A-Array Configurations with 16 Elements

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This report summarizes a study of A-array configurations for a 16-element array on Upper Harkless Flats. The objective of this report is to determine antenna locations which provide the best beams and uv coverages within the constraints of the site. These positions are not carefully optimized at the 20-30 meter level because the final positions should take advantage of local geographic considerations, ie flat spots, avoidance of rock outcroppings, avoidance of trees, etc.

Assumptions and Goals:

The following assumptions were made:

- It is desirable to locate pads along existing roads as much as possible.
- It is desirable to locate pads in areas without trees as far as possible.
- The target maximum baselines for the array are approximately 2 km.
- The A array observations can be complemented by the B array as needed so good coverage of the inner uv plane is not important.

The following are treated as design goals to be achieved:

- Good uv coverage in both 3 hour "snapshots" and in full tracks.
- Minimum redundancy in baseline lengths.
- Minimum sidelobes in the synthesized beam for source declinations from +55 to -20 degrees.
- The best possible resolution within the constraints of the maximum baseline length, and the goal of good uv coverage beyond 250 kλ (the limit where the B-array coverage becomes spotty).

A-Array Configuration 1

Configuration 1 is the A-array proposed by Steve Scott and Kevin Marvel in 1997. It is presented here for comparison purposes. I have made no attempt to re-optimize the array taking the above considerations into account. Tables 1 list the antenna locations. Figure 1 shows the antenna layout superimposed on a contour map of elevation. Figures 2 and 3 show beams and uv coverages for this configuration. The two sets of figures show the results for hour angle coverages of ± 5 and ± 1.5 hours from transit, restricted to elevations above 17 degrees. Each figure is divided into two columns; the left column shows the synthesized beam and the right column the uv coverage. The four panels in each column refer to four specific source declinations: -20, -5, 18, and 55 degrees.

East (meters)	North (meters)
0.0	0.0
-26.8	177.5
-67.1	443.8
-161.1	1065.2
114.7	57.4
286.7	143.6
758.1	594.6
121.6	-123.3
303.9	-308.2
889.4	-679.7
-85.6	-165.1
-493.9	-572.8
-103.5	-690.6
-132.9	22.0
-332.1	55.0
-657.1	-68.0

Table 1: A-Array Configuration 1 Antenna Positions

Tables 2 reports the beam sizes and sidelobe levels for each of the beams presented. The beam size is the Gaussian fitted FWHM. The sidelobe levels are in percentages of the main beam with the first number corresponding to the largest negative sidelobe and the second the largest positive sidelobe.

Decl.	HA =	± 5 hours	HA =	± 1.5 hours
	syn beam	sidelobes	syn beam	sidelobes
-20	0.77 x 0.48	-6,10	0.74 x 0.44	-6,12
-5	0.60 x 0.50	-7,15	0.55 x 0.44	-8,29
18	0.53 x 0.44	-5,7	0.46 x 0.40	-7,13
55	0.49 x 0.40	-4,5	0.46 x 0.38	-7,11

Table 2: A-Array Configuration 1 Beam Characteristics

A-Array Configuration 2

Configuration 2 differs from Configuration 1 in that it has more pads located off the primary star. The goal of this relocation of pads is to put more antennas on longer baselines than in Configuration 1. This will improve the effective resolution of the array and make its uv coverage more complementary to the B-array. Configuration 2 drops one of the outer pads in Configuration 1, the one to the far southwest. It adds three pads, one along each of the north extensions and one along the southeast extension. The exact pad locations are given in Table 3.

East (meters)	North (meters)
-35.7	131.0
-92.0	503.5
89.6	117.4
261.5	203.4
278.7	-248.0
-143.8	-169.1
-238.8	-352.5
-356.9	115.0
-230.0	-700.0
650.0	100.0
595.0	-410.0
-125.0	730.0
-161.1	1065.2
758.1	594.6
940.0	-565.0
-657.1	-68.0

Table 3: A-Array Configuration 2 Antenna Positions

Figure 4 shows the antenna locations superimposed on a contour map of the elevation. The beams and uv coverages are shown in Figures 5 and 6. The two set of figures show the results for hour angle coverages of ± 5 and ± 1.5 hours from transit. Each figure has a left column displaying the synthesized beam and a right column with the corresponding uv coverage. The four panels in each column correspond to the same four source declinations as for the star-configurations.

Table 4 reports the beam sizes and sidelobe levels for each of the beams presented.

Decl.	HA = syn beam	± 5 hours sidelobes	HA = syn beam	± 1.5 hours sidelobes
-20	0.64 x 0.38	-6,7	0.64 x 0.34	-6,11
-5	0.47 x 0.40	-6,16	0.45 x 0.34	-7,23
18	0.41 x 0.36	-5,7	0.36 x 0.32	-6,15
55	0.39 x 0.33	-5,5	0.35 x 0.32	-6,9

Table 4: A-Array Configuration 2 Beam Characteristics

A-Array Configuration 3

Configuration 3 is a small modification on Configuration 2. The antenna at (595E,-410N) in Configuration 2 is moved to (745E,-460N). Tables 5 and 6 give the antenna positions and beam characteristics, respectively, for Configuration 3. Figures 7 and 8 give the beams and uv coverages.

