

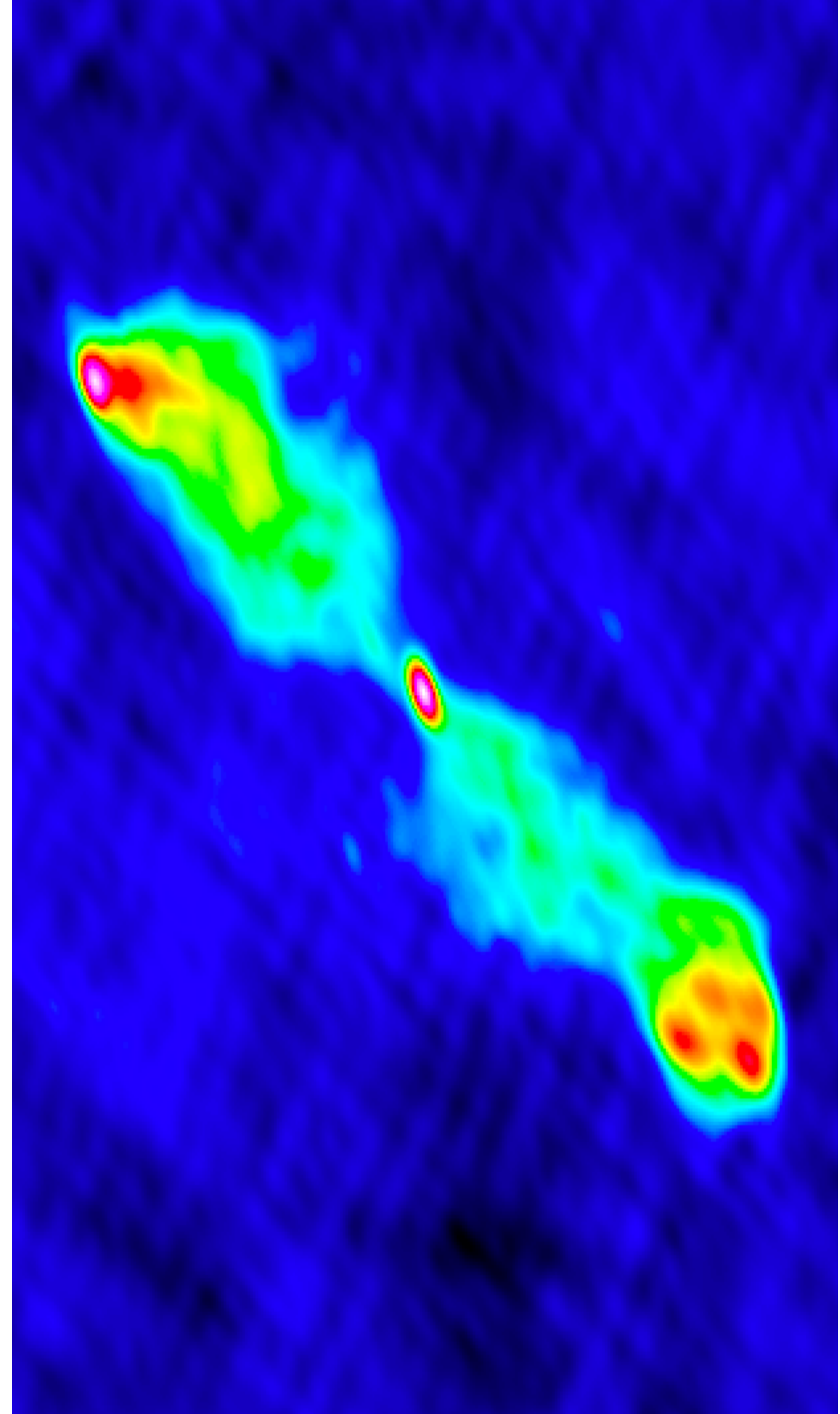
GIANTS IN THE SKY

Probing restarting activity in
soft gamma-ray selected giant radio galaxies

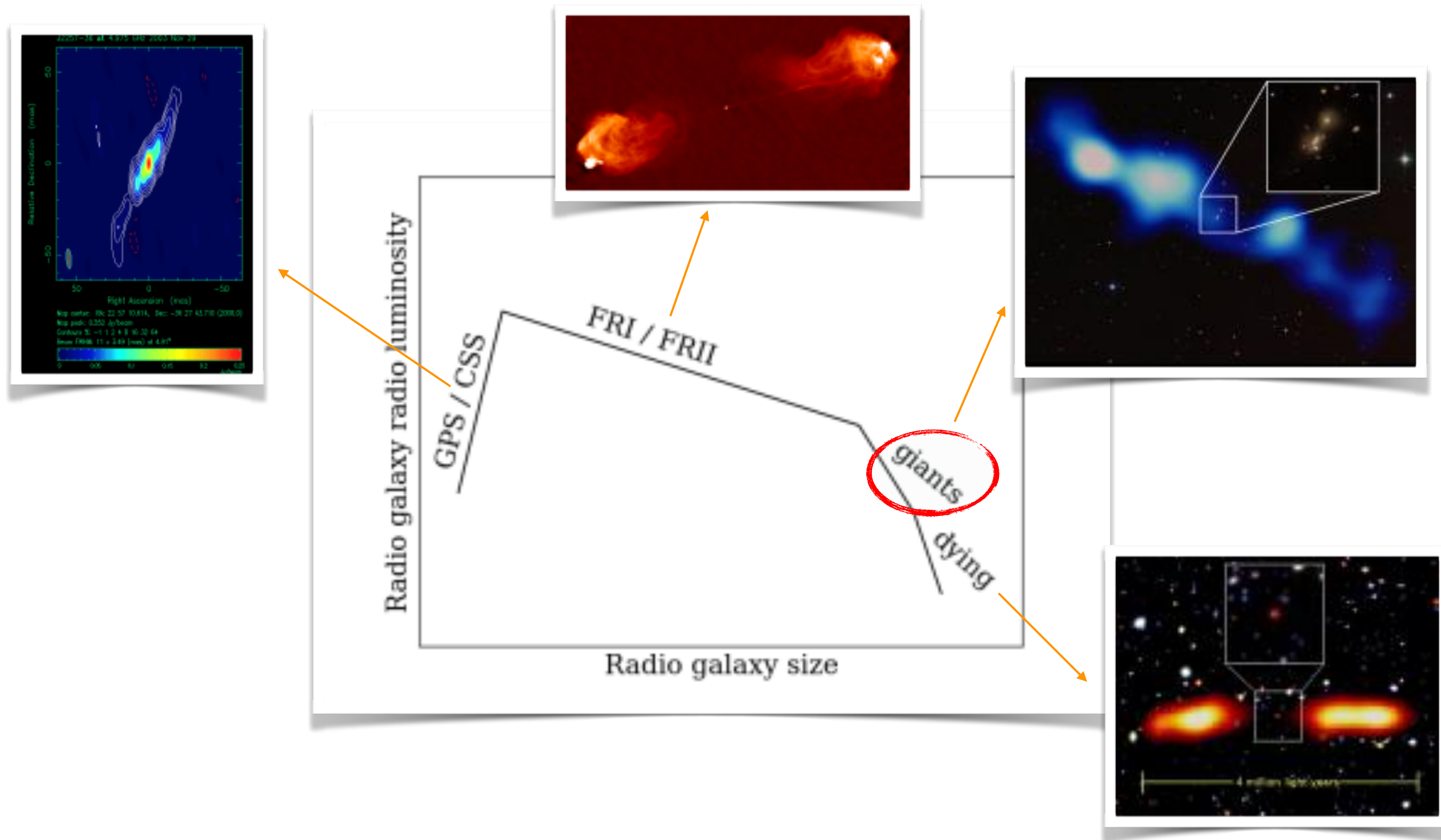
Gabriele Bruni, INAF-IAPS



Collaborators: F. Panessa, E. Chiaraluce, A. Bazzano, P. Ubertini (INAF-IAPS)
L. Bassani, A. Malizia, M. Molina, F. Ursini (INAF-OAS)
D. Dallacasa, T. Venturi, M. Giroletti (INAF-IRA)
L. Hernandez-Garcia (U. Valparaíso)

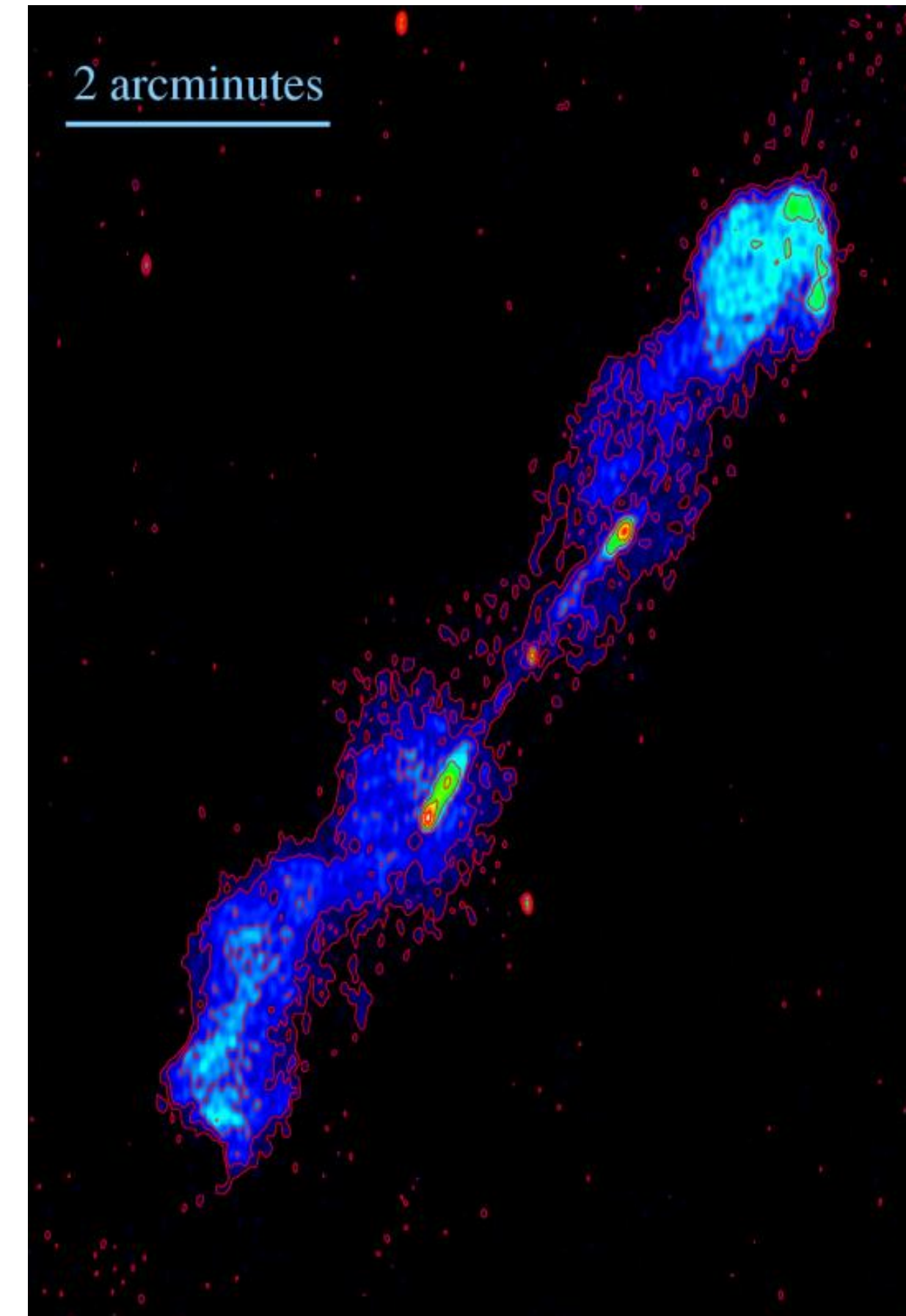


GIANT RADIO GALAXIES



GIANT RADIO GALAXIES

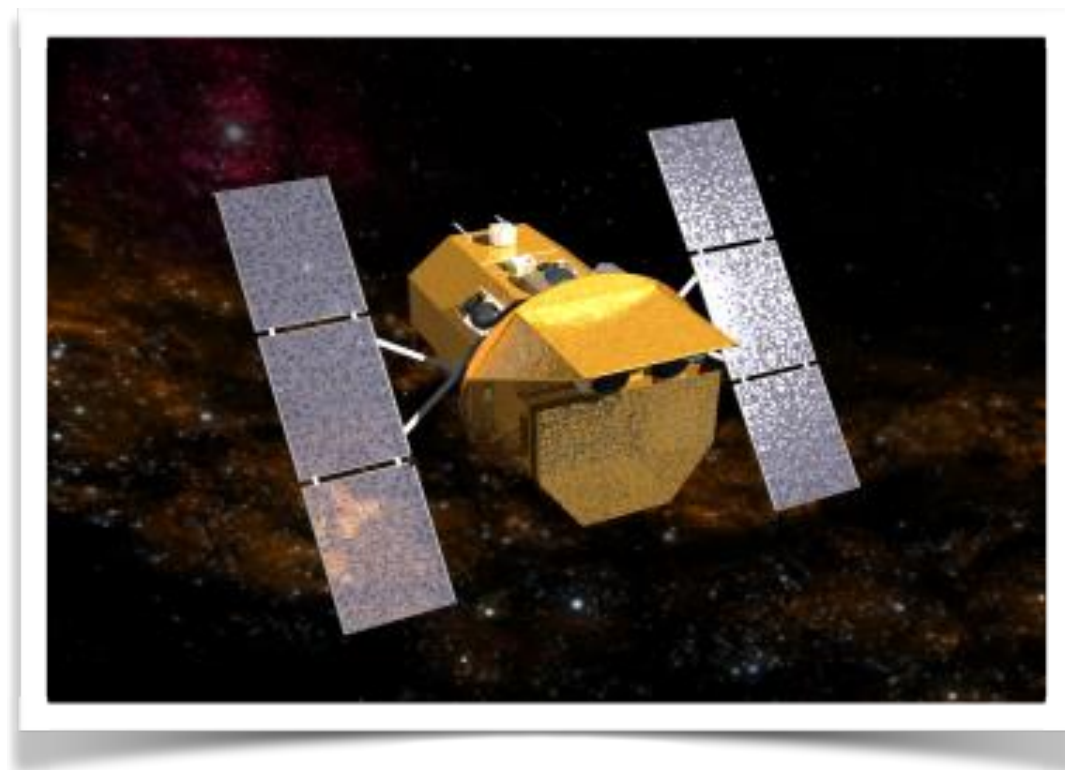
- GRG are the largest single-entities in the Universe (>0.7 Mpc)
- Low surface brightness, complex morphology, difficult to discover
- In radio surveys, only 1-6% of objects are GRG (~ 300 GRG known to date)
- Size due to environment, or high jet power, or long activity time?



