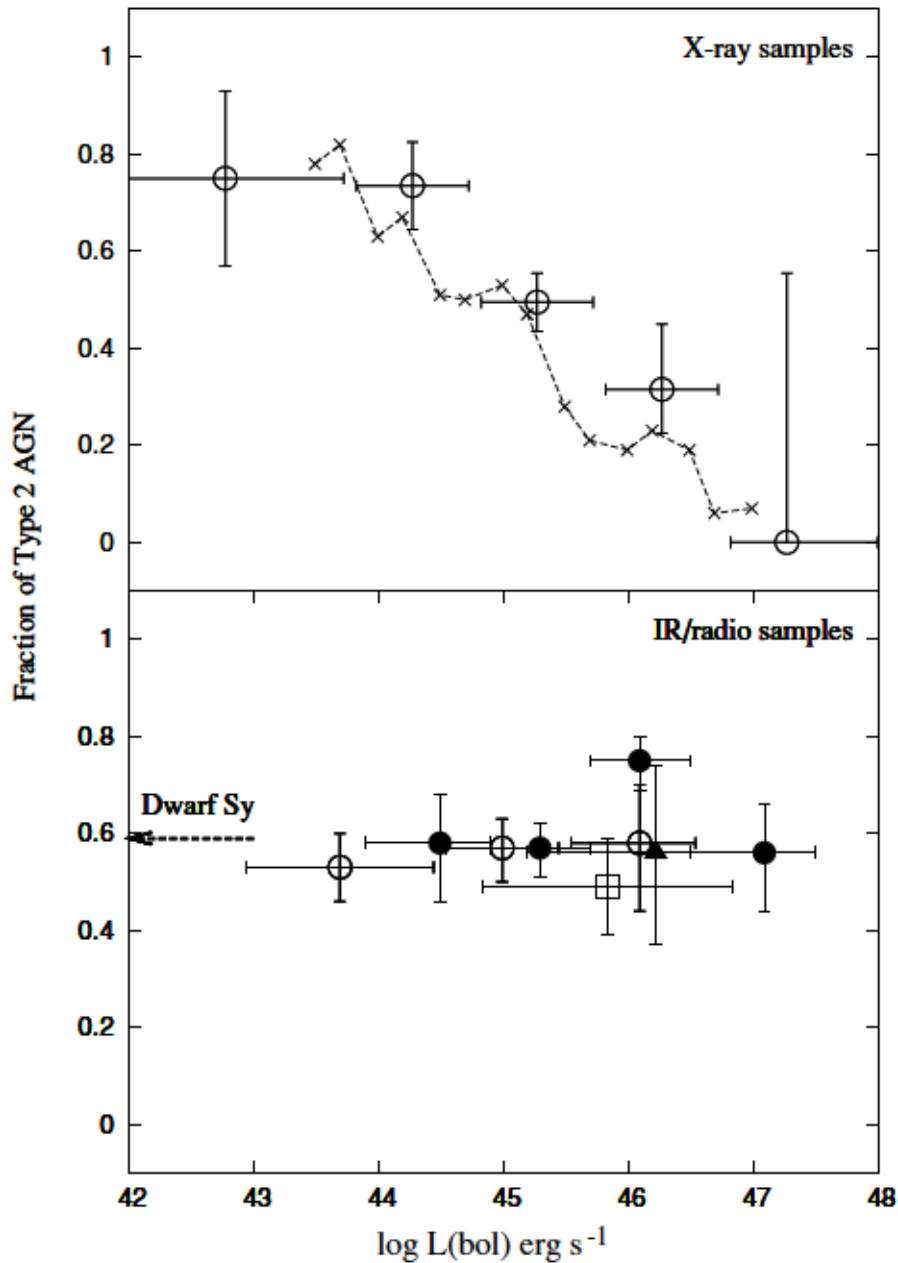
... and in X-ray (below 10 keV) surveys



Hasinger 2008

(Chandra, XMM, ASCA, HEAO-1)

