VLA Commensal Observing & ngVLA

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VLA Commensal Observing Systems

- **VLITE**
- *realfast*
- **COSMIC**

Commensal systems on the VLA may be backends or data pipelines which have been approved to run on NRAO telescopes while some PI science experiments are running.

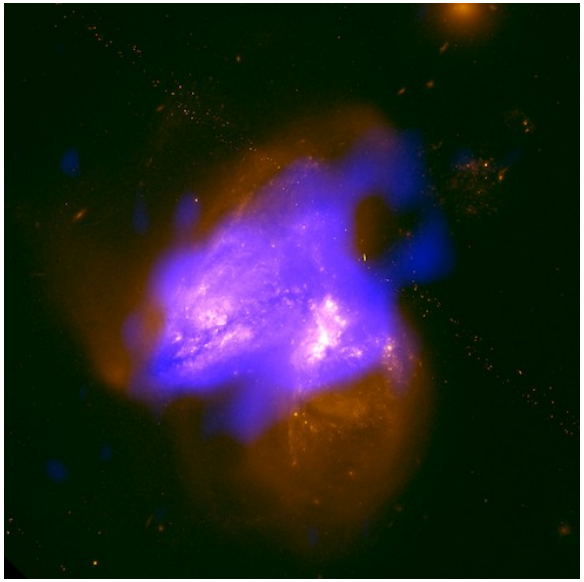
The peer-reviewed, open-skies PI science projects approved via community and Observatory review processes are protected, and that ownership of data is defined – commensal systems are here restricted.

VLITE

VLA Low Band Ionospheric & Transient Experiment

Commensal system capable of continuously accessing 64 MHz from the new **236-492 MHz** Low Band system deployed on the VLA.

Collaboration between U.S. **Naval Research Laboratory (NRL) and NRAO**, first fringes in July 2014, and regularly in use since (but not when P-band PI observing!).



Technical aspects:

– VLITE backend includes dedicated samplers, fiber optics, and a DiFX-based real-time software correlator

– currently 16 VLA antennas equipped in VLITE commensal systems

VLITE

VLA Low Band Ionospheric & Transient Experiment

Modifications & expansion:

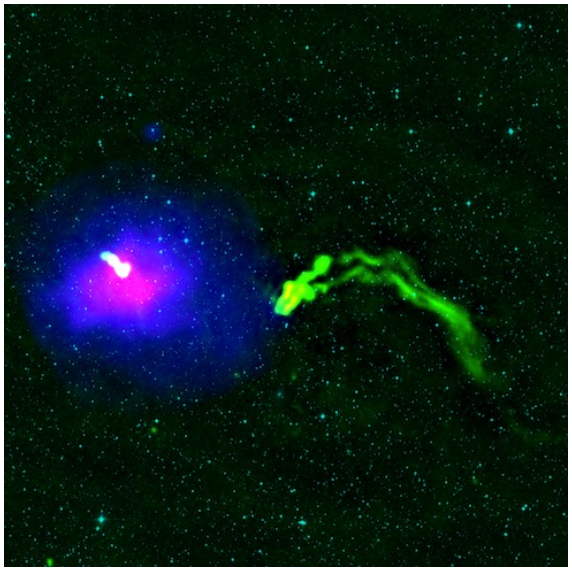
– since 2016 VLITE on-the-fly (OTF) mapping supported to observe along VLASS,

