The X-ray Background

Günther Hasinger, MPE Garching

CDFS: J. Bergeron, S. Borgani, R. Giacconi, R. Gilli, R. Gilmozzi, K. Kellerman, L. Kewley, A. Koekemoer, I. Lehmann, V. Mainieri, M. Nonino, C. Norman, M. Romaniello, P. Rosati, E. Schreier, A. Streblyanskaya, G. Szokoly, P. Tozzi, J.X. Wang, W. Zheng, A. Zirm

Lockman Hole: X. Barcons, H. Böhringer, H. Brunner, A. Fabian, A. Finoguenov, Y. Hashimoto, P. Henry, I. Lehmann, V. Mainieri, I. Matute, M. Schmidt, A. Streblyanskaya, G. Szokoly, M. Worsley

Overall Sample & Luminosity Function: T. Miyaji, M. Schmidt

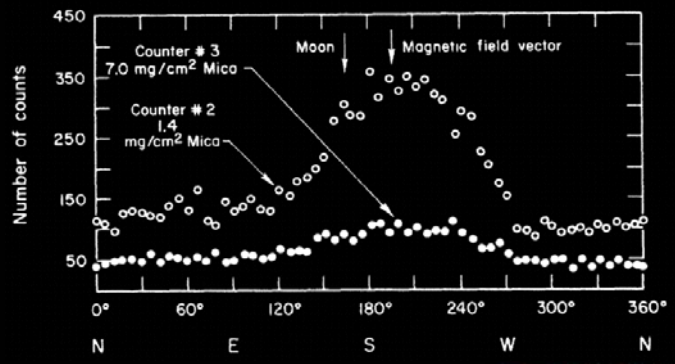
22nd Texas Symposium, SLAC Stanford, December 14th, 2004

The X-ray Background

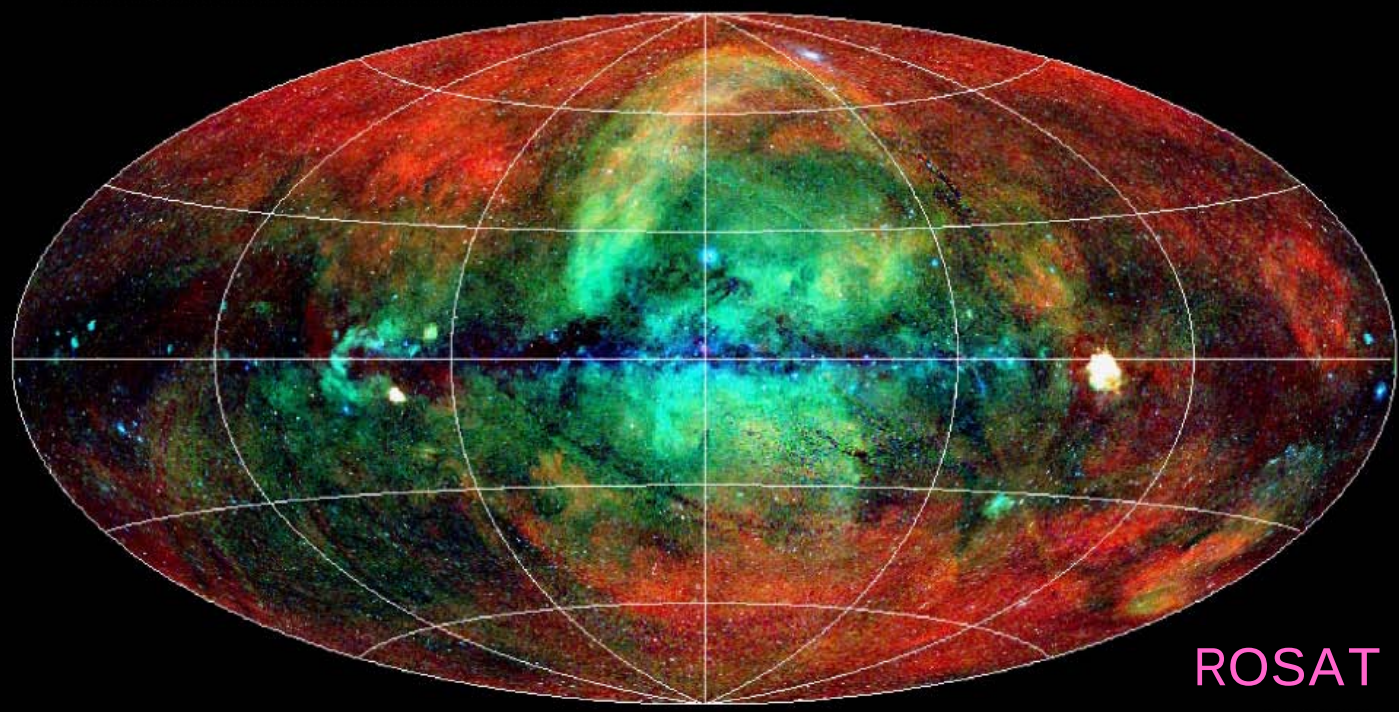
ROSAT

XMM-Newton

Chandra



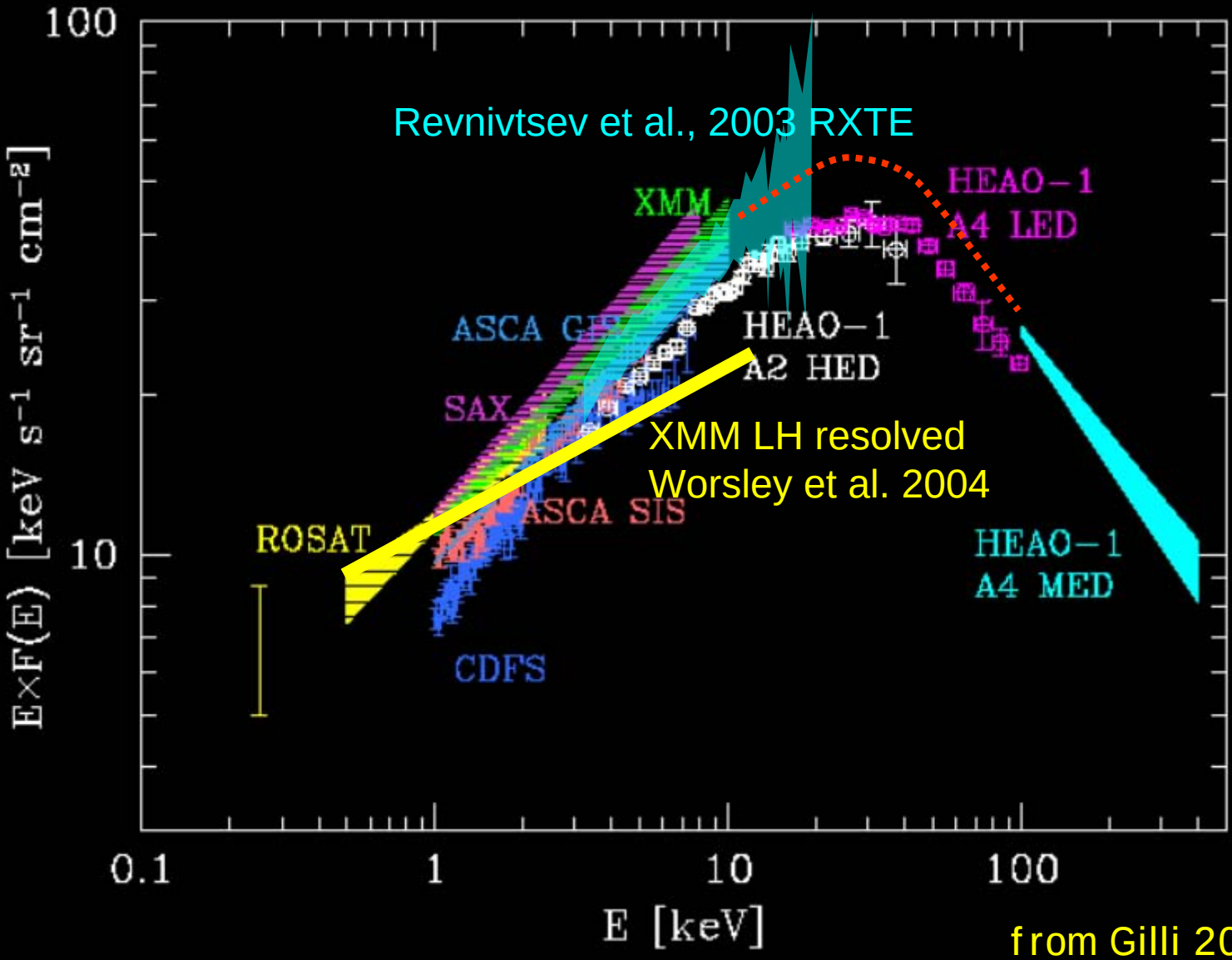
ROSAT



ROSAT

The background is the Echo of the formation of Supermassive Black Holes throughout the history of the Universe !

