# Mid-Infrared Properties of Young Radio-Selected Active Galactic Nuclei

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## 1. Introduction

GHz Peaked Spectrum (GPS) and Compact Steep Spectrum (CSS) radio sources are thought to represent the earliest phases of the development of radio loud Active Galactic Nuclei (AGN). Using radio observations alone, the time since the onset of jet activity can be estimated reasonably accurately and is typically of the order of a few thousand years. These systems therefore provide a unique laboratory in which to study the relationship between nuclear activity, circumnuclear interstellar matter, and any associated star formation. Using multi-frequency radio data obtained with the GMRT, VLA and RT, we are defining a sample of young radio AGN in the Spitzer FLS field which are associated with mid-infrared sources. We intend to model the broad-band mid- and far-infrared colours of these systems to constrain the evolution of AGN and dust relative to the onset of radio-loud phase of the AGN.

## 2. GMRT Observations

The Spitzer extragalactic First Look Survey (FLS) field was observed with the Giant Metrewave Radio Telescope (GMRT, Figure 1), Pune, India, at 610 MHz in March 2004. The relatively wide field of view of the GMRT at this frequency (42' half-power beam-width) made it possible to cover almost the entire FLS field in seven pointings. Total integration time per pointing was four hours, split across four days to maximise *uv*-plane coverage, giving a theoretical sensitivity of 50 $\mu$Jy/beam. Dynamic range constraints mean, however, that this sensitivity may not be achievable across all of the field. The high sensitivity and 5" resolution make these observations highly complementary to the 1.4 GHz VLA survey of the same area by Condon et al (2003): we should be able to detect *all* of the sources with spectral indices $\alpha$>0.7.

We present here preliminary results from one of the seven fields, chosen because it is free of relatively bright sources and therefore less likely to be limited by dynamic range issues.

**Figure 1:** Three of the antennas in the inner square kilometre of the Giant Metrewave Radio Telescope (GMRT). The GMRT consists of 30 antennas in total, each with a diameter of of 45 m. Twelve of these are in the inner square kilometre with the remainder distributed in three approximately radial arms extending in NE, NW and S directions. The maximum baseline is approximately 25 km allowing a resolution of 5 arcseconds at 610 MHz.

## 3. GMRT Data Reduction

The observations were carried out using two 16 MHz sidebands, each split into 128 channels (to mitigate the effects of narrow band interference). The data were calibrated using standard intereferometry techniques:

- Identifiable interference was edited out.
- Band passes were determined for each antenna.
- The flux scale was set using daily observations of 3C48 and 3C286.
- Observations of a nearby compact source, repeated every 30 or so minutes, were used to monitor the antenna based amplitude and phase variations.

The 128 channels of calibrated visibilities were then averaged down to 11 channels (per sideband), sufficient to avoid bandwidth smearing problems, and images were synthesised. Because of the wide field of view of the GMRT compared with its resolution, it was necessary to use a hexagonal grid of 19 images, each 1024 by 1024 pixels in size. Finally, these images, for both sidebands, were combined into a single 4096 by 4096 image which is shown in Figure 2. The root-mean-square noise on this image, away from the brighter sources, is 48 $\mu$Jy/beam.

Using the experience and data we have obtained, we hope to use the GMRT to make deep radio images at 610 MHz of most of the extragalactic Spitzer FLS field.

## 4. Preliminary analysis

Our preliminary analysis of spectral indices of the radio sources detected at both 610 MHz and 1.4 GHz is shown in Figure 3. Twenty-five of the sources detected are found to be rising-spectrum which indicates that we should obtain a sample of the order of 150 sources when the 610 MHz map of the entire field is obtained.

A mid-infrared colour-colour plot of all of the sources detected by VLA, GMRT and IRAC is shown in Figure 4.