– since 2017 16 VLA antennas equipped in VLITE

– development of a fast-transient GPU-based processing system

VLITE 10 Antenna Specification

Config.	FoV	θ	σ (10 min)
B+	4°	12"	4.2 mJy
B	4°	15"	6.3 mJy
C	6°	40"	12.0 mJy



VLITE

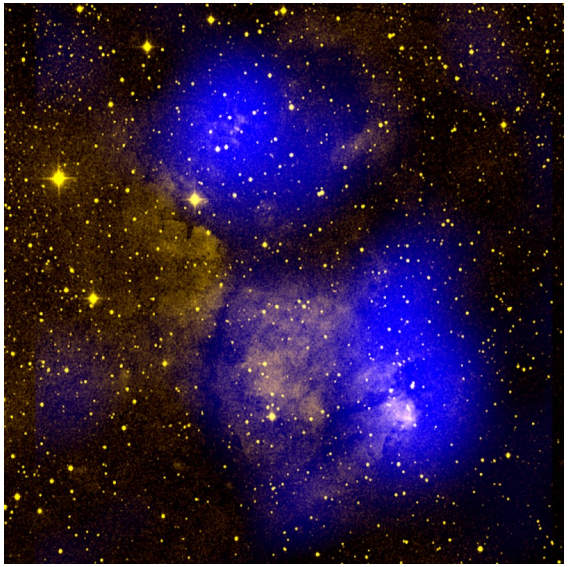
VLA Low Band Ionospheric & Transient Experiment

VLITE data are proprietary, but VLITE raw data and calibration products are archived at NRL and distributed to the community upon request.

General enquires: **Namir Kassim (NRL)**

VLITE Project Scientist: **Tracy Clarke (NRL)**

Website: https://vlite.nrao.edu/index.shtml



realfast

Commensal observing system that searches VLA data for millisecond-timescale dispersed transient signals in real-time (since 2019).

How it works:

→ Typical VLA time resolution: several seconds.

→ WIDAR correlator integrates visibility data in time in two places: initial in the correlator FPGA hardware, and additional in the correlator backend (CBE) computer cluster.

→ *realfast* system gets a copy of the fast-sampled (5-20 ms) visibility data stream from the CBE.

realfast data stream is sent to a dedicated compute cluster with 160 graphical processing units (GPUs) running custom data processing code.

Fully public data with no proprietary period

COSMIC

Commensal Open-Source Multimode Interferometer Cluster

Commenal SETI on the VLA

Newest addition to the commensal observing systems → development stage.

Lead: SETI Institute

Contributors: NRAO

COSMIC will commensally search ~all VLA science observations for drifting narrowband signals potentially indicative of advanced technology.

Science goals:

– Form up to 64 beams within FoV to target nearby stars.

– Process each beam to search for very narrow-band (~Hz) signals, drifting up to ~tens of Hz/sec.

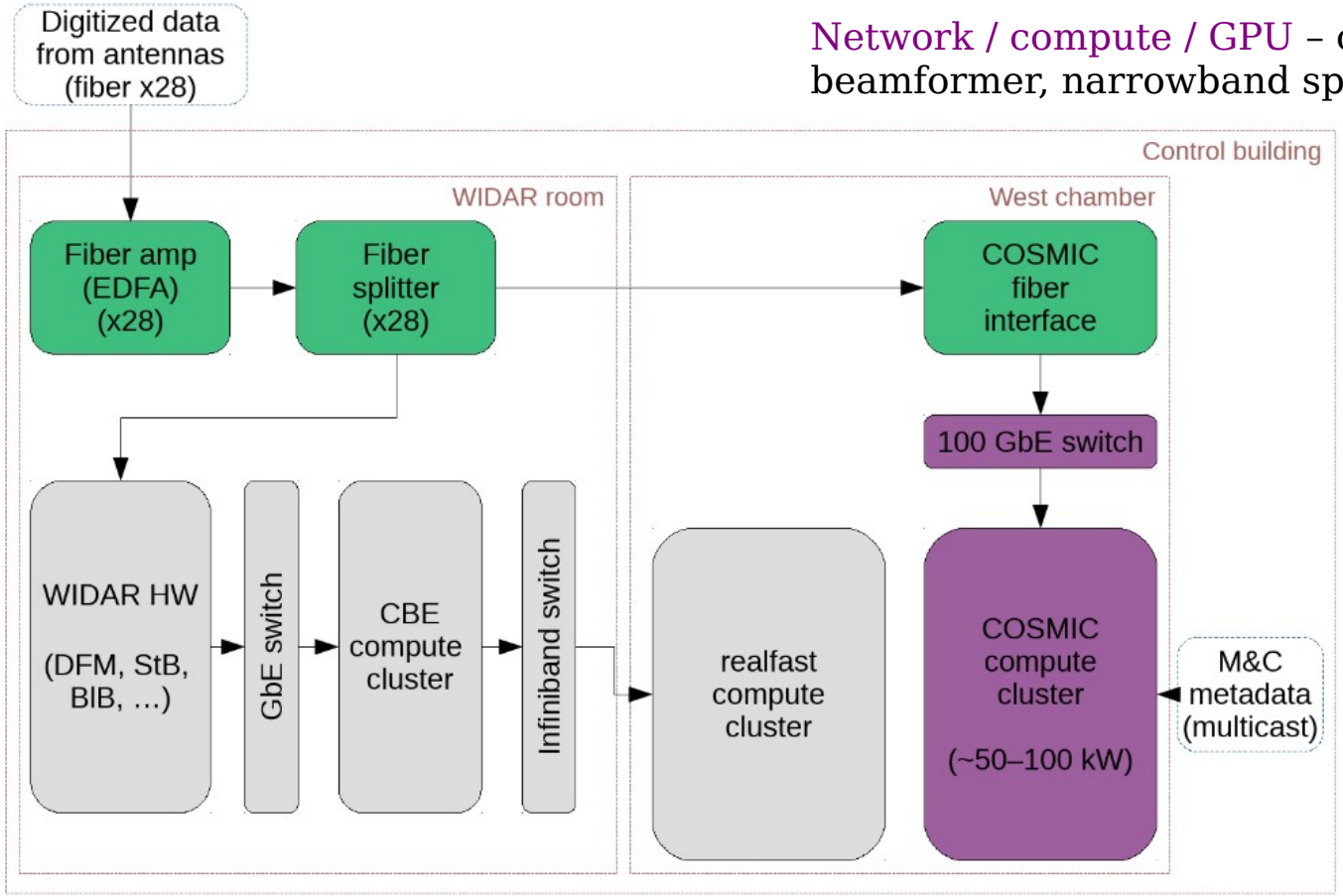
Current status:

→ transitioning from commissioning/testing to early science operation

COSMIC in the VLA context

Fiber / DTS / F-engine – splits 1-GHz band into 1-MHz channels, Ethernet packetize

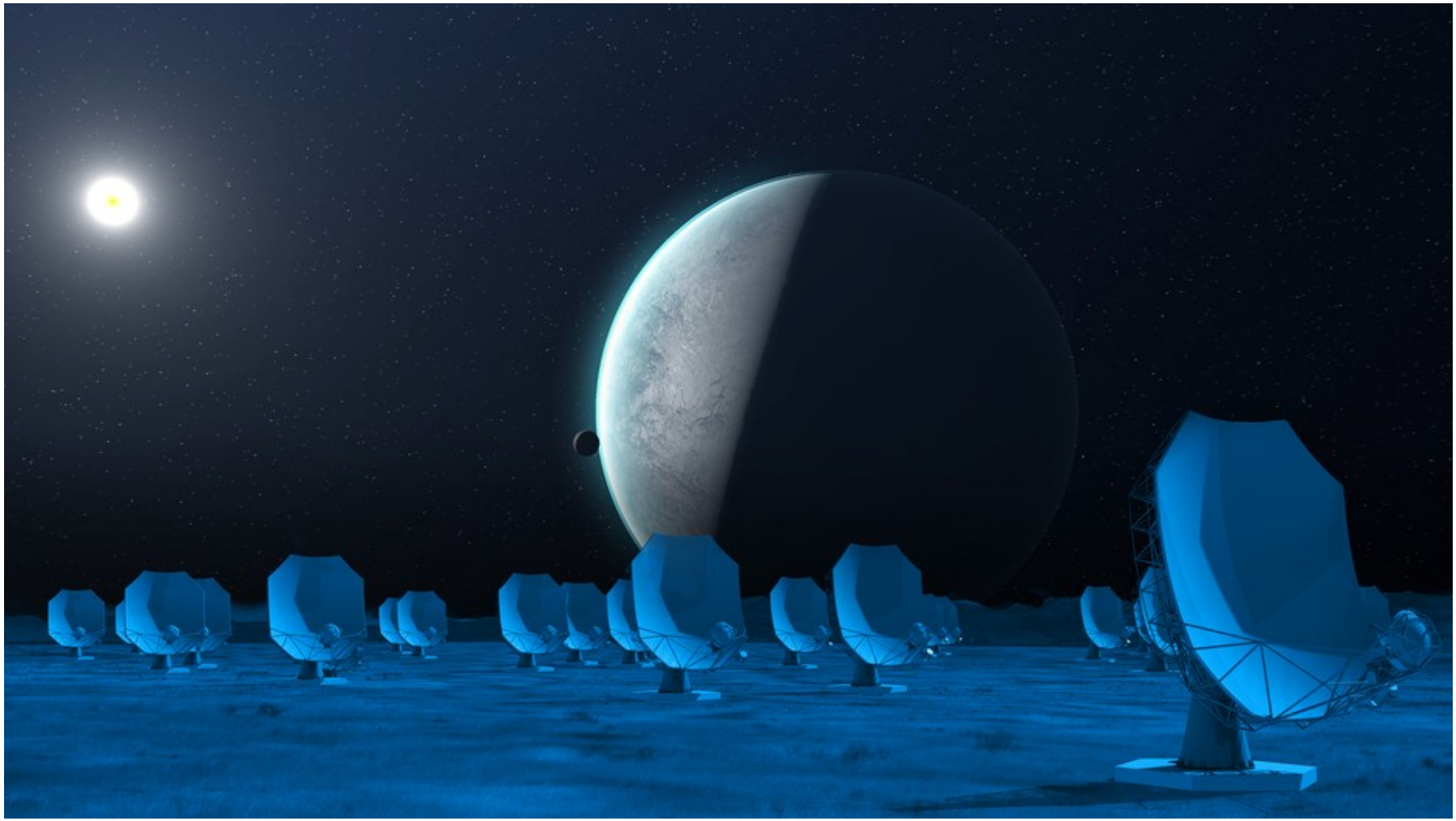
Network / compute / GPU – correlator, beamformer, narrowband spectral processing



