MWA EOR Array Configuration Requirements

** DRAFT v2 **
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1. The array configuration shall be circularly symmetric (on average) and have a constant density core surrounded by a power-law distribution of antennas out to the maximum radius of the array. The core shall have the maximum allowed density of antennas. The density of antennas shall be continuous across the boundary between the core and power-law regions.

   References: Bowman, Morales & Hewitt (2006); Effects of Antenna Distribution on EOR Power Spectrum Measurements, Judd D. Bowman, Sept. 14, 2006; Thermal Uncertainty in the Redshifted 21 cm Power Spectrum from Realistic Antenna Layouts, Including an Off-Center Core, Judd D. Bowman, February 5, 2008.

2. The power law index of the antenna distribution shall be between -1 and -3. The current agreed upon value of the power law index is -2. The number of antennas in the core and the radius of the core will be determined by the power law index such that the sum over the two regions matches the total number of antennas planned for the array.

   References: Bowman, Morales & Hewitt (2006); Effects of Antenna Distribution on EOR Power Spectrum Measurements, Judd D. Bowman, Sept. 14, 2006; Thermal Uncertainty in the Redshifted 21 cm Power Spectrum from Realistic Antenna Layouts, Including an Off-Center Core, Judd D. Bowman, February 5, 2008.

3. The array configuration shall satisfy the condition that the symmetry figure of merit ζ is less than 7.0.

   Reference: Beardsley, Hazelton &Morales, Memo: MWA Array Layout, Oct 2010

4. No antenna tiles shall have separations closer than 1.5 meters between their ground screens in order to provide space for beamformers and facilitate installation and maintenance access.

   Reference: Roger Cappallo (long ago communication, I think I have the number right!)

5. All antenna tiles in the core and power-law region shall be distributed pseudo-randomly to meet the symmetry figure of merit requirements. Antenna tiles shall *not* be configured on a regular grid, but must be arranged with pseudo-random offsets in their positions. Clumping of antenna tiles shall be avoided in both the core and power-law regions.

6. All antenna tiles shall be arranged so that the X-dipole polarization points north and the Y-dipole polarization points east. (TBD: I might have this reversed!)

7. When installing antennas in the field in the power-law region of the array, any dislocation from the planned position of an antenna by *more* than 6 meters is allowed only after recalculation of the symmetry figure of merit is shown to meet its requirement with the new antenna location. Dislocations by *less* than 6 meters are allowed with no additional actions as long as the minimum spacing requirement is satisfied. The rationale for this is that, at the small radii of the power-law antennas, changes in the position of a tile by less than half the dimension of the tile will not produce significant effects on the PSF.

8. When installing antennas in the field in the core region of the array, any dislocation from the planned position of an antenna by *more* than 3 meter is allowed only after recalculation of the symmetry figure of merit is shown to meet its requirement with the new antenna location. Dislocations by *less* than 3 meter are allowed with no additional actions as long as the minimum spacing requirement is satisfied. In general, the location of the antennas in the core region of the array should be planned with detailed knowledge of the placement restrictions so that no changes are needed when the antenna tiles are installed in the field. The rationale for this is that the core is very dense and any changes in the antenna tile locations during installation would be very difficult to accommodate without affecting the locations of other antennas.

9. All beamformers shall be located on the south sides of their antenna tiles. All beamformers shall be centered on their tiles with 25 cm of separation from the edges of the ground screens to the closest sides of the beamformers. The 32 dipole inputs on the beamformers shall be facing north toward the tiles and the outputs to the receivers shall be facing south.

10. All coaxial cables running between the beamformers and dipoles shall be configured identically for every tile. Cable stays shall be used to secure the cables in place on the ground screens.

11. No metallic object other than a beamformer enclosure shall be within 1.5 meters of an antenna tile.

12. No object (metallic or non-metallic) taller than 1 meter above the ground shall be within 4 meters of an antenna tile. This includes trees, bushes, rocks, sign posts, fences, power lines, electrical transformers, fiber optic relay boxes, etc. The motivation for this is that a 1 meter object at 4 meters is at the same elevation above the ground as a dipole on the closest possible neighboring antenna tile.

13. No object (metallic or non-metallic) shall appear from the center of any antenna tile above an elevation angle of 15 degrees, as measured from ground-level, regardless of distance from the antenna tile. This includes trees, bushes, rocks, hills, power lines, other radio telescopes, buildings, aerials, etc. The rationale for this elevation angle is that the power response profile of the embedded dipoles in an antenna tile is generally modeled to be below -10 dB relative to the zenith response below 15 degrees elevation angle. Hence, the height of an object can be no larger than the distance to the object times *tan(15°)*.

14. No antenna shall be closer than 4 meters to a receiver enclosure. *Note: I think Roger could comment on how well this matches to the receiver layouts that have been studied. It may have to be relaxed.*

15. All antennas tiles shall placed with a north-south/east-west alignment accuracy of <5 degrees. *Note: Mitch says the RTS will take whatever it gets, so 5 degrees is based on what I think is practical in the field. We don't know how alignment would affect EoR foreground subtraction.*

16. All antenna tiles shall have normal vectors within <5 degrees of the mean normal of the full array. *Note: Same comments as above.*

17. All antenna tiles other than the "outliers" shall have relative elevations within 5 meters of the mean plane bisecting the array.

    Reference: Co-planarity requirements for the MWA-LFD, Randall Wayth, March 6, 2007.

18. All antenna tiles shall have their final locations surveyed to an accuracy of <20 cm when installation is complete. *Note: I think this achievable; it is only to facilitate the initial*

convergence of the calibration. Antenna positions will be determined through astronomical observations to much higher precision.

SHI Outlier Antennas

1. 16 "outlier" tiles shall be placed between radii of 1.2 km to 1.8 km (TBD) to support high-resolution solar imaging. The locations of these antenna tiles will be determined by the SHI science collaboration. When installing these antennas in the field, any dislocation from the planned position of an antenna by *more* than 6 meters is allowed only after recalculation of the instantaneous PSF is shown to meet the SHI requirements with the new antenna location(s). Dislocations by *less* than 6 meters are allowed with no additional actions. The rationale for this is that changes in the position of a tile by less than the dimension of the tile will not produce significant effects in the PSF at the large radius of the outliers.