



U.S. NAVAL
RESEARCH
LABORATORY



LWA Future

Greg Taylor (UNM)

On behalf of the LWA Collaboration
LWA Users Meeting, 8/2/2019



LWA Outreach

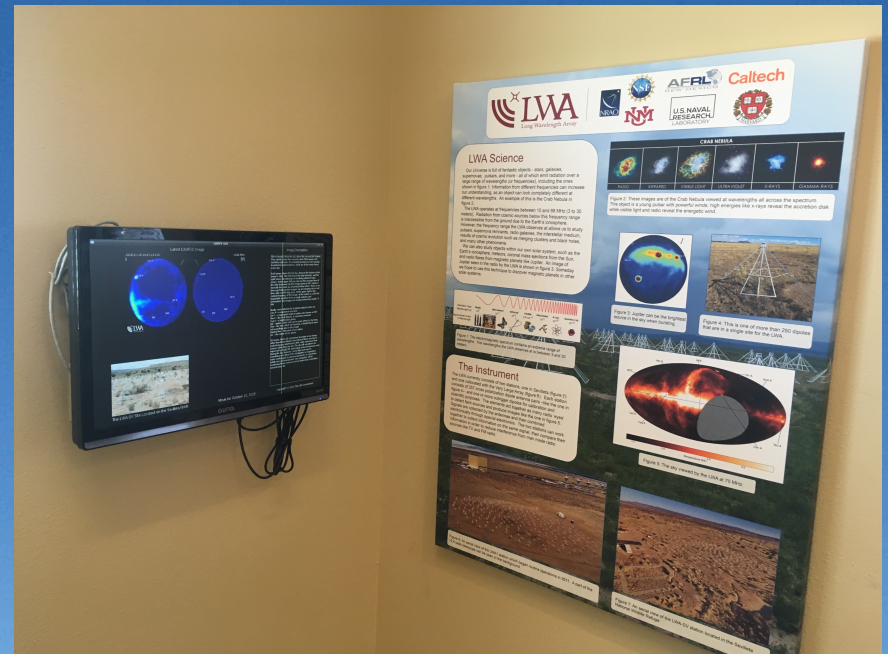
- LWA-TV and LWA-TV channel 2 (GUI available in LSL)
- LWA-TV running at Sevilleta, PandA, VLA Visitor Center, NRL, ERAU, others?
- LWA demos/tutorials

- **Pulsar B0329+54**
- **Unknown Pulsar**
- **Pulsar Rotation Measure**
- **Jovian Burst**
- **Solar Burst**
- **Crab Pulsar Giant Pulses**
- **All-Sky Meteor Echoes**

- Numerous tours and class trips
- LWA interactive sky maps:

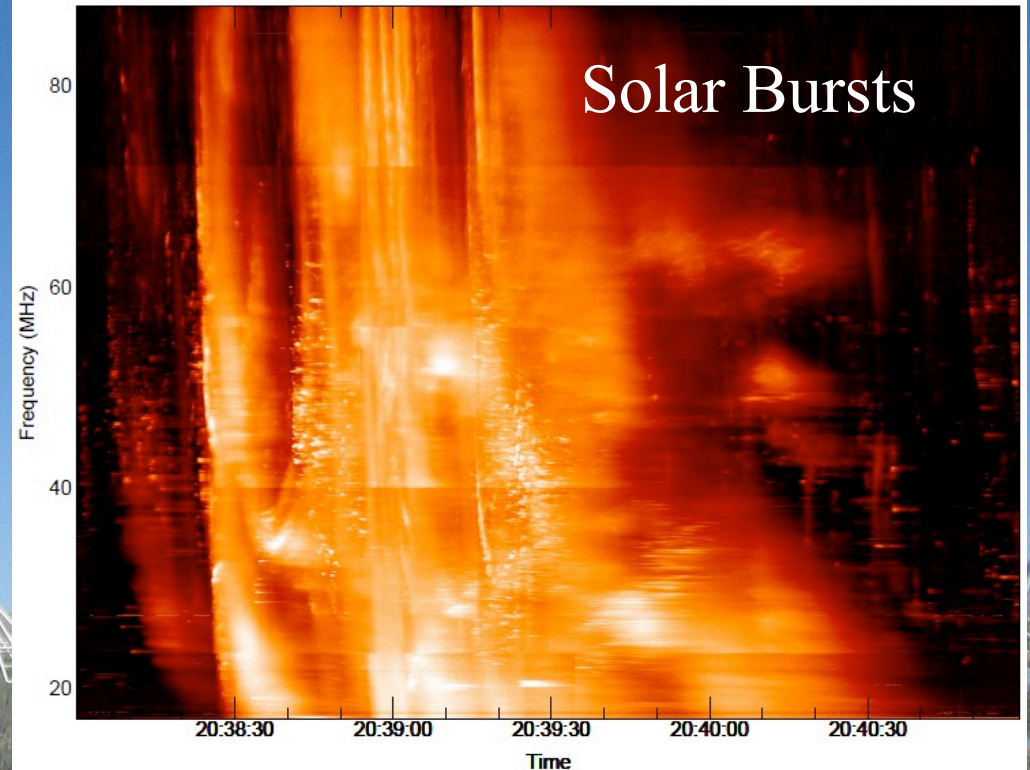
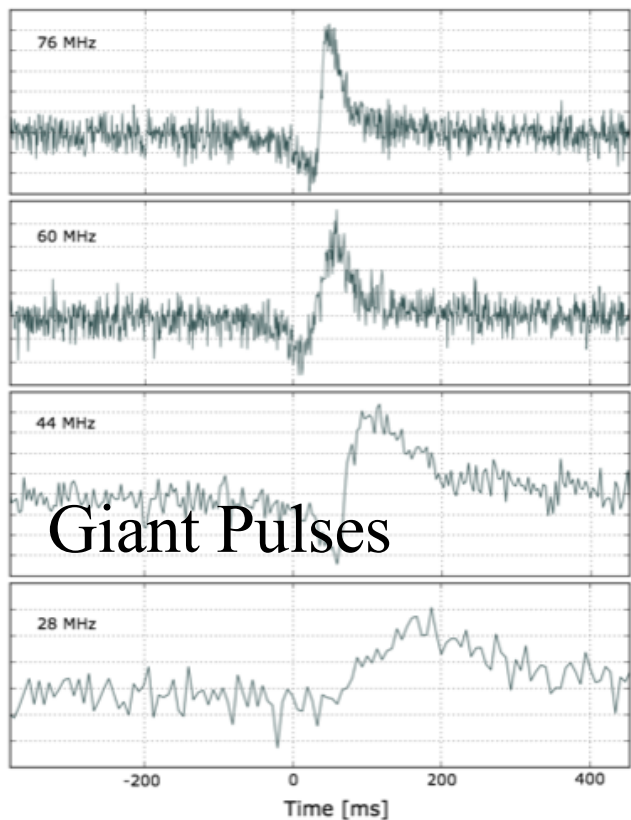
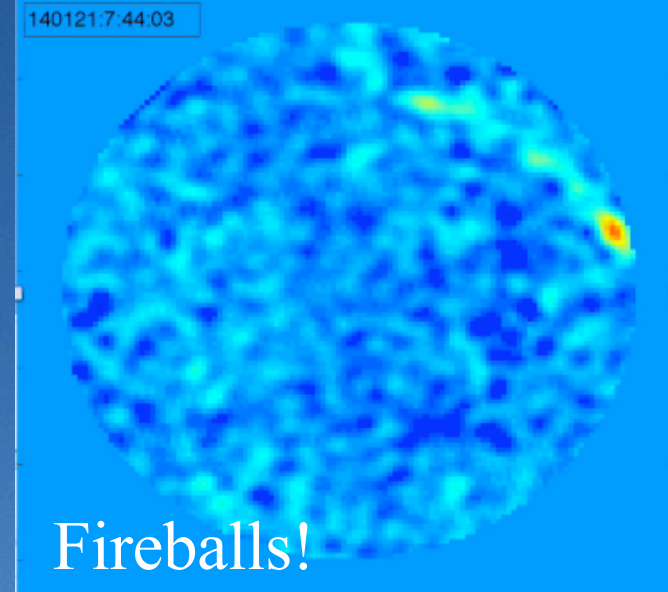
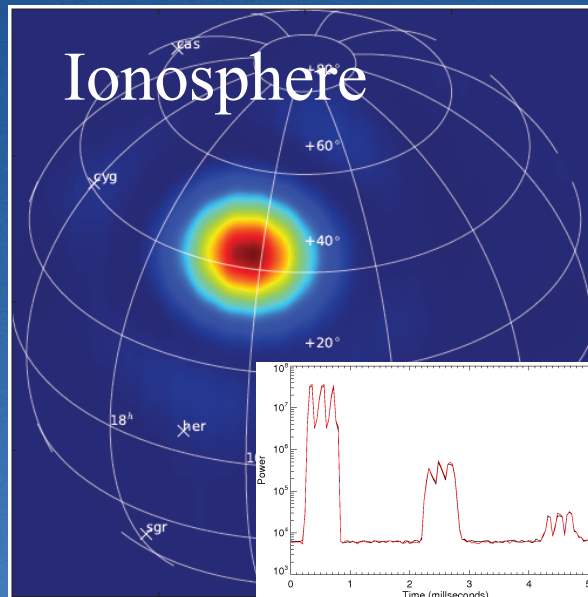
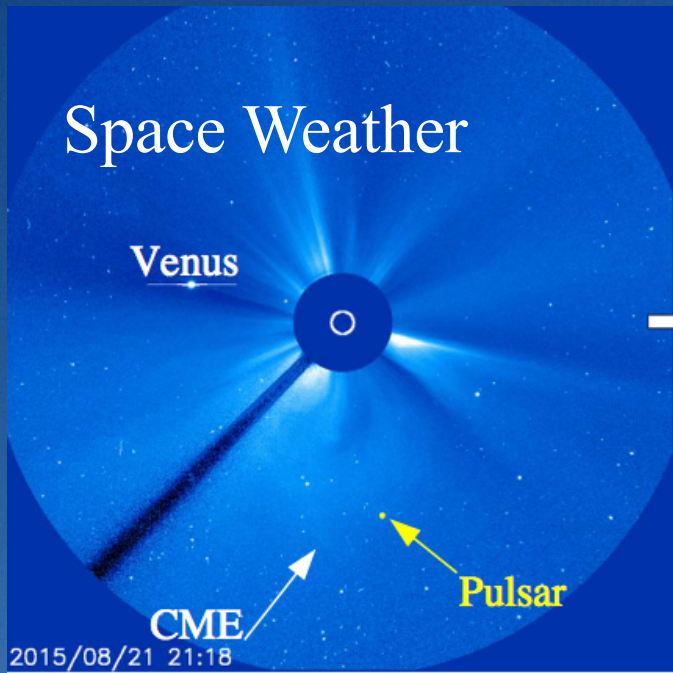
<http://fornax.phys.unm.edu/low-frequency-sky/index.html>

