Union Radio-Scientifique Internationale — International Union of Radio Science

Monthly Newsletter of International URSI Commission J – Radio Astronomy

March 2019

Officers

Chair:	Richard Bradley	ECRs:	Stefan Wijnholds
Vice-Chair:	Douglas Bock		Jacki Gilmore

Prepared by R. Bradley, Chair, Commission J, rbradley@nrao.edu

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News Items

Greetings Commission J Members!

The Pacific Radio Science Conference (AP-RASC) is occurring this week! On behalf of URSI and the Organizing Committee, thank you for supporting AP-RASC 2019!

We are in search of conveners for the 2020 URSI General Assembly and Scientific Symposium. The 2020 GASS Commission J program is given below. Preparations for the GASS are currently underway so please contact me as soon as possible to volunteer.

Our Activities Spotlight this month is on the the Next Generation Very Large Array (ngVLA). Special thanks to Tony Beasley, Eric Murphy, Rob Selina, Mark McKinnon & the ngVLA Project Team at NRAO for contributing a very nice article that details the overall concept, key science goals, instrument suite, and broader impacts of the ngVLA.

I kindly request your ideas, articles, news, photos, etc. for upcoming editions of Newsletter. Let's keep it interesting and informative! I thank all of you who have already contributed.

Submitted by R. Bradley

100 Years URSI 1919 2019

2020 URSI General Assembly and Scientific Symposium (2020 URSI GASS)
Rome, Italy

We are now actively planning for the next URSI General Assembly and Scientific Symposium.

Volunteer to convene a session or organize a one-day topical workshop around an important area of research. Let's work together to maintain the long tradition of excellence that the GASS provides to the radio science community.

***** Final Draft Program for Commission J – GASS 2020 *****

Sessions:

New Telescopes on the Frontier
Recent and Future Space Missions
Conveners: Joseph Lazio, Heino Falcke, and Yuri Kovalev
Single Dish Instruments
Very Long Baseline Interferometry
Millimeter/Submillimeter Arrays
Receivers and Radiometers: Design and Calibration
Convener: Jacki Gilmore
Digital Signal Processing: Algorithms and Platforms
Big data: Algorithms and Platforms
Conveners: Stefan Wijnholds
Short-Duration Transients, FRBs, and Pulsars: Observations, Techniques, and Instrumentation
Power spectrum observations
Solar, Planetary, and Heliospheric Radio Emissions
Historical Radio Astronomy
Conveners: Richard Schilizzi
Latest News and Observatory Reports
Conveners: Rich Bradley and Douglas Bock

Shared Sessions

Radio astronomical characterisation of the ionosphere and related models (Commissions JG)
Characterization and Mitigation of Radio Frequency Interference (Commissions JEFGH)
Some aspects of radio science in space weather (Commissions GHJ)
Conveners: Richard Fallows (J), Iwona Stanislawska (G), Baptiste Cecconi, Patricia Doherty, Willem Baan
Spectrum Management (Commissions ECJ)

2020 URSI General Assembly and Scientific Symposium (2020 URSI GASS)
Rome, Italy

GASS Session Descriptions

Current and Future Space Missions

Convenors: Joseph Lazio, Heino Falcke, & Yuri Kovalev

One of the long-term themes of radio astronomy is to obtain higher angular resolution. The motivations are diverse, from basic considerations such as mitigating source confusion to understanding the physics by which radio sources emit and whether an inverse Compton catastrophe occurs to the potential for imaging the event horizons of black holes.

Following initial pioneering work using a Tracking and Data Relay Satellite System spacecraft and the successful VLBI Space Observatory Programme (VSOP)/HALCA mission, there is a resurgence of interest in space-based antennas for radio astronomy, motivated by a number of recent, current, and potentially near-term missions and instruments. A likely incomplete list includes

- The successful RadioAstron mission;
- The Netherlands-China Low-Frequency Explorer (NCLE) experiment on the Chang'e 4 orbiter;
- A radio astronomy payload on the Chang'e 4 lander;
- The Sun Radio Interferometer Space Experiment (SunRISE), currently in an extended Phase A study for consideration as a constellation of small spacecraft;
- Multiple NASA Astrophysics concept studies for space-based radio telescopes; and
- Multiple concepts for one or more millimeter-wavelength space-based interferometers.

Further, while there has been historical activity by the United States, Japan Russia, and Europe, there is growing interest and capability such as from China. Moreover, the possibility of commercial launch opportunities may reduce the cost of future missions, increase the availability of launch options, or both.

This Commission J session would provide an opportunity to review the science results from the RadioAstron mission and the NCLE experiment as well as look to the future possibilities for space-based radio astronomy experiments and missions.

Meeting and Workshop Announcements

Cerenkov Telescope Array Symposium

“*Science opportunities with CTA*”

Bologna, 6-9 May 2019

Abstract submission deadline has passed!

