The AGN radio mode feedback
radio observations of complete hard X-ray AGN samples

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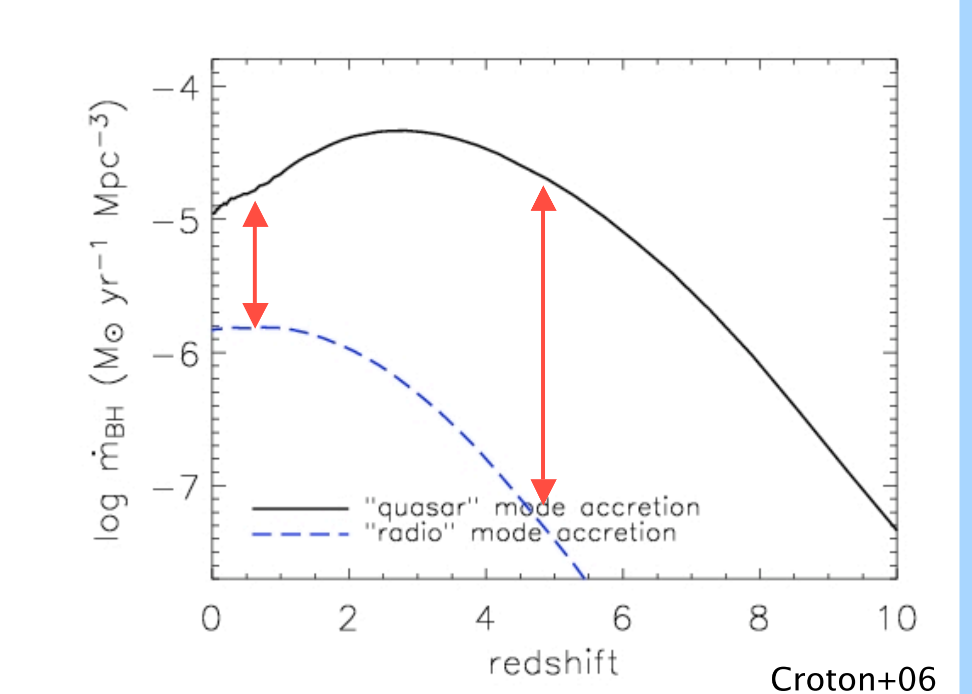
Context

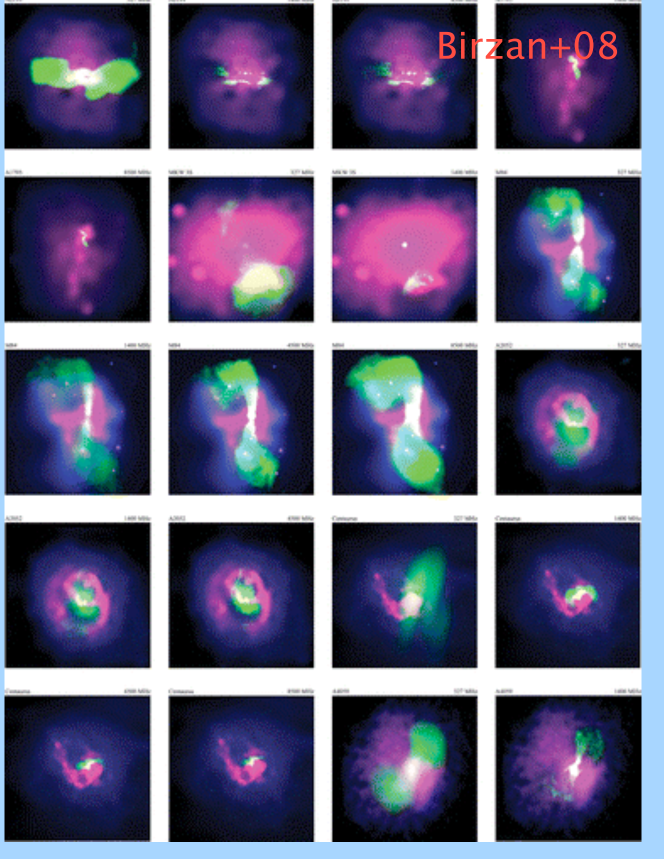
-Many galaxy formation models require a process of suppression of gas cooling, specially at low redshift, in order to reduce the formation of stars or massive systems in the local Universe;

-It has been proposed that the "radio mode" activity of AGN can be responsible for such a process by the injection of kinetic energy in the ISM/IGM;

-In order to "work" properly, the fraction of released kinetic power density should be larger at low redshift (e.g. Croton+06).



