X-ray Luminosity Function of AGNs

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Collaborators on XLF Projects

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Introduction

- This poster shows some highlights of the following three recent AGN XLF projects.
  - Extended Soft X-ray (0.5-2 keV) luminosity function of (type 1) AGNs with Chandra Deep Fields data (Hasinger et al; Miyaji, Hasinger, Schmidt in prep.)
  - Complete ASCA/XMM spectroscopic followup of 49 bright AGNs (from HEAO-1 A2 Piccinotti+A1/A3 Grossan sample) and local Hard X-ray (2-10 keV) Luminosity function. (Shinozaki, Miyaji, Ishisaki, Ueda et al. in prep.)
  - Cosmological Evolution of hard XLF (Ueda, Akiyama, Ohta, Miyaji 2003 ApJ 598, 886)

Soft X-ray (0.5-2 keV) vs Hard X-ray (2-7 keV) Surveys

- Photoelectric absorption (mostly in type 2 AGNs) absorbs soft X-ray photons.
- Using the hard band-selected sample with spectroscopic (or X-ray color) information can trace the evolutions of absorbed (within Compton-thin [Log N_H [cm-2]<24 limit) and unabsorbed AGNs.

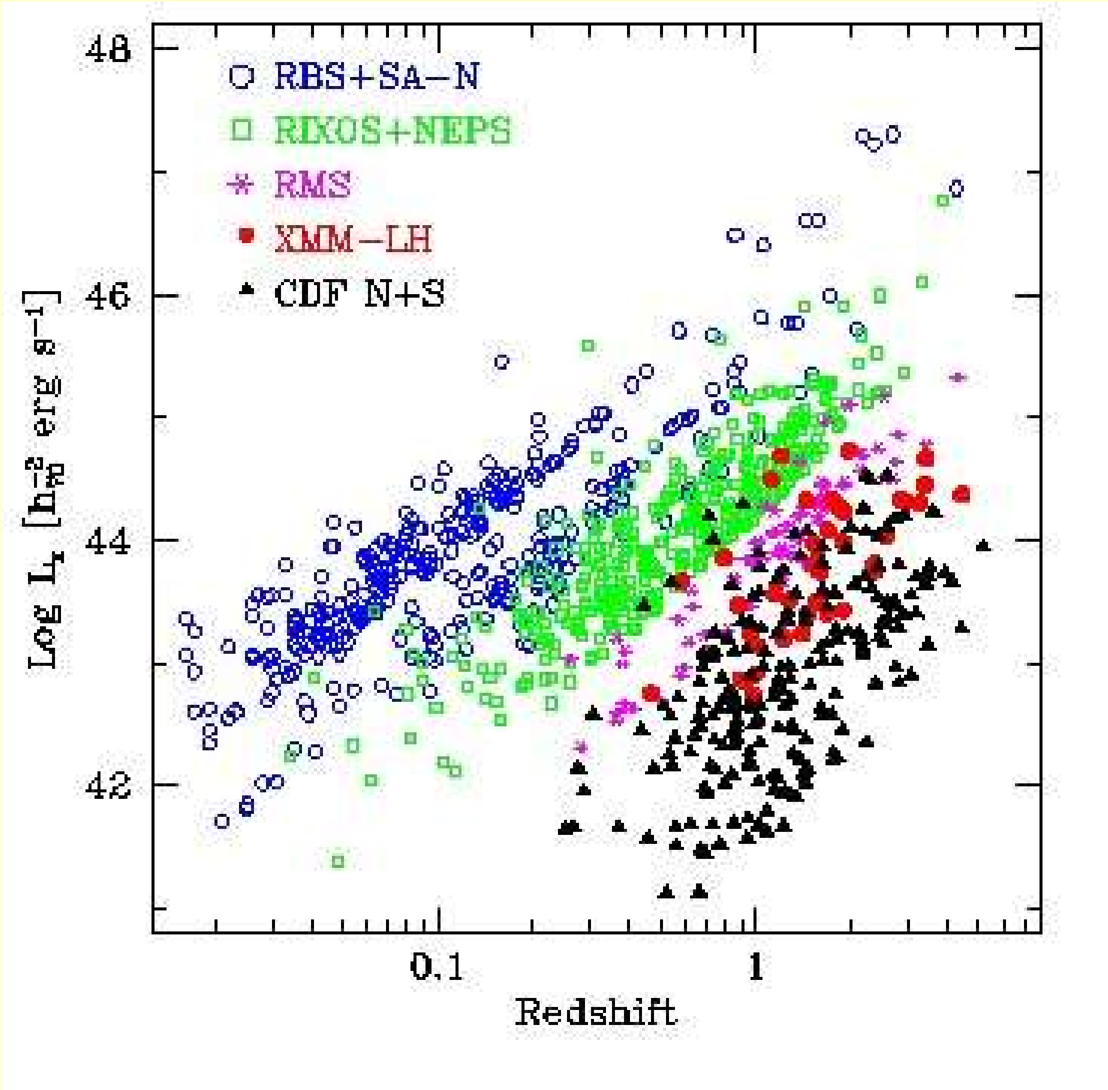
XLF from Soft X-ray Survey (SXLF) is a Complementary Probe to hard X-ray surveys

- Legacy from ROSAT surveys (Miyaji, Hasinger, Schmidt 2000; 2001).
- In Chadra Deep fields (and others), the soft (0.5-2 keV) band is an order of magnitude more sensitive than the hard (2-10 keV) band.
- Number of available objects (in luminosity function-grade surveys) and wide flux-area coverage enables us to trace the detailed structure of AGN XLF and its evolution.

