Exploring the parent population of beamed NLS1s: from the black hole to the jet

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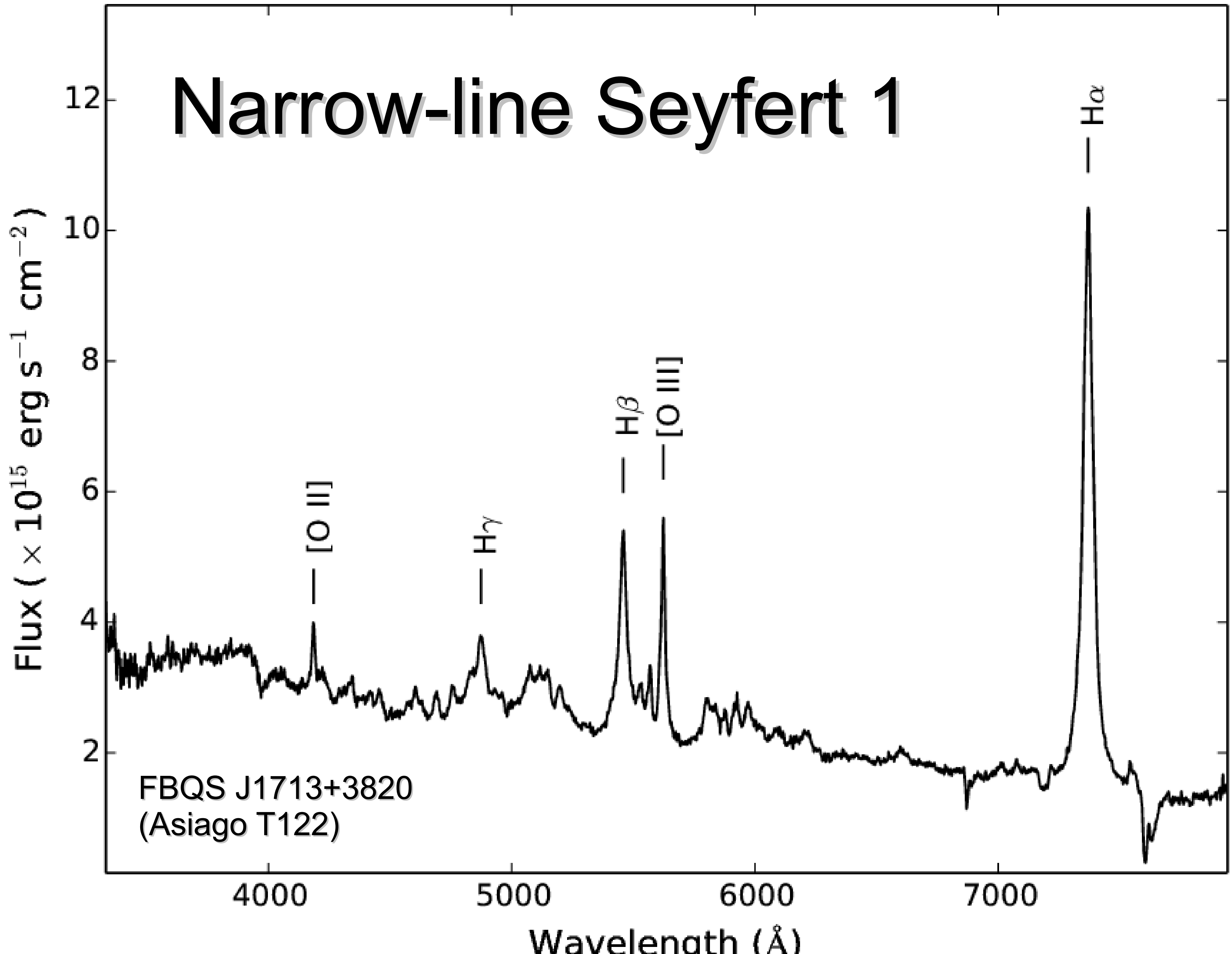
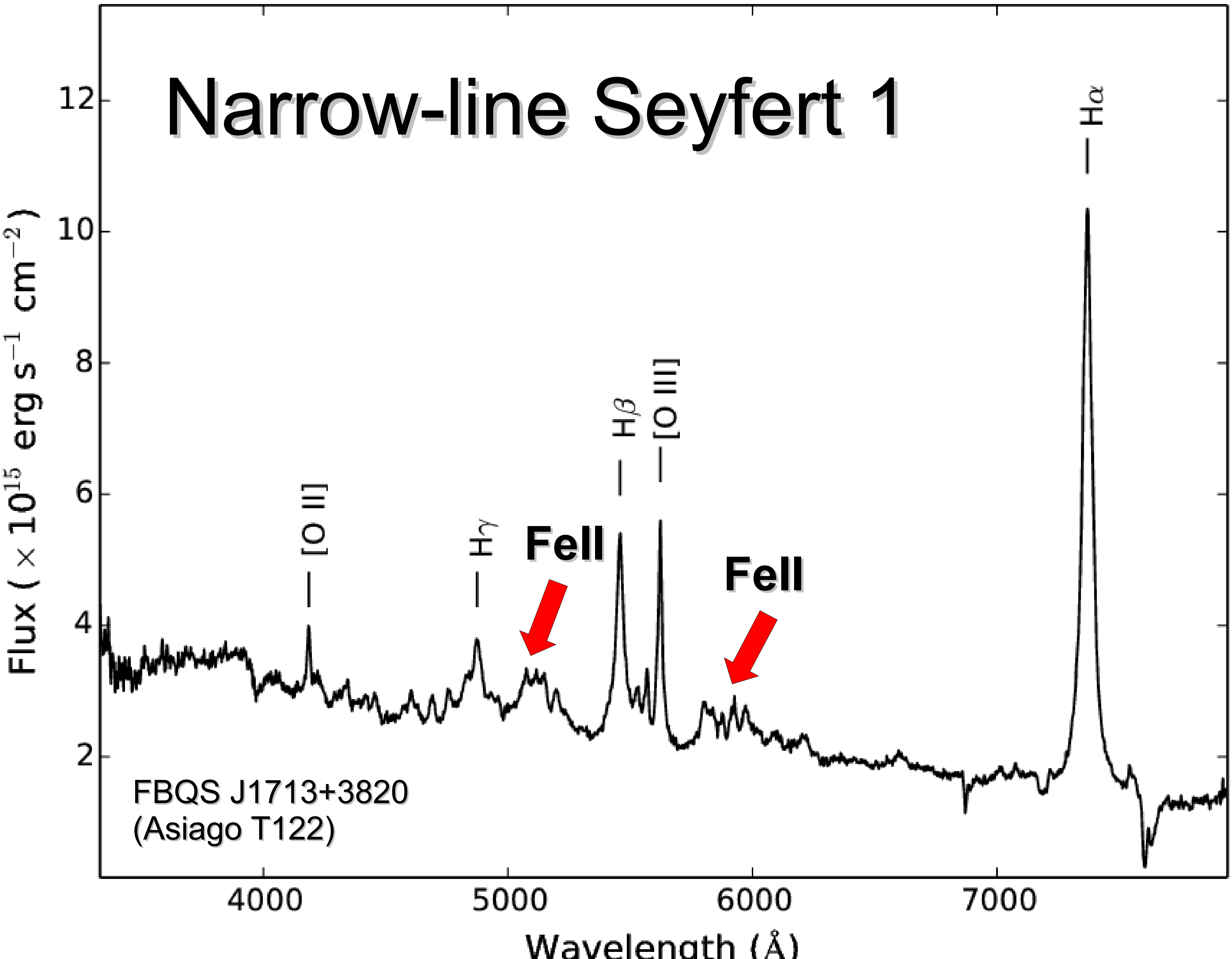

