Jet production efficiency in the sample of the youngest radio galaxies

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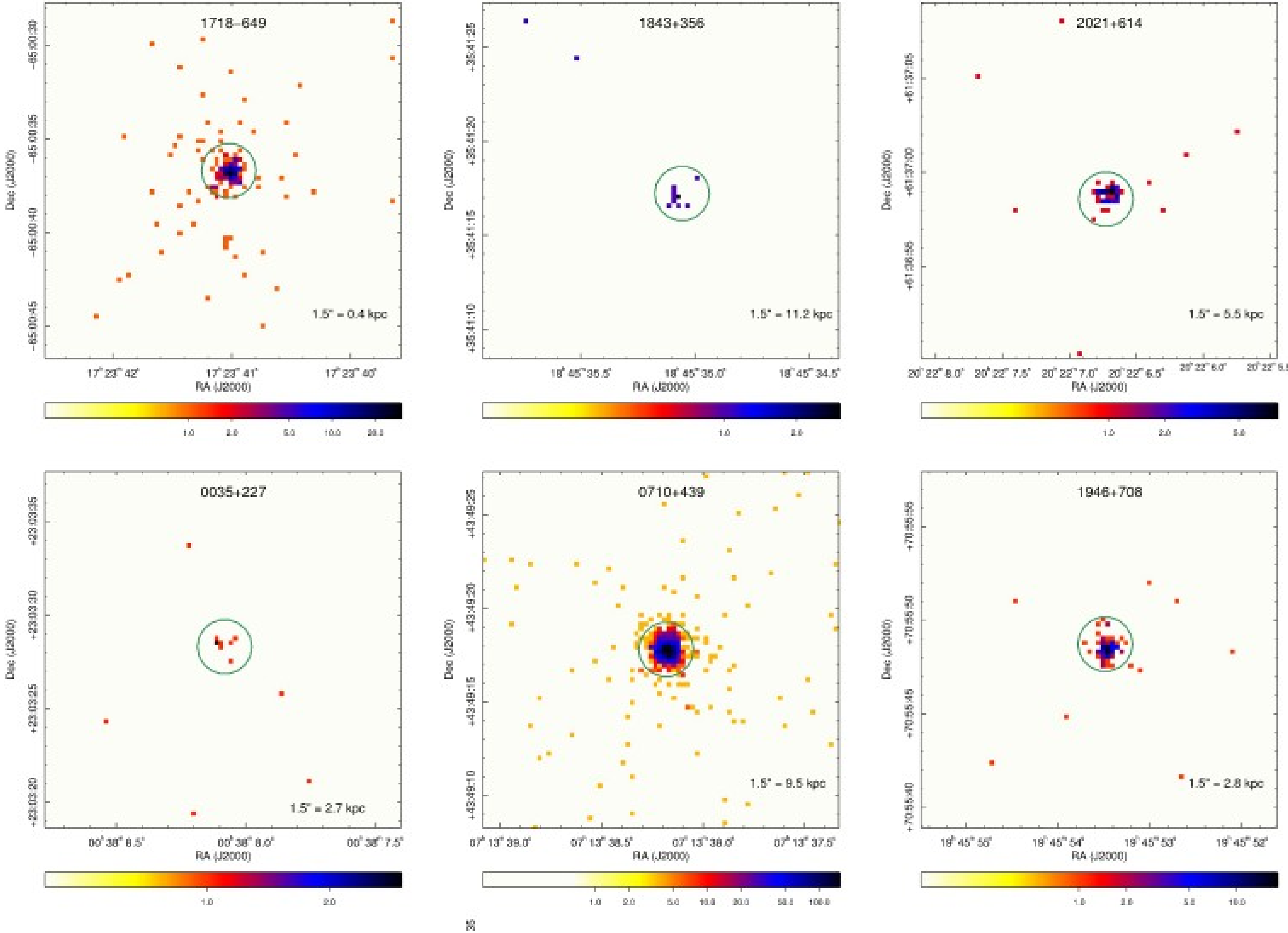
source	z	LS	τ
		[pc]	yrs
(1)	(2)	(3)	(4)
0035+227	0.096	21.8	450 [a]
0108+388	0.669	22.7	404 [a]
0116+319	0.059	70.1	501 [a]
0710+439	0.518	87.7	932 [b]
1031+567	0.460	109.0	620 [c]
1245+676	0.107	9.6	188 [a]
1323+321	0.368	278.1	1030 [d]
1404+286	0.077	7.0	219 [e]
1511+0518	0.084	7.3	300 [f]
1607+26	0.473	240	2200 [g]
1718–649	0.014	2.0	91 [a]
1843+356	0.763	22.3	180 [b]
1934–638	0.183	85.1	1603 [a]
1943+546	0.263	107.1	1308 [a]
1946+708	0.101	39.4	1261 [a]
2021+614	0.227	16.1	368 [b]
2352+495	0.238	117.3	3003 [b]

High quality X-ray observations of Chandra



Siemiginowska et al. 2016

Data selection:

-measured redshift

-kinematic ages

-high quality X-rays observations

Representative sample of 17 CSOs

How to describe AGN?

