Karl G. Jansky Very Large Array

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The (Jansky) VLA

- 27x25m antennas (Y-shape) reconfigurable on baselines 35m to 36km
- located in New Mexico at 2100m altitude
- Construction from 1973-1980, upgrade 2003-2012.

Spatial Resolution

- With reconfiguration of the antennas, the array can vary its spatial resolution by a factor of ~40.
- Configuration sequence: D (B_{max}~ 1 km) → C → B → A (B_{max}~ 36 km).
- Reconfiguration about every 4 months.
- The August 1, 2019, proposal deadline is for both the C and B configurations.

Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
Band	**Synthesized Beamwidth θ_{HPBW}**(arcsec)[1,2,3]			
74 MHz (4)	24	80	260	850
350 MHz (P)	5.6	18.5	60	200
1.5 GHz (L)	1.3	4.3	14	46
3.0 GHz (S)	0.65	2.1	7.0	23
6.0 GHz (C)	0.33	1.0	3.5	12
10 GHz (X)	0.20	0.60	2.1	7.2
15 GHz (Ku)	0.13	0.42	1.4	4.6
22 GHz (K)	0.089	0.28	0.95	3.1
33 GHz (Ka)	0.059	0.19	0.63	2.1
45 GHz (Q)	0.043	0.14	0.47	1.5

Largest Angular Scale

- The *shortest* baseline sets the largest angular scale that an interferometer is sensitive to.
- Compact configurations have less spatial resolution but cover larger angular scales.

Field of view (depends on diameter of a single antenna)

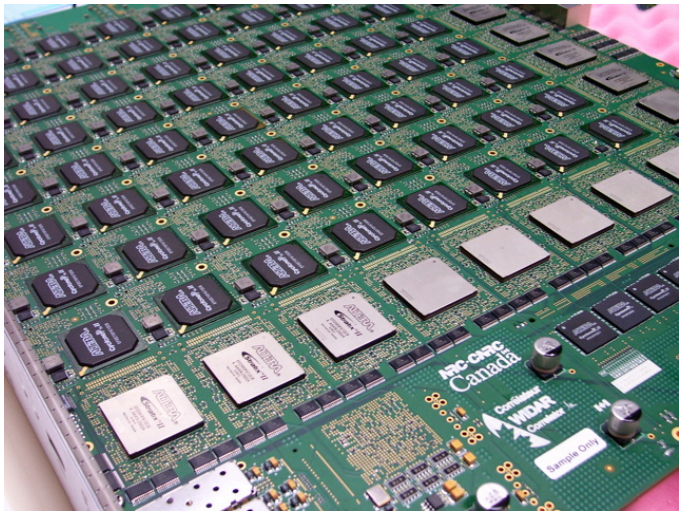
Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
Band	**Largest Angular Scale θ_{LAS}(arcsec)[1,4]**			
608' 74 MHz (4)	800	2200	20000	20000
129' 350 MHz (P)	155	515	4150	4150
30' 1.5 GHz (L)	36	120	970	970
15' 3.0 GHz (S)	18	58	490	490
7.5' 6.0 GHz (C)	8.9	29	240	240
5.3' 10 GHz (X)	5.3	17	145	145
3' 15 GHz (Ku)	3.6	12	97	97
2' 22 GHz (K)	2.4	7.9	66	66
1.4' 33 GHz (Ka)	1.6	5.3	44	44
1' 45 GHz (Q)	1.2	3.9	32	32

The VLA

- Nine Frequency Bands
  - Eight cryogenic bands, covering 1 – 50 GHz. Utilizes cassegrain subreflector.
  - One uncooled, prime-focus band, covering 50 – 450 MHz.
- Up to 8 GHz instantaneous bandwidth
  - All digital design to maximize instrumental stability and repeatability.
    - Two sets of samplers: 8-bit (2 GHz), and 3-bit (8GHz)
- Full polarization correlator with 8 GHz instantaneous BW
  - Provides 64 independent 'sub-correlators', and 16384 spectral channels.
  - Many specialized operations modes (burst, pulsar binning, phased arrays …)

The ‘WIDAR’ Correlator

- The VLA’s correlator was built to NRAO’s requirements by the DRAO correlator group, located at the HIA facility near Penticton, BC.
- This ‘WIDAR=**W**ideband **I**nterferometric **D**igital **AR**chitecture’ correlator was paid for by the Canadian government, as part of a cooperative agreement between NRC and NSF.



