Jet-accretion system in the nearby mJy Radio Galaxies

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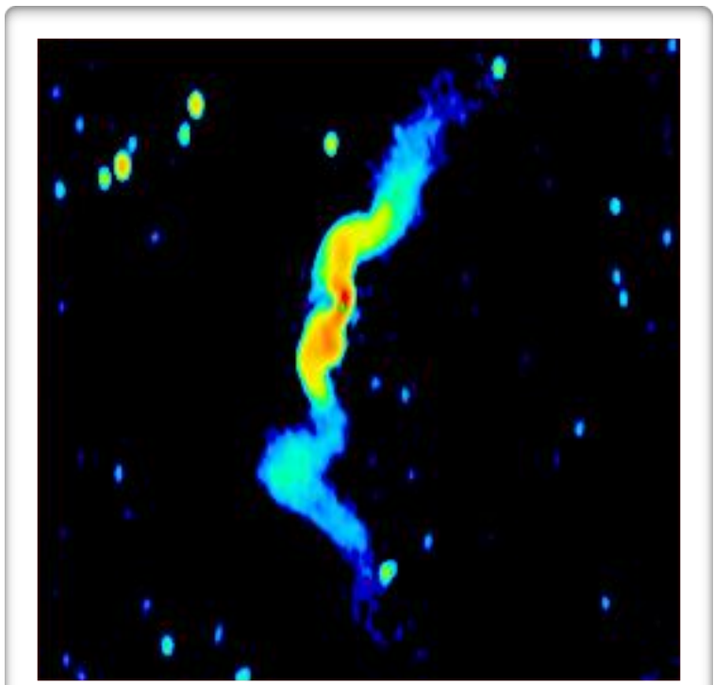
Grandi et al. 2021 ApJ

Classical Picture based on bright radio galaxies F_{radio}> Jy

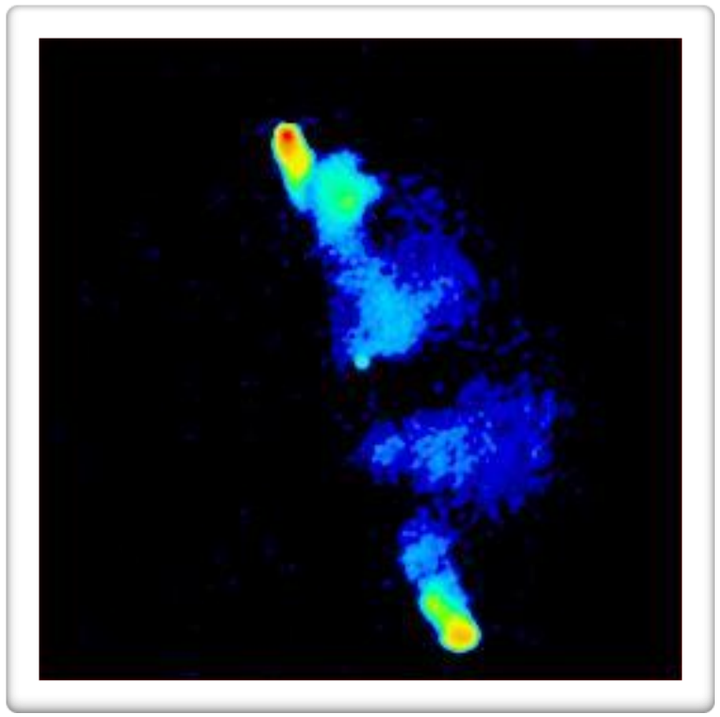
FR I

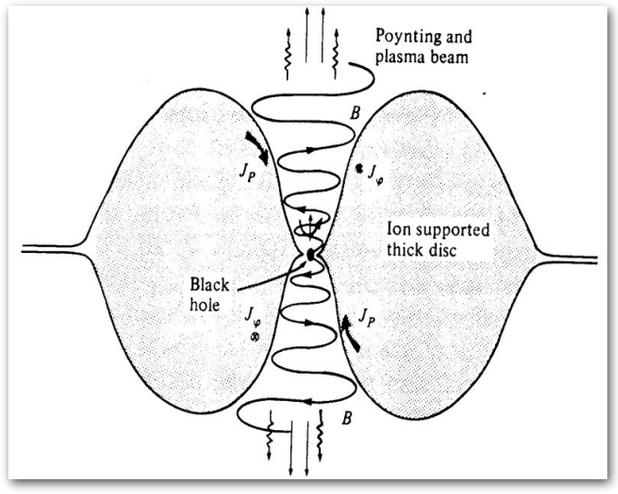
LERG

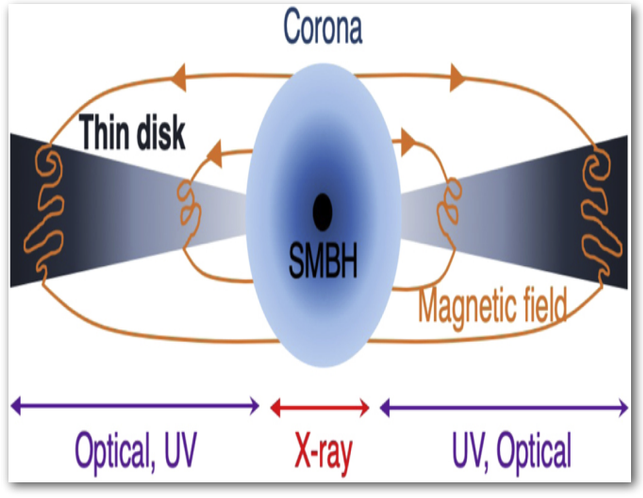


FR II

HERG







Credits: M. Sun 2020

CROSS-POPULATION RADIO GALAXIES do not fit the framework

see Laing'talk

for FRII-LERG class => Macconi 's poster

From Jy to mJy

Radio flux limit ~ Jy

Radio flux limit ~ mJy

FRCAT catalogs
z<0.15

Cross-correlation between deep optical (SDSS DR7) and radio (NVSS/FIRST) surveys

Table 1. Sample selection criteria: $F_{1.4\,\mathrm{GHz}} > 5\mathrm{mJy}$

Sample	z	Optical Class	Extension (kpc)
FR0cat	< 0.05	LERG	< 2.5
FRIcat	< 0.15	LERG	> 30
sFRIcat	< 0.05	LERG	> 10 and < 30
FRIIcat	< 0.15	LERG/HERG	> 30

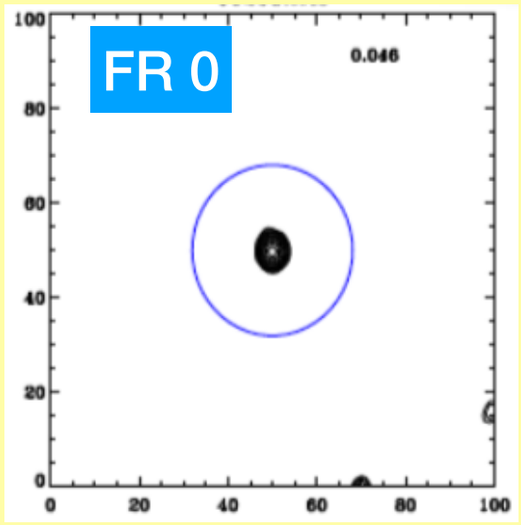
From Jy to mJy

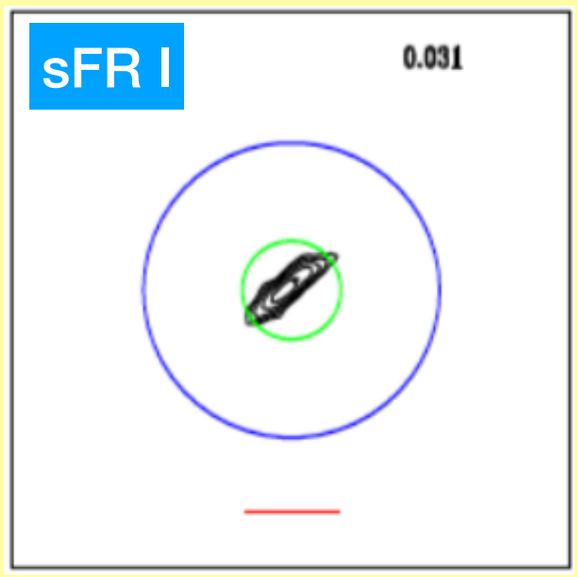
RG population changes going down in flux density challenging our historical RG view

