Design and Commissioning of an LWA Swarm Station:

The Long Wavelength Array – North Arm

C.A. Taylor, *G.B. Taylor, J. Dowell*

University of New Mexico Physics and Astronomy

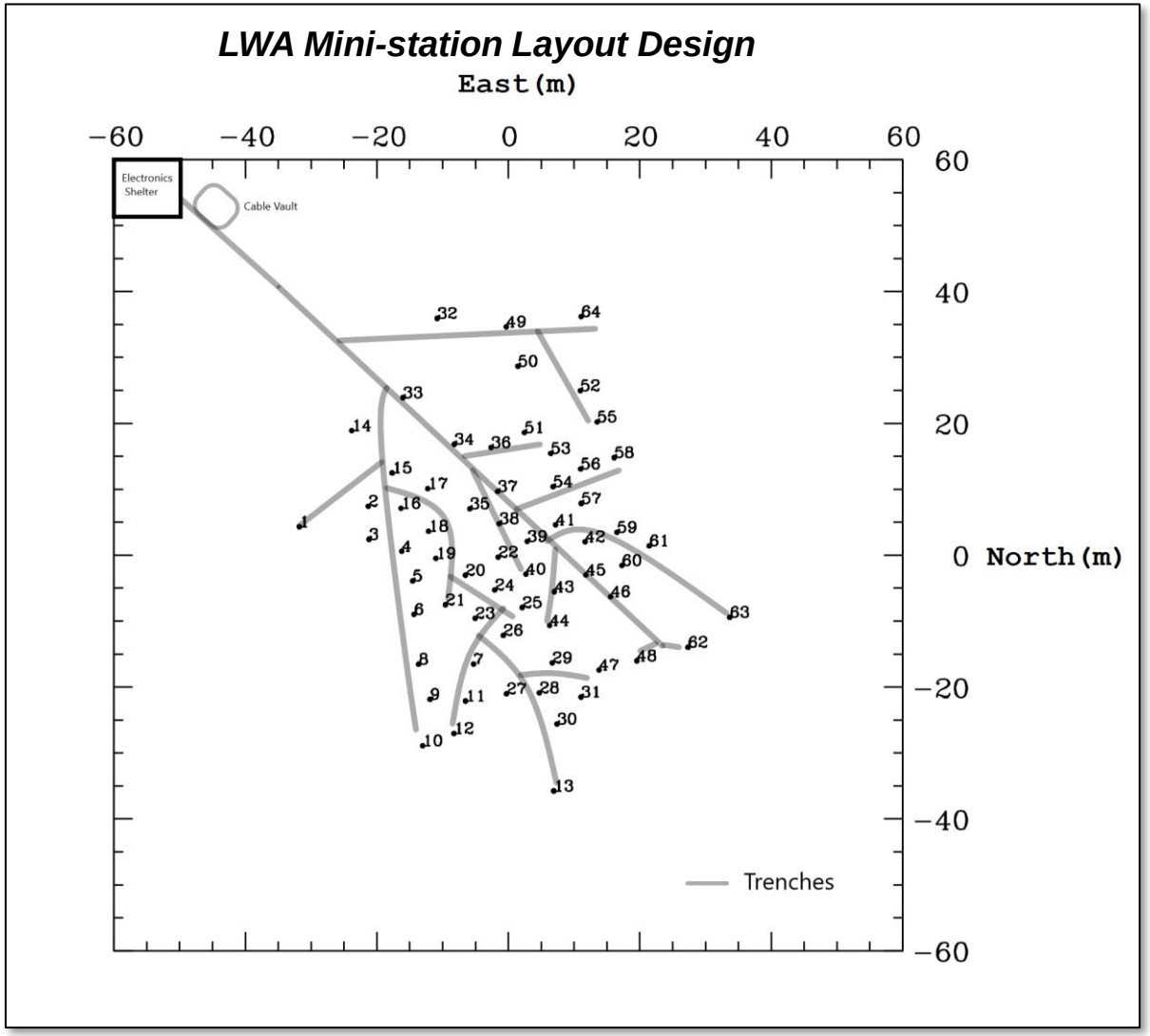
Swarm Telescope Concept

- Break up modern observatory operations into bite-sized pieces
- Distributing hardware to partner institutions to maintain and use
- Foster a community for single group and collaborative science
- Facilitated by software defined monitor and control, cooperative observing, data transport

LWA Swarm Station

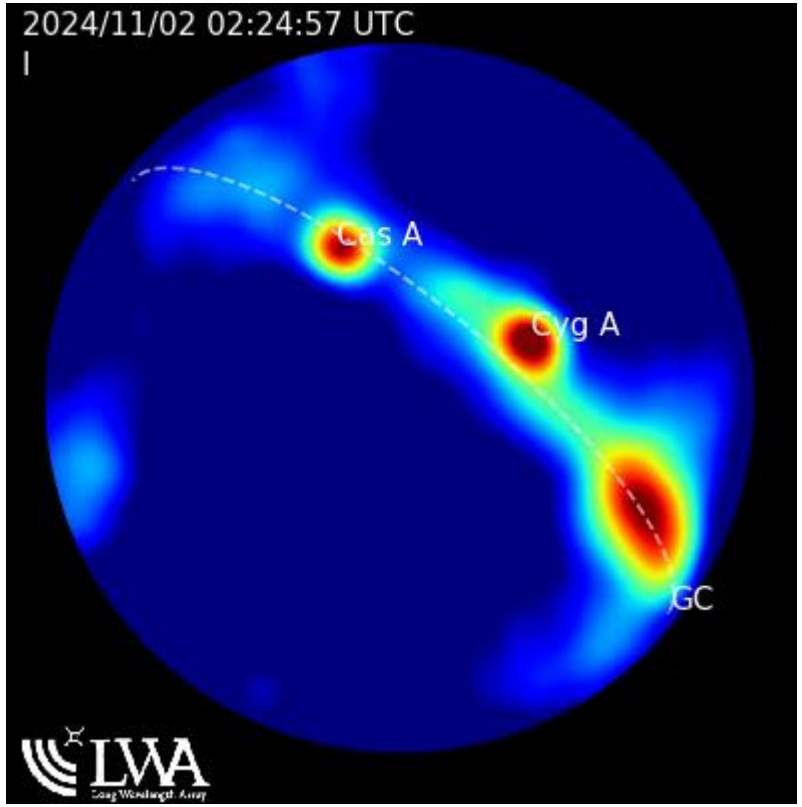
LWA – North Arm

- 64+1 dipoles in 74m x 67m
- 4 steerable beams & all-sky imaging
- Frequency coverage 3 – 88 MHz
- Incorporate commercially available hardware in construction
  - Electronics Shelter
  - SNAP2 FPGAs

