

Restarting activity in the nuclei of Giant Radio Galaxies (GRG)

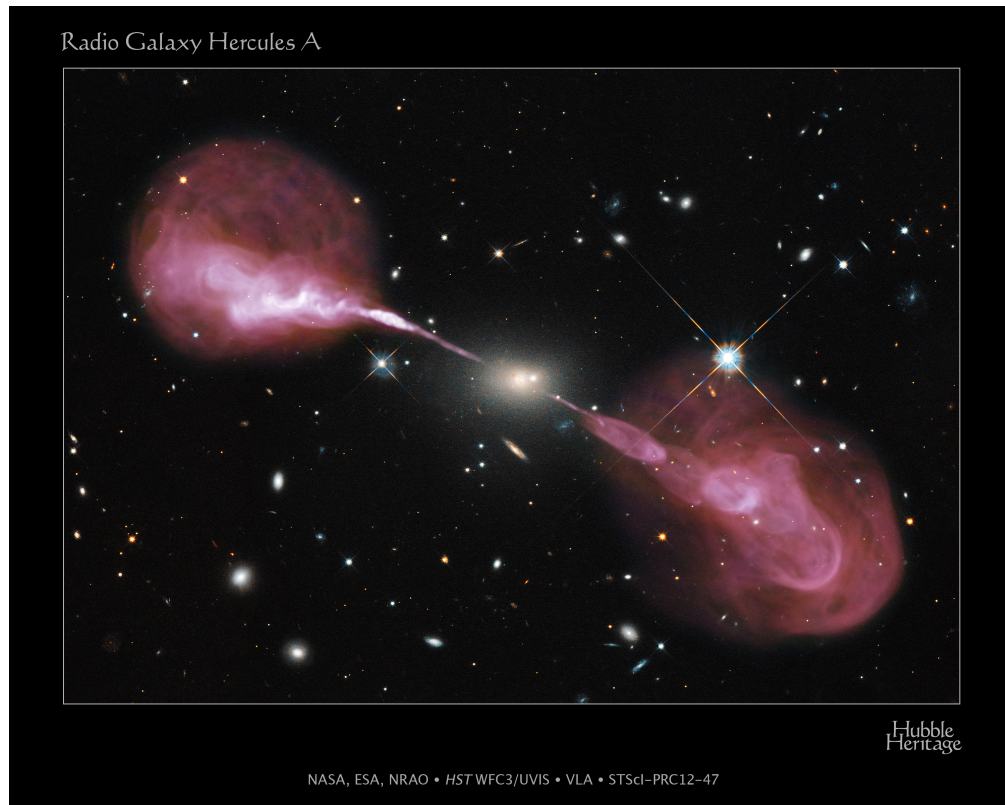
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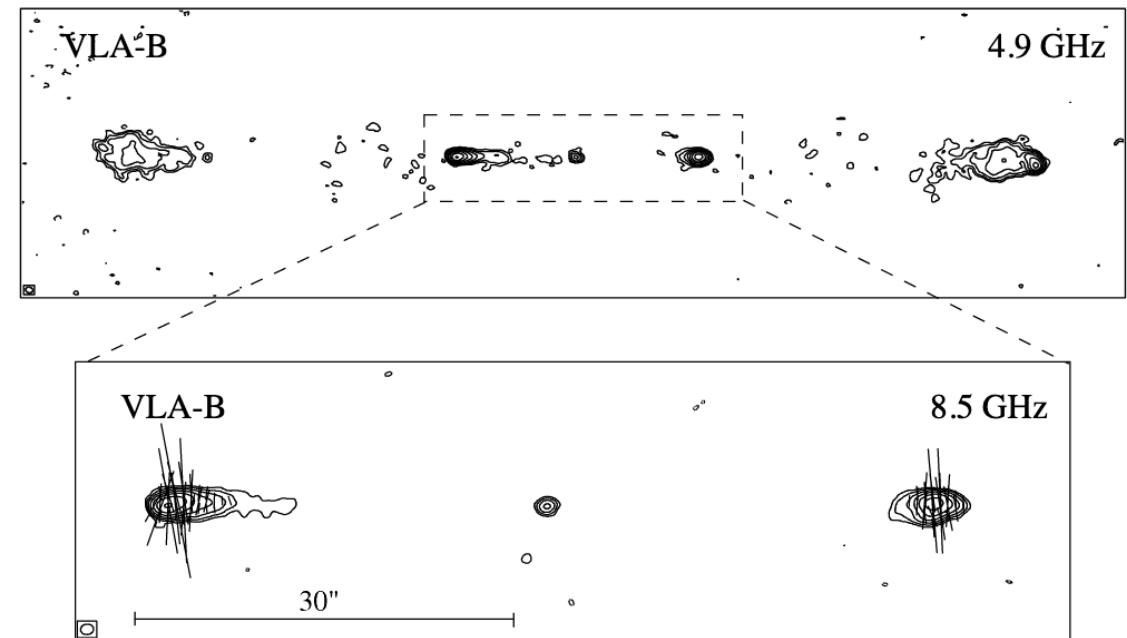
Giant radio galaxies (GRG) are defined as those active galactic nuclei (AGN) whose radio morphology show linear extended emission above 0.7 Mpc. The lobes in these galaxies can be as old as 10^8 years, whereas the AGN activity can be reactivated within 10^{4-8} yrs, thus GRG are perfect laboratories to study AGN evolution and restarted activity. The usual way to find restarting activity is through the radio morphology, where different phases of nuclear activity can be observed in the same dataset. However, we might be missing a fraction of restarting activity in galaxies because we are not able to detect the earliest phase where the new jets have recently formed and are not visible in the radio band. This work is focused on two cases of restarted activity on early phases, namely PBC J2333.9-2343 and Mark 1498. These sources were selected on a hard X-ray basis and we performed multiwavelength analyses in order to gain information of different emitting regions and to have the most comprehensive view of their nuclei.

