ACCRETION AND JET POWERS IN VIRGO RADIO GALAXIES

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I - Accretion plays a fundamental role in powering AGN
II - Radio Loud AGN ➔ Relat. jets ➔ Mainly kinetic output

Two main kinds of accretion processes*:*

Cold accretion: Thick torus + bright disk (major merging)

Hot accretion: **No bright disk and torus, matter from *IGM***

Efforts in these last years to find evidence for a true correlation between the ***accretion*** and the ***AGN*** powers

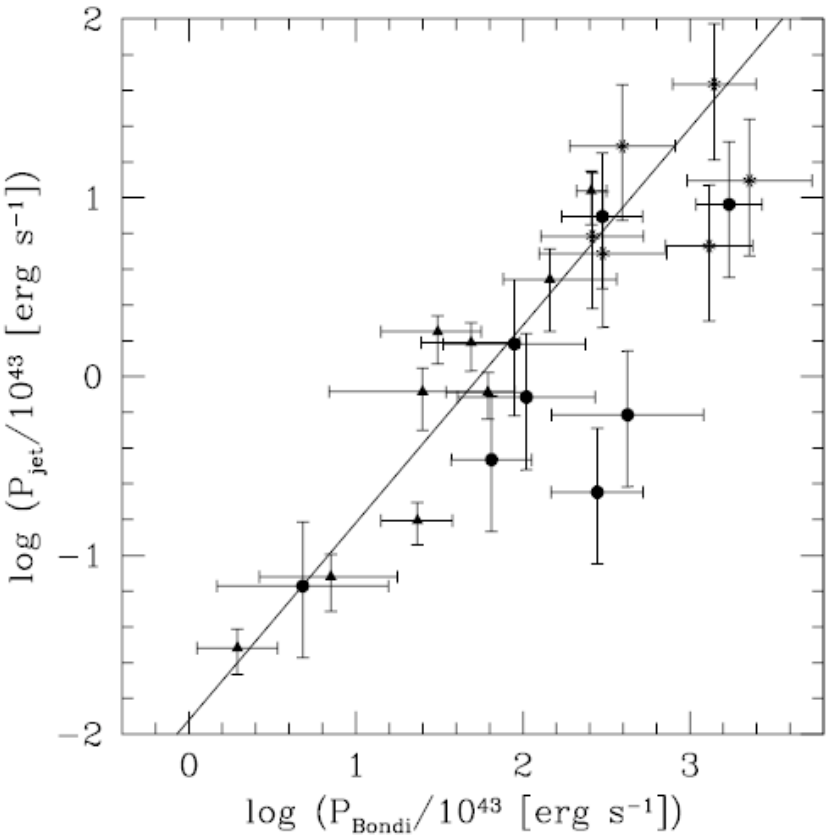
Very recently ***Allen et al.*** (***2006***; ***9*** objects) and ***Balmaverde et al.*** (***2008***; ***23*** objects) obtained independent estimates of the accretion power P_{accr} and the jet power P_J and found their strict correlation

$$\mathrm{Log}\ P_{accr} = 1.1\ \mathrm{Log}\ P_J - 1.9$$

➔ ~ ***linear dependence*** P_{accr} - P_J

➔ $P_J \sim 0.02\ P_{accr}$

Does the correlation hold to low values of P_J and P_{accr}?

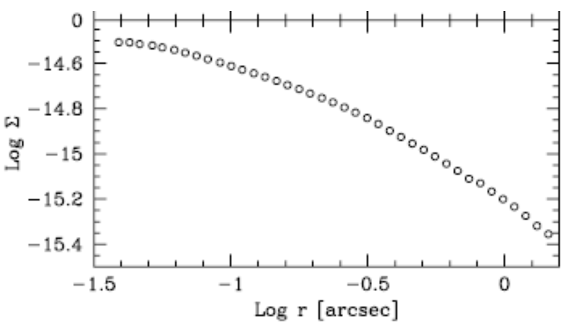


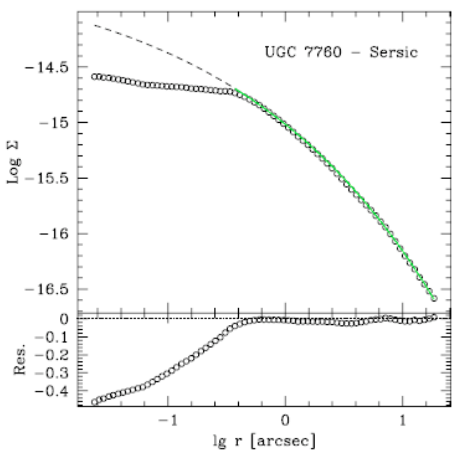
Evaluation of the jet and accretion powers

