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SMA Synthesized Beam Characteristics
SMA Memo #131

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ABSTRACT

This memo presents a summary of the (u, v) coverages and synthesized beam characteristics for the four basic SMA antenna configurations on Mauna Kea for a range of source declinations (-40, -20, -5, 20, 40, 60 degrees). We use natural weighting of the visibilities in combination with a $1/T_{sys}^2$ weighting as will be done in practice to obtain the best sensitivity. The characteristic FWHM beam sizes at 345 GHz are 0.25, 0.7, 2, and 5 arcseconds in the A, B, C, and D configurations, respectively. We descibe a simple *csh* script that drives tasks in the **miriad** package to compute model visibilities and present an example.

1. Introduction

The antenna stations for the SMA on Mauna Kea are arranged approximately in four tangential Releaux triangles that provide "optimally" uniform (u, v) sampling and good instantaneous coverage (Keto 1997). In order to better plan scientific observations, we simulate the (u, v) coverage obtained for full tracks on sources located at various declinations and tabulate the expected synthesized beam sizes and orientations.

2. Pad Locations and Configurations

The project book lists the as-built antenna pad locations in local ground based coordinates measured to the north, to the east, and in elevation. Table 1 reproduces these locations after subtracting constant offsets that render the scale appropriate to the baseline lengths. There are four basic configurations, denoted A, B, C, and D, that range from most extended to most compact, and Table 2 lists the pads used for these configurations. Each configuration employs eight antennas except the A configuration which makes use of only six antennas for now. Exactly which two additional pads should be included in the A configuration will be the subject of a future investigation. Figure 1 shows a schematic of the four configurations with the pads numbered for easy identification.

Pad	North	East	El
1	27.22	78.70	0.78
2	8.07	54.20	0.76
3	0.23	0.75	0.58
4	31.73	-3.83	0.66
5	81.74	16.42	0.53
6	69.91	45.53	0.74
7	884.61	12.80	0.45
8	-24.39	-130.89	-9.75
9	45.56	-144.46	-14.92
10	174.46	-88.71	-21.24
11	140.57	-9.99	-16.05
12	-111.45	-97.37	-8.23
13	-165.01	-515.08	-36.90
14	38.23	-507.98	-36.80
15	417.53	-369.99	-37.85
16	340.63	-156.06	-34.78
17	-323.85	-359.63	-33.26
18	166.83	-1068.56	-80.21
19	578.27	-1492.93	-117.88
20	1128.31	-746.72	-60.17
21	1081.08	-162.50	-65.80
22	57.42	0.84	0.69
23	139.93	-116.74	-21.01
24	387.10	-478.66	-37.72

Table 1: SMA Antenna Pad Locations (unit: ft)

Array	Pads
A	1 17 18 19 20 21 (+two)
B	1 12 13 14 15 16 17 24
C	1 7 8 9 10 11 12 23
D	1 2 3 4 5 6 7 22

Table 2: Pads for SMA Array Configurations

3. Synthesized Beam Characteristics

We have used the **miriad** task `uvgen` to simulate (u, v) samples along source tracks and standard algorithms to image out to the primary beam half power size at a fiducial frequency of 345 GHz. Figures 2 to 9 show the (u, v) tracks and synthesized beams for sources at declinations of -40, -20, -5, 20, 40, and 60 degrees. Observing was limited to 6 hours before and after transit and elevations higher than 20 degrees. Shadowed data were omitted. In all cases, the beams are made using natural weighting of the visibilities in combination with a $1/T_{sys}^2$ weighting, as will be done in practice to obtain the lowest noise level. Uniform (or robust) weighting will result in slightly better angular resolution at the expense of sensitivity. For a bandwidth of 2 GHz and antenna gains of 140 Jy/K (aperture efficiency 70%) , a full track at 345 GHz in good conditions (zenith opacity 0.184) on a high declination source will result in an rms sensitivity of about 0.5 mJy, not including losses from atmospheric decorrelation. The sensitivity decreases by a factor of 1.3 for a source at declination -20, and by a factor of 2.0 at declination -40 where high airmass prevails throughout and the tracks are shorter.

Table 3 lists the FWHM synthesized beam sizes and orientations at 345 GHz. The characteristic FWHM beam sizes at 345 GHz are 0.25, 0.7, 2, and 5 arcseconds in the A, B, C, and D configurations, respectively.

As an additional aid to planning observations, we have developed a simple *csh* script to drive (modified) versions of the miriad tasks `uvgen` and `uvmodel` with parameters appropriate for the SMA. This script provides an easy facility to compute simulated visibility data for a variety of model source distributions, taking into account the noise, etc., expected for the SMA system. The computed visibilities may then be Fourier transformed and the resulting maps deconvolved in the usual way.

Figure 10 shows an example from this script. The model consists of two Gaussian continuum sources with FWHM 3 arcseconds and 0.1 arcseconds, respectively, each with total flux 100 mJy. Figure 10 shows the results obtained with the four standard SMA array configurations. (Note that the FWHM 3 arcsecond source is heavily resolved except in the D configuration.) Spectral line models are handled, too. Instructions may be obtained from David Wilner (e-mail: dwilner@cfa.harvard.edu). Ultimately, we would like to have a seamless method of following an SMA observing script through the production of model visibilities and maps to compare with data obtained by the instrument. This tool comprises one step toward that goal.

