NLSRT Memo No. 27

December 8, 1988

A horn-reflector configuration for the 300-ft replacement

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It is highly desirable that any new radiotelescope, whether built as an element of an array or as a single filled aperture, be designed with minimum aperture blockage so as to reduce the effects of interference, instrumental spectral baselines, polarized sidelobes, and stray radiation. A fully offset-feed parabolic design, as described in the memo by Dick Thompson, can have sidelobes that are perhaps 30 dB below those of any conventional center-fed paraboloid. There may, however, be serious practical difficulties in constructing and operating such an asymmetric structure when it is made very large. This memo is intended to point out that the horn-reflector configuration has several characteristics that are attractive to radio astronomy, especially when an aperture $\sim$ 100 meters is desired.

The basic horn-reflector geometry is shown in the accompanying two figures (from Crawford, Hogg and Hunt, Bell Systems Technical Journal 1961, 44, 1095). The antenna is broadband, has good polarization properties, and is very low-noise. The specific telescope shown here was built for Project Echo. It has an aperture efficiency of 75% and a main beam efficiency > 92%. Virtually all of the remainder of the response lies in sidelobes within $\sim$ 7 HPBW of the main beam. A mechanical advantage of the horn-reflector over other designs is that while the reflector moves in elevation and azimuth, the focal point moves only in azimuth – it stays at a constant distance from the ground.

We would not want to construct a scaled version of this instrument. Rather, we would separate the "focus house" from the main reflector and illuminate the dish using more conventional feeds. I have attached two sketches which illustrate the configuration. A large section of a paraboloidal antenna (shown here with an aperture of 100 meters) is mounted on two large vertical wheels which move the dish in elevation. The wheels are mounted on a track on which the dish moves in azimuth. The focus is at a point 200 meters away from the center of the dish (this distance is scaled from the Crawford Hill instrument), and perhaps 50 meters above the ground. A large tower is built to hold receivers which are placed in the focal plane. The tower moves in azimuth on a separate track.

Advantages of this configuration are:

(1) It is a fully unblocked system with very low sidelobes and good efficiency. It is the perfect instrument for the Radio Quiet Zone.

(2) It is fully steerable and thus has good sky coverage (except for a small area around the zenith).

(3) The focal plane is inside a building and any number of instruments can be placed in it. There are no limits on size or weight of receivers. One could operate at many frequencies simultaneously using dichroic reflectors. Any number of experiments could run simultaneously.

(4) There is no natural frequency limit of this system. The upper frequency limit will be set by the reflector surface accuracy.

Here are a few other considerations. If the focus room tower can be moved at speeds of up to 5 mph it will track at an azimuthal rate of order 40 degrees/min. which is the rate for the VLA antennas. This gives satisfactory zenith coverage and minimum move time between sources (always less than 5 min.). The track that the tower rides on (and azimuthal positioning of the tower itself) need not be extremely precise. The receiver in the focus room can be servoed to keep it at the correct azimuth, elevation and focal length, in essence supplying any fine-tracking that the tower lacks. Accuracy in azimuth to 1mm insures pointing accuracy to 1 arc-sec.

I offer this design to show that it is not inconceivable or even improbable that we could construct a fully offset system in our current circumstances. Other configurations besides this one may be even simpler and easier to build. The extra power that we could offer to our users: low interference, good baselines, access to the focal plane, etc., and the opportunity that we would have for development of focal plane arrays, multi-frequency observing schemes and so on that follow from bringing the focus "to earth" in a large sealed room, demand that we take offset systems seriously. We have the rare opportunity to build a great, modern instrument. Let's take advantage of it.