Slide courtesy of Paul Demorest

The next generation VLA (ngVLA)

Slides contribution: Bryan Butler (NRAO) and ngVLA lead team



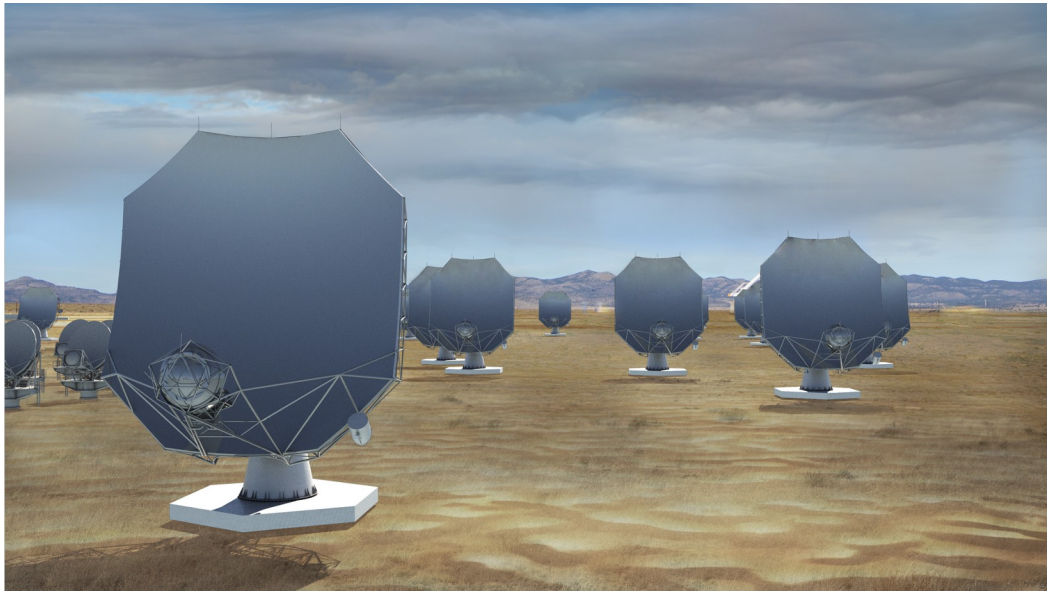
The next generation VLA (ngVLA)

The ngVLA will be a new facility to replace the VLA and VLBA, to tackle a new scientific frontier: thermal imaging at milliarcsecond scales.