Dear colleagues,

Registration for the First CTA symposium is now open. Participants can register online at http://www.cta-symposium.com/registration. Your registration will be confirmed by the workshop secretary as soon as the registration fee has been received.

The workshop registration fee is 300 Euros before 20 March, 2019 and 350 Euros after this date. A special rate of 200 (250 after 20 March) euros is available for students.

The theme for the First CTA Symposium is “Science opportunities with CTA” and will take place at the historical Teatro Duse in Bologna 6-9 May 2019 (https://www.cta-symposium.com). The meeting specifically addresses the larger Multi-Wavelength/Multi Messenger communities and aims to set up new channels of communication with those communities. It will feature a combination of invited and contributed talks. The preliminary programme is available on the symposium webpage.

Contributions to the First CTA Symposium in the following areas:

- Cosmic particle acceleration
- Compact objects and relativistic shocks
- Role of cosmic particles in galaxy evolution and star-forming systems
- Gamma rays as cosmic probes
- Fundamental physics
- Multi-wavelength and multi-messenger observations

Or any other topic connected to the scientific possibilities of CTA.

The scientific organising committee (SOC) will consider the submission for inclusion in the preliminary programme and will notify the authors whether their contribution has been selected for an oral/poster presentation by March 15, 2019.

Confirmed invited speakers include:

Marco Ajello
Roger Blandford
Catherine Cesarsky
Federico Fiuza
Giancarlo Ghirlanda
Gabriele Ghiselini
Francis Halzen
Werner Hofmann
Jamie Holder
Takaaki Kajita
Robert Laing
Julie McEnery
Andrii Neronov
Subir Sarkar
Anatoly Spitkovsky
Rai Weiss
Wolfgang Wild

We look forward to seeing you in Bologna in May.
With best regards,

Stefan Funk
on behalf of the SOC:

Roger Blandford, Kavli Institute of Particle Astrophysics and Cosmology, Stanford University, USA; Catherine Cesarsky, CEA, France; Andrea Comastri, INAF, Italy; Emma de Oña Wilhelmi, University of Barcelona, Spain; Stefan Funk, University of Erlangen, Germany; Jim Hinton, Max Planck Institute for Nuclear Physics, Germany; Giovanni Pareschi, INAF, Italy; David Reitze, California Institute of Technology, USA; Richard Schilizzi, University of Manchester, UK; Christian Spiering, DESY, Germany; Matthias Steinmetz, IAP, Germany; Wolfgang Wild, CTAO, Italy

The Next Generation Very Large Array (ngVLA)

A.J. Beasley, E. Murphy, R. Selina, M. McKinnon & the ngVLA Project Team (NRAO)

Over the past decade, the National Radio Astronomy Observatory (NRAO) Jansky Very Large Array (JVLA) and the jointly-operated Atacama Large Millimeter/submm Array (ALMA) have led the way in establishing the scientific importance and unique relevance of centimeter and millimeter-wavelength radio astronomy. For more than four decades, the NRAO has kept the JVLA at the forefront of radio astronomy, supporting the global research community through innovative technical and algorithmic development of an instrument originally built in the 1970s. To explore new science opportunities that have emerged over the past two decades, the NRAO, in close consultation with the global scientific community and a group of international partners, are now developing a concept for a more powerful instrument - currently known as the next-generation Very Large Array (ngVLA).

Based on science and operational requirements solicited from the astronomical community, the ngVLA will operate at centimeter wavelengths (25 to 0.26 centimeters, corresponding to a frequency range extending from 1.2 GHz to 116 GHz). The instrument will be a synthesis radio telescope, with a Main Array constituted of approximately 214 reflector antennas each of 18 meters diameter, operating in a phased or interferometric mode. An additional short-spacing array (SSA) of 19 reflector antennas of 6m aperture will be sensitive to larger angular scales undetected by the main array. The ngVLA will also include continental-scale long baselines (the Long Baseline Array – LBA) by merging the existing Very Long Baseline Array (VLBA) capabilities into ngVLA, with clusters of antennas replacing each VLBA station (10 sites each site containing approximately three 18m antennas).

The ngVLA will have approximately ten times the sensitivity of the JVLA and ALMA, with more than thirty times longer baselines (~9000km), providing milliarcsecond-scale resolution, plus a dense core on km-scales for high surface brightness sensitivity. Such an array bridges the gap between ALMA, the premiere mm/sub-mm array, and the future SKA1, optimized for longer wavelengths. The angular resolution of ngVLA compared to other existing or planned instruments is shown in Figure 1.

