Optimizing Phased Array Feeds to Reduce Elevation-dependent Spillover Noise in Radio Telescopes

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Abstract

Spillover noise from the warm ground surrounding a reflector dish is a major contributor to the overall system temperature of a radio telescope. It has been observed that tipping a reflector dish from zenith toward the horizon while using a fixed feed horn reduces this effect since portions of the spillover beampattern are now aligned with much cooler sky rather than hot ground. As the pointing approaches the horizon, noise temperature again increases due to the main beam cutting a longer path through the atmosphere, thus increasing the sky noise seen in the high gain beam. Phased array feeds (PAF) provide an opportunity to adapt the dish illumination and spillover patterns during tipping so as to exploit this asymmetric spillover noise field to minimize the overall noise temperature. We have developed a detailed numerical model of this effect for noise received by a PAF. Model accuracy has been validated by comparison to field data collected during recent experiments with a 19 element PAF on the Green Bank 20 meter antenna at the National Radio Astronomy Observatory (NRAO). Both the experimental and simulated results suggest that a reduction (as compared to a fixed horn feed) in spillover noise is possible by adaptive beamforming with the PAF as the elevation angle of a reflector dish is reduced (see Figure 1). Thus sensitivity may be increased at mid elevation angles without detrimental effects on the dish mainbeam pattern.

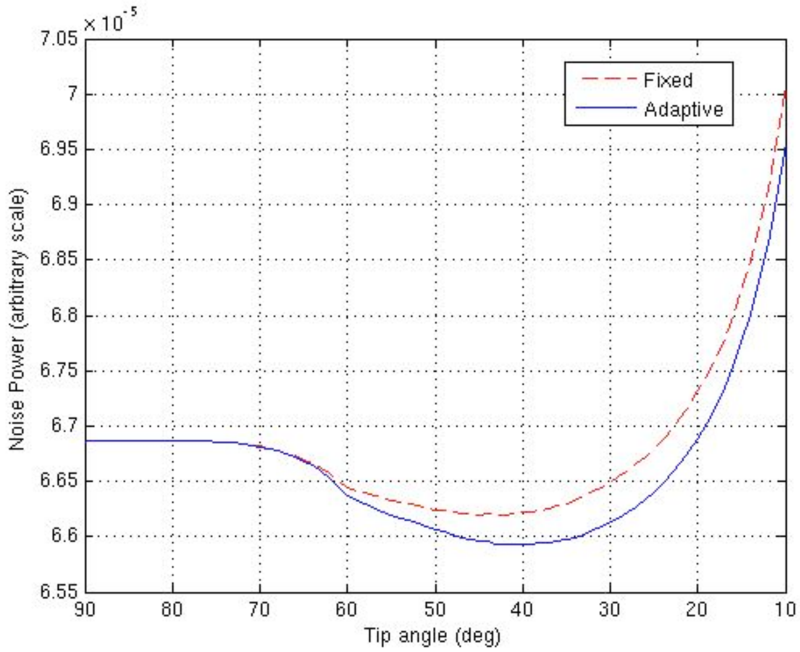

Figure 1. Comparison of noise power as a function of dish tipping angle with use of fixed and adaptive beamformers.