Commissioning, Operations, and early results for the LWA1 Radio Observatory

Joe Craig - University of New Mexico
On behalf of the LWA1 Radio Observatory

URSI NRSM
Jan. 4, 2012

The LWA1 Radio Observatory

- **Frequency Range: 10-88 MHz**
- **4 beams x 2 pol. x 2 tunings x 16 MHz**
- **2 all-sky transient obs. modes**

- **"LWA1" starting scheduled observations, Feb 2012.**
- **LWA1 Radio Observatory is a funded University Radio Observatory.**
- **Second small station at the end of the VLA North-Arm.**

The LWA1 Station

- 256 dual-polarization "stands"
- D = 100 m, pseudo-random distribution
- Outrigger @ 300 m baseline for calibration
- SEFD ~ 3 kJy (zenith)
- S_{min} ~ 5 Jy (5 sigma, 1 sec, 16 MHz, zenith)

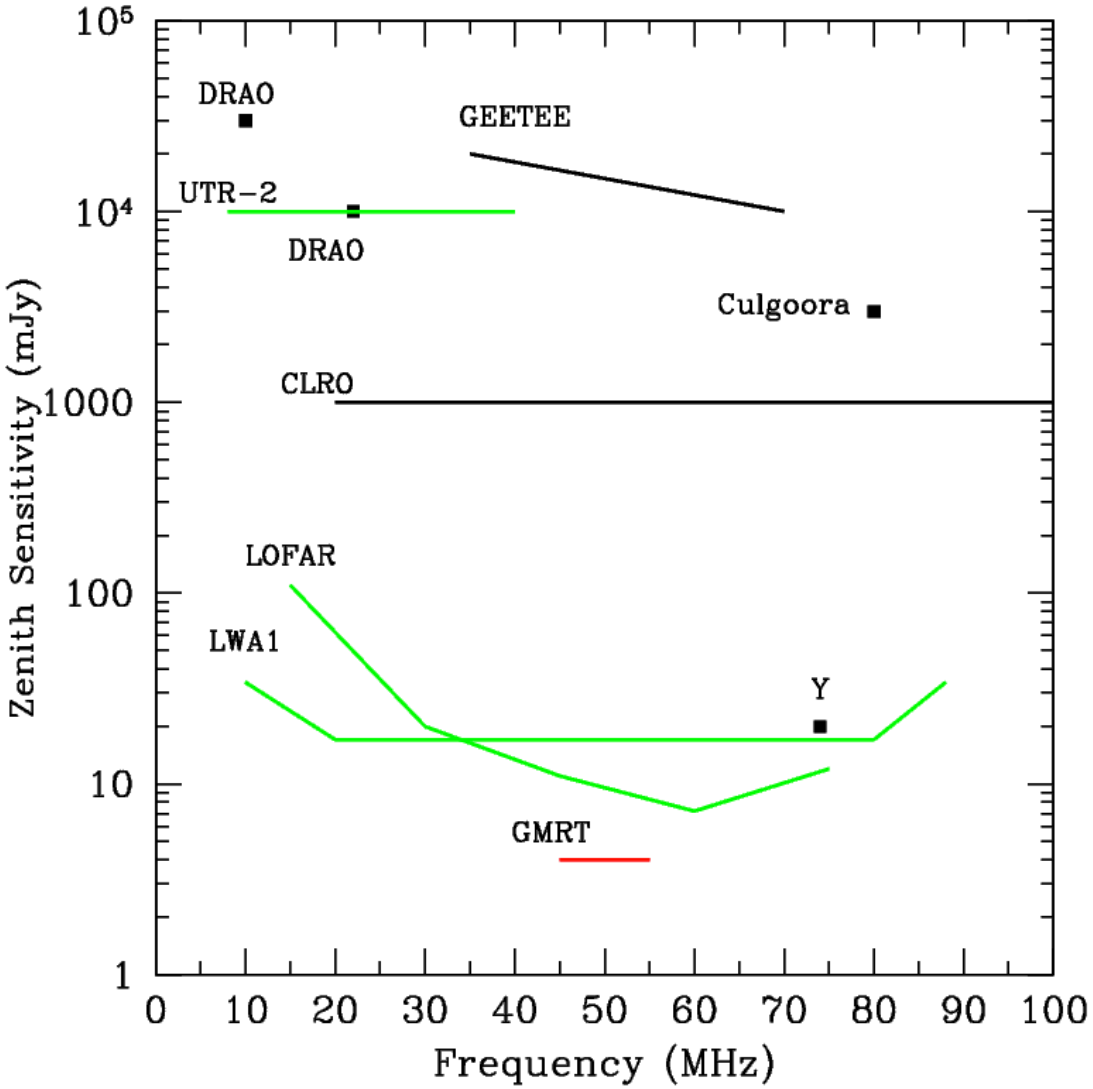
- 4 x Simultaneous Beams
  - 2 pol. x 2 tunings
  - Up to 16 MHz of bandwidth each tuning
  - Rapid pointing ~ 10 ms

- All-Sky (all dipoles) modes:
  - TBN - 67 kHz; continuous
  - TBW - 78 MHz; 61 ms bursts

LWA-1 science emphasis: Transients, Pulsars, Sun, Jupiter, & Ionosphere

Additional Science Programs: Cosmic Dawn/Dark Ages, Hot Jupiters, Radio Recombination Lines, ...

Comparison to other Instruments



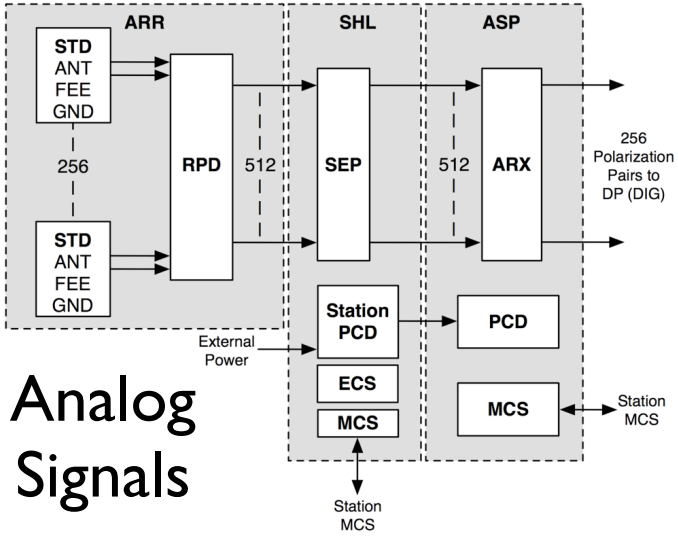
	Declination Range	Δν (MHz)
UTR2:	-30° to +60°	33
LOFAR:	-11° to +90°	3.6
Y=VLA:	-35° to +90°	3
LWA1:	-30° to +90°	16
GMRT:	-53° to +90°	10

Integration times of 1 hour. No effects of confusion noise are considered.

