NATIONAL RADIO ASTRONOMY OBSERVATORY

Exploring Low frequency Options for the ngVLA: Providing a Path to a Next Generation Low Band Observatory (ngLOBO)

ngVLA
The Next Generation Very Large Array

ngLOBO Collaboration

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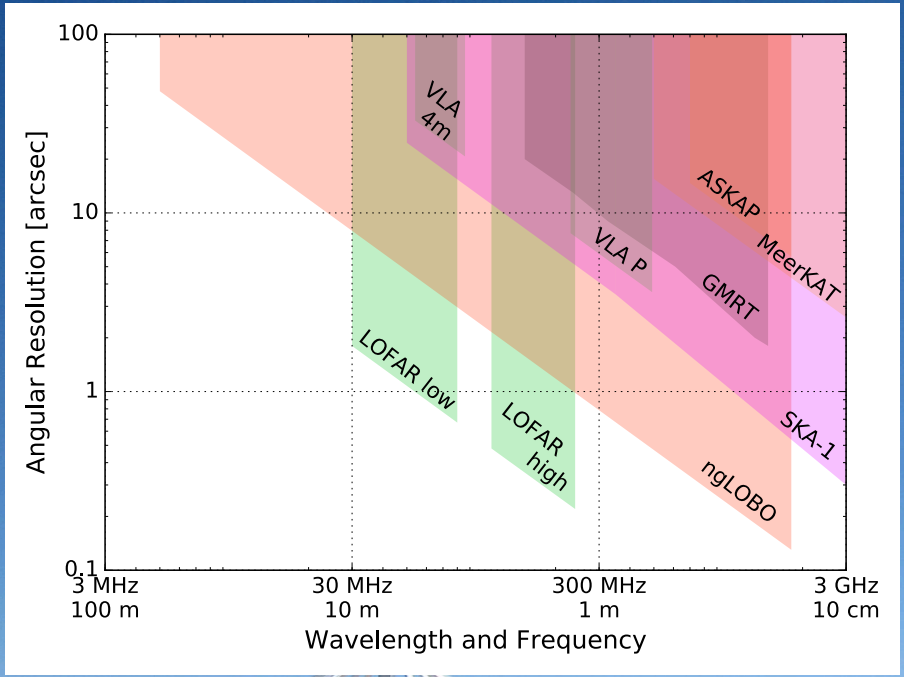
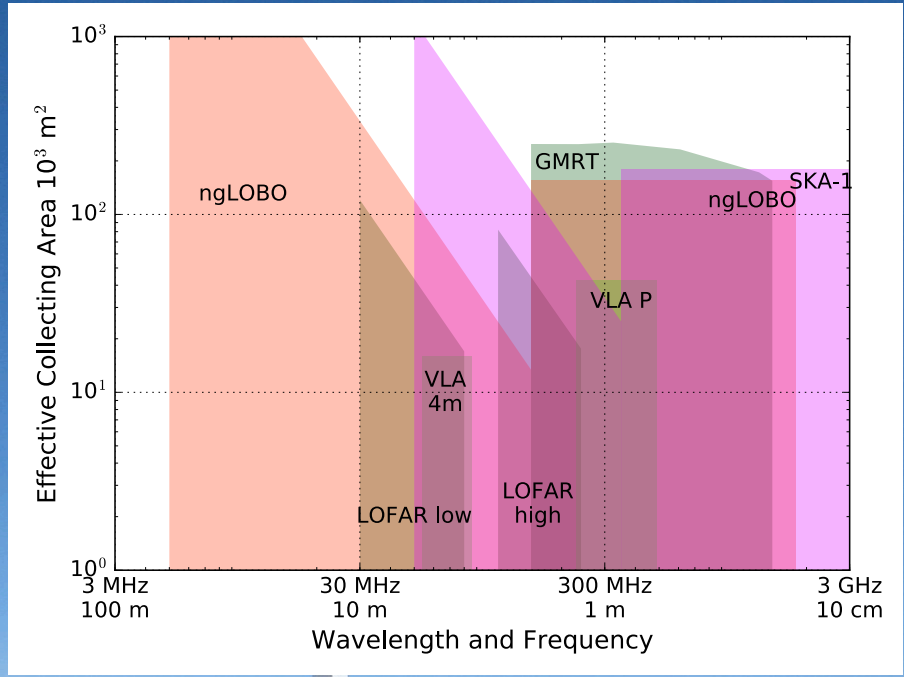
- Namir Kassim, Tracy Clarke, Simona Giacintucci, Jason Kooi, Wendy Peters, Emil Polisensky (NRL)
- Frank Schinzel, Kevin Stovall (NRAO)

Low Frequency Specifications

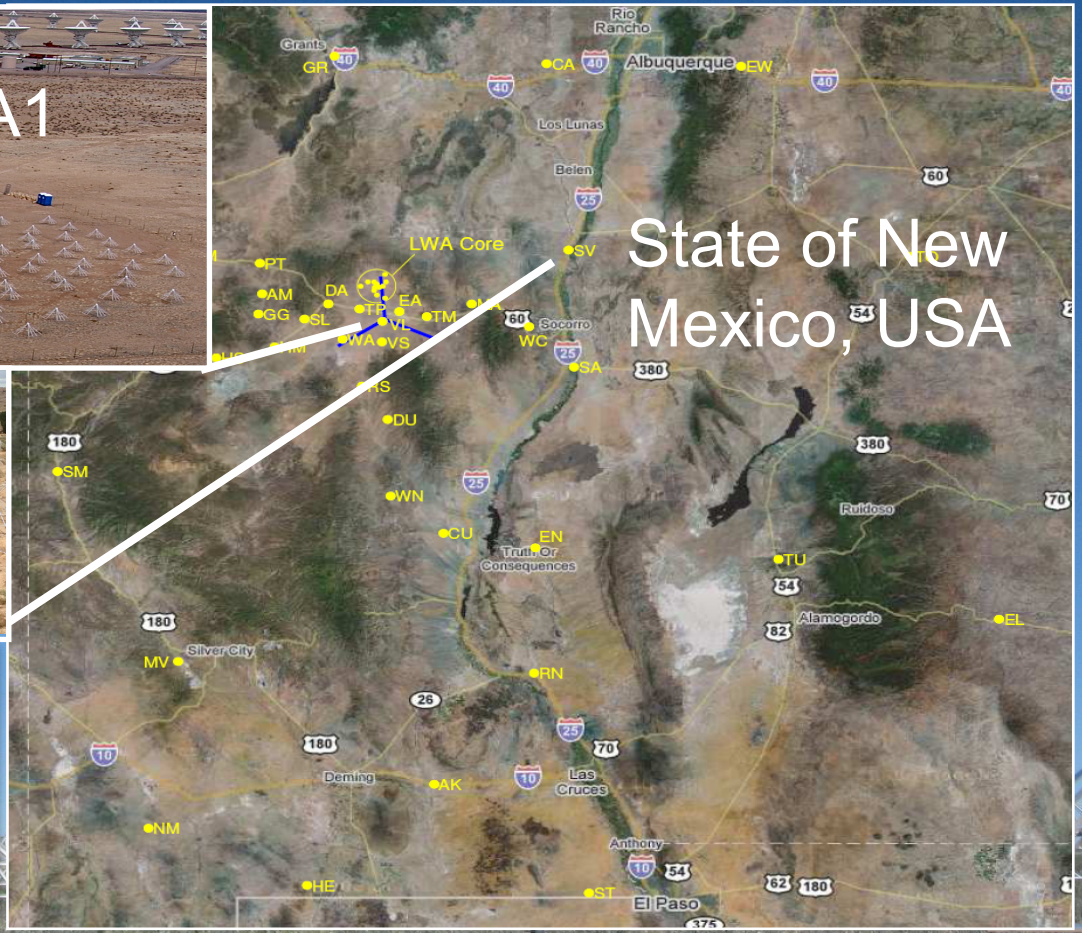
- 5-1500 MHz frequency coverage
  - + 5-150 MHz dipole array (all-sky, multi-beam; ngLOBO-Low)
  - + 150-1500 MHz prime focus feeds in ngVLA dishes; ngLOBO-High)
- Arcsecond resolution and sub-mJy sensitivity
- Share infrastructure (land, fiber, power) with ngVLA
- Commensal with ngVLA high frequency bands
- Independent operation (dedicated correlator)
- ~5% of cost of ngVLA