Caveats in SXLF

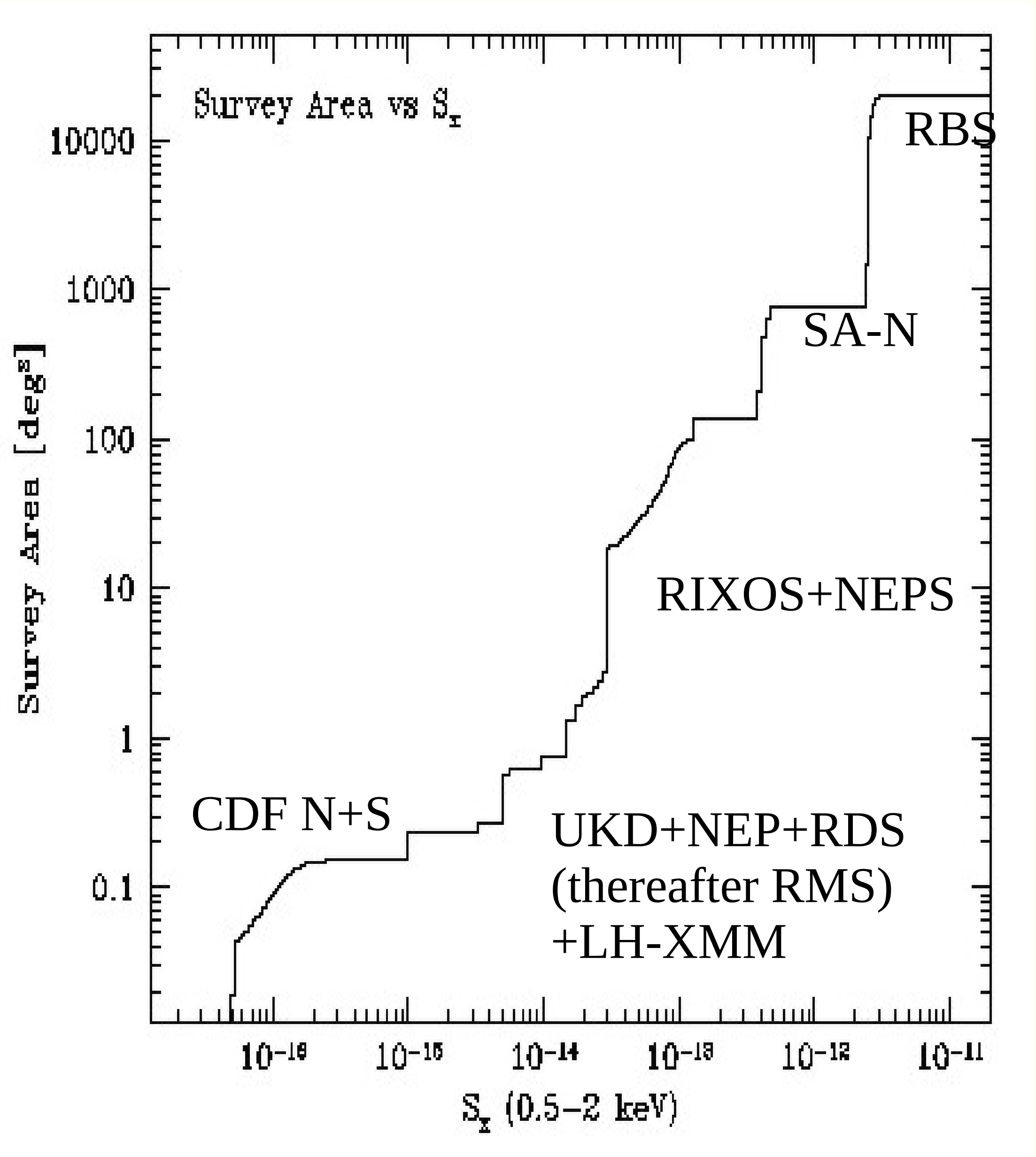
- Selects against absorbed AGNs.
- Absorbed AGNs are more likely to be in the sample at high redshift, causing mild population shift of population as a function of redshift.
- Selection of the sample must be carefully examined if a SXLF is used for, e.g. population synthesis modeling.
- Joint analysis of soft and hard X-ray selected samples is an important next step.

Soft X-ray Sample: Selection



- Current sample limited to heterogeneously defined type I AGNs (X-ray hardness and optical properties)
- ROSAT sample updated and revised. Total 794 AGNs
- XMM-Newton Survey on Lockman Hole, 42 AGNs.
- Chandra Deep Field - South and North. Chandra type I selection: optical+X-ray hardness ratio. Total 212 Chandra AGNs
- **Total of 1032 AGNs**