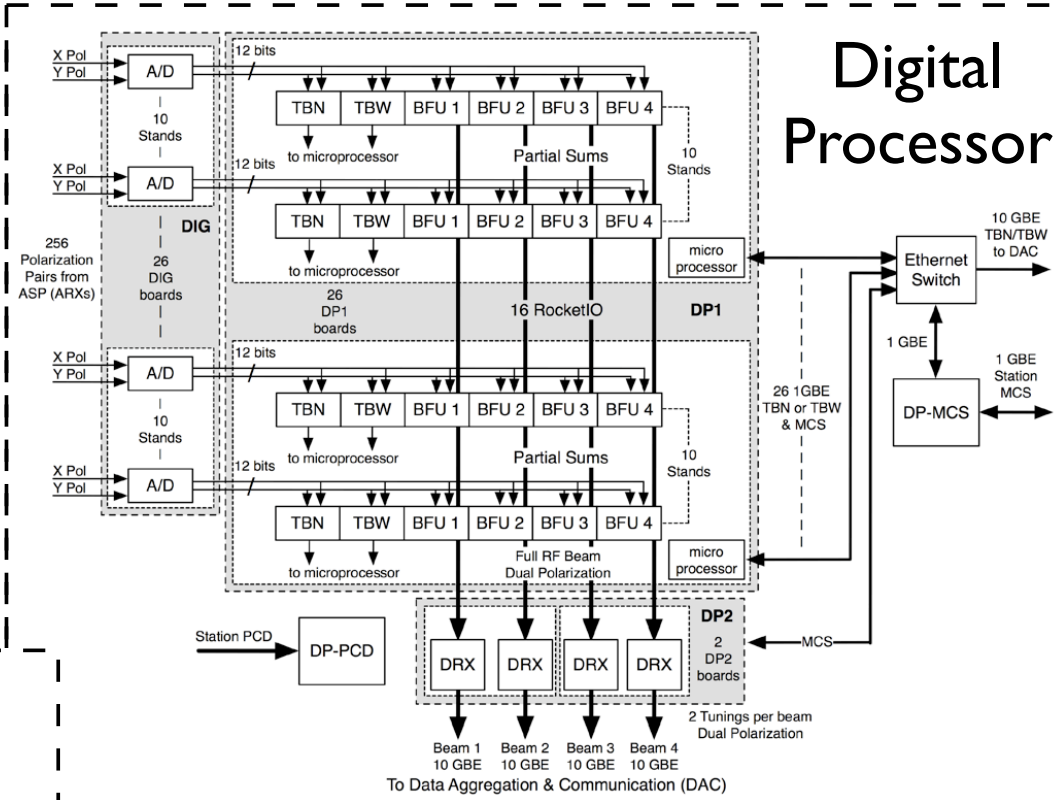
*** Assumes 36 stations consisting of 96 antennas each, of which only 48 can be used simultaneously, for a total of 1728 antennas. LOFAR antenna system temperatures are 1:1, whereas LWA antennas are 4:1.**

LWA1 has comparable sensitivity to all of LOFAR*

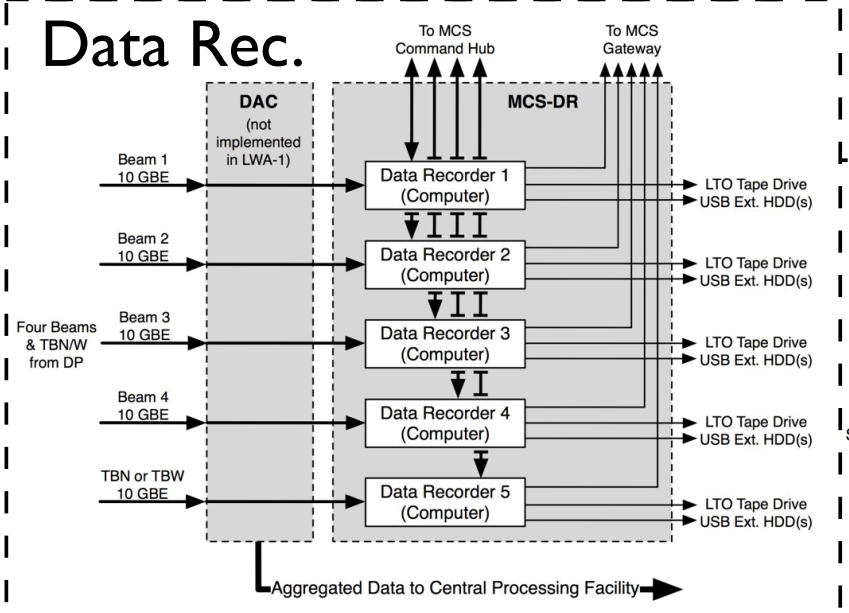
Station Architecture



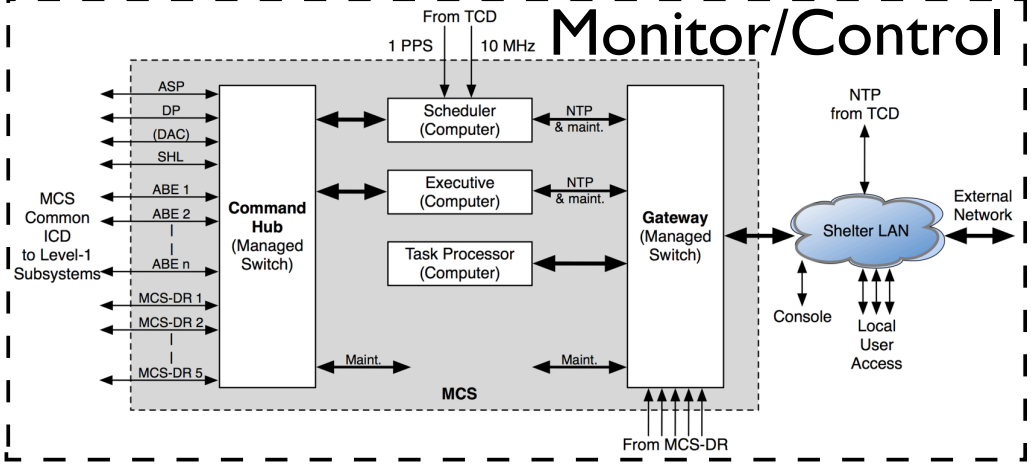
Analog Signals



Digital Processor



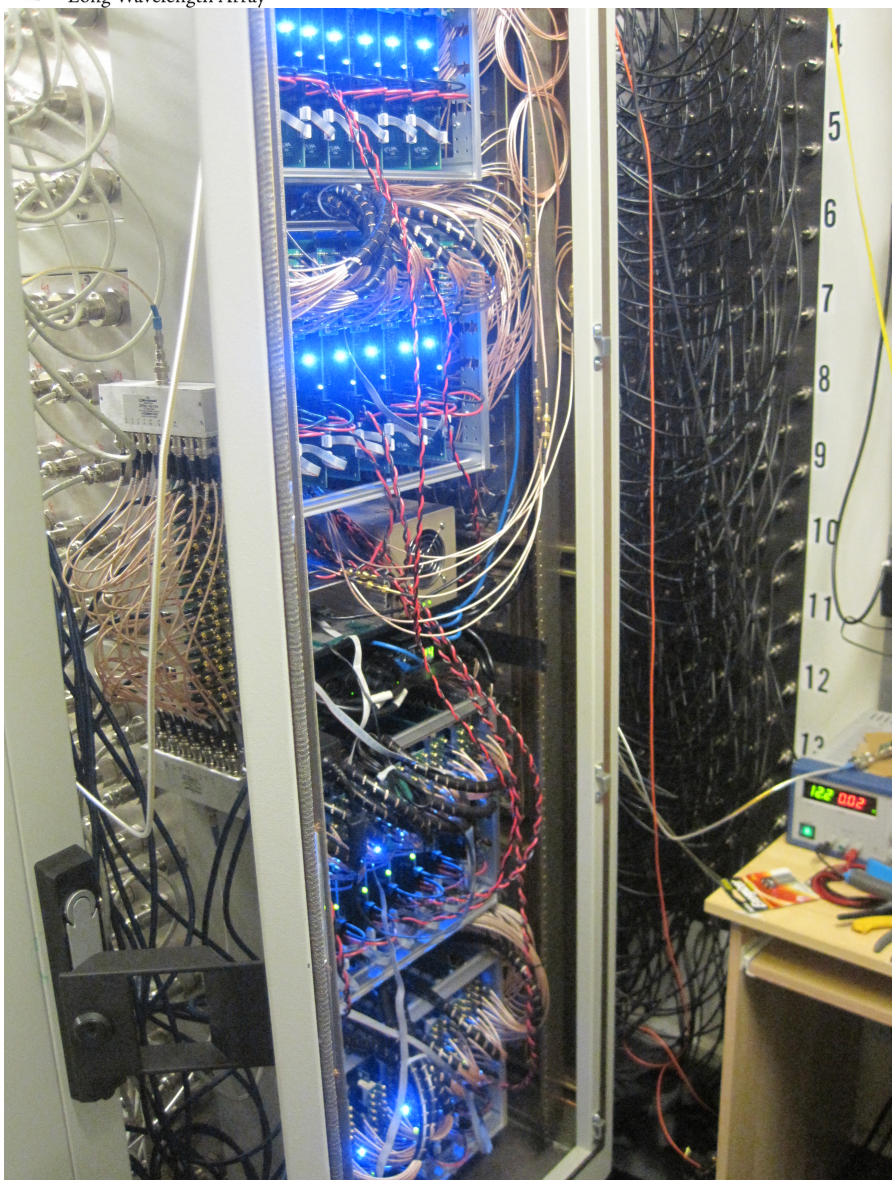
Data Rec.