P_J: Correlation with the core radio luminosity: $P_J \propto L_\nu^{12/17}$
(*Heinz et al.* 2007)

Different brightness profiles for Radio Loud and Radio Quiet AGN
(*Capetti & Balmaverde 2005, 2006*)

'Power law' ➔ R. Q. ***'Core' ➔ R. L.***





Selection of 'Core' galaxies
Included objects with
upper limits for L_ν

$$P_{accr} = \eta \dot{M} c^2 , \quad \eta = 1$$

- ***Bondi model*** (***1952***): accretion rate at $r_B = 2GM_{BH}/c_s^2$

$$P_B = \dot{M}_B c^2 \qquad\qquad \dot{M}_B \propto n_B M^2_{BH} T_B^{-3/2}$$

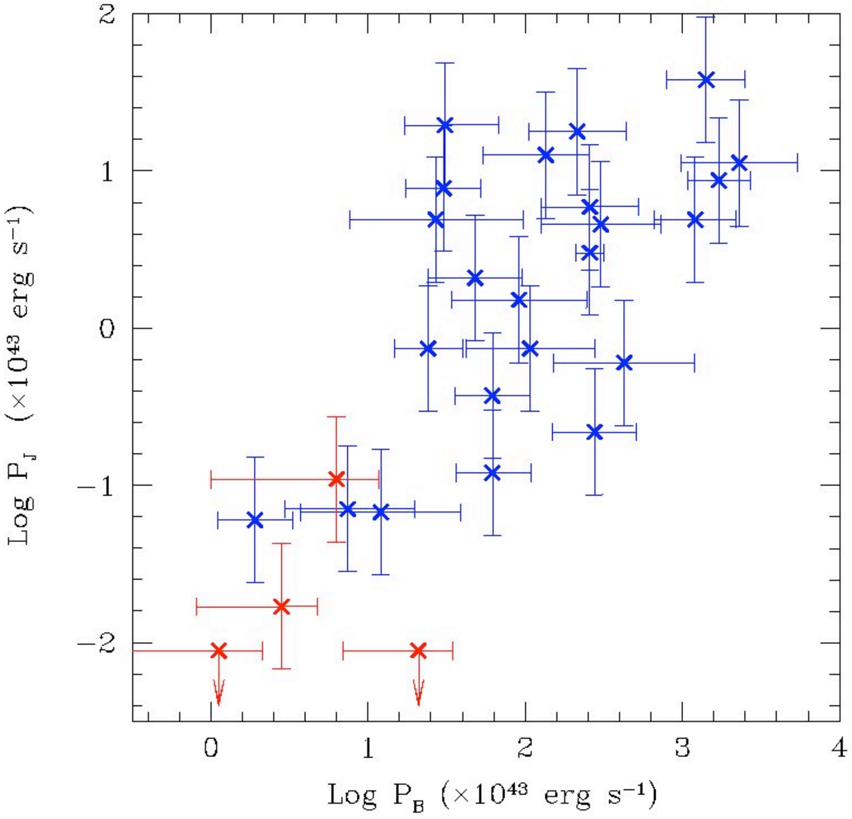
M_{BH} from the M_{BH} - σ correlation (***Tremaine 2002***)
n_B and T_B from the ***X-ray properties*** of the ***IGM***

X- ray analysis from Chandra archive data

- ***Erase from the extended map spurious sources (XRB)***
- ***Divide the image in annuli and from spectroscopic and morphological analysis deduce n_B and T_B***

Useful data only for : ***M 85, M 86, NGC 4365, NGC 4526***

- Upper limits for L_ν in M 85 and NGC 4365



Support that correlation extends down to very low radio luminosities

Something more …..

Extended sample

Previous four objects belong to the Virgo Cluster
Can we include other galaxies of this Cluster ?

