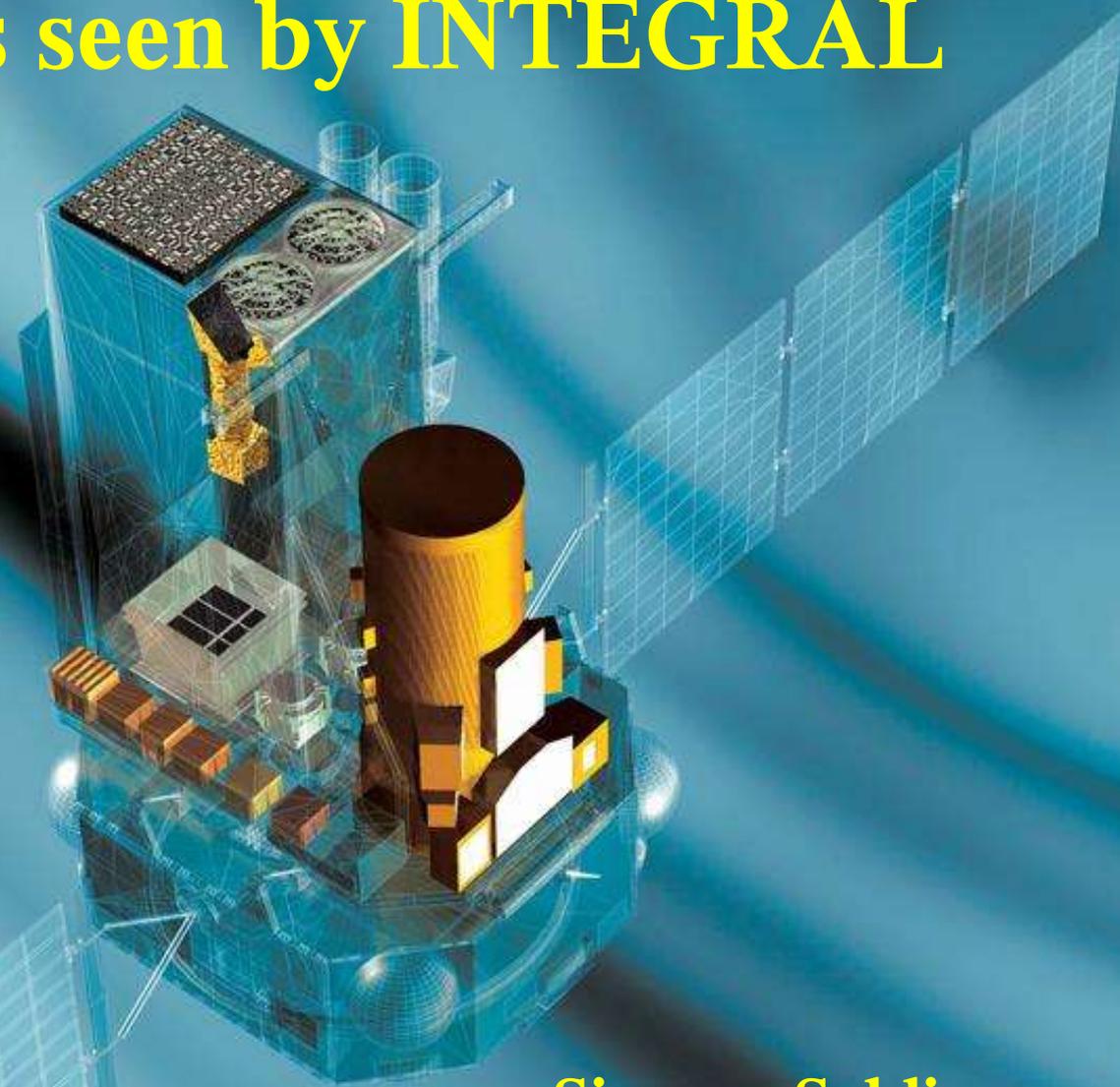
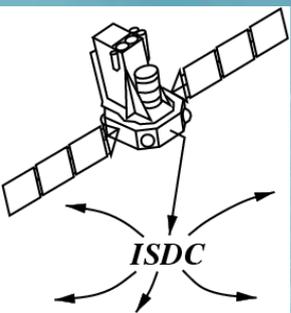


