AGN demography and evolution

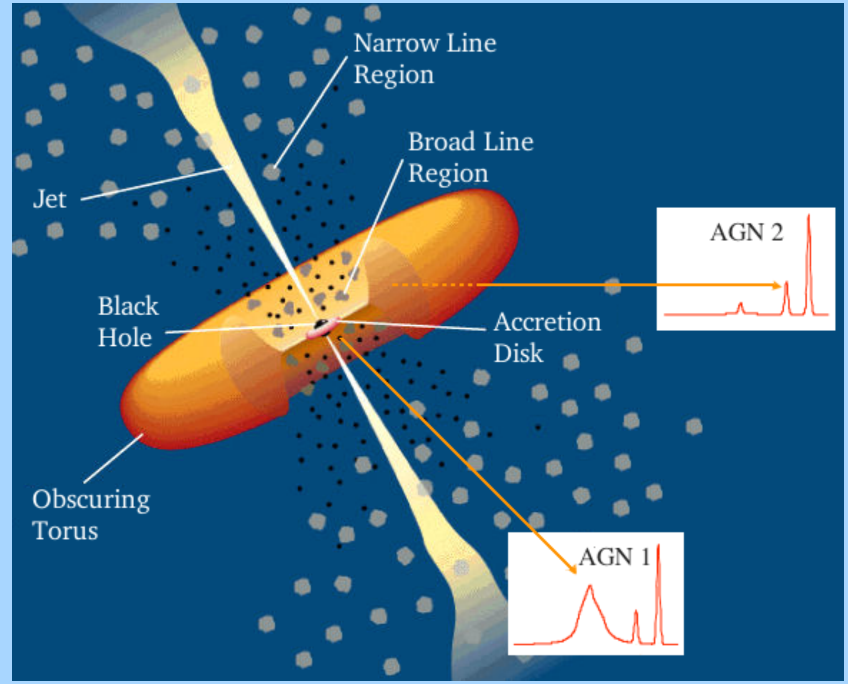
Fabio La Franca

Dipartimento di Matematica e Fisica

Universita` degli Studi ROMA TRE

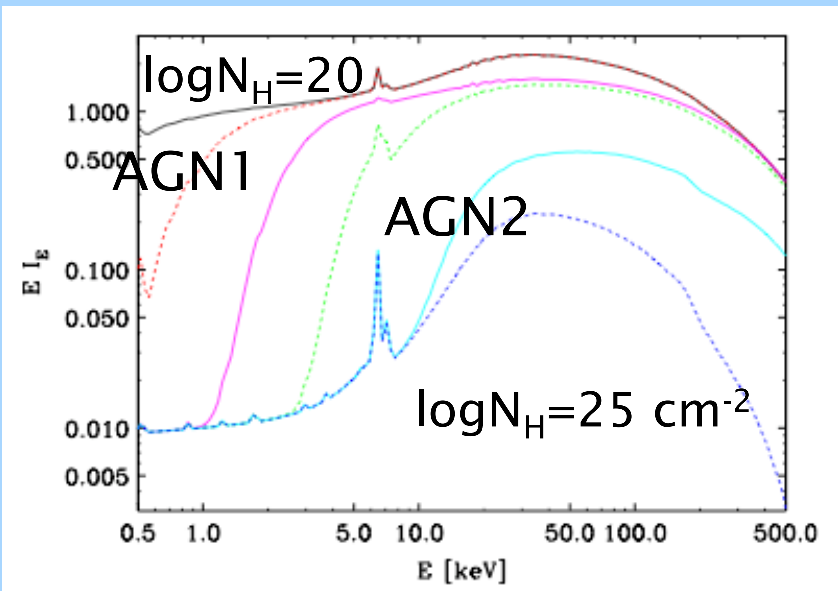
Active Galactic Nuclei – Unified Model

According to the Unified Model AGN1 and AGN2 are the same objects seen at different viewing angles.



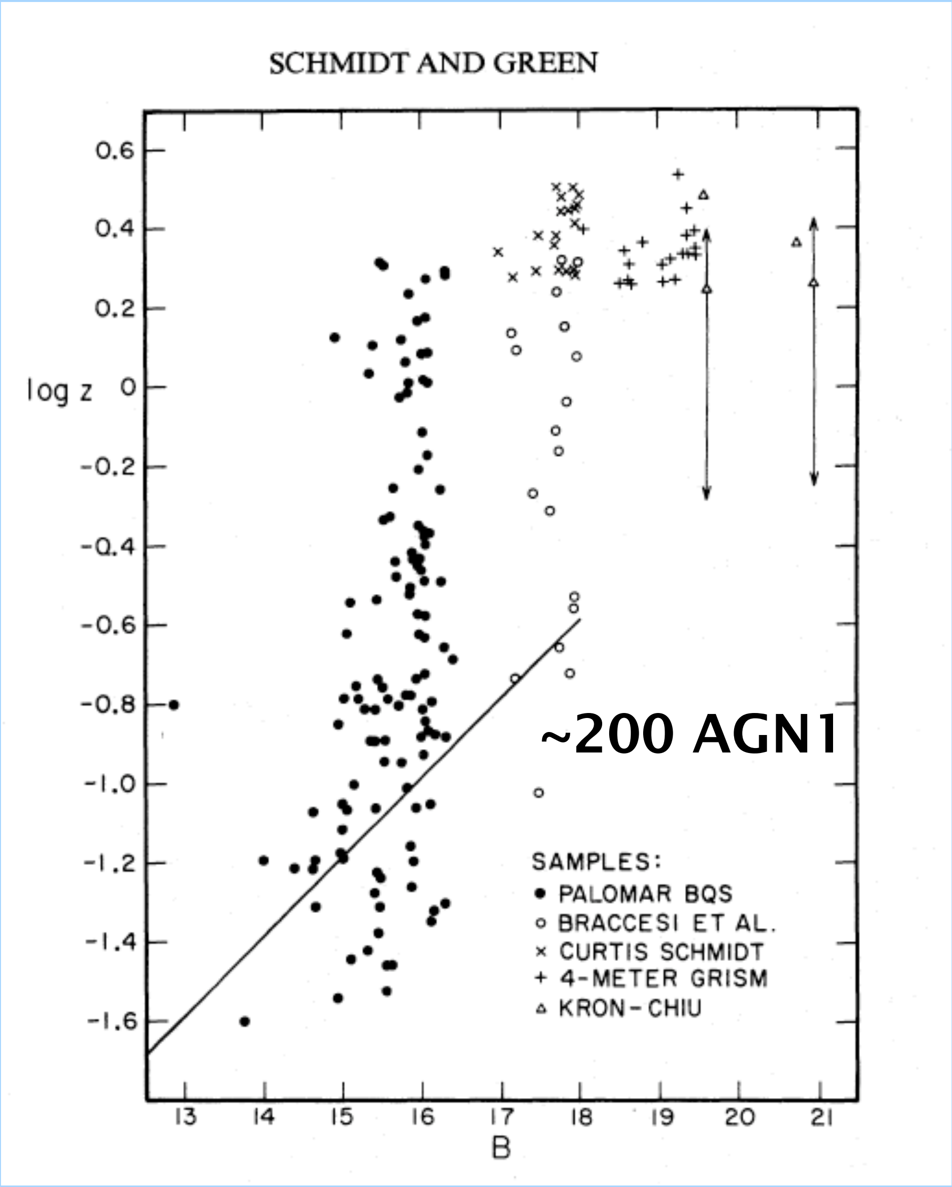
AGN2
NLR

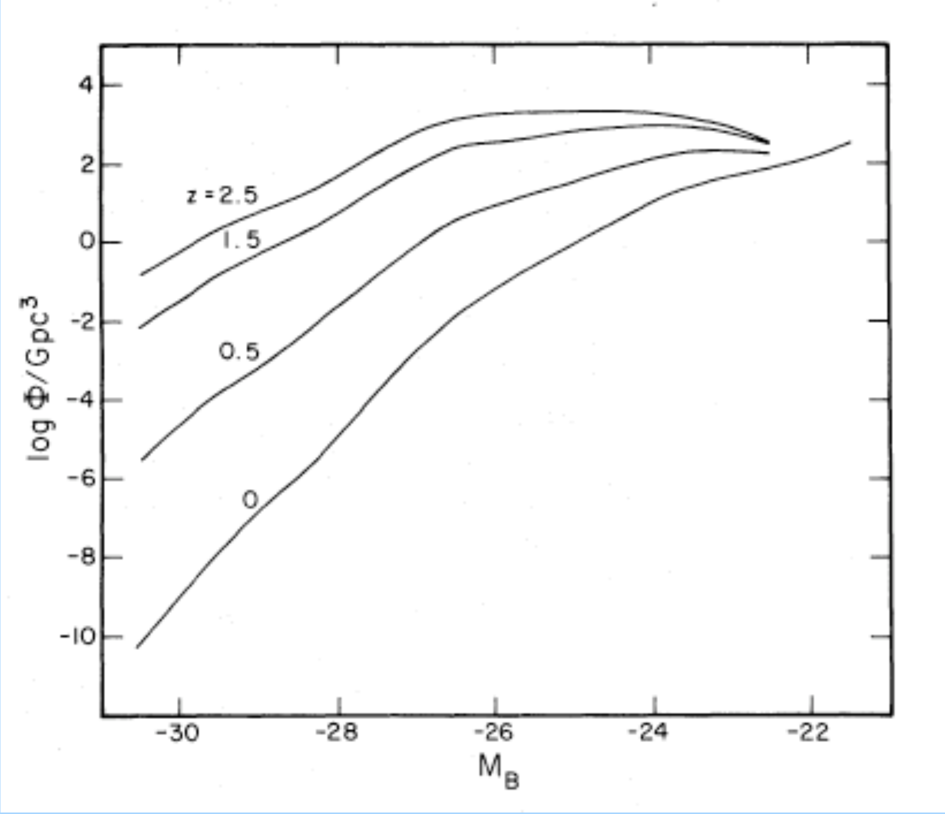
AGN1/QSO - BLR & NLR visible



However AGN1 and AGN2 show:
- different luminosity functions (Ueda +03, La Franca+05, Ueda+14)
- different BH masses and accretion rates

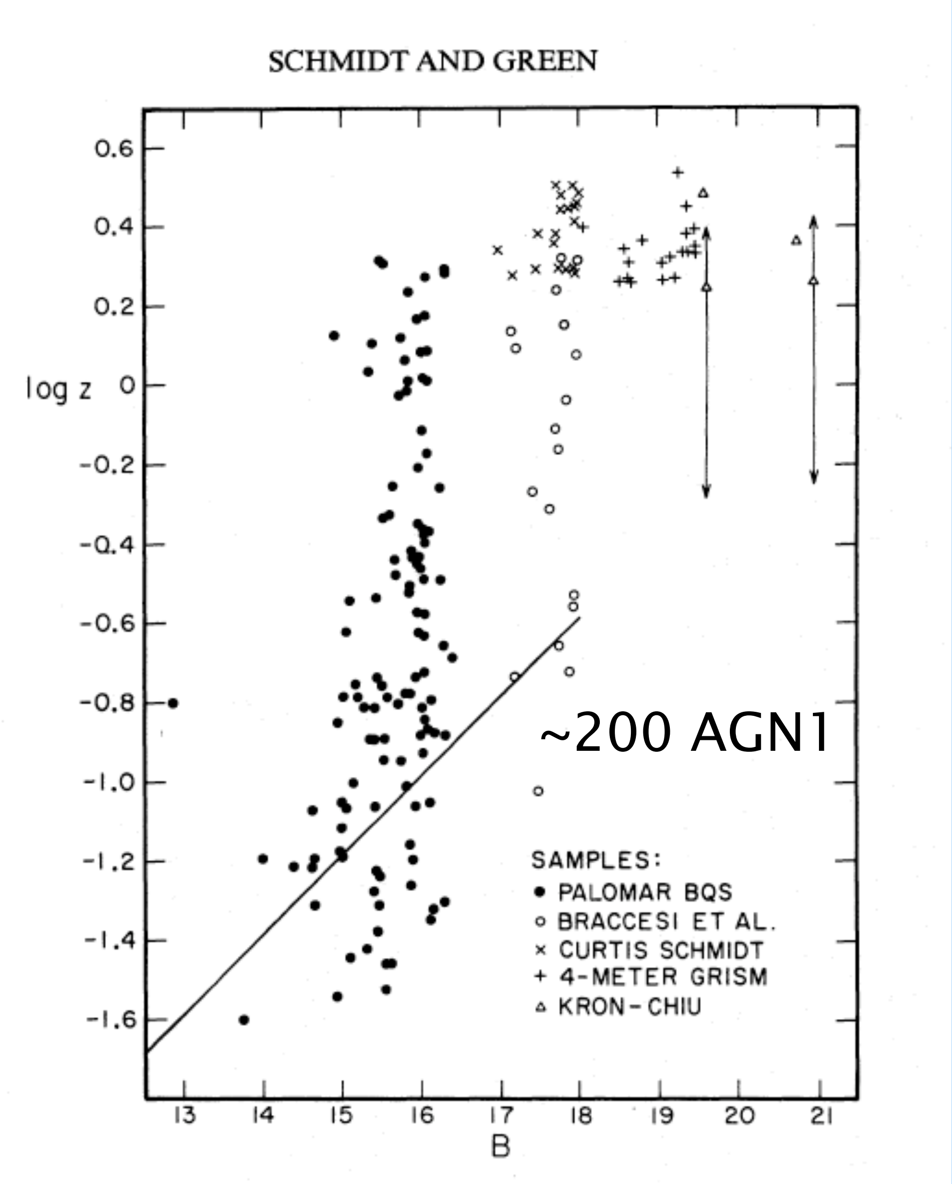
Schmidt & Green 1983: first steps



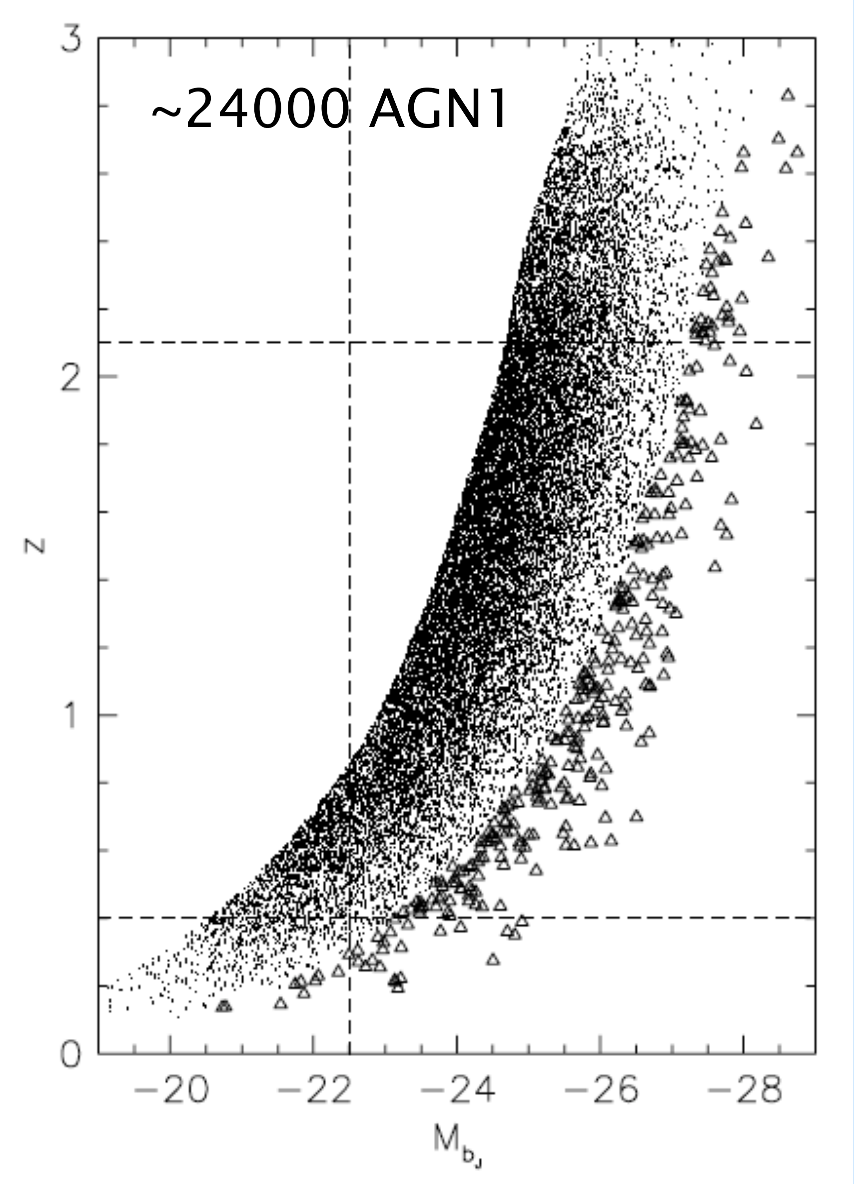


20 years after…and two order of magnitude larger samples

Schmidt & Green 1983



Croom+04, 2dF QSO Redshift Survey

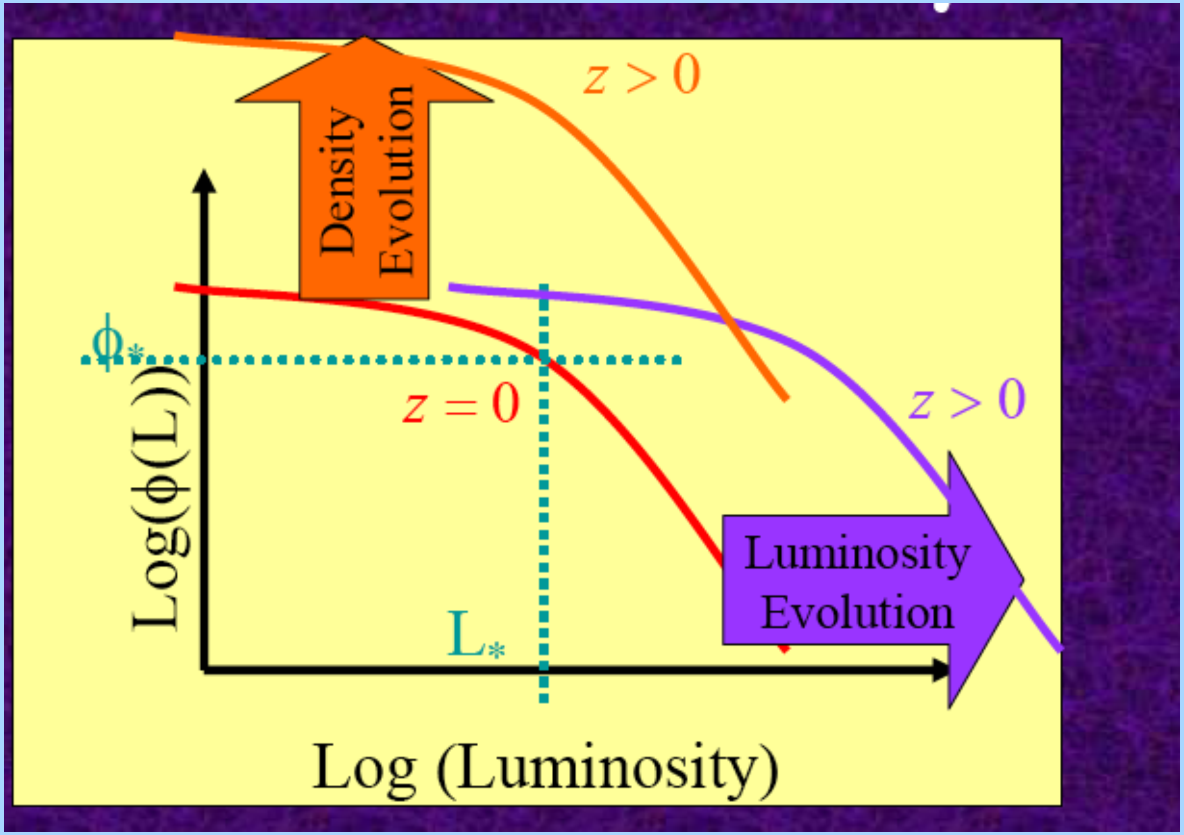


Parameterization

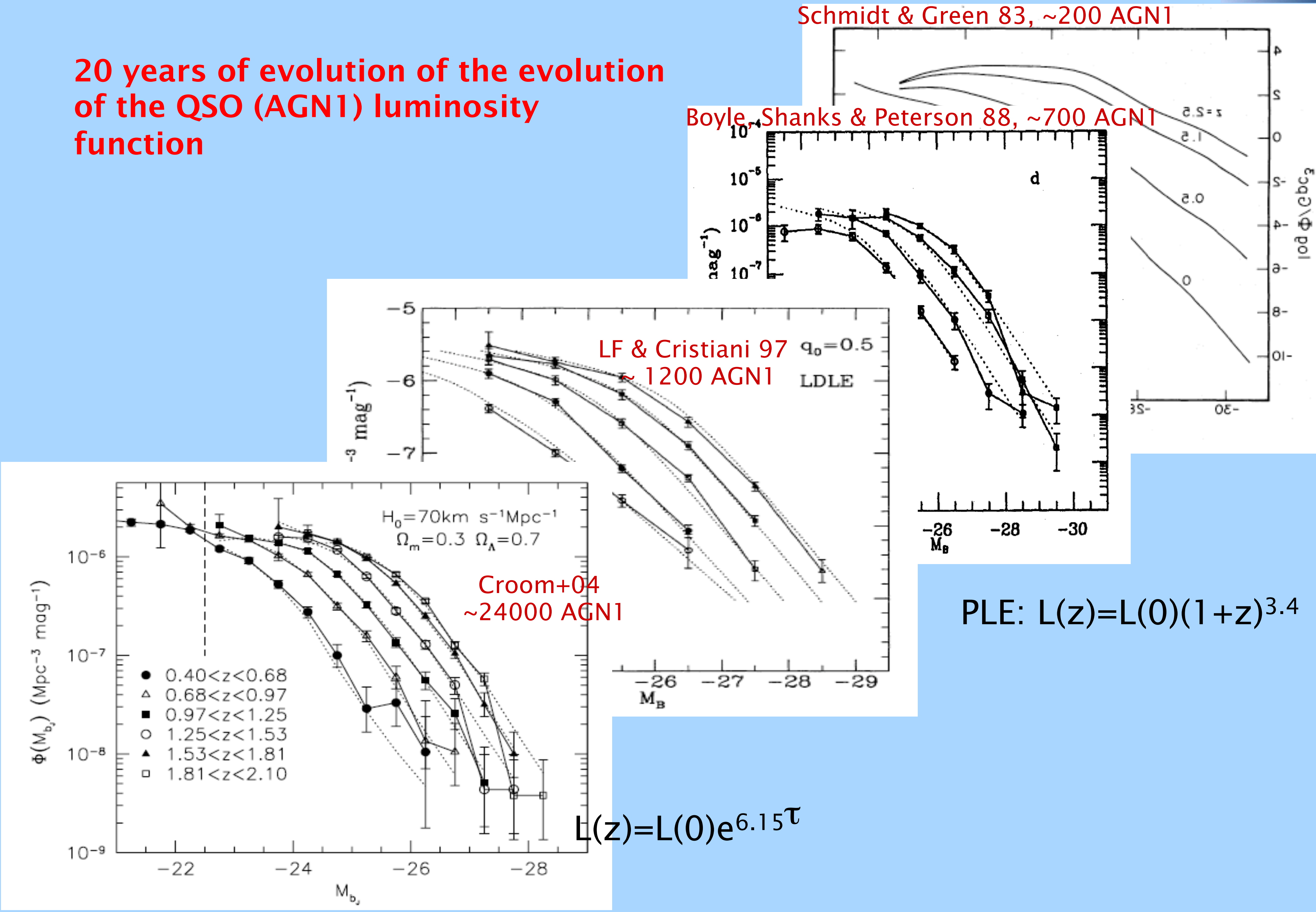
$$\Psi(L) = \frac{\Psi^*}{(L/L^*)^{\beta_h} + (L/L^*)^{\beta_l}}$$