1 - ***Objects at similar distances***
2 - ***Objects belonging to the same ambient***

From the sample of ***Balmaverde et al.*** (***2008***) we can include ***6*** more galaxies, for a ***Virgo*** subsample of ***10 objects***:

M 85	***M 49***	***M 89***
M 86	***M 60***	***NGC 4636***
NGC 4365	***M 84***	
NGC 4526	***M 87***	

Consistency between the correlat. of the VCC (10 obj.) and total samples (27 obj.)

$$\mathrm{Log}\ P_{J,43} = \mathcal{A}\ \mathrm{Log}\ P_{B,43} + \mathcal{B}$$

$\mathcal{A}$ = 1.3 ± 0.3

$\mathcal{B}$ = - 2.2 ± 0.4

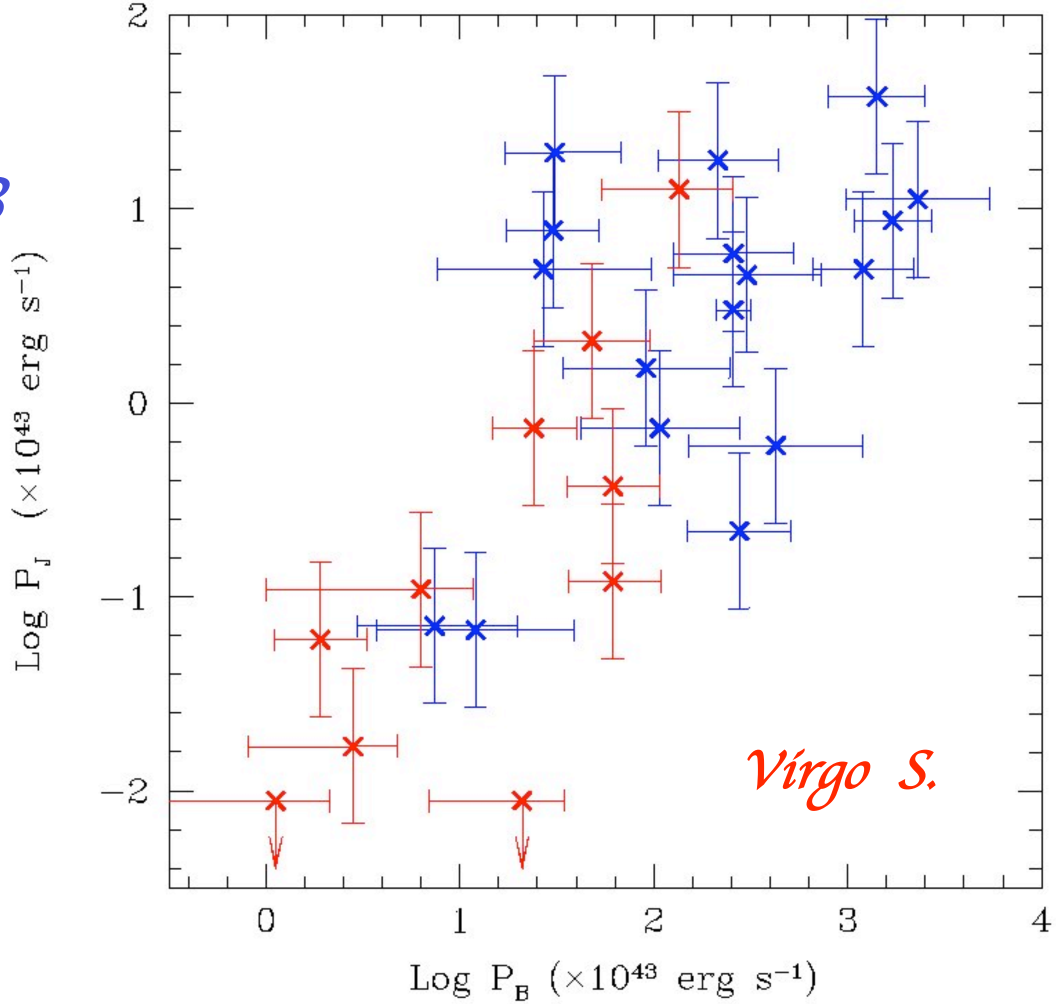
rms = 0.52

In the total sample:

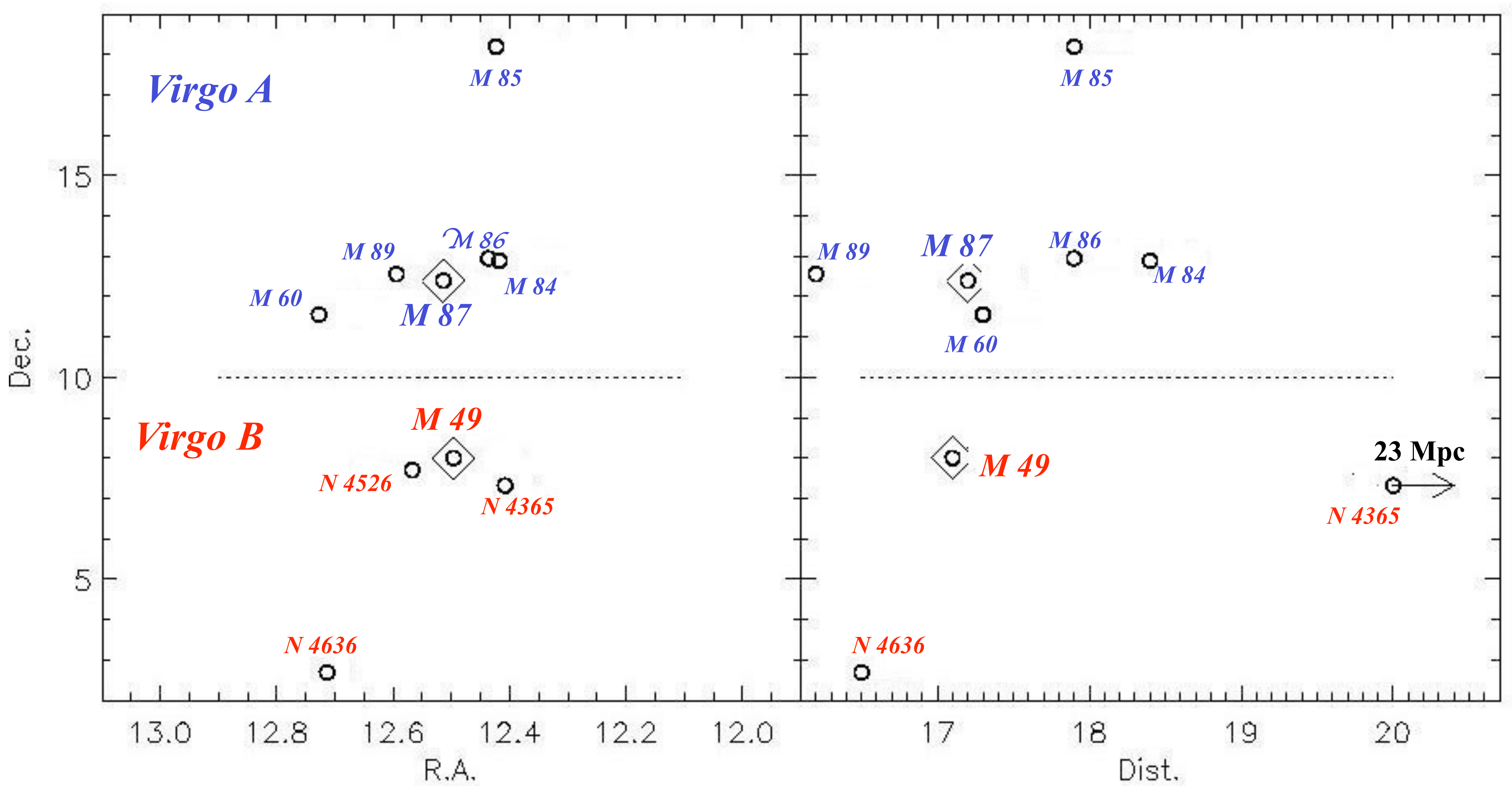
$\mathcal{A}$ = 1.1 ± 0.15

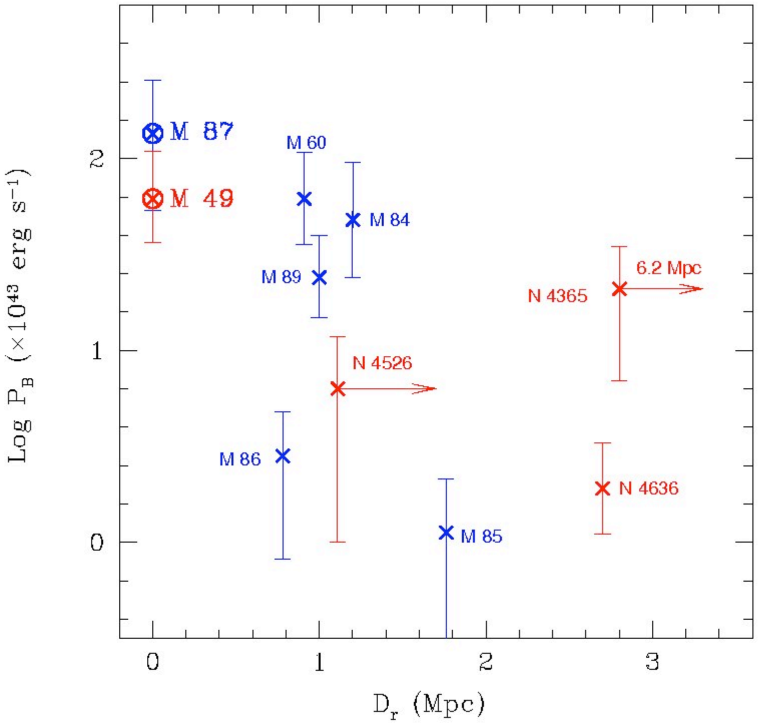
$\mathcal{B}$ = - 2.0 ± 0.25

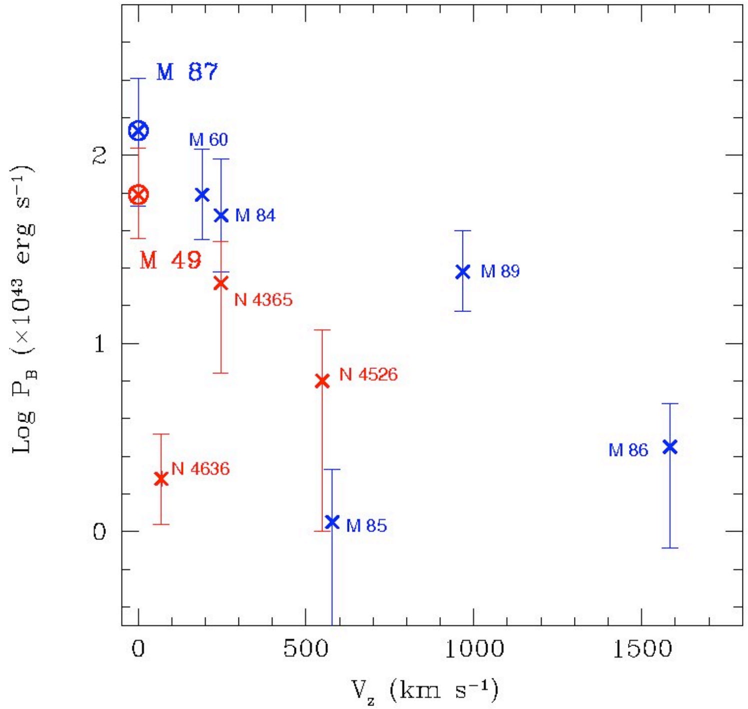