B1545-321 (ATCA, 13cm)

THE SOFT GAMMA-RAY SKY

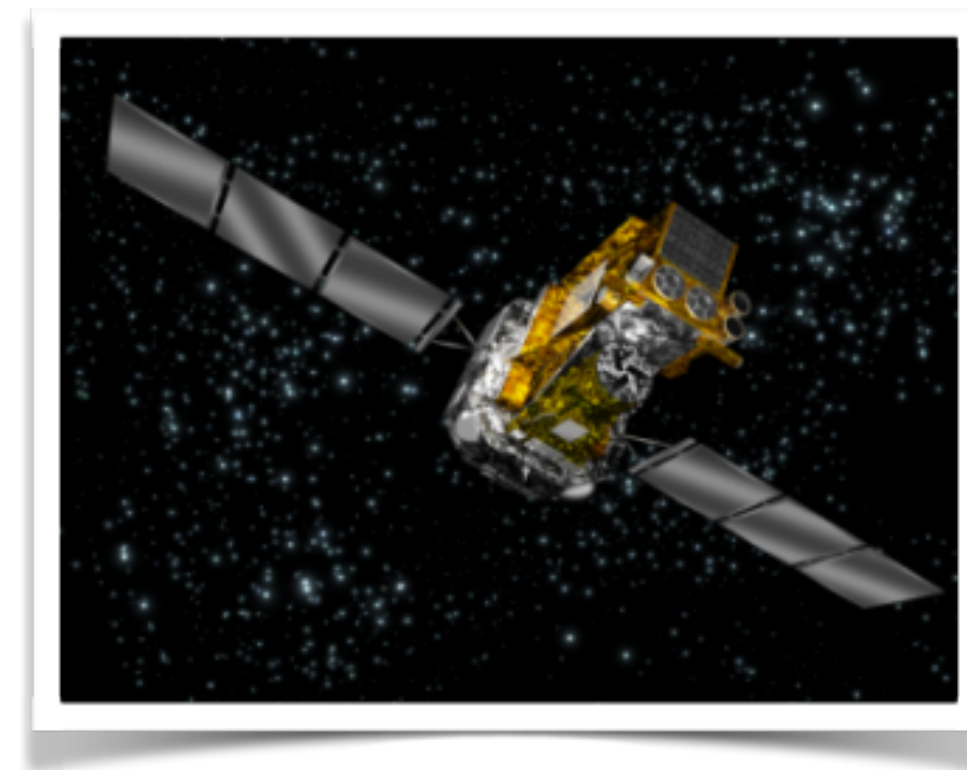
Space-based observatories scanning the soft gamma-ray sky since 2002...



Swift/BAT
(15 keV - 150 keV)



Baumgartner et al. 2013



INTEGRAL/IBIS
(15 keV - 10 MeV)



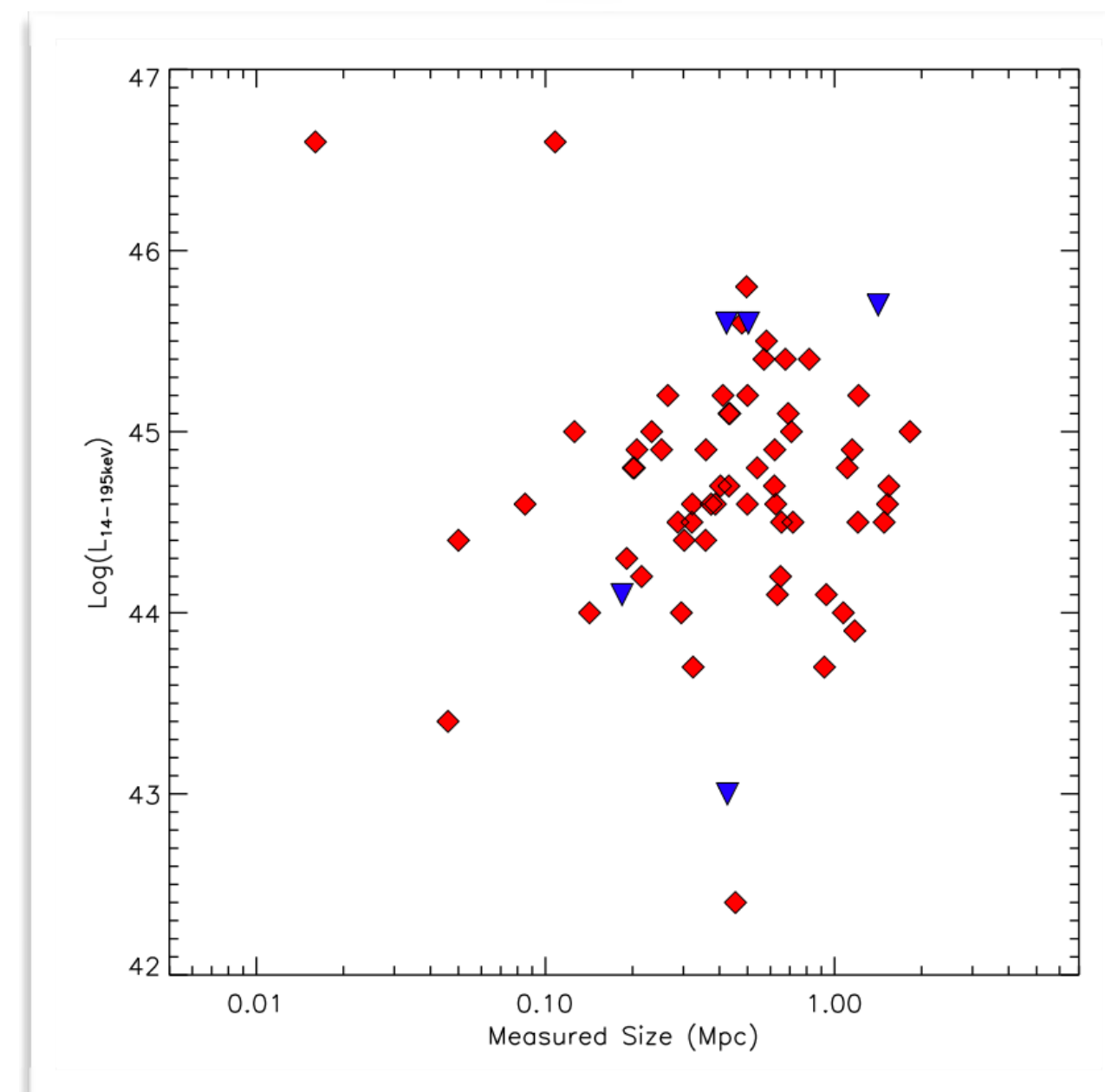
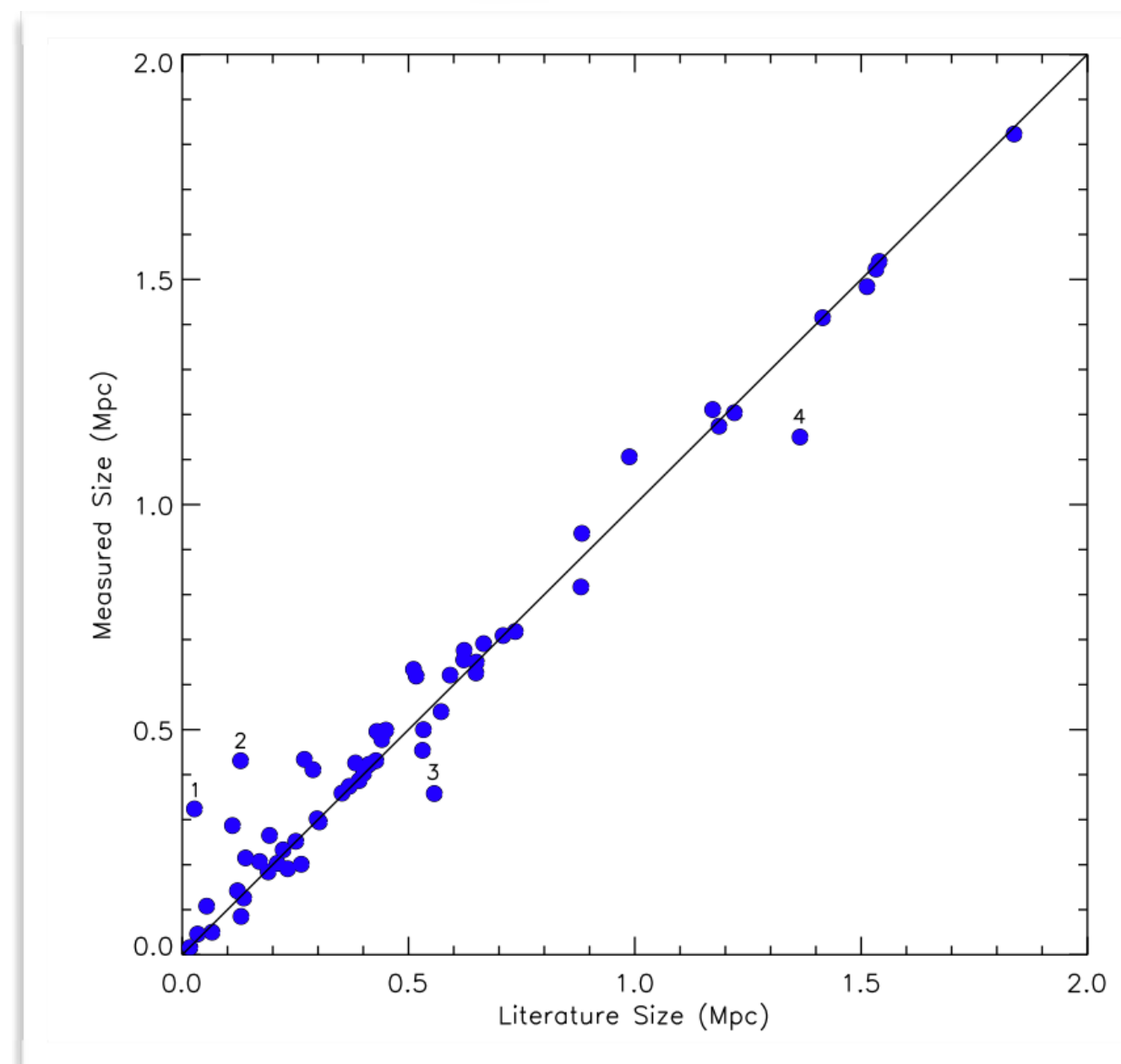
Bird et al. 2010
Malizia et al. 2012

...most extensive list of soft gamma-ray selected AGN

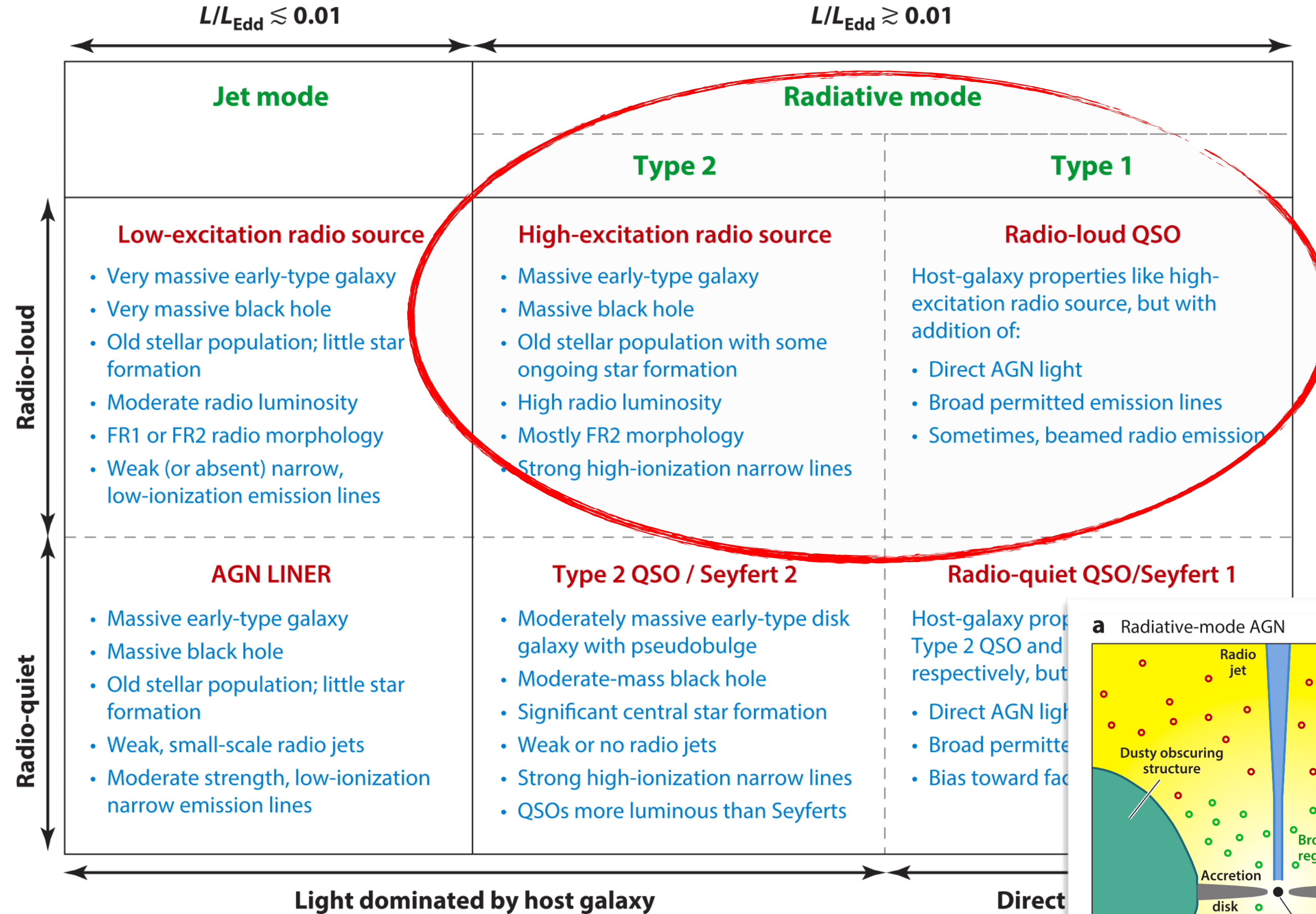
RADIO COUNTERPARTS

- Cross-correlation with NVSS, FIRST, and SUMSS
- Visual inspection of 1000 images, searching for extended structures...
- ...and measuring the largest angular size, and linear size in Mpc

67 radio galaxies with double morphology
31 RG with size >0.5 Mpc
14 GRGs >0.7 Mpc (22%)

