Breakthrough Listen scans entire galaxies for signals from extremely advanced civilizations

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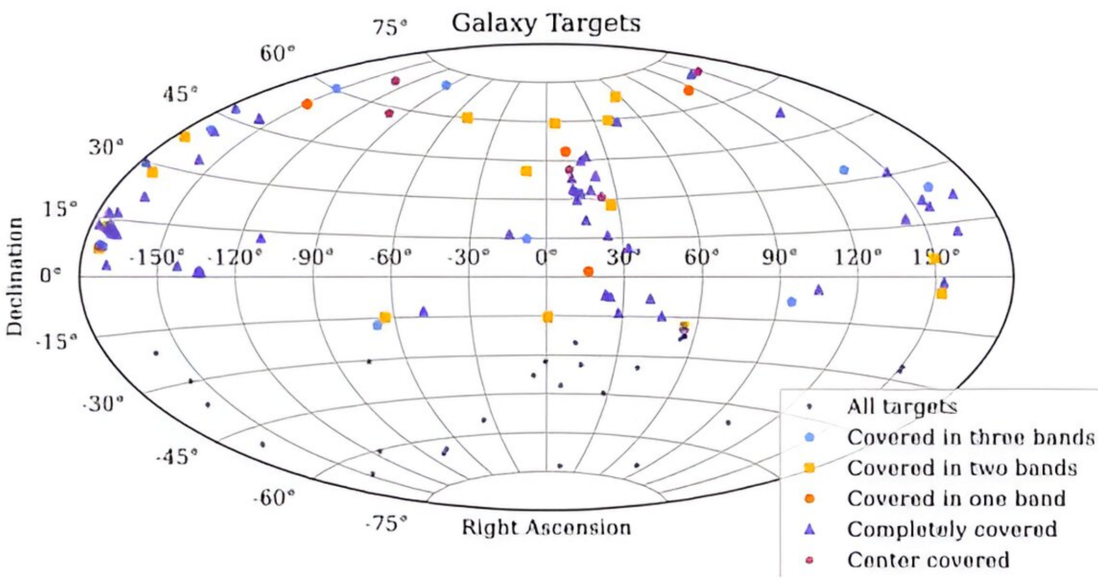

Sky map of galaxy targets. The colored squares indicate whether the full source is covered by the GBT beam at all four bands (see Table 1), three bands, two, one, or none. Credit: Choza, C. et al (2023)

In 1960, Dr. Frank Drake led the first Search for Extraterrestrial Intelligence (SETI) experiment at the National Radio Astronomy Observatory in Green Bank, West Virginia. In the more than sixty years that have since passed, astronomers have conducted multiple surveys in search of technological activity (aka technosignatures). To date, Breakthrough Listen is the most ambitious SETI experiment, combining data from the Robert C. Byrd Green Bank Telescope, the Parkes Murriyang Telescope, the Automated Planet Finder, and the MeerKAT Radio Telescope and advanced analytics.

The program includes a survey of the 1 million closest stars to Earth, the center of our galaxy and the entire galactic plane, and the 100 closest galaxies to ours. In a recent paper, members of Breakthrough Listen presented the results of their radio technosignature search of the centers of 97 nearby galaxies observed by the Robert C. Byrd Green Bank Telescope. This search was one of the largest and broadest searches for radio evidence of extraterrestrial intelligence ever undertaken, surveying trillions of stars at four frequency bands. Unfortunately, no compelling candidates were found.

The team was led by Carmen Choza, an Assistant Researcher with the SETI Institute and a Berkeley SETI Research Center Intern with Breakthrough Listen. She was joined by colleagues from Breakthrough Listen and the SETI Institute and researchers from the Institute of Space Sciences and Astronomy at the University of Malta, the International Center for Radio Astronomy Research (ICRAR) at Curtin University, and the Green Bank Observatory (GBO).

The paper that details their findings, "The Breakthrough Listen Search for Intelligent Life: Technosignature Search of 97 Nearby Galaxies," was recently published in *The Astronomical Journal*.

