

# Reaching completeness of the radio loud AGN sample

## 1 Introduction

About 10% of active galactic nuclei (AGNs) exhibit parsec scale radio emission. Emission from the core region characterizes the processes that occur in the vicinity of supermassive black holes. Understanding these processes can be achieved with two ways: 1) we select a specific source and make intensive observations of the object using different instruments; 2) we observe a sample of sources. In the first case we aim to draw causative conclusions, in the second case we aim to draw statistical inference. The statistical inference can be generalized to the entire population if the sample is complete. If the sample is incomplete and biased, there is the risk of this bias to propagate to our conclusions.

Among full samples, the all-sky samples are special. First, if we found no object in the specific search area we can say much more than “we did not find”: we can say “*there does not exist an object brighter than some limit there*” or did not exist on epoch of observation. Second, if we cross-match a trial population with poor position localization against the complete sample, we can draw an inference about their interrelationship using statistical methods.

## 2 VLBI sample

Starting with the VLBA Calibrator Survey–1 (Beasley et al. 2002), a systematic study of the VLBI sky at the declination range  $[-40^\circ, +90^\circ]$  commenced. Observations of 44 observing campaigns were used to derive the Radio Fundamental Catalogue<sup>1</sup> that is updated on a quarterly basis since 2009. The catalogue contains positions, images and estimates of median flux densities at VLBA projected baselines shorter 900 km and longer 5,000 km at 8 GHz and other frequencies. Parsec-scale emission at 8 GHz originates mainly from from the core. Therefore, this sample, hereafter called the RFC sample, senses synchrotron emission in the jet base. By 2021.01.15 the RFC has 18,764 objects (17,437 with declinations  $> -40^\circ$ ). However, its completeness is poorly understood. Classical logN–logS test shows the deviation from the straight line below 260 mJy. Figure 1 shows the area of parsec scale flux densities 100–260 mJy by yellow color. We interpret this deviation as a lack of completeness. The origin of the incompleteness is the incompleteness of parent samples used in VLBI surveys.

## 3 The use of the the all-VLBA-sky full sample

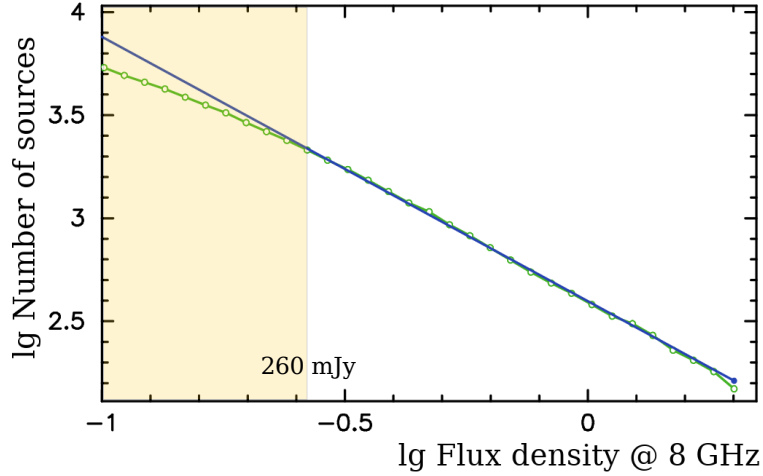
**Yura:** here please write how this sample will be used

## 4 Proposed observations

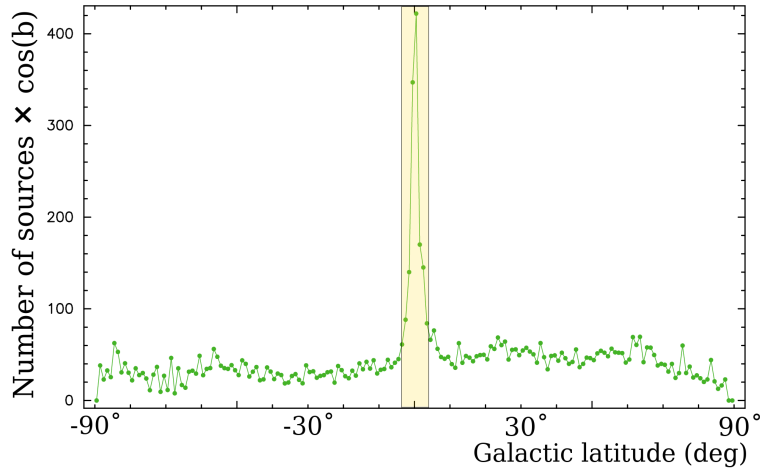
In order to reach completeness, we cross-matched within the  $60''$  search radius the list of sources observed with VLBI and used for deriving the RFC against the sample that we consider a priori as complete. of the a priori sample. We take single dish catalogues GB6 and PMN at 4.85 GHz as the parent sample. This catalogues covers declination range  $[-90^\circ, +75^\circ]$  and has completeness over 99% at 100 mJy level.

We propose to observe all remaining sources from GB6 and PMN brighter 100 mJy at  $\delta > -40^\circ$  that were not observed before with VLBI. In total, there are 5543 sources that satisfy this criteria. The distribution of the source count as a function of galactic latitude normalized by  $\cos b$ , where  $b$  is Galactic plane, shows a very strong peak in the zone of galactic latitude  $|b| < 4^\circ$  because of the population of galactic sources. Most of these sources are extended and not detectable with

<sup>1</sup>Available at <http://astrogeo.org/rfc>



**Fig. 1:** logn–logs dependence of radio loud AGNs from the RFC catalogue using declinations  $< -40^\circ$ . The median flux density at 8 GHz at projected VLBA baseline length less than 900 km is used for computation.



**Fig. 2:** The distribution of the remaining sources in GB6+PMN catalogues brighter 100 mJy over the galactic latitude. The count is normalized by cosine of galactic latitude. The sources with galactic latitude  $|b| < 4^\circ$  is excluded from the list of target sources.

VLBI. We exclude 1154 these sources from our sample. GB6 and PMN do not cover zone with  $\delta > +75^\circ$ . We have selected 105 sources from the preliminary VLASS catalogue at 3 GHz with the total flux density over 100 mJy to cover this area. Thus, our parent sample has 4504 objects.

## 5 Data release plan

We waive the proprietary period. Images and source positions will be available from the project web site immediately upon processing, typically with a lag of one month of observations. Upon completion the project the positions will augment the Radio Fundamental Catalogue and the images will be submitted to the the Astrogeo VLBI FITS image database.

## References

- Gregory, P. C., et al., 1996, ApJS, 103, 427  
Beasley, A. J., Gordon, D., Peck, A. B., et al. 2002, ApJS, 141, 13.  
Petrov, L., 2021, AJ, 161(1), 15 (25pp).