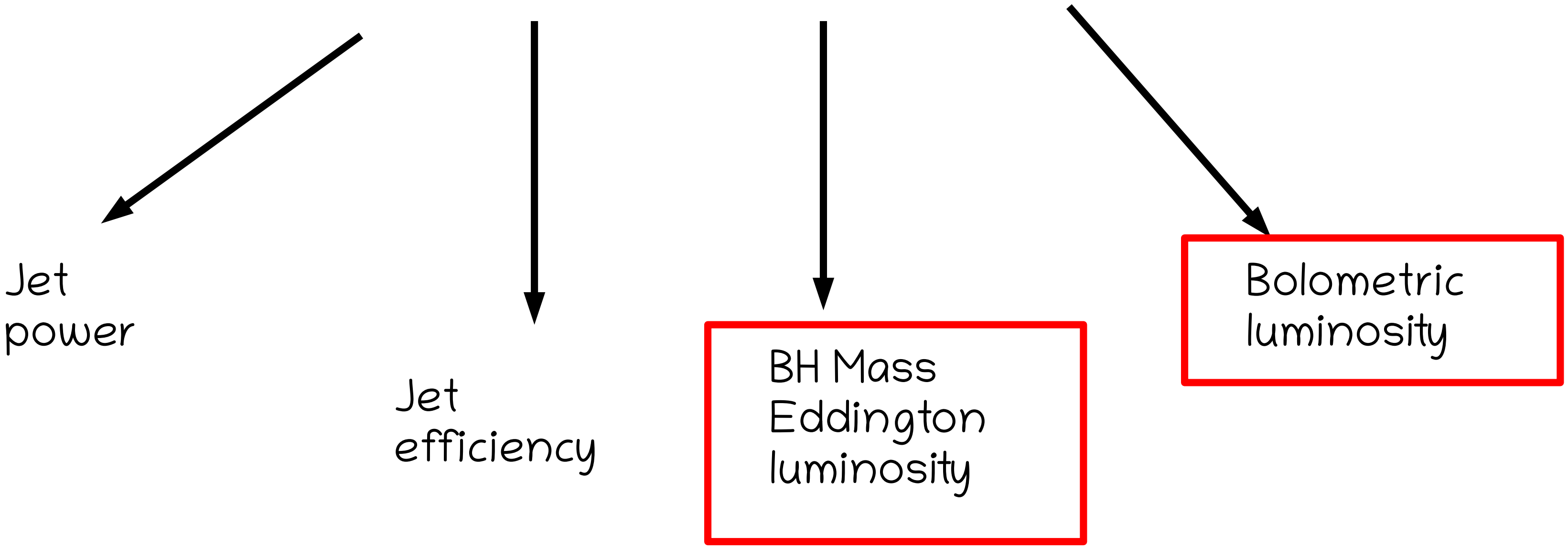
Jet power

Jet efficiency

BH Mass, Eddington luminosity

Bolometric luminosity

How to describe AGN?



Our sample of CSOs

name	z	d_L [Mpc]	$L_{2-10\,\mathrm{keV}}$ [10^{42} erg/s]	$\log \frac{\mathcal{M}_{BH}}{M_\odot}$	method	L_{bol} [10^{44} erg/s]	method
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1718–649	0.014	60	0.15 [S16]	8.5	L_{blg} [W10]	3.77	$H\beta$ [P96]
1843+356	0.763	4612	56 [S16]	–	–	–	–
2021+614	0.227	1086	$112^{\dagger}$ [S19]	8.9	M_R [W09]	14.8	[OIII] [W09]
0035+227	0.096	418	0.75 [S16]	8.4	$\sigma_\star$ [S12]	5.98	$H\beta$ [S12]
0116+319	0.059	255	$< 1.0^{\dagger\dagger}$ [S16]	8.8	L_{blg} [W10]	8.71	[OIII] [W09]
0710+439	0.518	2868	394 [S16]	8.4	M_R [W09]	46.5	$H\beta$ [L96]
1946+708	0.101	444	12 [S19]	8.5	L_{blg} [W10]	–	–
1943+546	0.263	1285	7.31 [S16]	8.5	$\sigma_\star$ [S12]	–	–
1934–638	0.183	845	6 [S19]	8.5	M_R [W09]	78.8	$H\beta$ [R16]
1607+26	0.473	2569	37.9 [S16]	8.6	$\sigma_\star$	36	$H\beta$
1511+0518	0.084	370	$30^{\dagger}$ [S16]	8.6	$\sigma_\star$	6.03	SED [T13]
1245+676	0.107	478	$0.31^{\star}$ [Wa09]	8.5	$\sigma_\star$ [S12]	4.11	$H\beta$ [S12]
1404+286	0.077	336	$100^{\dagger}$ [G04]	8.6	$\sigma_\star$	43.3	12 μm [K19]
0108+388	0.669	3907	70 [T09]	7.9	M_R [W09]	4.85	[OIII] [W09]
1031+567	0.460	2480	22 [T09]	8.3	$\sigma_\star$	10.7	$H\beta$
2352+495	0.238	1143	13 [T09]	8.4	M_R [W09]	8.0	$H\beta$ [L96]

Jet power estimate

1. Willott et al. 1999 scaling relation

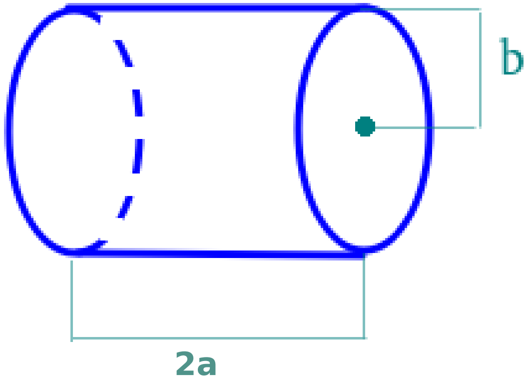
$$P_{j(W)}[erg\,s^{-1}] = 5.0\times10^{22}\left(\frac{L_{1.4GHz}}{W\,Hz^{-1}}\right)^{6/7}$$