rms = 0.66



Large Scale ($r >> r_B$): the structure of the Virgo Cluster

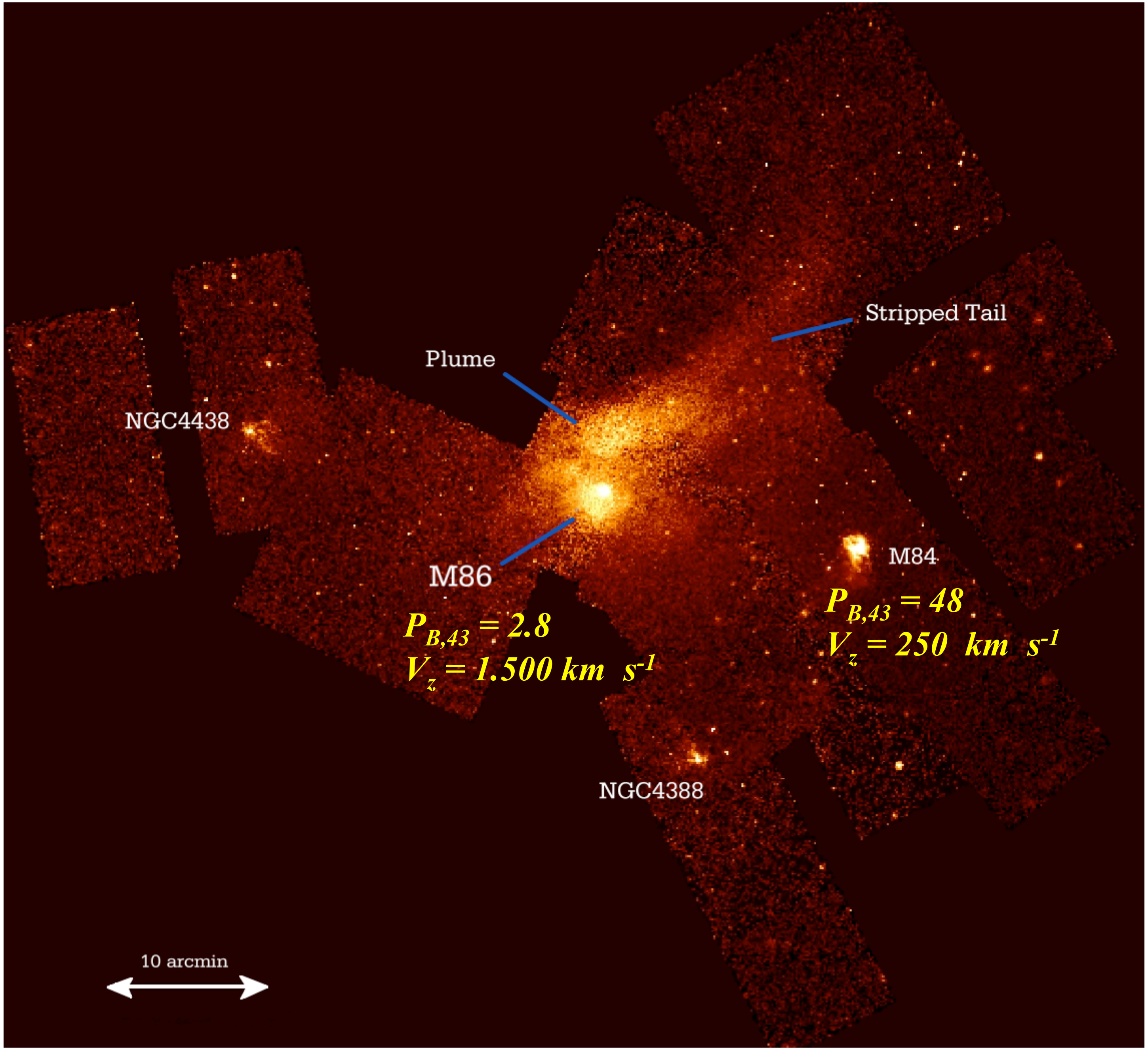






P_B is maximum for the dominant components and apparently decreases with the relative distances and velocities from the dominant components ***M 87*** and ***M 49*** in Virgo ***A*** and ***B***

Interaction of the IGM with the Cluster environm.



