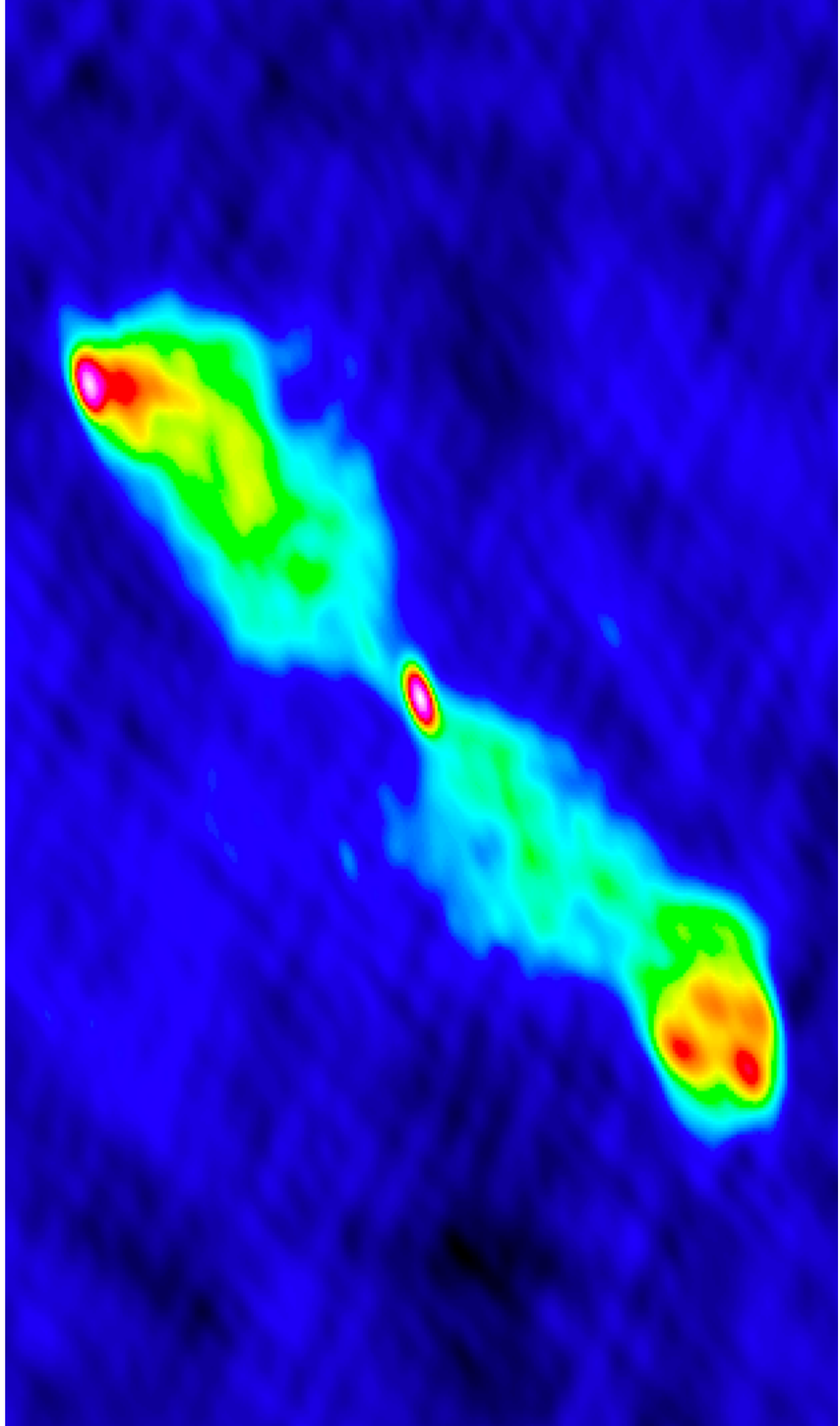
GIANTS IN THE SKY

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

Gabriele Bruni, INAF-IAPS



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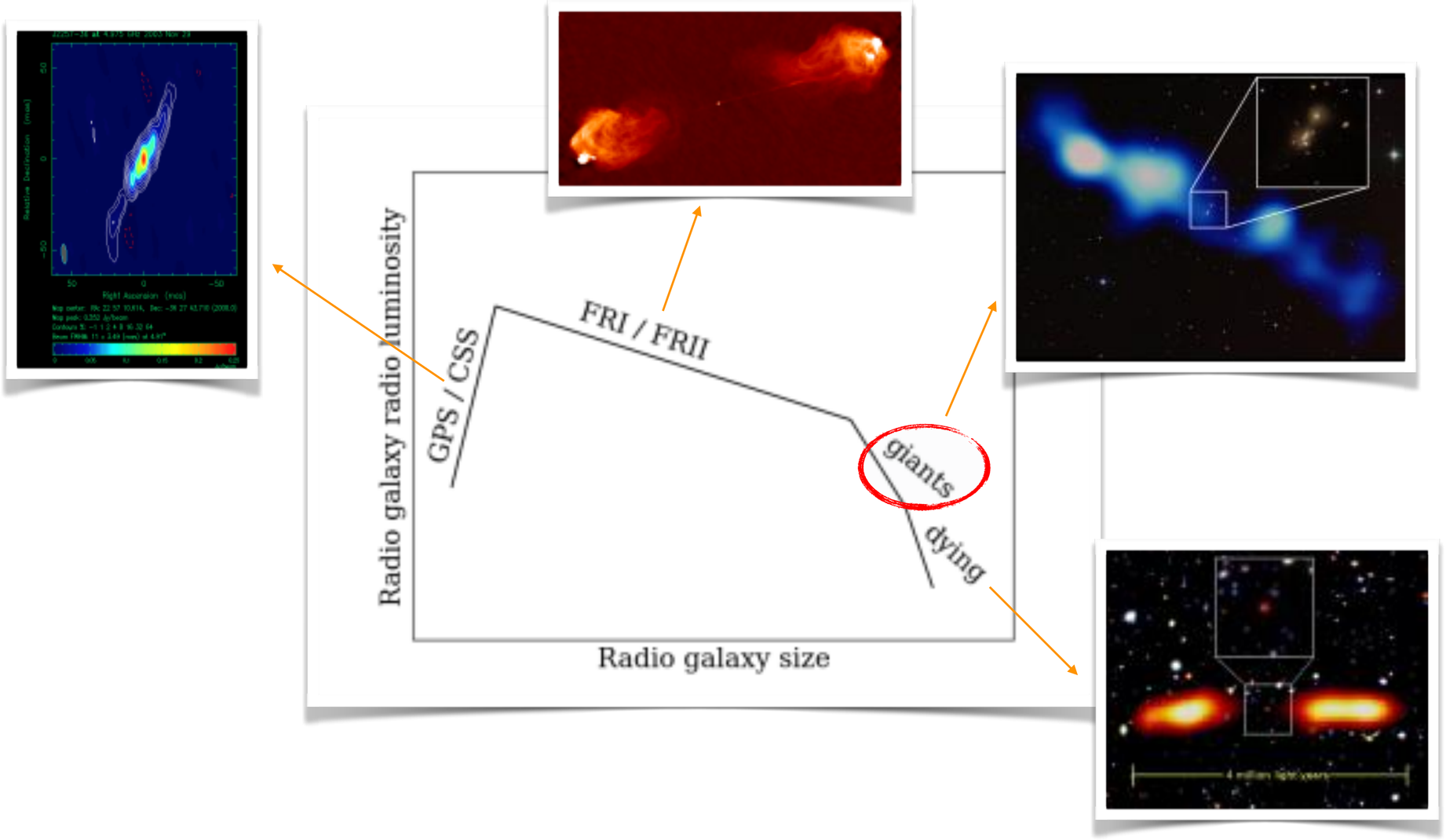
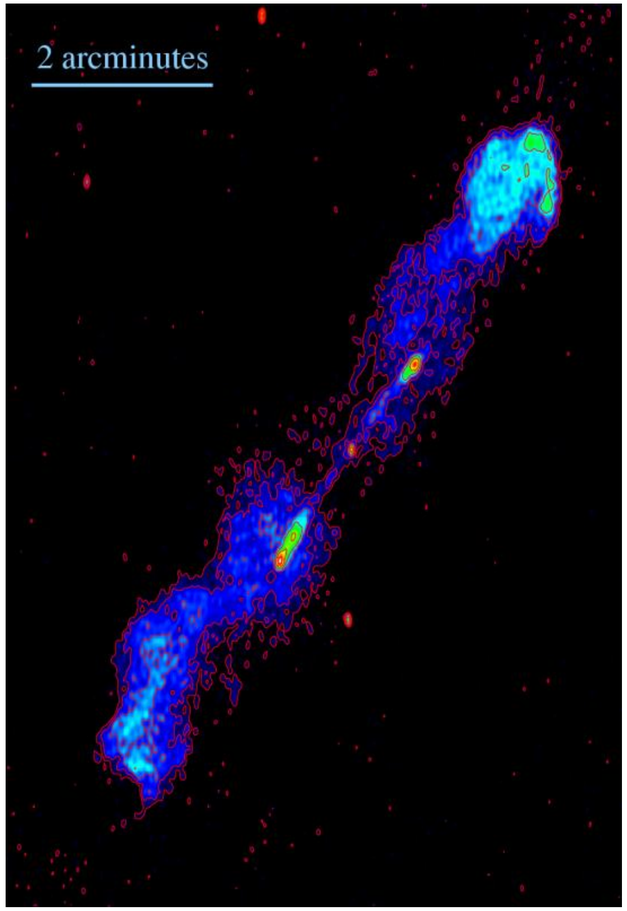
L. Hernandez-Garcia (U. Valparaiso)

