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NEW ARRAY CONFIGURATIONS FOR HAT CREEK

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ABSTRACT

This memo presents suggested new antenna configurations for the 10-antenna array at Hat Creek. We use 4 antenna configurations with angular resolutions $18''$, $6''$, $2''$, and $0.4''$ at 100 Ghz. We have re-designed the $6''$ and $2''$ arrays to have more uniform uv-coverage and lower sidelobes. The new arrays have better instantaneous uv-coverage. Two antennas do not need to be moved when re-configuring the array.

1. Introduction

The optimum antenna configuration depends on the scientific goals, as the best *uv* sampling depends quite strongly on the source structure. Array design is unfortunately a compromise, so it's always a temptation to try to do better. Although the current arrays provide a reasonable compromise for the Hat Creek array, there are several reasons to re-examine the possibilities.

. there are new stations available.

. the new d-array was well designed for spacings from 6 to 30m.

. the current c- and b-arrays have poor sidelobes ± 10 deg in declination (see BIMA memo 51).

. scheduling is often a compromise between c- and b-arrays, both to satisfy the science that is proposed, and to accomodate the atmospheric phase coherence which is often poor in the current b-array.

Two problems are: 1) it is hard to get a good uv-coverage with a T-array, and 2) it is hard to span from 6m to 2 km with 10 antennas, using only three array configurations.

This memo proposes revised antenna configurations which address these issues.

2. Array design

Although at high declinations earth rotation synthesis gives good uv-coverage, for sources close to the equator all stations along the east-west arm of the T-array give similar projected baselines in a N-S direction (the v coordinate). This suggests that for good uv-coverage at all declinations, we should use as few E-W stations as possible. On the other hand, diagonal baselines with E-W stations at large radii do give good uv-coverage, so we should avoid using E-W stations close to the intersection of the T-array. Short uv-spacings can now be obtained by using some of the new d-array stations which are off the T-array.

A more complete uv-coverage is also obtained by reducing the scale factor between antenna configurations. For example, the ATNF with 6 antennas has scaled arrays with a scale factor of 2, the VLA with 27 antennas has a scale factor of 3.3 and the design for the joint OVRO/BIMA array with 16 antennas has a scale factor of 2.5. The current BIMA arrays with 10 antennas have scale factors between 3.5 and 4.5. Better uv-coverage is obtained with a scale factor less than about 3. The problem of the current large scale factor also shows up as a poor overlap of large and small scale structure when imaging with multiple antenna configurations.

A possible solution is to use the d-array, if necessary, to provide high sensitivity to large scale structure. The d-array provides good uv-coverage from 6 to 30m ($18''$ at 100 GHz). The c-array should then be expanded by about 10% ($6''$ at 100 GHz), and the b-array resolution reduced by about 10% ($2''$ at 100 GHz). This still leaves a large gap between the b-array and the a-array with a resolution of $0.4''$ at 100 GHz. The a-array provides the highest resolution for studying compact structures. Although there is enough overlap in uv-coverage to cross calibrate between the 4 array configurations, a lower resolution a-array would make better continuity in images formed from multiple antenna configurations.

Another issue is the sensitivity of the array to different sized structures. A simple way to measure this is to look at the distribution of the sampled uv-points as a function of uv-distance. The array configurations have been designed so that the c-array samples uniformly between 6m and 60m and tapers off at larger spacings. The b-array samples between 60m and 120m and tapers at both larger and small uv radii. Both b- and c-arrays provide good sensitivity at lower resolutions; the c-array has $\sim$ 40% of its sensitivity at spacings between 6m and 30m, and the b-array has $\sim$ 30% of its sensitivity at spacings between 6m and 60m.

The proposed b- and c-arrays complement the existing d- and a-arrays. The d-array provides the maximum sensitivity between 6m and 30m. The a-array has $\sim$ 80% of its sensitivity at spacings between 120m and 1000m, and tapers to a minimum spacing of 70m and a maximum of 1800m. Thus the new b- and c-arrays, together with the d- and a-arrays provide good uv-coverage and high sensitivity at all spacings between 6m and 1000m. If the highest resolution is not required, then substituting a shorter spacing for the largest antenna spacing (4320N) in the a-array produces better beams and more sensitivity from 120m to 720m, tapering to a maximum spacing of 1200m.