Low Frequency Comparisons





Current Status



- Dipole arrays can deploy before/after ngVLA
- Cost is ~$0.5M/station in quantity with available power and fiber

LWA1 – Pathfinder for ngLOBO-Low

10-88 MHz usable Galactic noise-dominated (>4:1) 24-87 MHz

4 independent beams x 2 pol. X 2 tunings each ~16 MHz bandwidth

All sky (all dipoles) modes: TBN (70 kHz-bandwidth; continuous)
TBW (78 MHz-bandwidth, 61 ms burst)

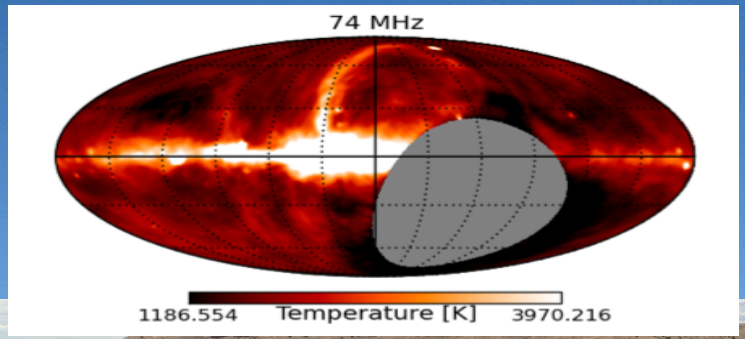
Five “outrigger” antennas at up to 500 m baselines

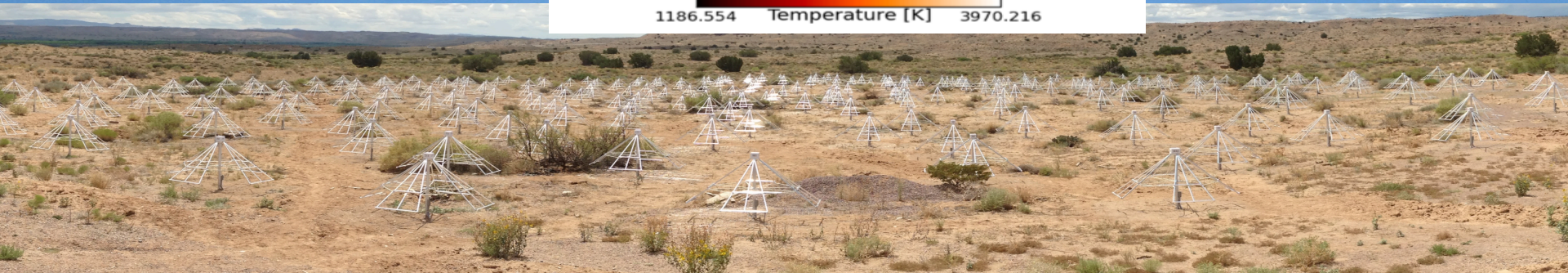
LWA1 discoveries: meteors, pulsars, Sun, Jupiter & Ionosphere

38 refereed publications to date

LWA-SV station

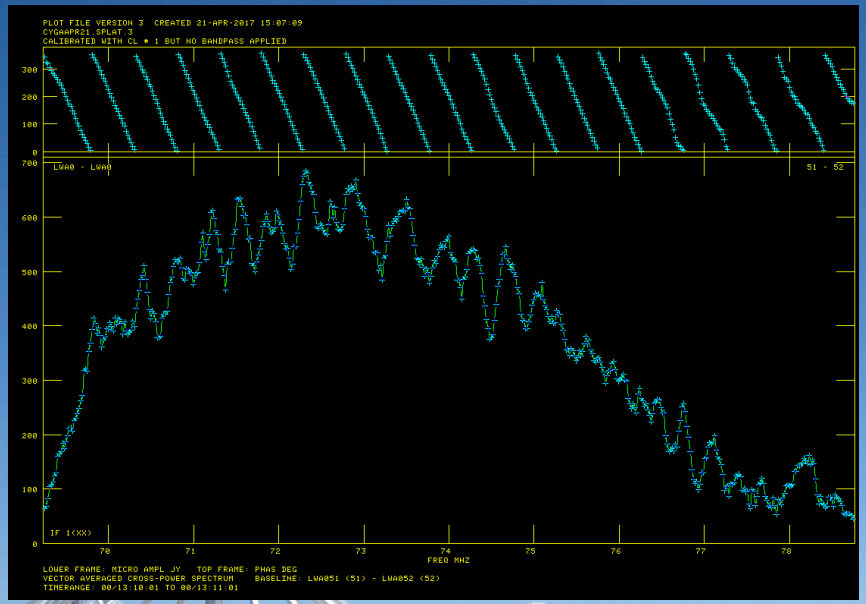
- New station as part of the Long Wavelength Array
- 257 dual polarization LWA dipoles
- 20 MHz bandwidth beamforming
- 20 MHz bandwidth all-sky imaging
- 70 km baseline provides 15” resolution in conjunction with LWA1
- Pathfinder for ELWA and ngLOBO-Low

