National Radio Astronomy Observatory *MEMORANDUM*

To: VLBA Site Group, NRAO Council *Date:* January 15, 1987
From: Craig Walker
Subject: Effects of using Green Bank

The choice between Green Bank and a New England site for the Northeast antenna of the VLBA will soon be considered again. The decision must be made as a trade off between u-v coverage, which is better for New England, and logistical and political factors which seem to favor Green Bank. Demonstrating the difference in the u-v coverage has proven difficult. This memo is an attempt to display the difference in ways that might have more impact than the methods that I have used before (cf. Council Memo 52 which is also VLBA Memo 535).

Figure 1 shows the u-v coverage, on an 8000-km scale, of three arrays at three intermediate declinations. The arrays are the VLBA (meaning the design configuration using New England), a 9-station array with no Northeast site, and the VLBA using Green Bank as the Northeast site. The 9-station array shows those portions of the coverage that are not affected by the Green Bank/New England choice. It also shows the holes that the Northeast site is supposed to fill. The most significant differences between the two complete arrays are seen at about +2500 km in both u and v (note the scale numbers are thousands of km) where the VLBA does a better job of filling the most significant hole in the 9-station coverage.

The declinations shown in Figure 1 are those at which the differences are greatest, although there are still significant effects at lower declinations. For circumpolar sources, there are no significant differences. The above referenced memo shows the coverages for the full declination range although it does not have the 9-station coverage. Note that the declination range shown is where much of the high-dynamic-range work with the VLBA will be attempted.

Figure 2 shows the same information as Figure 1 except for an array that includes five stations of the EVN. Attempts to achieve very high dynamic range on complex sources will use such an array. The EVN does not affect the holes in the VLBA-with-Green Bank coverage and those holes are now especially apparent with the much better coverage on longer spacings. Adding the antenna being built in Sicily does not make a difference. It is possible to fill the holes by using Haystack, but the cost of supporting Haystack for astronomical VLBI may cancel any savings to NSF of a move of the VLBA antenna to Green Bank.

Figure 3 is an attempt to show the effect of the differences in the u-v coverage on the mapping ability of the array. It shows beams made from fake data based on the VLBA with New England or Green Bank in the Northeast. The beams were made using weighting and tapering that one might use when trying for maximum dynamic range. In particular, the taper was chosen to emphasize the portion u-v plane where the coverage is good. Higher resolution could be obtained without a taper but, with the rather isolated Hawaii-to-Virgin Islands baseline (forced by geography), the sidelobes are higher. The difference between the configurations is a factor of about two on the highest sidelobes, which are near the main lobe. With New England, the highest sidelobes are about five percent; with Green Bank, they are over 10 percent. I have not tried other declinations, but suspect that this is the one for which the differences between arrays is largest. However, the differences will probably not be much smaller over a declination range of about 0 to 50 degrees.

Modern deconvolution algorithms can compensate to some degree for the differences in sidelobe levels, making a true comparison of the mapping abilities difficult. However, it is likely that lower sidelobes can only help, especially in the VLBI case

where the phases are initially uncalibrated and iterative self-calibration must be used to make maps.

The hole that Green Bank (or other stations at similar longitudes such as Algonquin) has trouble filling is the result of a simple geographical reality — it is farther from Hawaii to California than it is from California to New England by a small amount. There is no way to shorten the Hawaii-to-California baselines significantly so when the longest continental baselines from California and Washington to the East are shortened by moving the eastern station west, a hole is produced. Actually this points out an additional disturbing feature of the hole — with it, over a large range of hour angles the Hawaii baselines are all well separated from any baselines between other antennas. This may make self-calibration more difficult because it eliminates any constraints on the Hawaii gain imposed by the equivalent of crossing points. The lack of short baselines to Hawaii and the resulting difficulty of calibration has long been a source of concern and is one reason we want a very good site in Hawaii. The move to Green Bank would make the problem worse.

Note that I have previously studied (a Council Memo) a variety of possible configurations in which a Green Bank antenna was assumed and three other antennas were allowed to have a variety of locations including the four VLBA sites at Owens Valley, Washington, Iowa, and New England. The island sites and the other Southwest sites (some being acquired by then) were held fixed. The option using the VLBA sites except New England was the best I found, although I consider it significantly worse than the original VLBA.

Recall that Green Bank was considered a constraint in early VLBA studies but was dropped, after discussion with project management, when it was realized that it was too close to New England which, in turn, was required for a good match to the Hawaii baselines. If Green Bank were to be considered a constraint, it should have been made so while the whole configuration could be adjusted to compensate.

