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The 90 meter Configuration of the Proposed NRAO mm Array

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The smallest proposed configuration for the large (6-13 m.) antennas for the proposed NRAO mm array is roughly 90 meters in diameter. With this size scale it is not possible to use the circular, Y-shaped, etc. arrays that are prime candidates for the larger configurations of these large antennas. In this memo we evaluate some of the obvious characteristics of two different 90 meter configurations. In keeping with the recently discussed paradigm parameters, we will specifically discuss configurations of 21 10 meter antennas, corresponding to 1600 square meters collecting area.

The two configurations that we will consider in these memo are a "gridded" version in which antennas are located at "nodes" of a repeating diamond-shaped pattern, and, based upon experience from mm Array memo 21, a "filled circle" in which eleven antennas are located at "random" positions on a circle and ten other antennas are located at "random" locations inside this circle. Figures 1a and 1c show the antenna locations for these two arrays, labeled GR2190M (or 90M) for the "gridded" array, and FCIR21 for the filled circle array. Note that we are assuming that the antenna transportation system will allow flexible locations for the antennas. In the end, of course, the are practicalities such a power and data communications that will remove some of the flexibility in antenna locations; however, at this stage it seems useful to plan the best array characteristics, and accomodating to these practicalities is a future problem.

As has been discussed in earlier memos, a possibly important parameter of an array is the radial distribution of data points in the u-v plane. This is shown for the two 90 meter arrays in Figures 1b and 1d, indicating the same result as for all very compact arrays: there is, at best, only a slight tendency for the filled circle array to put a larger proportion of data points further out in the u-v plane.

In Figures 2 and 3 we show plots of the u-v coverage, naturally weighted beam profiles, and uniformly weighted beam profiles for the GR2190M and FCIR90M configurations, respectively, for three different observing situations: a 12 hour observation of a source at 60^o declination, a ten minute snapshot observation of a source at 60^o declination, and a 6 hour observation of a source at -30^o declination.

The qualitative information in Figures 2 and 3 can be supplemented with useful quantitative information. In Table 1 we list the following: a name for the array; the declination, δ; the percentage of data that is not usable because of one antenna shadowing another; the fraction of potentially fillable cells that contain data; the number of occupied cells in the 17 X 17 grid, N_{occ}; the mean number of data points in each occupied cell, N_M; the harmonic mean number of data points in each occupied cell, N_{HM}; synthesized HPBW for natural ($\theta_{B,na}$) and uniform ($\theta_{B,un}$) weighting divided by the wavelength in mm (λ_{mm}); the rms sidelobe levels for natural and uniform weighting using the formulas discussed in mm Array memo numbers 18 and 20; the rms map noise in mJy for natural and uniform weighting, assuming a system temperature of 100^{o}K, an antenna aperture efficiency of 0.5, bandwidths of 1 GHz or 0.1 MHz, and twenty-one 10m antennas; and finally, the rms brightness temperatures derived from the previously listed rms map noise and synthesized HPBW, in units of mK for 1 GHz bandwidth and units of K for 0.1MHz bandwidth. The synthesized HPBW, θ_B, used in these and other tables in this memo were derived by numerically integrated the beam solid angle of the central beam and converting this to the HPBW of a Gaussian with the same beam solid angle.

The snapshot beams for the "gridded" 90 meter array are, as seen from Figure 2, horrible near the antenna half-power points. However, the "filled circle" array has excellent beam characteristics, particularly for snapshot situations. The randomization, first on the circle, then on the interior, was computed with a random number generator, with acceptable configurations subject to the constraint that antennas could be no closer that 15 meters. The FCIR21 array was one of the several generated that has excellent u-v plane characteristics.

We conclude that it is very possible to obtain a relatively packed 90 meter configuration with excellent beam and sidelobe characteristics, giving array characteristics not significantly different from those shown in Figure 3 and Table 1. Figure 4 shows a schematic of the appearance of the FCIR21 array next to one of the possible designs of a mutli-telescope system in which 21 3-5 meter antennas are mounted on, and pointed by, a structure the order of 25 meters in diameter. The details of possible designs of the M-T array are discussed in an independent memo.