Pure density evolution: $\phi(L,z) = f(z)\phi(L, z=0)$

Pure Luminosity evolution: $\phi(L,z) = \phi\left(\frac{L}{g(z)}, z=0\right)$



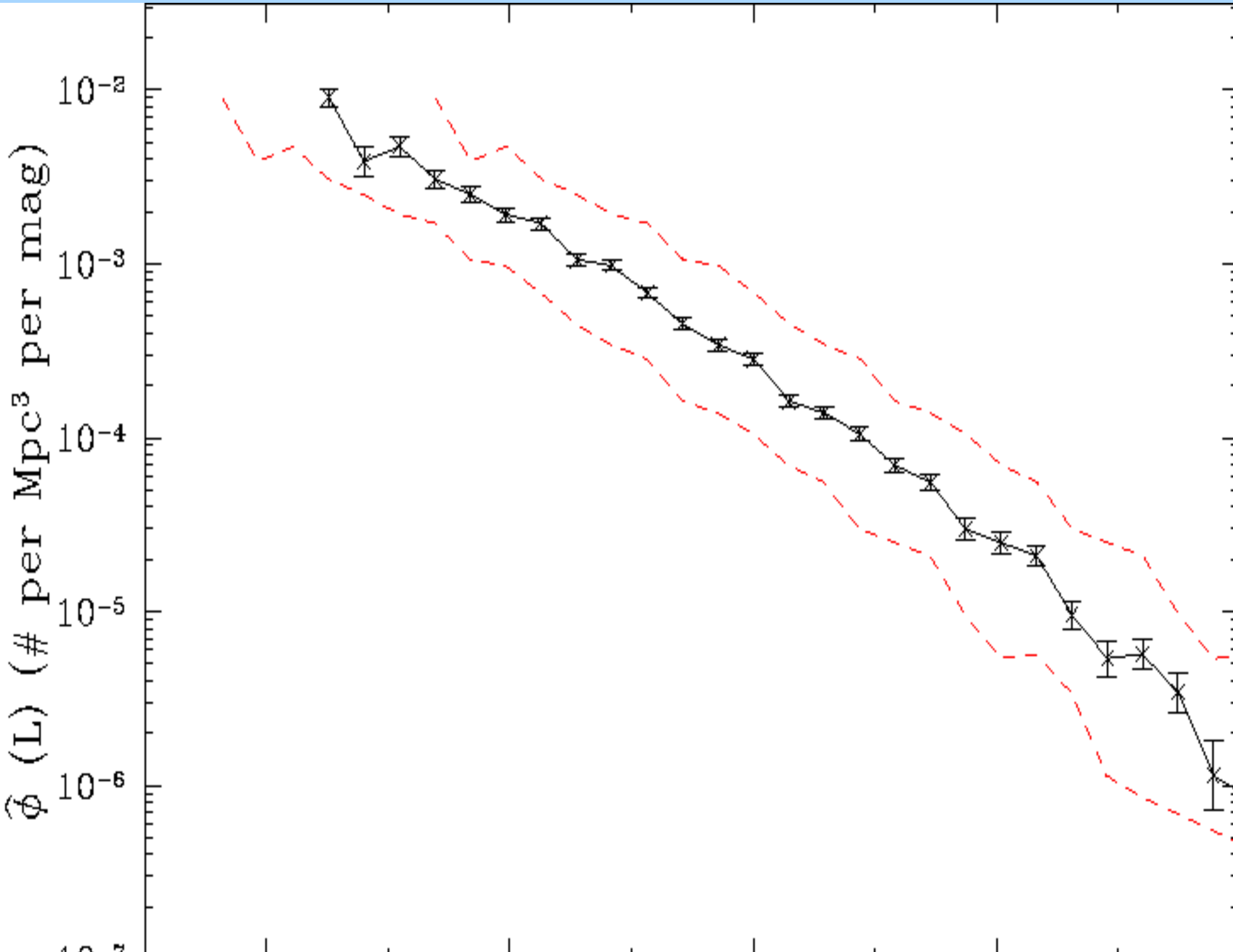
20 years of evolution of the evolution of the QSO (AGN1) luminosity function



PLE: $L(z)=L(0)(1+z)^{3.4}$

$L(z)=L(0)e^{6.15\tau}$

What's the Faint End Slope of QLF?



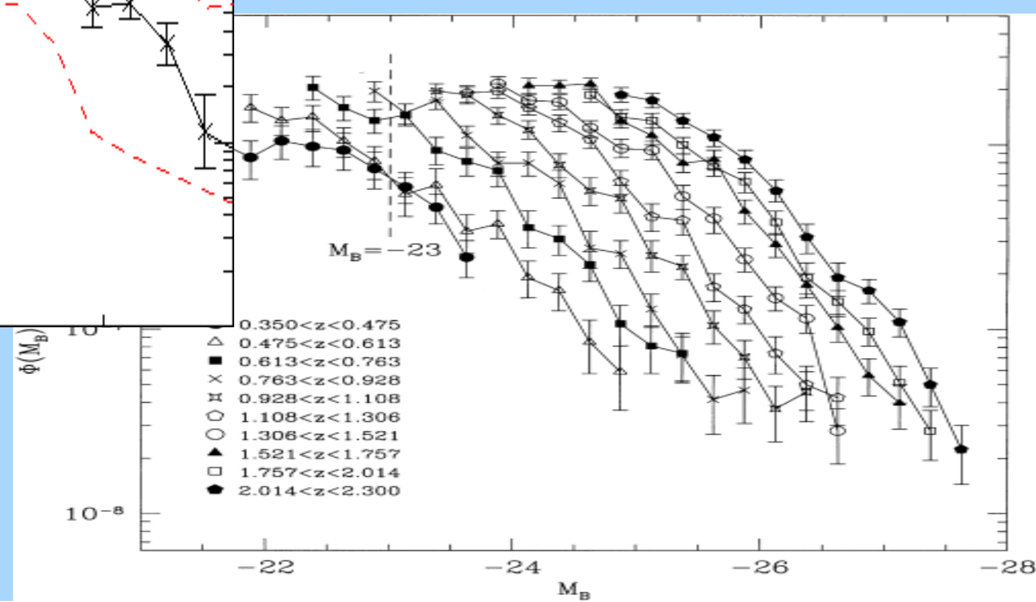
Faint slope measurement

Ranges from -1.0 to -2.0…

→lead to uncertainties in

in the total luminosity and

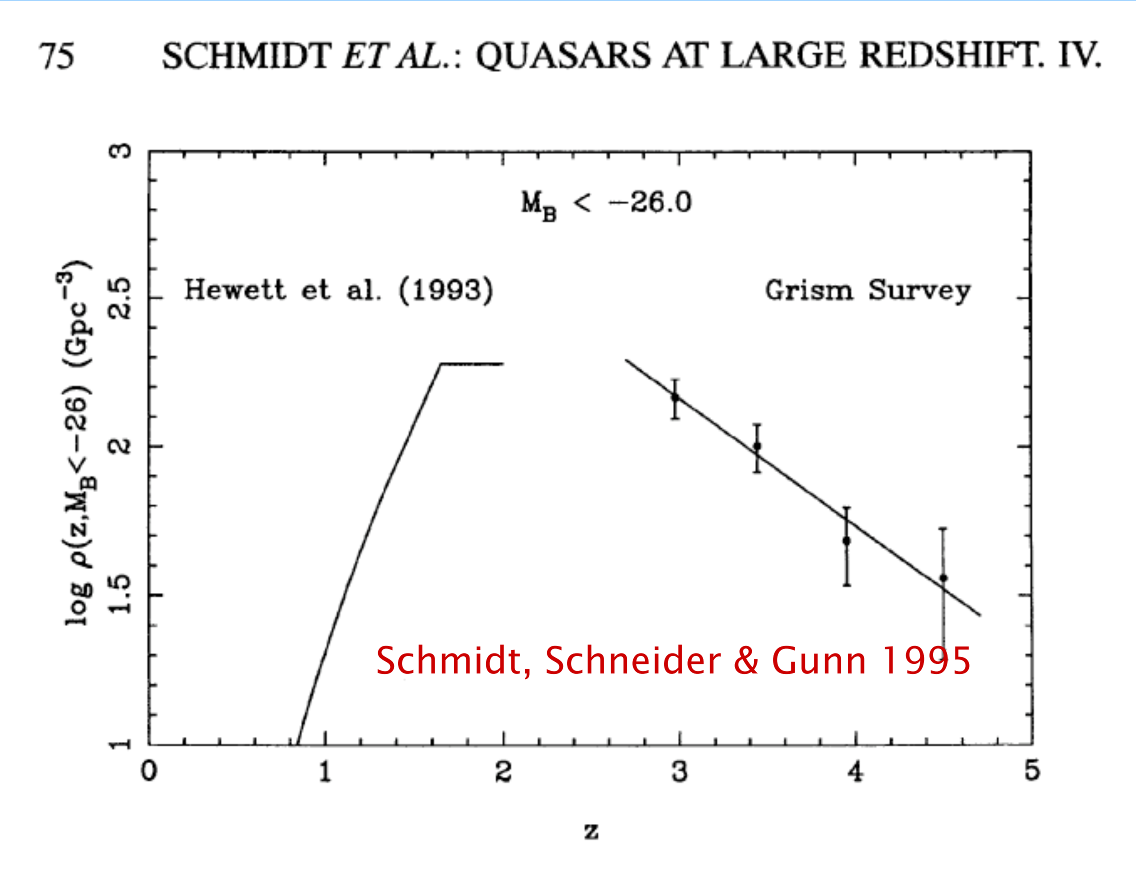
mass density of quasar pop.

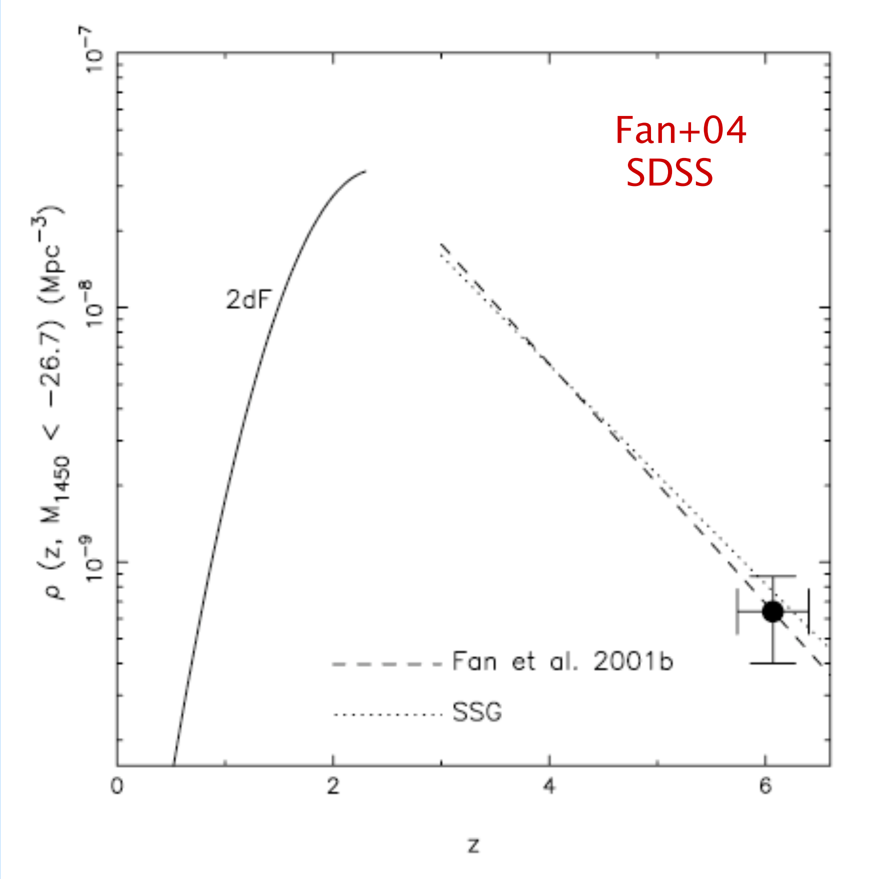


Hao et al. 2004

NLR Hα and [OIII] LF

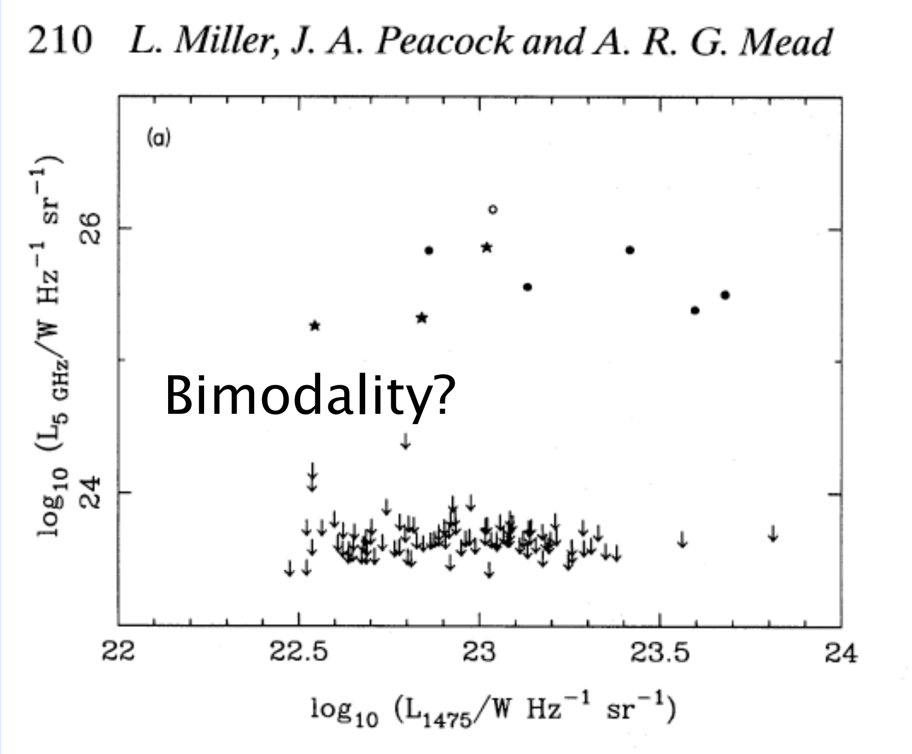
Decline at high redshift of the QSO (AGN1) density optical (grism) selection



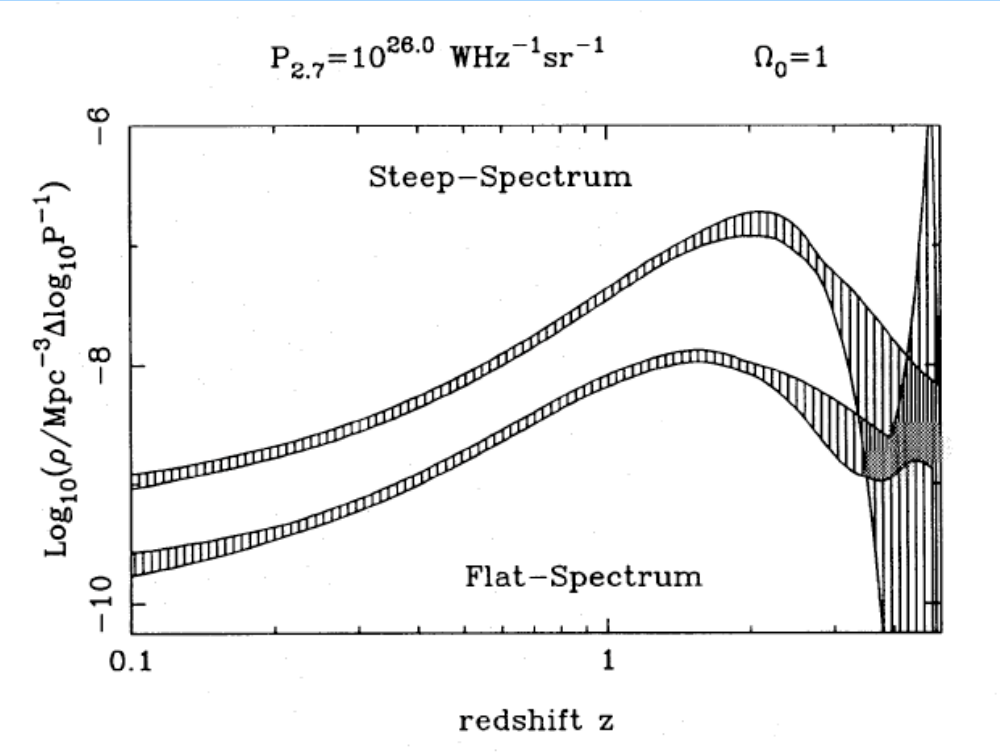


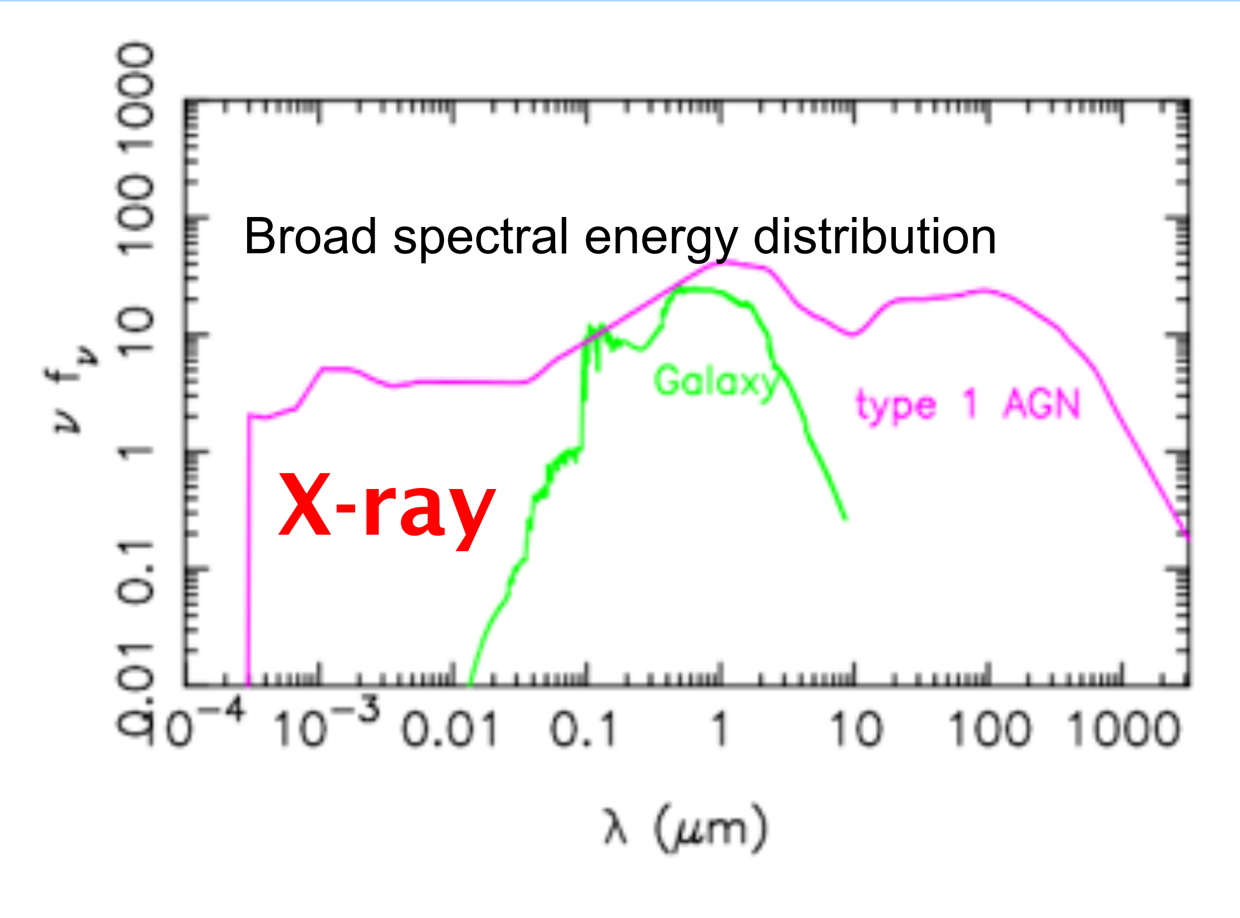
Decline at high redshift of the QSO (AGN1) density radio selection