Narrow-line Seyfert 1
Hα
[O III]
Hβ
Hγ
[O II]
FBQS J1713+3820
(Asiago T122)
Flux (× 10^15 erg s^−1 cm^−2)
Wavelength (Å)
12
10
8
6
4
2
4000
5000
6000
7000



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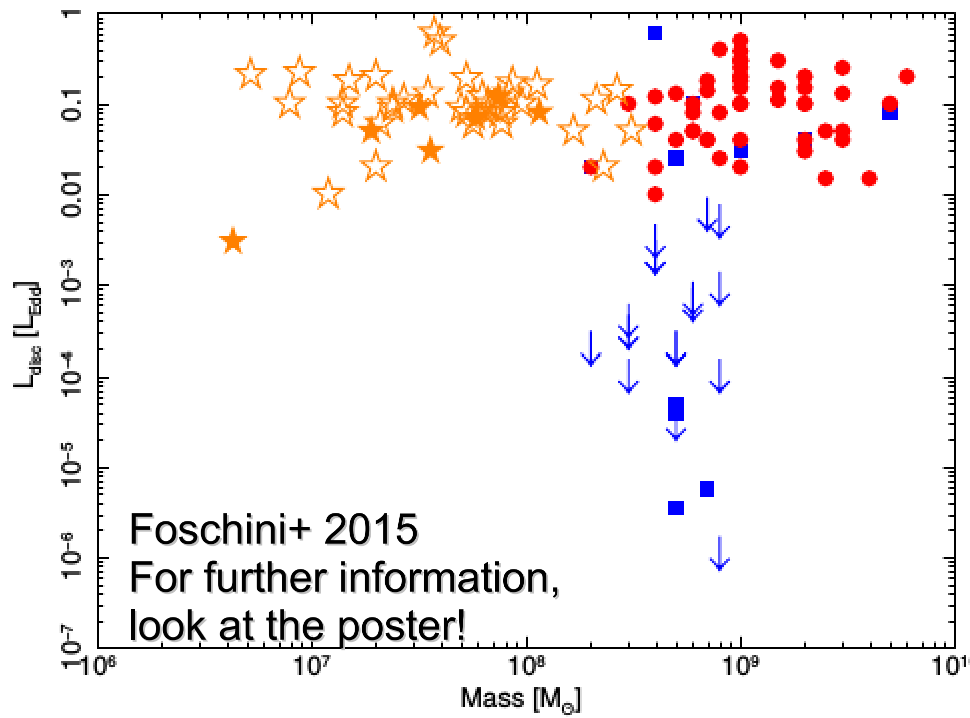
Flat-spectrum radio-loud NLS1s

7% of NLS1s are radio-loud (Komossa+ 2006), and some show blazar-like properties (Yuan+ 2008).

Fermi satellite detected γ-ray emission coming from them (Abdo+ 2009a), indicating a relativistic beamed jet.
To date they are 9 (and counting...), between z = 0.061 (Abdo+ 2009b) - 0.966 (Yao+ 2015).