Table 1

Parameters for the Gridded (GR2190M)
and Filled Circle (FCIR2190M) Arrays of 21 10 m. Antennas

Name	GR2190M	GR2190M	GR2190M	FCIR90M	FCIR90M	FCIR90m
H Range	$-6^h,6^h$	$0^h,0.17^h$	$-3^h,3^h$	$-6^h,6^h$	$0^h,0.17^h$	$-3^h,3^h$
δ	60°	60°	-30°	60°	60°	-30°
Shadowed	0.16%	0	6.3%	0.52%	0	5.7%
$\theta_{B,na}/\lambda_{mm}$	2.55"	2.23"	3.16"	2.21"	2.01"	2.97"
$\theta_{B,un}/\lambda_{mm}$	1.73"	1.69"	2.14"	1.55"	1.83"	1.90"
N_{occ}/N_{theo}	0.63	0.16	0.31	0.88	0.47	0.56
N_{occ}	217	54	106	304	162	194
N_M	139	7.8	131	99	2.6	2.0
N_{HM}	16	2.9	14	19	2.0	21
Sidelobe σ_{na}	0.112	0.199	0.155	0.753	0.899	0.0976
Sidelobe σ_{un}	0.068	0.136	0.097	0.057	0.079	0.072
Noise σ_{na}(1GHz)	0.065 mJy	0.55 mJy	0.095 mJy	0.065 mJy	0.55 mJy	0.088 mJy
Noise σ_{un}(1GHz)	0.19 mJy	0.90 mJy	0.29 mJy	0.15 mJy	0.63 mJy	0.18 mJy
Noise σ_{na}(0.1GHz)	6.5 mJy	55 mJy	9.5 mJy	6.5 mJy	55 mJy	8.8 mJy
Noise σ_{un}(0.1GHz)	19 mJy	90 mJy	29 mJy	15 mJy	63 mJy	18 mJy
$T_{b,na}$(rms,1GHz)	0.14 mK	1.49 mK	0.13 mK	0.18 mK	1.83 mK	0.14 mK
$T_{b,un}$(rms,1GHz)	0.86 mK	4.29 mK	0.87 mK	0.82 mK	2.56 mK	0.67 mK
$T_{b,na}$(rms,0.1GHz)	0.014 K	0.149 K	0.013 K	0.018 K	0.18 K	0.014 K
$T_{b,un}$(rms,0.1GHz)	0.086 K	0.429 K	0.087 K	0.082 K	0.256 K	0.067 K

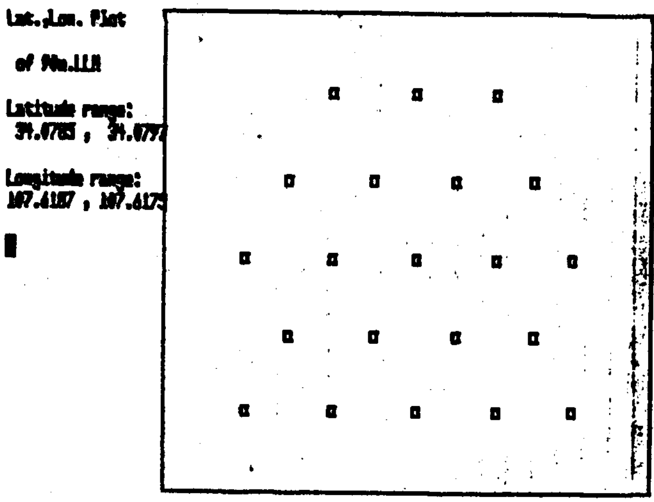


Fig. 1a - Location of 21 antennas in a "gridded" version of a 90 meter configuration, labeled 90M or GR2190m.