The ngVLA concept:

- 10x sensitivity of VLA/ALMA
- >10x resolution of VLA/ALMA
- Frequency: 1.2-116 GHz
- Antennas (offset Gregorian):
  - 244 x 18m, and
  - 19 x 6m

- Centered at the VLA site and concentrated in the southwest US, with fixed antenna locations across North America



ngVLA Science Goals

The ngVLA has **five Key Science Goals** (KSGs), determined by a massive amount of input from the scientific community (→ ngVLA memo #19):

1. Unveiling the **Formation of Solar System Analogues** on Terrestrial Scales
2. Probing the Initial Conditions for **Planetary Systems and Life** with Astrochemistry
3. Charting the Assembly, Structure, and Evolution of **Galaxies Over Cosmic Time**
4. Using Pulsars in the Galactic Center as **Fundamental Tests of Gravity**
5. Understanding the Formation and Evolution of Stellar and Supermassive Black Holes in the Era of **Multi-Messenger Astronomy**

… and many more “use cases” from community → 2018 ngVLA Science Book

ngVLA Science Goals

NRAO has been proactive in engaging the scientific and technical community, both in the US and internationally:

→ **Science Advisory Council**: 30 members of the community who advise NRAO/ngVLA on issues that may impact science;

→ **Technical Advisory Council**: 8 members of the community who advise NRAO/ngVLA on issues that are important technically;

→ **International input** requested when needed from various entities;

→ **"Community Studies"** – one year (funded) studies in a particular area important to the ngVLA;
52 have been supported since 2016.

… and upcoming joint meeting with SKA in Vancouver, CA

Meeting website – Dates: 1 – 5 May 2023

ngVLA Technical

Documentation: 3-volume description of an ngVLA “reference design”.

Important high-level points are:

- 1.2-116 GHz frequency coverage
- Continuum sensitivity ~0.1 uJy/bm @ 1cm in 10 hr
  (10 mas → T_b ~ 1.8 K)

- A “**Main Array**”: 214 x 18m Offset Gregorian (OG) antennas
- A “**Short Baseline Array**”: 19 x 6m OG antennas
- A “**Long Baseline Array**”: 30 x 18m OG antennas
  (many at current VLBA station locations)

ngVLA Configuration

Currently on “Revision D” of the configuration design (led by Chris Carilli).

Main Array → 214 X 18m antennas, subdivided into 3 sub-components:

- “Core” – 114 antennas; baselines 38-4269 m
- “Spiral” – 54 antennas on 5 spiral arms on Plains of San Agustin; baselines 0.8-39 km
- “Mid” – 46 antennas roughly continuing the 5 spiral arms of “Spiral”; baselines 17-1068 km

Short Baseline Array → 19 X 6m antennas

- near the “Core” sub-component.