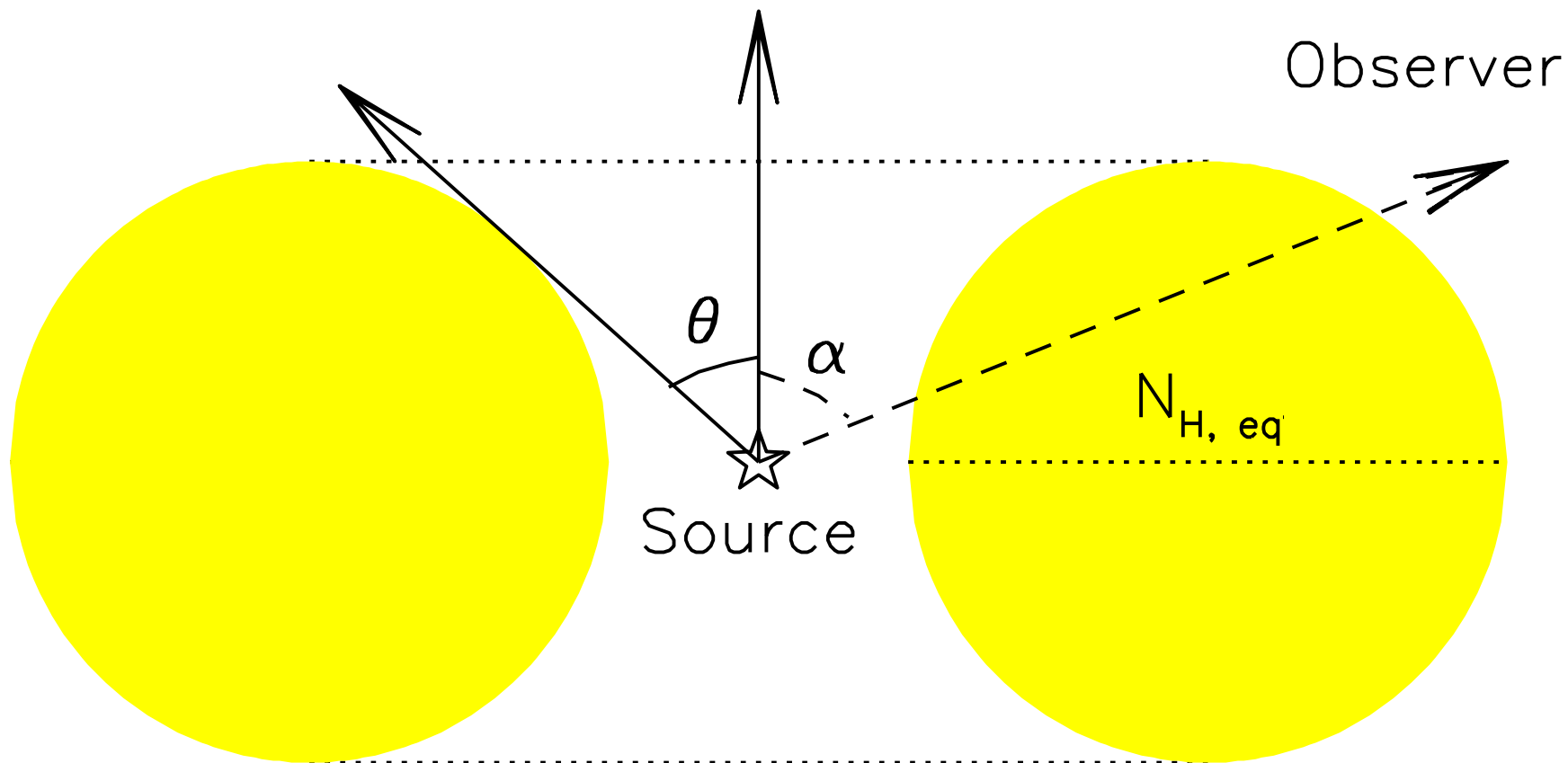
AGN obscuration vs luminosity



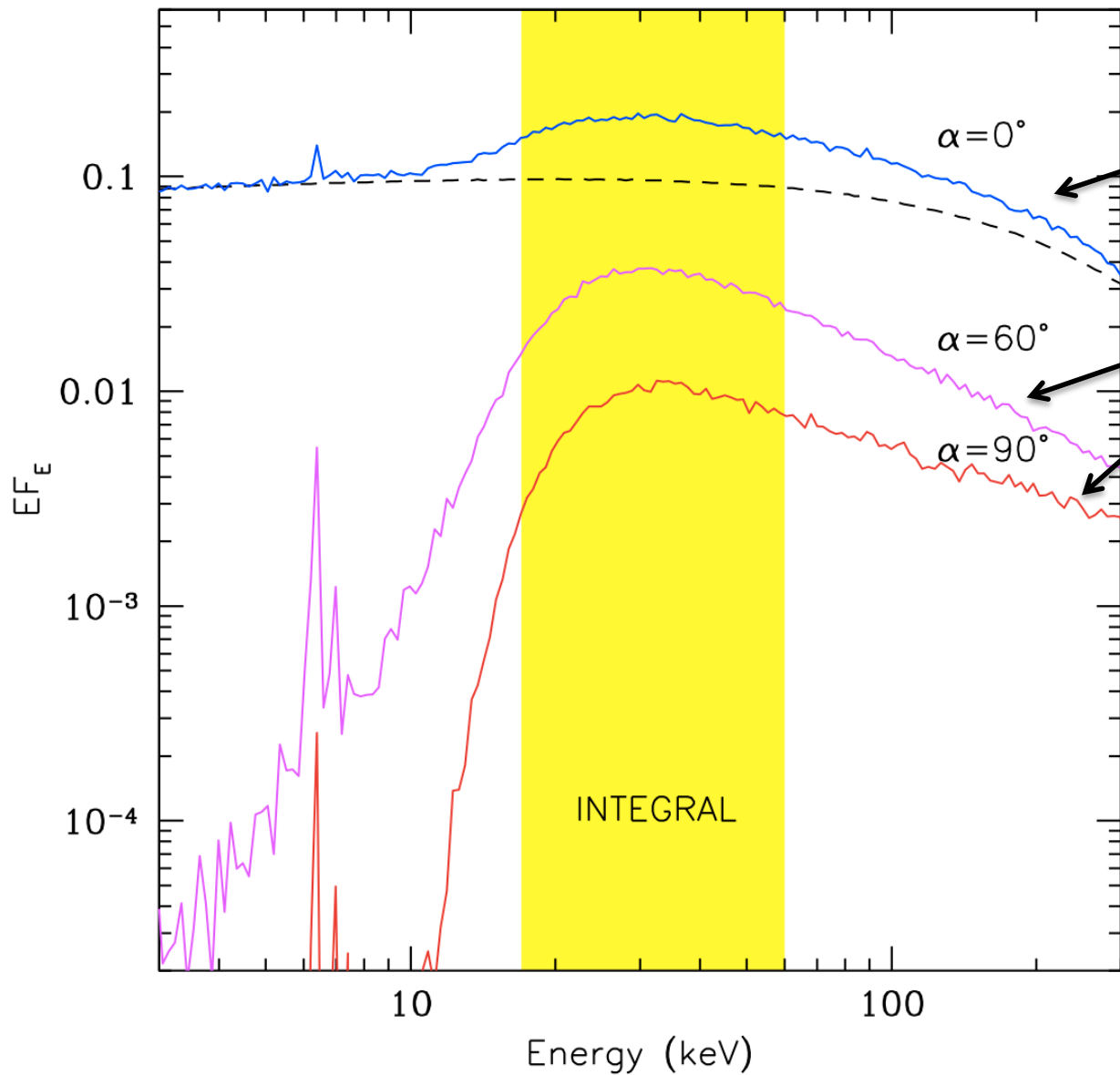
Discrepancy with IR/radio selected samples?

