Configuration Design for Large N Arrays

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Several new interferometer arrays are planned which will have hundreds and even thousands of antennas. The configuration of these arrays will depend on the science requirements as well as the area available for siting the array. The DSA-2000 consisting of 2,048 5-m antennas with a planned frequency range from 700 to 2,000 MHz is one such array. This array will enable a wide range science observations but the primary requirement that drives the array configuration design is a deep synoptic survey of the sky visible from 38 deg north latitude with 3 arcsec resolution and dynamic range of 10^6. The DSA-2000 will be a Radio Camera that processes the visibilities in a real-time pipeline that produces high dynamic range and high fidelity images for the survey without requiring any offline processing. The high dynamic range, fidelity and sensitivity requires that the configuration produce a synthesized beam PSF (point spread function) with near-in sidelobes of <-30 dB and similarly low far sidelobes with minimal sensitivity loss from tapering or reweighting of the UV sample.

This paper describes the design methodology for designing the DSA-2000 configuration that meets the demanding requirements. The method starts from a pinwheel non-repeating tiling using Conway triangles followed by a conformal mapping of the tiling to give a nominal large-scale distribution. This is followed by a dithering of the telescope locations to add more randomness. The choice of the conformal mapping is critical for determining the PSF central beam and near-in sidelobes. Different conformal mappings can be quickly evaluated by treating the distributions of the 2,048 antennas and $2x10^6$ UV samples as circularly symmetric continuous functions and using Hankel Transforms. The effect of reweighting of the UV data can also be evaluated using Hankel Transforms.

The UV coverage for the nominal DSA-2000 configuration is very close to a Gaussian limited by the 15 km x 19 km footprint (giving a circular distribution at 0 DEC) in the available remote valleys in the western US that provide good geographic shielding from RFI. Fig. 1 shows the instantaneous point spread function for the array. Earth rotation over the typical imaging time of 15 minutes and frequency synthesis dramatically reduce the far sidelobes and a modest reweighting of the UV data can reduce the near-in sidelobes below -30 dB.

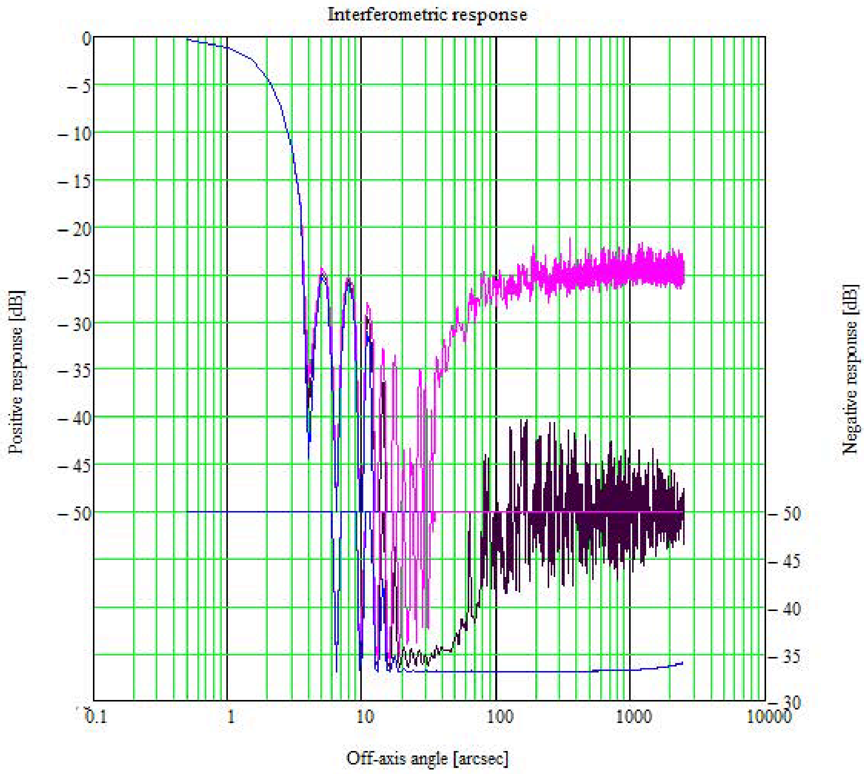

Fig. 1. Synthesized PSF for the DSA-2000 array at 1350 MHz. The black, magenta and blue lines are respectively the azimuthal average, peak and minimum responses.