5th Workshop on Compact Steep Spectrum and GHz-Peaked Spectrum Radio Sources

The new class of FRO radio galaxies

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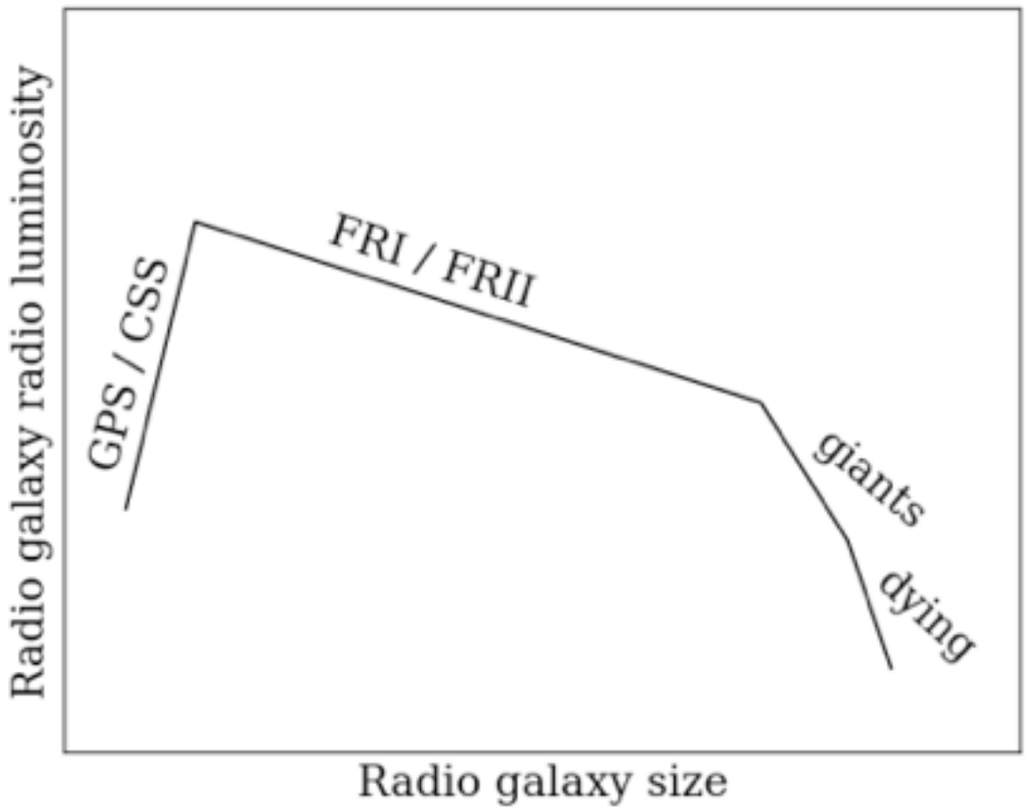
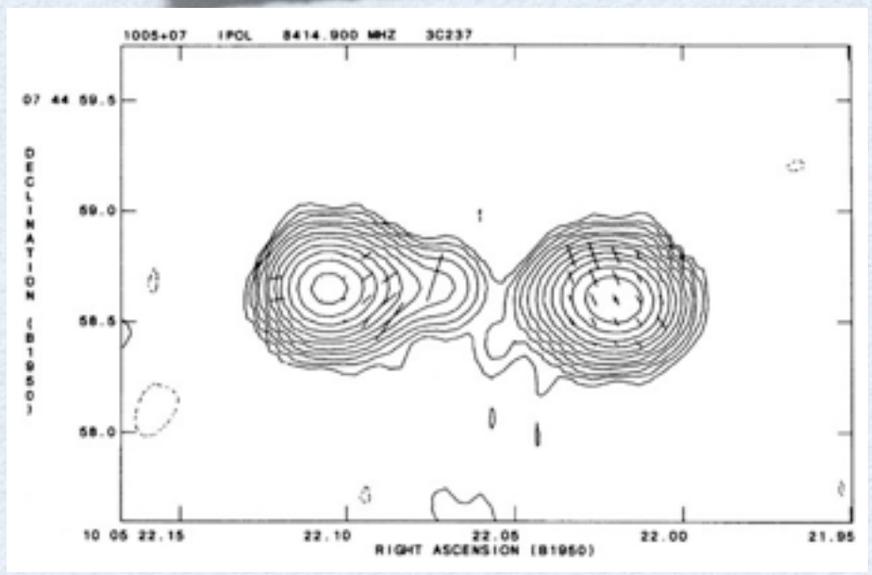
Radio Galaxy evolution

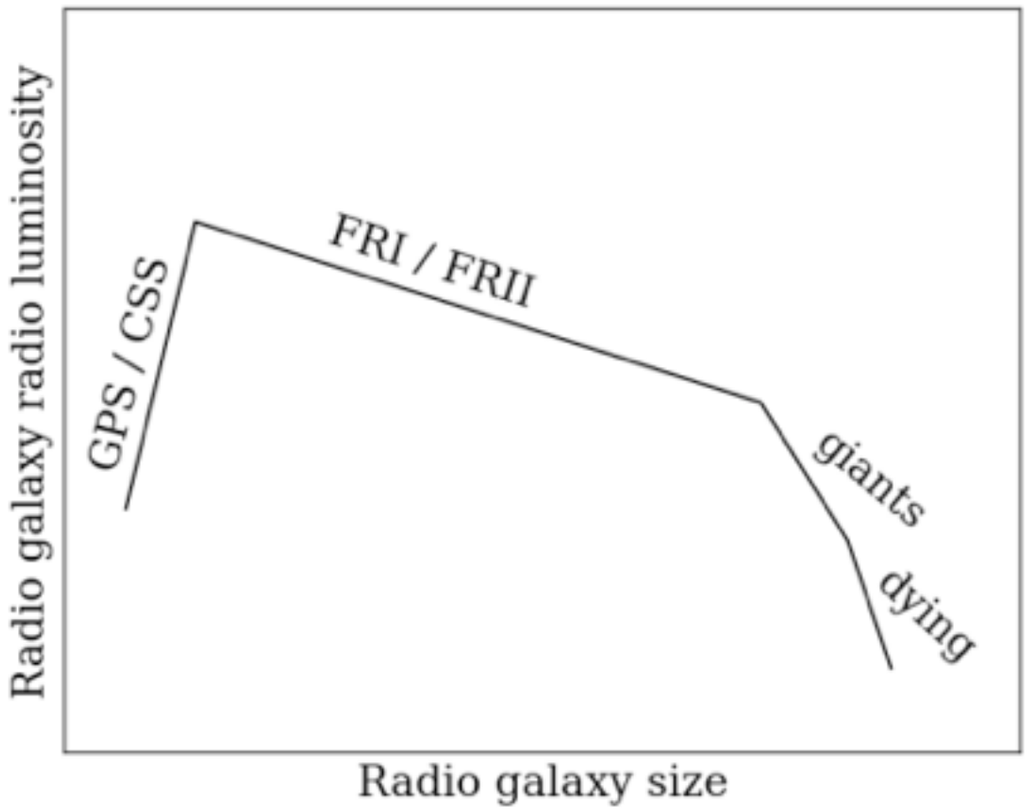


Kapinska & Kaiser 09, Snellen+ 00,
Kunert-Bajraszewska+ 10, An & Baan 12

The evolution of radio sources is analysed mainly through the distribution of observed sources in the P -D (radio power–linear size) diagram introduced by Shklovskii (1963) and discussed in terms of evolutionary tracks of sources by Baldwin (1982).

Radio Galaxy evolution





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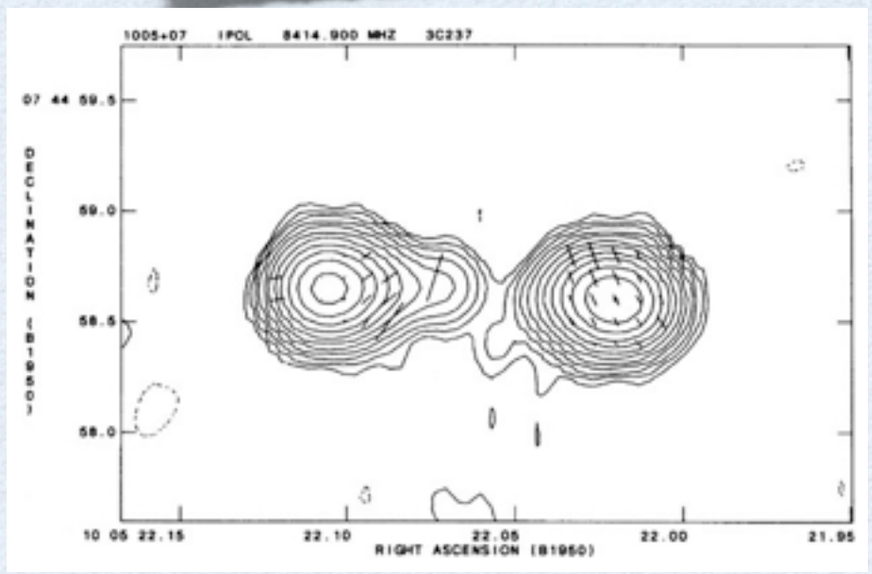

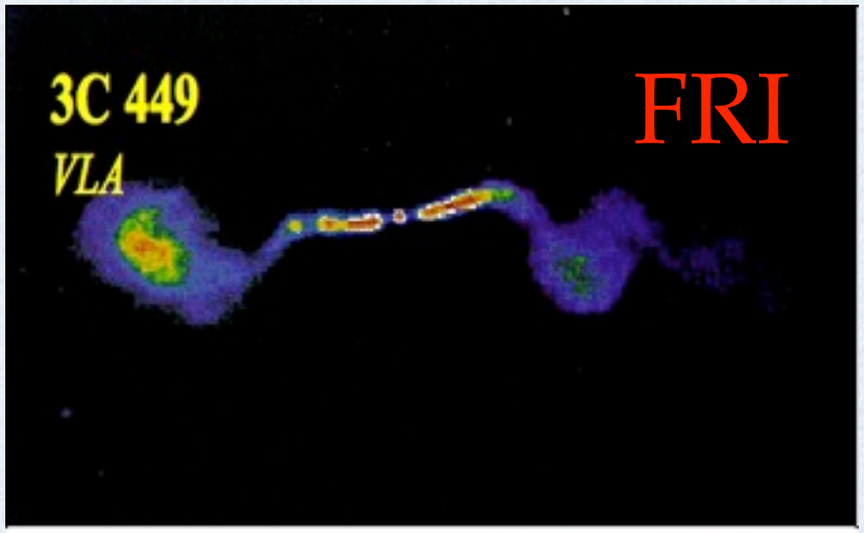

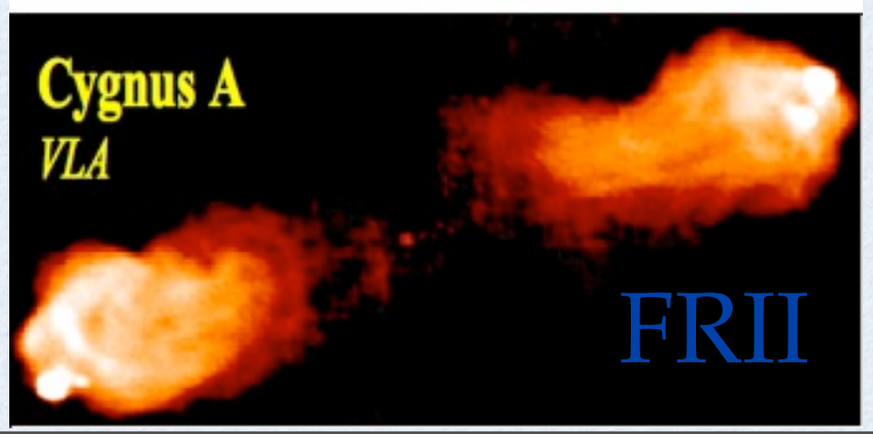

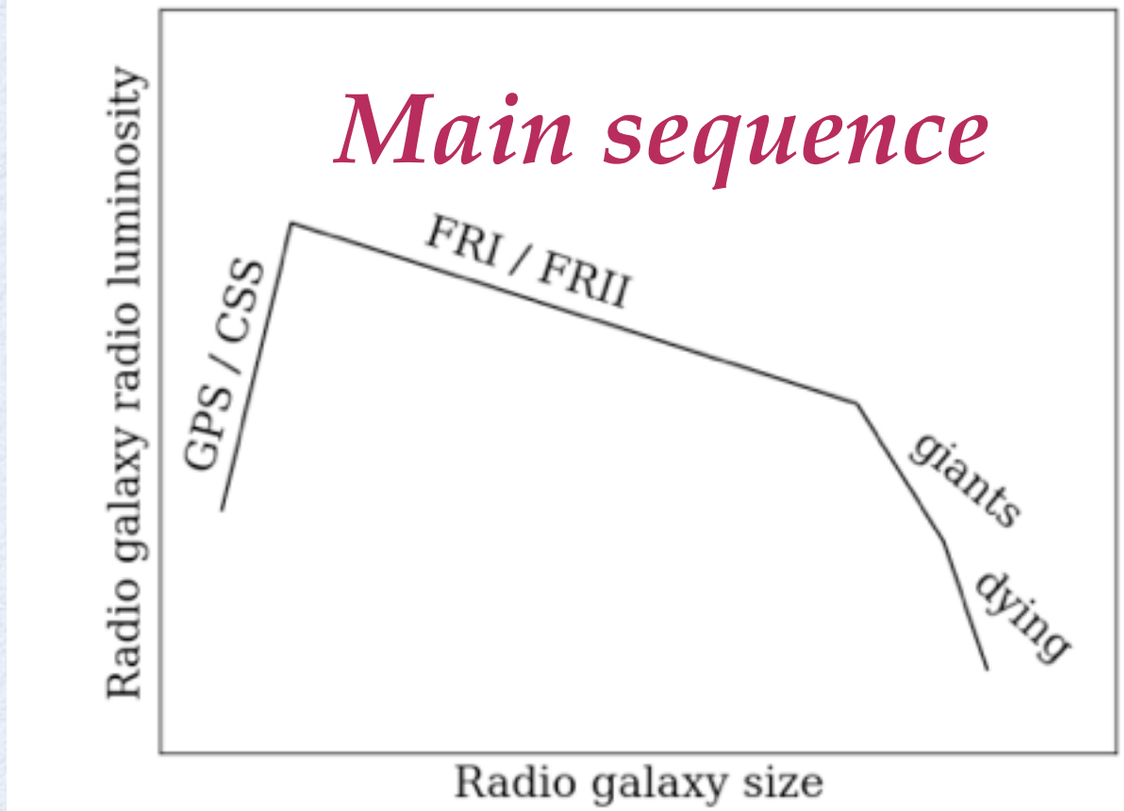

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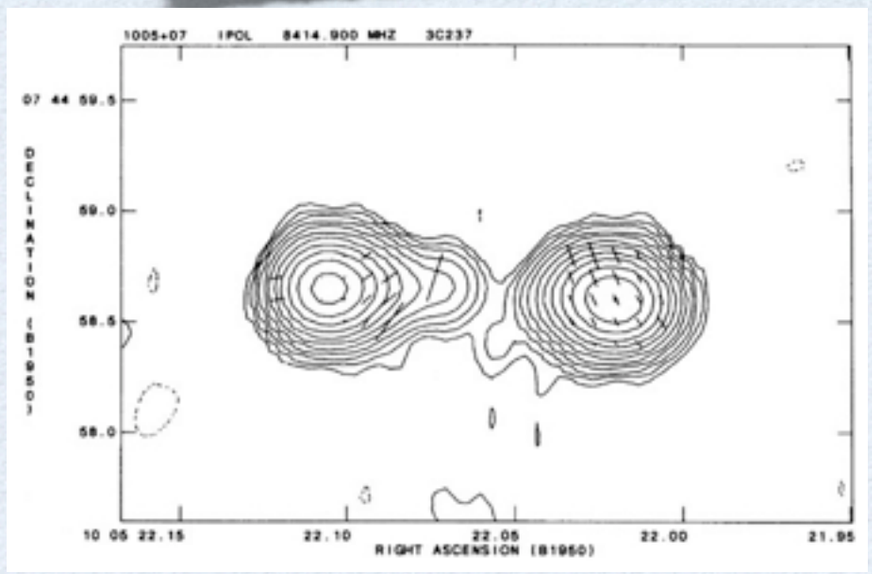