East (meters)	North (meters)
-35.7	131.0
-92.0	503.5
89.6	117.4
261.5	203.4
278.7	-248.0
-143.8	-169.1
-238.8	-352.5
-356.9	115.0
-230.0	-700.0
650.0	100.0
745.0	-460.0
-125.0	730.0
-161.1	1065.2
758.1	594.6
940.0	-565.0
-657.1	-68.0

Table 5: A-Array Configuration 3 Antenna Positions

Decl.	HA = syn beam	± 5 hours sidelobes	HA = syn beam	± 1.5 hours sidelobes
-20	0.63 x 0.37	-6,7	0.64 x 0.34	-7,11
-5	0.46 x 0.39	-6,16	0.45 x 0.33	-7,25
18	0.40 x 0.36	-5,6	0.36 x 0.32	-6,14
55	0.38 x 0.32	-5,5	0.35 x 0.31	-6,9

Table 6: A-Array Configuration 3 Beam Characteristics

Comparison of Configurations

The following points summarize the main differences between Configurations 1 and 2:

- Configuration 2 includes three new pads compared to Configuration 1 and drops the remote pad to the southwest in Configuration 1. In terms of construction gains and losses, Configuration 2 incurs the cost of two additional pads, but saves the cost of road improvement/construction to the southwest remote station.

- The baselines in Configuration 2 are generally longer than in Configuration 1 due to the two additional antennas off of the primary star. This difference shows up as a more uniform coverage in the uv plane and as a smaller synthesized beam FWHM.

- The more uniform uv coverage of Configuration 2 suppresses the near-in pedestal on the primary synthesized beam compared to Configuration 1, as shown in Figure 9. This results in a better beam shape down at the 10-20% level. The peak sidelobe levels for the two configurations are very similar.

Configurations 2 and 3 are different in only one antenna location and the resulting sidelobes levels and coverages are slightly better for Configuration 3 than for Configuration 2. This difference is more apparent in the sidelobes within 10" of the primary lobe than in the maximum amplitude of the sidelobes; as can be seen from Table 6, the maximum positive and negative sidelobes are nearly the same for the two configurations.

Conclusions and Recommendations

We prefer Configurations 2 or 3 over Configuration 1 due to the improved sidelobe levels and smaller beams. As indicated by the modest differences between the results for Configurations 2 and 3, the uv coverages and beams can be reasonably robust to the exact placement of individual antennae.

We recommend that the proposed sites for the remote antenna pads be visually inspected and the locations of nearby acceptable sites measured relative to the array center. If no site within 20 meters of our proposed site is reasonable, we recommend that 2-3 alternative sites be measured. These alternative sites can be run through the uv modeling to chose the best one.

Important caveats:

> The game of putting more antennas off the star array can be played a little more at the cost of more environmental impact. For example, an extension of Configuration 2 which populates the remote southwest station would result in more longer baselines. Within the current site footprint, the only other realistic option for remote pads would be to consider placing an antenna off the end of the west arm, around the northwest side of the hill located due north of the end of the west arm.