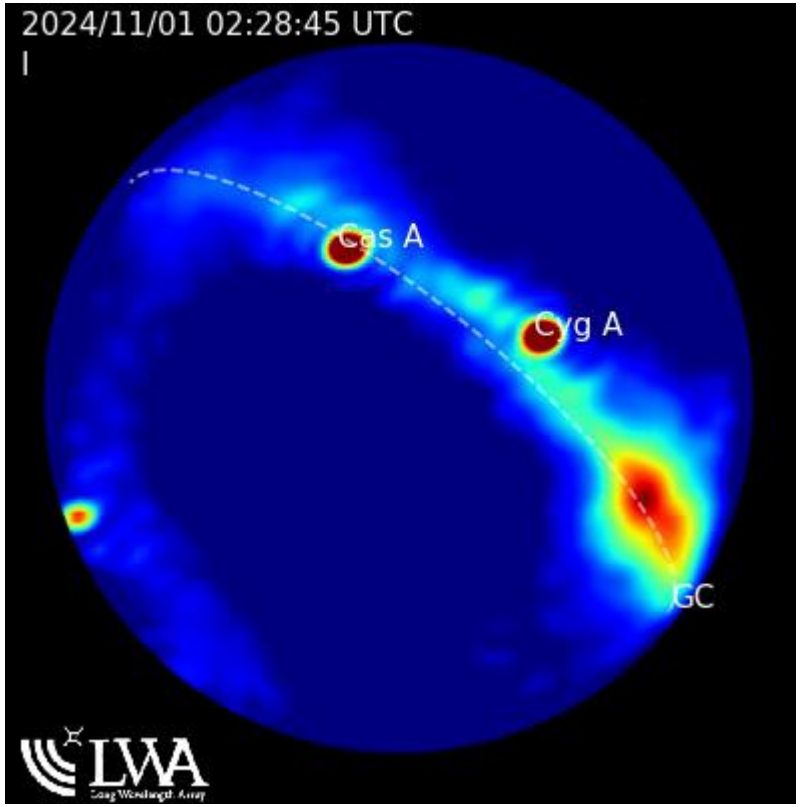


A Typical LWA-NA Sky

LWA-TV Snapshots

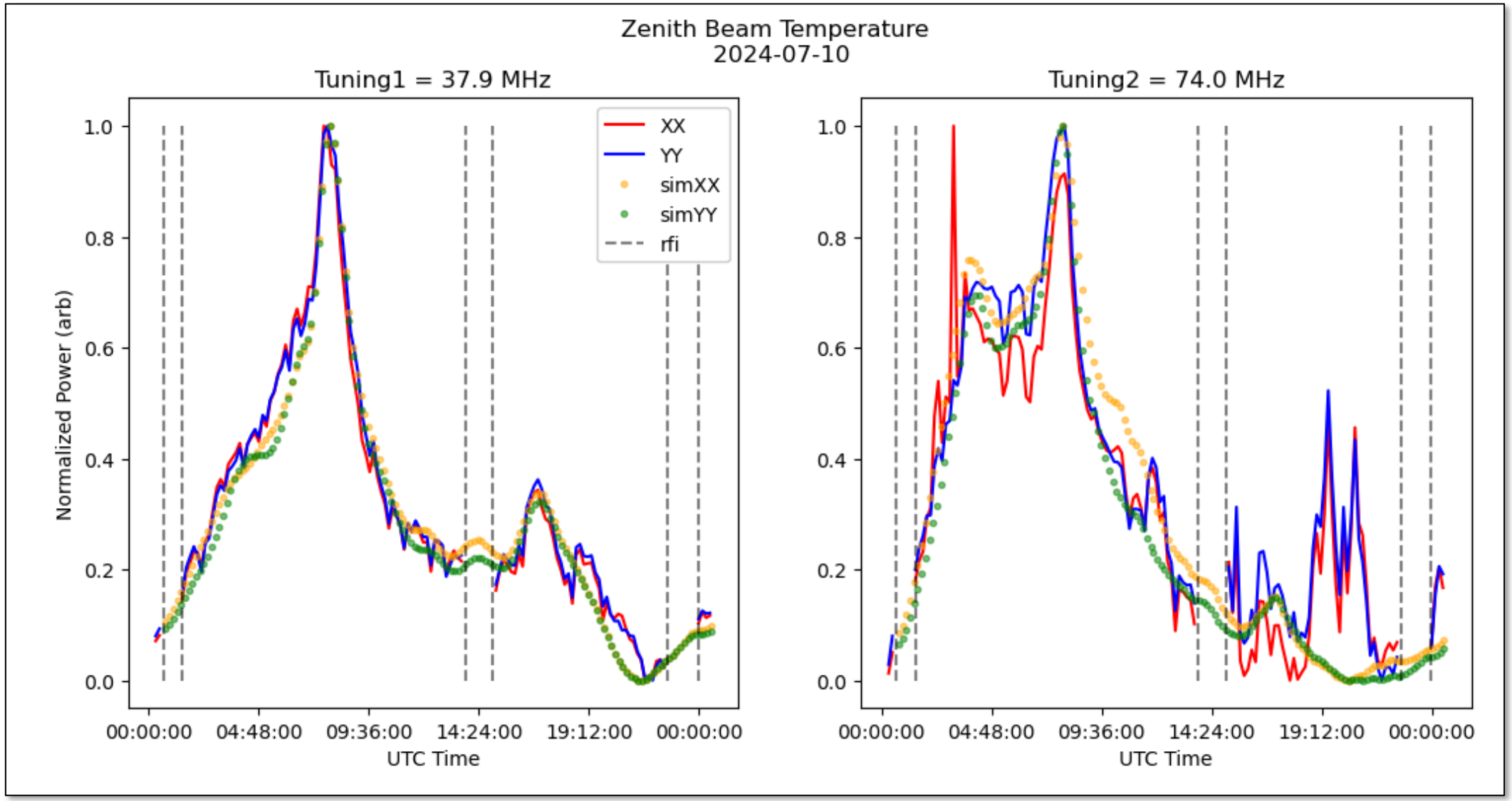


LWA-NA (N=64)



