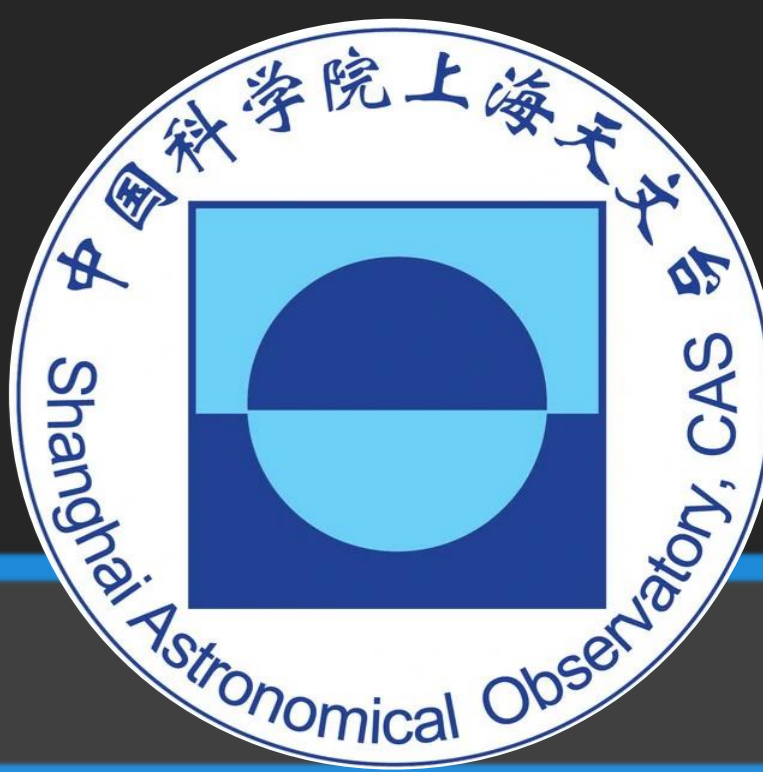


Study GCpsrs in low frequencies below 300 MHz by MWA



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Project Description

Pulsars in globular clusters (**GCpsrs**) are crucial for probing GC structure, dynamics and evolution. Especially ~90% among them are millisecond pulsars (MSPs), which are crucial to contribute in the pulsar timing array for the detection of the gravitational wave.

To study those MSPs in low frequencies below 300 MHz are interesting to confine their spectral index and emission beam structure. Only a few have been detected in the time domain (e.g., Malofeev et al. 2000; Kuzmin et al. 2001) due to the strong scattering or possible intrinsic spectral turnover or flattening.

The **Murchison Widefield Array (MWA)** is feasible to this study by its Voltage Capture System (MWA-VCS) through its tied-array beams, which enables highly sensitive detections. We analyzed two VCS observations (ObsIDs: 1339948096 and 1221832280) and detected GCpsrs in NGC 6624 and M2 (positions shown below). The China-SRC-PROTO provides the computational resources and plans to conduct a GCpsr survey in the south sky by MWA.

