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COMMENTS ON ARRAY CONFIGURATIONS

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ABSTRACT

This memo briefly compares radial, circular and irregular antenna configurations for aperture synthesis arrays. The best array configuration depends on the source structure. Combining arrays with different antenna sizes is discussed.

1. Introduction

Aperture synthesis arrays containing mixed antenna sizes are being considered for the combined BIMA & OVRO arrays (CCA: 10 6m-antennas + 6 10m antennas) and for the combined US and European millimeter arrays. In order to get the full sensitivity of the combined arrays, cross-correlations between all antennas should be made. Initially, however, observations can be obtained using the existing BIMA and OVRO correlators without any cross correlations between 10m and 6m antennas.

2. Science and Sensitivity

The optimum antenna configuration depends on the science goals. The best array configuration depends quite strongly on the source structure. Radial antenna configurations gives a tapered visibility density distribution in the u-v plane. This gives a low sidelobe level and better sensitivity to large scale structure; good for mapping sources with low brightness extended envelopes such as protostellar objects.

Reuleaux, or circular, configurations give a more uniform uv-coverage with better sensitivity to small scale structure; better for mapping compact structures, e.g CO in merging galactic nuclei.

The best sensitivity to small scale structure is obtained with relatively few well separated clusters of antennas. This gives poor u-v coverage and sensitivity for intermediate angular scales.

3. Observing strategies

The array configuration can be optimized to use different antenna sizes. The smaller antennas are best suited for mapping large source structure, and are best placed close together at short baselines in order to sample extended structure. Mosaiced observations with a mixture of 10m and 6m antennas are disussed in BIMA memo 59. The larger antennas at longer baselines increase the sensitivity to small scale structure.

4. Radial arrays

Earth rotation provides azimuthal u-v coverage after a time 12/(number of arms) i.e. 2 – 4 hours for the 5-arm arrays designed by Lee.

The 5-arm arrays designed by Lee do a good job meeting his design goals: good u-v coverage in 2–4 hours, minimum redundancy, and excellent sensitivity to extended structure.

Three arrays, scaled by a factor 2.5 in size, give resolutions 1, 2.5, and 6.3$''$ at 100 GHz. The 3 scaled arrays, which share 12 stations, require a total 2.0 km of roadway and 36 stations.

Figure 1 and 2 show the u-v tracks and beam pattern for a 5-arm radial array with observations over 4 hours at DEC=-30.

5. Reuleaux arrays

Reuleaux arrays (Keto, 1997) give a more uniform u-v sampling and much better instantaneous coverage, which is important at the highest frequencies when the atmosphere is marginal and only short intervals may be available for observations. Assuming only 1 common station, 3 Reuleaux arrays require 3 km of roadway and 46 stations. Figure 3 shows the instantaneous u-v coverage for a 17-antenna Reuleaux configuration. Figure 4 and 5 show the u-v tracks and beam pattern for a 17-antenna Reuleaux array with observations over 4 hours at DEC=-30. Comparison with Figure 1 and 2 shows the more uniform u-v sampling, and slightly higher sidelobe level.

6. Topographic constraints

The Reuleaux array configurations were obtained with Eric Keto's neural network code which iterates to find the most uniform u-v coverage within a circular boundary. We have adapted this code to to work with other boundary conditions. Topographic constraints, or existing road infrastructure can be used as a boundary condition. For example, Figure 6 shows that a reasonably uniform u-v coverage can be obtained with the antennas placed along a T shaped array with a width about 10% of the length. Good u-v coverage can similarly be obtained for other constrained geometries with a width about 10% of the length.

7. Getting started

In order to get the full sensitivity of the combined arrays, cross-correlations between all antennas should be made. Initially, however, the CCA could make observations using the existing BIMA and OVRO correlators without any cross correlations between 10m and 6m antennas . This could be done using the existing control systems, since there is then no requirement to observe with common hardware or sampling interval. All that is required is to observe the same source over a common frequency interval. There is adequate experience in combining data from different instruments.

Both radial and circular arrays give reasonable u-v coverage without cross-correlations between 10m and 6m antennas. For the 5-arm array with the six 10m antennas at longer baselines, the u-v tracks and beam pattern are shown in Figures 7 & 8. A full 4-hour track is required for complete u-v coverage; significant gaps appear with shorter tracks. For circular arrays, the best placement of the 10m and 6m antennas is not so obvious. Some adjacent 6m antennas are required to get short u-v spacings; distribution of both 10m and 6m antennas around the circle is required to get reasonable u-v coverage.