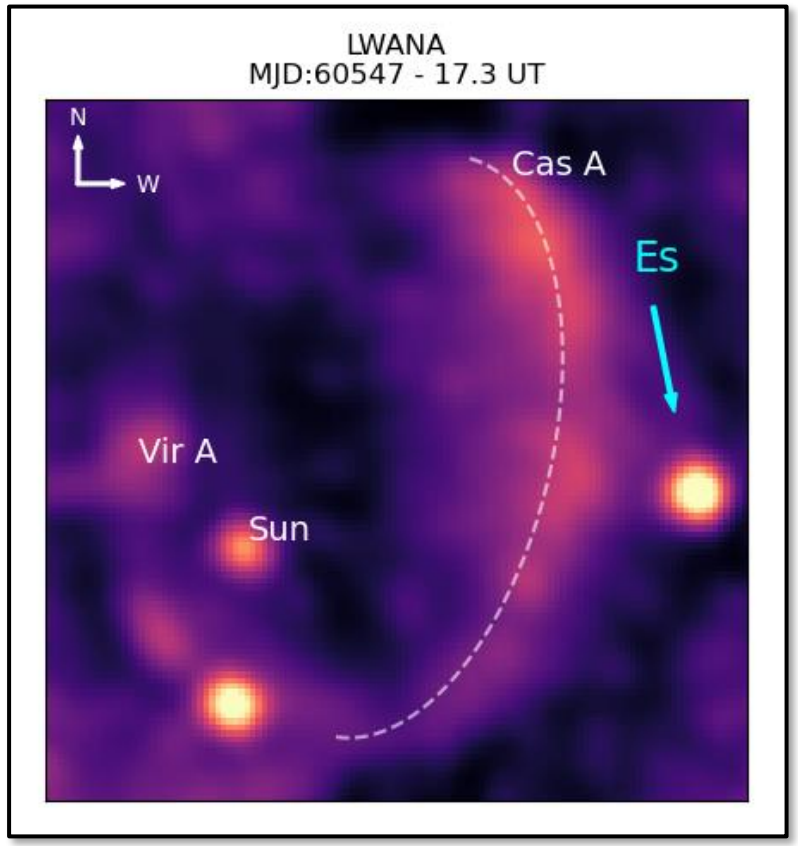
LWA-SV (N=256)

