Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

February 6, 1968

To: B. Clark, J. Gore, D. Hogg, H. Hvatum, G. Swenson, C. Wade

From: N. C. Mathur

Subject: Attached

Some comments on the VLA Configuration Study are enclosed. I would like to have these discussed at the meeting on February 9, 1968.

N. C. Mathur
February 6, 1968

VLA CONFIGURATION

A. Statement of the Problem

Design a correlator supersynthesis array with the following specifications:

Performance Specifications:

1. Resolution: 1", 3", 9", and 27"
2. Field of View (defined as distance of first grating lobe from main beam): 120 x resolution.
3. Sidelobe Level:
   (a) No sidelobe greater than -15db within the field of view.
   (b) RMS distant sidelobe level no greater than -30db. Distant sidelobe is defined as the sidelobe in the outer half of the field of view.
4. Sky Coverage: The same configuration should give the above performance at all declinations in the range of -15° to +90°.
5. Observing time: The above beam specifications should be achieved in one day's observation.

The design study will result in specifying the following:

Configuration Specifications:

1. The number of antennas.
2. The layout of the track
3. Number and locations of observing stations.

The design should minimize the overall cost of the array. Approximate figures for cost are:

1. Antenna - $500 K each
2. Track - $55 K/km
3. Observing Station - $10 K each

B. Current Status

A Pseudo-Dynamic Programming technique is being used to optimize the array. This is coupled with the empirical approach tried earlier by D. E. Hogg. The symmetrical Wye with one arm rotated 5° from the north-south line, as proposed by Hogg, is taken as the layout of the track. The computer program finds the optimum location of an antenna from a given set of possible locations for specified locations of the remaining N-1 antennas. For the 10" - 20' array 126 possible locations are used on a

2100m Wye. (These locations are at 50m spacings on the Wye). The "optimum location" is the one which, amongst a number of possible locations, produces a transfer function having the minimum value for the weighted holes. The "weighted holes" is a count of the unsampled cells with a 15 db gaussian taper applied so that holes far from the center of the transfer function are given less weighting than the holes near the center. This criterion is found to give better results than a count of the actual number of holes.

The computing time for optimizing one antenna position for N = 30, tracking time = 12 hours and number of possible locations = 126, is about 16 minutes.

The starting configuration is taken as the best found empirically for the declination under question. The program optimizes one antenna location at a time and keeps improving the configuration at each step.

By optimizing at declination 0°, a configuration using 30 antennas has been found which performs 'well' at all declinations. 'Well' is used here with reference to specifications given in A1. The maximum sidelobe is less than -15 db within the field of view and the RMS distant sidelobe is less than 30 db for all declinations in the range -15° to +90°. Tracking time used is no greater than 14 hours.

The Pseudo-Dynamic Programming is giving good results and looks promising. The following factors generate confidence in this approach:

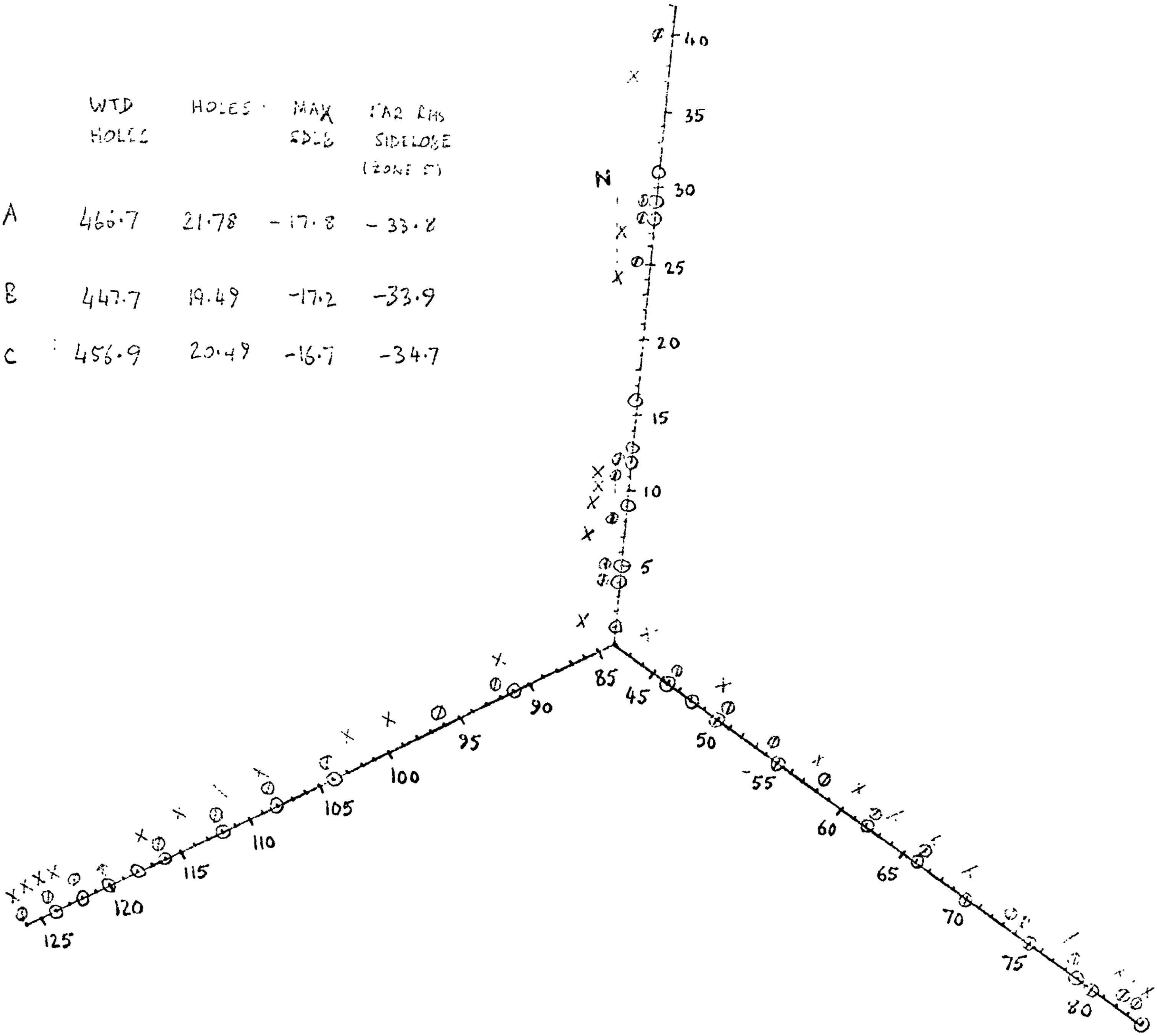
1. When applied to a six element, linear, non-tracking array, the program quickly led to a configuration which is the same as given by Leech's method.
2. As more and more antennas are optimized, the "weighted holes" decrease almost exponentially and converge to a limit. This limit is reached, for example, when all 30 antennas have been optimized once.
3. Although the final configuration is dependent on the starting configuration, the performances of the final configurations (obtained from different starting configurations) are the same to within a db. For example, the attached figure shows the resulting configurations and performance for three approaches used for declination 0°.

C. Questions

1. The performance specifications given in A-1 are arbitrarily set. These specifications are required urgently and in detail in order to carry on the configuration studies.
2. The place of the configuration study in the VLA time schedule needs definition.
3. The course of future work needs definition. Some possibilities are:
   (a) Study of complimentary arrays using Pseudo-Dynamic Programming.
   (b) Consideration of track layout other than Wye.
   (c) Possible improvement of results by increasing the number of possible locations on the Wye from the 126 presently used.
   (d) Investigation of the bandwidth effect on the field of view.
   (e) Detailed study of the effect of antenna failure (one or two antennas) on performance of array.
   (f) Further efforts at finding minimum number of antennas required after the performance specifications have been finalized. For example, the performance specs of A-1 can be achieved with 27 elements at declination 0°.

Effect of Starting Configuration and Procedure

	WTD HOLES	HOLES	MAX SDLB	FAR RMS SIDELOBE (ZONE 5)
A	466.7	21.78	-17.8	-33.8
B	447.7	19.49	-17.2	-33.9
C	456.9	20.49	-16.7	-34.7



⊙ A — Approach 2 : 24 antennas optimised at 0° (starting 1600m Uniform Wye)
Rest 6 optimised one by one, also at 0°

○ B — Approach 1 : All 30 antennas optimised at 0°. Starting 2000m Uniform Wye

× C — Approach 1. All 30 antennas optimised [illegible]