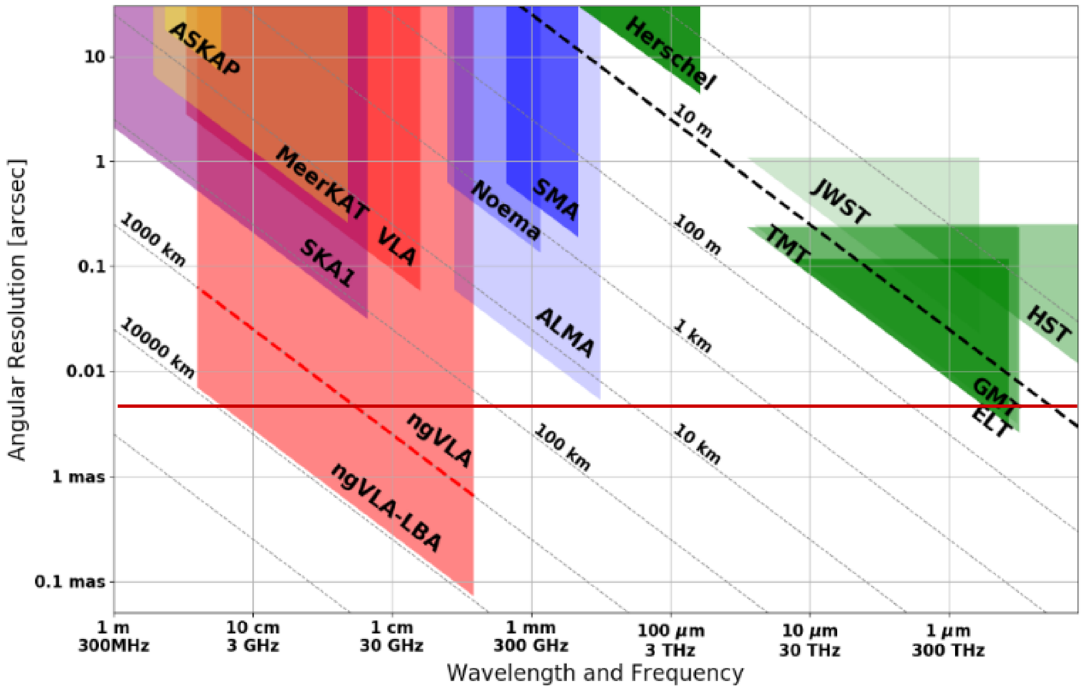


Figure 1: Spatial resolution versus frequency set by the maximum baselines of the ngVLA as compared to that of other existing and planned facilities. The horizontal line indicates the resolution needed to detection objects on 1 astronomical unit scales at a distance of 140 parsec (a typical distance to nearby star-forming regions).

Science

The ngVLA will uniquely explore a broad range of high- priority scientific questions in modern astronomy, physics, chemistry, and biology by simultaneously delivering the capability to: unveil the formation of Solar System analogues on terrestrial scales; probe the initial conditions for planetary systems and life; characterize the assembly, structure, and evolution of galaxies from the first billion years to the present; perform fundamental tests of gravity using pulsars in the Galactic Center; and understand the formation and evolution of stellar and supermassive black holes in the era of multi-messenger astronomy. In delivering transformational new science in each of these areas, the ngVLA will be highly complementary to other National Science Foundation (NSF) astronomy investments.

The ngVLA Science Advisory Council (SAC), a group of leading scientists with a wide range of interests and expertise appointed by NRAO, in collaboration with the broader international astronomical community, has recently defined over 80 compelling science cases requiring observations between 1.2 – 116 GHz with sensitivity, angular resolution, and mapping capabilities far beyond those provided by the Jansky VLA, VLBA, ALMA, and SKA1. These science cases were used to inform a set of key science goals (KSGs) for the ngVLA, which in turn formed the basis of the current ngVLA science requirements. These KSGs include include:

KSG1: Unveiling the Formation of Solar System Analogues on Terrestrial Scales

The ngVLA will measure the planet initial mass function down to a mass of 5 – 10 Earth masses and unveil the formation of planetary systems similar to our own Solar System by probing the presence of planets on orbital radii as small as 0.5 AU at the distance of 140 pc. The ngVLA will reveal circumplanetary disks and sub-structures in the distribution of mm-size dust particles created by close-in planets and measure the orbital motion of these features on monthly timescales. See Figure 2.

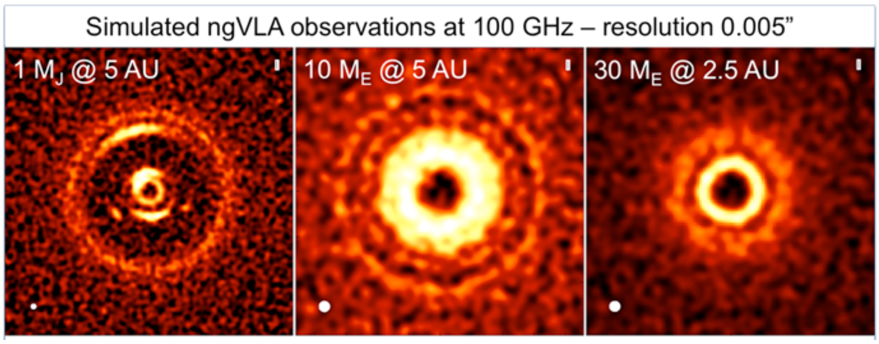


Figure 2: Simulated ngVLA observations of protoplanetary disk continuum emission perturbed by a Jupiter mass planet orbiting at 5 AU (left column), a 10 Earth mass planet orbiting at 5 AU (center column), and a 30 Earth mass planet orbiting at 2.5 AU (right column). The ngVLA's combination of frequency coverage and angular resolution will be able to directly image the formation of Earth-like planets (Ricci, L., Isella, A., Liu, S., Li, H. "Science with a ngVLA: Imaging Planetary Systems in the Act of Forming with the ngVLA" in ASP Monograph Series 7, "Science with a Next-Generation VLA", ed. E. J. Murphy 2018, (ASP, San Francisco, CA)) (2018).