Survey Limits and Areas

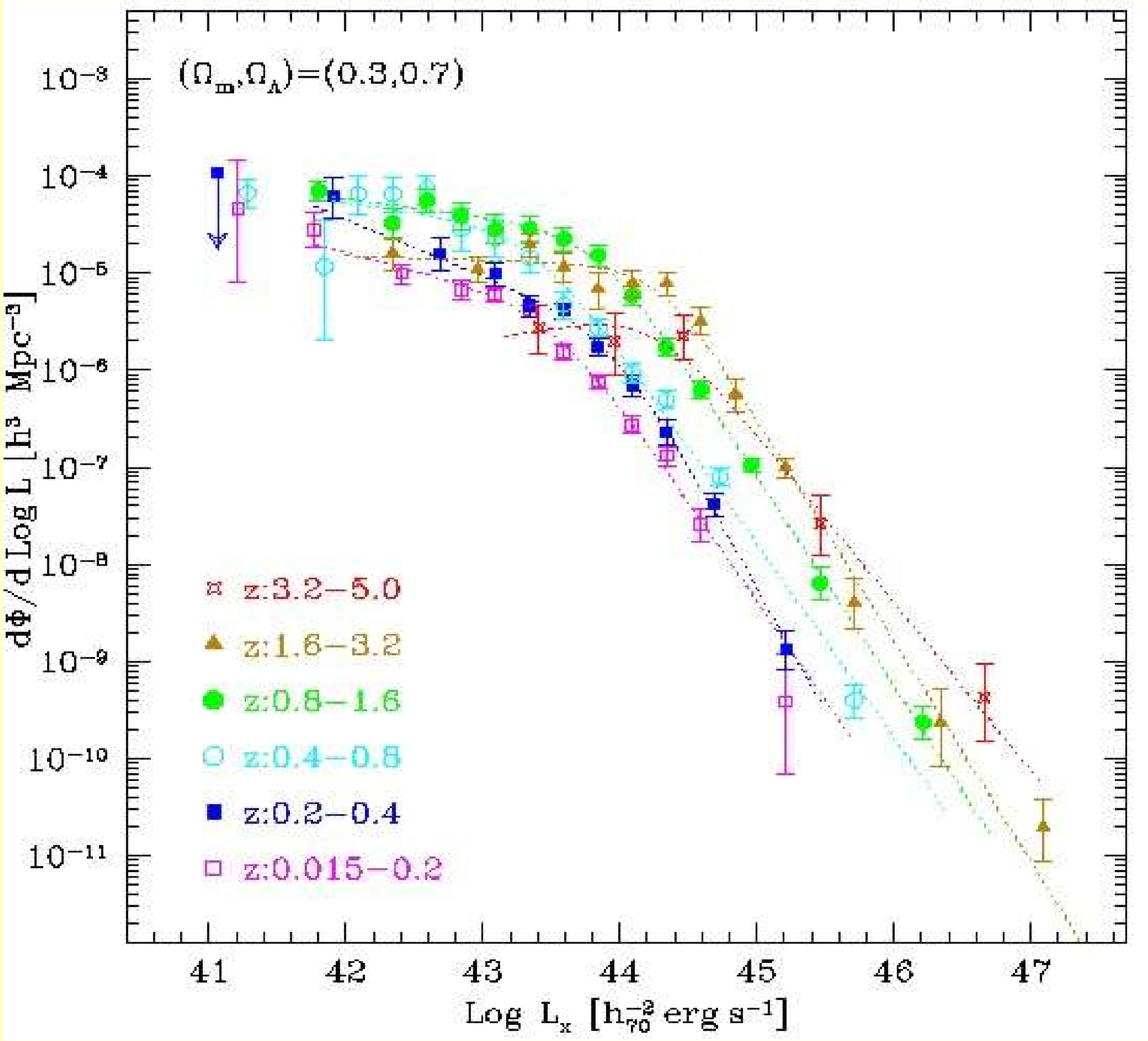


- ROSAT Bright Survey (RBS; Schwope et al. 2000, AN 321, 1)
- Selected Area-North (SA-N; Appenzeller et al 2000,A&A 364,443)
- ROSAT North Ecliptic Pole Survey (NEPS; Gioia et al. astro-ph/0309788)
- ROSAT International X-ray Optical Survey (RIXOS; Mason et al. 2000,MN 311, 456)
- UK DEEP Survey (UKD;McHardy et al. 1998, MN 295, 641)
- North Ecliptic Pole (NEP;Bower et al. 96, MN 281,59.)
- ROSAT DEEP Survey(RDS) -- Marano Field (Zamorani et al. 1999, A&A, 346, 731) and Lockman Hole/PSPC (e.g. Schmidt et al. 1998 A&A, 329, 495)
- XMM-Newton Lockman Hole (Mainieri et al. 2002 A&A, 393, 425)
- Chandra Deep Field-North (Barger et al., 2003, AJ 124, 1839)
- Chandra Deep Field-South (Szokoly et al. , submitted)

Incompleteness Correction

- ROSAT Samples 100%-90% complete. No reason to suspect systematic effect. In each sample, adjust effective survey area (divide by completeness).
- XMM and Chandra Samples: Firstly take the same method (~80% complete).
- Most unidentified XMM/Chandra sources are optically faint ($R>24$). Their redshift distribution may be skewed. Plot upper bounds: these unidentified XMM/CXO sources are assigned, in duplicate, the central redshift of each bin ($z>1$).