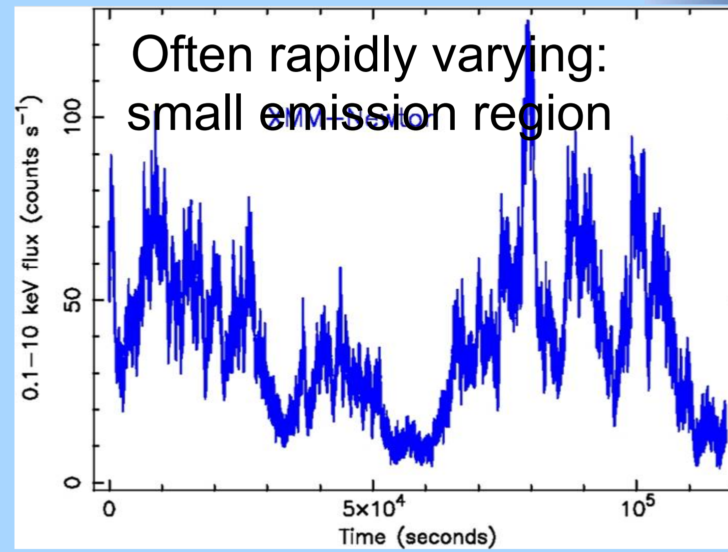
Miller, Peacock & Mead 90



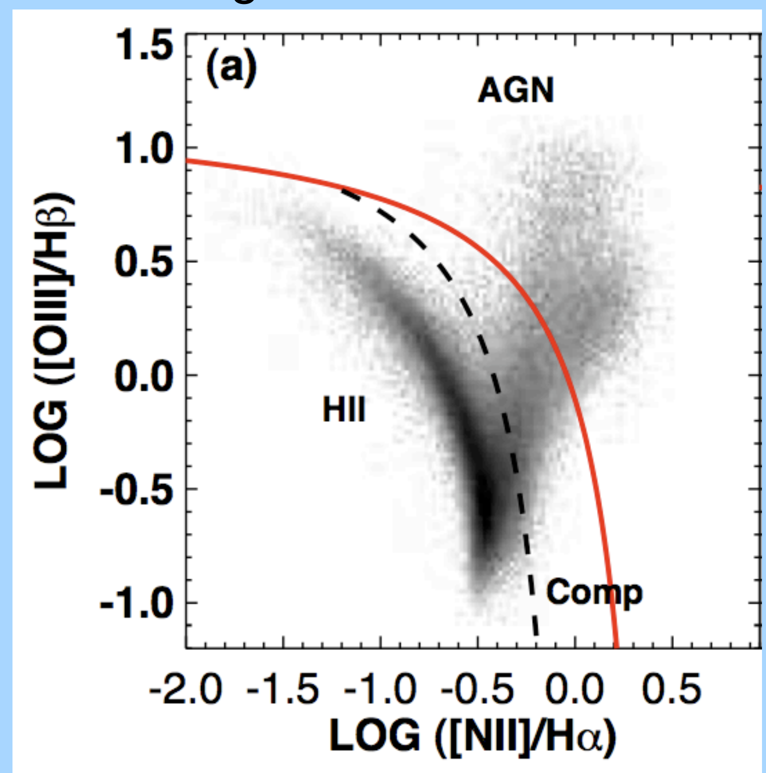
Dunlop & Peacock 90



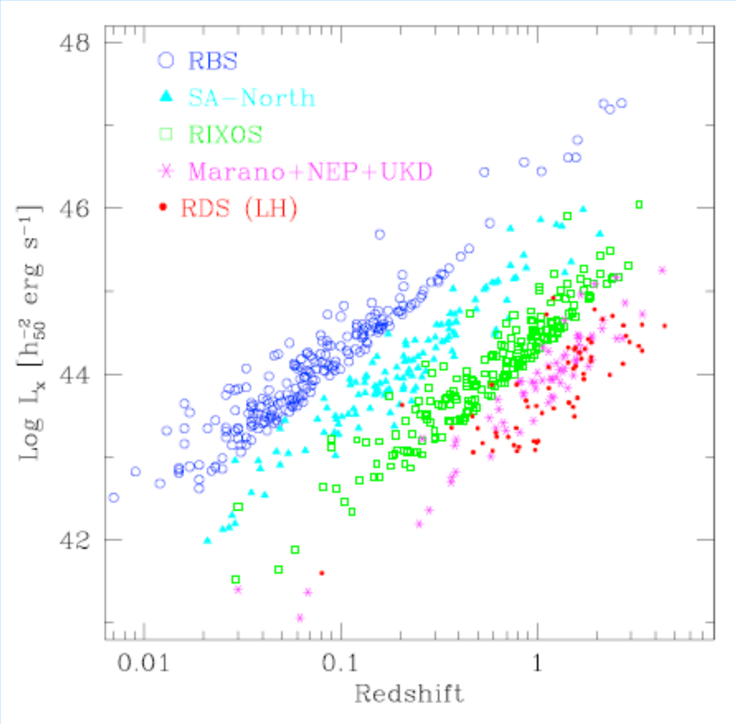




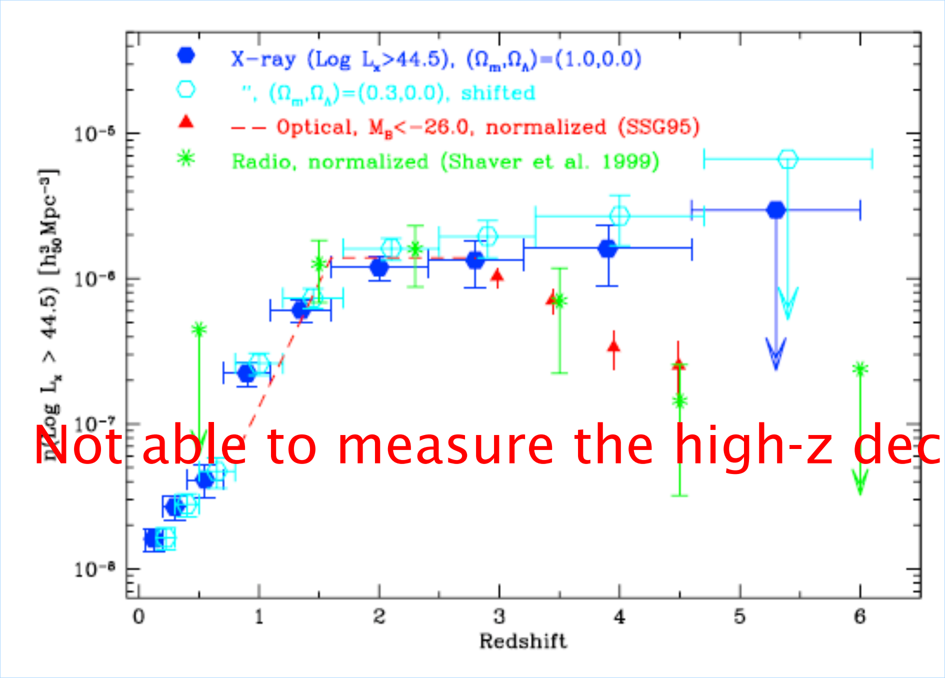
High-excitation emission



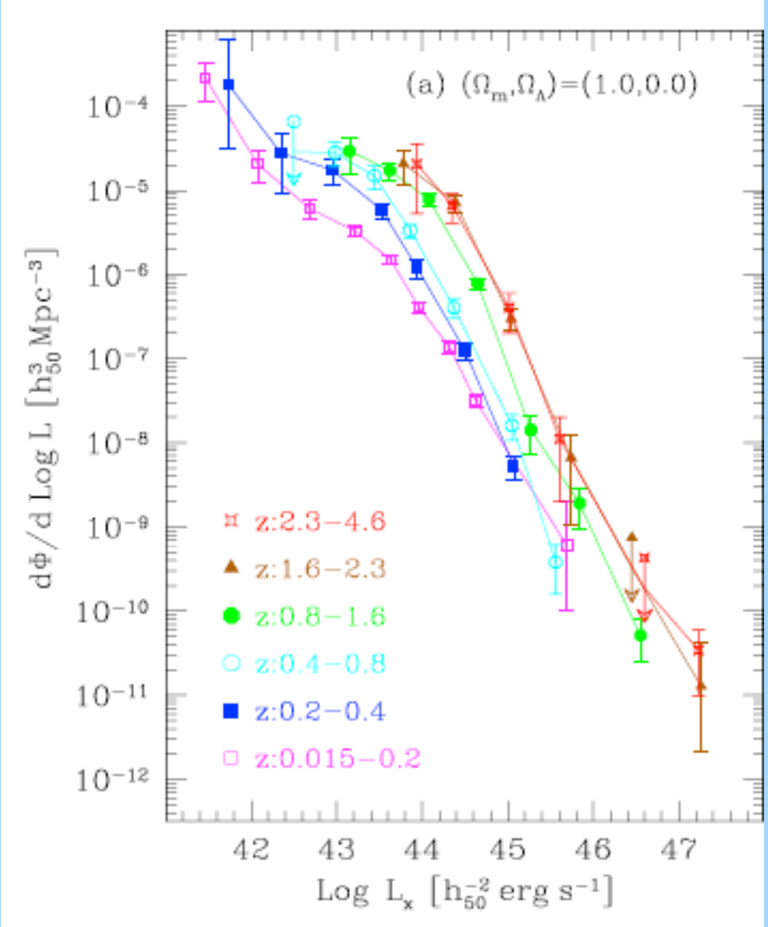
- Non-stellar emission produced at the core of a galaxy (not always visible at optical wavelengths)
  - Broad wavelength SED: bright from X-rays (even gamma rays) to radio wavelengths, unlike stars
  - High-excitation emission lines not found in star-forming galaxies
  - Sometimes highly variable, indicating very compact emission region



Before XMM and Chandra:
the X-ray LF from ROSAT
(Miyaji, Hasinger, Schmidt 2000)
0.5-2keV --> mainly AGN1
Previous works from the Einstein
satellite data: e.g. Della Ceca+92



Not able to measure the high-z decline



X-ray background

the need for the AGN2/absorbed population

Astron. Astrophys. 224, L21–L23 (1989)

ASTRONOMY AND ASTROPHYSICS

Letter to the Editor

Active galactic nuclei and the spectrum of the X-ray background

G. Setti[1,*] and L. Woltjer[1,2]

[1] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-8046 Garching bei München, Federal Republic of Germany
[2] Observatoire de Haute Provence, F-04870 Saint-Michel l'Observatoire, France

Received August 3, accepted September 8, 1989

Summary - Recent unified theories of Active Galactic Nuclei (AGN) predict the existence of numerous AGN with low energy X-ray cutoff in the 10 keV range. The resulting spectrum of the X-ray background produced by all AGN may easily reproduce the observed spectrum. This removes the main obstacle against theories in which most of the X-ray background is due to AGN.

Key words: Active galactic nuclei - X-ray background

1. Introduction

The contribution of Seyferts, quasars and other Active Galactic Nuclei to the X-ray background (XRB) at energies of a few keV has often been discussed (Setti and Woltjer, 1972, 1979, 1982; Zamorani et al., 1981). Newer data have led to improved calculations (Schmidt and Green, 1986; Setti, 1987), but the uncertainties in the evolution of the weaker AGNs and the absence of an adequate sample of X-ray observations of high redshift objects, have left the quantitative contribution of AGNs uncertain.

Because of the wealth of data obtained with the Einstein Observatory the estimates of the integrated contribution of discrete sources to the XRB are conveniently made at the monochromatic energy of 2 keV, although the XRB itself is only known for energies ≥ 3 keV. The reference XRB at 2 keV is obtained by smoothly extrapolating downward the observed XRB in the 3-50 keV energy interval which is well fitted by an optically thin thermal bremsstrahlung with a temperature of ≈ 40 keV (Marshall et al., 1980). The contribution of quasars to the 2 keV XRB is still uncertain within a factor of two but should fall in the range 8-15 percentage points, while the Sy type 1 nuclei contribute a minimum (no cosmological evolution) of 29% (Schmidt and Green, 1986). Among other known classes of objects the main contribution comes from galaxies and clusters of galaxies which should account for at least 20% of the 2 keV XRB. So all together the AGNs contribute at least 40%, but it could be as high as 100% or more of the reference XRB at 2 keV since the actual value of the XRB at this energy is not known.

The main problem for models in which most of the XRB is due to AGNs is the incompatibility of the spectral properties, what Boldt (1987) calls the "spectral paradox". While the energy spectrum of the XRB up to ~ 10 keV is well approximated by a power law with exponent $\alpha = -0.4$, the spectra in the 2-10 keV energy interval of Sy 1 nuclei are characterized by an average slope of $\langle\alpha\rangle \approx -0.7$ with a small dispersion around the mean (Turner and Pounds, 1989). Fewer quasar spectra have been measured in this energy interval, but the results which are being obtained by the Japanese space mission GINGA in the 2-20 keV interval are consistent with the above average slope and dispersion (Inoue, 1988). Even if the AGNs would account for all of the nominal XRB at 2 keV, their contribution at several tens keV, where most of the energy flux resides, would be marginal. This difficulty and the inspiring "thermal" shape of the observed XRB spectrum have revived models in which the XRB is produced by a diffuse hot intergalactic gas (Guilbert and Fabian, 1986; Taylor and Wright, 1989). Here the main difficulties are the energy requirement (the heat stored in the gas at the reheating epoch should be of the same order as the energy in the radiation field of the cosmic microwave background) and the relatively high gas density which exceeds the upper limit on the present baryon density derived by the primordial nucleosynthesis computations in the framework of the standard hot big-bang model. Moreover, the subtraction of the contributions from discrete sources even under minimal conditions leads to a "residual" background whose spectrum is much too flat to be interpreted in terms of an optically thin bremsstrahlung from a diffuse hot intergalactic gas (Giacconi and Zamorani, 1987).

This state of affairs has led to many alternative proposals in which new classes of sources and/or cosmological evolution in the physical properties of known objects have been hypothesized (e.g. Setti (1989) for a recent review). However in the following we shall show that current unified models of AGN predict the existence of strongly absorbed sources with spectra which peak at high energies; including these we obtain a mean AGN spectrum which satisfactorily reproduces the spectrum of the XRB.

2. The Model

In recent unified models of AGN orientation dependent effects, related to the presence of an absorbing torus around the central source, play a dominant role. Antonucci and Miller (1985) first introduced such a model to explain the observed polarized Sy 1 type emission lines seen in Sy 2 galaxies. They ascribed these lines to scattering of the light from a nucleus hidden by an absorbing torus. More recently Barthel (1989) has given reasons for believing that such a torus also accounts for the differences between radio galaxies and radio quasars: in the former the line of sight to the central source passes through the torus and is obscured, while in the latter it is visible. Barthel suggests that a similar relationship might

Send offprint requests to: G. Setti
* On leave from University of Bologna

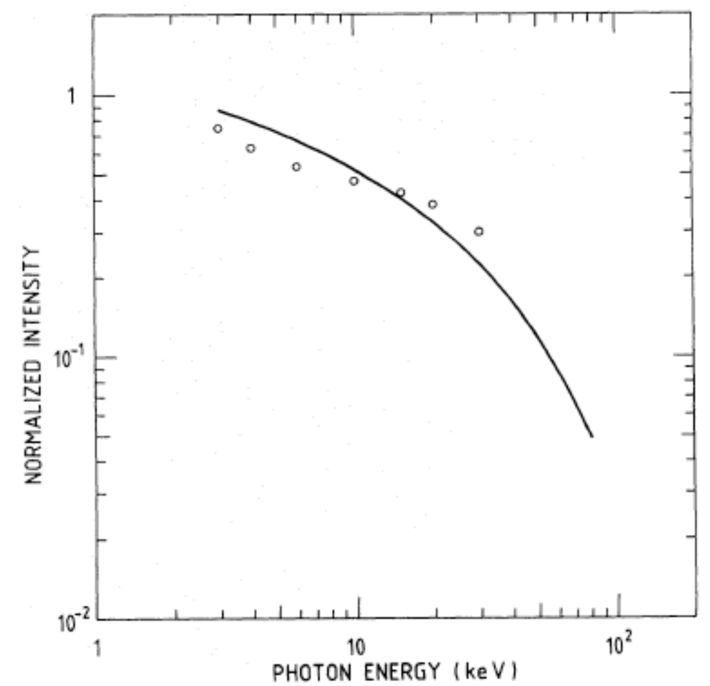
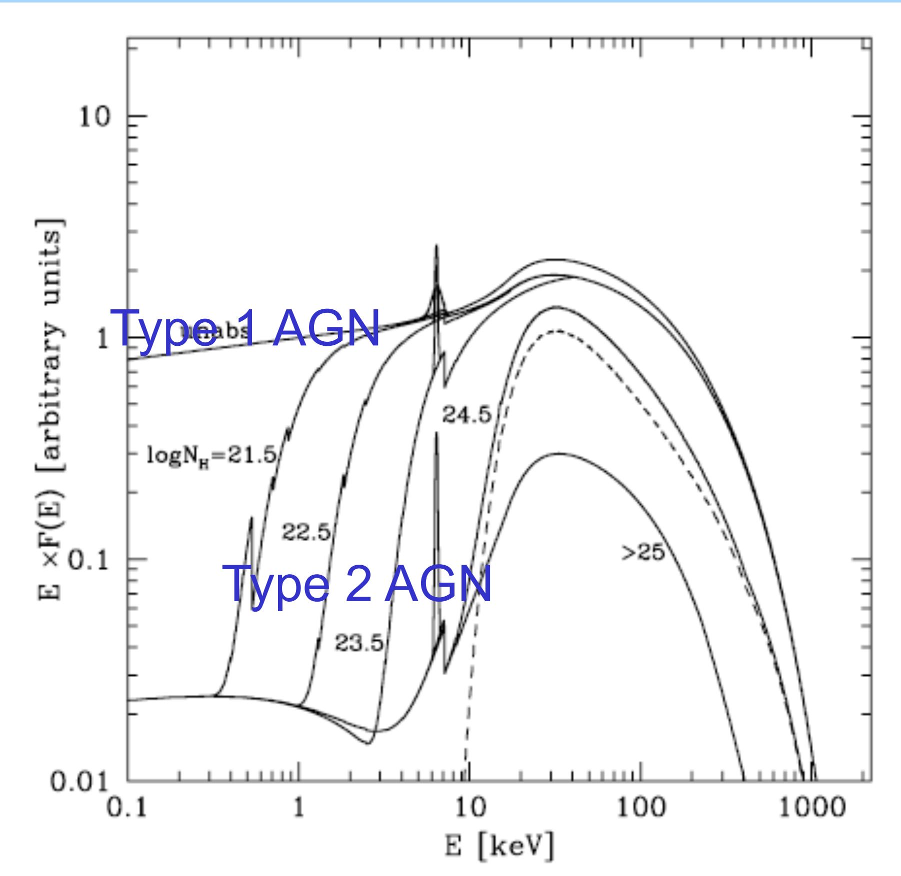


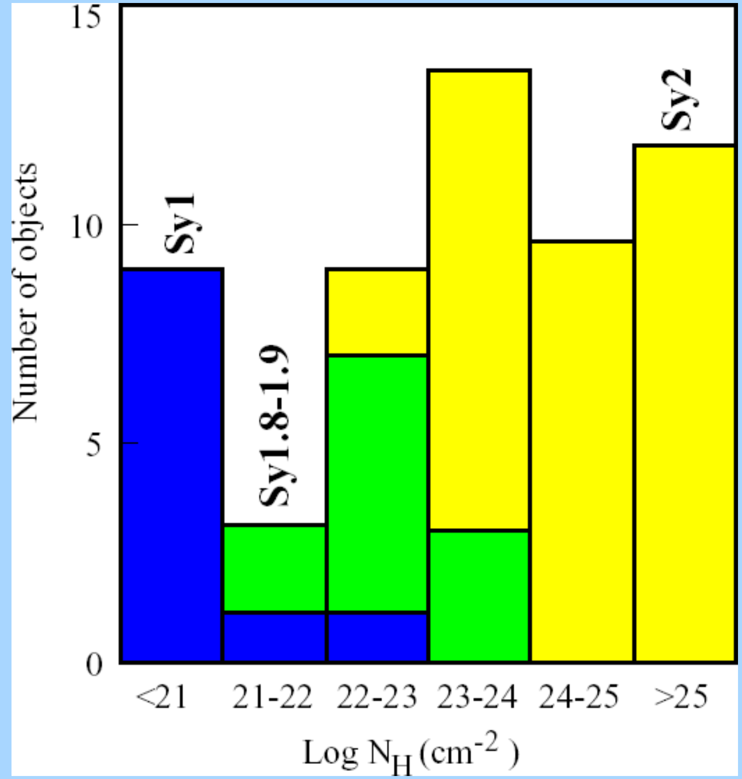
Fig. 1. The solid line represents the 40 keV optically thin thermal bremsstrahlung fit to the observed extragalactic XRB normalized at 2 keV. The open circles are the computed integrated contributions from AGNs in the model described in the text. At the lower energies sources with cutoffs below ~ 10 keV may make an additional contribution, while at higher energies the source spectra should steepen thereby lowering the model points.

Setti & Woltjer 89

X-ray Evidence for Absorption

- X-ray observations show Type 2 AGNs have larger column densities of gas than Type 1 AGNs (they are more absorbed)

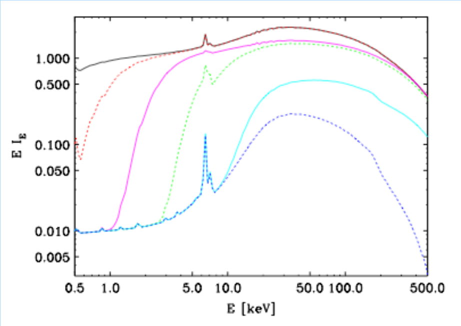




There is rough correspondence between optical AGN1/AGN2 classification and column densities

BUT there were no efficient ways of selecting AGN2 (they are red; no broad emission lines)

X-ray background
the need for the AGN2/absorbed population



The largest part of the AGN population was still missing

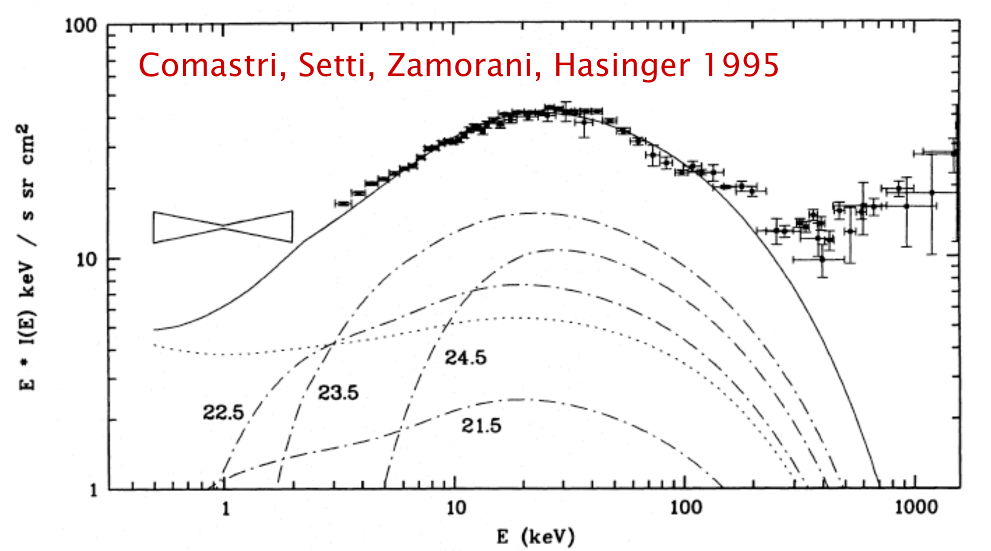
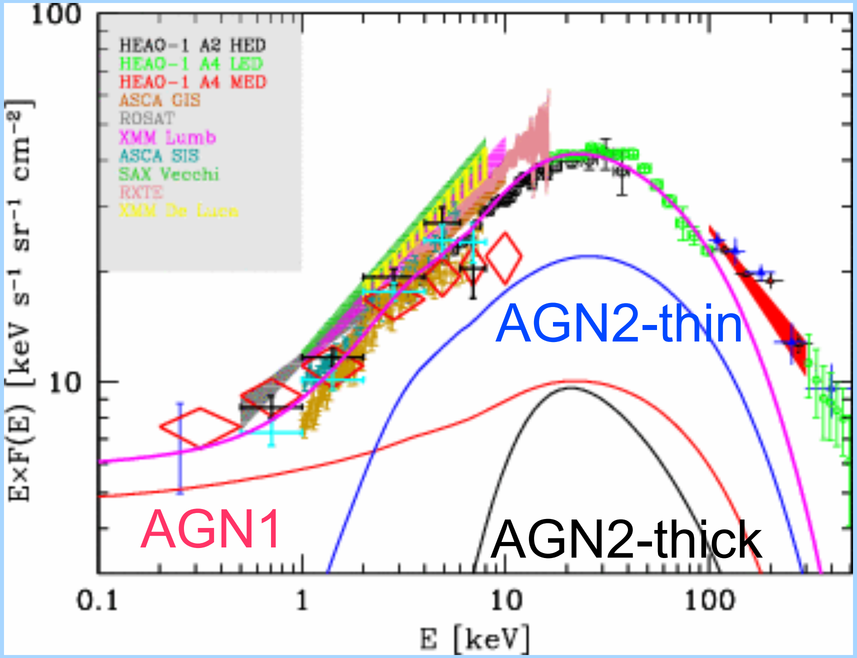


Fig. 1a. The XRB spectrum compared with our baseline model. The 0.5-2.0 keV data are from ROSAT (solid line: Hasinger 1992), while the high energy data are a compilation of best results from various experiments (Gruber 1992). The solid line represents our best fit, the dotted line represents the contribution of unabsorbed sources, while the absorbed sources are indicated by dot-dashed lines. The labels are the logarithms of the corresponding hydrogen column densities



Some other CXRB synthesis models: Matt & Fabian (94); Madau, Ghisellini & Fabian (94); Gilli+99; Pompilio, LF & Matt (1996); Treister & Urry (05); LF+05; Gilli, Comastri & Hasinger (07); Ueda+14

The New Millennium
First Spectroscopic identification of Chandra sources

Eventually we found the AGN2 population but…

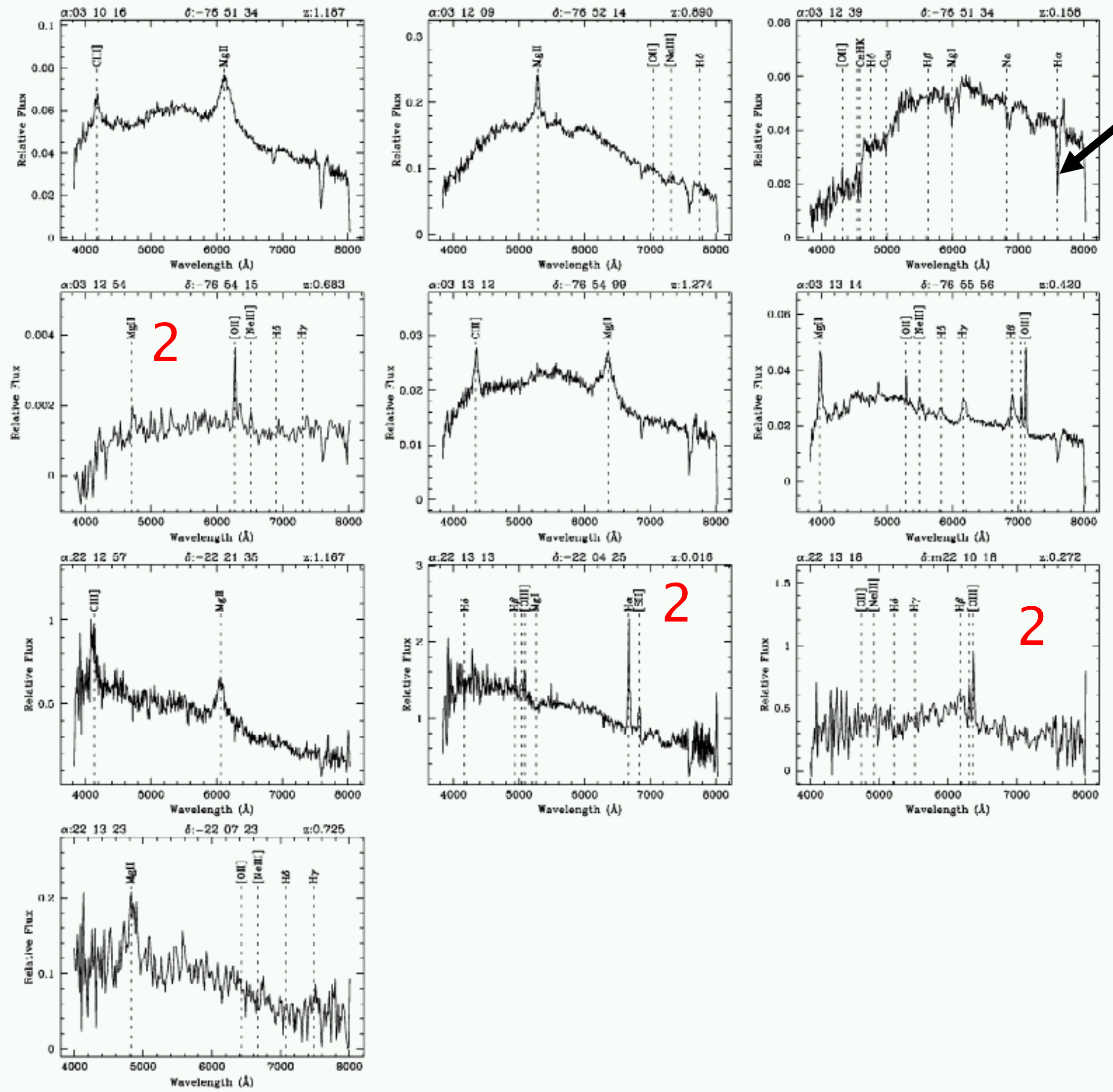


Fig. 1. The EFOSC2 spectra of the ten spectroscopically identified *Chandra* hard X-ray selected sources. Vertical dashed lines are the most important expected atomic transitions, and are reported only for reference.