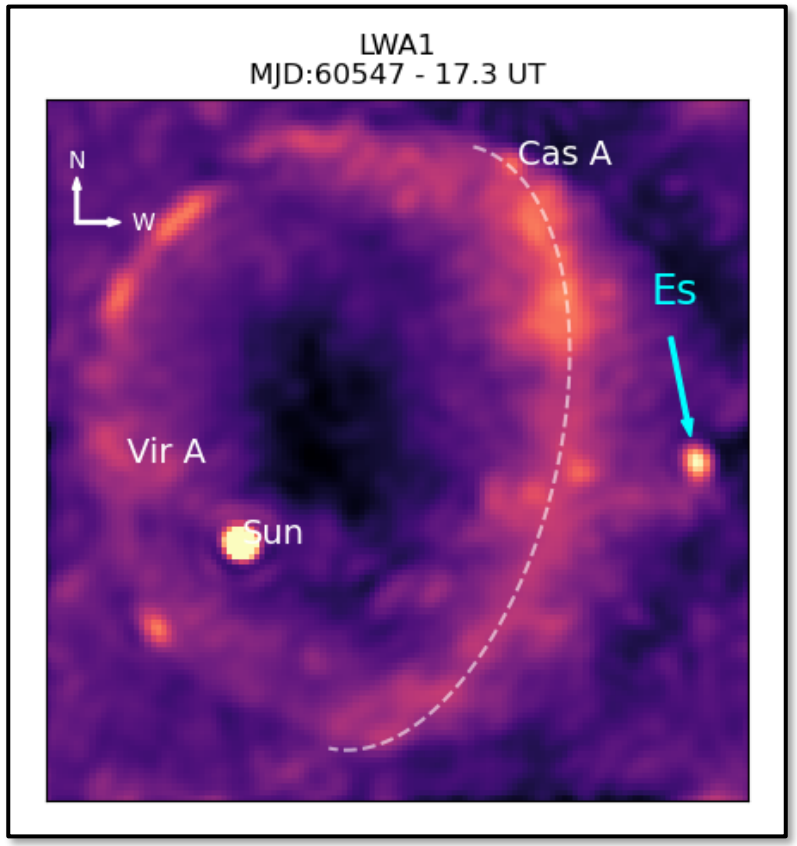
Diurnal Temperature vs LFSM

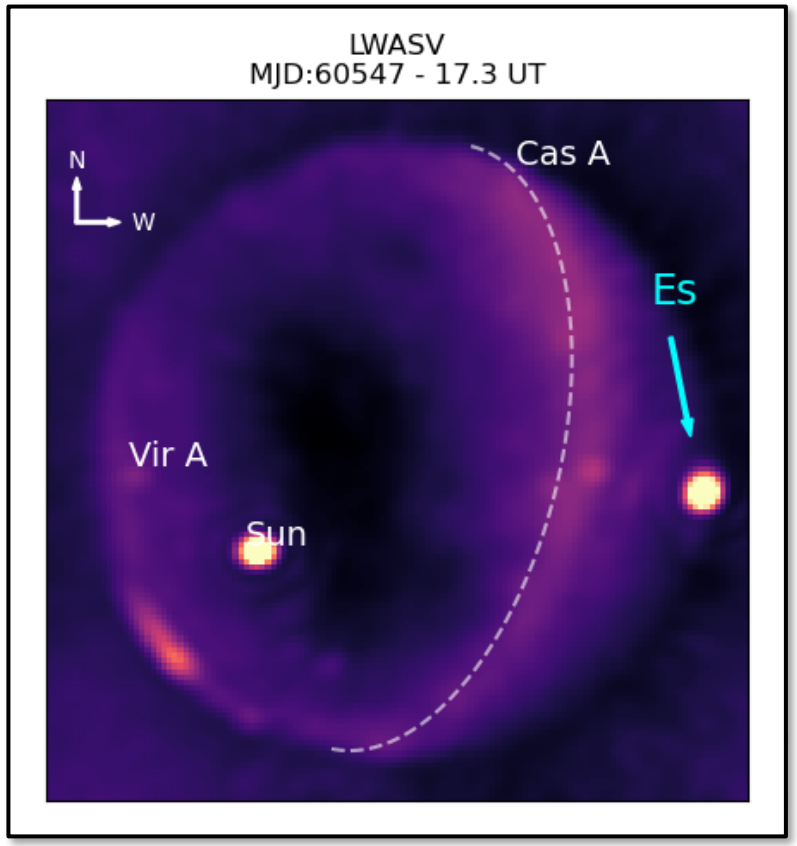


Ionosphere Science

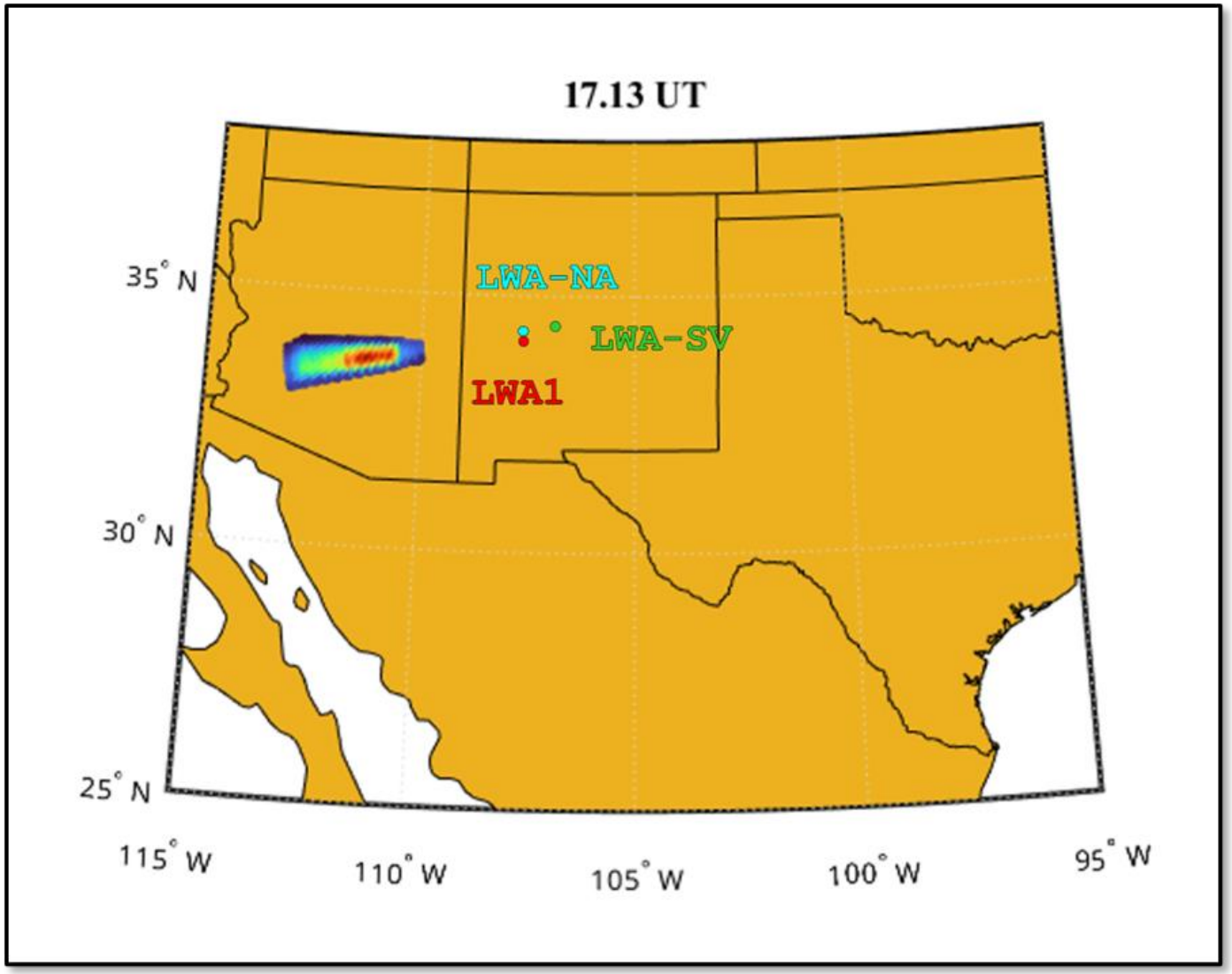
Sporadic Es are thin, transient enhancements to the electron density of the ionosphere E-region around 100km altitude