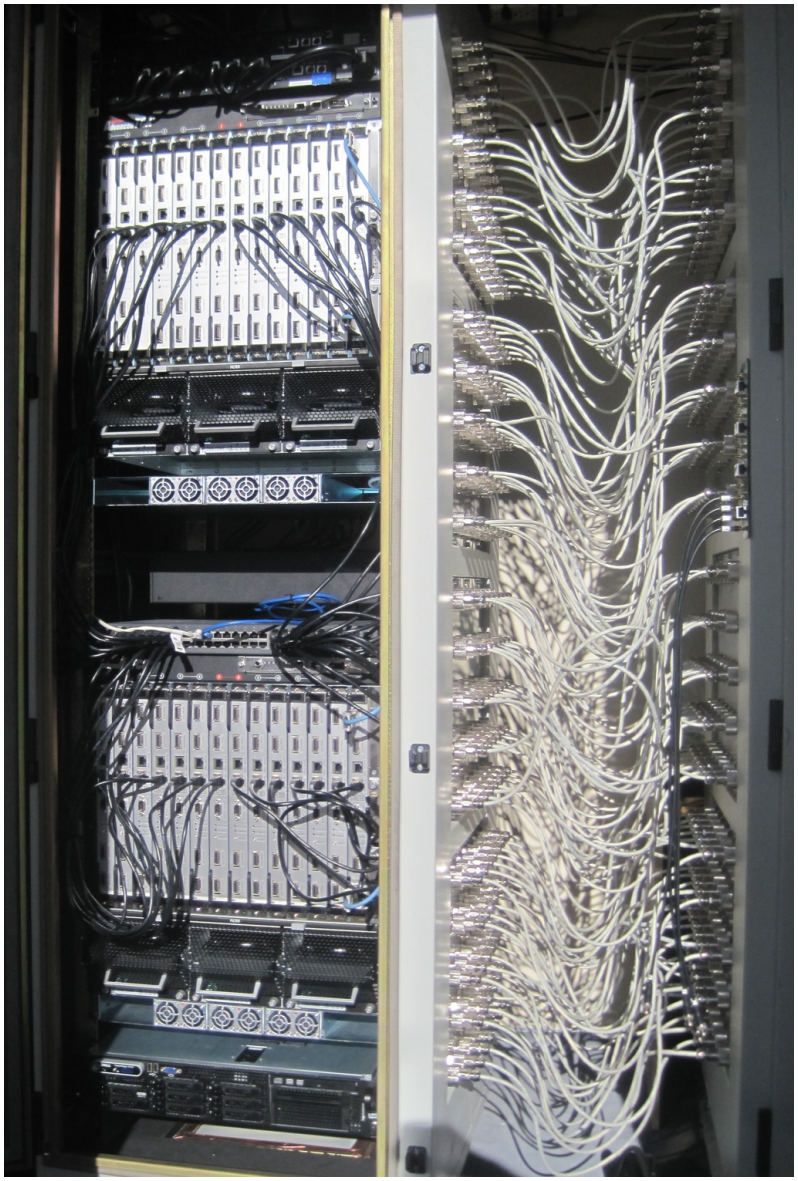


Monitor/Control

LWA
Long Wavelength Array

As-Built Station

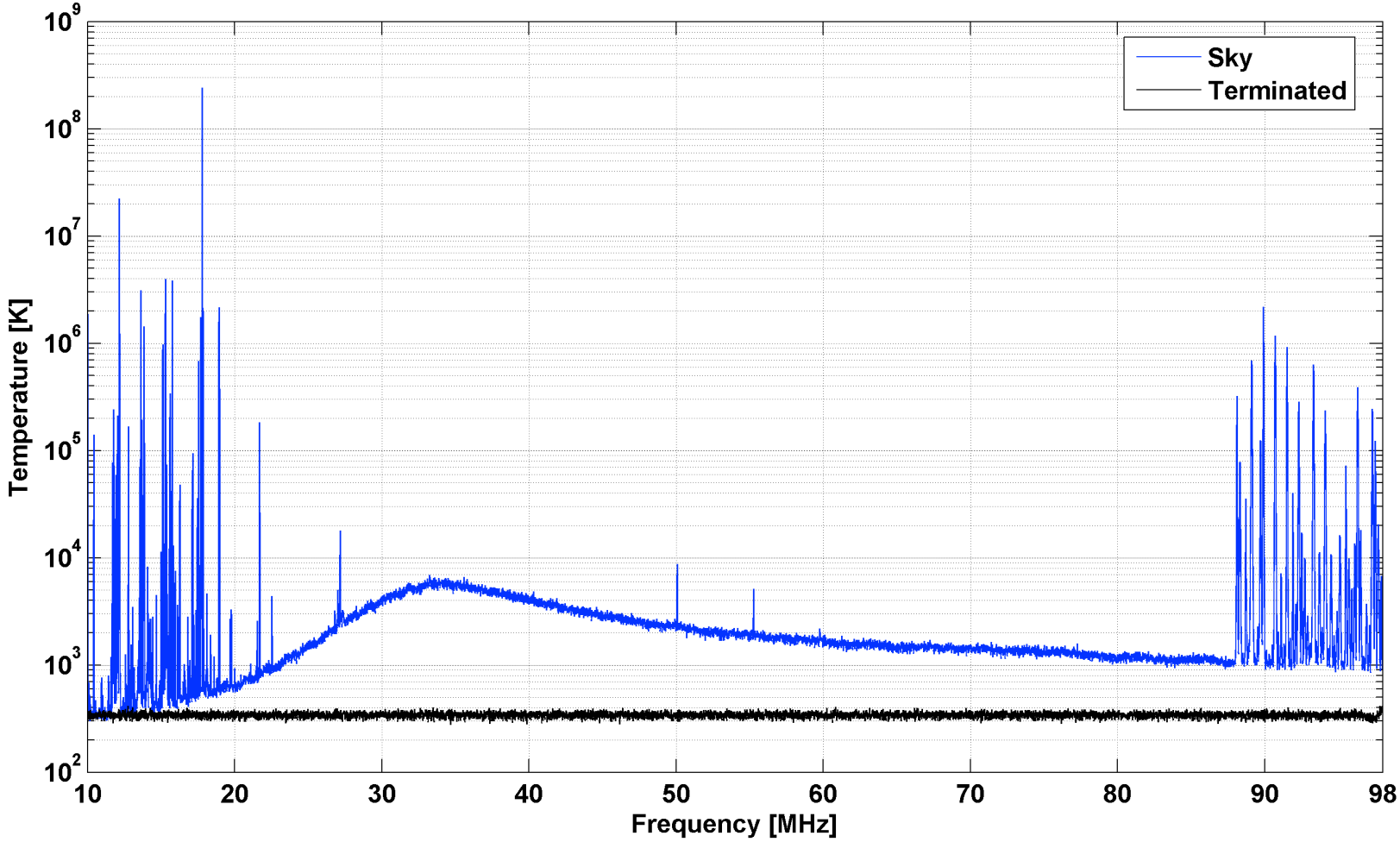




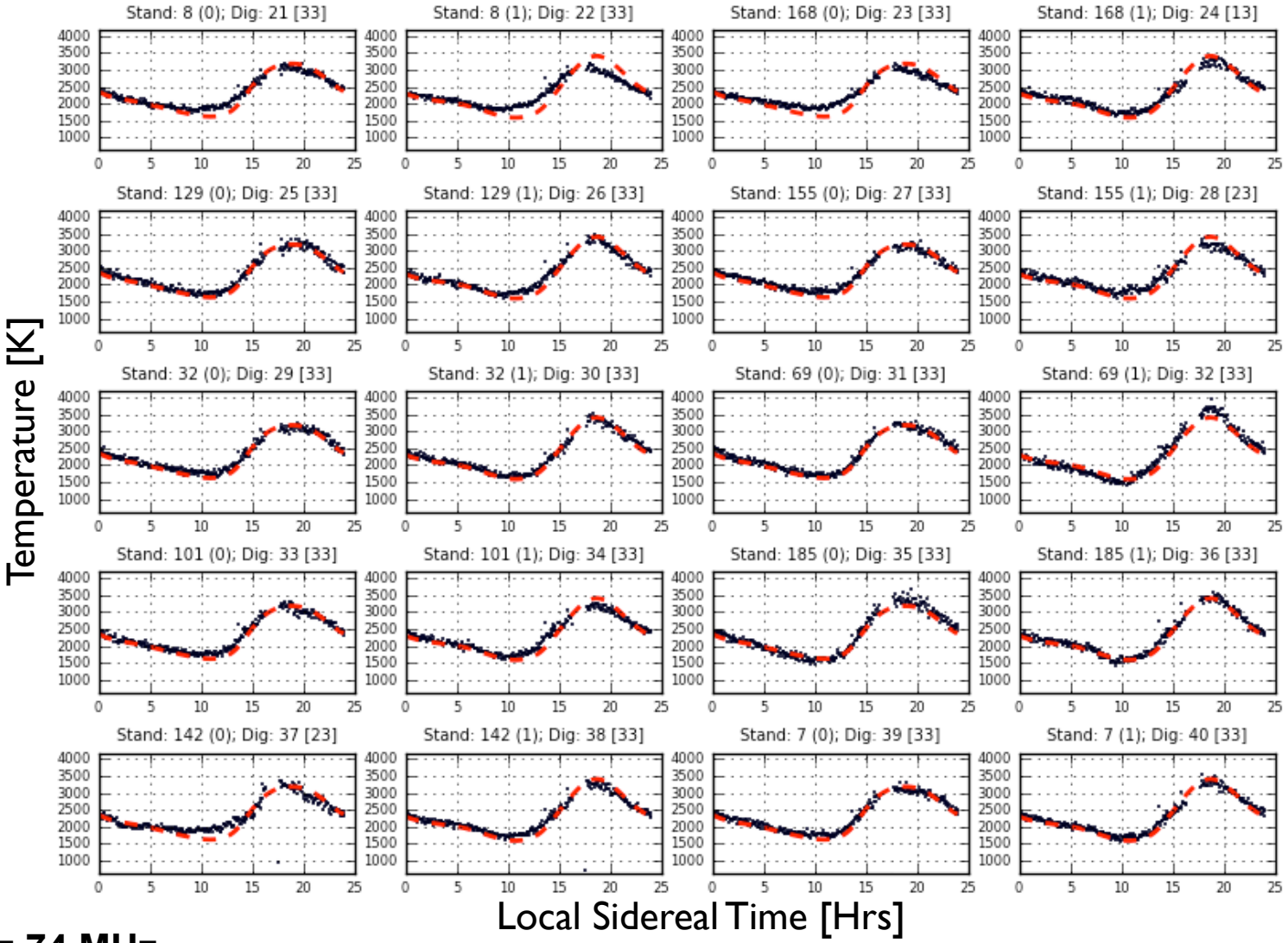
Every dipole is digitized for flexible beamforming & "all-dipole" modes.

Antenna Temperature

- **Captured with production antenna thru digitizer, 12-bits @ 196 MSPS**
- **10 seconds of integration captured between 12:30 PM and 2:30 PM (local time)... worst time for RFI below 30 MHz**
- **6 kHz spectral resolution**