8. Conclusions

1. The best array configuration depends on the source structure.

2. Radial arrays give a tapered u-v sampling; good for mapping extended structure.

3. Reuleaux configurations give a more uniform uv-coverage with better sensitivity to small scale structure.

4. Good u-v coverage can be obtained for constrained geometries with a width about 10% of the length.

5. Both radial and circular arrays give reasonable u-v coverage without cross-correlations between 2 sub-arrays.

REFERENCES

Keto, E., ApJ, 1997, 475, 843-852
Wright, M.C.H., 1997, BIMA memo 59

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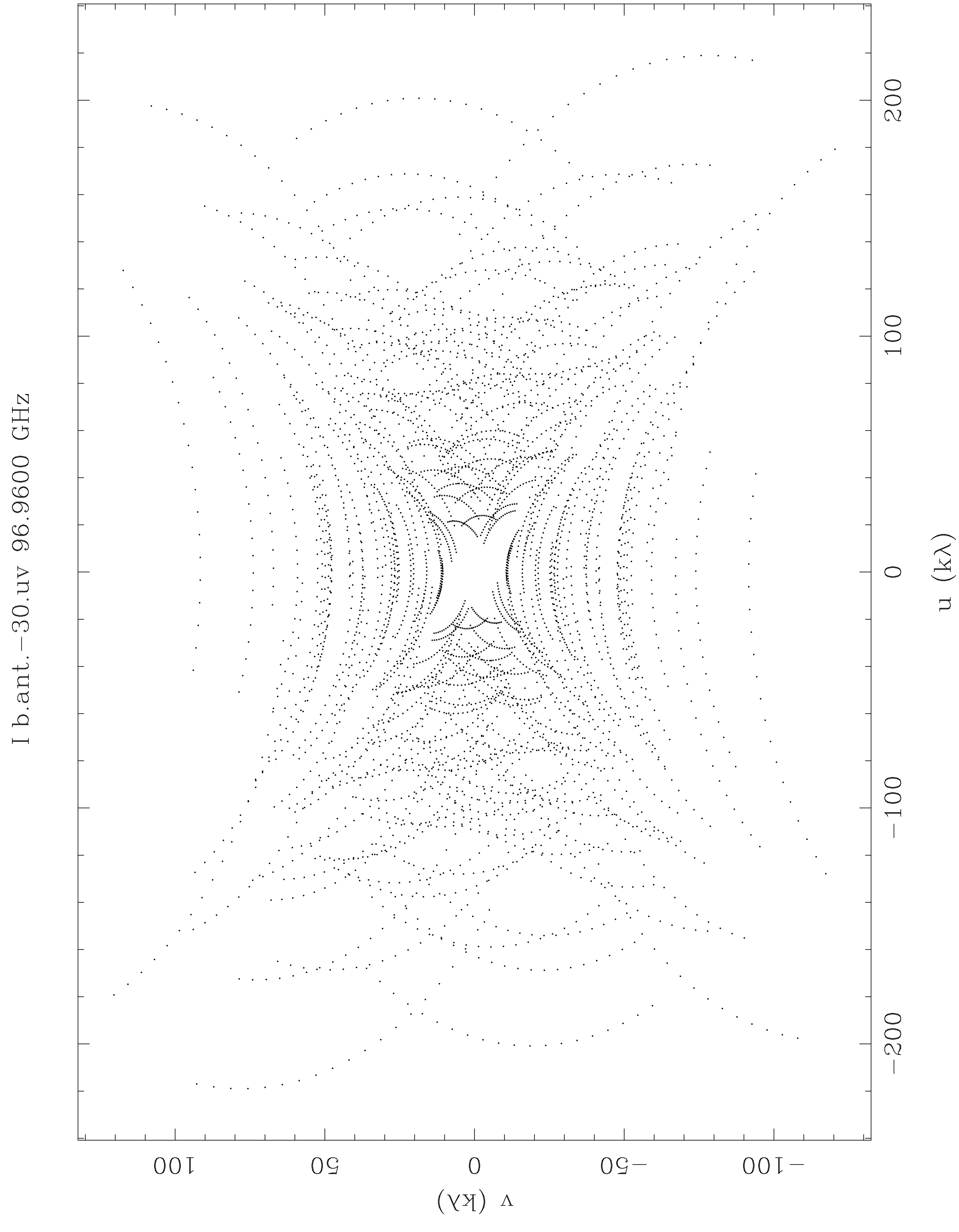