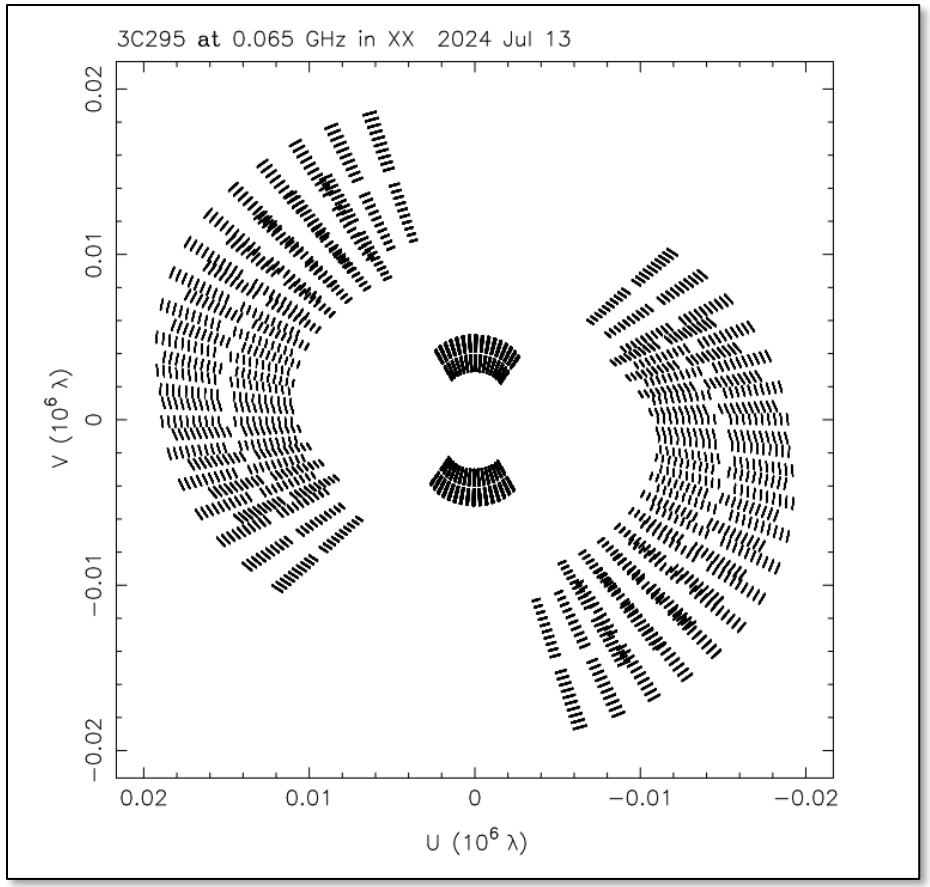


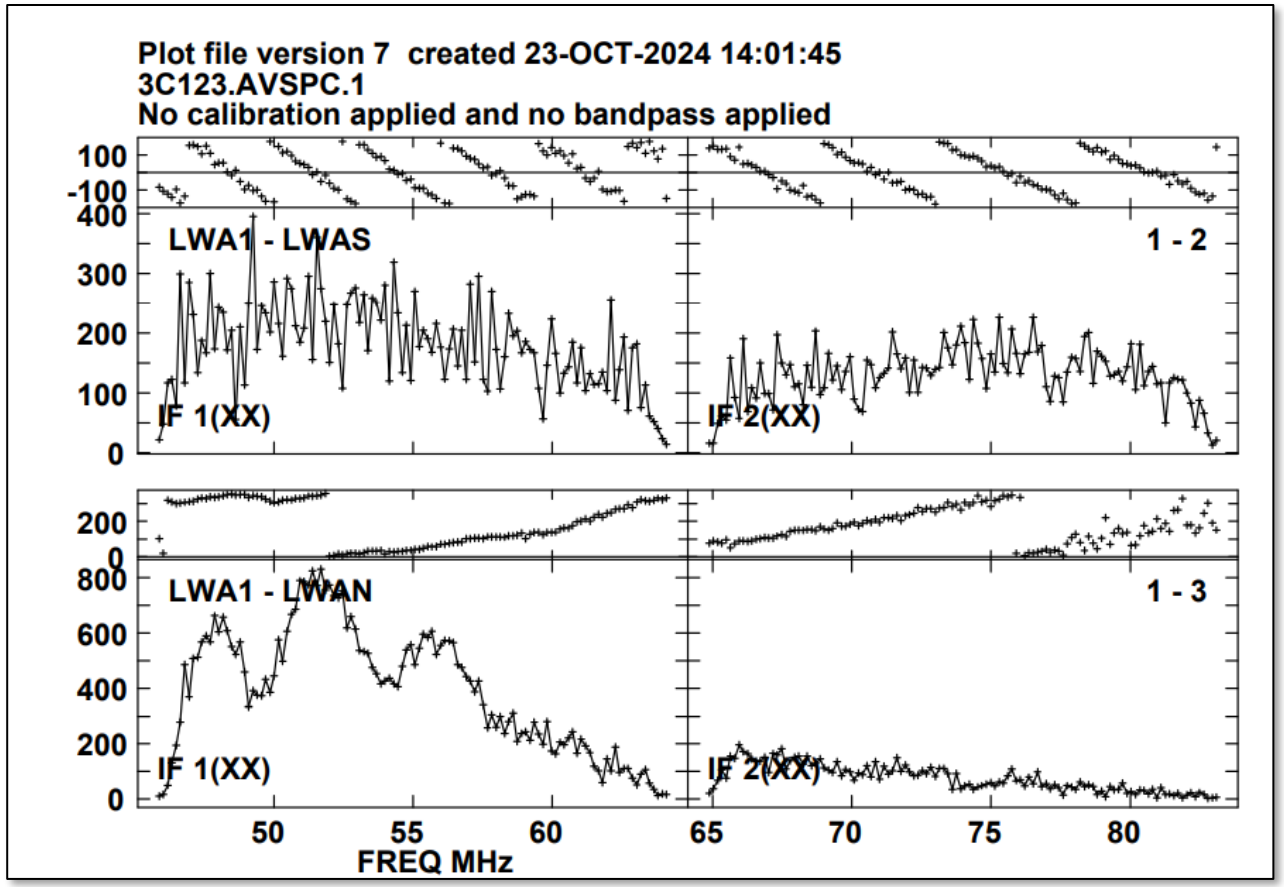


Triangulation of Sporadic Es



LWA Interferometry



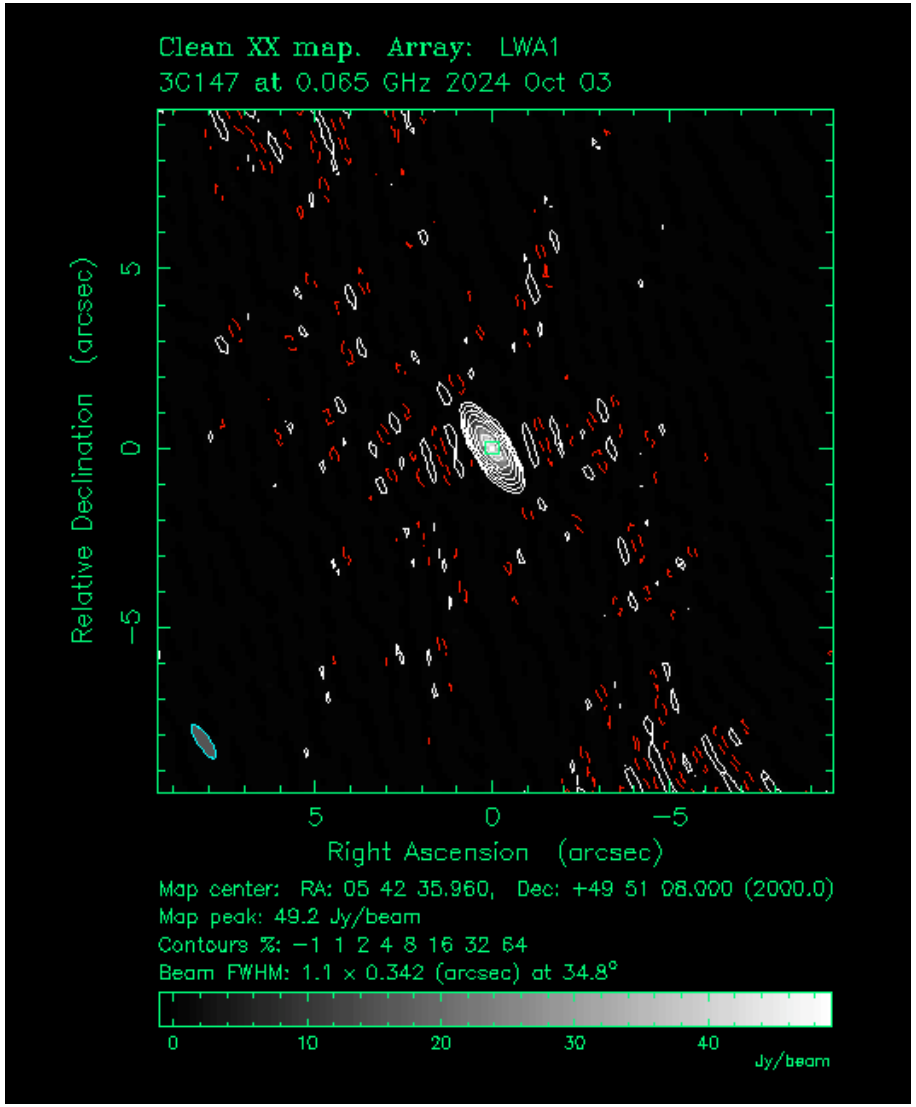


Actively observing to build up an LWA Interferometry Calibrator List using a combo of VLA Calibrators and sources from the VLSSr

LWA Interferometry

OVRO Test Observation

- Oct. 3rd 2024
- Targets: 3C147, 3C123 (resolved out)
- LWA1, LWA-SV, LWA-NA, OVRO-LWA



Upcoming Work

Coming Soon!

Journal of Astronomical Instrumentation

Design and Commissioning of an LWA Swarm Station: The Long Wavelength Array – North Arm

C. A. Taylor[1], J. Dowell[1], G. B. Taylor[1], K. S. Obenberger[2], S. I. Chastain[1], J. Verastegui[1], L. H. Cordonnier[1], P. Kumar[3], E. Sheldahl[1], S. Bruzewski[4], T. Dolch[5,6] and C. Siders[1]

[1] *University of New Mexico, Department of Physics and Astronomy, Albuquerque, NM, USA*
[2] *Air Force Research Laboratory, Space Vehicles Directorate, Kirtland AFB, NM, USA*
[3] *Curtin Institute of Radio Astronomy, Curtin University, Perth, WA, Australia*
[4] *United States Naval Observatory, Washington, DC, USA*
[5] *Hillsdale College, Department of Physics, Hillsdale, MI, USA*
[6] *Eureka Scientific, Oakland, CA, USA*

Next Steps for the Swarm

Current and in-development LWA Swarm Stations

Upcoming Work