<https://fornax.phys.unm.edu/multi-wavelength-sky/index.html>

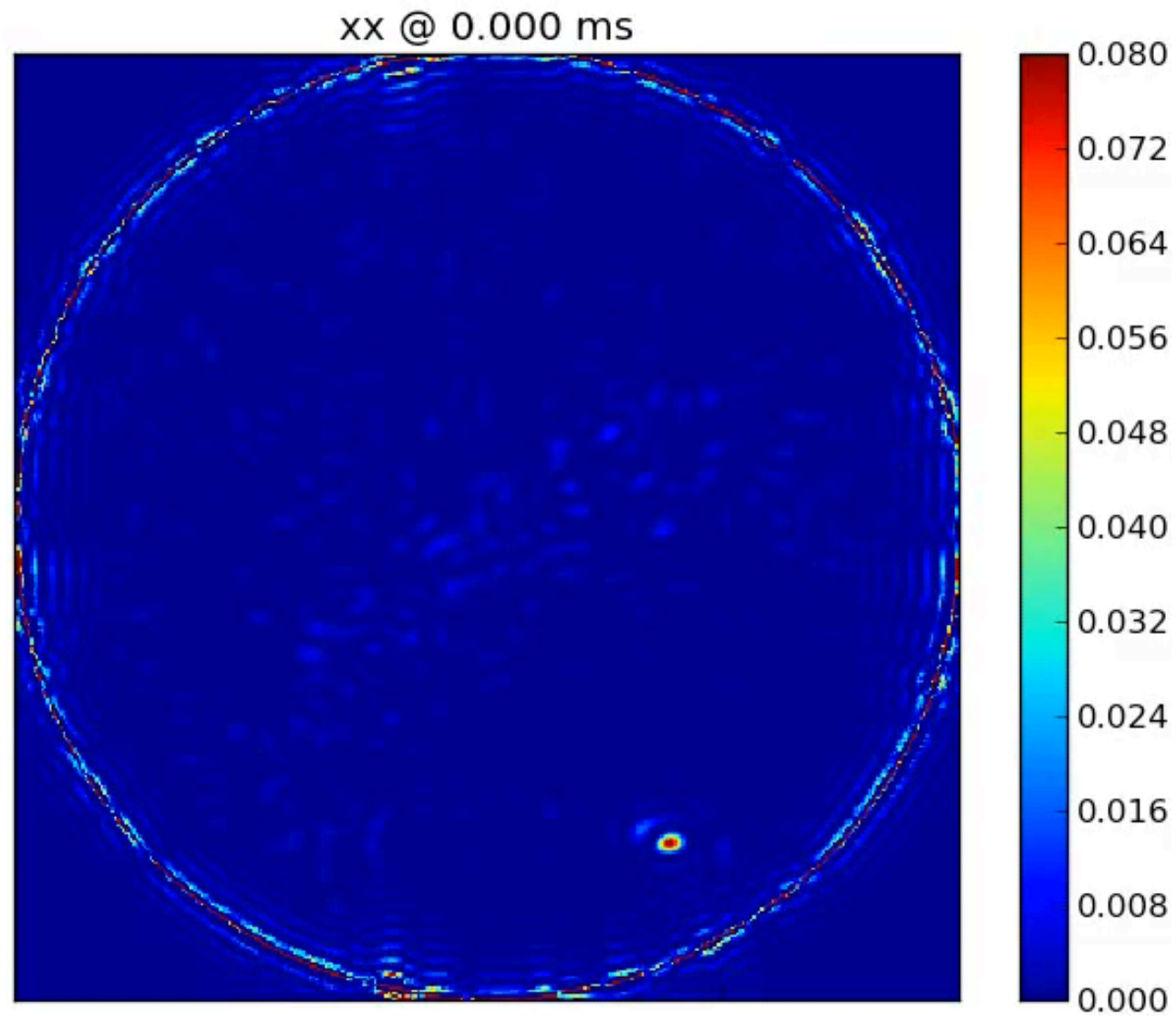


LWA Single Station Science