# Hard X-ray emission of AGN as seen by INTEGRAL

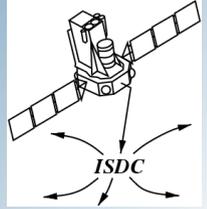


**Simona Soldi**  
**INTEGRAL Science Data Centre**

Astrophysical Spring School, Cargèse, Corsica, 3-14 April, 2006



# INTEGRAL contribution



Signature of **Comptonisation in Seyfert** galaxies

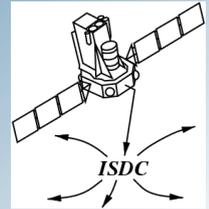
→ Studies of single objects

**Absorbed sources/Seyfert 2** dominant at 20-100 keV ?

→ Population studies

# INTEGRAL AGN Catalog

Beckmann, Gehrels, Shrader, Soldi 2006, ApJ 638, 642  
Beckmann, Soldi, Gehrels, Shrader, Produit 2006, submitted to ApJ



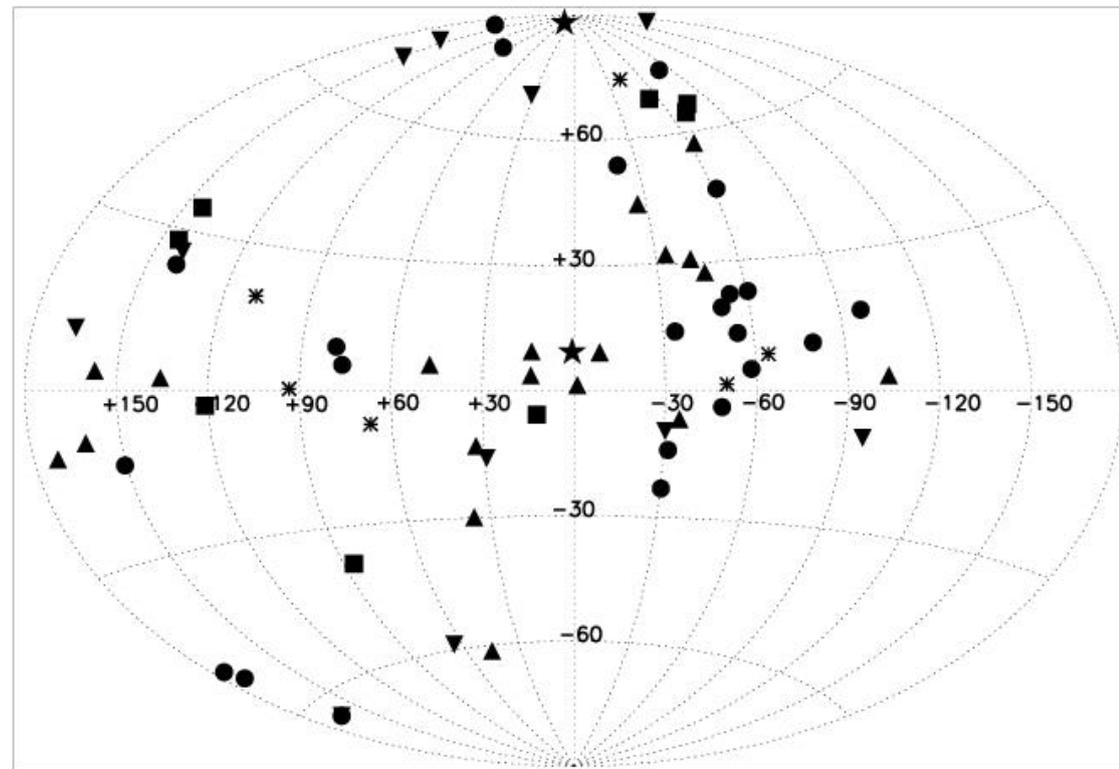
## Data:

- 1.5 years of INTEGRAL public data
- Look for AGN in ISGRI images
- Extracted images and spectra with ISGRI, SPI and JEM-X