KSG2: Probing the Initial Conditions for Planetary Systems and Life with Astrochemistry

The ngVLA should detect predicted complex prebiotic species that are the basis of our understanding of chemical evolution toward amino acids and other biogenic molecules. It shall also allow us to detect and study chiral molecules, testing ideas on the origins of homochirality in biological systems. The detection of such complex organic molecules will provide the chemical initial conditions of forming solar systems and individual planets.   See Figure 3.

KSG3: Charting the Assembly, Structure, and Evolution of Galaxies from the First Billion Years to the Present

The ngVLA will survey cold gas in thousands of galaxies back to early cosmic epochs, while simultaneously enabling routine sub-kiloparsec scale resolution dynamical imaging of their gas reservoirs. In doing so, the ngVLA will afford a unique view into how galaxies accrete, process, and expel their gas through detailed imaging of their extended atomic reservoirs and circum-galactic regions. The ngVLA shall also have enough sensitivity to map the physical and chemical properties of molecular gas over the entire local galaxy population. These studies will reveal the detailed physical conditions for galaxy assembly and evolution throughout the history of the universe.

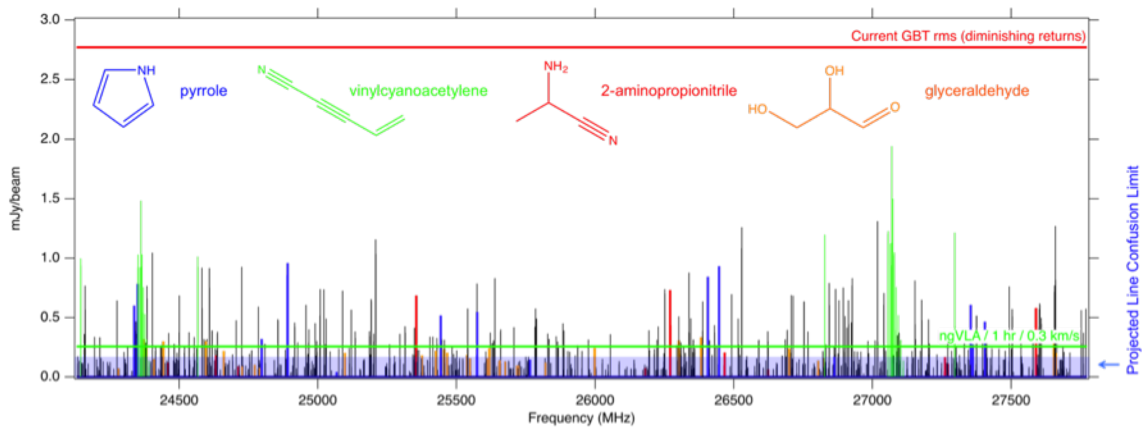


Figure 3: A conservative simulation of a representative set of 30 currently undetected complex interstellar molecules that are likely to be detectable by the ngVLA above the confusion limit of an ngVLA survey in and around 'hot' cores with source sizes typically of ~1" – 4". These lines are not observable with current facilities. A few key molecules are highlighted in color. (Credit B. McGuire).

KSG4: Using Pulsars in the Galactic Center to Make a Fundamental Test of Gravity

Pulsars in the Galactic Center represent clocks moving in the space-time potential of a super-massive black hole and would enable qualitatively new tests of theories of gravity. More generally, they offer the opportunity to constrain the history of star formation, stellar dynamics, stellar evolution, and the magneto-ionic medium in the Galactic Center. The ngVLA can achieve a combination of sensitivity and frequency range that enables it to probe much deeper into the likely Galactic Center pulsar population to address fundamental questions in relativity and stellar evolution.

KSG5: Understanding the Formation and Evolution of Stellar and Supermassive Black Holes in the Era of Multi-Messenger Astronomy

The ngVLA will to survey everything from the remnants of massive stars to the supermassive black holes that lurk in the centers of galaxies, making it the ultimate black hole hunting machine. High-resolution imaging abilities are required to separate low-luminosity black hole systems in our local Universe from background sources, thereby providing critical constraints on the formation and growth of black holes of all sizes and mergers of black hole-black hole binaries. The ngVLA can identify the radio counterparts to transient sources discovered by multi-messenger alerts from gravitational wave, neutrino, and optical observatories. This requires high-resolution, fast-mapping capabilities to make it the preferred instrument to pinpoint transients associated with violent phenomena such as supermassive black hole mergers and blast waves. See Figure 4.