XBONG
(X-ray Bright Optically Normal Galaxy)
NO EMISSION LINES

It became more evident that emission line diagnostics are not able to select all the AGNs

Fiore, LF, Vignali et al. (2000)

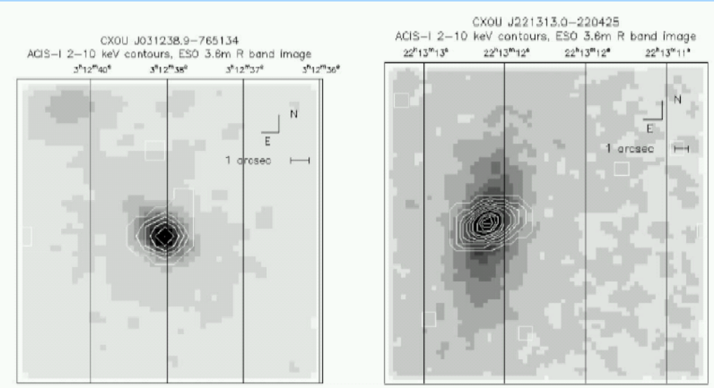
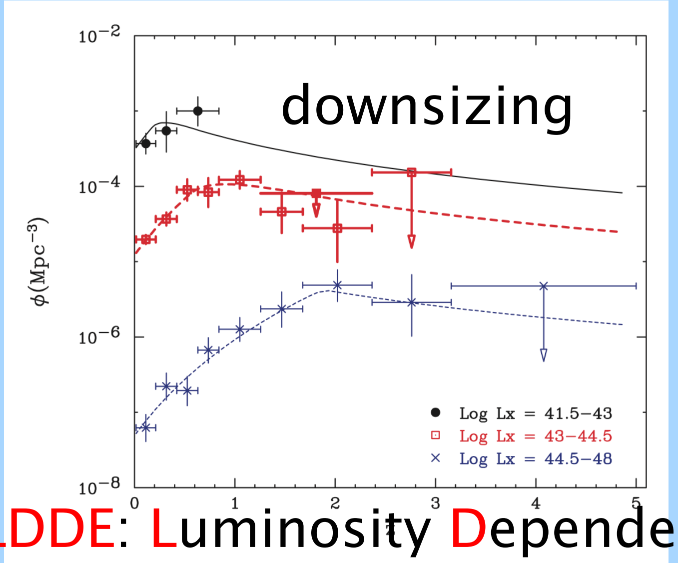


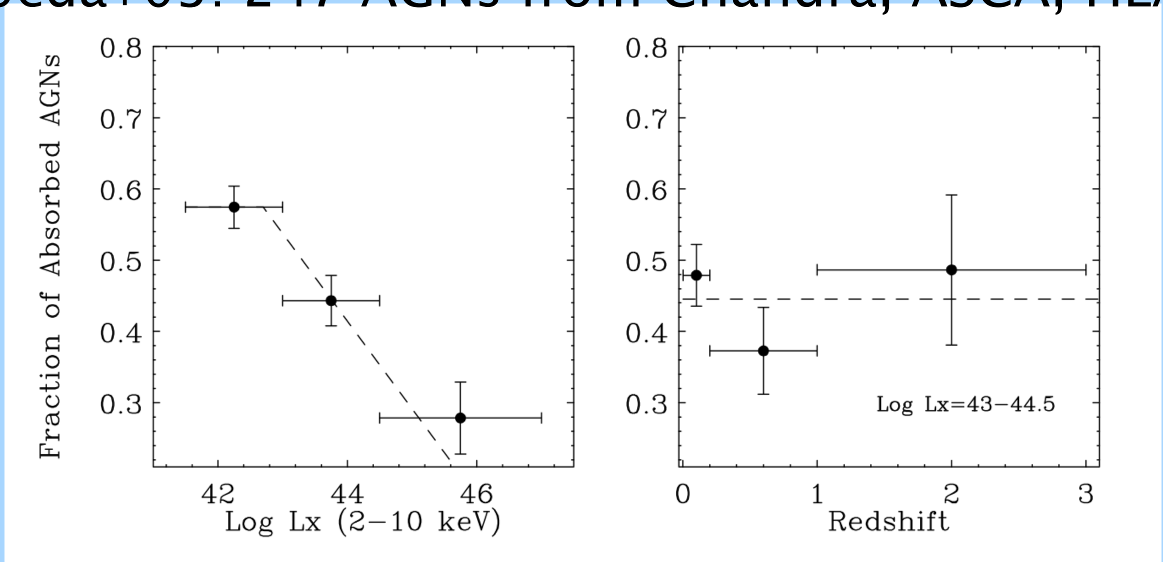
Fig. 2. *Chandra* ACIS-I (contours) and R band images (grayscale) of CXOUJ031238.9−7651, P3 (a), and CXOUJ221313.0−220425, LAR5 (b). The second source was observed by ACIS-I at an off-axis angle of 6 arcmin leading to contours slightly elongated in the East-West direction.

Hard (2-10 keV) X-ray surveys



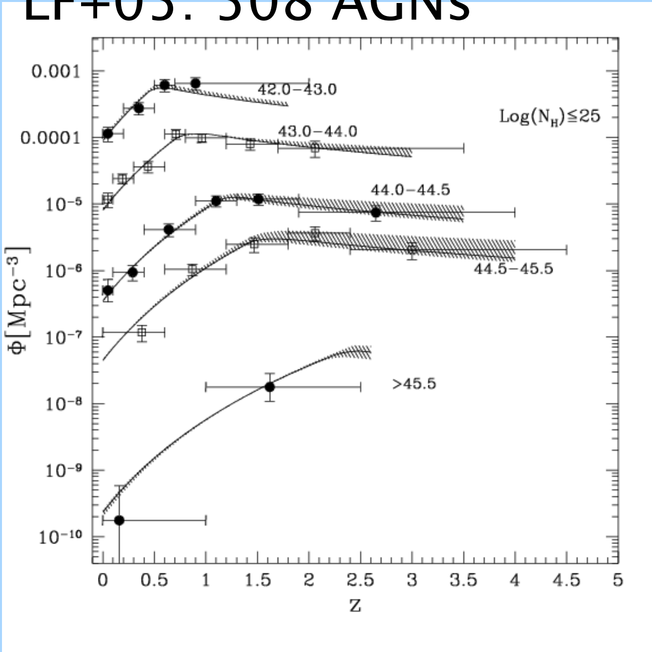
LDDE: Luminosity Dependent Density Evolution

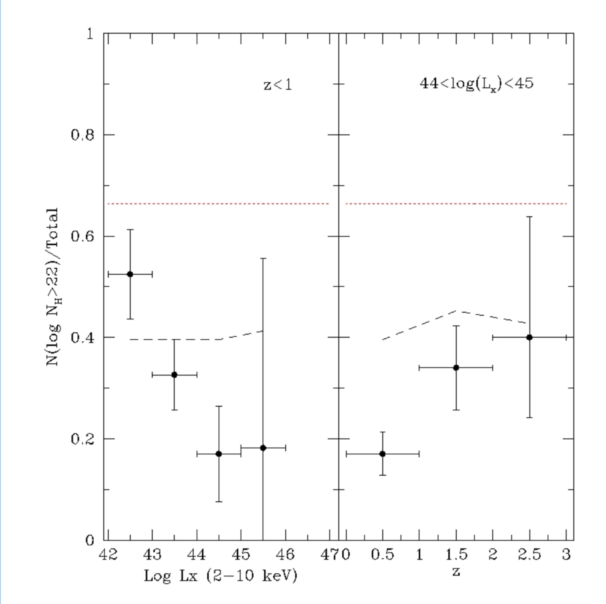
Ueda+03: 247 AGNs from Chandra, ASCA, HEAO1



More absorbed AGN at low luminosities

LF+05: 508 AGNs

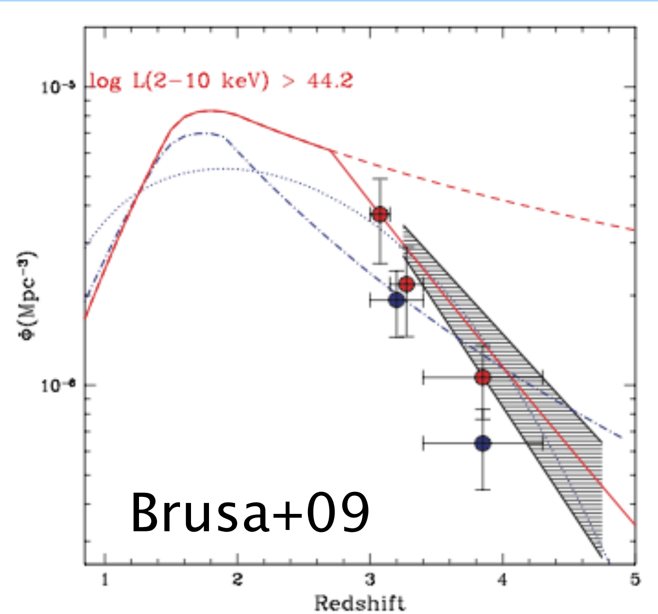




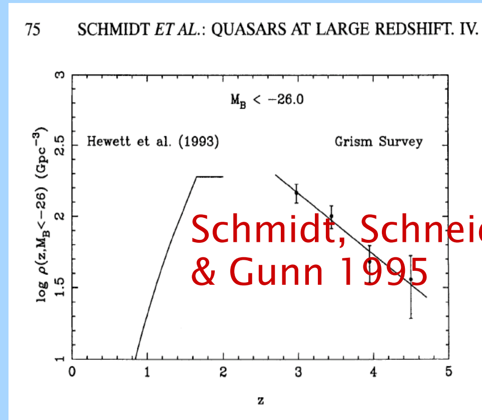
More absorbed AGN at low luminosities and high-z

Hard (2-10 keV) X-ray surveys: z>3

We eventually see the decline at high z of the (almost) complete AGN population



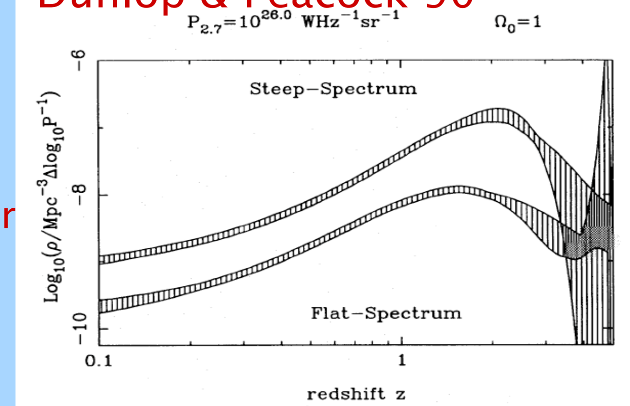
Brusa+09



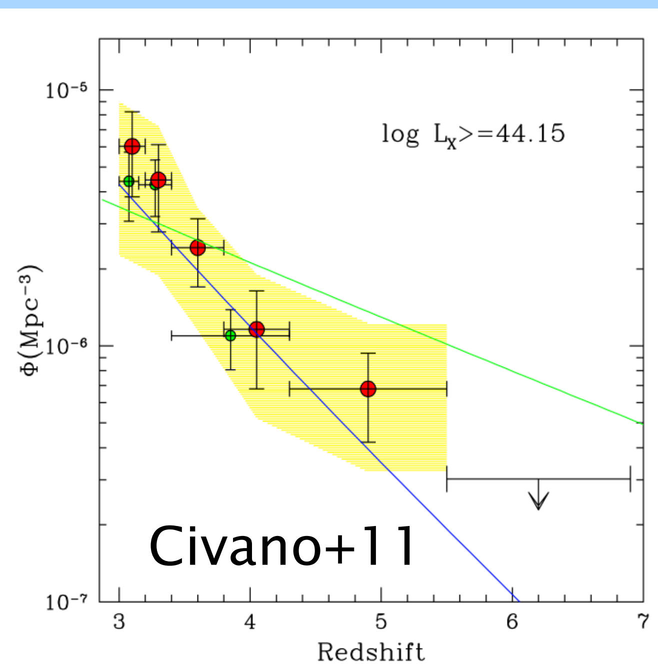
Schmidt, Schneider & Gunn 1995

AGN1- OPTICAL

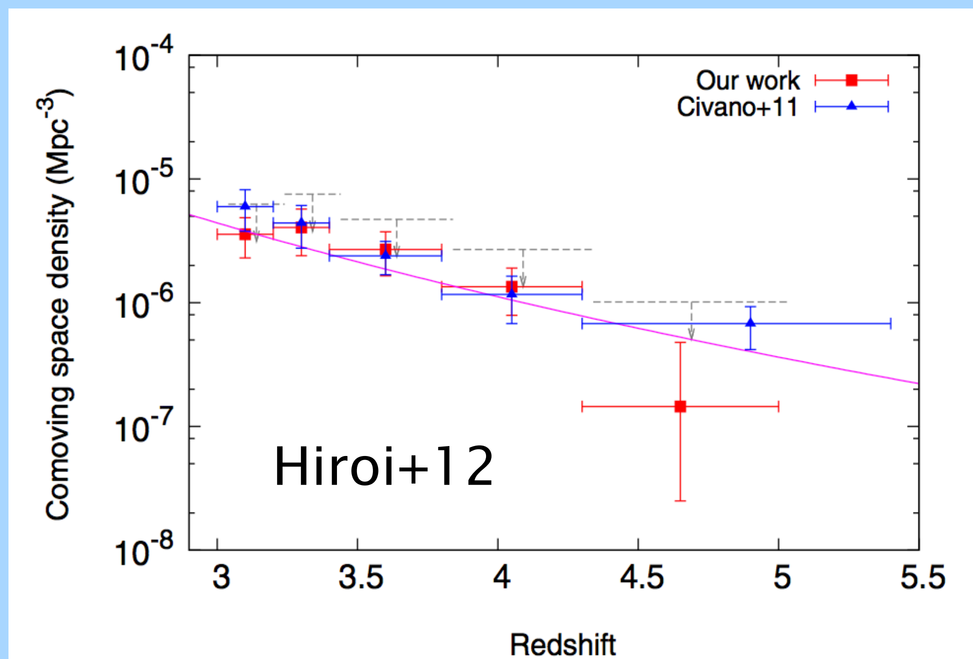
Dunlop & Peacock 90



RADIO



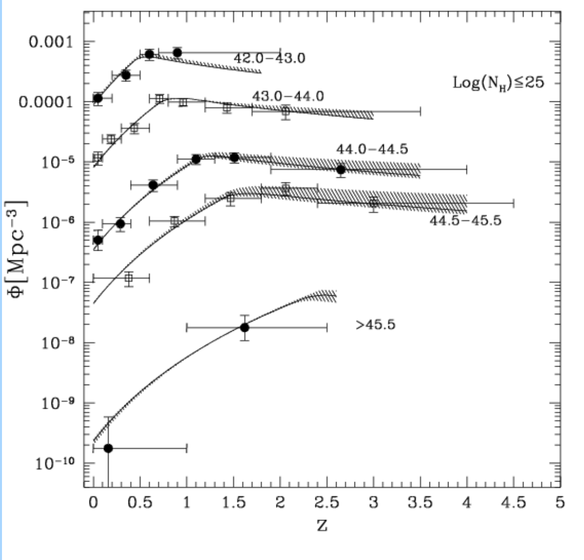
Civano+11

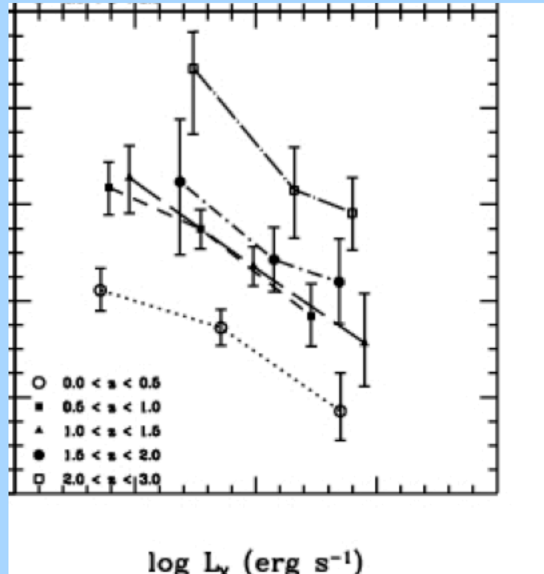


Hiroi+12

Downsizing and absorption=f(L,z)

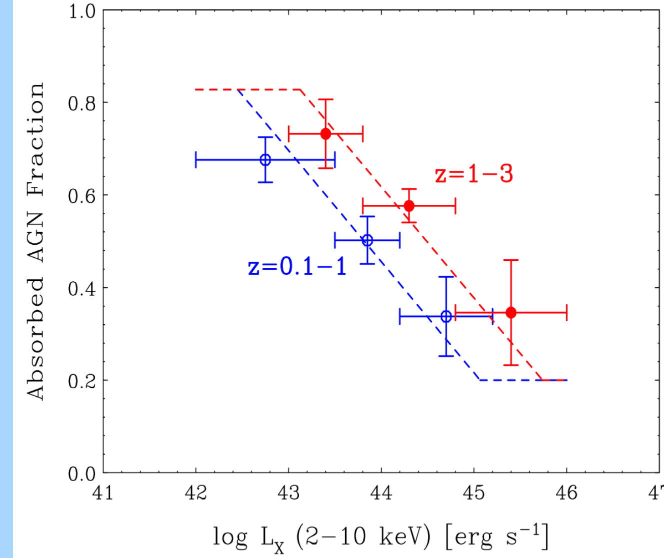
LF+05





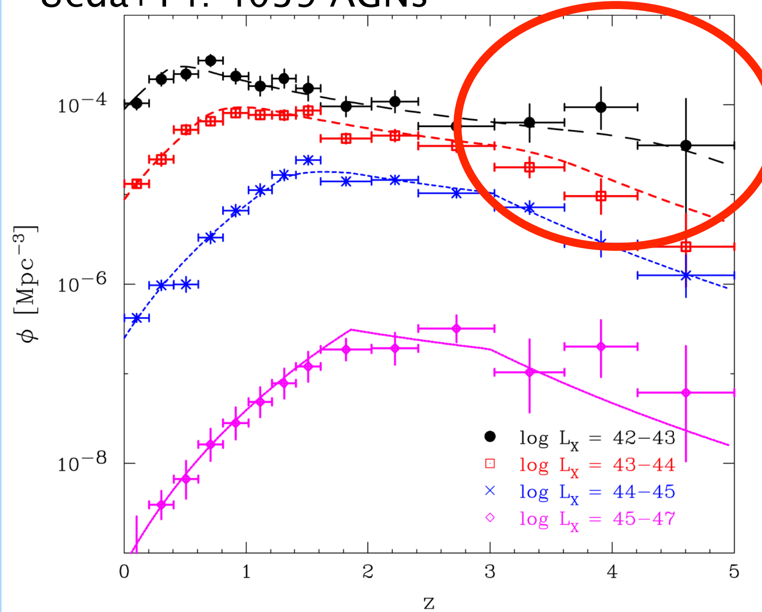
Melini,PhDTh,09

Ueda+14: 4039 AGNs



More absorbed AGN at low luminosities and high-z

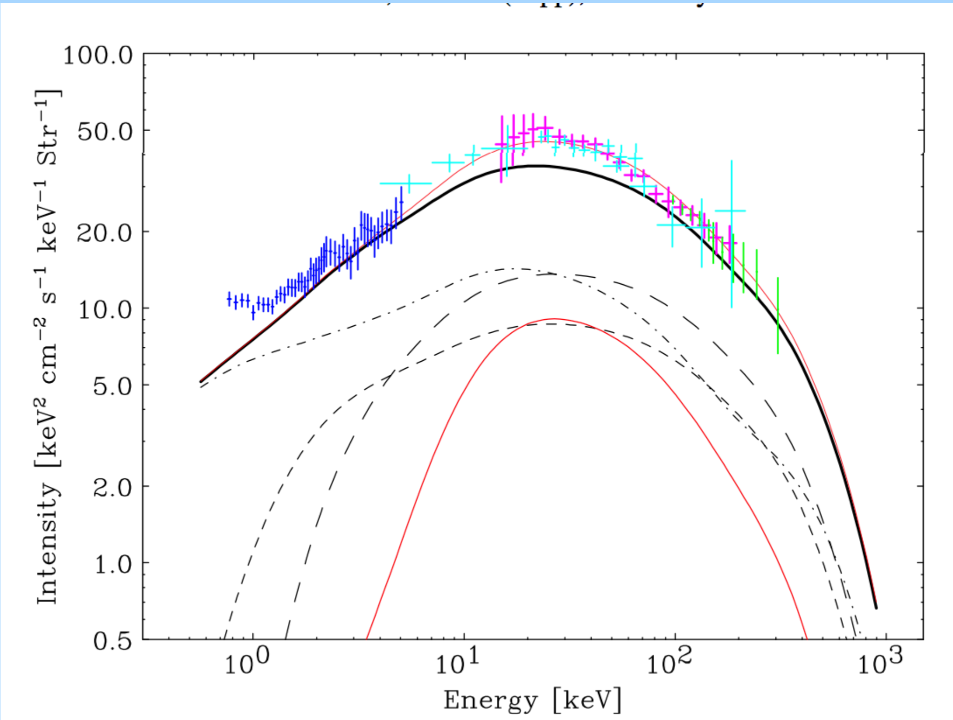
Ueda+14: 4039 AGNs



“upsizing” evolution (i.e., the number ratio of less luminous AGNs to more luminous AGNs is larger at earlier epochs). This is what is expected from the hierarchical structure formation in the early universe. Thus, the SMBH growth must be correctly described by *“up-downsizing”* (Ueda+14)