Soft X-ray Luminosity Function



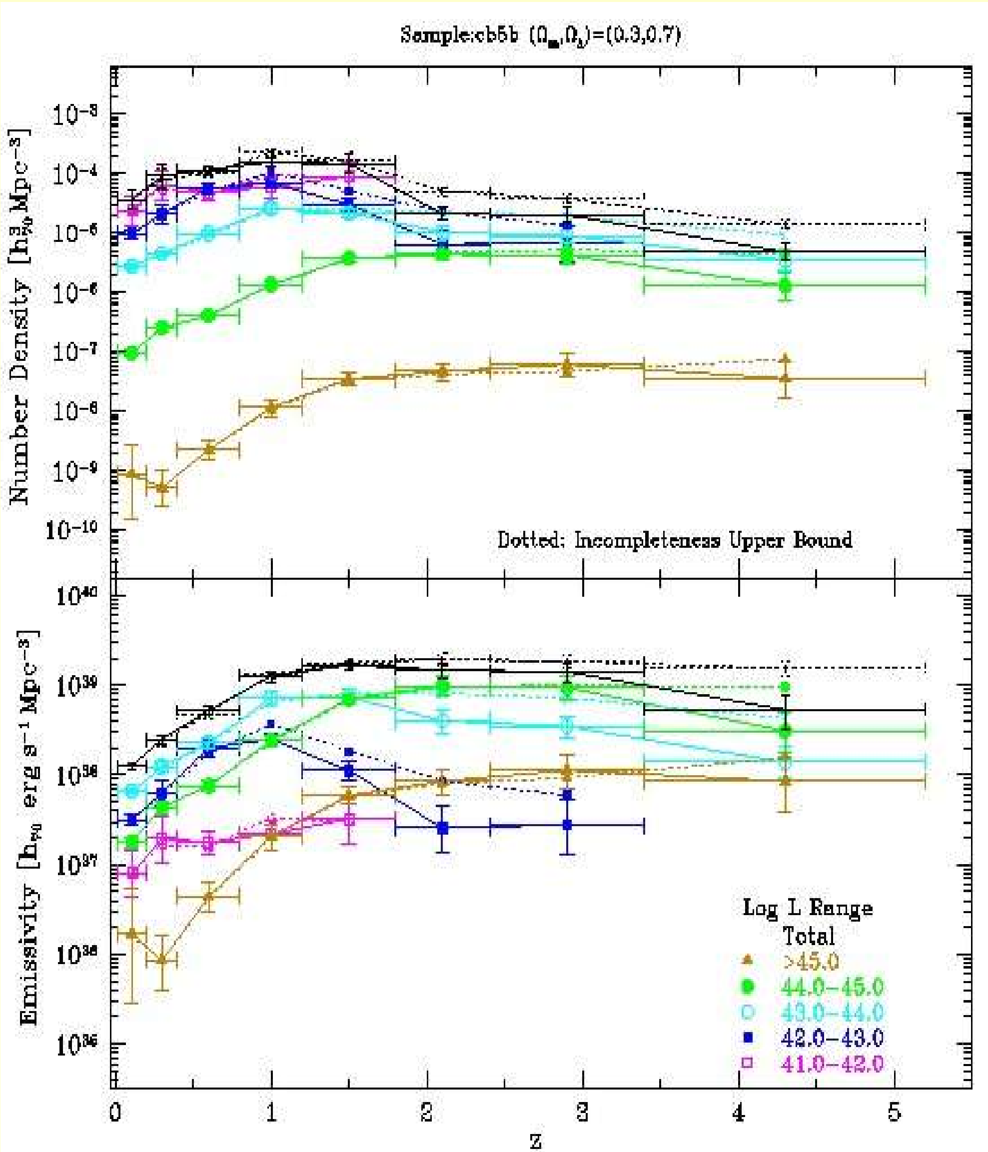
Smoothed 2-PL model

$$\mathbf{d\Phi/dLog\ L_x = [(L_x/L_*)^{\gamma 1}+(L_x/L_*)^2]^{-1}}$$

K-correction using photon index Γ=2.0

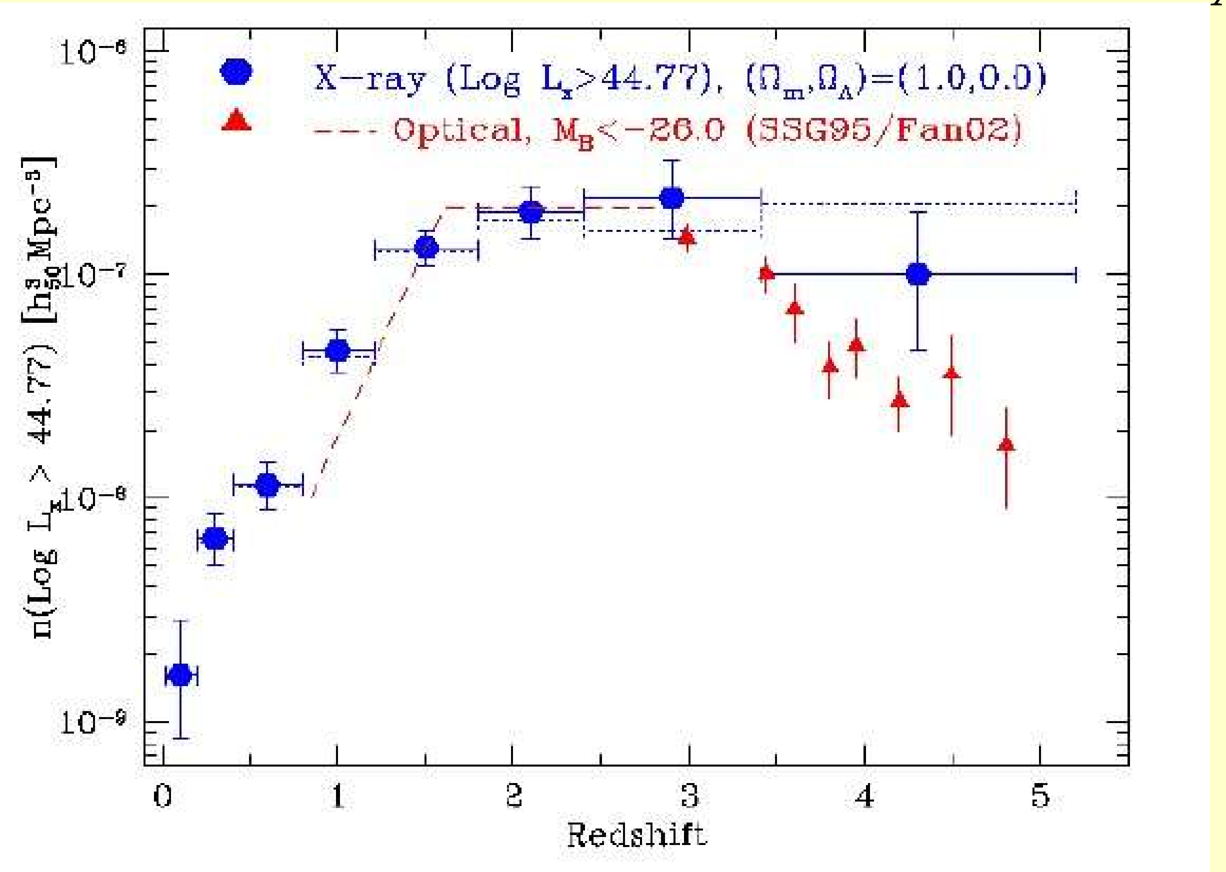
Consistent with NEITHER Pure Luminosity Evolution (PLE) nor Pure Density Evolution (PDE)

