Introduction

The survey is a part of the Large Survey Proposal TRAPUM (TRAnsients and PULSars with MeerKAT). Fermi LAT has provided an amazing roadmap to assist with pulsar searches. We are conducting a survey using the MeerKAT telescope to find new radio pulsars associated with gamma-ray sources. In this paper, we will focus on the preparation for this survey. The main goal in this survey is to help uncover the population of energetic from our galaxy.

Telescope and catalogue

MeerKAT is a 64-dish radio interferometer in the Northern Cape, South Africa. The Fermi Large Area Telescope Fourth Source Catalogue (4FGL) [1] contains a total of 5064 gamma-ray sources, 239 are pulsars and 1336 are unidentified sources.

<table>
<thead>
<tr>
<th>MeerKAT parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of antennas</td>
<td>64</td>
</tr>
<tr>
<td>Dish diameter (m)</td>
<td>13.5</td>
</tr>
<tr>
<td>L-band (MHz)</td>
<td>856-1712</td>
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<tr>
<td>UHF (MHz)</td>
<td>544-1088</td>
</tr>
<tr>
<td>Gain (K/Jy)</td>
<td>2.75</td>
</tr>
<tr>
<td>Trec (K)</td>
<td>18</td>
</tr>
<tr>
<td>Number of beams</td>
<td>480</td>
</tr>
<tr>
<td>Coherent beam size (°)</td>
<td>~20 (L), ~25 (UHF)</td>
</tr>
</tbody>
</table>

Source selection

We selected 79 sources for the first phase of our survey. These were chosen based on 1) probability of being a pulsar from gamma-ray properties, 2) source visibility, and 3) gamma-ray localisation allowing for a single radio pointing. We do the cross-matched (Figure 1) with the PSC list to avoid duplicating effects. NE2001 [2] electron density model was used to evaluate maximum dispersion measure (DM) along the line of sight.

De-dispersion plan

At this step, we design a processing strategy (Figure 3) using PRESTO [7]. The set up is to reach DM from 0 to 300 pc/cc with steps of 0.05 pc/cc, a sampling time of 57 μs, 2048 channels and 480 coherent beams with overlap at 70 % power.

Acceleration search

Acceleration search [8] is a technique to find pulsars in binary systems using Doppler-shifted kernel matching for periodicity search in the Fourier space. For the planning, we plot the relationship between acceleration (a), Fourier shifted bin (z) and orbital period with orbital parameters for four common types of pulsar systems (Figure 4).

Result and Localisation

We discovered eight new pulsar candidates. Those have been confirmed as a pulsar by several telescopes. In order to find the position, we use a beam tiling script and a localisation script from Weiwei Chen and Tiaan Bezuidenhout, respectively. Lastly, we use the gamma-ray detection of known pulsar from Lars Nieder with the scripts for localisation (Figure 5).

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Figure 1: Targeted sources in Galactic coordinates. The data colour bar represents the maximum DM along the line of sight. Sources circled with a black circle represent the ones that have not been observed by the PSC. The purple line is 20°declination. The black line is MeerKAT's sky coverage and the dot size indicates the pulsar probability.

Figure 3: De-dispersion plan from PRESTO's ddplan. Key setup parameters are indicated at the top.

Figure 4: The plot between the orbital period and acceleration (a) for pulsar binary system with distinct companions: Black widow (BW), Redback (RB), white dwarf (WD) and pulsar (PSR). The colour region represents the orbital periods from 1.4 to 2 solar mass. Finally, we assume that the pulsar is a millisecond pulsar with an observing time of 10 minutes.

Figure 5: Localisation map for J0312.1−0921. The colour map depicts the localisation probability, with the pink dot marking the centre of each beam while the white contour is the beam shape at 70 % power point. Green and cyan contour represent 58 and 90 percent probability, respectively. The red cross is the location from the gamma-ray detection of J0312.1−0921.