X-ray background
Uncertainties on the density of heavily obscured (CTK) AGNs

Ueda+14



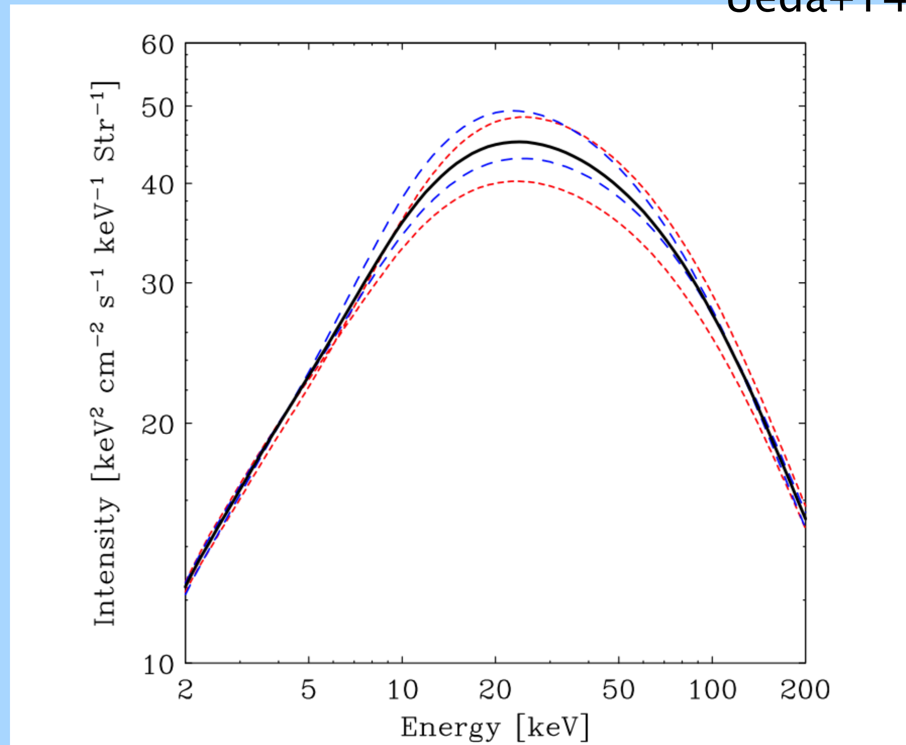
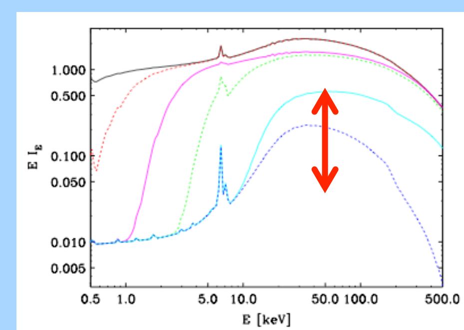
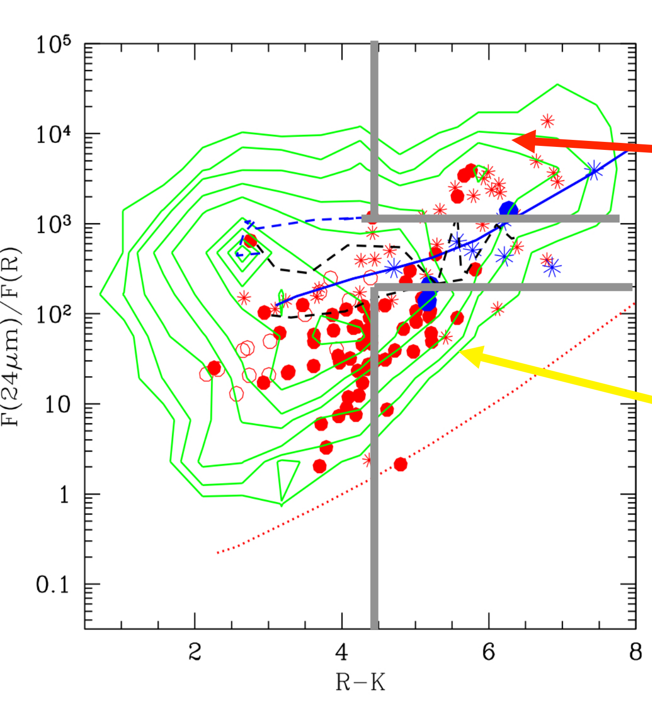


Figure 19. The predicted XRB spectra by assuming different fractions of CTK AGNs relative to obscured CTN AGNs (short-dashed, red; $f_{CTK} = 2$ and 0.5 from upper to lower), or different reflection strengths from the accretion disk (long-dashed, blue; $R_{disk} = 1.0$ and 0.25 from upper to lower). The baseline model ($f_{CTK} = 1.0$ and $R_{disk} = 0.5$) is plotted by the solid line (solid, black).

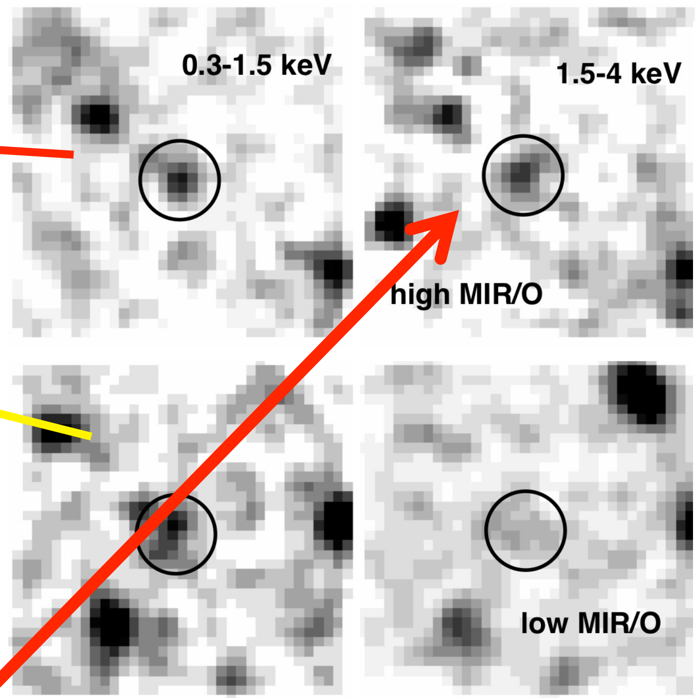
There are degeneracies between the estimate of CTK AGN fraction and the strength of Compton reflection components in the AGN spct.
The best-estimate of CTK density will be changed by +/- 50% when we assume Rdisk = 0.25 and 1.0, respectively, although the choice of Rdisk = 0.5 is the most reasonable



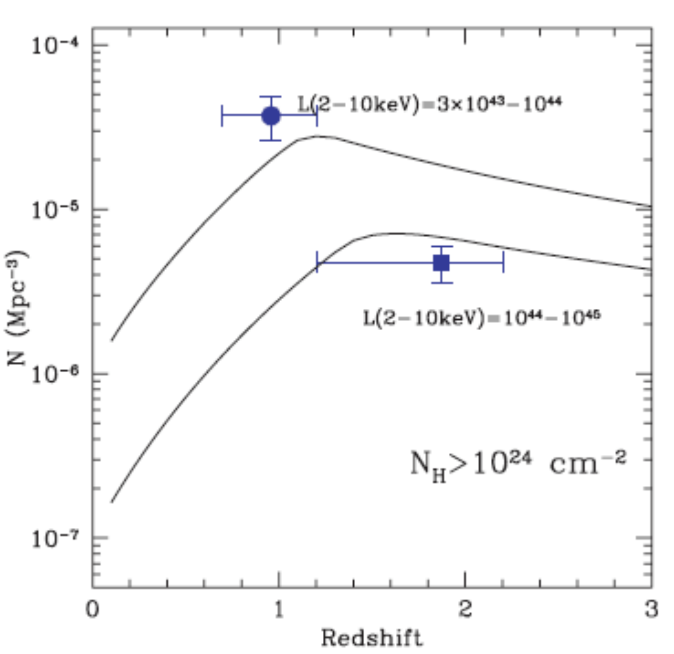
The search of CTK AGN in the MIR



SOFT HARD



Fiore+08+09



Hard spectrum
logN_H>24 CTK AGNs

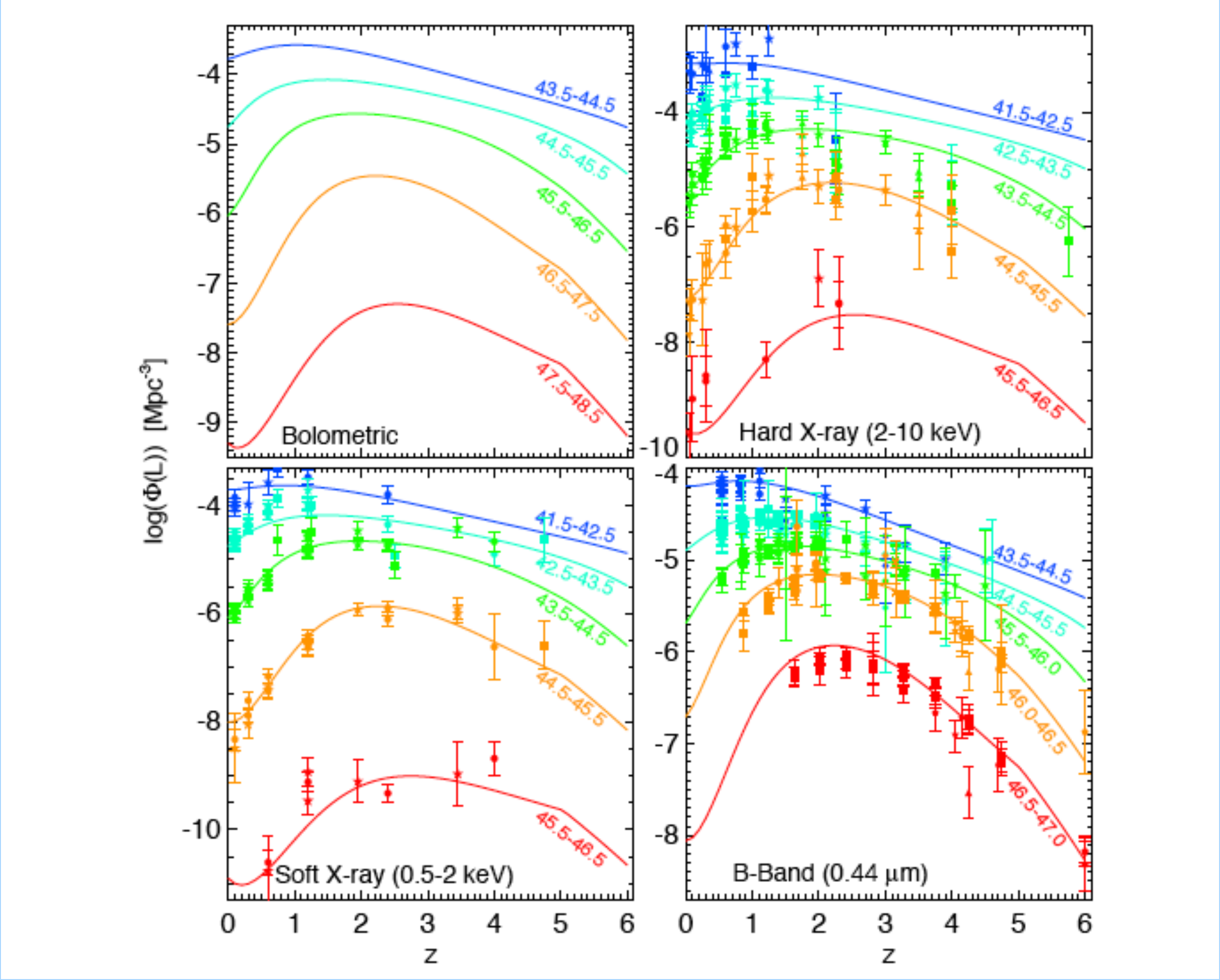
Stack of Chandra images of MIR sources not **directly** detected in X-rays

See:
Daddi+07
Fiore+08,09
Lanzuisi+09
Bauer+10
Alexander+11
Melini+ in prep.

But there is no evidence of a large undetected CTK AGN population that could change our understanding of the AGN evolution

Downsizing observed in all bands

Hopkins, Richards & Hernquist (2007)

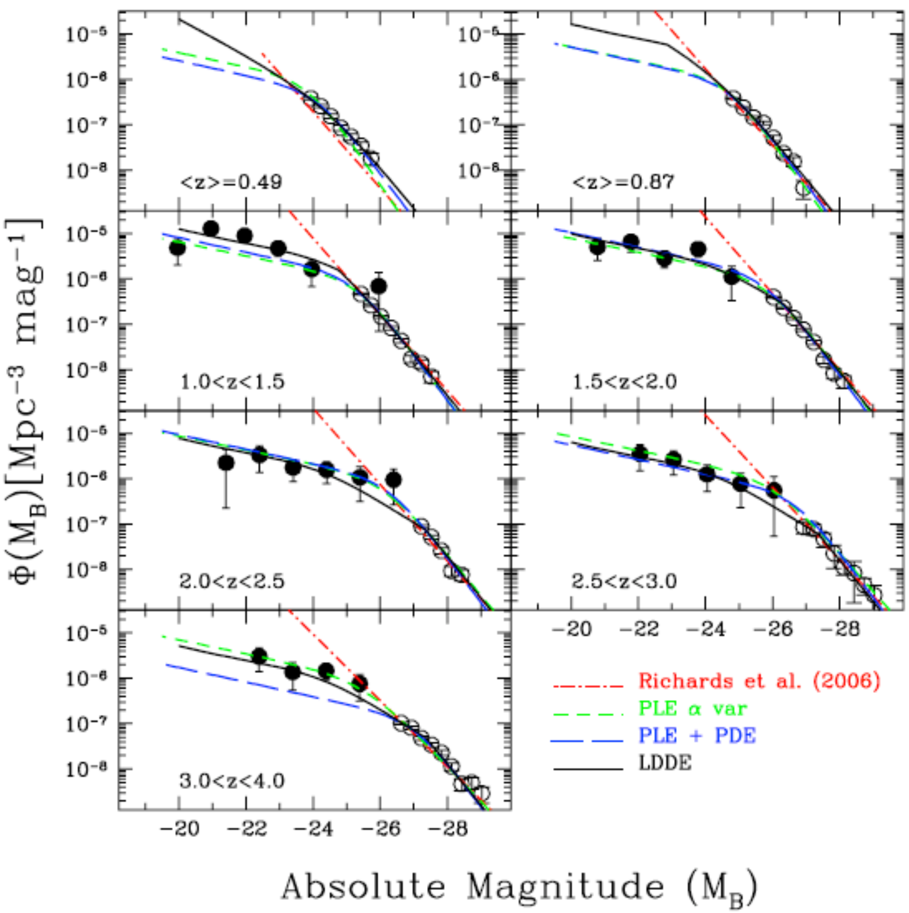


Attention: this is a downsizing of the LF (accretion rate) and not of the BHMF

LDDE found also for optically selected AGN1 once the faint end of the LF is probed

Bongiorno+08

A. Bongiorno et al.: The VVDS type-1 AGN sample: the faint end of the luminosity function



A. Bongiorno et al.: The VVDS type-1 AGN s

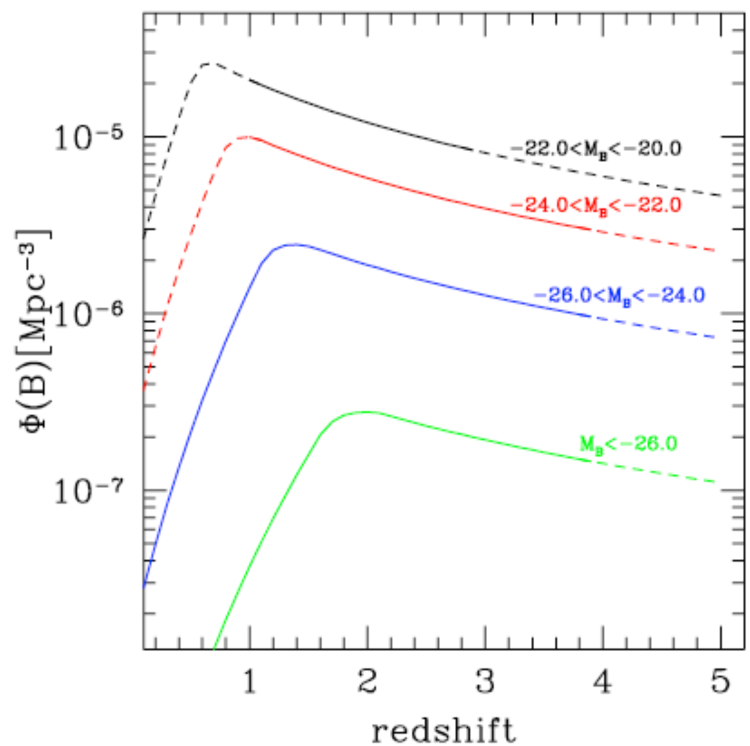
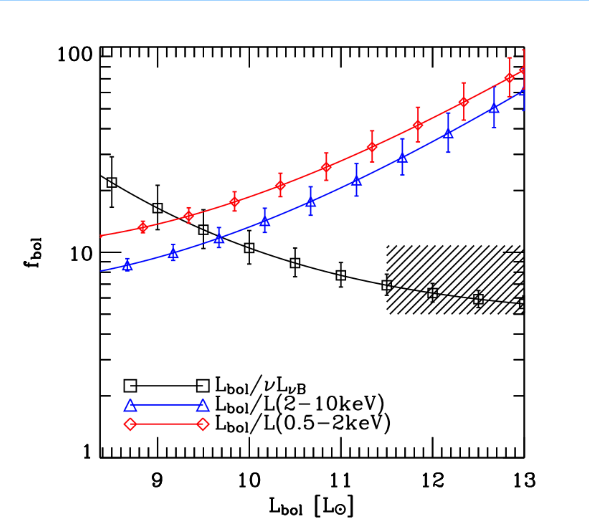


Fig. 10. Evolution of comoving AGN space density with redshift, for different luminosity range: $-22.0 < M_B < -20.0$; $-24.0 < M_B < -22.0$; $-26.0 < M_B < -24.0$ and $M_B < -26.0$. Dashed lines correspond to the redshift range in which the model has been extrapolated.

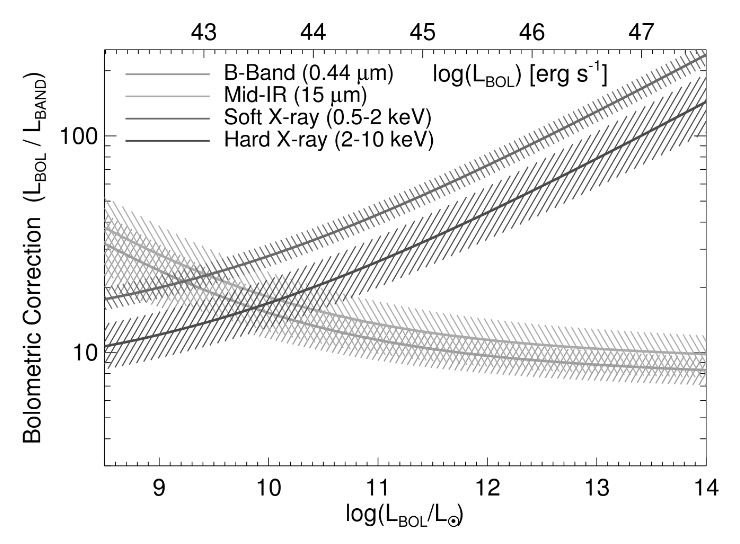
See also e.g. Fontanot+07, Shankar & Mathur 07; Cirasuolo+10; Rigby+11

Bongiorno+10 find LDDE also for the AGN2 [OIII] LF

To derive the Bolometric LF we need to know the Bolometric correction



Marconi+04



Hopkins+07

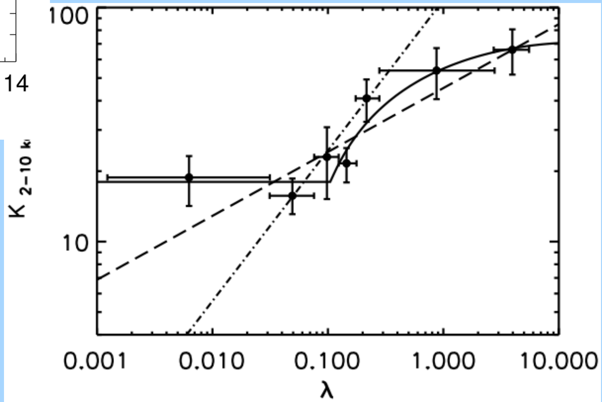
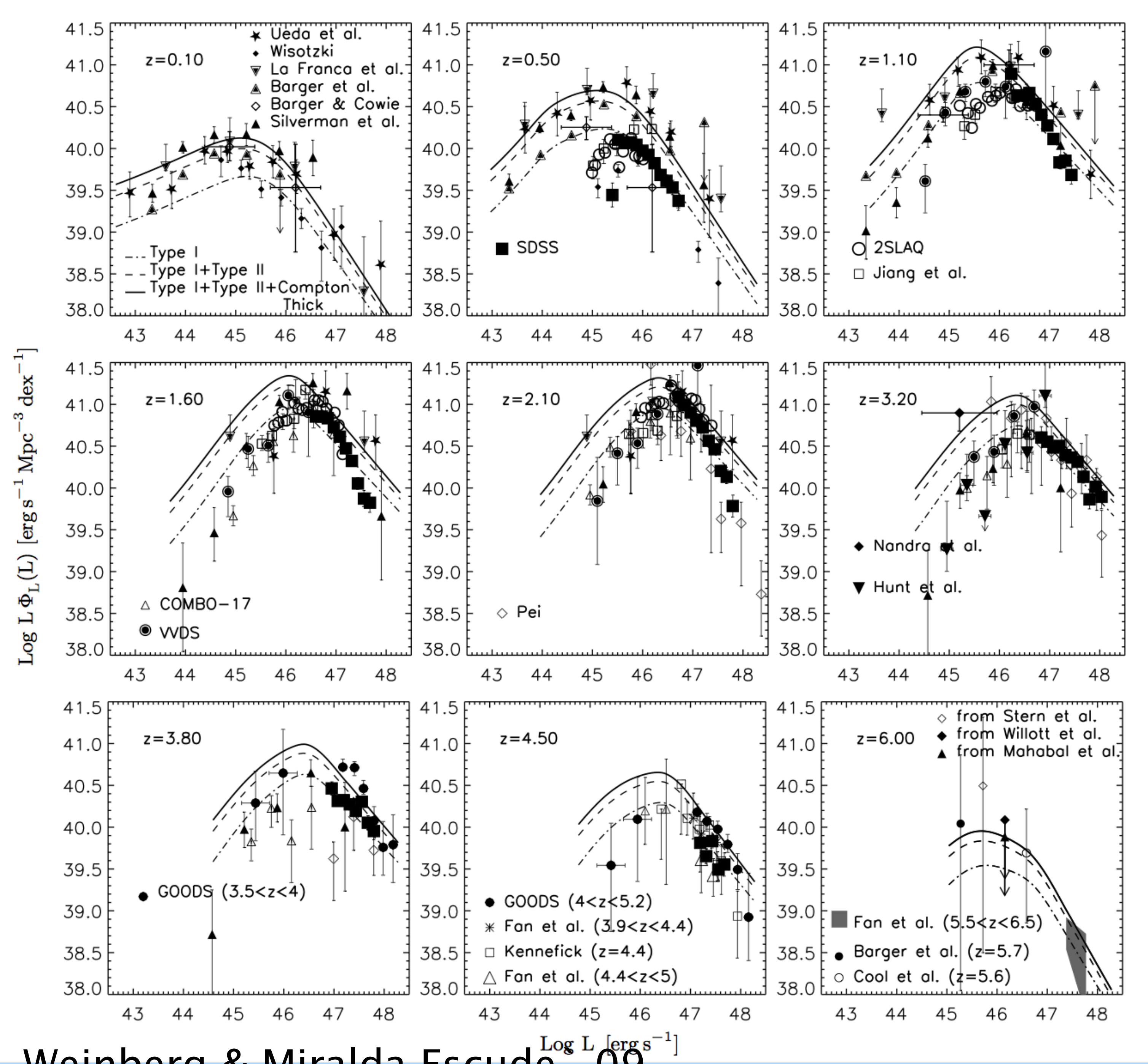


Figure 14. Binned data on the 2 – 10 keV X-ray bolometric correction as a function of Eddington ratio from Vasudevan & Fabian (2007). The *solid* line is the analytical approximation used in this paper, while the *long-dashed* and *dot-dashed* lines are the results from Lusso et al. (2010).