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?



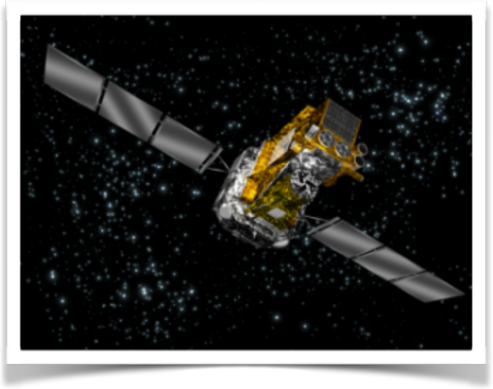
B1545-321 (ATCA, 13cm)

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)

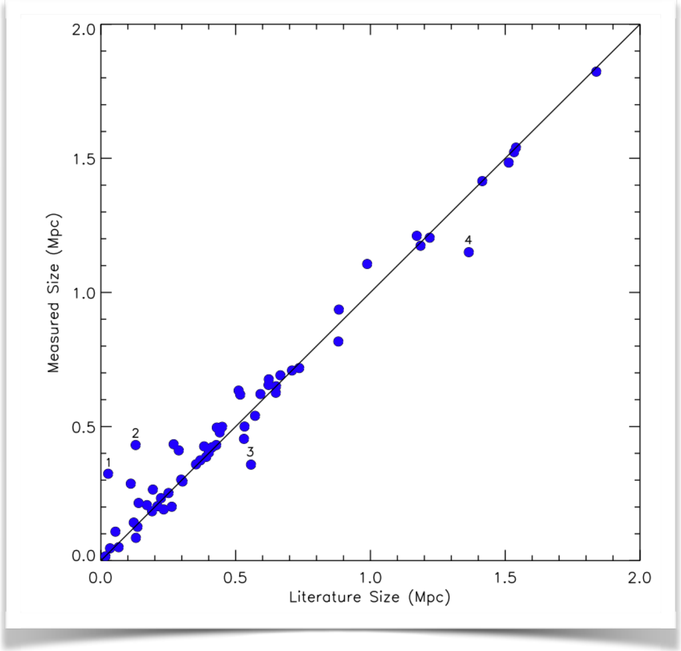
Bird et al. 2010
Malizia et al. 2012

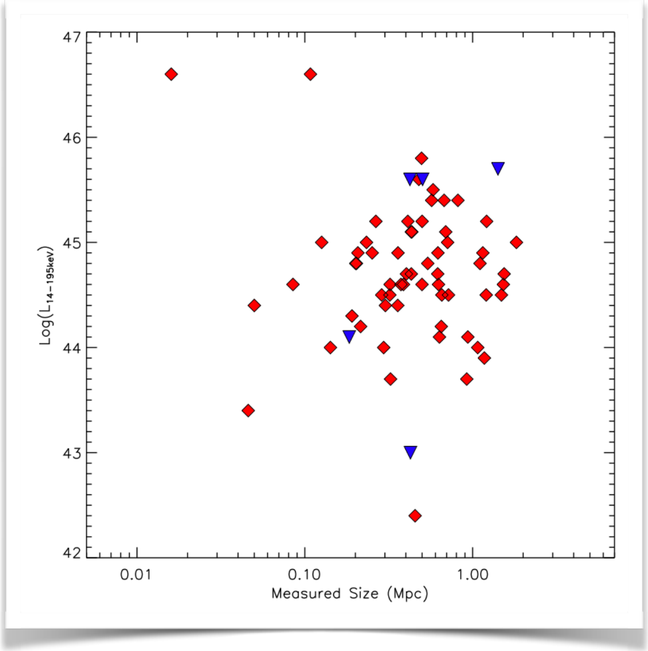
…most extensive list of soft gamma-ray selected AGN