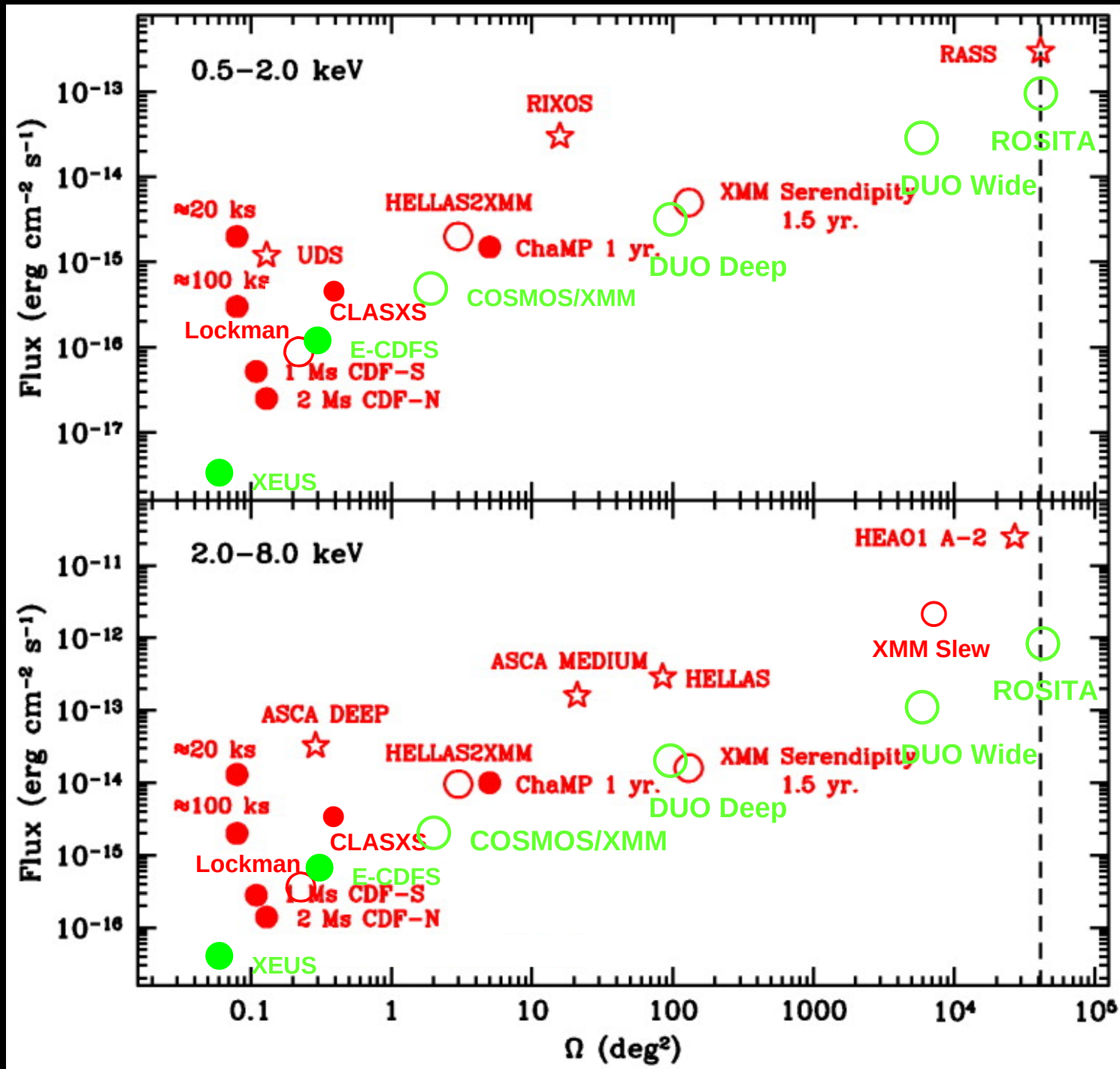
X-ray Background Spectrum



from Gilli 2003

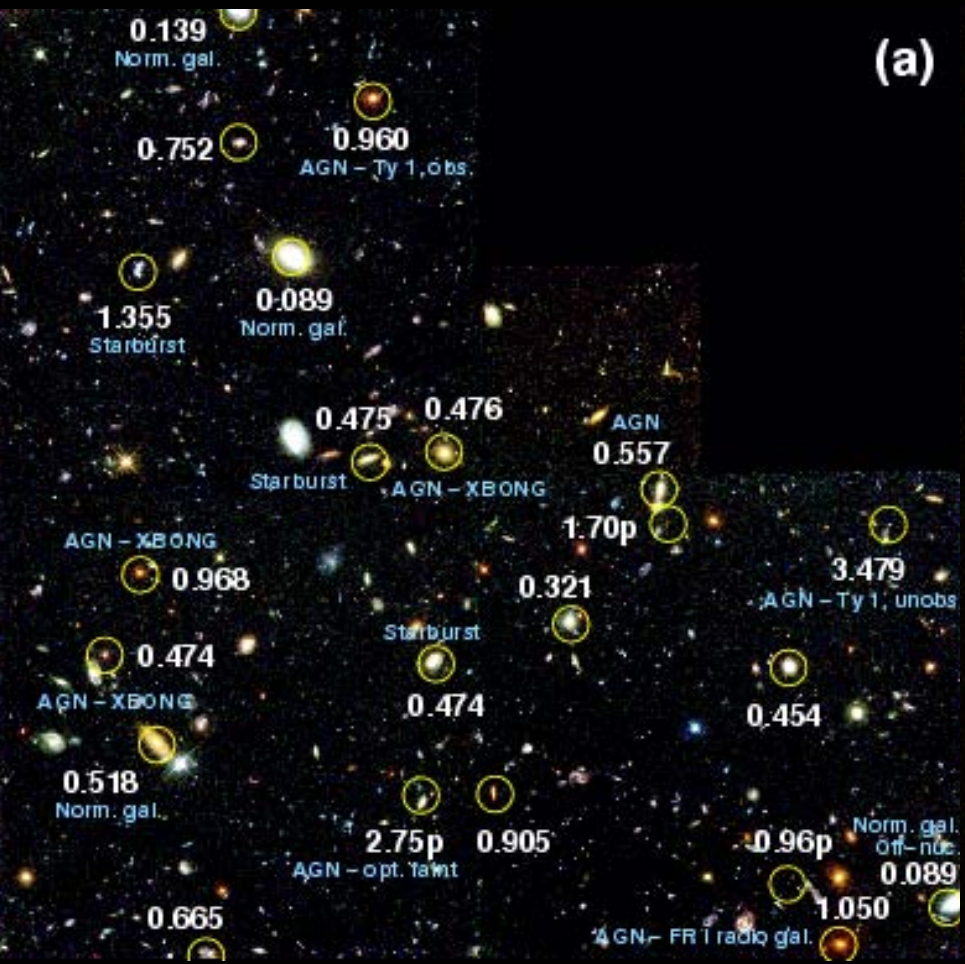
=> E<2keV XRB resolved; at E>5keV still very much work to do!

Large X-ray surveys

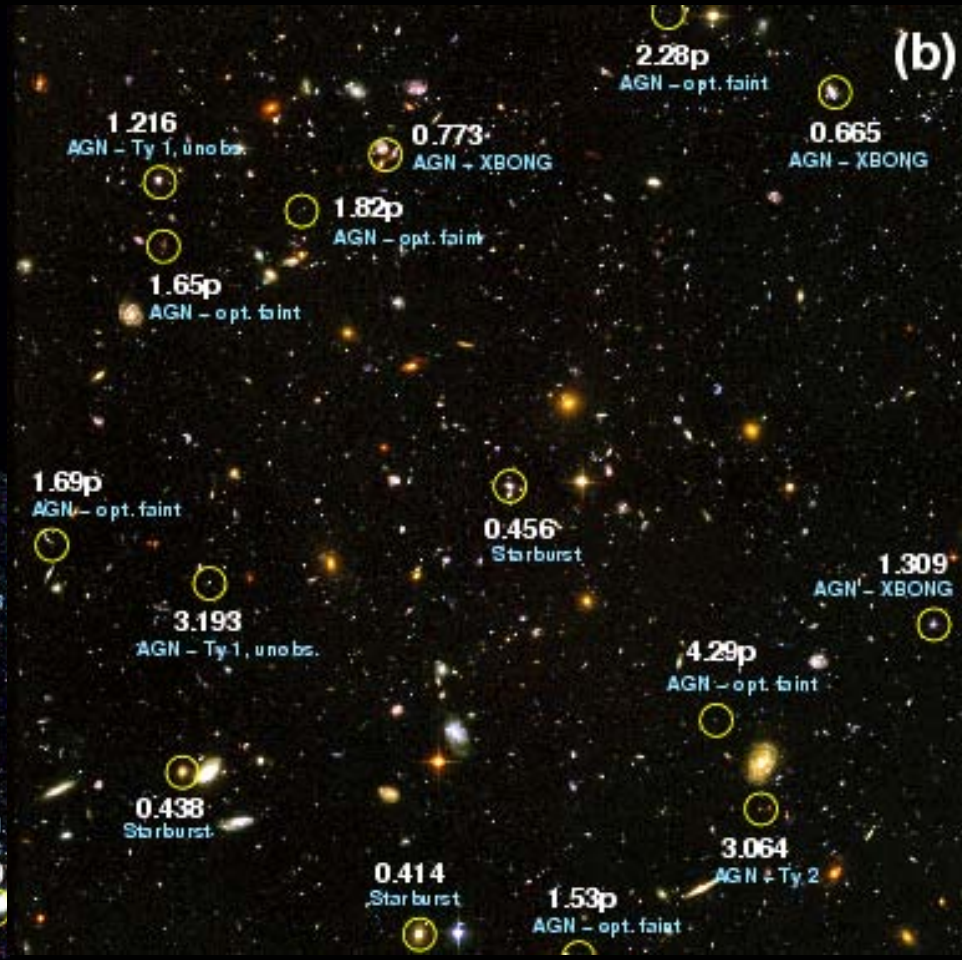


Alexander et al. 2003, AJ, 126, 539

The Deepest X-ray Surveys

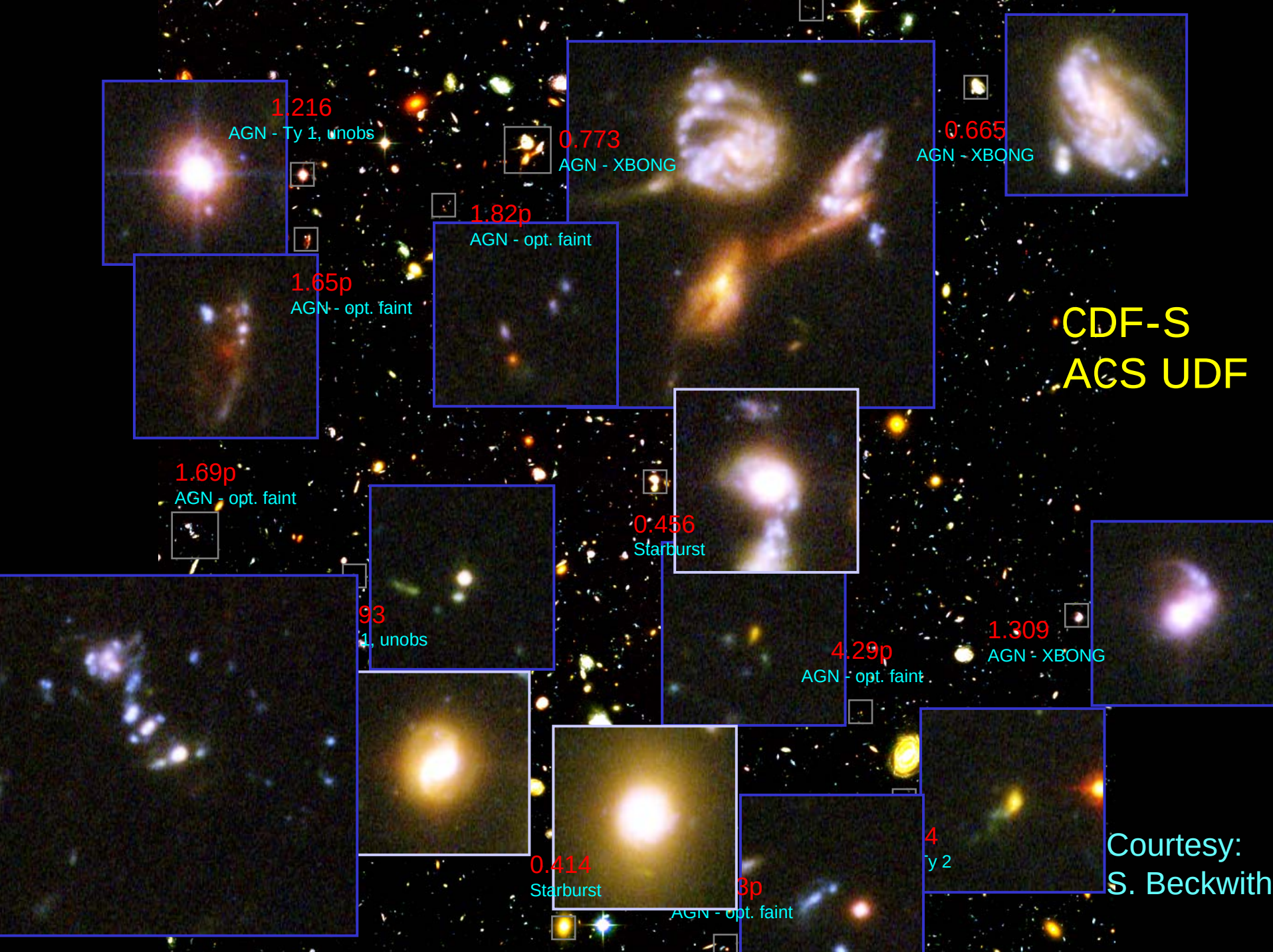


CDF-N (HDF-N)



