Karl G. Jansky Very Large Array (VLA)

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VLA interferometer

Located in New Mexico, on the San Agustin Plains,
at 6970 ft (2120m) altitude.

→ 28 antennas: 27 observing at any time, 1 for maintenance
→ arranged in Y-shape
→ each antenna of 25m diameter
→ 4 configurations allowing for
range of angular resolutions
→ observing north of –40°

Originally constructed in 1973-1980,
upgraded in 2003-2012

Angular resolution

Depends on frequency (0.074-45 GHz) and VLA configuration

Configurations: **A** (largest) ← **B** ← **C** ← **D** (smallest)

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

14 arcmin

43 mas

Angular resolution

Depends on frequency (0.074-45 GHz) and VLA configuration

Configurations: **A** (largest) ← **B** ← **C** ← **D** (smallest)

Reconfiguration:

approx. every 4 months

Call for proposals:

2x year – 1st Feb & 1st Aug

Next proposal deadline in August for **C** and **B** configurations (2020A)

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Largest angular scale (LAS) & Field of View (FoV)

LAS: Depends on frequency and VLA configuration

LAS is the largest angular scale the interferometer is sensitive to. Source features more extended than that will be "*resolved out*".

FoV: Depends on frequency and individual antenna size

This will be more than LAS, FoV is the amount of sky the antennas "see" with a single pointing (→ primary beam)

Largest angular scale (LAS) & Field of View (FoV)

LAS: Depends on frequency and VLA configuration

FoV: Depends on frequency and antenna size

approx. formulas:

$$\theta_{PB} = 50/\nu_{GHz}$$

$$\theta_{PB} = 42/\nu_{GHz}$$

$$\Theta = f \frac{\lambda}{D_{ant}}$$

11.3 deg

28 arcmin

4.2 arcmin

56 arcsec

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]**			
74 MHz (4)	800	2200	20000	20000
350 MHz (P)	155	515	4150	4150
1.5 GHz (L)	36	120	970	970
3.0 GHz (S)	18	58	490	490
6.0 GHz (C)	8.9	29	240	240
10 GHz (X)	5.3	17	145	145
15 GHz (Ku)	3.6	12	97	97
22 GHz (K)	2.4	7.9	66	66
33 GHz (Ka)	1.6	5.3	44	44
45 GHz (Q)	1.2	3.9	32	32

5.5 deg

1.2 arcsec

Frequency specifications

Ten frequency bands from 50 MHz to 50 GHz

- 8 cryogenic bands, with Cassegrain subreflector, covering 1–50 GHz (L to Q bands)
- 2 uncooled, prime-focus bands, covering 50–450 MHz (4 and P bands)

VlA can observe up to 8 GHz instantaneous bandwidth (wide-band)

- Two set of samplers: 8-bit ($\Delta\nu$=2 GHz) and 3-bit ($\Delta\nu$=8 GHz)

& in full polarisation (circular and linear depending on band).

Observing modes

- Continuum (Stokes I)
- Polarimetry (Stokes Q,U,V)
- Spectral lines
- Sub-arrays [each sub-array can perform completely independent observing program simultaneously]
- Mosaicking [multiple pointings and phase centres]
- On-the-fly mapping (OTF) [“scanning mode”]
- Solar system objects
- Using VLA as a VLBI station
- Pulsar observing

WIDAR Correlator

WIDAR=Wideband **I**nterferometric **D**igital **AR**chitecture

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 0.5 kHz)
- **100 msec dump times** with up to 16,384 channels and full polarization (faster if spectral resolution, bandwidth, or number of antennas is decreased)
- **Up to 8 sub-arrays**. Maximum implemented to date is 3.
- **Phased array** capability with full bandwidth (pulsar and VLBI)
- **Special pulsar modes:** 2 banks of 1000 time bins, and 200 μsec time resolution (all spectral channels), or 15 μsec (64 channels/spw).