A selection effect?

Propagation of hard X-rays through TORUS



isotropic emission, $\theta=30^\circ$, $N_{\text{H,eq}}=10^{25}$

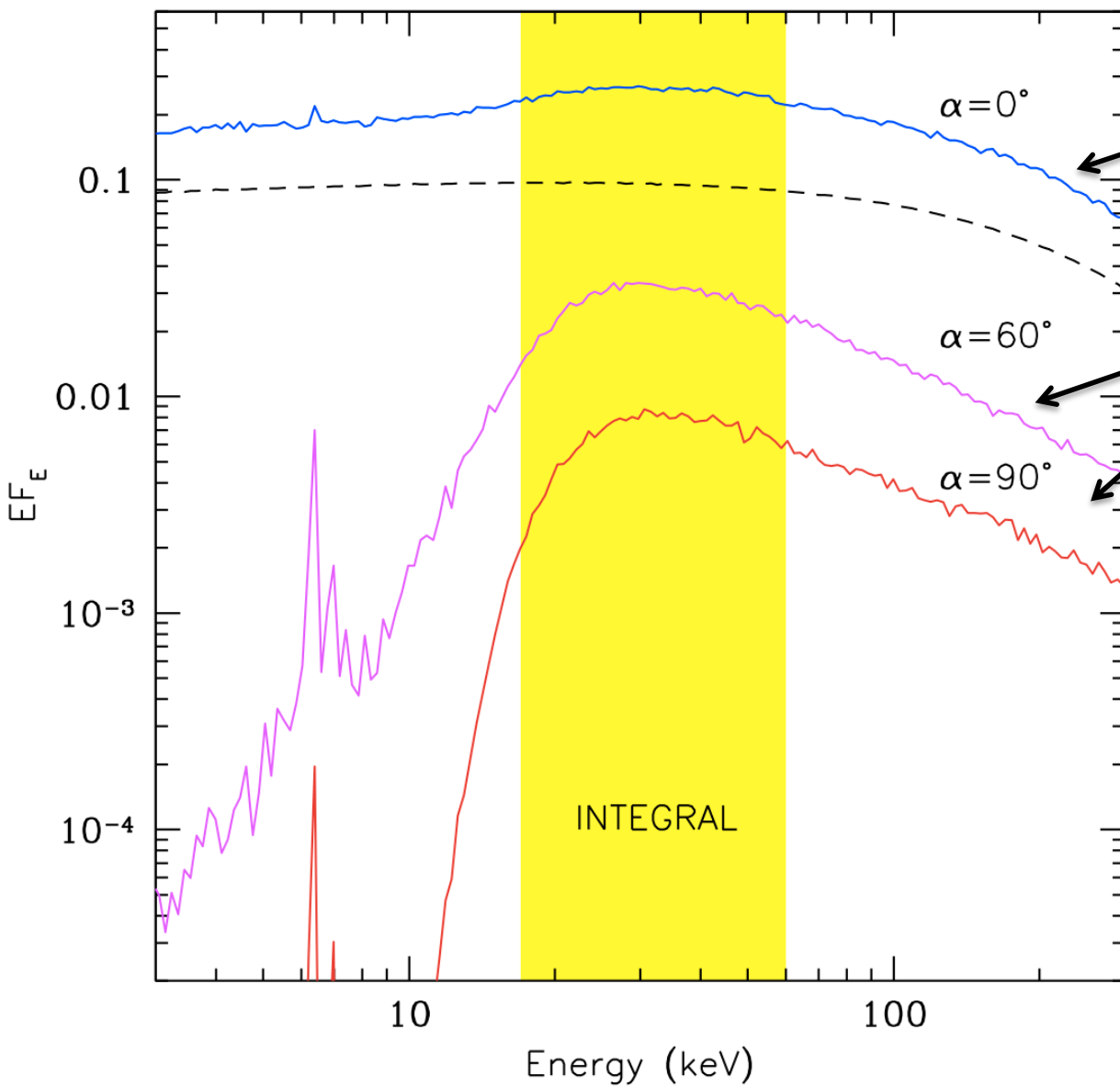


AGN-1

AGN-2