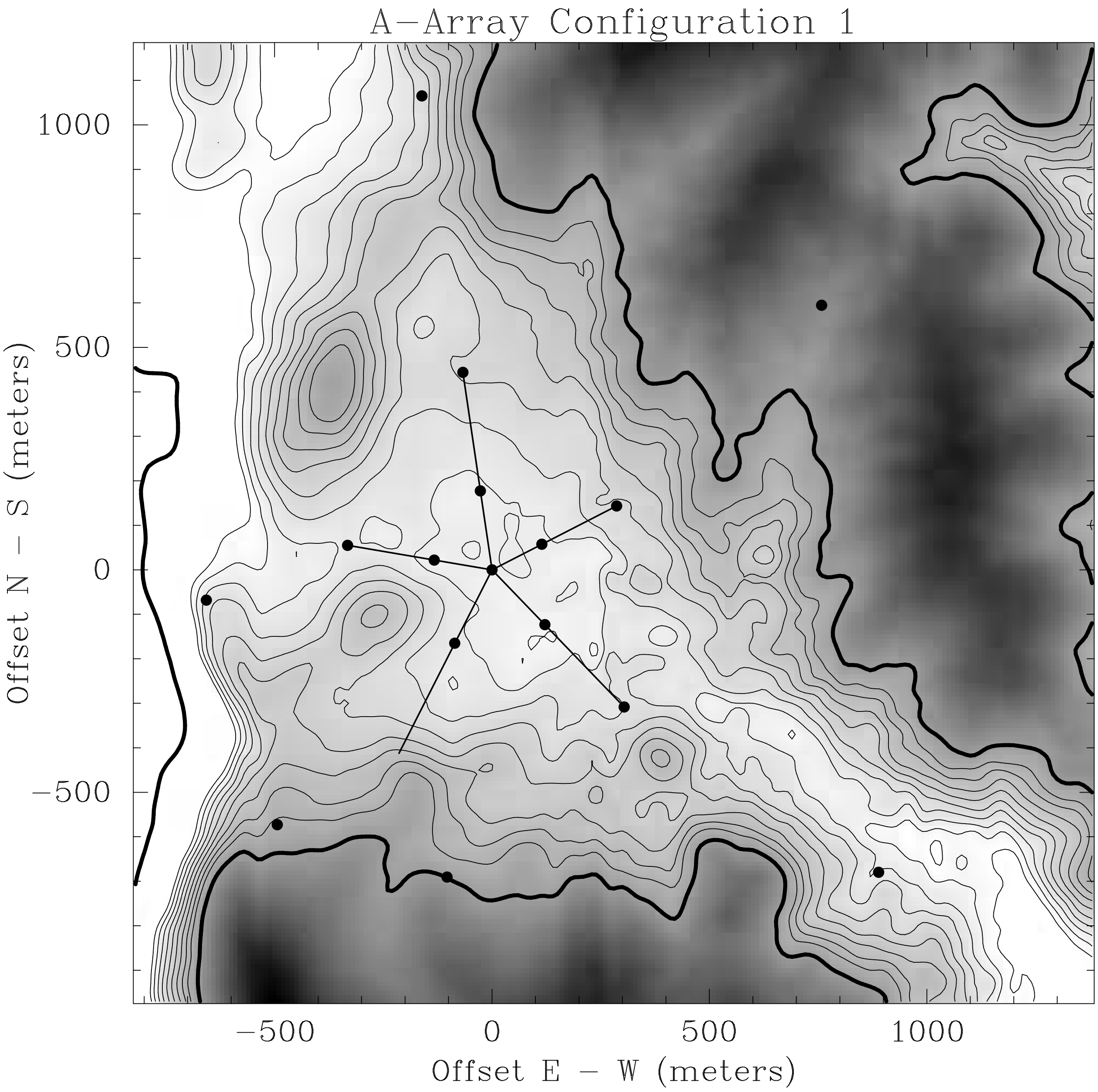

Fig. 1.— Antenna locations for Configuration 1 overlayed on a contour plot of site elevations. The thin contours run from 2650 to 2690 meters in steps of 5 meters. The thick contours are at levels of 2600 and 2700 meters. The filled dots mark the locations of antennas. The stick-figure star represents of location of the primary star layout for the D, C, and B configurations.

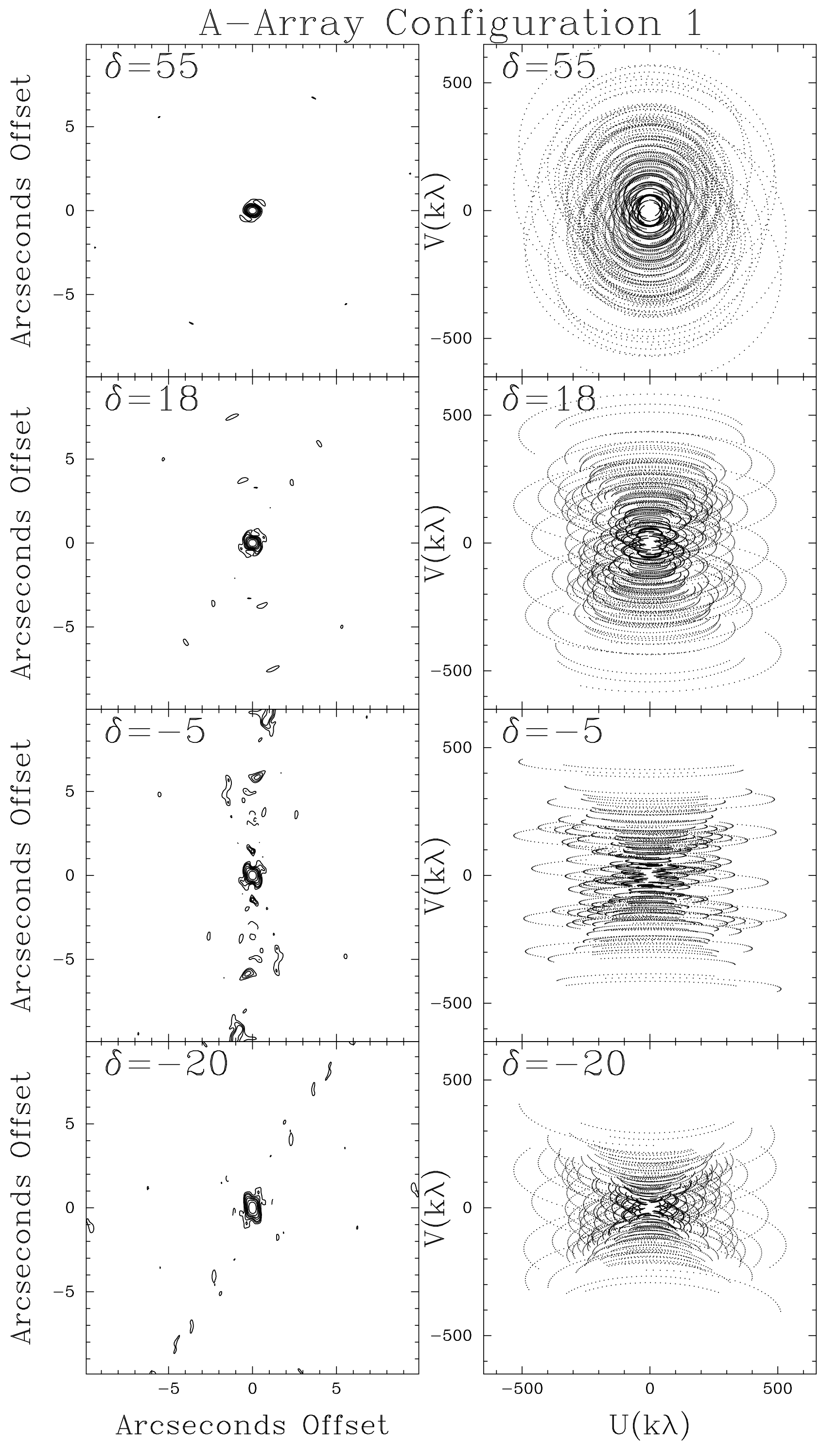

Fig. 2.— Plots of the beams and uv coverages for the proposed Configuration 1 for ±5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

