The Green Bank Array

Science from Ten ngVLA Antennas and the Green Bank Telescope

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Abstract

The Green Bank Array (GBA) is a telescope concept comprised of ten 18-m radio antennas at the Green Bank Observatory. These ten antennas, based on the ngVLA antenna design, would have the stand-alone collecting area of the Parkes telescope. The GBA could operate as a stand-alone instrument, in conjunction with the GBT, or as a long baseline component of the ngVLA. The GBA+GBT combination would more than double the collecting area of the planned ngVLA long-baseline components, providing the ngVLA with high sensitivity baselines from 1.2 - 115 GHz. At 3mm in particular, the GBT+GBT would contribute significantly to long baseline interferometry. The GBA+GBT will also match or exceed the sensitivity of ALMA over much of their overlapping frequency range. GBA antennas distributed around the GBT with a ~1 km radius would enable angular resolution from 42" at 1.4 GHz (HI line) to 0.7" at 115 GHz (CO (J=1-0)). At the low-frequency end, the GBA could allow for localization of fast radio bursts and increased cadence of pulsar timing. At higher frequencies, the GBA would enable significant advances in the study of the environment surrounding star forming regions, with both impressive sensitivity and resolution.

What is the Green Bank Array?

The Green Bank Array (GBA) is a concept for a versatile instrument for :

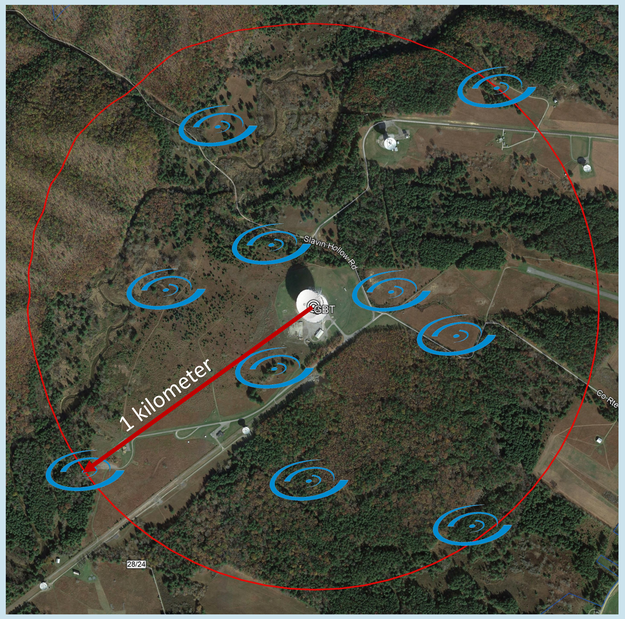
- VLBI observations
- Pulsar timing for gravitational wave detection
- Fast Radio Burst searches and follow-up observations
- Transient searches and follow-up observations
- Co-observation transient searches with LSST, CHIME, etc.
- Radar and other remote sensing observations

Array Design

Location – All ten 18m antennae would be within 1 km of the Green Bank Telescope (GBT) at the Green Bank Observatory in the National Radio Quiet Zone. We avoid shadowing for all observations above 30 deg. elevation for telescopes at least 300 m from the GBT.

Antennae – The GBA would use the ngVLA antenna design with frequency coverage of 1.2—115 GHz, saving on design cost and allowing the array to be easily integrated into the full ngVLA system and as a large VLBA core. Science requirements for pulsar timing requires the GBA to consist of at least 10 antennae.

Existing Infrastructure – The Green Bank Observatory has readily available infrastructure (power, optical fiber, machine shop, electronics shop, etc.).



The Green Bank Array would lie within 1 kilometer of the Green Bank Telescope. Ten possible locations for ngVLA antennae are shown here, though **we have not yet completed a detailed study of array location.** Terrain north and west of the telescope is mountainous, while fiber and power are readily accessible elsewhere.

Array Sensitivity

The GBA would have the stand-alone sensitivity of Parkes. Combined, the GBA+GBT would provide roughly the sensitivity of ALMA in the North.

Frequency (GHz)	Point Source RMS (μJy beam^{-1} min^{-1})		Spectral Line RMS (mJy min^{-1} @ 10 km s^{-1})		Mapping Speed (deg^2 hr^{-1} to 0.25 mJy RMS)	
2.0	106	*(32)*	20	*(6.0)*	37	*(50)*
6.6	61	*(18)*	12	*(3.6)*	10	*(14)*
15.9	56	*(21)*	7.0	*(2.6)*	2	*(2.5)*
26.4	57	*(24)*	7.0	*(2.9)*	0.7	*(0.8)*
39.2	78	*(31)*	10	*(3.8)*	0.17	*(0.2)*
90.1	200	*(90)*	16	*(7.4)*	4.6 x 10^{-3}	*(5.4 x 10^{-3})*

GBA Sensitivity and mapping speed for the stand-alone array and in combination with the GBT. GBA+GBT parameters are given *(in parentheses)*.

Future 3mm Global Millimeter VLBI Array (GMVA) observations will be dominated by the GBA+GBT, ALMA, and ngVLA. The full Northern Hemisphere array would have 89 microarcsecond resolution and ten-second 0.18 K (km s^{-1})$^{-1}$ sensitivity.

7σ Baseline Sensitivity (mJy/beam for 10 sec. integration)					
	ALMA50	**ngVLA**	**LMT**	**VLBA (NL)**	**VLBA (PT)**
GBA+GBT	4	2.9	14.3	37.3	23.1
ALMA50		2.2	11	28.8	17.9
ngVLA			7.82	102.1	63.3
LMT				102.1	63.3
VLBA (NL)					166.3

The GMVA sensitivity for all current North American VLBA observatories is 5.87 mJy/beam in 10 seconds. Adding the GBA+GBT and the ngVLA, this decreases to 1.44 mJy/beam. We only include two VLBA stations here with the highest and lowest GBA+GBT sensitivity to represent the full sample.

Selected Science Cases

GMVA, VLBI – Image any Jupiter-sized planets within 5.2 pc and any AU-sized structures within 11 kpc.
Deeper sensitivity makes it possible to observe new 3mm VLBI sources.

Stand Alone Array – Quickly follow-up and localize gravitational wave (GW) triggers, "filter" GW triggers before committing other ngVLA resources.
Sub array the system to allow up to three independent GW search fields, each with ~0.75 degree filed of view at 1.4 GHz.
Commensal observations with LSST, CHIME, and other large facilities.

GBA+GBT – Phase up the array to search for pulsars with 1.3 times the sensitivity of current GBT surveys.
Conduct unique near-Earth radar observations thanks to the array's geometry, collecting area, and short-wavelength performance.
New phased array feeds on the GBT will allow simultaneous measurements of the zero spacing flux across the entire field of view of the GBA.

We are interested in identifying new science cases and improving current science cases for the Green Bank Array. If you have any suggestions for projects, requirements, etc., for the GBA, please contact any of the Green Bank Observatory staff.

For more information, see "The Green Bank Array: Concept & Capabilities" by Brian S. Mason (NRAO) 20 Dec. 2018

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