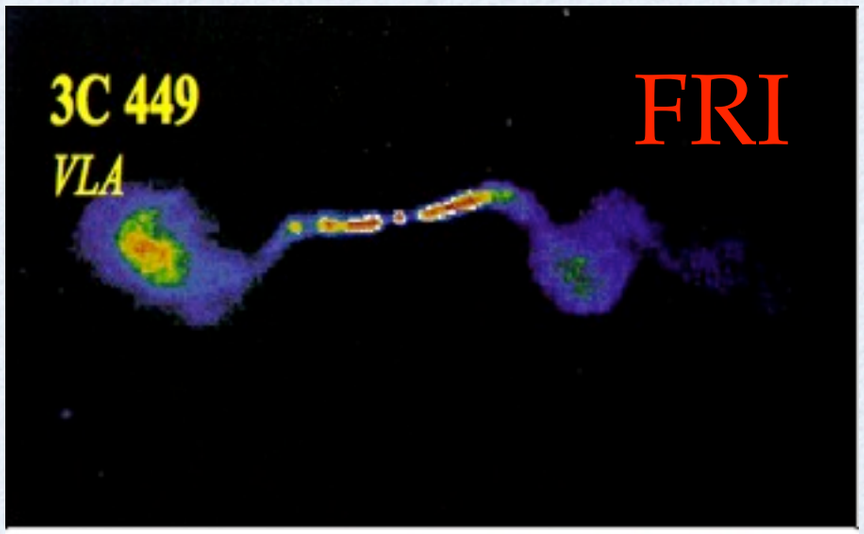

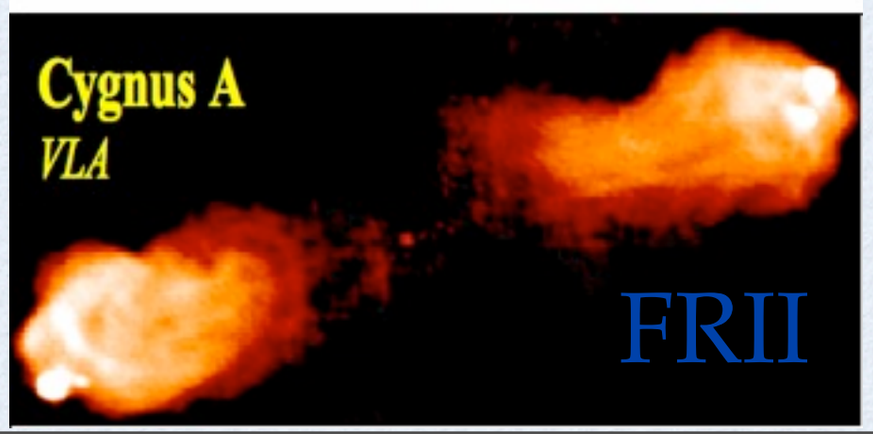

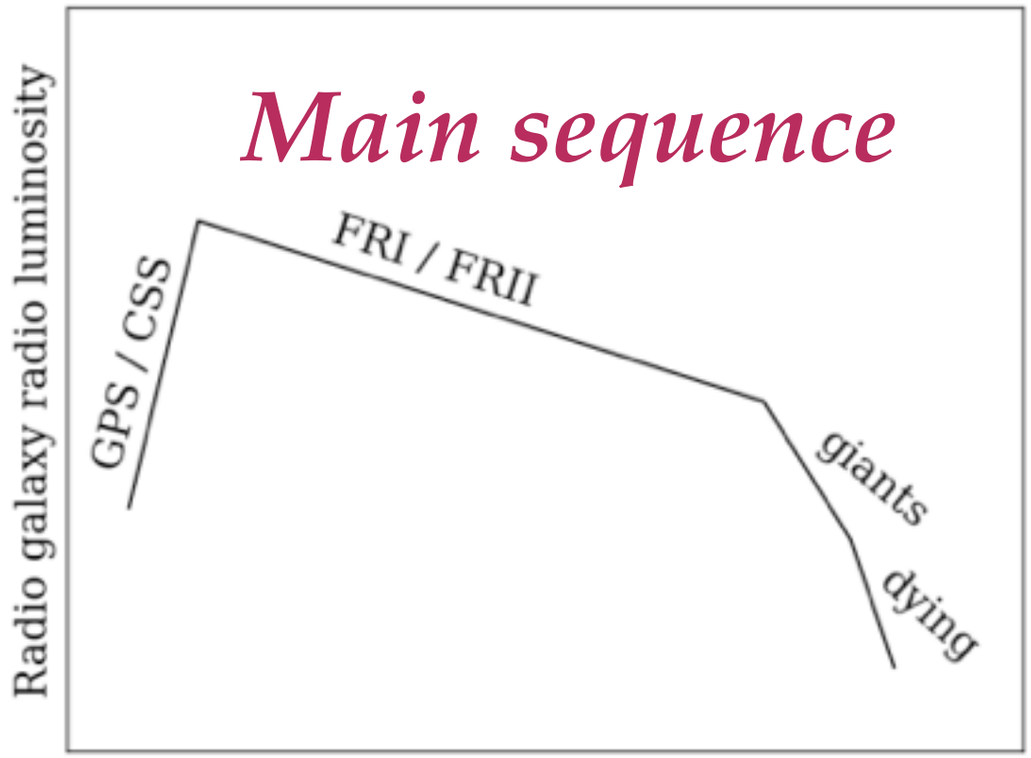

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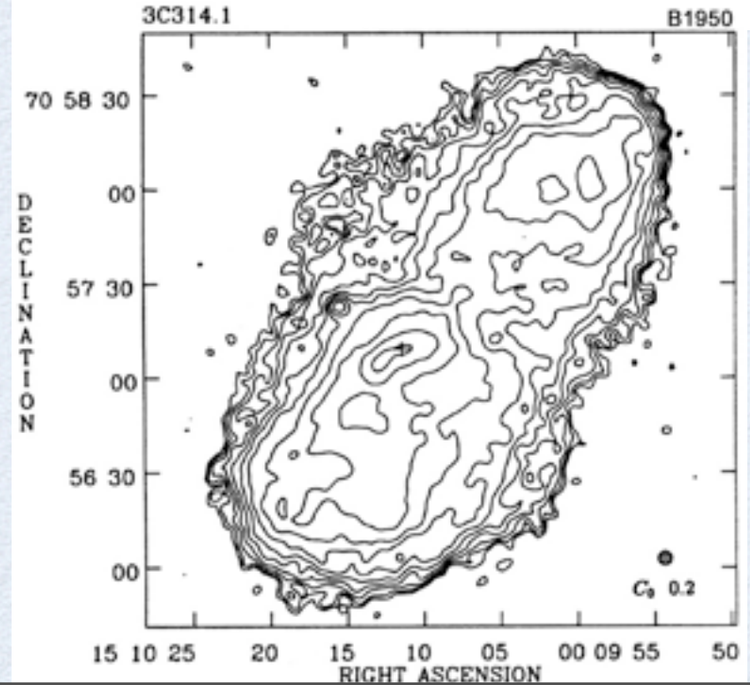

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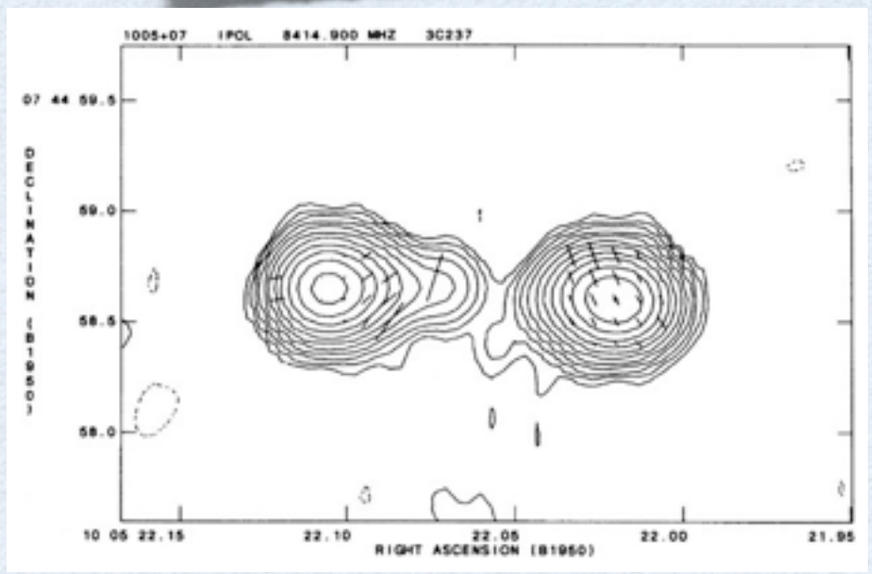

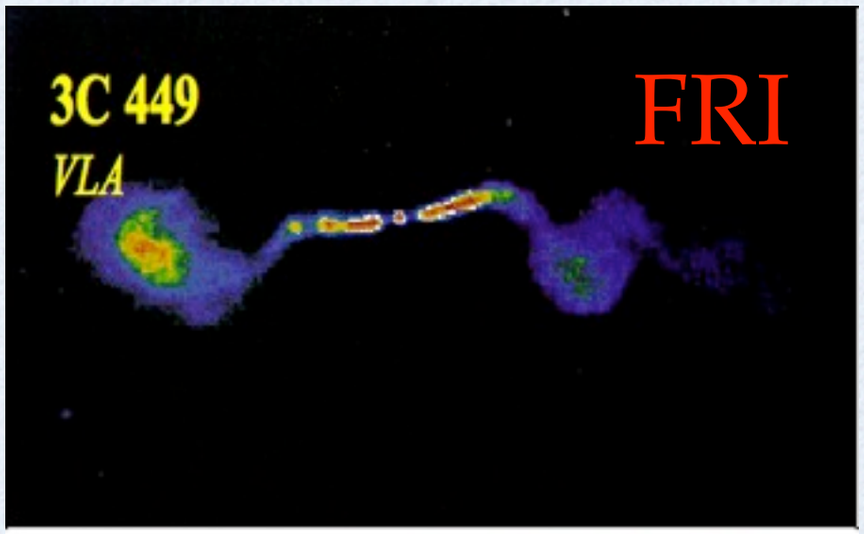

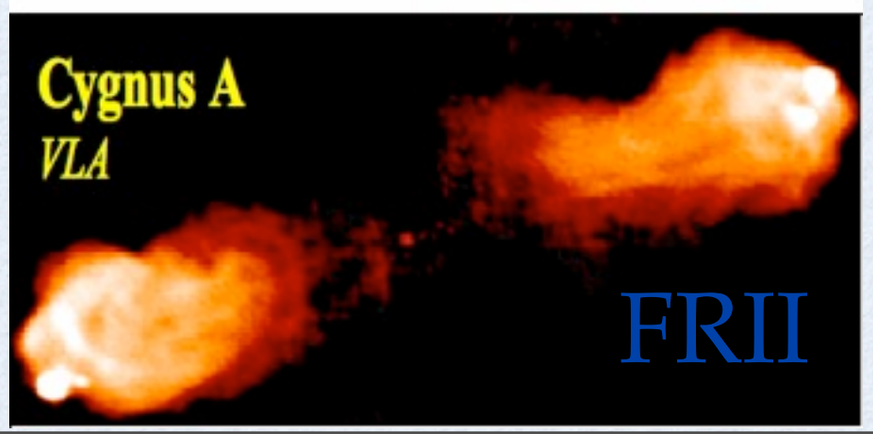

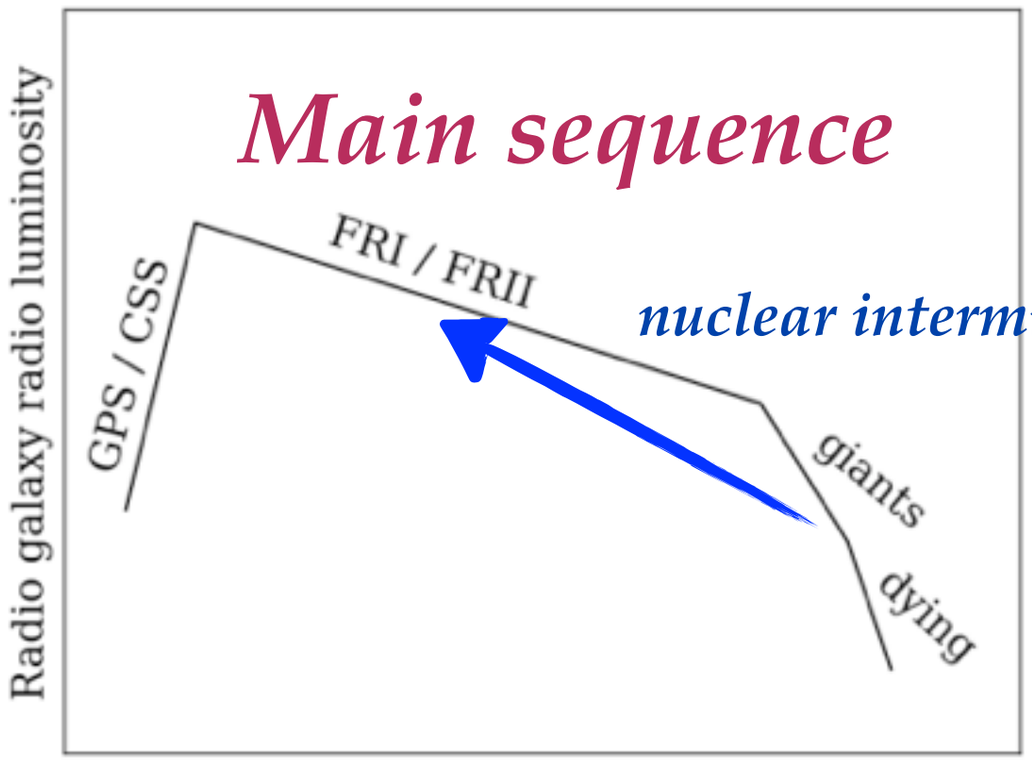

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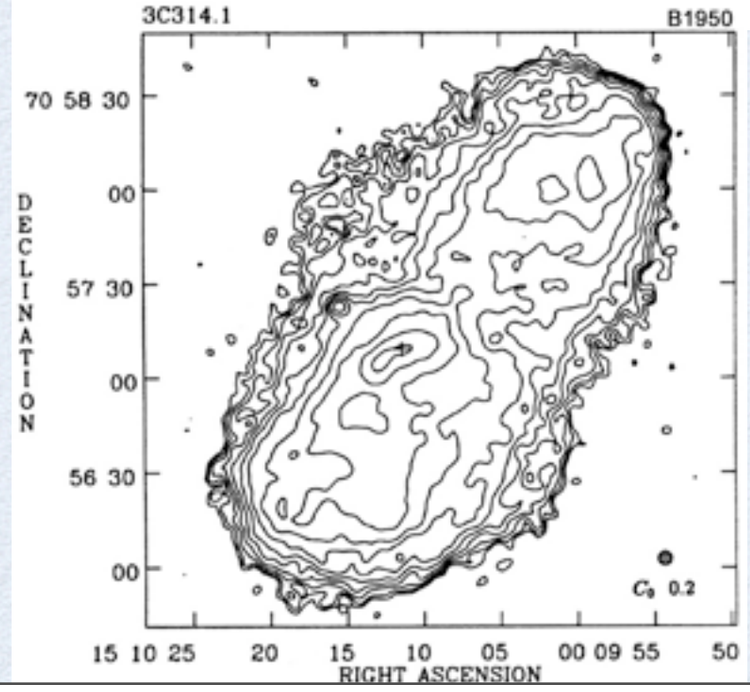

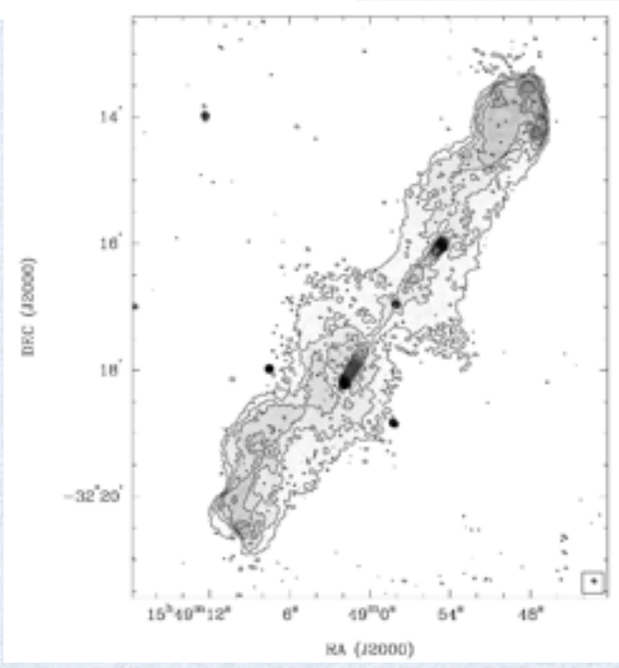

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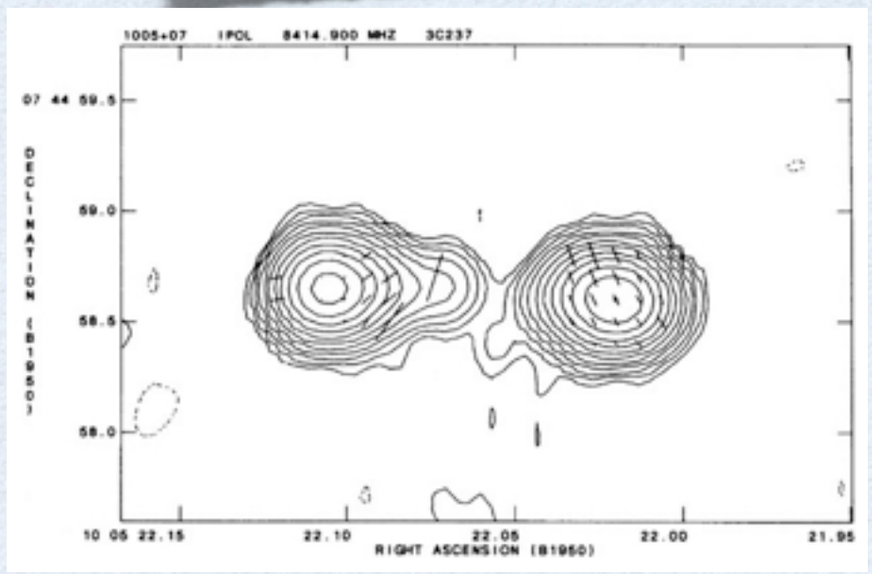