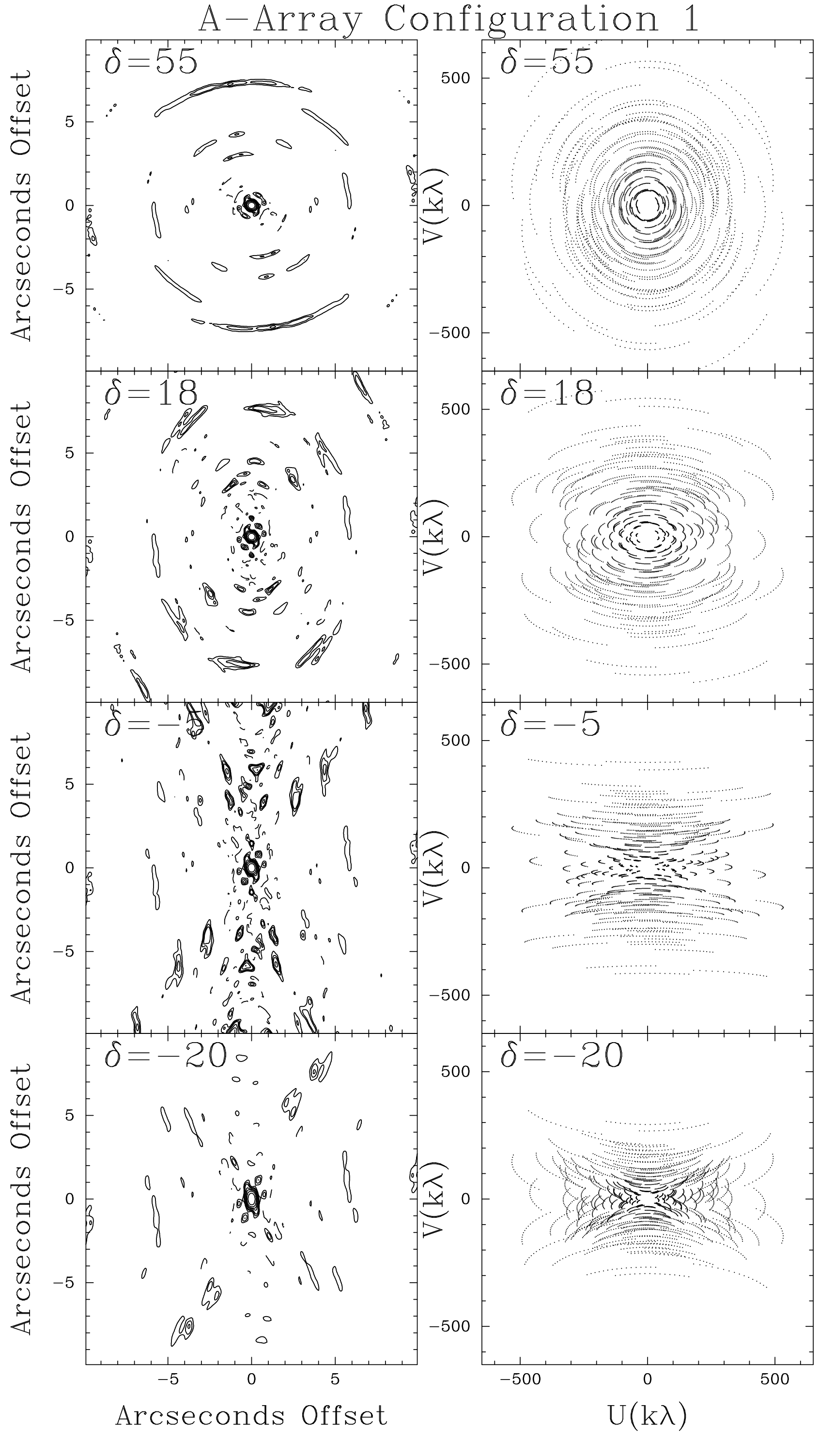

Fig. 3.— Plots of the beams and uv coverages for the proposed Configuration 1 for ±1.5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