As they indicate in their study, the experiment by Choza and her colleagues consisted of a narrowband Doppler drift search at four frequencies (1.1–2.7 GHz and 4.0–11.2 GHz) of 97 galaxy centers. These galaxies were part of a previous Breakthrough Listen survey (conducted in 2017) of 123 nearby galaxies that represented a complete sample of morphological types (i.e., spirals, ellipticals, dwarf spheroidals, and irregulars). This approach breaks with most traditional SETI surveys, in that it did not focus on individual stars or stellar clusters. As Choza told Universe Today via email:

"When searching for life out there in the universe, we expect that it would form on planets like it did on ours. Many previous studies have focused on one star at a time, often stars that have known planets around them. The stellar densities we can target by aiming for the galaxy centers means we can search millions of stars, and potentially millions of stellar systems with planets, for the chance at finding a signal.

"Galaxies allow us to cast an immense net, with the catch that the signal would need to be more powerful than any signal current human technology could generate. Therefore, targeting galaxies allows us to search for civilizations far more technologically advanced than humankind. Although civilizations capable of producing such a signal might be vanishingly rare, a successful detection would be profoundly heartening–it would mean there is a definitive chance for humankind to gain far greater levels of technology than it now possesses without collapsing.

All data for this experiment was gathered by the 100-meter Green Bank Telescope (GBT) located at the GBO in West Virginia. The team selected the GBT because its backend allows for the storage and analysis of greater volumes of SETI data than was ever before possible. Moreover, GBT observations employ a "cadence" strategy, where targets in the sample are observed for five minutes, and then an offset location is observed several beamwidths from the target. This pattern is repeated three times with three separate offset locations (each of which is observed for five minutes), resulting in a 30-minute ABACAD cadence.

Each cadence was then analyzed using the turboSETI pipeline's to search for linearly-chirped narrowband Doppler-drifting signals. "This search targets narrowband, drifting technosignatures; that is, signals a few Hz wide that show frequency drift, indicating that the transmitter is accelerating relative to the Earth," said Choza. "If it drifts, it's from elsewhere, whether that means satellites in orbit, Voyager sailing through space far away, or a transmitter on a distant planet. We choose a drift rate of -4 Hz/s to 4 Hz/s to search a range of accelerations one might expect from transmitters located on real exoplanets."

Moreover, the team established constraints on the data to too look for possible transmitters with the equivalent isotropic radiated power of 10^{26} W—or 10,000 zetawatts (ZW). As Choza explained, this power level was chosen because it corresponds to the theoretical power consumption of a civilization capable of harnessing all the energy of its star system—i.e., a Type II Civilization on the Kardashev Scale:

"With a well-characterized instrument like the Green Bank Telescope and some assumptions about the signals we're searching for, we can calculate the minimum power an isotropic signal—that is, a signal broadcasting out in all directions into the universe—would have to transmit with in order for us to be able to detect it. For the furthest galaxies in our sample, our search could detect a hypothetical beacon transmitting with power on the order of 10^{26} Watts—similar to the full power output of the sun. A Kardashev Type II civilization, theorized to be able to capture the full power resources of a host star, could theoretically construct a beacon of sufficient scale to communicate across intergalactic distances."

In the end, the team obtained 1,519 candidate signals that were not attributable to radio frequency interference. Upon algorithmic processing, correlation of signal characteristics with known RFI populations, and extensive visual inspection, they found no compelling evidence of technosignatures. However, this latest survey was groundbreaking in many ways and will have significant implications for

SETI research going forward. As Choza explained, it's important to maximize the field of view when searching for rare signals and to rigorously account for foreground and background sources:

"This survey represents a landmark in the completion of the Breakthrough Listen mission's original search goals, and complements searches of nearby individual stars for lower-power transmitters, given that we don't know how numerous or bright extraterrestrial transmitters might be, it also serves as an inflection point in the development of new search methods to improve and re-analyze previous searches. We place the deepest constraints to date on the presence of technosignatures in nearby galaxies."

"This paper is the culmination of a year's worth of effort and the contributions of many authors to improving Breakthrough Listen methods and driving technosignature science forward towards ever-deeper constraints and ever-greater numbers of star systems. The program has been an amazing way to get young people involved in science, myself included, and some of the most exciting papers coming out of the collaboration are spearheaded by graduate students, postbacs, or interns."

These results could also help inform future searches by Breakthrough Listen, including the planned observations of our own galactic center, a sample of nearly 2,000 nearby stars, and another sample of galaxies observable from the Southern hemisphere using the Parkes Murriyang Telescope.

More information: Carmen Choza et al, The Breakthrough Listen Search for Intelligent Life: Technosignature Search of 97 Nearby Galaxies, *The Astronomical Journal* (2023). DOI: 10.3847/1538-3881/acf576

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