Croton+06

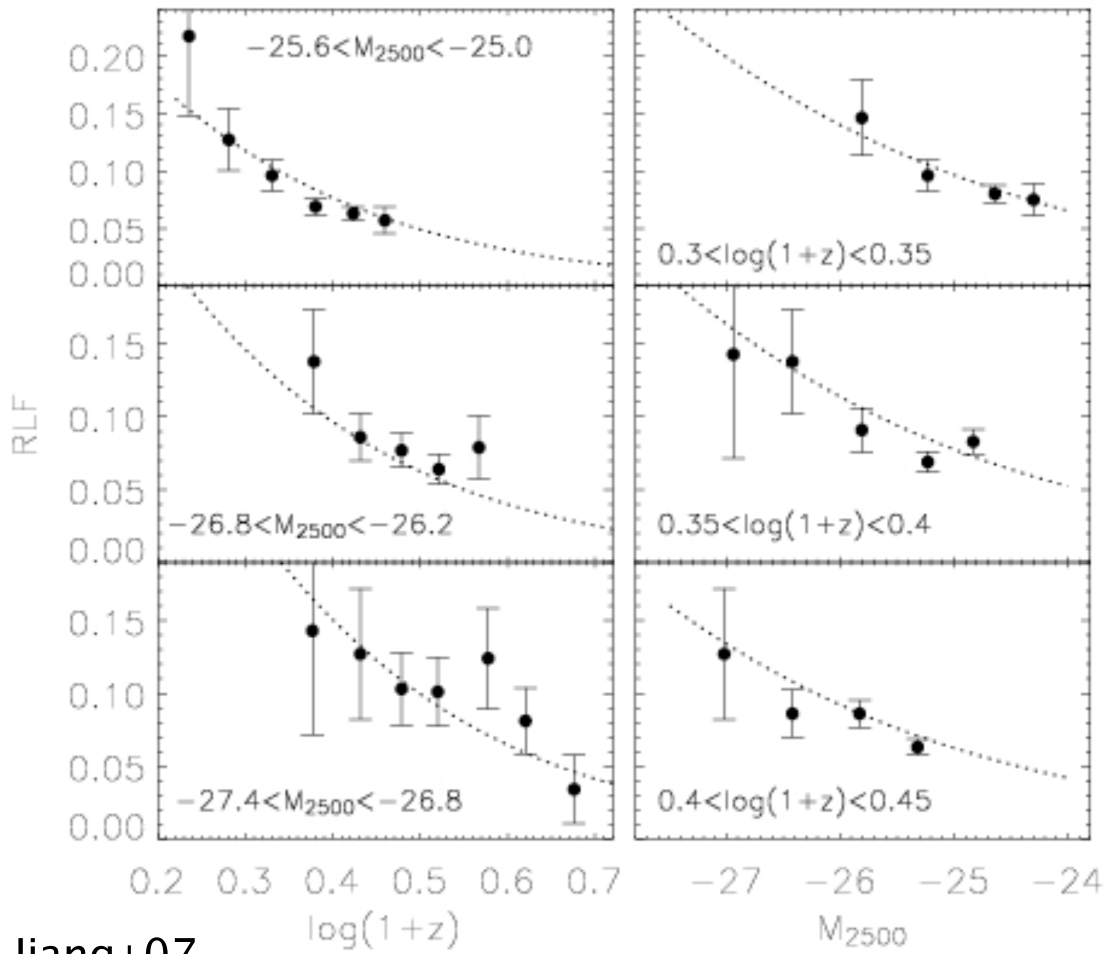


Birzan+08

Context

-Many studies have shown that the fraction of radio loud AGN (based on optically selected AGN1 only) tends to drop with decreasing luminosity (e.g. Miller+90, Padovani+93, La Franca+94, Goldschmidt+99, Cirasuolo+03) and increasing redshift (e.g. La Franca+94, Goldschmidt+99).

-Recently Jiang+07 have better measured these trends on a sample of about 30,000 Quasars from the SDSS.



Jiang+07

Work scheme

In order to evaluate the kinetic energy budget released by the AGN it is necessary to convolve the AGN radio luminosity function with a relation between the radio and the kinetic luminosity.

We have “measured” the AGN radio luminosity function up to z=4.5 by

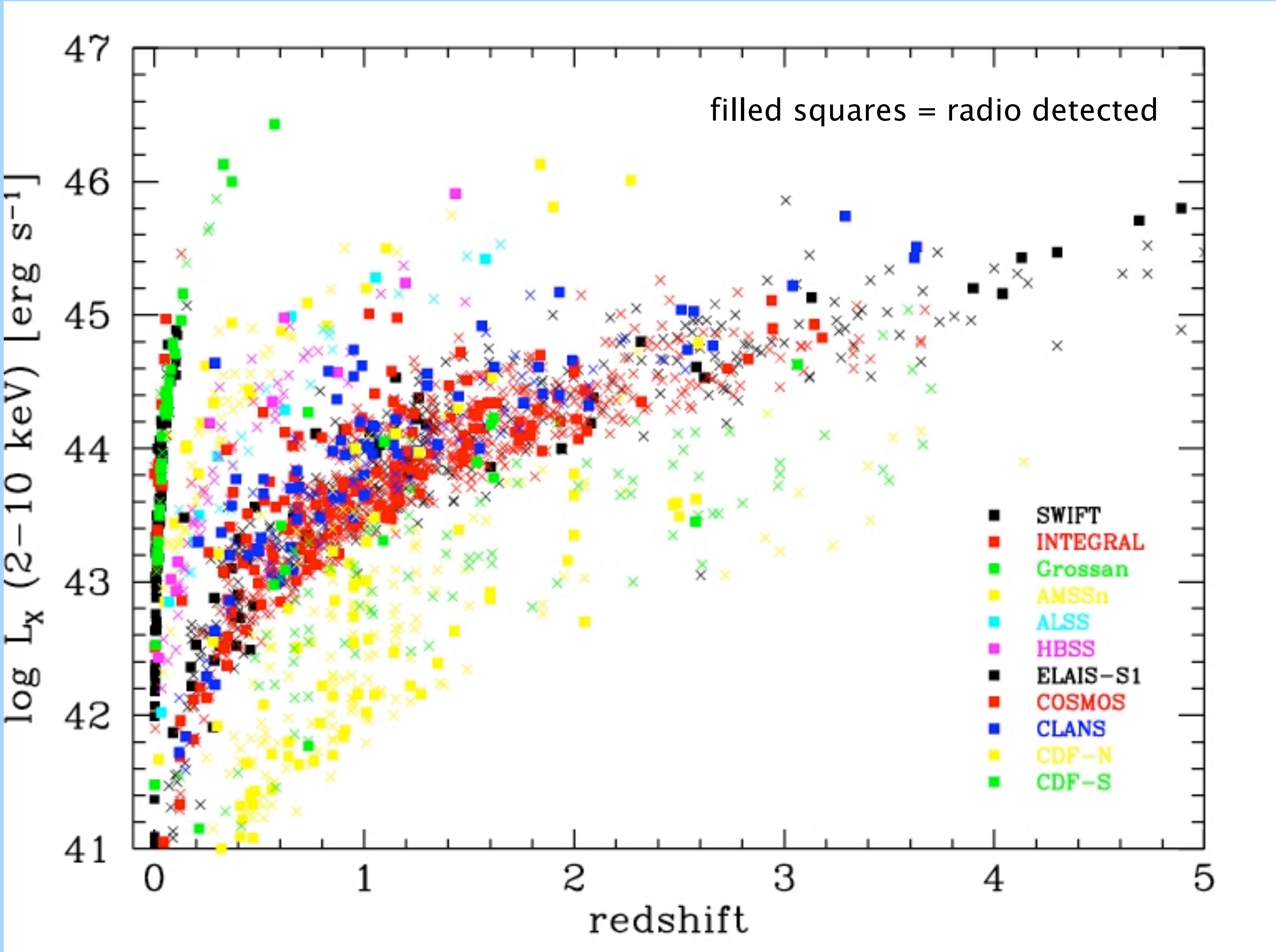
1a) measuring the conditional probability distribution function of the radio loudness $R=L_R/L_X$, $P(R \mid L_X, z)$, as a function of the intrinsic 2-10 keV X-ray luminosity and z, from more than 1800 AGN (AGN1 and AGN2 with $\mathrm{Log}L_X>42$) belonging to complete X-ray samples.