SXLF:Evolution with Redshift



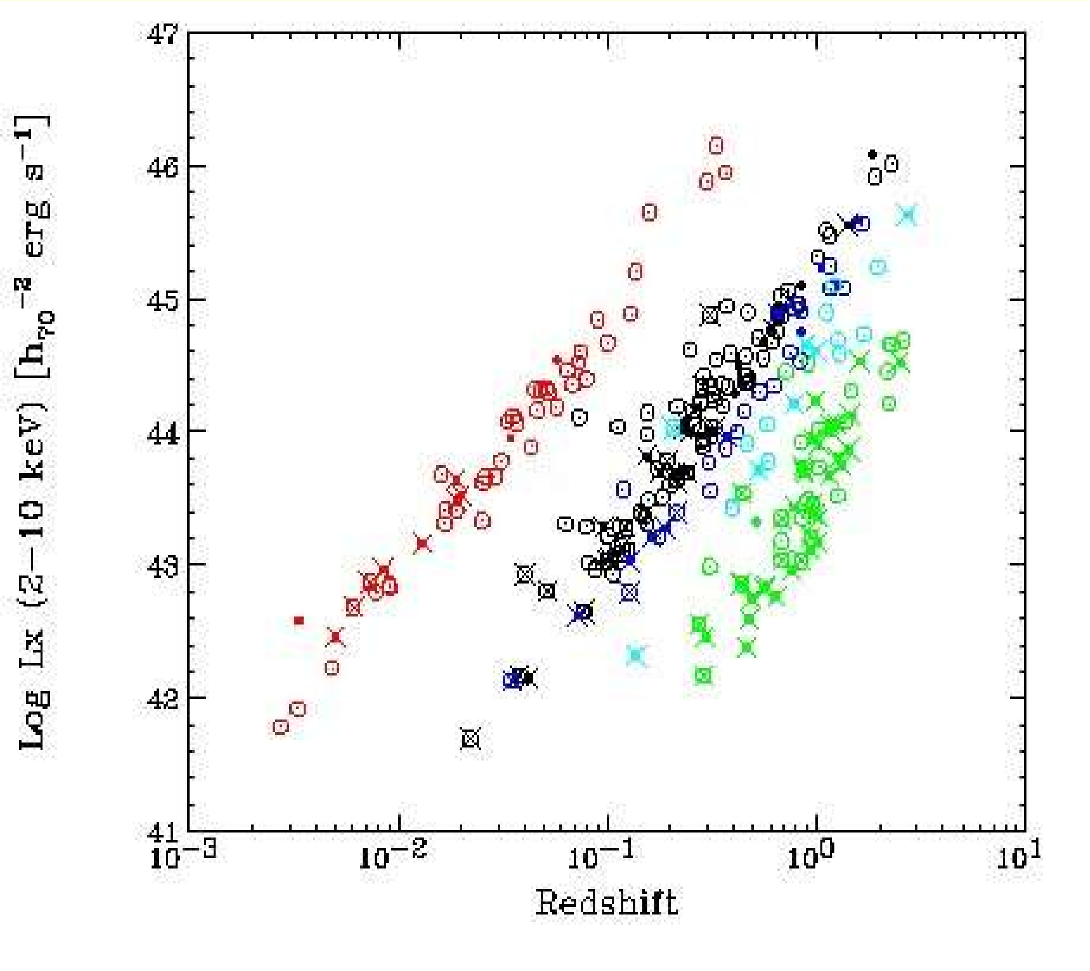
- Dotted lines: upper bounds, where unidentified XMM/CXO sources are assigned central redshift of each bin at z>1.
- Number density peaks at z<1 at low luminosities. **Detection of a decline at z>1.**
- Luminosity-dependent density evolution (>100 between z=0 to 2 at Log Lx>45, ≤ 10 at Log Lx<43)

Evolution with redshift (Log L_x >44.77)



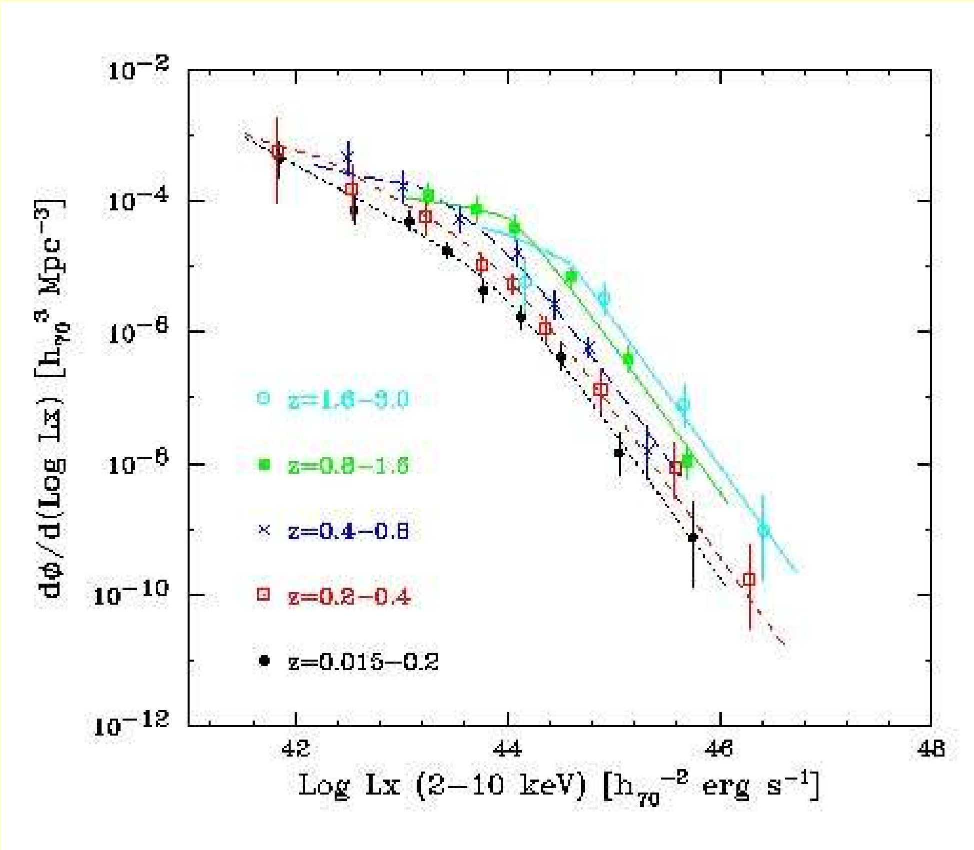
- No scaling. Lx limit adjusted to match M_B<-26 QSO number
- No evidence (yet) for decline at z>2.7 detected inoptical (Schmidt, Schneider, Gunn 95;Warren, Hewitt, Osmar; Fan et al.)

