Jet production efficiency in the sample of the youngest radio galaxies

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in a collaborotion with Łukasz Stawarz & Emily Kosmaczewski

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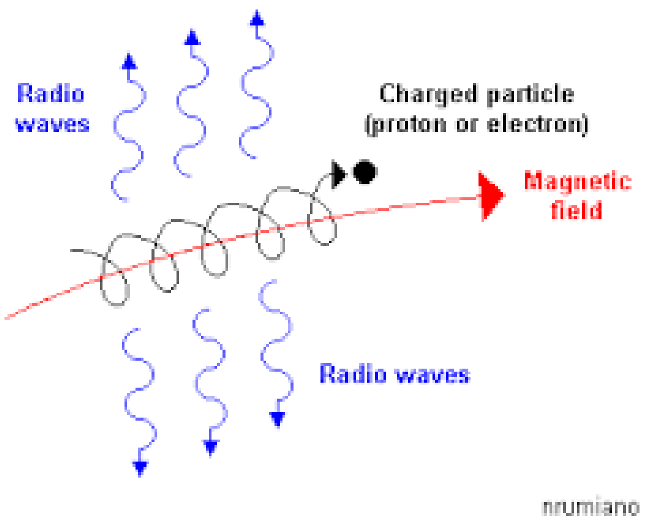
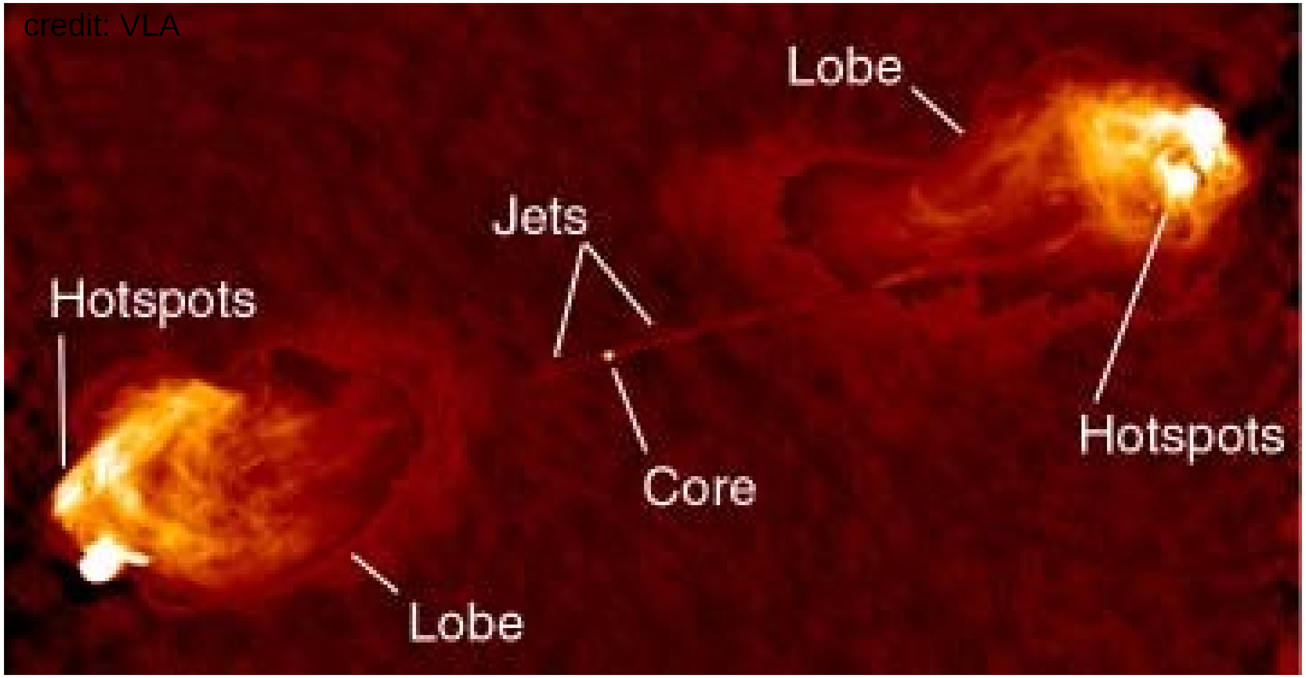
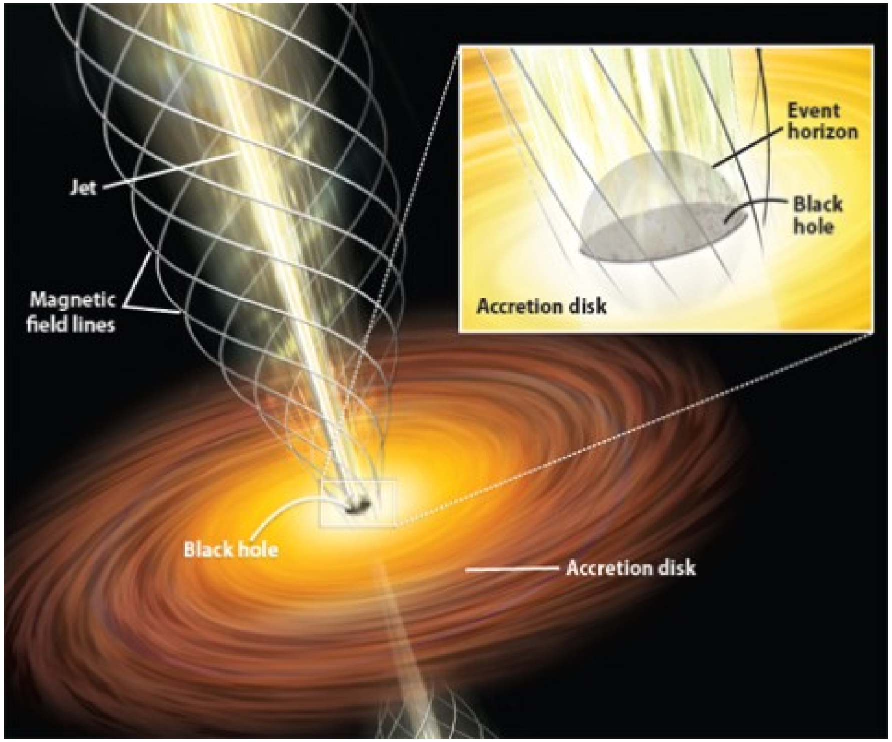
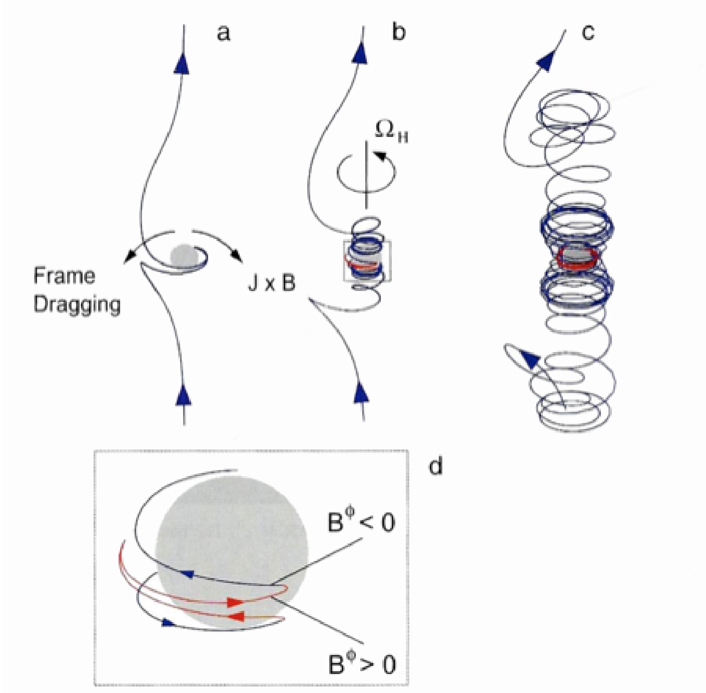
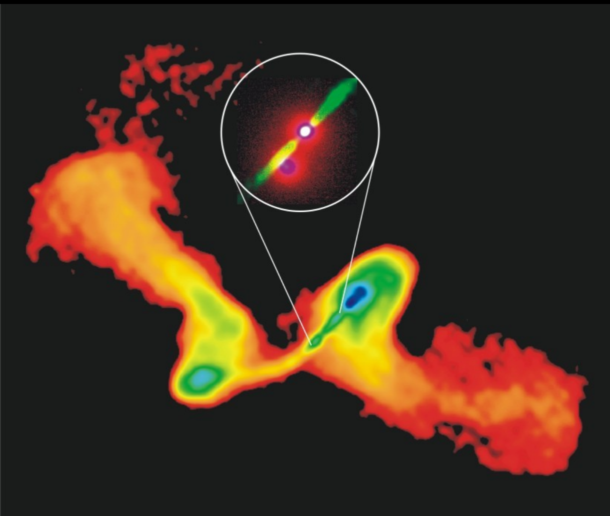
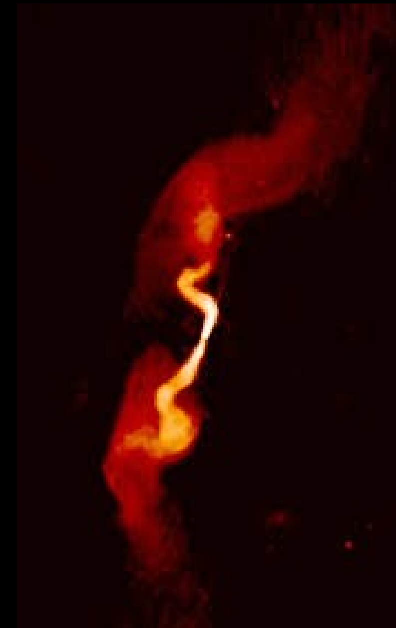