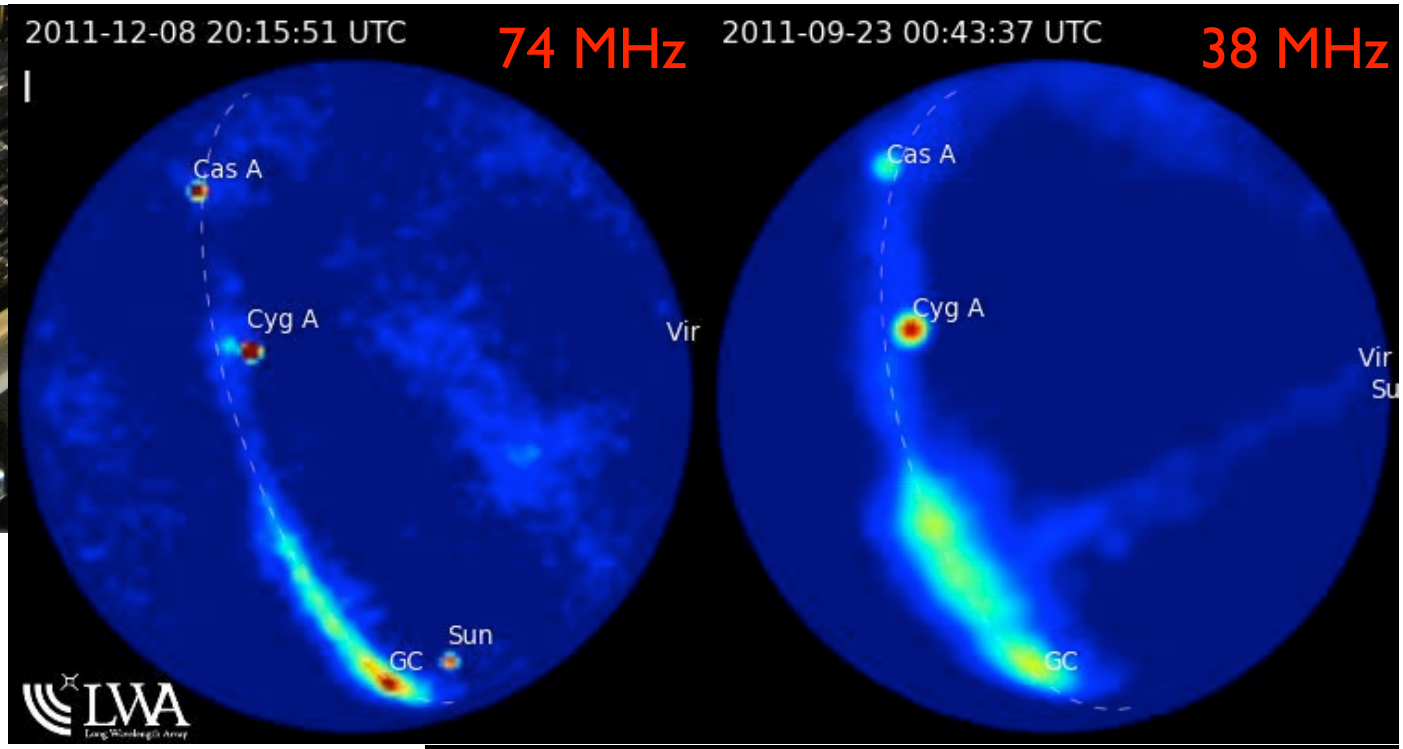


Dipole Drifts - TBW



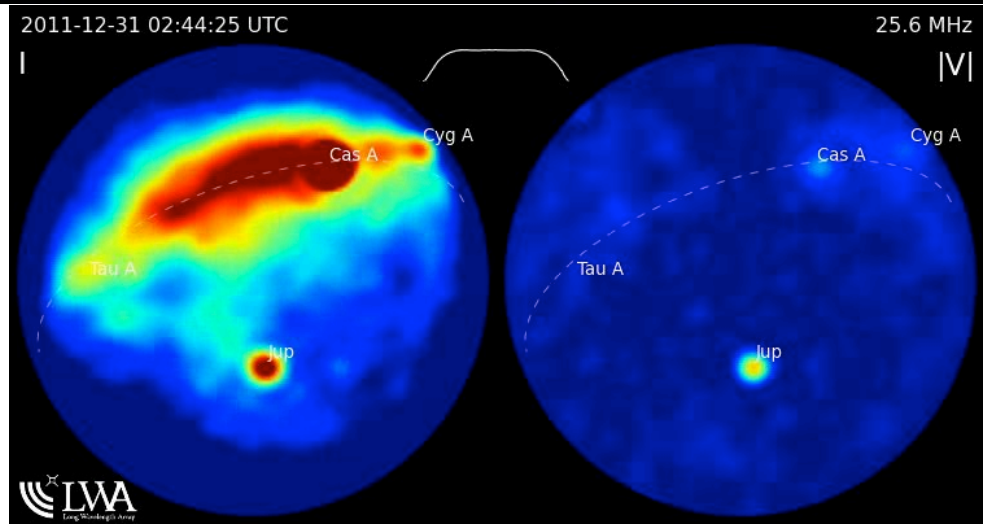
- **Fc = 74 MHz**
- **T_int = 61 msec, every 4 min**
- **Red = Modeled sky temperature with simulated antenna pattern**

All-Sky Imaging - TBN



- PASI (Prototype All-Sky Imager) is a backend to the LWA1's digital processor