1b) convolving the conditional probability distribution $P(R \mid L_X, z)$ with the AGN X-ray luminosity function (La Franca+05 and Brusa+09).

2) eventually, the evolution with time of the kinetic power density has been estimated by convolving the AGN radio luminosity function with the L_{RADIO}<-->L_{KIN} as measured by Birzan+08.

$$\Omega(L_{kin}) = \iint \frac{L_{kin}}{L_R} L_X R \; P(R|L_X, z)\Phi(L_X, z) \mathrm{dlog}\, L_X \mathrm{d}R$$

The sample
1815 AGN with intrinsic $L_X > 10^{42}$ erg/s (470 radio detected)

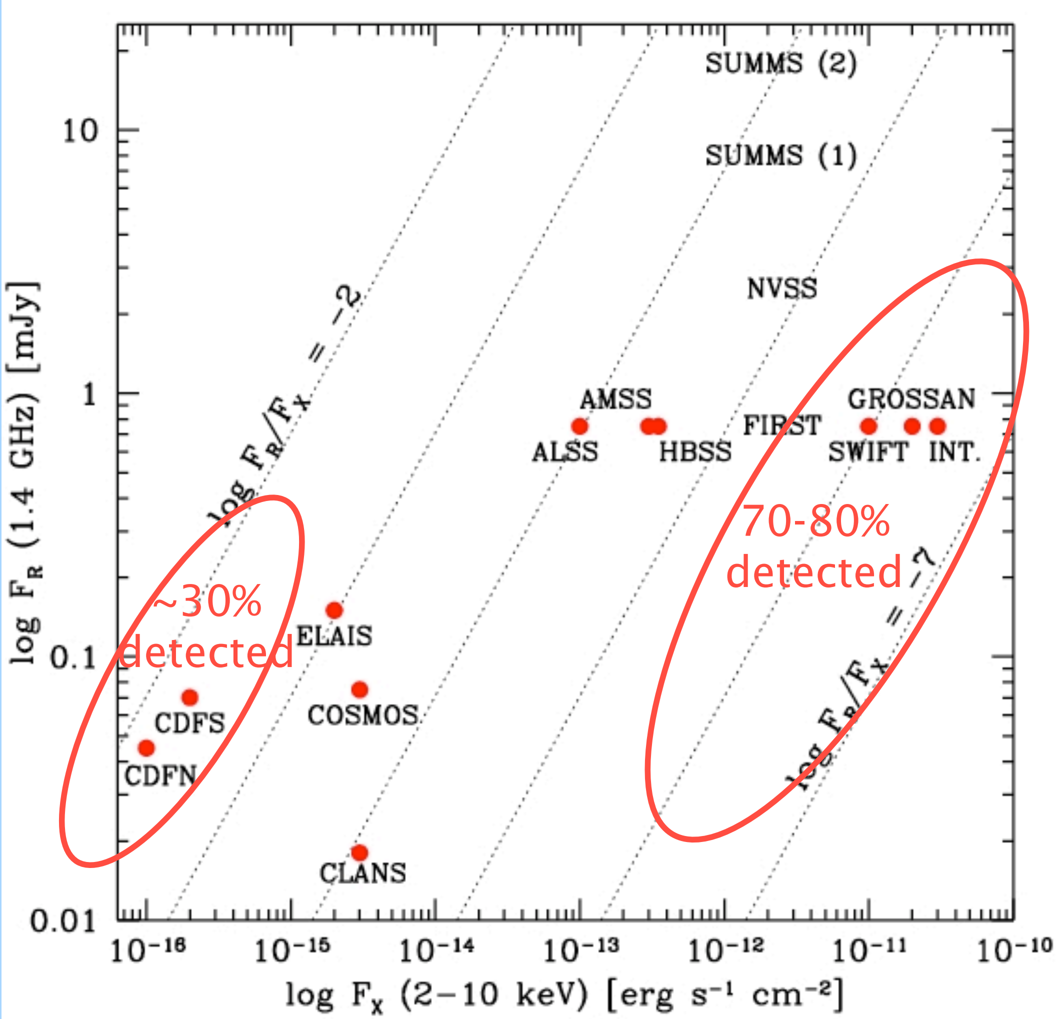


The sample

1815 AGN with intrinsic $L_X > 10^{42}$ erg/s (470 radio detected)

$R = \log(L_R/L_X) \sim \log(F_R/F_X)$

survey	$F_{X_{lim}}$ [erg s^{-1}cm^{-2}]	$F_{R_{lim}}$ [mJy]	N_{tot}	N_{zsp}	N_{zph}	$N_{L_X>10^{42}}$	N_{rad}
SWIFT	3×10^{-11}	0.750	105	104	-	98	82
INTEGRAL	2×10^{-11}	0.750	21	18	-	17	11
Grossan	2×10^{-11}	0.750	41	41		40	27
AMSS	3×10^{-13}	0.750	76	76	-	75	19
ALSS	1×10^{-13}	0.750	31	30	-	30	9
HBSS	3.5×10^{-13}	0.750	62	62	-	62	10
ELAIS-S1	2×10^{-15}	0.150	458	247	197	421	45
COSMOS	9×10^{-15}	0.075	699	399	290	677	141
CLANS	5×10^{-15}	0.018	150	115	29	140	69
CDF-N	1.4×10^{-16}	0.045	290	193	53	161	45
CDF-S	2×10^{-16}	0.070	108	80	26	94	12