3. Proposed arrays

We computed the synthesised beam patterns for source declinations +30, +10, -5, -15, and -30. Figure 1 and 2 show the the synthesised beams for the old (BIMA memo 51) and the new, proposed c-array. The most obvious improvement is in the reduced sidelobe level at low declination. The high sidelobe level causes images of sources within about ± 10 deg declination to be effectively confusion limited. This defect is especially severe when mapping extended structures. The new array configurations have fewer gaps in uv coverage, as evidenced by the lower sidelobe levels.

Figure 4 and 5 show the the synthesised beams for the old (BIMA memo 51) and new b-array.

Table 1 lists the proposed antenna stations. The c-array requires one new station at 165W. This station can be placed directly on the concrete, as have other stations which have been used successfully in the past.

Table 2 lists the synthesized beam sizes.

Plots of uv-coverage are easily obtained using the Miriad script *beamgen*, and histograms of uv-sampling can be printed using the Miriad task *uvcheck*.

4. Other nice features

1) A nice feature of the new c-array is much improved instantaneous uv-coverage. This means that good beams can be obtained with only a few hours of observation. Figure 3 shows the beams obtained with only 2 hours of observation around transit. This is important at the highest frequencies when the atmosphere is marginal and only short intervals may be available for observations. The beams are only slightly distorted if a similar observing time is obtained away from transit. A corollary is that gaps in the observations are less important. The new b-array is less improved in this respect since the longer antenna spacings are constrained to be on the T-array.

2) The new b-array uses the same two antenna stations off the T-array as the c- and d-array; these two antennas do not need to be moved when re-configuring the array. The antenna moves between c- and b-array are straightforward.

3) The short spacings in the new c- and b-arrays are derived from the d-array stations, which have less shadowing and antenna collision problems than the short spacings on the T-array.

4) Since the uv-coverage is more uniform, there is less degradation either in sensitivity, or in beam pattern for different weighting of the uv-data. For example, Figures 6 and 7 show the beams for robust weighting. The new arrays have good beam patterns and sensitivity when convolved to lower resolution, obviating the need for multiple antenna configurations for many projects.

5. Conclusions

1. The proposed new array configurations have about the same resolution and brightness sensitivity as before, but with more uniform uv-coverage, and lower sidelobes.

2. The new arrays have better instantaneous uv-coverage; important at high frequency, and for dynamic scheduling.

3. The new arrays have good beam patterns and sensitivity at lower resolution. Multiple antenna configurations may not be required for many projects, although a short observation in the d-array is best for high sensitivity to large scale structures.

4. The b- and c-arrays, together with the existing d- and a-arrays provide good uv-coverage and high sensitivity at all spacings between 6m and 1000m.

REFERENCES

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Shapes of cross-correlation interferometers, Keto, E., ApJ, 1997, 475, 843-852
Proposed 10-Antenna Arrays for the Coming Year, W.J. Welch and T.T. Helfer, December 1996, BIMA memo 51
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Table 1: Proposed new antenna configurations

—	c-array			b-array	
North (ns)	East (ns)	Station	North (ns)	East (ns)	Station
0	125	125E	0	400	400E
0	80	80E	0	320	320E
27	3	27N	0	180	180E
0	-100	100W	0	-240	240W
0	-165	165W	0	-380	380W
88	-22	88NW	88	-22	88NW
53	-71	53NW	53	-71	53NW
60	0	60N	180	0	180N
140	0	140N	320	0	320N
200	0	200N	500	0	500N

Table 2: Synthesized Beams

Declination	c-array	b-array
30	$5.6'' \times 5.1''$	$2.3'' \times 2.0''$
10	$7.0'' \times 5.3''$	$2.7'' \times 2.2''$
-5	$8.9'' \times 5.5''$	$3.4'' \times 2.2''$
-15	$10.6'' \times 4.7''$	$3.9'' \times 2.1''$
-30	$18.1'' \times 4.2''$	$6.4'' \times 1.9''$