- Receives the TBN data stream: continuous 100 kSPS data from all the dipoles

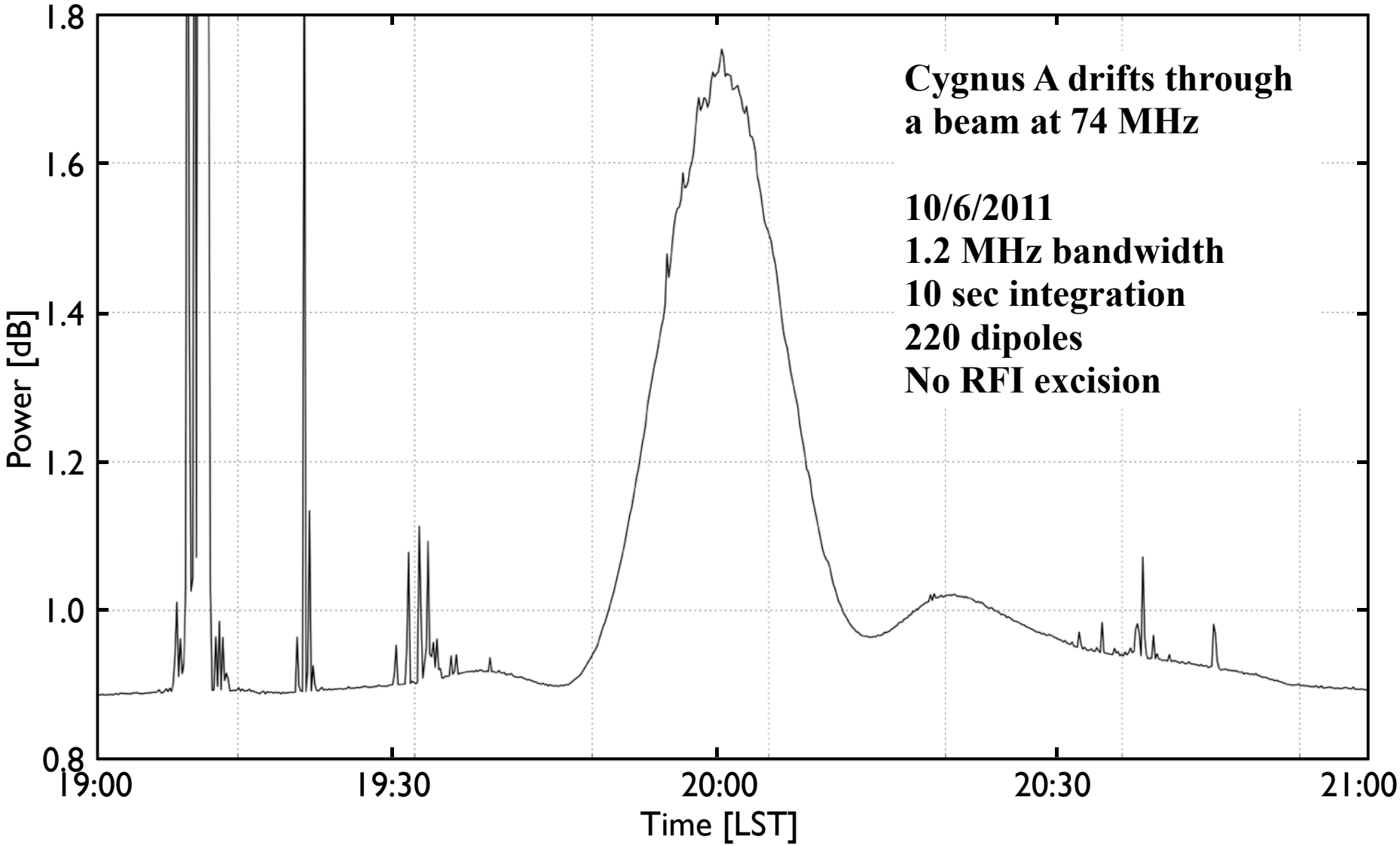
Imaging
5 sec, 75 kHz



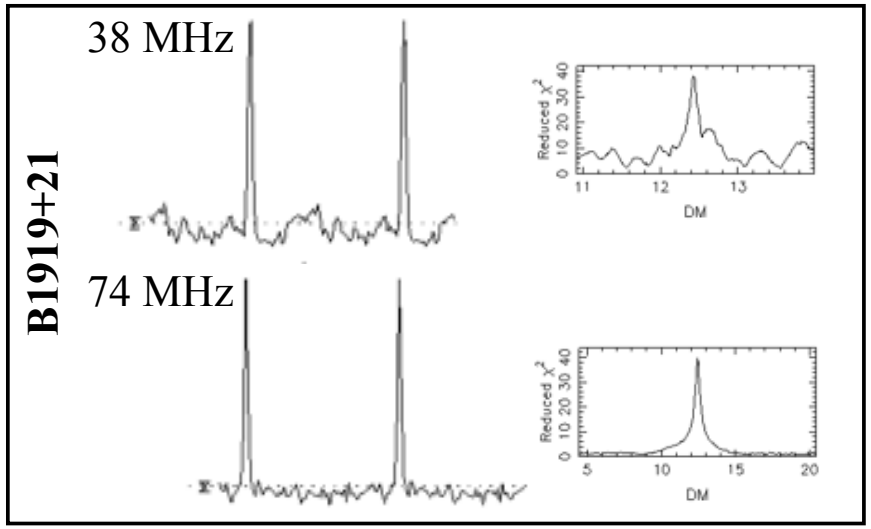
- Using a software FX correlator, PASI images most of the sky (≈1.5 π sr) *many times per minute at 100% duty cycle*

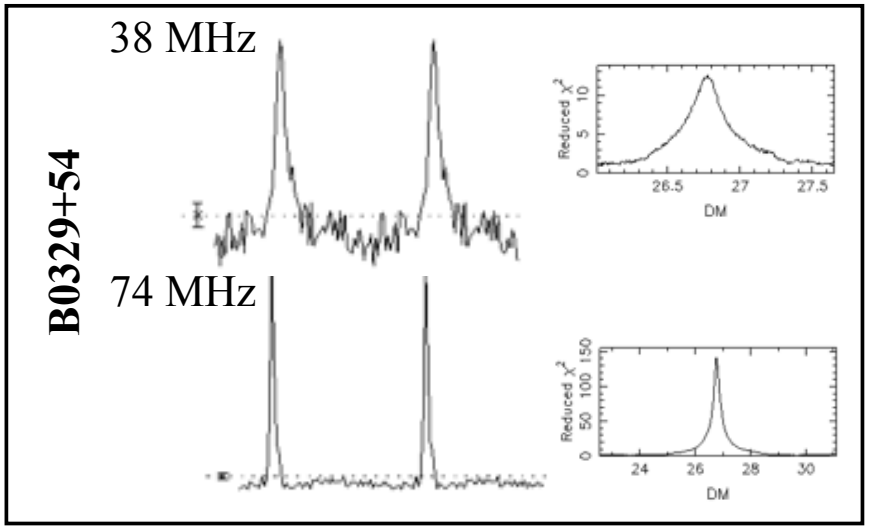
See LWA TV Live at http://www.phys.unm.edu/~lwa/lwatv.html