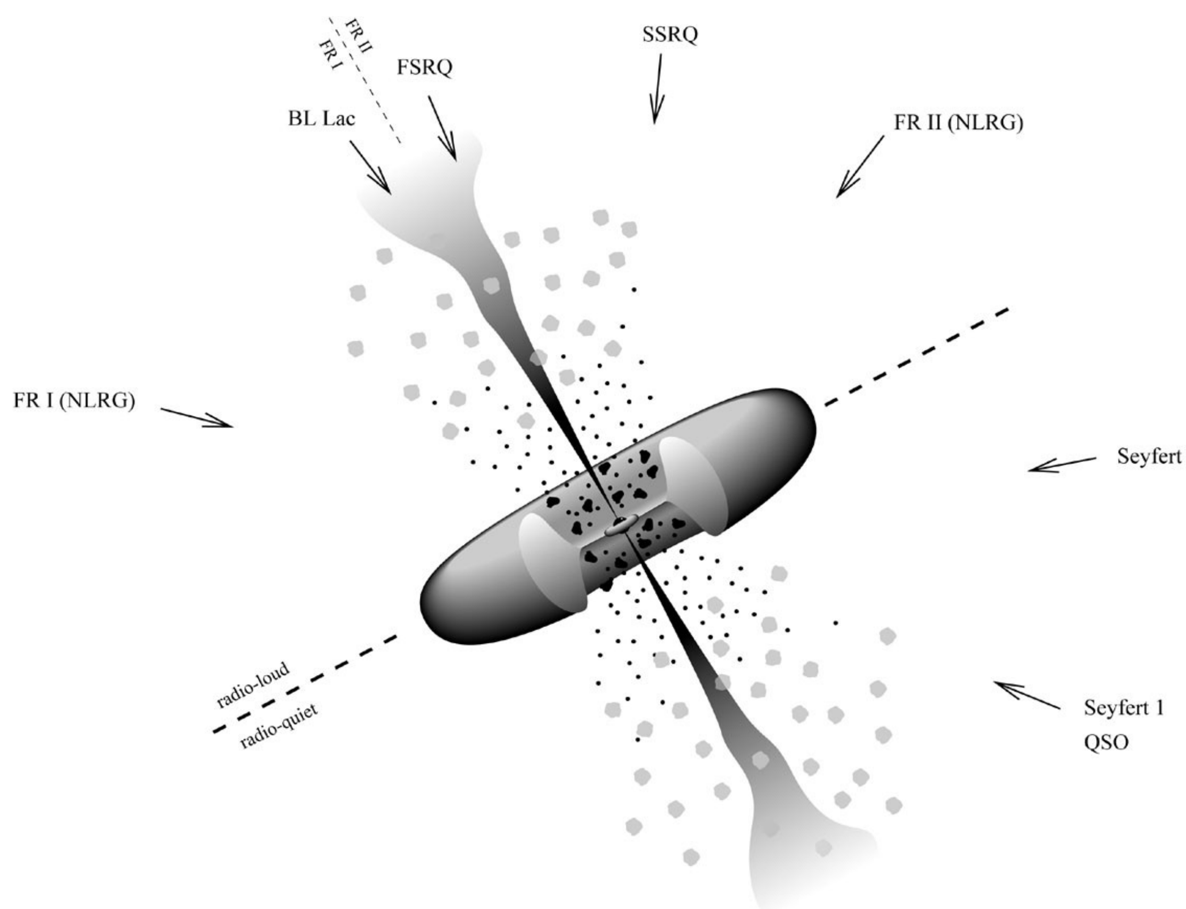
These F-NLS1s might represent the low-mass tail of γ-ray AGN.
They show lower jet power than FSRQs and comparable to BL Lacs.



Parent population

How do beamed sources look like when randomly oriented?

Being Γ around 10, for 9 beamed sources there should be >1800 misaligned sources...