VLBA

VLBA
No Northeast
(9 Antennas)

VLBA
Green Bank
as Northeast

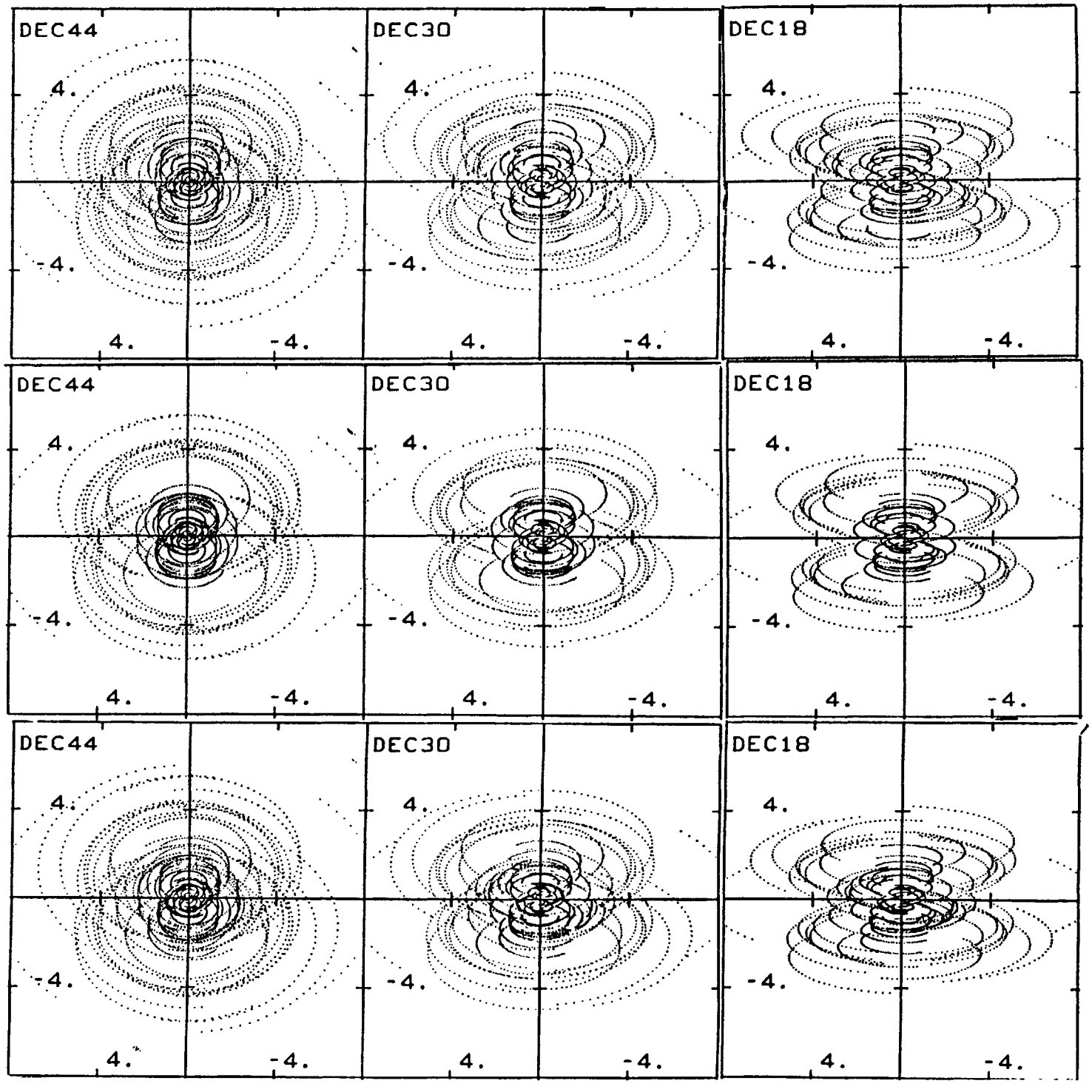


Figure 1

VLBA + EVN

EVN: WSRT
BONN
ONSALA
BOLOGNA
JODRELL

VLBA + EVN
No Northeast

(9 VLBA Antennas)