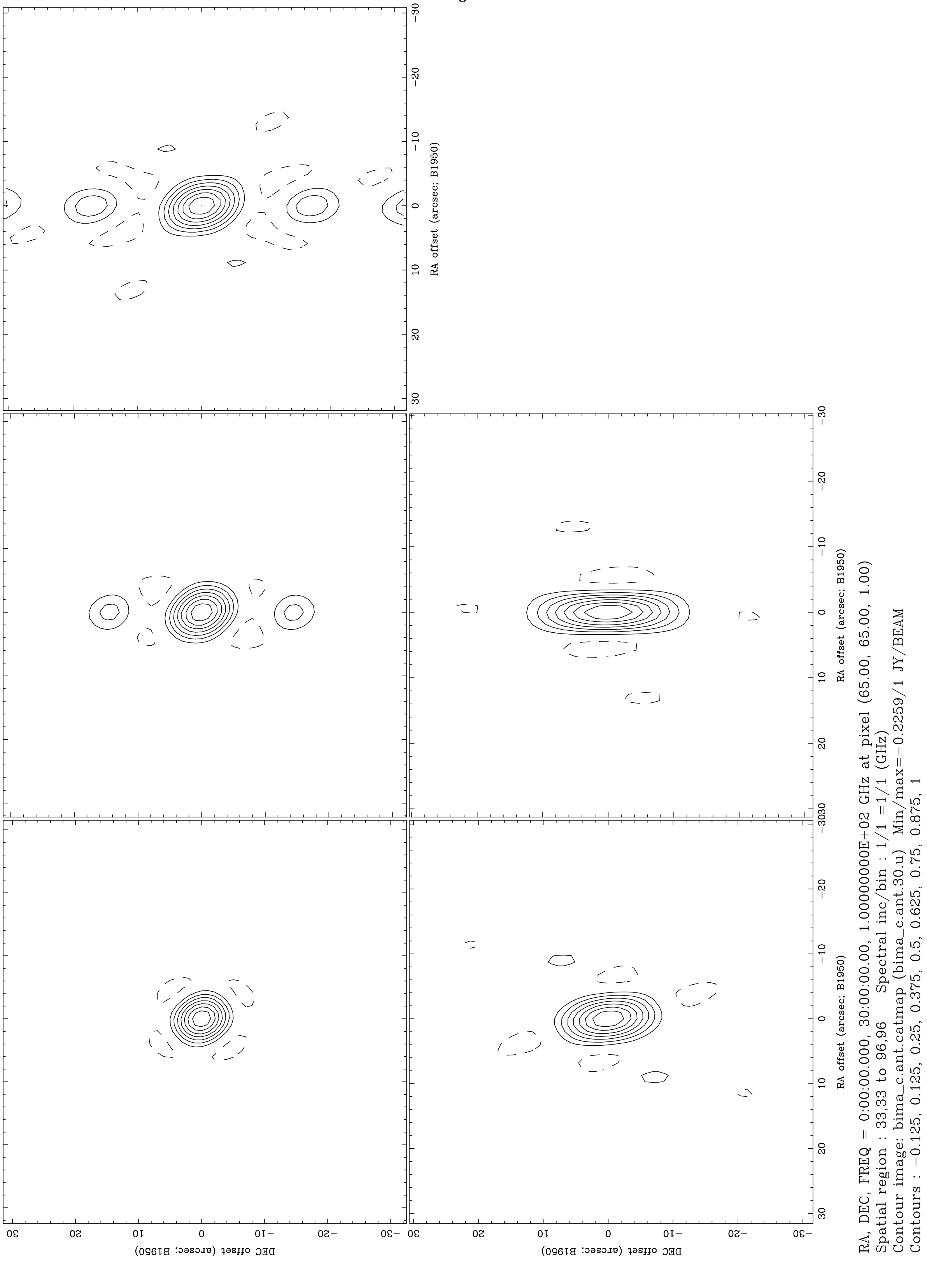

Fig. 1.— beam pattern for old c-array with an 8 hour observation at DEC 30, 10, -5, -15, -30