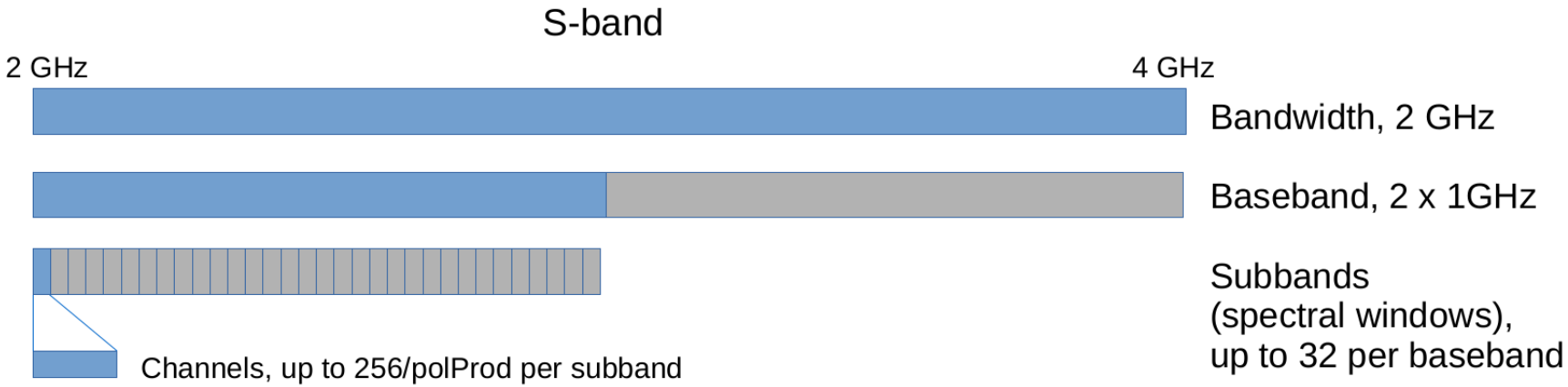
General Observing (GO)

Standard observing set ups available to anyone:

- up to 8GHz bandwidth (depending on band)
- 3-bit and 8-bit modes, can use combination of these
- up to 3 sub-arrays in 8-bit mode

- spectral set-up:
  - 1 or 2 GHz basebands (can have independent set-ups)
  - 1 baseband can be made of up to 32 independently tunable subbands
  - subband (spectral window) widths: max 128 MHz, min 31.25 kHz
  - single Baseline Board Pair (BIBP; one per subband is default)
    can handle 256 spectral points divided over polarisation products, i.e.:
    - 256 spectral channels in single polarisation
    - 128 spectral channels in dual
    - 64 spectral channels in full

General Observing (GO) – cont.



This gives up to 16,384 spectral channels.

If more is needed, there are options: (1) recirculation, (2) baseline board stacking, or using (1) and (2) simultaneously

Observing modes in GO: continuum, polarisation, spectroscopy, solar observing, OTF mosaicking (P,L,S,C bands), P band continuum and spectrocopy, 3 simultaneous subarrays, mix of 3-bit and 8-bit modes

Shared Risk Observing (SRO)

Allows access to extra capabilities that have not been as well tested as GO capabilities.

As of present these are:

- OTF in bands between X to Q
- Phased array mode for pulsar observing (YUPPI)
- P band polarimetry

Resident Shared Risk Observing (RSRO)

Access to even more extended capabilities that are currently being tested and commissioned

- In exchange for period of residency at NRAO to help the testing

As of present these are:

- Correlator dump times <50msec (incl. 5msec for transients)
- Data rates >60 MB/s
- Recirculation beyond factor of 64
- 4 band (58-84 MHz)
- More than 3 sub-arrays in 8-bit sampling mode
- Subarrays in 3-bit sampling mode

