32T Test Plan -- Verification of Antenna Location using Interferometry (3)

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1 Introduction

Precise knowledge of the positions of the antenna positions in an array is required for high-dynamic-range, wide-field imaging and for applications that require all-sky reception for bright continuum source removal. An error ΔX in antenna location causes a phase error in the measurement degrees of fringe visibility of as much as $360\ \Delta X/\lambda$ degrees, where λ is the wavelength of observation. MWA antenna tile locations have been tabulated using differential GPS measurements. These locations can be verified (and ultimately fine-tuned) by analyzing observations of compact radio sources. In fact, it is a requirement of the project's technical review that the antenna locations be verified. This plan is responsive to requirement #3 contained in the memo "MWA 32-T Objectives and Quality Assurance Evaluation Criteria", dated 4 September 2009 (46-03001.99).

There does already exist evidence in the phase calibration tables from the 26T interferometry observations in X4 (as analyzed by Chris Williams and Jackie Hewitt) that the antennas in the 26T array were located within a fraction a wavelength of the differential GPS positions.

2 References

- Wade, C.M 1970, ApJ, 162, 381, "Precise Positions of Radio Sources. I. Radio Measurements"
- Fomalont and Perley, 1989, in Synthesis Imaging in Radio Astronomy, eds Perley, Schwab, and Bridle, ASP Conference Series, Vol 6, p 90,
- AIPS Cookbook, in chapter on Calibration: note the description of task LOCIT and procedure BASFIT. (See also HELP and EXPLAIN for LOCIT – as well as the general discussion of phase calibration)
- Briggs, F, 2009, "Basics of Baseline Calibration and Sanity Checks," see attached memo.

3 Measurement Description

The measurements will be made with as many functioning antenna tiles as are available at the time of the observations. The measurements will consist of a series of short scans in interferometery (or "channel") mode, in which a number (at least four sources at a wide range of declinations) are observed over as wide as possible a range of hour angles. Due to the limited number of adequately bright, unresolved sources in the sky (for the 32T array), the observation will probably need to extend over two to three 24 hour days. The observations could be taken in a single frequency band. If it is desired to use the celestial observations to also verify the differential cable lengths (and specify the instrumental phase offset or Phi-zero term), then at least one source will need to be observed with several frequency settings. However, it makes sense to observe the entire set of compact to sources at two or more frequencies to provide both low precision (long wavelength) and high precision (short wavelength) location measurements.

3.1 Clock for Sidereal Time

Clock needs to be locked to GPS/UTC time throughout the observation period. A clock error of $\Delta T \sim 1$ second will lead to an error of ~3 cm in the X-Y antenna-coordinate plane.

3.2 Acquisition of Appropriate Data Sets

- Two or three days of observation in Channel Mode (to obtain confidence that possible ionospheric phase fluctuations do not dominate in the position uncertainties).
- One low frequency (say, 110 MHz) and one high frequency (say 220MHz) for observing the source list of at least 4 sources - preferably more, including all the bright (>100Jy), unresolved sources accessible around the sky - located at the widest possible range of declinations.
- In addition to the observations scattered over a full sampling of declination and hour angle, it would be useful to record a set of observations (in rapid succession) at ~20MHz intervals from 100 to 240 MHz of one bright, unresolved source to measure differential cable lengths.
- These observations could be made with either the software or hardware correlator systems.
- The relative timing and phase-lock of the receivers should not be disturbed during the entire observation, in order guarantee system stability. (Probably not fatal if the observation is interrupted, since the receivers should lock up again using the distributed SCTN from the Clock Distribution box. But, better to strive for stability.)

3.3 Analyses

The first step in the analysis of these data will be correct the fringe visibilities for geometric delay and differential cable length using the existing tables of instrumental dimensions as the starting point. Subsequent analyses will identify the deviations from the assumed values. These include inspection of calibration solutions (as sanity check) and subjecting the data to automated baseline fitting routines.

4 Resources Required

4.1 Staffing

- Astronomer to select sources and build the source list (prior to observation).
- Astronomer or M&C wizard to implement a schedule for observation (prior to observation).

- Staffing on site to power the array and verify interferometric functionality during the time of the observations (during observation).
- Astronomer to verify data quality during the observations (during observation).
- Astronomer to analyze datasets (post-observation).

4.2 Hardware

Functioning Array:

- As many antenna tiles as possible…
- GPS timing to determine sidereal time.
- M&C system to control pointing and reset sky frequency
- Phase lock of receivers, with verified fringe coherence, with celestial sources (preferred) and/or noise source
- Correlator: either software or hardware correlator

4.3 Software

- M&C control of pointing, frequency setting, scan start/stop.
- Correlator control in Channel Mode. (software or hardware correlator)
- Offline Processing:
  - Correction for geometric and differential cable delays
  - Averaging across the 128 channels of each 1.28MHz band
  - Conversion to UVFITS
  - Solution for antenna phases (for example, AIPS task CALIB)
  - Solution for antenna position errors (for example AIPS task LOCIT)

4.4 Execution Time and Constraints

Will require two to three days of continuous telescope observation time. Prefer to leave the array undisturbed through the observation. (i.e., only this observation is run during this time and construction/maintenance is avoided.)

5 Success Criteria

32T antenna locations specified with statistical positional uncertainties of ~5 cm, using interferometry of celestial sources.

Revision History

Rev Ltr	Date	Author	Description
01	2009-09-22	FHB	Initial Submission
02	2009-12-30	RFG	Formatting