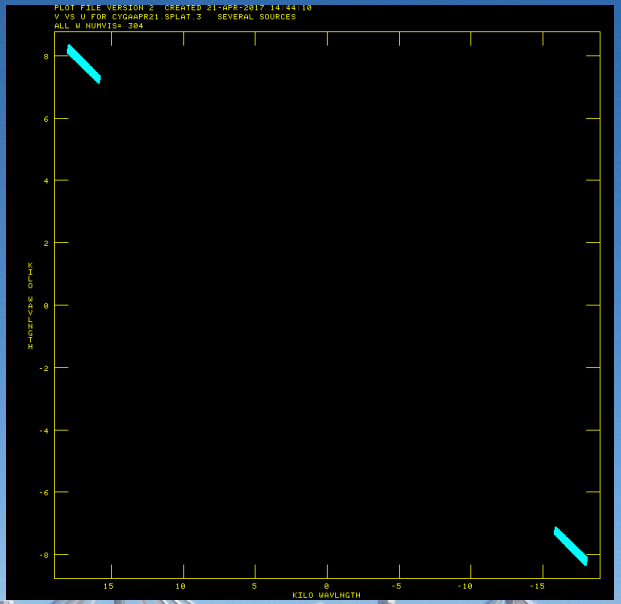




LWA1 – LWA-SV fringes

Fringes between LWA1 and LWA-SV on Cygus A on April 21, 2017 and resulting (u,v) coverage





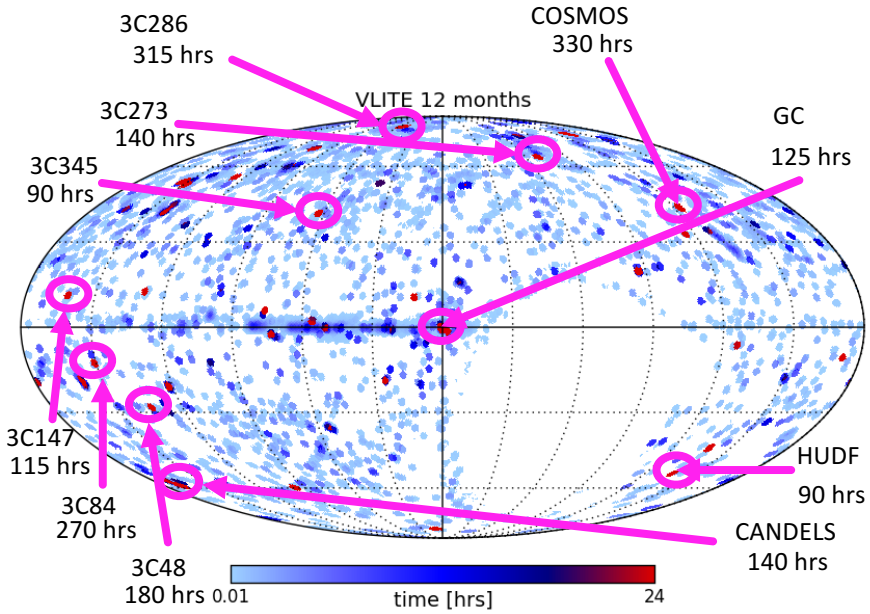
VLA 50-86 and 220-500 MHz

New 4 band feeds (MJP)
4 meter band: 50-86 MHz
19 installed

VLITE Contemporaneous
320-384 MHz
10 antennas (expanding to 15)