- LWA-NA and future deployments will improve sensitivity and resolution of interferometry observations

- New Stations Coming Soon:
  - Meteor Crater National Landmark (ASU)
  - Comanche Springs Astronomy Campus (TTU)

- Major upgrades to LWA1 and LWA-SV coming in 2025

- Swarm Correlator upgrade (ATI proposal)

Next Steps for the Swarm

Current and under development LWA Swarm Stations

Overflow Slides

Long Wavelength Array (LWA)

Standard LWA Station

- 256 dual-polarization dipole antennas distributed over 110m x 100m
- Multiple steerable beams and all-sky imaging
- Frequency coverage from 10 – 88 MHz
- Controlled using LWA Software Library

LWA station located on the Sevilleta National Wildlife Refuge (LWA-SV)

Building an LWA Swarm

The LWA system is well equipped to approach this observatory architecture.

- Quickly deployable platform for radio astronomy
- Already equipped for autonomous M&C
- Development of an LWA swarm is already underway!

LWA Swarm Station

LWA – North Arm

- 64+1 dipoles in 74m x 67m
- 4 steerable beams & all-sky imaging
- Frequency coverage 3 – 88 MHz
- Incorporate commercially available hardware in construction
  - Electronics Shelter
  - SNAP2 FPGAs

Aerial view of LWA-NA Site

Construction

May 2022:

Site Survey and Mast Install

Nov. 2022:

Electronics Shelter deployed

May-Aug 2023:

Trenching and Cabling

Sept - Oct 2023:

Antenna Assembly

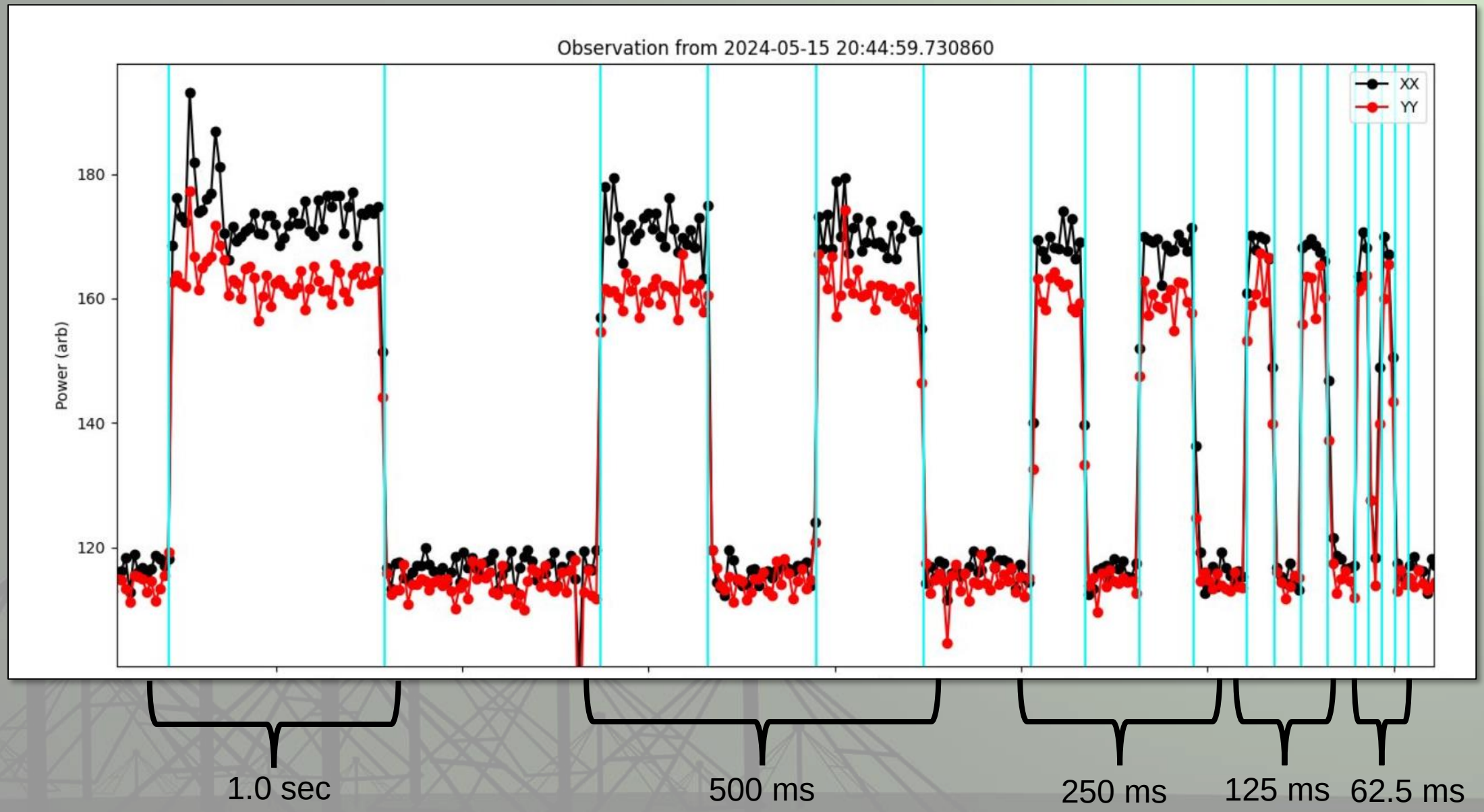
Nov. 2023:

On sky!

Commissioning Observation Highlights

- Diurnal Temperature Variations
- Transient Response Testing

Transient Response Test

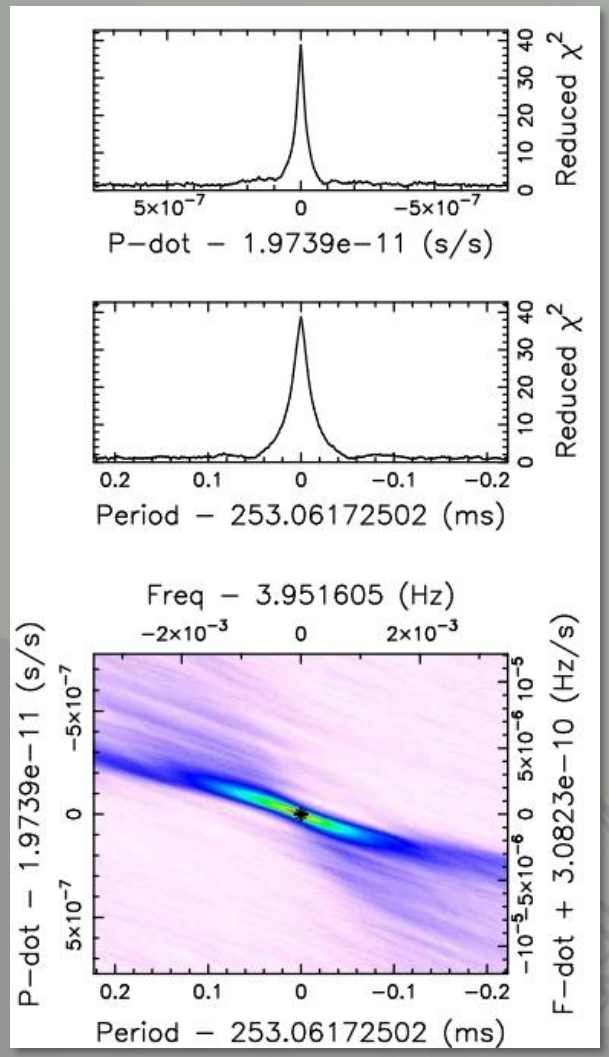


Preliminary Science Observing Tests:

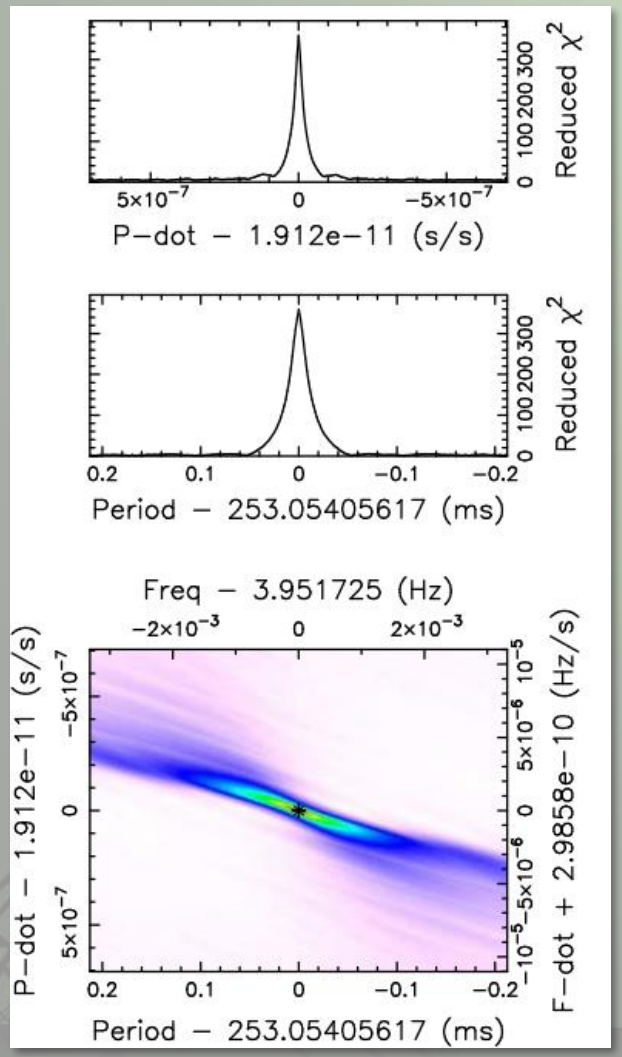
- Pulsars
- Sporadic Es
- LWA Interferometry

Pulsar Comparison: B0950+08 (74 MHz)

LWA-NA (24/08/28)



LWA-SV (24/09/16):



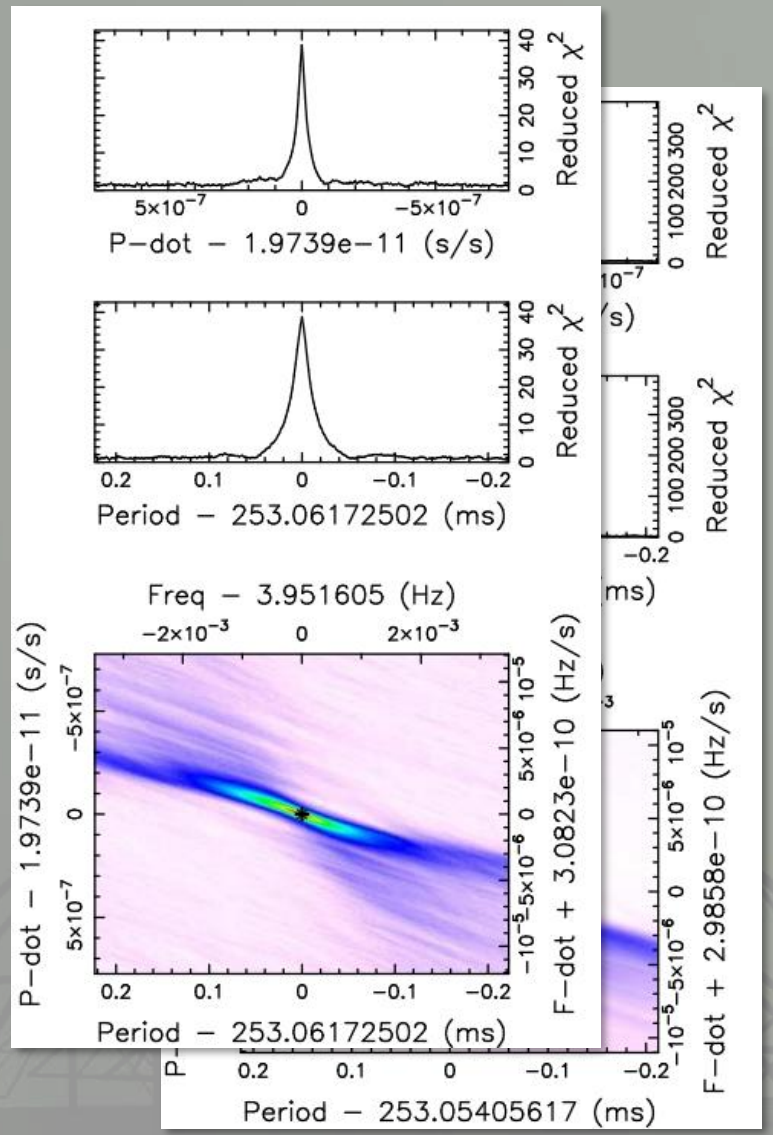
$\dot{P}$ vs χ^2 at optimal DM

P vs χ^2 at optimal DM

$P - \dot{P}$ surface

prepfold plots produced using PRESTO (Ransom 2001)

Pulsar Comparison: B0950+08 (74 MHz)



Pulsar Radiometer Equation (Lorimer & Kramer)

$$\Delta S = \frac{1}{\eta_c} \frac{SEFD}{\sqrt{n_p \Delta\nu \times t_{acc}}} \sqrt{\frac{W_{eq}}{P - W_{eq}}}$$

Station	***LWA-NA***	***LWA-SV***
SNR	45.4σ	145.7σ
Calculated SEFD	44.9 kJy	19.5 kJy
Station Cygnus-A SEFD	43.6 kJy	15.8 kJy

Abstract:

Design and Commissioning of an LWA Swarm Station: The Long Wavelength Array -- North Arm

The 'swarm telescope' concept proposes to decentralize observatory facilities into a collection of independently managed, but autonomous, elements that form a more flexible and powerful instrument when used in concert. To this end, the Long Wavelength Array (LWA) Swarm aims to build a low-frequency long baseline radio interferometer by deploying LWA stations to host institutions for individual single-station science or use in cooperation with other swarm sites for VLBI observations. Here we present the design, construction, and commissioning of the Long Wavelength Array -- North Arm (LWA-NA) station, a prototype 64-element LWA swarm telescope. LWA-NA is a cost-efficient, rapidly deployable platform for radio astronomy, and serves as a pathfinder for future LWA Swarm sites. Including two funded LWA swarm stations under development in collaboration with Arizona State University at Meteor Crater National Monument and with Texas Tech University at their Comanche Spring Astronomy Campus.