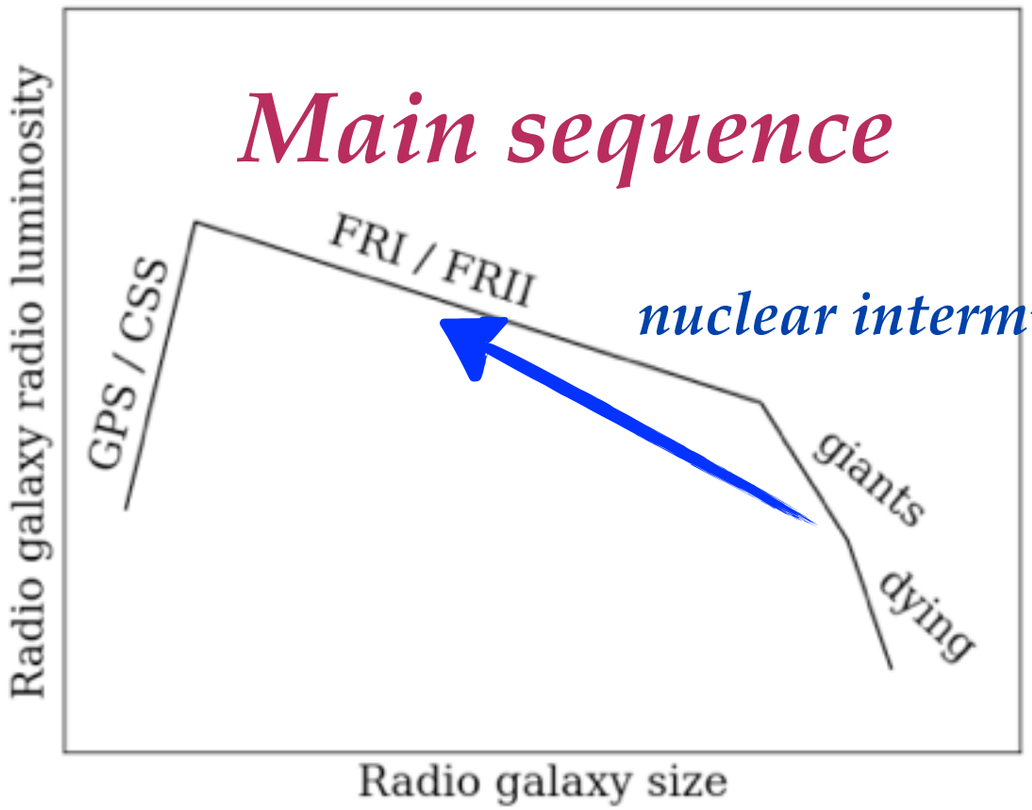

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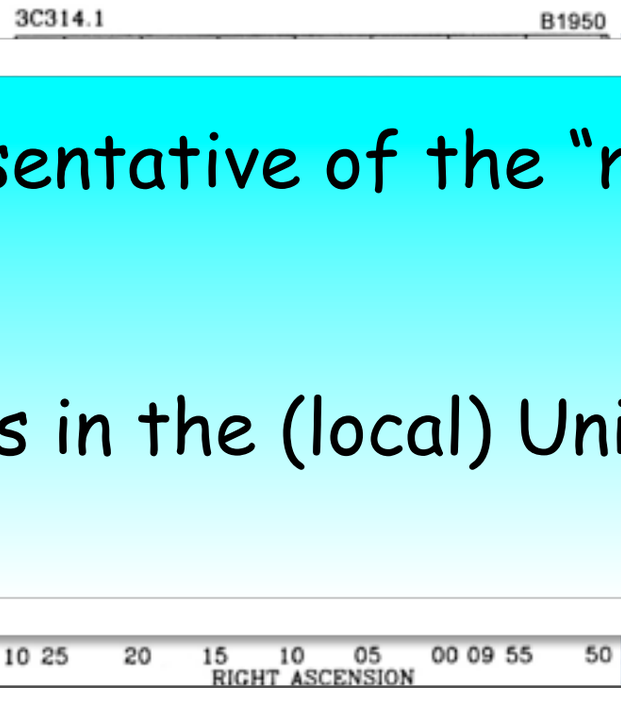
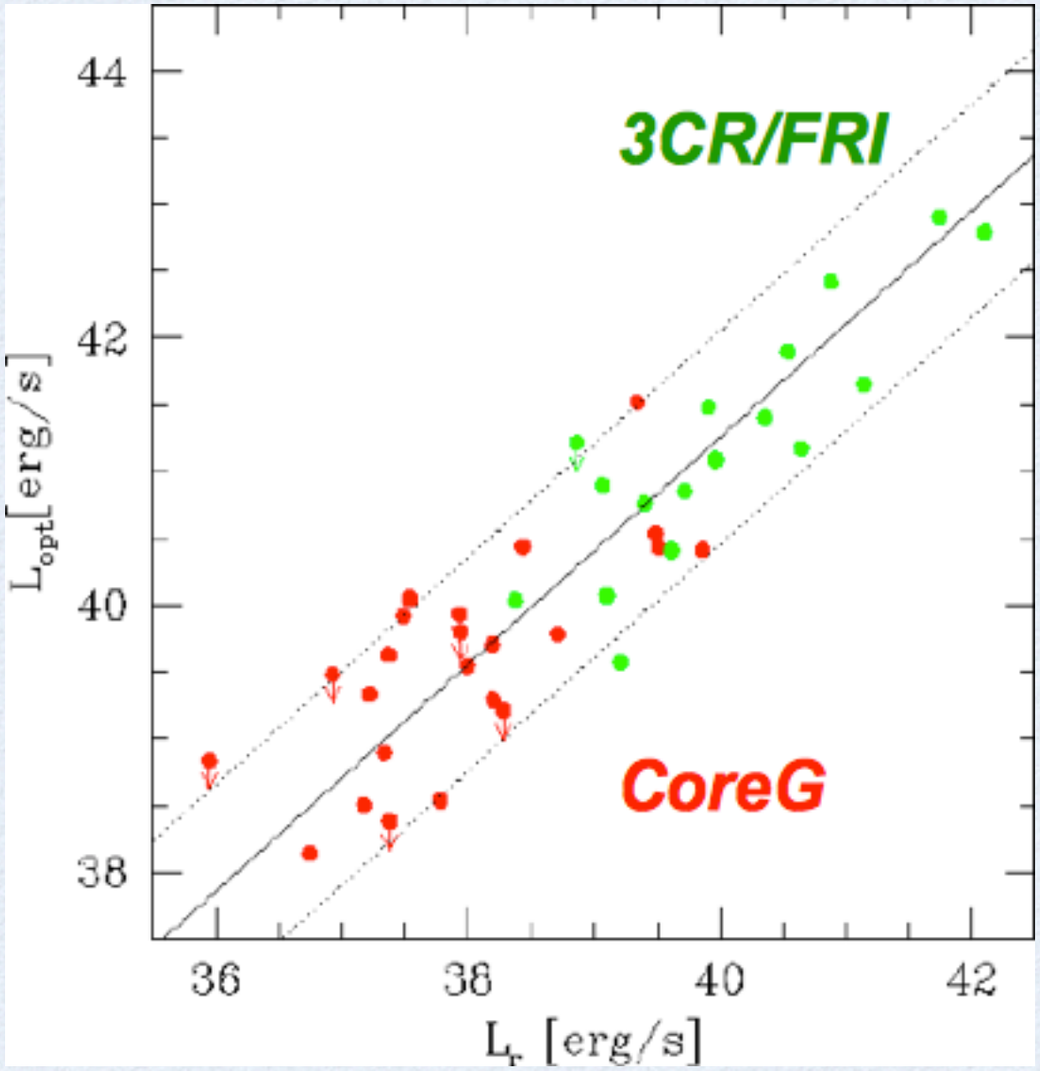
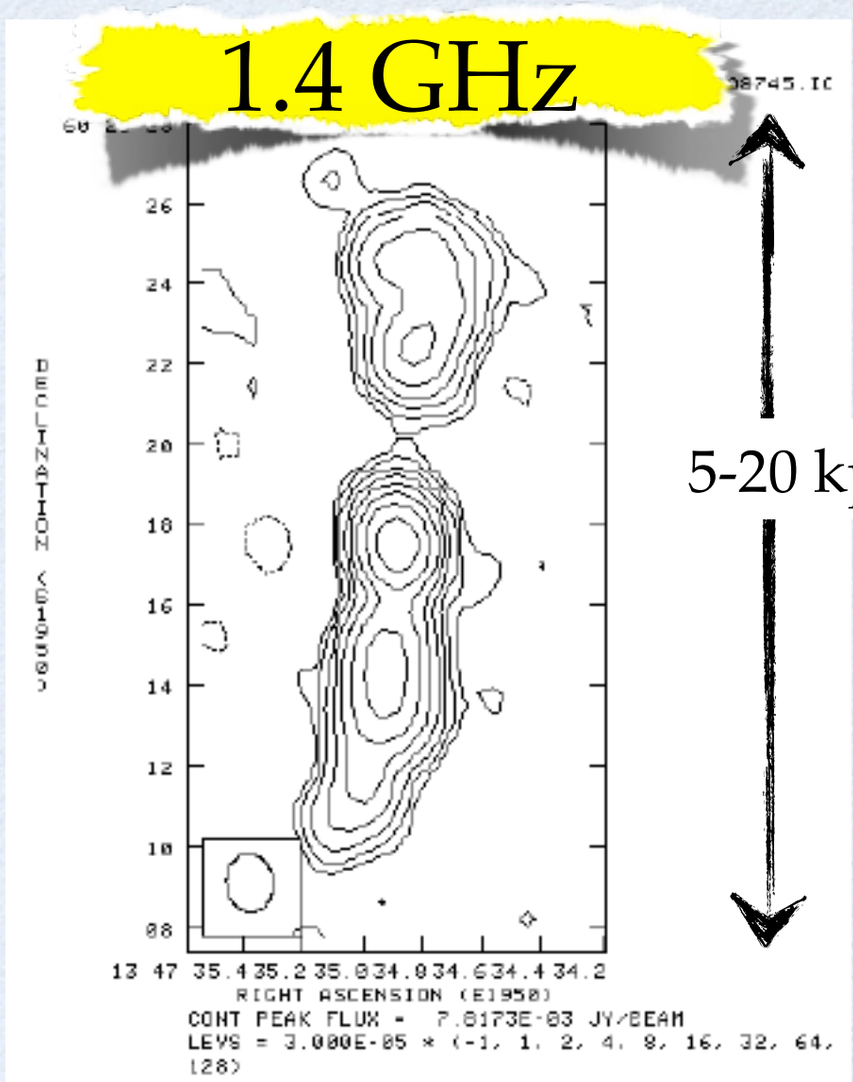


- Are FRI and FRII representative of the "main sequence" radio galaxy population?
- Most of the radio galaxies in the (local) Universe are FRI or FRII?

low-power Radio Galaxies

let us study the low-luminosity RG which are expected to be the bulk of the local RL AGN population: ***CoreG***

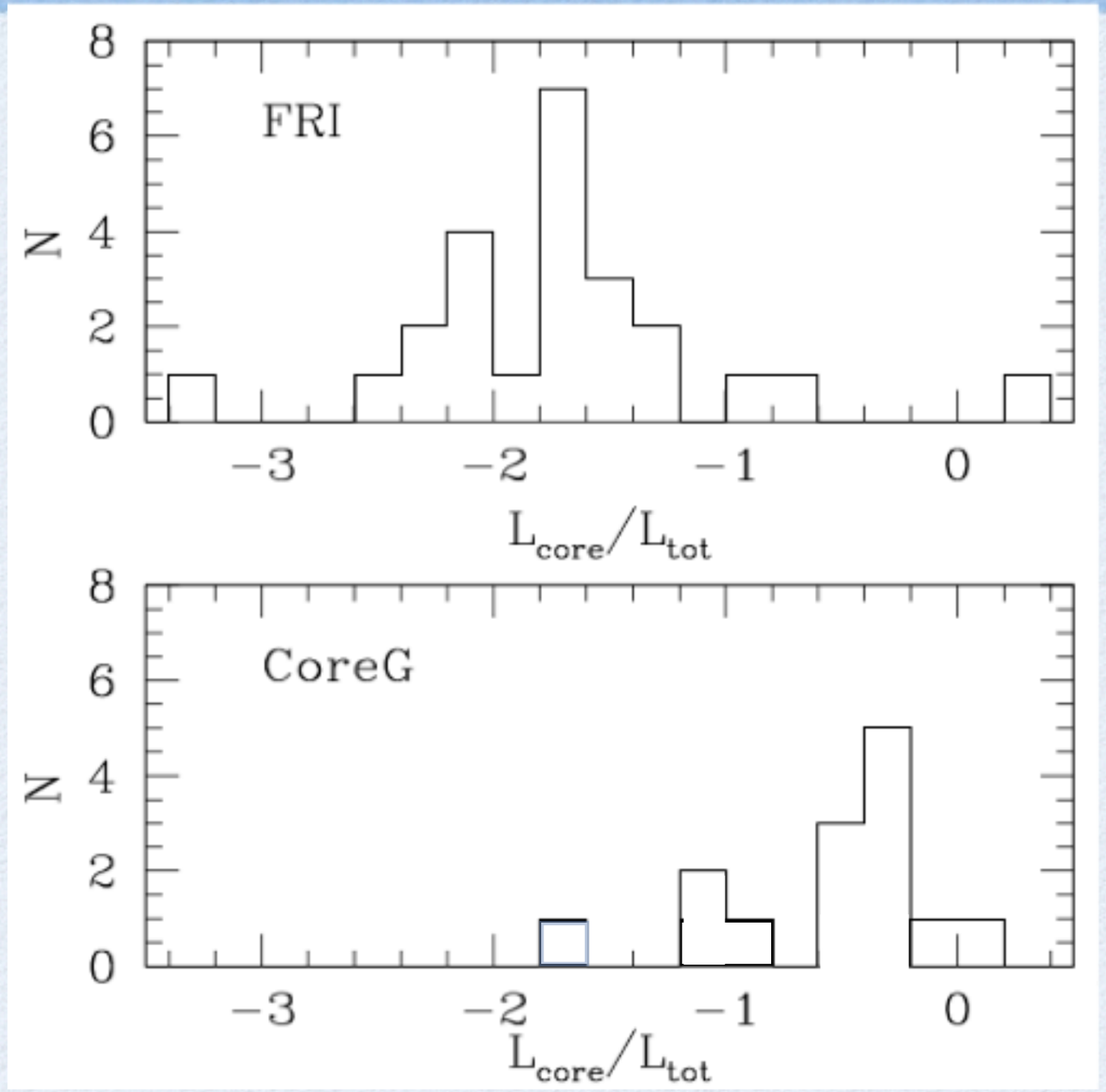


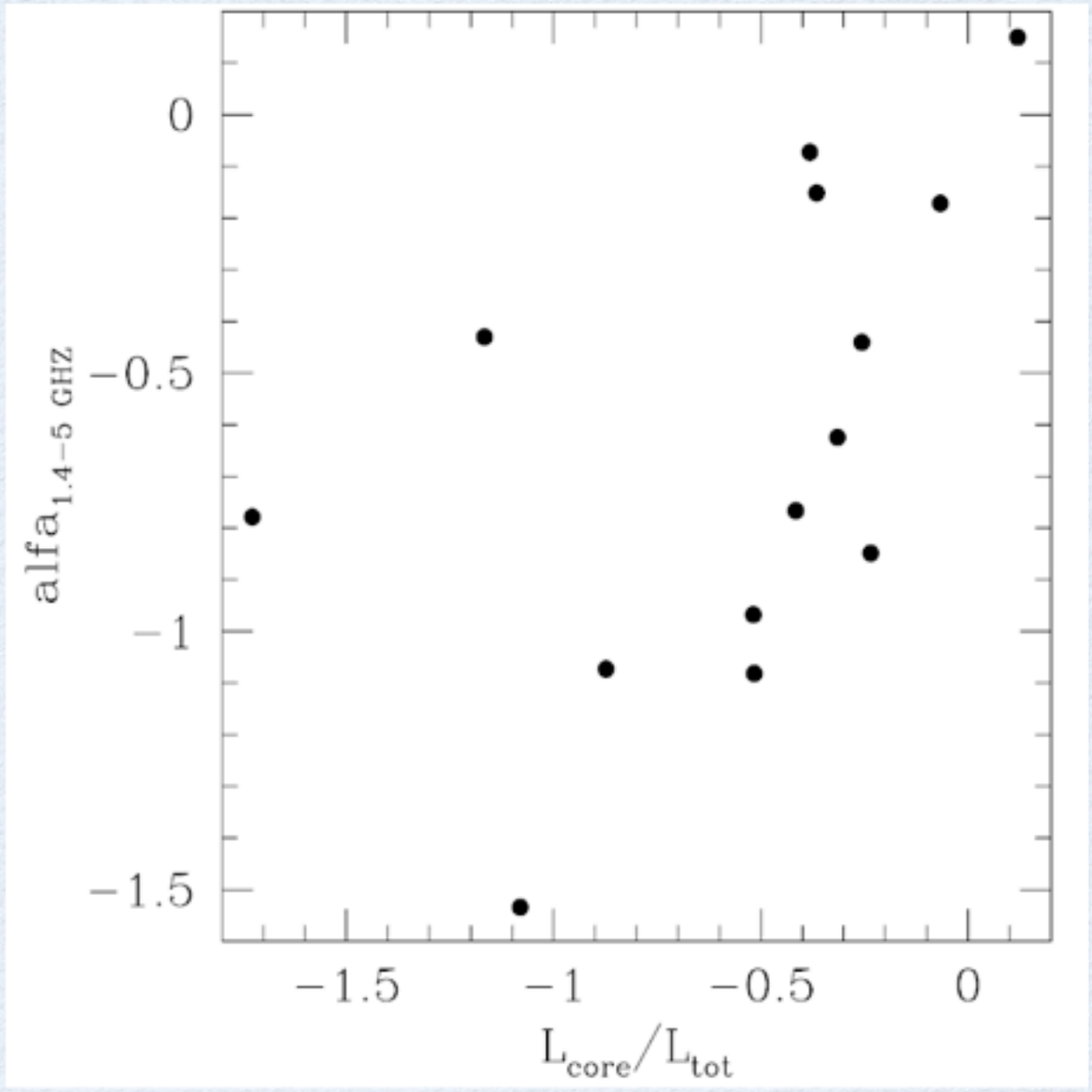


Balmaverde & Capetti 06,
Balmaverde, Baldi & Capetti 08

The CoreG are '*miniature*' radio galaxies with nuclear and host properties indistinguishable from FRI (red host and LEG spectrum)

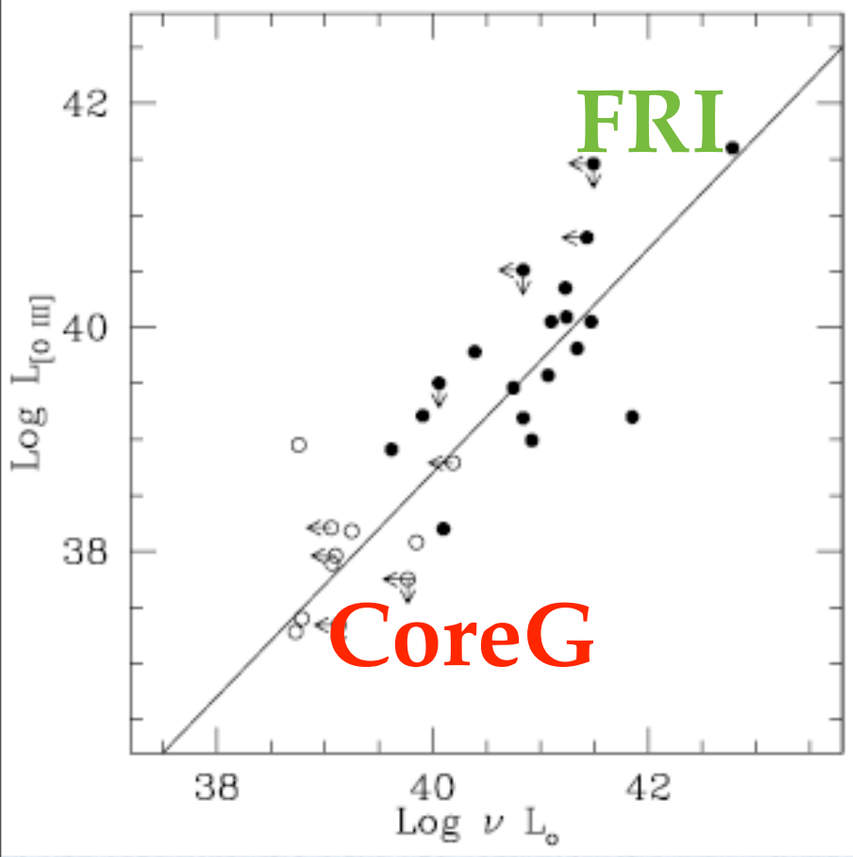
High Core Dominance

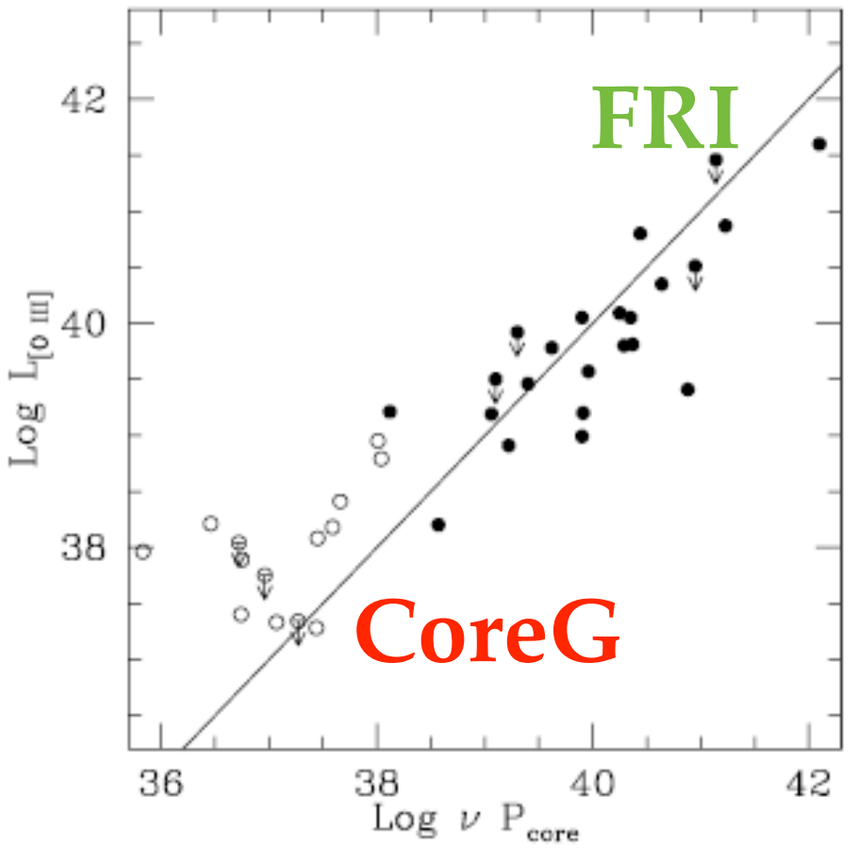


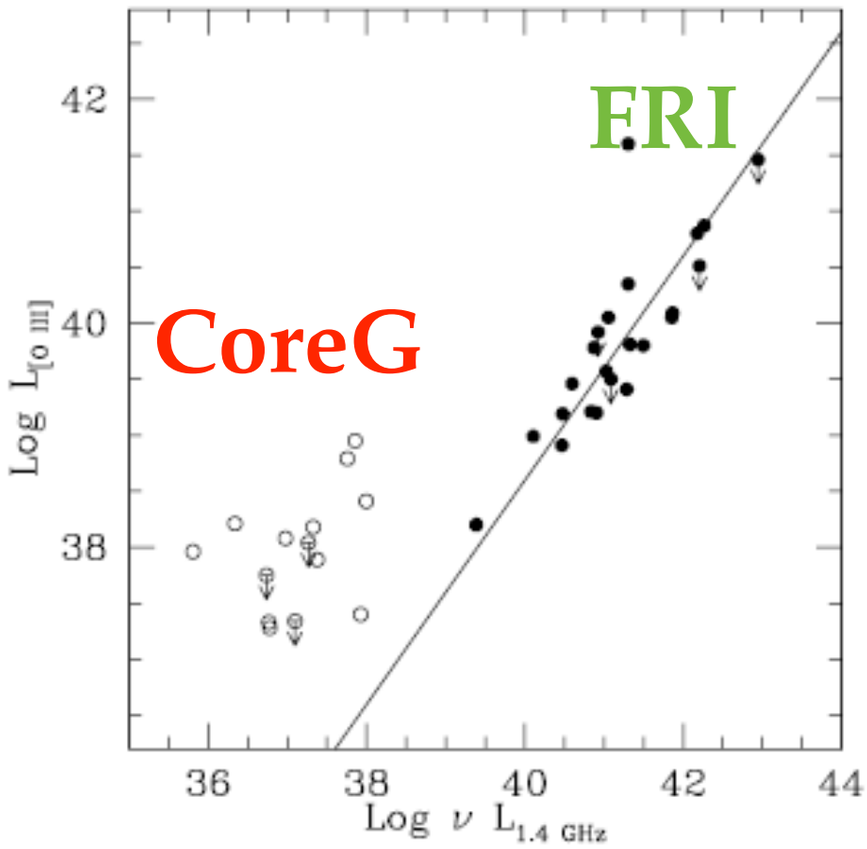


The CoreG show a core dominance larger than the classical 3C/FRI of a factor ~100 (Baldi & Capetti 09)