Intermediate scales ($r > r_B$): ***interaction jet - IGM***

Comparison of P_J with $L_{X,IGM}$

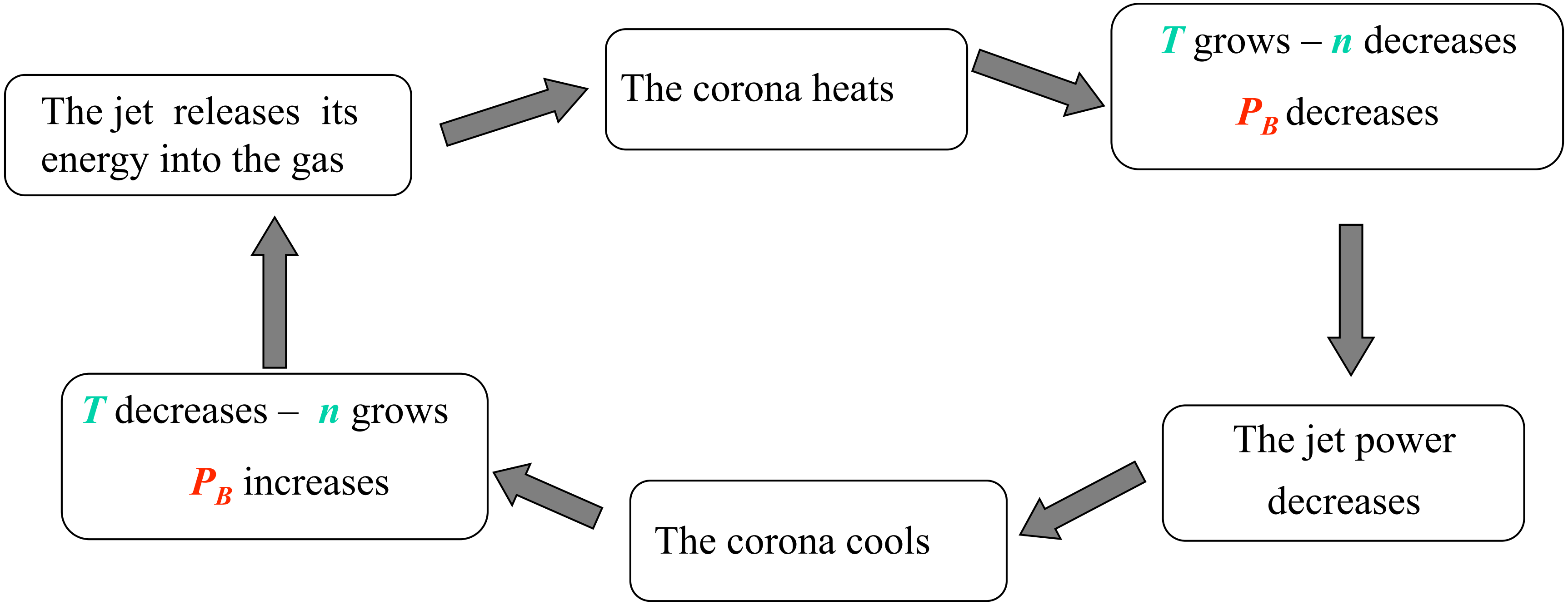
$$L_{X,IGM} / P_J \sim 0.1 - 0.001$$

From X-ray data we can evaluate the thermal content of the IGM

➔ **The jet heats the IGM within time scales** $\sim 10^7 - 10^9$ yrs

Scenarios: *Variable activity of the AGN*

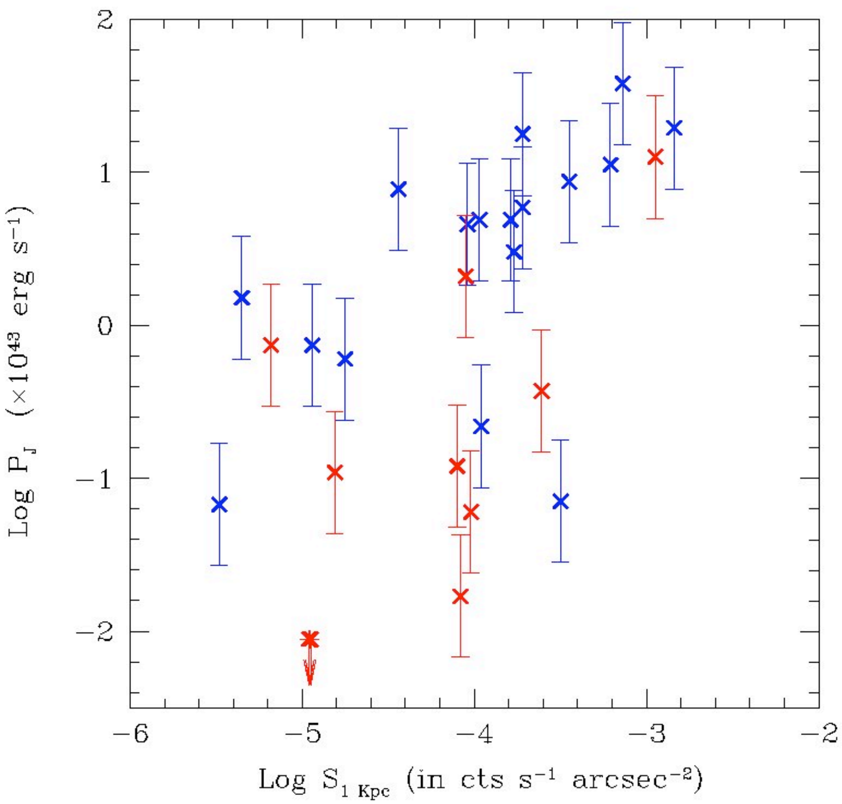
Feedback IGM/ jet: Duty cycle



Intermediate scales: brightness at 1 kpc

P_J *vs* S_{1kpc} *(counts at 1 Kpc)*

$S_{1kpc} \propto$ ***the density in the IGM***



Linear correlation holds with:

$P(\rho) \sim 0.1$ rms ~ 0.7

~ 0.001 rms ~ 0.8 (27obj.)

