



# Karl G. Jansky Very Large Array

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# The Karl G. Jansky VLA

- 27x25m antennas (Y-shape) reconfigurable on baselines 35m to 36km
- Located in New Mexico at 2100m altitude
- Original construction 1973-1980, upgrade 2003-2012 to Jansky VLA





# Spatial Resolution

- With reconfiguration of the antennas, the array can vary its spatial resolution by a factor of  $\sim 40$ .
- Configuration sequence: D ( $B_{\max} \sim 1$  km)  $\rightarrow$  C  $\rightarrow$  B  $\rightarrow$  A ( $B_{\max} \sim 36$  km).
- Reconfiguration about every 4 months.
- Proposal deadlines every 6 months:  
1<sup>st</sup> February and 1<sup>st</sup> August
- 1 Feb 2019 proposal deadline is for D configuration.

Configuration	A	B	C	D
$B_{\max}$ (km <sup>1</sup> )	36.4	11.1	3.4	1.03
$B_{\min}$ (km <sup>1</sup> )	0.68	0.21	0.035 <sup>5</sup>	0.035
<b>Band</b>	<b>Synthesized Beamwidth <math>\theta_{\text{HPBW}}</math>(arcsec)<sup>1,2,3</sup></b>			
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 <sup>1</sup> )	36.4	11.1	3.4	1.03	
$B_{\min}$ (km <sup>1</sup> )	0.68	0.21	0.035 <sup>5</sup>	0.035	
<b>Band</b>	<b>Largest Angular Scale <math>\theta_{\text{LAS}}</math>(arcsec)<sup>1,4</sup></b>				
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





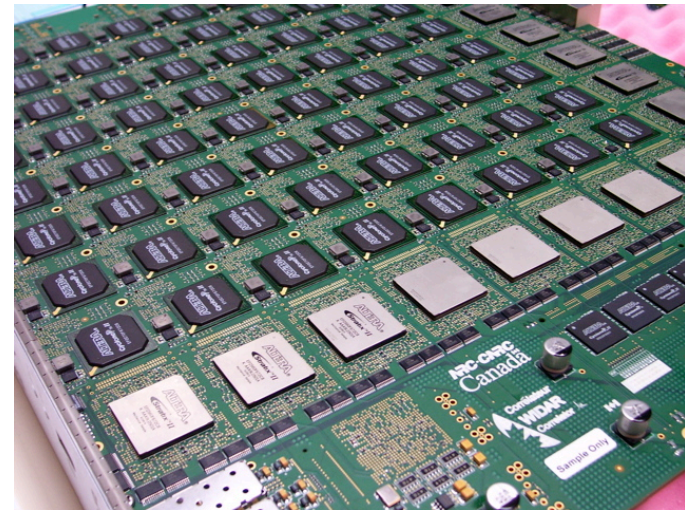
# The VLA

- **Nine Frequency Bands**
  - Eight cryogenic bands, covering 1 – 50 GHz, Cassegrain subreflector.
  - One uncooled, prime-focus band, covering 50 – 450 MHz.
- **Up to 8 GHz instantaneous bandwidth**
  - All-digital design maximizes 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 modes (pulsar binning, phased array, subarrays...)



# 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 Interferometric **D**igital **A**Rchitecture' 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 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  $\mu$ sec time resolution (all spectral channels), or 15  $\mu$ sec (64 channels/spw).



# 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)
- Up to 32 subbands per baseband with the 8-bit samplers
- Frequency averaging in the correlator (up to factor of 4):  
C through Q bands for 3-bit wide-band continuum science projects
- Pulsar observations: phase binned imaging