CDF-S (ACS UDF)

Brandt & Hasinger, ARAA 2005

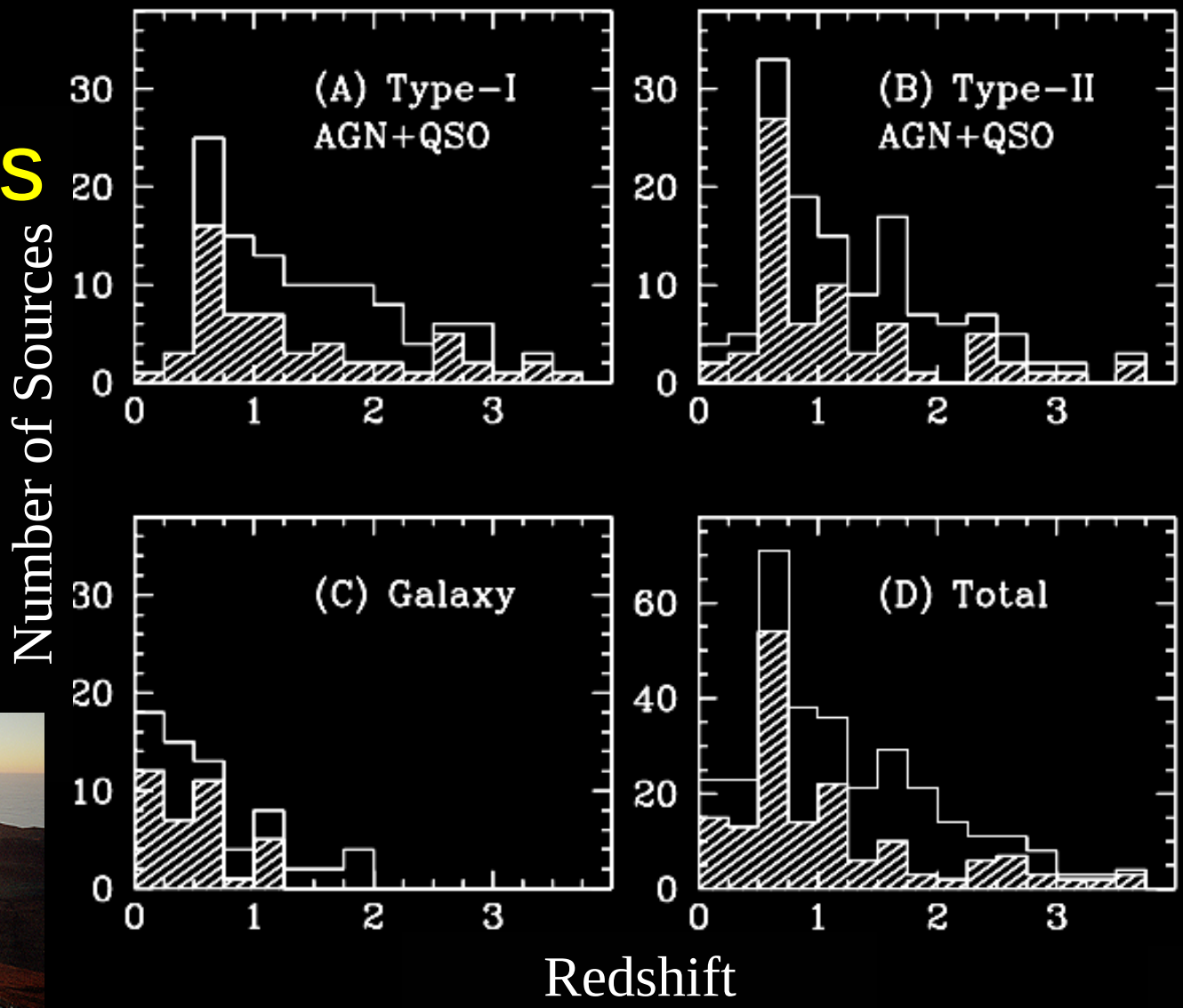

1.216
AGN - Ty 1, unobs
0.773
AGN - XBONG
0.665
AGN - XBONG
1.82p
AGN - opt. faint
1.65p
AGN - opt. faint
CDF-S
ACS UDF
1.69p
AGN - opt. faint
0.456
Starburst
93
1, unobs
4.29p
AGN - opt. faint
1.309
AGN - XBONG
0.414
Starburst
3p
AGN - opt. faint
4
y 2
Courtesy:
S. Beckwith

CDFS Optical IDs

Szokoly et al., 2004 (spectro-z)

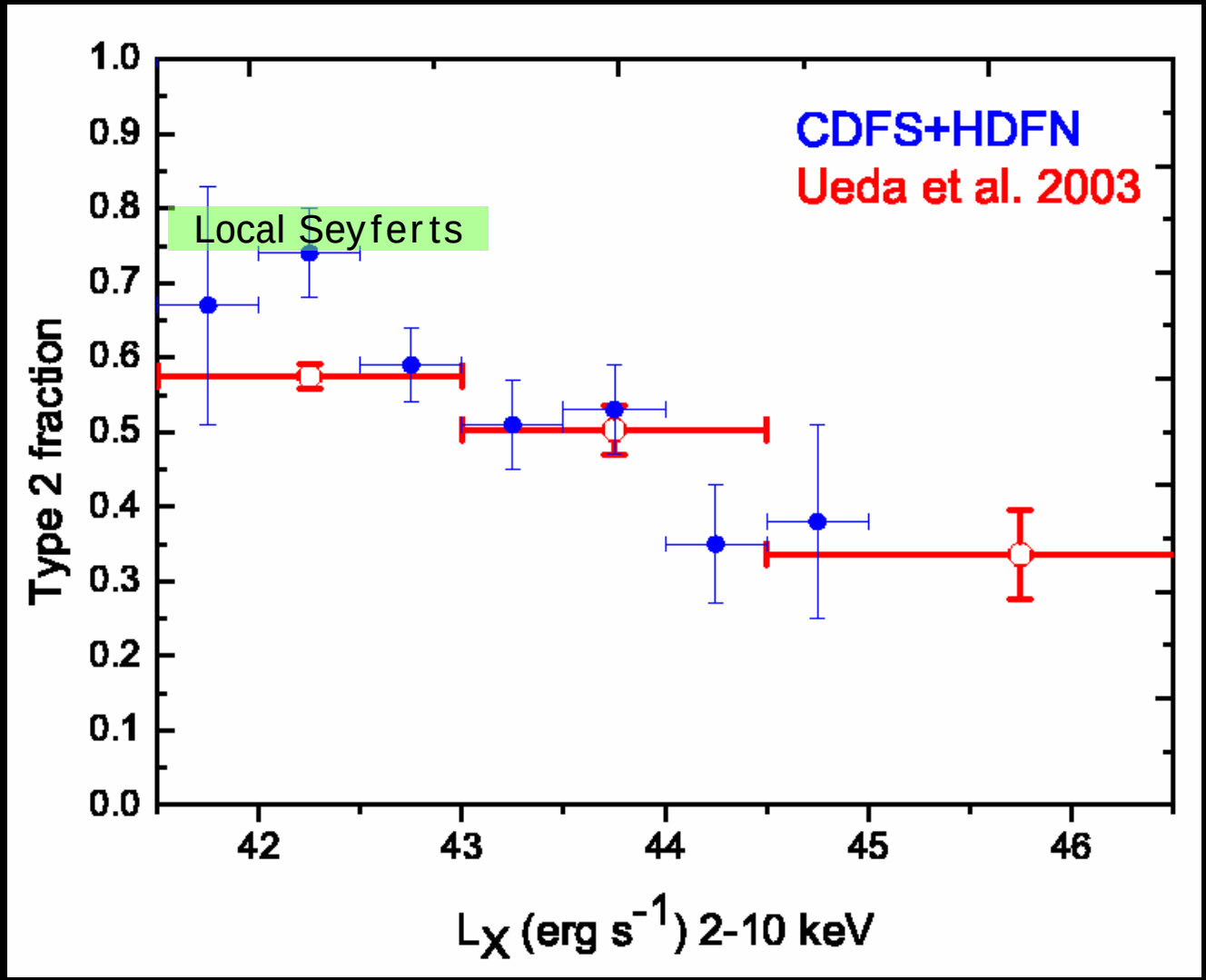
Wolf et al., 2004 (Combo-17)

Zheng et al., 2004
Mainieri et al., 2004 (photo-z)



> 95% have spectro- or photo-z thanks to VLT, GOODS, GEMS, ACF UDS etc.
Photo-z at higher z, but all peak at z~0.7