Basic Features of the 'WIDAR' Correlator

The correlator's basic features (not all implemented yet):

- **64 independent full-polarization subbands** Each can be tuned to its own frequency, with its own bandwidth (128 MHz to 31.25 kHz) and spectral resolution (from 2 MHz to .12 Hz)
- **100 msec dump times with 16384 channels and full polarization**
  - Faster if spectral resolution, BW, or number of antennas is decreased.
- **Up to 8 sub-arrays**. Maximum to date is three.
- **Phased array capability** with full bandwidth – for pulsar and VLBI applications.
- **Special pulsar modes**: 2 banks of 1000 time bins, and 200 μsec time resolution (all spectral channels), or 15 μsec (64 channels/sp.window).

General Observing (GO)

- Up to 8 GHz bandwidth with 16384 spectral channels – 2 MHz spectral resolution (full pol)
- Any of the 64 subband pairs can be separately tuned, and set to any of 128, 64, 32, 16, … ,0.03125 MHz widths
- Up to 16384 spectral channels (no recirculation), or up to 1048576 (with recirculation)
- Three simultaneous, fully independent subarrays (8-bit continuum)
- Mix 3-bit and 8-bit modes
- P-band (224–480 MHz) Stokes I continuum and spectroscopy
- Solar observing
- On-the Fly mosaicking (P, L, S, and C bands); subject to data rate limits

Shared Risk Observing (SRO)

Access to extra capabilities that have not been as well tested as GO capabilities. These currently are:

- On-the Fly mosaicking (X through Q-bands)
- P-band (230-470 MHz) polarimetry
- YUPPI (phased array pulsar observing mode)

Stay tuned for the formal Call For Proposals for the details and the final list.

Resident Shared Risk Observing (RSRO)

Access to extended capabilities that require more testing

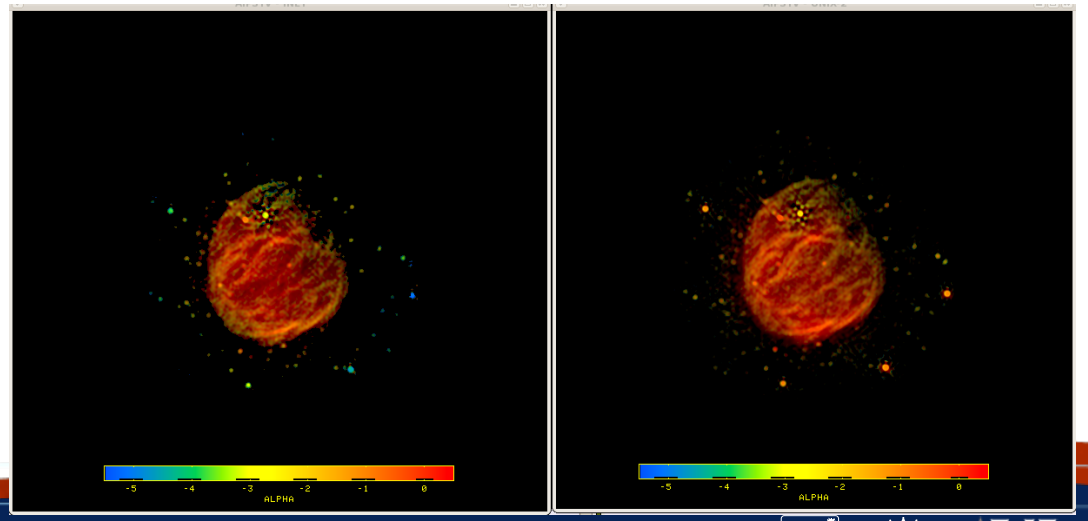
– In exchange for a period of residence

- Correlator dump times < 50 msec (Including as short as 5 msec for transients)
- Data rates above 60 MB/s
- Recirculation beyond a factor of 64
- 4-band (58-84 MHz)
- More than 3 subarrays with the 8-bit samplers
- Subarrays with the 3-bit samplers

Post processing

- Data reduction software: CASA
  - Handles complex observing set-ups
  - Task interface to suite of C++-based reduction tools
  - Python interface provides access to data for manipulation
  - Effective platform for algorithm development (e.g., handling effect of wide fractional bandwidths, $\Delta\nu/\nu$)