Giant Radio Galaxies (GRG) and Restarting Activity

- Extended linear emission > 0.7 Mpc (Ishwara-Chandra & Saikia 1999)
- Spectral ages can be 10^7 - 10^8 yr (Alexander & Leahy 1987)



- Intermittent activity occur every 10^4 - 10^8 yr (Reynolds & Begelman 1997; Saikia et al. 2010), GRG are perfect laboratories
- Radio morphology: Double-double radio galaxies (DDR, Lara et al. 1999, Schoenmakers et al 2000) or X-shaped radio galaxies (XRG, Rottmann et al. 2001, Gopal-Krishna et al. 2012)

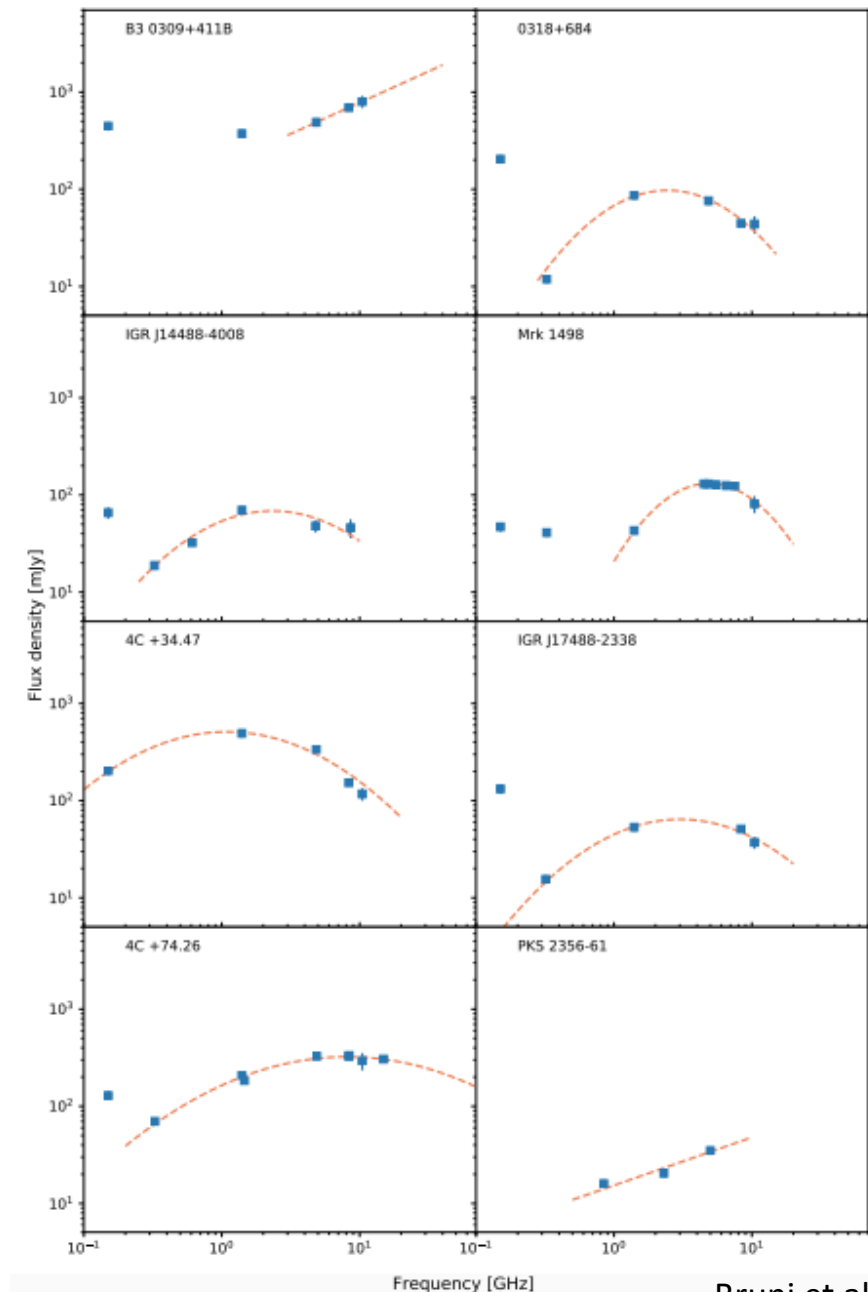


Credits: VLA total intensity maps of the DDRG J1835+620 (Lara et al. 1995)