Radio waves
Charged particle (proton or electron)
Magnetic field
Radio waves
nrumiano

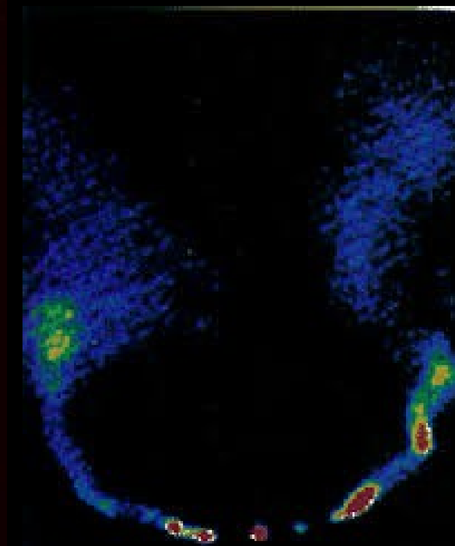

credit: VLA
Lobe
Jets
Hotspots
Core
Hotspots
Lobe

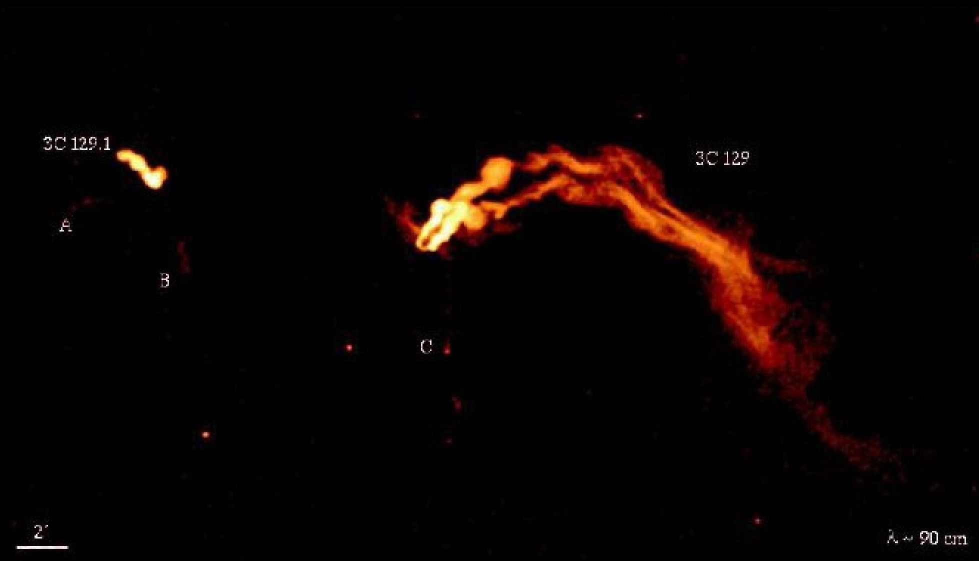

Event horizon
Black hole
Accretion disk
Jet
Magnetic field lines
Black hole
Accretion disk