# Resident Shared Risk Observing (RSRO)

Access to extended capabilities that require more testing

– In exchange for a period of residence

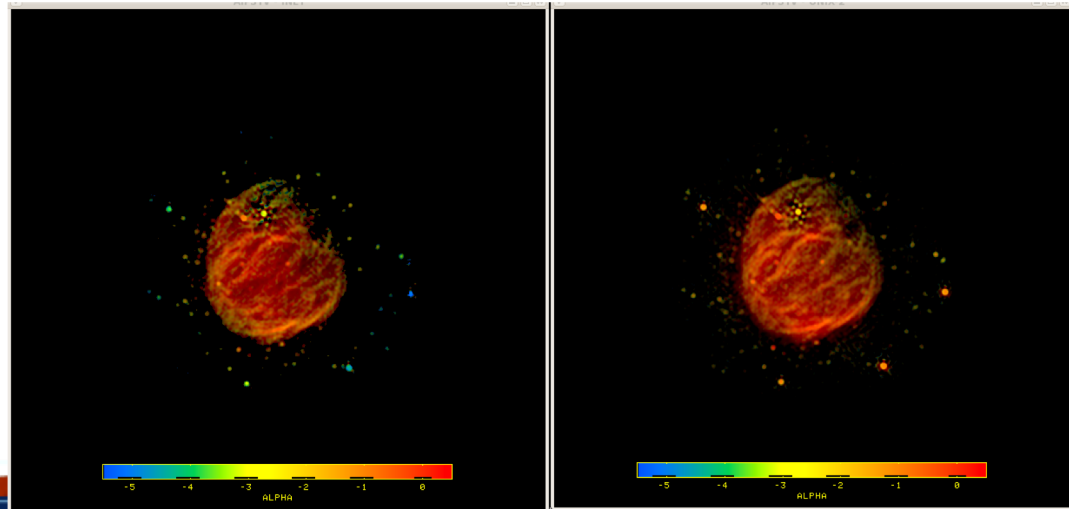
- Correlator dump times < 50 msec (Including as short as 5 msec for transients)
- Pulsar observations: phased array (YUPPI)
- Data rates above 60 MB/s
- Recirculation beyond a factor of 64
- P-band (230-470 MHz) polarimetry
- 4-band (58-84 MHz)
- More than 3 subarrays with the 8-bit samplers
- Subarrays 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,  $\Delta\nu/\nu$ )

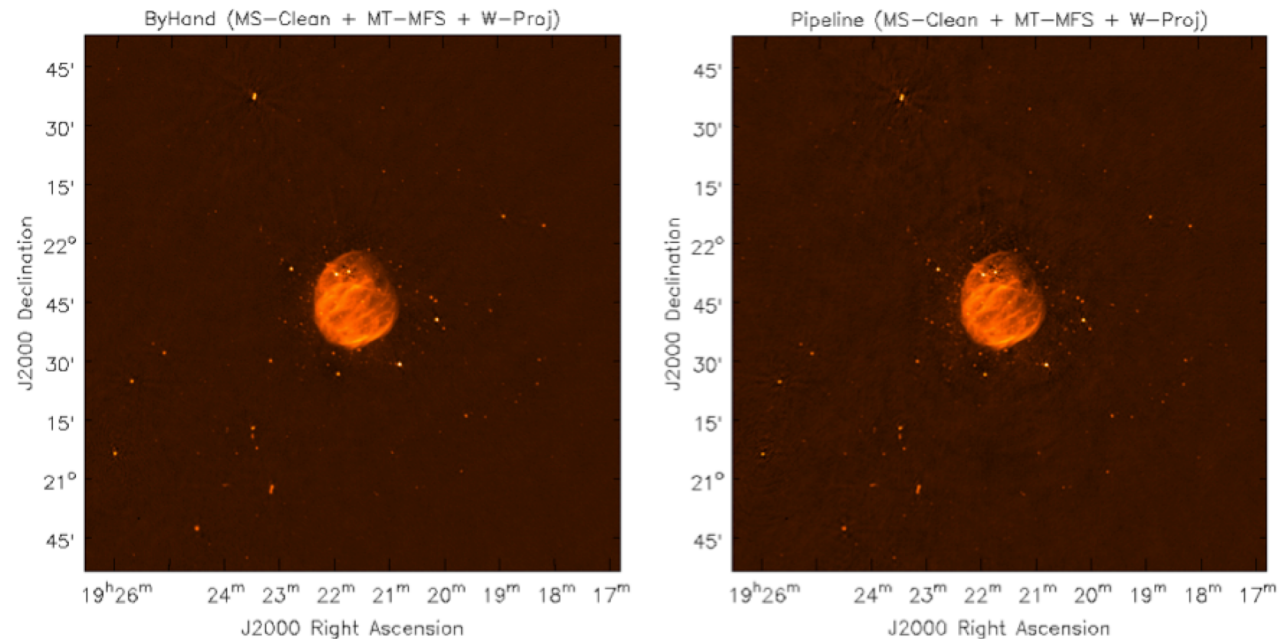
Spectral index of 1–2 GHz emission from SNR G55.7+3.4, before correction for the frequency-dependence of the primary beam (left), and after correction (right)