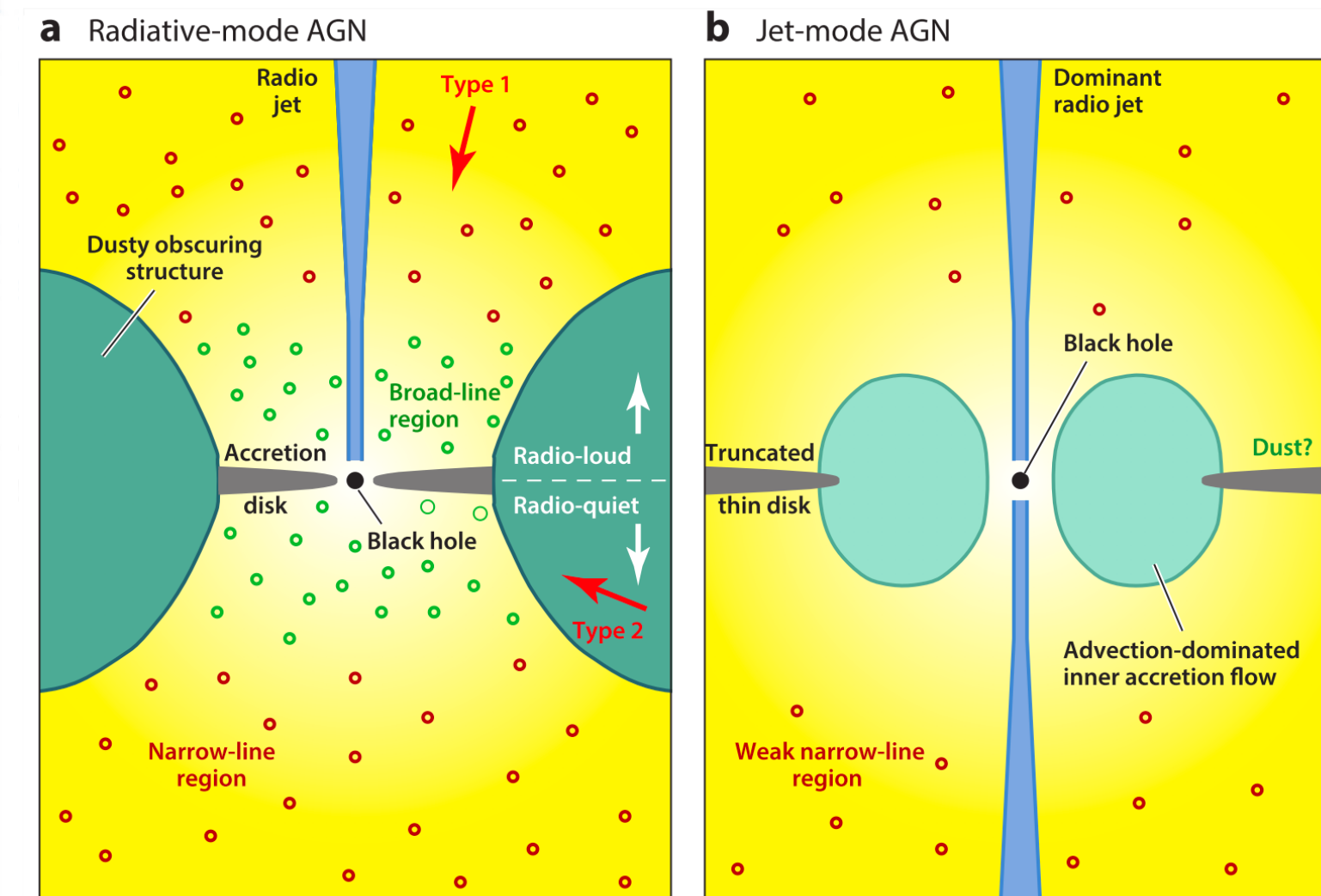


THE SAMPLE



51 FR II objects
6 FRI
6 FRI/FR II
1 C

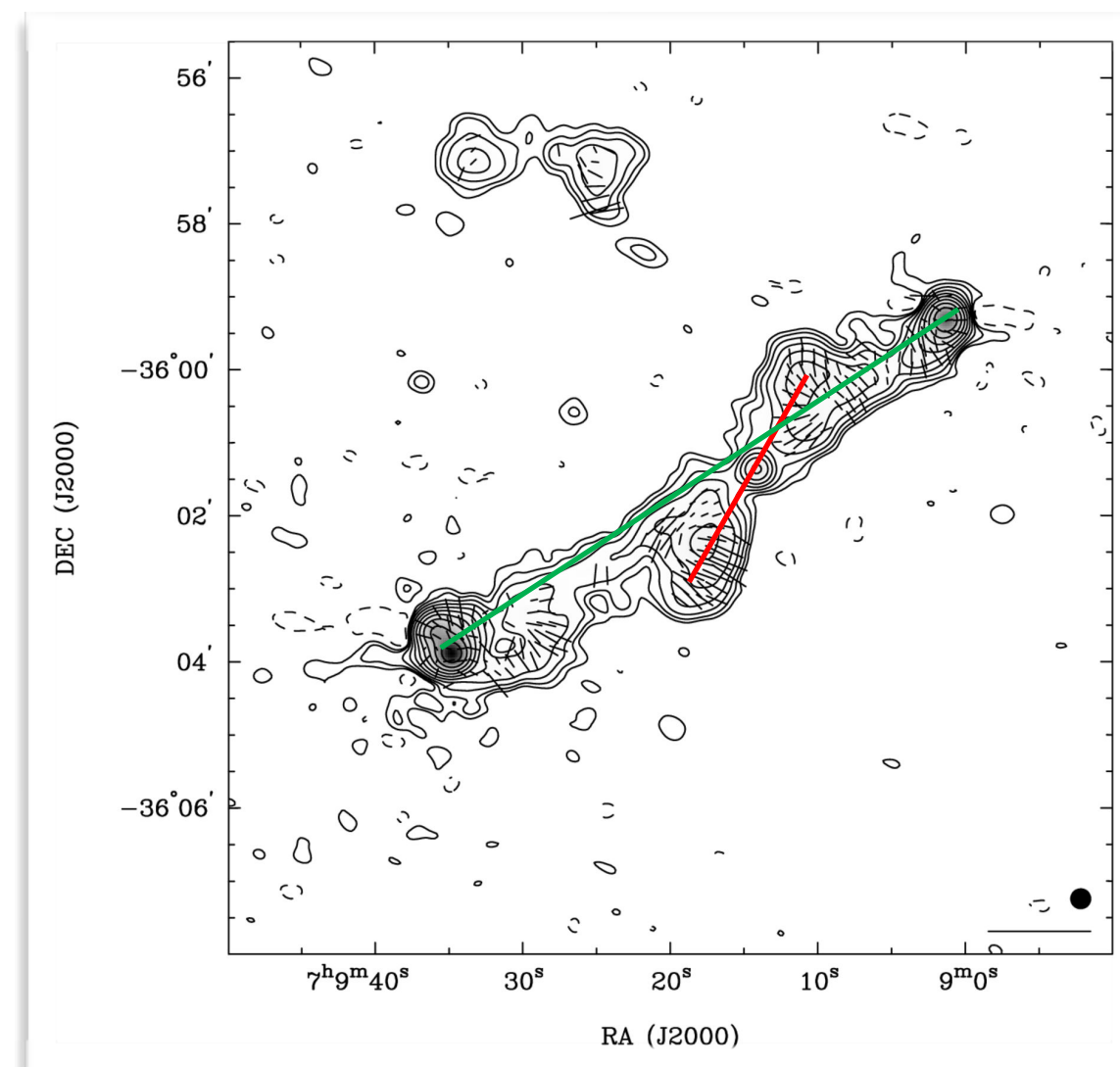
35 type 1-1.5 AGN
26 type 1.8-2.0 AGN
5 Other
Mostly HERG



SIGNS OF RESTARTING ACTIVITY

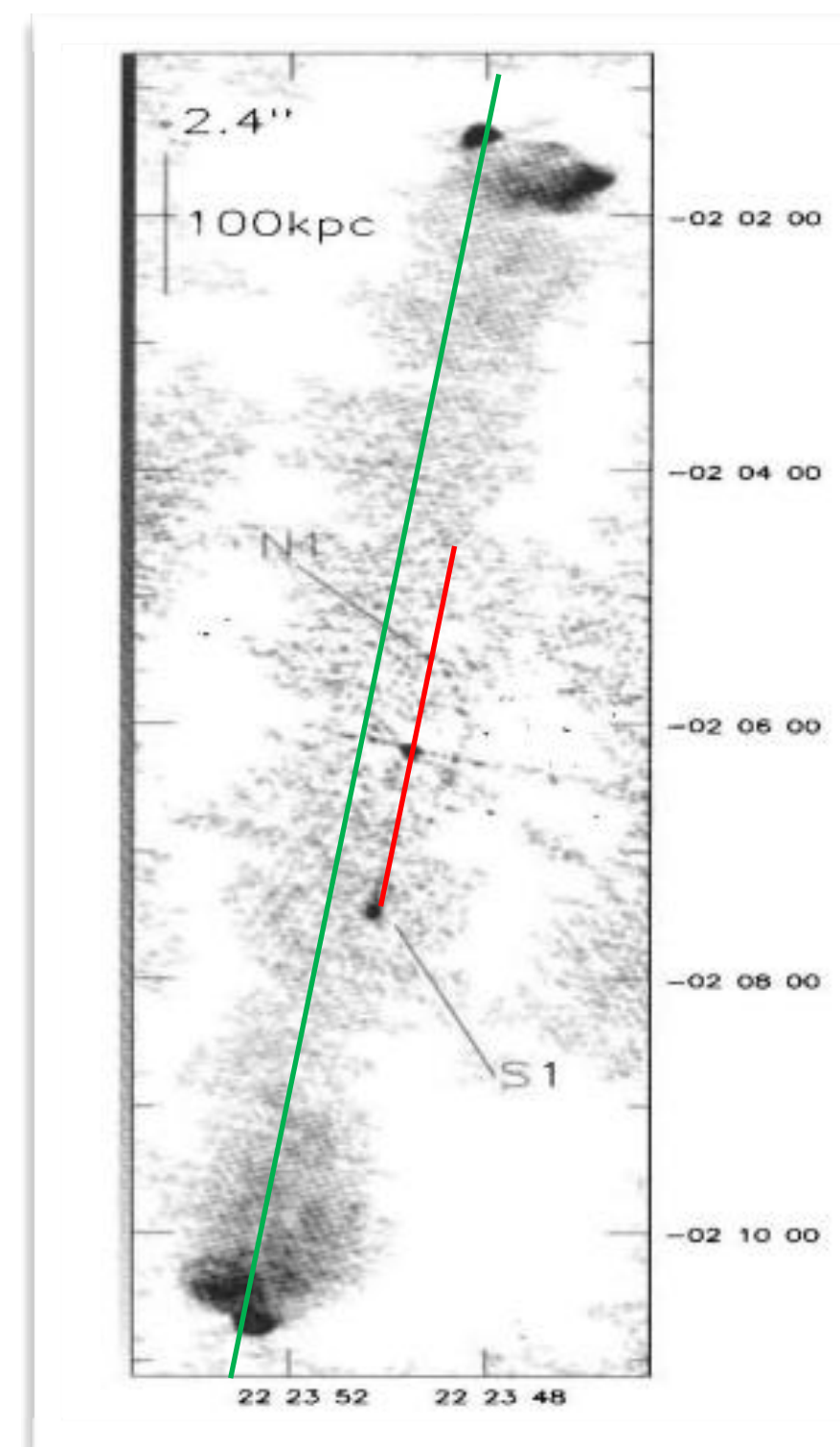
Double-Double RG

B0707-359
Axis change



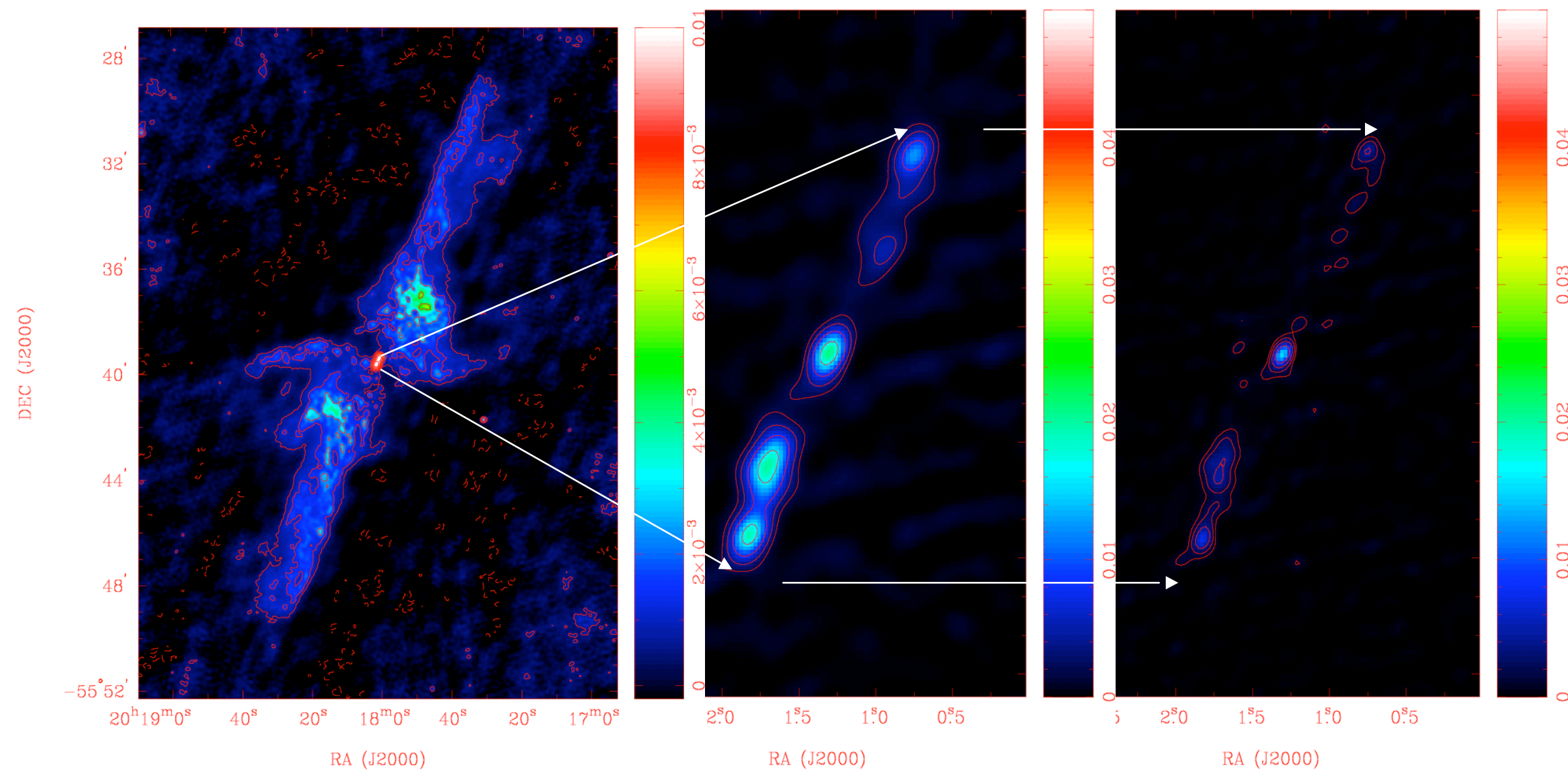
Saripalli et al. 2013

3C 445
No axis change



Leahy et al. 1997
(not in our GRG sample)