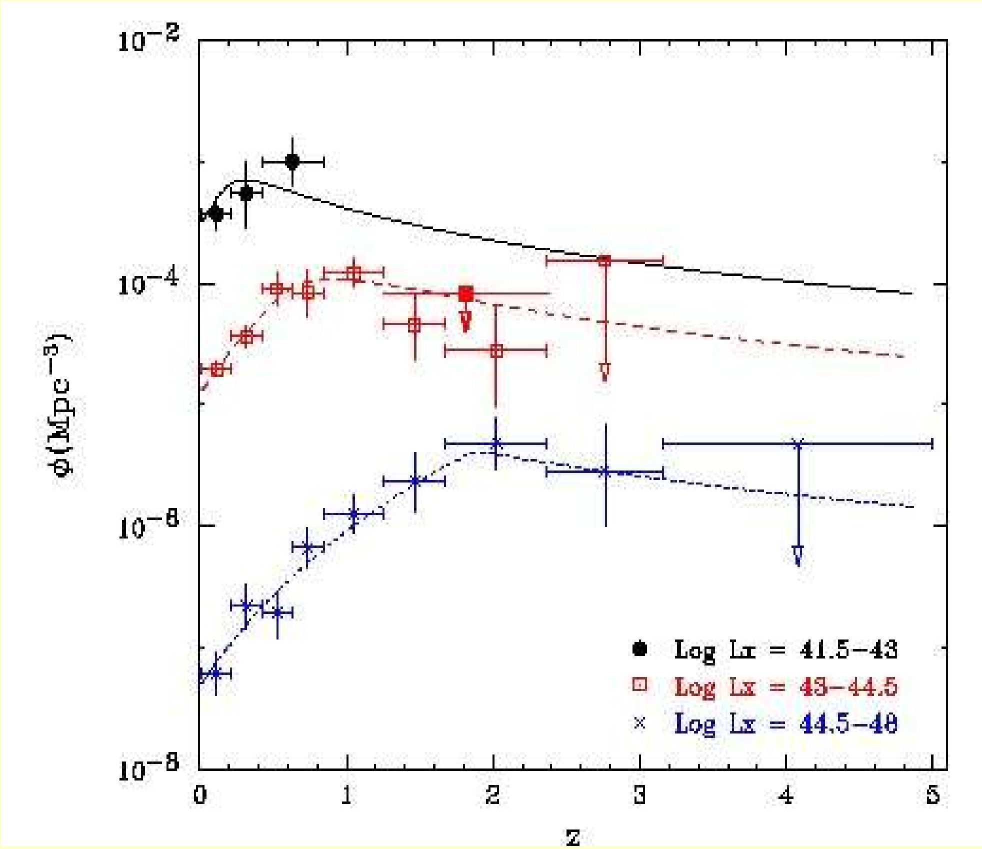
Hard X-ray LF (Ueda et al. '03) Sample



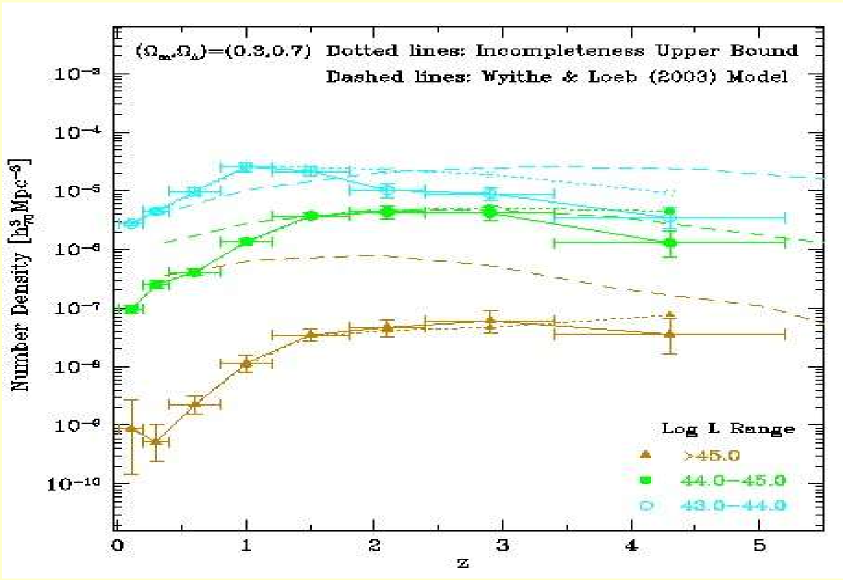
- Hard X-ray Samples of highly complete redshift identification and spectral (or HR) information.
  - HEAO-1 Piccinotti et al. ('82) + area-limited Grossan ('92)sample. Almost complete spectroscopy with ASCA/XMM, 49 AGNs
  - ASCA ALSS+AMSS+Deep Surveys (many refs including Ueda et al;Akiyama et al.; Ohta et al.; Ishisaki et al.) 141 AGNs
  - Chandra Deep Field – North from Barger et al. ('03 AJ 126, 632).
- **Total of 247 AGNs**

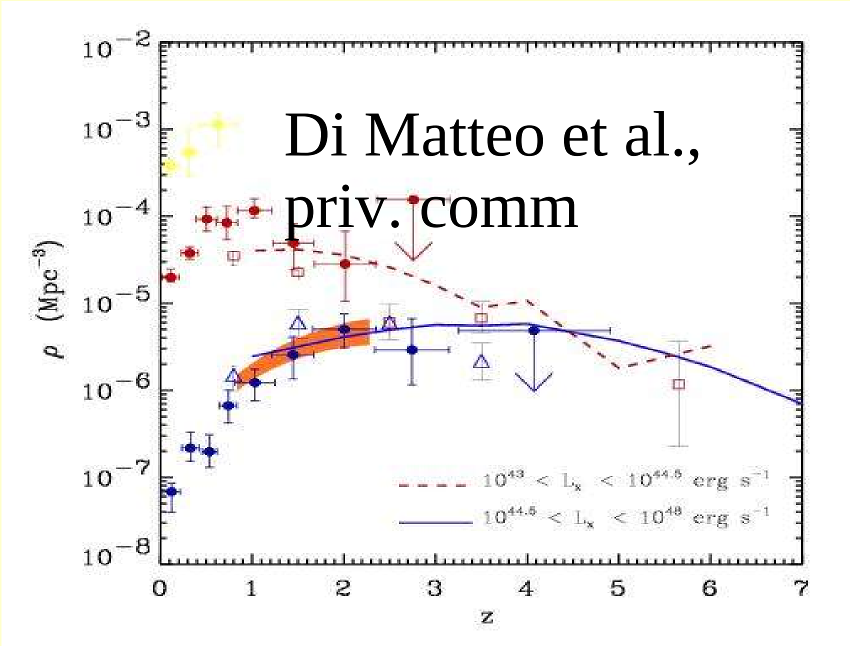
HXLF and Number Density Evolution of intrinsic (de-absorbed) XLF





