NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

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VLA SCIENTIFIC MEMORANDUM #103

FROM: B. G. Clark

In the initial design of the VLA, it was regarded as always producing the same beam at a given configuration, and thus a given ratio of beam size to field-of-view. Therefore, the ratio of beam size to source size depends on the source under investigation. It was our intuitive feeling that we did not want to be out by more than a factor of three from the "ideal" ratio of beam size to source size, and therefore the compressed arrays were chosen at a ratio of three.

Ed Fomalont has recently introduced a viewpoint yielding somewhat more quantitative considerations. From this viewpoint, we consider that the source is observed at the configuration next larger than the "ideal", and then the map is smeared to "ideal" resolution by applying a strong Gaussian taper to the array. We may then calculate the array efficiency (relative to the "natural" weighting, each minute weighted equally) and the array sidelobe pattern.

The array sidelobe pattern devides into two regions; near the main beam we find the diffraction sidelobes, due to difraction from the edge of the array. Far from the main beam, we have mainly incompleteness sidelobes, due to incomplete u,v coverage. As the taper is increased, the diffraction sidelobes go down, as the edge of the array becomes less and less visible through the taper, and the incompleteness sidelobes go up, because one has fewer and fewer effective tracks crossing the plane.

The beam pattern for these tapered arrays has been calculated, and the array efficiency and the incompleteness sidelobes evaluated. The incompleteness sidelobes are represented by the sidelobe level in square annuli whose outer side is twice the inner, interpolated to an inner radius of ten half power beamwidths.

The plot of efficiency against beam broadening factor is shown in Figure 1 for a declination of 30°. Efficiency plots for all declinations are essentially similar.

Shown in Figure 2 are the RMS and maximum sidelobes interpolated to the annulus described above, plotted against beam broadening factor, for declinations of 30° and 0°. Plots at -30° and +60° have very similar shapes, except that the rms sidelobes for -30° never get very low, even at optimum taper.

The net argument to be made from this is that one can have a range between subarrays of a factor of 2.5 at no cost in sidelobe performance, and a factor of 1.5 in sensitivity. The limiting array separation is about a factor of 4, which deteriorates sidelobe performance by a factor of about 2, and efficiency by a factor of slightly more than two.

I think it is clear from this that we need four configurations to cover the entire range of angular sizes of interest, from ~1/50 m to 1/21000 m. It seems clear to me that the final configuration should end up very small, for line work purposes, between about 600 and 350 meters, center to ends, giving a step between subarrays between 3.3 and 4.0. Table I is a suggested set of subarrays with the desired properties, with a ratio of 3.606 between subarrays. Element locations are in meters from the center. Where the spacing has been changed from a scaled volume 3 27 element array, to avoid shadowing or to minimize stations, the scaled value is in parentheses beside it. I have taken a 40 meter minimum spacing, which results in shadowing at elevations as high as 39°. It seems a reasonable compromise between good u,v coverage on a grid smaller than 25 meters, and reasonable sky coverage without shadowing.

It is probably all right to cut the number of stations to 98 by deleting stations SE453 and SW302 and replacing them by SE440 and SW315 respectively.

COPIES TO:

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TABLE I

3.606

North Arm

21 Km	6 Km	1.5 Km	400 m
3500	962	264	64 (73)
4500	1238	340	104 (94)
8500	2338	642 (643)	154 (177)
9000	2475	682 (681)	194 (187)
10500	2888	794	234 (218)
17500	4812	1324	360 (364)
19000	5225	1437	400 (395)

South-East Arm

1512 (1500)	400 (412)	120 (113)	40 (31)
6000	1650	453	80 (124)
8000	2200	605	120 (166)
9500	2612	717 (718)	160 (198)
10000	2750	757 (756)	200 (208)
14500	3988	1097	240 (302)
16000	4400	1210	280 (333)
17000	4675	1285 (1286)	320 (354)
17500	4812	1325 (1323)	360 (364)
20000	5500	1512	400 (416)
21000	5775	1588	440 (436)