Type 2 fraction



Fraction of type-2's decreses with luminosity

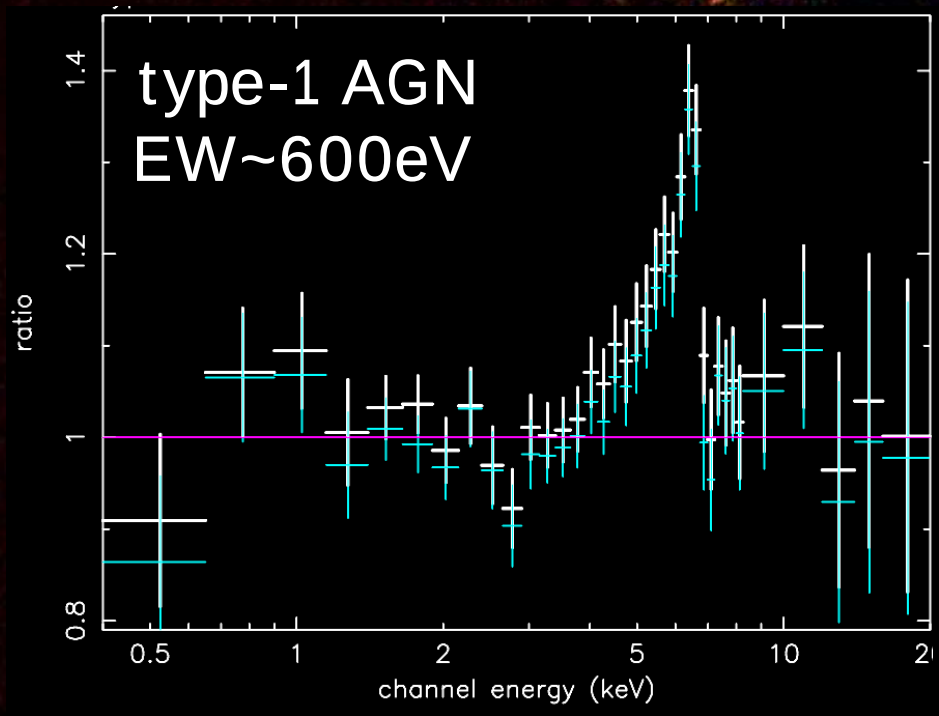
Ueda et al., 2003; Szokoly et al., 2004

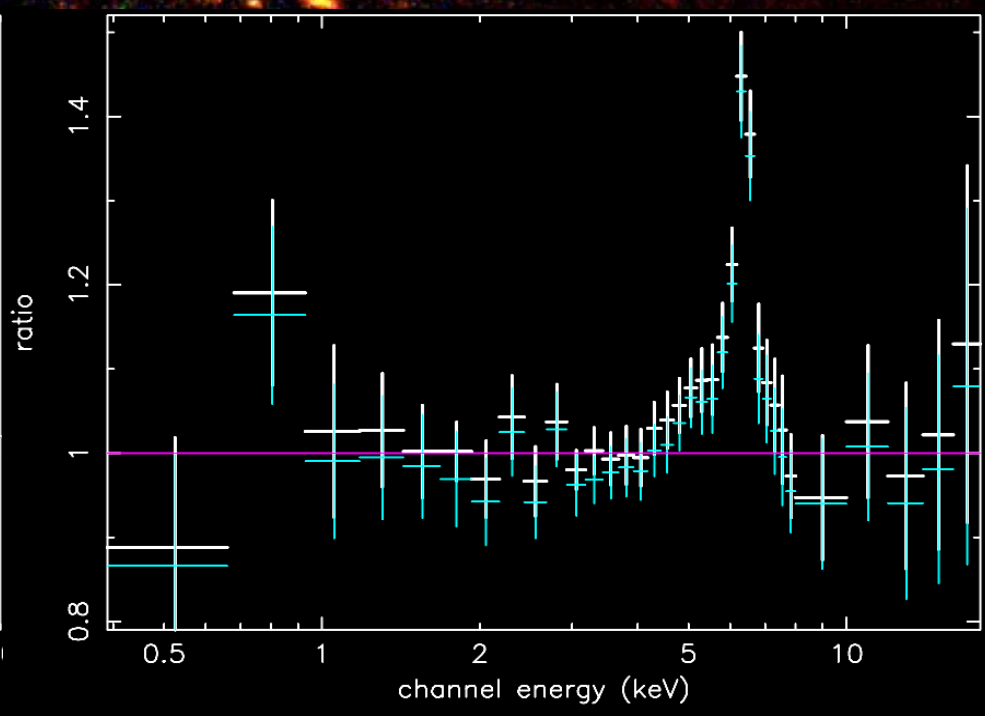
Lockman Hole

800 ks XMM-Newton observation

Keck Spectroscopy:
Lehmann et al., 2001
M. Schmidt, P. Henry

Average rest-frame spectra show relativistic Fe-lines





Streblyanskaya et al., 2004

Large equivalent width can be explained by 3 x solar metallicity.
BH spin within reach.

Good news for XEUS/Con-X

The type-1 AGN 0.5-2keV X-ray luminosity function

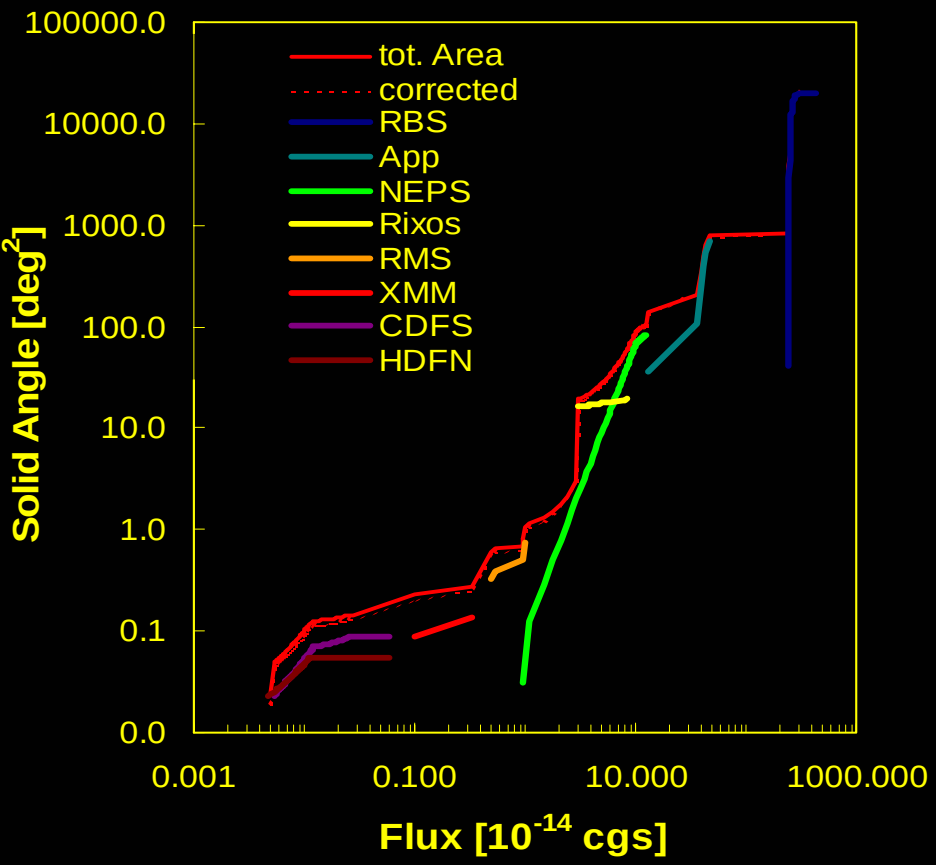
Multi-Cone Surveys

- Type-1 AGN in the 0.5-2 keV band
  - Continuation of ROSAT work, most sensitive & complete
- ROSAT Samples (Miyaji et al., 2000)
  - ROSAT Bright Survey: 203 (0) AGN (Schwope et al., 2000)
  - RASS Selected North: 134 (5) AGN (Appenzeller et al., 1996)
  - RASS NEP Survey: 101 (9) AGN (Gioia et al., 2003)
  - RIXOS serendipitous: 194 (14) AGN (Mason et al., 2000)
  - ROSAT Deep Surveys: 84 (7) AGN (e.g. Schmidt et al., 1998)
- XMM Deep Survey (Mainieri et al., 2002)
  - Lockman Hole: 48 (8) AGN (Lehmann et al., 2001 ++)
- Chandra Deep Surveys
  - CDF North/HDF-N: 67 (21) AGN (Barger et al., 2003)
  - CDFS spec.+phot.: 113 (1) AGN (Szokoly, Zheng et al. 2003)
- Total: 944 (65) AGN1