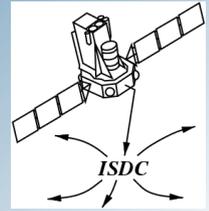
- |               |                    |
|---------------|--------------------|
| ▲ Seyfert 1   | ■ Blazar           |
| ▼ Seyfert 1.5 | ★ Galaxy Cluster   |
| ● Seyfert 2   | * Unidentified AGN |

## Objects:

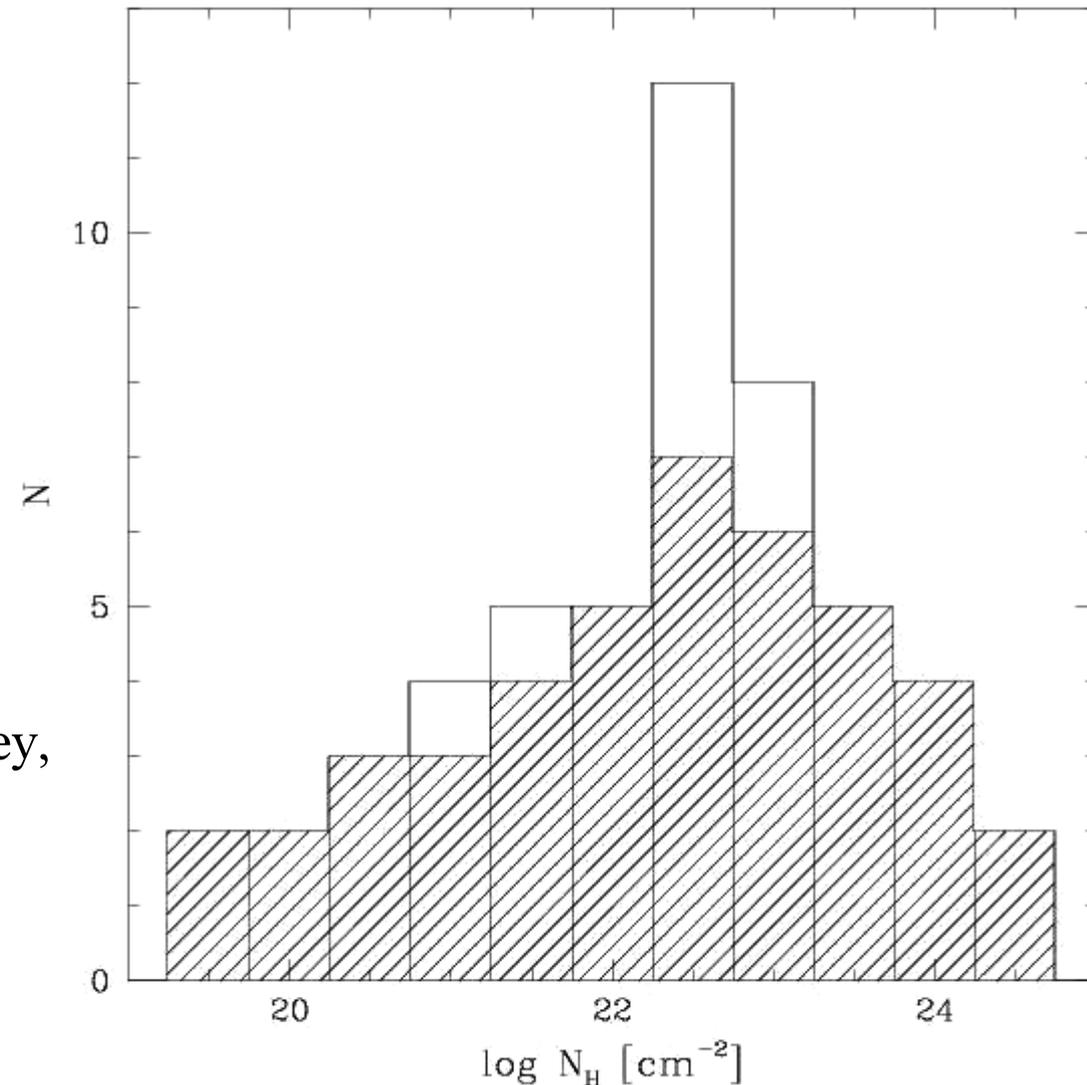
- 65 total objects (+ 3)
- 19 Sey1, 10 Sey1.5, 22 Sey2
- 7 Blazar/BL Lac
- 2 Clusters of galaxies
- 5 AGN of unknown type
- Low redshift:  $z = 0.024$
- Bright objects:  $L_x = 43.1 \text{ erg/s}$