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

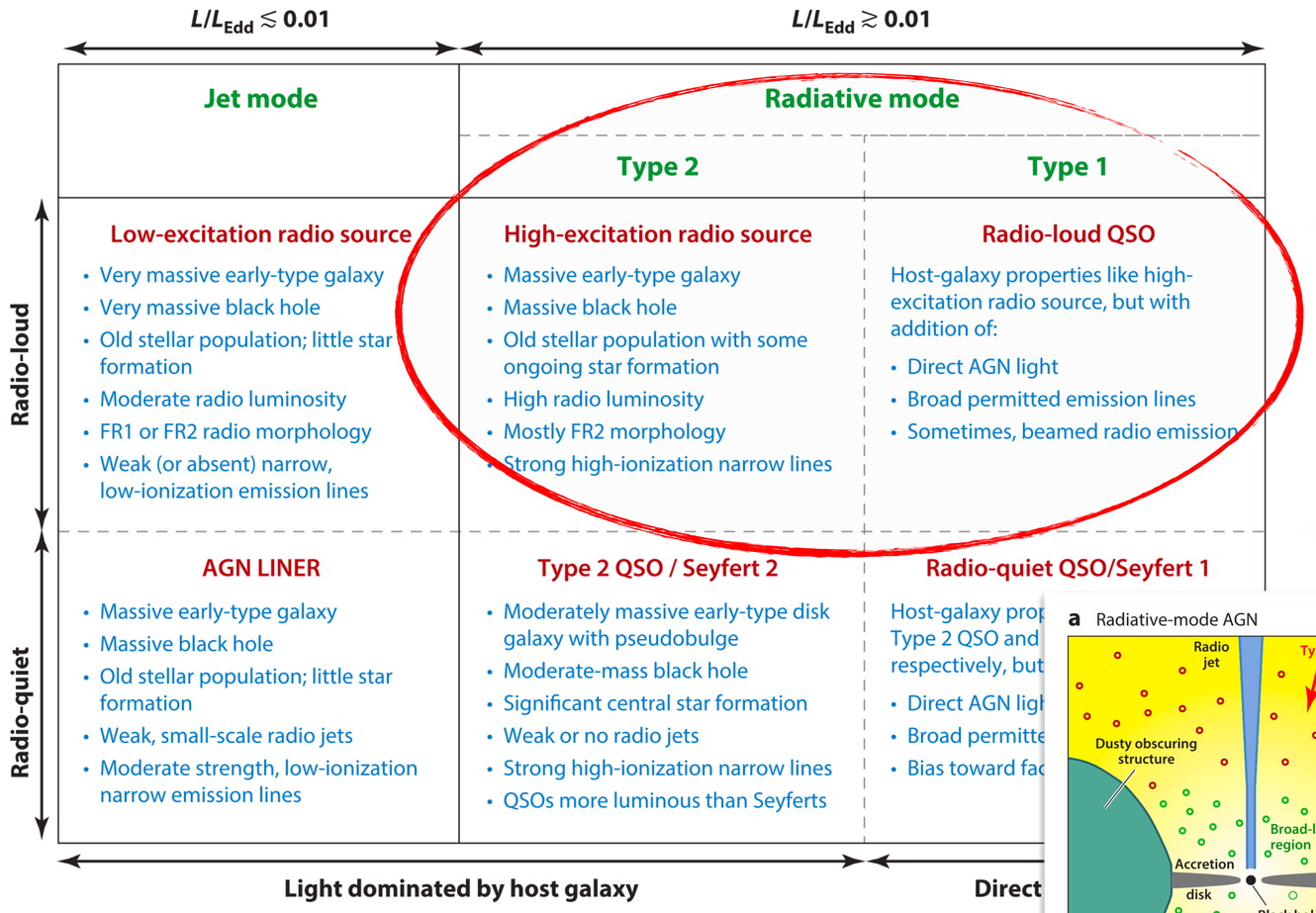
67 radio galaxies with double morphology
31 RG with size >0.5 Mpc
14 GRGs >0.7 Mpc (22%)