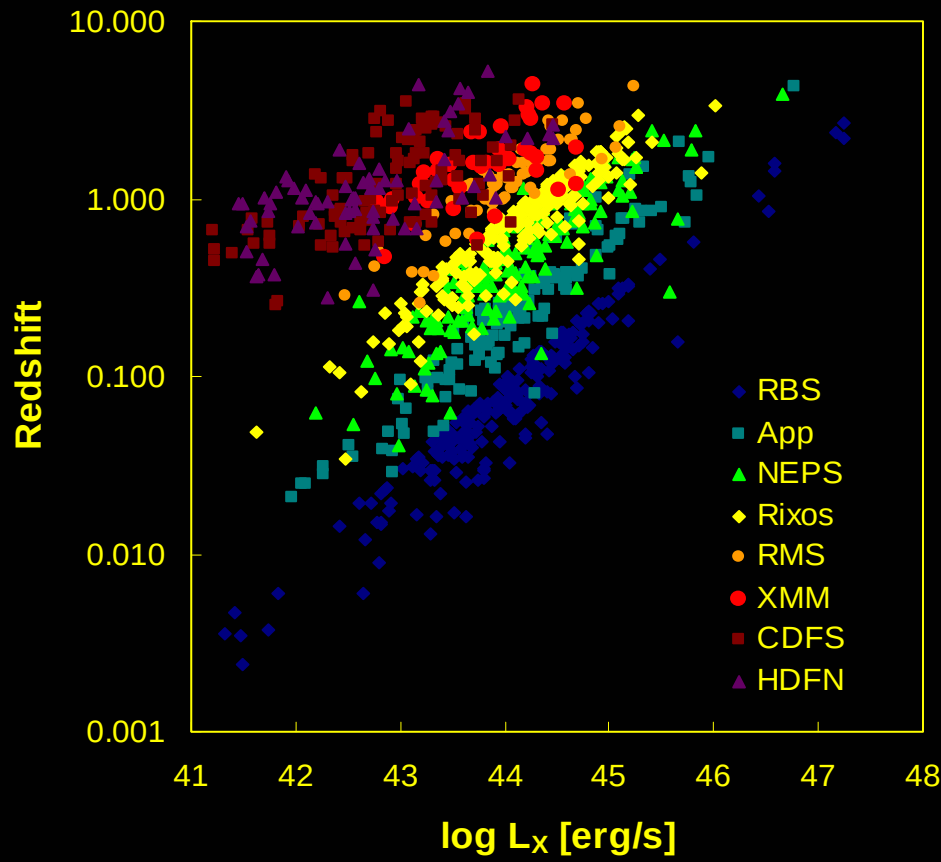
Yellow: unidentified

Multi-Cone Surveys

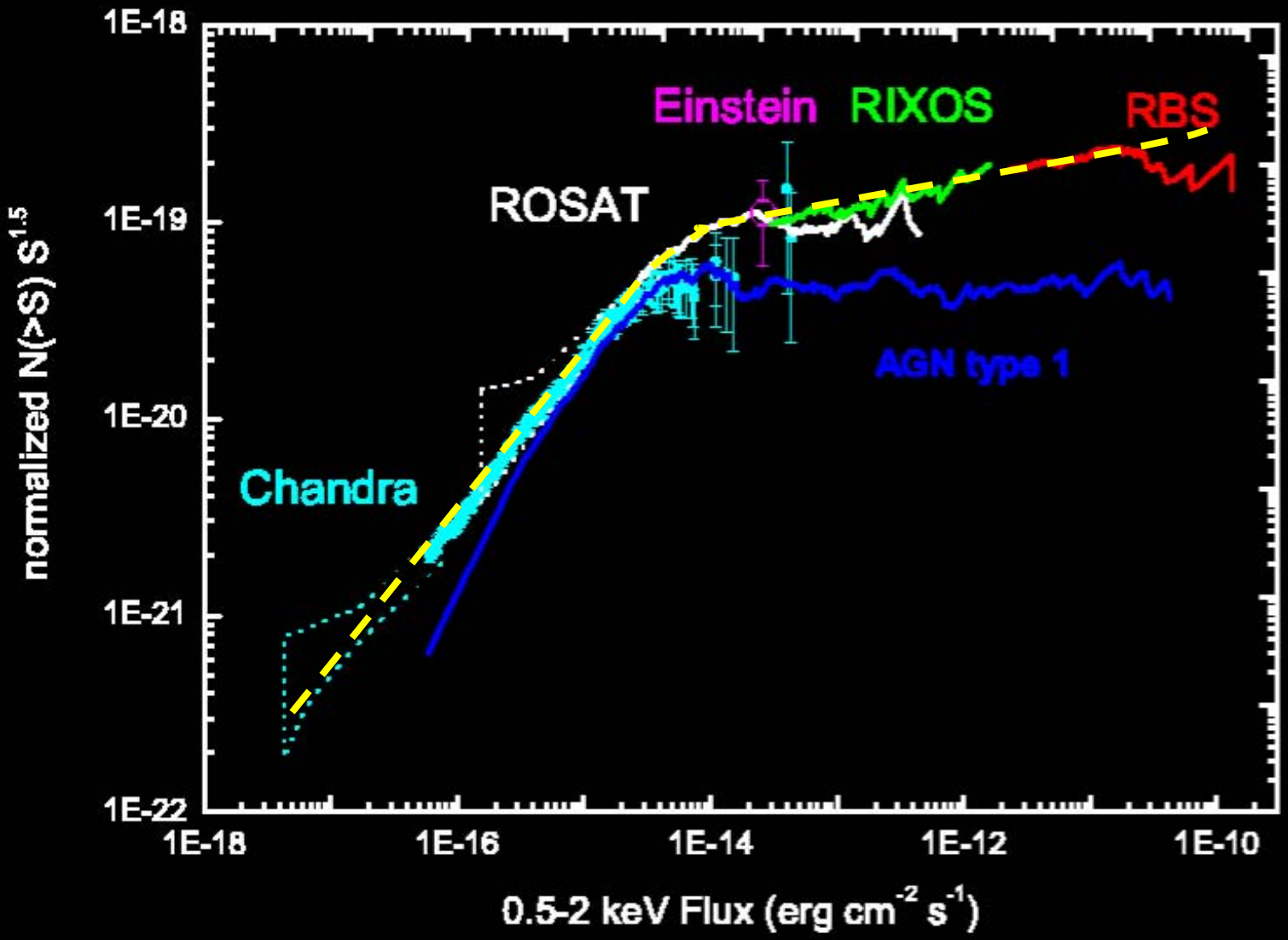
Survey Area



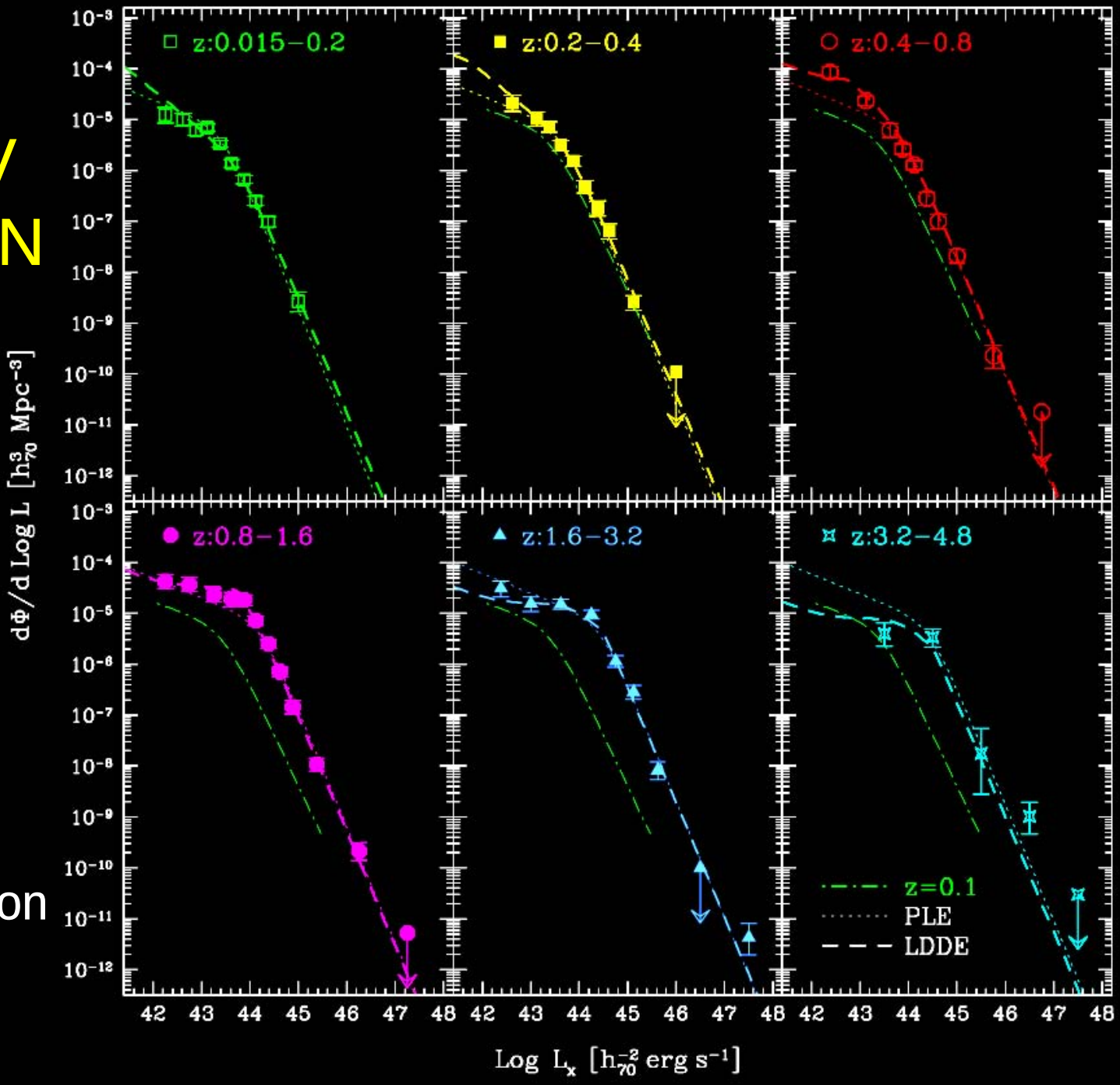
Hubble Diagram



Multi-cone logN-logS

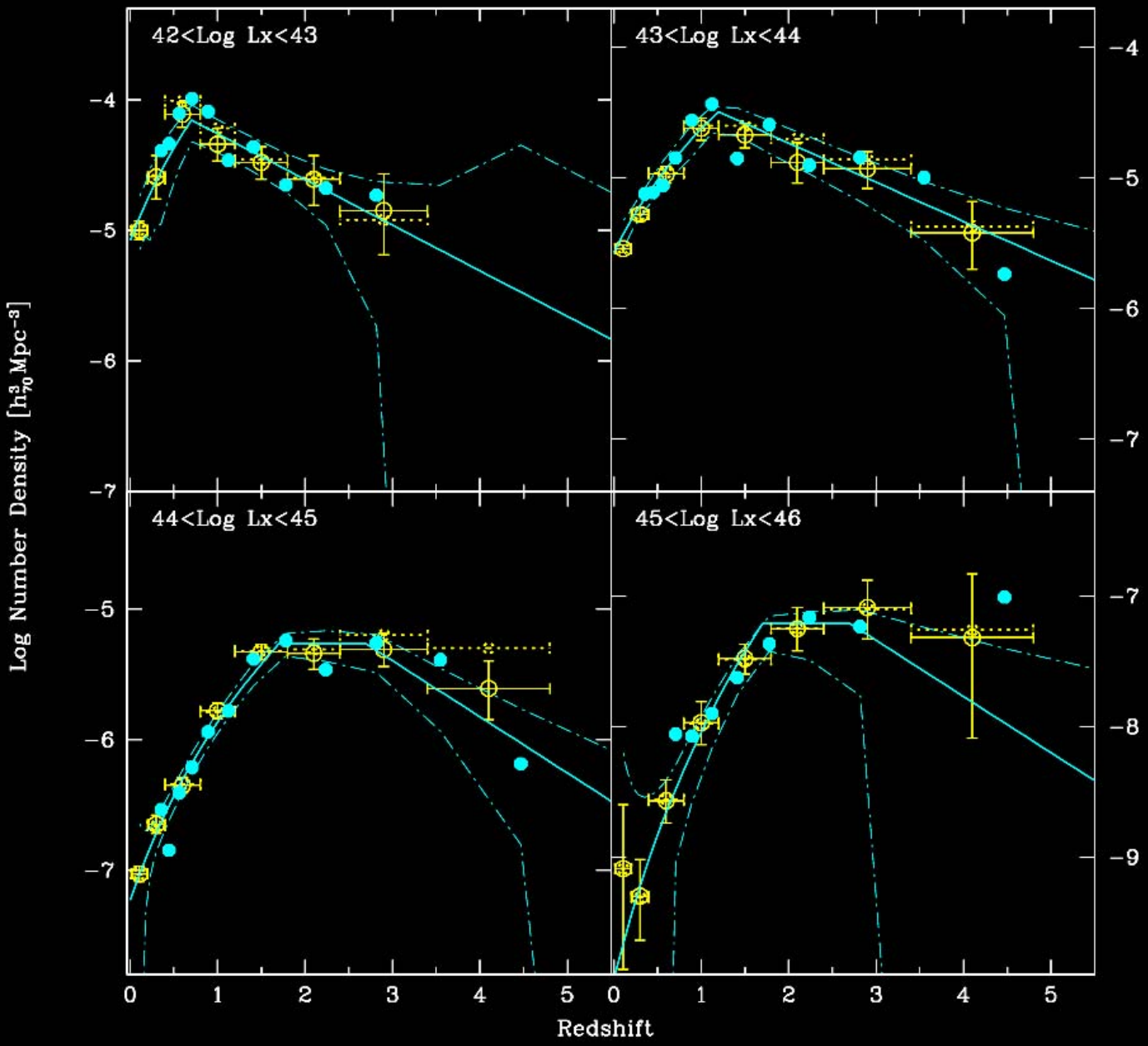


XLF
0.5-2 keV type-1 AGN



Luminosity-dependent density evolution (LDDE) confirmed

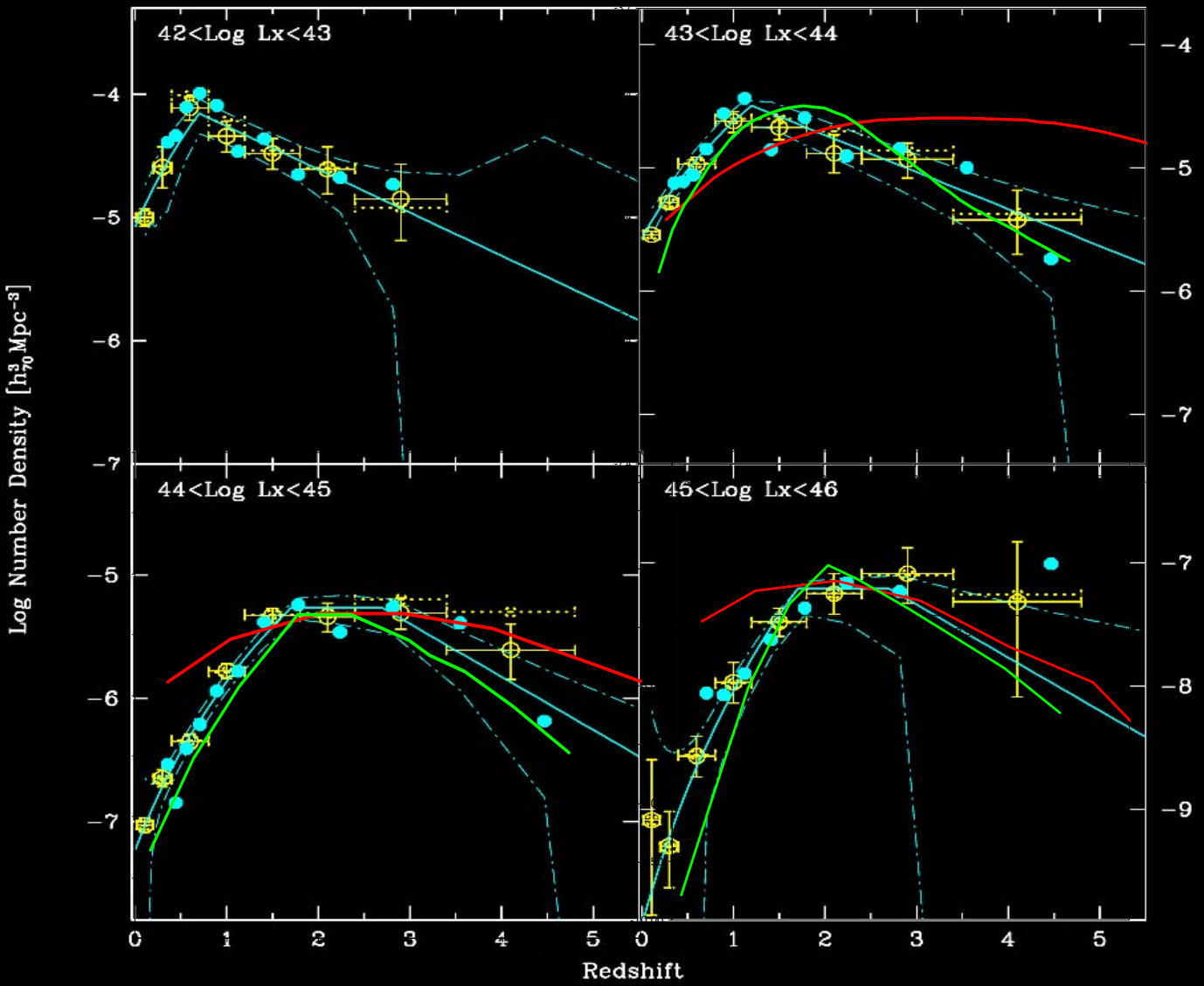
AGN Space Density $\phi(z)$



Hasinger, Miyaji & Schmidt, 2004, A&A submitted

M. Schmidt method
T. Miyaji treatment
(dotted: upper limit)

Semianalytic Model Comparison



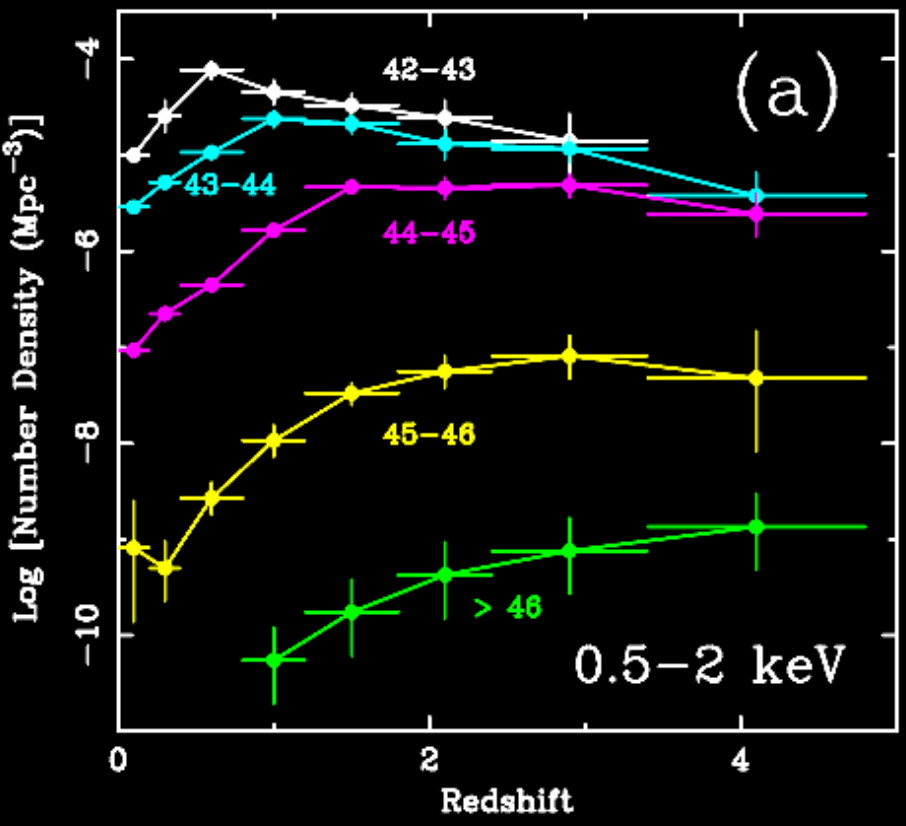
Wyithe & Loeb, 2003, ApJ, arbitrary norm