Cygnus A Drift Scan



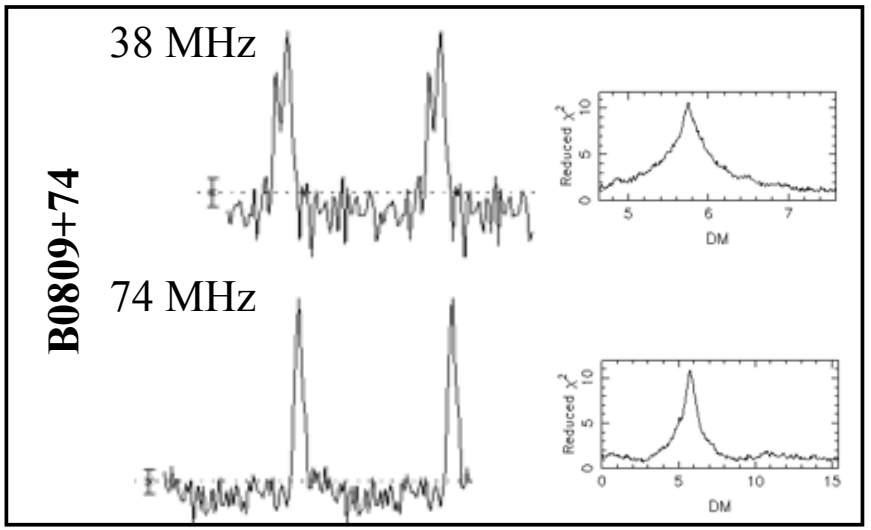
First Pulsar Detections





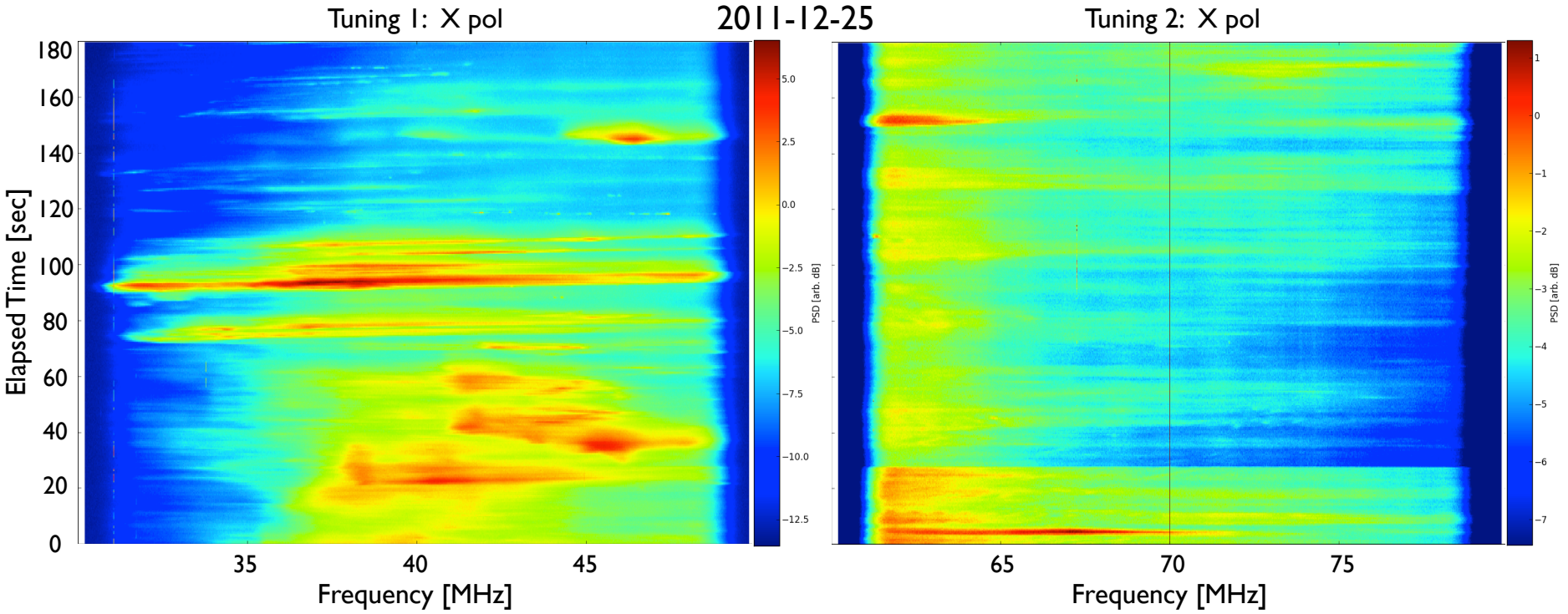
Observation Parameters

- 20 min, 19.6 MSPS (~16 MHz of BW) at each tuning
- Tunings at 38 MHz & 74 MHz
- Folding, de-dispersion, averaging with PRESTO-prepfold
- No RFI excision

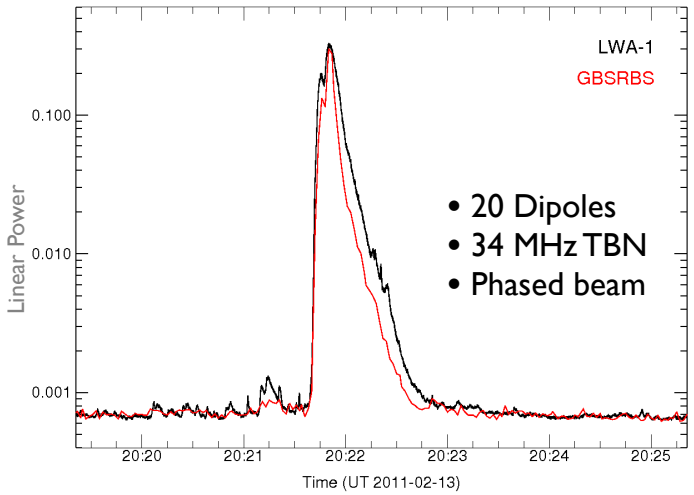


Pulsars with LWA-1
courtesy Kevin Stovall (UTB)