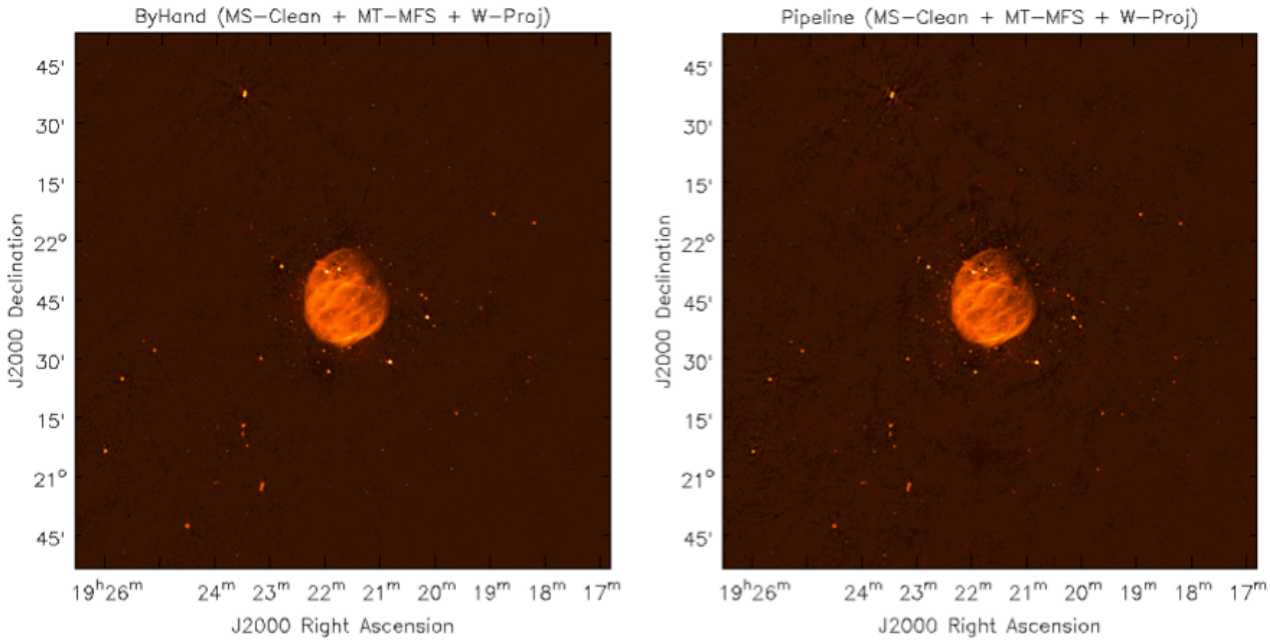
Spectral index of 1–2 GHz emission from SNR G55.7+3.4, before correction for the frequency-dependence of the primary beam (left), and after correction (right)



VLA Calibration Pipeline

- Designed for Stokes I continuum.
- Work is in progress to support spectral line and polarization.