2. Kinetic jet power

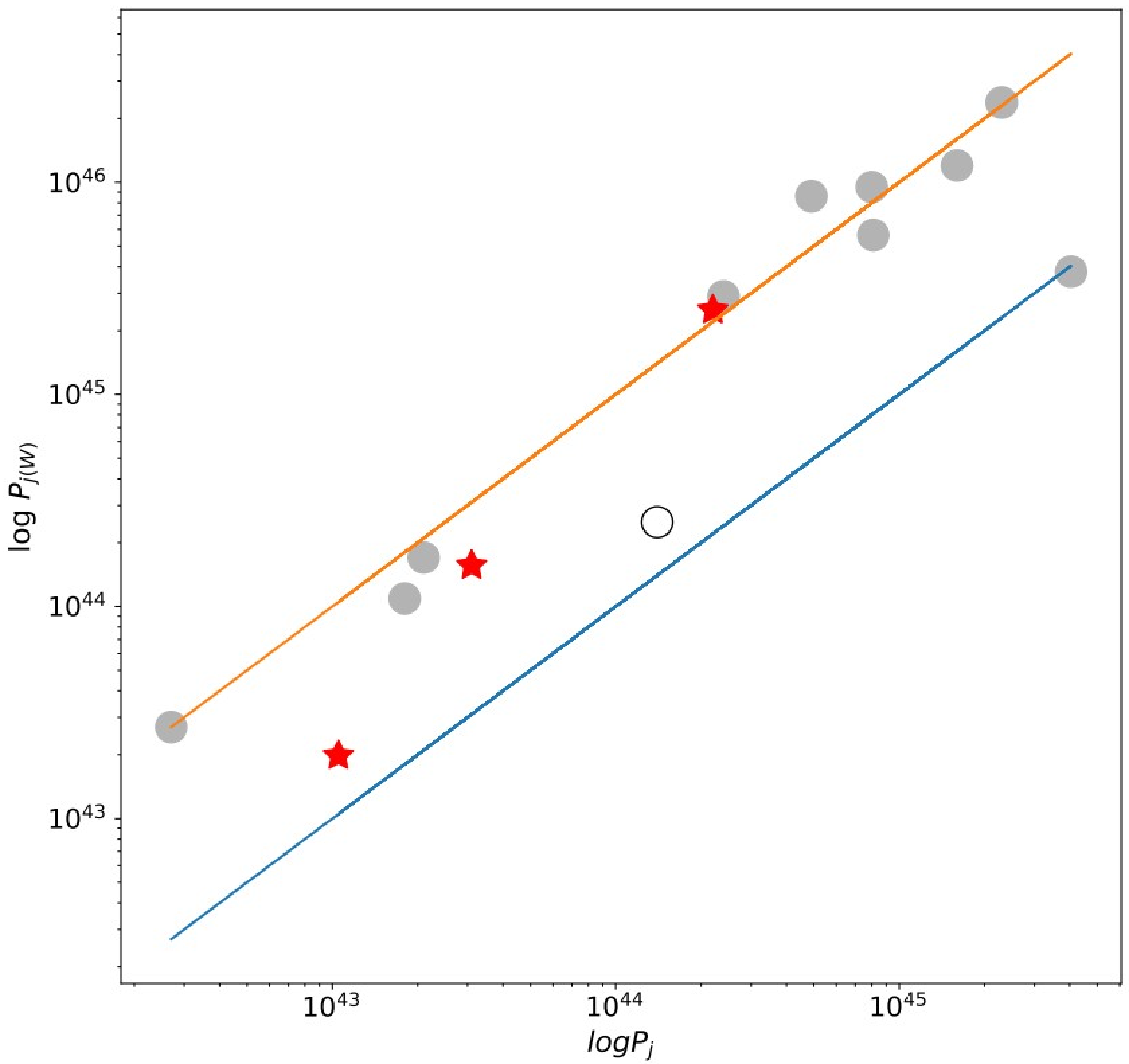
$$P_j = \frac{4pV}{\tau_j} = \frac{32}{3}\pi R^3 \frac{B_{eq}^2}{8\pi\tau_j}$$

Kawakatu et al. 2008

$$\frac{b}{a} \approx 0.25$$

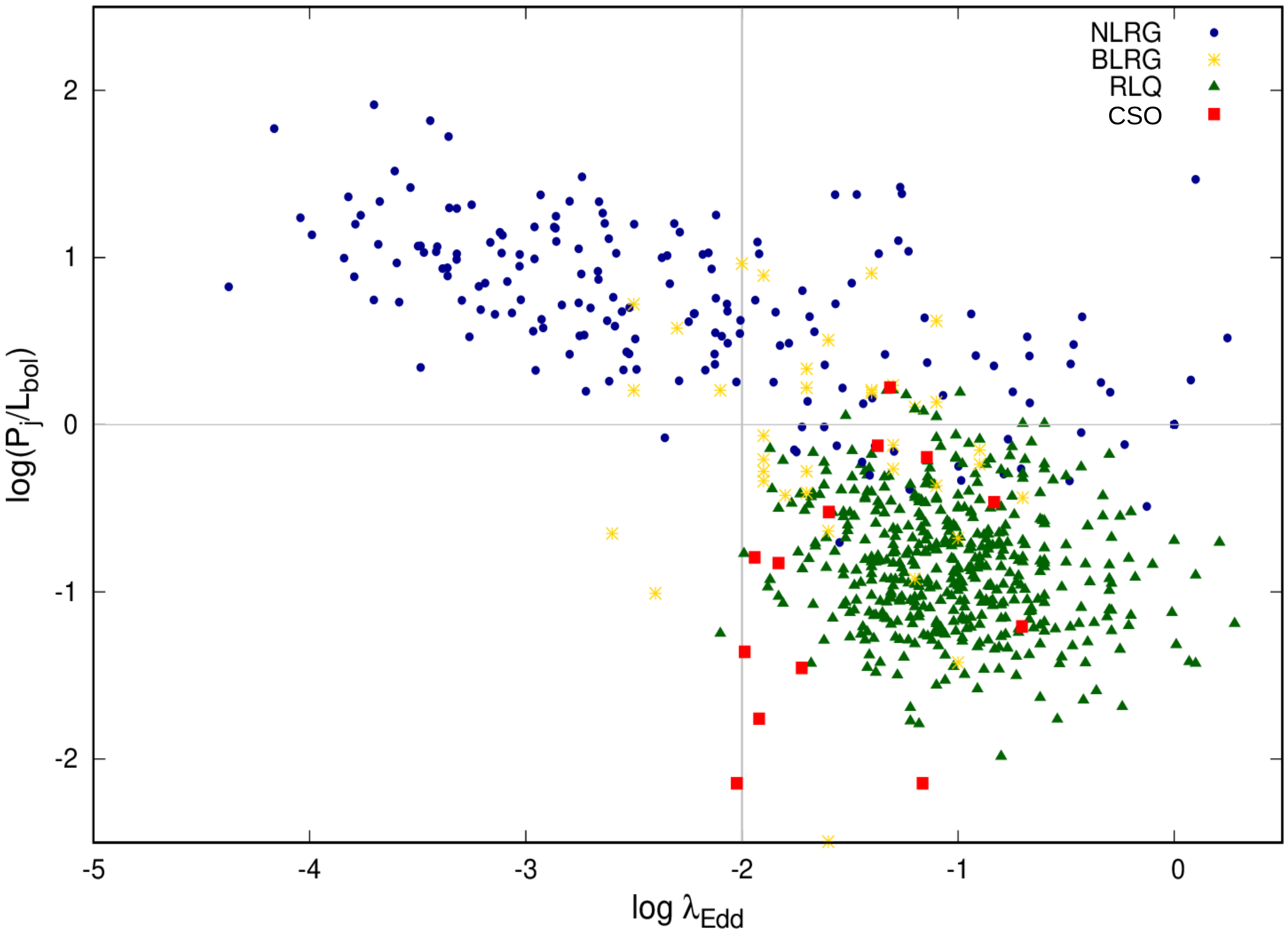


The minimum jet kinetic luminosities P_j for the studied sample of CSOs vs. the corresponding jet powers derived from the Willott et al. (1999) scaling relation, $P_{j\,(W)}$