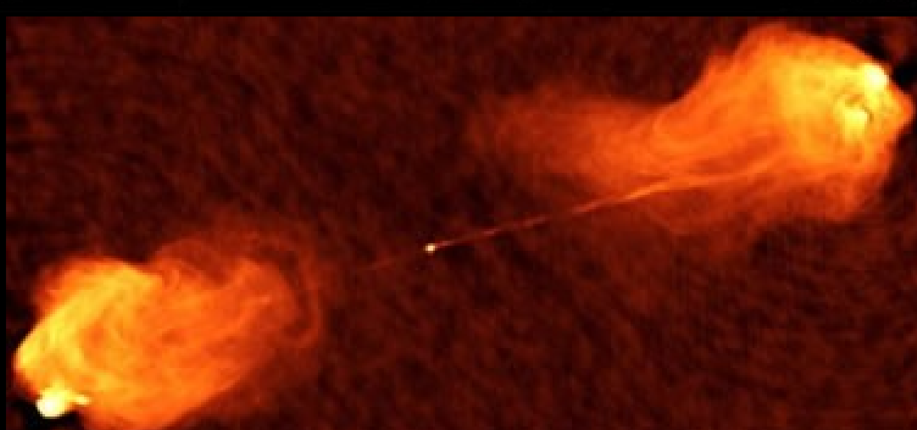

a
b
c
Ω_H
Frame Dragging
J x B
d
$B^\phi < 0$
$B^\phi > 0$

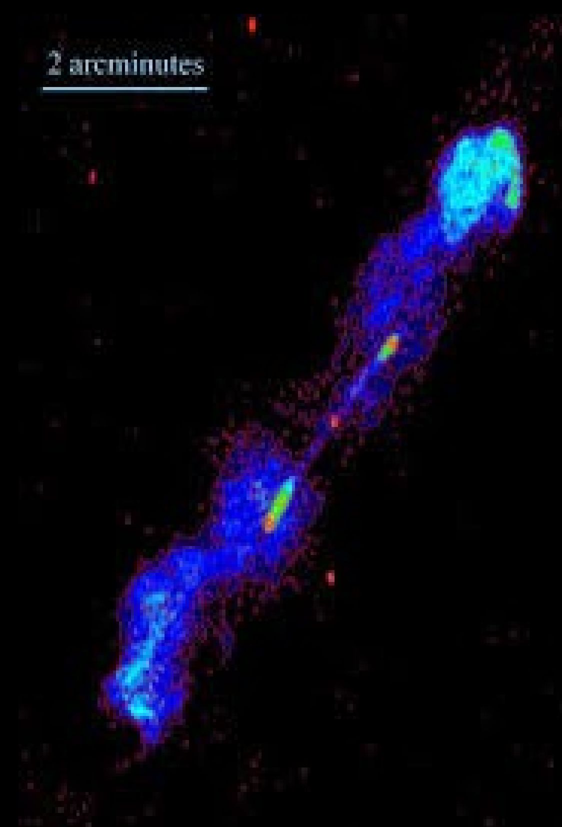




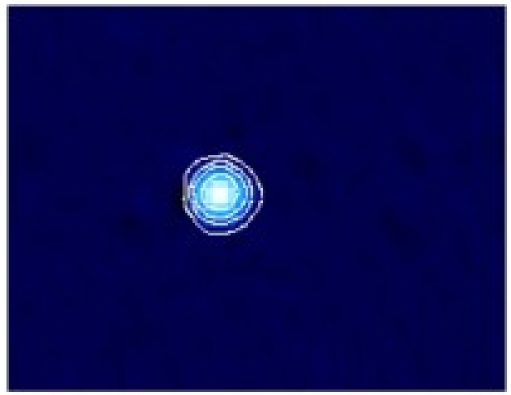


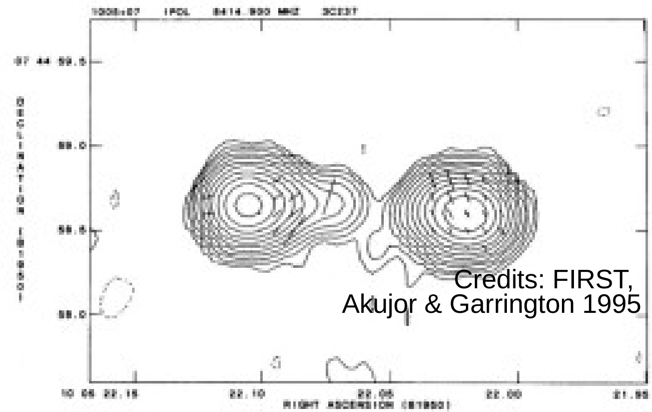

3C 129.1
3C 129
A
B
C
2'
λ ~ 90 cm



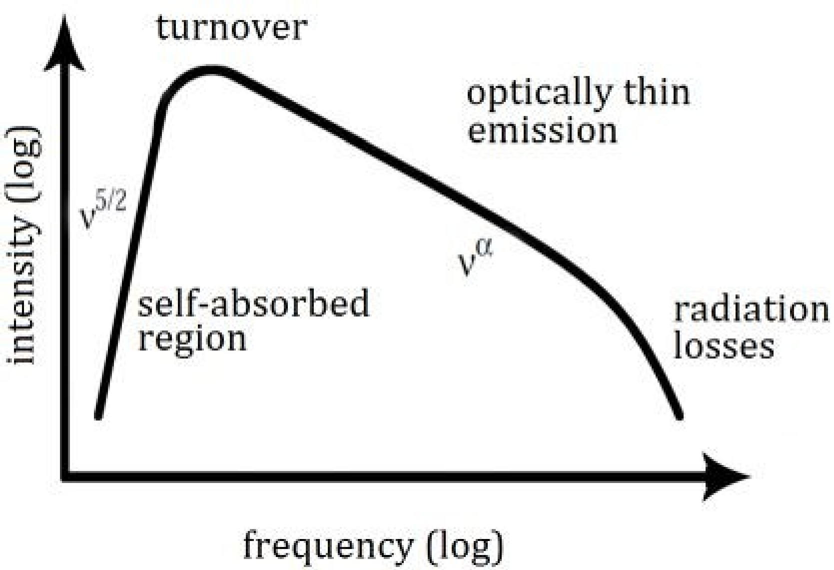

2 arcminutes

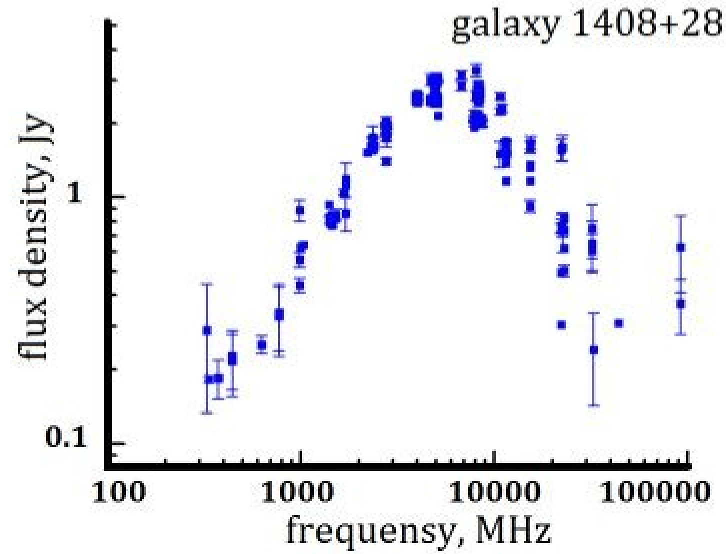
Compact Symmetric (CSO)/GHz Peaked (GPS)