Fig. 1.— u-v tracks for 5-arm radial array for a 4 hour observation at DEC=-30

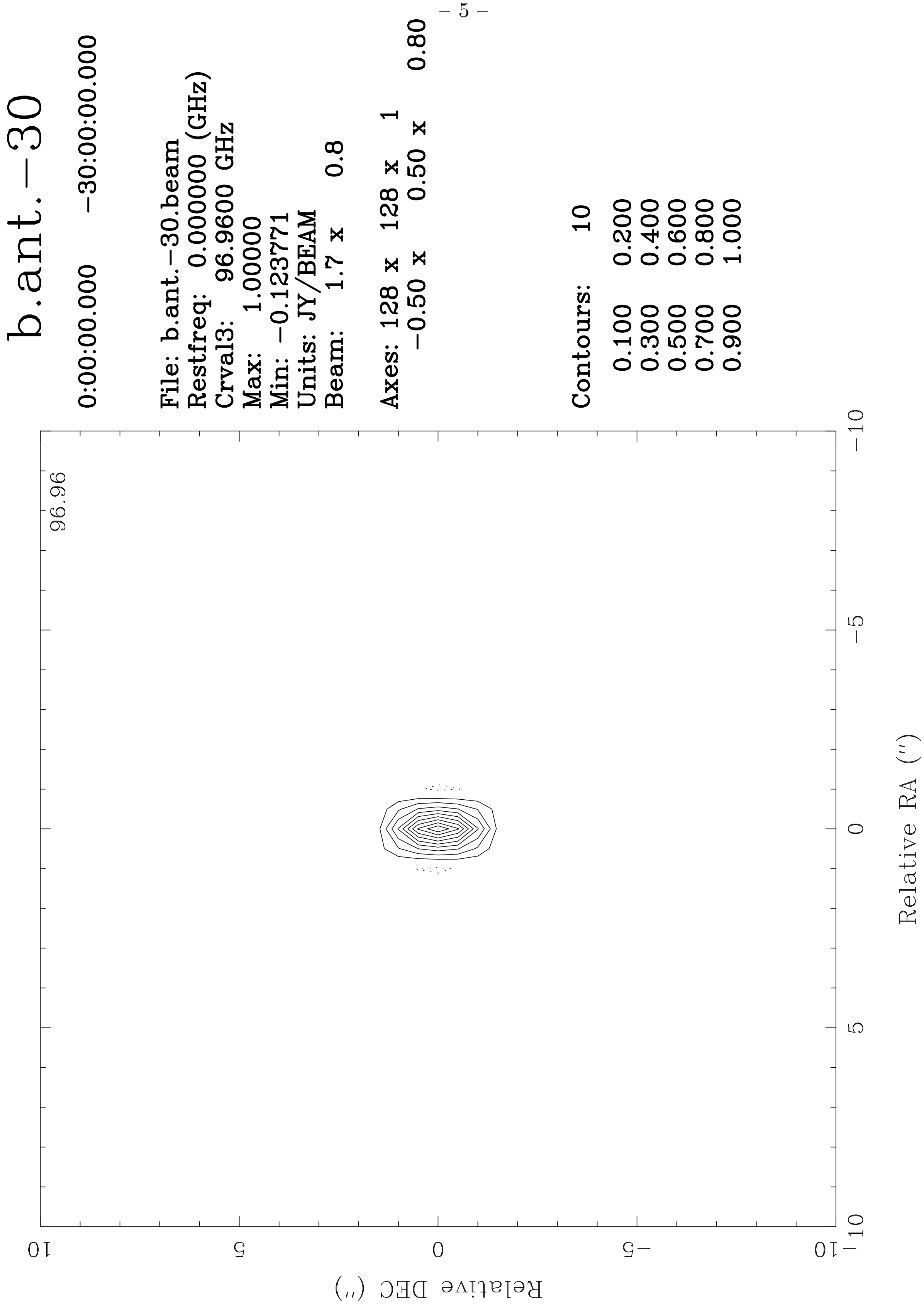

Fig. 2.