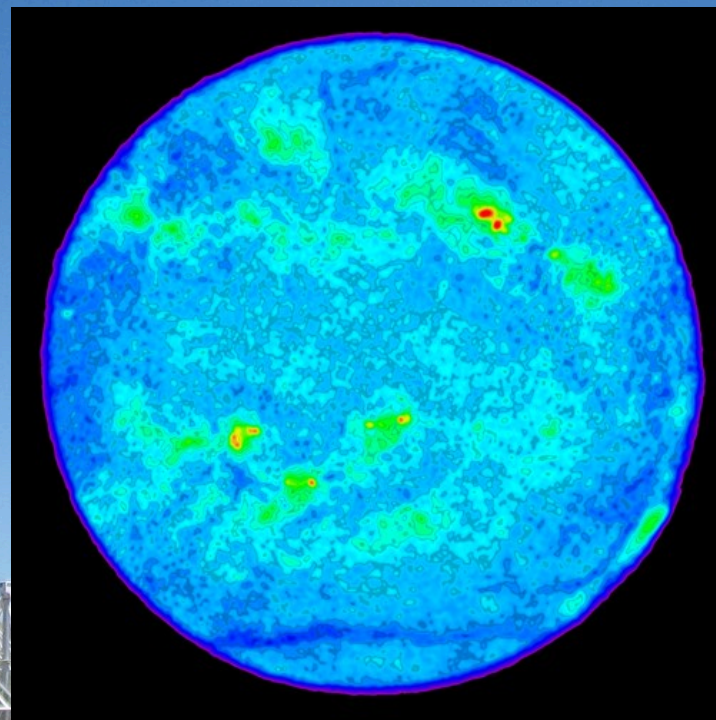
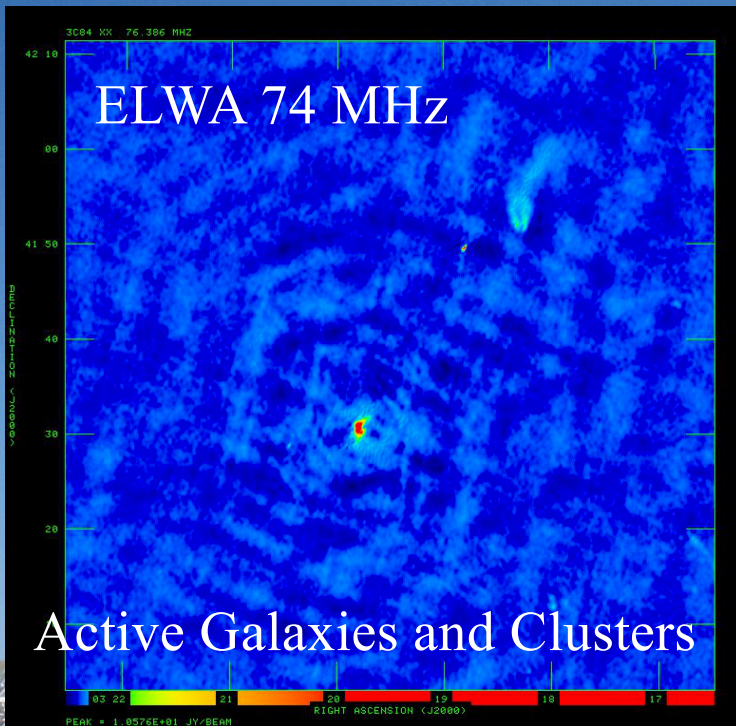
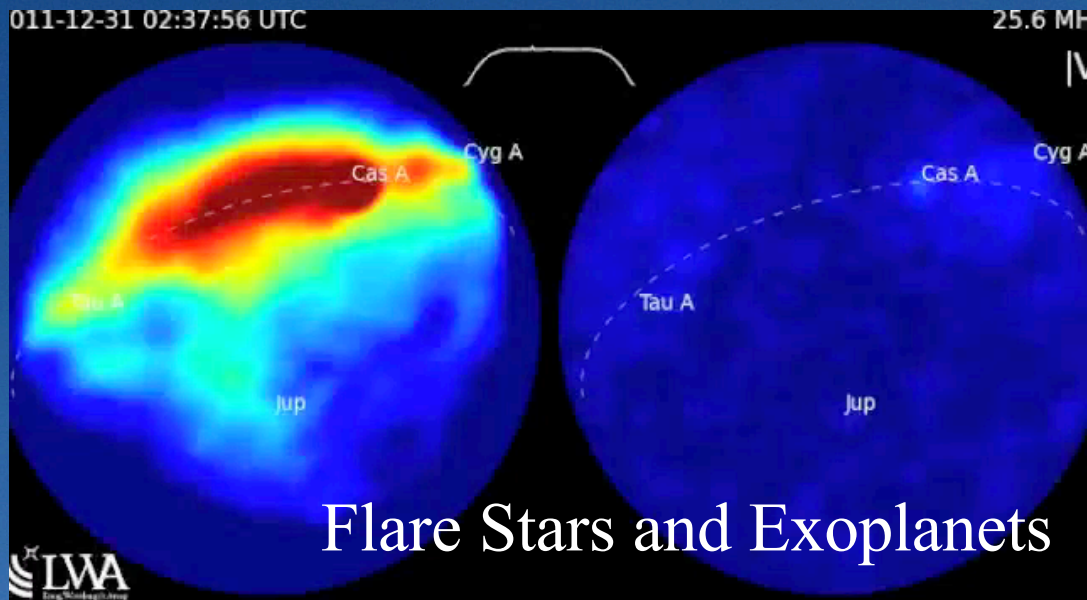
Space Weather



