Summary of:

Next Generation Very Large Array Memo No. 5 Science Working Groups Project Overview by Carilli et al.

Justin Hyatt

University of Arizona

28 October 2016

Background

The Next Generation Very Large Array is a proposed radio observatory that will allow rapid, high resolution observations in the wavelength range of 3 to 30 mm. This fills the gap between the ALMA observatory, which observes in the submillimeter range, and the future Square Kilometer Array, which will observe in the centimeter range.

Scientific Justification

Such an array is required to see protoplanetary disks, the disk of dust and gas that is near stars (within 1 AU). This would allow us to watch planet formation. The high sensitivity would enable observations of

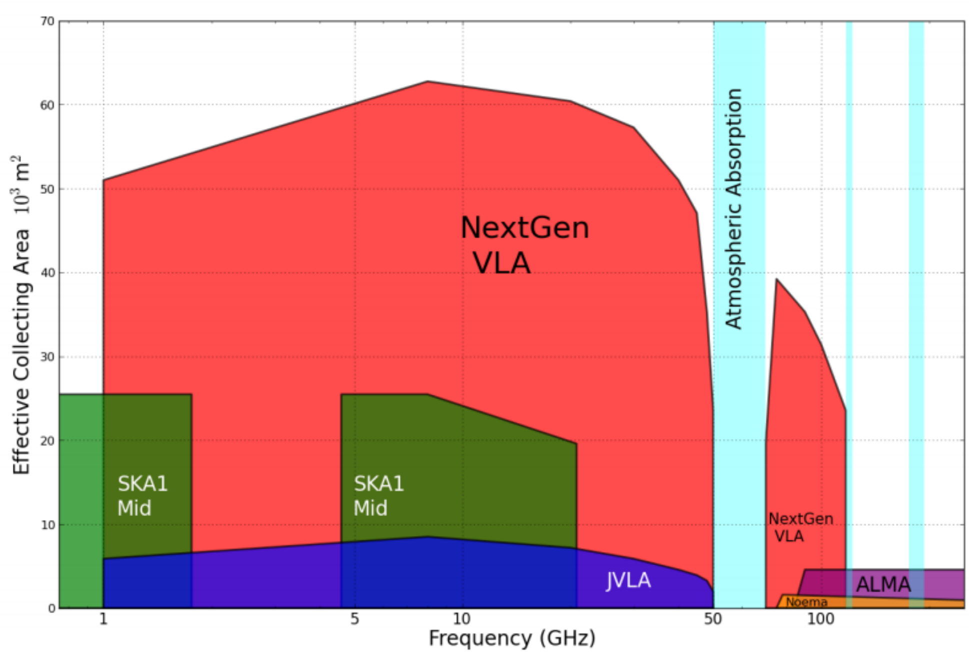

Figure 2: *Effective collecting area versus frequency for the ngVLA, and other existing or planned facilities operating in a comparable frequency range. We have not included much higher and lower frequencies, eg. the SKA-1 will extended to below 100MHz (including SKA-Low), while ALMA extends up to close to a THz.*

star formation in clouds near the Milky Way and as far out as the Virgo cluster (~100 parsecs). Also the large collecting area will allow for an all-sky survey of cold gas that fuels star formation. This will also provide us with a history of star formation in the universe. CO emits at about 1cm, and is the standard tracer molecule used to determine total gas density.

Currently there is a gap in observable wavelengths that will be filled by the proposed observatory. See Figure 2. Also the greatly increased aperture area increases the number of detectable feint objects. It also increases the speed at which observations can be made.

Telescope Specifications.

The proposed instrument will have 10 times the collecting area of either ALMA or the VLA. This will allow for rapid observing including surveys. It will also allow imaging of fainter objects. It will also have a 10 times longer baseline (300km). This allows for high resolution imaging, up to miliarcsecond range. The current plan is for 18m diameter dishes. The dishes must function at 75% efficiency at 30GHz. The layout of dishes will need to accommodate two competing goals: one to have high resolution when observing point sources, and the other to observe wide fields as large as the aperture. Table 1 below shows the optical requirements of the system. In order to achieve the required resolution of 10 miliarcsecond at a wavelength of 10mm, the baseline of the array will need to be approximately 300 km.

Table 1: Next Generation VLA nominal parameters

	2GHz	10GHz	30GHz	80GHz	100GHz
Field of View FWHM (18m[a]) arcmin	29	5.9	2	0.6	0.51
Aperture Efficiency (%)	65	80	75	40	30
A^b_{eff} x10^4 m^2	5.1	6.2	5.9	3.1	2.3
T^c_{sys} K	29	34	45	70	80
Bandwidth[d] GHz	2	8	20	30	30
Continuum rms[e] 1hr, μJy bm^{-1}	0.93	0.45	0.39	0.96	1.48
Line rms 1hr, 10 km s^{-1}, μJy bm^{-1}	221	70	57	100	130
Resolution[f] FWHM milliarcsec	140	28	9.2	3.5	2.8
T^g_B rms continuum 1hr K	14	7	6	15	23
Line[h] rms 1hr, 1", 10 km s^{-1}, μJy bm^{-1}	340	140	240	860	–
T^i_B rms line, 1hr, 1", 10 km s^{-1}, K	100	1.8	0.32	0.17	–

[a]Under investigation: antenna diameters from 12m to 25m are being considered.
[b]300 x 18m antennas with given efficiency.
[c]Current performance of JVLA below 50GHz. Above 70GHz we assume the T_{sys} =60K value for ALMA at 86GHz, increased by 15% and 25%, respectively, due to increased sky contribution at 2200m.
[d]Under investigation. For much wider bandwidths, system temperatures are likely to be larger.
[e]Noise in 1hour for given continuum bandwidth for a Clark/Conway configuration (ngVLA memo 2 and 3) scaled to a maximum baseline of 300km, using Briggs weighting with R=0. Using R=1 decreases the noise by a factor 0.87, and using R=-1 increases the noise by a factor 2.5.
[f]Synthesized beam for a Clark/Conway configuration scaled to a maximum baseline of 300km, using Briggs weighting with R=0. For R=1, the beam size increases by a factor 1.36, and for R=-1 the beam size decreases by a factor 0.63.
[g]Continuum brightness temperature corresponding to point source sensitivity (row 6) and resolution of Clark/Conway configuration, using Briggs weighting with R = 0 (row 8).
[h]Line rms in 1hr, 10 km s^{-1}, after tapering to 1" resolution for the Clark/Conway configuration.
[i]Line brightness temperature rms in 1hr, 10 km s^{-1}, after tapering to 1" resolution for the Clark/Conway configuration.

Optomechanical Implications

The proposed array has such a high number of dishes that the manufacturing costs begin to dominate the project budget. Unlike many telescope projects where the engineering is a primary cost, these dishes will need to be designed for inexpensive manufacturing in quantity. This requires simplifying the design of the dish surface and the support structure. Also, the large location distribution of the dishes and their remote location increases the cost of maintenance. This requires simplifying mechanisms and moving parts to minimize maintenance