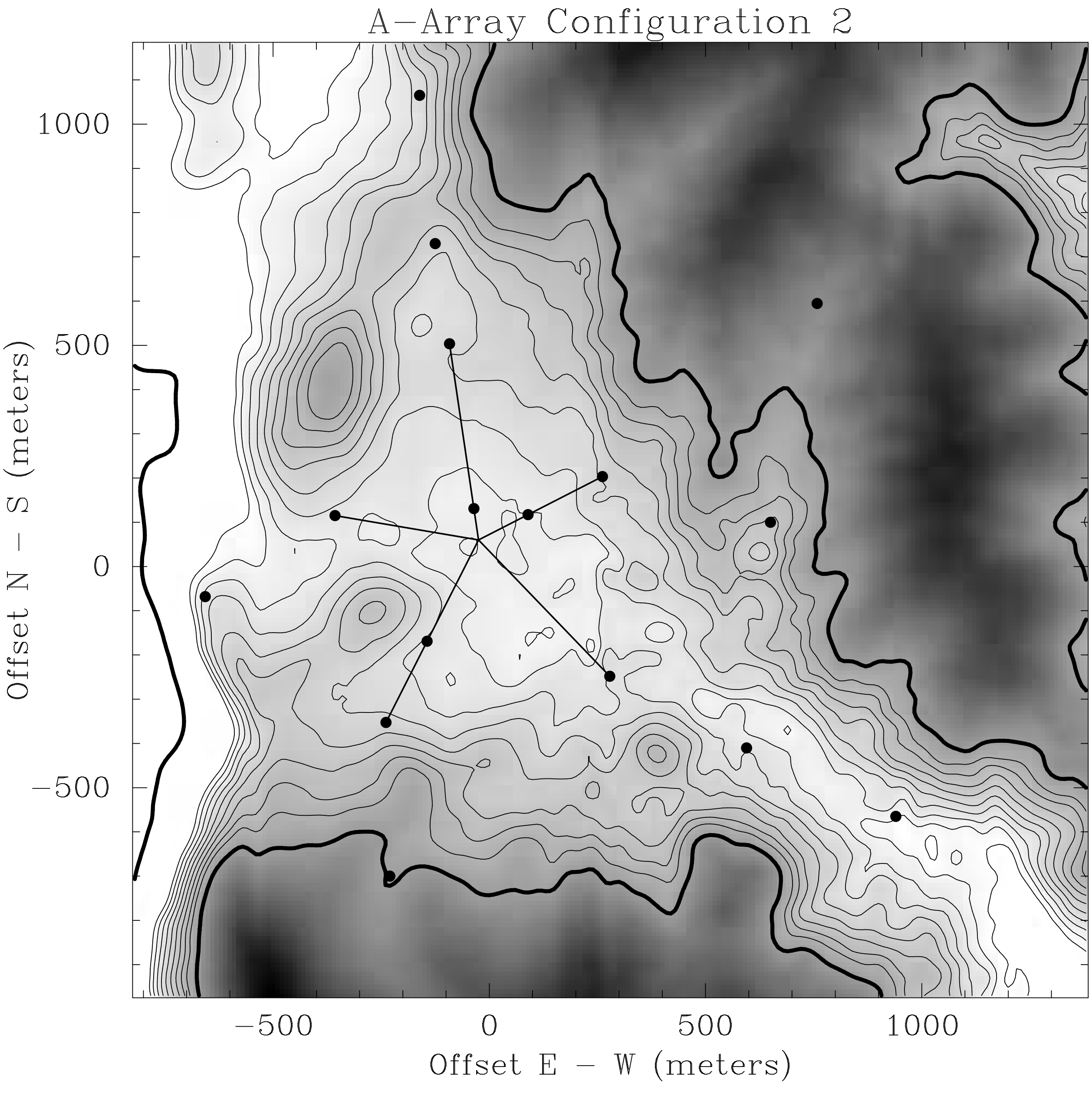

Fig. 4.— Antenna locations for Configuration 2 overlayed on a contour plot of site elevations. The thin contours run from 2650 to 2690 meters in steps of 5 meters. The thick contours are at levels of 2600 and 2700 meters. The filled dots mark the locations of antennas. The stick-figure star represents of location of the primary star layout for the D, C, and B configurations.

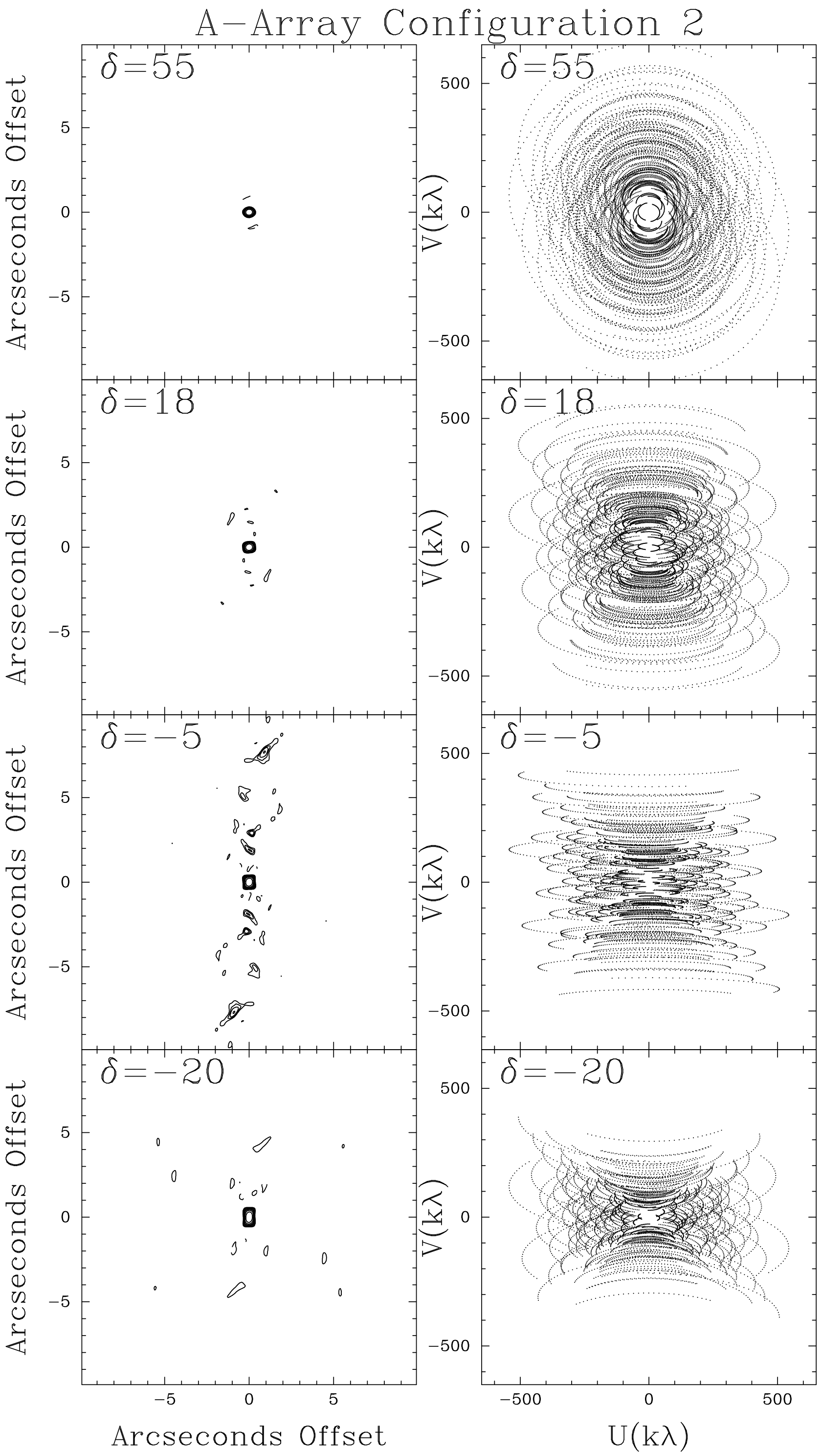

Fig. 5.— Plots of the beams and uv coverages for the proposed Configuration 2 for ±5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

