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

- “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.

- Frequency Range: 10-88 MHz
- 4 beams x 2 pol. x 2 tunings x 16 MHz
- 2 all-sky transient obs. modes
The LWA1 Station

- 256 dual-polarization “stands”
- D = 100 m, pseudo-random distribution
- Outrigger @ 300 m baseline for calibration
- SEFD ~ 3 kJy (zenith)
- $S_{\text{min}}$ ~ 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

LWA1 has comparable sensitivity to all of LOFAR*

<table>
<thead>
<tr>
<th>Declination Range</th>
<th>Δν (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTR2:</td>
<td>-30° to +60°</td>
</tr>
<tr>
<td>LOFAR:</td>
<td>-11° to +90°</td>
</tr>
<tr>
<td>Y=VLA:</td>
<td>-35° to +90°</td>
</tr>
<tr>
<td>LWA1:</td>
<td>-30° to +90°</td>
</tr>
<tr>
<td>GMRT:</td>
<td>-53° to +90°</td>
</tr>
</tbody>
</table>

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.
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

- $F_c = 74$ 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
- Using a software FX correlator, PASI images most of the sky ($\approx 1.5 \pi$ sr) many times per minute at 100% duty cycle

See LWA TV Live at [http://www.phys.unm.edu/~lwa/lwatv.html](http://www.phys.unm.edu/~lwa/lwatv.html)
Cygnus A drifts through a beam at 74 MHz

10/6/2011
1.2 MHz bandwidth
10 sec integration
220 dipoles
No RFI excision
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

- 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.

- 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
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)
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:


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

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

The LWA is on Facebook