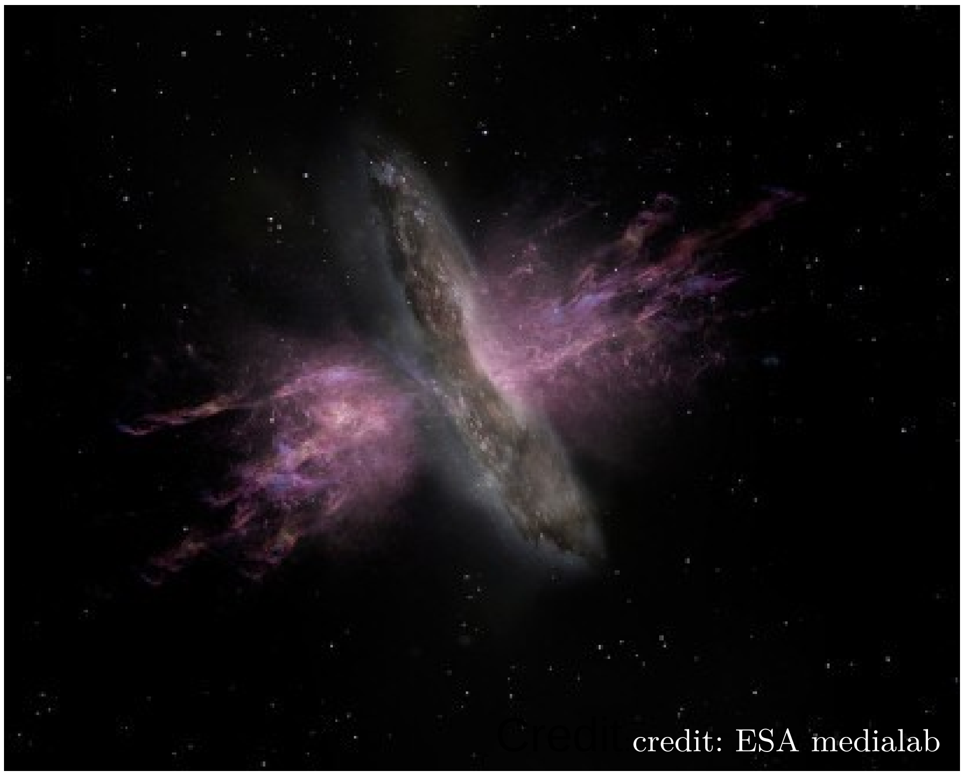


Credits: FIRST,
Akujor & Garrington 1995





Why GPS?



credit: ESA medialab

Jet-ISM interaction:

- Star formation?
- Galaxy growth
- Why elliptical?
- Why so many of them?

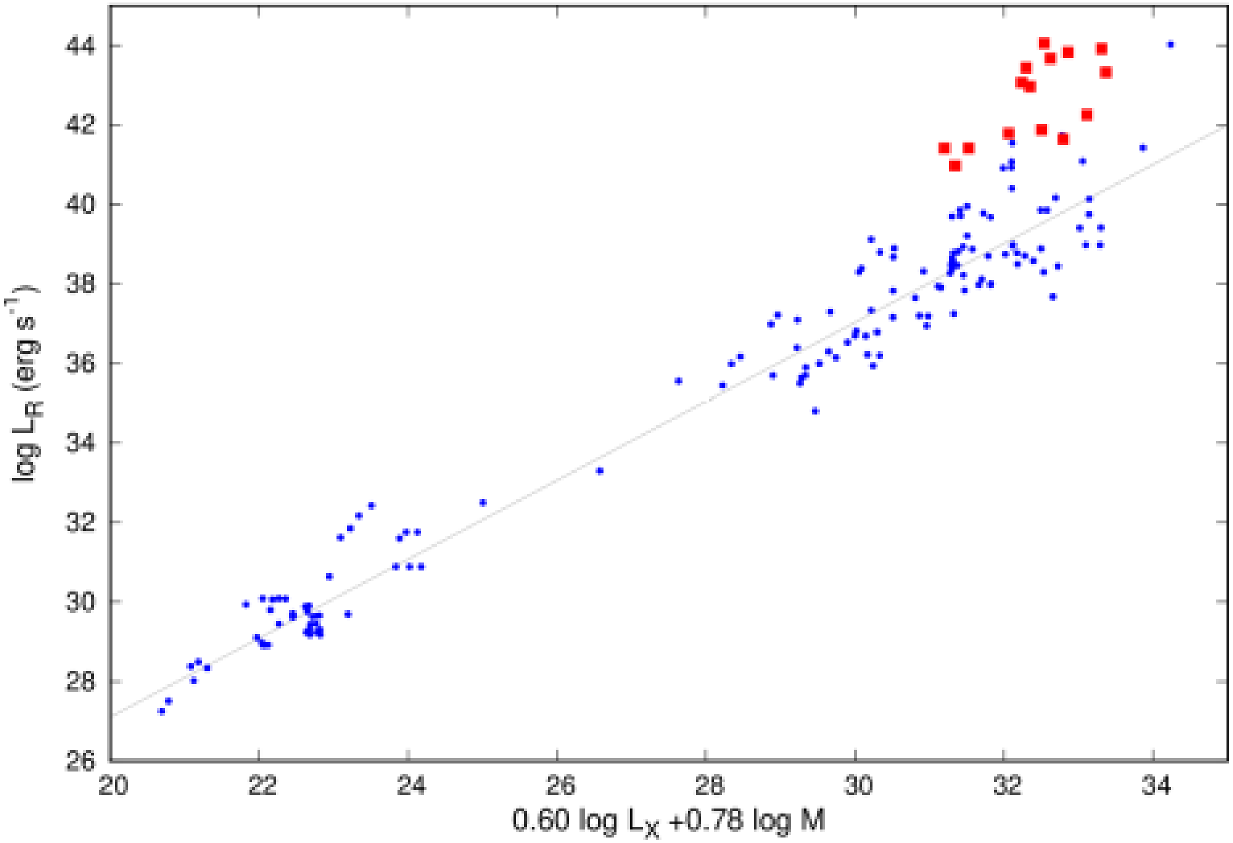
What did we do?

Table 3
Kinematic ages and linear sizes from Siemiginowska et al. (2016) work.

name	size (pc)	age (yrs)	Refs. (Age)
1718–649	2.0	91	(1)
1843+356	22.3	180	(2)
2021+614	16.1	368	(2)
0035+227	21.8	450	(1)
0116+319	70.1	501	(1)
0710+439	87.7	932	(2)
1946+708	39.4	1261	(1)
1943+546	107.1	1308	(1)
1934–638	85.1	1603	(1)
1607+26	240	2200	(3)
1511+0518	7.3	300	(4)
1245+676	9.6	188	(1)
OQ+208	7.0	219	(5)
0108+388	22.7	404	(1)
1031+567	109.0	1836	(2)
2352+495	117.3	3003	(2)