— beam pattern for 5-arm radial array for a 4 hour observation at DEC=-30

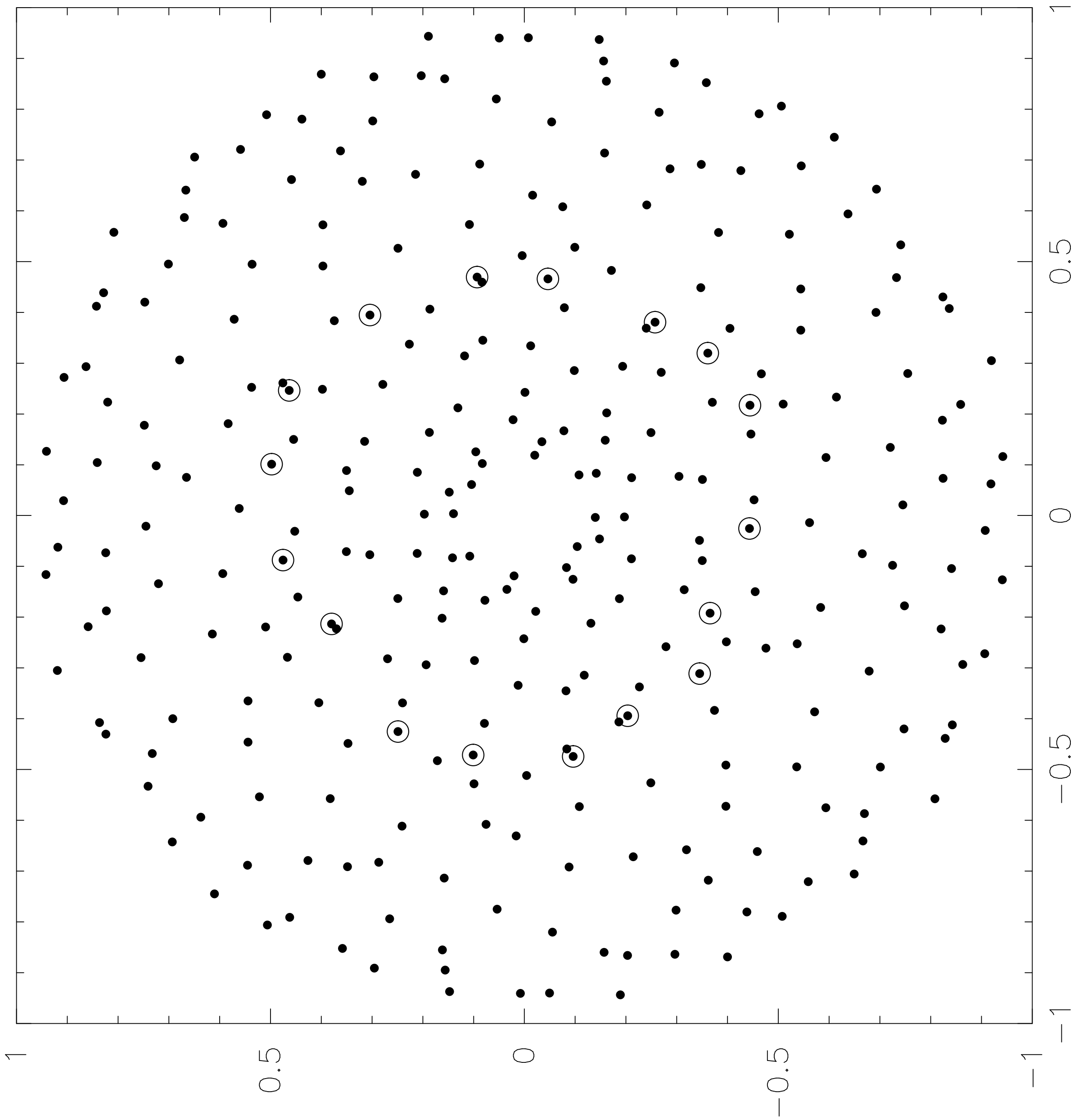

Fig. 3.— Instantaneous u-v coverage for 17-antenna