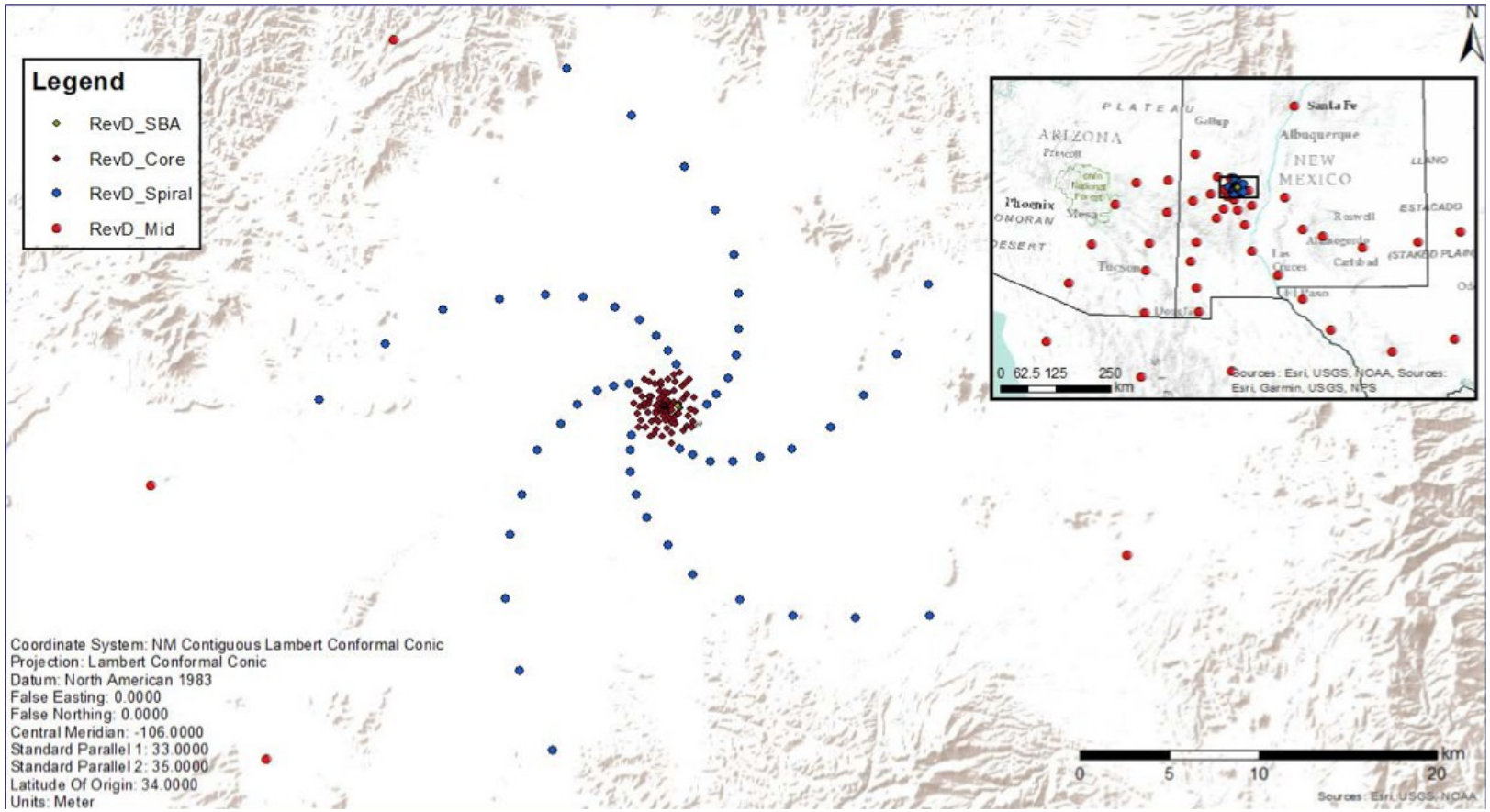
Long Baseline Array → 30 X 18m antennas

- 3 antennas per location
- mostly at current VLBA stations

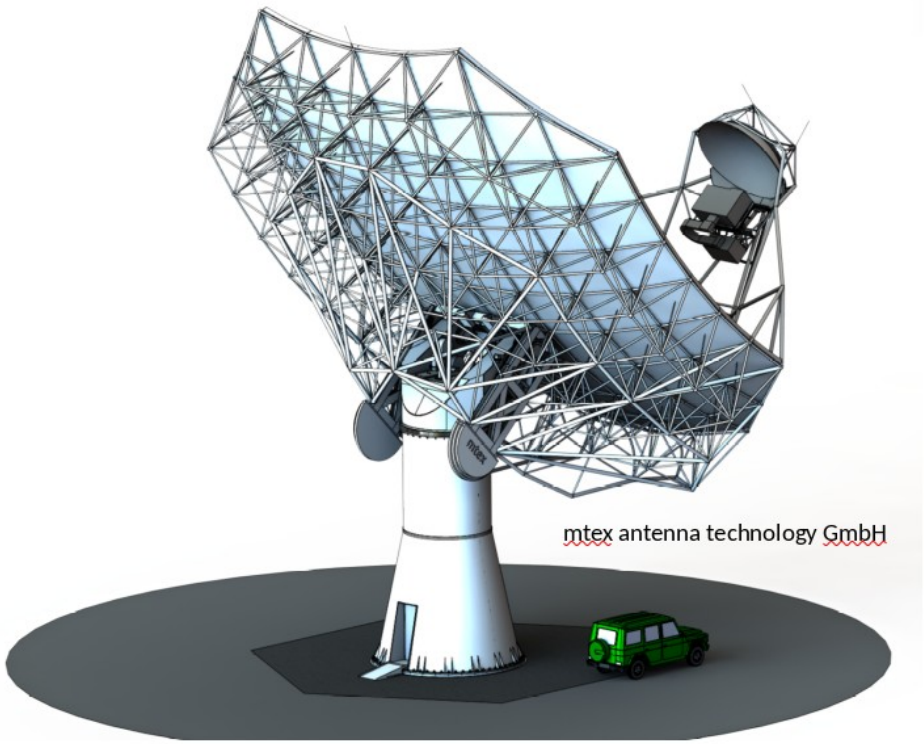
Decision was made early on to center the array near the existing VLA site, for many of the reasons that the VLA was originally chosen to be there, plus now existing infrastructure there.