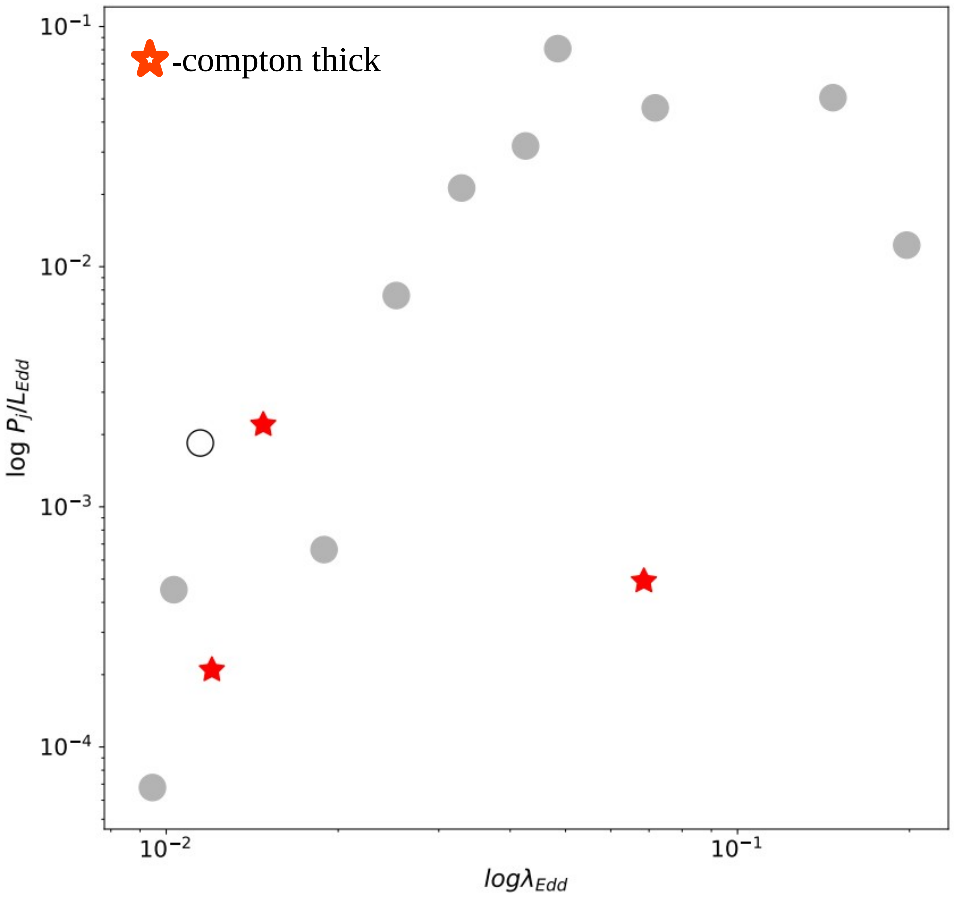


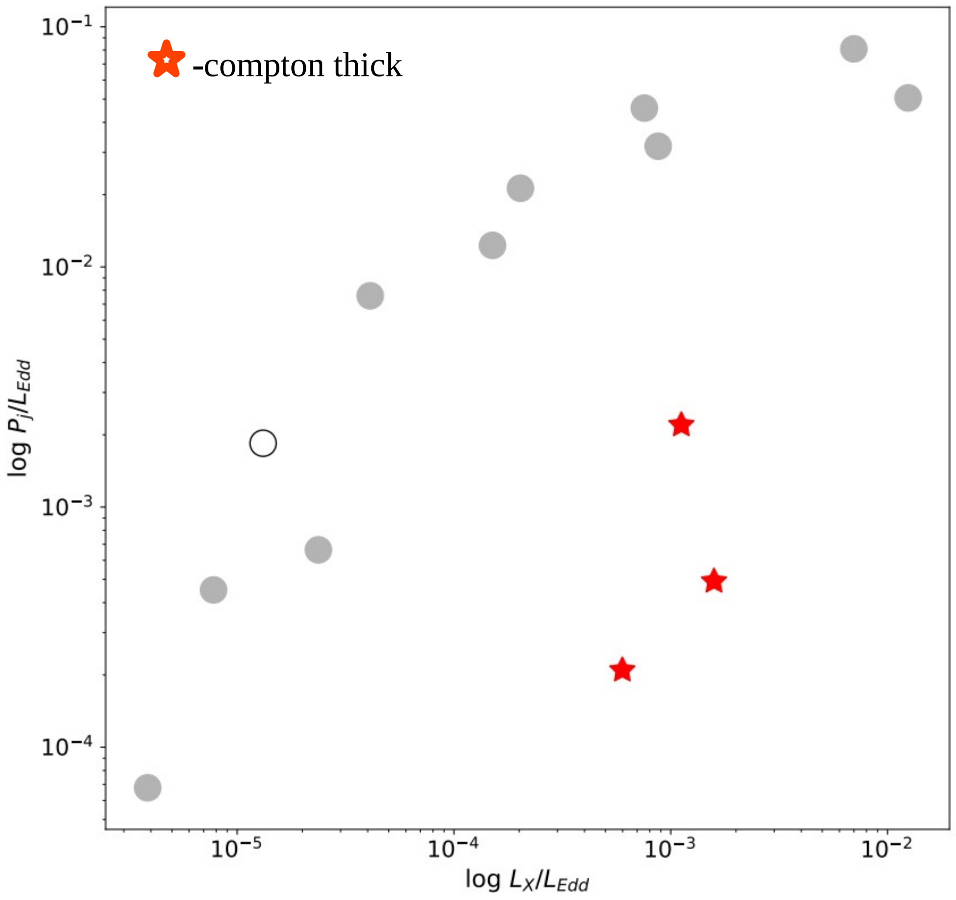
Enhanced radio radiative efficiency of compact structure