Genuine radio deficit







CoreG show a genuine extended radio emission deficit of a factor ~100 wrt FRI

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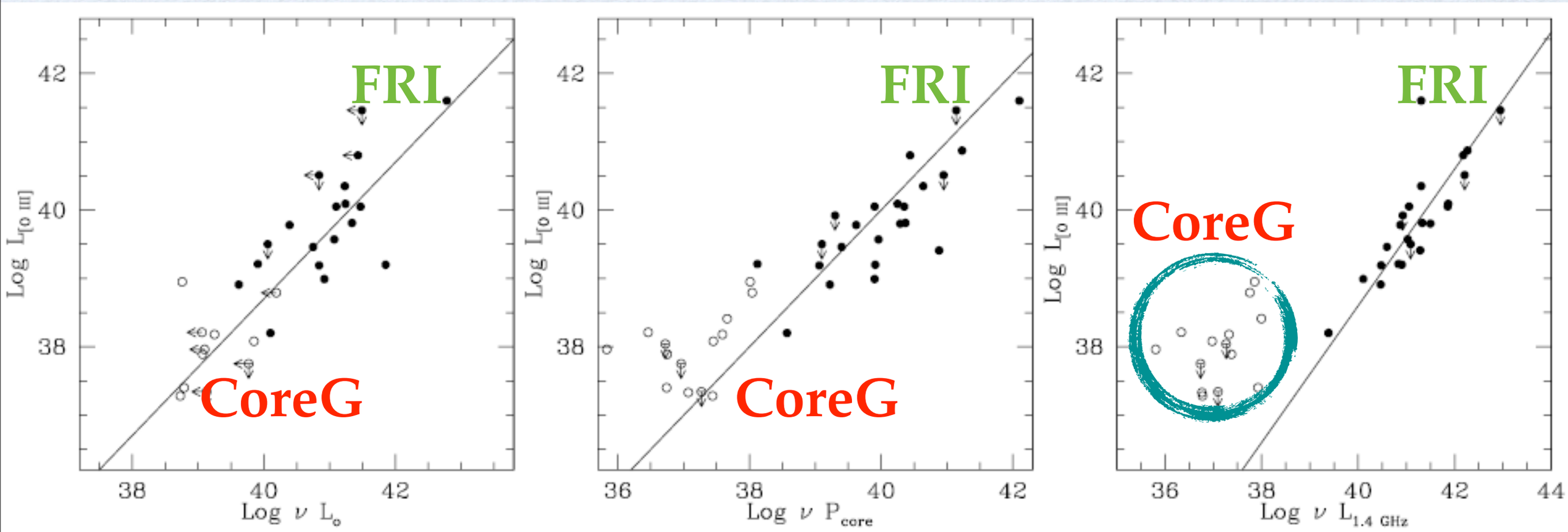

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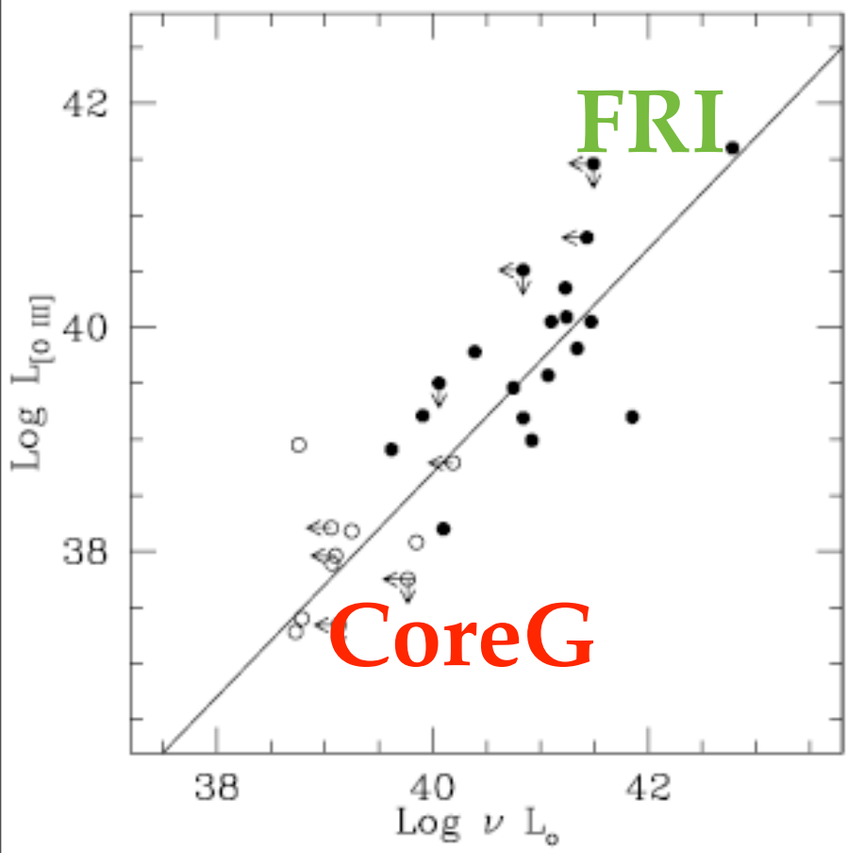
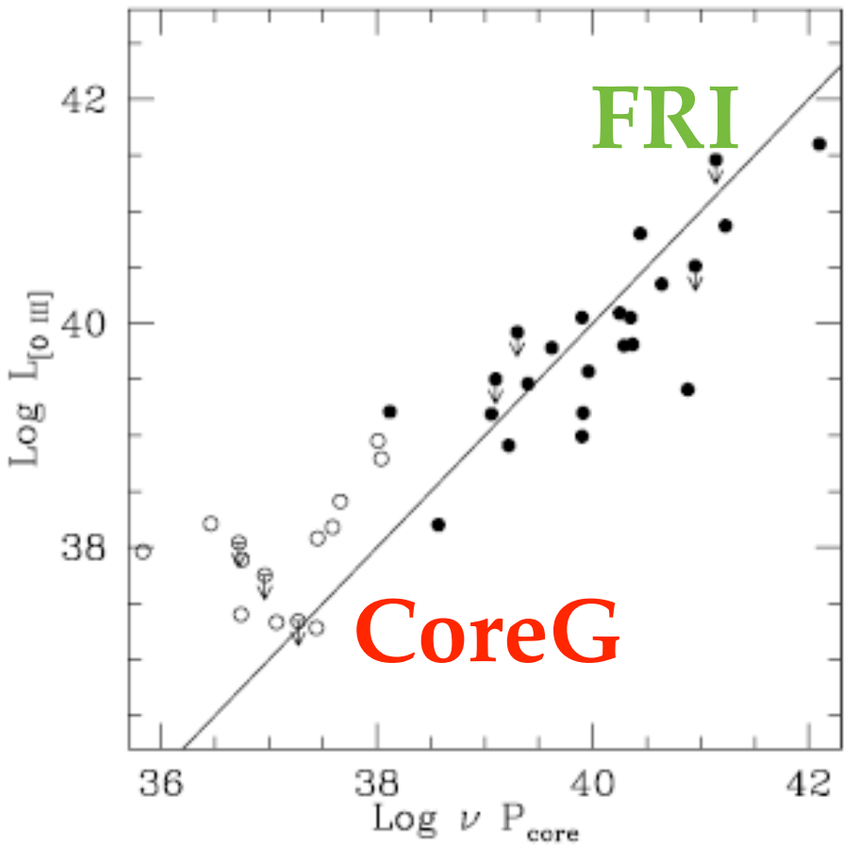
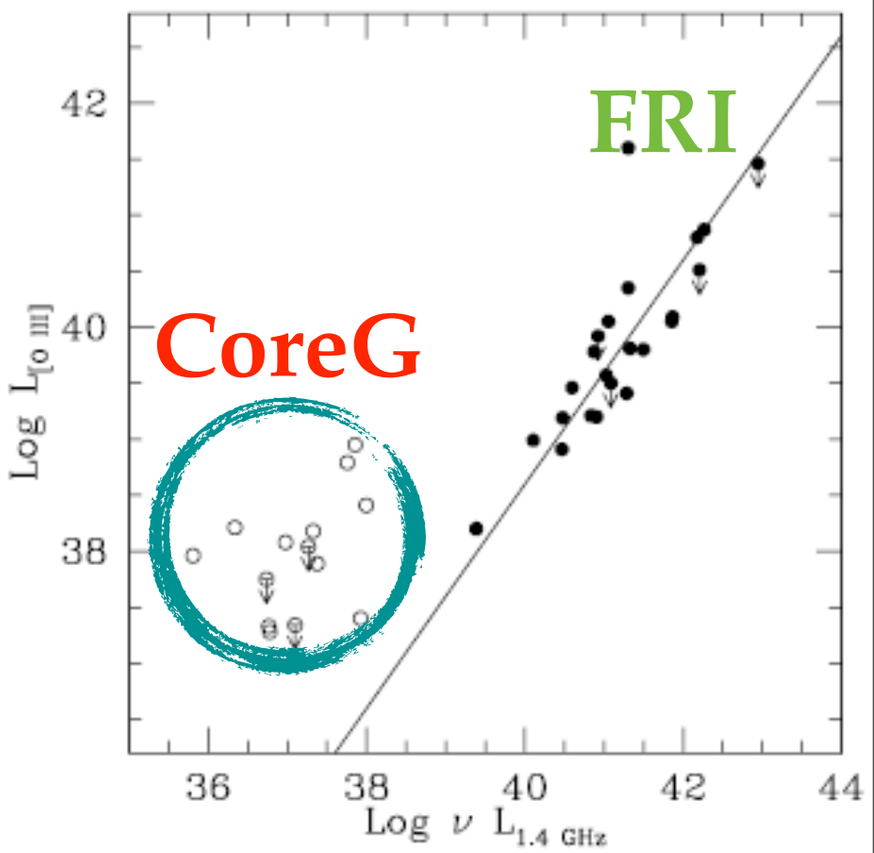




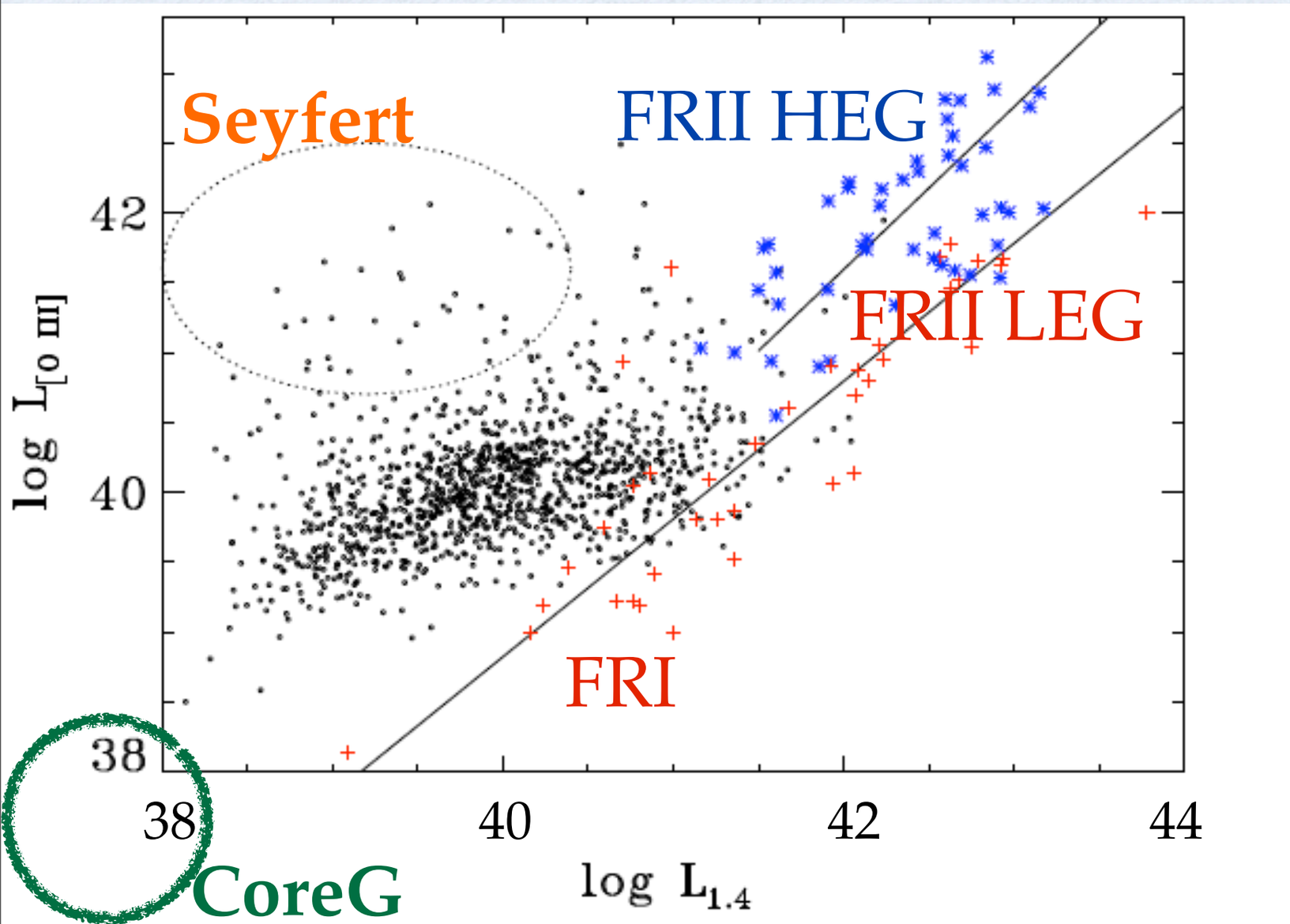


CoreG show a genuine extended radio emission deficit of a factor ~100 wrt FRI

The CoreG are exceptions and not representative?

Local RL AGN population

Best et al 2005 select 2215 low-luminosity radio-loud AGN (F > 5mJy) cross-matching SDSS (DR2) and NVSS and FIRST in the local Universe (z < 0.3)



CoreG

Most of the Best el al. sample shows a clear deficit in total radio emission with respect the classical RG similar to CoreG.

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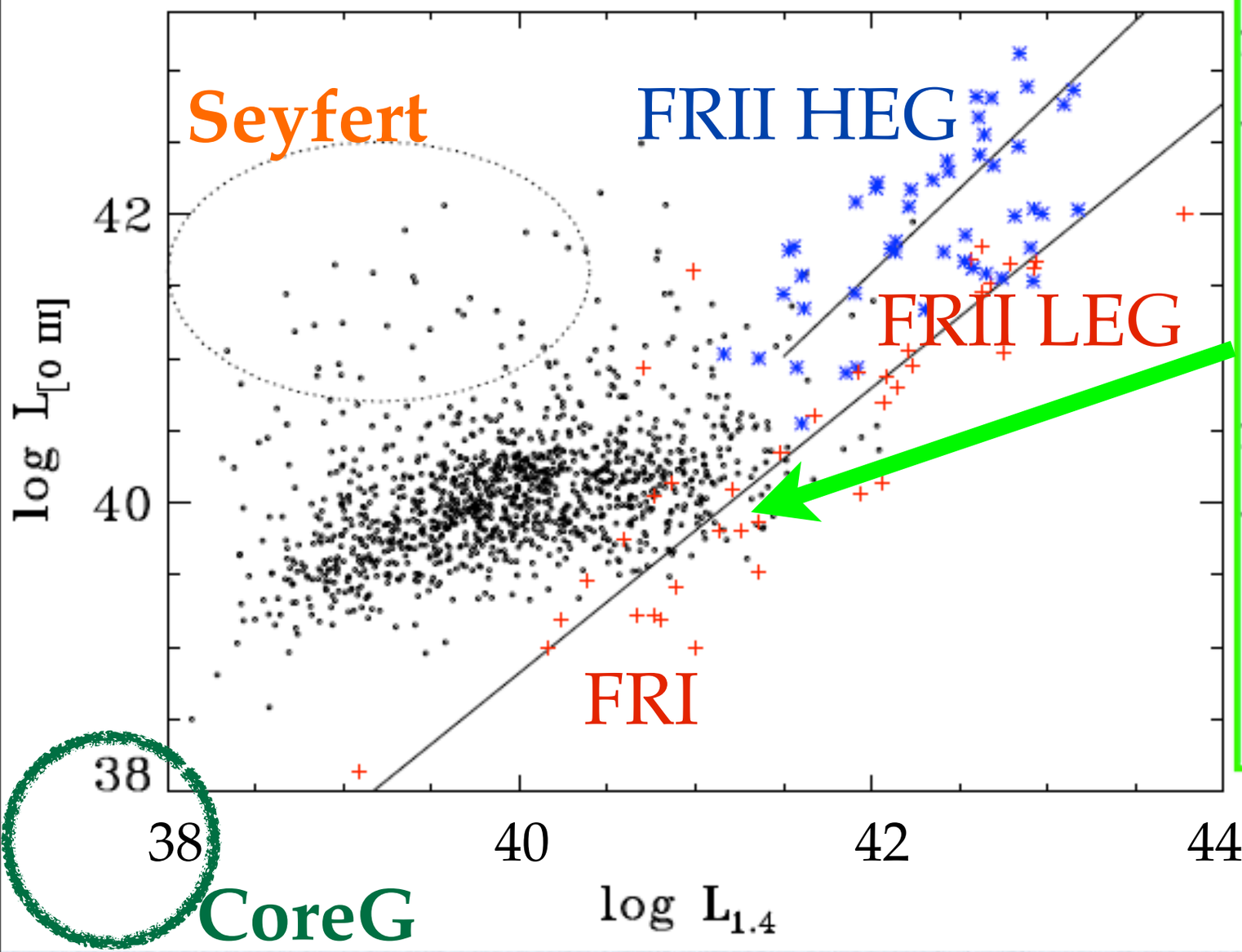