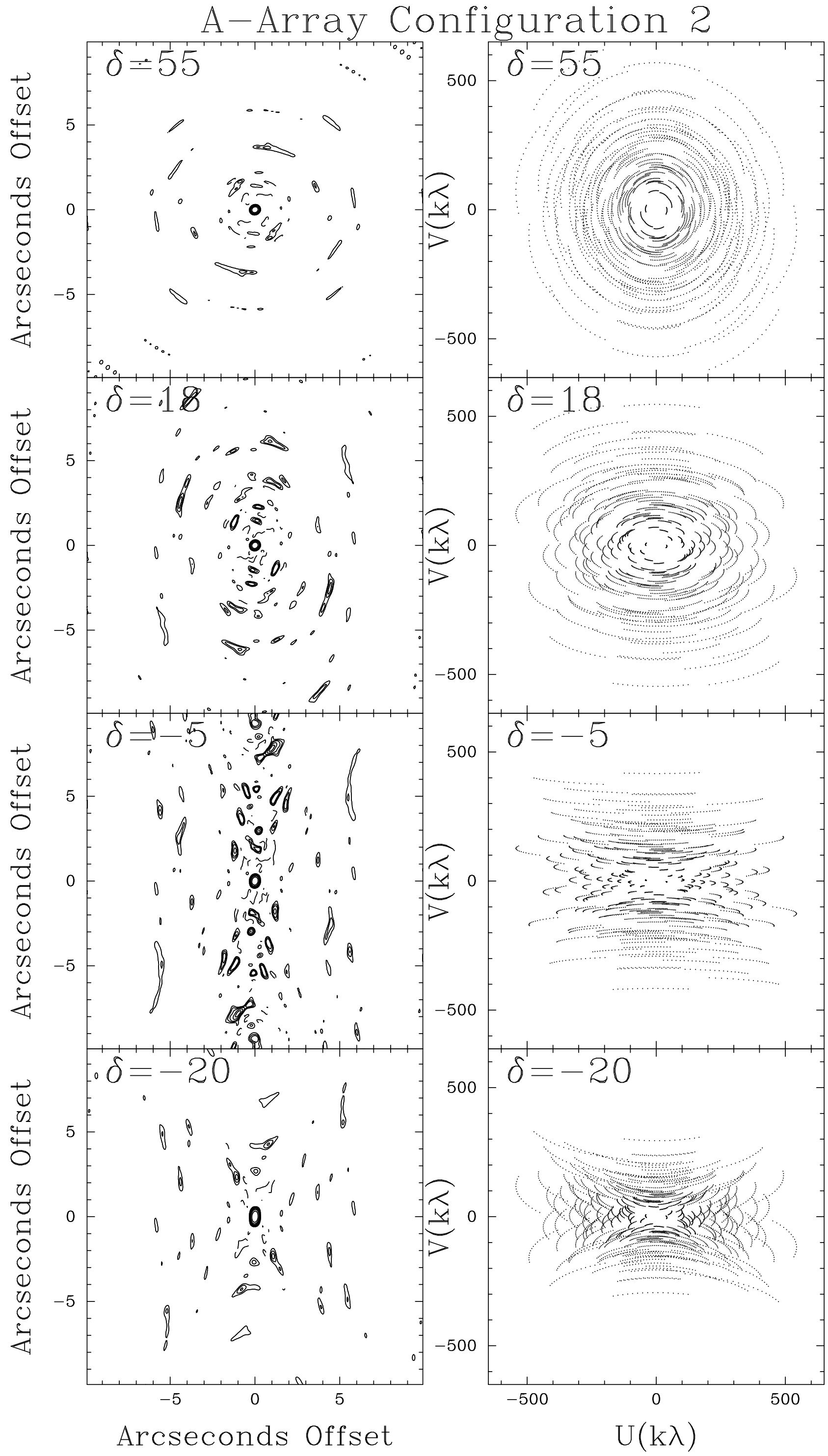

Fig. 6.— Plots of the beams and uv coverages for the proposed Configuration 2 for ±1.5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