Figure 4: Two tiny, but very dense neutron stars merge and explode as a kilonova. Such a very rare event produces gravitational waves and electromagnetic radiation, as observed on 17 August 2017. The ngVLA will play a pivotal role in characterizing the physics of such events in the era of multi-messenger astronomy. (Artist's impression, Credit: ESO/L. Calçada/M. Kornmesser).

Instrument Definition

The main array, SBA and the signal processing center of ngVLA will be located at the Very Large Array site, on the plains of San Agustin, New Mexico. The array will include stations in other locations throughout the state of New Mexico, west Texas, Arizona, and northern Mexico (the current reference configurations on three physical scales are shown in Figure 5).

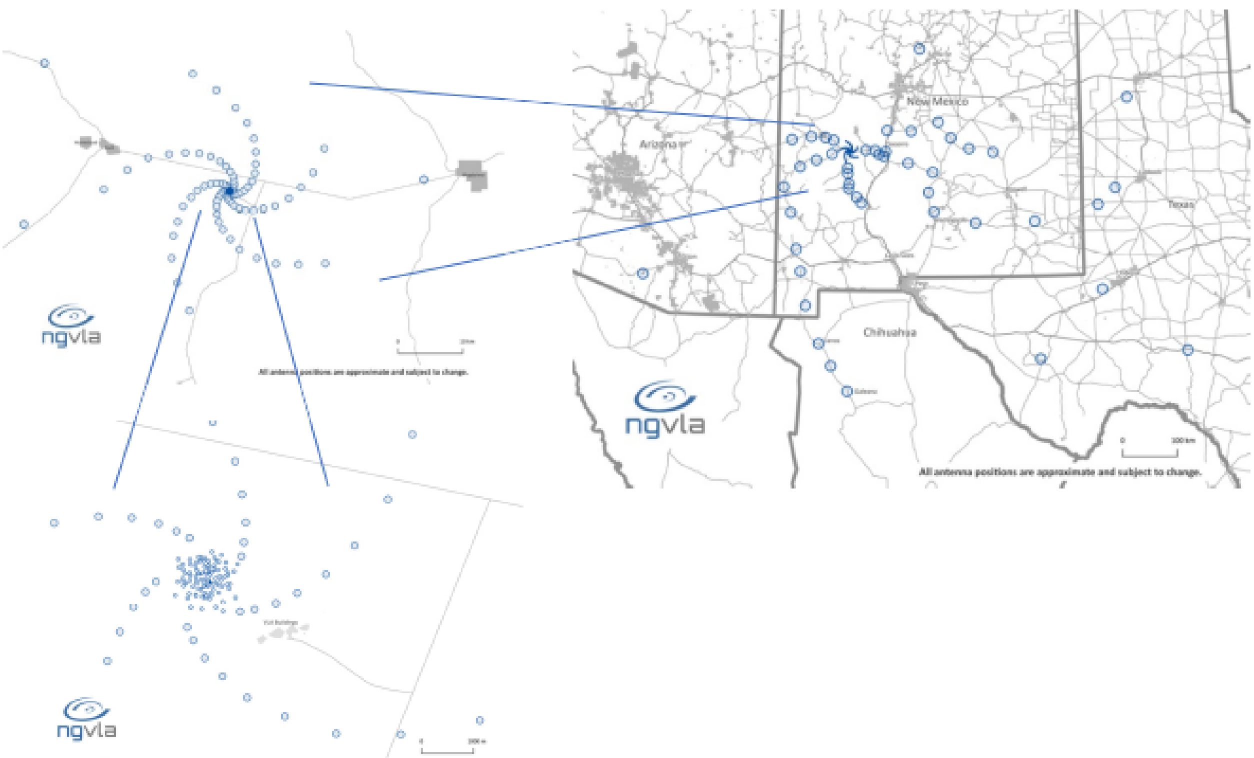


Figure 5: SBA and , Main Array configurations of the ngVLA (March 2019).

The high desert plains of the Southwest U.S., at over 2000m elevation, provide excellent observing conditions for the frequencies under consideration, including excellent phase stability and opacity at 3mm wavelength over a substantial fraction of the year. Engineering operations will be conducted from the VLA site facilities and the Array Operations Center in Socorro, NM. The full ngVLA configuration, including the location of the 10 LBA stations, is shown in Figure 6.