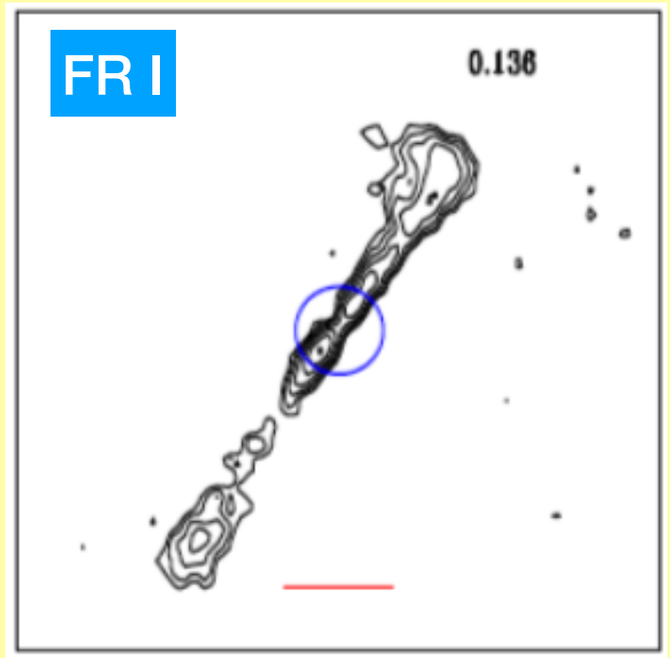
From Jy to mJy

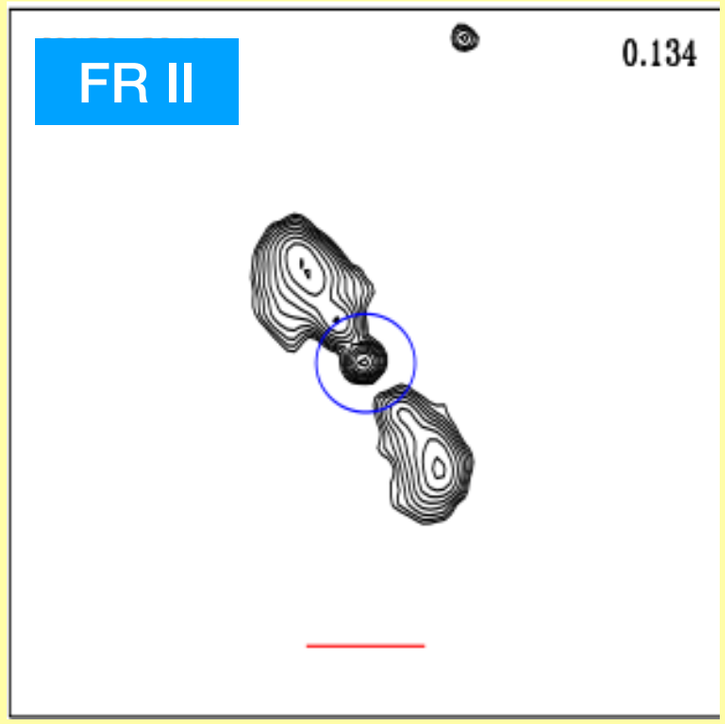
NUMBER DENSITY OF THE FRCat SAMPLES (z<0.15)

104 : 14 : 7 : 1









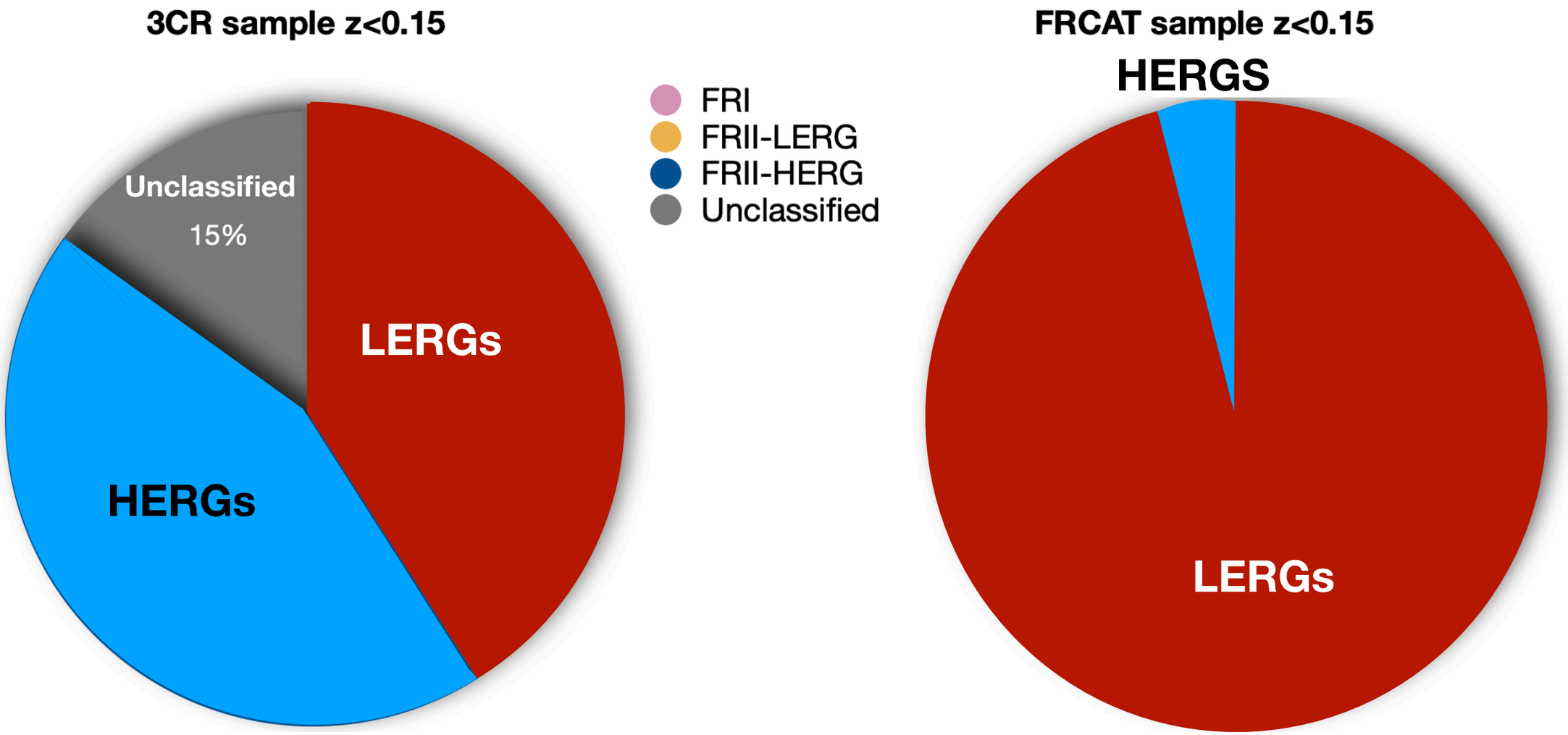
5 | 10<r<30 | >30 | >30

Credits: R.D. Baldi

RADIO SIZE (kpc)

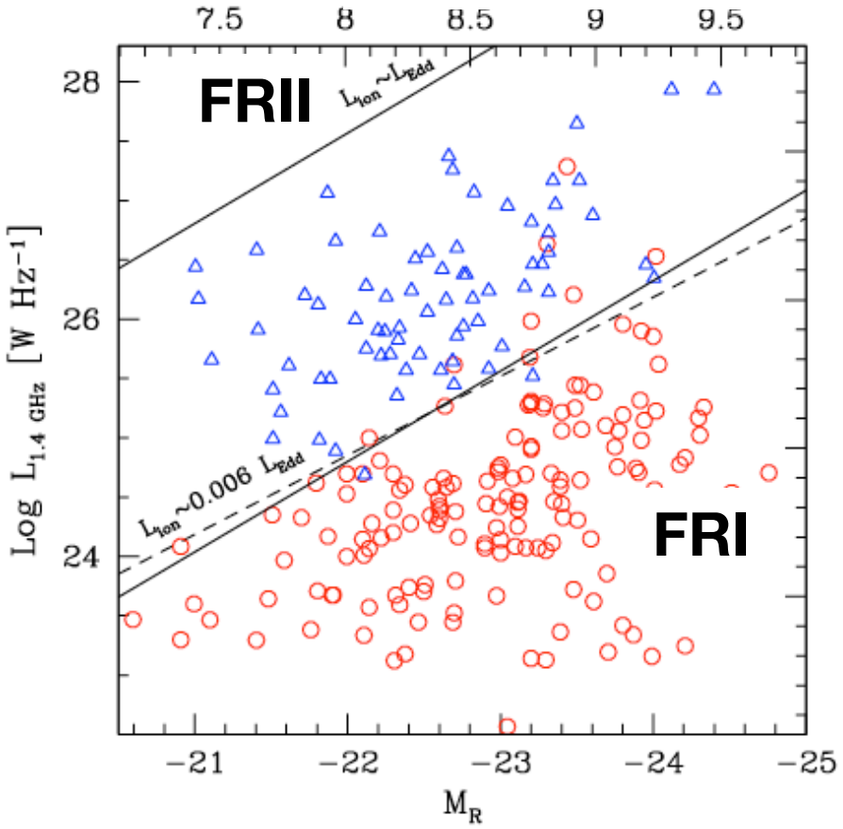
The majority of the radio sources at low redshift show compact emission