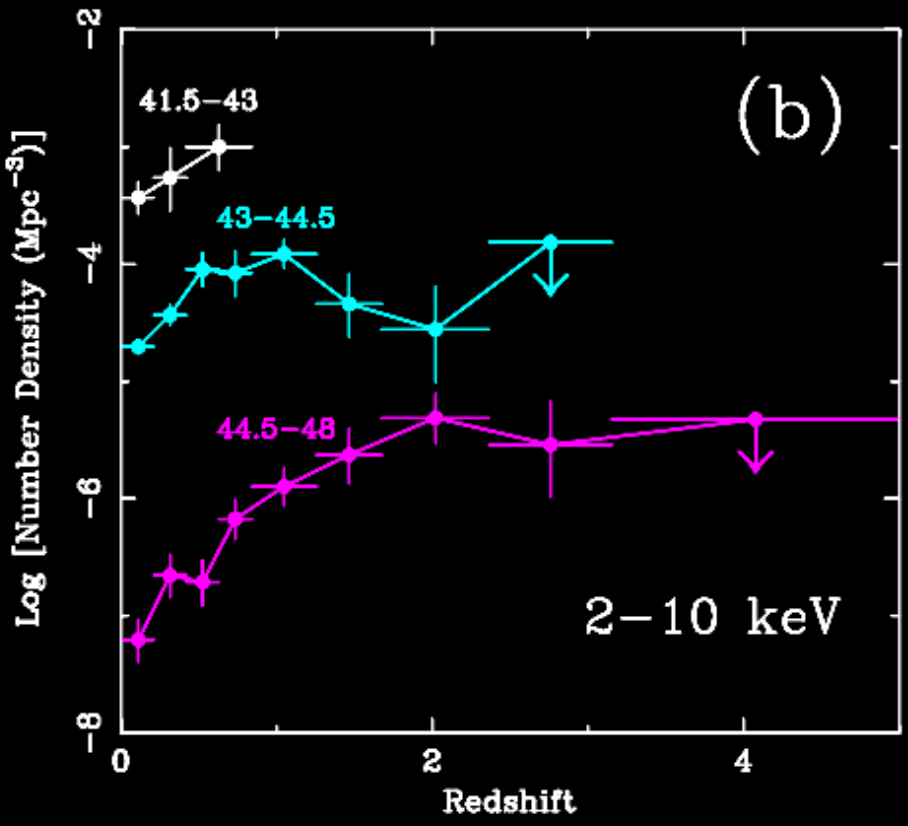
Menci et al., 2004, ApJ, arbitrary norm

Hasinger, Miyaji & Schmidt, 2004, A&A submitted

M. Schmidt method
T. Miyaji treatment
(dotted: upper limit)

Densities in soft and hard band





Hasinger, Miyaji & Schmidt, 2005
based on ~1000 AGN-1

Ueda et al., 2003,
based on ~250 AGN

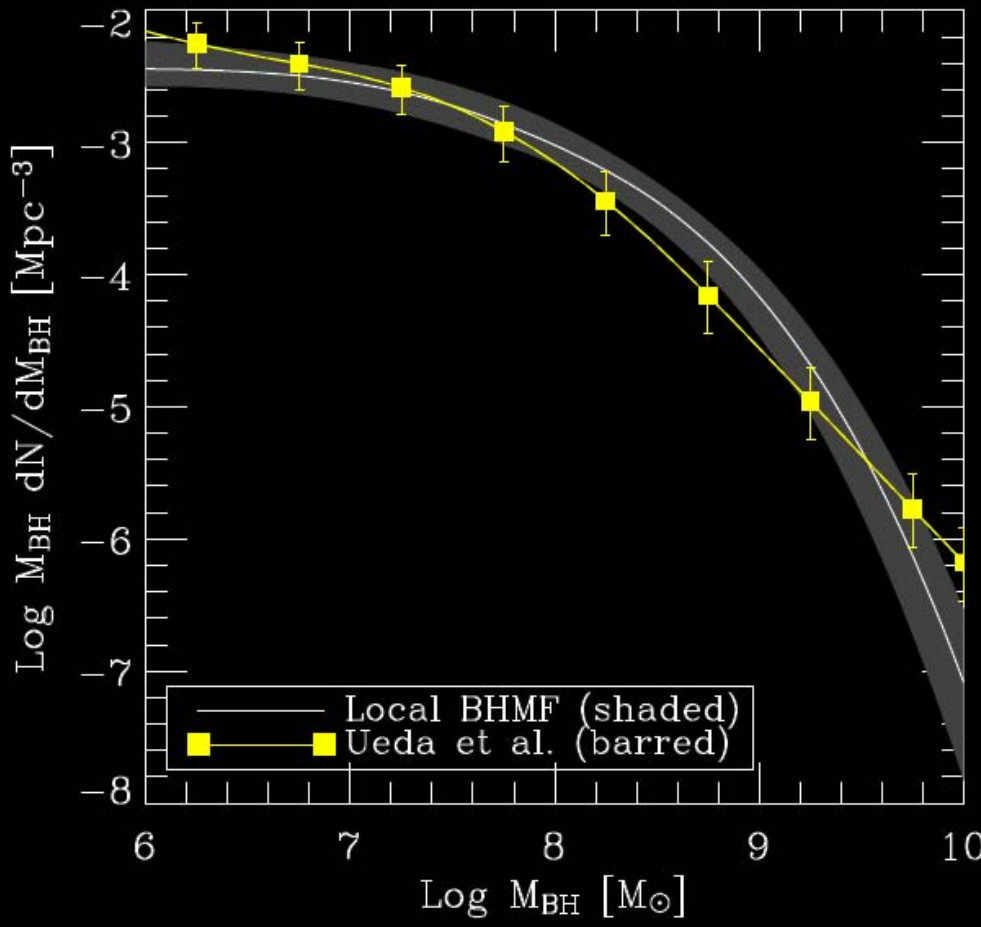
Very similar behaviour in hard and soft band.
Soft samples go deeper and are more complete.

Local BH mass vs. accreted BH mass function

- Accreted Black Hole mass function derived from X-ray background can be compared with the mass function of dormant relic black holes in local galaxies (Soltan 1982).