Solar Activity in a Beam

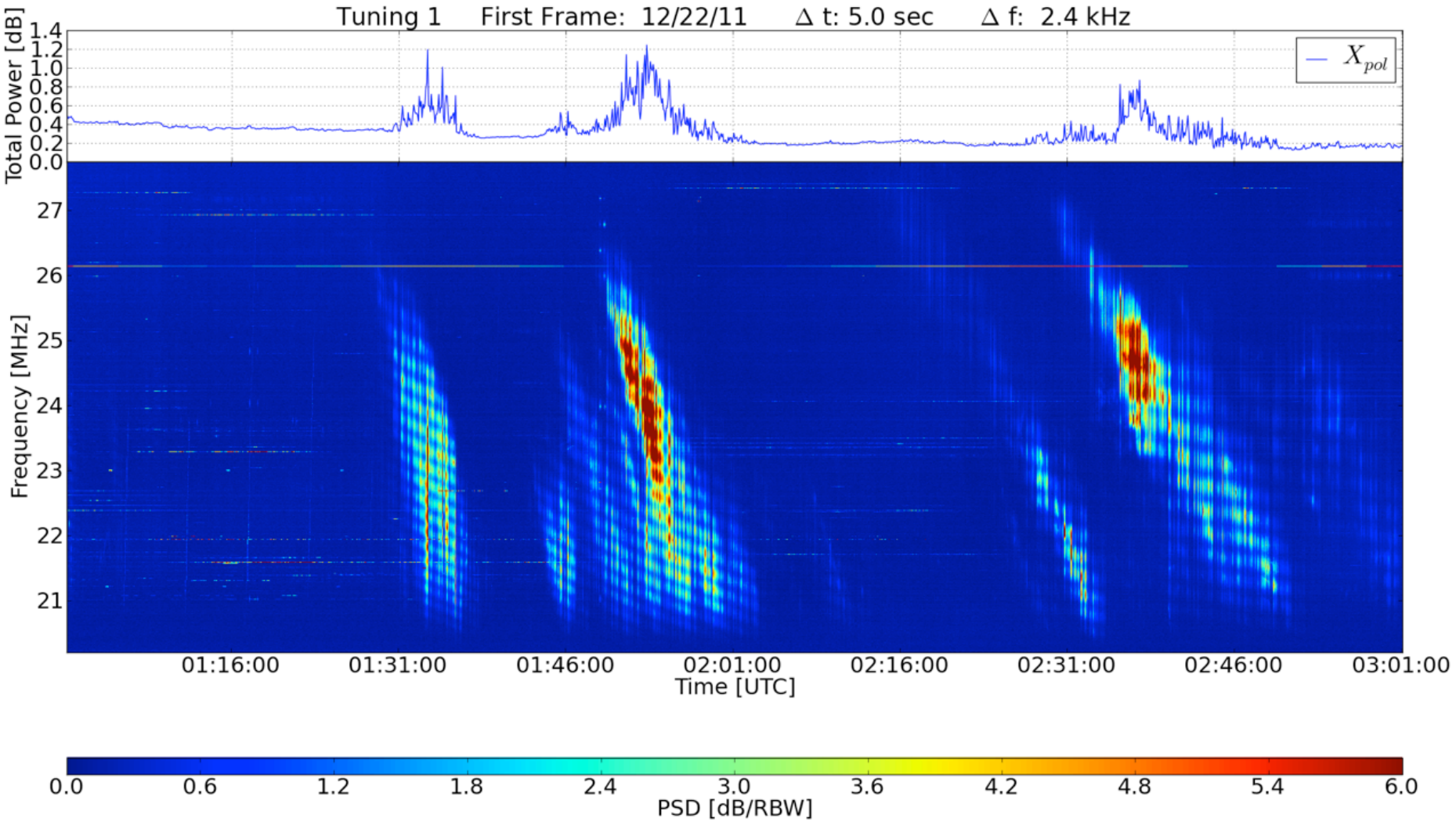


- 211 Stands, Beamformer/DRX
- Beam repointed every 4 min
- No Bandpass Cal. or RFI excision
- Shown ~13:00 (local)
- Temporal Res. ~ 0.5 sec
- Freq. Res. ~ 2.4 kHz

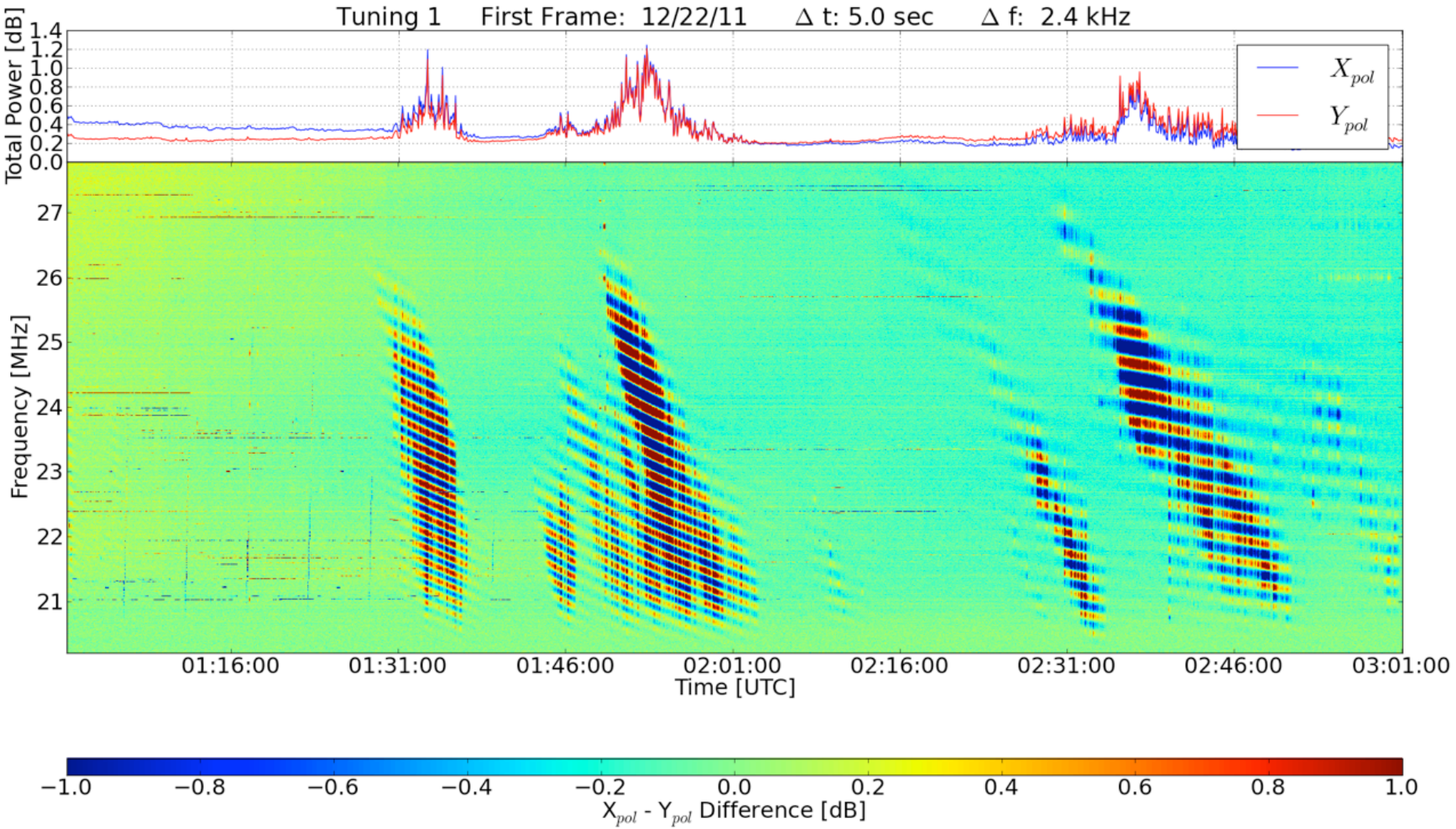


- **Solar bursts are an easy target for LWA1:**
  - **Fundamental plasma physics with high time and frequency sampling of bursts from electron beams and shocks.**
  - **Possibly track moving bursts from CMEs.**

Decametric Jovian Emission



Decametric Jovian Emission



Some LWA1 Projects

Transients

- S. Ellingson et al., ALTES project for beam-based transient searches (GRB Prompt Emission, Single Dispersed Pulses, ...)
- G. Taylor/J. Hartman, PASI Continuous, All-Sky Imaging/Transient Universe
- J. Hartman/G. Hallinan, Searching for Hot Jupiters
- R. Jenet, LoFASM - Low Frequency All Sky Monitor for Radio Transients

EoR/Dark Ages

- L. Greenhill et al. LEDA project to detect/constrain the signal from the Dark Ages. New correlator, total power hardware and data reduction pipeline (CASPER Roach II & GPU)
- Bowman et al. Cosmic Dawn project to detect/constrain the final absorption peak; dual-beam technique to minimize foreground