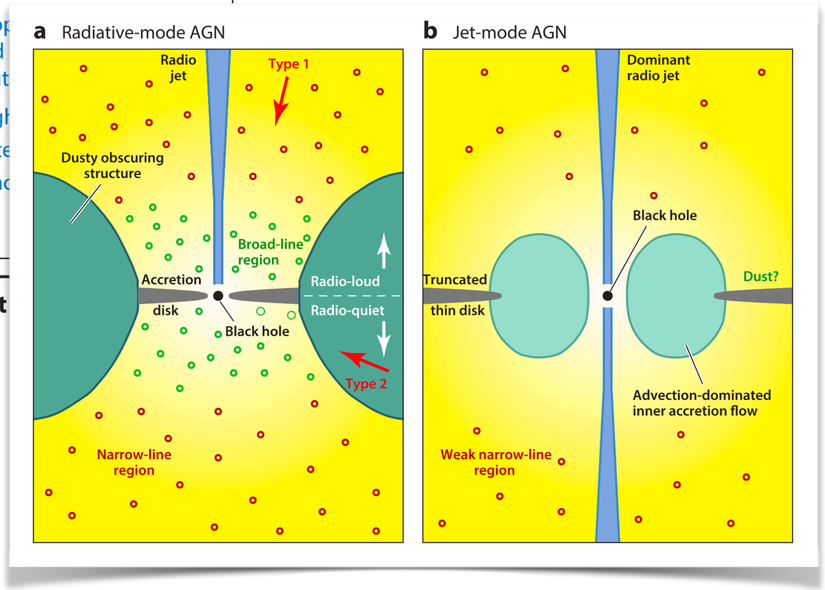
Bassani et al. 2016

THE SAMPLE



51 FRII objects
6 FRI
6 FRI/FRII
1C

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

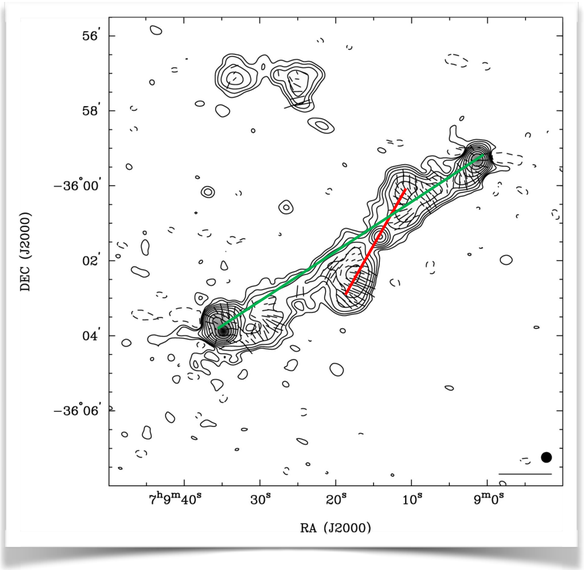


Heckman & Best 2014

SIGNS OF RESTARTING ACTIVITY

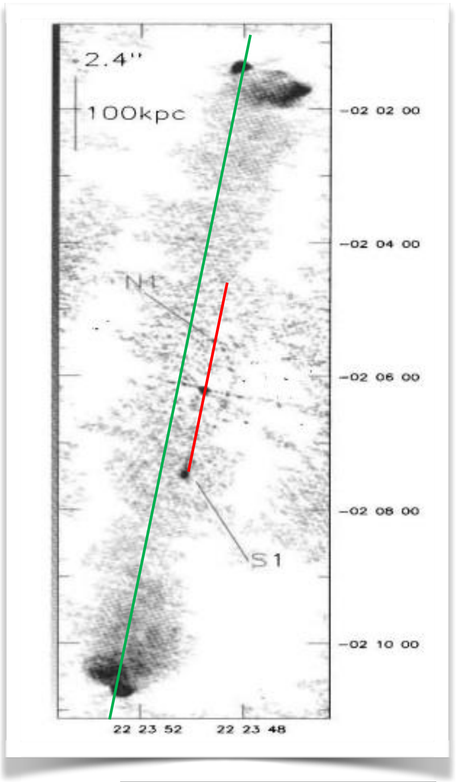
Double-Double RG

B0707-359
Axis change



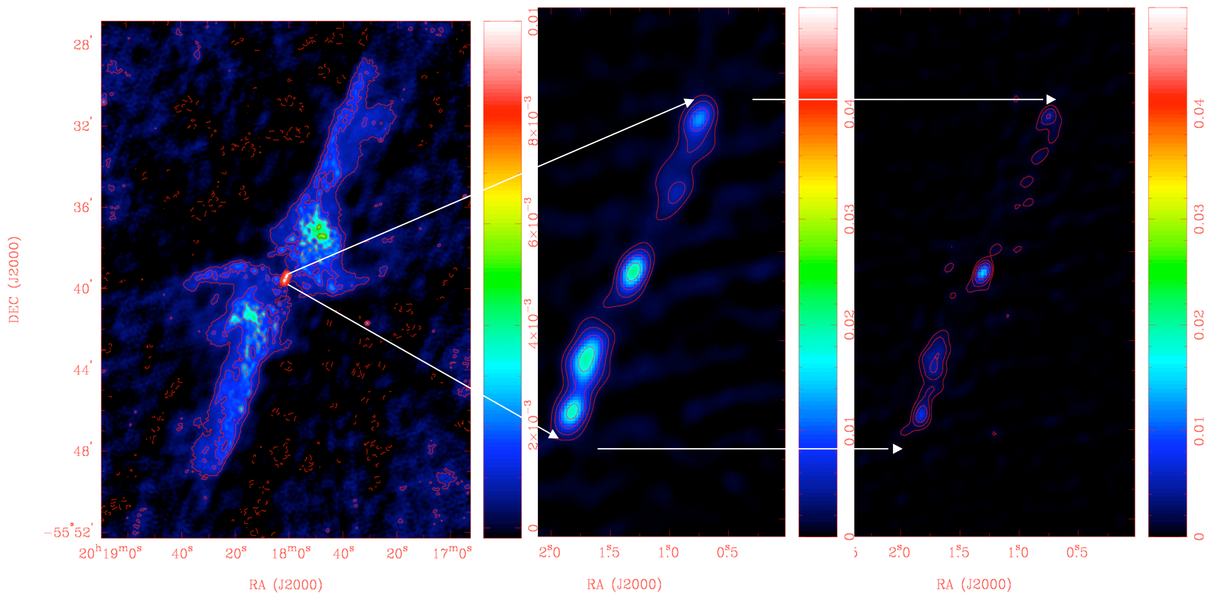
Saripalli et al. 2013

3C 445
No axis change



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

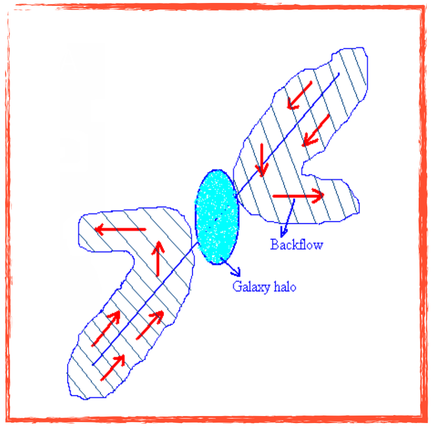
SIGNS OF RESTARTING ACTIVITY



X-shaped RG

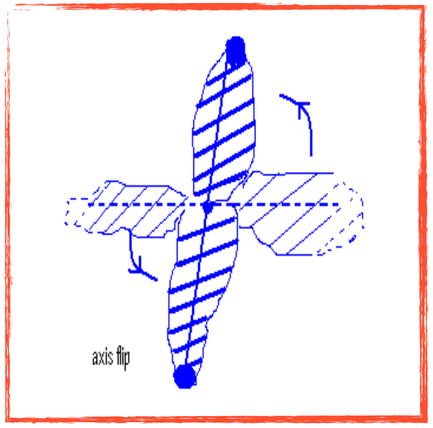
PKS 2014-55

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.