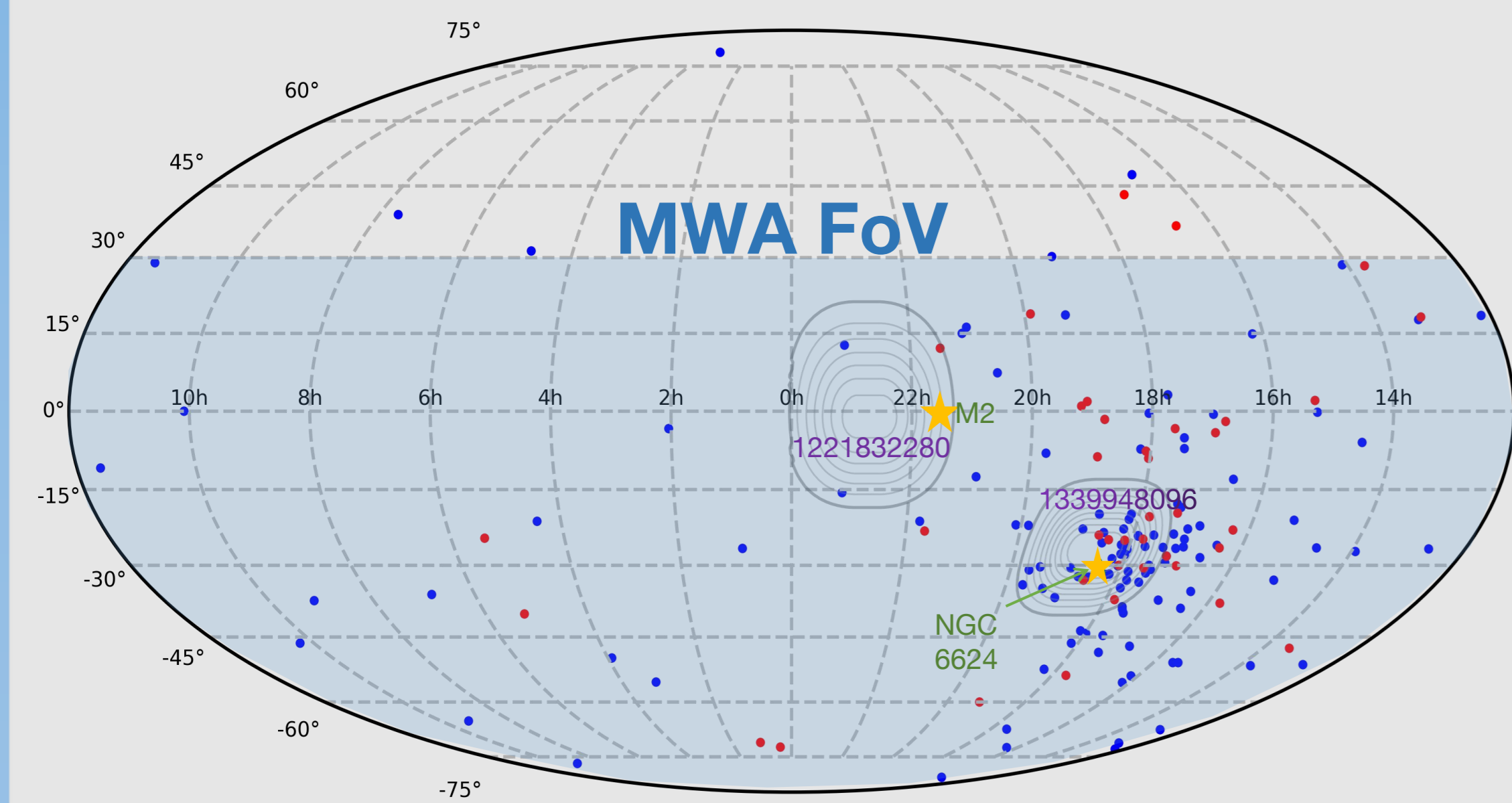
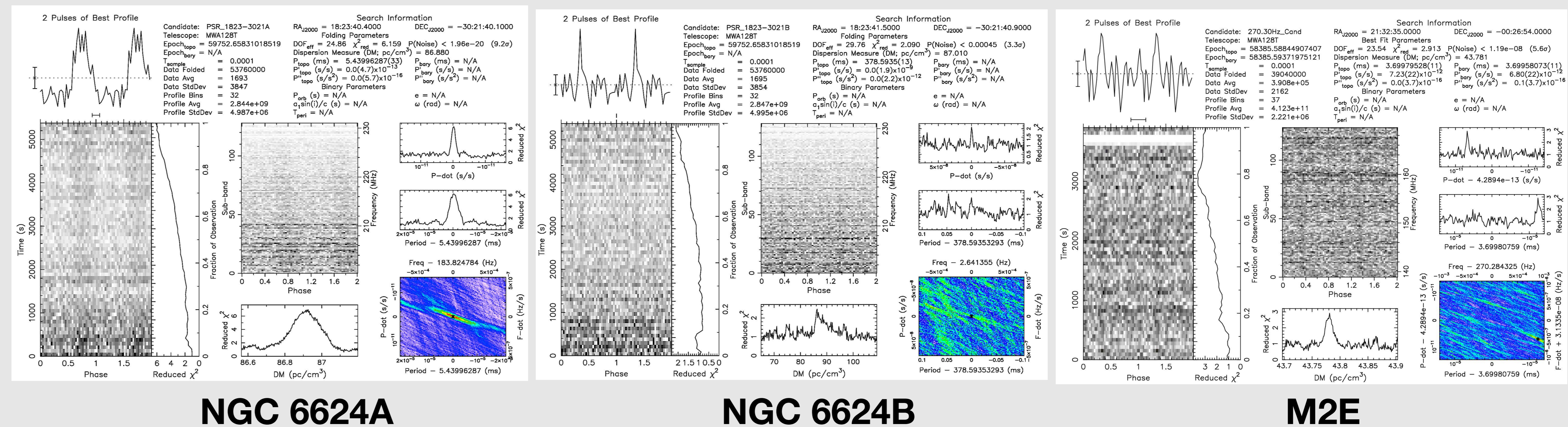


Figure 1: Distribution of GCs without detected pulsars (blue) and with detected pulsars (red) and our targets and observations.