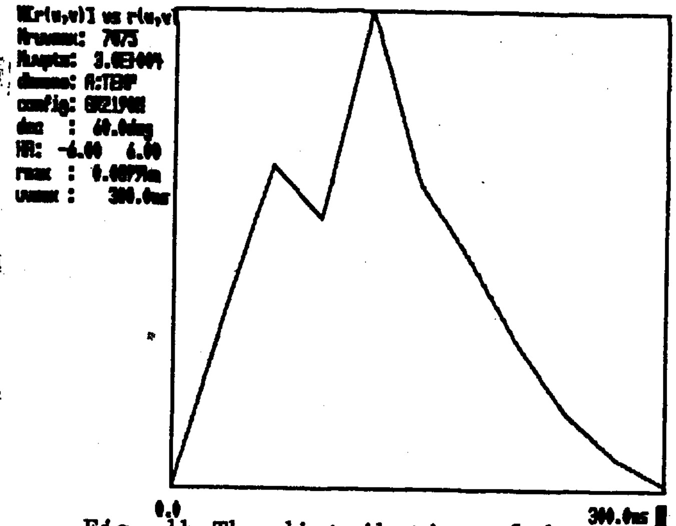


Fig. 1b The distribution of data points in equal thickness rings in the u-v plane for a 60°, 12 hour observation with the GR2190M, 90m. configuration.

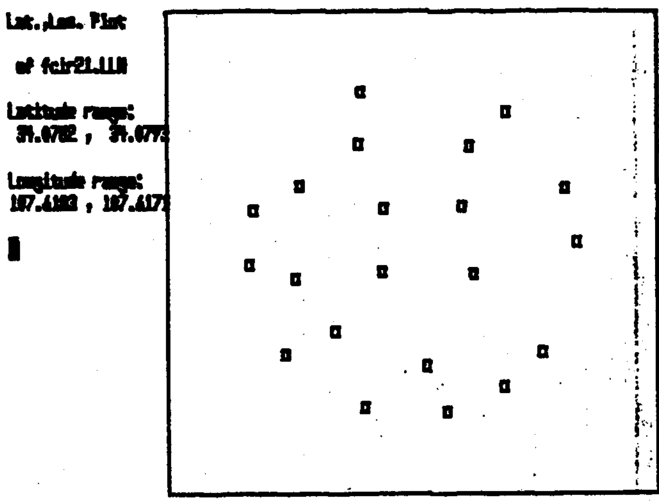


Fig. 1c - Location of 21 antennas in a "filled circle" version of a 90 meter configuration labeled FCIR21.