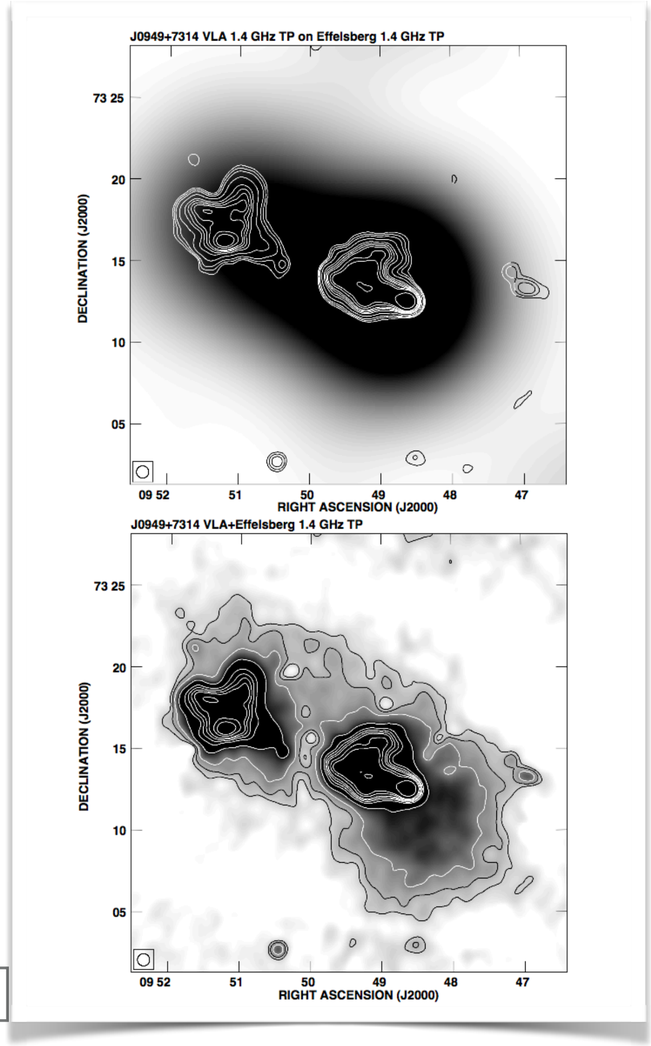
Saripalli et al. 2008

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



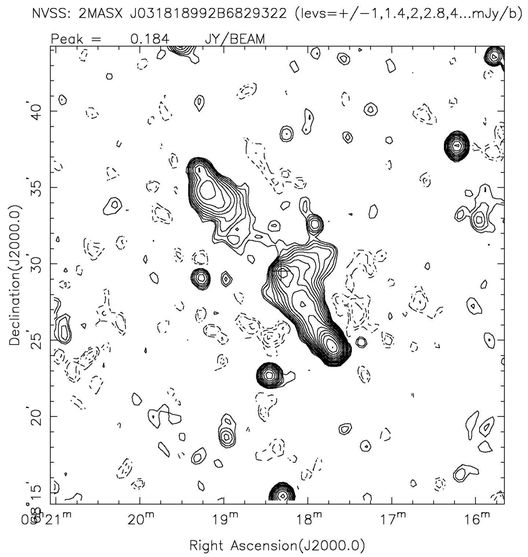
Wezgoviec et al. 2016

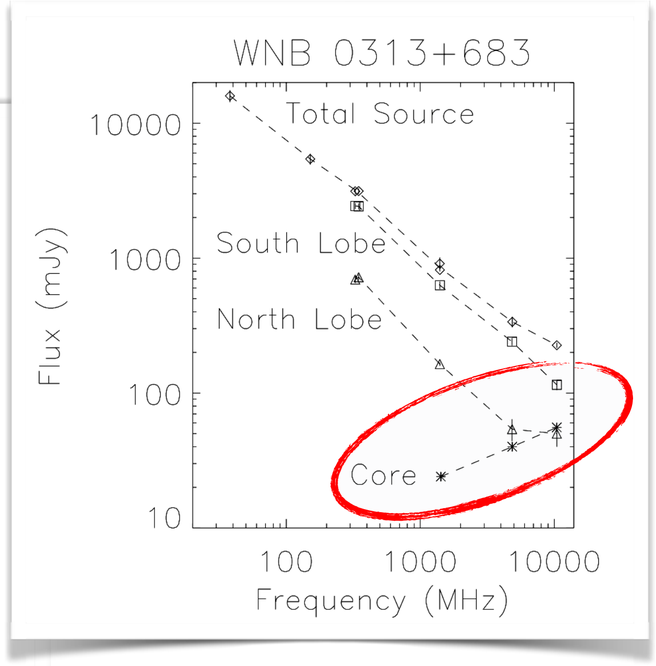
SIGNS OF RESTARTING ACTIVITY

GPS-like core

WNB 0313+683

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



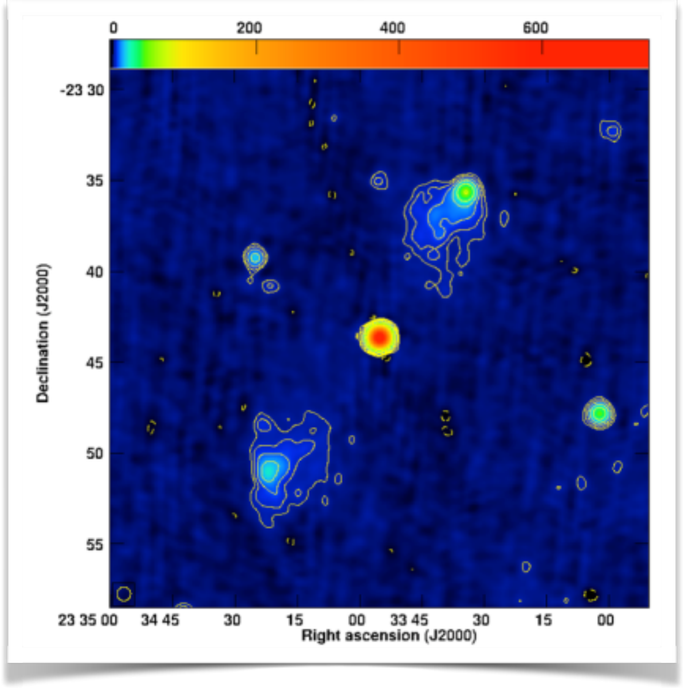


Schoenmakers et al. 1998

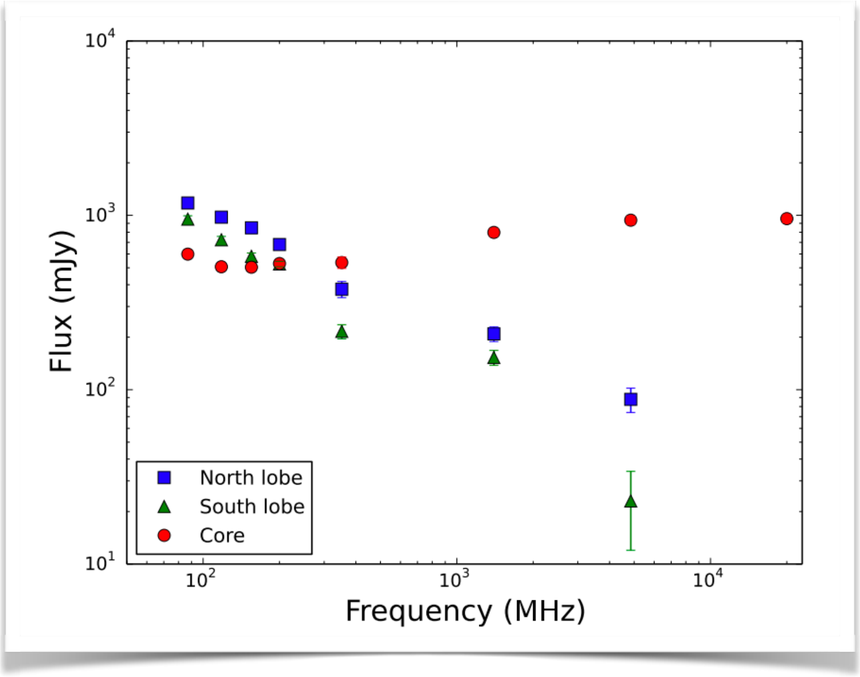
SIGNS OF RESTARTING ACTIVITY

Blazar-like core!