Reuleaux configuration

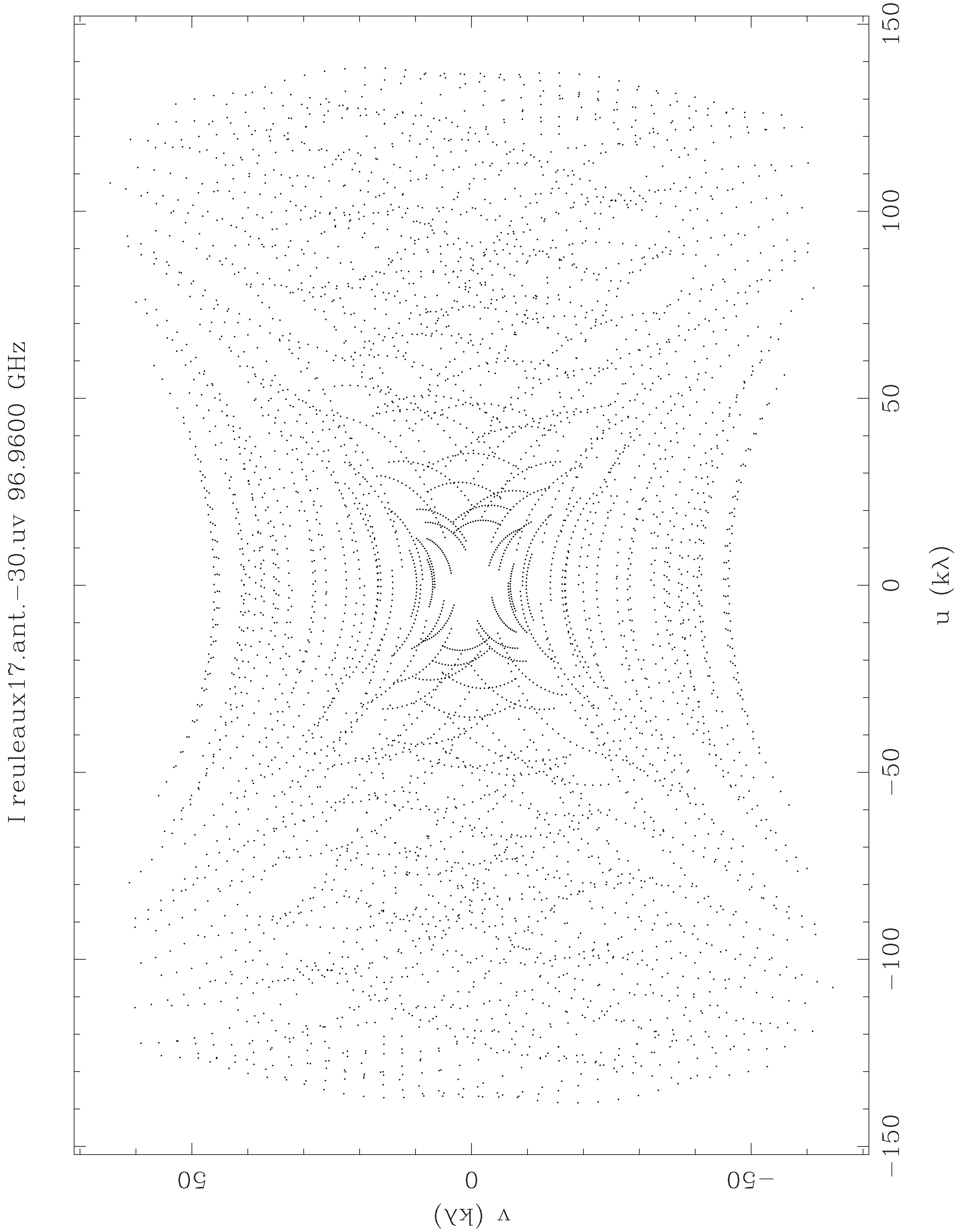

Fig. 4.— 17-antenna Reuleaux u-v tracks for a 4 hour observation at DEC=-30