$\lambda_{Edd} - P_j/L_{bol}$ distribution of the CSOs plotted along with different types of AGN as analyzed by Rusinek et al. (2017)

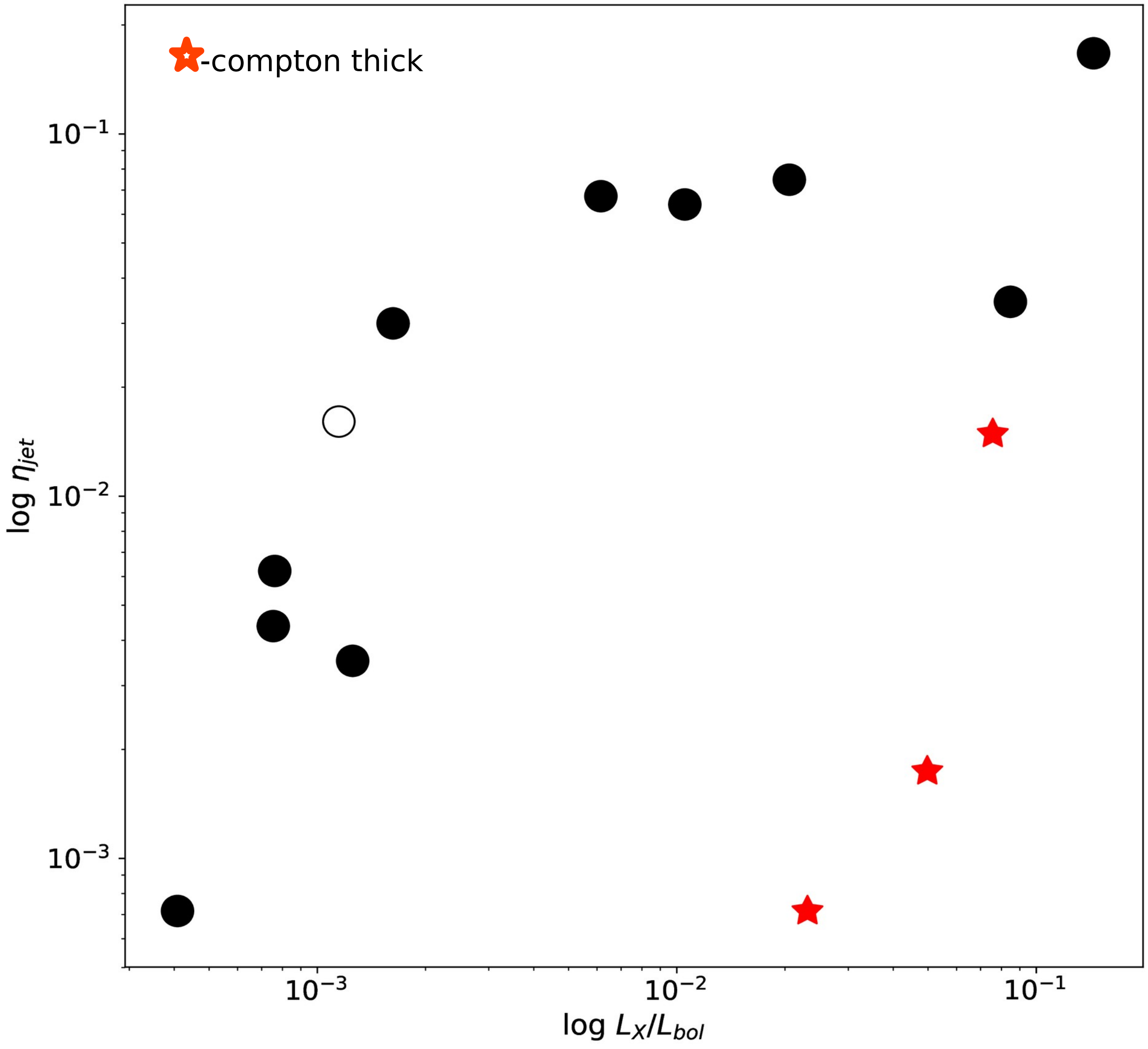


Distribution of CSOs form our sample of M_{BH}-scaled P_j-L_{bol} and P_j-L_X plane