Description of the work

- 64 AGN selected at hard X-rays from *INTEGRAL*/IBIS and *Swift*/BAT all sky catalogues with NVSS, FIRST and SUMSS counterparts with extended radio emission (Bassani et al. 2016)
- 60% show linear sizes > 0.4 Mpc, **22% are GRG**
- Bruni et al. (2019) found that 61% of the GRG subsample show Giga-Hertz Peaked Spectrum (GPS) sources, suggestive of young sources, **compatible with restarting activity**

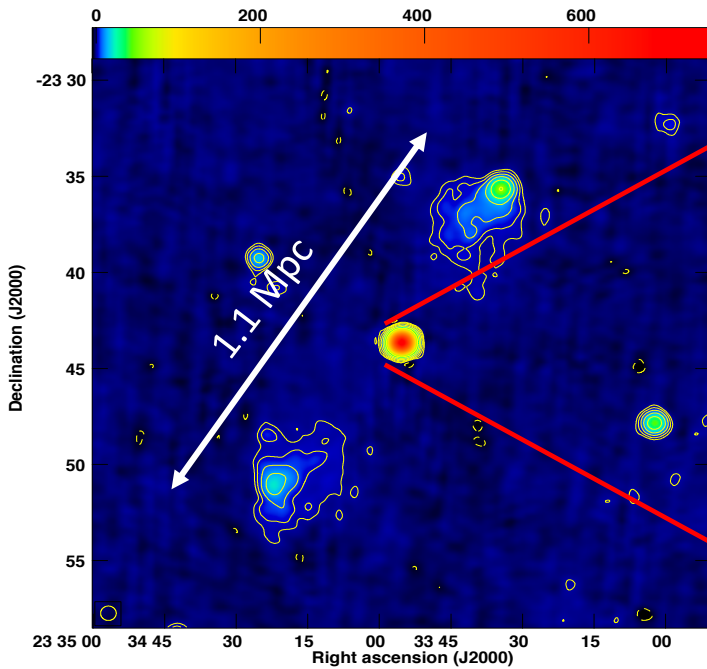
We perform **multiwavelength analyses** of two individual GRG:
PBC J2333.9-2343 and Mrk 1498



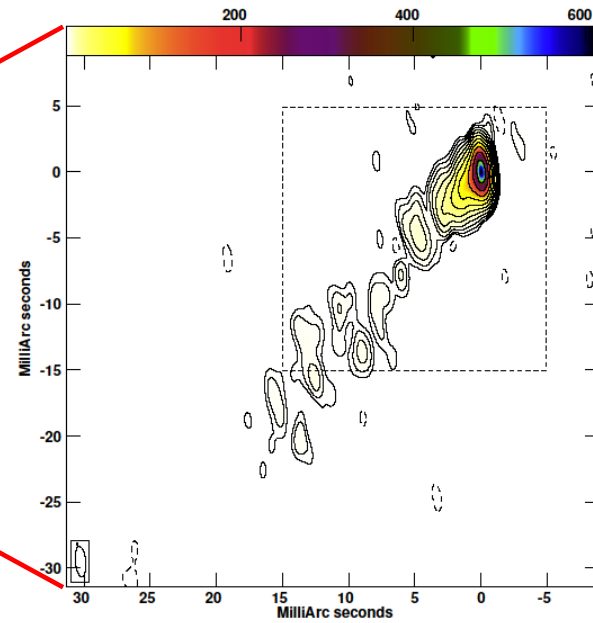
Bruni et al. (2019)