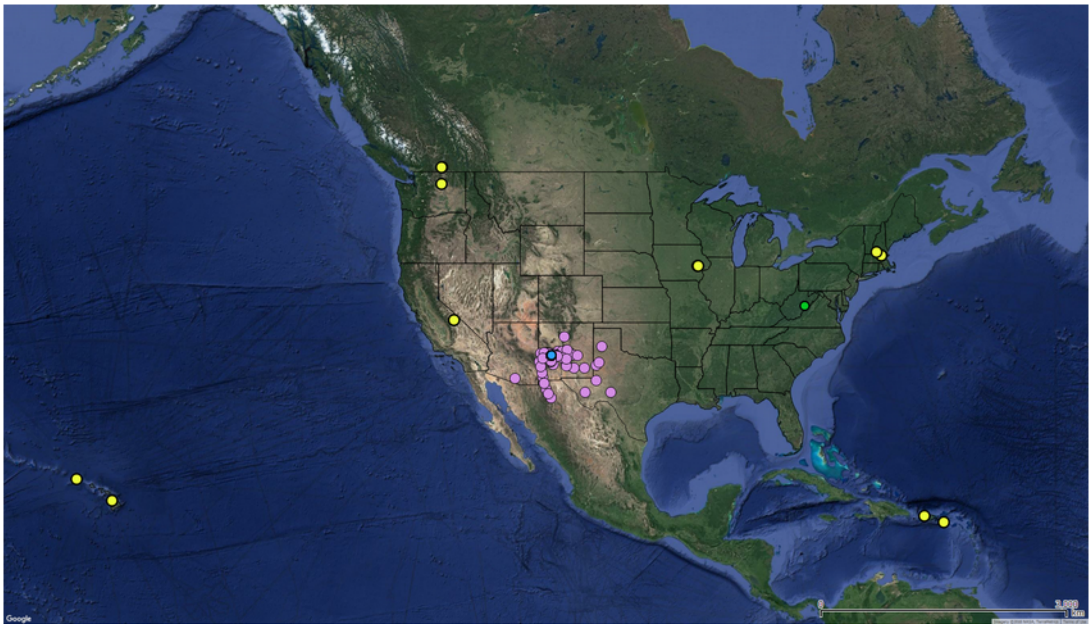


Figure 6: The full ngVLA configuration including the location of the ngVLA LBA stations.

The predicted performance of the array is summarized in Table 1, and a more detailed review of the technical definition of the instrument can be found in Selina et al. (SPIE Astronomical Telescopes & Instrumentation, AS18, 10700-55, 2018). The continuum and line rms values indicated in Table 1 are for point source sensitivity with a naturally weighted beam. Imaging sensitivity will vary depending on the quality of the (sculpted) synthesized beam[1] (defined as the ratio of the power in the main beam attenuation pattern to the power in the entire beam attenuation pattern as a function of the FWHM of the synthesized beam[(1)]) required to support the science use case.

1 The quality of the (sculpted) synthesized beam is defined as the ratio of the power in the main beam attenuation pattern to the power in the entire beam attenuation pattern as a function of the FWHM of the synthesized beam.

Receiver Band	B1	B2	B3	B4	B5	B6	Notes
Center Frequency, f	**2.4 GHz**	**8 GHz**	**16 GHz**	**27 GHz**	**41 GHz**	**93 GHz**	
Band Lower Frequency [GHz]	1.2	3.5	12.3	20.5	30.5	70.0	a
Band Upper Frequency [GHz]	3.5	12.3	20.5	34.0	50.5	116.0	a
Field of View FWHM [arcmin]	24.4	7.3	3.6	2.2	1.4	0.6	b
Aperture Efficiency	0.77	0.76	0.87	0.85	0.81	0.58	b, e
Effective Area, $A_{eff,}$ x 10^3 [m^2]	47.8	47.1	53.8	56.2	50.4	36.0	b, e
System Temp, T_{sys} [K]	25	27	28	35	56	103	a, e
Max Inst. Bandwidth [GHz]	2.3	8.8	8.2	13.5	20.0	20.0	a
Sampler Resolution [Bits]	8	8	8	8	8	4	
Antenna SEFD [Jy]	372.3	419.1	372.1	485.1	809.0	2080.5	a, b
Resolution of Max. Baseline [mas]	2.91	0.87	0.44	0.26	0.17	0.07	c
Continuum rms, 1 hr [μJy/beam]	0.38	0.22	0.20	0.21	0.28	0.73	d, e
Line Width, 10 km/s [kHz]	80.1	266.9	533.7	900.6	1367.6	3102.1	
Line rms, 1 hr, 10 km/s [μJy/beam]	65.0	40.1	25.2	25.2	34.2	58.3	d, e

Table 1: ngVLA Key Performance Metrics

Notes:
(a) 6-band 'baseline' receiver configuration.

(b) Reference design concept of 244 18m aperture antennas. Unblocked aperture with 160μm surface.

(c) Rev. C 2018 Configuration. Resolution in EW axis.

(d) Point source sensitivity using natural weights, dual pol, and all baselines.

(e) Averaged over the band. Assumes 1mm Precipitable Water Vapor for Band 6, 6mm PWV for others; 45 deg elev. on sky for all.