VLBA + EVN
Green Bank
as Northeast

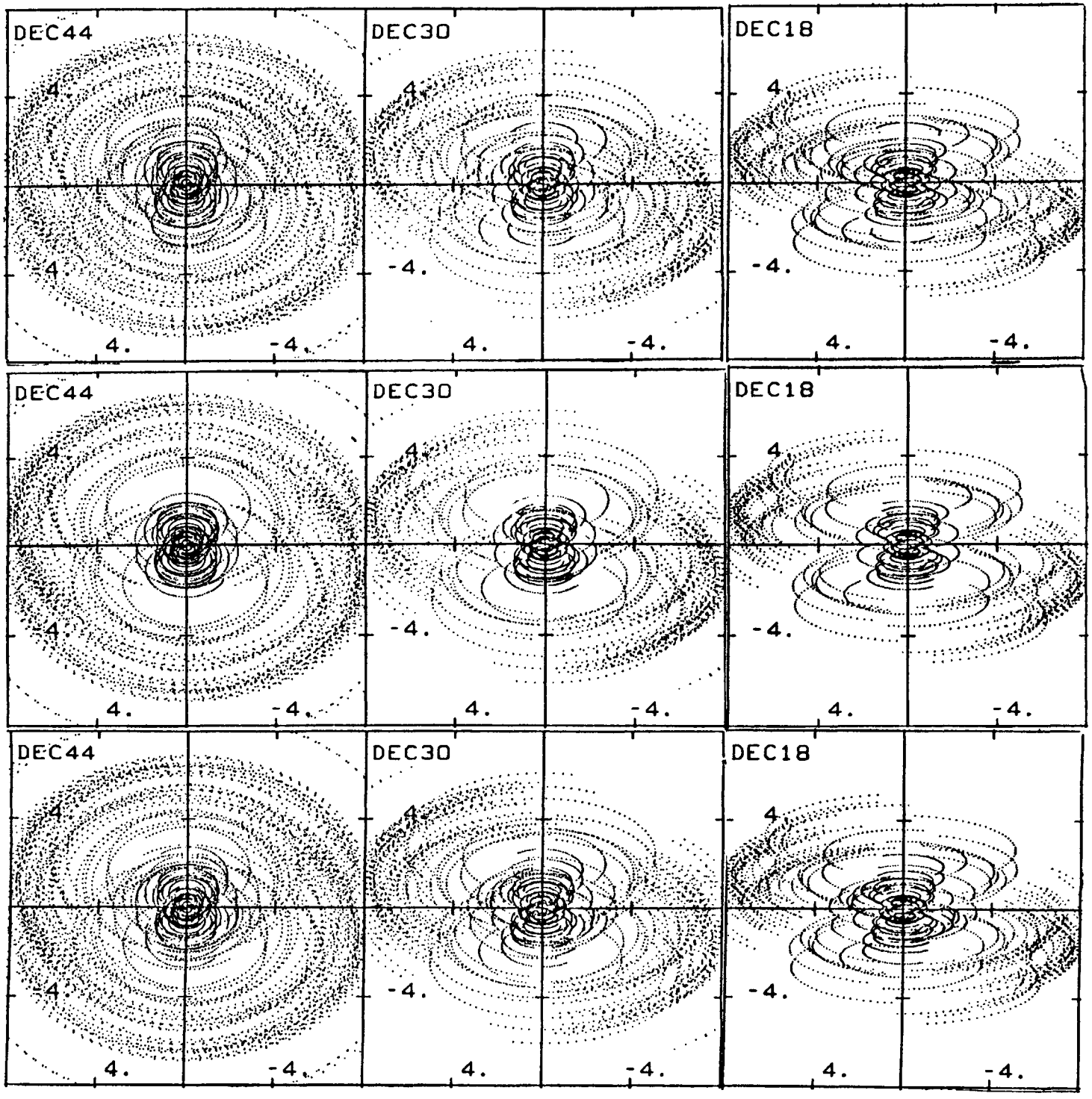


Figure 2

Beams

2% Contours

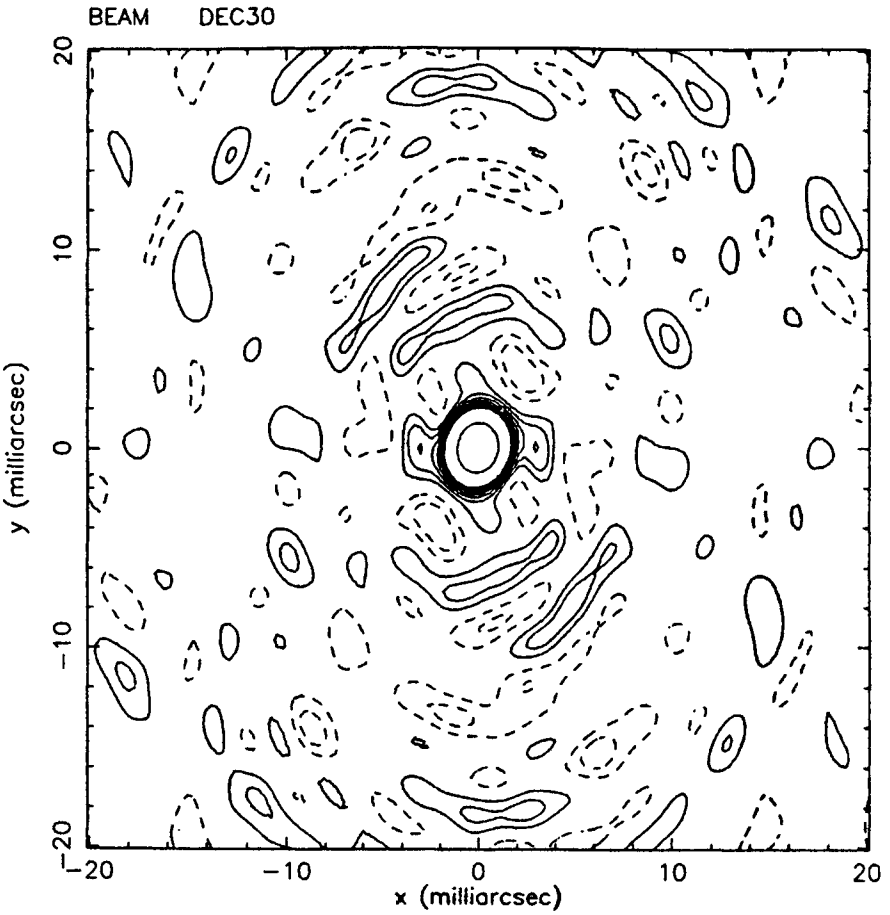