Fundamental Plane of the Black Hole activity

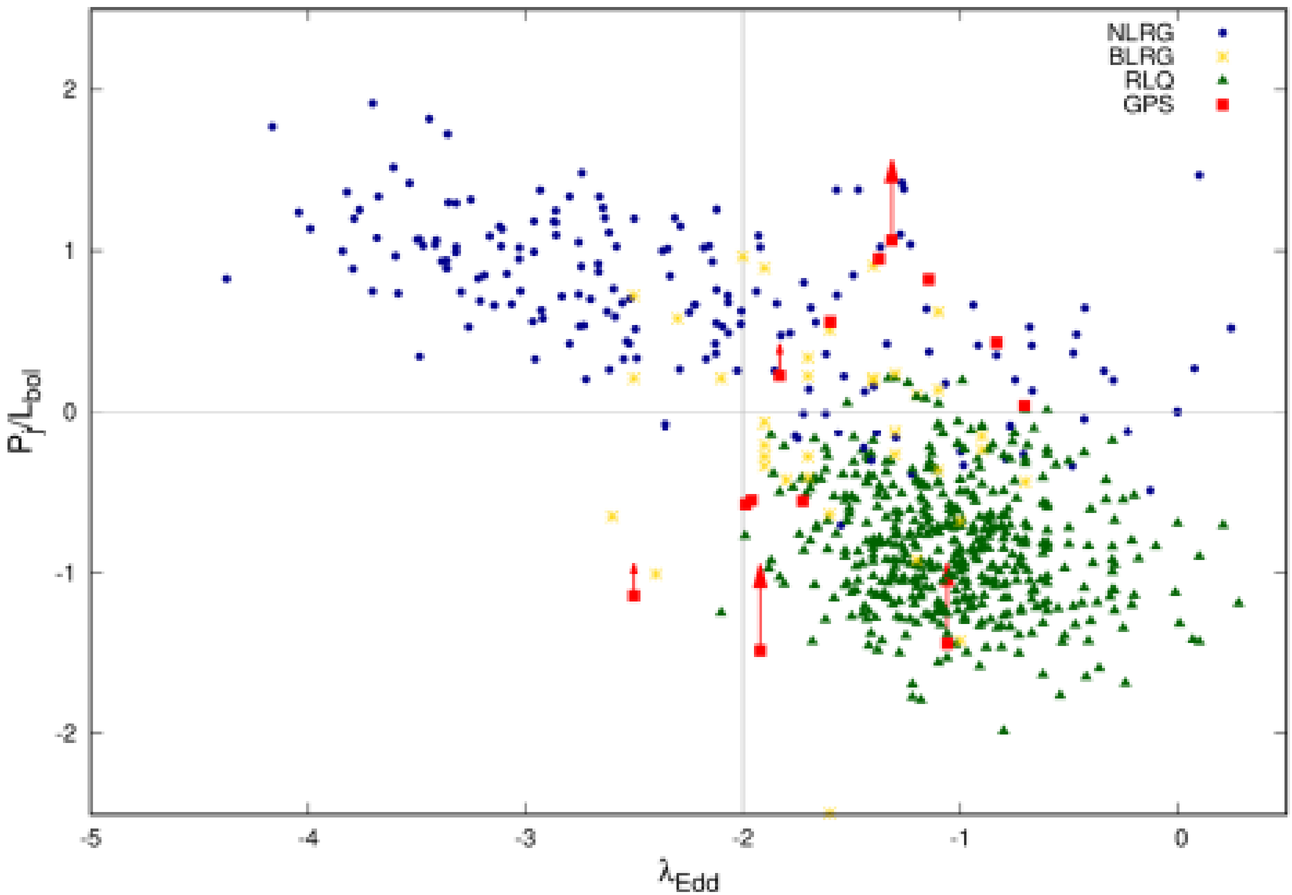
Merloni et al. 2003



How can we calculate the jet power?

Willot et al. 1999

$$P_j[ergs^{-1}] = 5.0 \times 10^{22}(f/10)^{3/2}(L_{1.4GHz}[WHz^{-1}])^{6/7}$$



Is there a better way?

$$P_j = H_j/\tau_j$$

For relativistic particle assuming equipartition

$$P_j = \frac{4pV}{\tau_j} = \frac{16\pi R^3}{3}(u_B + u_e)/\tau_j = \frac{32}{3}\pi R^3 \cdot \left(\frac{B_{eq}}{8\pi}\right)^2/\tau_j$$

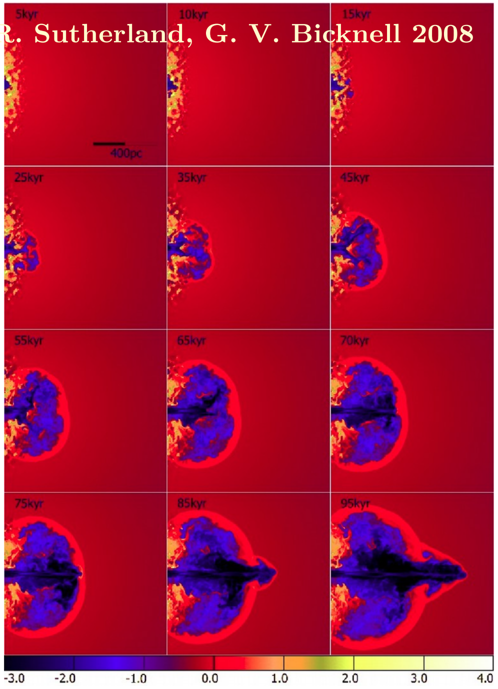
$$B_{eq} = [4.5\ L_R\ c_{12}]^{2/7}\ R^{-6/7} \quad [G]$$

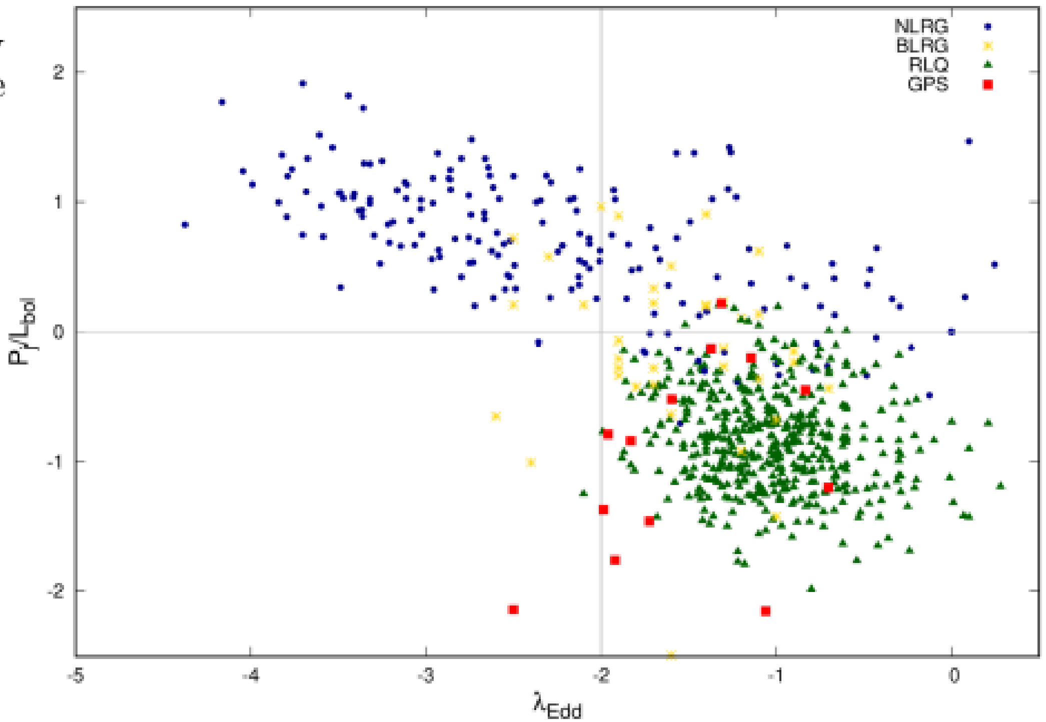
We assume constant spectra index in energy range $\gamma \in \{0.01\text{ GHz-}100\text{ GHz}\}$ to be equal $\alpha = 0.73$ (de Virios et al. 1997*).