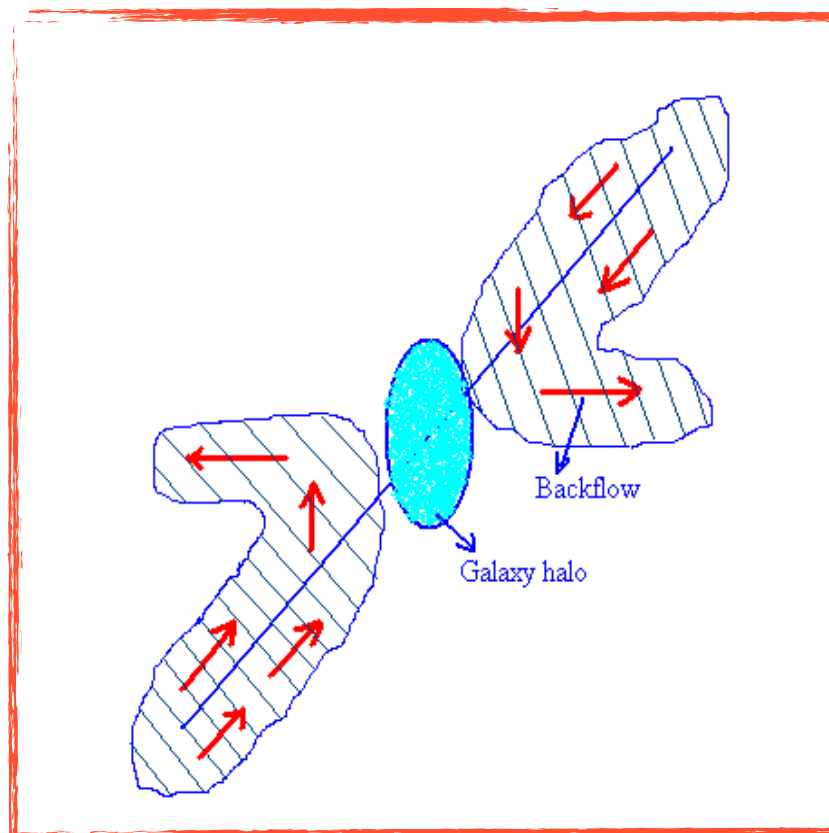
SIGNS OF RESTARTING ACTIVITY



X-shaped RG

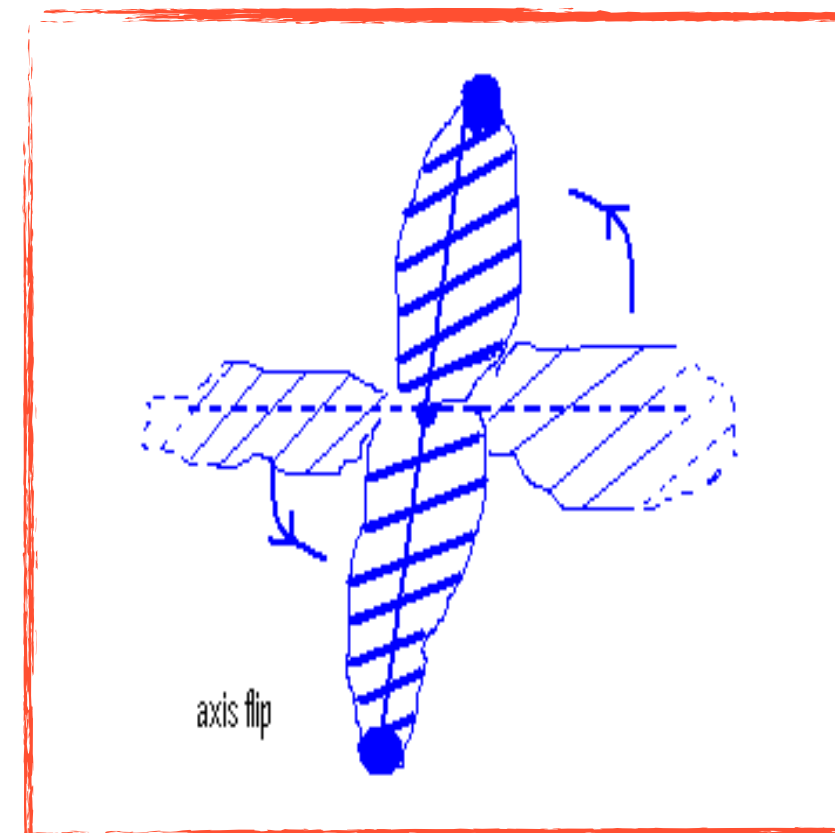
PKS 2014-55

X-shaped,
edge-brightened inner double



Backflow model

Lobe material back
flowing towards core,
deflected by thermal gas
halo.



Jet reorientation

Jet axis flips over a large
angle, producing new
lobes.

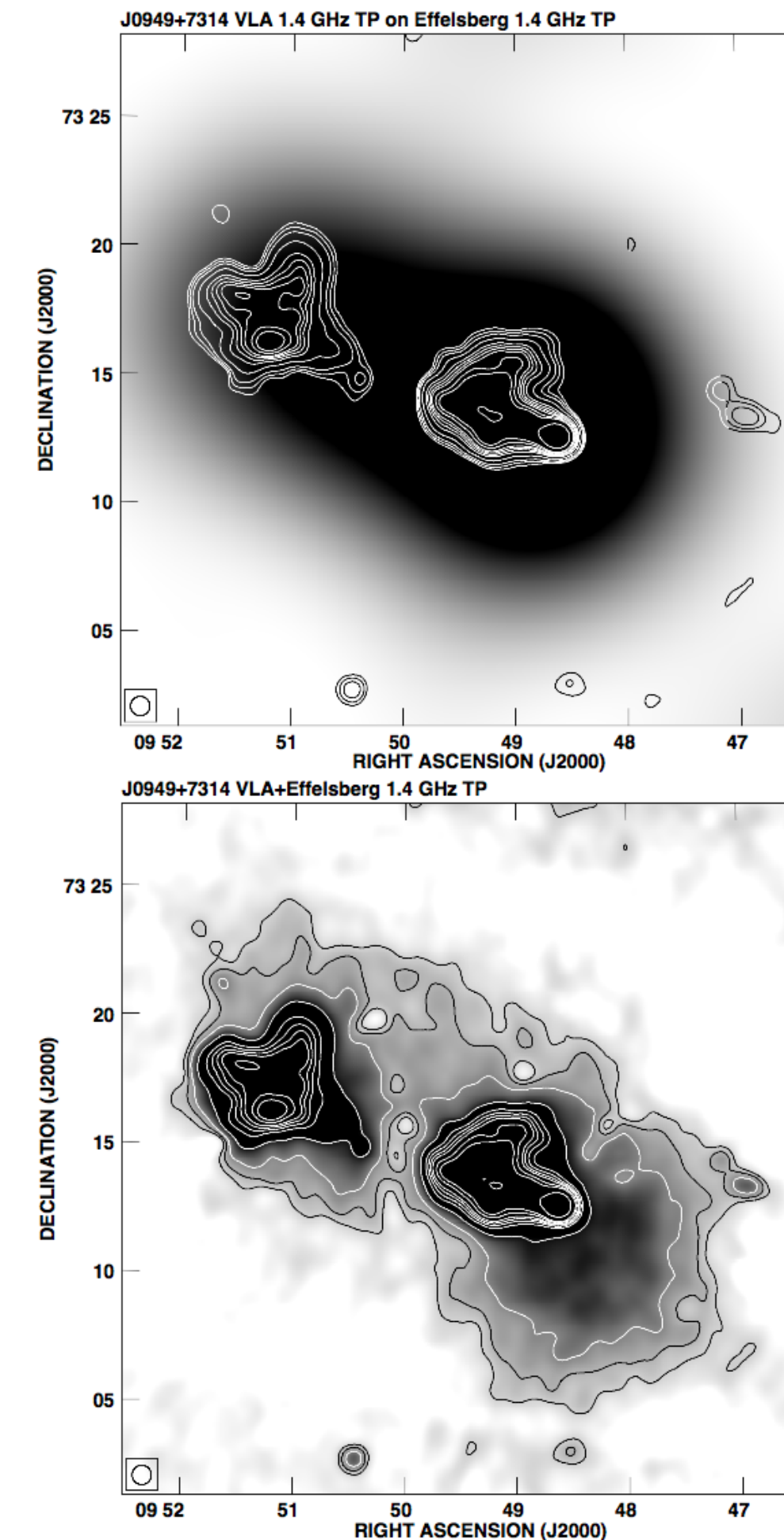
Saripalli et al. 2008

SIGNS OF RESTARTING ACTIVITY

Radio cocoon

Weak extended emission with large angular size (639 kpc, >200 My in age) within which a compact edge-brightened double-lobed source (36 kpc, >33 My in age) is embedded.

4C 73.08



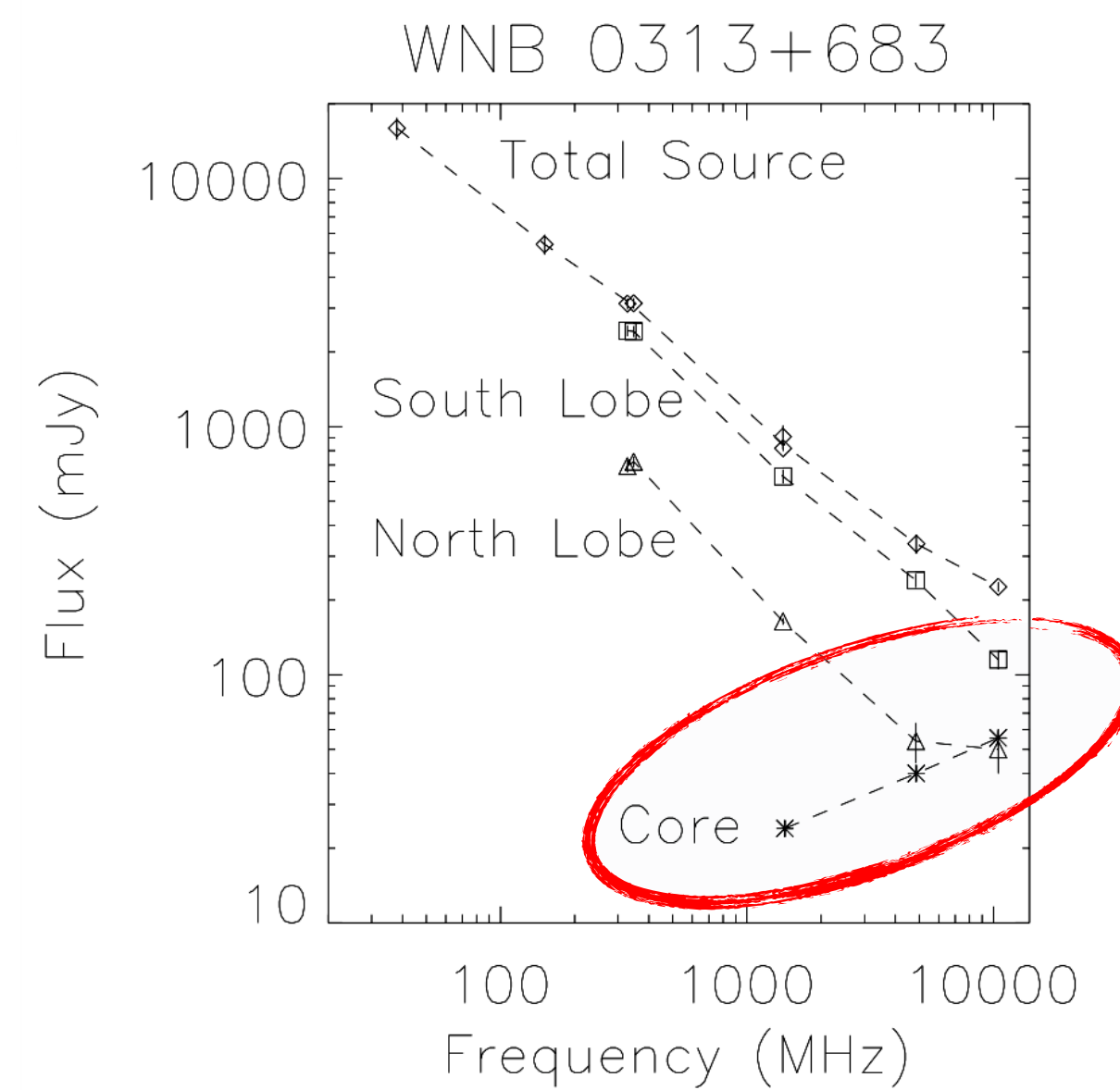
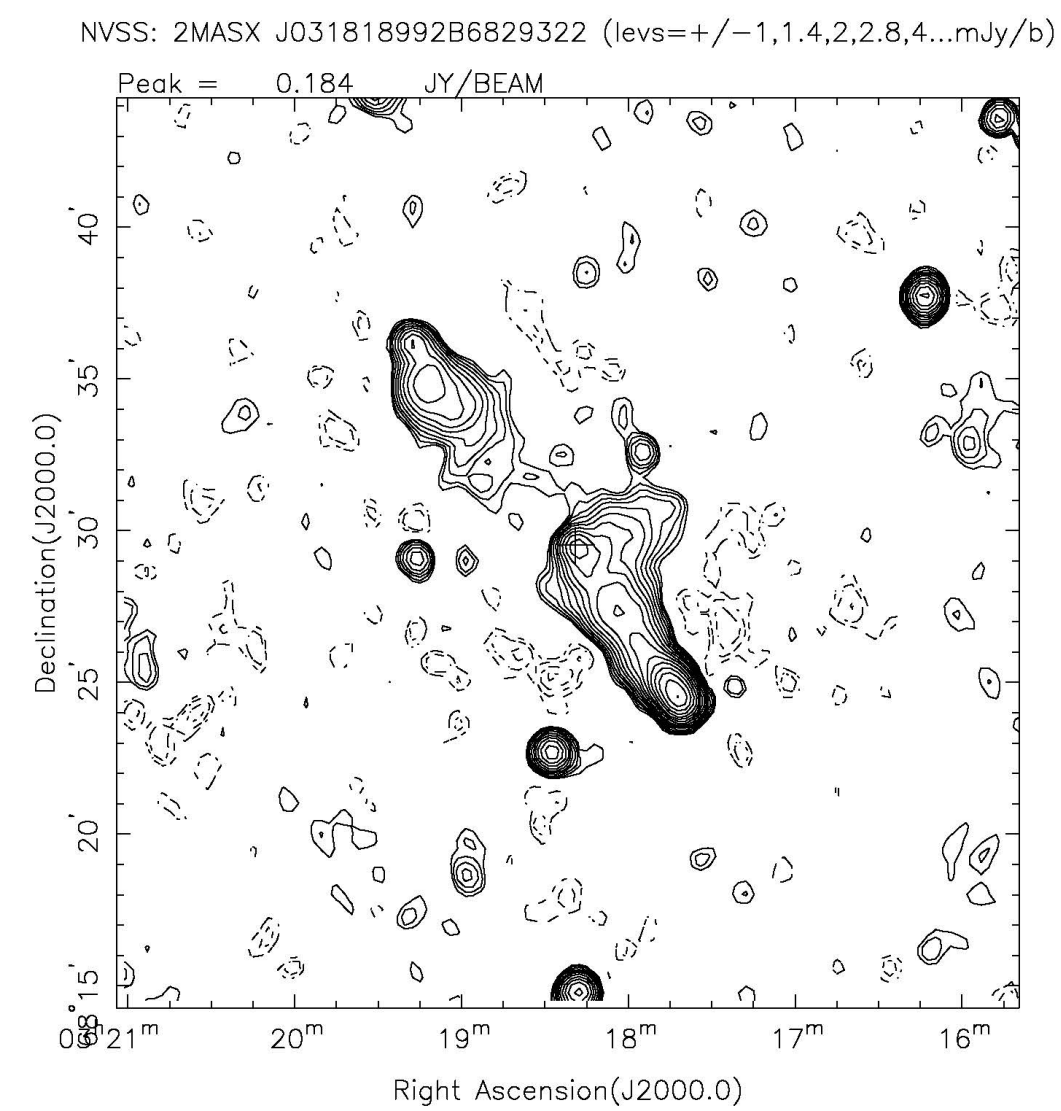
Wezgowiec et al. 2016

SIGNS OF RESTARTING ACTIVITY

GPS-like core

WNB 0313+683

Inverted spectrum from the core,
new episode of radio activity?

