Steve Croft
Andrew Siemion
Greg Hellbourg
(UC Berkeley)

The Search for Cosmic Company: SETI on ngVLA

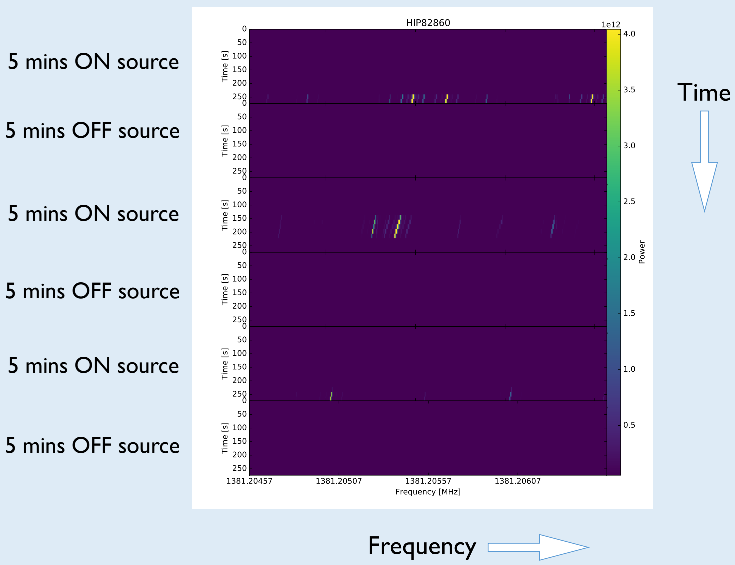
BERKELEY SETI RESEARCH CENTER

@BerkeleySETI

"Are we alone?"

is one of the most profound human questions. The unprecedented capabilities of next generation radio telescopes, including ngVLA, will allow us to probe hitherto unexplored regions of parameter space, placing meaningful limits on the prevalence of technological civilizations in the Universe, or perhaps making one of the most significant discoveries in the history of science.

How to find ET



One method of performing a radio SETI search (such as that used by Breakthrough Listen at the Green Bank Telescope, in the example shown here, from Enriquez et al. 2017) consists of alternating observations of a target star (the "ON" source) and one or more comparison stars ("OFF"). Algorithms search for features that appear artificial, and that are present in the ON observations and absent in the OFFs, to attempt to distinguish between SETI signals of interest and terrestrial (human-generated) radio frequency interference (RFI).

Classical SETI algorithms have typically focused on the search for narrow-band signals, but increased computing power and more sophisticated algorithms (including machine learning approaches) will enable the search for increasingly complex signals, as well as better classification of RFI.

Through both targeted and commensal observations, ngVLA data will be searched for signatures of technology that can be localized to particular positions on the sky.

Maximizing the chance of success

As with searches for astrophysical transients, the chances of a successful detection of ETI can be increased by searching large volumes of parameter space:

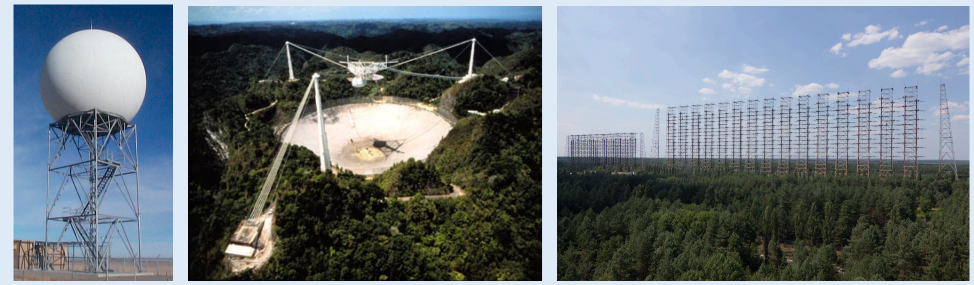
- Frequency coverage
- Frequency resolution
- Time resolution
- Time cadence
- Time duration
- Sensitivity
- Sky area (number of targets)
- Signal type

As a fast survey instrument with high sensitivity, wide frequency coverage, and back-end flexibility, ngVLA will excel in these metrics.

30 years ago, no planets were known outside our solar system. We now know that our Galaxy is a target-rich environment for "cradle of life" science (astrobiology and SETI).

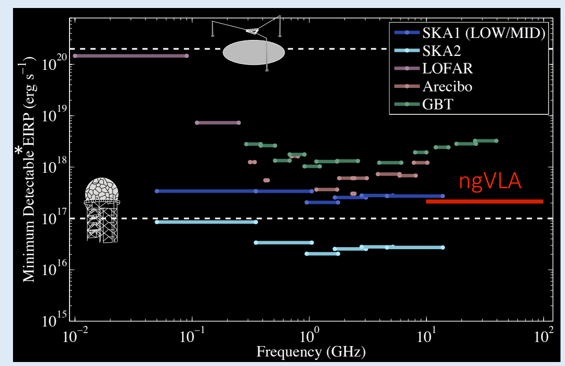
References

Enriquez et al. (2017) ApJ, 849, 104
Chennamangalam et al. (2017) ApJS, 228, 21
Harp et al. (2016) AJ, 152, 181
MacMahon et al. (2018) ApJ, in press
Siemion et al. (2015), SKA science book



We do not know what power, frequency, duty cycle, or antenna gain ETI might use, but these examples of some of the brightest Earthbound radio transmitters provide a benchmark to compare the sensitivity of current SETI experiments.

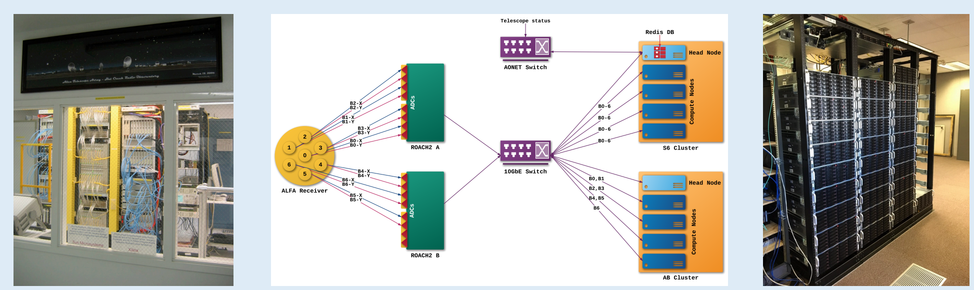
Finding Earth Analogs



** at 15pc, in a 15-minute observation*

This diagram (Siemion et al. 2015) shows the minimum detectable equivalent isotropic radiated power (EIRP) for an extraterrestrial transmitter with a variety of Earthbound telescopes. ngVLA (red line) will complement SKA1-LOW and SKA1- MID as the only facilities with the capability to detect "leakage" transmissions from omnidirectional extraterrestrial transmitters with power close to the brightest transmitters on Earth (EIRP ~ 10^{17} erg / s). It will also provide critical capabilities in the 10 – 100 GHz range, a region of the spectrum used by many human technologies.

Never Stop Searching



SETI instruments can operate with control of the telescope (e.g. SonATA, left, Harp et al. 2016), commensally (performing a search on a copy of the data from the primary user driving the telescope; e.g. SERENDIP VI, center, Chennamangalam et al. 2017), or in either mode (e.g. Breakthrough Listen, right, MacMahon et al. 2018). A commensal capability for ngVLA is important to enable a continuous SETI search regardless of the primary science target being observed.

We gratefully acknowledge support from the Breakthrough Prize Foundation.

ngvla NRAO NSF Associated Universities, Inc.