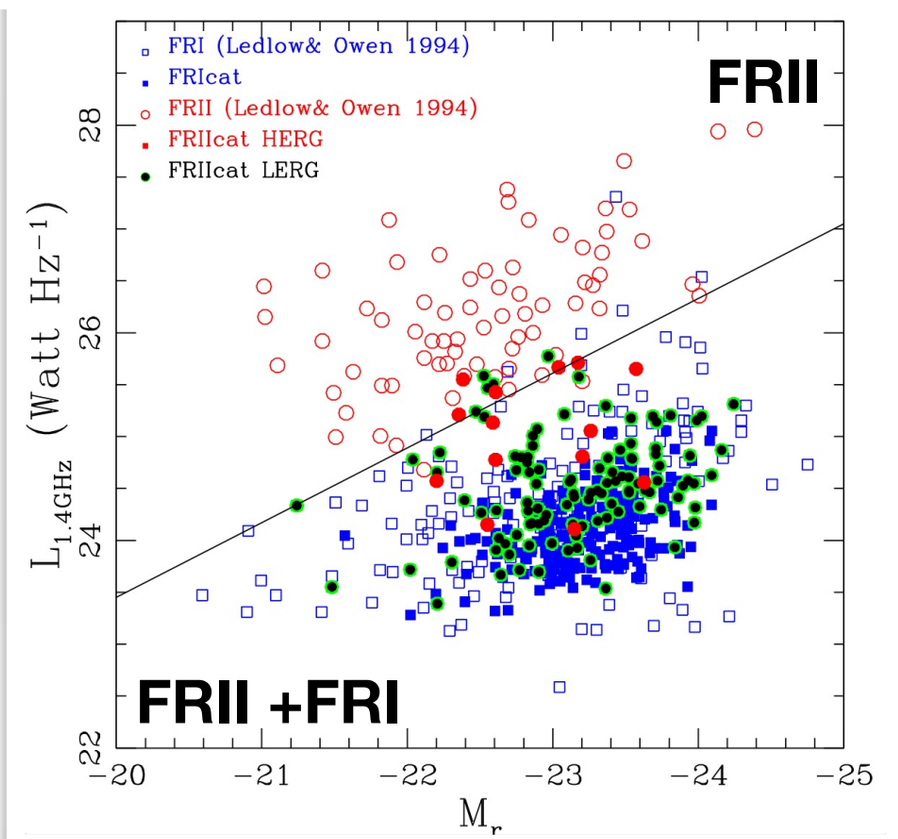
From Jy to mJy



mJy Universe dominated by LERGs

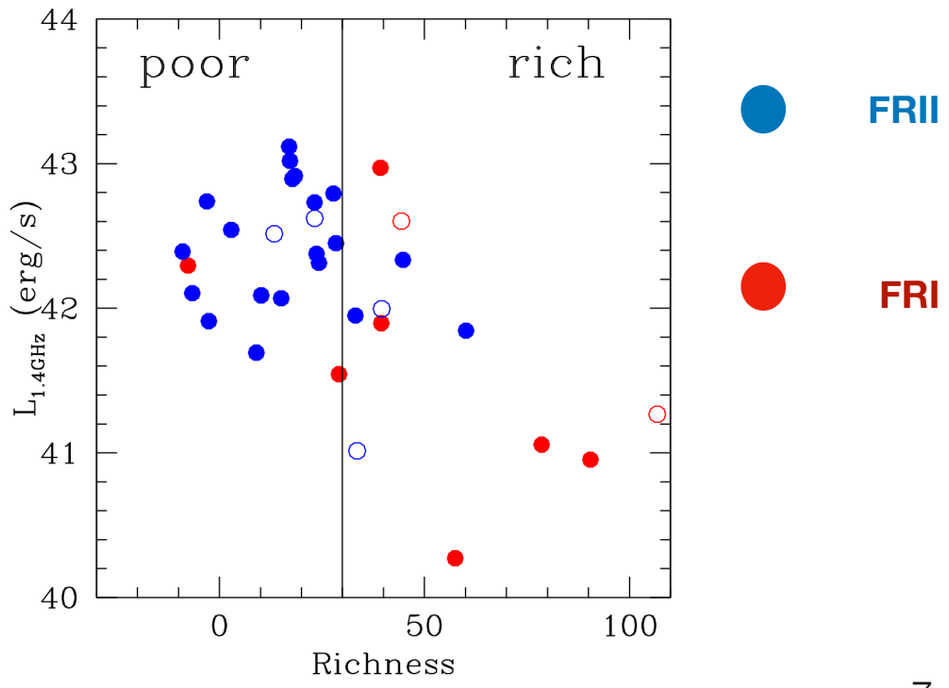
Ledlow&Owen diagram does not work anymore