Examples of front-end concepts currently being explored for ngVLA are shown in Figure 7. The ngVLA will provide continuous frequency coverage from 1.2 – 50.5 GHz and 70 – 116 GHz in multiple bands. Receivers will be cryogenically-cooled with the receiver cryostat(s) designed to integrate multiple receiver bands to the maximum extent possible. Bands 1 and 2 employ wideband feed horns and LNAs, each covering the L+S band and, C+X bands. Quad-ridged feed horns (QRFH) are used, with coaxial outputs. The four high-frequency bands (12.6 – 116 GHz) employ waveguide-bandwidth (~1.67:1) feeds & LNAs, for optimum noise performance. Axially corrugated feed horns with circular waveguide output ensure even illumination over frequency and minimal loss.

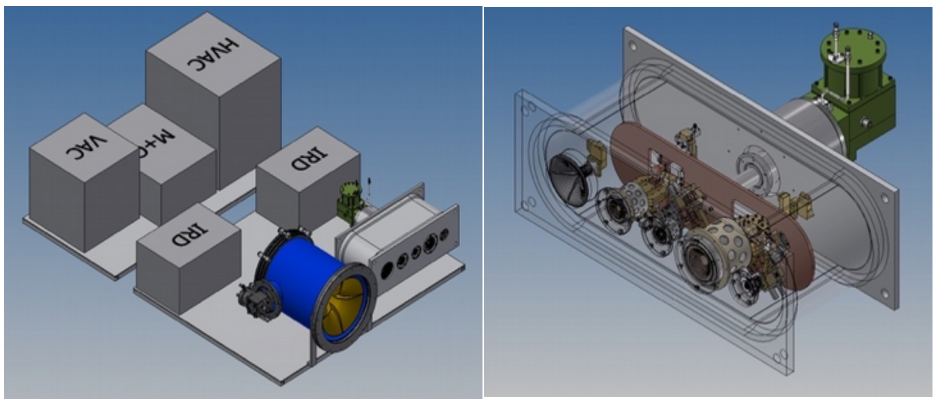


Figure 7: Front end component packaging at the secondary focus of the antenna. Band selection and focus are achieved with a dual-axis translation stage.

A Central Signal Processer (CSP) will ingest the voltage streams recorded and packetized by the antennas, producing low level data products for archiving. The operating modes of the CSP will include:

- Auto-correlation;
- Cross-correlation;
- Beamforming capabilities, for VLBI recording, pulsar search, and timing;
- Pulsar timing engine;
- Pulsar/transient search engine;
- Transient input-stream buffering (to external recorder or processing engine).

CSP development is ongoing at NRAO and with our ngVLA partners. The ngVLA will be operated as a proposal-driven, PI-pointed instrument, and the fundamental data products provided to researchers will be science-ready data products (i.e., images and cubes) generated using calibration and imaging pipelines created and maintained by the observatory. Both the pipeline products along with the “raw” visibilities and calibration tables will be archived, opening the door to future re-processing and archival science projects.

Additional science options (including a commensal low-frequency array) are being proposed by partner U.S, institutions. An ancillary aperture array observing at frequencies below 150 MHz at ngVLA antenna stations, utilizing the common infrastructure deployed for the ngVLA, is also under consideration (the ngLOBO project).

Broader Impacts

The NRAO closely considers the broader impacts of facility development and operations, including opportunities for student training, increased participation of underrepresented groups, tangible benefits to the wider U.S. research community (e.g., data archive access and the commercialization of new technologies), and impacts to the environment and economy of the communities that host NRAO-run facilities. The project will also engage with experienced individuals and groups within the U.S. university community to (a) advise us on the approach and performance of the project, and (b) to carry out appropriate engineering and software tasks related to specific work packages and deliverables associated with the project. Strong collaboration with the university community has been an important part of the success of all major instrument efforts at NRAO.

The ngVLA antenna project will likely have a direct impact on fostering a revitalized U.S. high-tech manufacturing hub in the southwest, with precision machine fabrication in New Mexico and Texas. The design and fabrication of precision composite, steel and aluminum structures could have long-term benefits to the local economy, enabling high-tech precision manufacturing of other structures such as wind turbines. Such work could have an international impact given the complex supply chains that cross the U.S.-Mexico border. The ngVLA will require fiber optic infrastructure that would extend across the southwest and exceed the information-carrying capacity of the current Los Angeles metropolitan area. The requisite physical infrastructure will renew the telecommunications network of the southwest, and enable rural broadband connections that have been identified as a key utility for high-tech start-ups and job growth.

Future

The ngVLA will be a transformative, multi-disciplinary scientific instrument that will significantly advance our knowledge of the Universe and our place within it. By delivering an order of magnitude improvement in both sensitivity and angular resolution compared to existing and planned radio facilities at frequencies spanning 1.2 – 116 GHz, the ngVLA will open extensive new discovery space through ultra-sensitive imaging of thermal line and continuum emission down to milliarcsecond-scale resolutions, as well as deliver unprecedented broad band continuum polarimetric imaging of non-thermal processes. The ngVLA concept is a large-scale research infrastructure project under development for the NSF Astronomy Division. A successful deployment of the ngVLA will continue and advance U.S. world leadership in radio astronomy, and support NSF’s mission to provide leading-edge instrumentation to the global multi-disciplinary scientific community.