Transients with a Commensal System: Wide-Shallow & Narrow Deep

50% to > 30 sec 30% to > 12 min 10% to > 2 hr

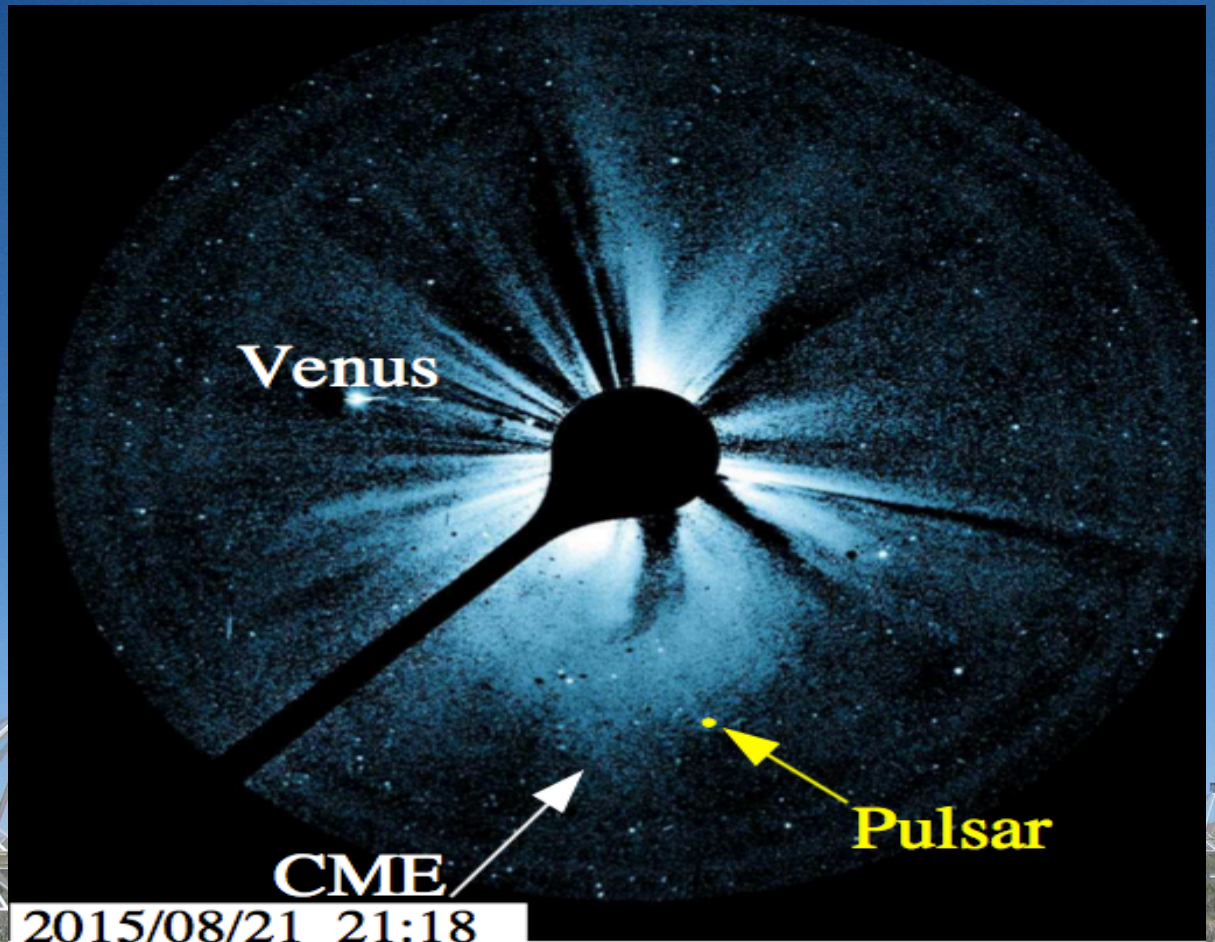


Swallowing the data

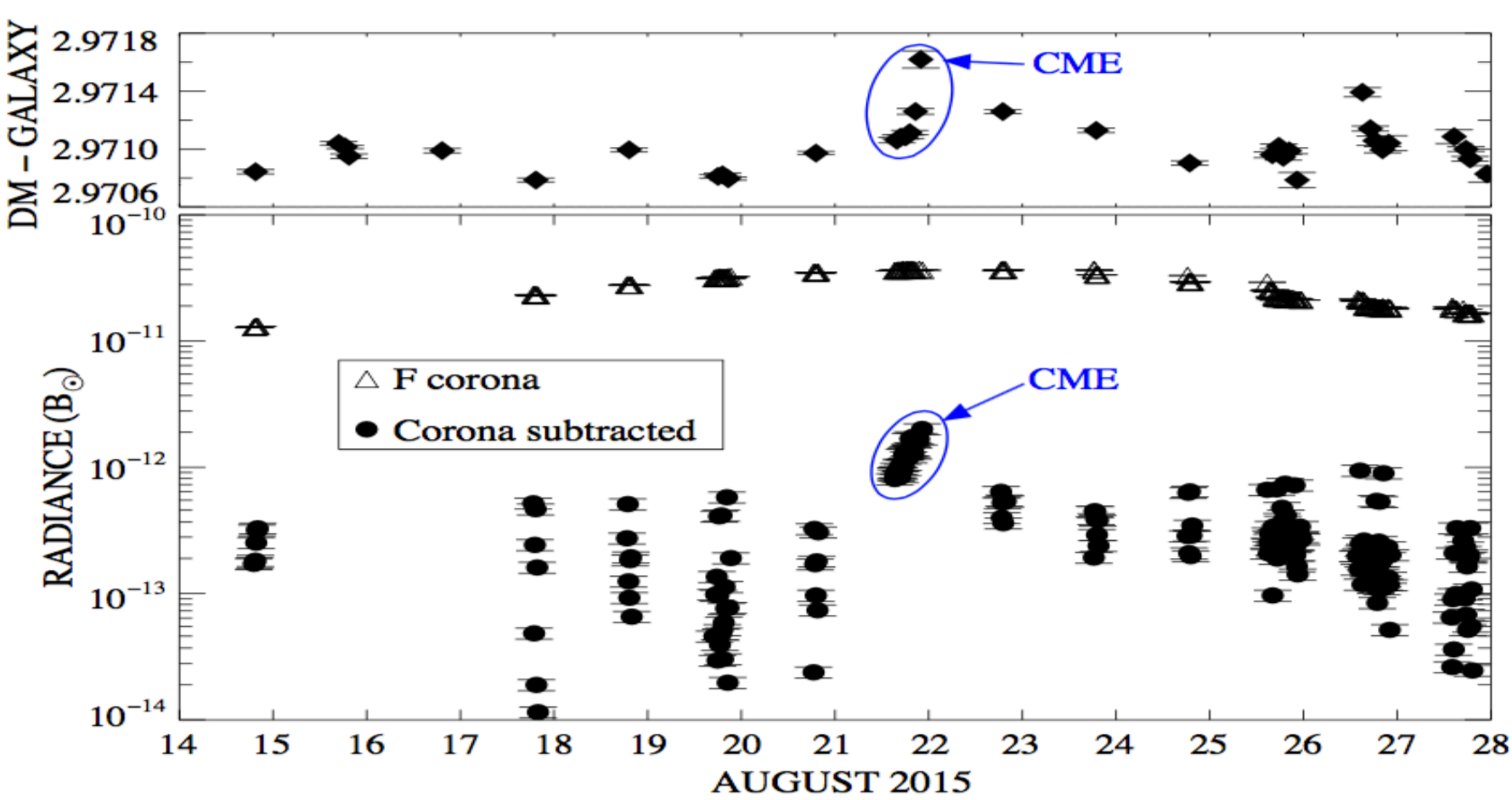
- *1 year of data with VLITE:* 250,000 sources, 60,000 unique, 1100 candidates
- Automation: 2 candidates per day requiring human follow-up - >99% filtering.
- Automated transient hunting with ngLOBO Low and High can be tremendously efficient