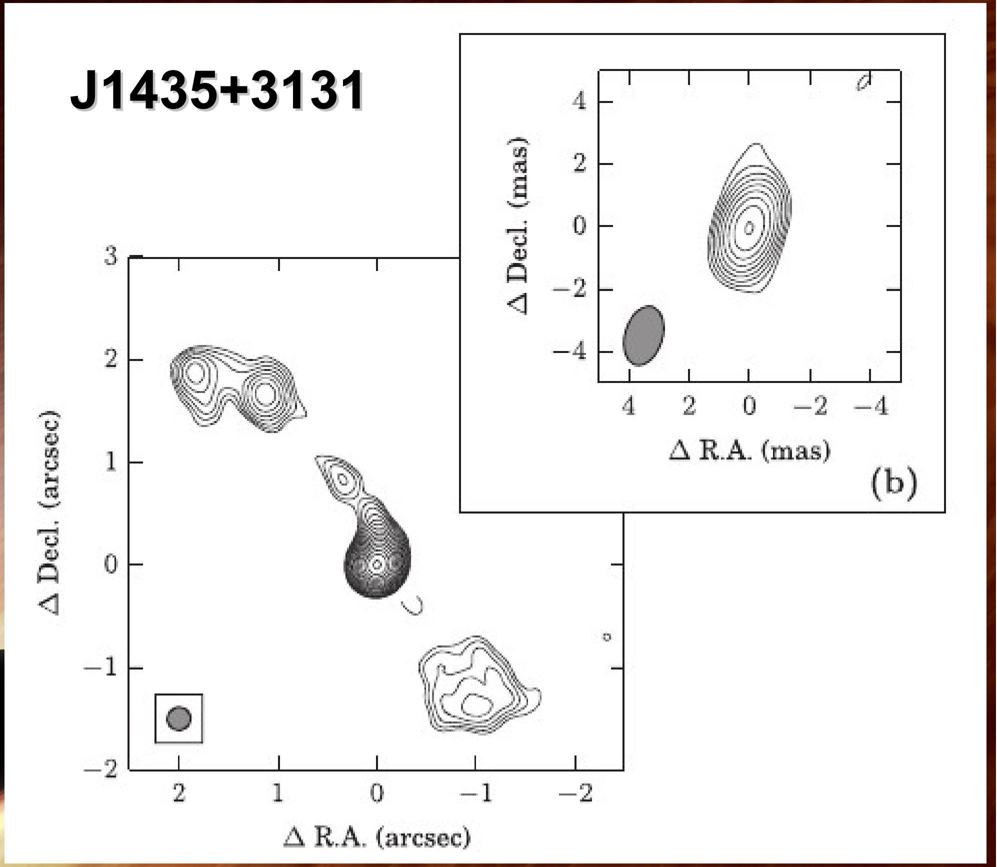


Hypotheses

1. ***NLS1s with jets***

2. RQ-NLS1s

3. BLRG/NLRG



Richards & Lister 2015

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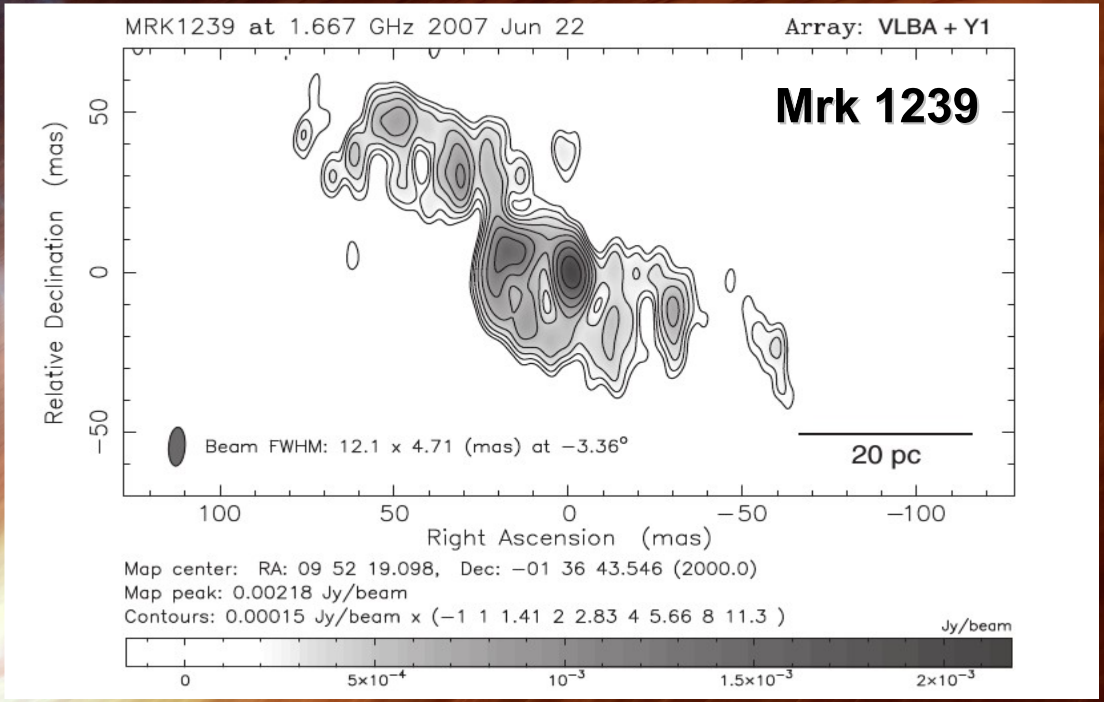

Doi+ 2015

Hypotheses

1. NLS1s with jets

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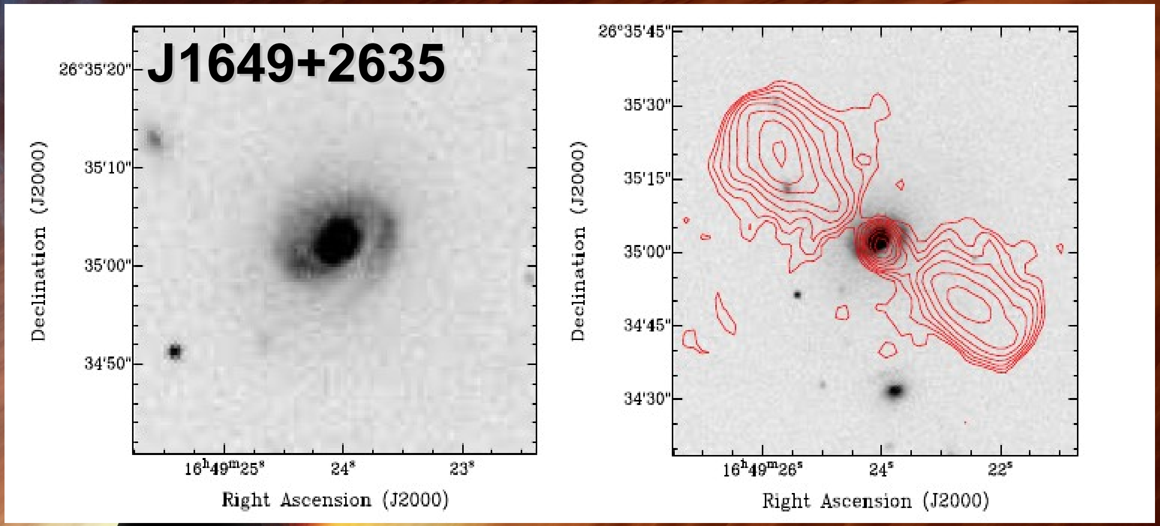
3. ***BLRG/NLRG***



Mao+ 2015

Black hole mass

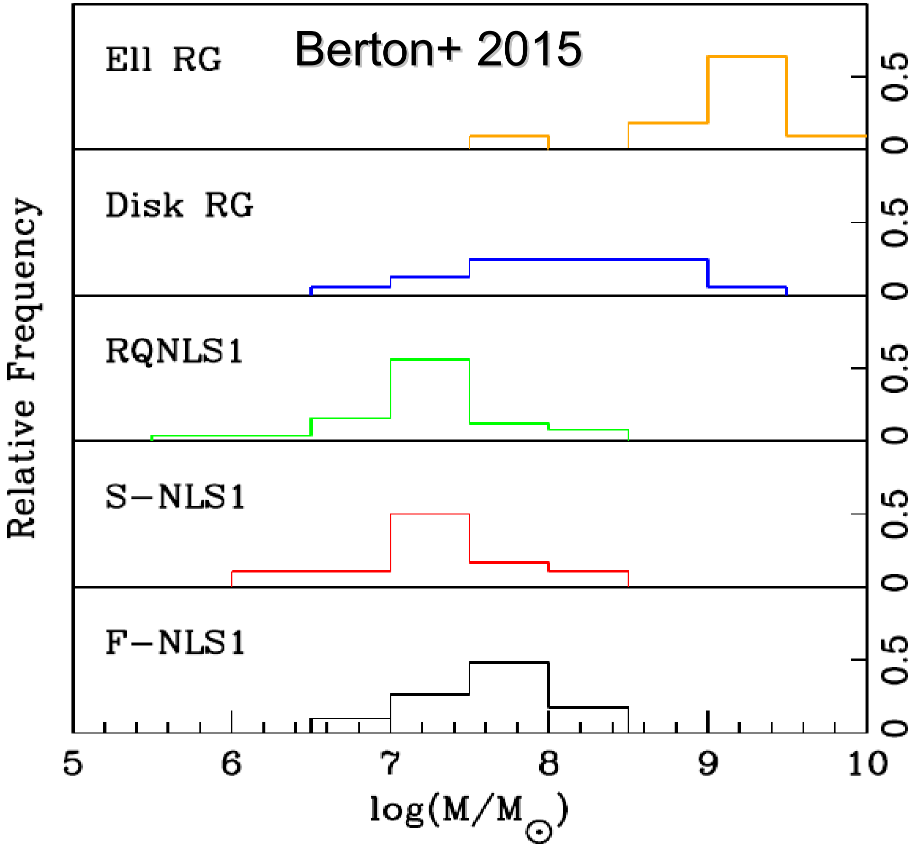
We analyzed optical spectra to derive the Hβ second order momentum σ (type 1) or the stellar velocity dispersion (type 2). Then we calculated the black hole mass via:

$$M_{BH} = f\left(\frac{R_{\rm BLR}\sigma^2_{\rm H\beta}}{G}\right),$$

or

$$\log\left(\frac{M_{\rm BH}}{M_\odot}\right) = 8.49 + 4.38\log\left(\frac{\sigma_*}{200\,{\rm km\,s^{-1}}}\right).$$

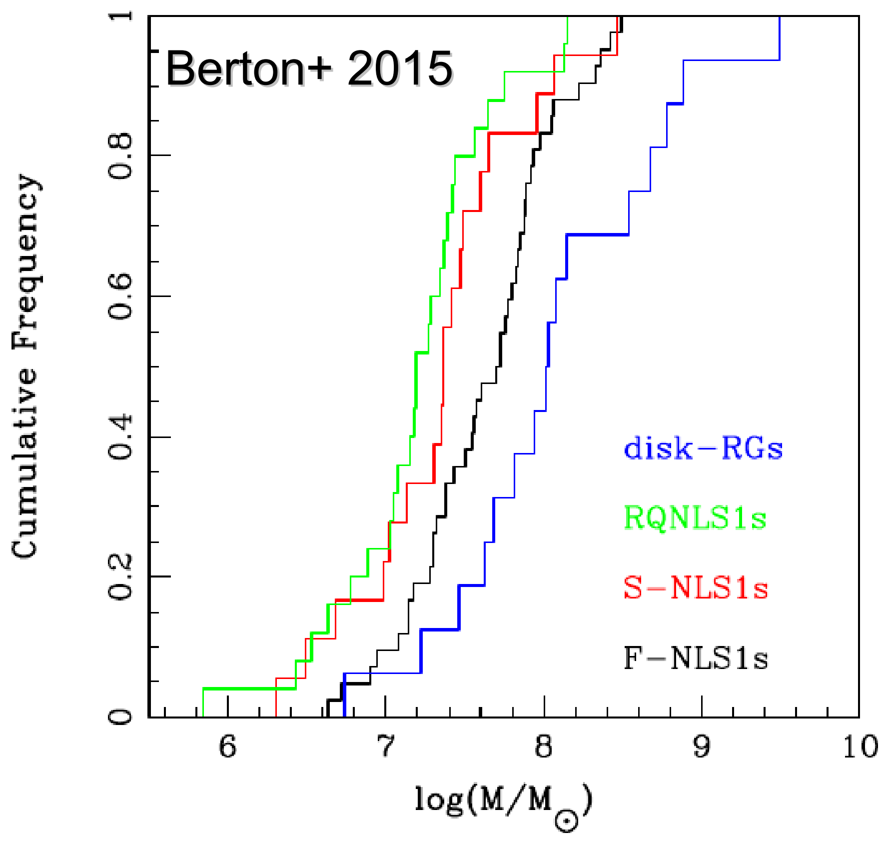
Lines are less affected by the jet contribution than the continuum, and σ is less biased than FWHM for black hole estimation (Collin+ 2006). We obtained the following mass distributions.

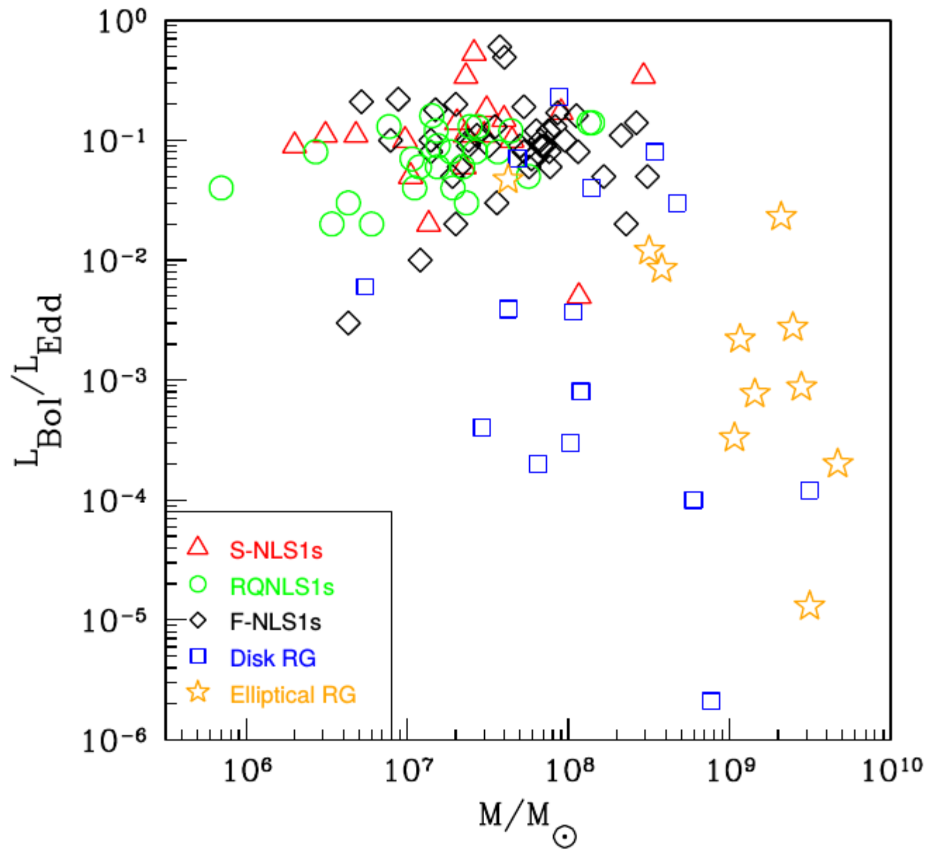


Black hole mass

The Kolmogorov-Smirnov test reveals whether the BH mass cumulative distributions can originate from the same population