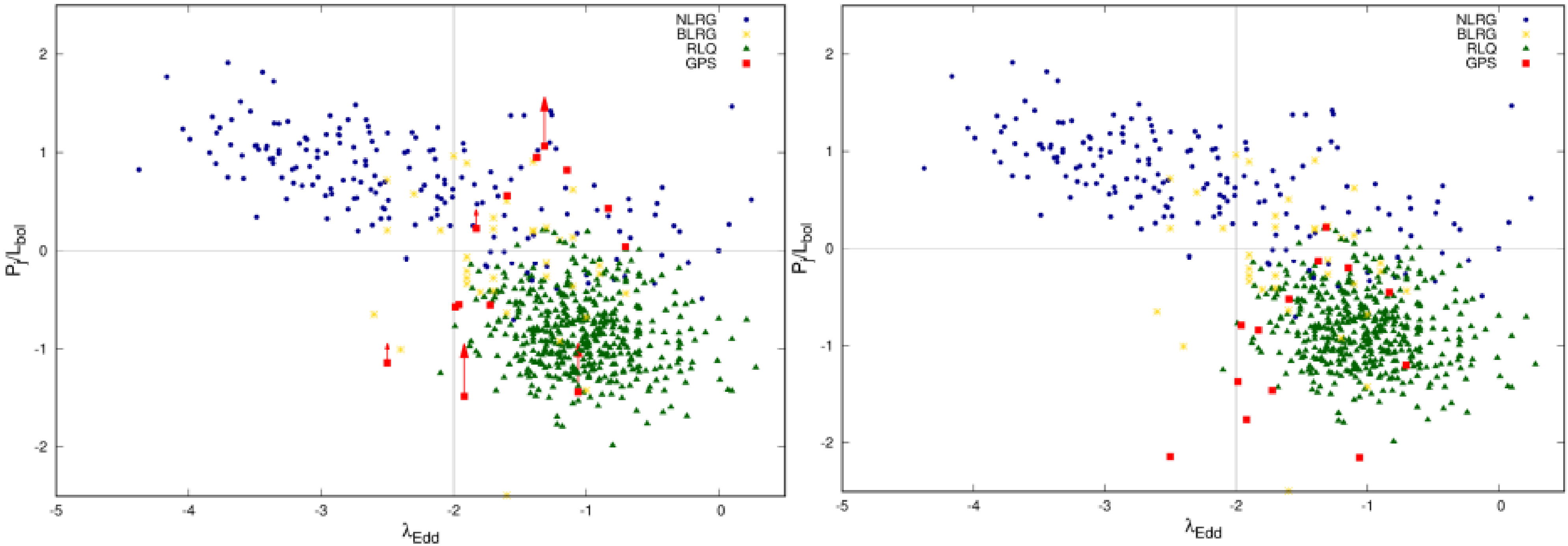
$$L_R = L_{5GHz} \int_{0.01/5}^{100/5} x^{-\alpha} dx = 7.62 \times L_{5GHz}$$