Lower gas density → ~ lower P_B

~ " P_J

The ambient and intermediate properties of the IGM play some role in the accretion process

Internal region ($r \ll r_B$): *dynamical properties*

$P_J/P_B \sim 0.02$ ➔ ***Constraints on the driving processes for relativistic jets ?***

I - Blandford & Znajek (1977): $P_J \propto B^2 j^2$ $\quad (j = J/J_{Max} < 1)$

II - ADAF model for the accretion (***Nemmen et al. 2007***):

$$P_J = \eta_J(j, \alpha, \varepsilon)\, P_B \qquad \alpha \sim 0.1$$

$$\dot{M}_{io} = \varepsilon\, \dot{M}_B \quad (\varepsilon < 1)$$

$$A = \mathrm{Log}\,(P_J/P_B)$$

➔ $j > 0.90 - 0.95, \quad \eta_J \sim 0.1 - 0.5$

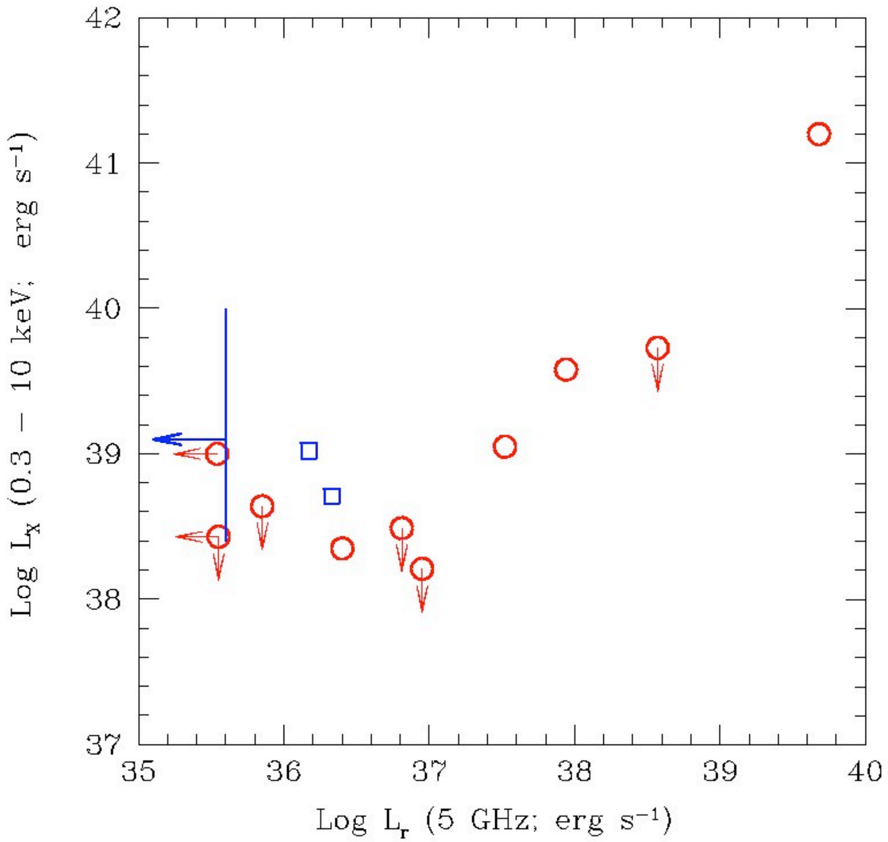
If a disk wind is included scenario not very different (***Meier 2001***)

Internal region: *radiative properties*

- A correlation exists between the core radio and X-ray luminosities

$L_{X,core} \sim \mathbf{0.001}\, P_J$

- ‘***Power Law***’ galaxies , much brighter than ‘***Core***’ objects



P_B originates from the IGM but ➔

R.L.: **Weakly emitting disk, relat. jet**

R.Q.: **Disk emission (non relat. outfl. ?)**

SUMMARY

- The correlation P_J - P_B holds over ~ ***4 decades*** (OK)

- The ambient and interaction of the IGM with the environment affects the accretion process and then P_B (~ OK)

- The fraction of $P_B \Rightarrow P_J$ seems to constrain acceleration of relat. jets only from SMBH with high spin (~, ***further modelling***)

- The accretion - ejection process different in ***R.L.*** and ***R.Q.*** ?

R.L.: $P_B \Rightarrow$ ***kinetic power***

R.Q.: $P_B \Rightarrow$ ***e.m. power***

~, ***further modelling***

~, ***analyze the IGM properties in R.Q. galaxies***