Results

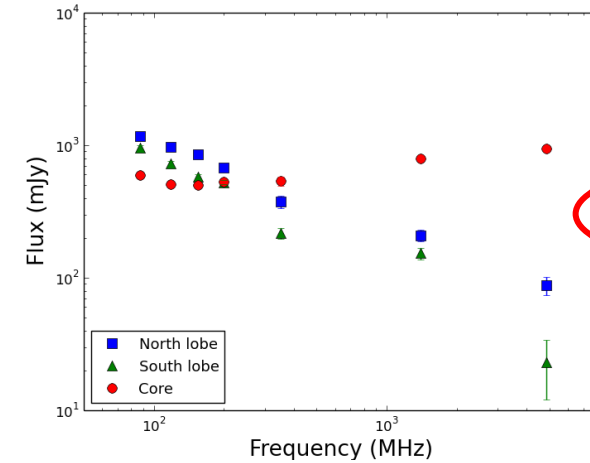
PBC J2333.9-2343: Classified as Sy 2 in the optical but unobscured at X-rays (Parisi et al. 2012), and blazar at radio frequencies (Massaro et al. 2009)



NRAO VLA Sky Survey (NVSS), Condon et al. (1998)



VLBA (Hernández-García et al. 2018)

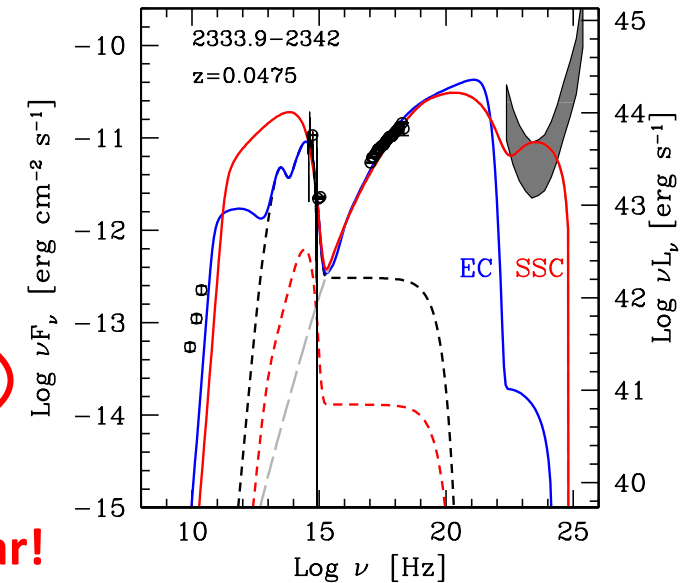


Radio spectrum:

Hints of restarted activity

Spectral energy distribution:

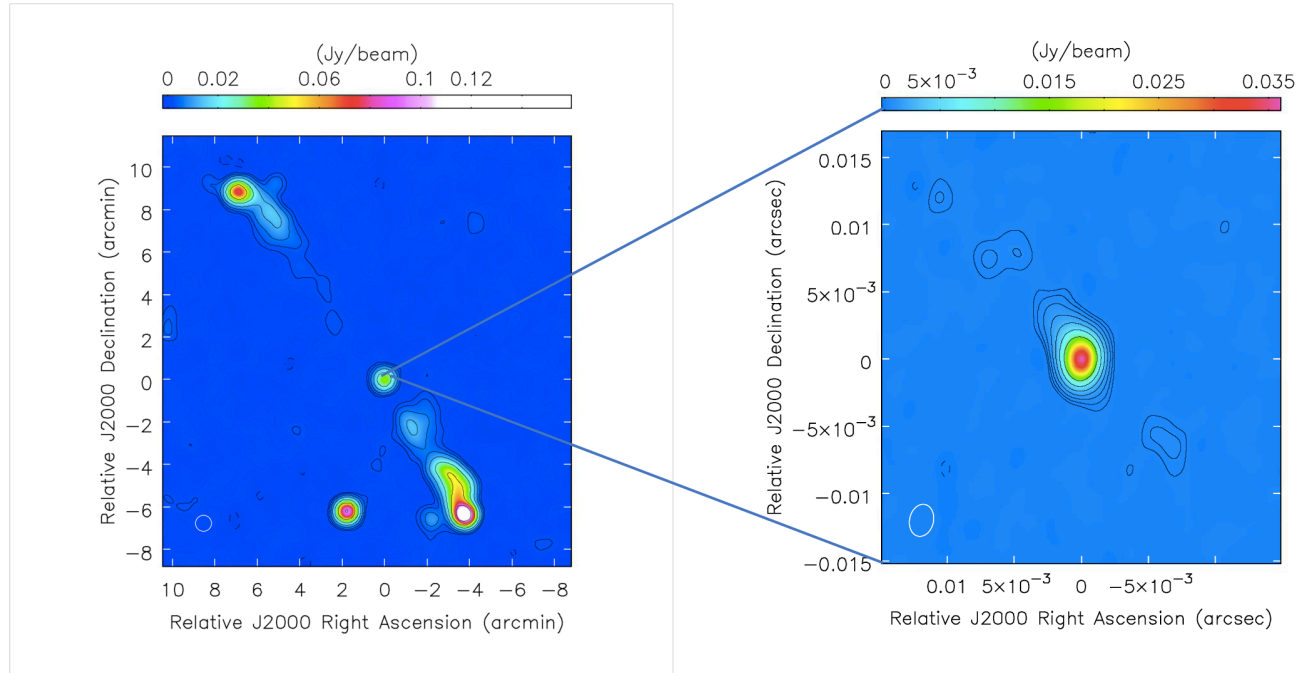
Jet Angle <math>< 6^\circ</math>



Change in the direction of the jet -> the galaxy passed from radio galaxy to blazar!

Results

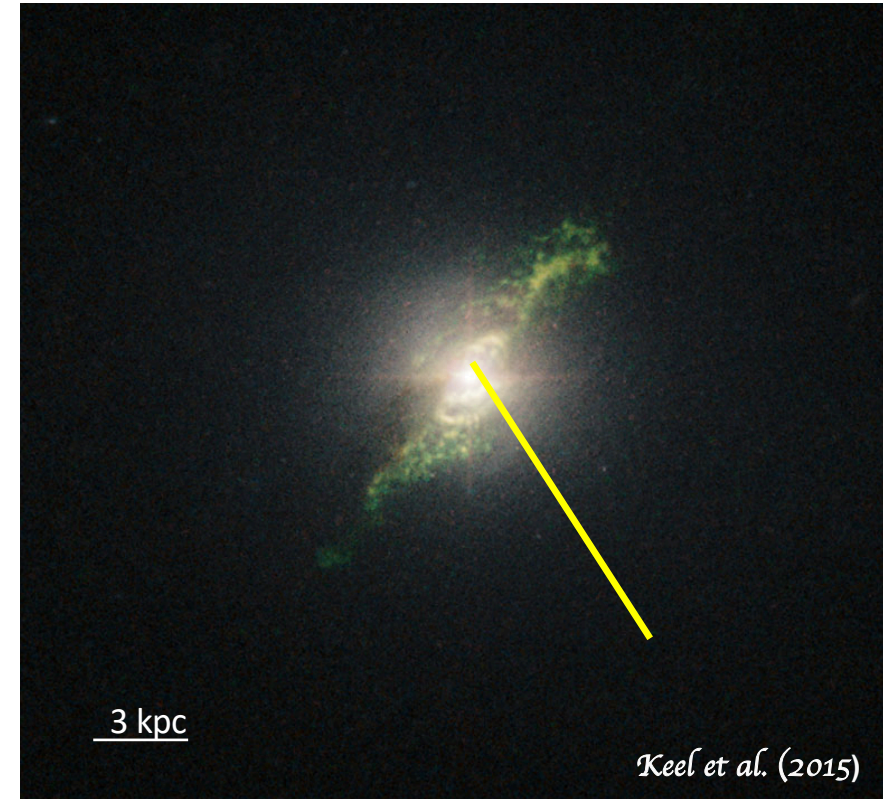
Mrk 1498: Reported as a faded AGN (Keel et al. 2012). Orientations of [OIII] emission line (extended up to 10 kpc) and radio jet misaligned by 70 degrees (Keel et al. 2015)



VLA: Mpc scale
Giant radio galaxy

VLBA: milliarcseconds
Active nucleus

Hernández-García et al (2019)



Restarted (radio) and obscured (X-rays and MIR) AGN!

Impact and prospects for the future

- Multiwavelength analyses of AGN can be very helpful in their study
- X-rays allow the selection of sources where the nuclear activity has recently restarted in giant radio galaxies
- We might be missing a fraction of restarted AGN
- We studied two individual cases:
 - **PBC J2333.9-2343** shows a change in the direction of the jet passing from a radio galaxy to a blazar (Hernández García et al. 2017). The jet seems to be at least responsible for the ionization of the BLR (Hernández García et al. 2018).
 - **Mrk 1498** is a GRG with a GPS in its center, suggestive of restarted activity. It is an obscured AGN that shows extended emission of intriguing origin (Hernández García et al. 2019).