NLS1s lay all in the same region; disk RGs are a "bridge" to ellipticals





Parent population

Steep-spectrum radio-loud NLS1s

Disk RGs

Radio-quiet NLS1s

Parent population

Steep-spectrum radio-loud NLS1s

Disk RGs

Radio-quiet NLS1s

OK

Parent population

Steep-spectrum radio-loud NLS1s

OK

Disk RGs

Low BH mass
High Eddington

Radio-quiet NLS1s

??

Parent population

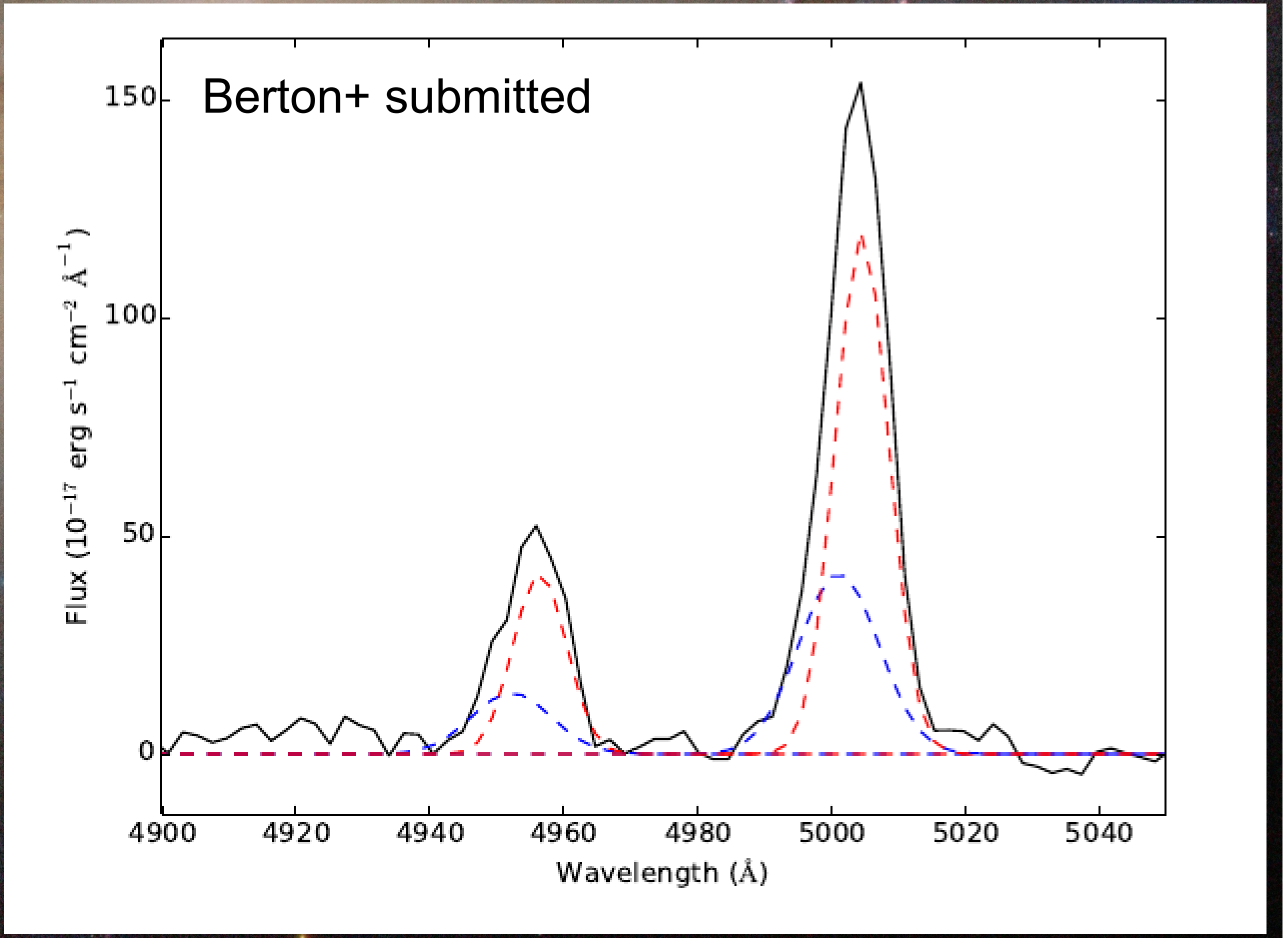
Steep-spectrum radio-loud NLS1s → *OK*

Disk RGs → Low BH mass, High Eddington

Radio-quiet NLS1s → ??

Radio-quiet NLS1s

We decomposed the [O III] lines in the optical spectra. We studied in particular the connection between radio emission and blue outliers.