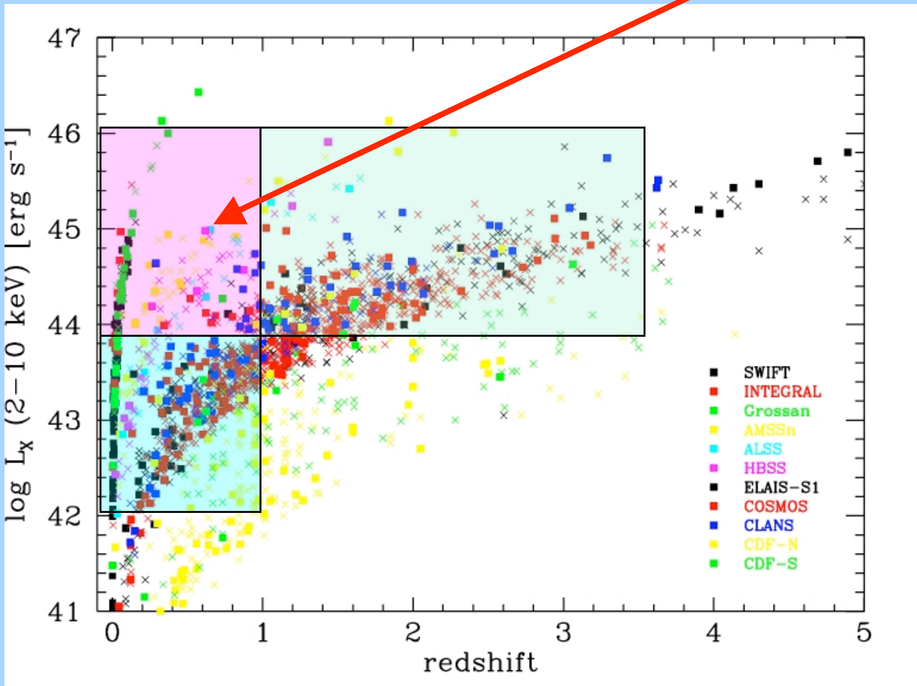


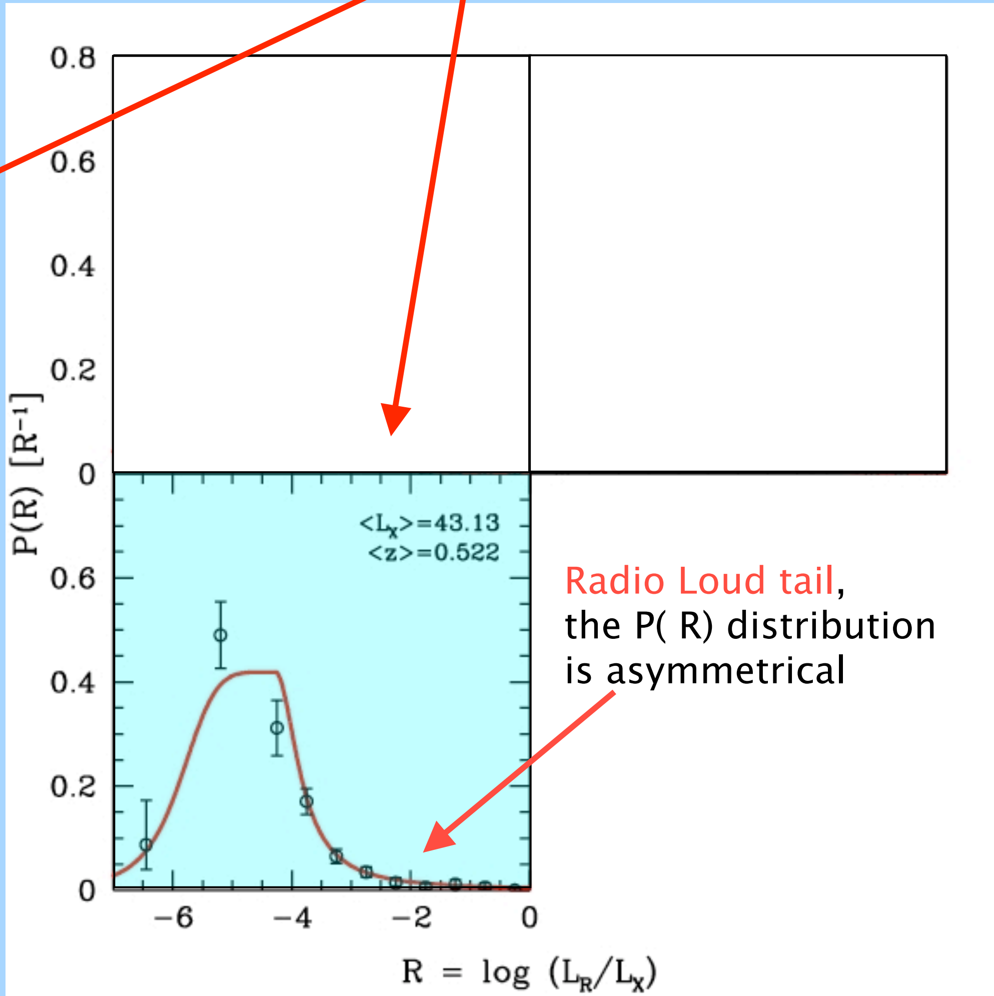
Only for the low-z samples (on ~150 AGN) the fraction of radio detections reaches about 80%, and it is therefore possible to measure the entire probability distribution of R: P(R)

Distribution of the radio loudness (R) as a function of L_X and z
$P(R|\ L_X, z)$

More radio loud AGN at **high L** & **low z**

Using a χ^2 minimization, comparing the observed and expected[a)] fraction of radio detections in each sample, we have evaluated the whole shape of P(R) and its evolution





Radio Loud tail, the P(R) distribution is asymmetrical

a) Once a model of the $P(R|\ L_X, z)$ distribution has been assumed;