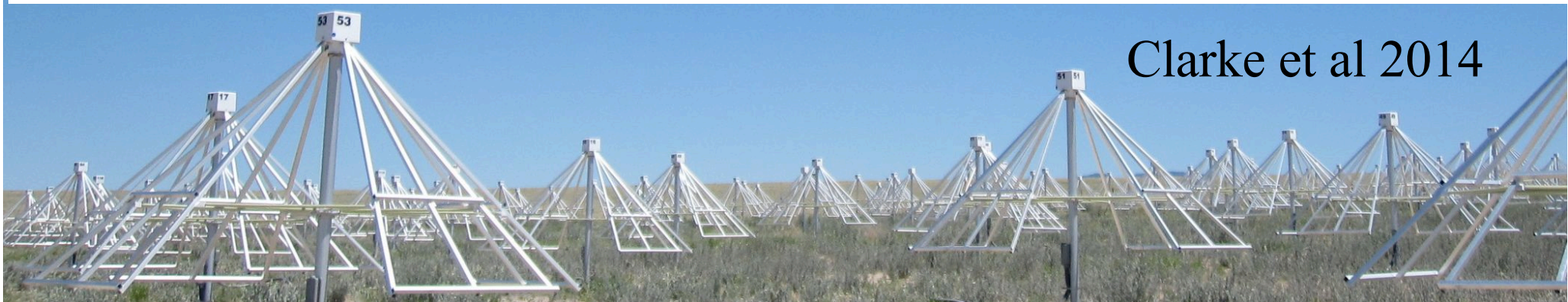
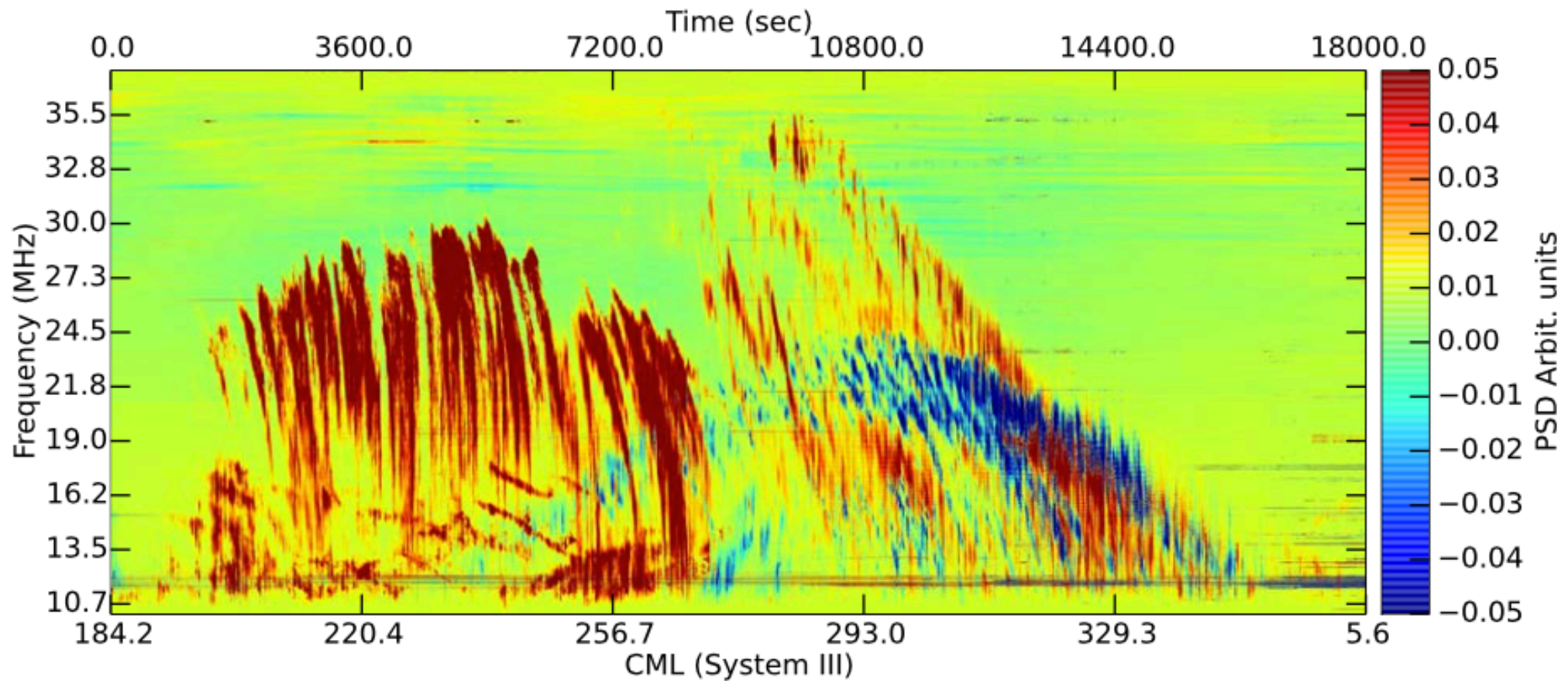
Lightning @40microseconds



LWA Science at arcsecond resolution



Jupiter



Exoplanet Searches

- Beamform on a number of known, nearby exoplanets at 30-70 MHz
- Improve sensitivity (factor 10) through broad band, all-sky imaging
- Problems:
 - High confusion noise for single LWA station
 - Large data rates for OVRO-LWA station
 - Sensitivity not adequate with a single station
- Solution: add more LWA stations ...



LWA Swarm Concept

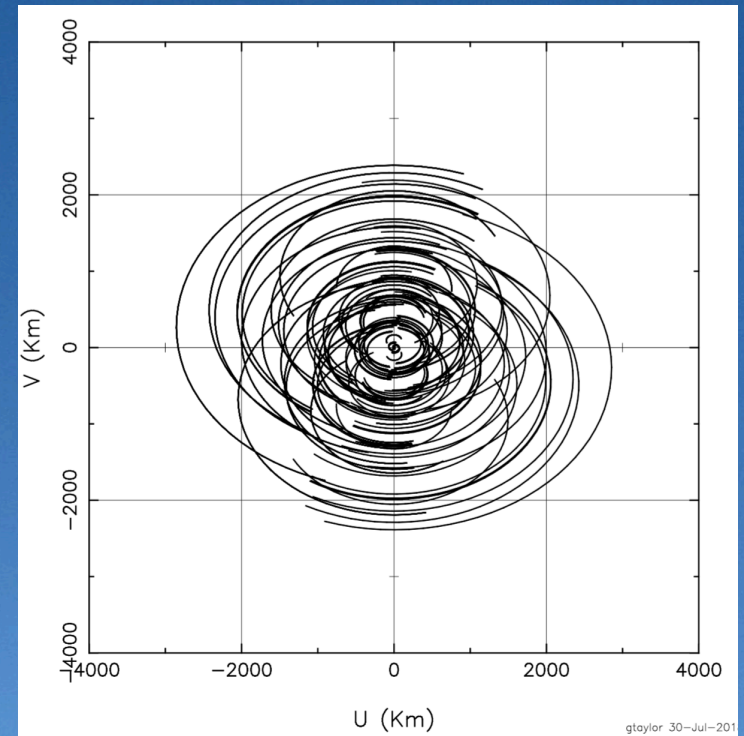
- Develop new scientific capability in the US
- Build on success of LWA with low risk investment
- Provide educational opportunities in STEM (including 3 MSI Universities)
- Technology Development platform (Bifrost, EPIC, HAL, AI, Swarm, etc)
- White paper submitted to 2020 Decadal Survey