$$\frac{dL}{dW} = \text{const}$$

cosine law, $\theta=30^\circ$, $N_{\text{H,eq}}=10^{25}$



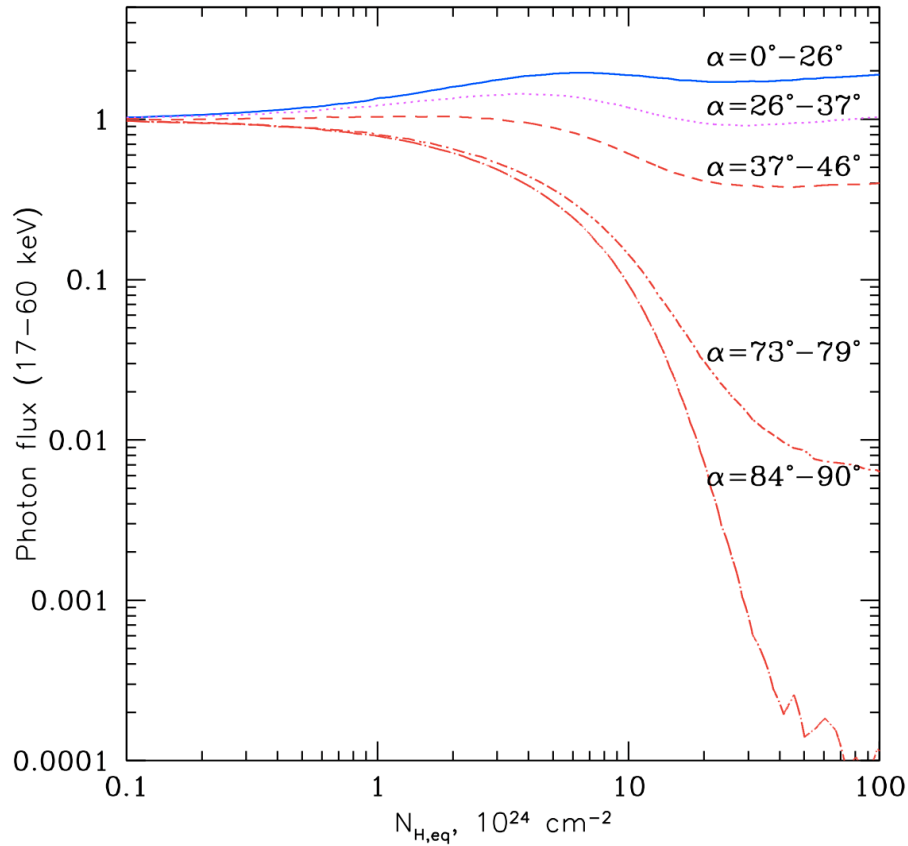
AGN-1

AGN-2

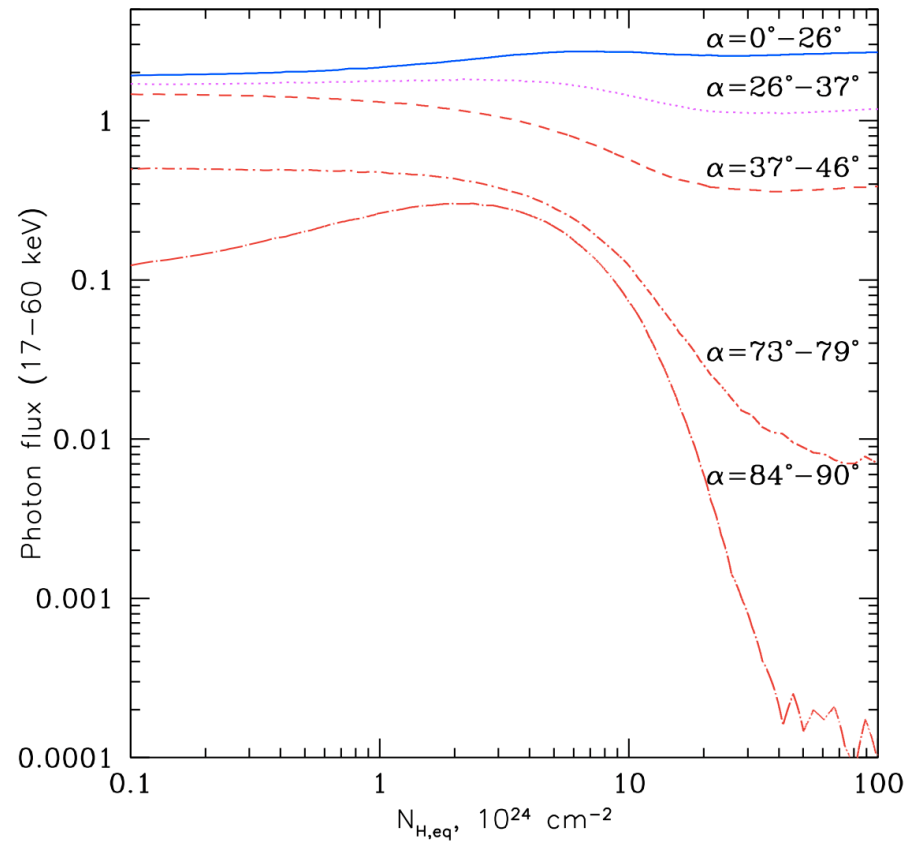
$$\frac{dL}{dW} \propto \cos a$$