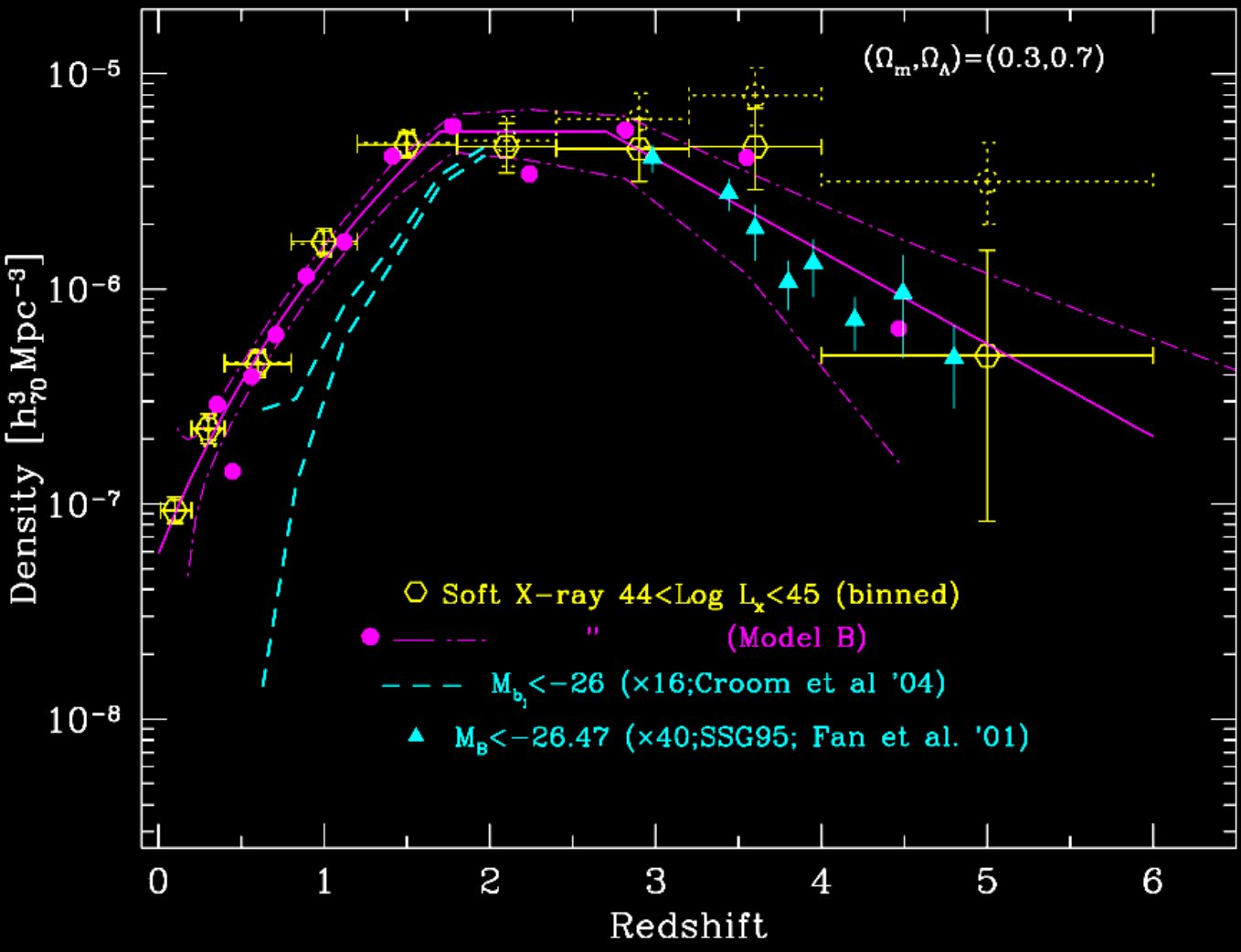
- These two estimates can be reconciled, if an energy conversion efficiency of ε=0.1 is assumed.

- Such high efficiency requires a spinning Kerr-BH!



Marconi et al., 2004, MNRAS

X-ray vs. optical QSOs



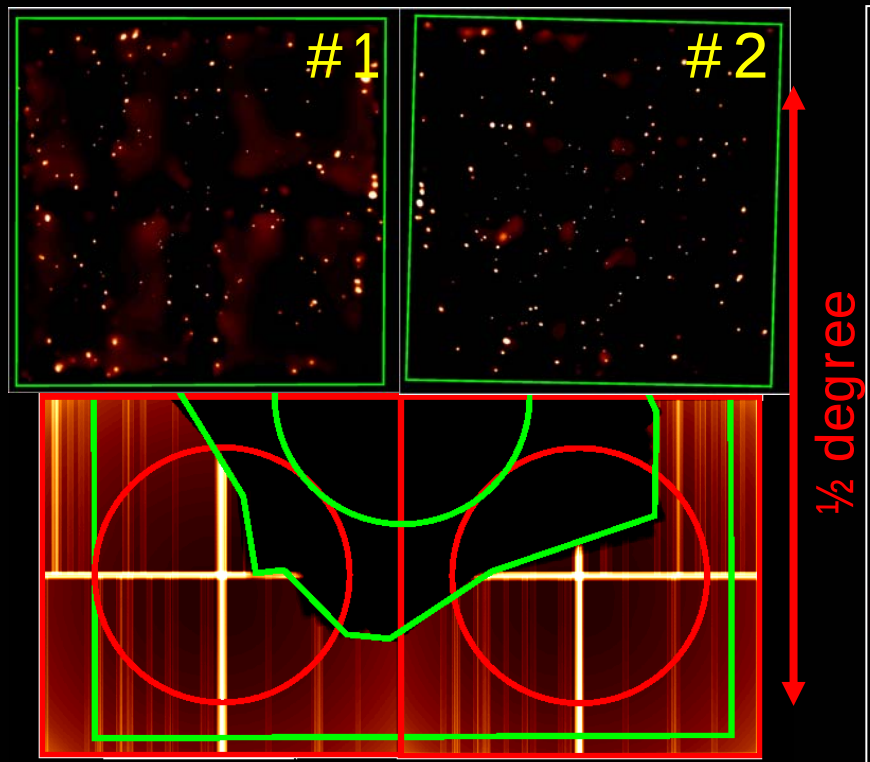
Very large solid angle deep surveys are required to discover z>5 QSOs

E-CDFS
XMM/COSMOS
DUO

High-z decline now seen in X-rays at all luminosities!