Coronal Mass Ejection

Catching a Coronal Mass Ejection



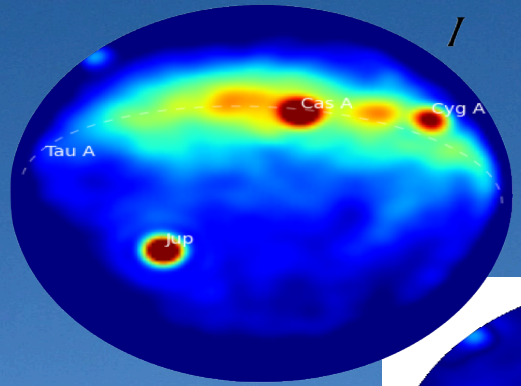
Catching a Coronal Mass Ejection



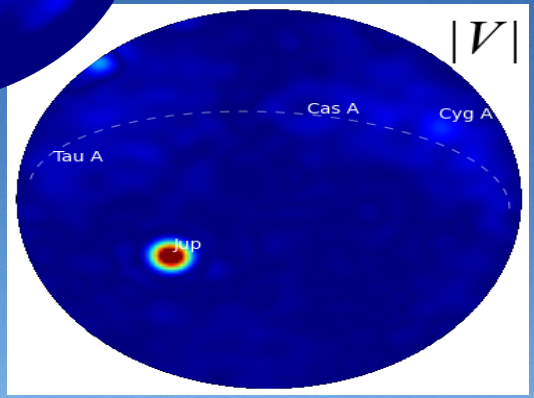
Searching for Exoplanets

Emission from Jovian Planets

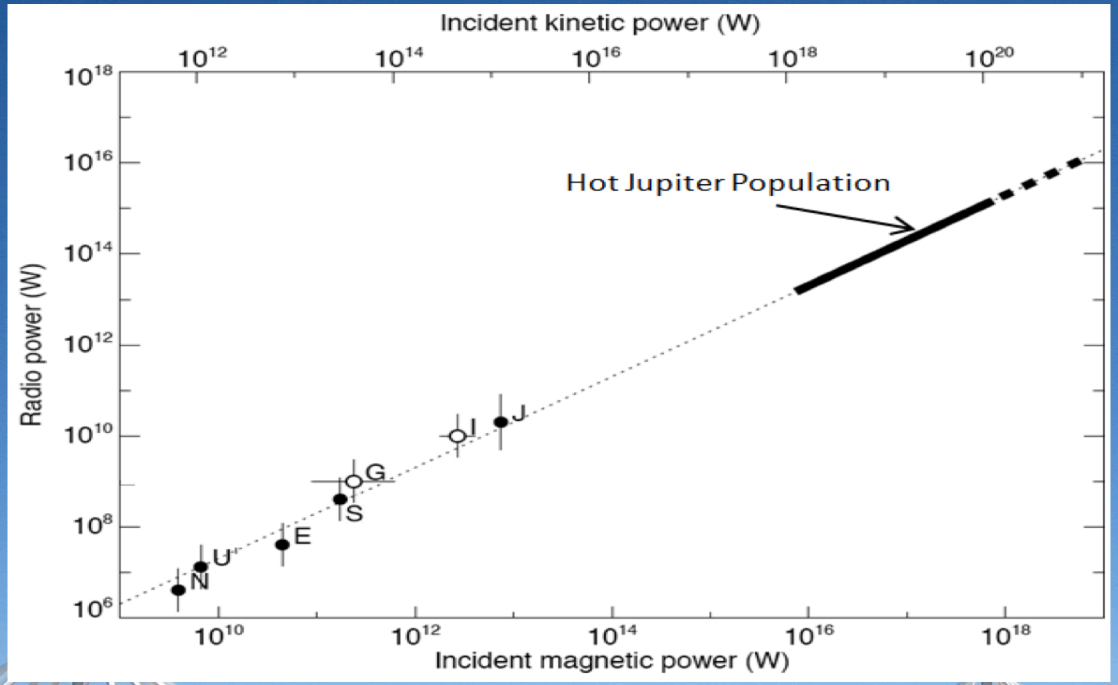
- Low frequency:
  $eB / 2\pi m_e = 28$ MHz at 10 G
- Bright! ~100 mJy flux density predicted at 10 pc
- High circular polarization:
  LWA is very good at this!
- Predictably time-variable:
  - pulsar-like emission
  - secondary eclipses
  - periastron passages of high-eccentricity HJs



PASI image of a Jovian burst
at 25.61 MHz



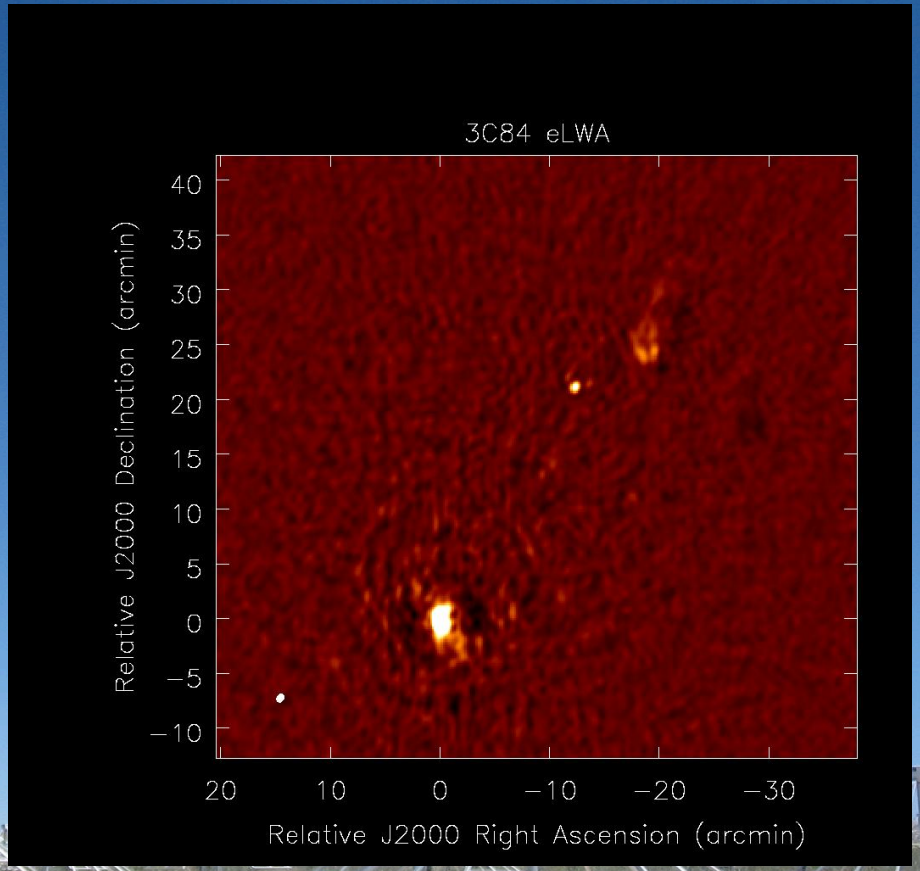
Searching for Exoplanets



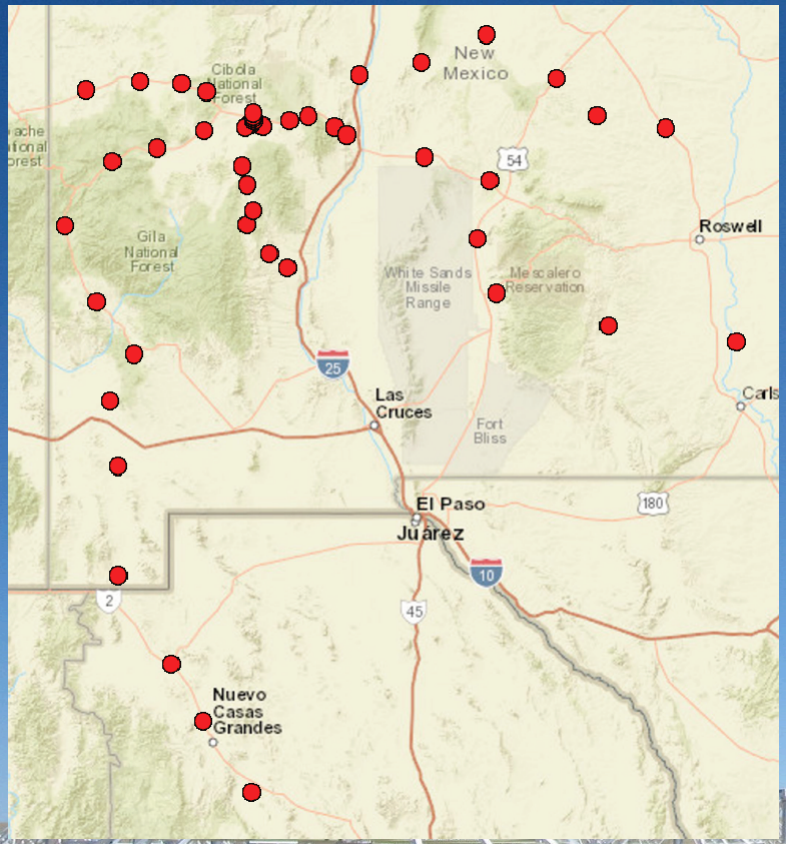
Zarka (2006)