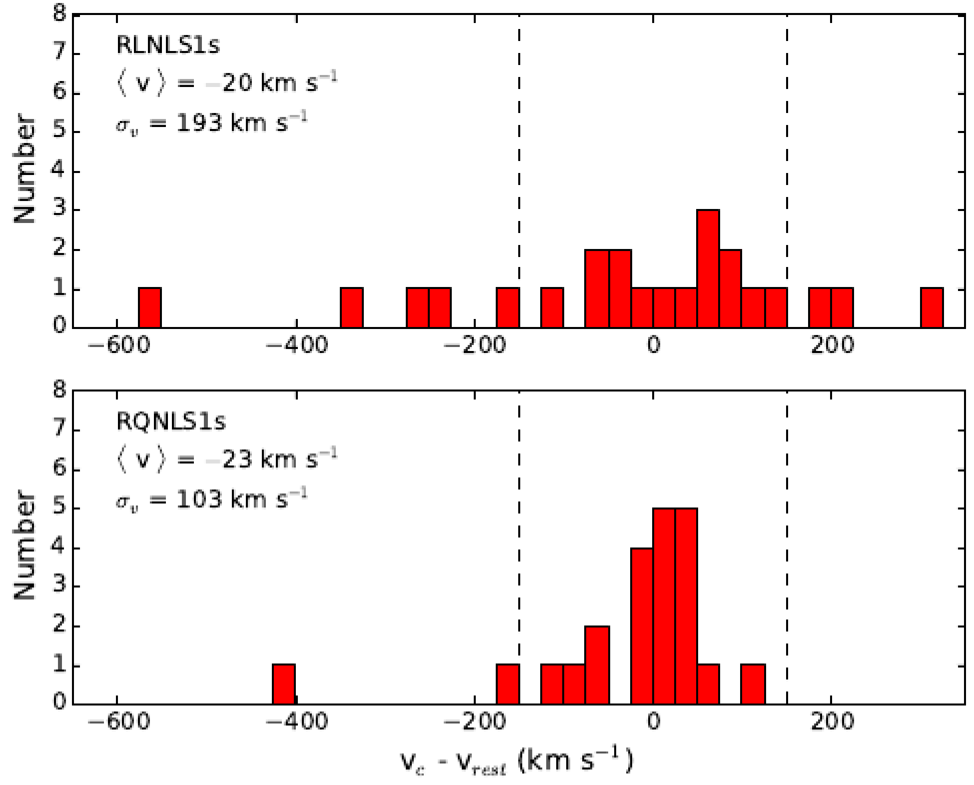


Blue outlier: spectrum showing a blueshift of the [O III] lines.

Radio-quiet NLS1s

We compared the results for RQ and RLNLS1s. The conclusions hold in larger samples (Cracco+ submitted).

Berton+ submitted



In RLNLS1s the jet is compact and it appears to interact with the NLR.

γ-ray NLS1s are particularly perturbed.

In RQNLS1s, the NLR is relatively unperturbed: no jet at all? Intermittent activity? Maybe Blandford-Payne...

The solution to the parent population problem will likely come from...

Steep-spectrum radio-loud NLS1s	Disk RGs	Radio-quiet NLS1s
↓	↓	↓
OK	Low BH mass High Eddington	No?

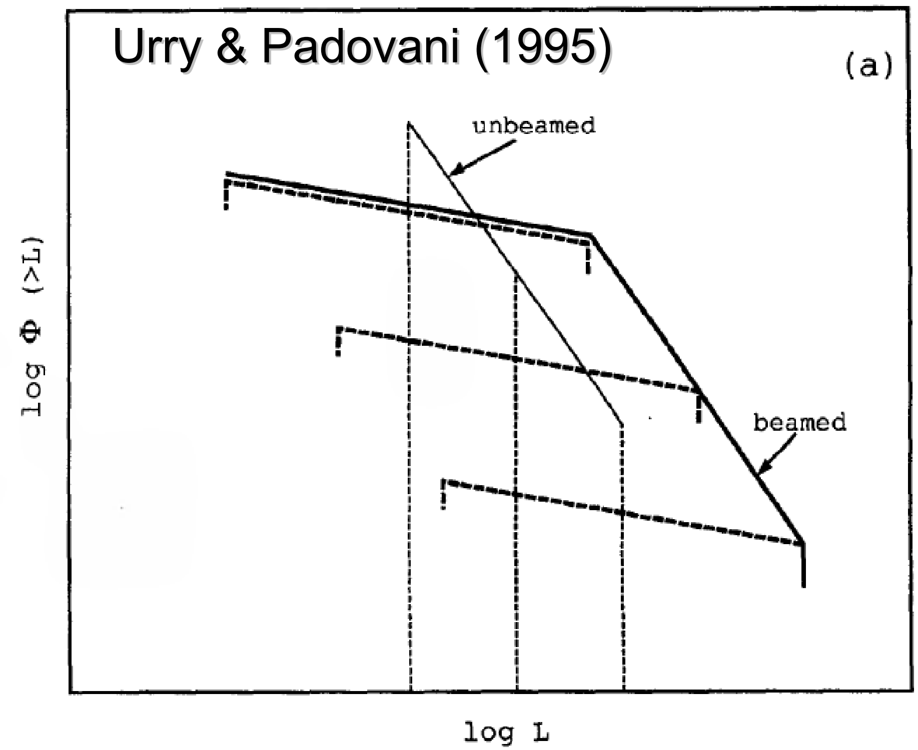
...radio luminosity functions

Luminosity function (LF) is the volumetric density of sources as a function of luminosity.

$$\Phi(L)\Delta L = \frac{4\pi}{A} \sum_{L_i \in (L \pm \Delta L/2)} \frac{1}{V_{max}(L)}$$

The LFs are particularly useful to compare beamed and unbeamed populations: relativistic beaming can be added to unbeamed sources.

Urry & Padovani (1995) used them to investigate the parent population of blazars.