South-West Arm

2062 (2000)	567 (550)	156 (151)	42
4125 (4000)	1134 (1100)	302	83
7500	2062	567	156
12000	3300	908	235 (250)
13500	3712	1021	275 (281)
15000	4125	1134	315 (312)
16000	4400	1210	355 (333)
19500	5362	1475	400 (405)
21000	5775	1588	440 (436)

100 Stations

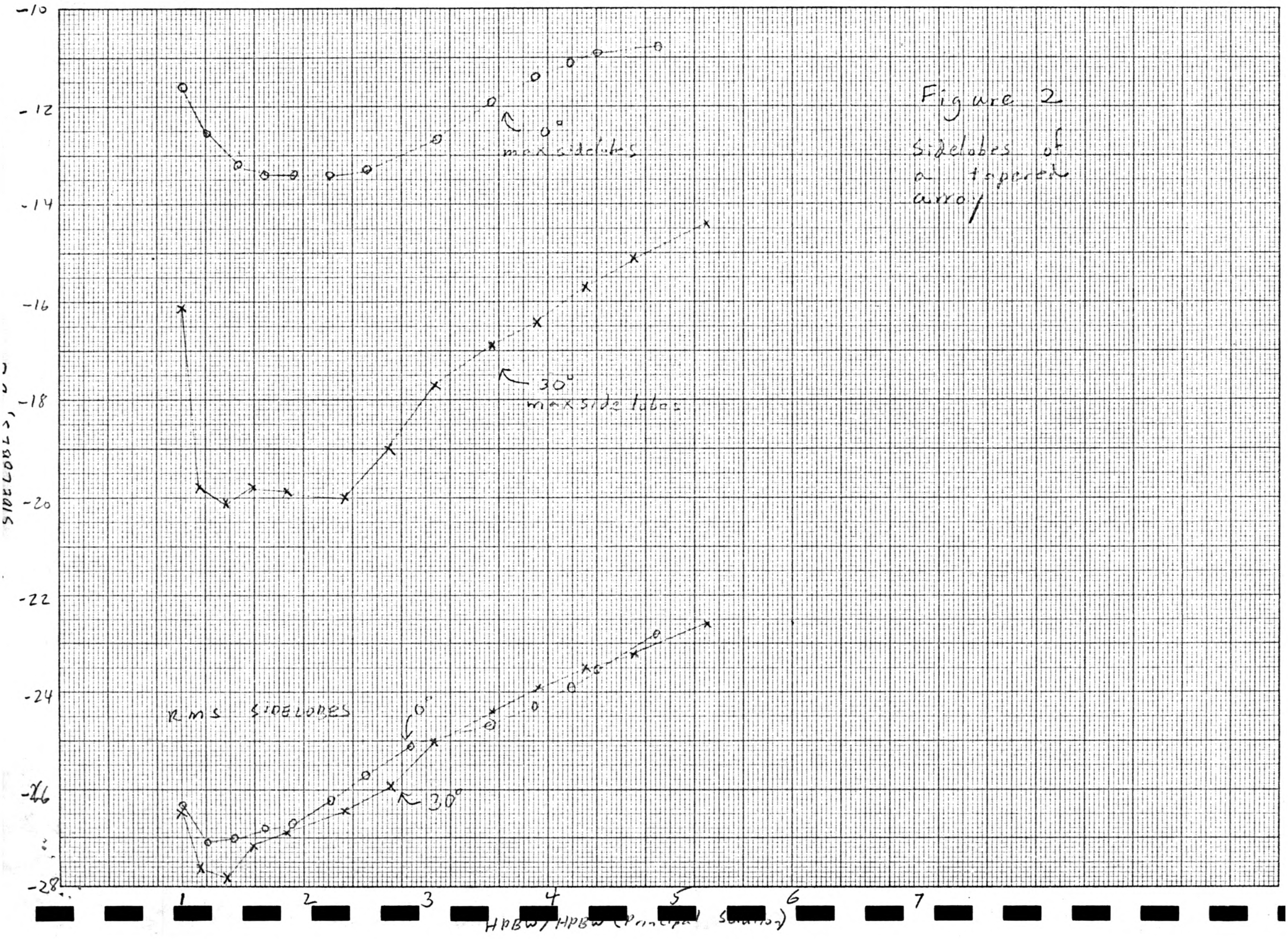

Figure 2
Sidelobes of a tapered array

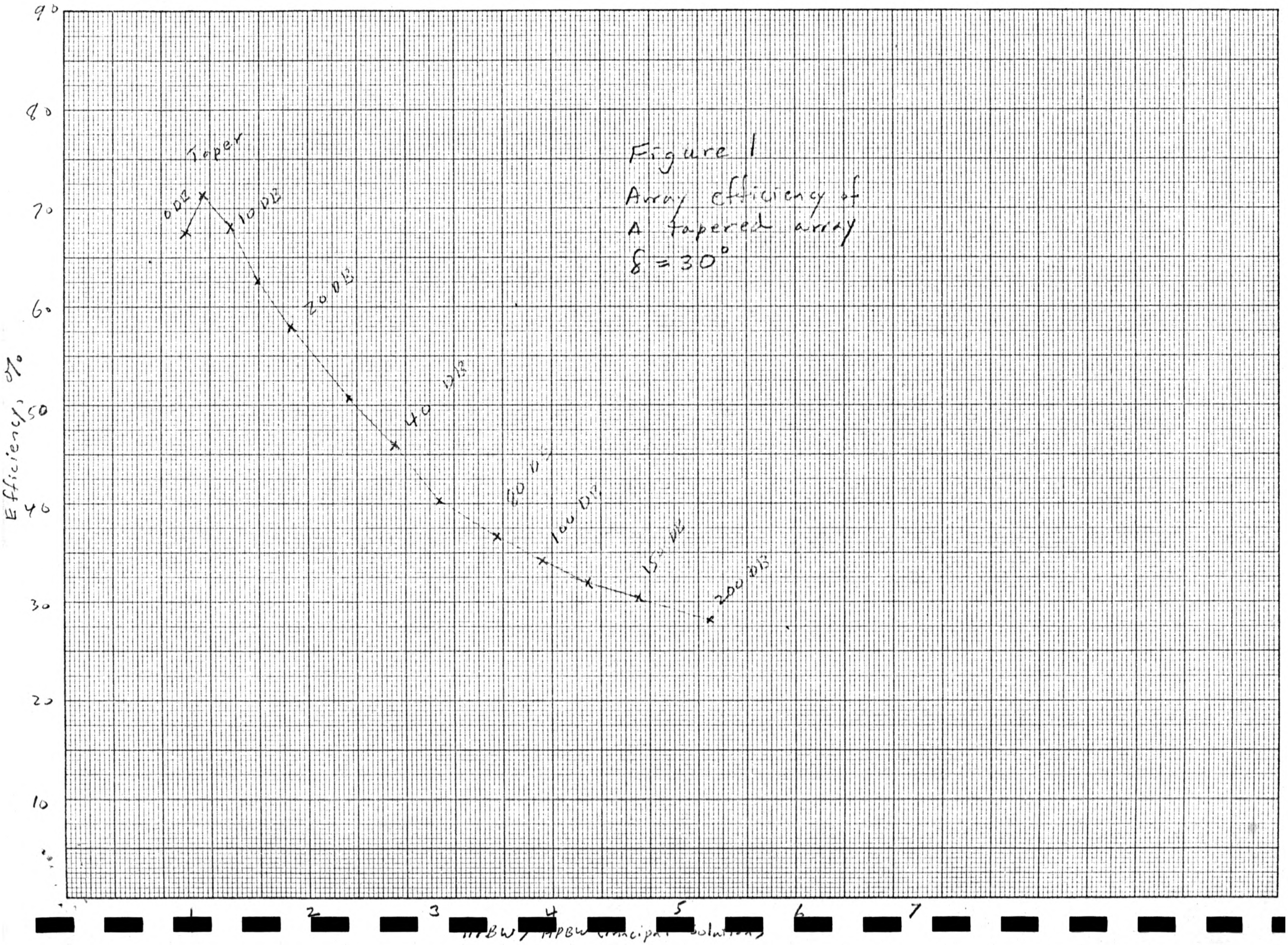

Figure 1
Array efficiency of A tapered array
$\delta = 30°$