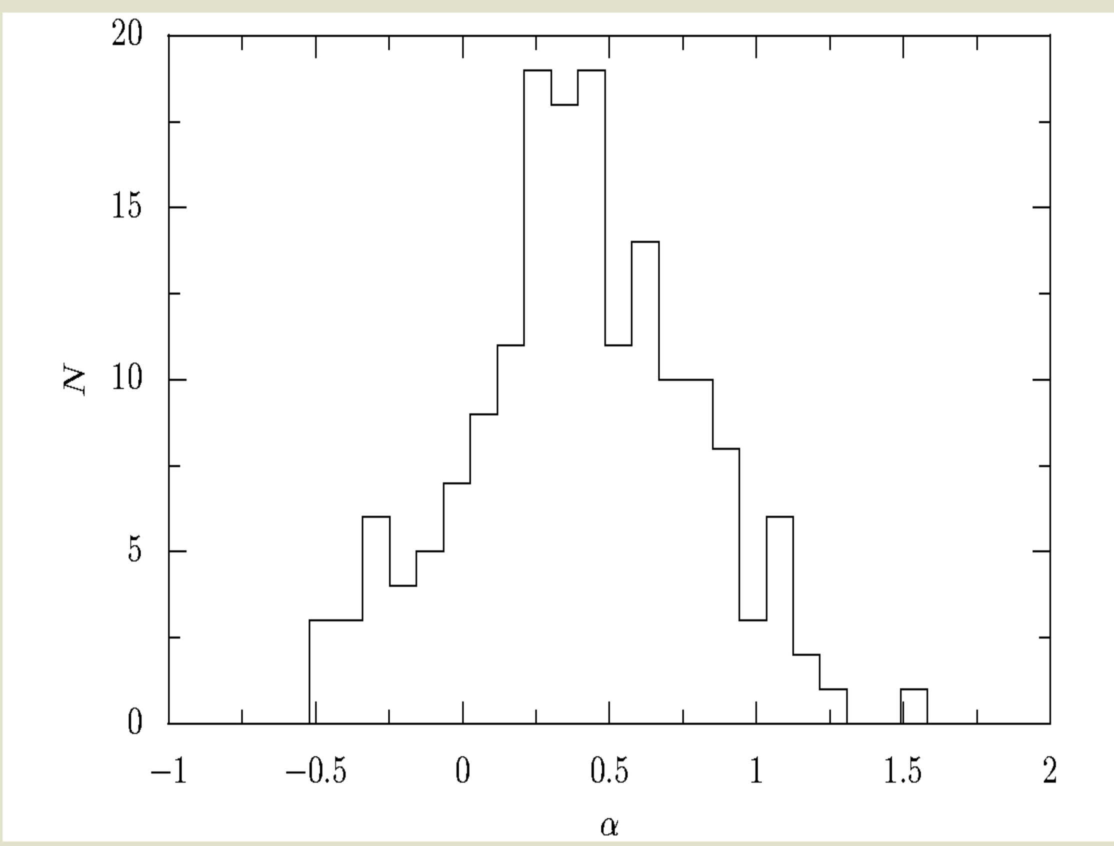


**Figure 3:** Distribution of spectral indices between 610 MHz and 1.4 GHz of radio sources detected in the VLA survey of the FLS and in the preliminary map made with the GMRT; $\alpha$ is defined as $f_\nu \propto \nu^{-\alpha}$.