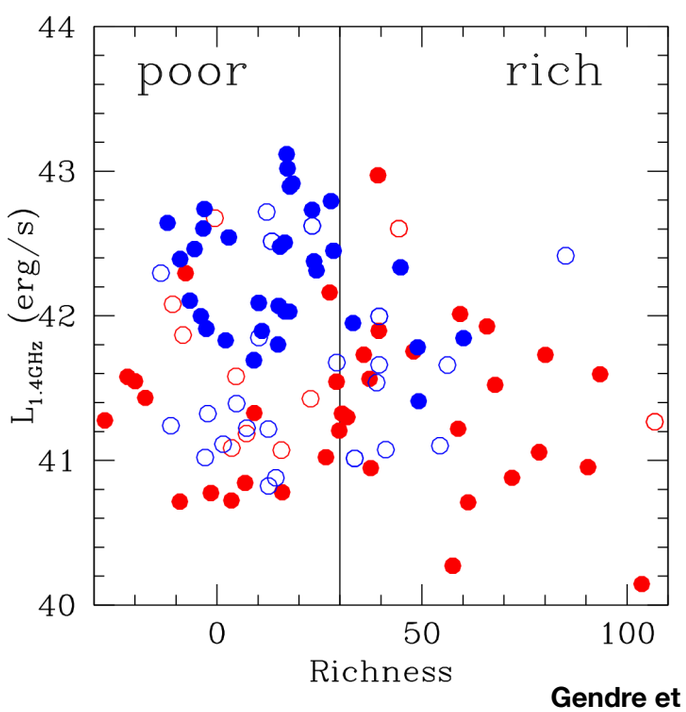


The environment role is less clear

3C sample

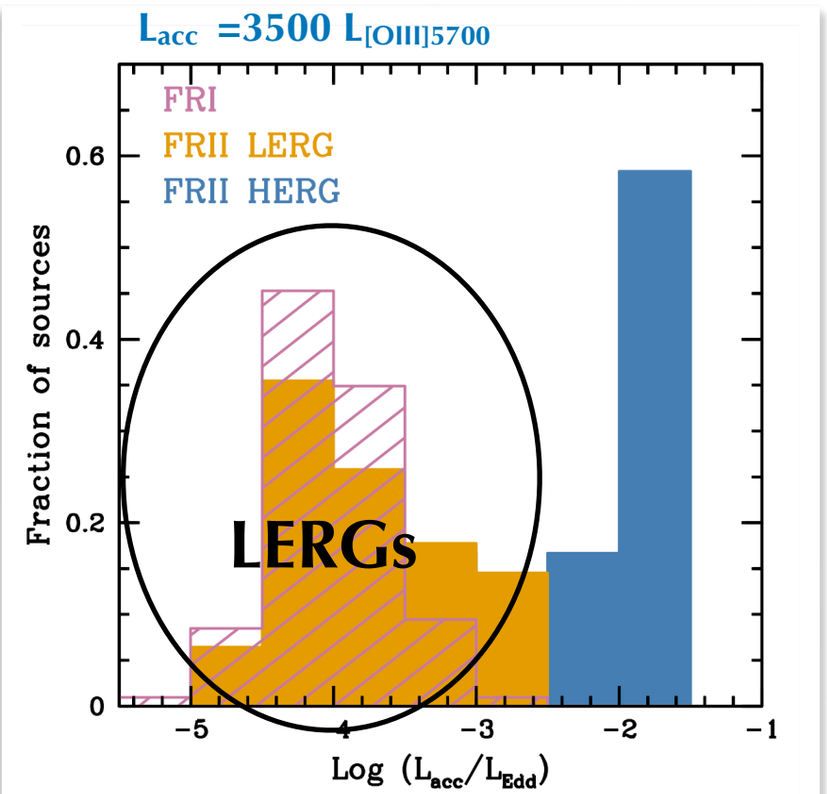


Config sample

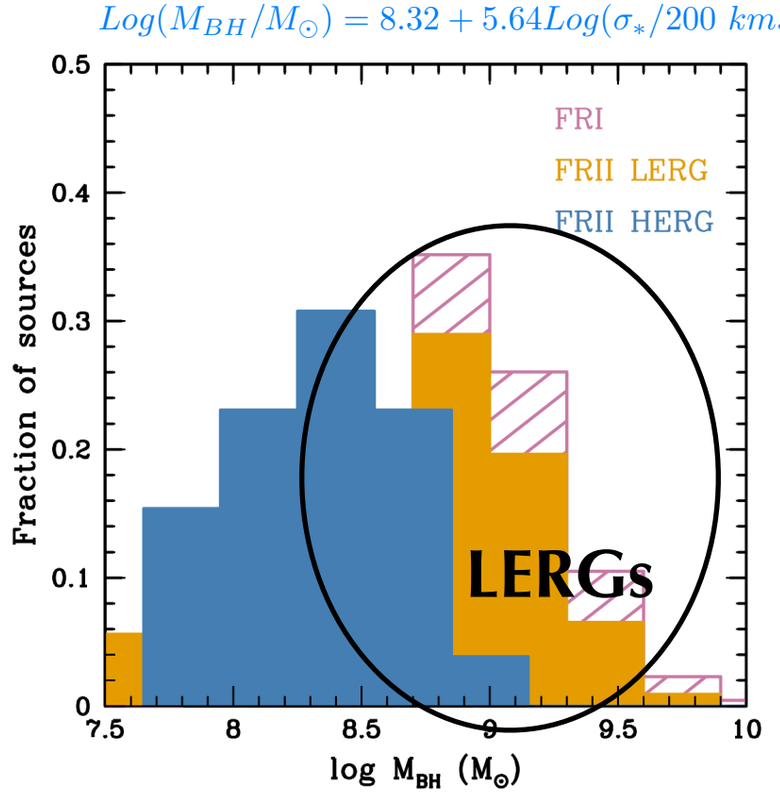


Gendre et al. 2013

mJy population: LERGs versus HERGs

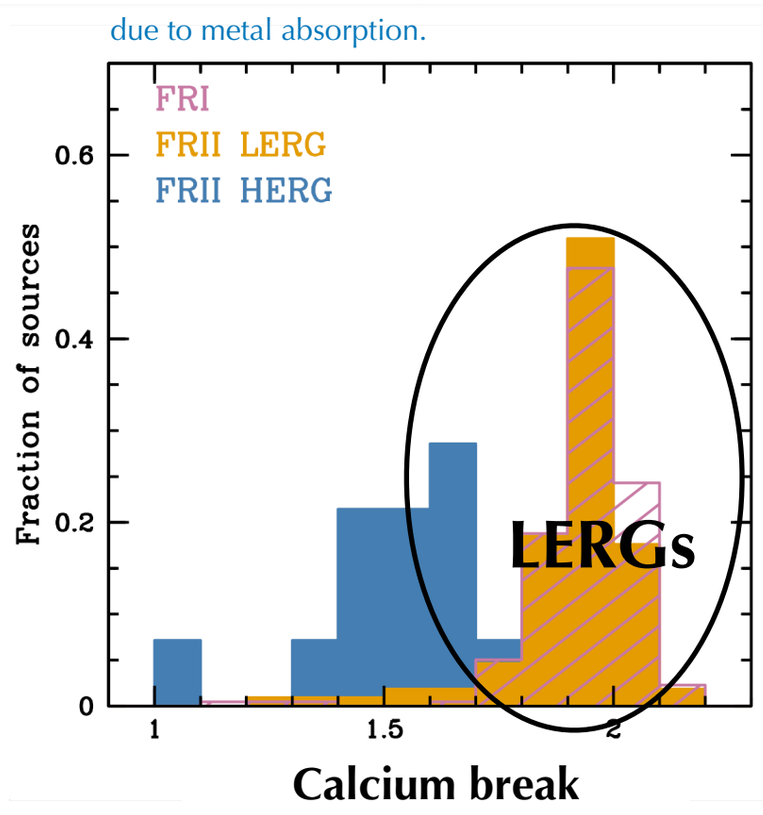


smaller accretion rates



more massive black holes

The calcium break is a drop in the optical spectra due to metal absorption.



more evolved stellar population

In the local mJy Universe, the majority of radio galaxies is in a late stage of their life.

1. L_{acc}: Heckam et al. 2004
2. MBH: McConnell & 2013
3. Calcium Break: Balogh et al. 1999

JET POWER VERSUS ACCRETION POWER
in mJy radio galaxies

$$P_{jet} = \eta \dot{M} c^2$$
$$L_{acc} = \epsilon \dot{M} c^2$$

$$P_{jet} = (\eta/\epsilon) L_{acc}$$

Efficiency Ratio

η = fraction of gravitational energy converted into jet power

ϵ = fraction of gravitational energy converted into thermal radiation

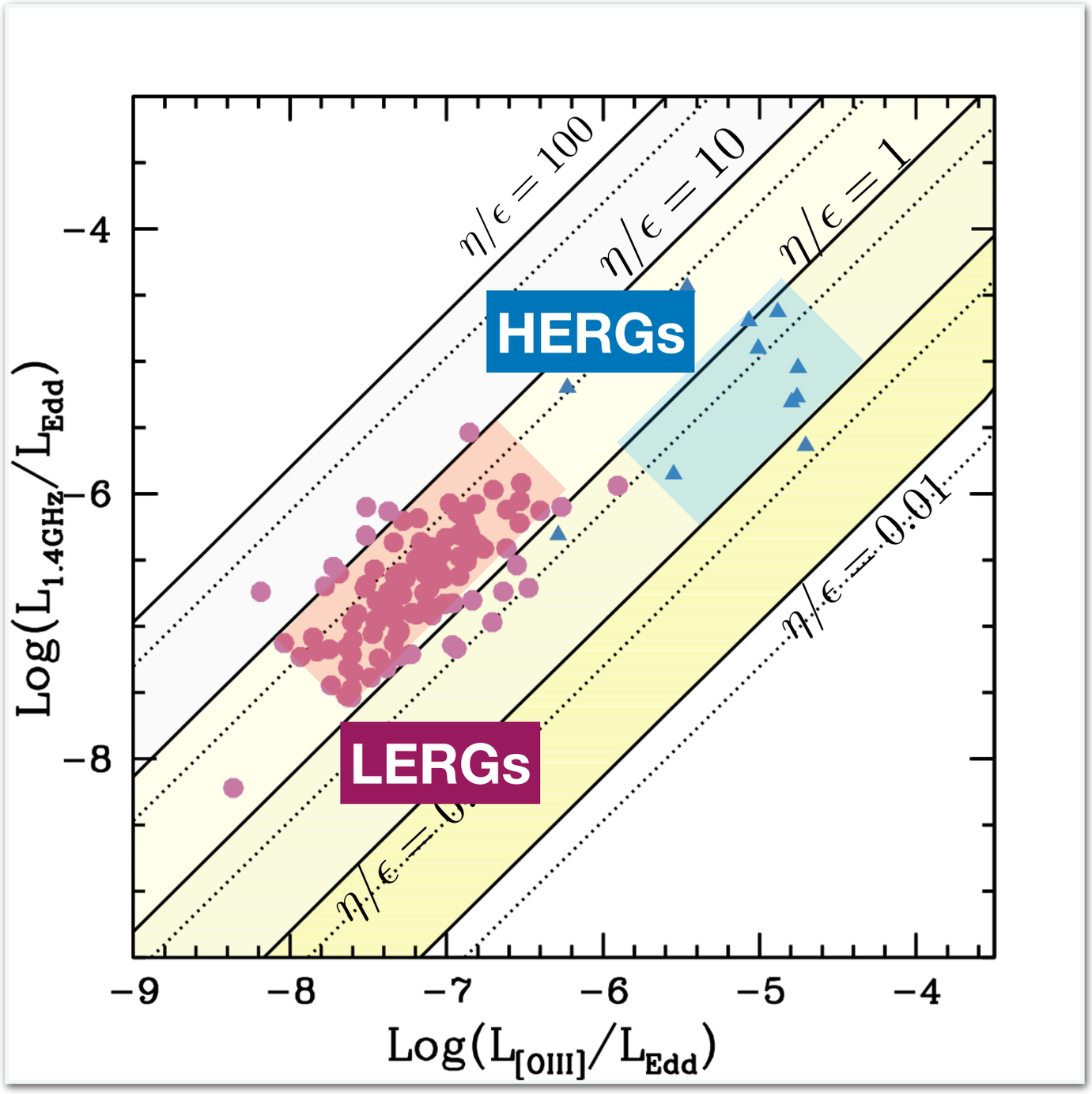
see Daly's talk

$M_{BH} = 10^{9.5}\ \mathrm{M}_\odot$ ——————

$M_{BH} = 10^{7.5}\ \mathrm{M}_\odot$ ..... **Predicted $L_{1.4GHZ}$ and L_{OIII} for η/ϵ = 0.01, 0.1,1,10,100**