Vasudevan+07; Lusso+10,12; Shankar+13

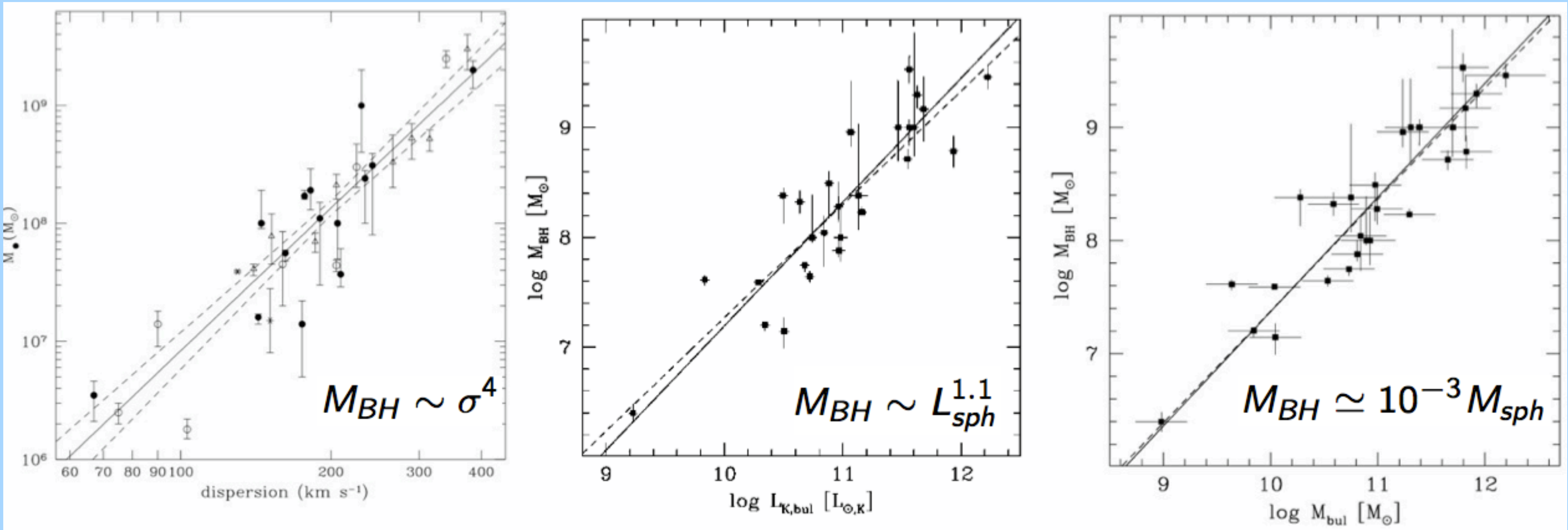
The Bolometric LF



Shankar, Weinberg & Miralda-Escude' 09

AGN/Galaxy co-evolution

Where the BH mass has been measured very important scaling relations with the bulge properties have been found locally, suggesting a strong link between the AGN and the host galaxy evolution.



Ferrarese & Merritt, 2000; Gebhardt et al., 2000; Kormendy & Richstone, 1995 Marconi & Hunt, 2003; Sani et al., 2011; Magorrian et al., 1998; Haring & Rix 2004

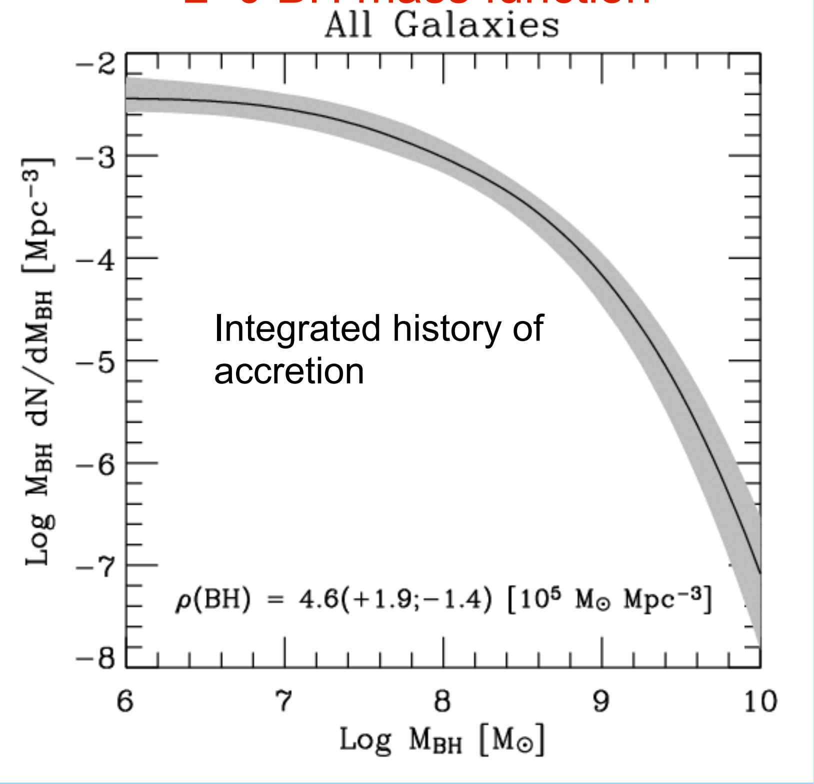
Are these relationships valid for AGN2 as well?
2/3 of the AGN are AGN2.

X-RAY LF, Bolometric LF, BH MF

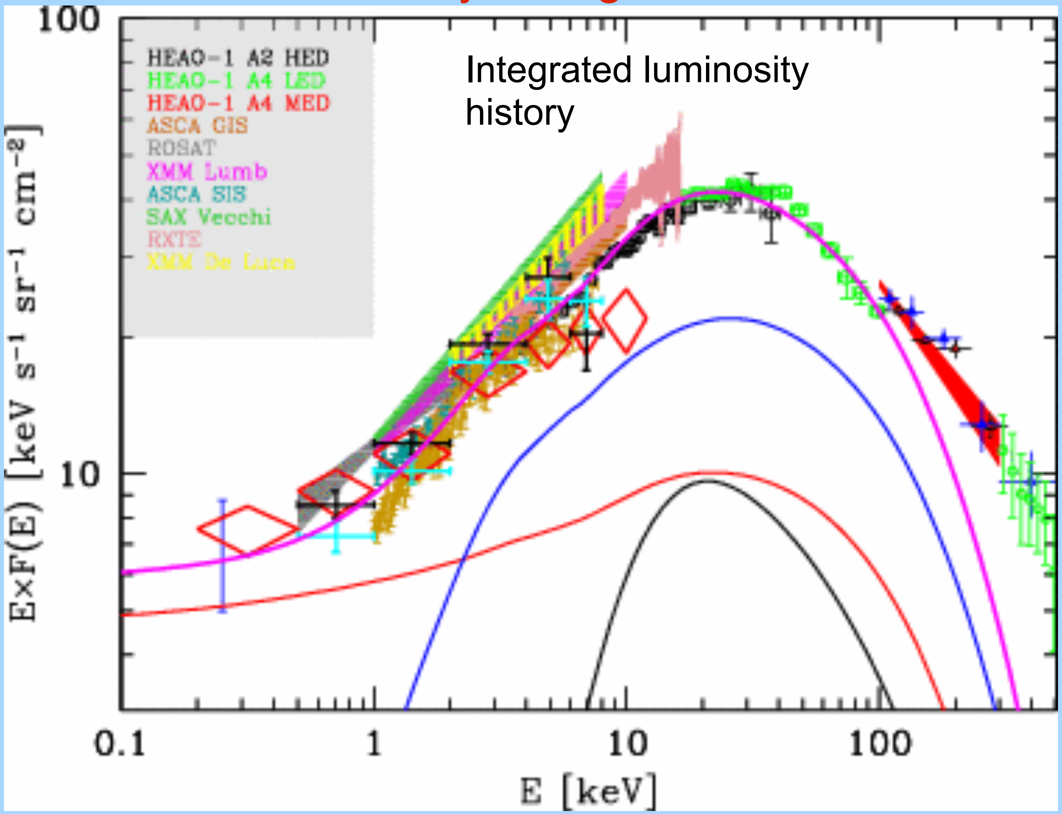
The studies of the local galaxy bulges allow to estimate the z=0 BH mass funtion

Both the z=0 BH mass function and the cosmic X-ray background are the “fossil” integrated result of the AGN evolution, i.e. of the total of accreted mass and of the total energy released in the Universe via accretion

z=0 BH mass function



X-ray background



Marconi et al. (2004)

Putting things together: Soltan's argument

Total mass density accreted = total local BH mass density

- Soltan's argument: AGN luminosity function ϕ(L,t) traces the accretion history of local remnant BHs (Soltan 1982), if BH grows radiatively

$$\int_0^\infty M n_M(M,t_0)\,dM = \int_0^{t_0} \mathrm{d}t \int_0^\infty \mathrm{d}L \, \frac{(1-\varepsilon)L_{\mathrm{bol}}}{\varepsilon c^2} \psi(L,t);$$

local accreted

$n_M(M,t_0)$: local BH mass function,

$\psi(L,t)$: QSO luminosity function,

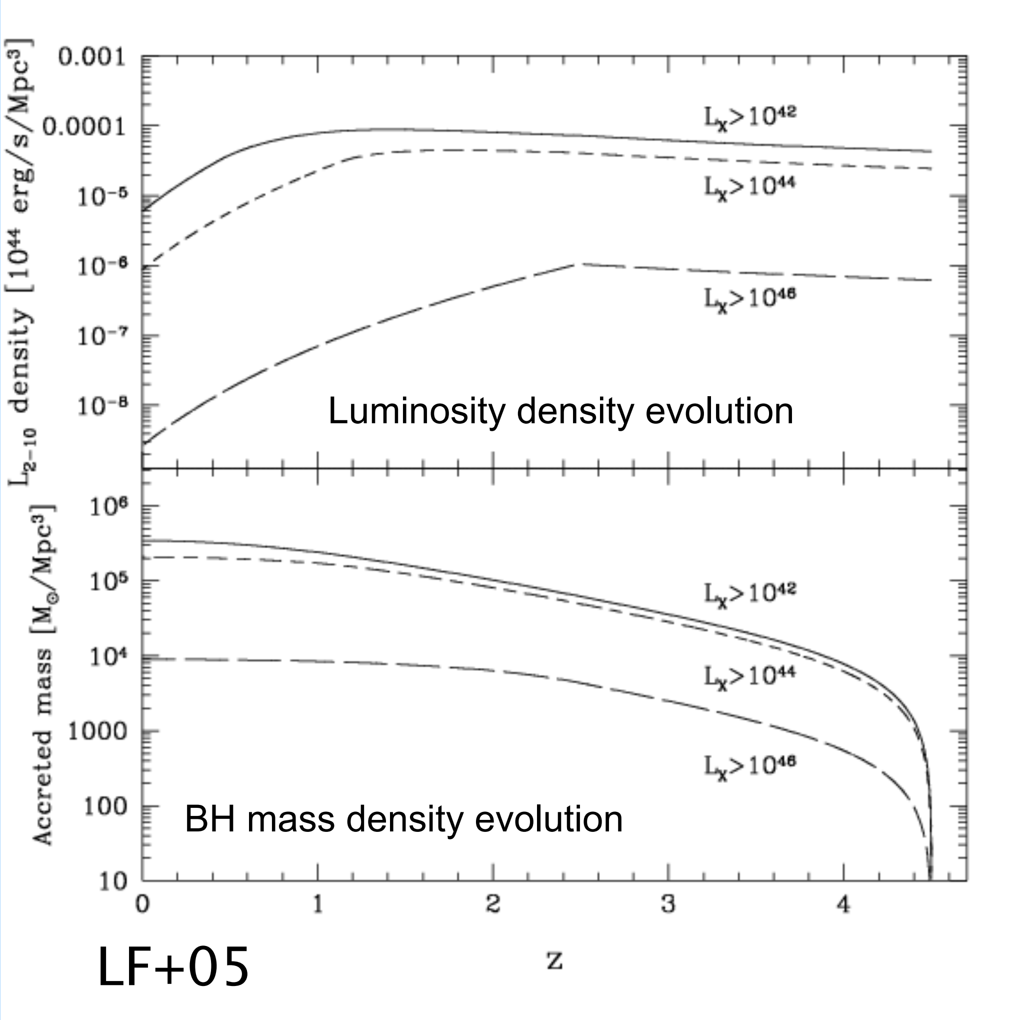
ε : efficiency, $\dot{M} = \frac{(1-\varepsilon)L_{\mathrm{bol}}}{\varepsilon c^2}$.

$$\frac{\partial N(z,M)}{\partial z}\frac{dz}{dt} = -\frac{\partial}{\partial M}[N(z,M)\langle \dot{M} \rangle]$$

Continuity Equation

Small & Blandford 92; Yu & Tremaine 02; Marconi+04; Shankar+04,09,13; Tamura+06; Cao & LI 08; Li+12

Accretion history of the Universe



Luminosity density

$$\int L_X \Phi(L_X, z)\, d\log L_X.$$

Accretion rate density

$$\dot{\rho}_{BH}(z) = \frac{1-\epsilon}{\epsilon c^2} \int K L_X \Phi(L_X, z)\, d\log L_X,$$

Bolometric correction (Marconi et al. 04)

ε=0.1, radiative efficiency

Mass density in BH

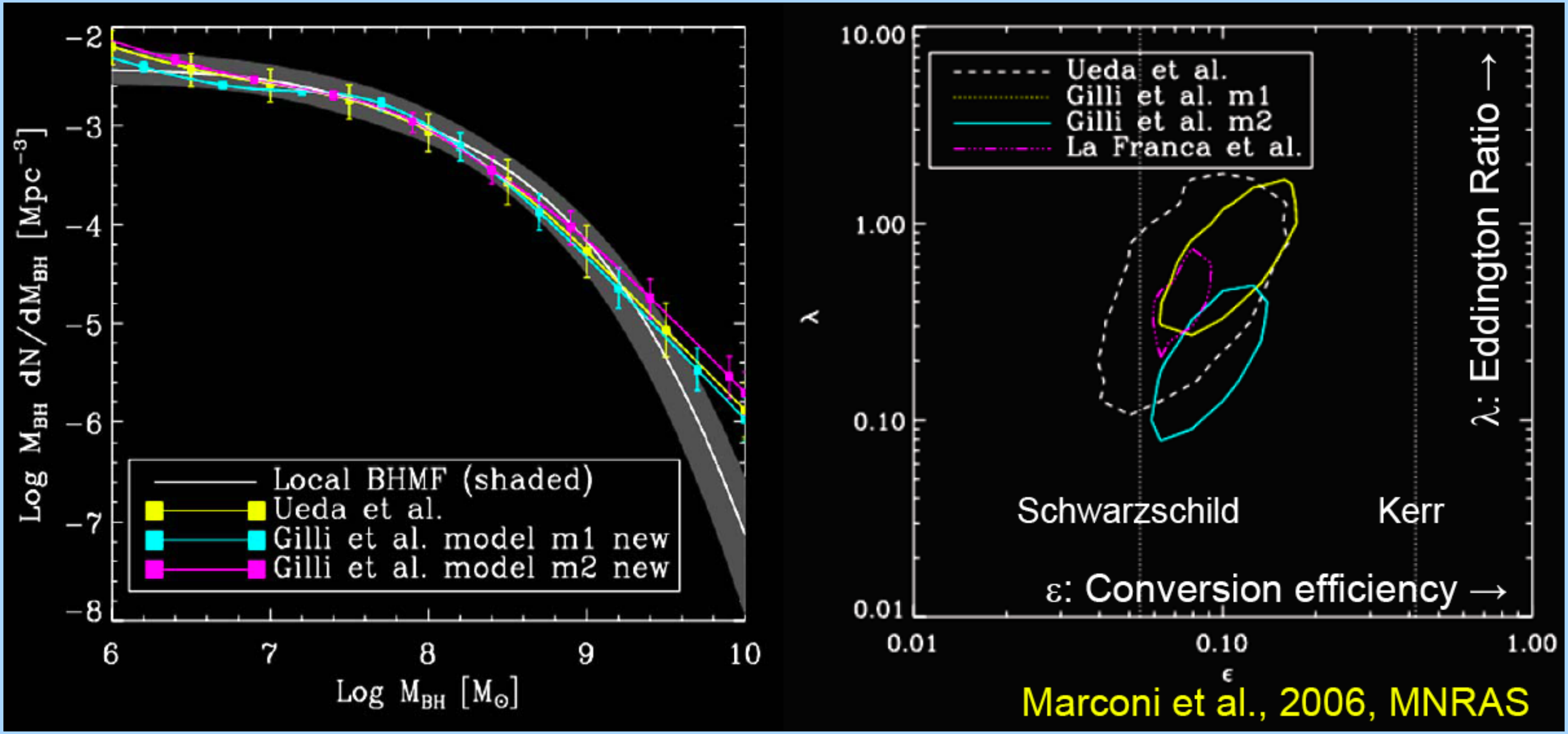
$$\rho_{BH}(z) = \int_z^{z_s} \dot{\rho}_{BH}(z) \frac{dt}{dz}\, dz.$$

$$\rho_{BH} = 3.2\ h_{70}^2 \times 10^5\ M_\odot\ \mathrm{Mpc}^{-3}$$

Vika et al. (2009): 4.9 (+/- 0.7) $M_\odot$ Mpc^{-3}
Marconi et al. (2004): 4.6 (+1.9;-1.4) $M_\odot$ Mpc^{-3}
McLure & Dunlop (2004): 2.8 (+/- 0.4) $M_\odot$ Mpc^{-3}

Expanding Soltan's Argument

Fitting the local BHMF with the AGN LF
using the continuity equation



Local BHMF measure using the M_{BH}-σ BH-bulge scale relation

$\varepsilon \sim 0.1 \qquad \lambda = (L/L_{ED}) \sim 0.2\text{-}0.7$

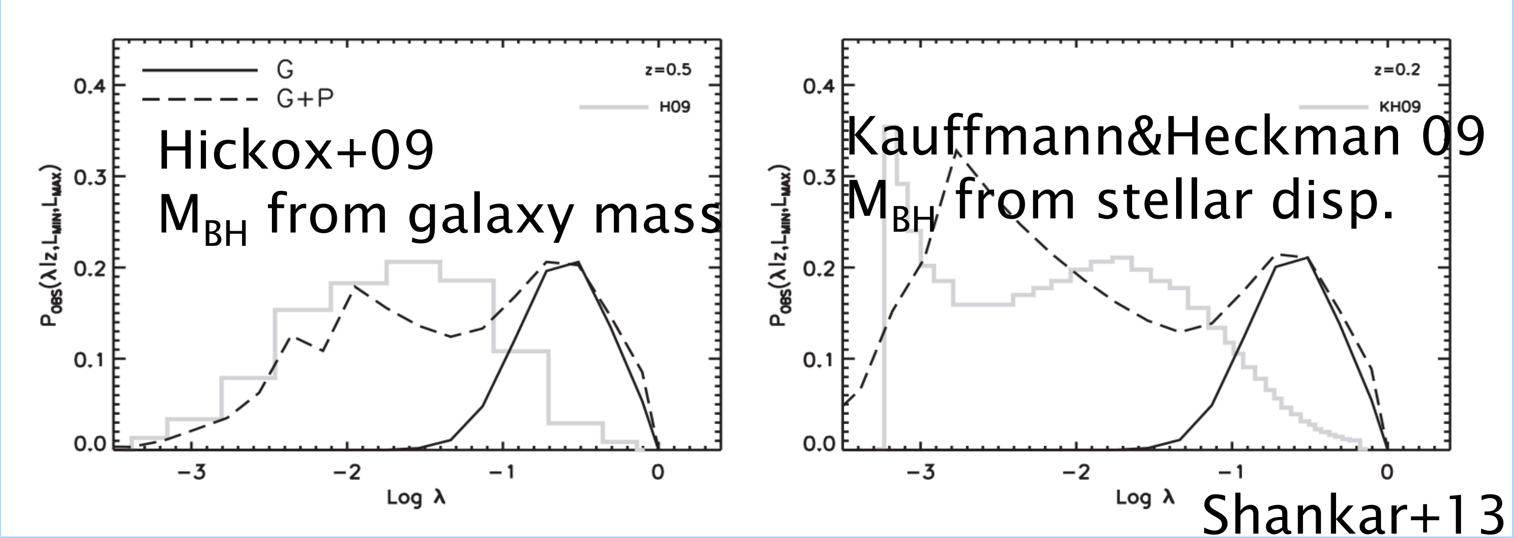
Uncertainties in deriving the SMBH MF

The MF of AGNs can be calculated as

$$N_{\rm AGN}(z, M) = \frac{d\log M}{dM} \int \frac{d\Phi_{\rm bol}(z, L)}{d\log L} \underline{P(\lambda|L, z)} d\log\lambda,$$

where $\underline{P(\lambda|L, z)}$ is the Eddington ratio distribution function per unit log λ at a given luminosity L and redshift z.

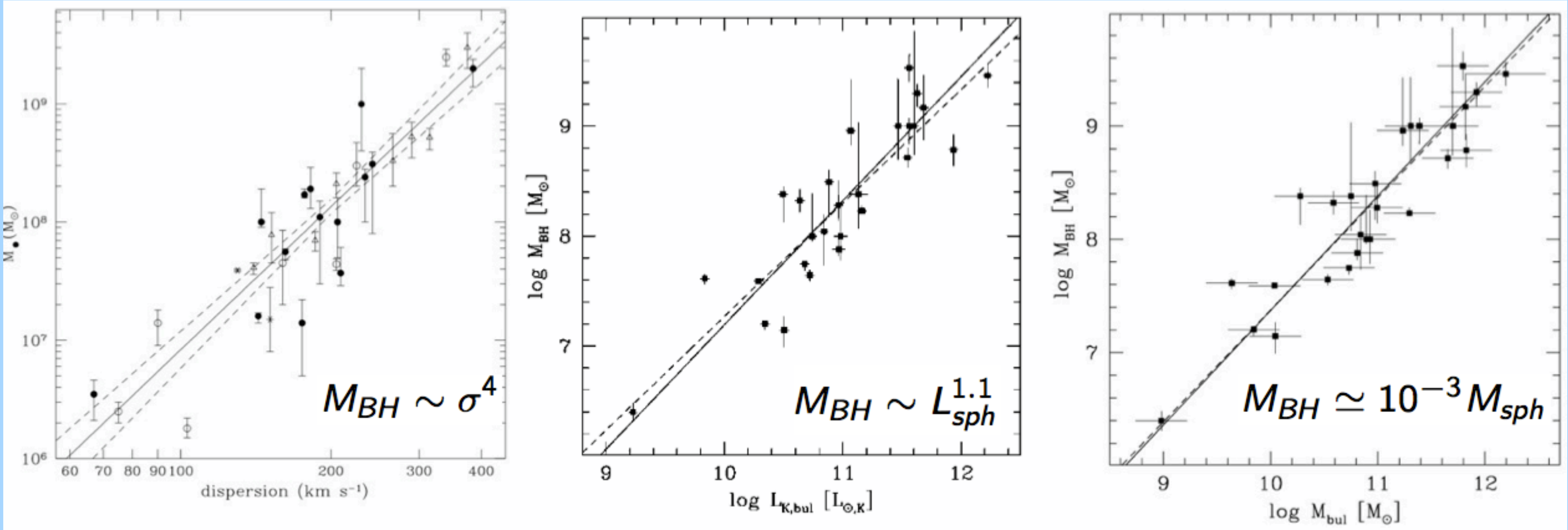
Eddington ratio distribution



We need to better measure the Eddington ratio distribution.
BUT at moment we are able to measure the BH mass on AGN1 only or we have to believe on BH-bulge galaxy scale relations which we do not know whether they are valid at low luminosities and high-z

AGN/Galaxy co-evolution

Where the BH mass has been measured very important scaling relations with the bulge properties have been found locally, suggesting a strong link between the AGN and the host galaxy evolution.