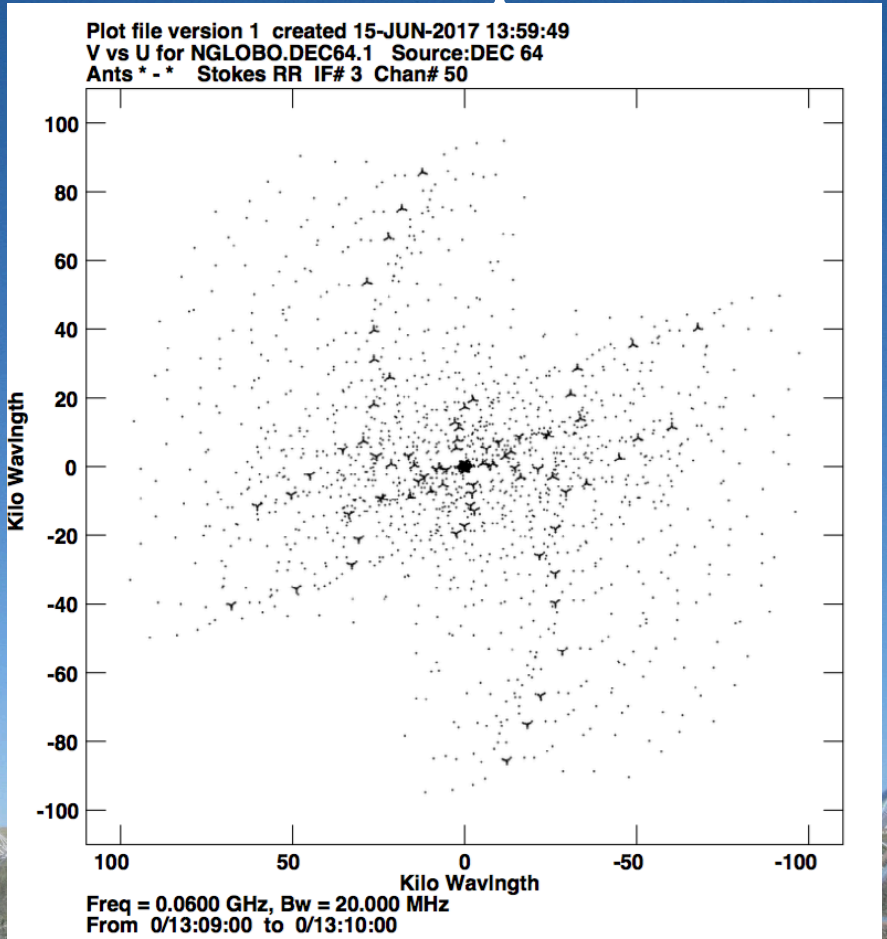
ELWA - Demonstration

3C84 at 70 MHz
Dec 3, 2016
LWA1 + 13 VLA

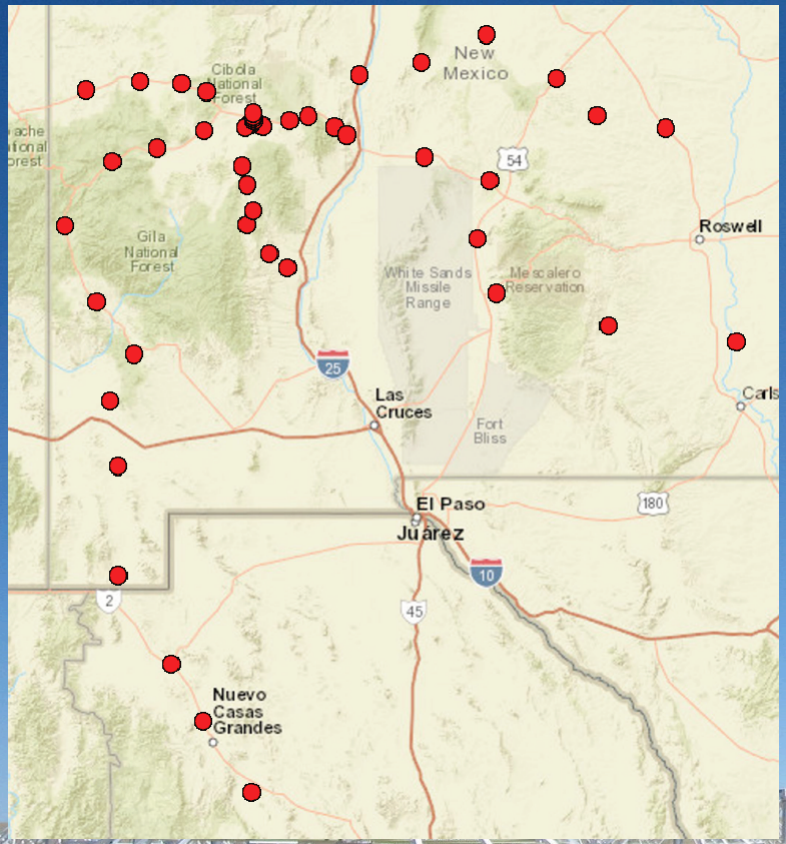


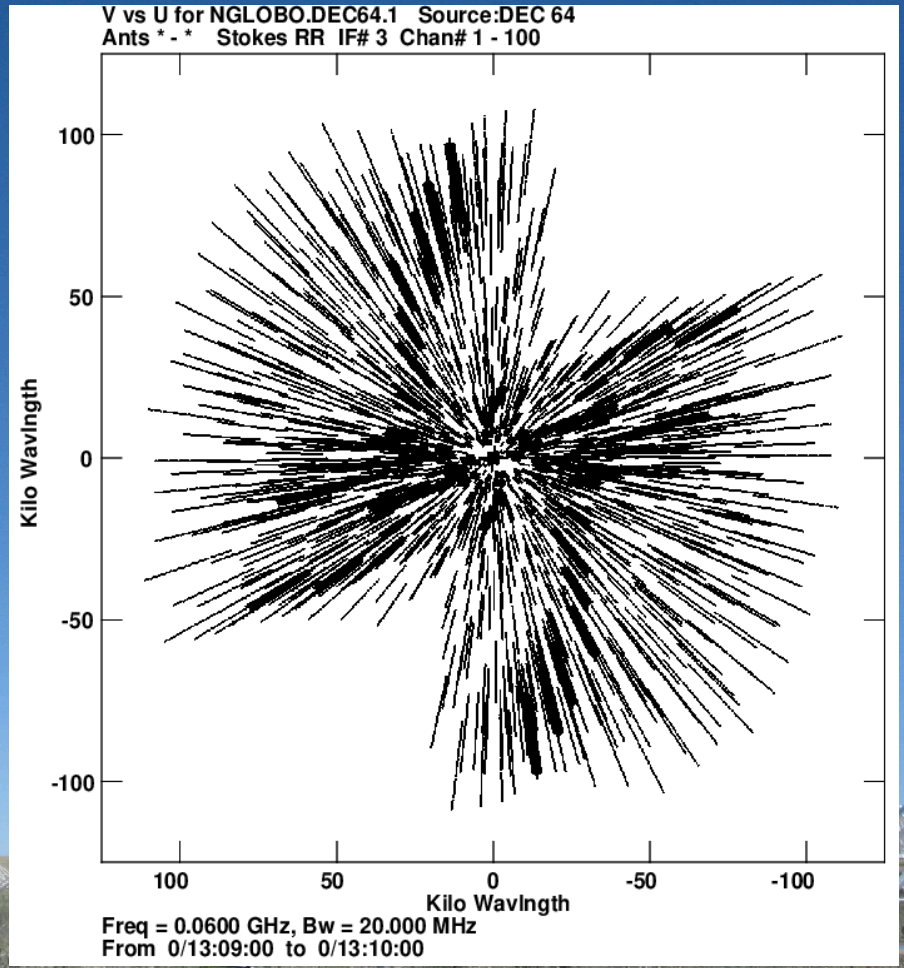