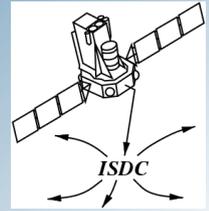
# Absorbed sources



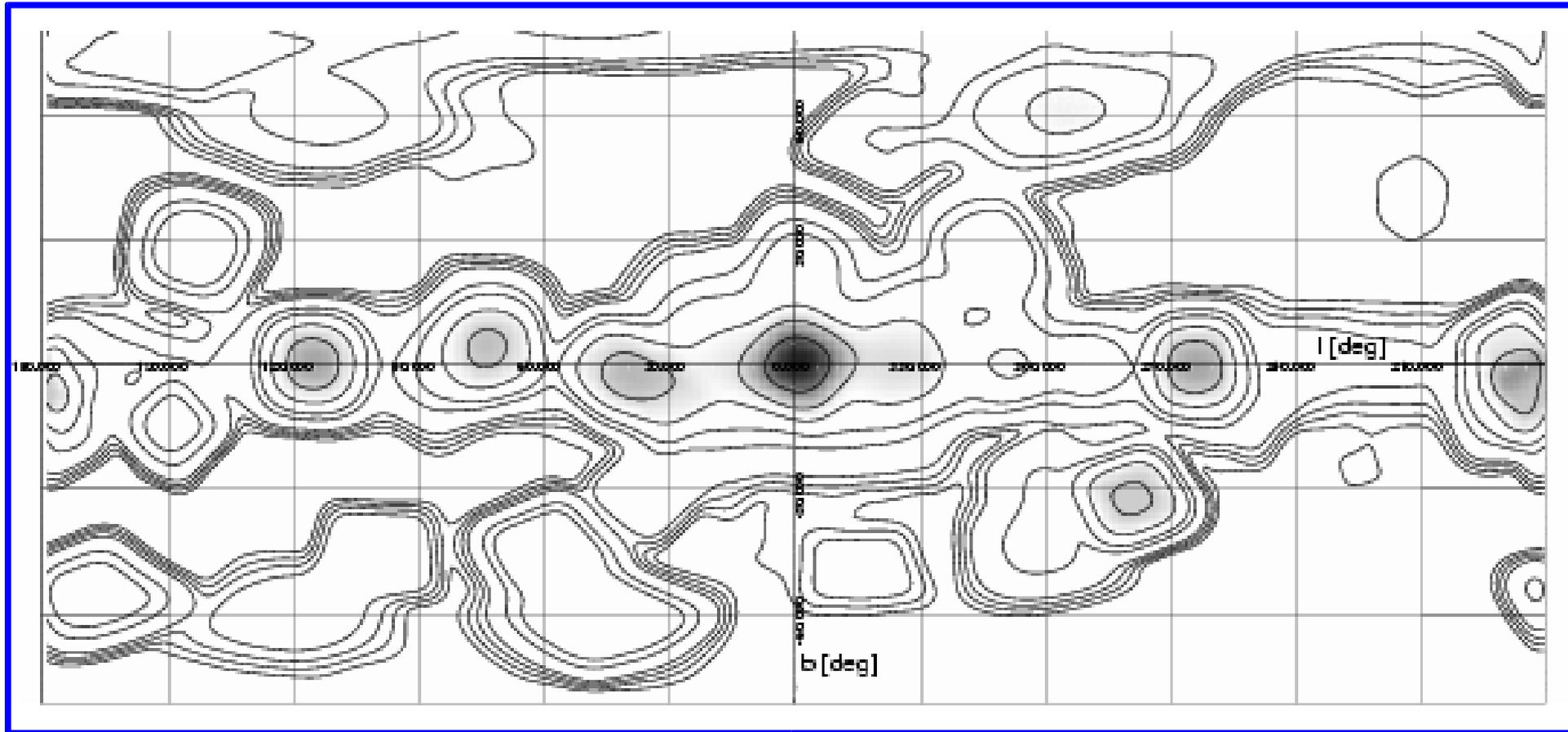
- 22 Seyfert 2, 19 Seyfert 1 ( $X=1.2$ )
- Absorbed  $\equiv N_{\text{H}} > 10^{22} \text{ cm}^{-2}$
- 27 absorbed, 23 unabsorbed ( $X=1.2$ )
- $X = 1.2 - 2.0$
- Swift/BAT High Latitude Survey, 15-200 keV,  $X = 1.5 - 2.2$  (Markwardt et al. 2005)
- INTEGRAL/IBIS Extragalactic survey, 20-100 keV,  $X = 1.9$  (Bassani et al. 2006)