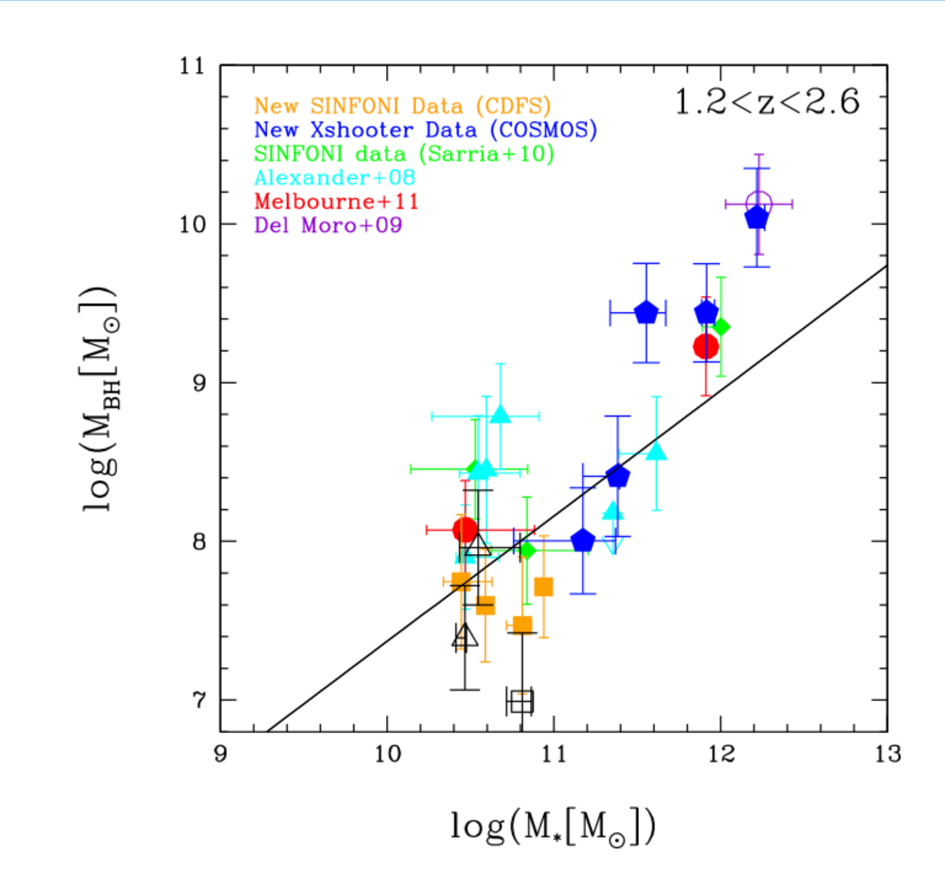
Ferrarese & Merritt, 2000; Gebhardt et al., 2000; Kormendy & Richstone, 1995 Marconi & Hunt, 2003; Sani et al., 2011; Magorrian et al., 1998; Haring & Rix 2004

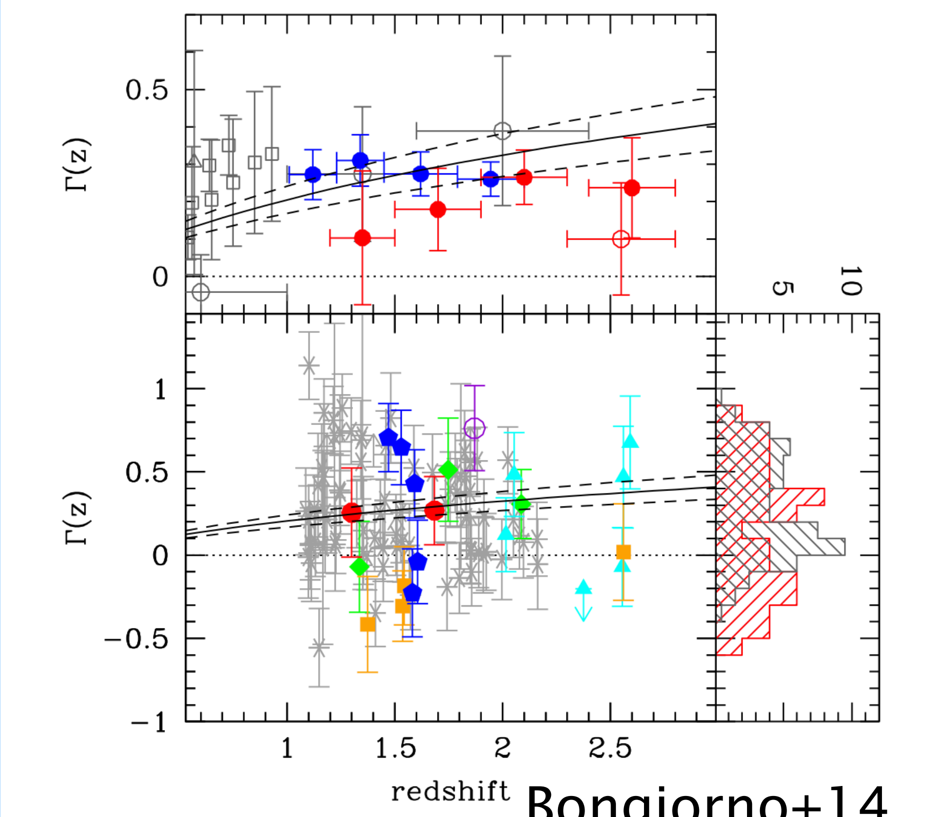
Are these relationships valid for AGN2 as well?
2/3 of the AGN are AGN2.

Evolution of M_{BH}/M_*

Marginal evidence that BH formed faster than galaxies
(using virial relations based on the width of the BLR emission lines)

$$\Gamma(z) = (M_{BH}/M_*)_Z/(M_{BH}/M_*)_0$$

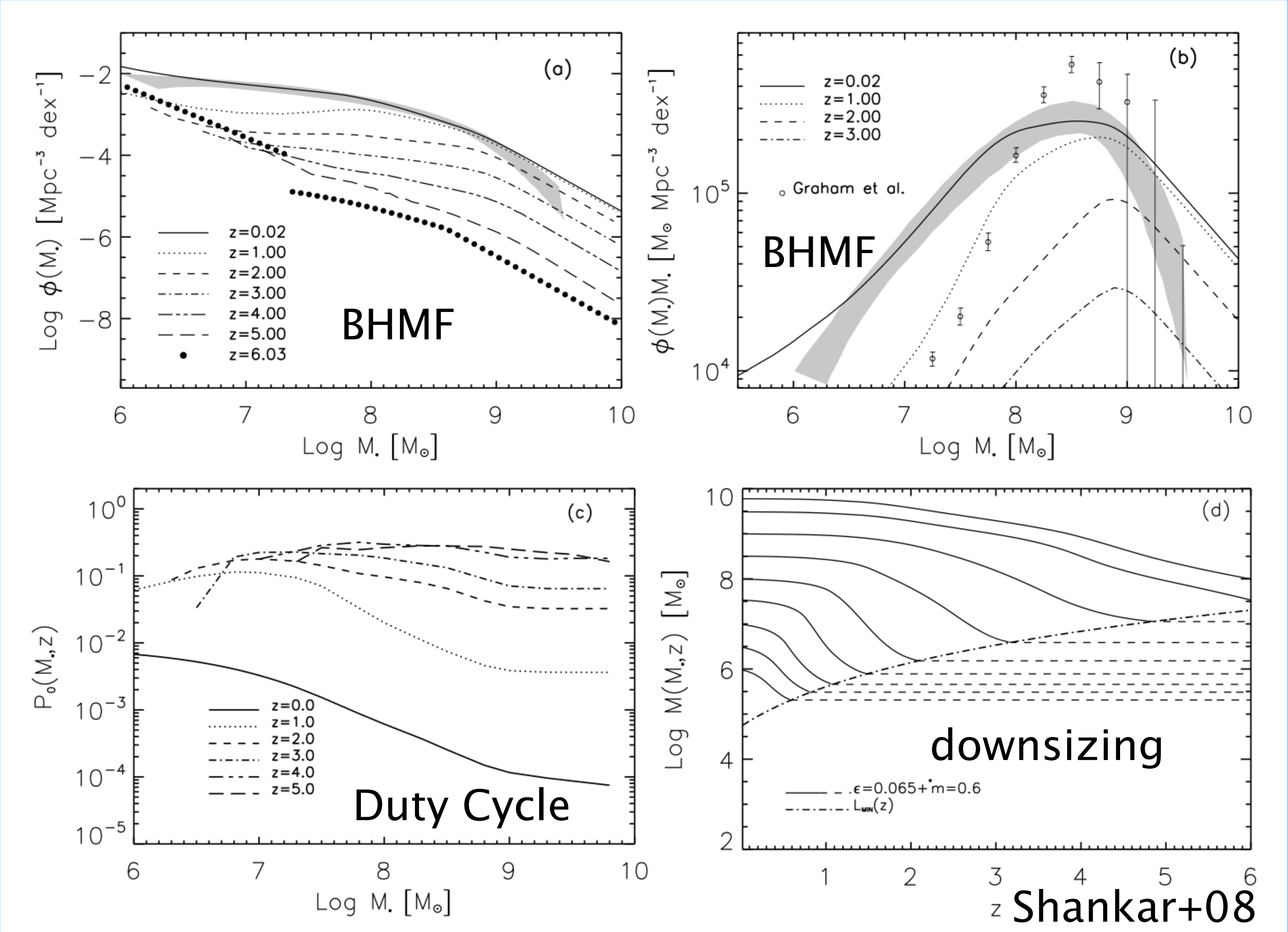




Bongiorno+14

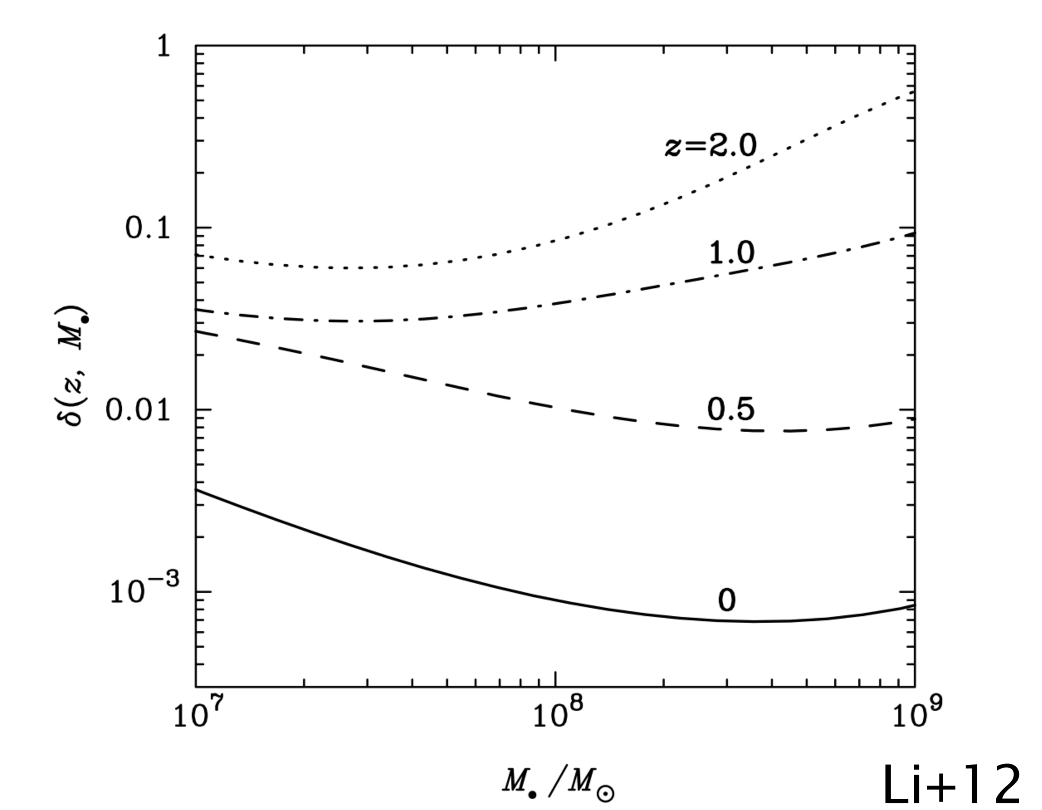
See: Shields+03, Peng+06, Salviander+07, Woo+08, Alexander+08, Del Moro+09, Sarria+10, Merloni+10, Melbourne+11
Discussion on selection effects: Lauer+07, Schulze&Wisotzki11

A possible solution on the BHMF evolution
(once an Eddington ratio distr. has been assumed)



The duty cycle (an example)

The result is strongly dependent on the Eddington ratio distribution

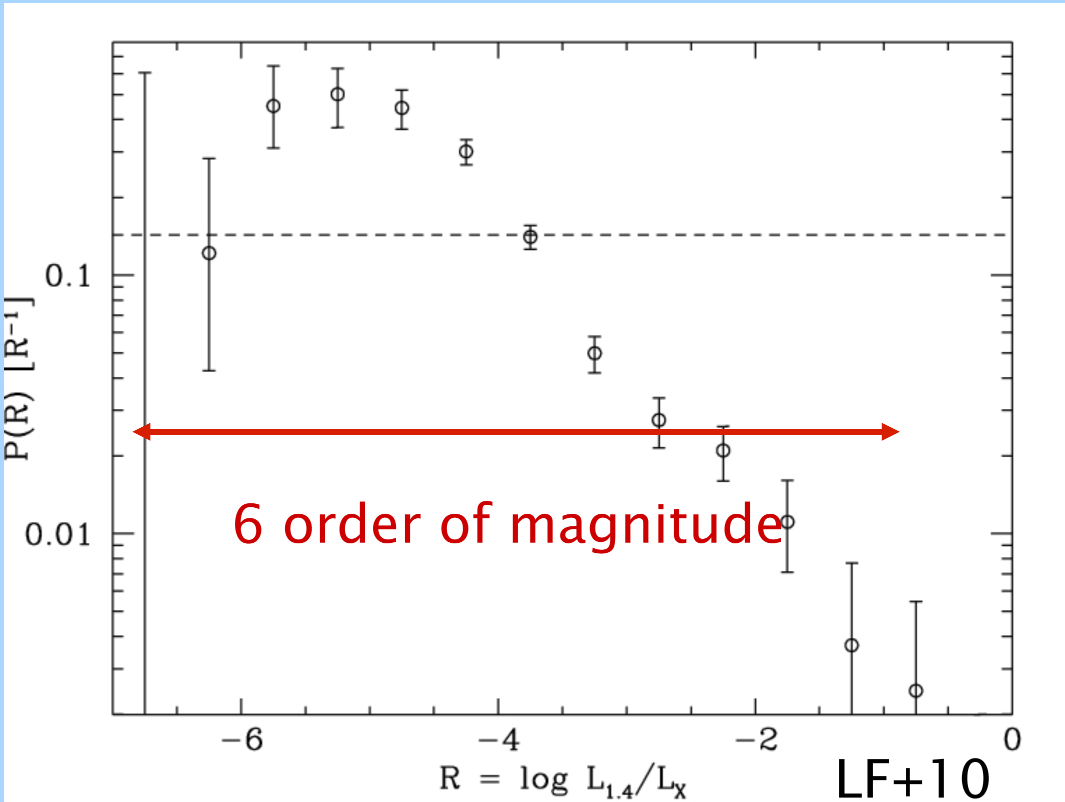


$$\delta(t, M_\bullet) = \frac{N_{\rm AGN}(t, M_\bullet)}{N_{\rm G}(t, M_\bullet) + N_{\rm AGN}(t, M_\bullet)},$$

Are the X-ray and radio LFs in agreement?

Are the X-ray and radio LFs in agreement?

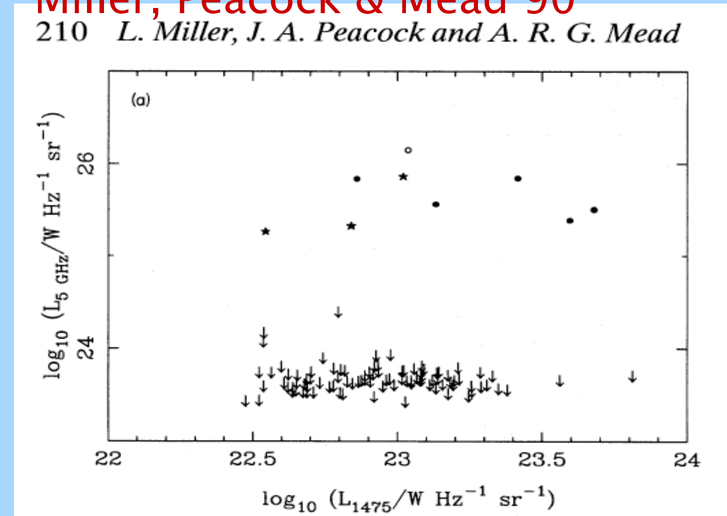
Probability distribution function of R_X



Only for the low-z samples (on ~150 AGN) the fraction of radio detections reaches about 80%, and it is therefore possible to measure the entire probability distribution of R: $P(R_X)$

No bimodality: the radio loud definition is arbitrary

Miller, Peacock & Mead 90



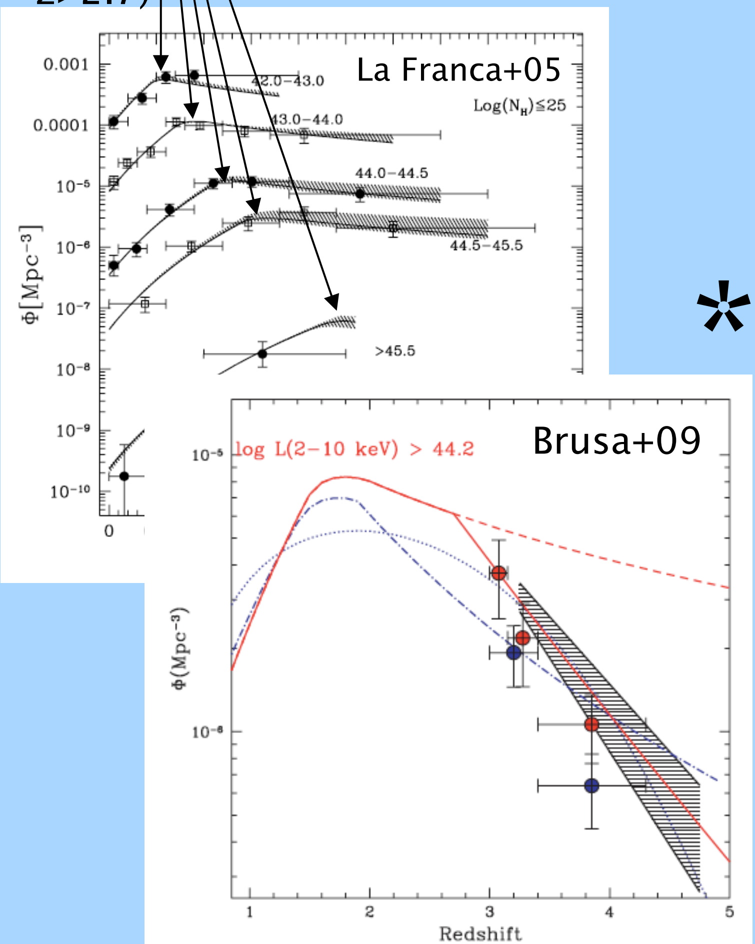
The probability distribution function of R_X has been Evaluated taking into account all observational selection effects, i.e. both detections and upper limits of all ~1600 AGN have been used

Are X-ray and radio bands telling the same story?
Reproduction of the AGN radio LF starting from HXLF

$$\Phi_R(L_{1.4},z) = \int P(R_X|L_X,z)\Phi_X(L_X,z)d\log L_X.$$

downsizing

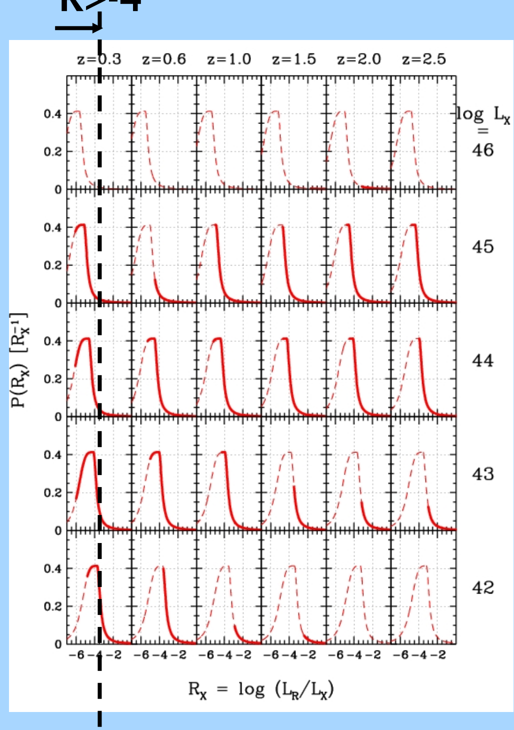
La Franca+05 (& Brusa+09 at z>2.7)



X-ray LF

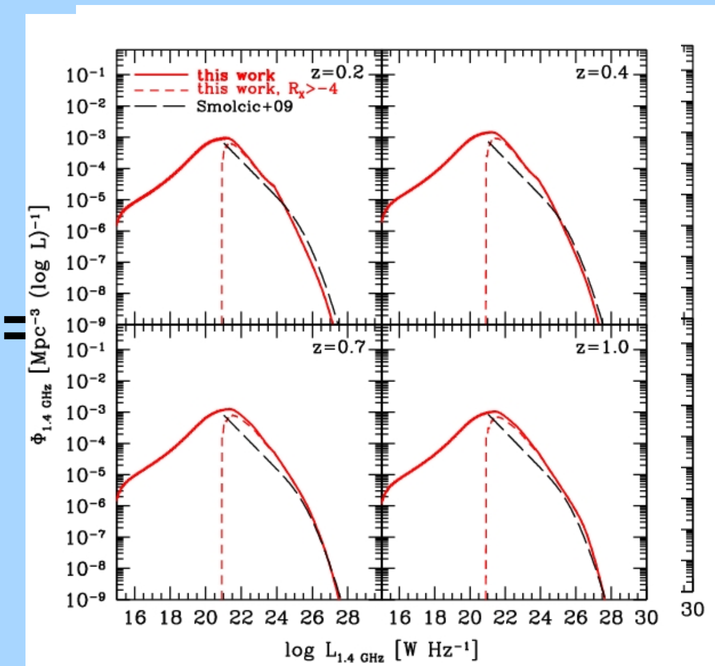
*

R>-4



P(R_X)

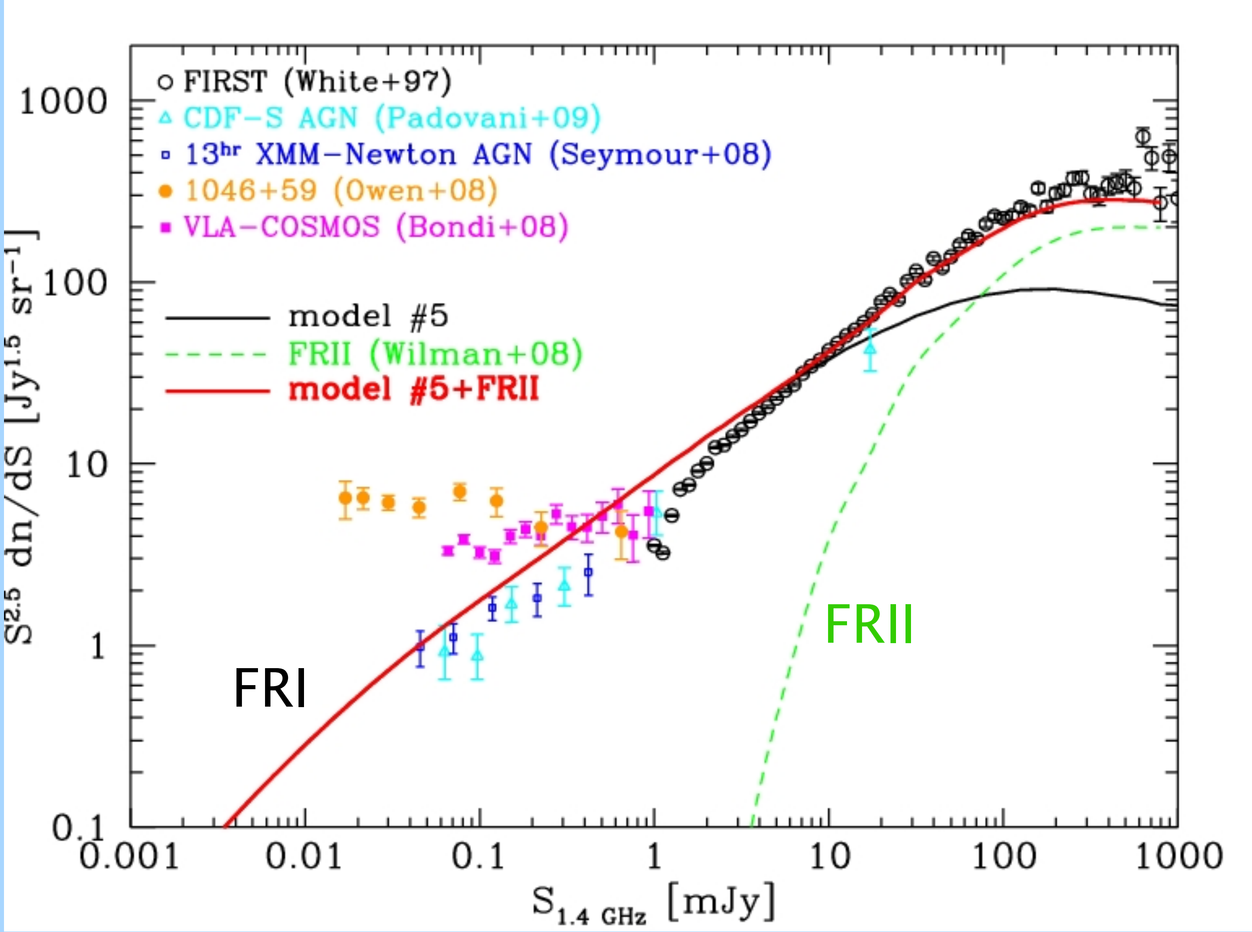
=



FRI LF

Reproduction of the AGN radio counts using the HXLF and the L_X-L_R

La Franca+10

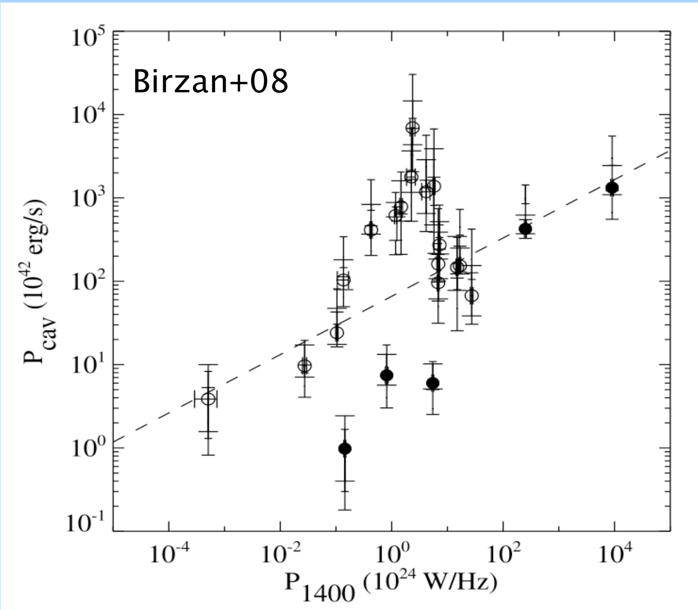


Reproduction of the counts/fraction of AGN in the radio sub mJy regime.