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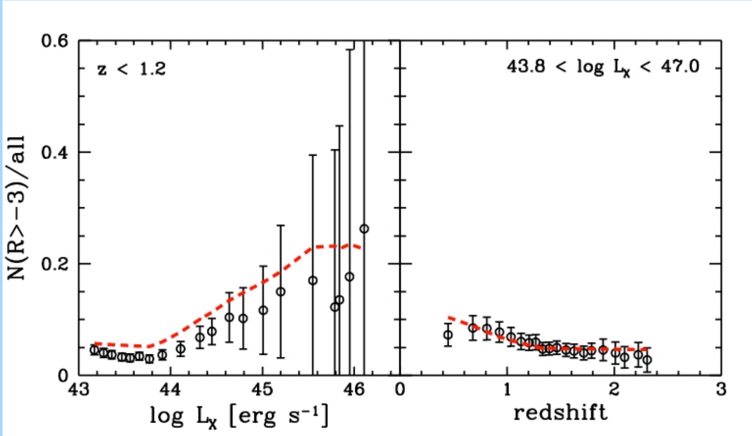
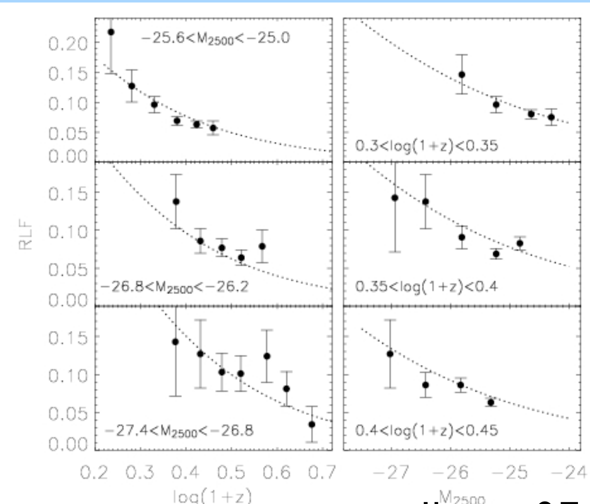
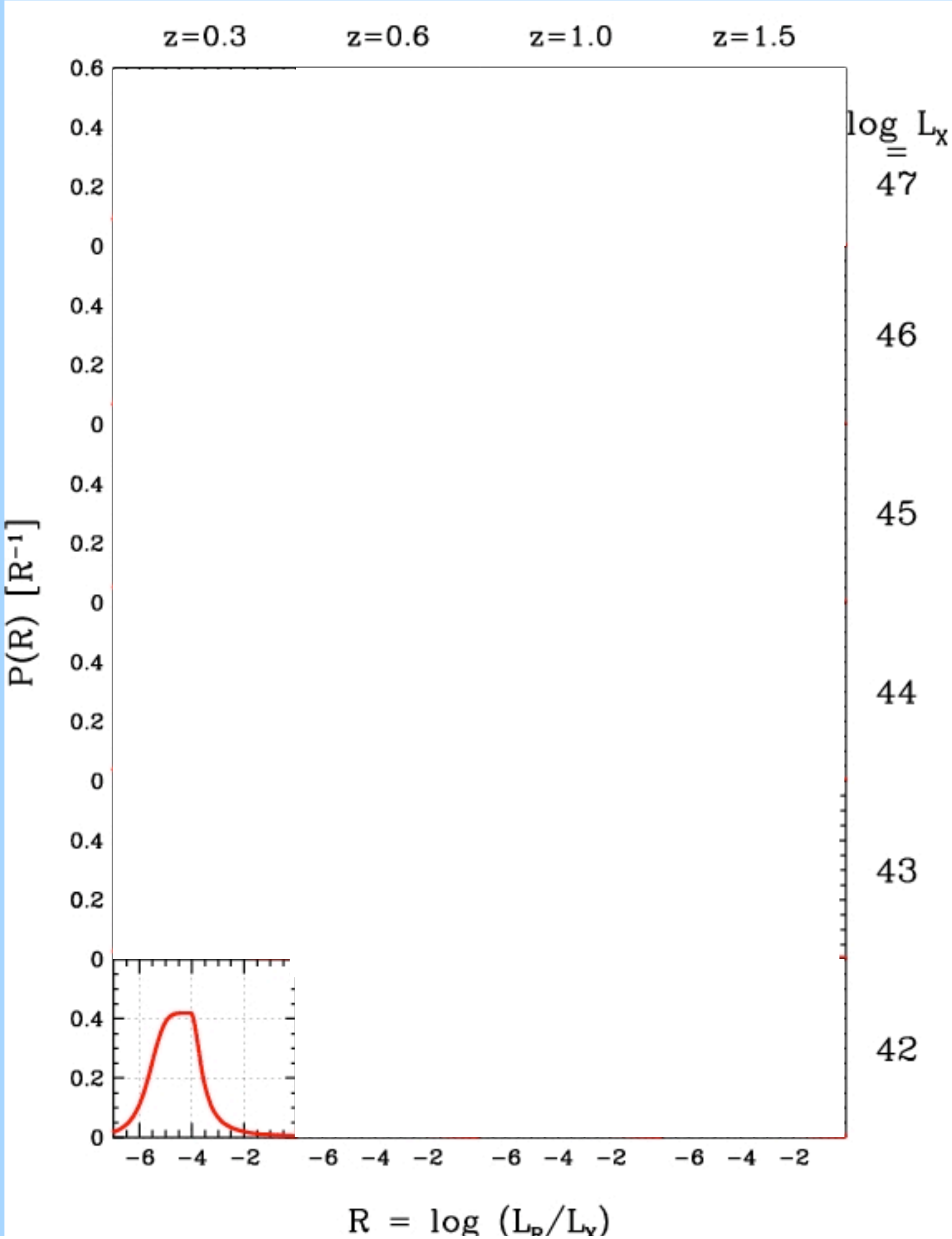