Measured hard X-ray flux as a function of viewing angle and N_{H}

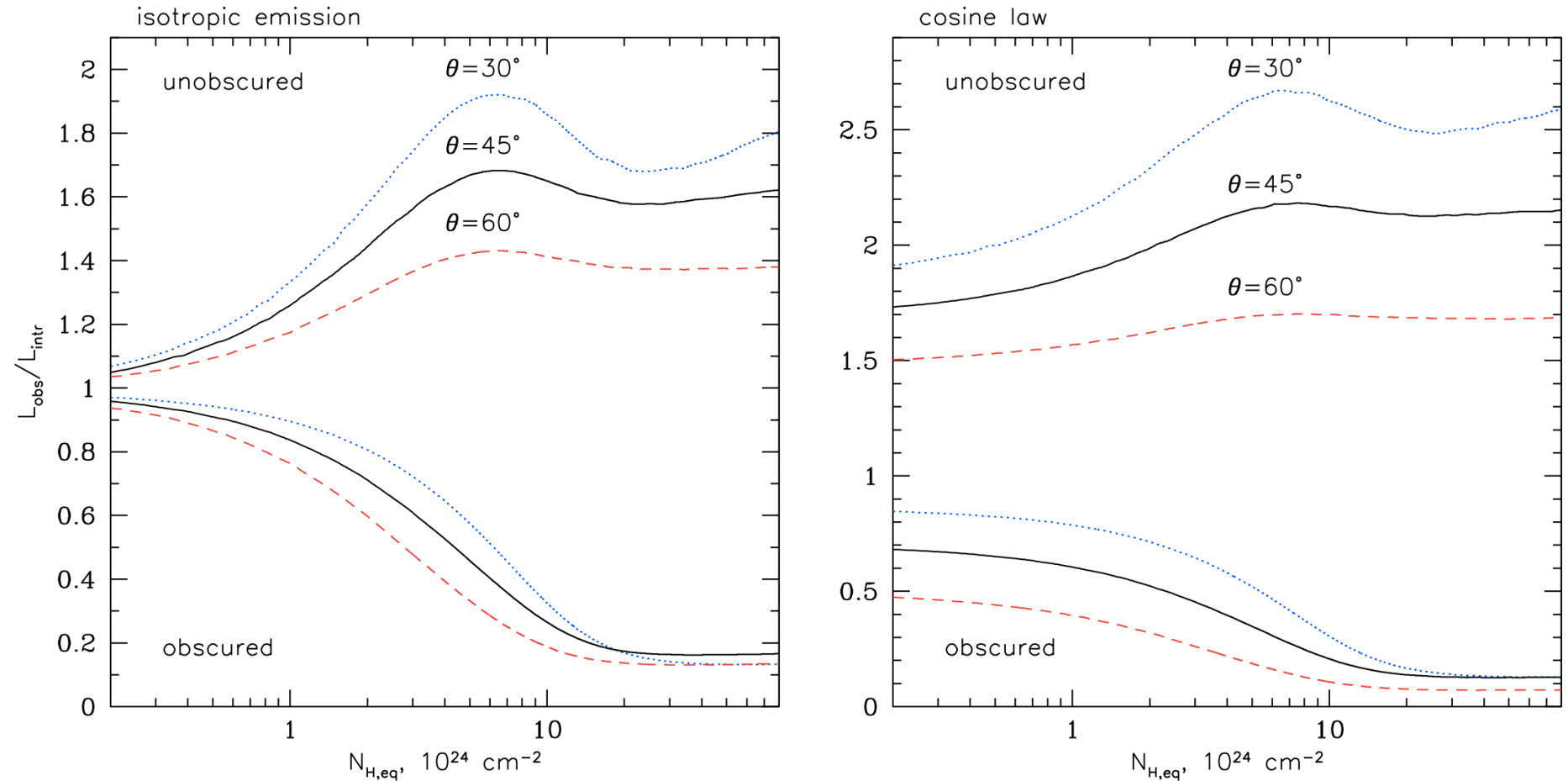
isotropic emission, $\theta=30^\circ$



cosine law, $\theta=30^\circ$