● **Extended (FRI)**

▲ **Extended (FRII)**



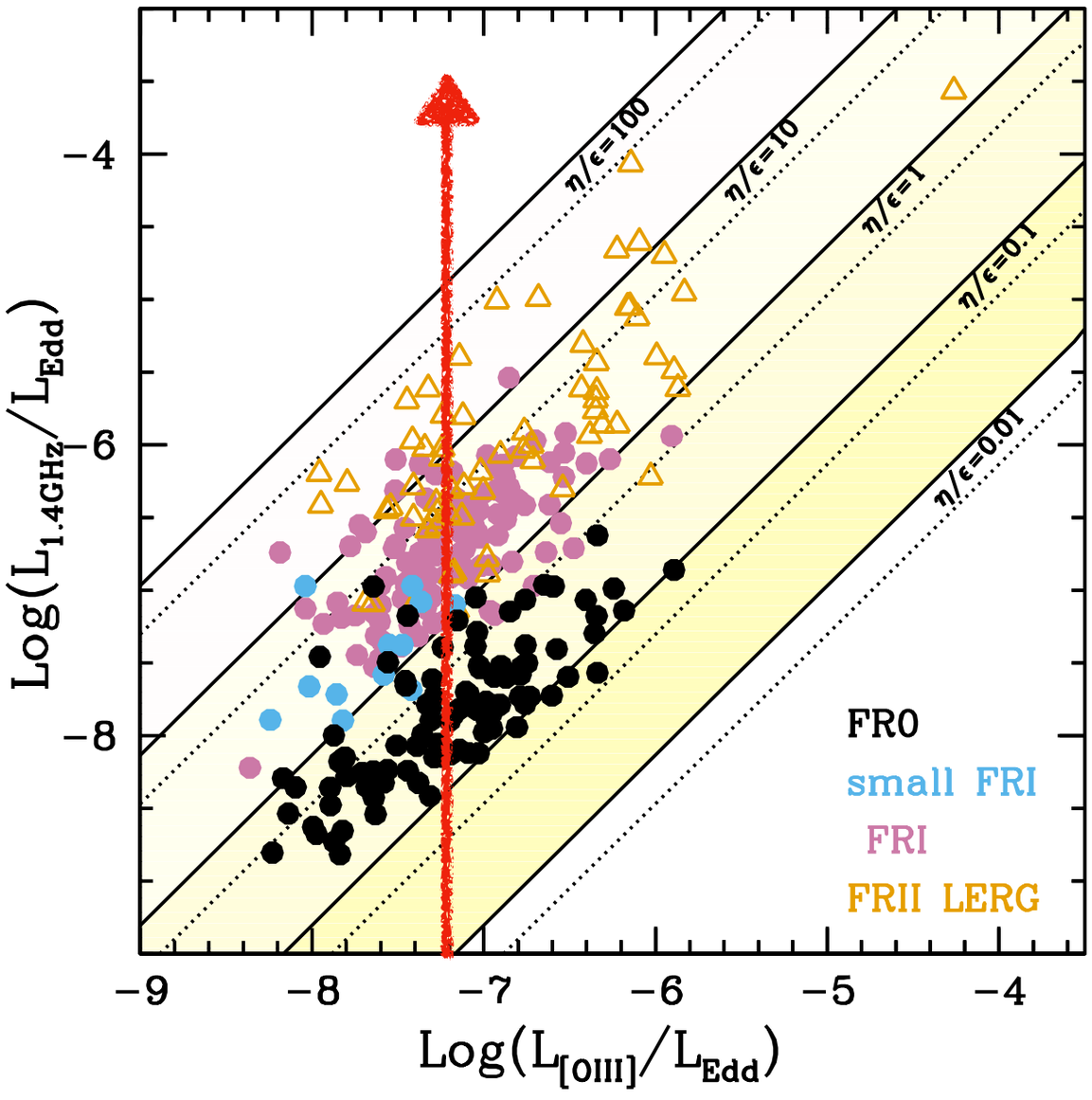
LERGs prefer larger η/ϵ

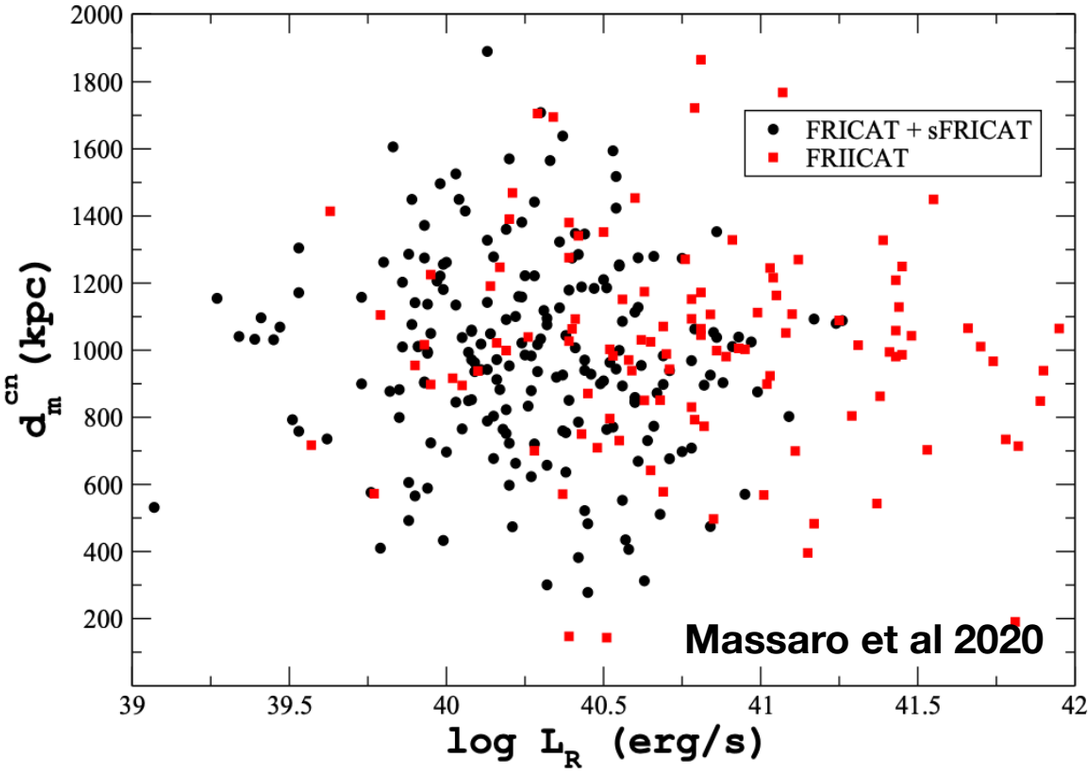
Jet-disk systems in HERGs (SS disk) favour a thermal dissipation of the gravitational power

Jet-disk systems in LERGS (ADAF) prefer a kinetic dissipation of the gravitational power

LERGs: FRI, small FRI, FR0, FRII-LERGS

wide range of $L_{1.4GHz}/L_{Edd}$ ($\propto$ P_{jet}) for similar $L_{[OIII]}/L_{Edd}$ ($\propto$ L_{acc})