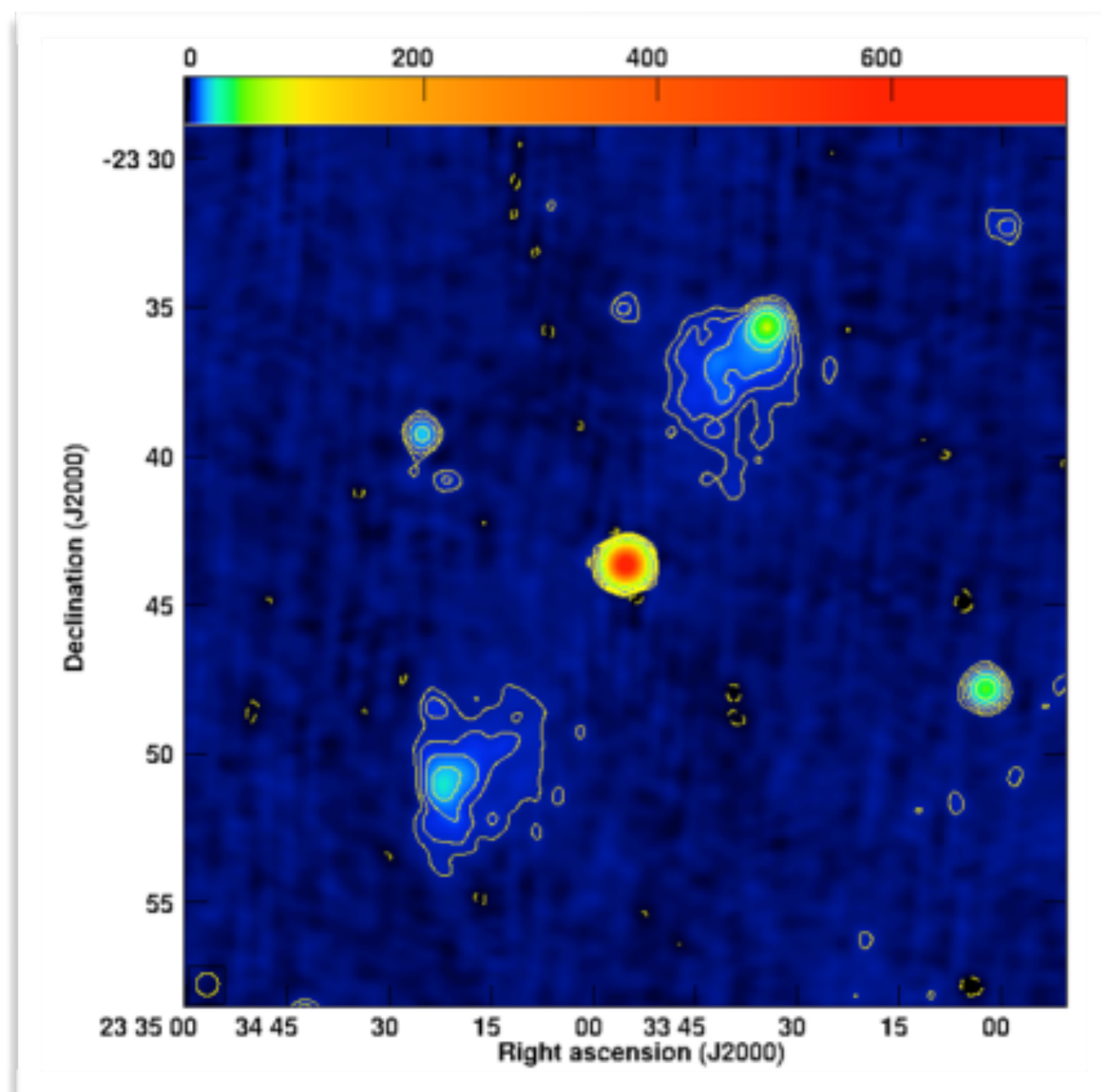


Schoenmakers et al. 1998

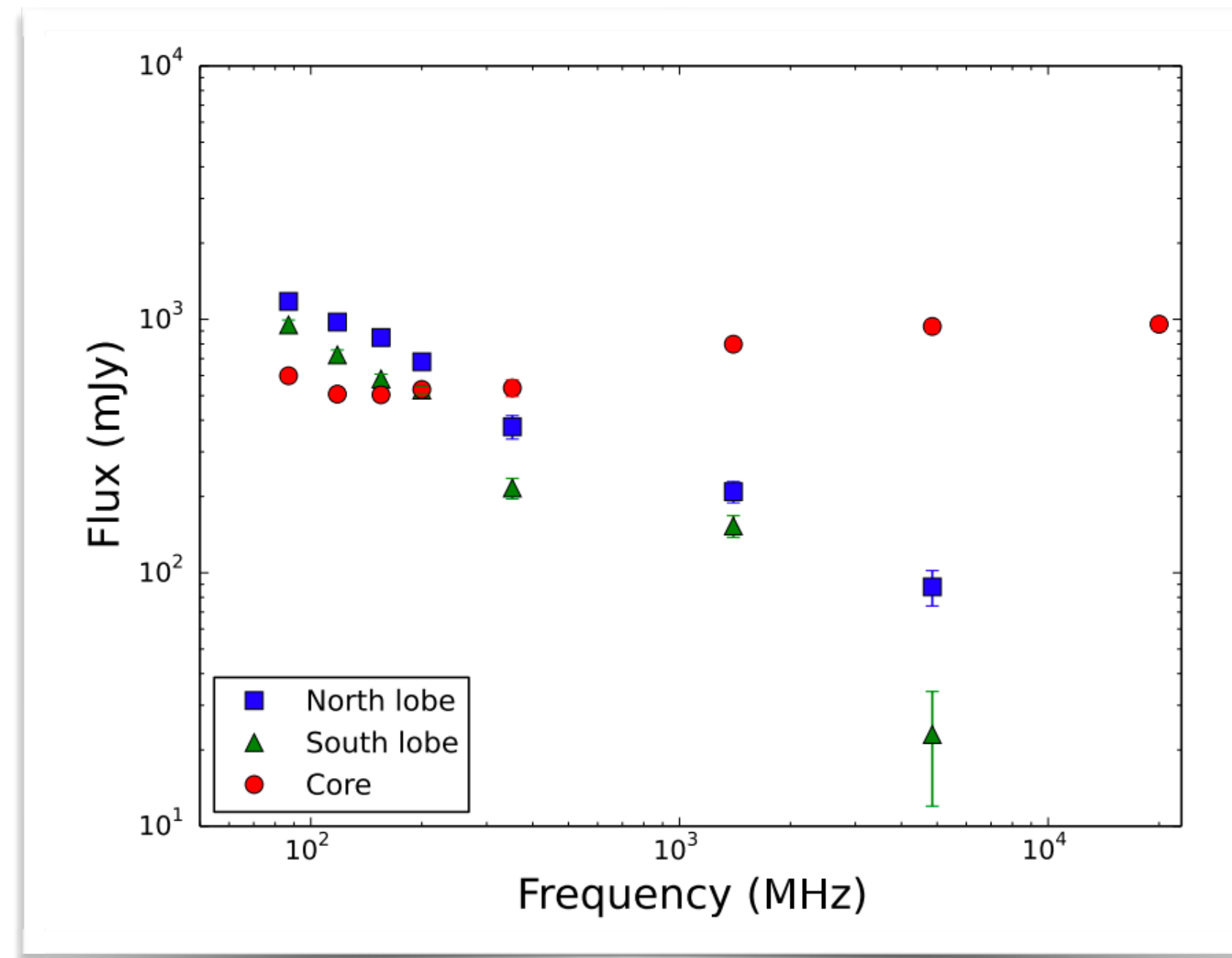
SIGNS OF RESTARTING ACTIVITY

Blazar-like core!