Dec.	Maj.	Min.	PA
D array			
-40	7.96	5.78	-25
-20	6.00	5.32	-59
-5	6.02	4.67	-87
20	6.19	4.32	-87
40	6.13	4.58	-86
60	6.13	5.34	-64
C array			
-40	3.06	2.02	-9
-20	2.19	1.96	-78
-5	2.25	1.68	-87
20	2.32	1.52	-89
40	2.35	1.58	-89
60	2.38	1.79	-90
B array			
-40	1.00	0.70	-5
-20	0.77	0.63	-88
-5	0.80	0.53	90
20	0.84	0.48	90
40	0.85	0.50	90
60	0.87	0.59	90
A array			
-40	0.41	0.24	2
-20	0.29	0.26	28
-5	0.28	0.24	68
20	0.29	0.22	79
40	0.30	0.22	82
60	0.31	0.24	84

Table 3: Synthesized beam characteristics for the four SMA antenna configurations.

REFERENCES

Keto, E. 1997 ApJ, 475, 843

prepared with AASTEX

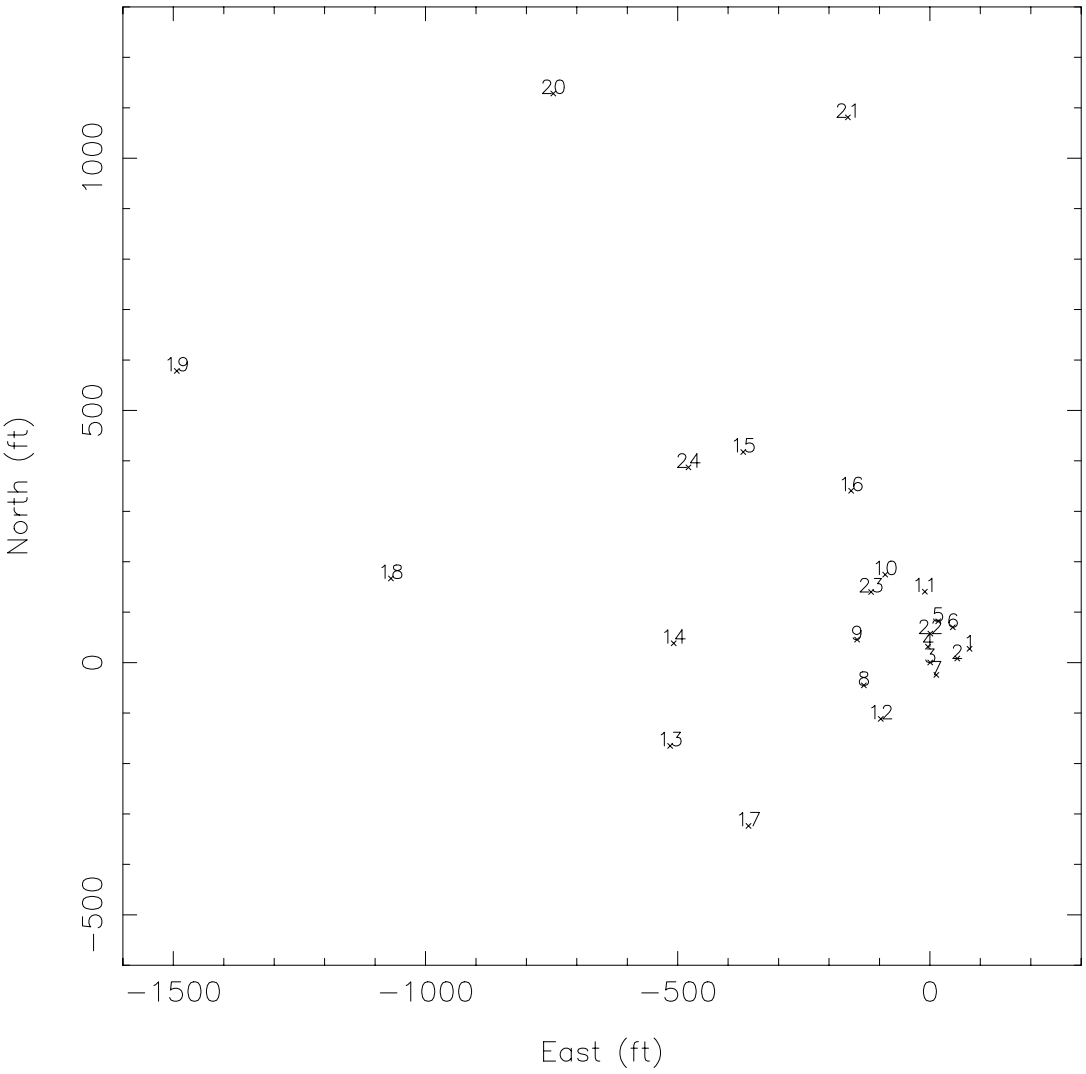

Fig. 1.— SMA pad positions (and pad numbers) on Mauna Kea showing the four tangential Releaux triangles that comprise the A, B, C, and D configurations, from Tables 1 and 2.