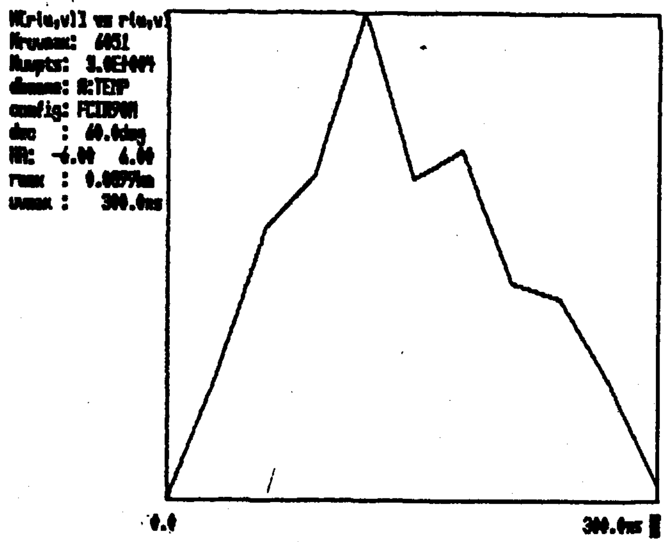
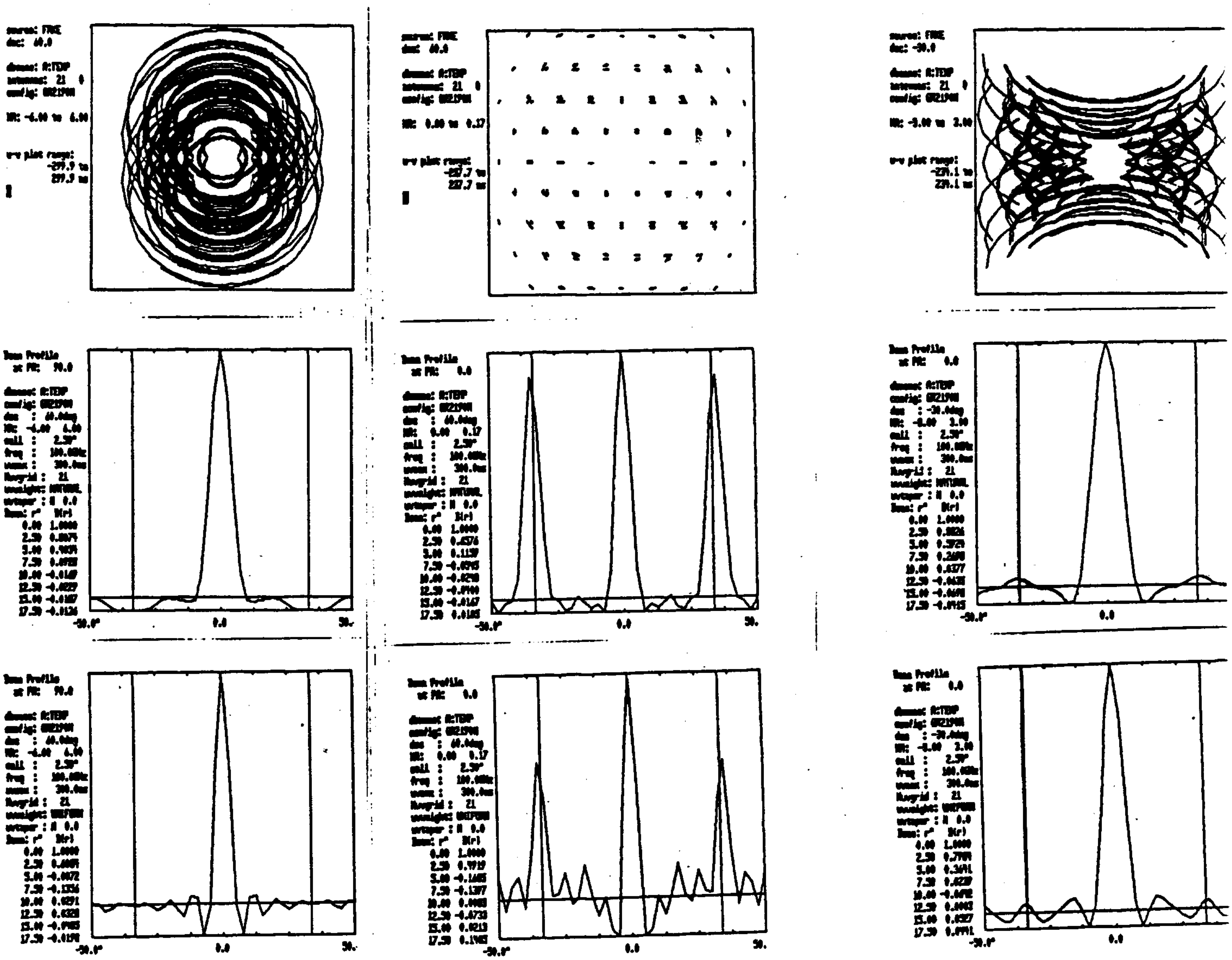


Fig. 1d - The distribution of data points in equal thickness rings in the u-v plane for a 60°, 12 hour observation with the FCIR21, 90m. configuration.