Configuration Studies - Snapshot



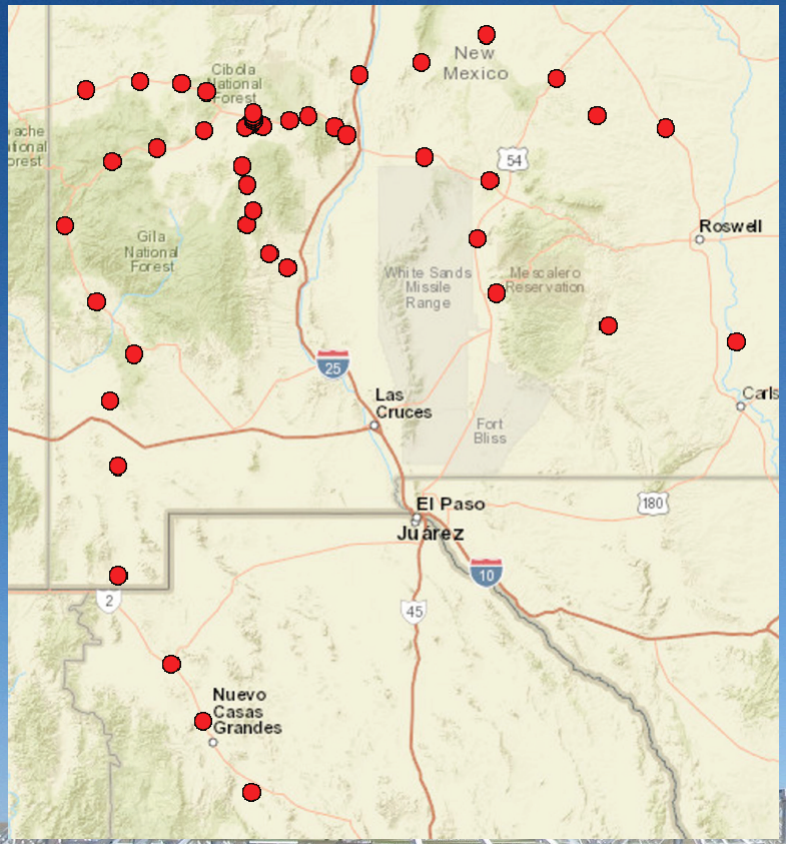


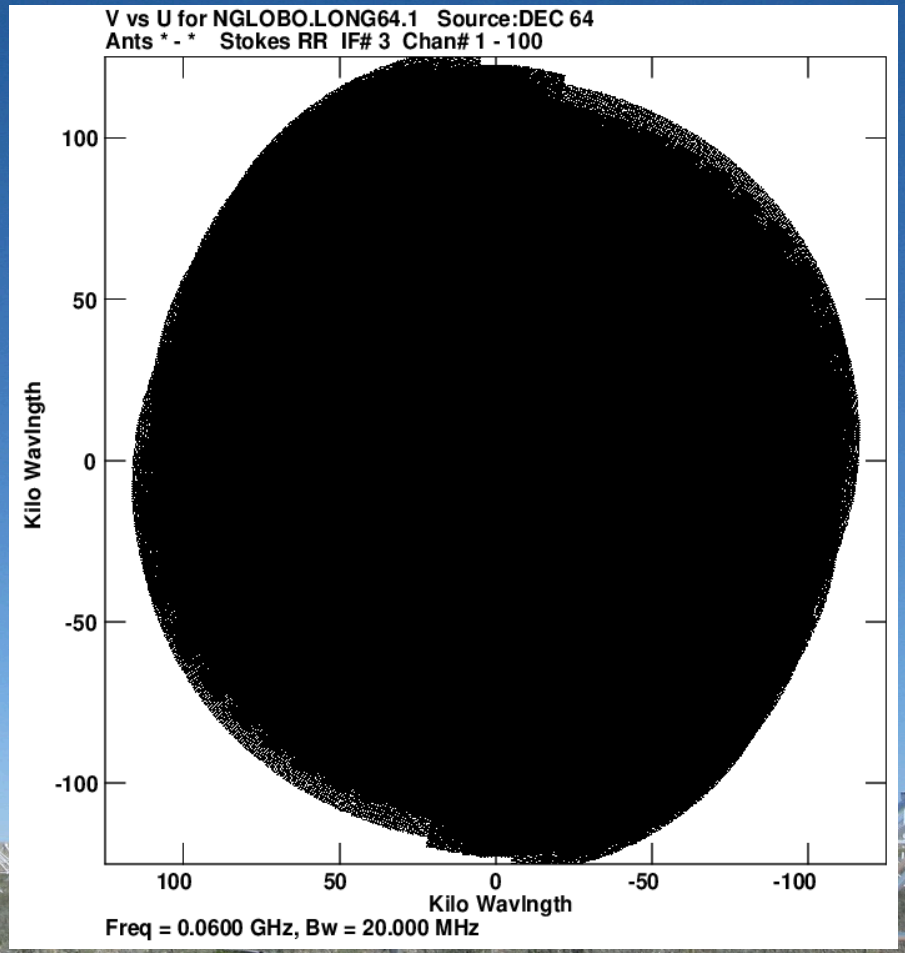
Configuration Studies – Bandwidth Synthesis