PBC J2333.9-2343

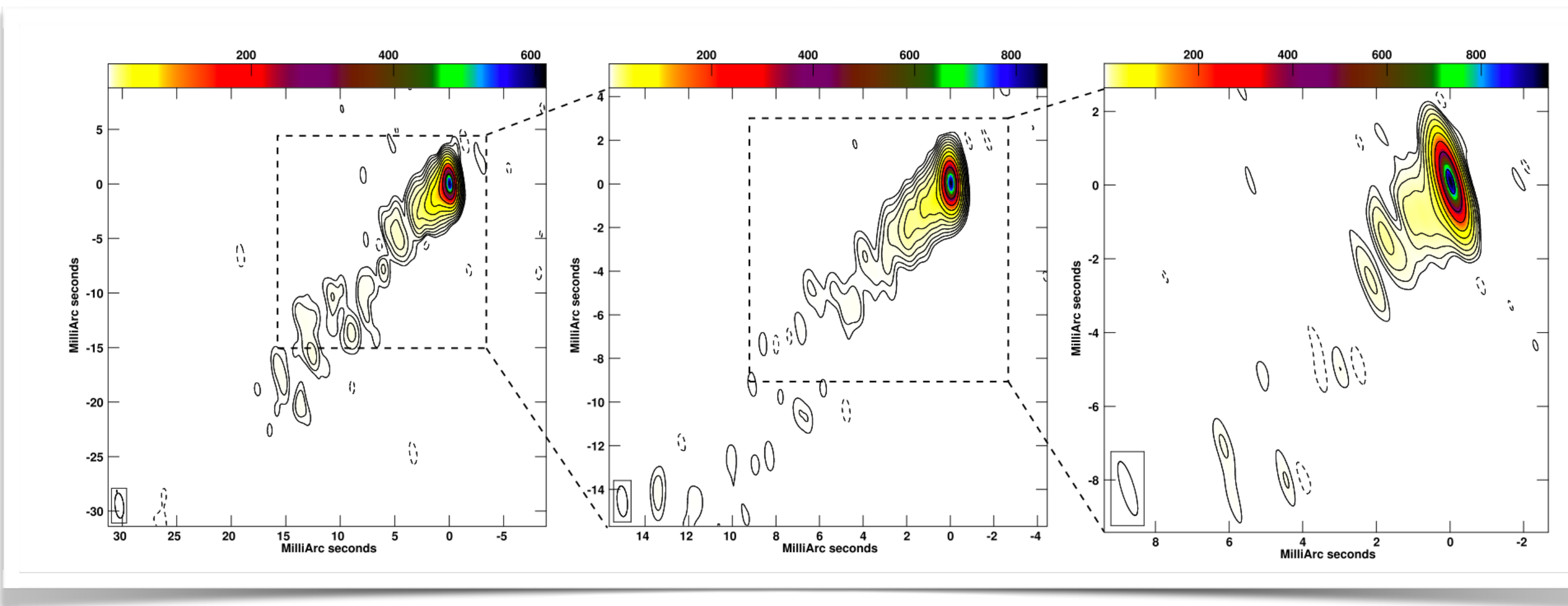


NVSS



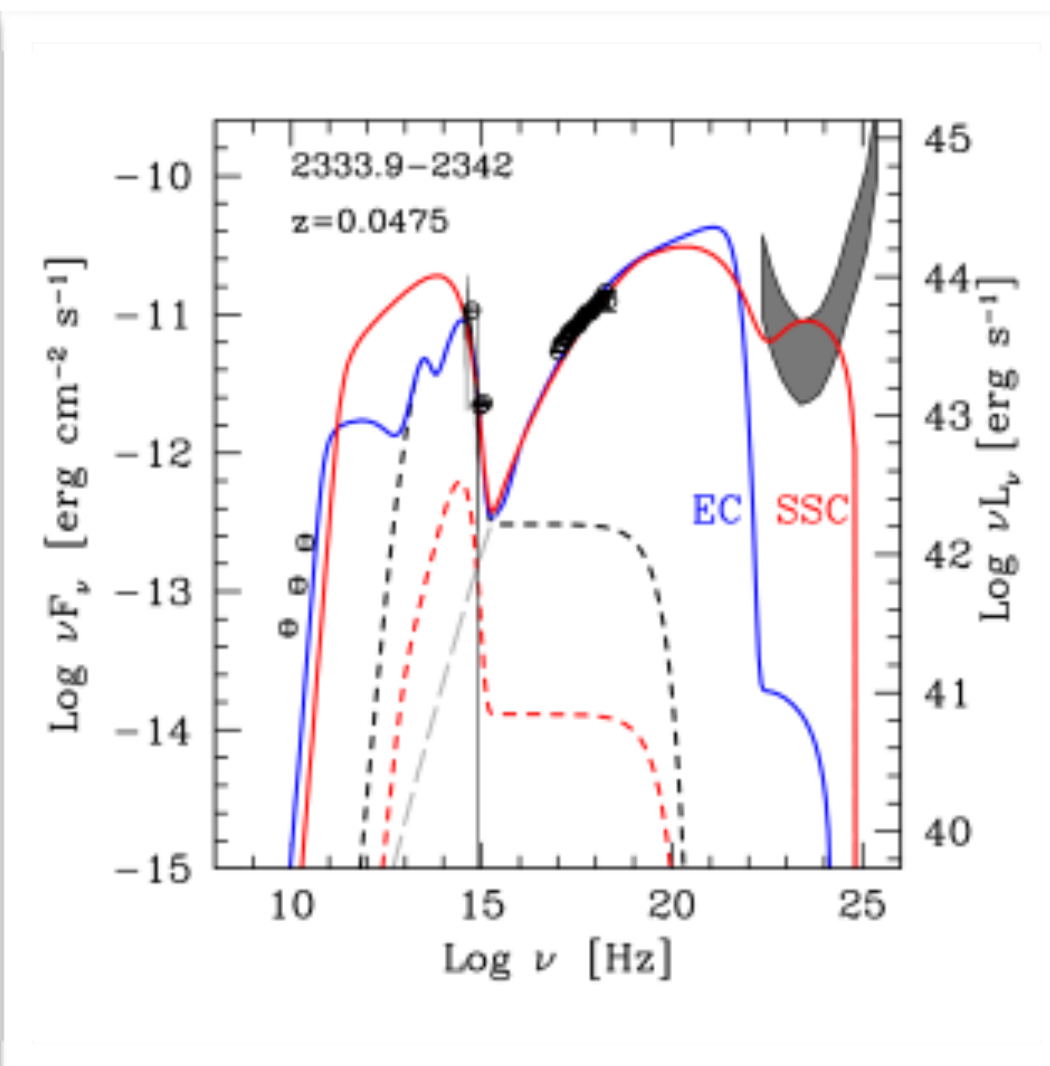
Radio SED from literature

SIGNS OF RESTARTING ACTIVITY

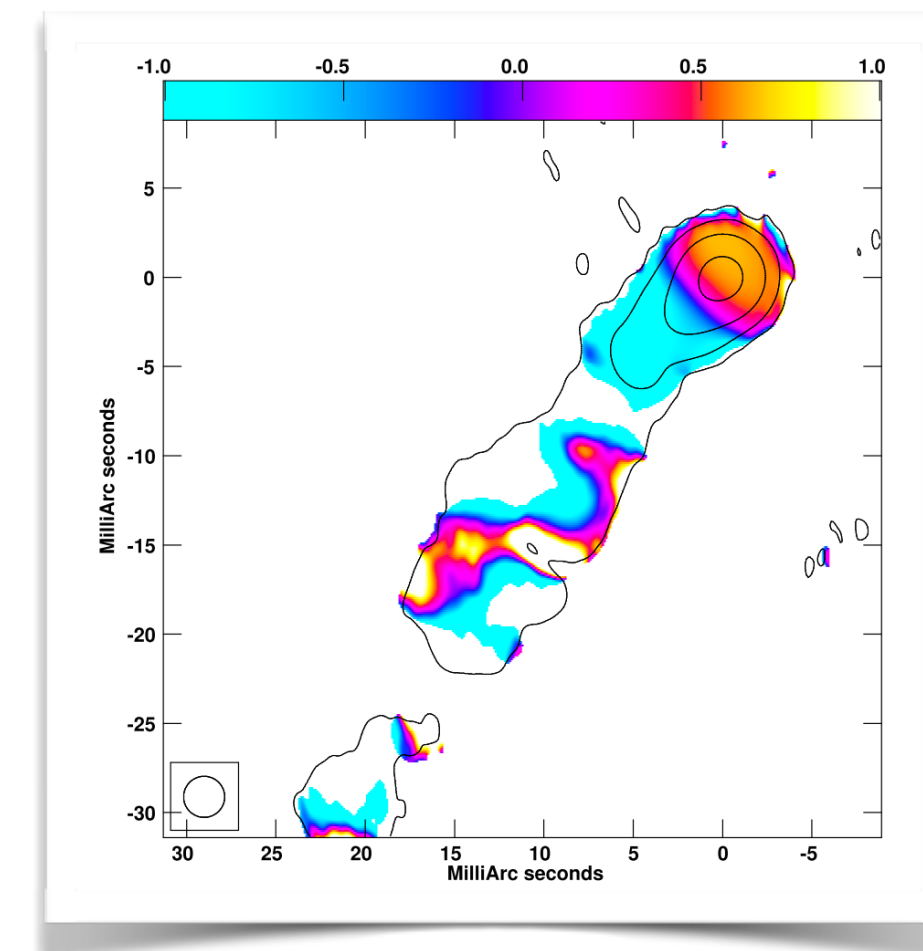


VLBA

8, 15, 22 GHz



...inner jet axis towards line of sight



SIGNS OF RESTARTING ACTIVITY

- 6/15 GRG present signs of restarting activity from the literature ($\sim 40\%$)
- Radio campaign to check the remaining objects via:

- *Single dish (Effelsberg) photometry to test presence of GPS cores (10/14)*
- *GMRT (MHz-range) observations to study morphology (4/14)*



- *TGSS images at 150 MHz (25x25 arcsec resolution, 12/14)*

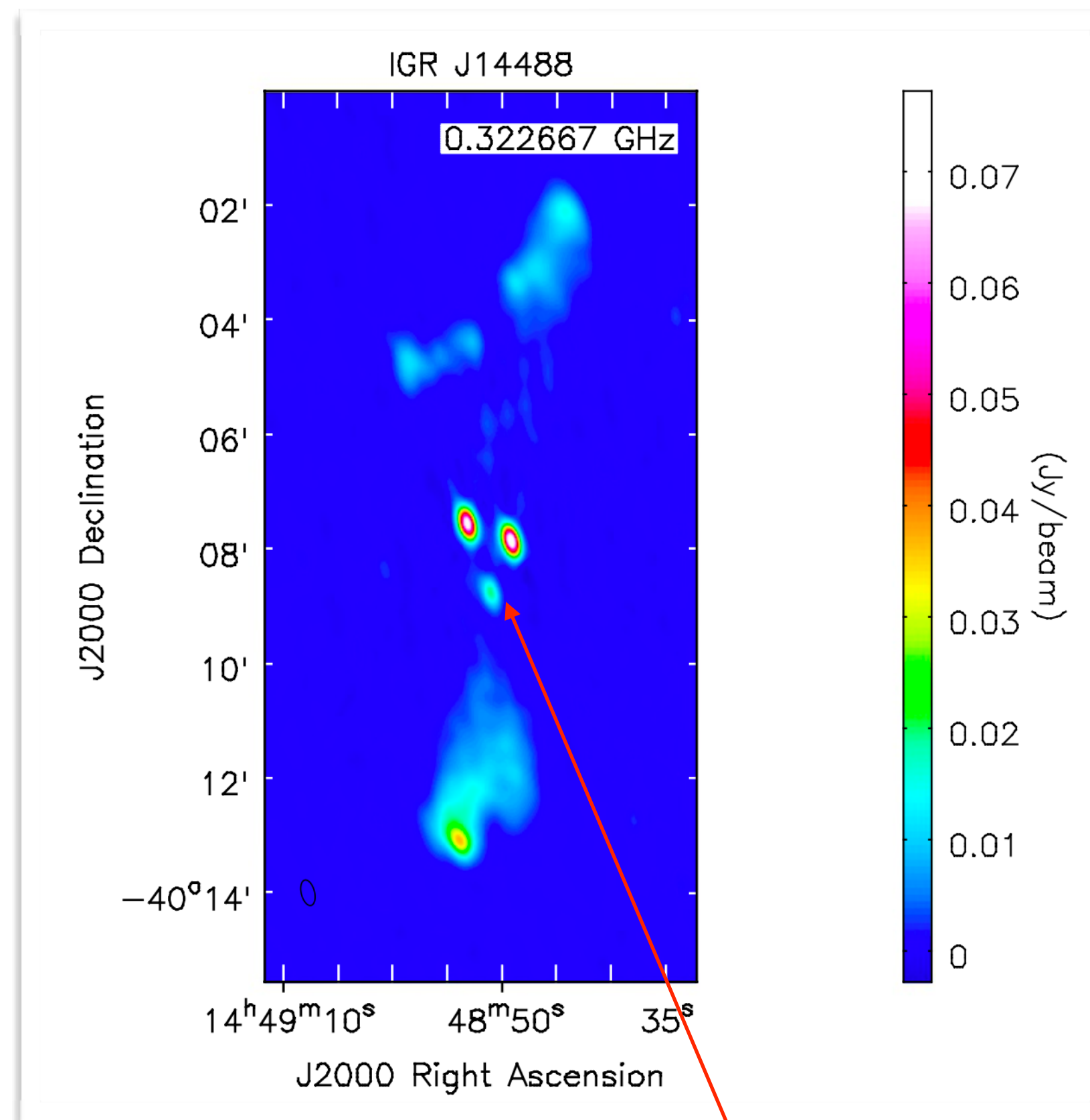
RESULTS FROM OUR CAMPAIGN



GMRT - data at 325 and/or 610 MHz for 4 sources, two newly discovered GRG:

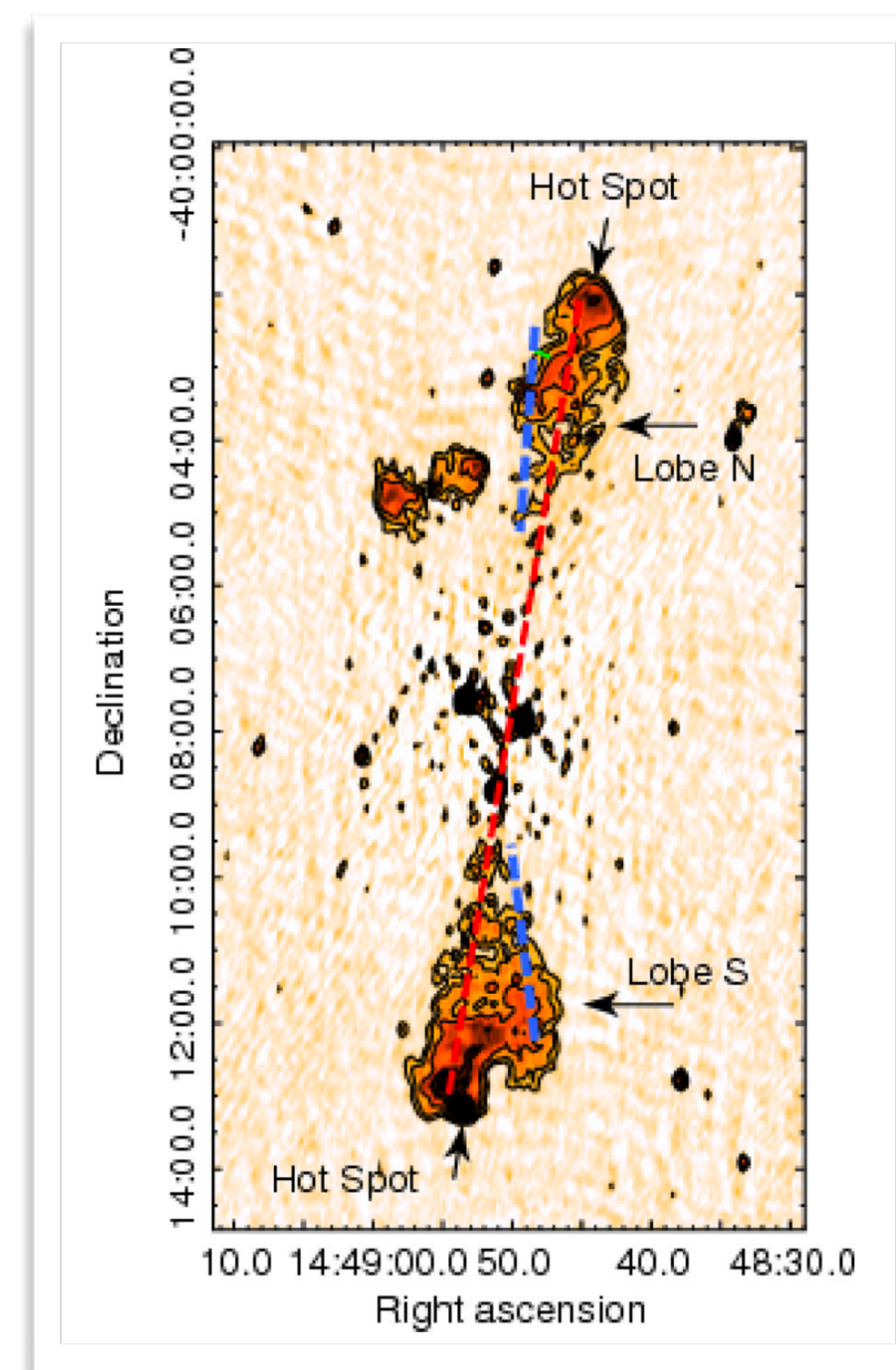
IGR J14488-4008

325 MHz



Bruni et al. 2019 (in prep.)

610 MHz



Molina et al. 2015

GPS core
(see next slides)

