1. Simulations and Analysis for the Long Wavelength Array

Masaya kuniyoshi (UNM), Sanjay Bhatnagar (NRAO), Greg Taylor (UNM)

(The LWA Project collaboration)
2. Waseda Nasu Observatory
Outline

1. Long Wavelength Array
2. LWA station beam
   - Elliptical beam
   - Asymmetric beam
   - Pointing error
3. LWA imaging simulation
4. Tapers on the station
5. Summary
Long Wavelength Array (LWA)

Distribution of 53 LWA stations

New Mexico

400km

50m

Dipole configuration in one station

LWA Dipole Configurations

Station beam at 60MHz

Station beam at 20MHz

grid

pseudorandom

Station Beam

\( \Phi[^\circ] \)

\( \theta[^\circ] \)

\( (-60,0) \)

\( (-60,0) \)
VLA Tour on May 1st
The End
Station Primary Beam

20MHz

[Diagram of a beam with coordinates and orientation]
Asymmetric Station Beam

The ratio of the HPBW of the down side to the up side.
Symmetric Station Beam
Asymmetric Station Beam
Asymmetric Station Beam
Relative Power Pattern (example1)

Above shows the simulation results when the LWA Elk station beam (latitude 32.9°) tracks the CygA position (Dec 40.7°).
Above shows the simulation results when the LWA Elk station beam (latitude $32.9^\circ$) tracks Dec $80^\circ$ position.
Elk station beam at 20 MHz

Above shows the simulation results when the LWA Elk station beam (latitude 32.9°) tracks the CygA position (Dec 40.7°).
Elk station beam at 50 MHz

Above shows the simulation results when the LWA Elk station beam (latitude $32.9^\circ$) tracks Dec $0^\circ$ position.
Elk station beam at 80 MHz

Above shows the simulation results when the LWA Elk station beam (latitude 32.9°) tracks Dec 80° position.
H = -100d (-6.7h)
Dec = 40.7d
El = +14.1d

Pointing error

(0,0)
\( H = -80d \ (-5.3h) \)

Dec = 40.7d

El = +27.7d

Pointing error

\( (0,0) \)
H = -60d (-4h)
Dec = 40.7d
El = +42.3d

Pointing error
\[ H = -40d \ (-2.7h) \]
Dec = 40.7d
El = +57.3d
$H = -20d \ (-1.3h)$

$\text{Dec} = 40.7d$

$\text{El} = +72.2d$

Pointing error
H = 0d (0h)
Dec = 40.7d
El = +82.0d

Pointing error
H = +20d (+1.3h)
Dec = 40.7d
El = +72.2d
H = +40d (+2.7h)
Dec = 40.7d
El = +57.3d

Pointing error

(0,0)
$H = +60d \,(+4h)\)$

$\text{Dec} = 40.7d$

$\text{El} = +42.3d$

Pointing error
H = +80d (+5.3h)
Dec = 40.7d
El = +27.7d

Pointing error

(0,0)
$H = +100d \ (+6.7h)$

$Dec = 40.7d$

$El = +14.1d$

Pointing error
Pointing error

Pointing error as a function of elevation angle (degree).

Elevation (degree)

- 20MHz
- 50MHz
- 80MHz

Pointing error (degree)

Antenna reception pattern
Side lobe at 50MHz

(1) El 32.3
-5.8dB
-6.4dB
-6.3dB

(2) El 34.0
-7.5dB
-8.2dB
-6.4dB

(3) El 35.8
-10.3dB
-10.8dB
-11.9dB

(4) El 37.4
-12.9dB
-13.6dB
-14.9dB
Circular Beam created by changing the effective area.
LWA image at 20MHz

Simulation model

(Jy/pixel)

Std Dev  |  RMS    |  Mean
5.974e-05 | 5.974e-05 | 3.694e-07
Median | Min     | Max
0.00    | 7.868e-05 | 0.01981

LWA image at 20MHz

(Jy/beam)

Std Dev  |  RMS    |  Mean
0.0005373 | 0.0005528 | 0.0001299
Median | Min     | Max
0.0001221 | -0.0007181 | 0.02770

(S.Bhatnagar & M.Kuniyoshi)
Summary and Future work

- Pointing error depends on the observing frequency and elevation.
- Sensitivity changes with observing elevation due to the primary beam of the dipole in the station.
- Phased station beams are not constant during tracking a target area.
- Asymmetric beams
- Taper scheme makes the sensitivity decrease, but make the beam constant.

Future Work
Simulations with a 110m x 100m station (possible LWA station size) using a taper scheme.
30m固定球面鏡
観測室
8素子20m固定球面鏡
8素子20m固定球面鏡
Radio Transients Surveys

- 20m ⬇️ 8 elements + 30m ⬇️
  Multi-beam surveys
- Observable latitude:
  20m ⬇️: +32deg< ⬇️ <+42deg
  30m ⬇️: +19deg< ⬇️ <+55deg
- Observing frequency:
  1.42 ⬇️ 0.02GHz
- Sensitivity: 〜300mJy
  (1sec integration, 2素子干計)
Radio transients detected at Waseda Nasu Observatory

• We started surveying for radio transients at 2004.

• Some radio transients have been detected.

• 1 - 3Jy (推定継続時間 4m-48hr, 24hr-72hr)

  Kida et al. 2008  Matsumura et al. 2007
  Kuniyoshi et al.2007  Niinuma et al. 2007

• High Galactic latitudes
I Fringe Search

Drift-scan observation data (upper graph) in a week. The Fringe detection flag data 0 0 1 1 1 ... are also shown (lower numbers), which are obtained by the fringe search algorithm.

B0415+3754 1st day

Fringe Finding Algorithm

0111111100000000000000000000000000000000

B0415+3754 2nd day

Fringe Finding Algorithm

0001111110000000000000000000000000000000

B0415+3754 3rd day

Fringe Finding Algorithm

00000011111100000000001111100000

II Burst Search

1) Fringe detection flags, which are shifting 236 seconds per day in drift-scan observations.

1st day 01111111 236s 000000000

2nd day 0000000111111236s 000000000

3rd day 1000000000000011111 236s 000000000

...

7th day 001110000111000011111 236s 000000000

2) Fringe detection flag data are shifted back by 236 seconds per day to adjust for transit time.

1st day 01111111 236s 000000000

2nd day 01111111 236s×2 00000111110

3rd day 01111111 236s×3 00000111110

...

7th day 1111111 236s×6 000000000

(3) One-week integration in fringe detectability.

Integration 7777777000000001111000000000044444

Steady

There is a possibility of a variable or transient source.
Niinuma et al. 2007

Kuniyoshi et al. 2007
Thank you