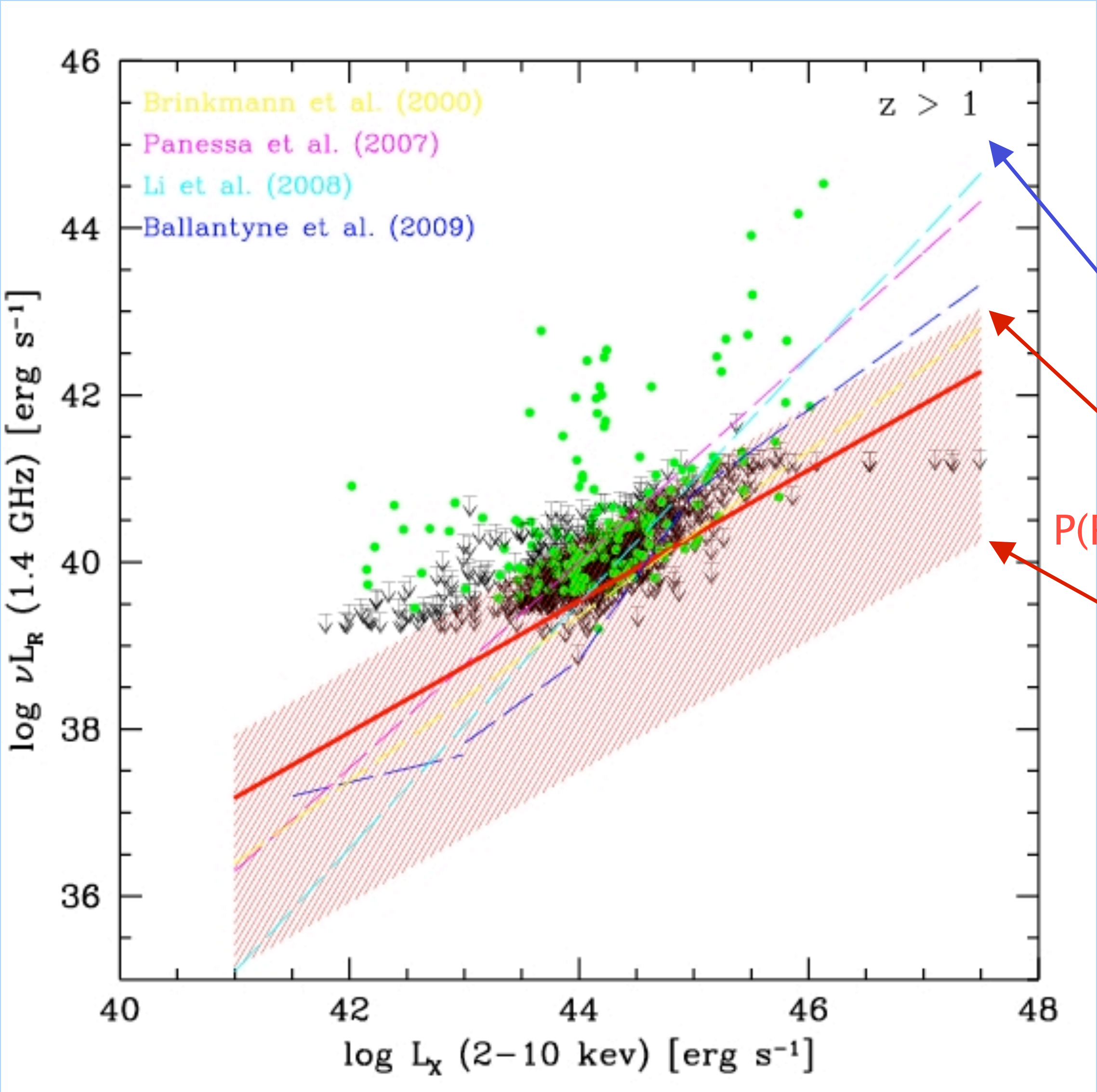
as observed for optical AGN1



Jiang+07



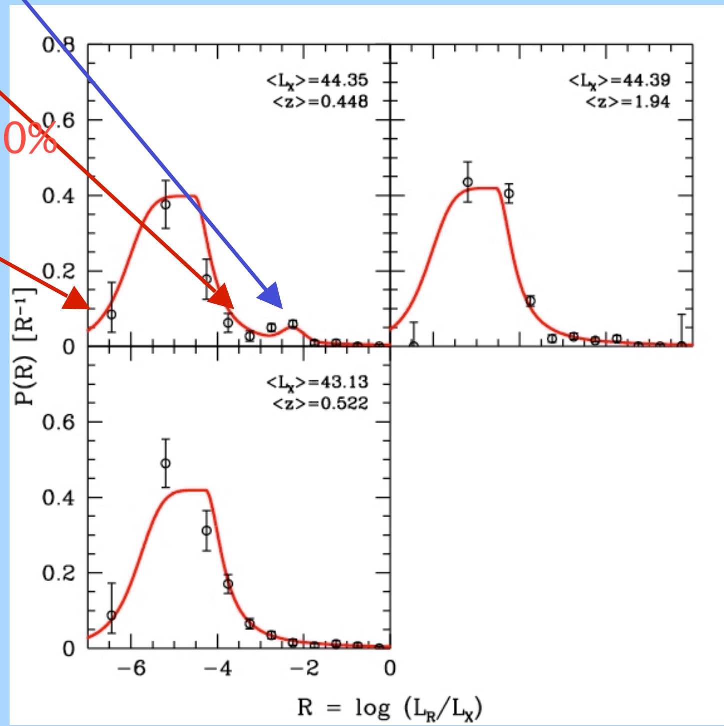
Distribution of the radio loudness (R) as a function of L_X and z
$P(R| L_X, z)$



As there are very few samples were almost all the AGN have been detected in the radio band, the previously derived L_X-L_R relationships do not correctly represent the entire AGN population