ngVLA Configuration

Core, Spiral, and Mid Sub-components:



ngVLA Antennas

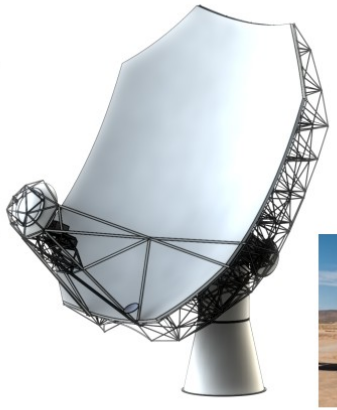


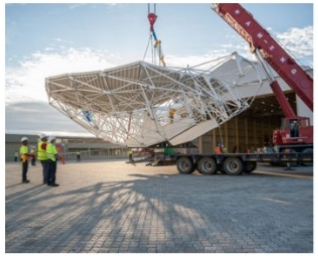
- **Feed Low**: Maintenance requirements favor a receiver feed arm on the low side of the reflector.
- **Mount concept**: Choice of a pedestal concept for life-cycle cost.
- **Drives:** Choice of motor-gearbox for both axes of motion.
- **Materials:** Cast and post-machined Al panels with steel BUS, composite sub-reflector and mostly carbon fiber feed arm.
- **Mtex antenna technology GmbH** (in Wiesbaden) chosen as antenna contractor; NSF approved $23M for prototype antenna to be delivered in 2023.

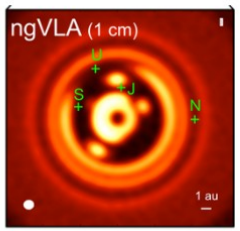
ngVLA (likely) Timeline & Next Steps

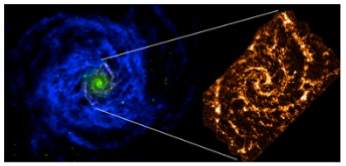
→ Project Technical Conceptual Design Review completed in summer 2022
→ Secure international partnership contributions for final design and construction (Canada, Japan, Mexico,...)
→ Preliminary and Final Design Reviews in FY24 and FY26.

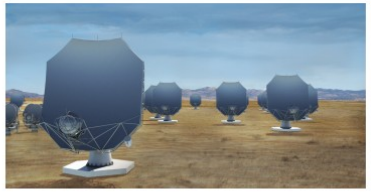
Timeline:

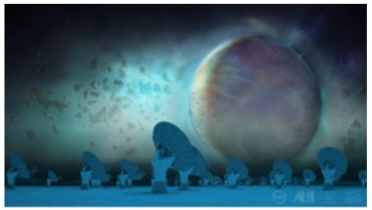












2019 — ngVLA Submission to Astro2020

2021 — Astro2020 Recommendation Published

2023 — Submit ngVLA Proposal to NSF/MREFC; Prototype Delivered to VLA Site

2026 — Complete NSF/MREFC FDR; ngVLA Construction

2029 — Initiate ngVLA Early Science (> VLA capabilities)

2035 — Achieve Full Science Operations

The next generation VLA (ngVLA)

https://ngvla.nrao.edu/

Next Generation Very Large Array

www.nrao.edu
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