Comparison with Theoretical Models



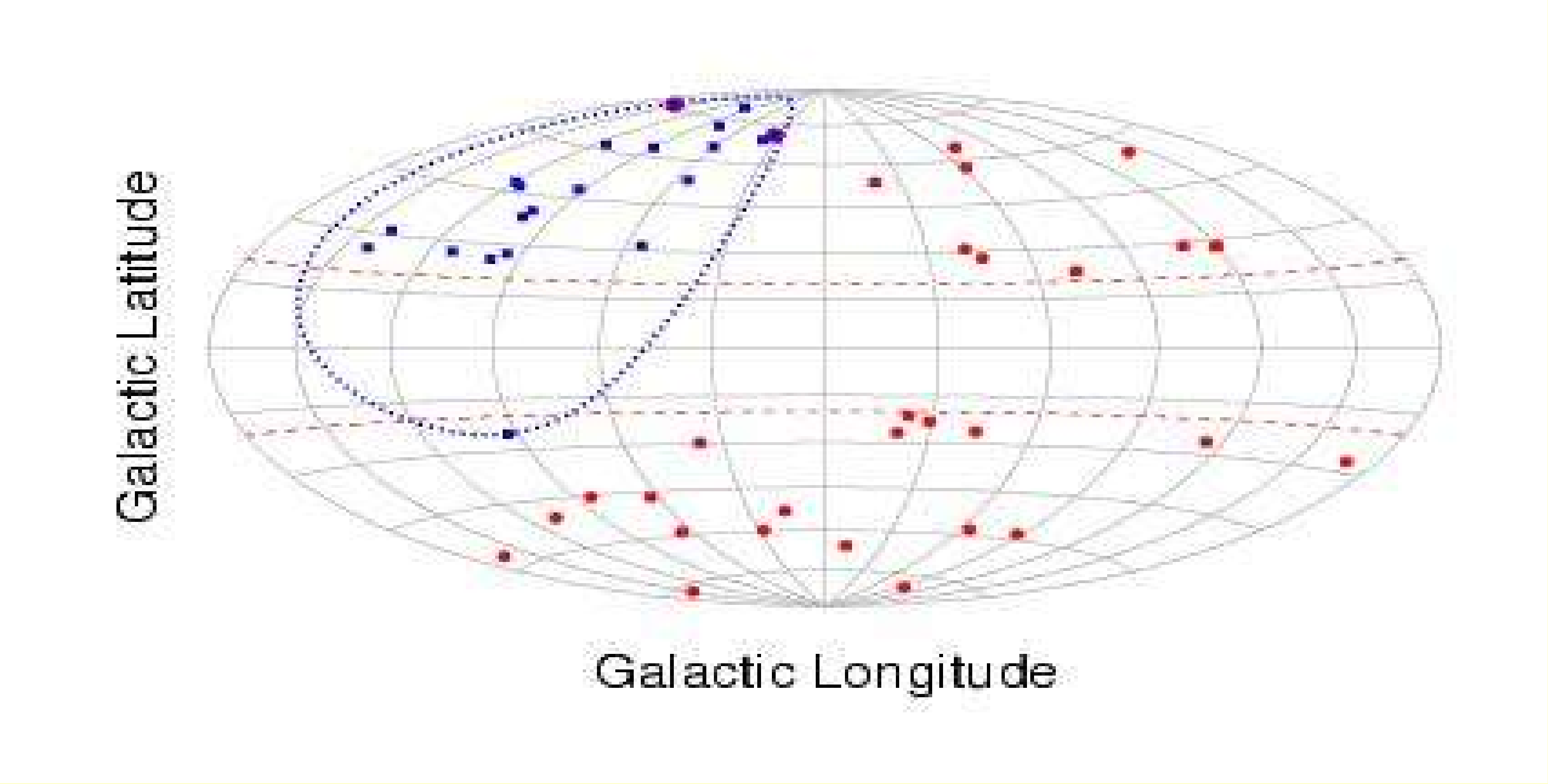


- Wyithe & Loeb (2003 ApJ 595,614): semi-analytical model with hierarchical merging halos and self-regulated blackhole feeding.
  - Model:Peak shifts to **lower z for higher Lx.**
  - Data: Peak shifts to **higher z for higher Lx**.
- Di Matteo et al. (2003;priv comm): based cosmological simulations show the opposite trend (i.e., the right direction). See also Menci et al. astro-ph/0401261).

Local Hard XLF from HEAO-1 Sample

- Sensitive large-area hard X-ray survey is missing nothing since HEAO-1 in 1979), till DUO?
- (Nearly) complete X-ray spectral followup of a HEAO-1 selected hard X-ray flux-limited sample (HEAO-1 A2 Piccinotti and HEAO-1 A1/A3 Remillard-Grossan) using ASCA and XMM-Newton, from archive or our own observation.
- Serves as the bright (near) end of hard X-ray luminosity function and population synthesis (Ueda et al., a part of this poster).