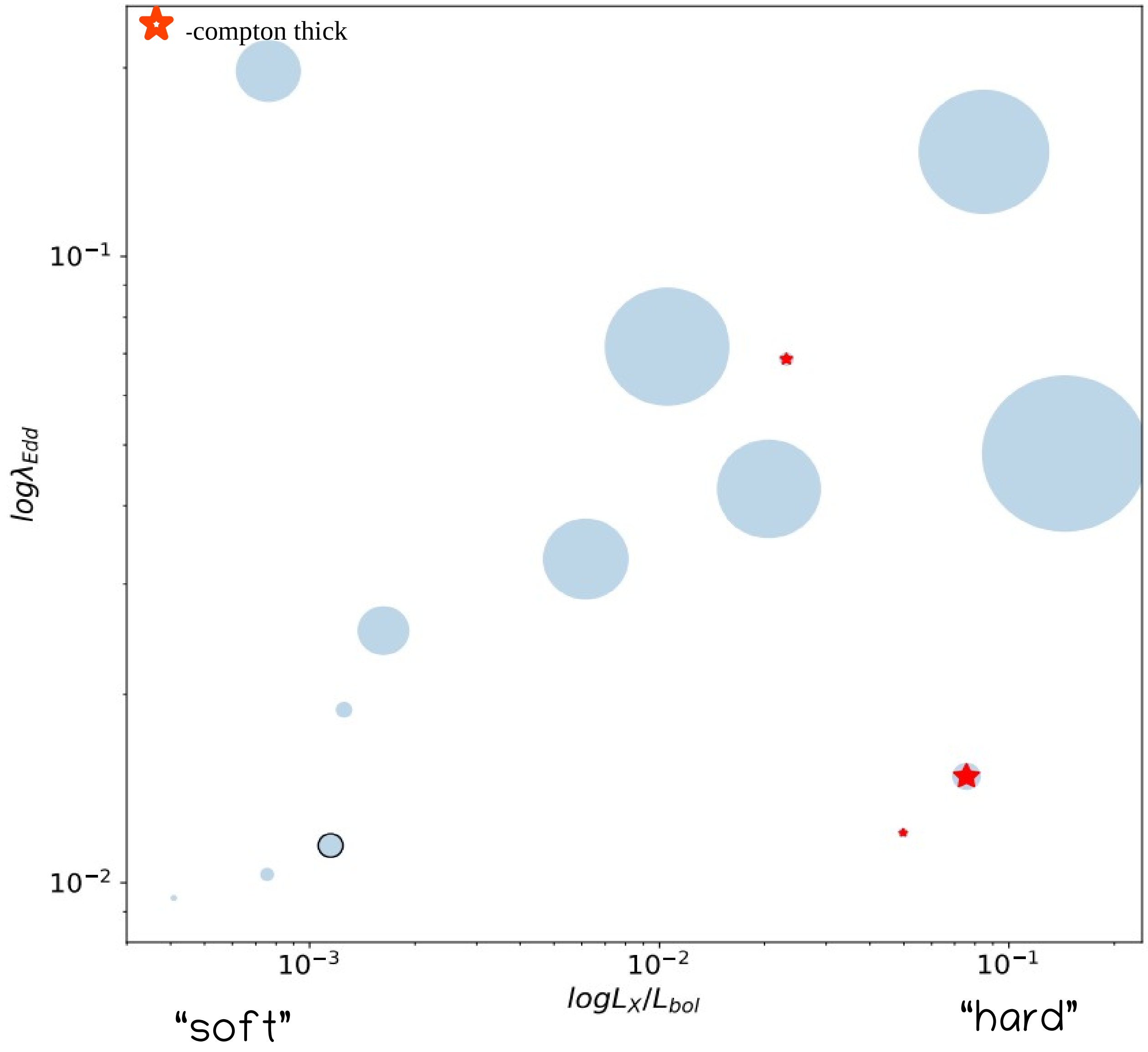


Jet efficiency distribution of CSOs from our sample vs. their L_X/L_{bol}

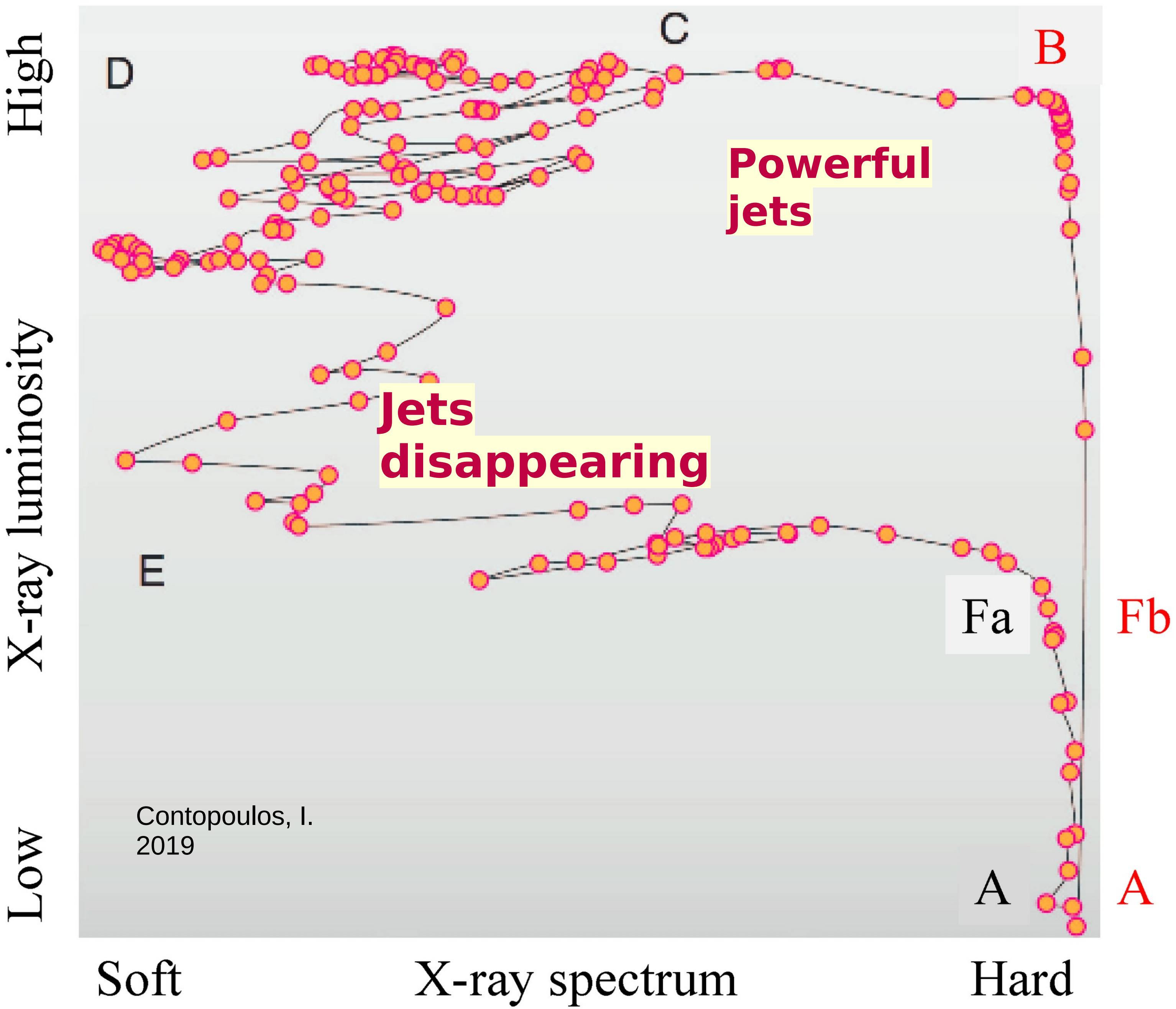


$$\eta_{jet}=\frac{P_j}{\dot{M}_{acc}c^2}=\frac{P_j}{10\,L_{bol}}$$

Dependence of the CSOs jet production efficiencies on λ_{Edd} and L_X/L_{bol}



XRB Hardness-Intensity Diagram (HID) (for XRB GX 339-4 during its 2002–2003 outburst)