Post observations: software

NRAO data reduction software, CASA

https://casa.nrao.edu/

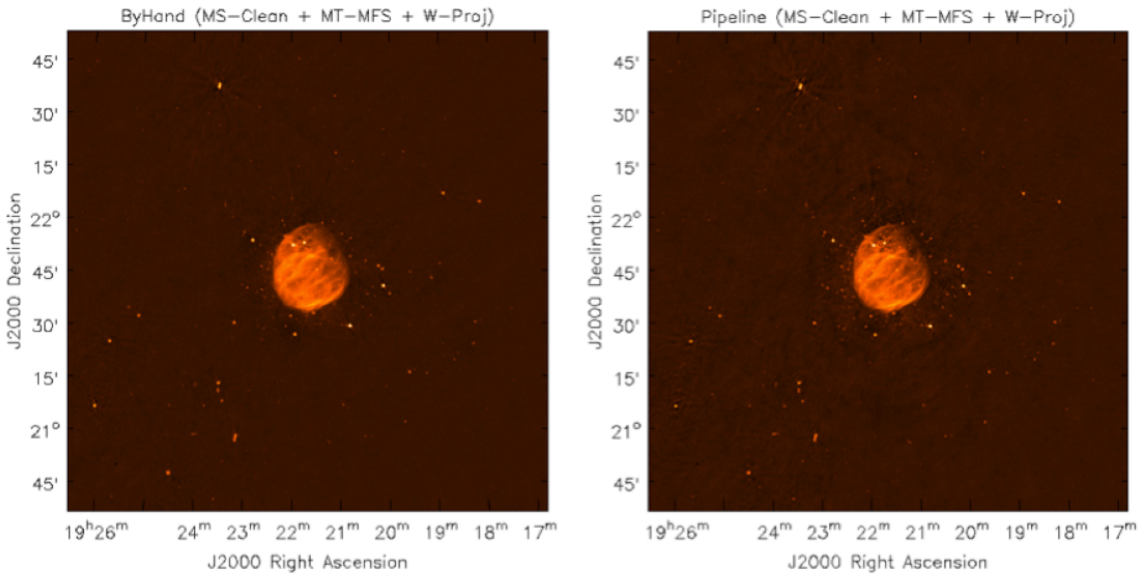
- Designed to handle wide-band upgraded-VLA and ALMA data
- Based on C++ reduction tools, with iPython interface for easy data manipulation
- Latest version: v5.4.1

We will learn basic CASA during these Community Days.

Developed by international consortium composed of:

VLA calibration pipeline

- Currently designed for continuum (Stokes I)
- Work in progress to support polarimetry and spectral lines, and improve RFI flagging
- Calibration only (imaging not supported yet)
- Latest version of CASA including pipeline: v5.4.1



hand-flagged and calibrated

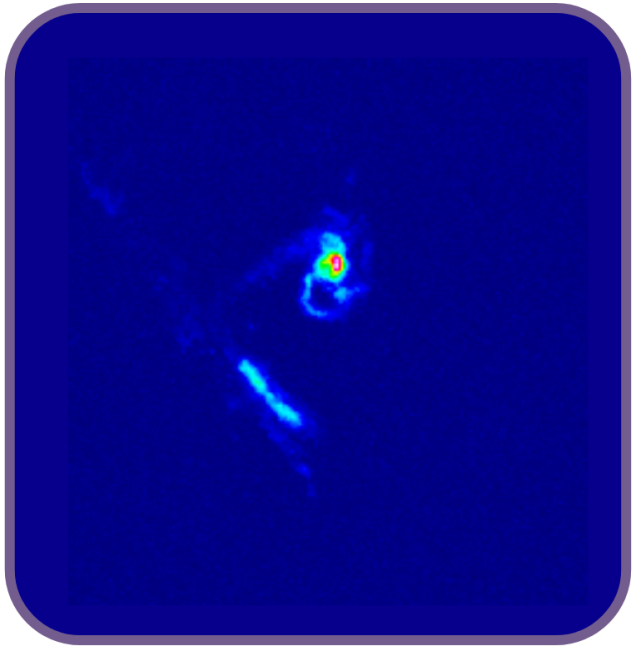
pipeline-calibrated

RMS is within 10%

Future: Science Ready Data Products (SRDP)

Science-Ready Data Products:

- Provide calibrated and imaged PI observations
- Provide expertise required for radio data processing, so users may focus on their science
- Make radio astronomy accessible to broader astronomy community
- Curate a rich collection of images and cubes for archival study
- Ultimately for all NRAO's instruments



- Now underway, the SRDP project will begin to deliver increasing levels of products and services over the next five years.

Useful 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: casa.nrao.edu/
- VLA Calibration Pipeline: go.nrao.edu/vla-pipe

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