

**Summary:** We investigate the relationship between radio morphology, nuclear activity, and environment in bent-tail radio galaxies (BTRGs) using multi-frequency radio surveys from LoTSS-DR2, FIRST, and VLASS. With the help of LOFAR's sensitivity to extended features of a radio source, we classified 130 sources based on WAT, NAT, and HT morphology, and based on active, quiescent, and restarted nuclear activity. We find that our sample has a large fraction of WAT radio galaxies with an active nuclear activity. They are expected to reside in a group or cluster environment.

## 1. Overview

Bent-tail radio galaxies (BTRGs) are a subclass of radio-loud AGN characterized by curved jets. They are typically classified into wide-angle tail (WAT)[1], narrow-angle tail (NAT) and head-tail (HT) [2] (see Fig1).

**Motivation** BTRGs are predominantly found in dense environments [3], where interactions with the intracluster medium can influence jet structure. These environmental effects may also play a role in the AGN life cycle, including phases of activity, quiescence, and possibly followed by repeated activity (see Fig2).

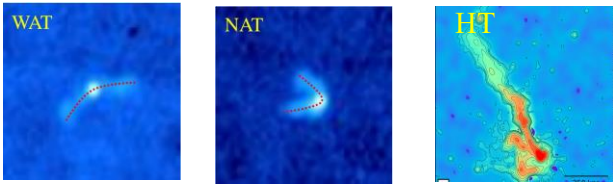


Figure 1: Examples of bent-tail radio galaxy morphologies.

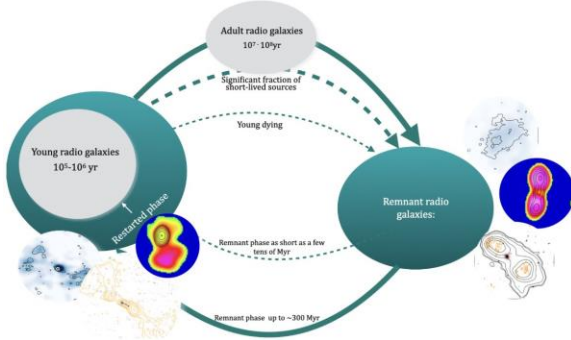


Figure 2: Schematic of the AGN life cycle highlighting different stages of radio activity [4].

## 2. The data we used

The parent sample for this study was drawn from the ROGUE I catalogue [5], which is primarily based on cross-matched radio sources from FIRST and SDSS DR7. We use LoTSS-DR2 as the primary dataset cross-matched with FIRST and VLASS datasets (see Table1).

Survey	Central Frequency (MHz)	Resolution; rms noise (arcsec; $\mu$ Jy/beam)	Ref
LoTSS	144	6; 71	[6]
FIRST	1400	5; 150	[7]
VLASS	3000	2.5; 120	[8]

Table 1: Summary of the surveys used in this project.

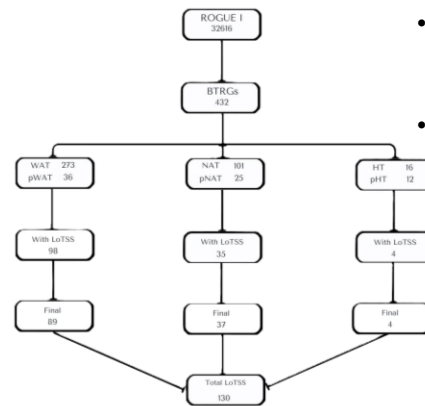


Figure 3: Flowchart of sample selection.

- The parent sample was made up of 432 BTRGs
- Final sample has 130 BTRGs, confirmed with LoTSS

## 3. Our results so far

The sample is dominated by 89 (69%) WAT, followed by 37 (28%) NAT and a small number of 4 (3%) HT radio galaxies (see Fig.4). Given that WATs are known to be in dense environments, we thus suggest our sample is most likely in a dense environment.

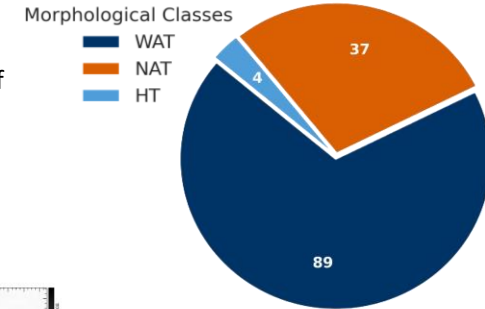


Figure 4: Distribution of BTRG morphology

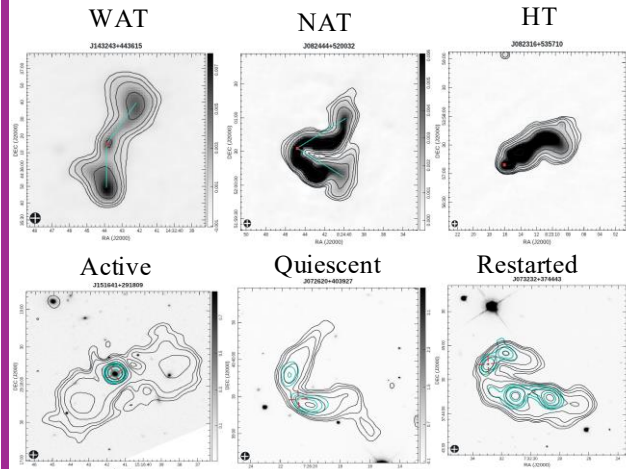


Figure 5: Examples of our BTRGs classified based on their morphology (top) and AGN activity (bottom) with LoTSS (black) overlaid with FIRST (cyan) radio data.

Active BTRGs are dominant, quiescent and restarted ones are also recovered in this sample. Quiescent sources are hard to detect because lobes fade quickly, and restarted sources have complex structures making their classification challenging, and hence a possible reason for their rarity.

## Main findings

Low-frequency observations reveal extended features in BTRGs which helps with both reclassification of morphology and nuclear activity. A large fraction of BTRGs resides in cluster environments which may reveal environmental effects on morphology and nuclear activity.

## 4. Way forward

- Final classification of the sample based on their nuclear activity.
- Correlation search of nuclear activity and large-scale environment.
- Comprehensive discussion of the overall results.