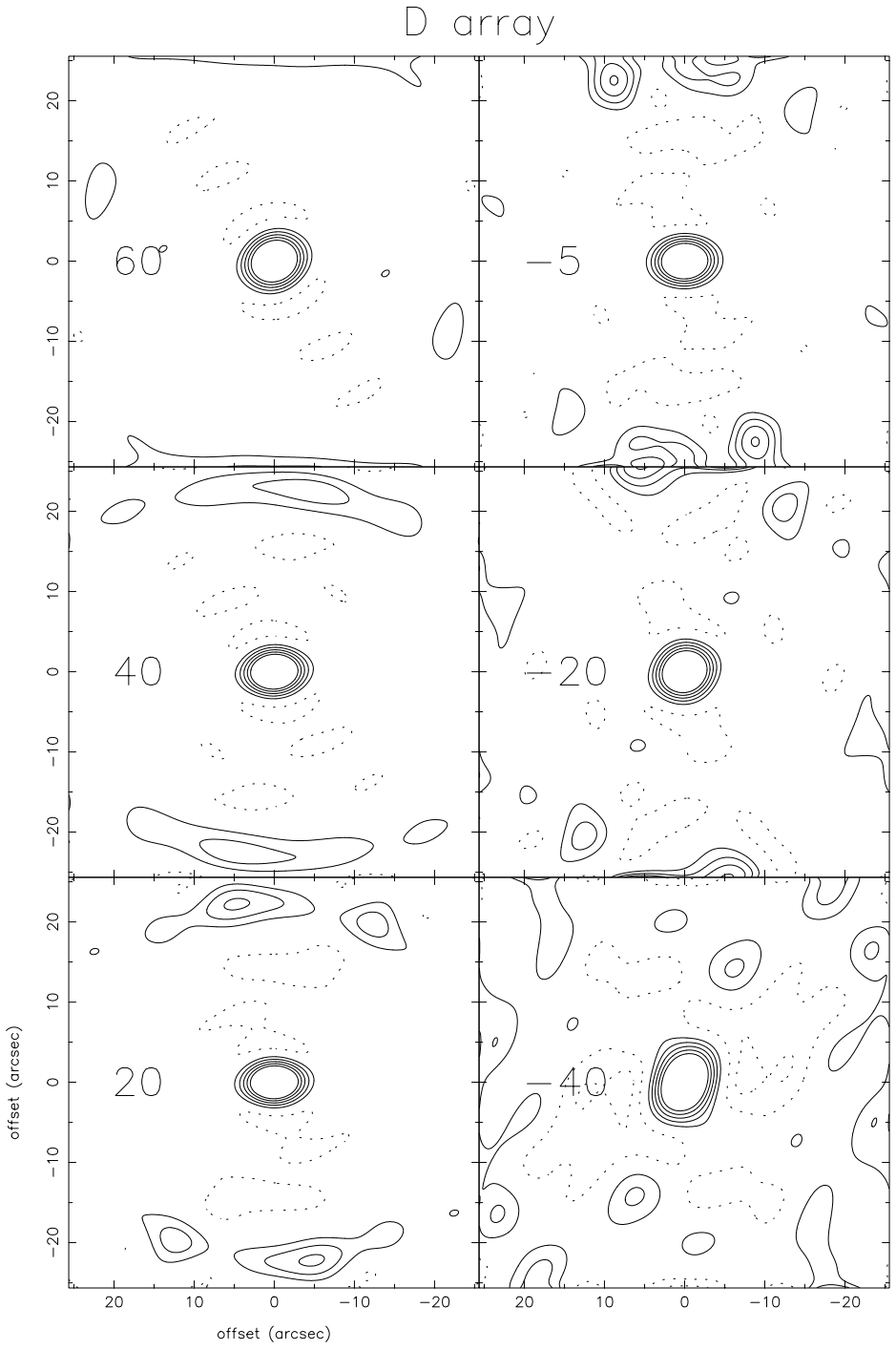

Fig. 2.— Dirty beam shapes for the standard D configuration for six declinations (labeled in the individual panels). The lowest contour level and contour step are 10%, up to 50%. Negative contours are dashed.