# Complete AGN sample

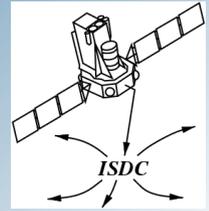


IBIS exposure map in Galactic coordinates

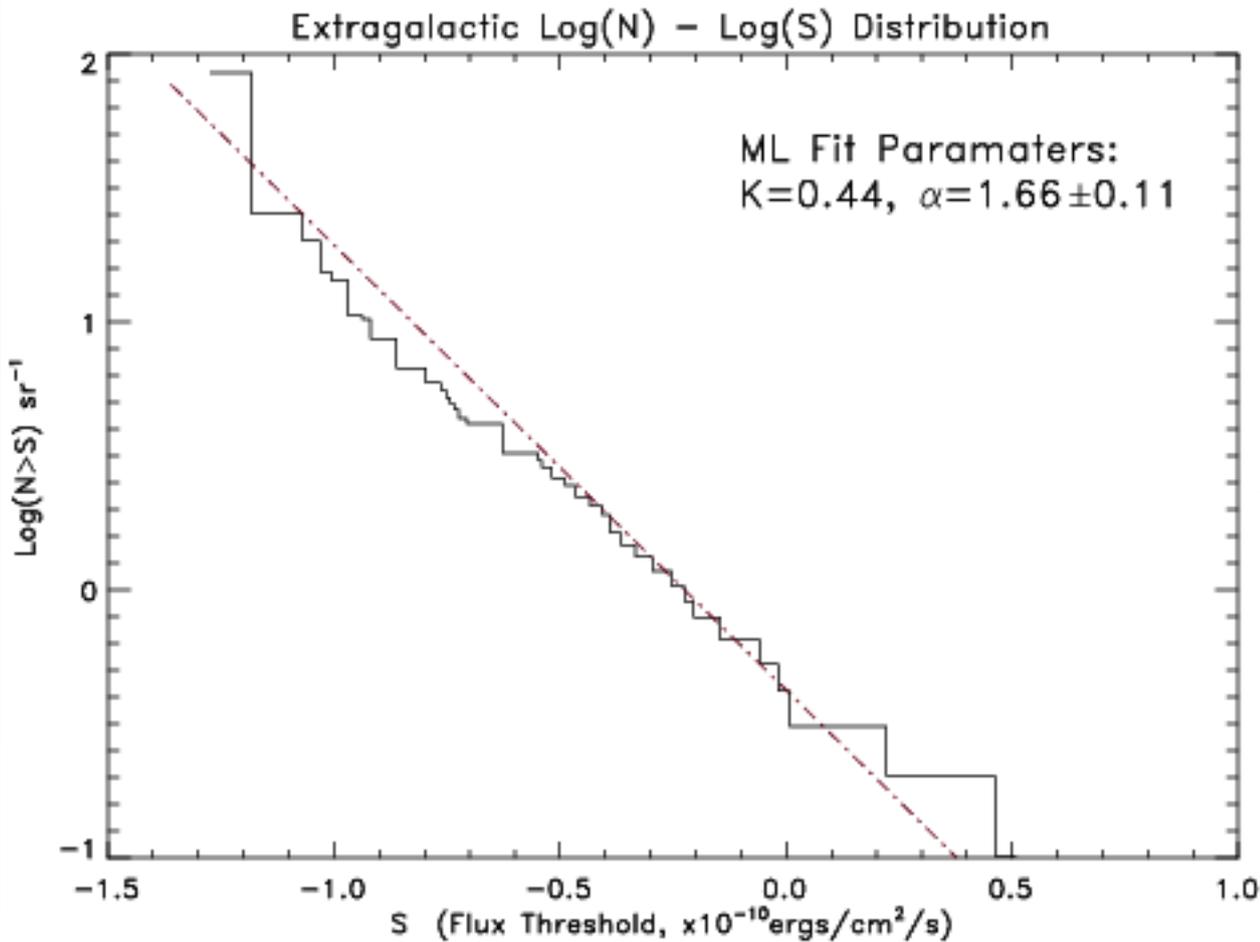


$V_e / V_a$  test: the INTEGRAL AGN sample  
is complete above 5 sigma (**38 objects**)