PBC J2333.9-2343



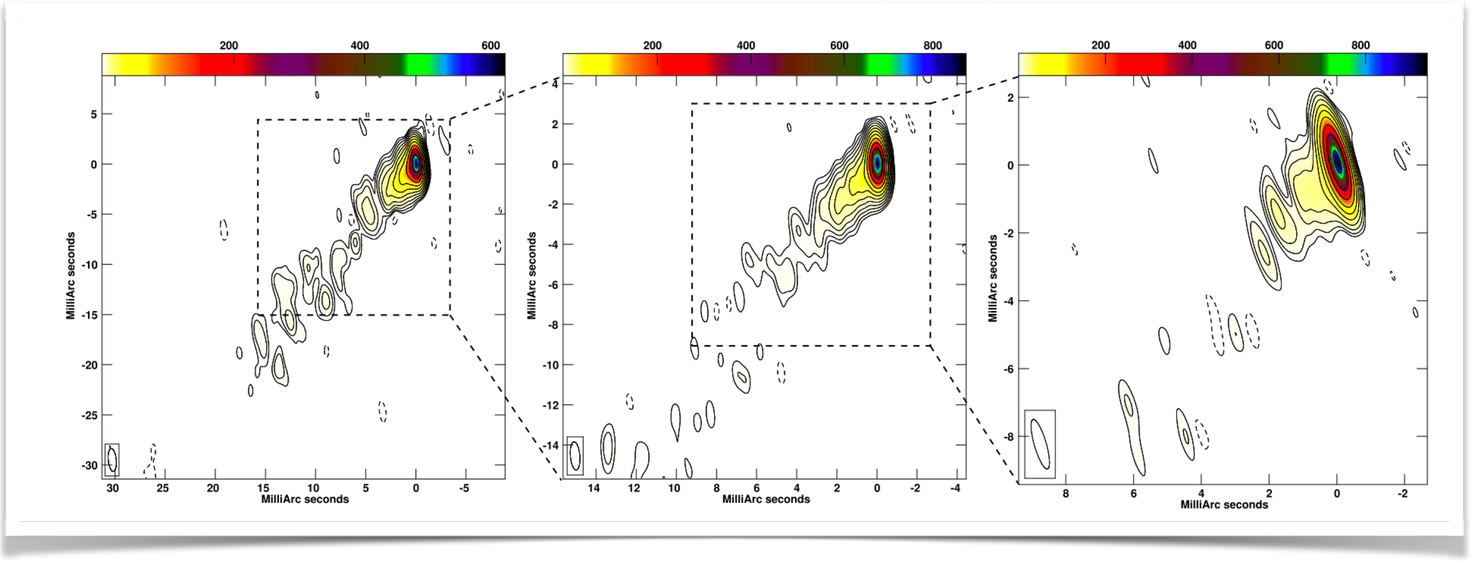
NVSS



Radio SED from literature

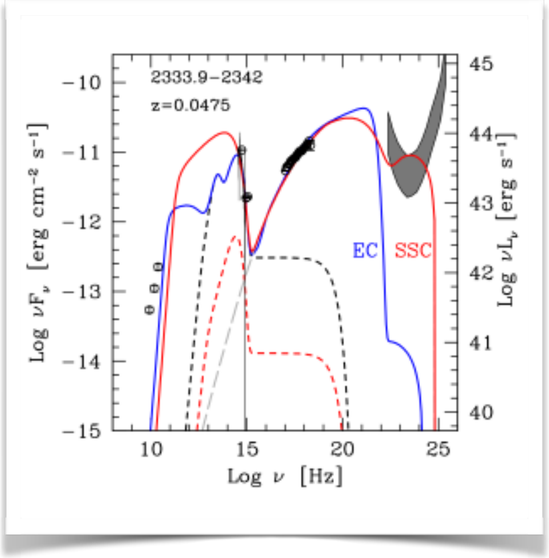
Hernandez-Garcia et al. 2017

SIGNS OF RESTARTING ACTIVITY

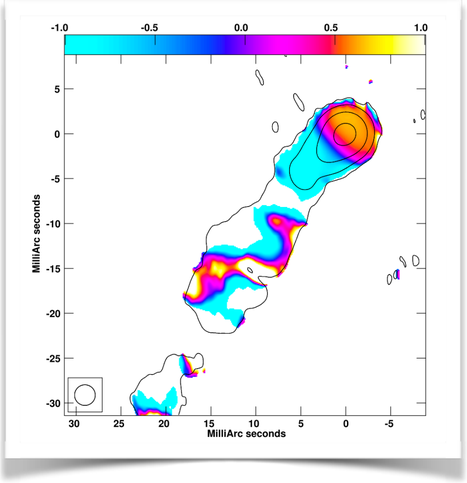


VLBA

8, 15, 22 GHz



…inner jet axis towards line of sight



Hernandez-Garcia et al. 2017

SIGNS OF RESTARTING ACTIVITY

- 6/15 GRG present signs of restarting activity from the literature (~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)*

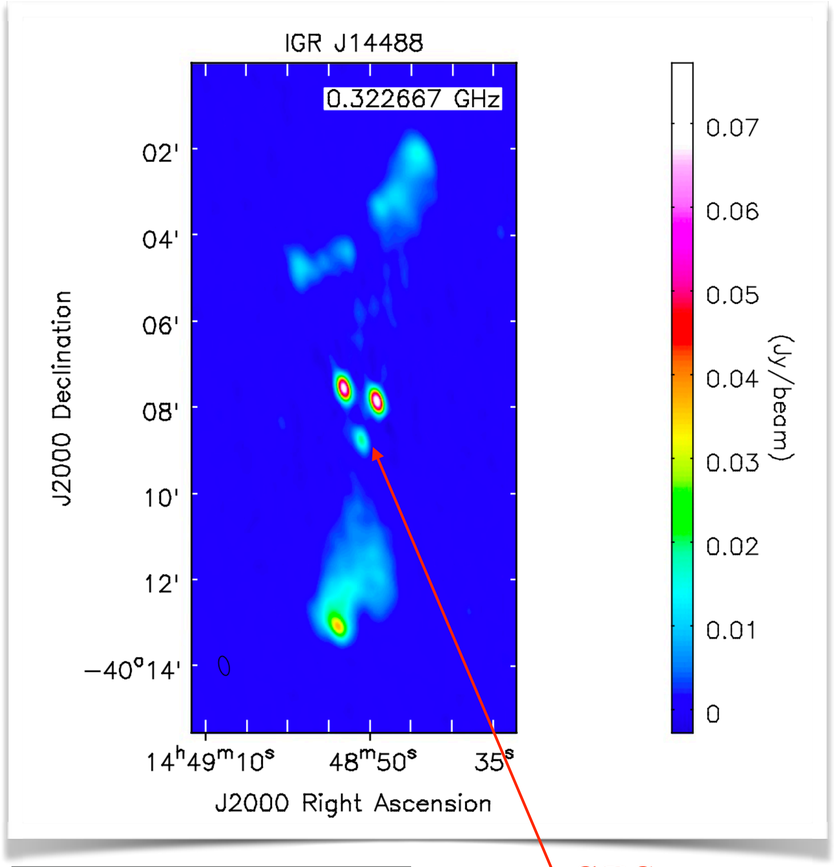
- *TGSS images at 150 MHz (25x25 arcsec resolution, 12/14)*

RESULTS FROM OUR CAMPAIGN

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

IGR J14488-4008

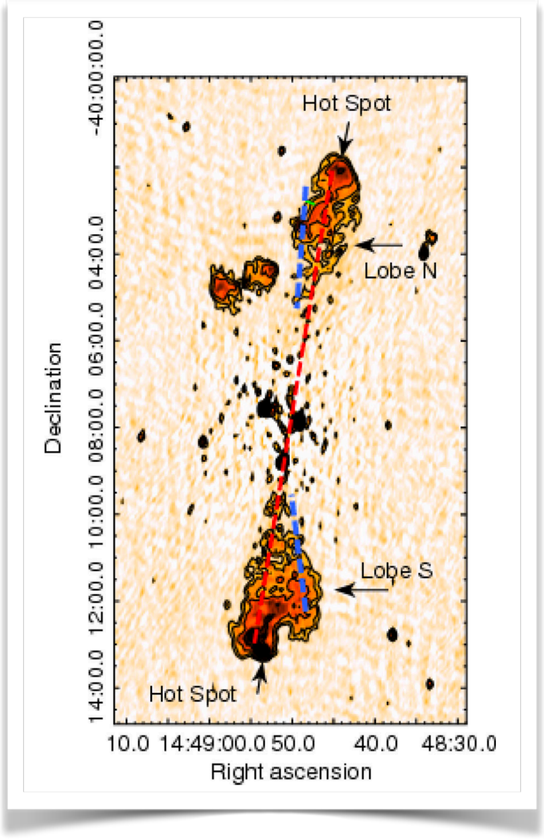
325 MHz



Bruni et al. 2018 (in prep.)