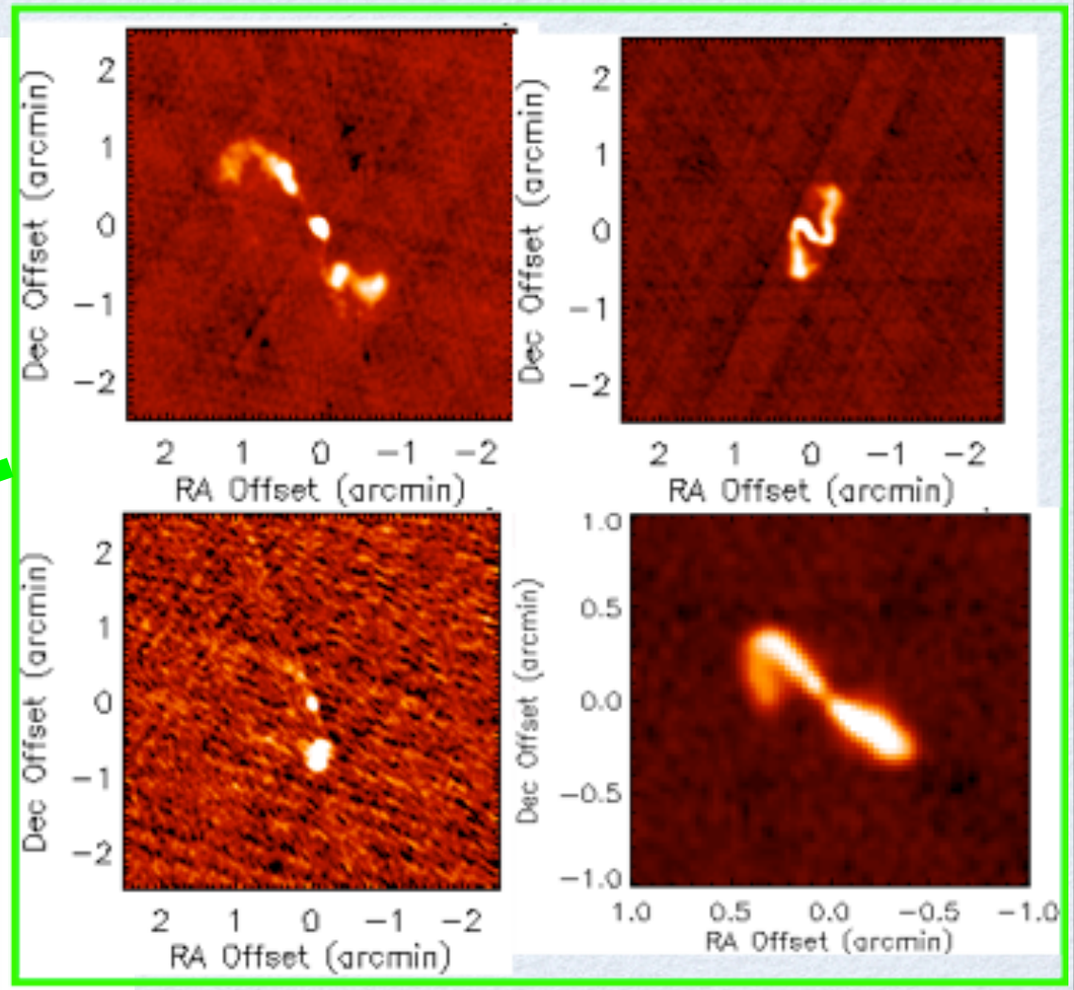

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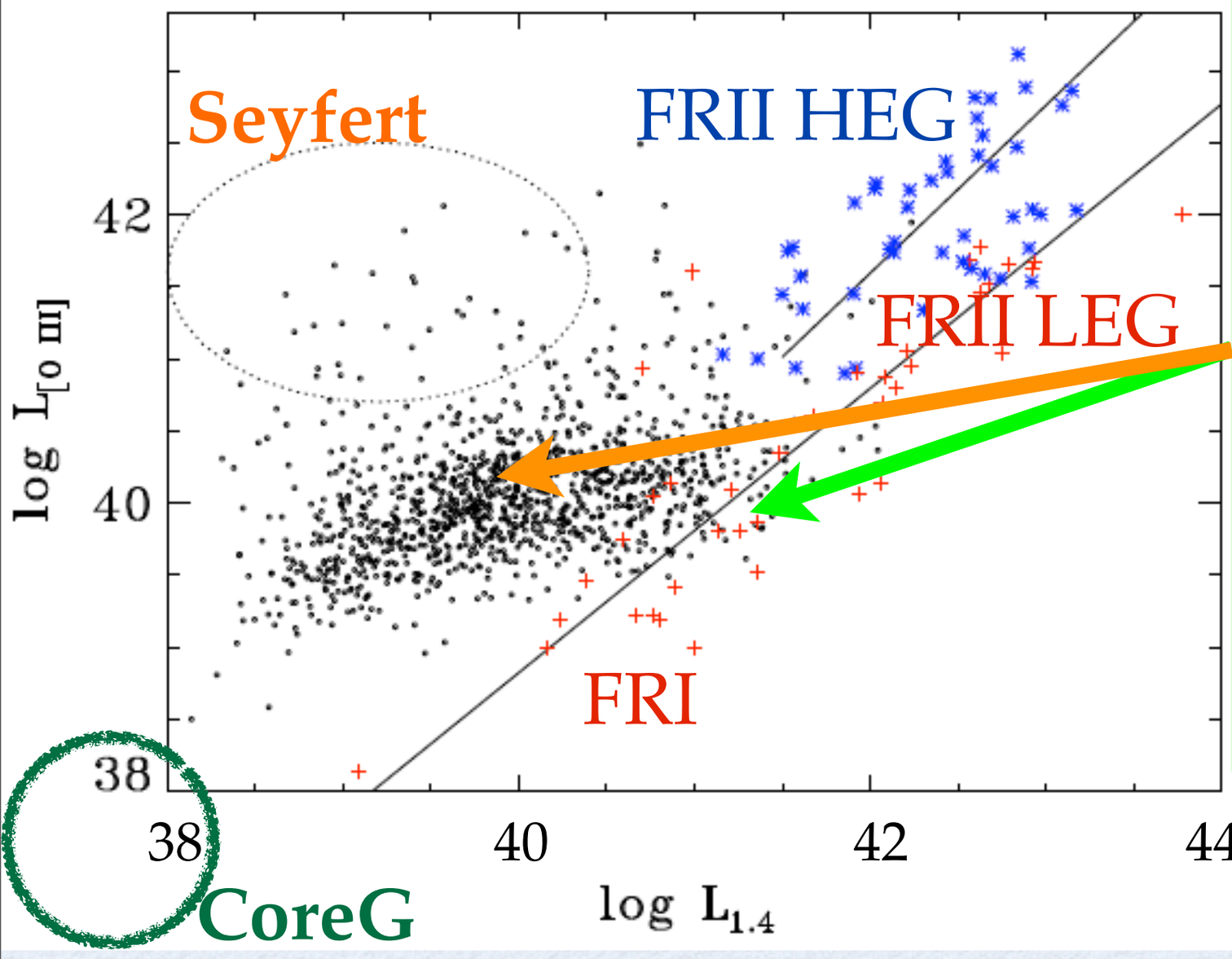
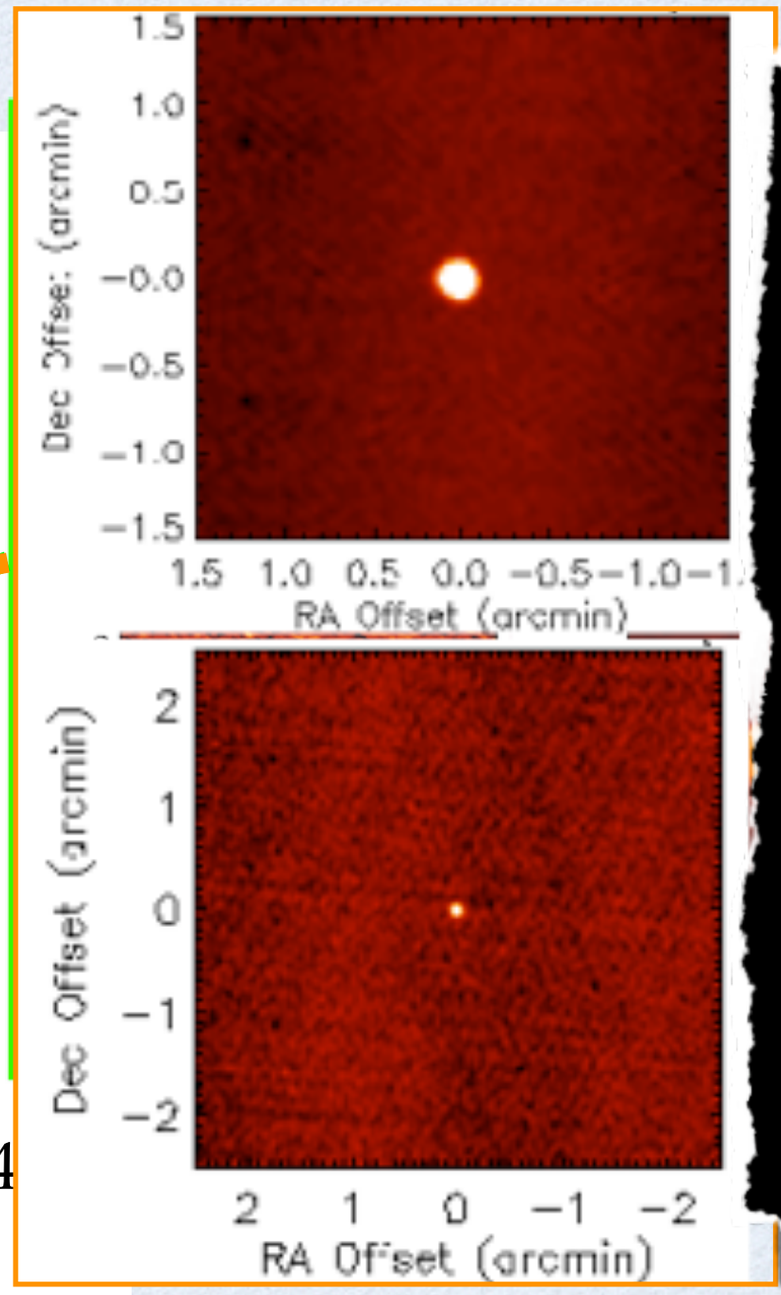
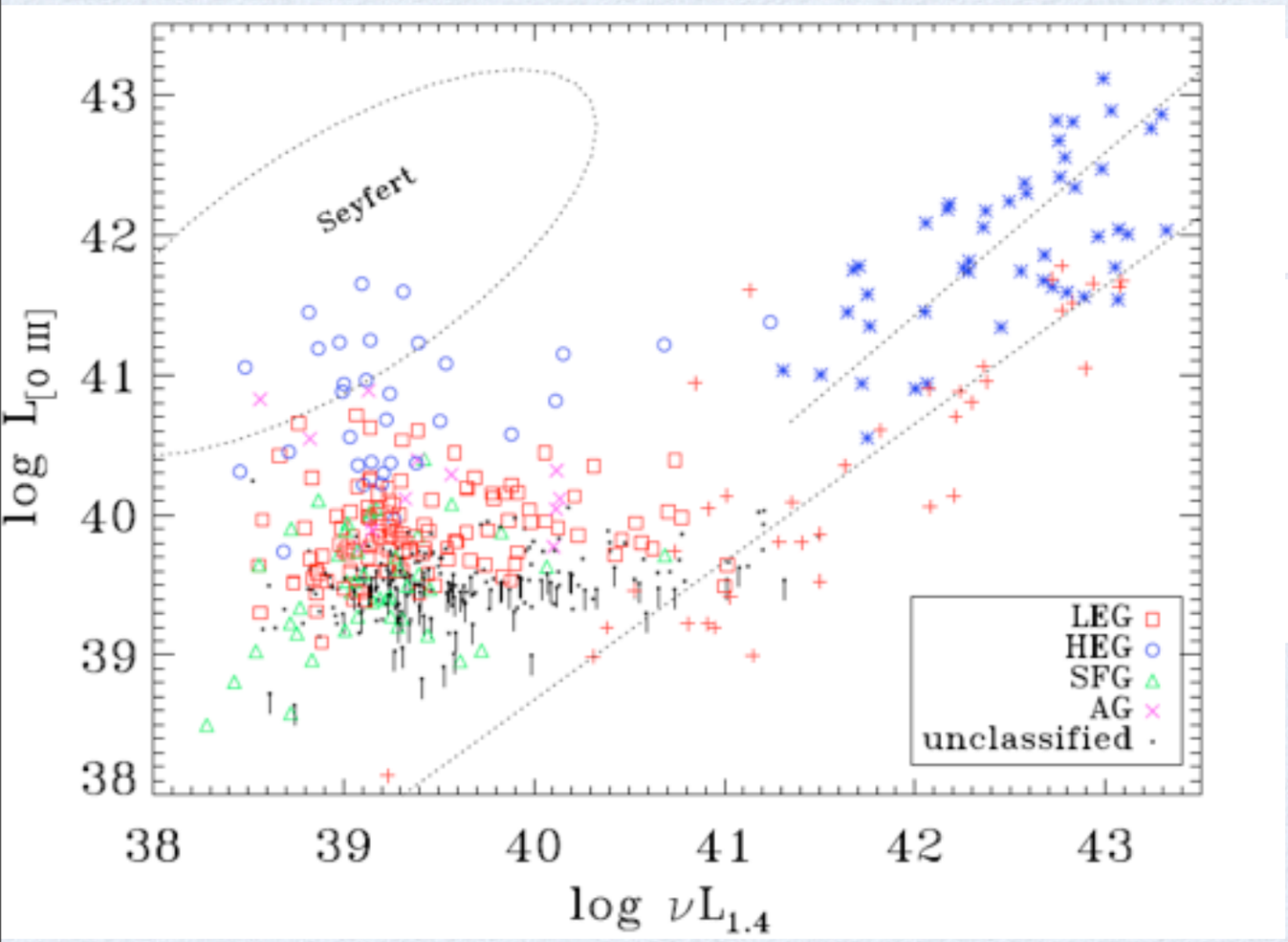


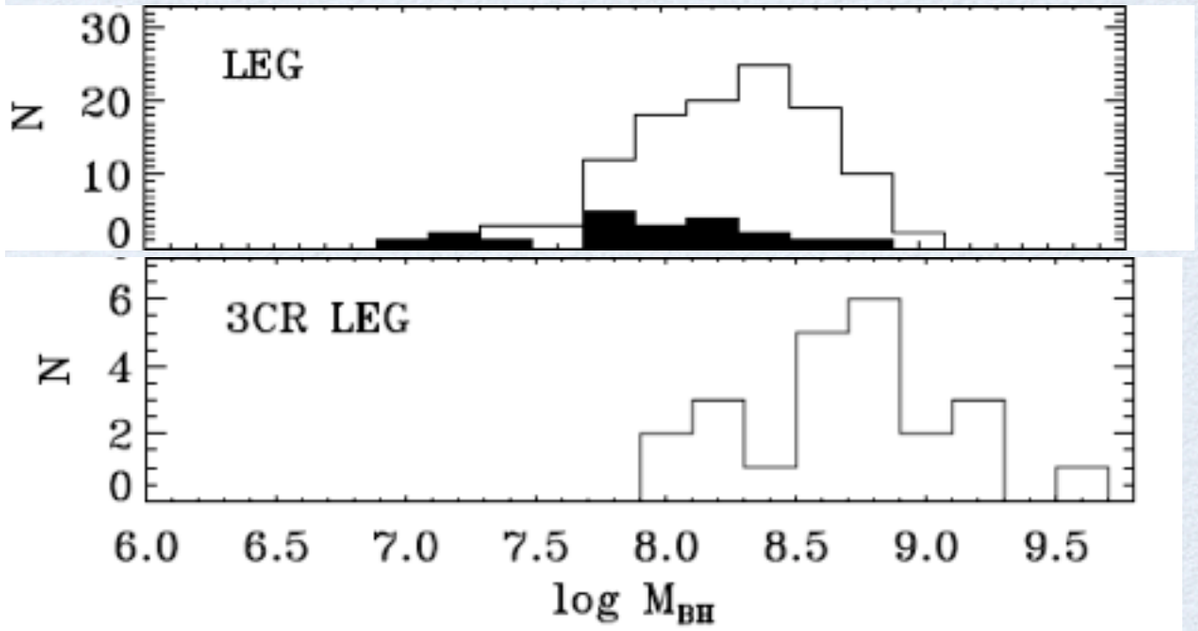


FIRST: resolution 5″, ~10 kpc

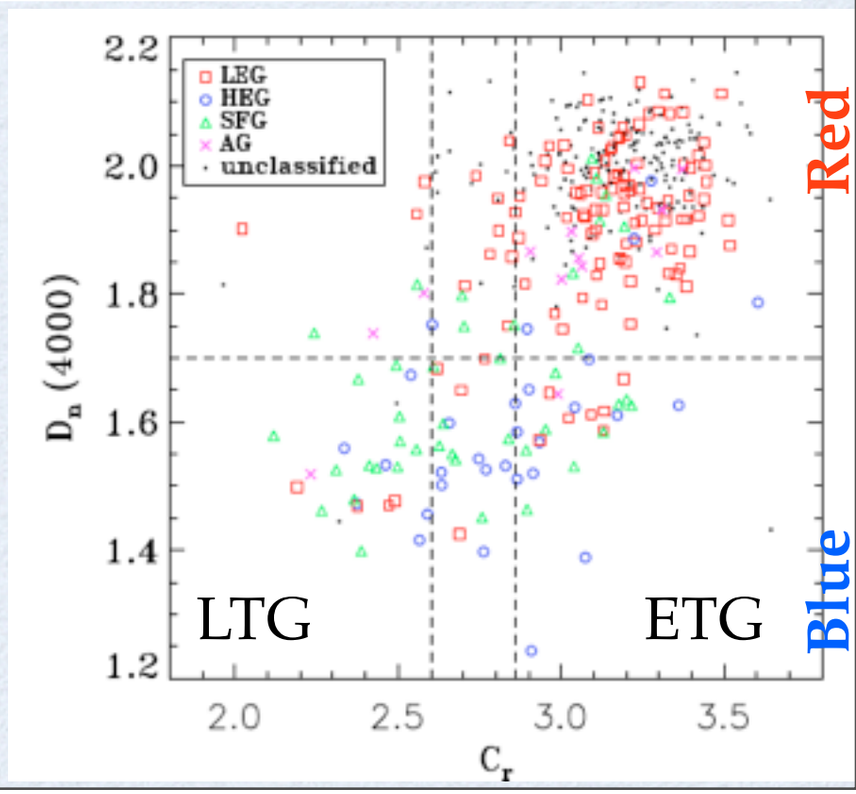
Spectro-photometric properties of Best et al. sample

Baldi & Capetti (2010) studied the properites of the sample:





Most of the Best et al. sample consits in AGN with nuclear and host properties similar to the 3CR/FRI (LEG) and CoreG