# Log N – Log S



INTEGRAL AGN



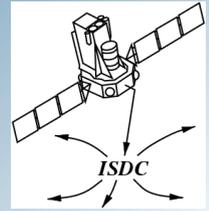
**Total AGN emitted flux:**

$$f_{20-40 \text{ keV}} = 2.6 \times 10^{-10} \text{ erg cm}^{-2} \text{ s}^{-1}$$

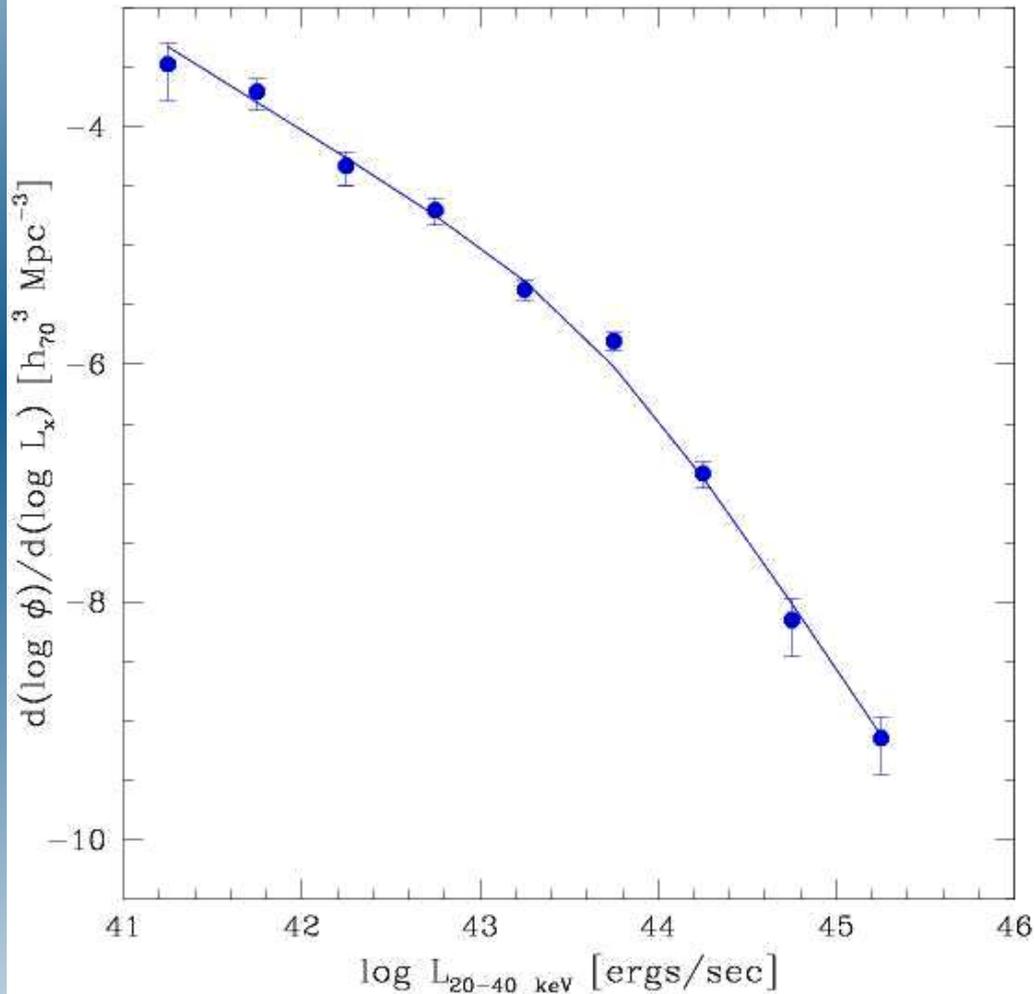
**1 % of the CXB** flux as measured by HEAO 1