Uniform Wt.

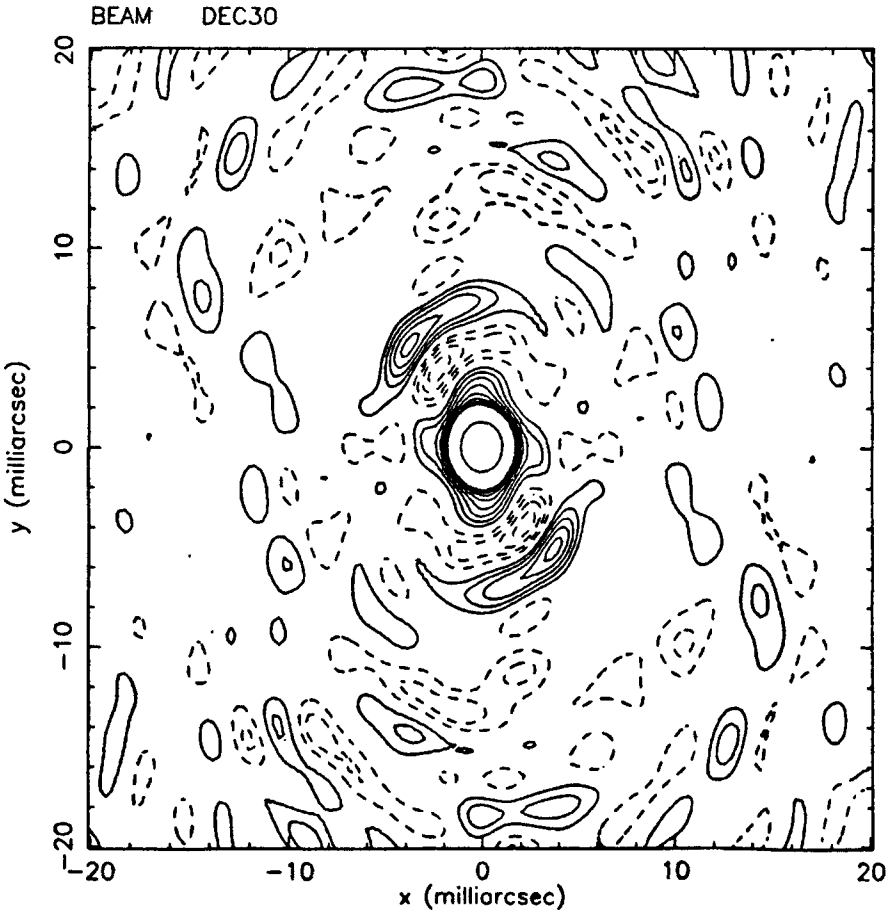
Taper:
0.2 at 4800 km

30° Declination

5.0 GHz

VLBA





VLBA
Green Bank as Northeast

Figure 3