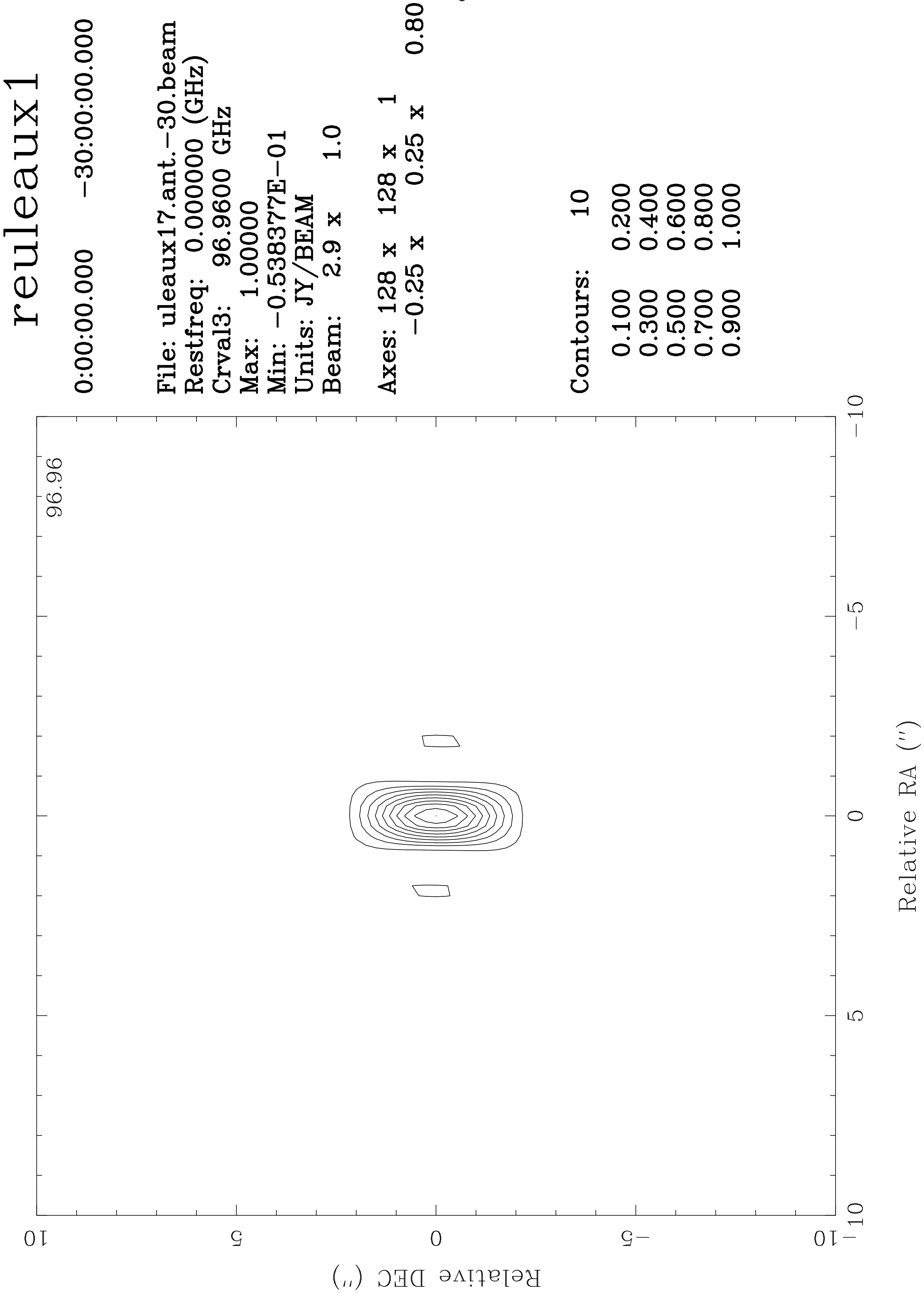

Fig. 5.— 17-antenna Reuleaux beam pattern for a 4 hour observation at DEC=-30

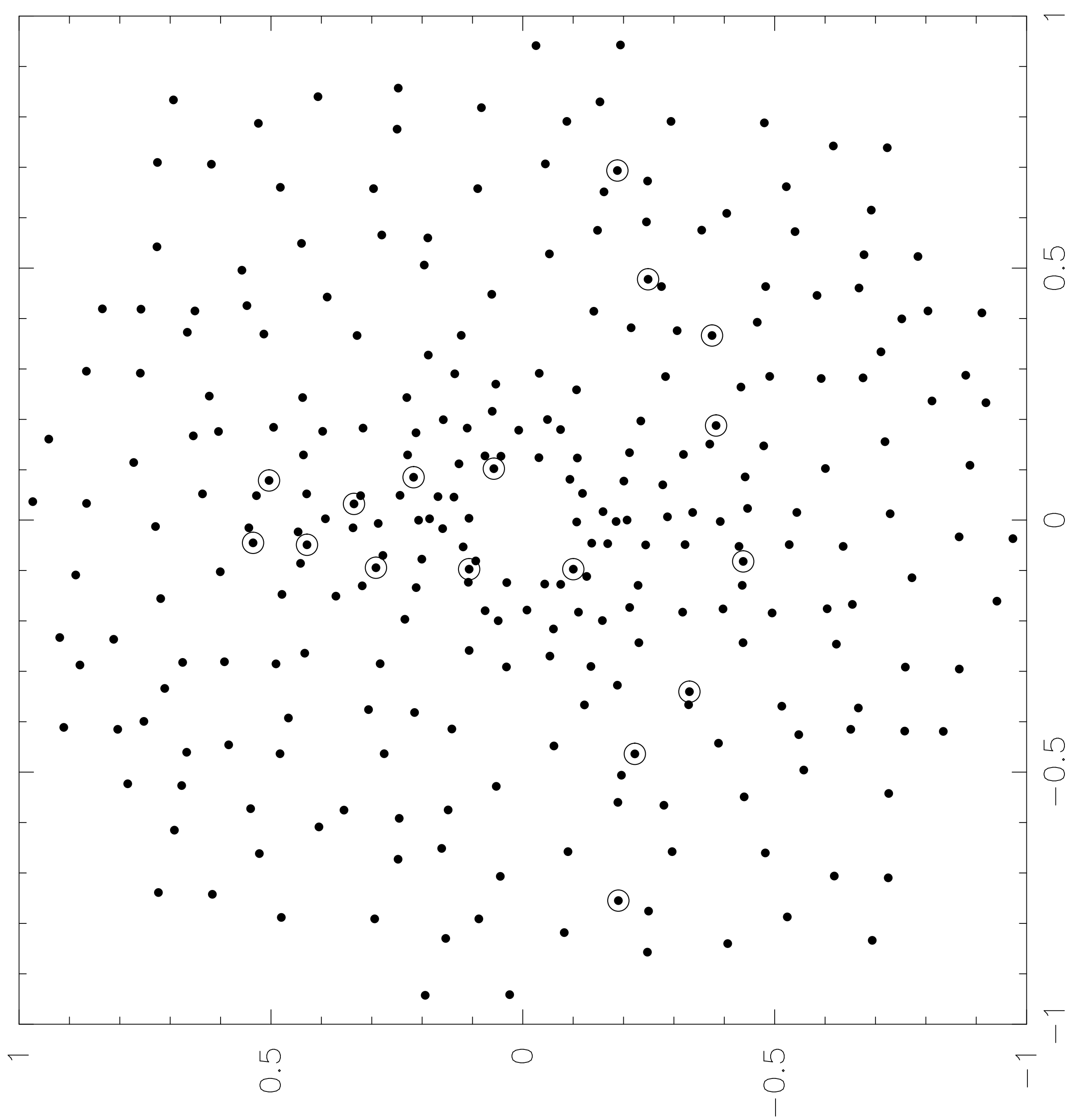