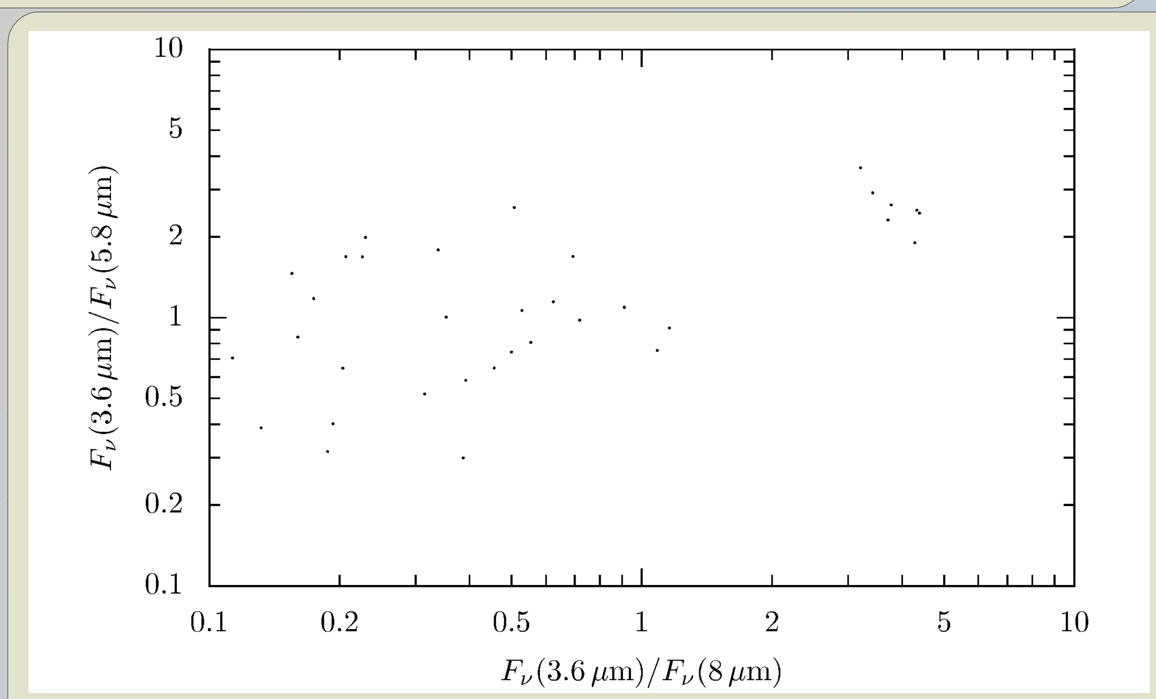


**Figure 4:** Preliminary mid-infrared colour-colour plot of the sources detected by VLA and one pointing with the GMRT.

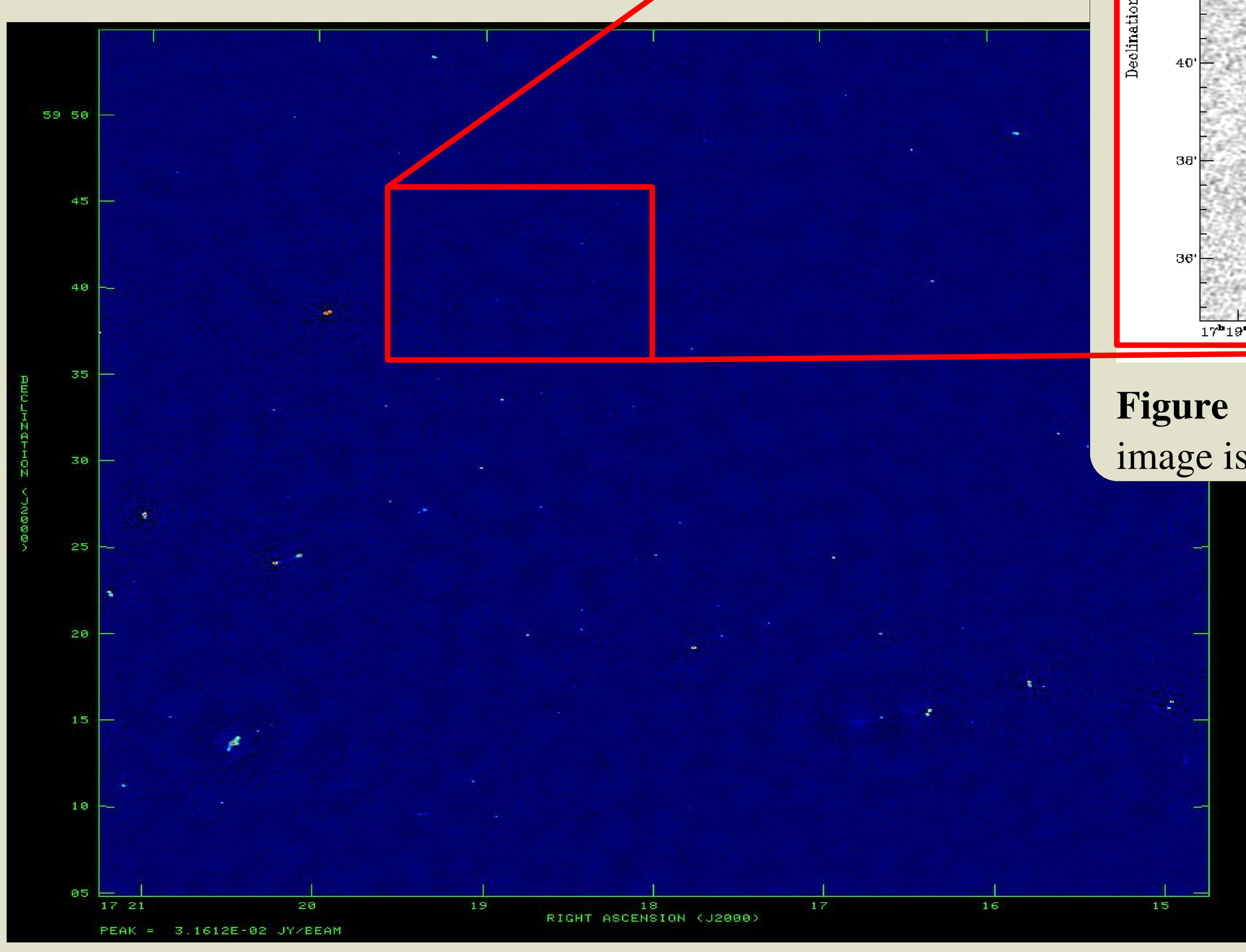


**Figure 2a:** A map, produced from a single pointing, of a part of the Spitzer extragalactic FLS field observed at 610 MHz with the GMRT.