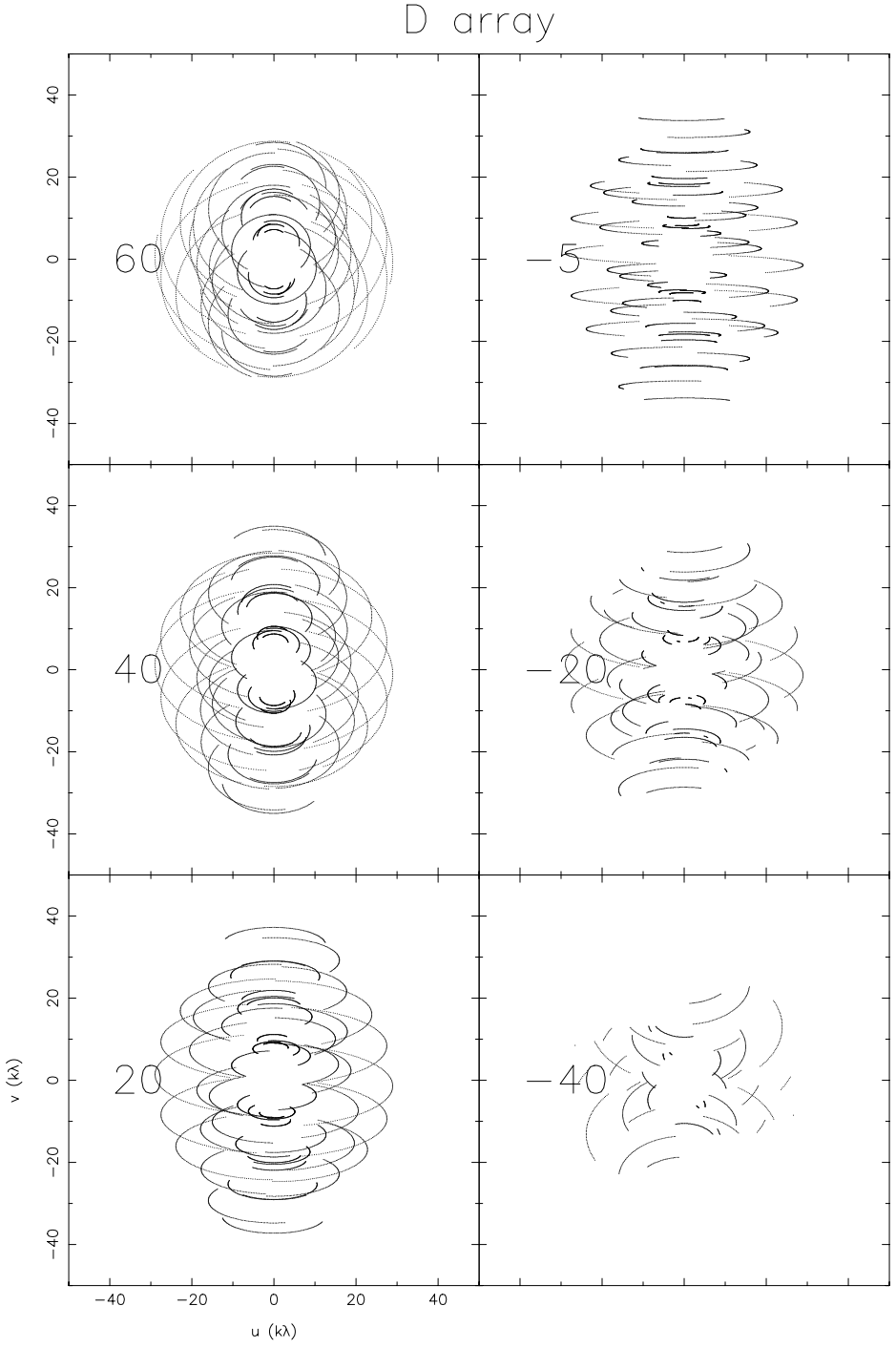

Fig. 3.— D array (u, v) coverages.

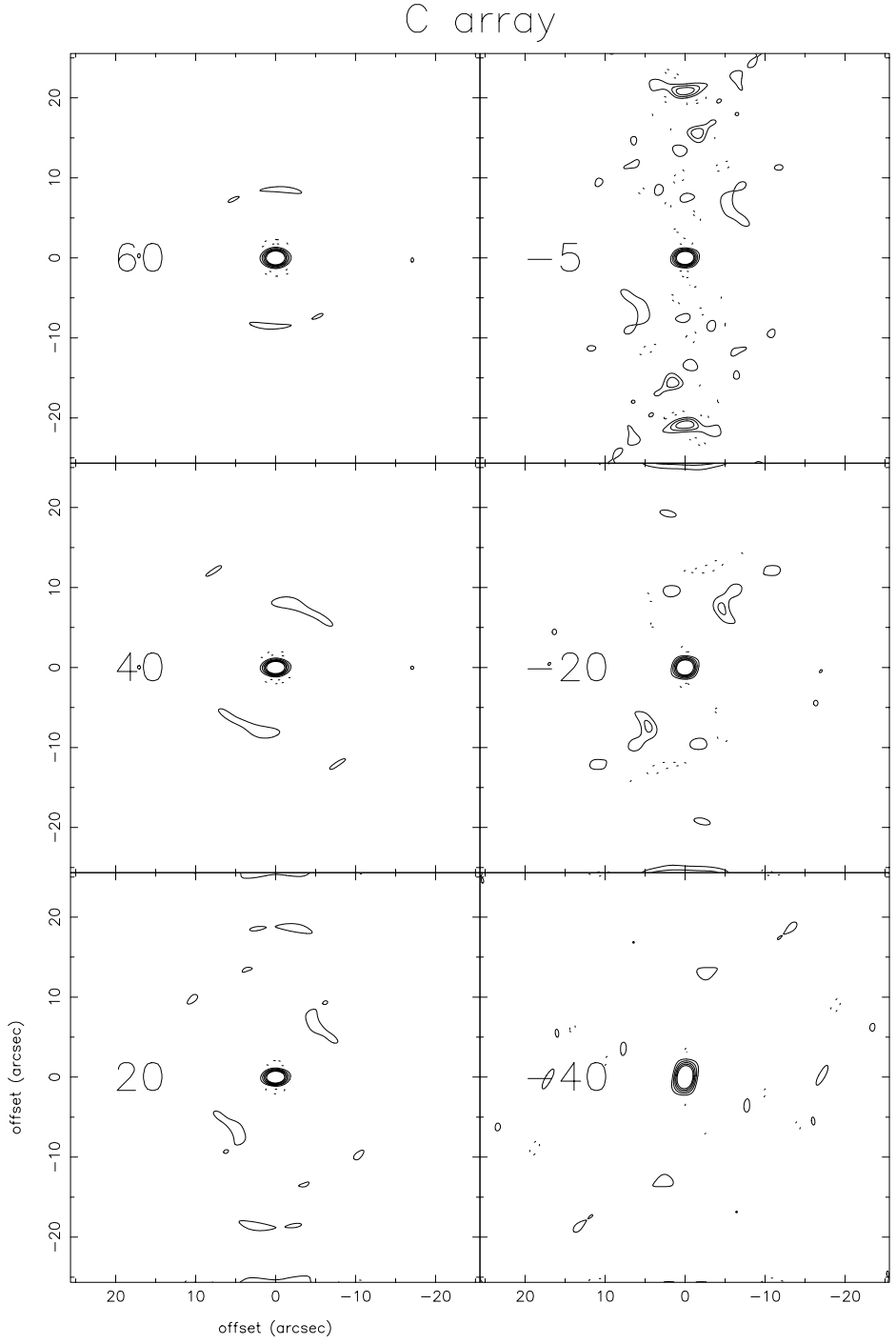

Fig. 4.— Same format as Figure 2, for the C configuration.