The Swarm Development Concept for the LWA

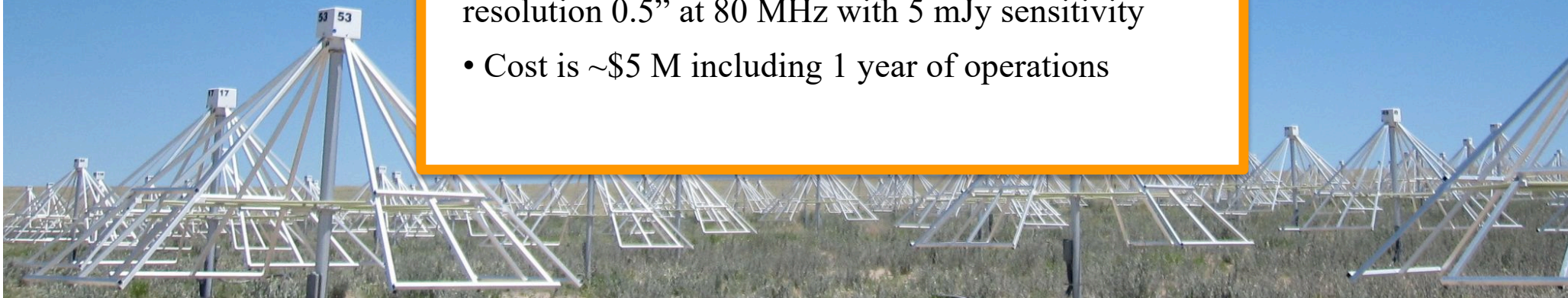
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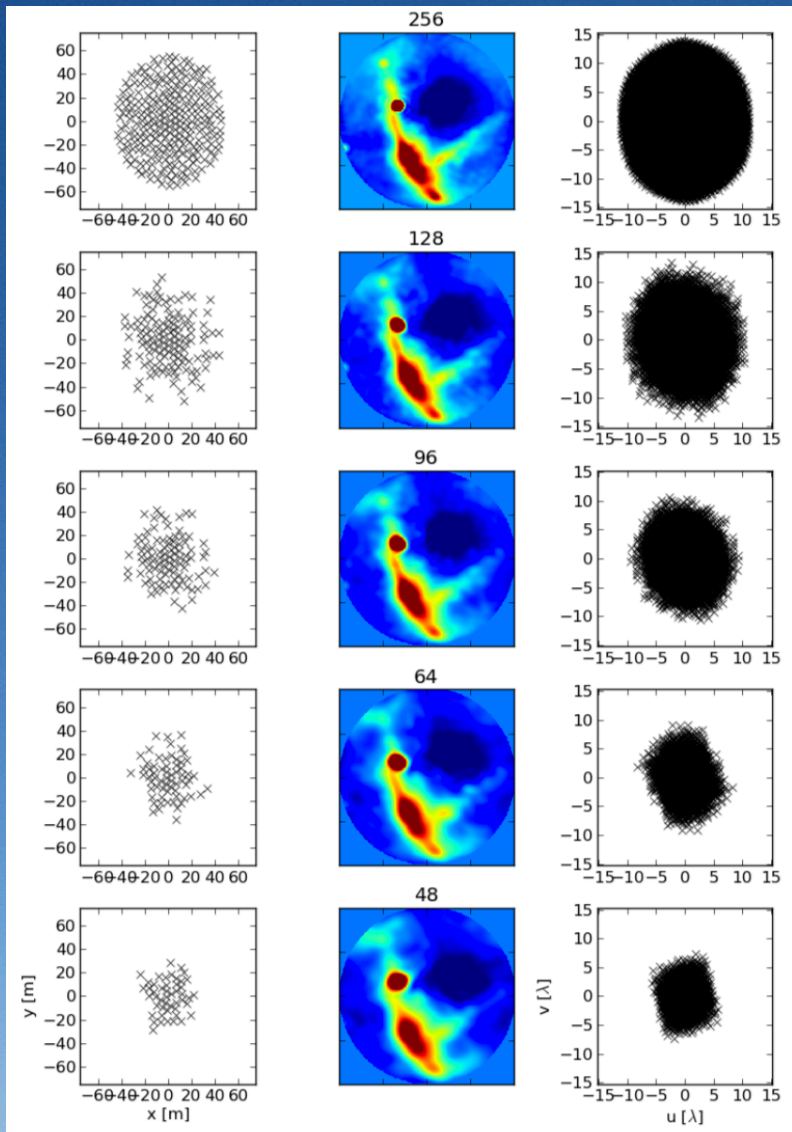
LWA Swarm Concept