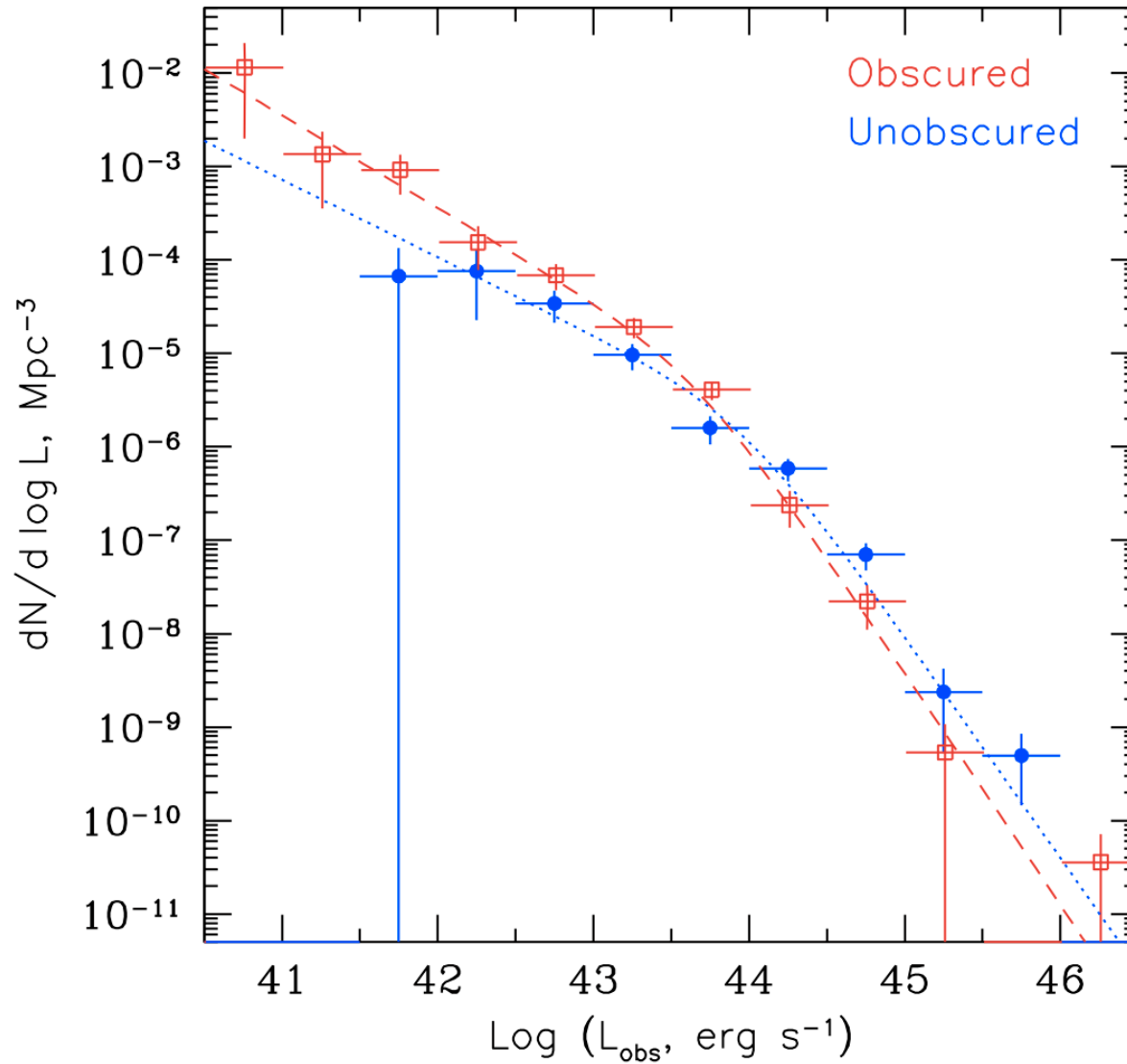


Average impact on AGN-1 and AGN-2 luminosities

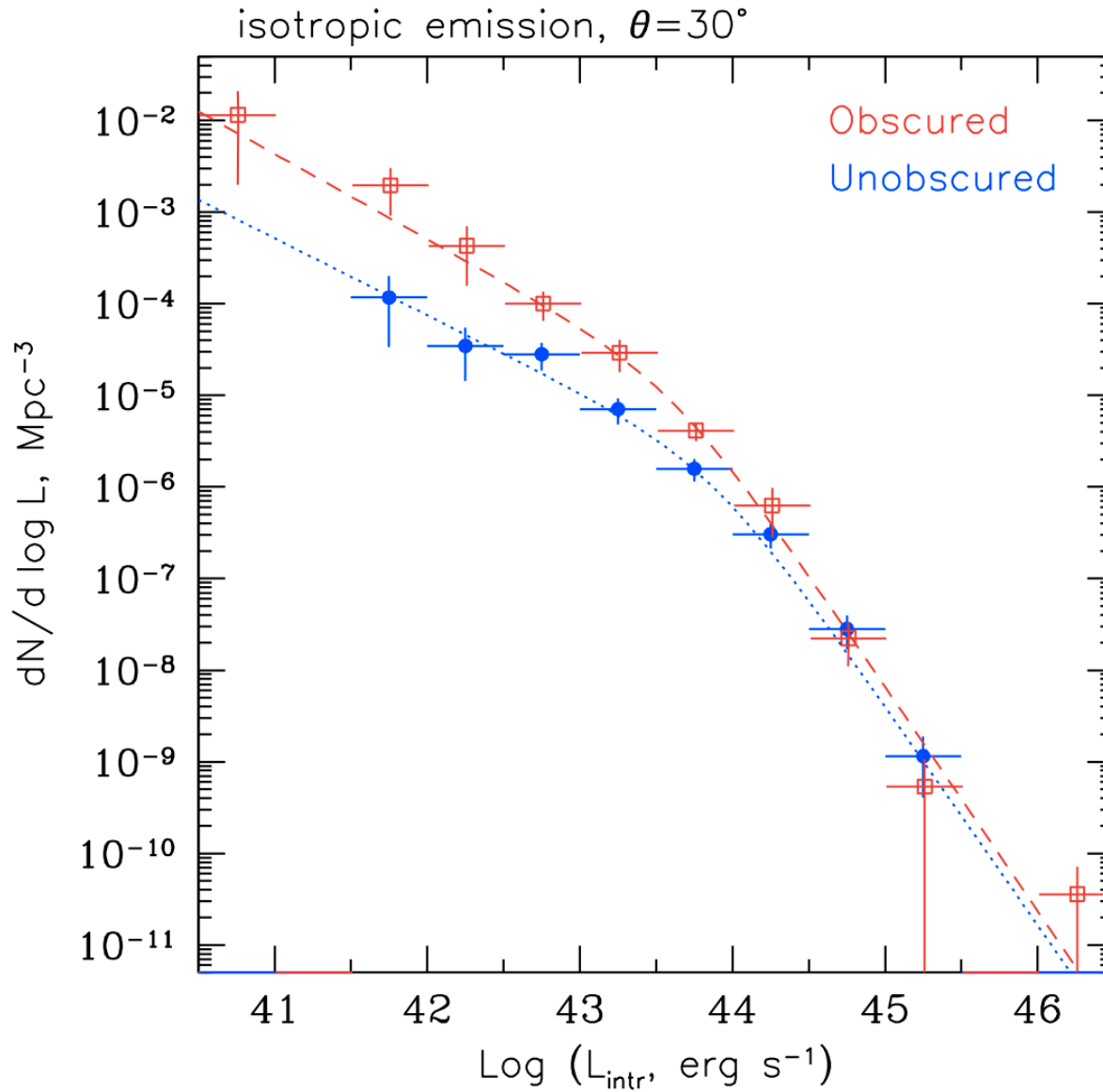


Number of detected sources is proportional to $V_{\text{max}} \sim L_{\text{obs}}^{3/2}$