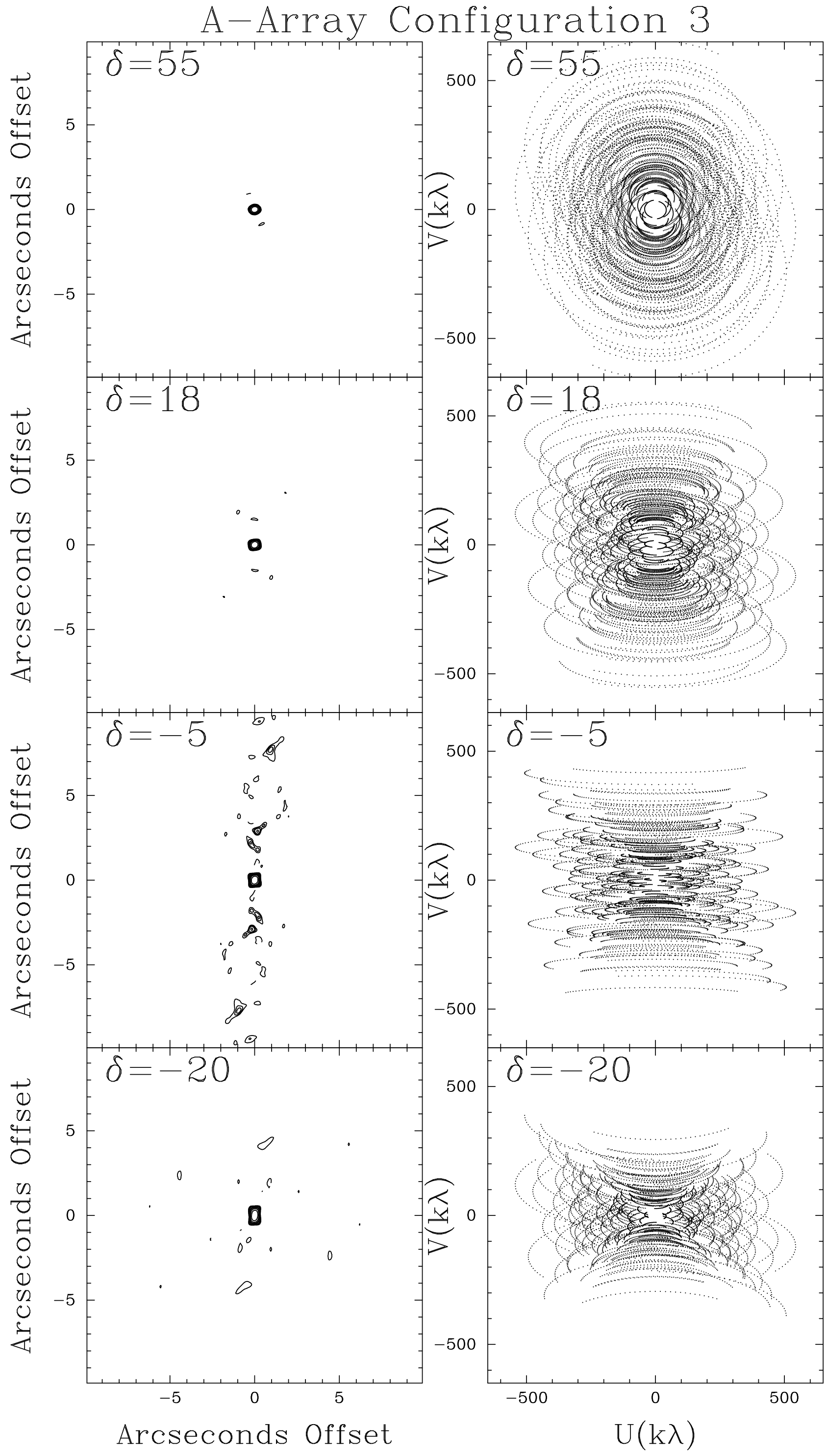

Fig. 7.— Plots of the beams and uv coverages for the proposed Configuration 3 for ±5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