GPS core
(see next slides)

610 MHz

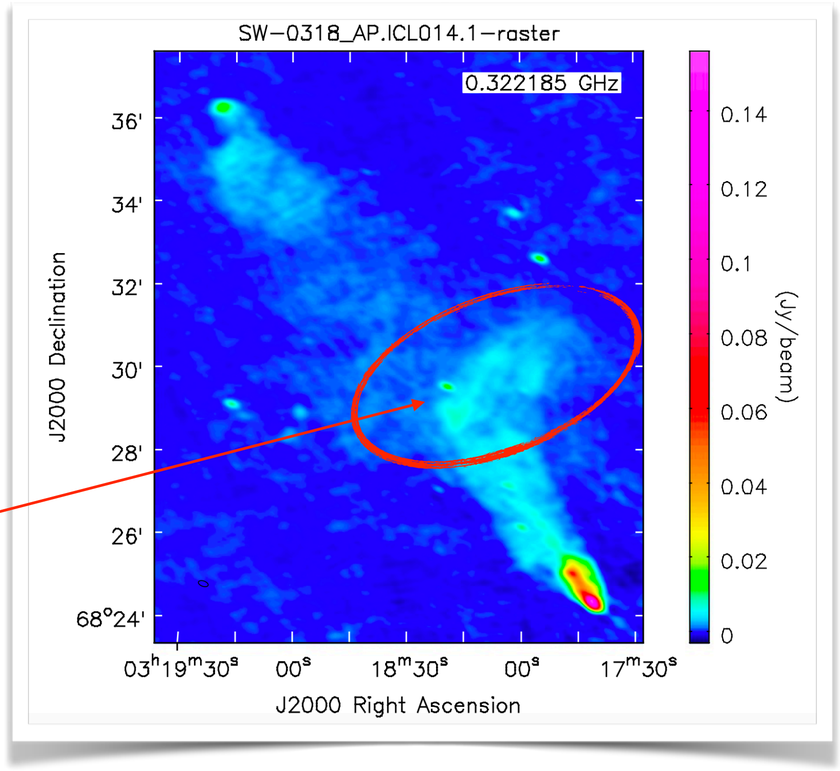


Molina et al. 2015

RESULTS FROM OUR CAMPAIGN

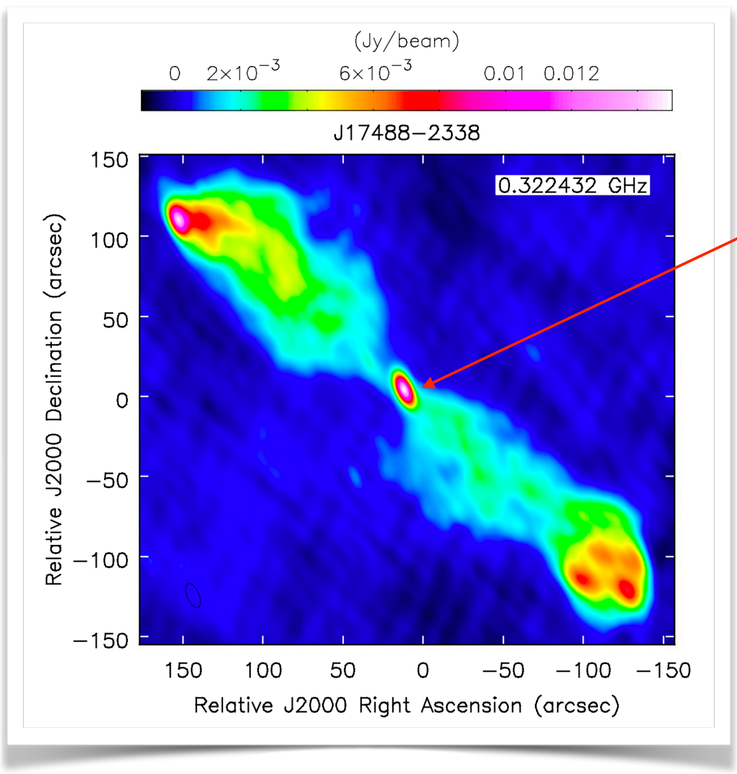
GMRT - data at 325 and/or 610 MHz for 4 sources, two newly discovered GRG:

SW-0318+68



GPS core
(see next slides)

IGR J17488-2338

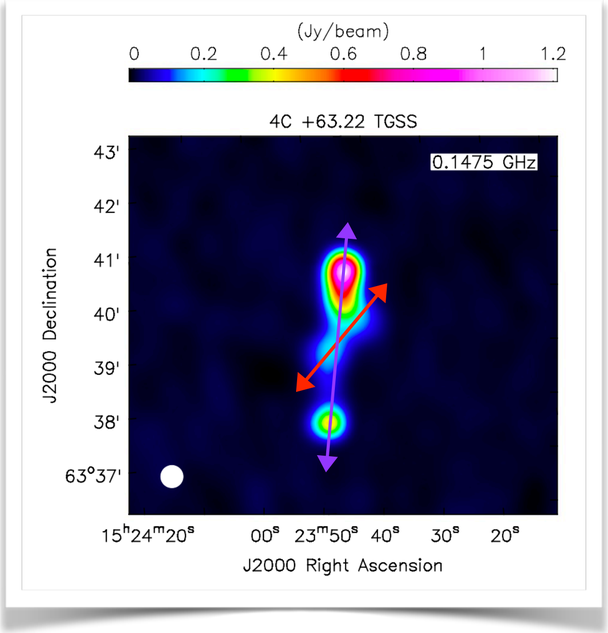


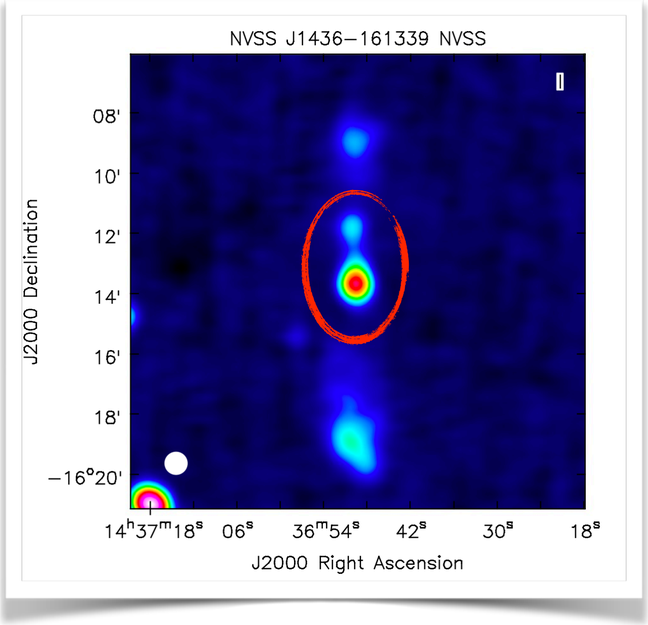
GPS core
(see next slides)

Bruni et al. 2018 (in prep.)

RESULTS FROM OUR CAMPAIGN

More restarting sources!