$$\frac{4}{3}\pi R^3 = \pi ab^2$$

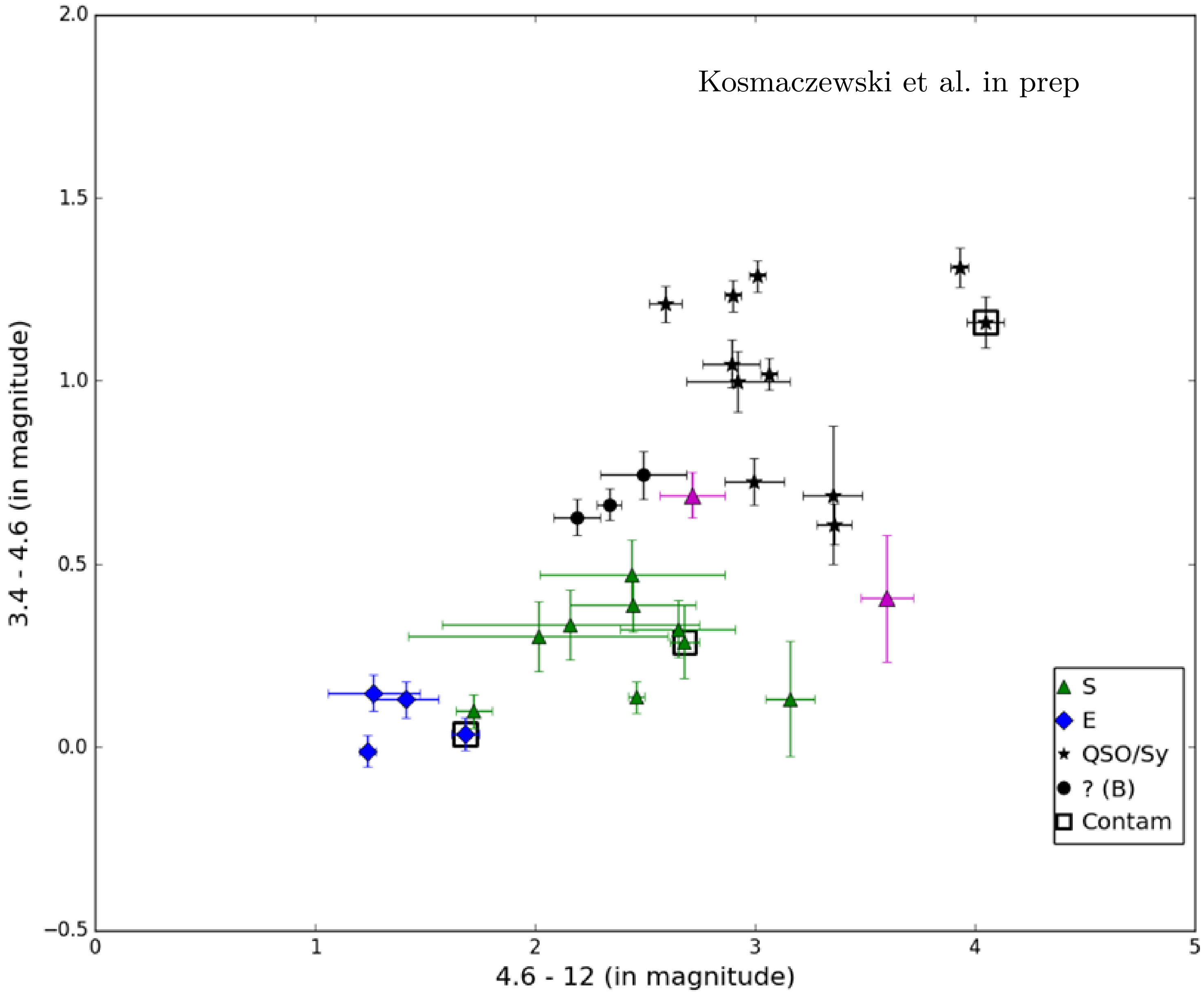
R=0.18 LS







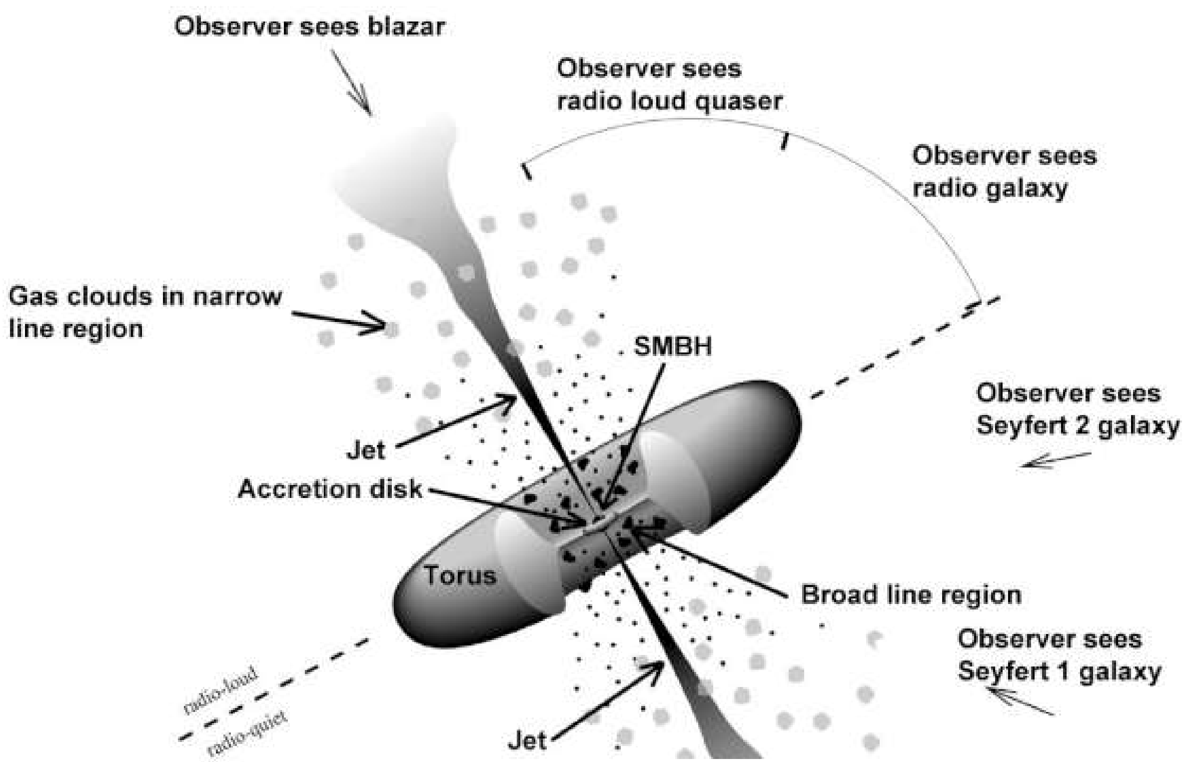
These disks are MAD!!!

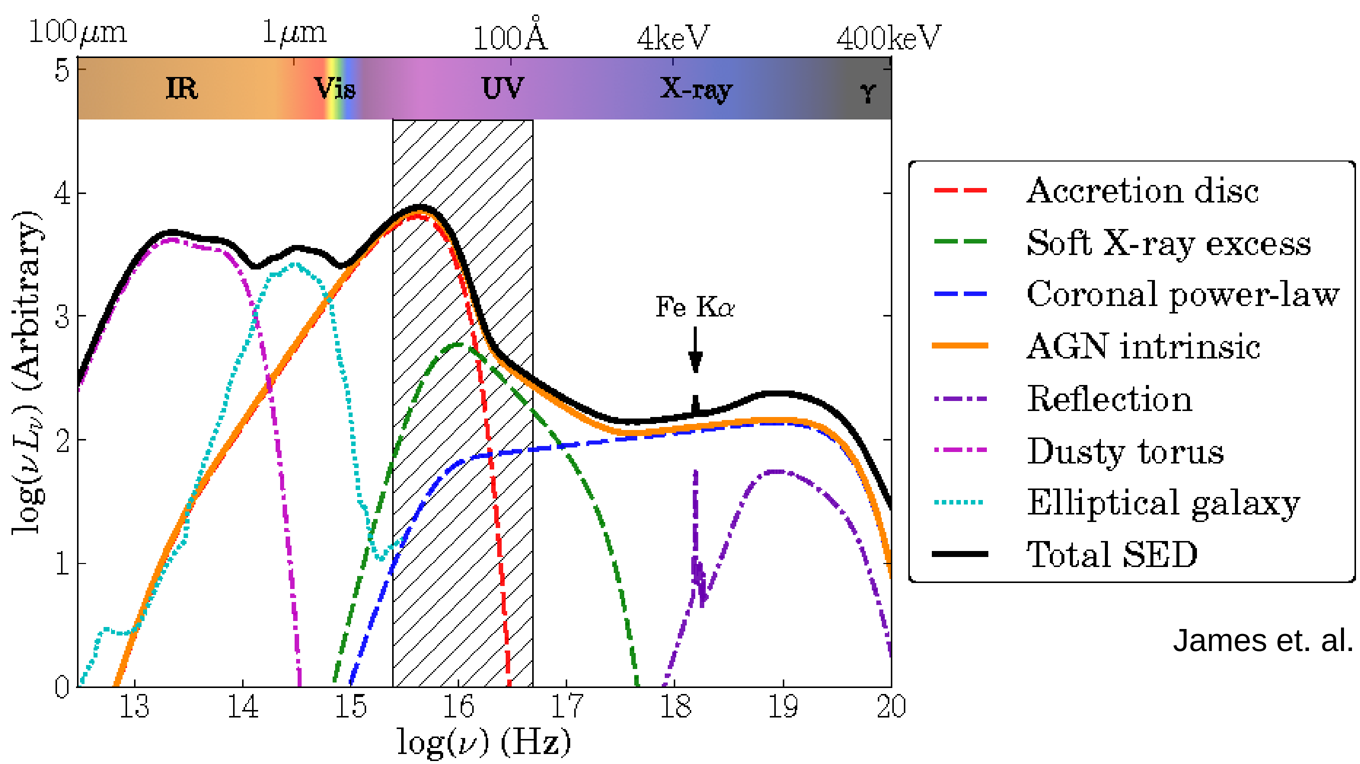

Kosmaczewski et al. in prep
3.4 - 4.6 (in magnitude)
4.6 - 12 (in magnitude)
S
E
QSO/Sy
? (B)
Contam
2.0
1.5
1.0
0.5
0.0
−0.5
0
1
2
3
4
5

Summary

- GPS are found in all kind of host galaxies
- Jet-efficiency consistent with MAD disk scenario
- Overluminous in radio$\rightarrow$ higher radiative efficiency

Thank you for your attention!