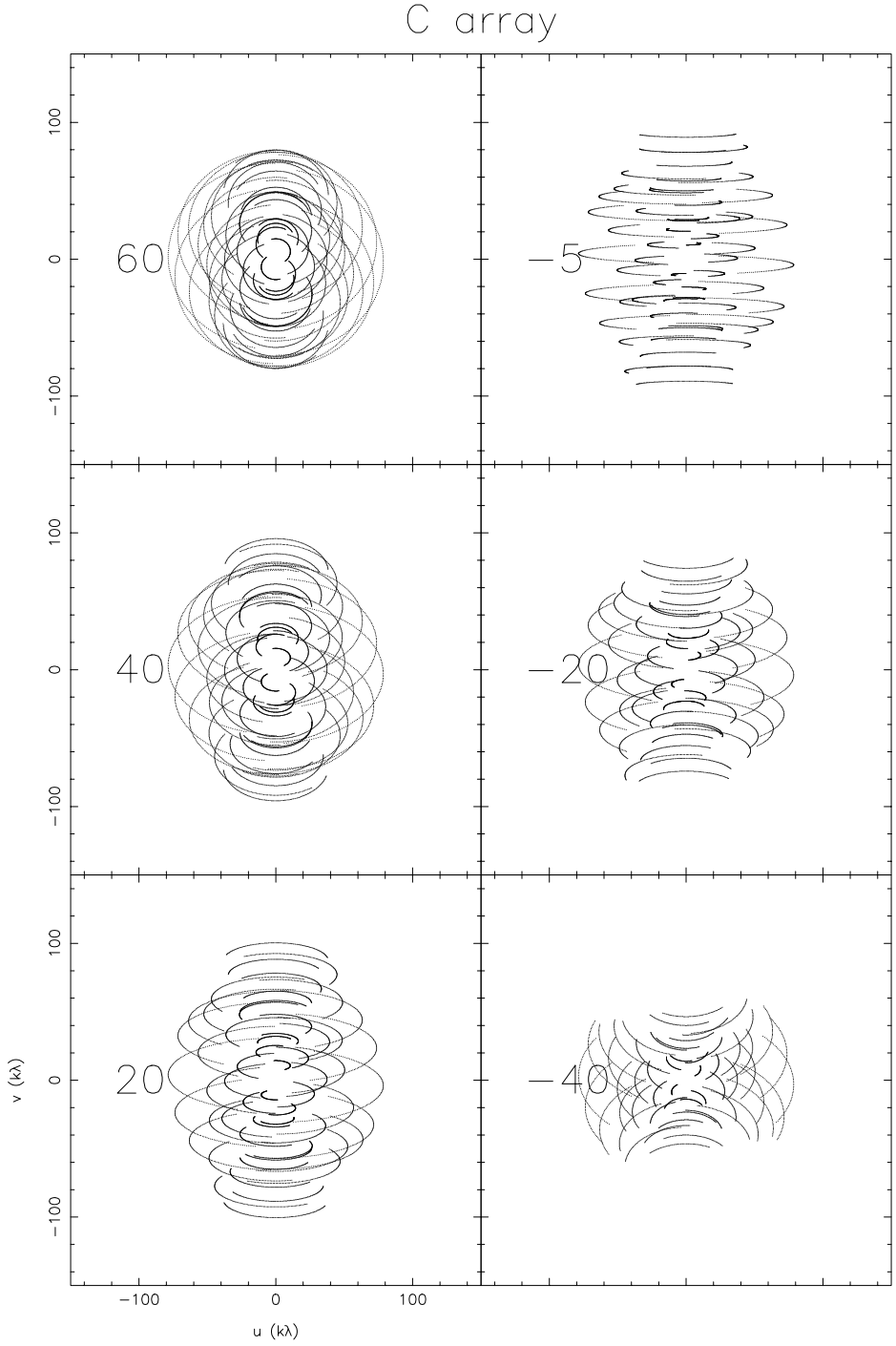

Fig. 5.— C array (u, v) coverages.