Wide & Deep Chandra and XMM surveys

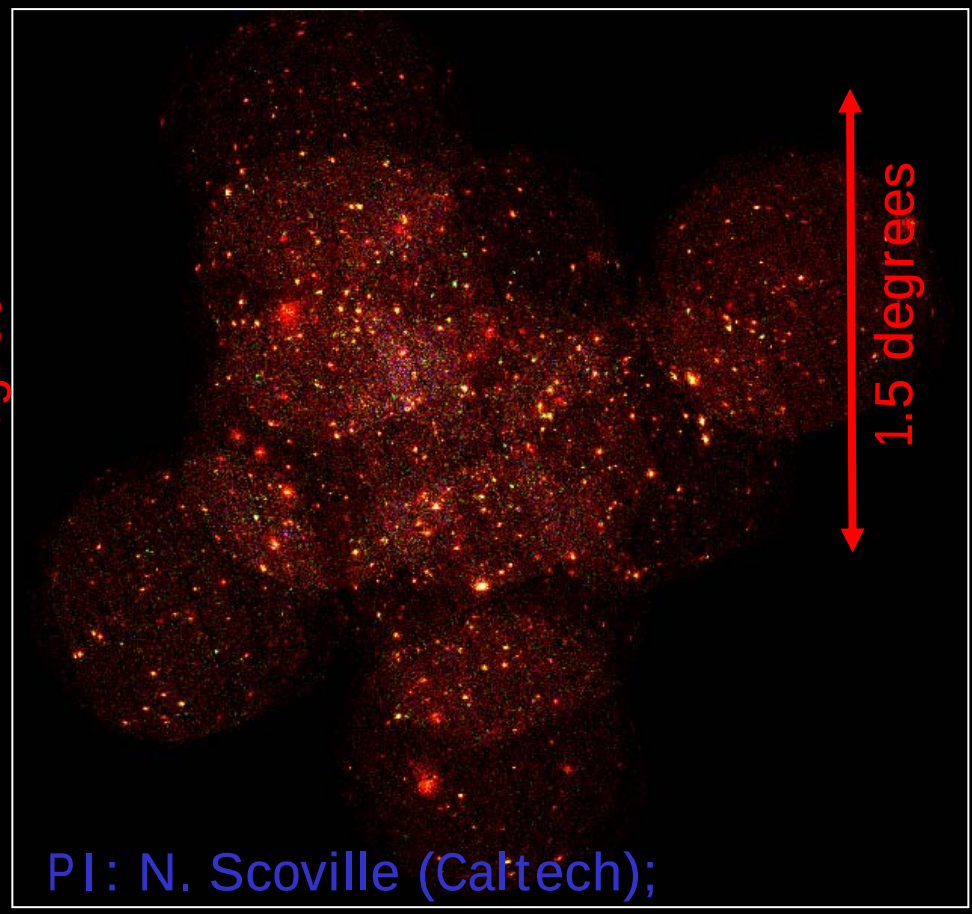
Extended Chandra
Deep Field South



PI: N. Brandt (PSU); 4x250 ksec

Observations are ongoing

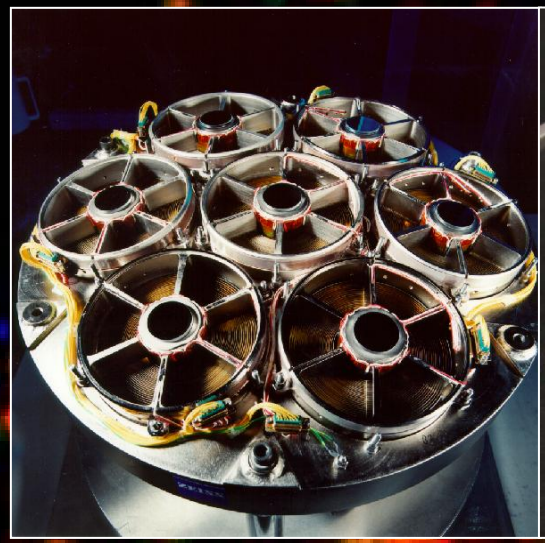
HST/XMM-Newton
COSMOS Field

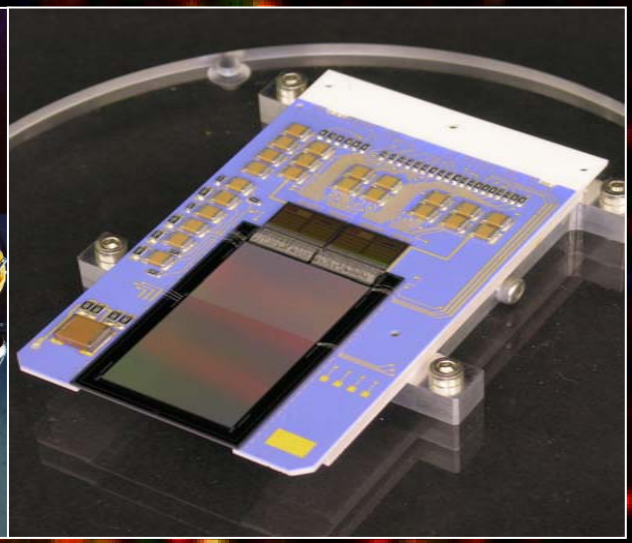


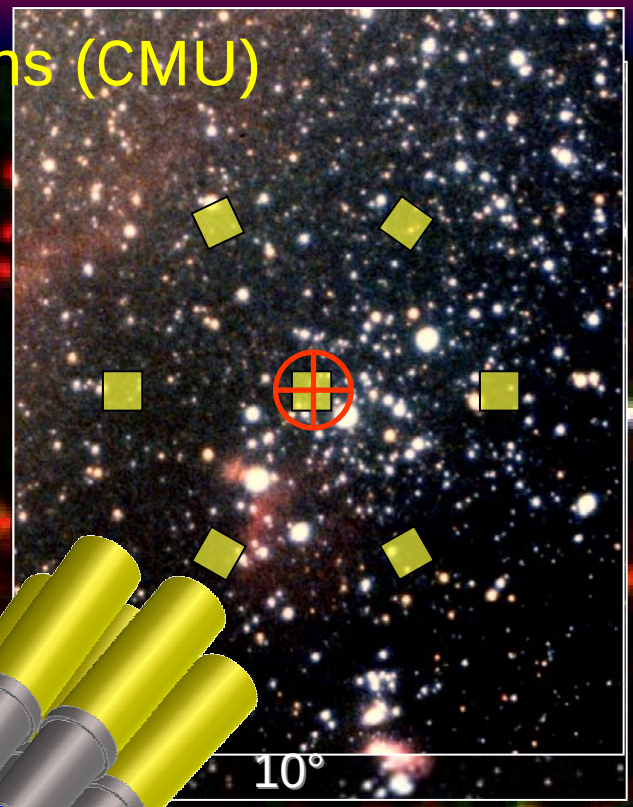
PI: N. Scoville (Caltech);
XMM: 1.4 Msec, G. Hasinger (MPE)

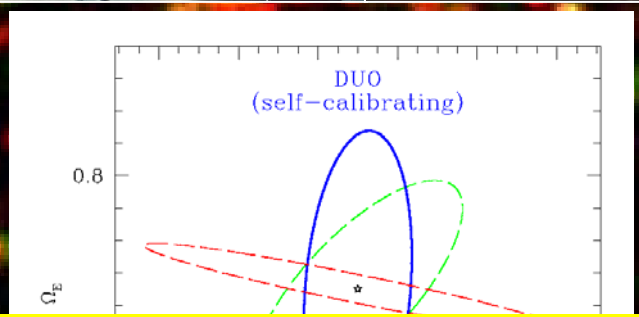
DUO Dark Universe Observatory

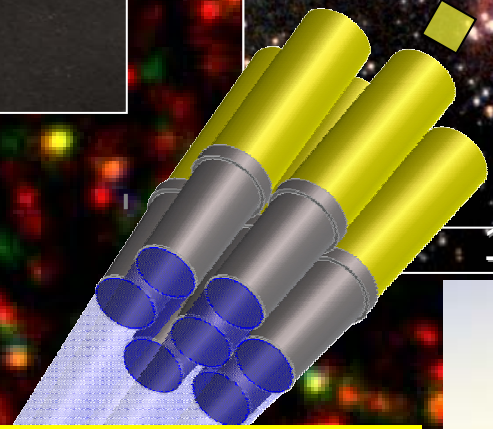
Current SMEX competition; PI: R. Griffiths (CMU)

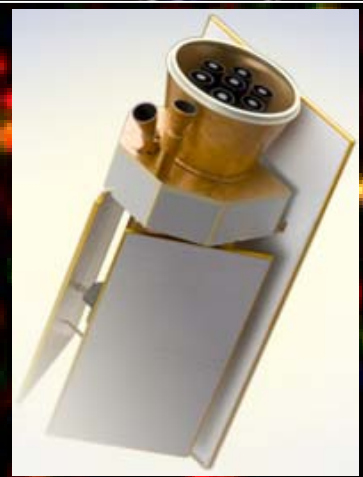












DUO will detect same number z>3 QSO, than are known from all other surveys to date, including SDSS & 2dF

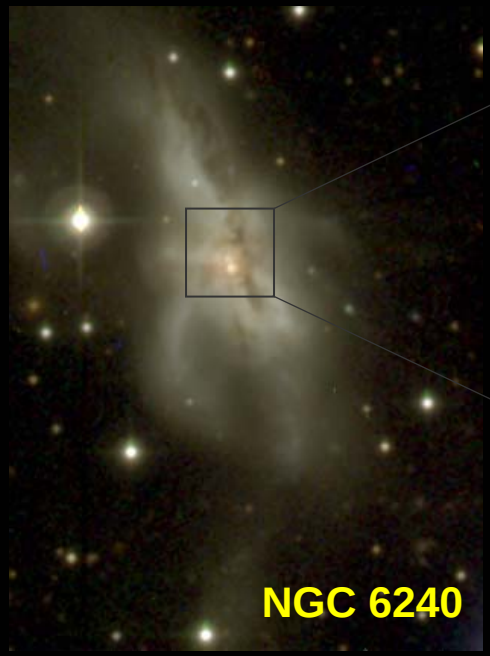
Summary

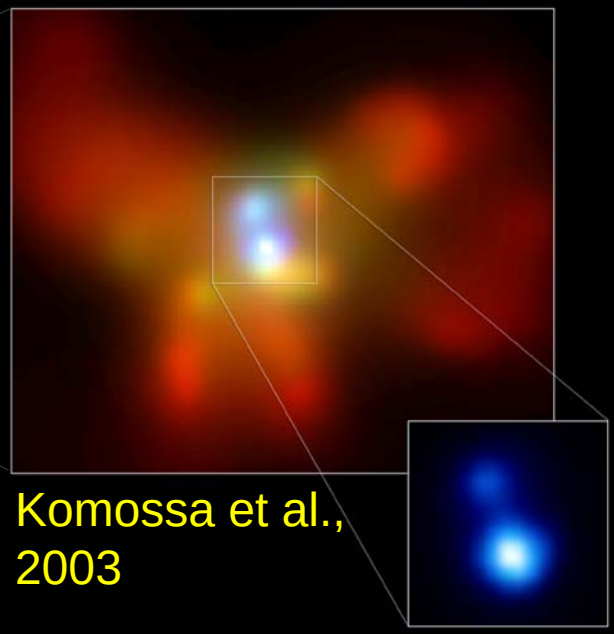
- X-ray background practically resolved below 2 keV
- At 2-10 keV about 50% resolved; still work to do
- Type-2 QSOs found, type-2 fraction decreases with L_X
- Background AGN have strong relativistic Fe line
- Luminosity-dependent density evolution
- Seyferts peak much later than QSO
- Anti-hierarchical evolution not predicted even by most recent semi-analytic models

=> Need (at least) 2 modes of BH accretion

Role of accretion through mergers?

Binary Black Holes in Major Mergers





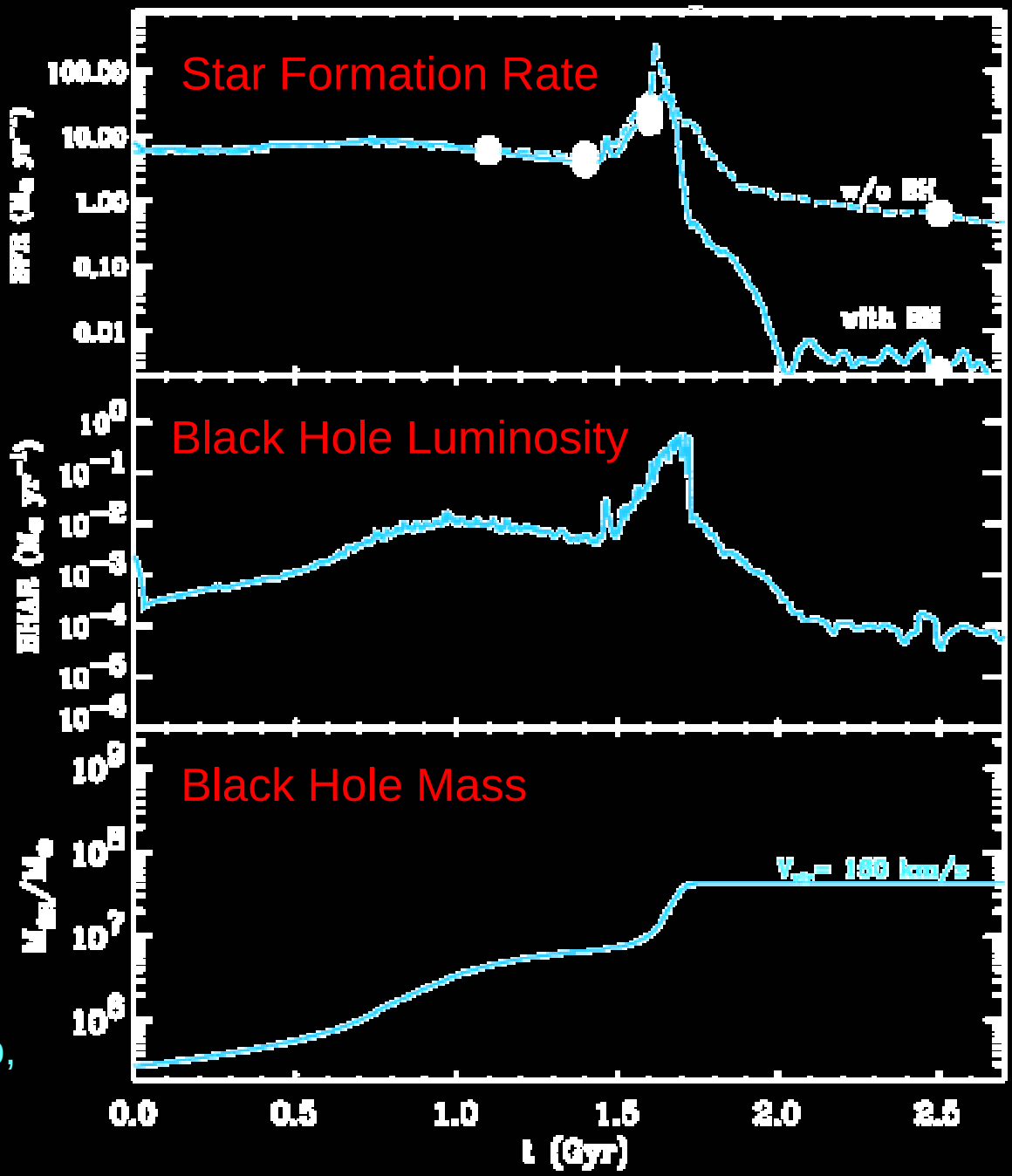
Komossa et al., 2003

Several more Binary Black Holes claimed in the meantime.

BBH could be present in a fraction of normal quasars.

Major accretion mode for quasars?

Co-evolution of Galaxy and BH



Simulation by Tiziana de Matteo, Volker Springel (MPA) & Lars Hernquist (CfA)

Thank you very much !