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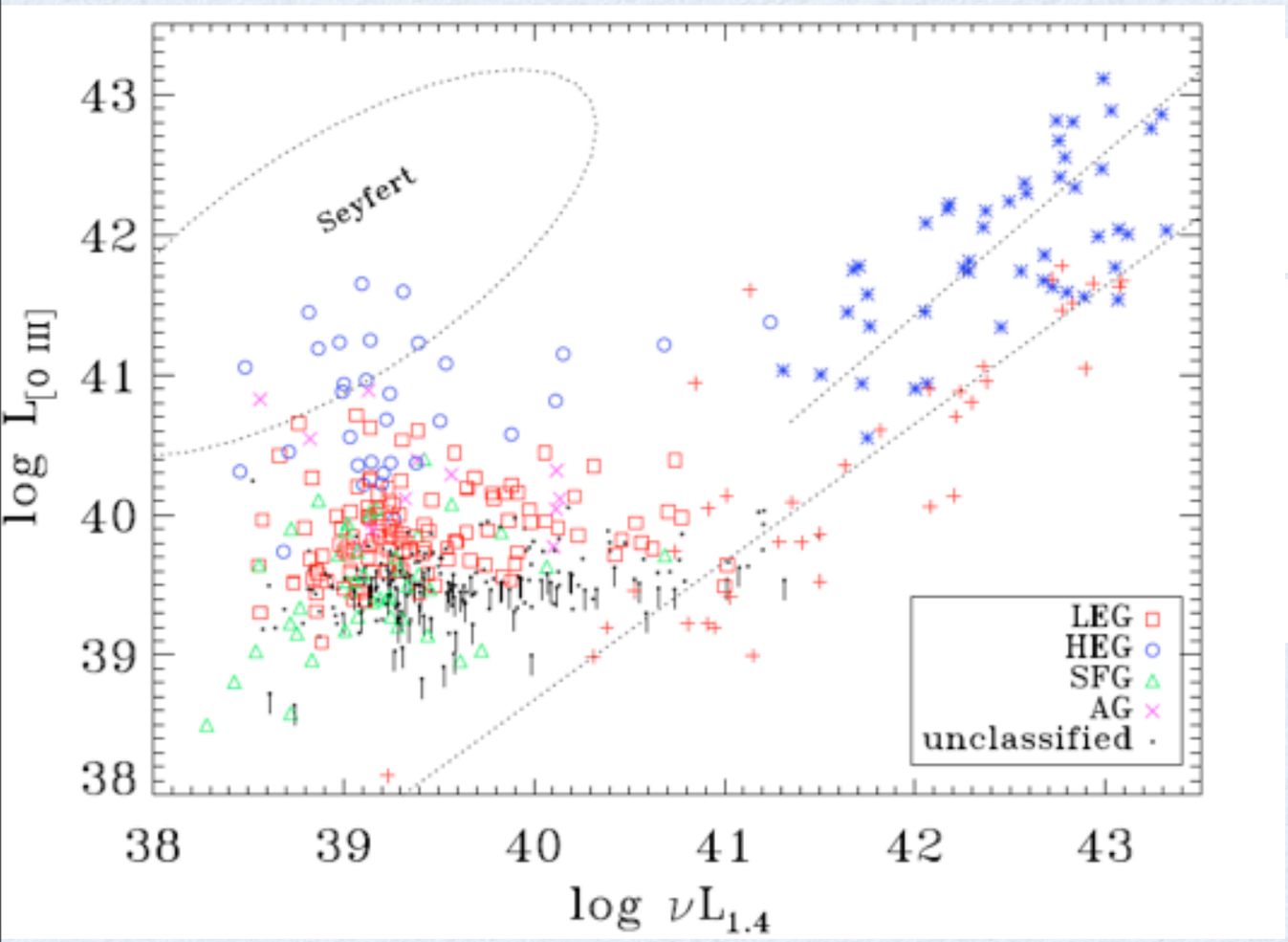

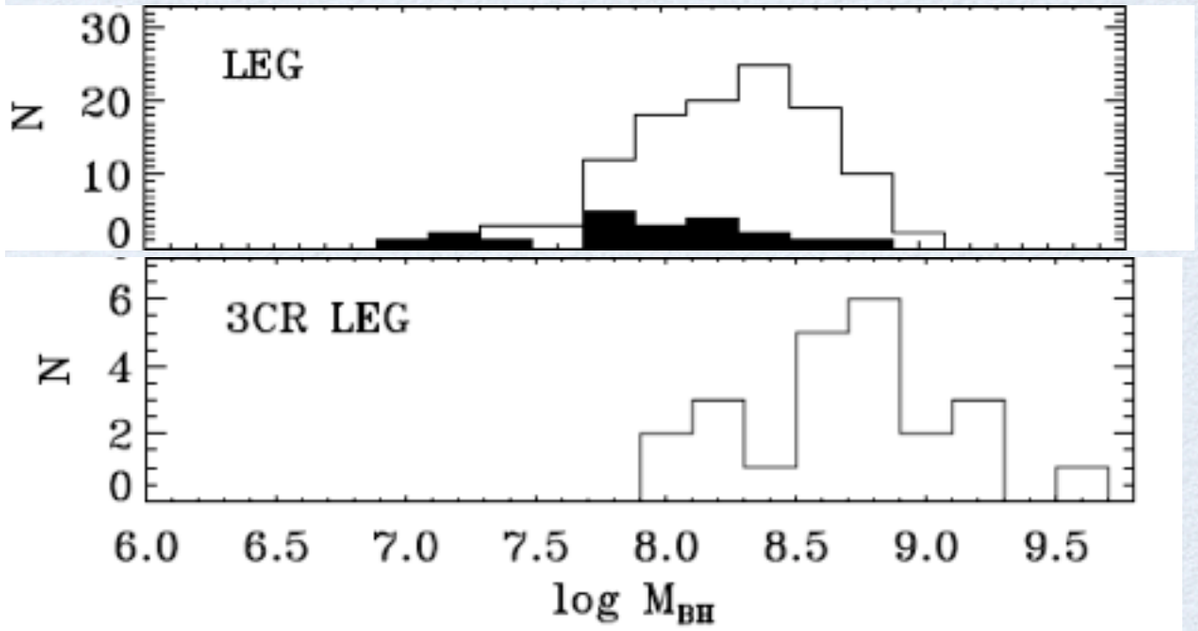

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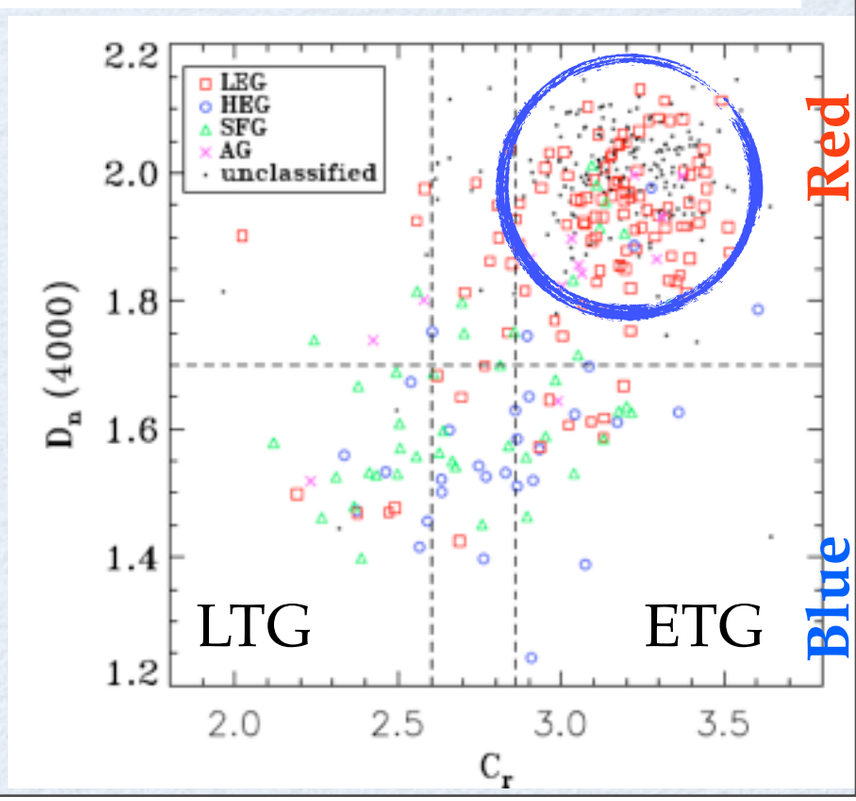


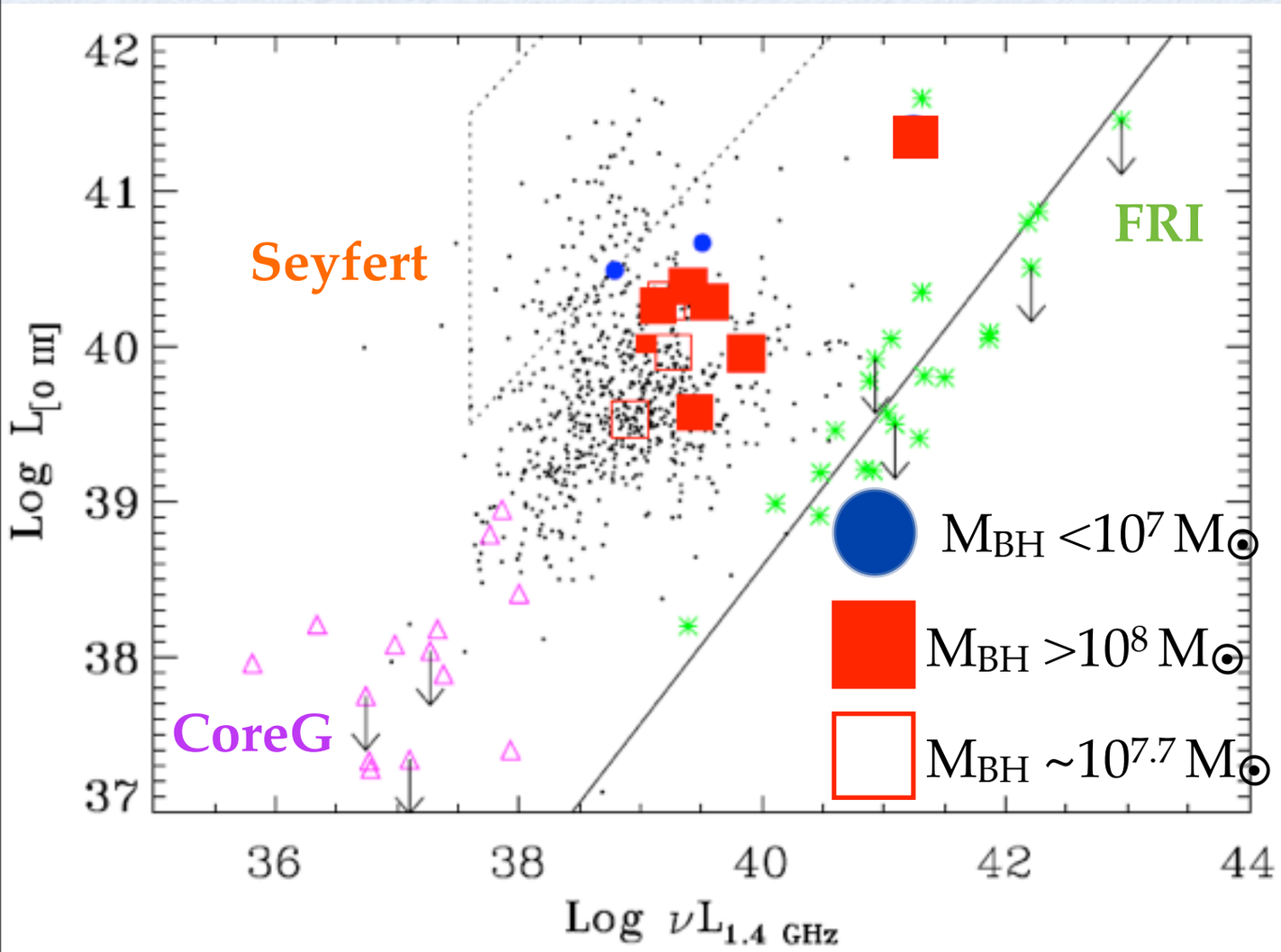
let me think...

The bulk of the local RL AGN population (with a space density 100 times higher than 3C sample) shows a lack of total radio emission w.r.t the classical 3C/FRI and LEG radio galaxies, although the nuclear and host properties are indistinguishable

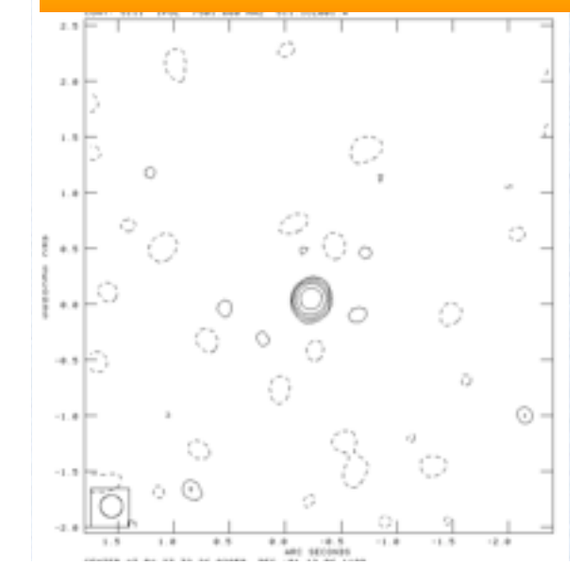
Let's focus the radio properties with a higher resolution

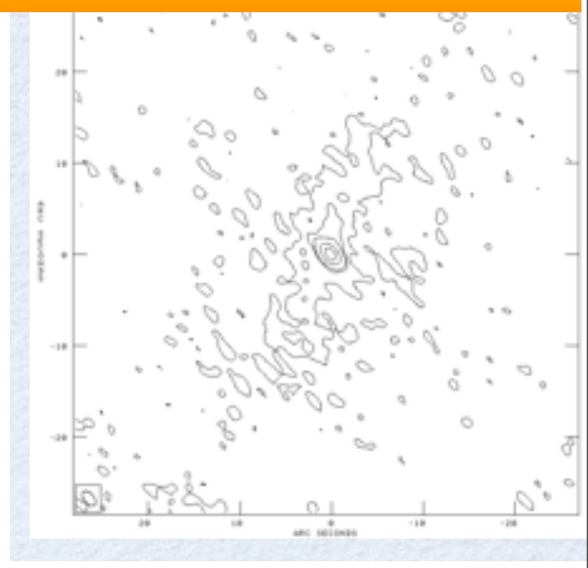
JVLA observations

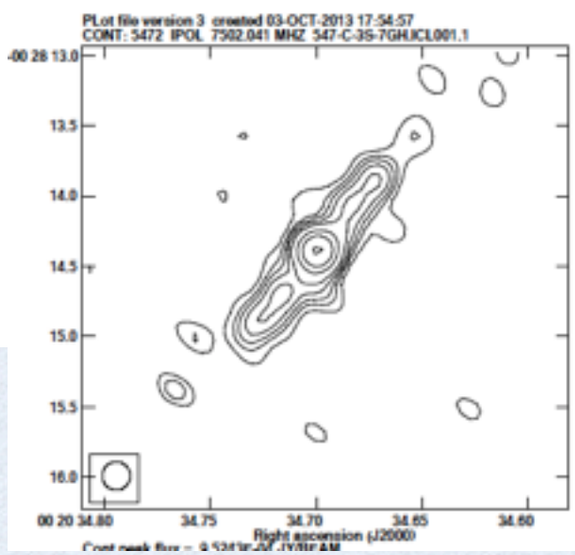
We propose to observe 40 objects with JVLA...but only 12 were observed!