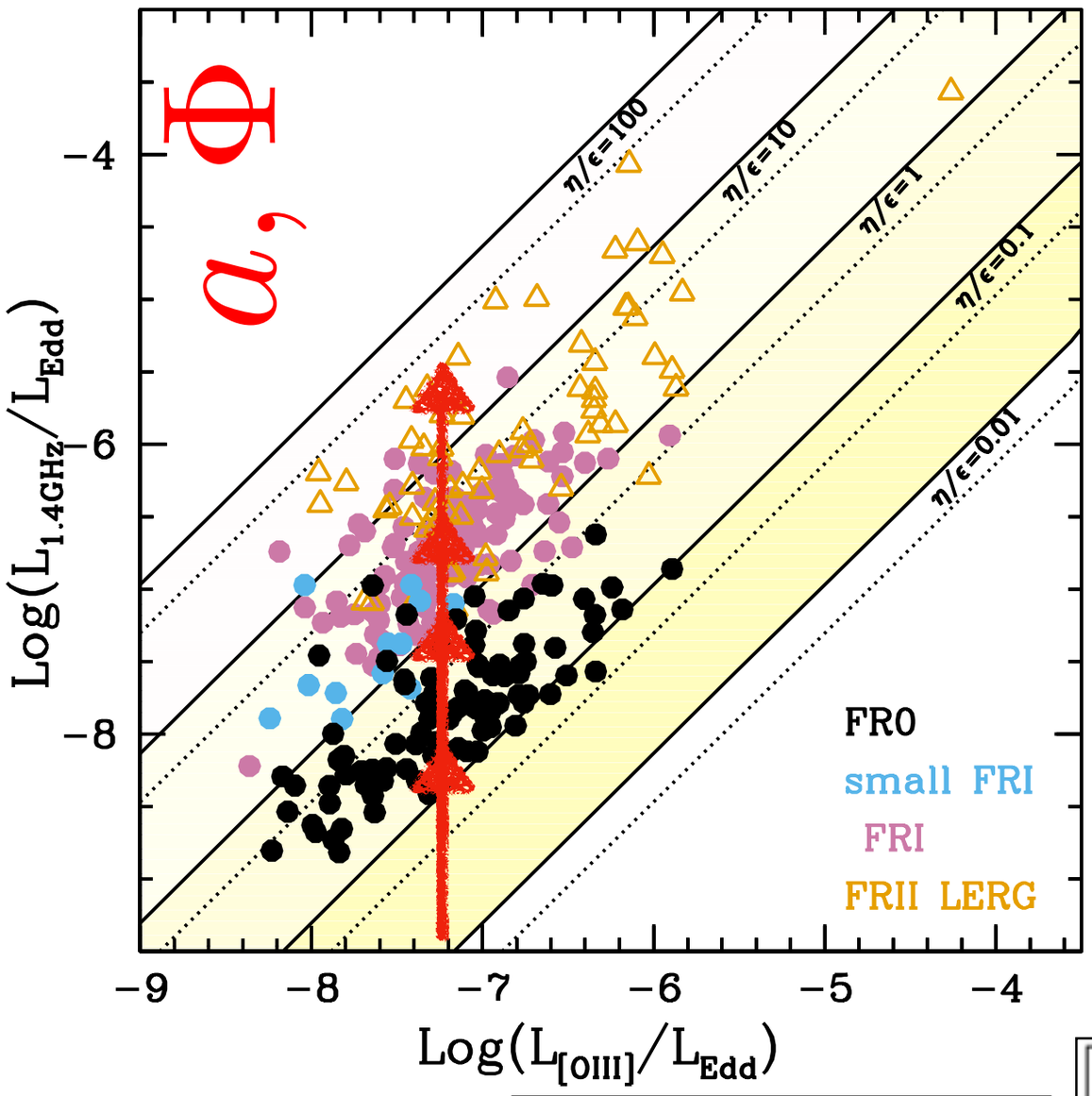




$$P_{BZ} \propto \Phi^2 a^2 M_{BH}^2.$$

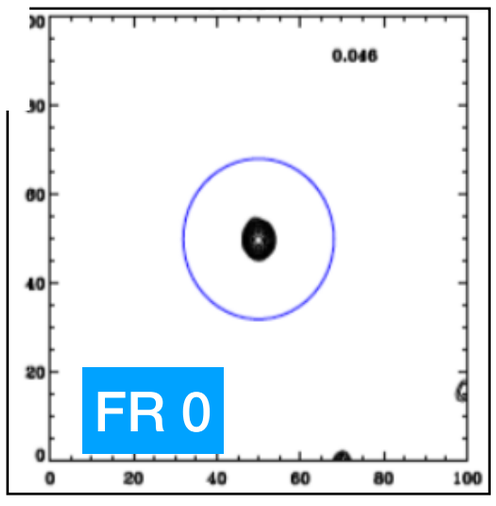
BH magnetic field ***spin***

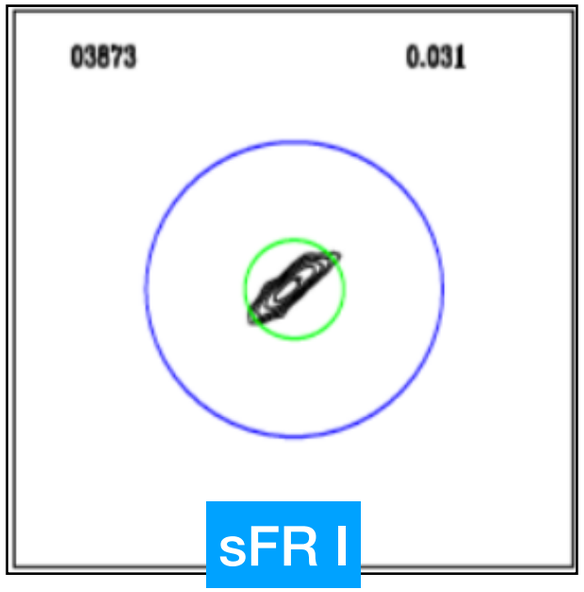
Blandford & Znajek 1977

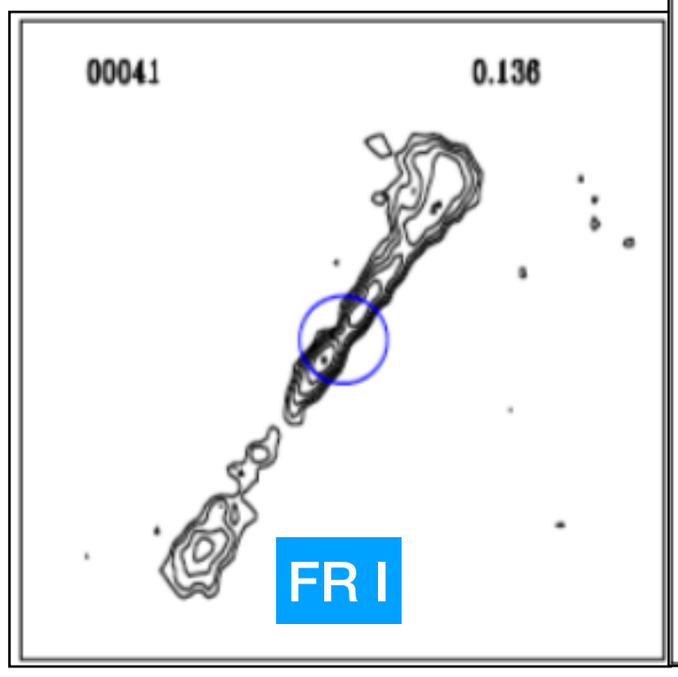


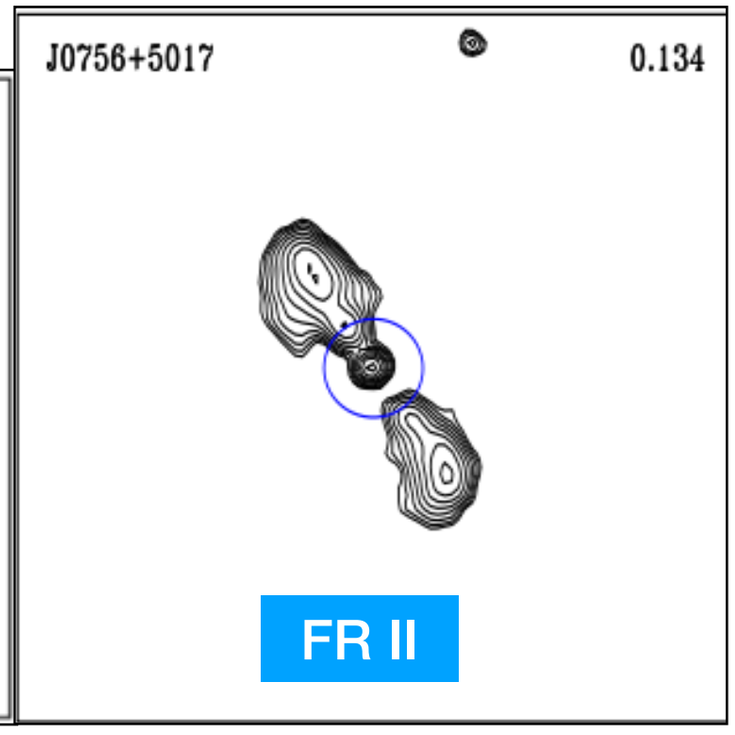
spin or/and magnetic flux density increase
from FR0 to FRI (FRII LERGS ?)