→ due to the **high flux limit** of our sample

# Luminosity function



INTEGRAL AGN

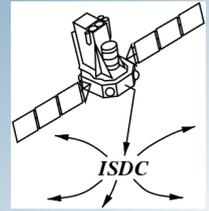


$$\frac{d\phi(L_X, z=0)}{d\log L_X} = A \left[ \left( \frac{L_X}{L_b} \right)^{\gamma_1} + \left( \frac{L_X}{L_b} \right)^{\gamma_2} \right]^{-1}$$

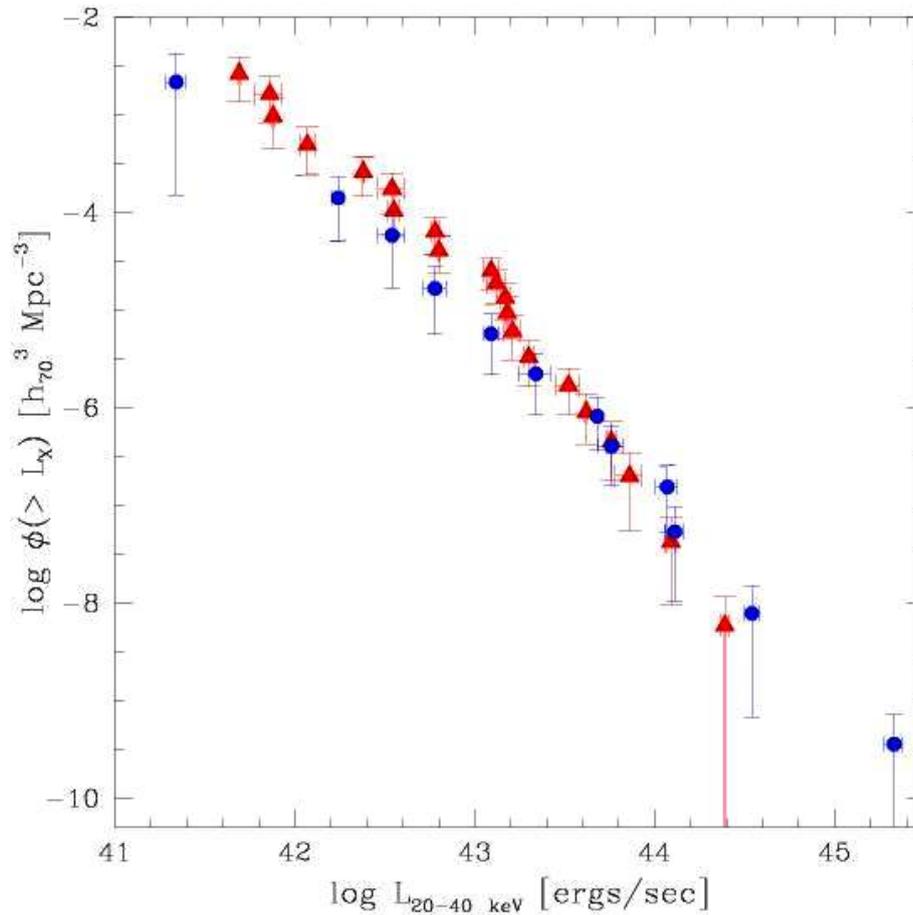
- $\gamma_1 = 0.93 \pm 0.15$ ,  $\gamma_2 = 2.23 \pm 0.15$
- $L_b = (4.6 \pm 2.0) \times 10^{43} h_{70}^{-2} \text{ erg s}^{-1}$
- Comparison with 3-20 and 2-10 keV (Sazonov & Revnivtsev 2004, Ueda et al. 2003, La Franca et al. 2005)
- ~60 % of the CXB explained
- Similar population as at lower energies