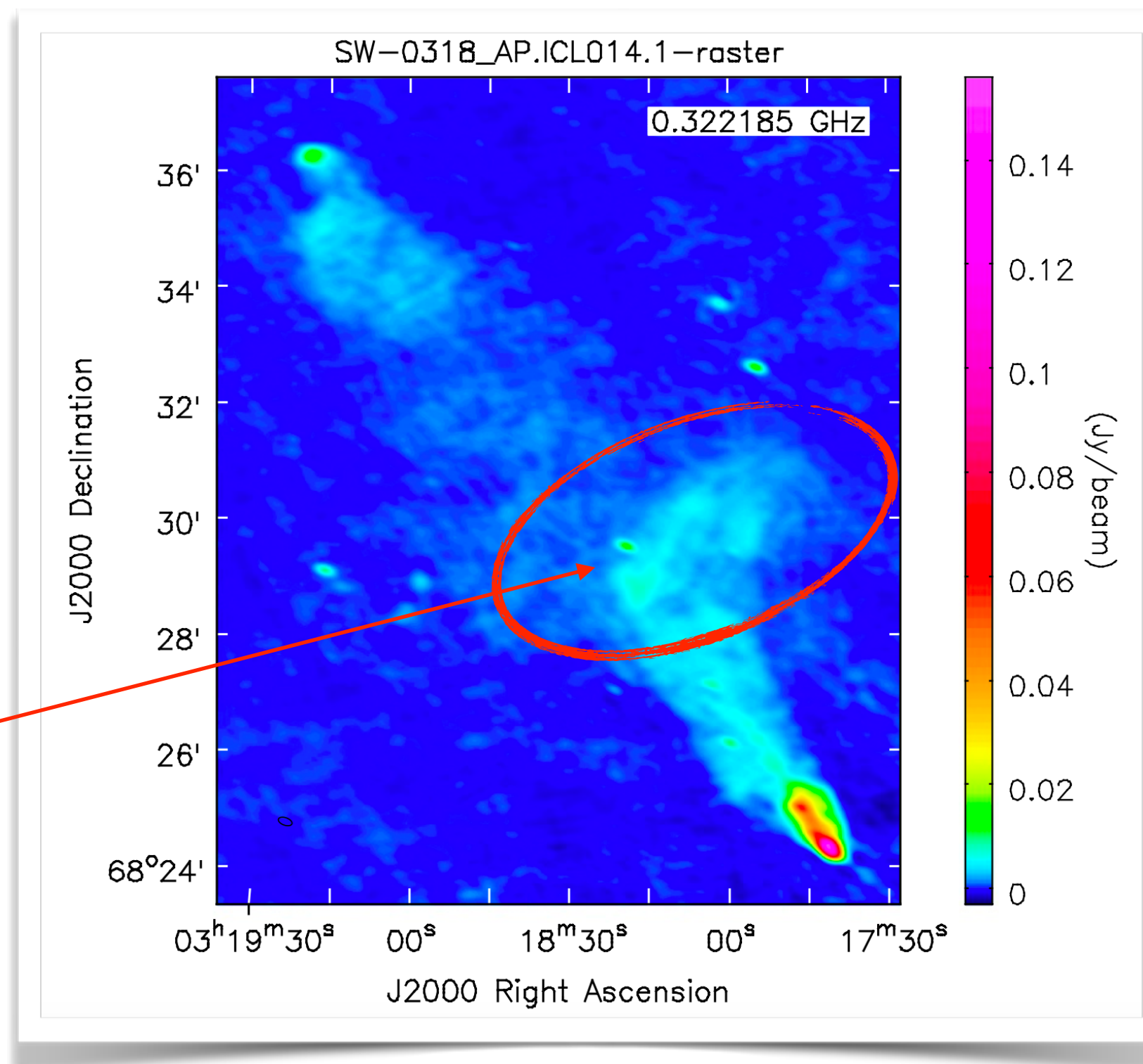
RESULTS FROM OUR CAMPAIGN



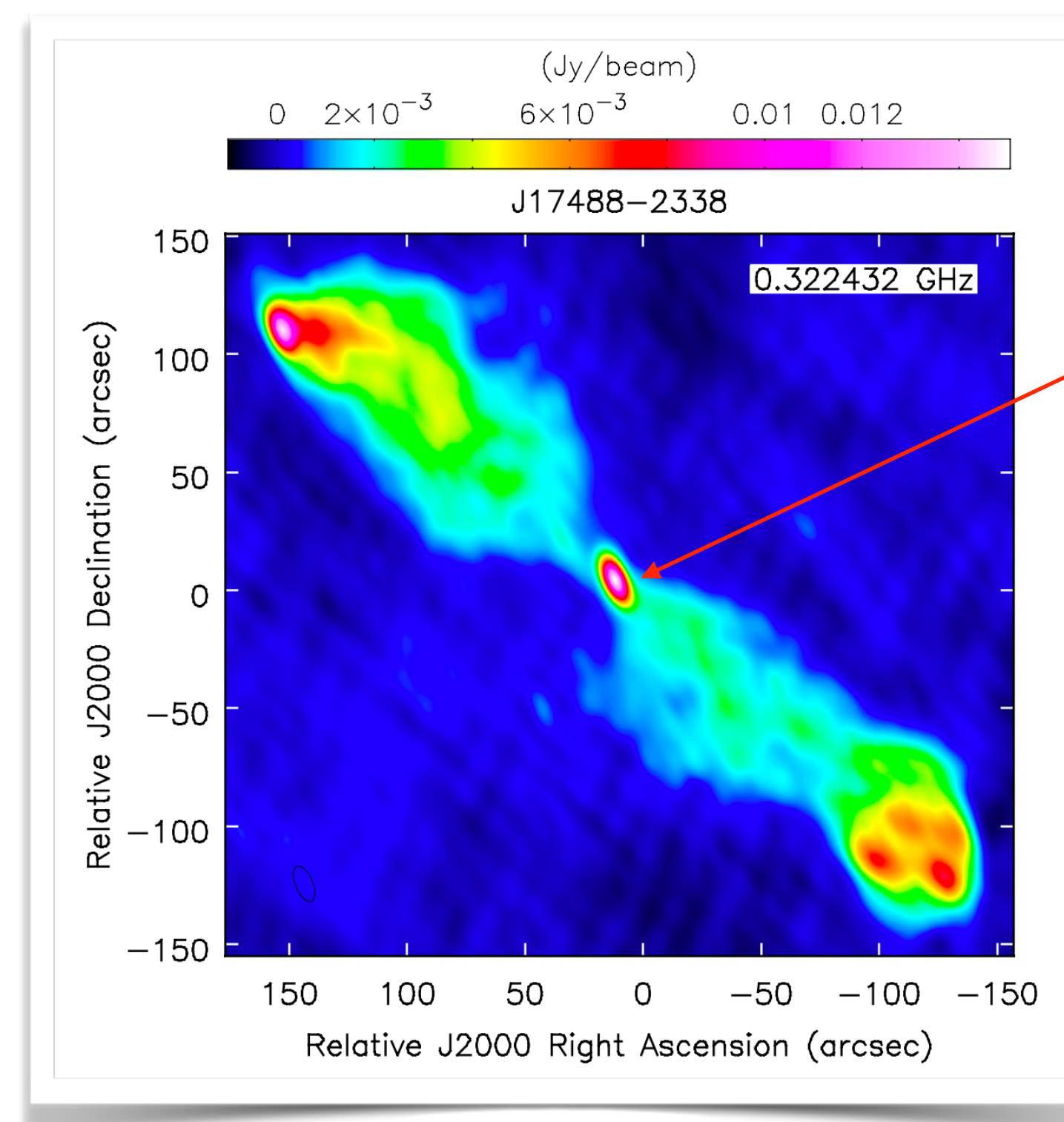
.....

GMRT - data at 325 and/or 610 MHz for 4 sources, two newly discovered GRG:

SW-0318+68



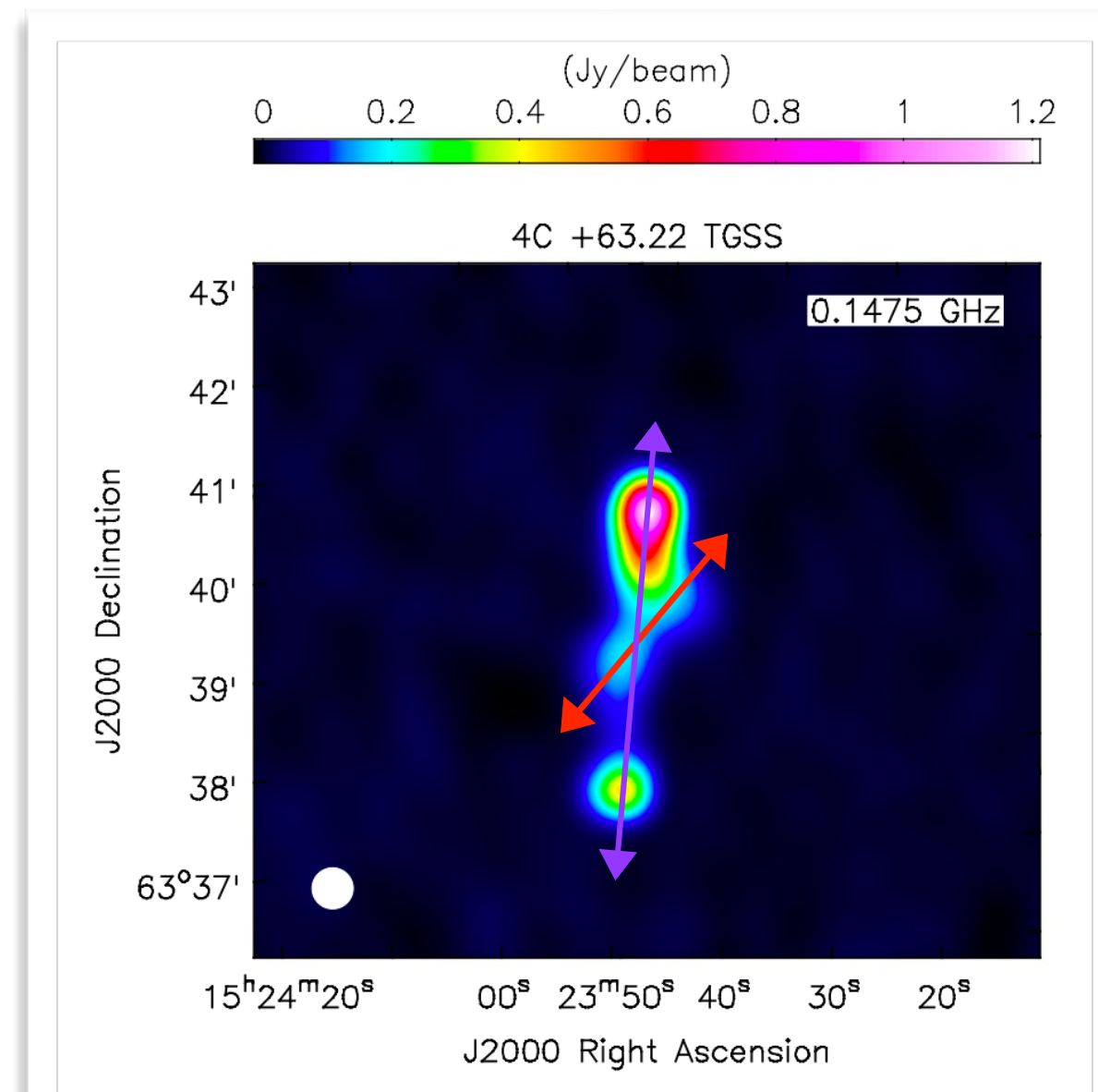
IGR J17488-2338



RESULTS FROM OUR CAMPAIGN

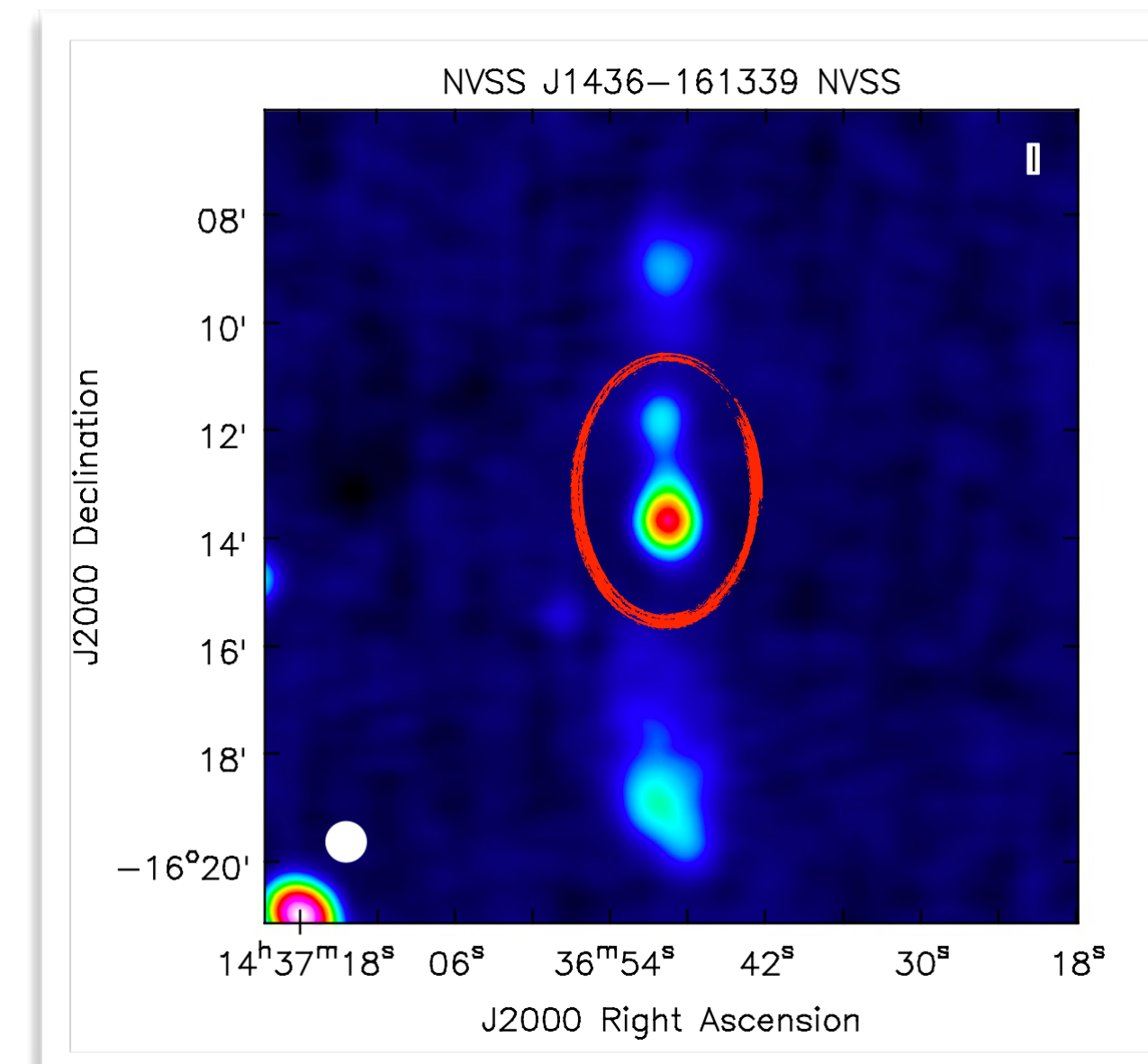


More restarting sources!