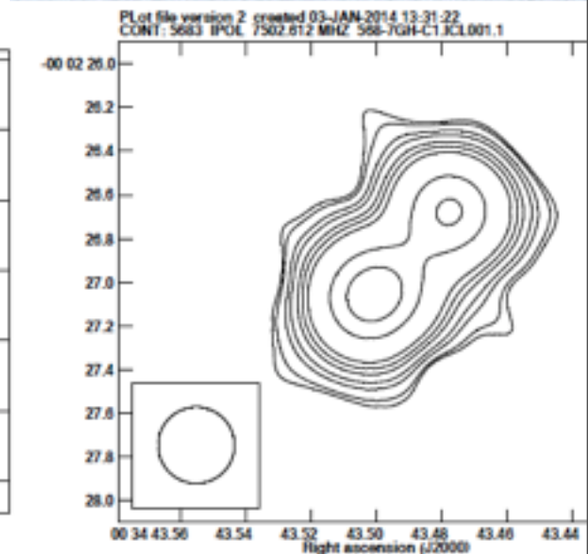


Radio maps: < 0.2″, < 3kpc





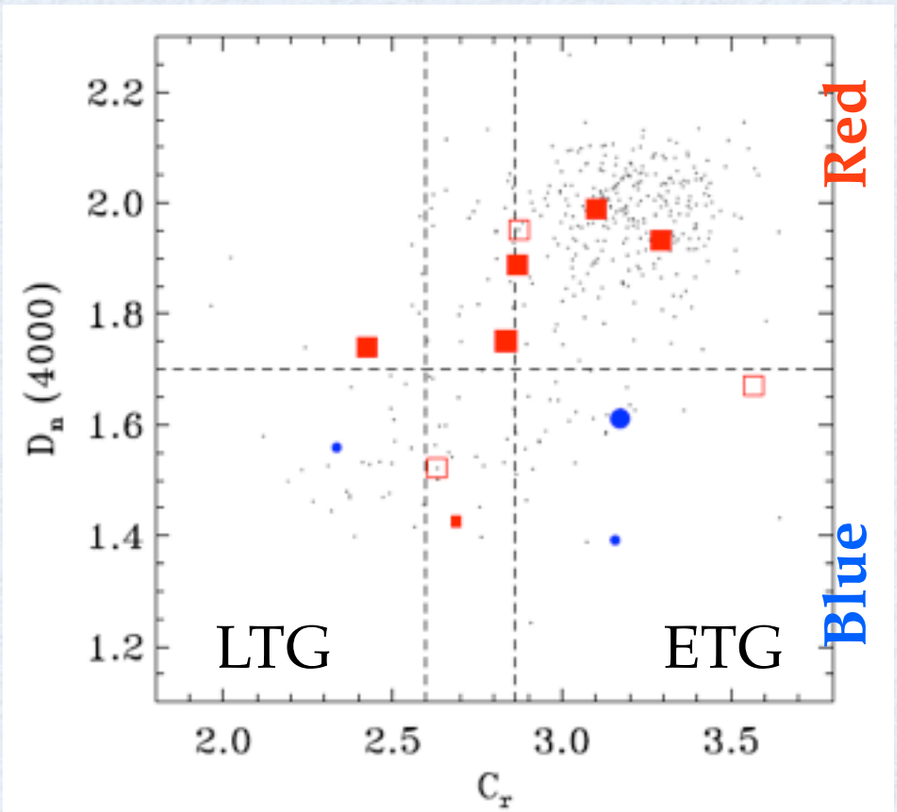




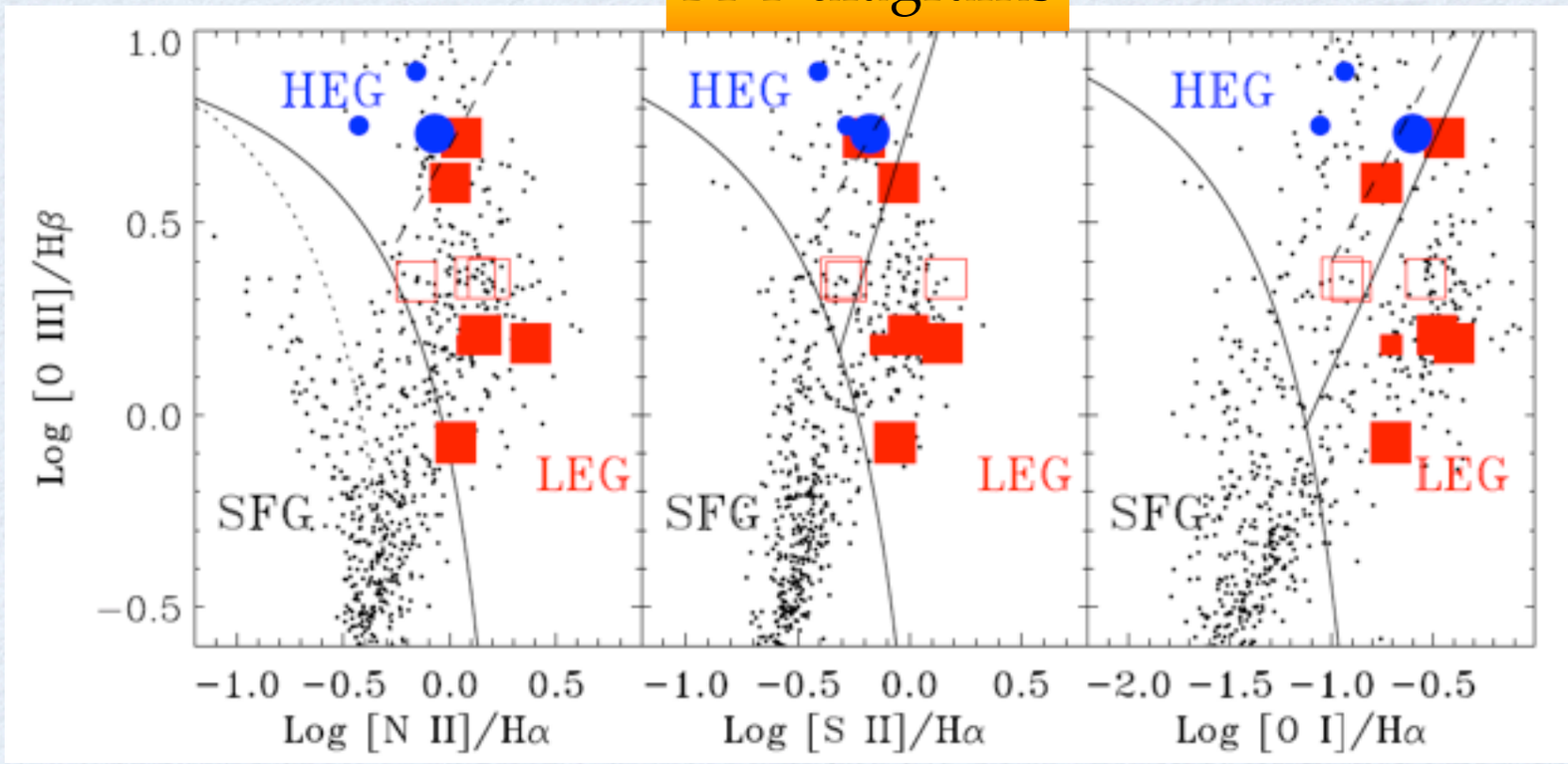
Observations at 1.4, 4.5, and 7.5 GHz with resolution 1.2″-0.2″

Spectro-photometric properties

SDSS images



BPT diagrams



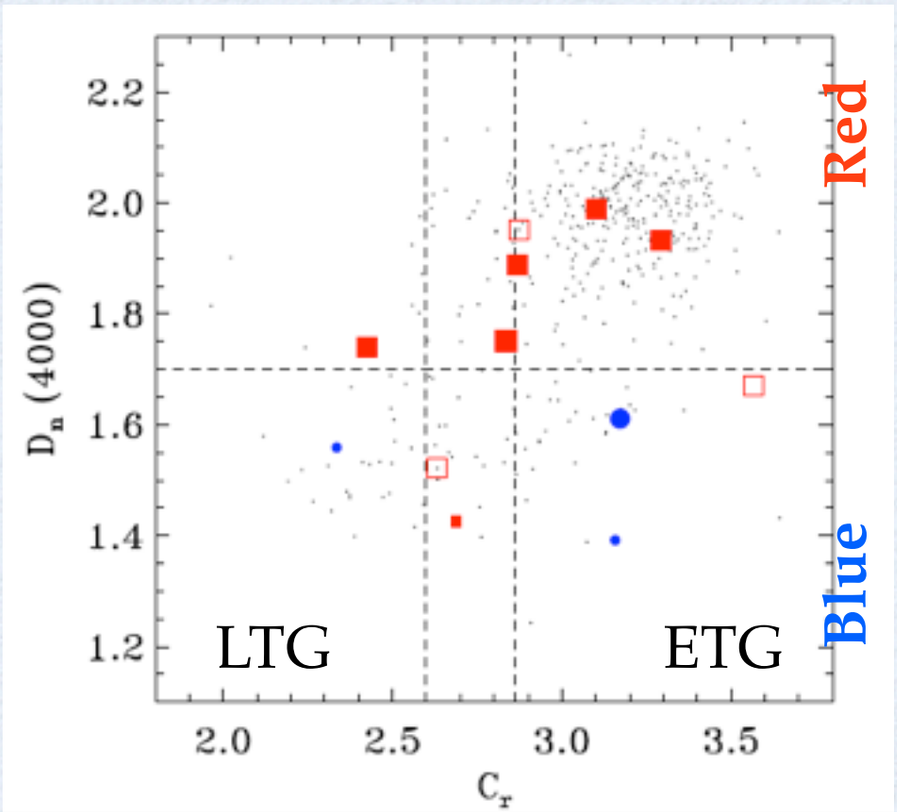
Radio-loud: LEG - $M_{BH} \gtrsim 10^8\ M_\odot$ - red host

Radio-quiet: Seyfert - $M_{BH} < 10^7\ M_\odot$ - blue host

Baldi, Capetti & Giovannini 15

Spectro-photometric properties

SDSS images



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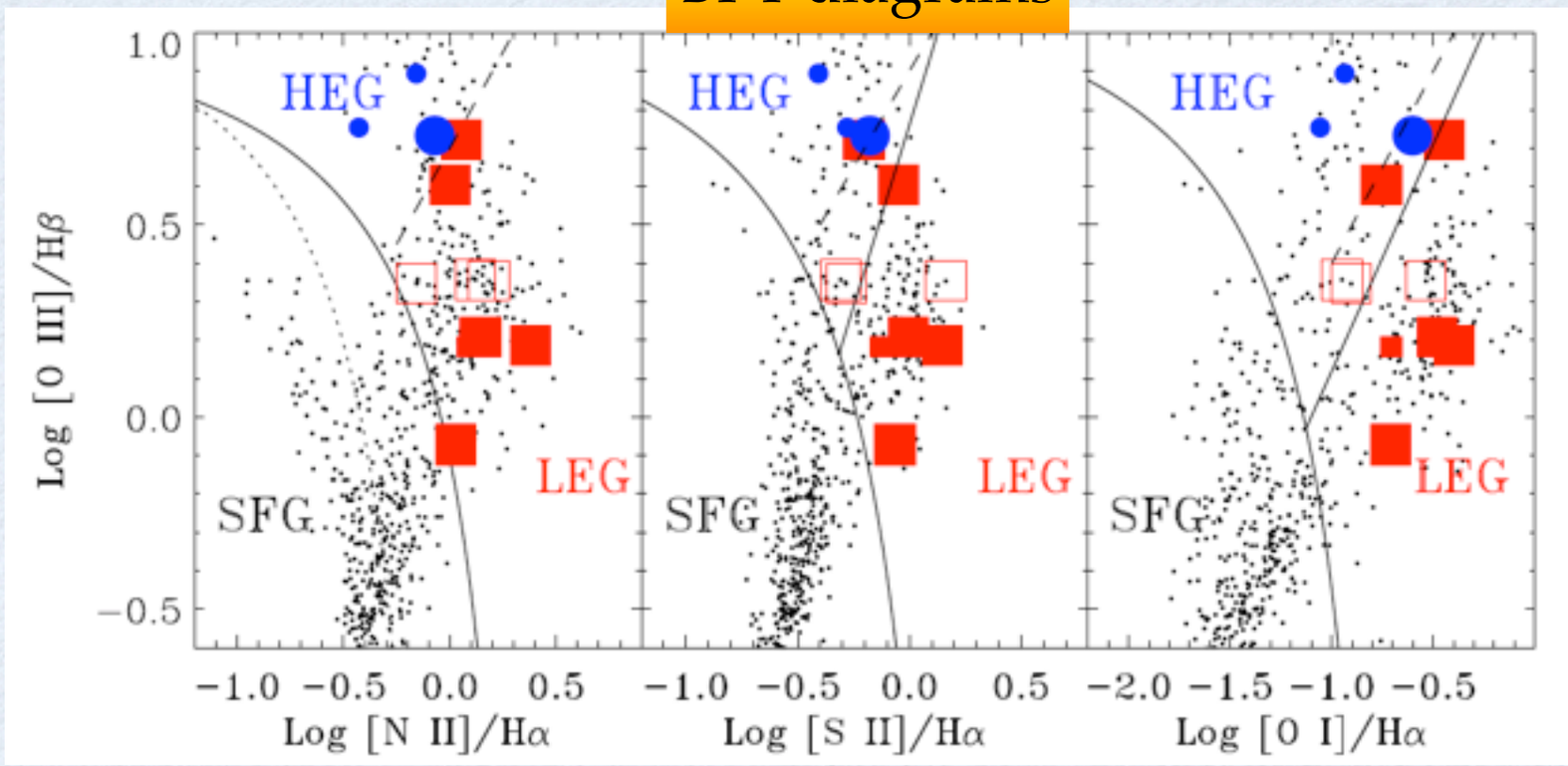

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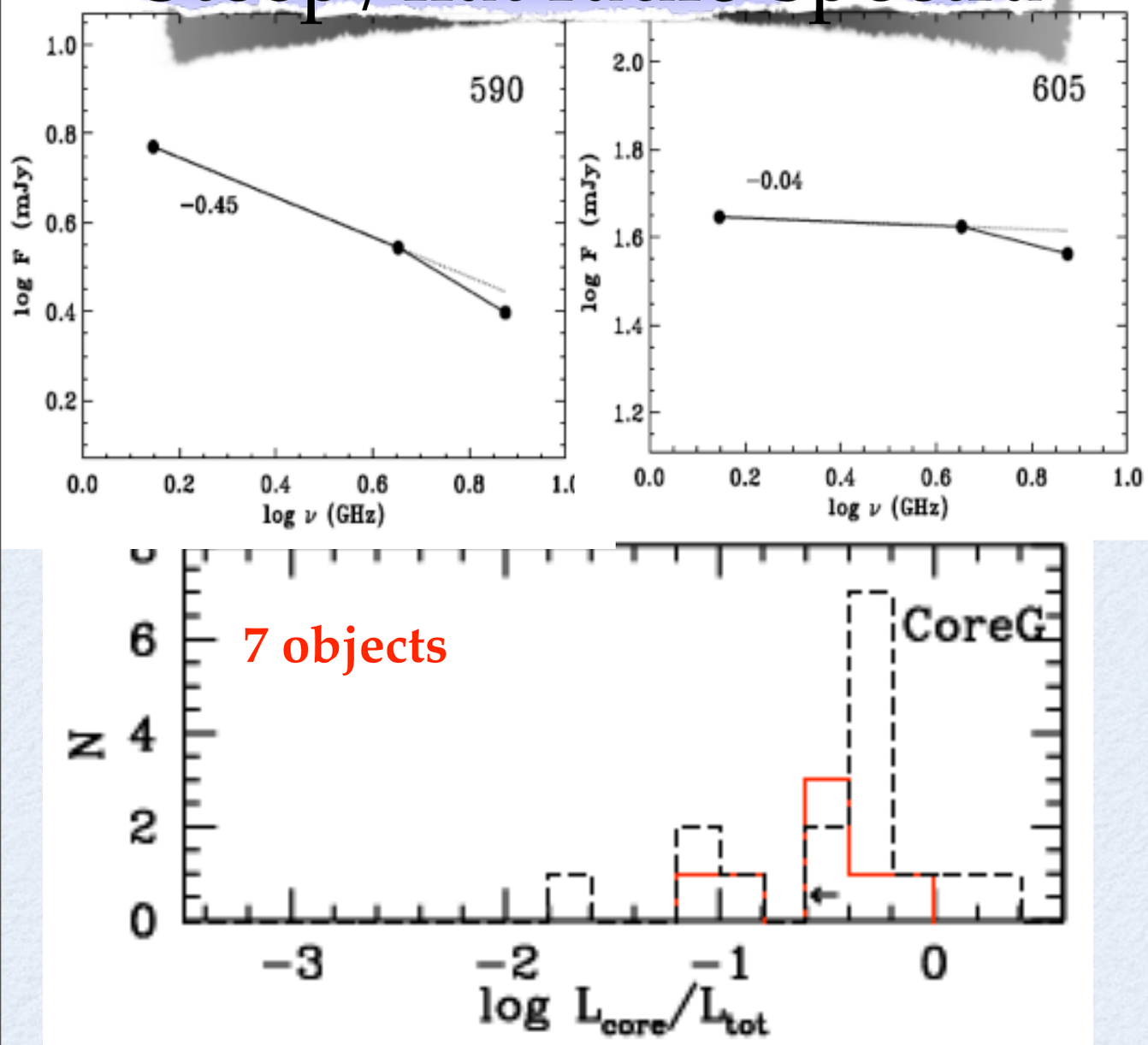
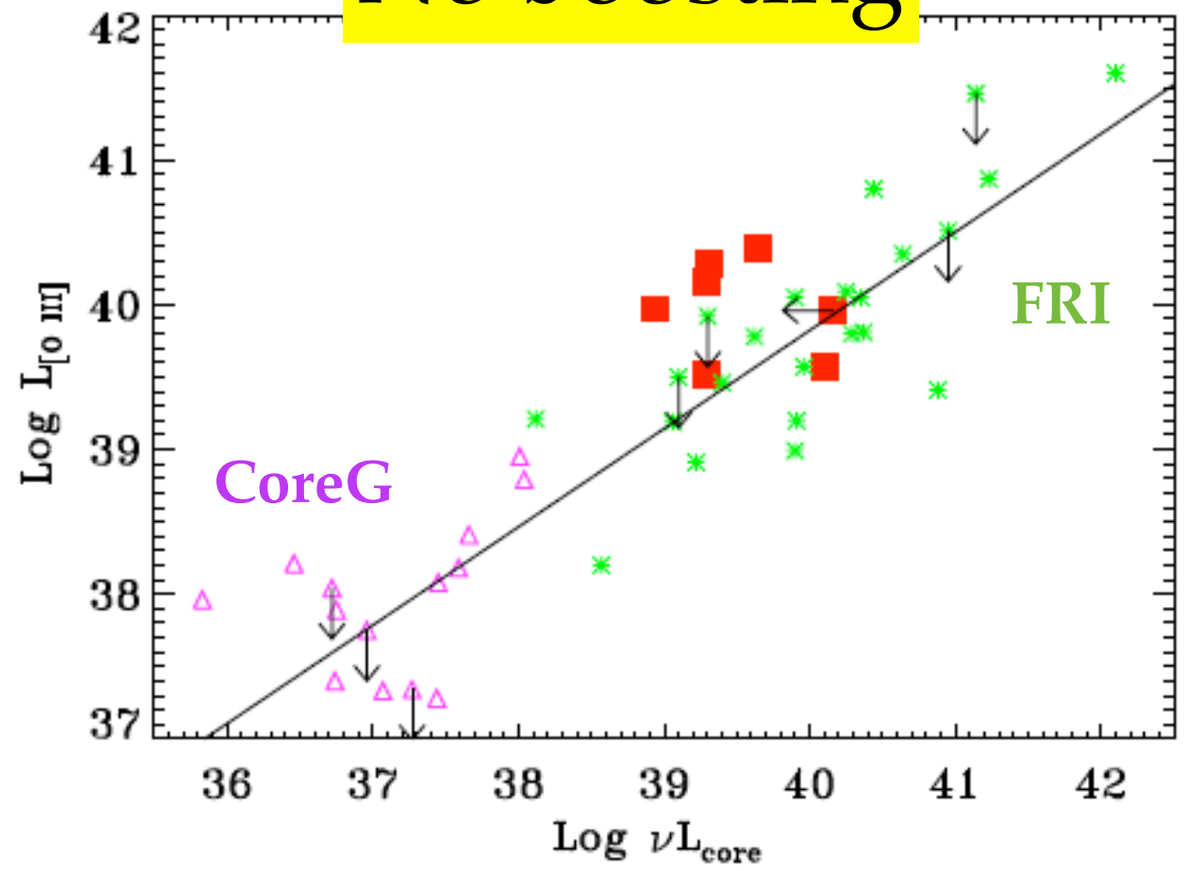
7 are radio-loud objects..

Steep / flat radio spectra



Baldi, Capetti & Giovannini 15

No boosting



The radio-loud objects are located in red massive early-type galaxies, have large BH mass ($\gtrsim 10^8\ M_\odot$), LEG optical spectra, and high core dominance:

similar to the CoreG

FR 0 radio galaxies

Baldi, Capetti & Giovannini 15

★ compact radio morph.

