# Results from the Allen Telescope Array: SETI Survey of the Galactic Center Region

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## ABSTRACT

We report initial results and status of a SETI Survey of the Galactic Center region. The survey spans longitude 357° to 7° and latitude -1° to + 1°, and covers the radio spectrum from 1410 MHz to 1730 MHz with a resolution of 0.7 Hz. The search system is sensitive to continuous and pulsed signals with frequency drift rates of up to ±1 Hz/sec and bandwidths less than ~ 10 Hz. In its current stage, the Allen Telescope Array (ATA-42) is an array of 42 six-meter dishes with two dual-polarization beamformers.

The beams observe two independent positions within the field of view at the same frequency allowing each to serve as an "off" positions for the other beam. This is a new approach to RFI mitigation. While SETI observations proceed, two independently tunable correlators are used to image the field for other radio astronomy projects. This demonstrates the Radio Sky Survey capability of the ATA.

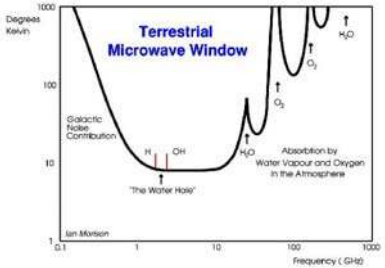
## ACKNOWLEDGMENT

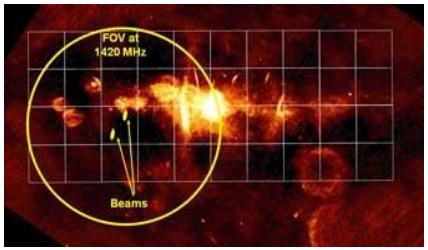
The first phase of the ATA was funded through generous grants from the Paul G. Allen Family Foundation. UC Berkeley, the SETI Institute, the National Science Foundation (Grant No. 0540599), Sun Microsystems, Xilinx, Nathan Myhrvold, Greg Papadopoulos, and other corporations and individual donors contributed additional funding.

## SETI Survey: Galactic Center Region

There are two basic strategies in the Search for Extraterrestrial Intelligence (SETI): sky survey and targeted search. The latter approach concentrates on nearby stars thought to be possible hosts for life-bearing planets. With relatively long integration times (minutes), targeted searches achieve good sensitivity for terrestrial-equivalent transmitters out to ~80 pc. A sky survey typically scans a portion of the sky with an integration time on the order of ten seconds. Sacrificing sensitivity to observe more stars, a sky survey searches for very strong transmitters that may be at great distances. Our strategy for this project is a "targeted survey." We cover an area of the sky, 20 square degrees, dividing it into a grid of 3519 positions, and observing each position for 98 seconds.

The observations span the traditional "Waterhole" in the radio spectrum, marked by the spectral line of Hydrogen (1420 MHz) and Hydroxyl (1720 MHz). The SETI processing system breaks about 60 MHz into 0.7 Hz channels, generating spectra with a time window of 1.5 seconds every 0.75 seconds. The spectra for an observation are examined in near real time for narrow band continuous and pulsed signals that may drift by up to one channel per spectrum.




The white squares are 0.5 degree on a side and show half the area to be covered in the Galactic Center Search. The yellow circle is the field of view of the array at 1420 MHz. The yellow ovals show the size of the phased array beams.

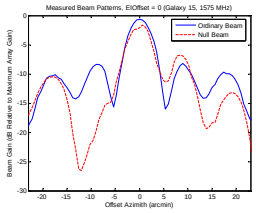
The background image shows radio emission at 330 MHz, from "Wide Field Radio Imaging of the Galactic Center"; Kassim, LaRosa, Lazio, and Hyman; ASP Conference Series, Vol. 186, 1999.

## RFI Mitigation, Part 1: Recent RFI Database

One of the biggest challenges facing any SETI program is discriminating between terrestrial and possible ETI signals. For convenience, we call all terrestrial signals RFI. Our first line of defense is a database of recent RFI, i.e., signals detected in the previous week. A newly detected signal that matches the frequency of a signal in the database within an empirically determined range of 1 kHz is classified as the same signal. This has proved to be very effective in our previous SETI projects.

## RFI Mitigation, Part2: Compare Multiple Beams

New for this project is a second phase of RFI mitigation: simultaneous observations of the same frequency band on different sky positions. The ATA can currently synthesize two beams (a third beam will be available soon). A signal seen on more than one beam is almost certainly RFI.




## Synthesized Beams and Nulls

The Initial 42 antenna configuration of the ATA is roughly equal in sensitivity to a 40 meter antenna. The span of the array is 440 by 212 meters so the size of synthesized beam is comparable to Arecibo (about 3x9 arcmin). However, due to the small number of dishes, the inner sidelobes are more sensitive than for an Arecibo-sized dish. So, for each synthesized beam we generate a broadened null beam in the direction of the other positions being observed. This means that if a signal appears at approximately the same strength in more than one beam, it is entering the beams through the sidelobes and therefore RFI. However, if a signal appears strongest in one beam but is detected in the others beams at lower strengths consistent with sidelobe and null suppression, it is considered a "candidate" ET signal and subjected to further tests.

## Immediate Follow-up Observations

A "candidate" ET signal must be persistent long enough for tests to determine that it is fixed on the sky. The system performs a series of ON-OFF observations. If the signals persists through several cycles of these observations, only appearing in the ON observations, the system will perform further tests and notify project personnel.

## Hot Off the Telescope

Results from June 3, 0530 – 1230 UT, excerpt from daily report.

```
Total for All Observations
Total Targets: 23
Candidate Resolution Counts:
+-------------+----+--------+------+-----------+
| Obs Type    |Num |Signals | NotDB| Candidates|
+-------------+----+--------+------+-----------+
| target      | 55 |  8616  |  843 |       180 |
| target-on1  | 41 |  7902  |  194 |         2 |
| target-off1 |  1 |   188  |    2 |         1 |
| target-on2  |  1 |   196  |    1 |         1 |
| target-off2 |  1 |   194  |    1 |         0 |
+-------------+----+--------+------+-----------+
```

## Commensal Radio Astronomy

The SETI Survey region is divided into half degree squares to facilitate commensal radio astronomy observations. The SETI control computer will point the array at the center of one of the predefined squares and move the synthesized beams within that square as long as possible. During that time, two correlators on two independently tunable IF chains can image that position for transients, molecular lines, etc. (See poster 601.03 "Results from the Allen Telescope Array: Launching the ATA Galactic Center Transient Survey".)