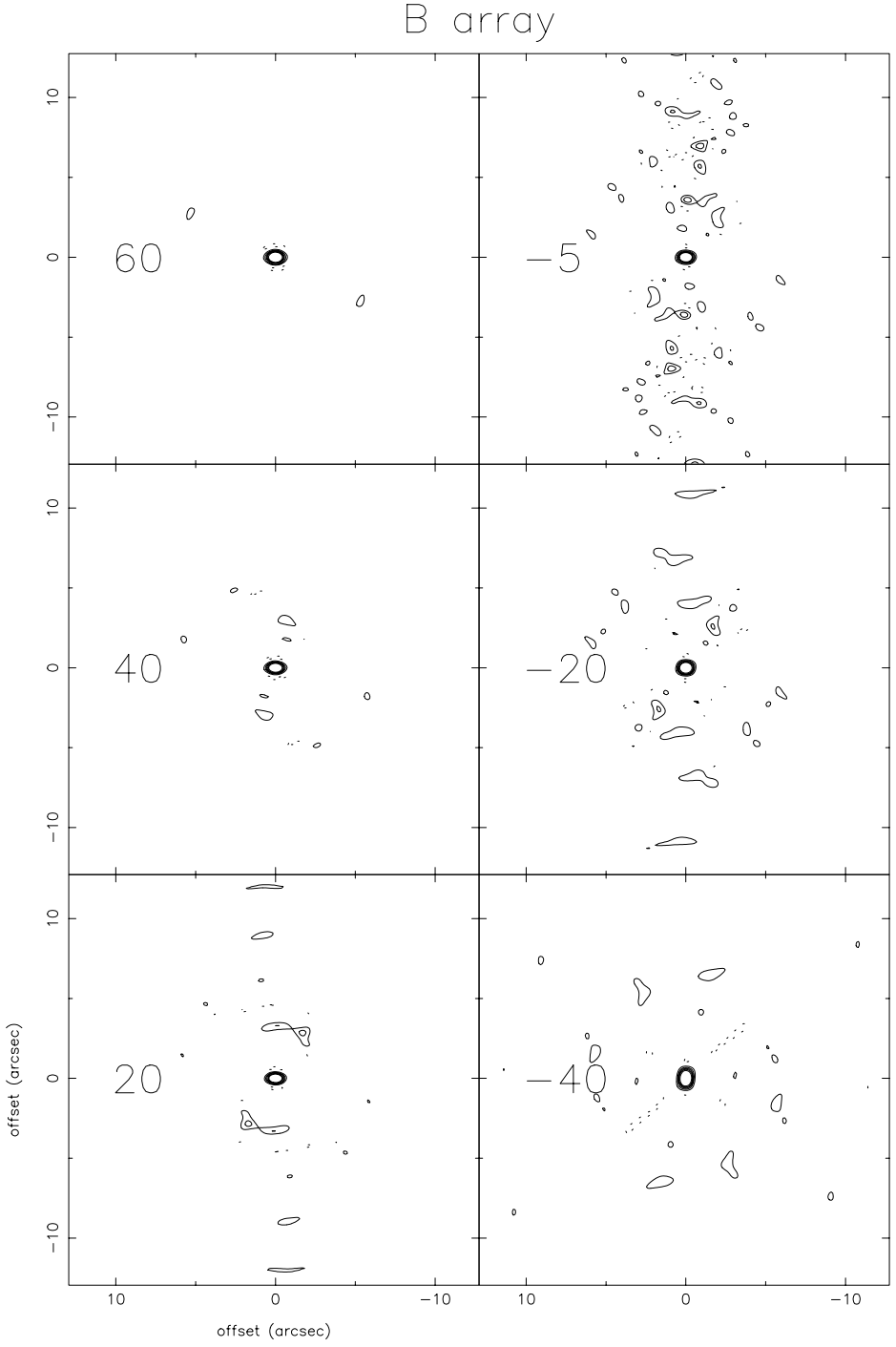

Fig. 6.— Same format as Figure 2, for the B configuration.

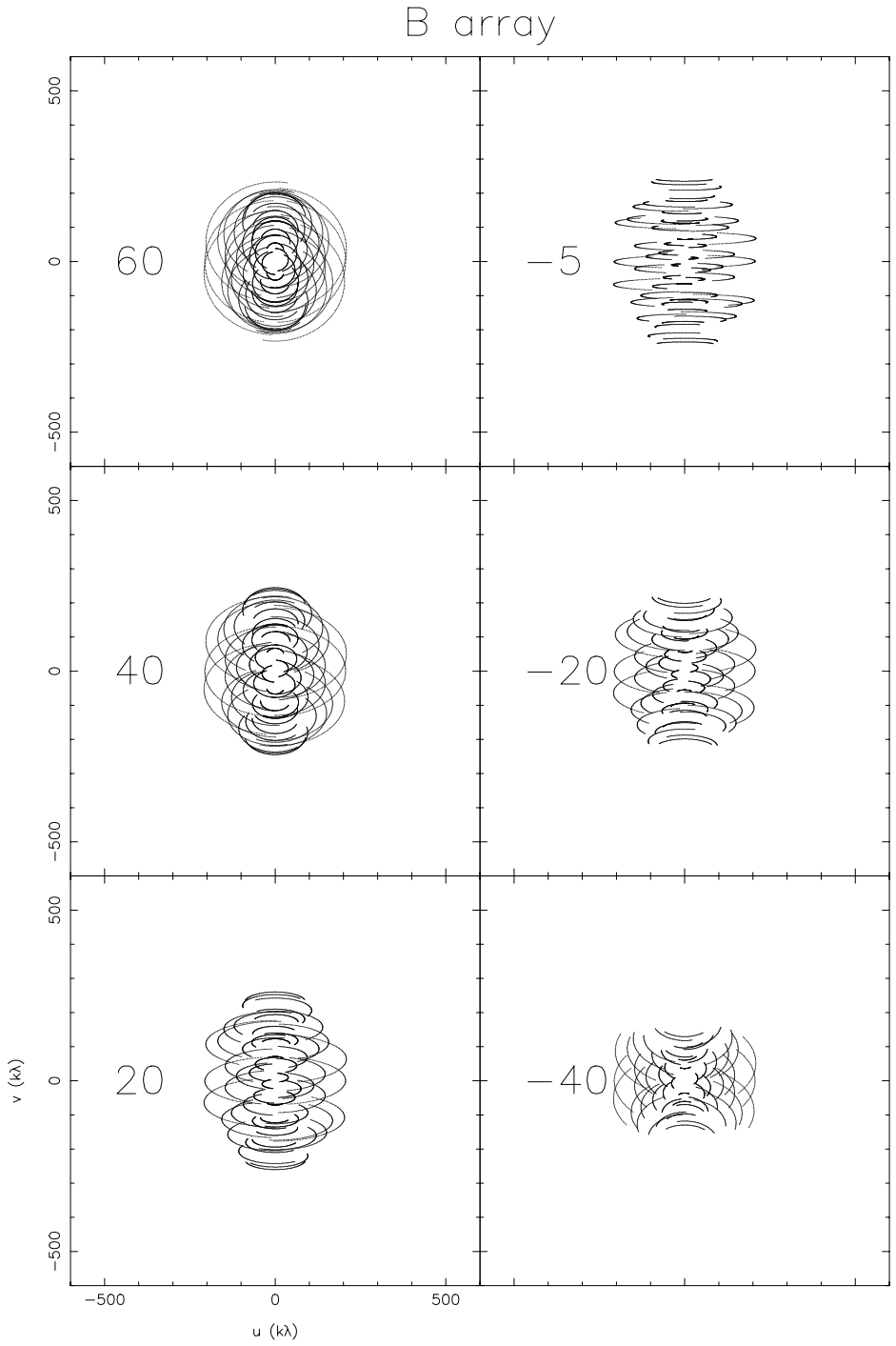

Fig. 7.— B array (u, v) coverages.