# 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



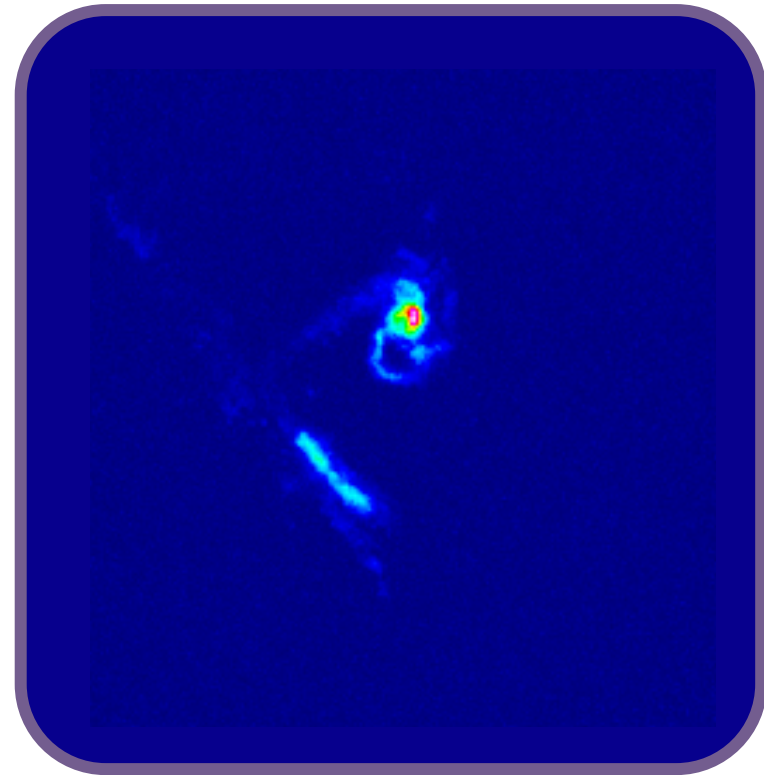
hand-flagged and calibrated

pipeline-calibrated

RMS is within 10%

# NRAO's SRDP Initiative

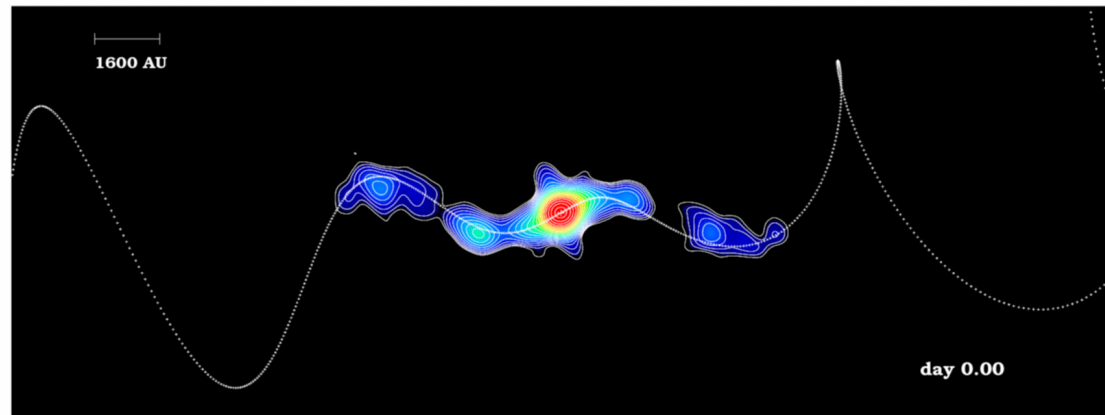
- “Science-Ready Data Products”:
  - Provide expertise required for radio data processing, so users may focus on their science
  - Make radio astronomy accessible to broader astronomy community by lowering barrier to use radio instruments
  - Curate a rich collection of images and cubes for archival study
  - For all NRAO's instruments (eventually)
- Now underway, the SRDP project will begin to deliver increasing levels of products and services over the next five years.





# Important Links

- NRAO Help Desk  
[go.nrao.edu/obs-help](http://go.nrao.edu/obs-help)
- VLA Observational Status Summary  
[go.nrao.edu/vla-oss](http://go.nrao.edu/vla-oss)
- VLA Exposure Calculator  
[go.nrao.edu/ect](http://go.nrao.edu/ect)
- Proposal Submission Tool  
[my.nrao.edu](http://my.nrao.edu)
- CASA– data reduction software  
<http://casa.nrao.edu/>
- VLA Calibration Pipeline  
[go.nrao.edu/vla-pipe](http://go.nrao.edu/vla-pipe)



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