Ionosphere/Space Weather

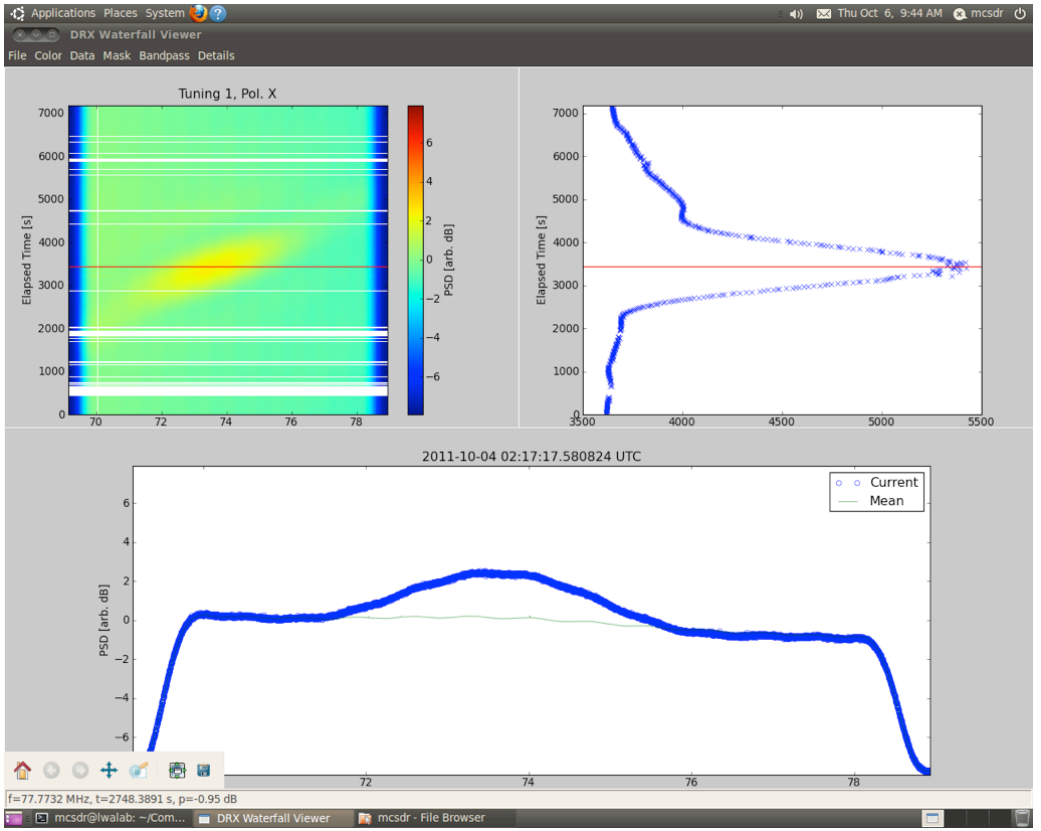
- White, Solar Radio Bursts at High Temporal and Spectral Resolution
- Clarke et al., Tracking the Dynamic Spectrum of Jupiter

See Related Talks:

- S. Ellingson - Results from LWA1 Commissioning: Sensitivity, Beam Characteristics, and Calibration (Wed, 14:20)
- J. Hartman - Observing Cosmic Dawn with the Long Wavelength Array (Fri, 10:20)
- L. Greenhill - Detecting the Universe Beyond Redshift 20 (Fri, 10:40)

Operations, Software, Users

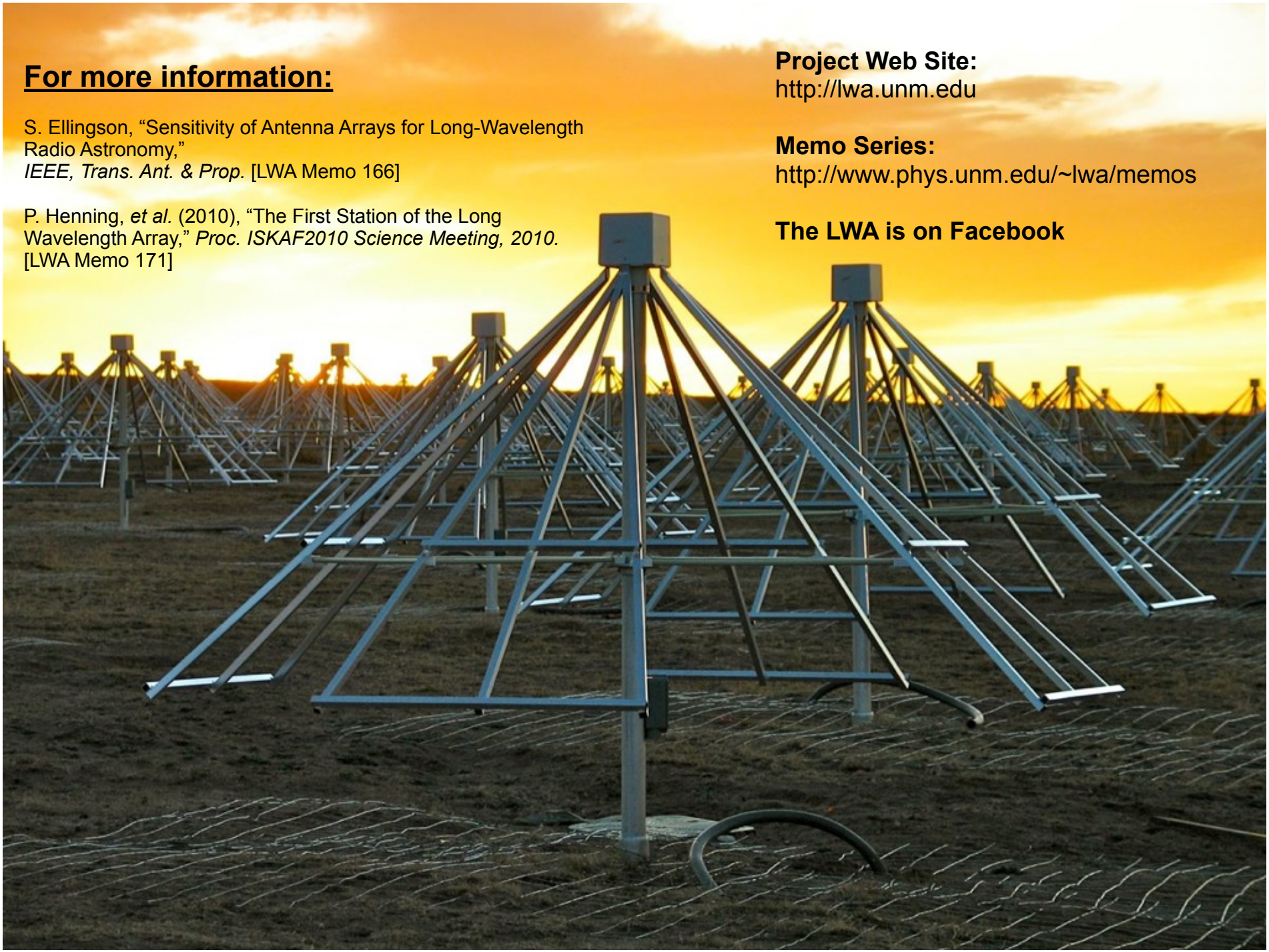
First LWA Users Meeting
May 11-12, 2011



340 TB/year recorded onto 2 TB drives and shipped to users

LWA Data Archive (LDA)

- Dell PC + 6 DRSUs in RAID5 provides 24 TB currently
- Grows at 340 TB/year to support Category 1 observing + maint.
- Located at the Center for Advanced Research in Computing (UNM), connected to Λ-rail and internet2
- Center is currently adding storage capacity scalable to 5 PB



For more information:

S. Ellingson, “Sensitivity of Antenna Arrays for Long-Wavelength Radio Astronomy,”
IEEE, Trans. Ant. & Prop. [LWA Memo 166]

P. Henning, *et al.* (2010), “The First Station of the Long Wavelength Array,” *Proc. ISKAF2010 Science Meeting, 2010.* [LWA Memo 171]

Project Web Site:
http://lwa.unm.edu

Memo Series:
http://www.phys.unm.edu/~lwa/memos

The LWA is on Facebook