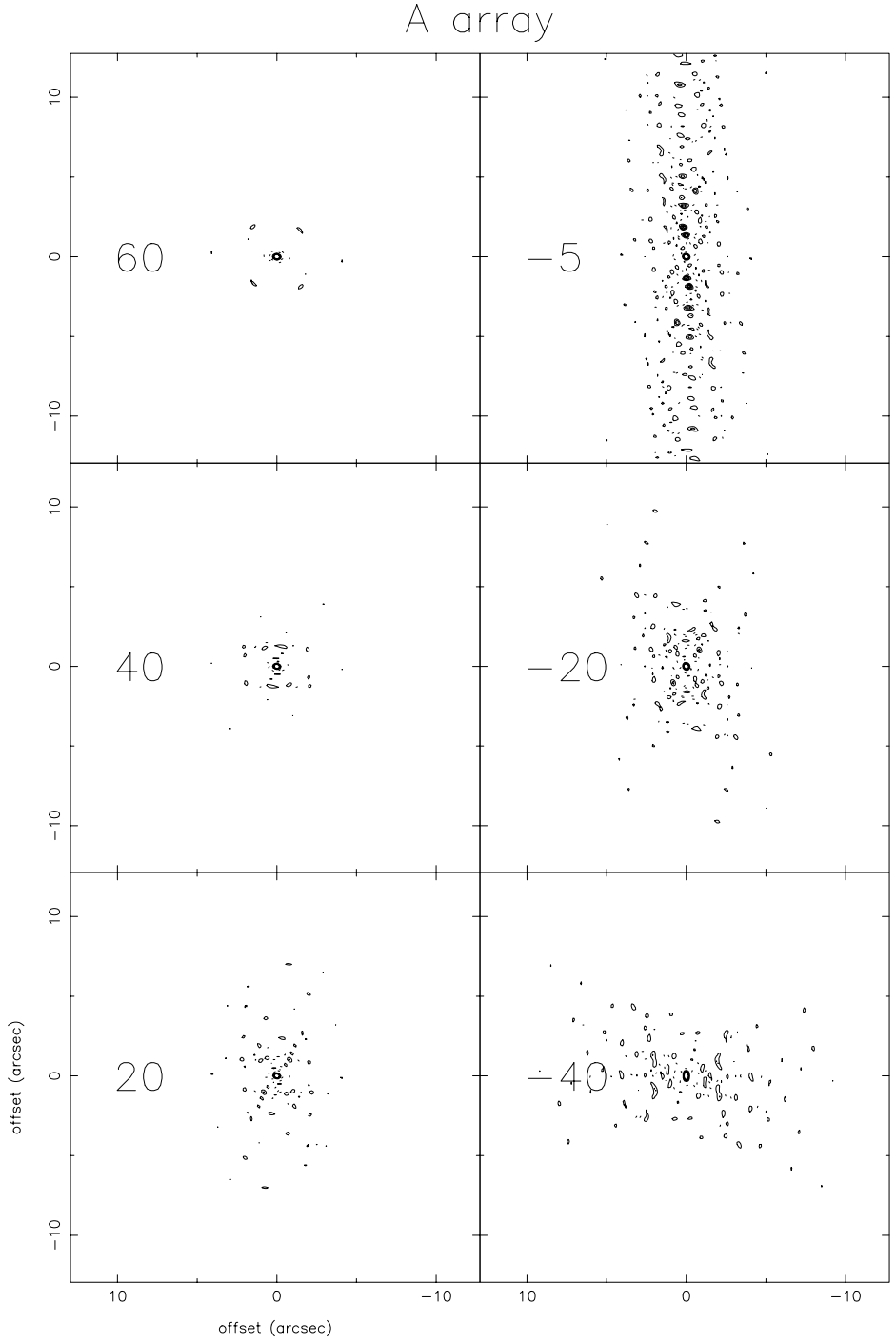

Fig. 8.— Same format as Figure 2, for the A configuration.