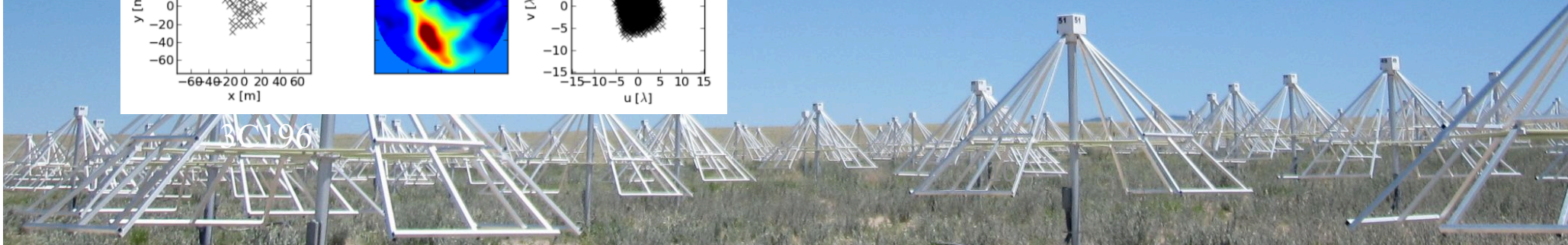
- Goal of 3 existing full stations (●) plus ~10 LWA full or mini stations (●), baselines up to 2500 km for resolution 0.5'' at 80 MHz with 5 mJy sensitivity
- Cost is ~\$5 M including 1 year of operations



Mini Stations



- Minimum 48 stands (3 ROACH2) or 64 stands (2 SNAP2)
- Design that allows upgrade to full station (256 stands)



LWA-NA mini station

- ~48 antennas
- 2 ROACH boards
- Electronics Shelter



Cost Model

- Phase 1
 - mini station at LWA-NA site plus Arizona (ERAU) & Texas (TTU)
 - Funded by NSF/ATI (deadline Nov 15, 2019)
 - \$112,000 parts cost for each mini-station
- Phase 2
 - Expansion across US including “backbone” of full stations (\$1M each) plus at least 10 mini stations
 - Funded by MSIP/MRI/DURIP/Private
- Operations costs on mini stations only \$7000/year (power, storage, maint)



Swarm MoU

- Signed by UNM, TTU, ASU, and ERAU in October 2018
- Above partners are responsible for maintaining their stations
- Contribute 144 hours/week (85% of time) to Swarm = 7488 hours/year
(many projects like meteors, cosmic rays, lightning can occur in parallel)
- UNM will schedule, correlate and archive Swarm observations
- Allocation of time in a year:
 - 750 hours (10%) maintenance and testing
 - 5620 hours (75%) community access
 - 1120 hours (15%) guaranteed time divided equally among partners
- New members can be added with majority consent of partners



Summary

- Capability at Low Frequencies is increasing rapidly
 - Knowledge of the Sky
 - New Hardware on the ground
 - New Firmware and Software
 - New Generation of researchers
- We have come a long way, still many discoveries ahead
- SALF VI December 9-11 2019 in Tempe AZ
- Next time will meet in new PAIS building at UNM, possibly in conjunction with SALF 2020



Discussion Topics

- A. What new capabilities would people like to have?
 - 1) At LWA-SV
 - 2) For the Swarm
- B. Would you rather have 4 frequency agile beams or 4 beams all at the same frequency? (4 agile beams will cost 25% more in constr + ops)
- C. How do we maintain relevance to astro/ionosphere/etc?
- D. How do we strengthen this community?
- E. How do we get the Swarm launched?
- F. Where else should LWA go – Australia? Moon?
- G. What about commensal systems (LOBO)?
- H. Anything else?



Extra Slides



LWA Science

Astrophysics

- Cosmology
Observing cosmic dawn through redshift 30 absorption of the 21 cm line. High redshift radio galaxies, containing the earliest black holes
- Acceleration, Propagation & Turbulence in the ISM
Origin, spectrum & distribution of Galactic cosmic rays, Supernova remnants & Galactic evolution, Pulsars and their environments
- Solar Science & Space Weather
Jupiter, Radio heliography of solar bursts & coronal mass ejections, Solar magnetic fields
- Exploration of the Transient Universe
New coherent sources, GRB prompt emission, poorly explored parameters space ...
- Meteors
Self-emission and reflections of man-made signals