4C +63.22

- Double-Double structure in TGSS
- LOFAR (LOTSS) data available



J1436-16

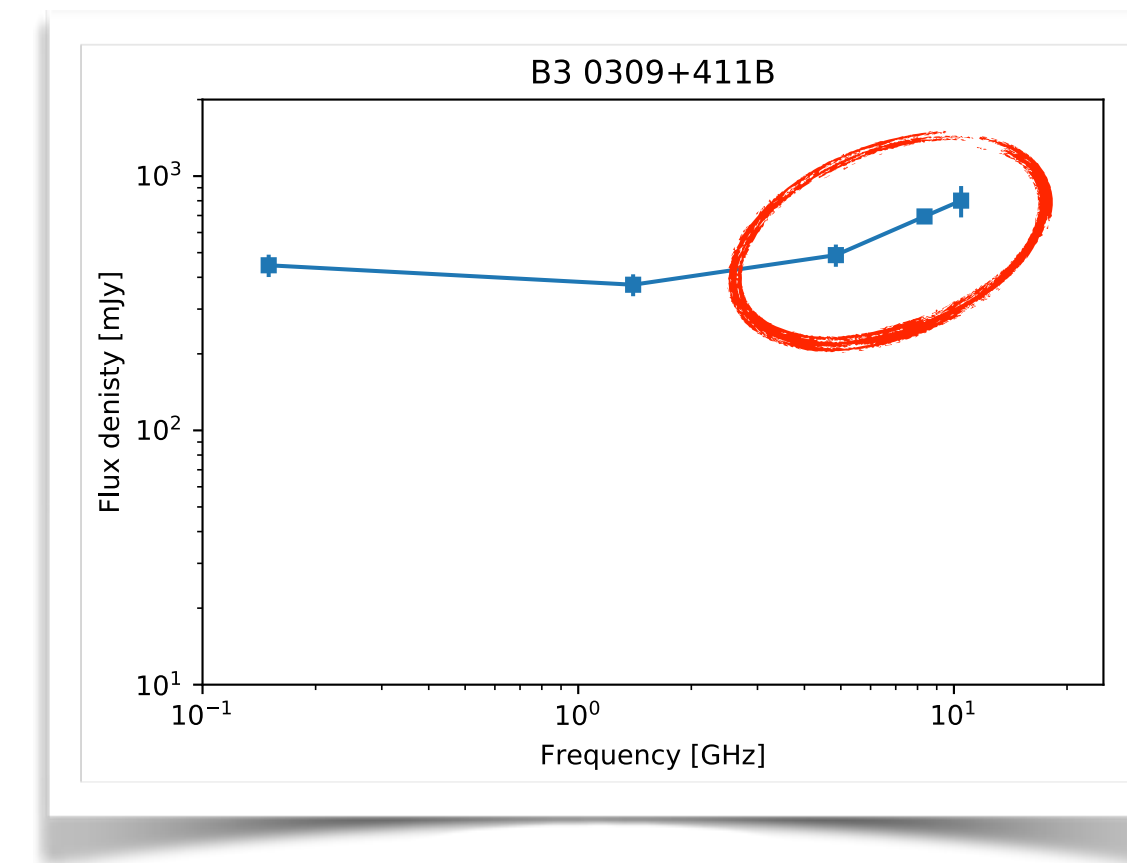
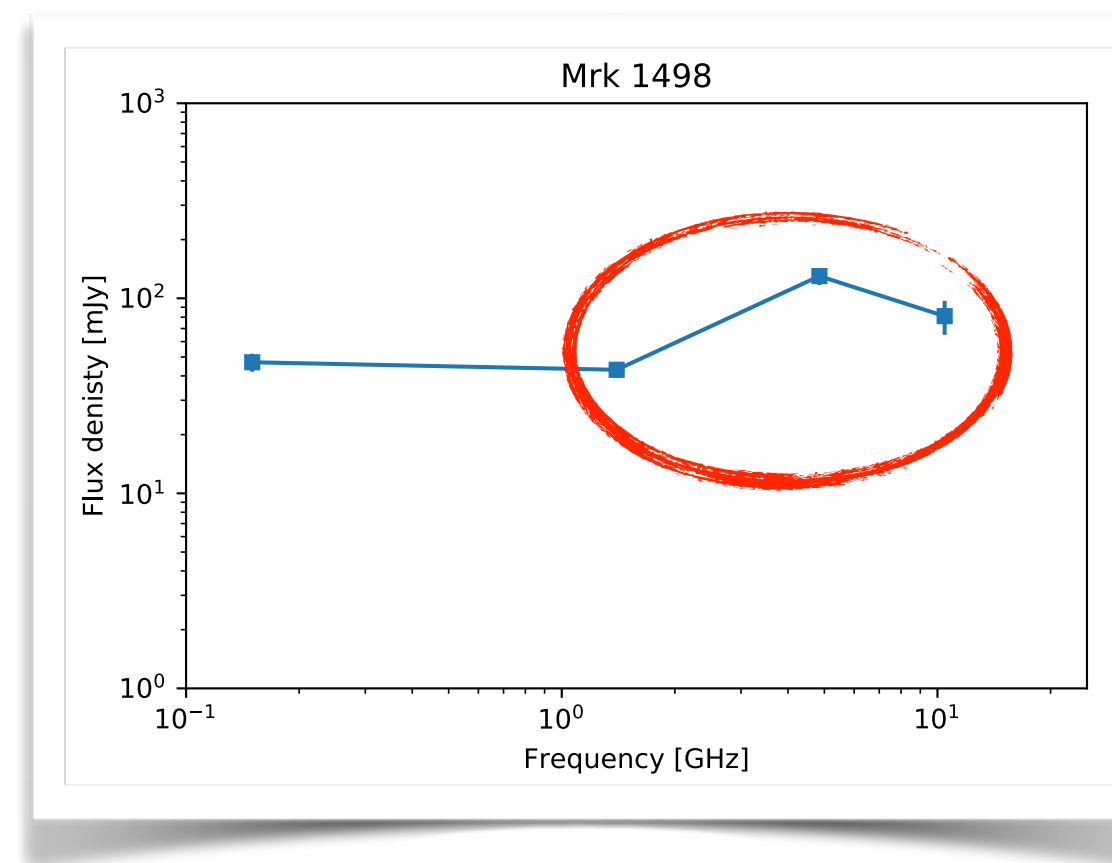
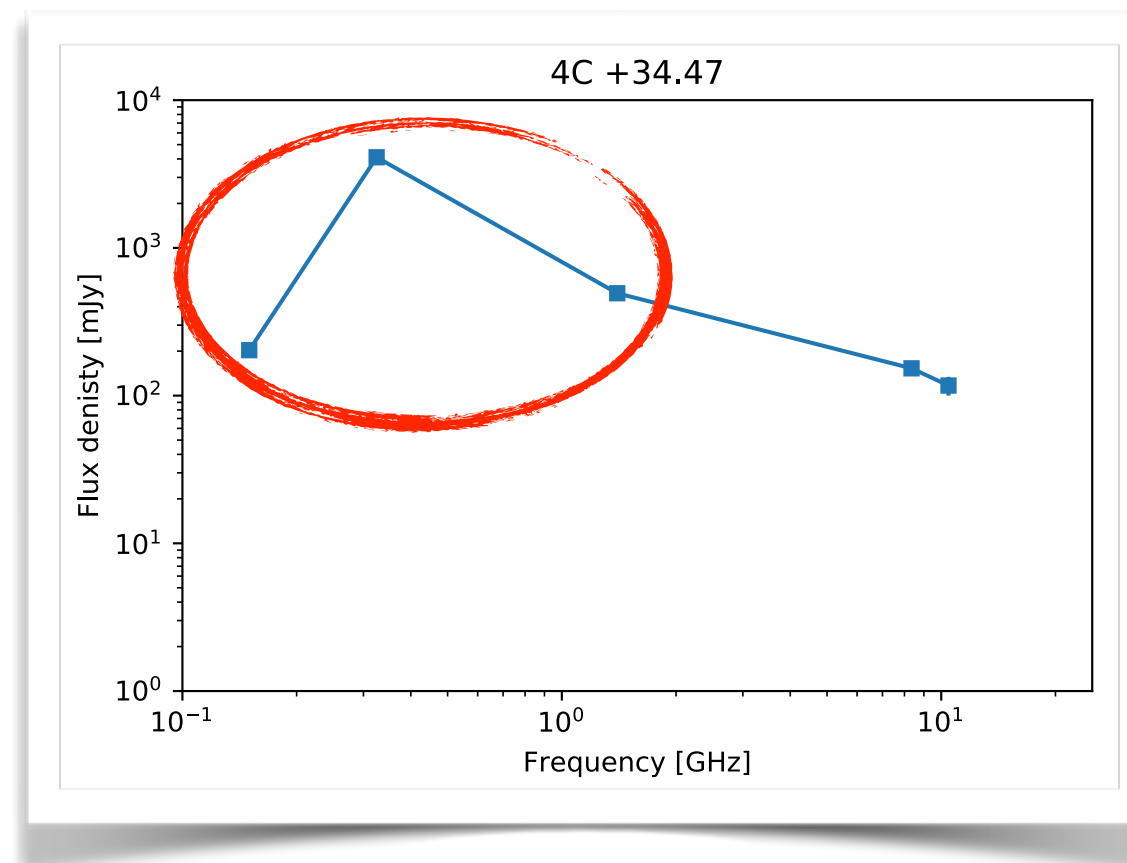
- Core-jet structure between the lobes in NVSS, possible re-orientation

RESULTS FROM OUR CAMPAIGN



More restarting sources!

0.150, 1.4 GHz from TGSS and NVSS
4, 8, 10 GHz from Effelsberg



4C +34.47

- CSS component, still young age

Mrk 1498

- GPS component
- ionization cones off-axis w.r.t jet (Hernandez-Garcia+18, in prep.)

B3 0309+411B

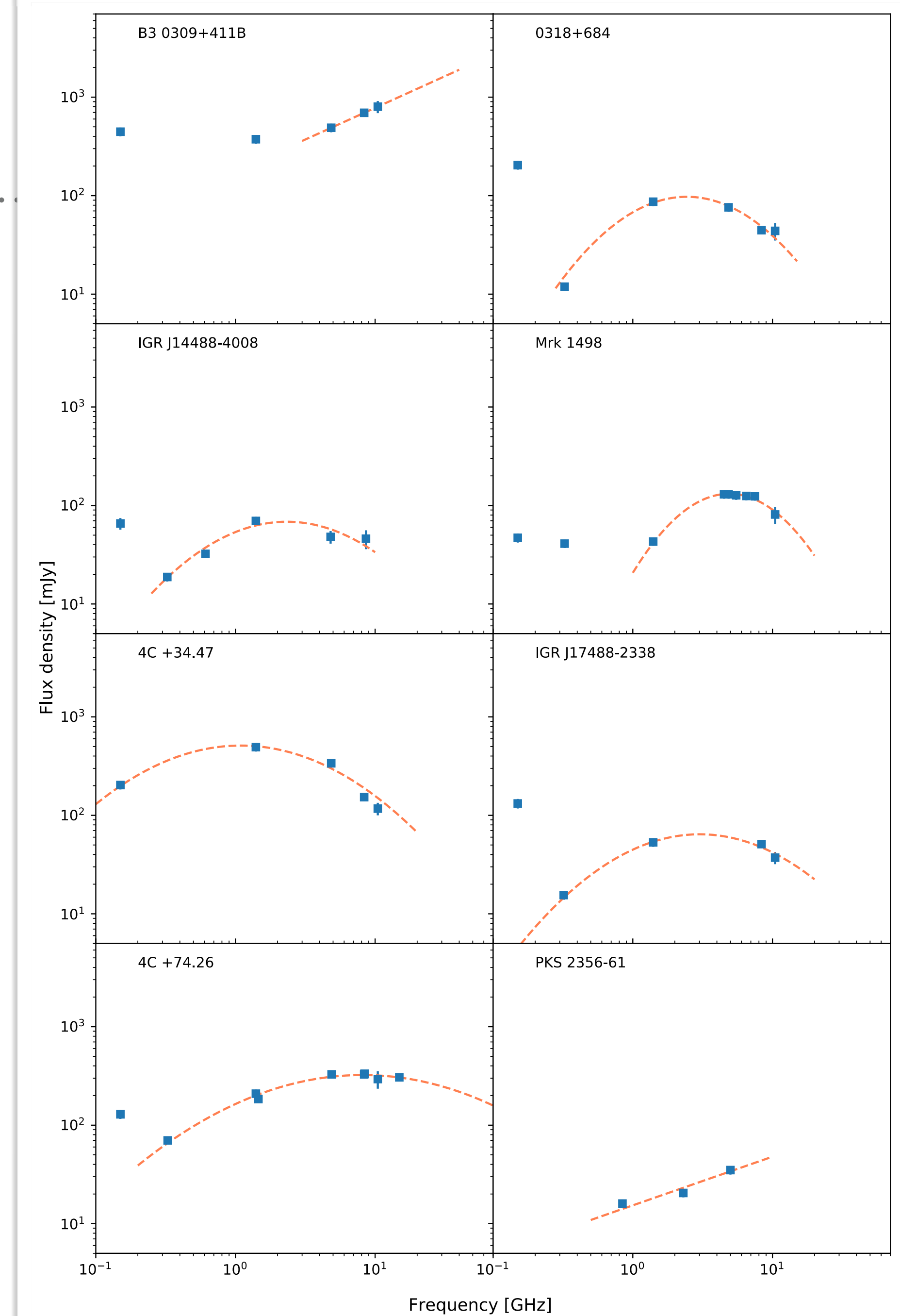
- 50% variability on a 6-months timescale at 10.8 GHz (Seielstad+83)
- Core detections up to 100 GHz, inverted spectrum (HFP?)

RESULTS FROM OUR CAMPAIGN

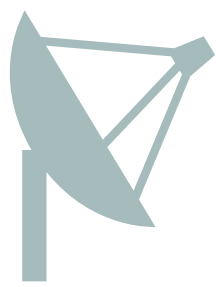
GPS fraction

- Collecting data from archive in the MHz-GHz range for all sources
- A GPS fraction of $61(+30 -21)\%$ is found
- Cores are often young radio sources

Bruni et al. 2019 (subm.)



RESULTS FROM OUR CAMPAIGN



Name	z	Notes
B3 0309+411B	0.134	Restarting (Bruni+19, GPS component)
LCF 2001 J0318+684	0.090	Restarting (Schoenmakers+1998; Bruni+19)
PKS 0707-35	0.111	Restarting (Saripalli+13)
4C 73.08	0.058	Restarting (Wezgowiec et al. 2016)
B2 1144+35B	0.063	Restarting (Schoenmakers+99; Giovannini+07)
NVSS J143649-161339	0.144	Restarting (Bruni+19, DDRG in NVSS)
IGR J14488	0.123	Restarting (Bruni+19, GPS component)
4C +63.22	0.204	Restarting (Bruni+19, DDRG in TGSS)
WN1626+5153 (Mrk1498)	0.055	Restarting (Bruni+19, GPS component)
4C +34.47	0.206	Restarting (Bruni+19, CSS component)
IGR J17488	0.24	Restarting (Bruni+19, GPS component)
4C +74.26	0.104	Restarting (Pearson+92; Bruni+19)
PKS 2331-240	0.048	Restarting (Hernandez-Garcia+17)
PKS 2014-55	0.060	Restarting (Saripalli+08)
PKS 2356-61	0.096	Restarting (Bruni+19, GPS component)

6 restarting from the literature + 9 from present work = 15/15

CONCLUSIONS



- We selected a GRG sample starting from INTEGRAL+Swift soft gamma-ray catalogues
- GRG fraction among soft gamma-ray selected RG is four times larger than in radio-selected samples
- All GRGs show signs of restarting activity: $\sim 60\%$ have a GPS core, $\sim 40\%$ restarting morphology
- Assuming no selection bias, this could suggest that restarting activity favors the growth and fraction of such spectacular objects
- More sources from Swift/BAT and INTEGRAL/IBIS latest catalogues releases
- Comparison sample study ongoing to exclude selection effect
- Agreement under discussion with ANTARES, to detect neutrino counterpart

GRAL

IAPS

GRAL

GAMMA RADIO ASTROPHYSICAL LAB



Home

Our Group

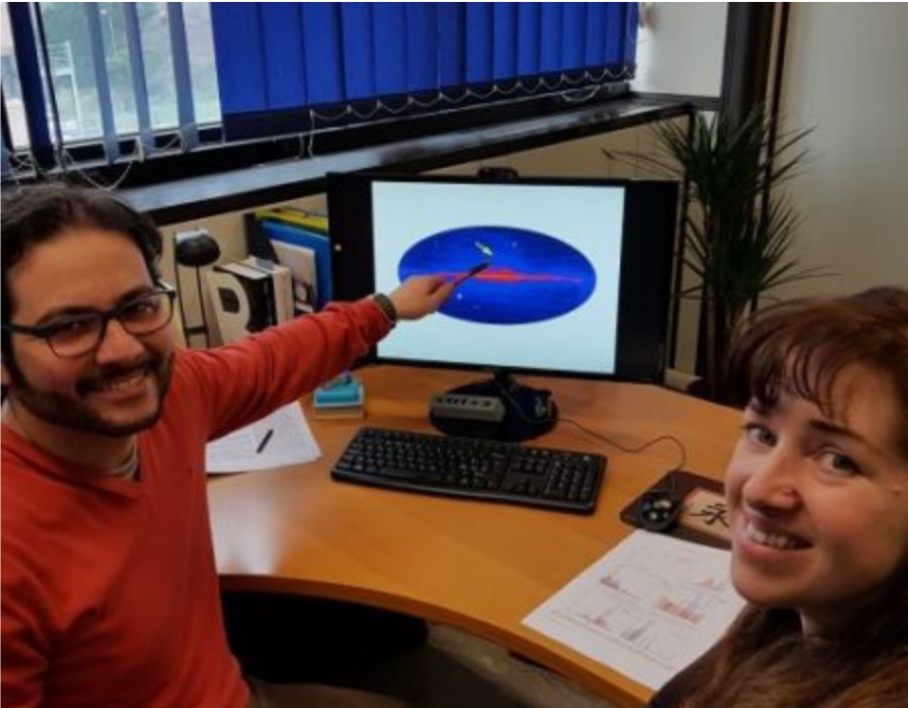
Research

Activities

Papers

Outreach

Links



THE GRAL

The Gamma-Radio group at IAPS has a long sought experience in High Energy Astrophysics and it has been involved in the design, realisation, calibration, management and science exploitation of instruments on board of astronomical satellites and stratospheric balloons. Recently, we are also acquiring expertise in Radio Astronomy. Our group is deeply involved in the investigation of Galactic and Extra-galactic astrophysics, including multi-frequency follow-up of the new transients, such as gravitational waves, neutrinos and fast radio bursts.

Search

GRAL CLOUD



Restricted area



<http://gral.iaps.inaf.it>