Fig. 6.— Instantaneous u-v coverage for 17-antenna T configuration

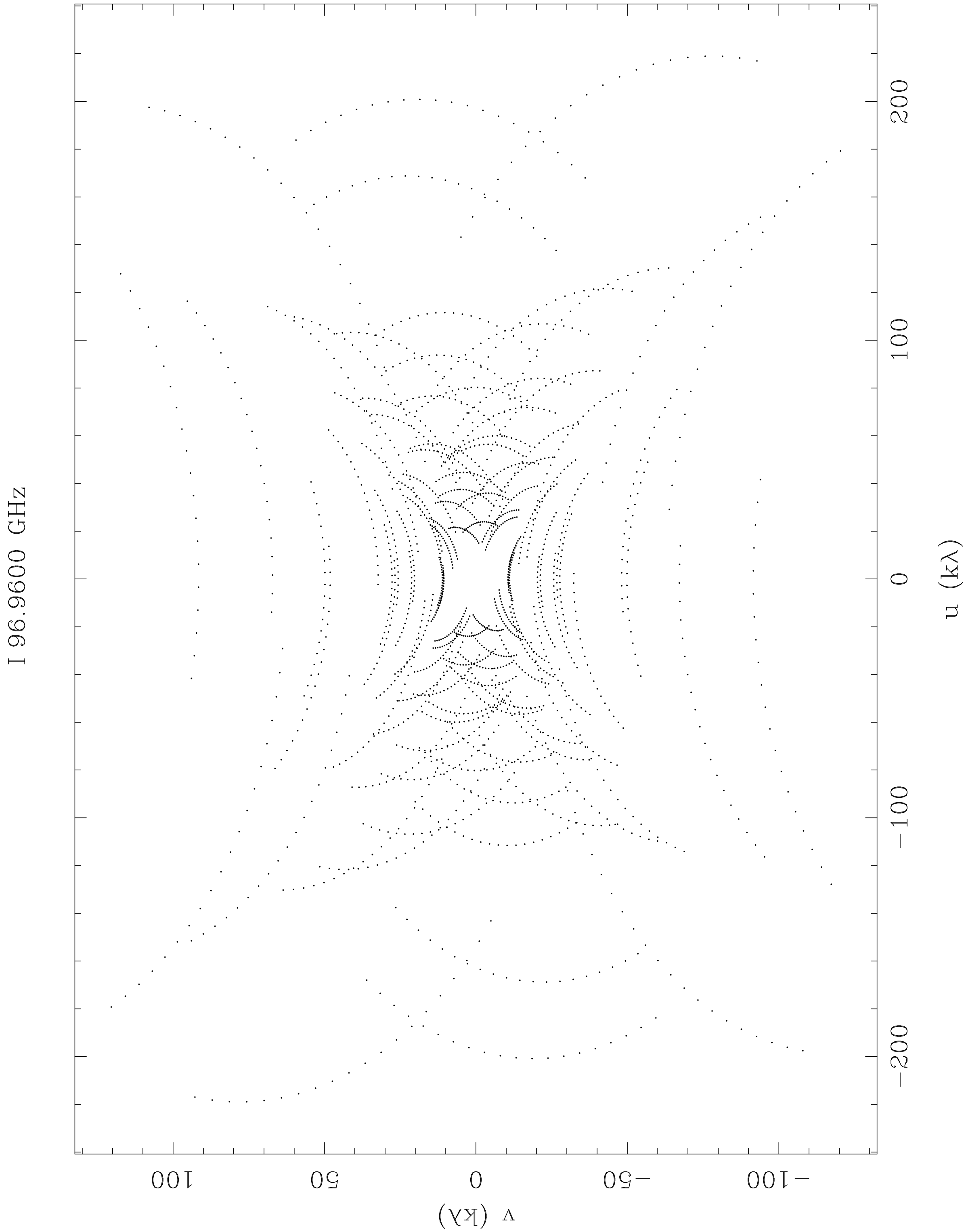

Fig. 7.— u-v tracks with no