The Brightest Hard X-raySample Complete spectroscopy with ASCA/XMM

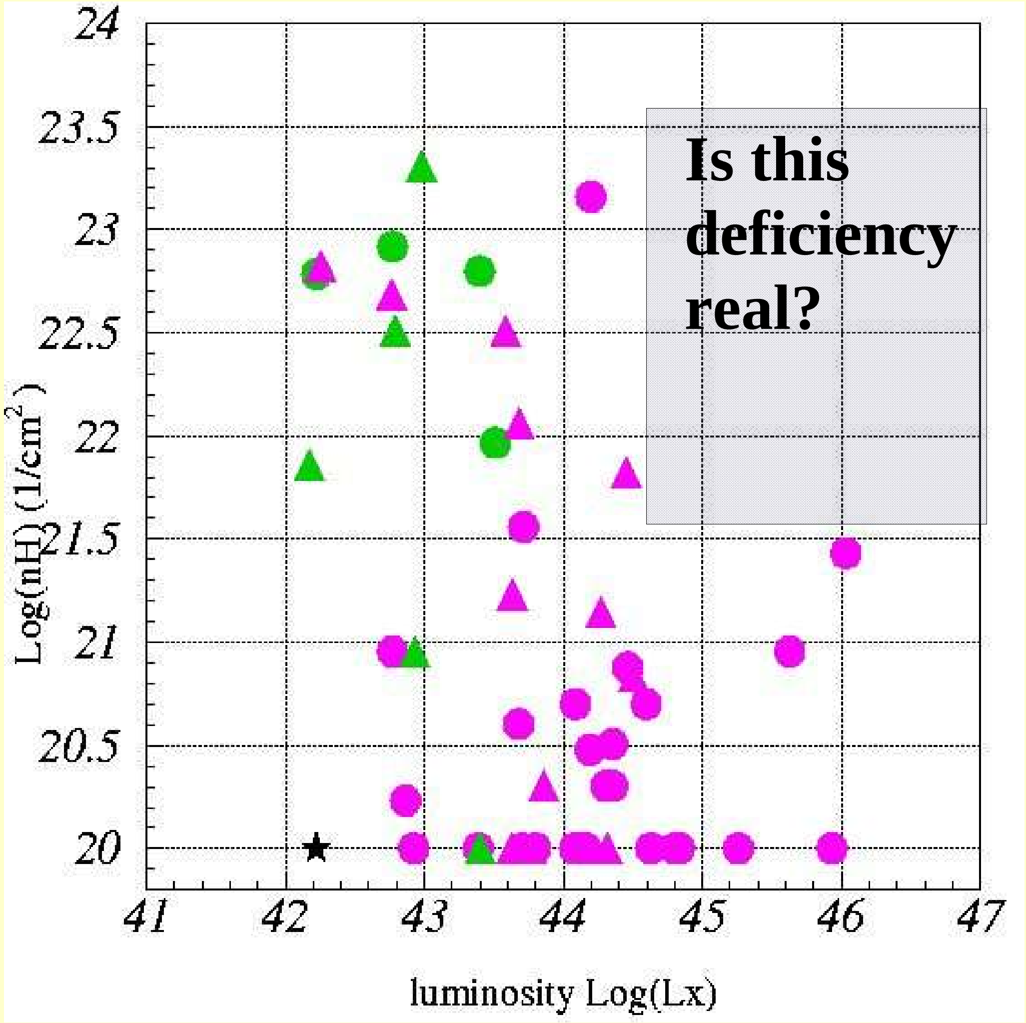


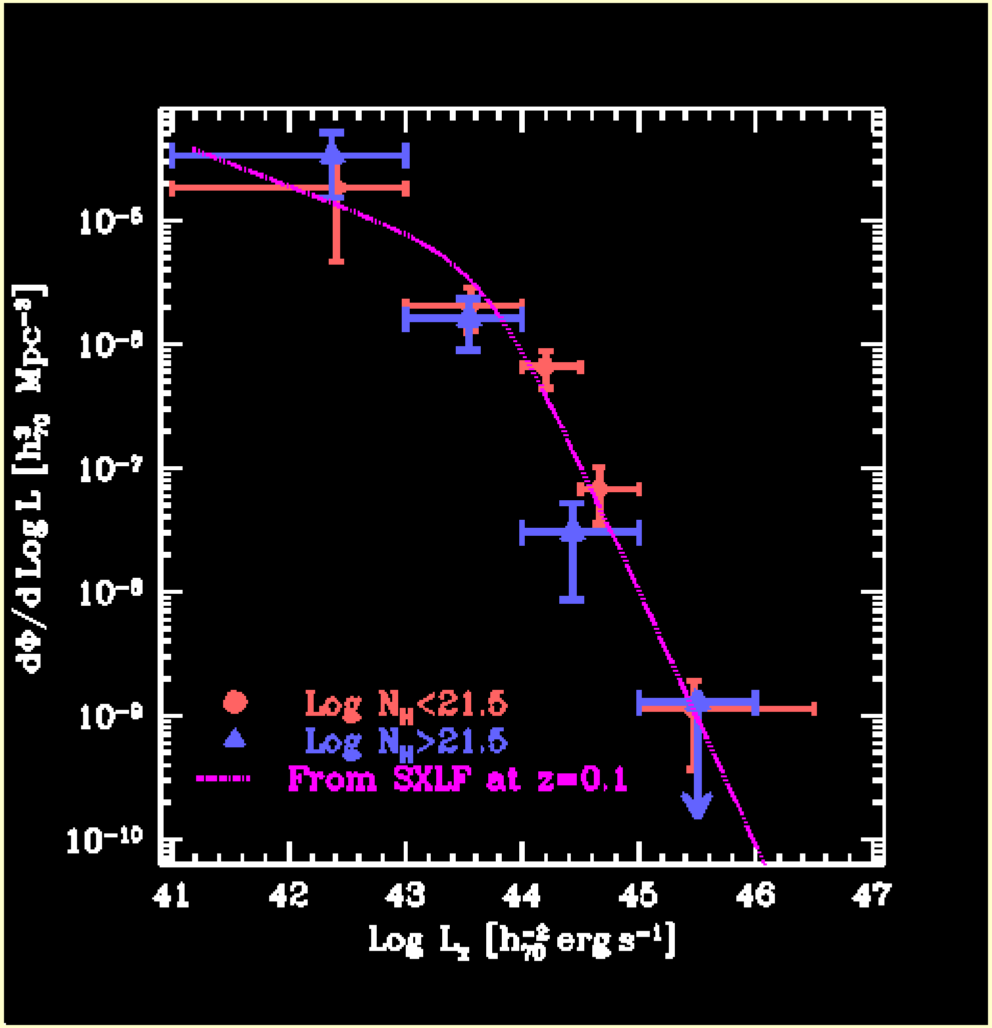
28 from Piccinotti et al (1982).
21 from Grossan (1992)

Shinozaki, Miyaji, Ishisaki, Ueda et al. 2004

Local (z=0) XLF (de-absorbed L_x)

Unabsorbed vs Absorbed





There should be~9 AGNs in the hatch if XLF(unabs)∏XLF(abs)