Job Postings – Radio Astronomy and Related Fields

Cavendish Astrophysics - Electromagnetic design and metrology

http://www.jobs.cam.ac.uk/job/20703/ - Antenna design and electromagnetic modelling
http://www.jobs.cam.ac.uk/job/20700/ - Electromagnetic metrology & antenna characterisation

HIRAX Postdoctoral Fellowships in Radio Astronomy and Instrumentation

The Astrophysics and Cosmology Research Unit (ACRU) at the University of KwaZulu-Natal (UKZN) is offering a postdoctoral research position in the area of radio astronomy and instrumentation. For more information, see https://acru.ukzn.ac.za/hirax-postdoc-jan2019/

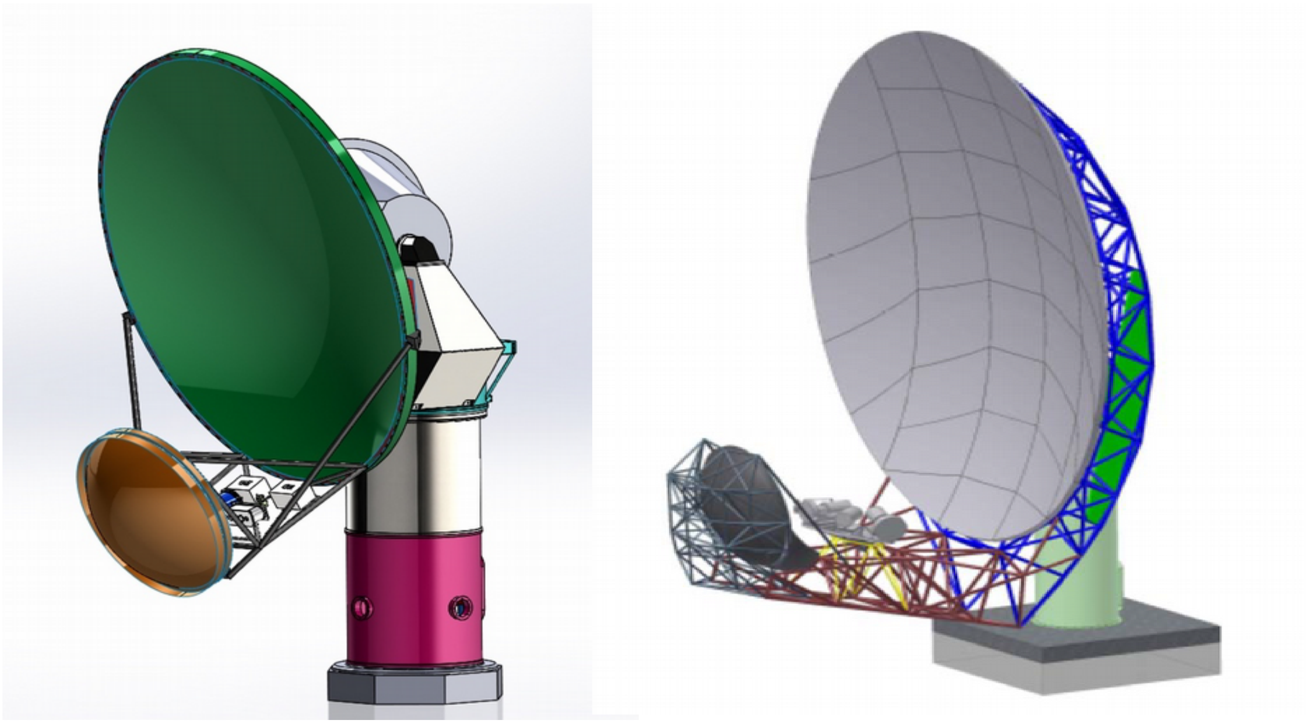
Arizona State University – 3 Positions

Research professional with expertise in radio-frequency engineering:

https://jobregister.aas.org/ad/a67137b8
Postdoc in Radio Instrumentation and/or Signal Processing
https://jobregister.aas.org/ad/6f5685cb
Postdoc in 21cm Data Analysis
https://jobregister.aas.org/ad/e56bb558

If your organization has an opening for a position that may be of interest to Commission J members please send the title, short description, and link for additional information to R. Bradley. Positions will only be posted by request from URSI members.

Photo from the Field



ngVLA conceptual antenna designs. National Research Council 6-m design (left), General Dynamics 18-m concept (right).

Submitted by A. Beasley

If you have an interesting photograph that you wouldn't mind sharing with others in the public domain I encourage you to send a copy to me along with a brief caption and the person's name or organization to whom I should credit.

Stimulating and co-ordinating, on an international basis, studies, research, applications, scientific exchange, and communication in the fields of radio science