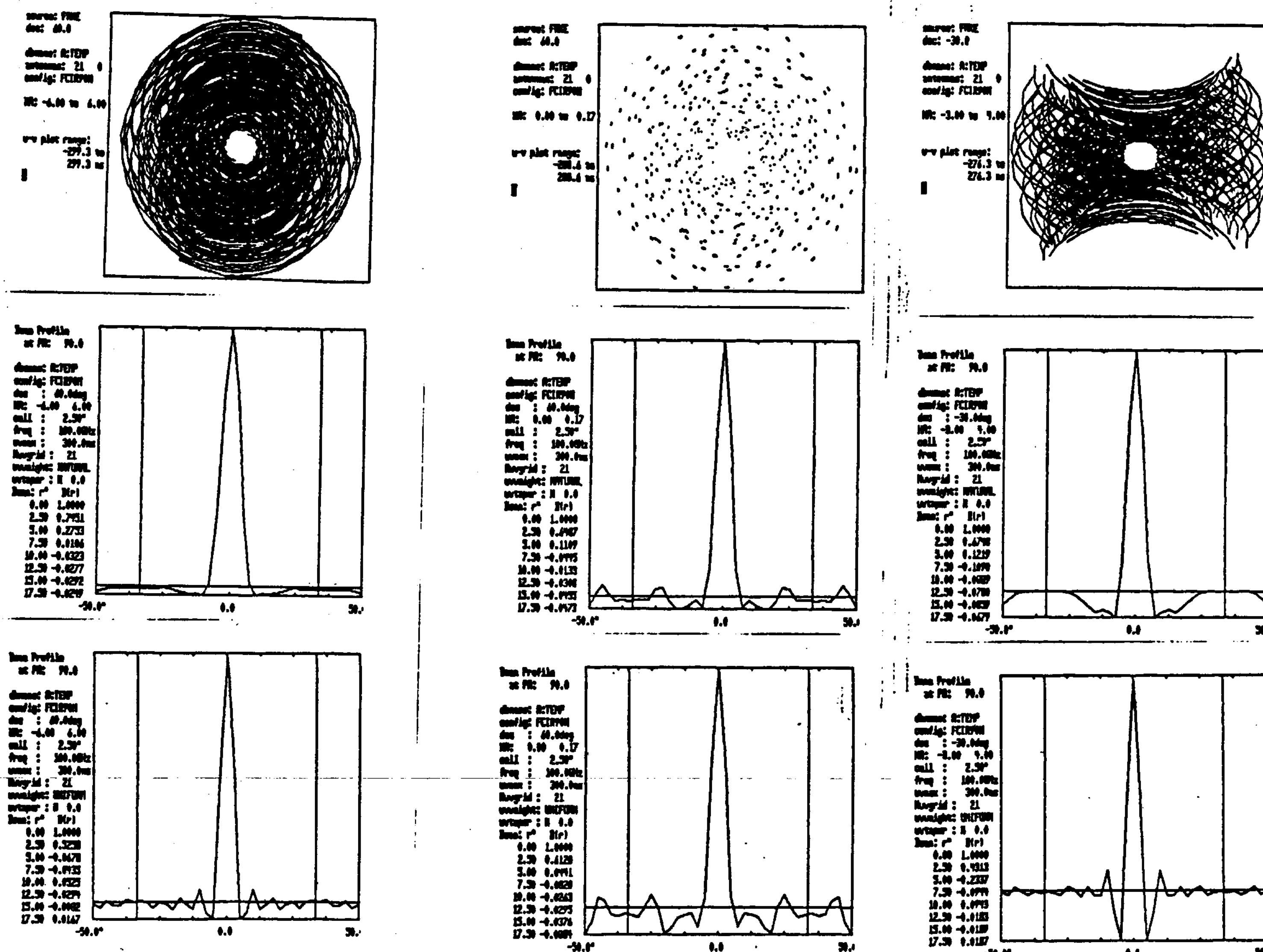


60^o declination -6^h, 6^h observation

60^o declination 0^h, 0.17^h observation

-30^o declination -3^h, 3^h observation

Fig. 2 - The u-v coverage, and natural and uniform weighted beam profiles for the "gridded" 90m. configuration GR2190M.