The supernova remnant G55.7+3.4



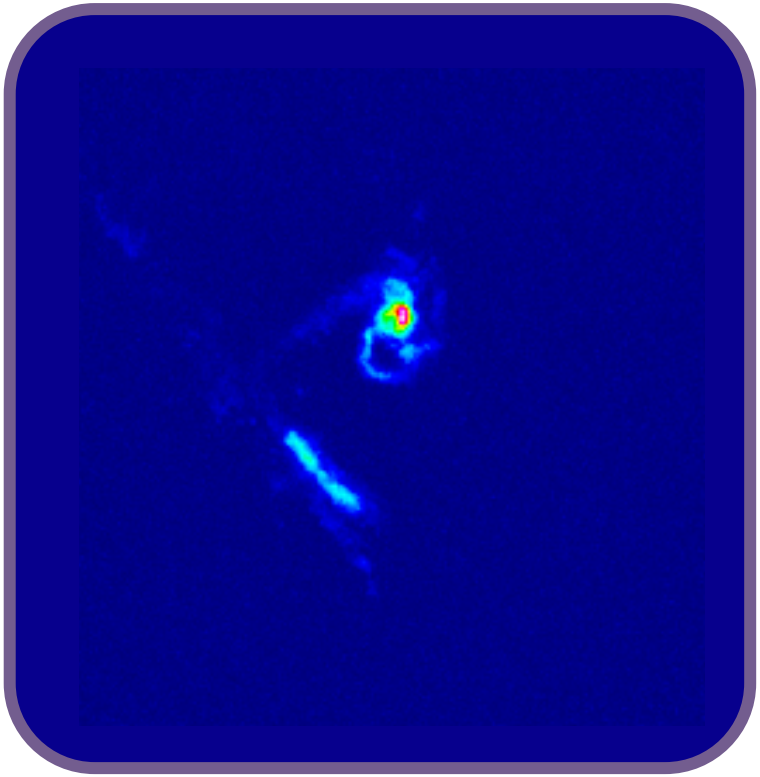
hand-flagged and calibrated

pipeline-calibrated

RMS is within 10%

NRAO's SRDP Initiative

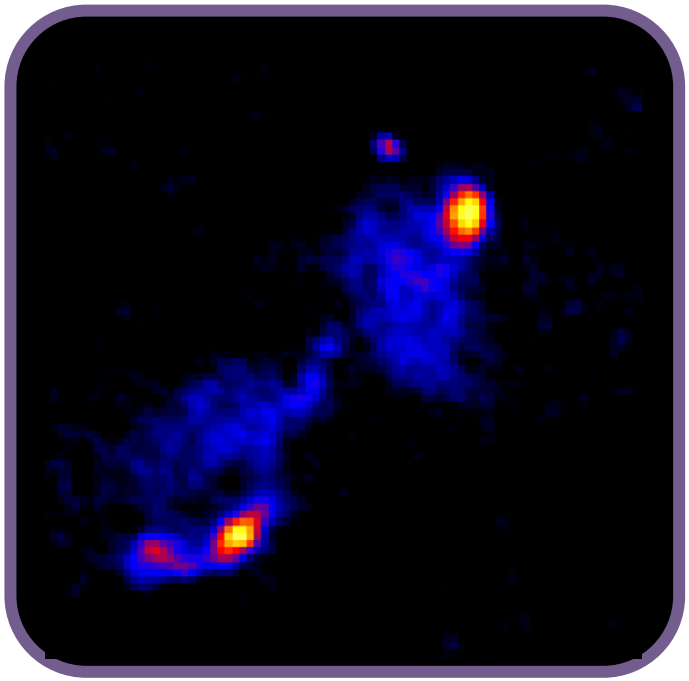
- The SRDP project will increase the scientific impact of NRAO's telescopes by:
  - Providing the expertise required to perform data processing, so users may focus on their science
  - Broadening the radio astronomy user community by decreasing the barriers to using radio interferometers
  - Curating a rich collection of images and cubes for archival study



- Now underway, the SRDP project will be delivering increasing levels of products and services over the next five years.

SRDP Services

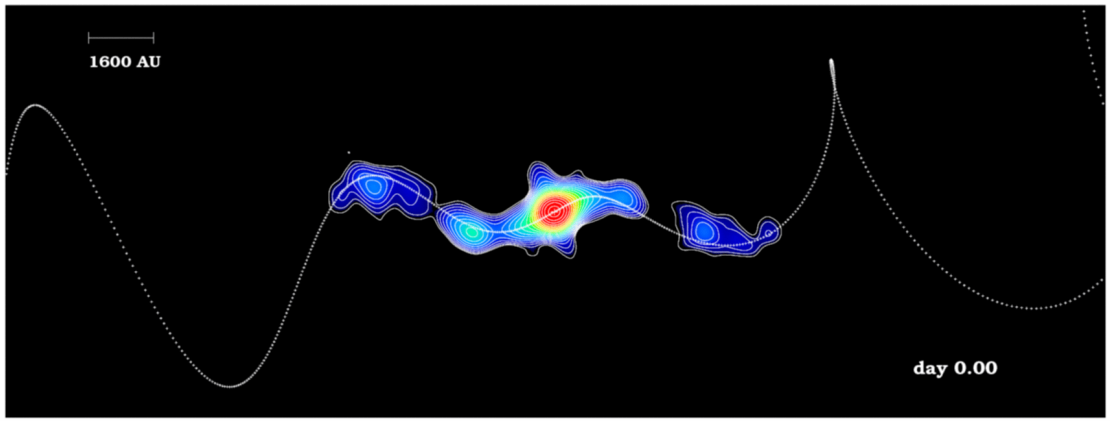
- SRDP will deliver science quality calibrated data and images for all of NRAOs telescopes.
  - Improving quality of ALMA products.
  - Developing the same capabilities for the VLA (and eventually the VLBA)
- Explore images and spectra online.
  - Search a rich archive of quality assured images and cubes
  - Customizable product downloads



- Download calibrated Measurement Sets.
- Trigger generation of images and cubes tailored for your science through the Archive

Important Links

- NRAO Help Desk
  go.nrao.edu/obshelp
- VLA Observational Status Summary
  go.nrao.edu/vla-oss
- VLA Exposure Calculator
  go.nrao.edu/ect
- Proposal Submission Tool
  my.nrao.edu
- CASA– data reduction software
  http://casa.nrao.edu/
- VLA Calibration Pipeline
  go.nrao.edu/vla-pipe



The X-ray binary SS433 at 26 GHz (0.095”; 520 AU resolution)
Credit: Miodusweski & Miller-Jones, EVLA demo science