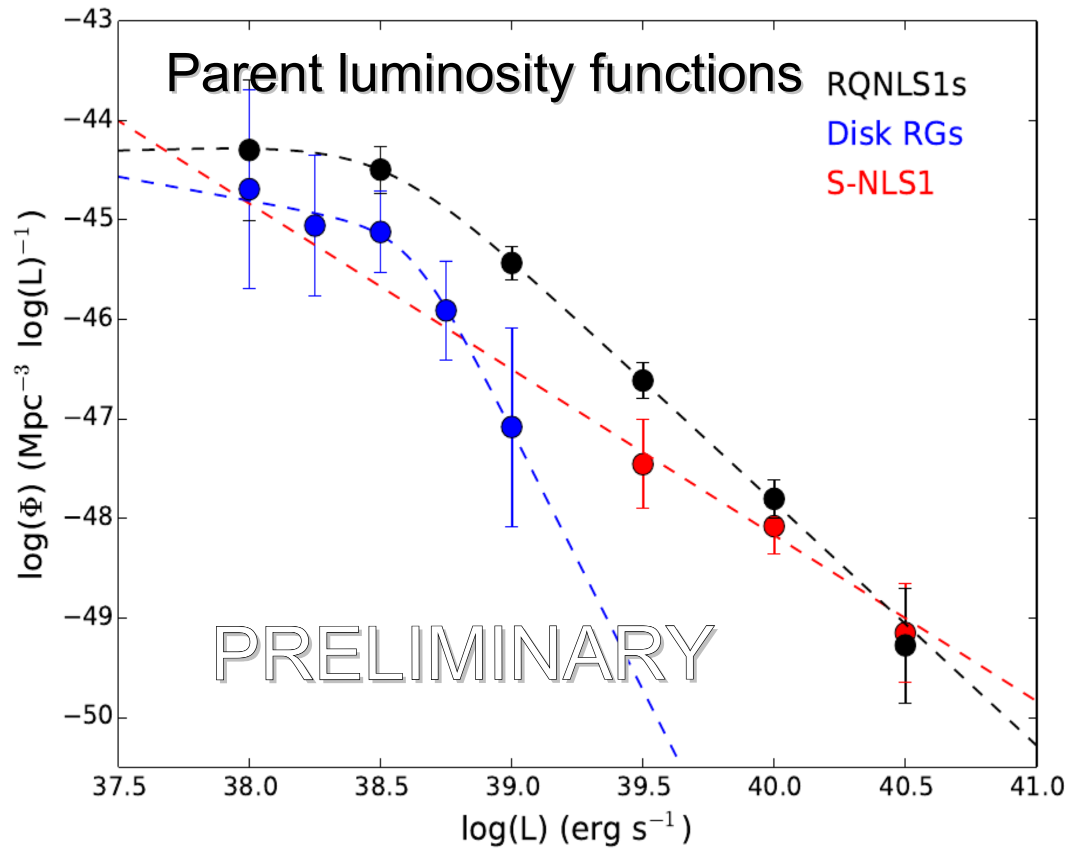


...radio luminosity functions

We are building three candidate samples cross-matching optical data with VLA-FIRST. The morphological classification for disk RGs is derived from Schawinski+ 2010. The NLS1s samples were derived from SDSS DR7 by analyzing the optical spectra. The F-NLS1s sample was derived from Foschini+ 2015.

The samples are made of:

- 21 flat-spectrum RLNLS1s
- 25 steep-spectrum RLNLS1s
- 132 RQNLS1s
- 14 disk RGs

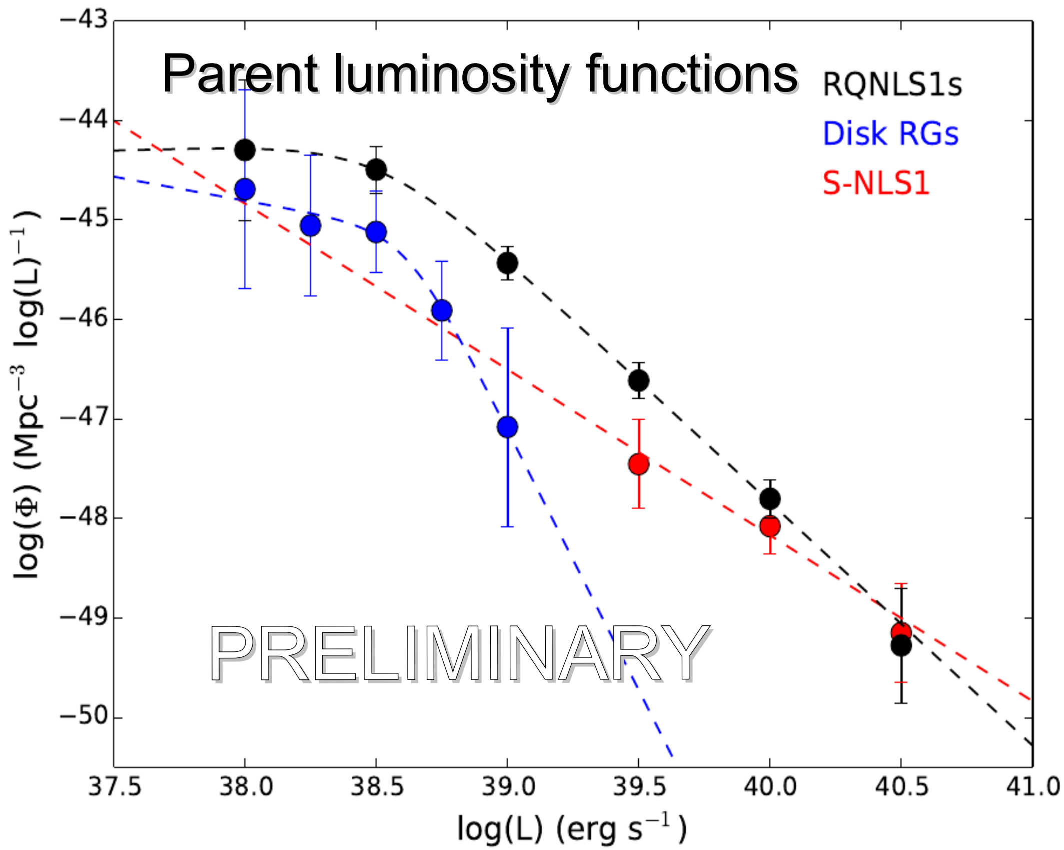


...radio luminosity functions

We are building the parent luminosity functions and comparing them with that of F-NLS1s by adding relativistic beaming.

We will then determine which unbeamed populations are compatible with beamed NLS1s.

An additional study on the radio morphology at 5 GHz of radio-quiet and radio-loud NLS1s is also ongoing.



Conclusions

- Steep-spectrum radio-loud NLS1s are very likely part of the parent population
- Disk-hosted radio-galaxies with high Eddington ratio and low BH mass are good parent candidates
- Radio-quiet NLS1s, with some exception, do not probably belong to parent population
- Radio luminosity functions will provide a more conclusive answer to this problem