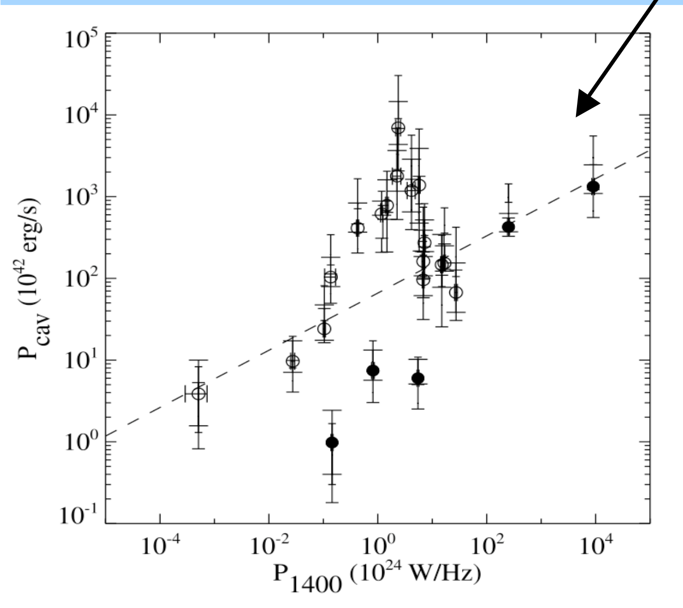
Peak of the radio Loud AGN

P(R)>10%



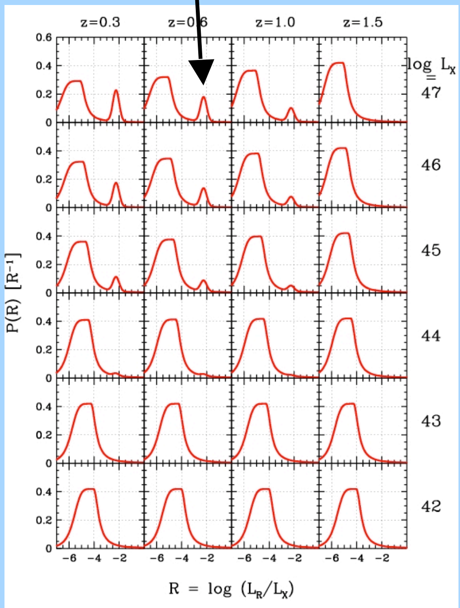
Evolution of the kinetic power density

$$\Omega(L_{kin}) = \iint \frac{L_{kin}}{L_R} L_X R \; P(R|L_X, z)\Phi(L_X, z) \mathrm{dlog}\, L_X \mathrm{d}R$$