4C +63.22

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

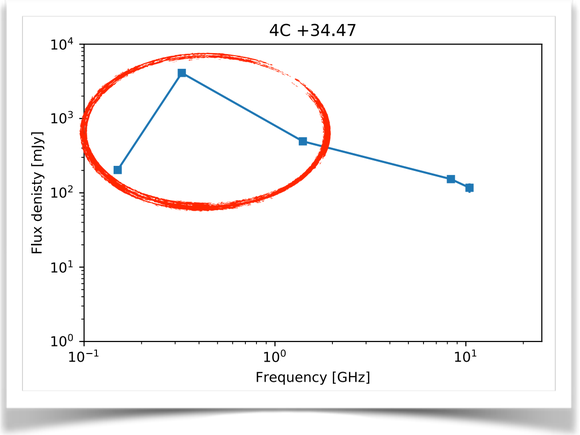
J1436-16

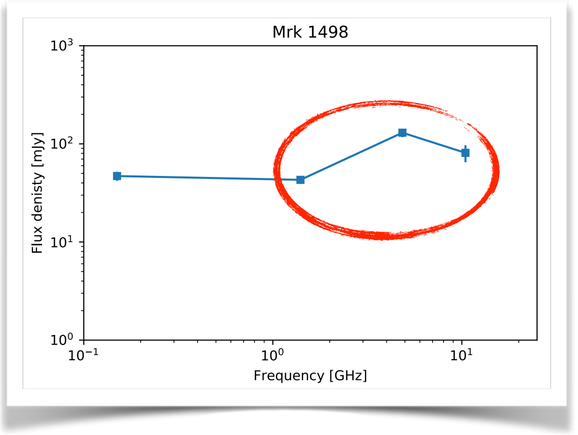
- Core-jet structure between the lobes in NVSS, possible re-orientation

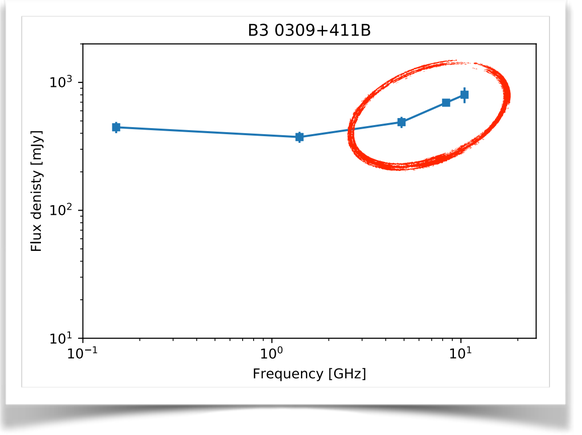
RESULTS FROM OUR CAMPAIGN

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.)

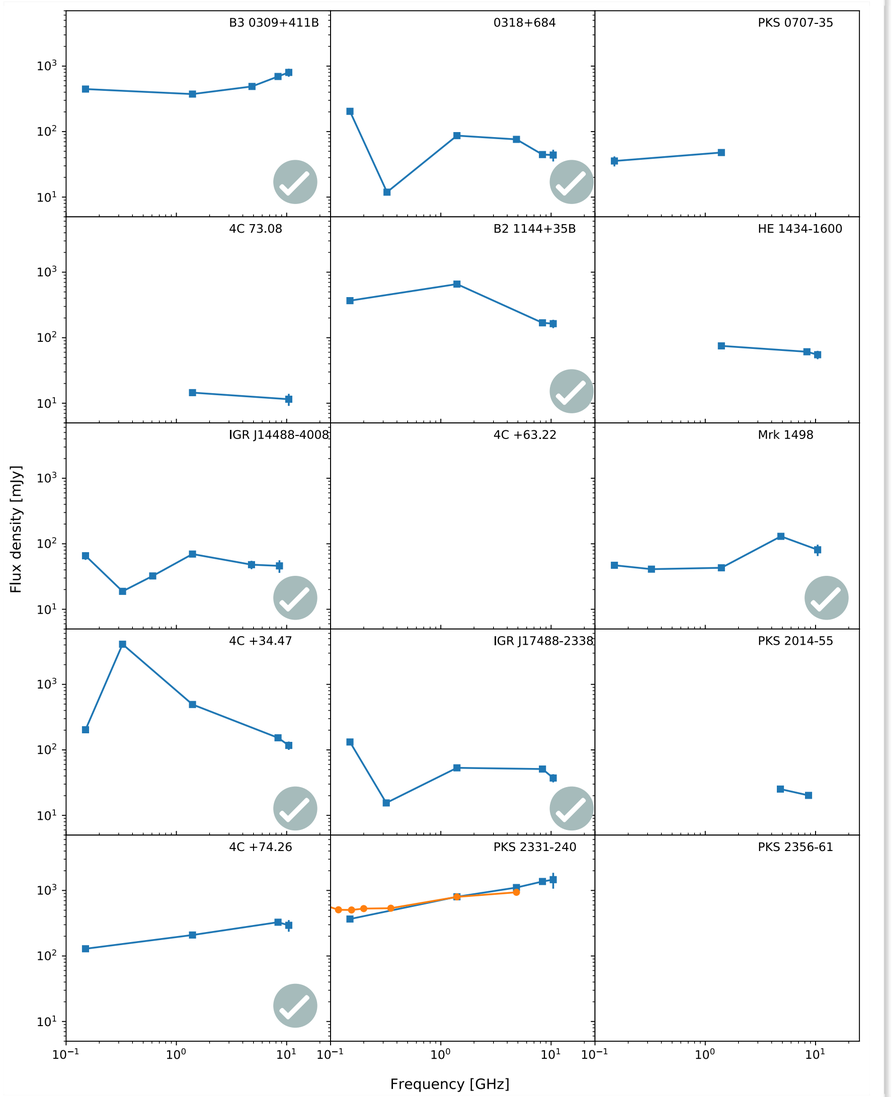
B3 0309+411B

- 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 66% is found
- Cores are often young radio sources



RESULTS FROM OUR CAMPAIGN

Name	z	Notes
B3 0309+411B	0.134	Restarting (Bruni+18, GPS component)
LCF 2001 J0318+684	0.090	Restarting (Schoenmakers+1998)
PKS 0707-35	0.111	Restarting (Saripalli+13)
4C 73.08	0.058	Restarting (Wezgoviec et al. 2016)
B2 1144+35B	0.063	Restarting (Bruni+18, GPS component)
NVSS J143649−161339	0.144	Restarting (Bruni+18, DDRG in NVSS)
IGR J14488	0.123	Restarting (Bruni+18, GPS component)
4C +63.22	0.204	Restarting (Bruni+18, DDRG in TGSS)
WN1626+5153 (Mrk1498)	0.055	Restarting (Bruni+18, GPS component)
4C +34.47	0.206	Restarting (Bruni+18, CSS component)
IGR J17488	0.24	Restarting (Bruni+18, GPS component)
4C +74.26	0.104	Restarting (Pearson+92)
PKS 2331-240	0.048	Restarting (Hernandez-Garcia+17)
PKS 2014-55	0.060	Restarting (Saripalli+08)
PKS 2356-61	0.096	?

6 restarting from the literature + 8 from present work = 14/15

CONCLUSIONS

- We selected a GRG sample starting from soft-gamma ray catalogues
- GRG fraction is four times larger than in radio-selected samples
- 14 over 15 objects show signs of restarting activity (~90%), ~70% have a GPS core
- Sources capable of multiple radio phases are more likely to become GRG
- This favors the core properties (vs environment) to explain the growth and fraction of such spectacular objects
- More sources from Swift/BAT and INTEGRAL/IBIS latest catalogues releases
- Agreement under discussion with ANTARES, to detect neutrino counterpart

FERMI transient J1544-0649

a flaring radio-weak BL Lac

Bruni et al. 2018, ApJL, 854, L23

Gabriele Bruni (INAF-IAPS)

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L. Hernandez-Garcia (IFA-U.Valparaiso)
V. Chavushyan, H. A. Pena-Herazo (INAOE)
A. Kraus (MPIfR)

Radio cores in low-luminosity AGN

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Dispersion and variability of the X-ray/UV ratio in active galactic nuclei

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http://gral.iaps.inaf.it