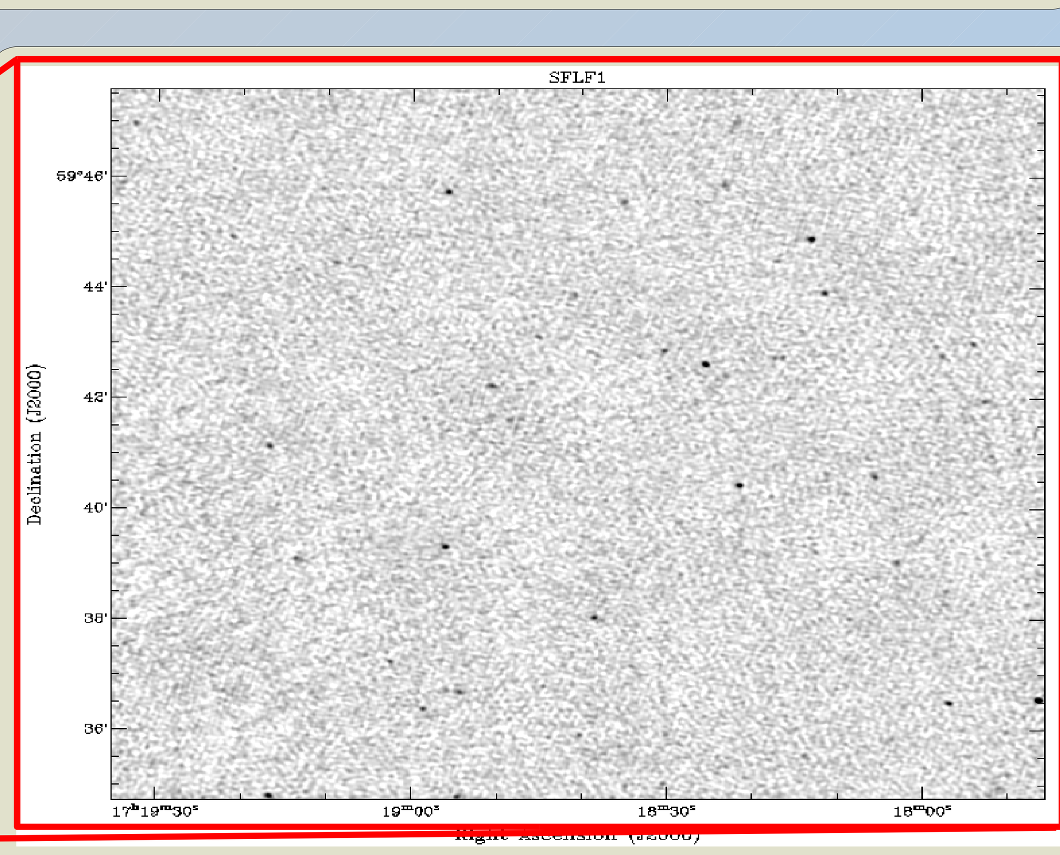


**Figure 2b:** Detail of Figure 2a. The full range of the image is -75 to 490 $\mu$J/beam.

## References

Condon et al, AJ, 125:2411, 2003

## Acknowledgements

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