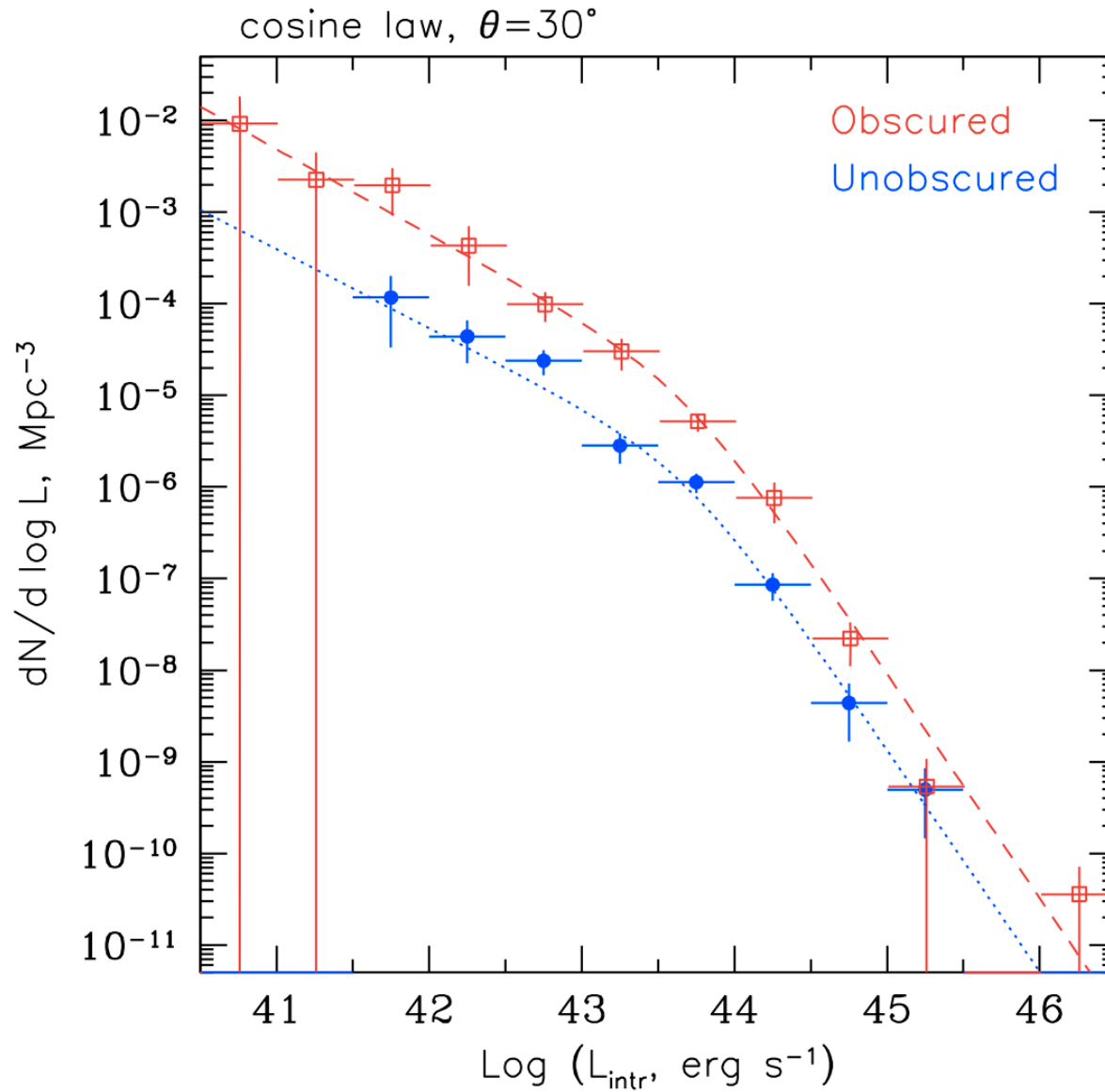
Observed AGN luminosity function



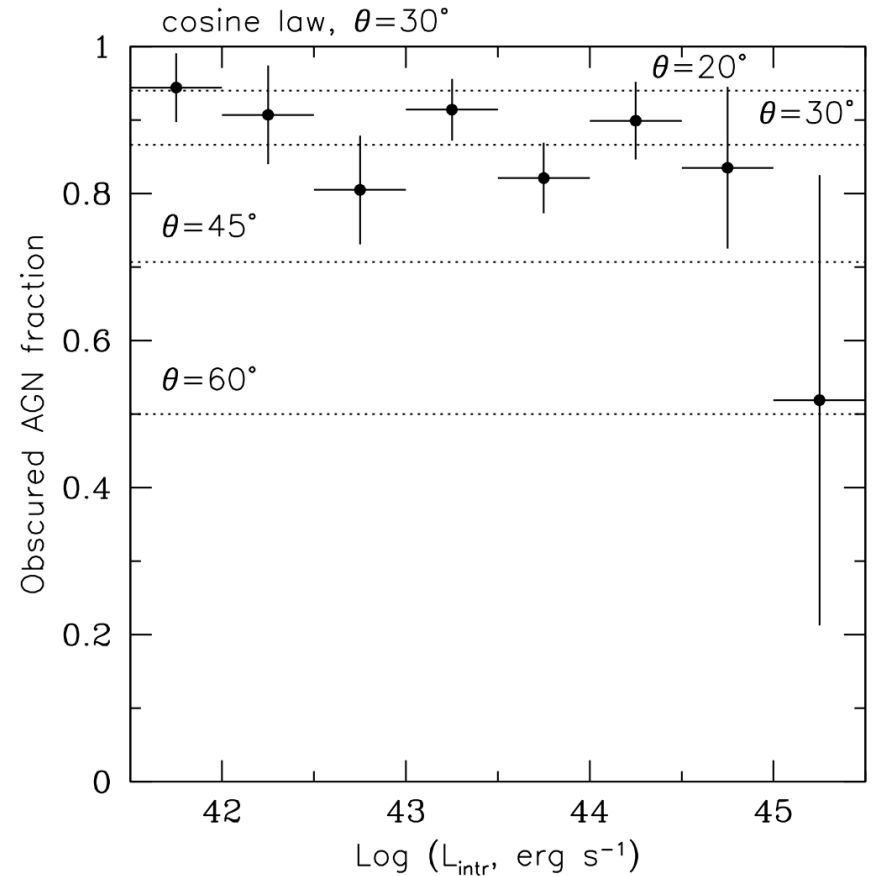
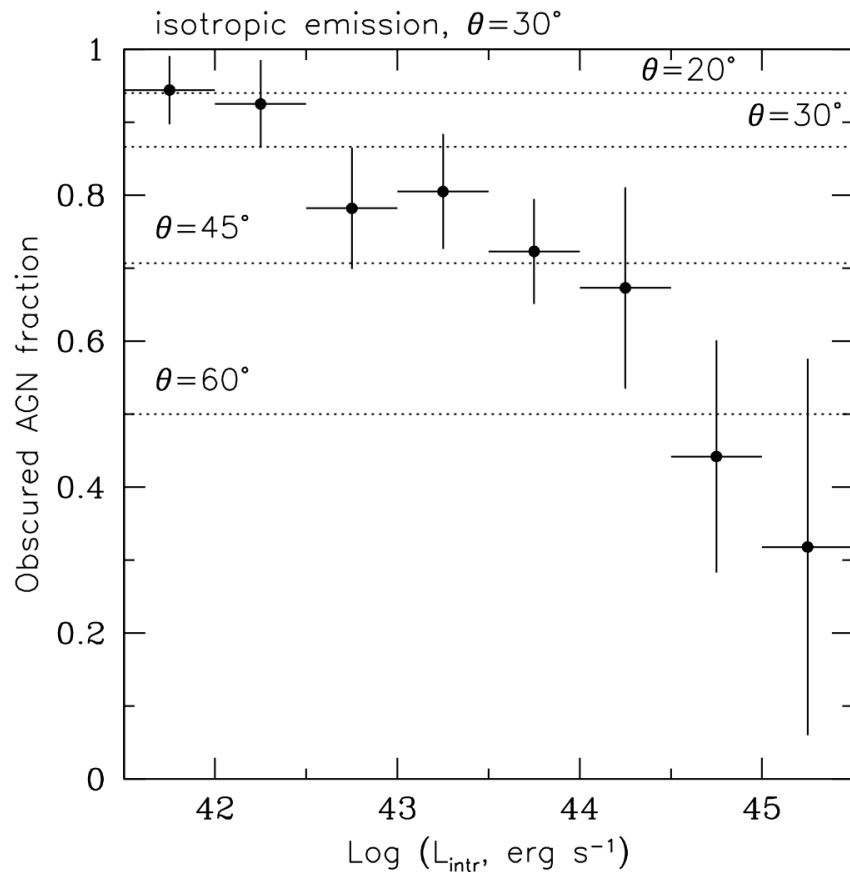
Intrinsic AGN luminosity function



Intrinsic AGN luminosity function



Intrinsic fraction of obscured AGN as a function of luminosity



Conclusions

- Observed fraction of obscured AGN decreases with luminosity.
- This trend retains when AGN counts are corrected for selection bias and assuming isotropic central source. However, the intrinsic fraction of obscured AGN is higher than observed.
- If AGN emission is moderately collimated, there is no intrinsic declining trend of obscured AGN fraction with luminosity. Constant opening angle of the Torus?

Future work:

- *Use larger local AGN samples*
- *Uniform spectral analysis for N_H estimation*
- *Comparison with clumpy torus models*
- *Extension to higher z and standard X-ray band*