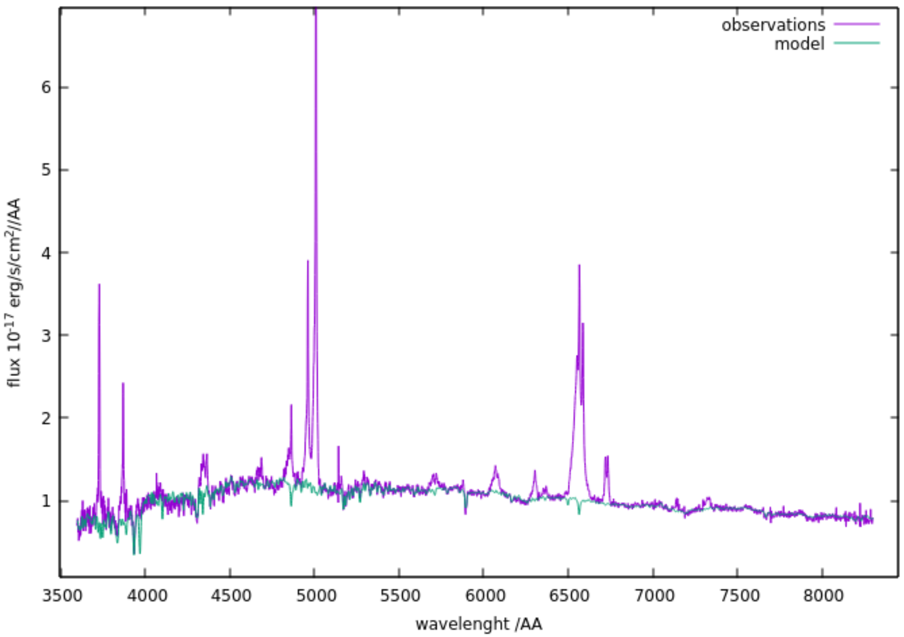




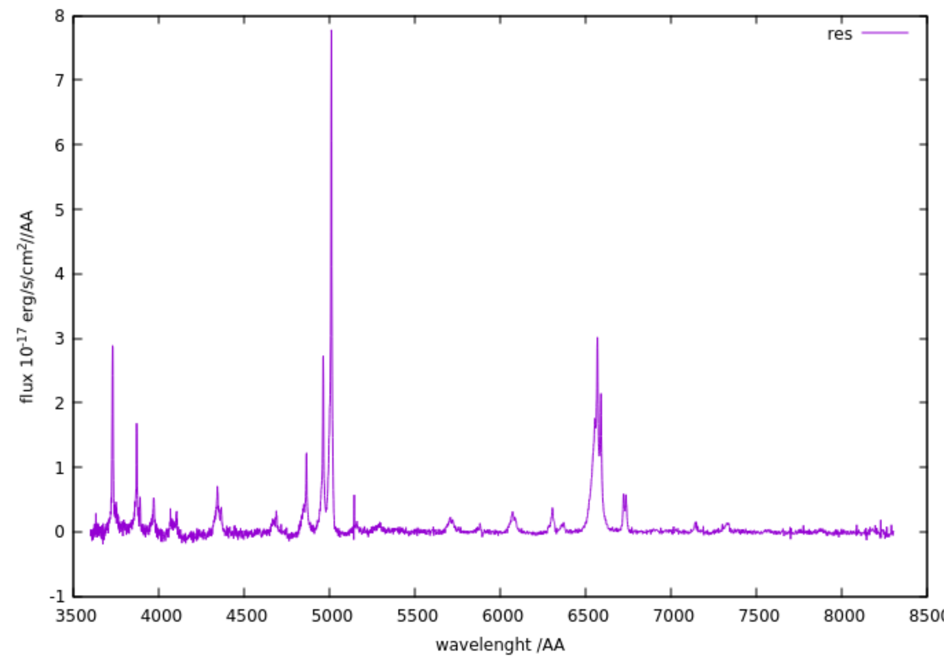
James et. al. 2017

STARLIGHT

Spectral Synthesis Code



Mini , Mcor , σ , AV



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

$$\log\left(\frac{M_{BH}}{M_\odot}\right) = \alpha + \beta \log\left(\frac{\sigma_\star}{200kms^{-1}}\right)$$

Jedno wystarczy

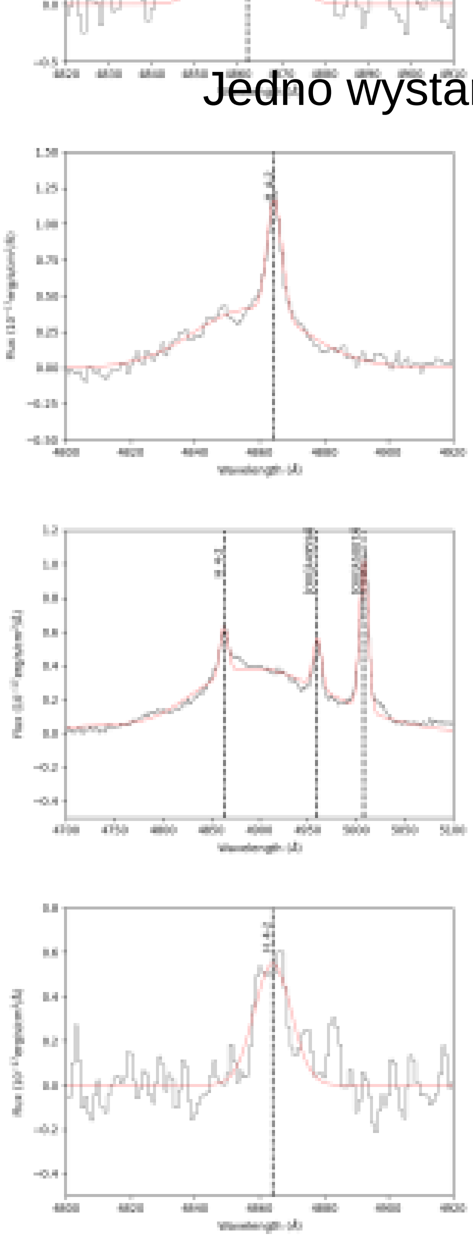


Figure 1. Fitted $H\beta$ profiles for (starting from the top) 1607+26, 1511+0518, OQ+208 and 1031+567 respectively.

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