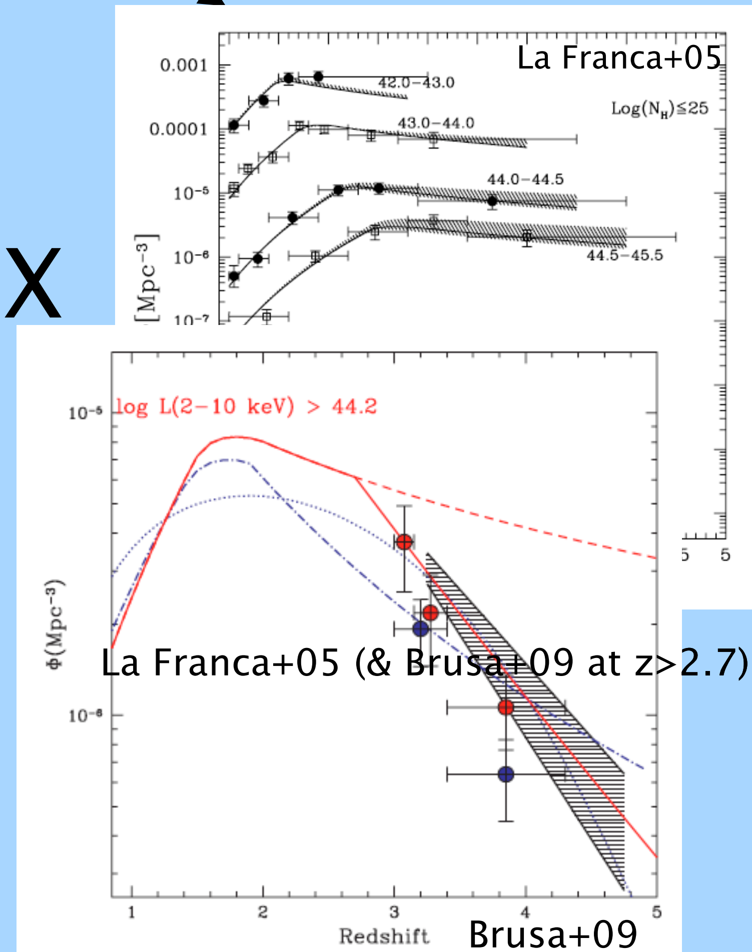
L_{KIN}/L_{RADIO} from Birzan+08

X



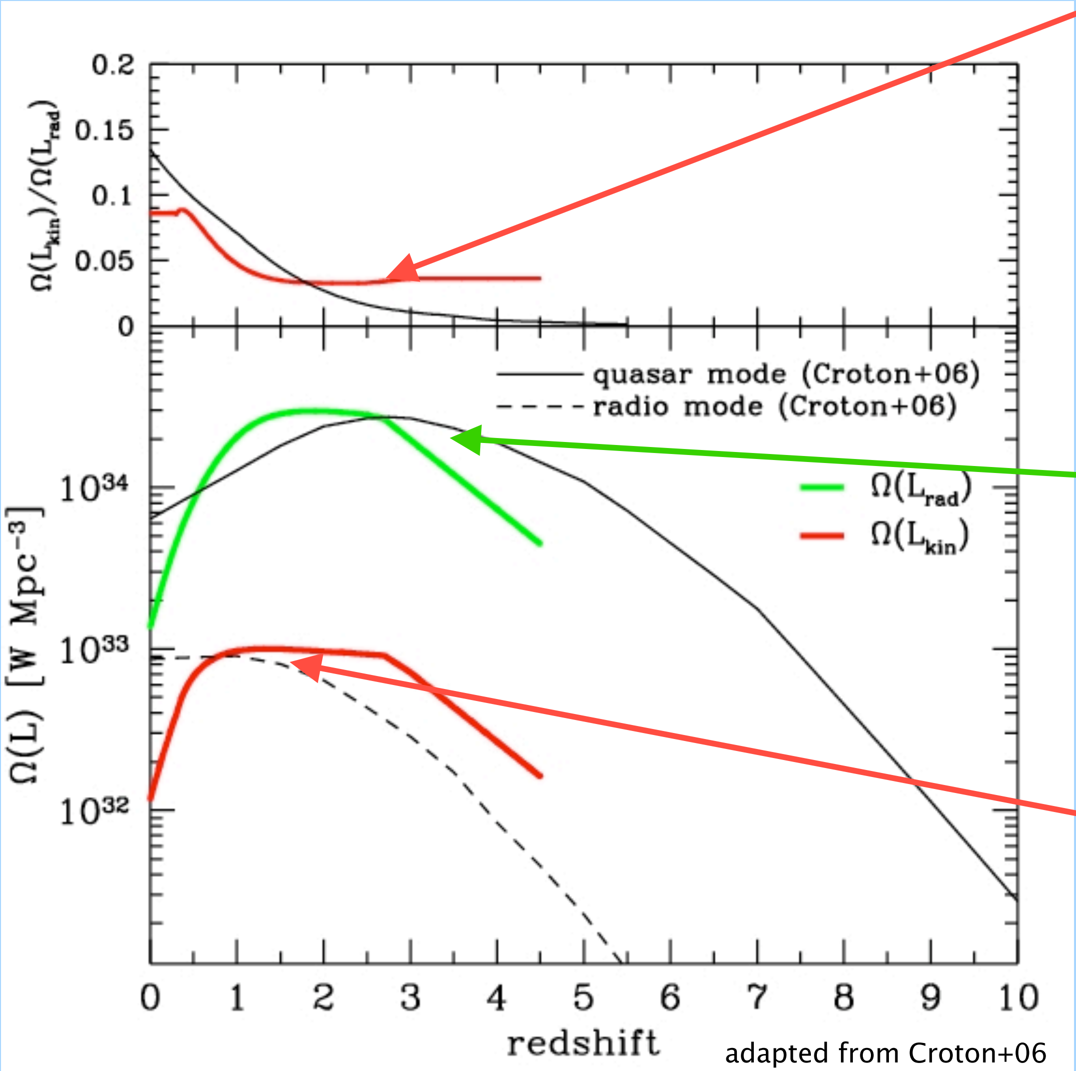
P(R| L_X, z) from this work

X



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

Evolution of the kinetic power density



adapted from Croton+06

The fraction of kinetic power density increases at low redshift as requested by some galaxy formation models (e.g. Croton+06)

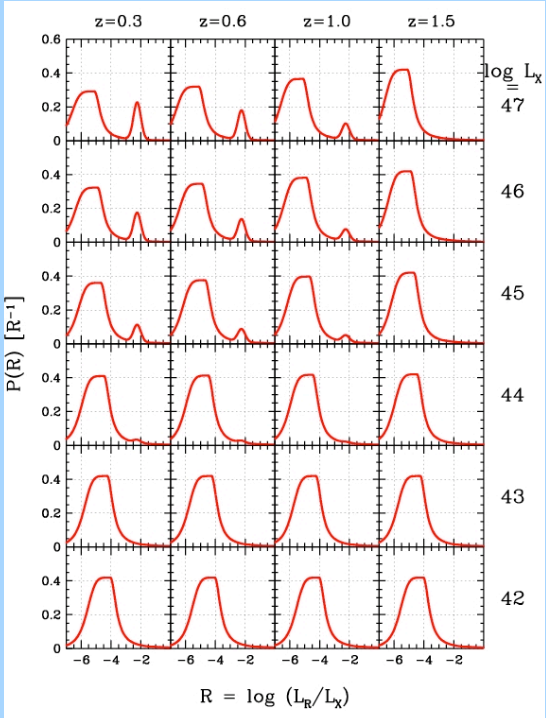
Radiative power density

$$\Omega(L_{rad}) = \int K(L_X) L_X \Phi(L_X, z) \mathrm{d}\log L_X$$

Kinetic power density

$$\Omega(L_{kin}) = \iint \frac{L_{kin}}{L_R} L_X R \; P(R|L_X, z) \Phi(L_X, z) \mathrm{d}\log L_X \mathrm{d}R$$

SUMMARY



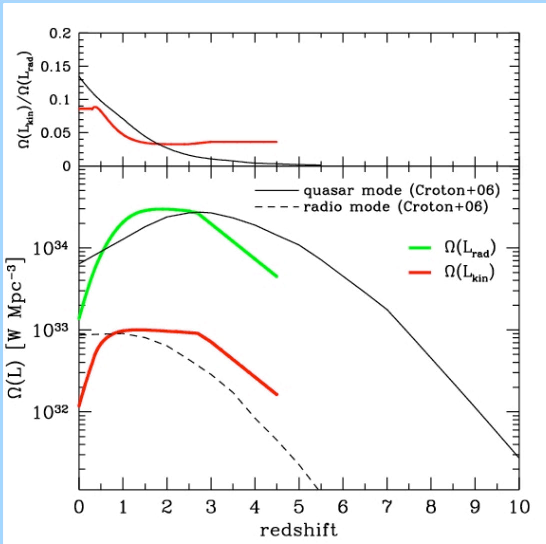
-We have built a catalogue of ~1800 X-ray selected AGN1 and AGN2 observed at 1.4 GHz (470 detected).

-The conditional probability distribution of $R=L_R/L_X$ as a function of the intrinsic X-ray luminosity and redshift has been measured: $P(R| L_X, z)$.

-The fraction of radio loud (R>-3) AGN increases at increasing luminosities and decreases at increasing redshifts.

-The kinetic power density evolution has been estimated by convolving the $P(R| L_X, z)$ distribution with the X-ray luminosity function and the L_{KIN}-L_{RADIO} relation measured by Birzan+08.

-It results that the fraction of kinetic energy power is of the order of magnitute (and increases at low redshifts) as requested by many galaxy evolution models.



THANKS