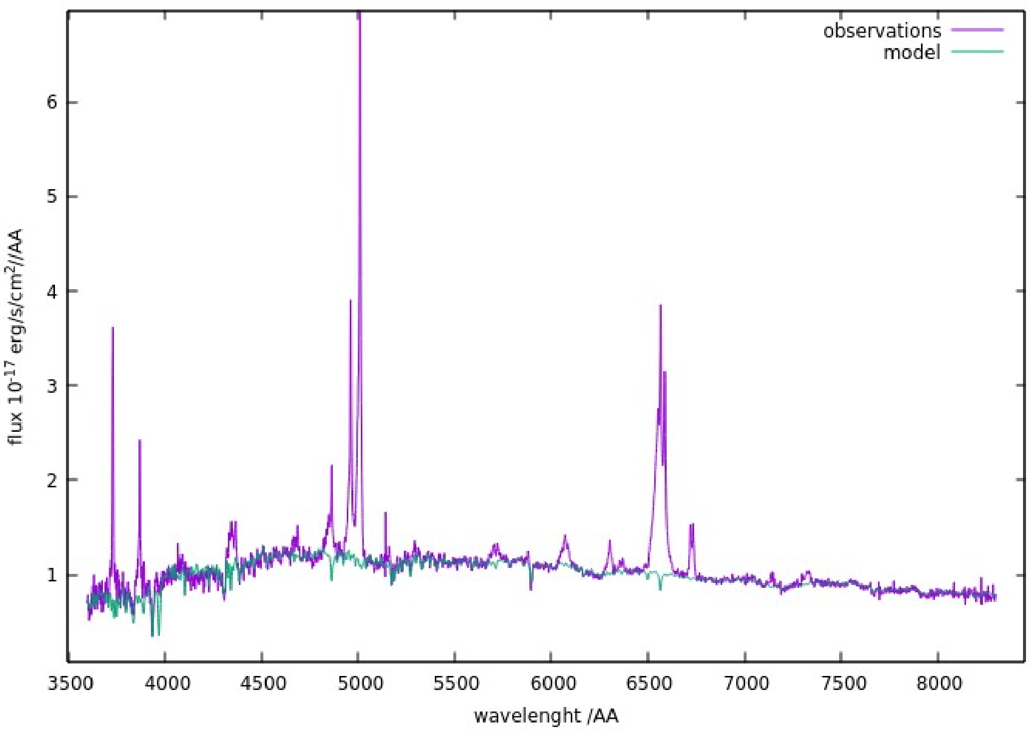
Summary

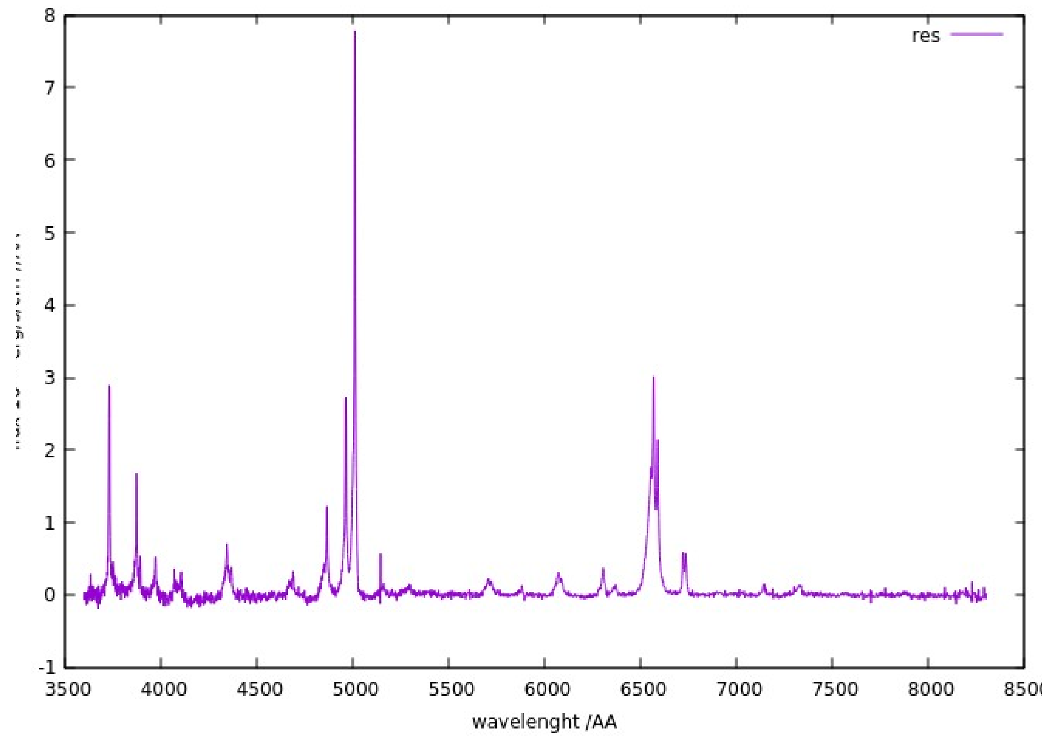
1. Low jet efficiencies $\eta_{jet} \lesssim 10\,\%$

2. normalize jet power correlates with accretion rate and normalized X-ray luminosity- possible saturation

3. Similarity to XRB- jets being produced the most efficiently during the high/hard states, and suppressed during the soft states