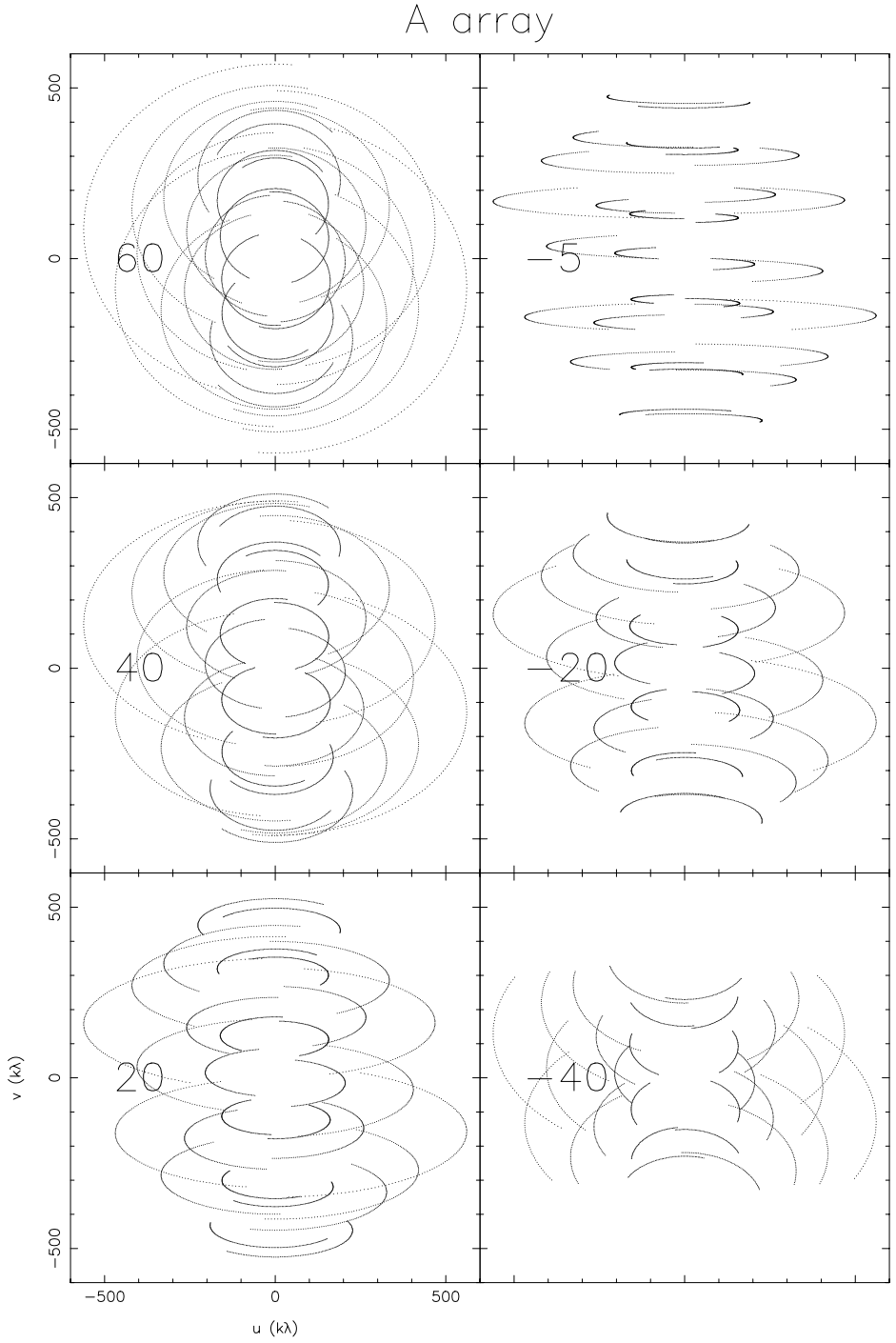

Fig. 9.— A array (u, v) coverages.

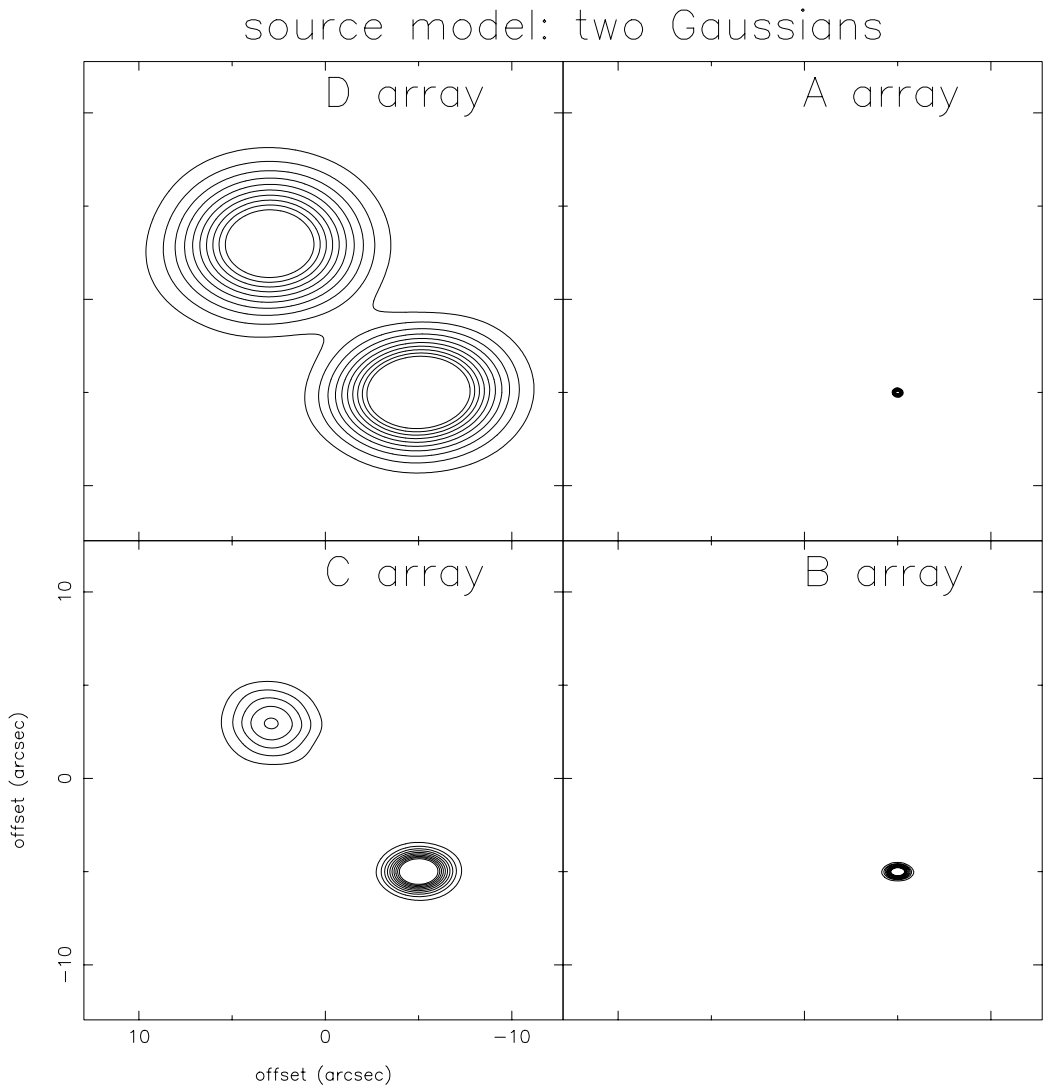

Fig. 10.— Example source model, two Gaussians at 20 degrees declination with FWHM 3 arcseconds and 0.1 arcseconds, total fluxes 100 mJy, located at offsets (3,3) and (-5,-5), respectively, observed with D, C, B, and A array (u, v) coverages at 345 GHz and imaged using the standard algorithms. The lowest contour and and contour step are 5 mJy/beam. Note that the larger source is heavily resolved in all but the most compact array configuration.