★ high core dominance

★ radio core - [OIII] luminosity

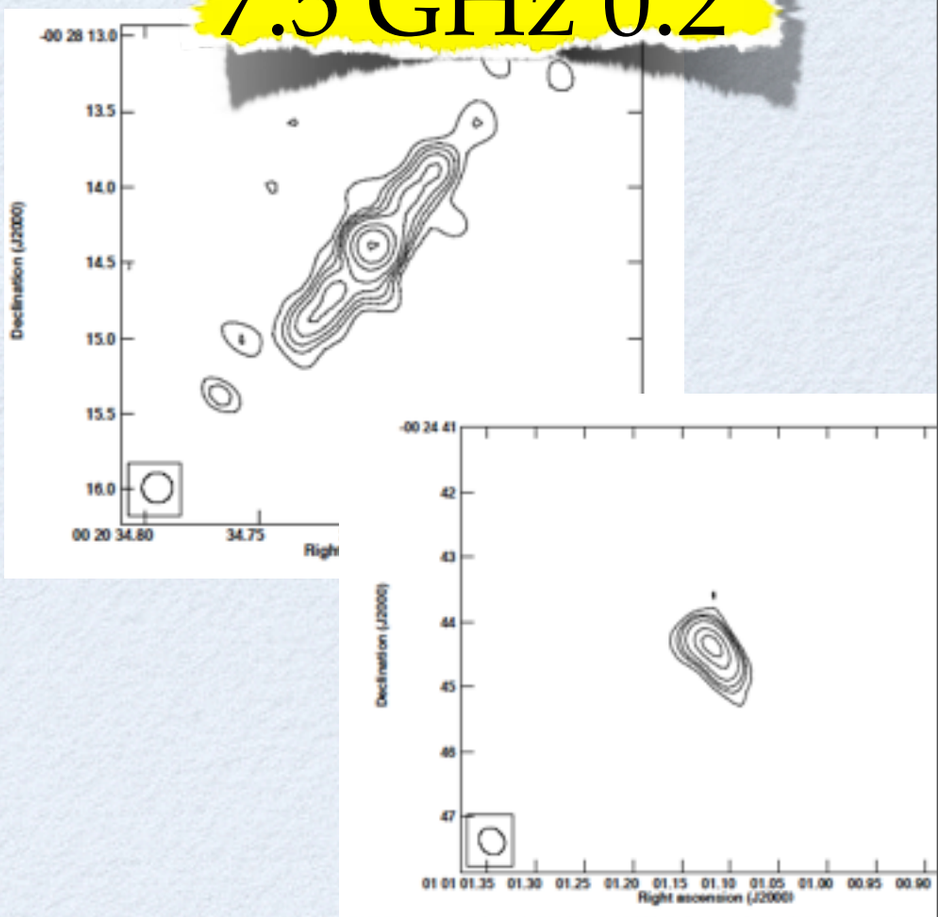
★ LEG spectrum

★ red (elliptical) hosts

} FRI

} CoreG are FR0

7.5 GHz 0.2”



Ghisellini 2011: “*The ‘FR 0’ radio ellipticals are a new population of radio sources (Baldi et al. 2009) having the same core radio luminosity of FR Is, but hundreds of times less power in the extended emission.*”

(Best et al sample)

Sadler+ 14

Compact FR0 are the dominant source population at 20 GHz (AT20G-6dFGS sample)

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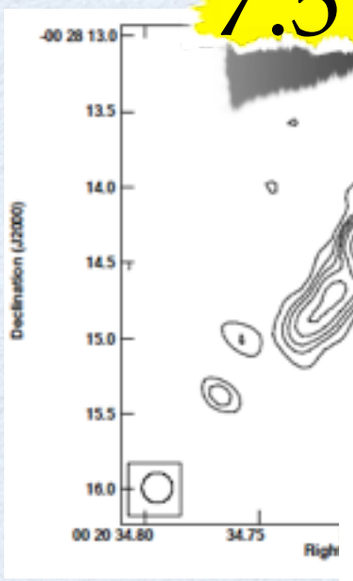

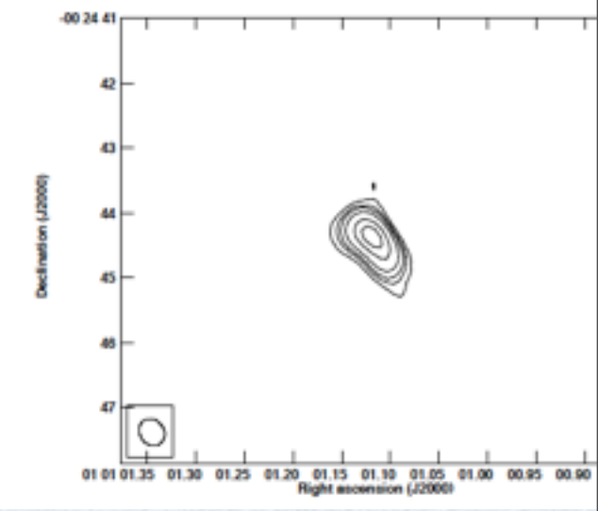

Sadler+ 14

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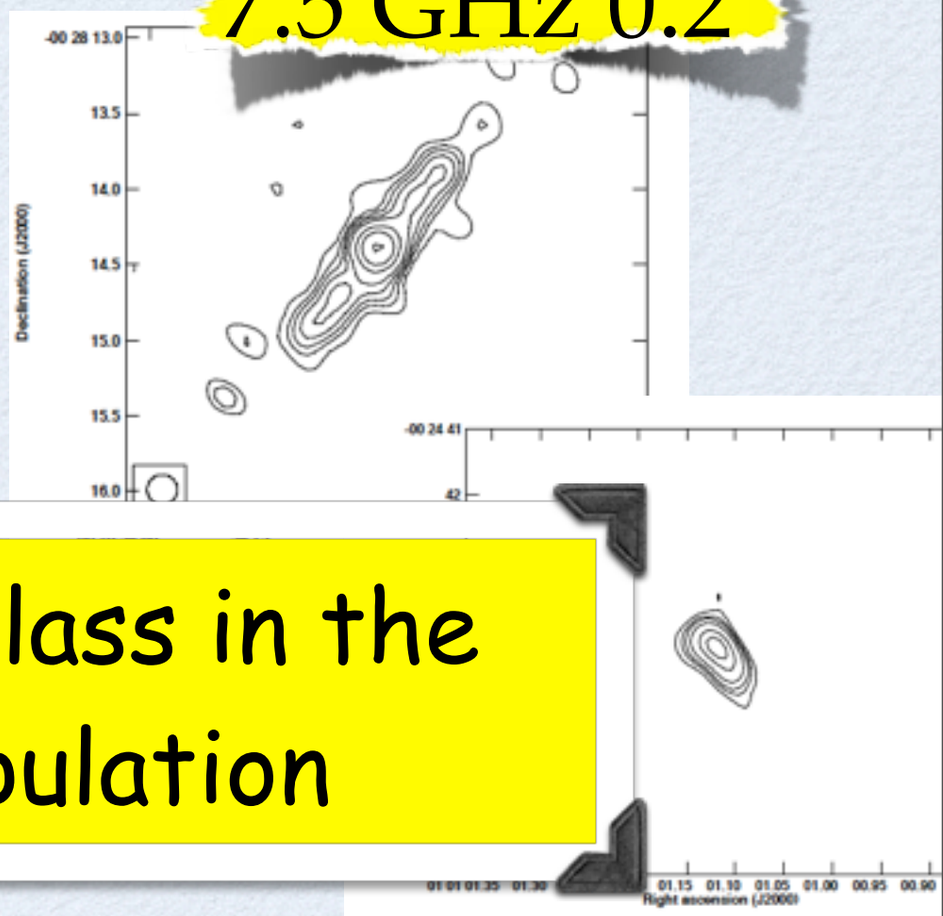

FR0 is the dominant radio class in the local radio-loud AGN population

Sadler+ 14

Compact FR0 are the dominant source population at 20 GHz (AT20G-6dFGS sample)

What sets a FR0?

To account for the numerous population of FR0 in the local Universe, two possible scenarios:

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Evolutionary effect

young radio sources?

intermittent activity?

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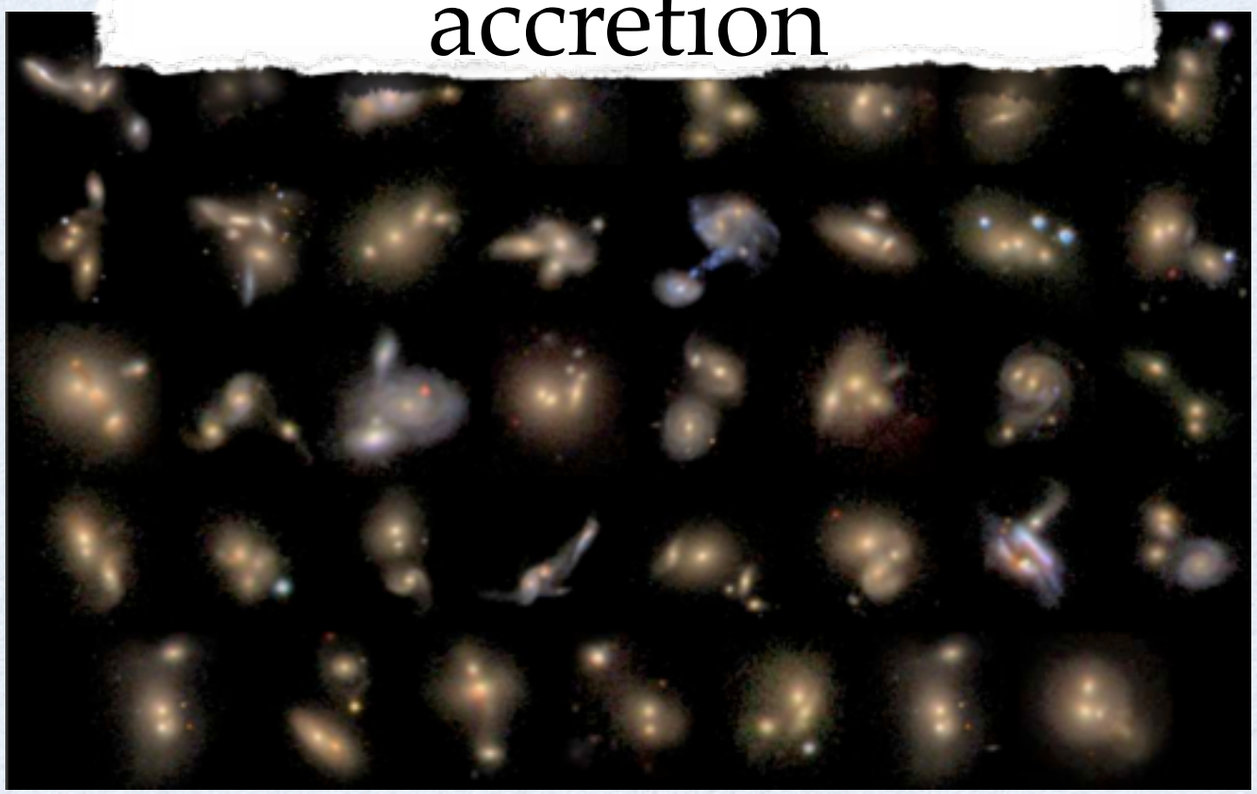
the ultimate origin of the low speed?

small BH spin

Galaxy evolution via BH mergers and gas accretion



Volonteri+ 13

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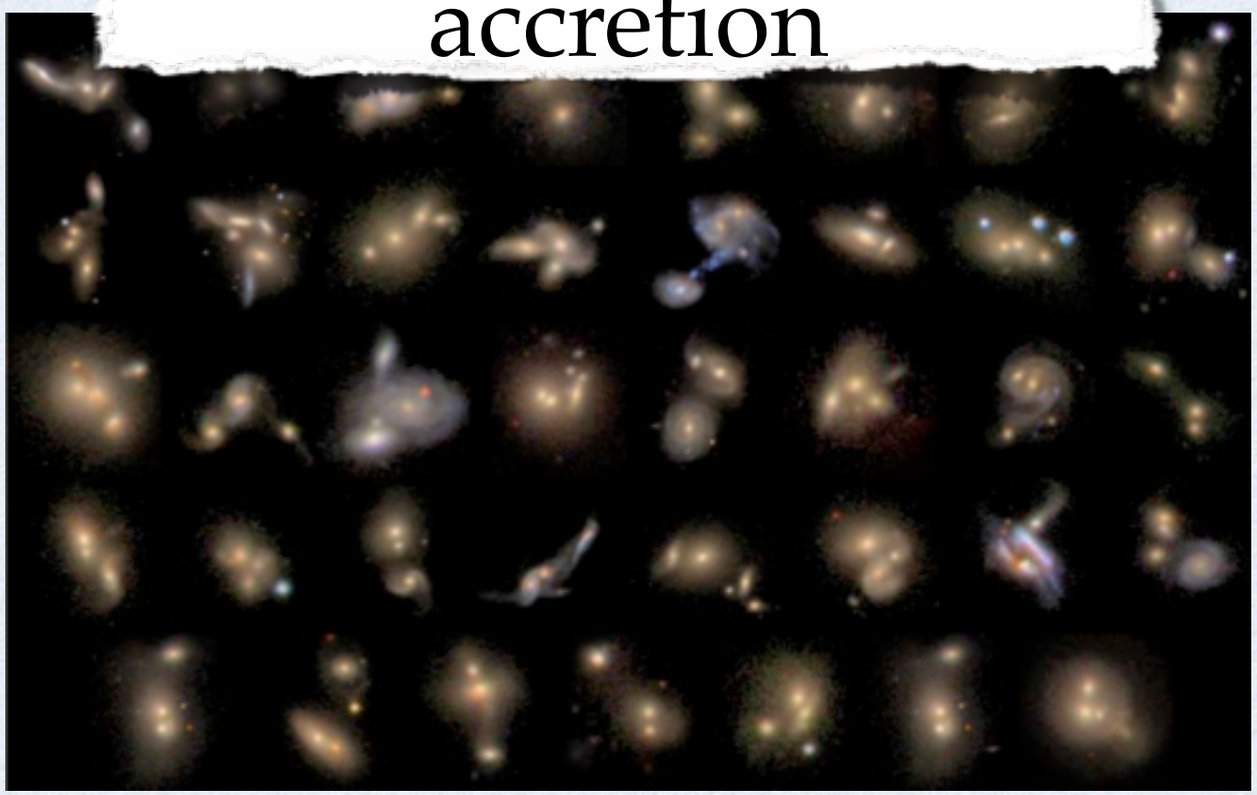

Volonteri+ 13

Assuming a dependence between BH spin (the BH mass) and jet Γ **(McKinney 05, Tchekhovskoy+ 10, Chai+ 12, Maraschi+ 12)**

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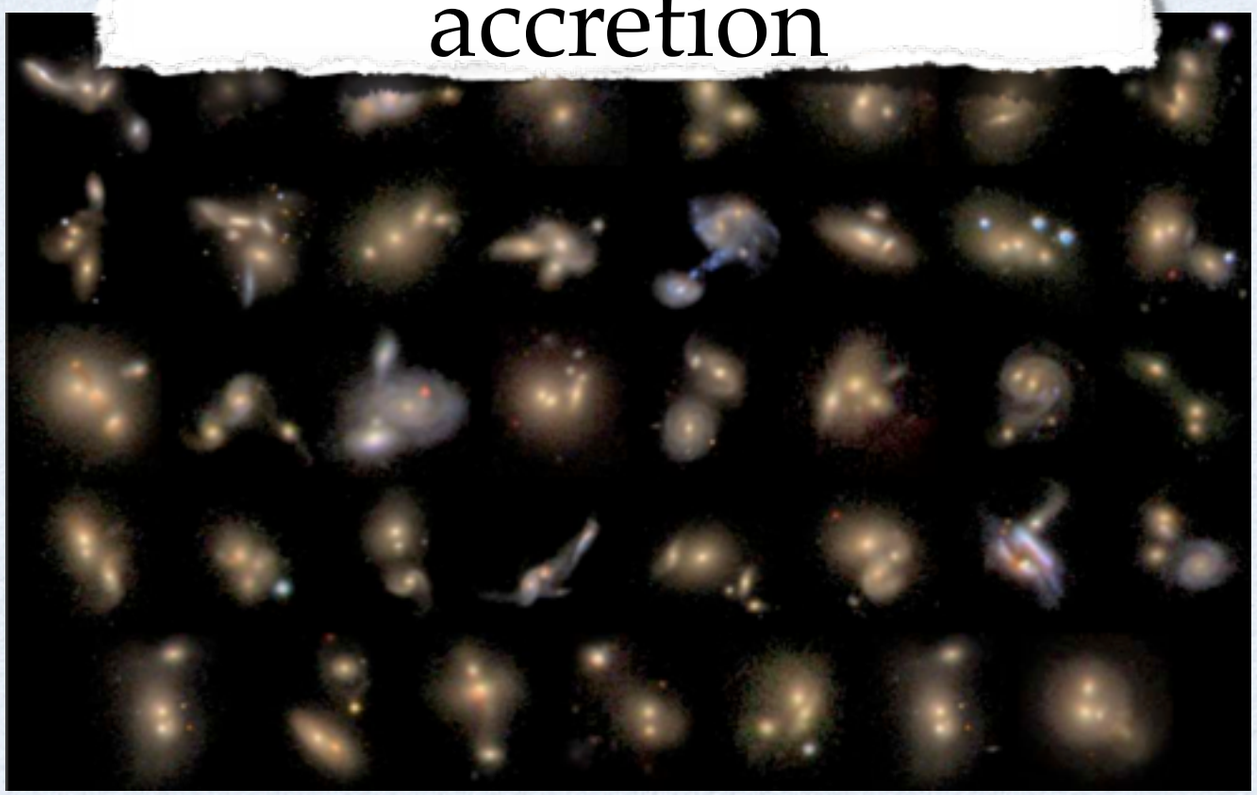

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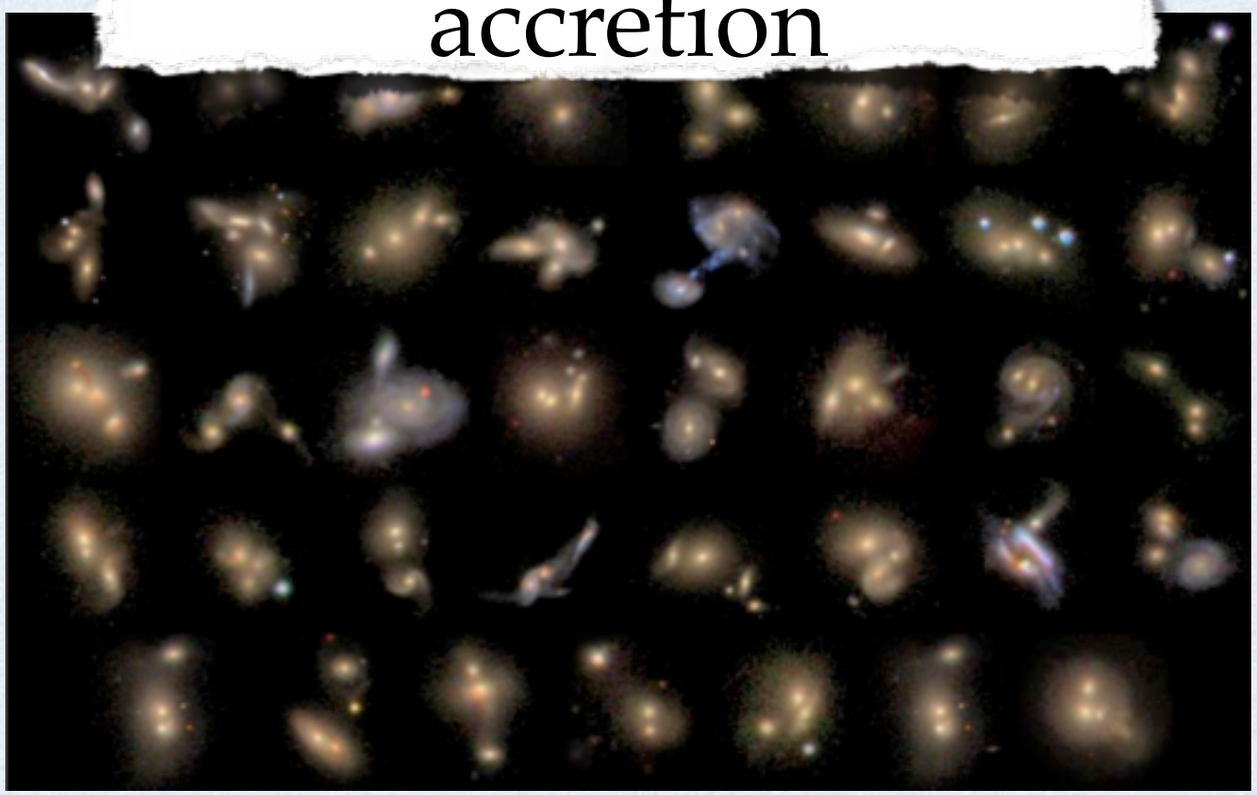

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BH Spin, Γ

FR0 **FRI-FRII**

Γ~1-3 **Γ > 5**

Summary & Future

- **FR0** : RG with similar nuclear and host properties of FRI, but compact radio structure and lack of substantial large scale radio emission

- FR0 population appears to be the dominant class of RG in the local Universe

- FRI and FRII do not represent the ordinary picture of a RG
- Slow jets (low Γ) may account for the FR0 radio properties
- The low jet speed might originate from their small BH spin
- How to test this scneario? study of the jet sideness
- Next: confirm FR0 population with a larger sample!!


THANK YOU