?









Credits: R.D. Baldi

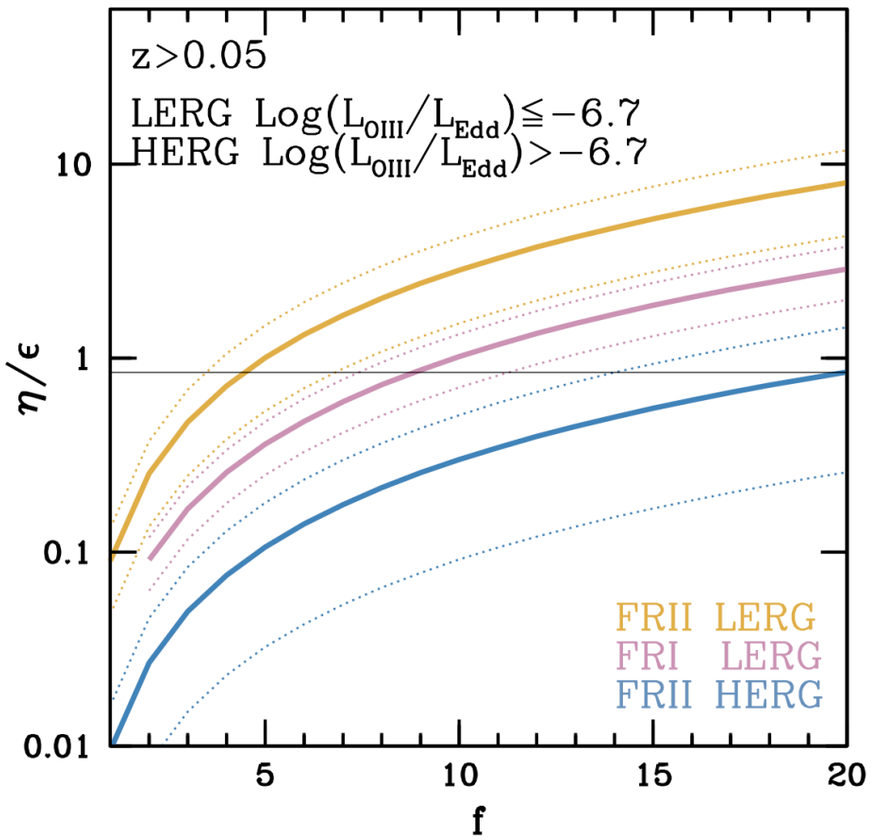
Conclusions

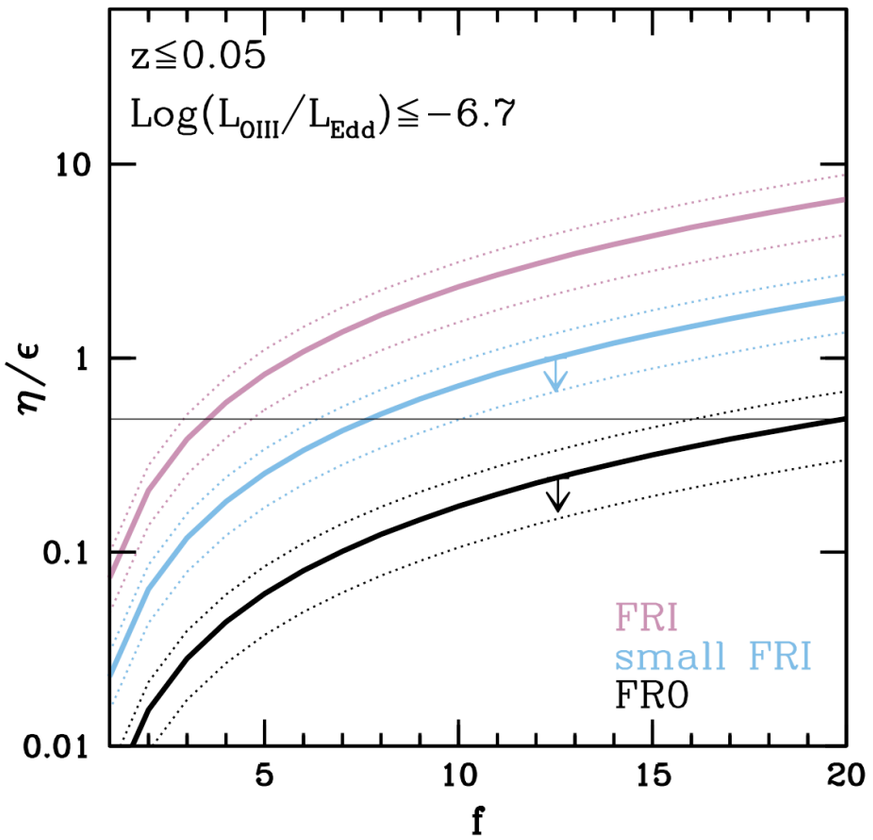
The local myJ Universe is mainly populated by LERGs in a late stage of their life (Massive BH, old stellar population). Should we taken into account population evolution?

Black hole spin and/or magnetic field threading its horizon might explain the wide range of $L_{1.4GHz}/L_{Edd}$ observed in LERGs with similar L_{OIII}/L_{Edd}.

The jet propulsion could be less potent in FR0s than in FRIs, because the black hole spin is slower and/or the magnetic field is weaker.