Iono- & Atmospheric Physics

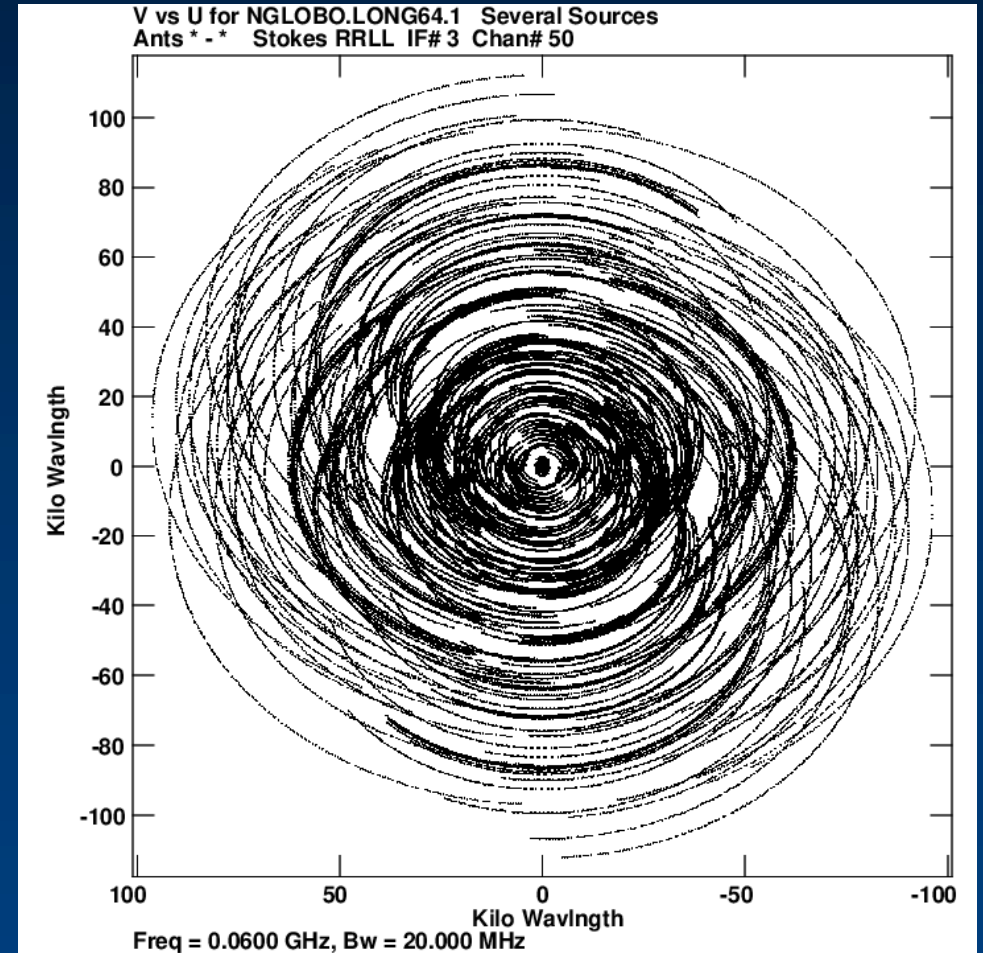
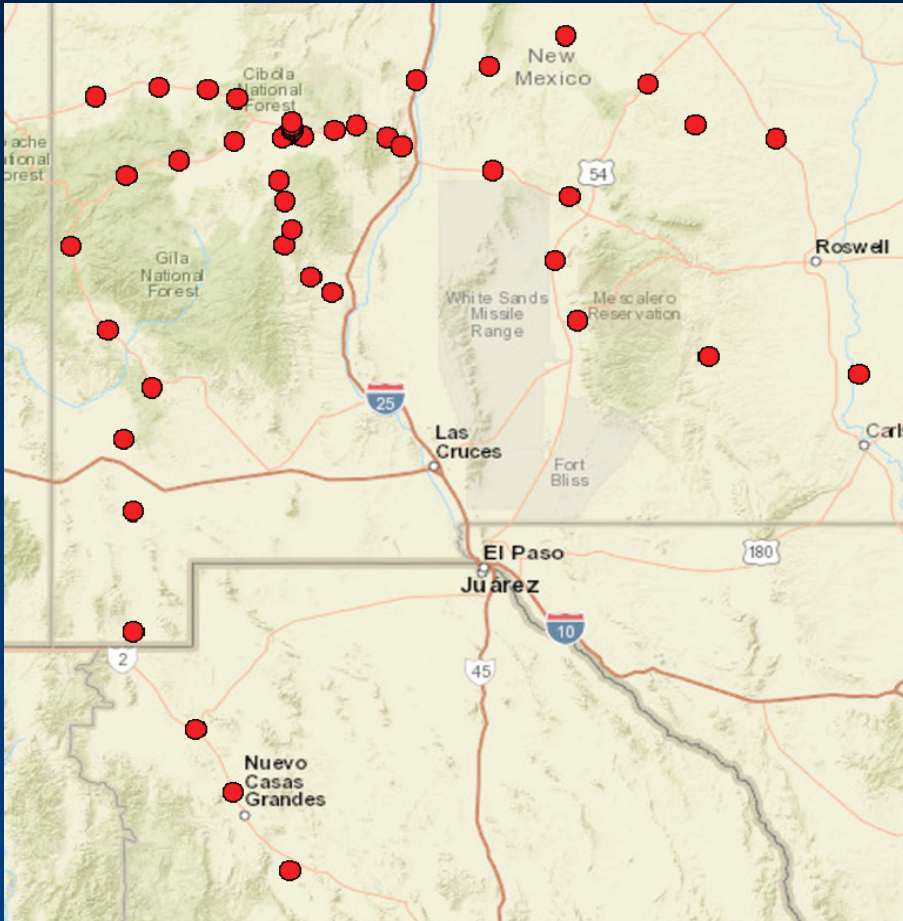
- Unprecedented continuous spatial & temporal imaging of the ionosphere
- Test and improve global ionospheric models
- High-time-resolution Imaging of Lightning

Cosmic Ray Physics

Your ideas?

All of LWA1 time is open skies.
Your observing proposals are welcome!

A Next Generation Low Band Array (ngLOBO)



- ✧ 5-150 MHz Aperture Array
- ✧ 50 stations
- ✧ ~0.1 mJy in 1 hour

Multi-frequency synthesis OFF