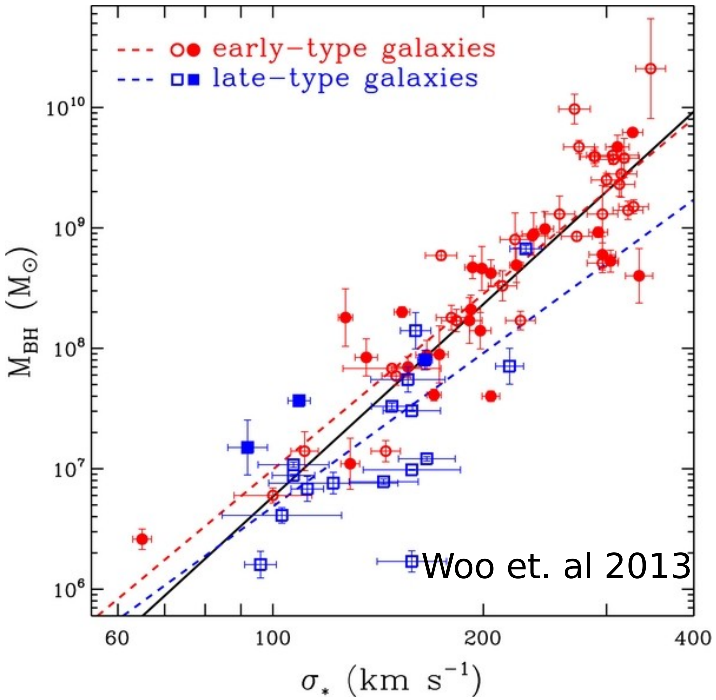
STARLIGHT
Spectral Synthesis Code





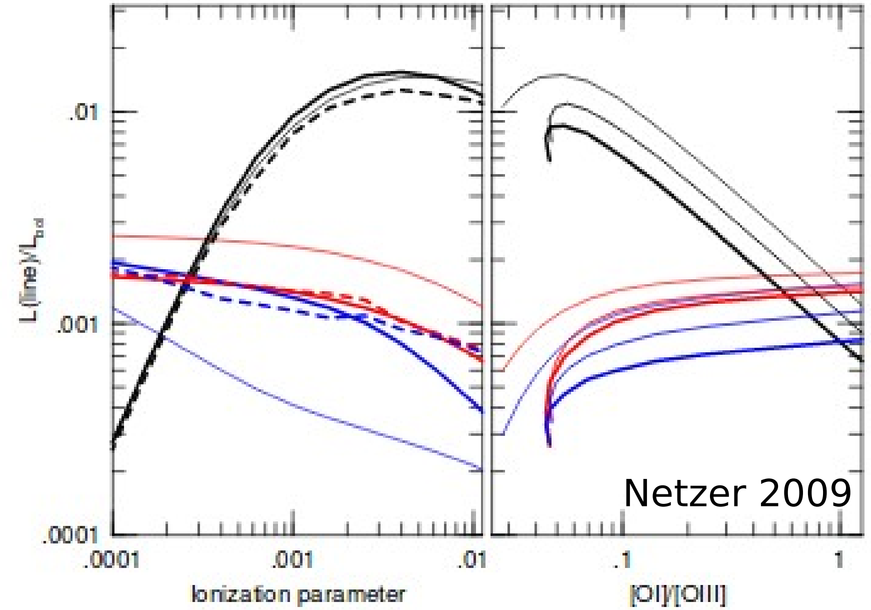
Green line: mixed population synthetic stellar spectra (Bruzual & Charlot 2003)+AGN continuum
(assuming Calzetti 2000 extincion law)

Extracted emission spectrum of AGN



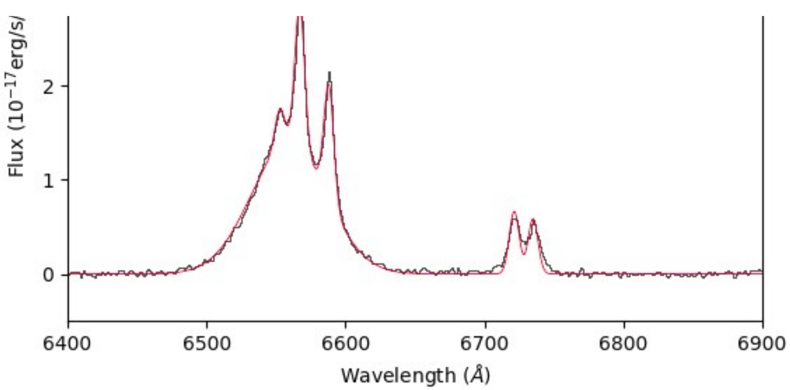
How to derrive BH mass?

$$\log(M_{\rm BH}/M_\odot) = \alpha + \beta \log(\sigma/\sigma_0) \ ,$$



Disk luminosity estimate

$$\log L_{bol} = \log L(H_\beta) + 3.48 + max\left[0., 0.31(\log \frac{[OIII]}{H_\beta} - 0.6)\right]$$



Bolometric luminosities estimat

Table 1
Measured velocity dispersion and narrow $H\beta$ fluxes for objects with available SDSS spectra.

name	Ref.	$\sigma_\star$ $[kms^{-1}]$	$F_{H\beta}$ $[\frac{erg}{scm^2}]$	comments
1607+26	SDSS	255.33	1.39E-15	Type-2 AGN
1511+0518	SDSS	199.75	8.33E-17	Type-1 AGN
OQ+208	SDSS	259.95	4.85E-17	Type-1 AGN
1031+567	SDSS	217.55	2.01E-16	Type-2 AGN

Table 2
Bolometric luminosities estimated from measured $H\beta$ luminosities in the literature.

name	method	$H\alpha/H\beta$	$L_{H\beta}\_cor$ [erg/s]	L_{bol} [erg/s]
0035+227	averaged	2.73	1.98E+041	5.97E+044
1245+676	averaged	1.84	1.36E+041	4.11E+044
2352+496	$H\alpha/H\beta$	4.57	2.65E+041	8.00E+044
1031+567	averaged	2.75	3.53E+041	1.06E+045
0710+439	averaged	–	1.54E+042	4.65E+045
1718–649	$H\alpha/H\beta$	3.4	1.25E+41	3.77E+044
1934–634	$H\alpha/H\beta$	5	1.45E+041	7.88E+045