GCpsrs detection in NGC 6624 and M2

We detected MSP **NGC 6624A** and normal pulsar **NGC 6624B** in a high MWA frequency band of 200.32-231.04 MHz, with estimated fluxes of 132 ± 32 and 18 ± 12 mJy respectively. We also detected binary pulsar **M2E** in Southern-sky Murchison Widefield Array Rapid Two-metre (SMART) Survey.



NGC 6624A

NGC 6624B

M2E

Figure 2: PRESTO diagnostic plots of NGC 6624A, NGC 6624B and M2E

Both NGC 6624A and NGC 6624B exhibit very steep spectra towards 200 MHz compared to the mean spectral indices of their respective populations. None clear polarization was detected. **They are first GCpsrs detected by MWA.**

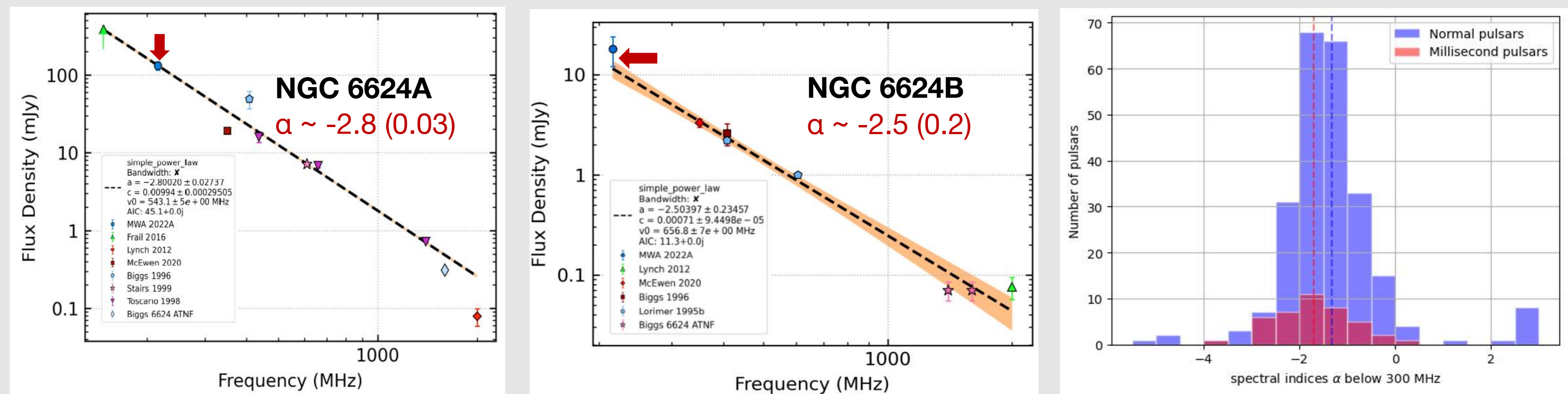


Figure 3: Fitted spectra of NGC 6624A and NGC 6624B, alongside power-law spectral index distribution below 300 MHz for normal pulsars (blue) and MSPs (red), with mean indices of -1.50 ± 0.83 and -1.81 ± 0.82 respectively. The sample data are from Swainston et al. (2022).

- References:**
- 1) Kuzmin, A. D., & Losovsky, B. Y. (2001). No low-frequency turn-over in the spectra of millisecond pulsars. *Astronomy & Astrophysics*, 368(1), 230-238.
 - 2) Malofeev, V. M., Malov, O. I., & Shchegoleva, N. V. (2000). Flux densities of 235 pulsars at 102.5 MHz. *Astronomy Reports*, 44, 436-445.
 - 3) Swainston, N. A., Lee, C. P., McSweeney, S. J., & Bhat, N. D. R. (2022). pulsar_spectra: A pulsar flux density catalogue and spectrum fitting repository. *arXiv preprint arXiv:2209.13324*.