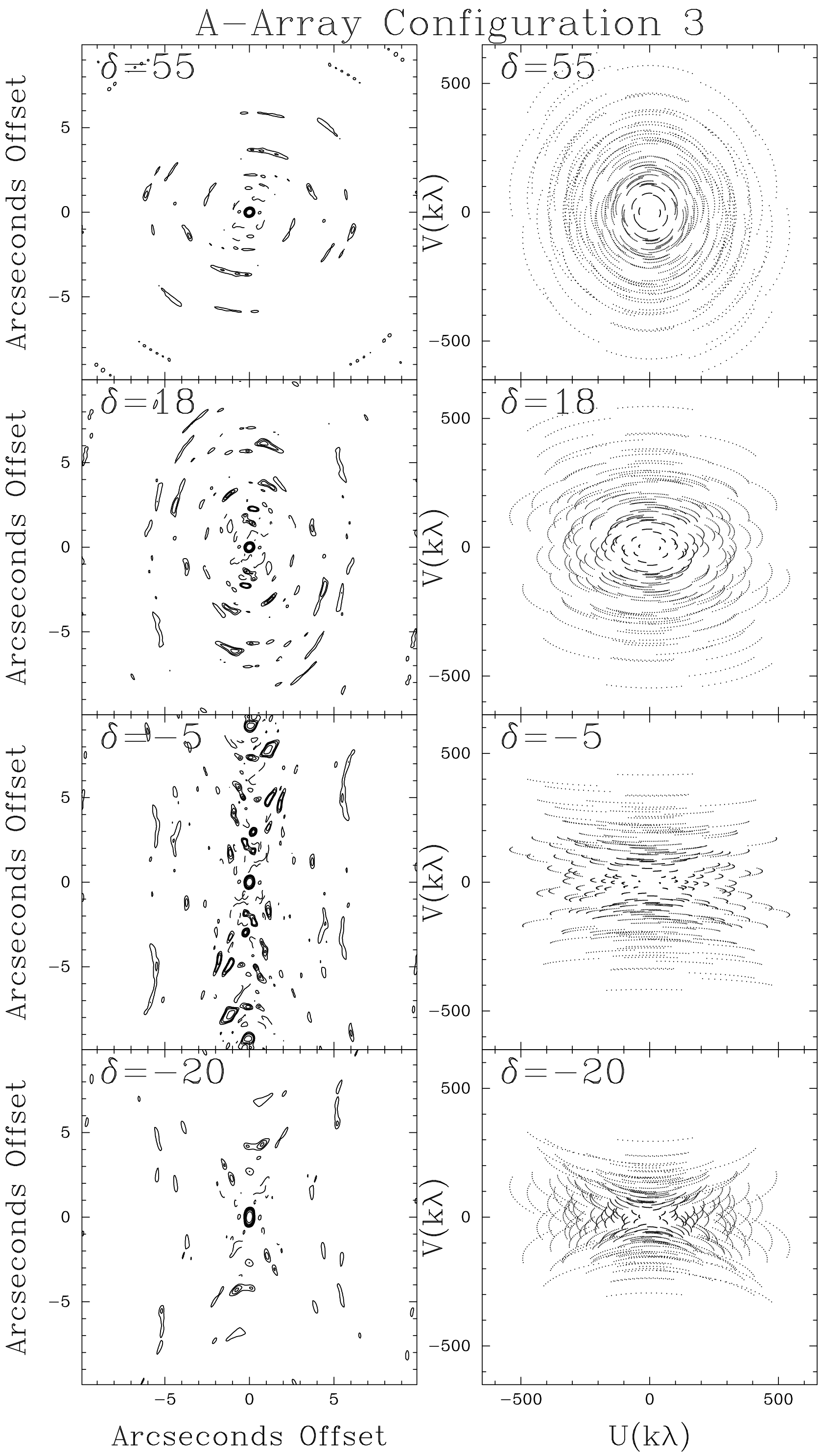

Fig. 8.— Plots of the beams and uv coverages for the proposed Configuration 3 for ±1.5 hours from transit. The contour levels in the beam panels are -20, -15, -10, -7.5, -5, 5, 7.5, 10, 15, 20, 30, and 50 percent of the peak. The source declinations for each panel is given in the upper-left corner.

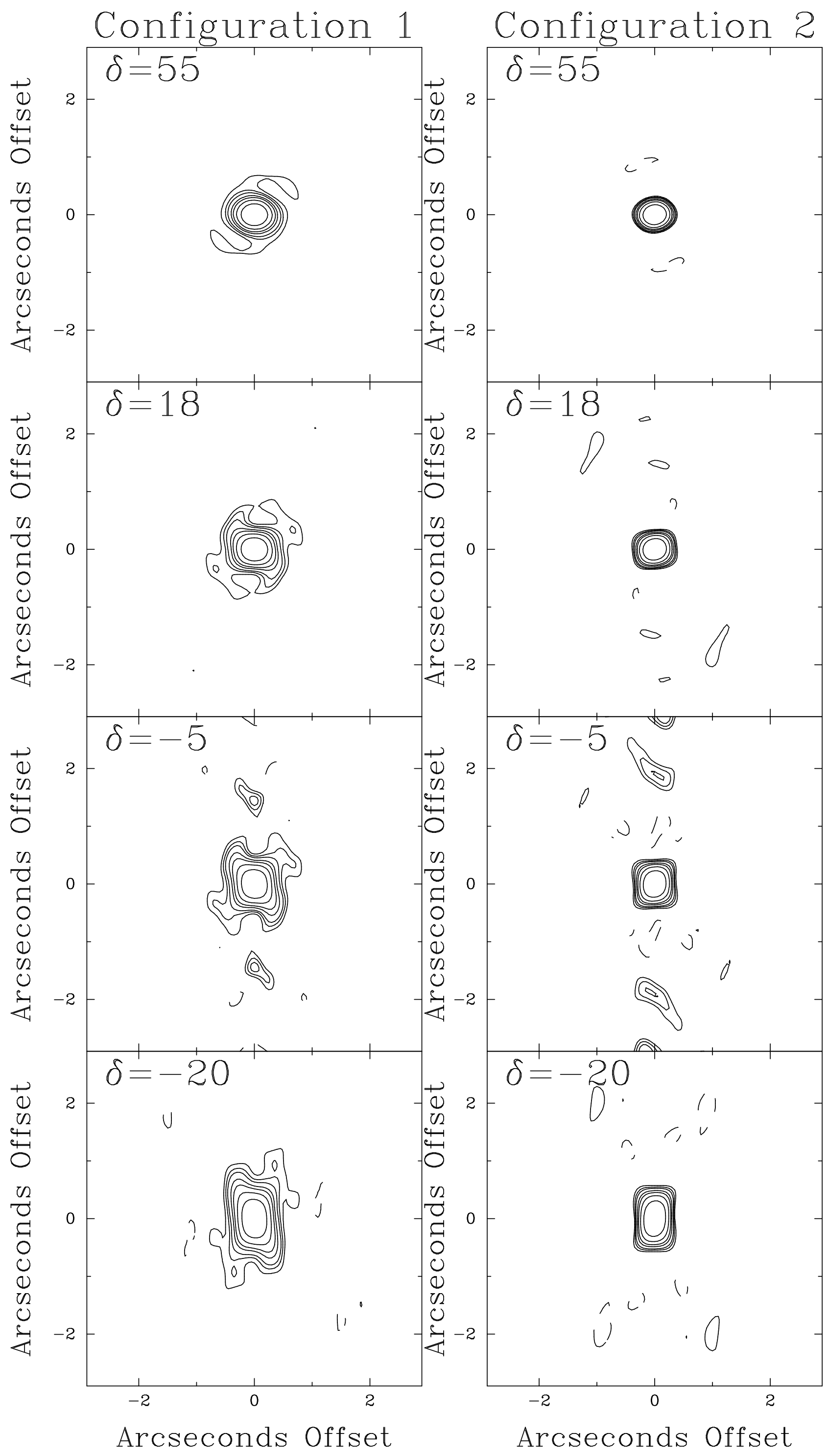

Fig. 9.— Comparison of the inner dirty beams for Configurations 1 and 2. The contour levels are the same as in the previous figures.