Configuration Studies – Full Track



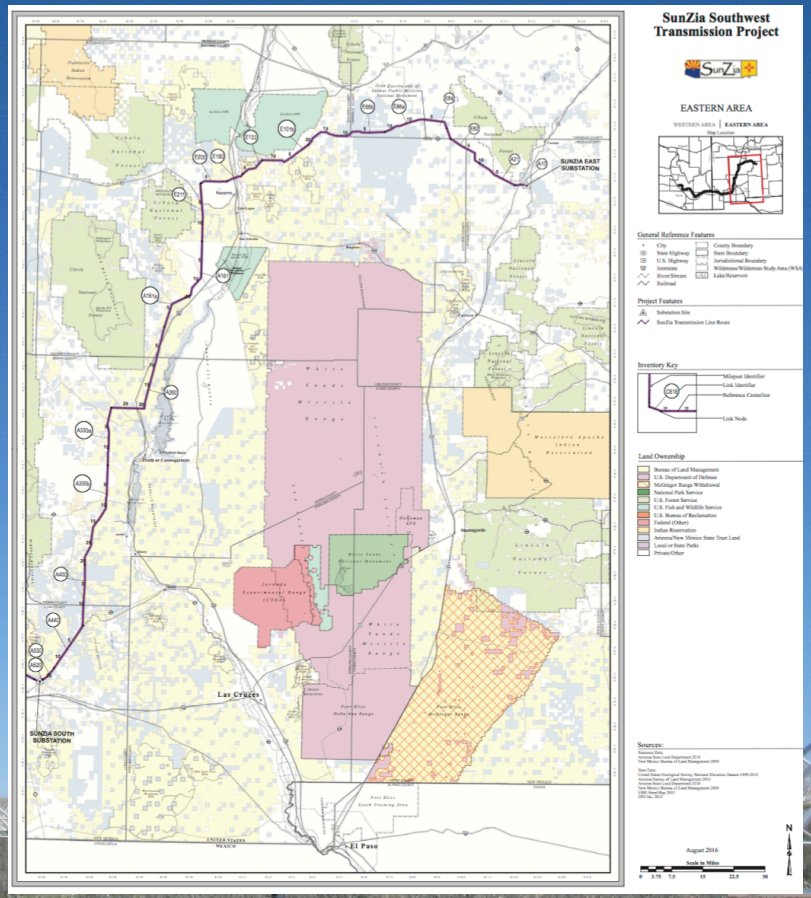


Lessons Learned - Power and Fiber

- Bury the fiber – it costs more than running on poles but reliability is far better
- Fiber is costly so find partners (schools, hospitals, other projects) to share expense
- Powerlines are noisy – work with the local utility to find problems and fix them
- Stay at least 10 miles away from high voltage lines

Powerlines

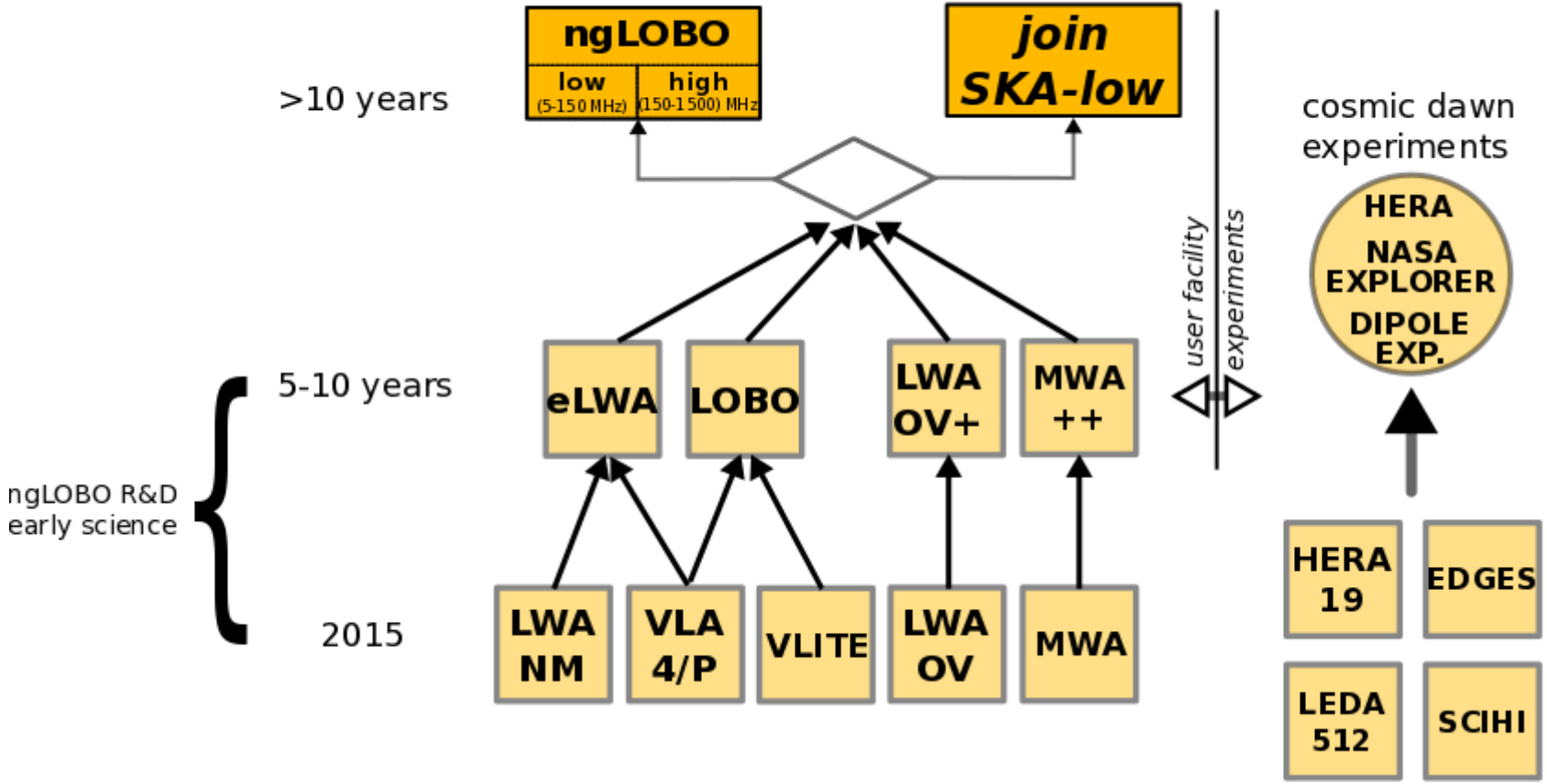
SunZia project taking power from windfarms in Eastern New Mexico to markets in AZ and CA.



Lessons Learned - Operations

- Computer control of station saves $$$
- Computer control allows triggers to happen in 10s of seconds instead of 10s of minutes
- Automate Everything: scheduling, observing, triggering, database ingest, etc.
- Computers are more watchful than people so can better protect against overheating, etc.

US long range low frequency vision



Summary

- The US can participate in the revolution at low frequencies through ngLOBO
- ngLOBO-Low
  - Aperture array, multi-beam, commensal, wide-field, 5-150 MHz
- ngLOBO-High
  - Prime focus, broad-band, commensal with uncooled receivers, 150-1500 MHz
- White paper in preparation
- See Jason Kooi's talk on Wednesday for more ngLOBO science