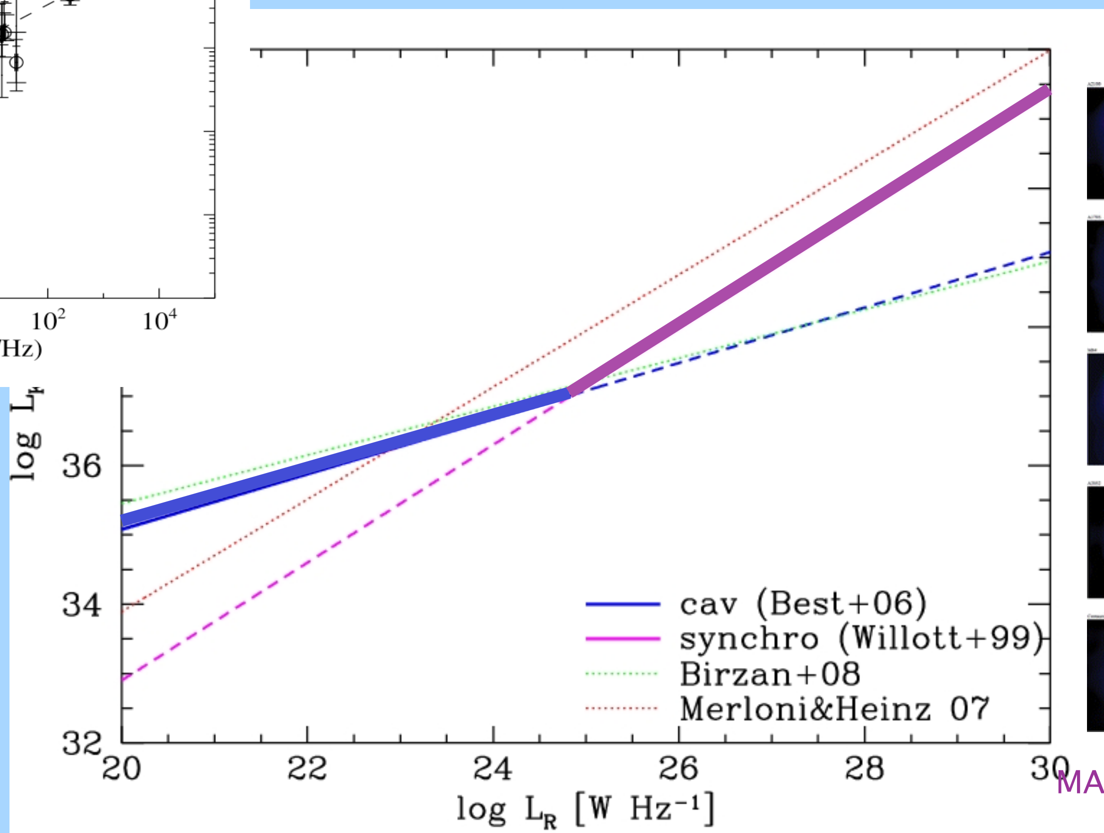
Jarvis & Rawlings 04
Wilman+08
Seymour+08
Padovani+09
Ballantyne 09
Draper+11

$$N(>S) = \frac{1}{4\pi}\int \frac{dv}{dz}dz \int_{Sk(z)4\pi d_l^2(z)}^{L_{max}} \Phi(L_{1.4},z)d\log L_{1.4},$$

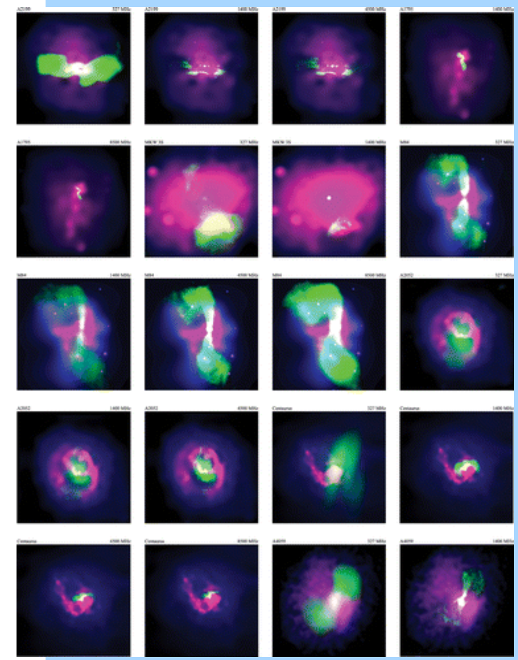
Conversion of radio luminosity into kinetic power



$$L_K = 1.4 \times 10^{37} \left(\frac{L_{1.4\,GHz}}{10^{25} \mathrm{W\,Hz^{-1}}} \right)^{0.85} \mathrm{W}.$$



Birzan+08



MAGENTA: X-RAY GREEN: RADIO

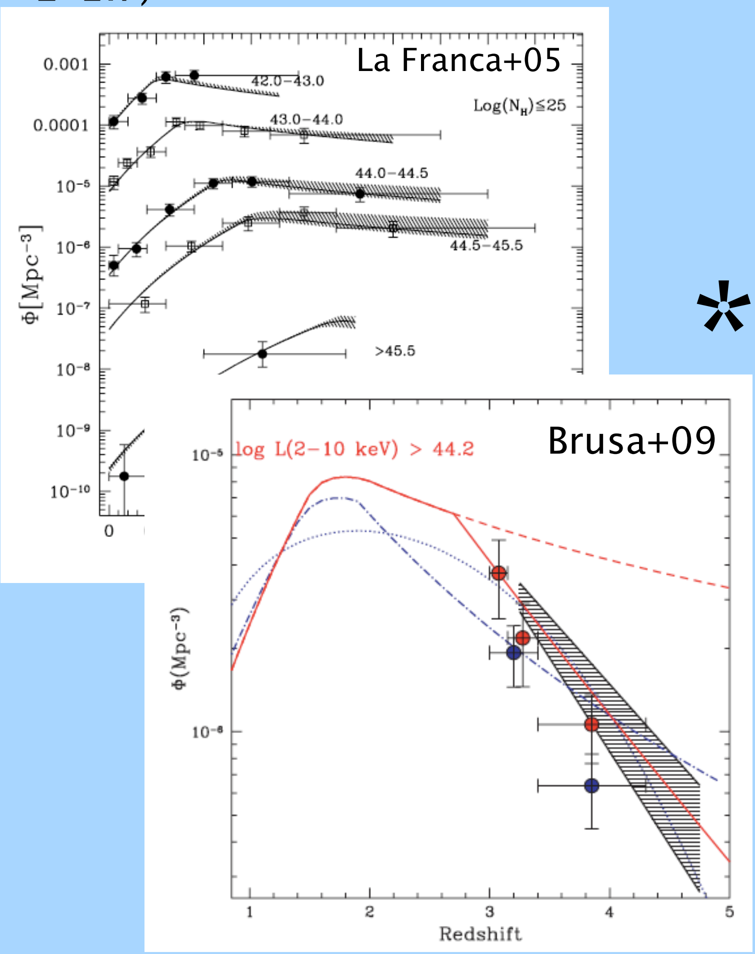
$$L_K = 1.2 \times 10^{37} \left(\frac{L_{1.4\,GHz}}{10^{25} \mathrm{W\,Hz^{-1}}} \right)^{0.40} \mathrm{W},$$

Following Cattaneo & Best 09, we used two different relations at high (L>10^{25} W/Hz) and low (L>10^{25} W/Hz) radio luminosities

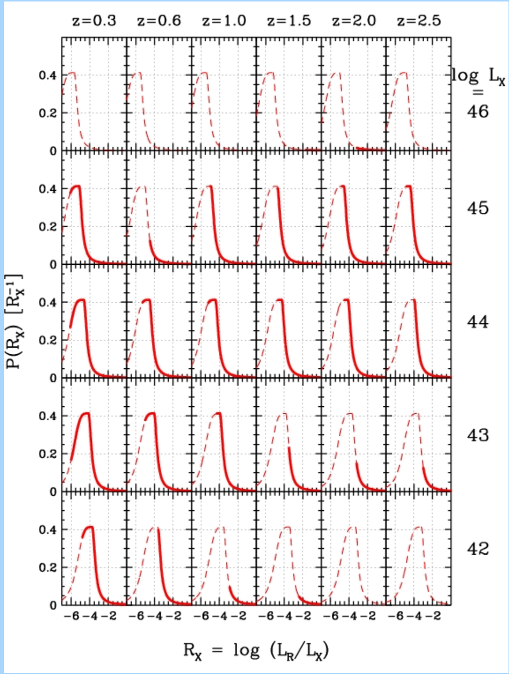
Measure of the kinetic luminosity function

$$\Phi_K(L_K,z) = \frac{dN(L_K,z)}{dV\,d\log L_K} = \Phi_{1.4}(L_{1.4}(L_K),z)\,\frac{d\log L_{1.4}}{d\log L_K},$$

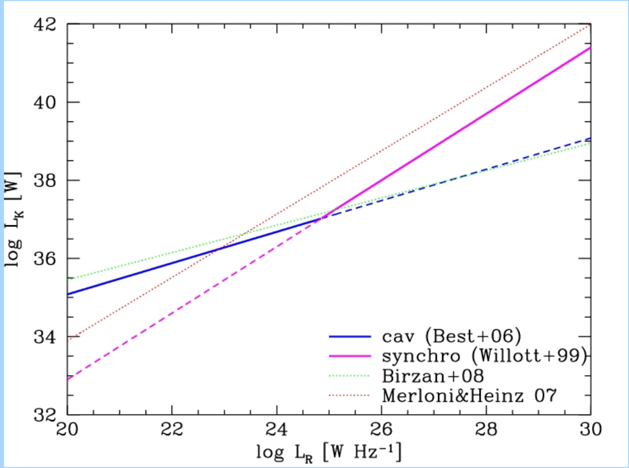
La Franca+05 (& Brusa+09 at z>2.7)



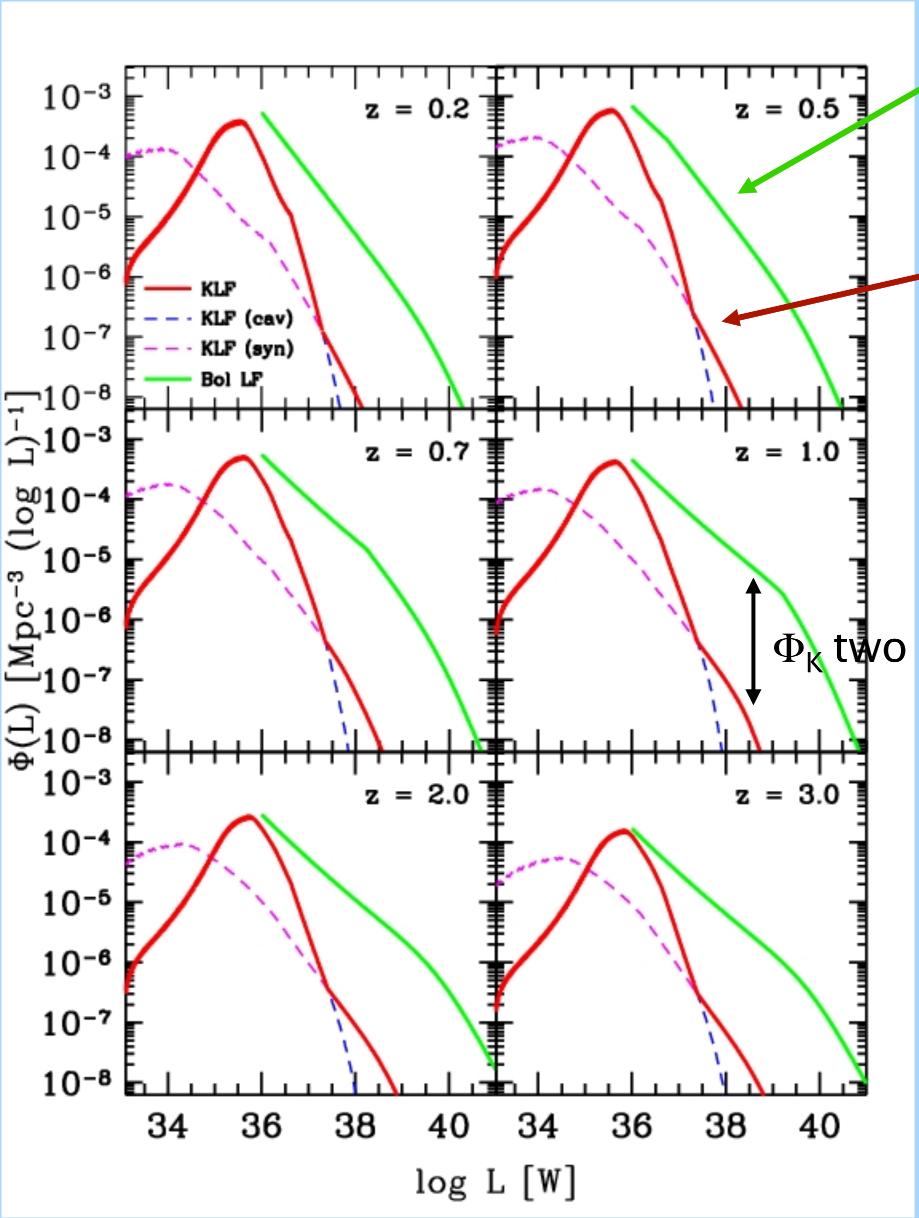
*



*



The kinetic and bolometric LF



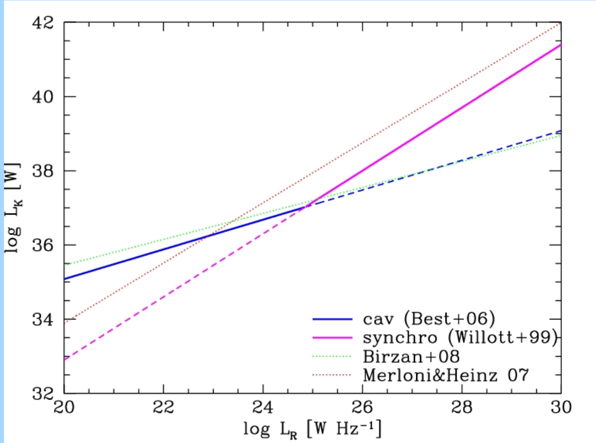
Bolometric LF

$$\Phi_{rad}(L_B,z)=\frac{dN(L_B,z)}{dV\,d\log L_B}=\Phi_X(L_X(L_B),z)\frac{d\log L_X}{d\log L_B},$$

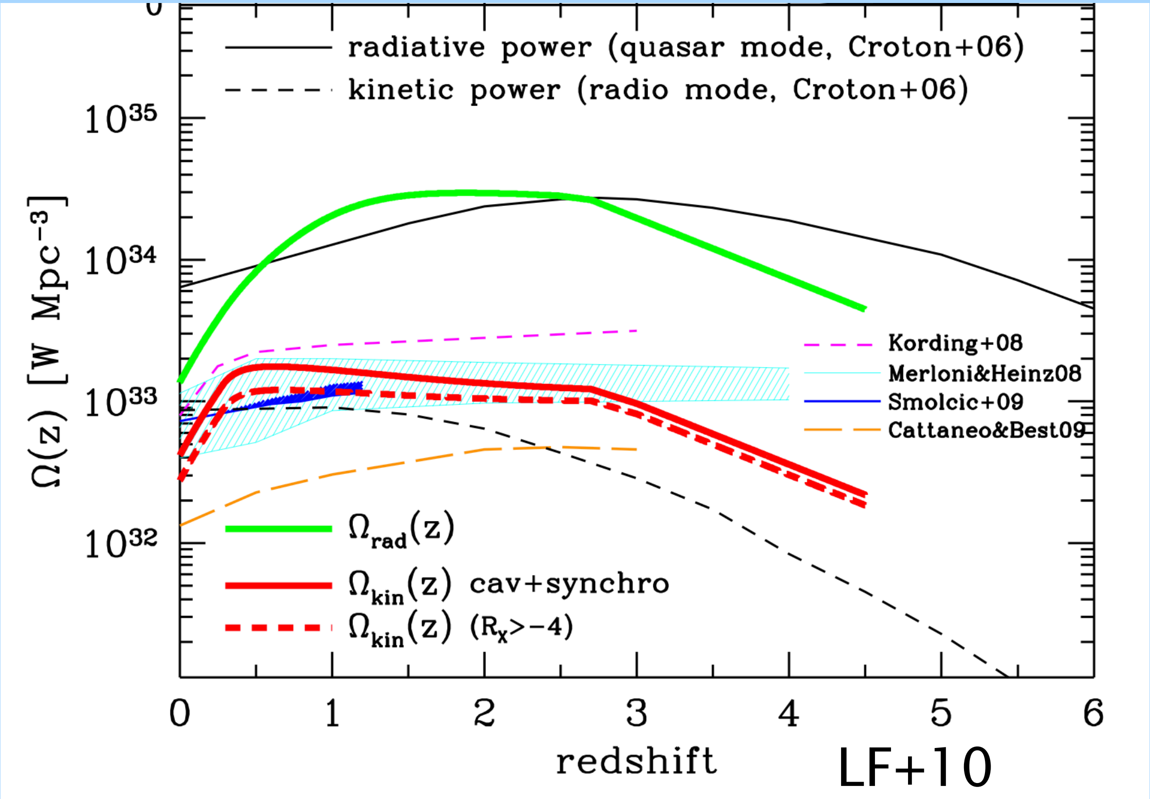
Kinetic LF

$$\Phi_K(L_K,z)=\frac{dN(L_K,z)}{dV\,d\log L_K}=\Phi_{1.4}(L_{1.4}(L_K),z)\frac{d\log L_{1.4}}{d\log L_K},$$

Φ_K two orders of magnitude smaller



AGN Power density history

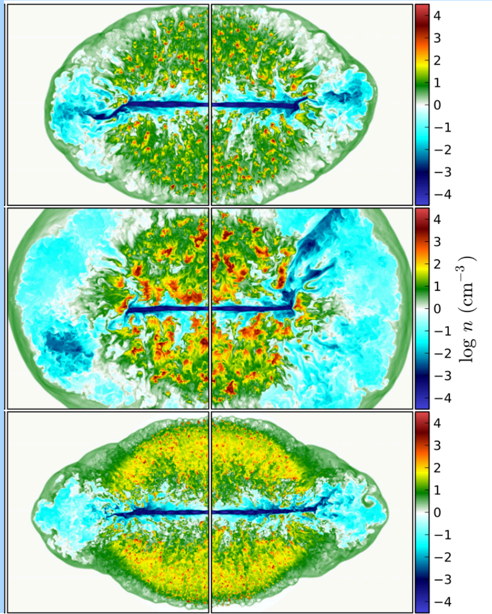


$$\Omega_{rad}(z) = \int L_{bol}(L_X)\Phi_X(L_x, z) d\log L_X,$$

$$\Omega_K(z) = \int L_K(L_{1.4})\Phi_{1.4}(L_{1.4}, z) d\log L_{1.4},$$

- Estimates are in qualitative agreement with the trends with redshift of the radiative and kinetic power density used by SAMs (e.g. Croton+06)

See 2D-3D hydrodynamical Feedback simulations by:
Saxton+05
Sutherland & Bicknell 07
Tortora+09
Krause & Gaibler 09
Gaspari+10
Wagner+12
Cielo+14 **and TALK this aft.**



- Kinetic efficiency $\varepsilon_K \sim 5\times10^{-3}$ (see e.g. Merloni & Heinz 08)

$$L_K = \epsilon_{kin}\dot{m}c^2$$

-$L_K/L_B \sim \Omega_K / \Omega_{rad} \sim 0.05$
compare with 0.10±0.38 (Shankar+08)

SUMMARY

-AGN LF (in the optical, [OIII], X-soft, X-hard bands) evolves accordingly to the LDDE model (-->downsizing)

-X-ray surveys are now probing the z>3 XLF which results in rough agreement with the decline of the AGN1 density, previously observed in the optical (and radio) bands

-X-ray obscuration increases with increasing redshift and decreasing luminosity

-MIR search for obscured AGN do not seem to find a significant new (large) population of X-ray obscured AGNs which clearly show an AGN like SED in the MIR.

-The radio AGN LF is in agreement with the XLF if the Radio/X distribution is taken into account. The estimates of the kinetic LF satisfy the energy budget necessary in the AGN feedback scenario

-By Integrating the AGN LF, the CXRB and the local BH mass function are fairly well (roughly ?) reproduced

-Marginal evidence that BH formed faster than galaxies

-BUT: the BHMF evolution is poorly constrained

-We need better estimates of the Eddington ratio distribution and evolution and we need a better measure of the BHMF for the AGN2/obscured/low-luminosity pop.

Nowadays the main issue is no longer
to measure the AGN LF
but instead to measure
the AGN BH masses and then the BH MF evolution