correlations between 10m and 6m antennas

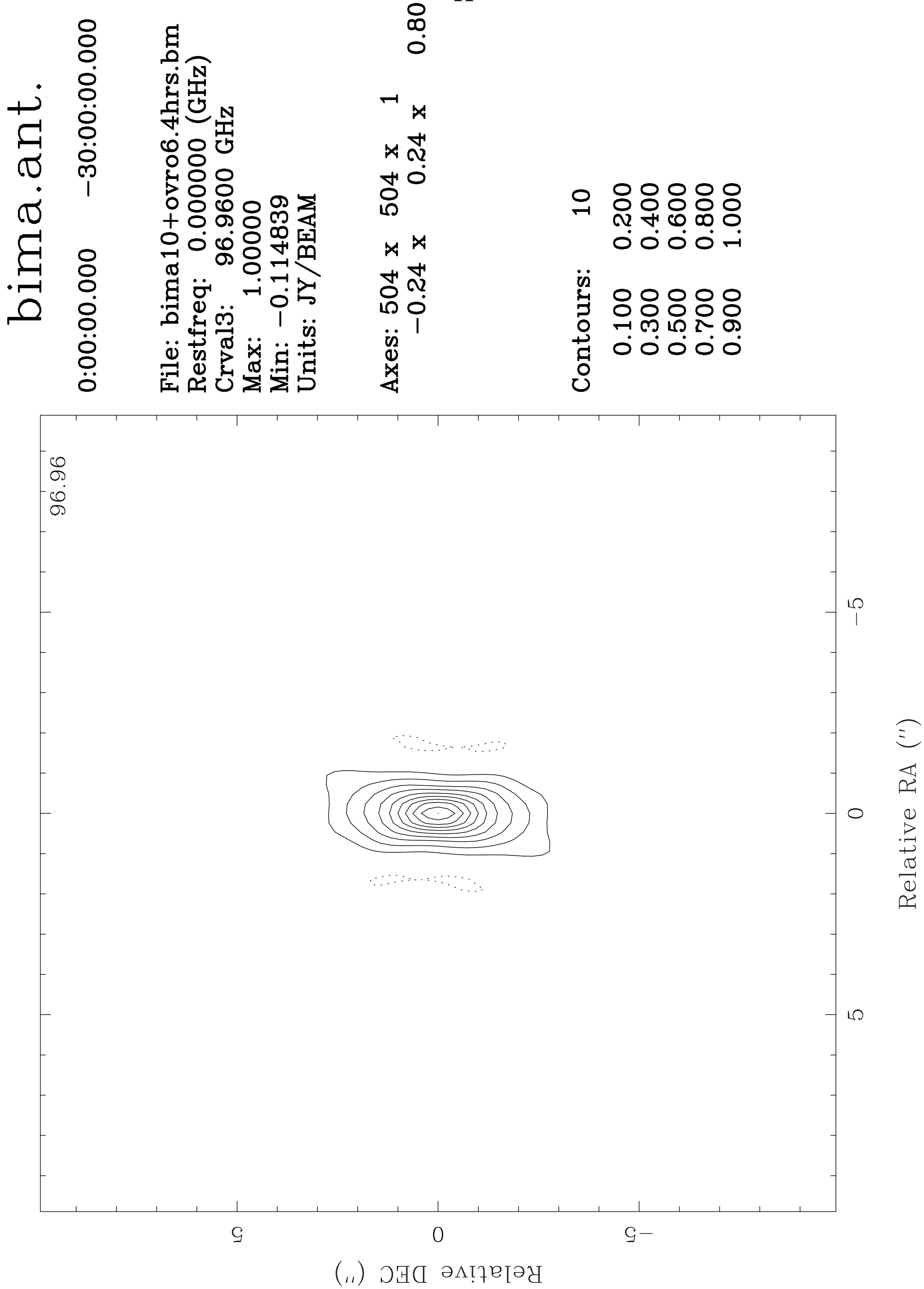

Fig. 8.— beam pattern with no correlations between 10m and 6m antennas