**What sources are responsible for the bump at 30 keV  
in the cosmic X-ray background?**

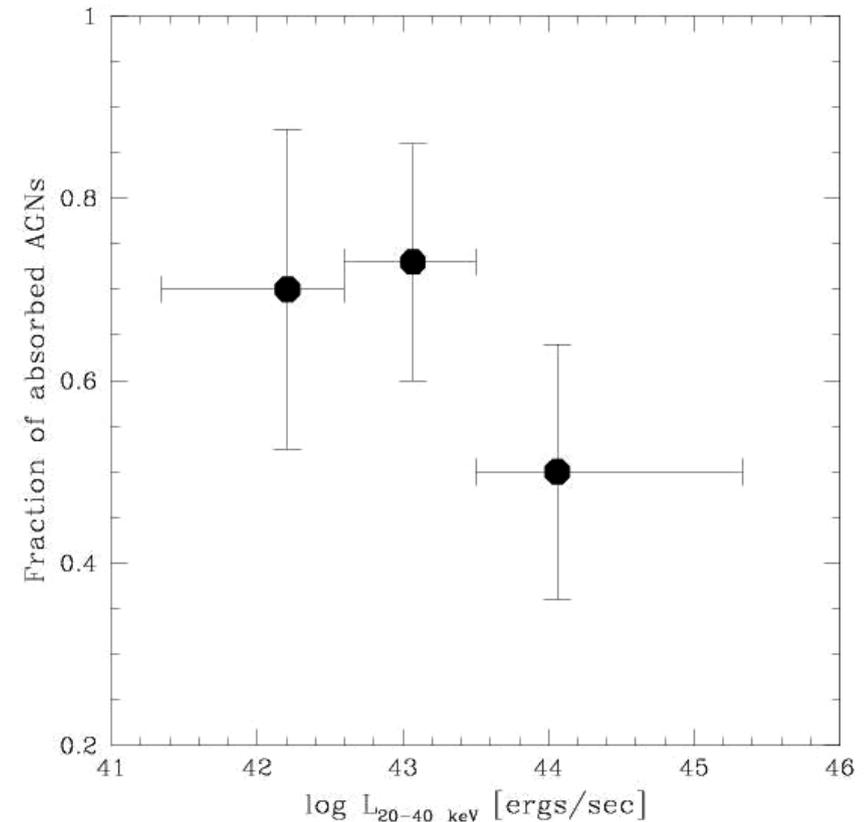
# Luminosity dependent XLF



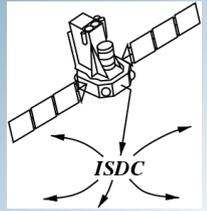
INTEGRAL AGN



- ▲ Absorbed AGN
- Unabsorbed AGN



# Conclusions

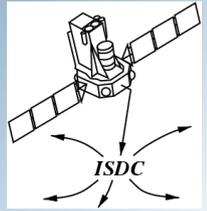


- 68 AGN detected in the first 1.5 years of INTEGRAL observations
- Detailed study for a few bright objects and population study
- Low redshift ( $z = 0.024$ ), bright sample ( $L_x = 43.1 \text{ erg/s}$ )
- No extreme overabundance of absorbed sources ( $\text{Abs/Unabs} = 1.2 - 2.0$ )
- Only 4 Compton thick AGN ( $N_H > 10^{24} \text{ cm}^{-2}$ )
- Complete sample with 38 objects
- Luminosity function: similar population as seen at lower energies

## How to account for the cosmic hard X-ray background?

- XLF depending on luminosity?
- XLF depending on redshift?
- Contribution of normal galaxies?

# AGN seen by INTEGRAL



- **Blazars** are variable – preferentially ToO objects: [S5 0716+716](#) (Pian et al. 2005), [3C 454.3](#) (Pian et al. 2006)
- **AGN seen so far:** [3C 273](#) (Courvoisier et al. 2003), [3C 279](#) (Collmar et al. 2004), [NGC 4388](#) (Beckmann et al. 2004), [NGC 4151](#) (Beckmann et al. 2005), [Circinus galaxy](#), [NGC 4945](#) (Soldi et al. 2005), [Centaurus A](#) (Rothschild et al. 2005, Soldi et al. 2005)
- **Some new AGN:** [26 IGR sources identified](#) (Masetti et al. 2004, Sazonov et al. 2005, Revnivtsev et al. 2005, Stephen et al. 2005)
- **Review papers:** Beckmann et al. 2006, Bassani et al. 2006, Bird et al. 2006