Parameter space

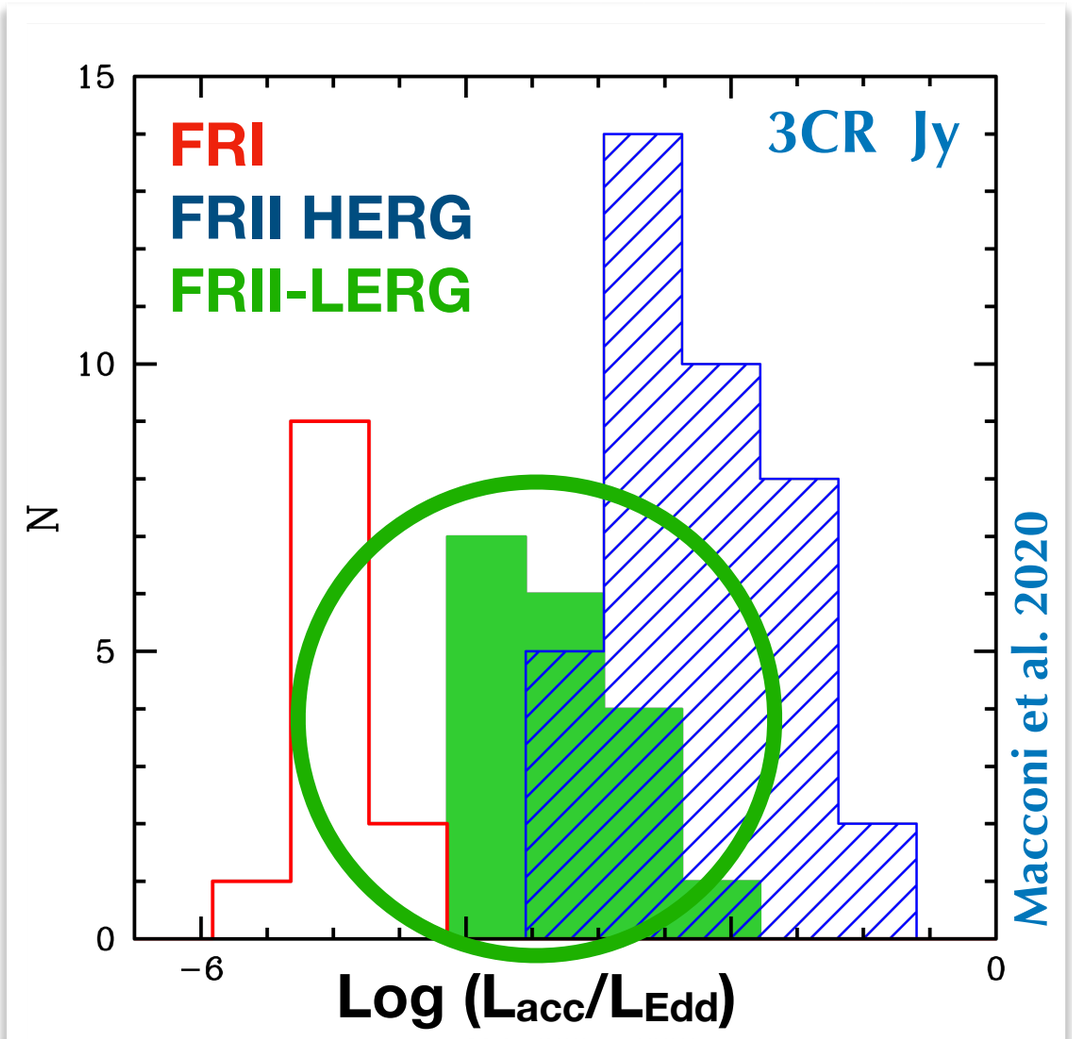




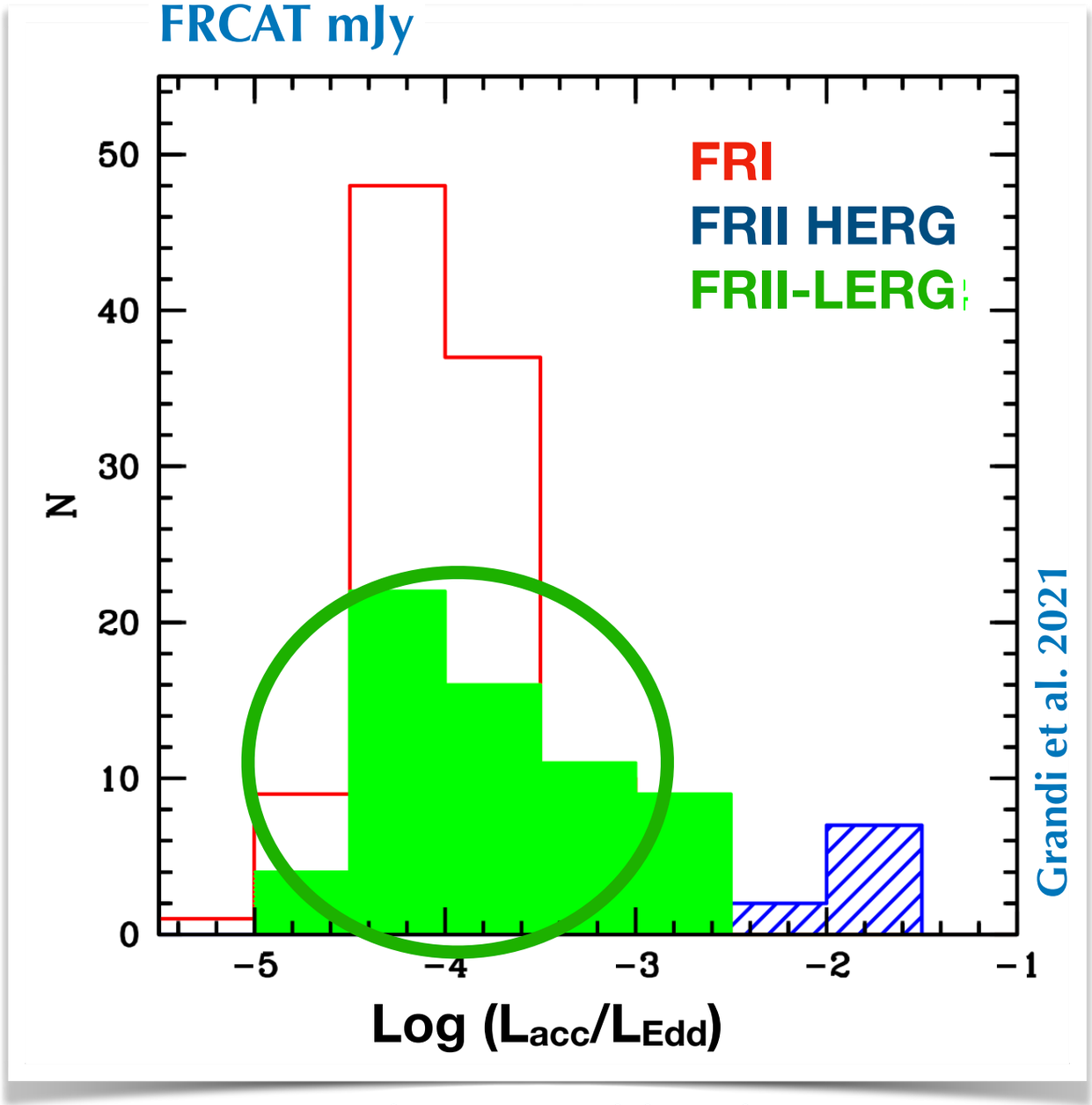
In order to have the similar efficiency ratio FRI/LERG should have smaller f

The largest uncertainty is the particle content
Smaller f would imply lighter jets in FRI
Simulations do not support this possibility

FRII-LERGs change their look from Jy to mJy regime



Jy FRII-LERGs are more "active"



mJy FRII-LERGs have FRI-like characteristics

Are FRII-LERGs aged FRII-HERGs RG?
Maybe yes

see Laing'talk

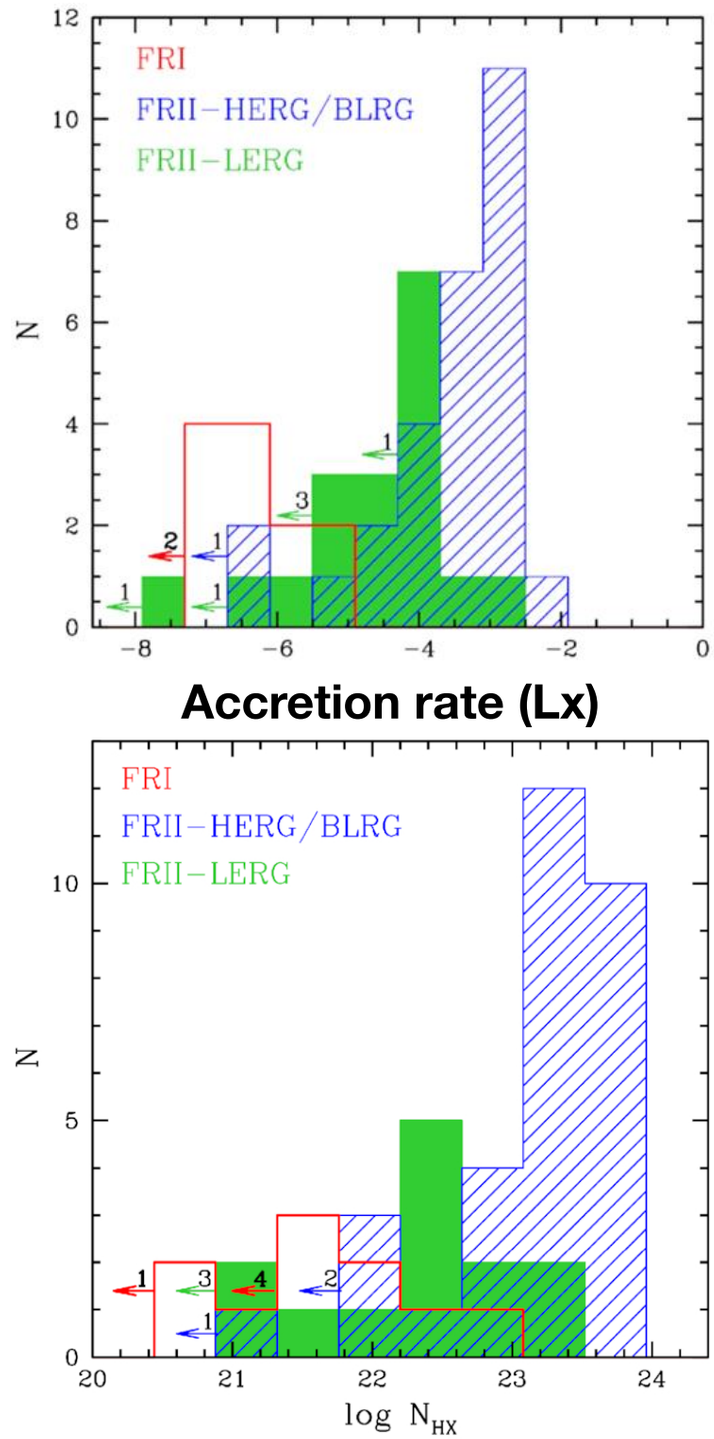
CROSS-POPULATION RADIO GALAXIES

14% of 3CR @z<0.3 are FRII-LERG

Accretion rate and column density increase from FRI/LERG to FRII/HERG with FRII/LERG in between

Are FRII-LERG evolved HERGs? or a class with own properties?

Macconi 's poster !!!



Macconi et al. 2020