60^{o} declination — -6^{h}, 6^{h} observation

60^{o} declination — 0^{h}, 0.17^{h} observation

-30^{o} declination — -3^{h}, 3^{h} observation

Fig. 3 - The u-v coverage, and natural and uniform weighted beam profiles for the "filled circle" 90m. configuration FCIR90M.

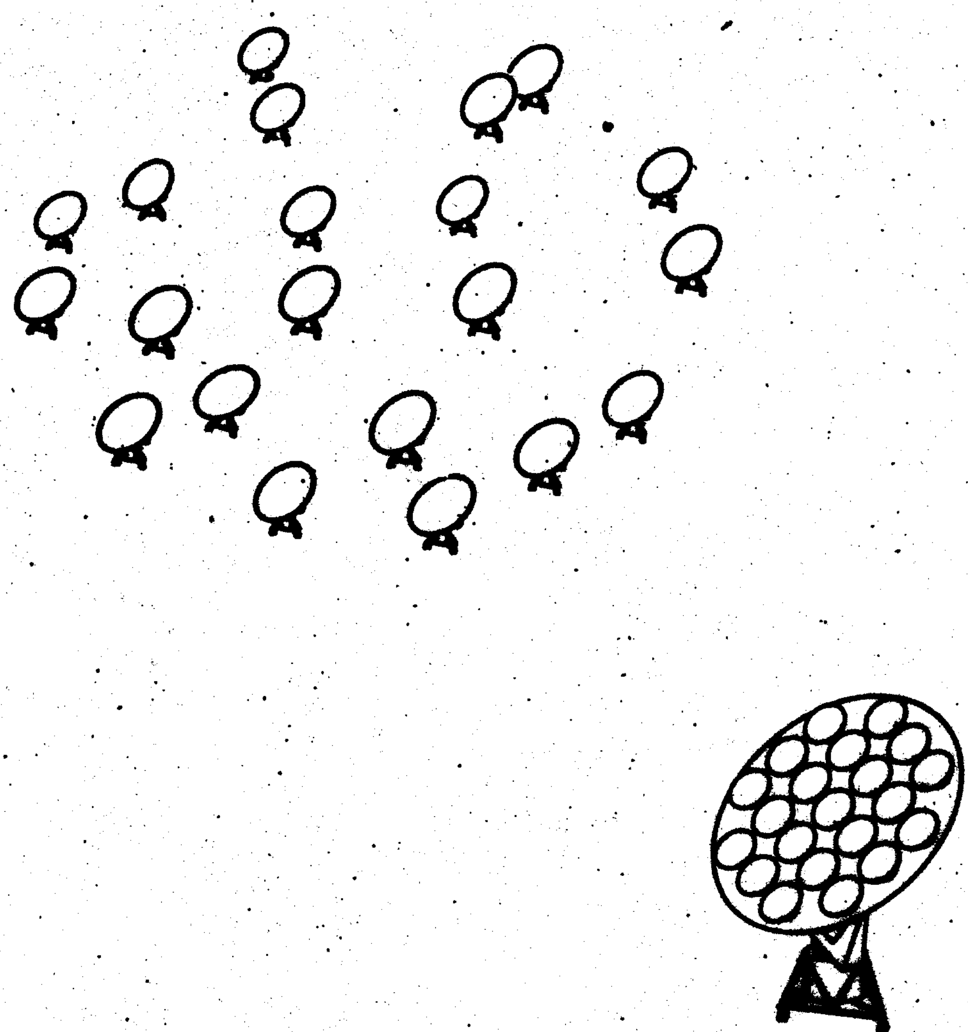


Fig. 4 - The filled circle configuration of 21 10 meter antennas in a 90 meter group next to the full tracking array.