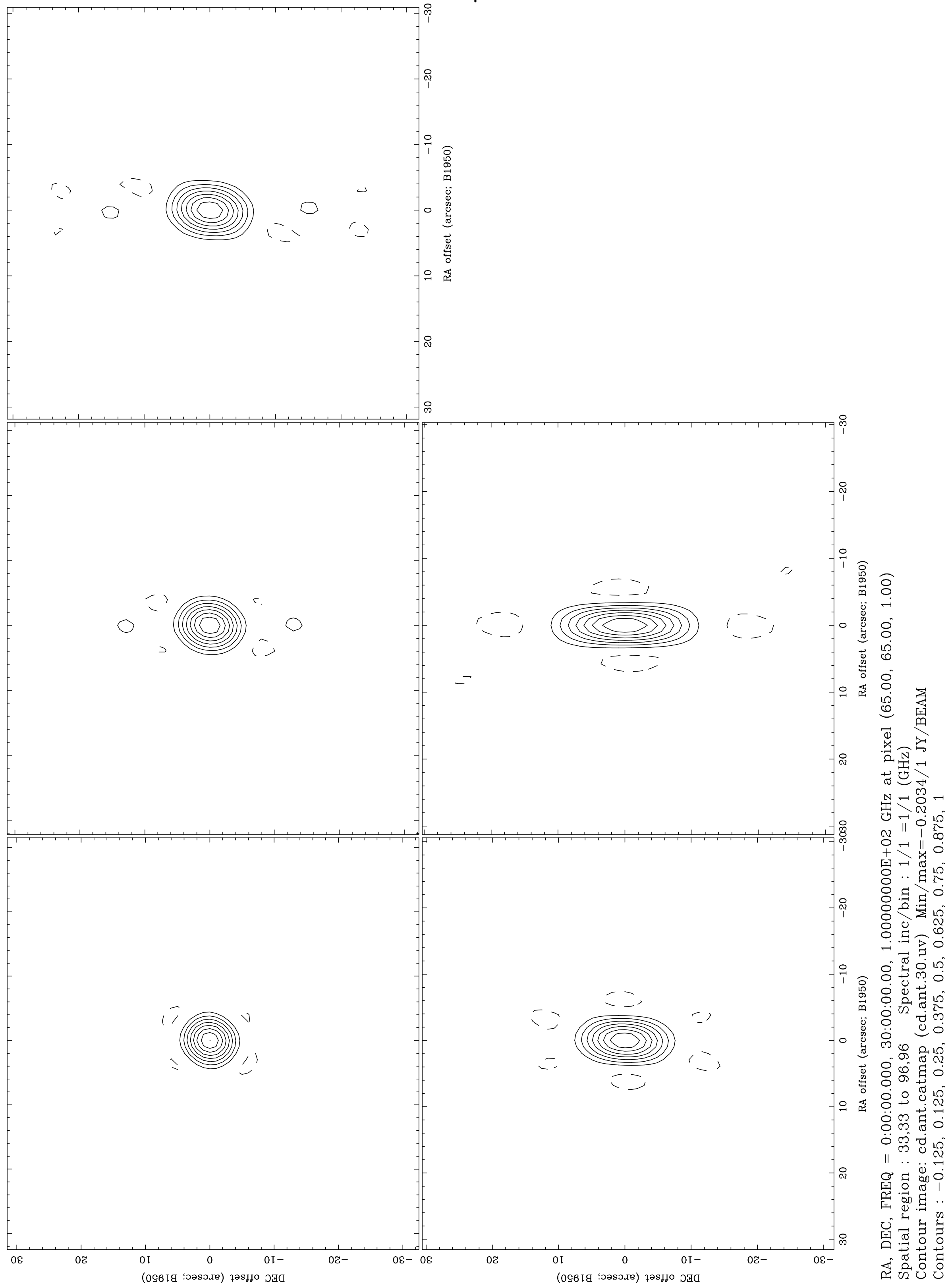

Fig. 2.— beam pattern for new c-array with an 8 hour observation at DEC 30, 10, -5, -15, -30

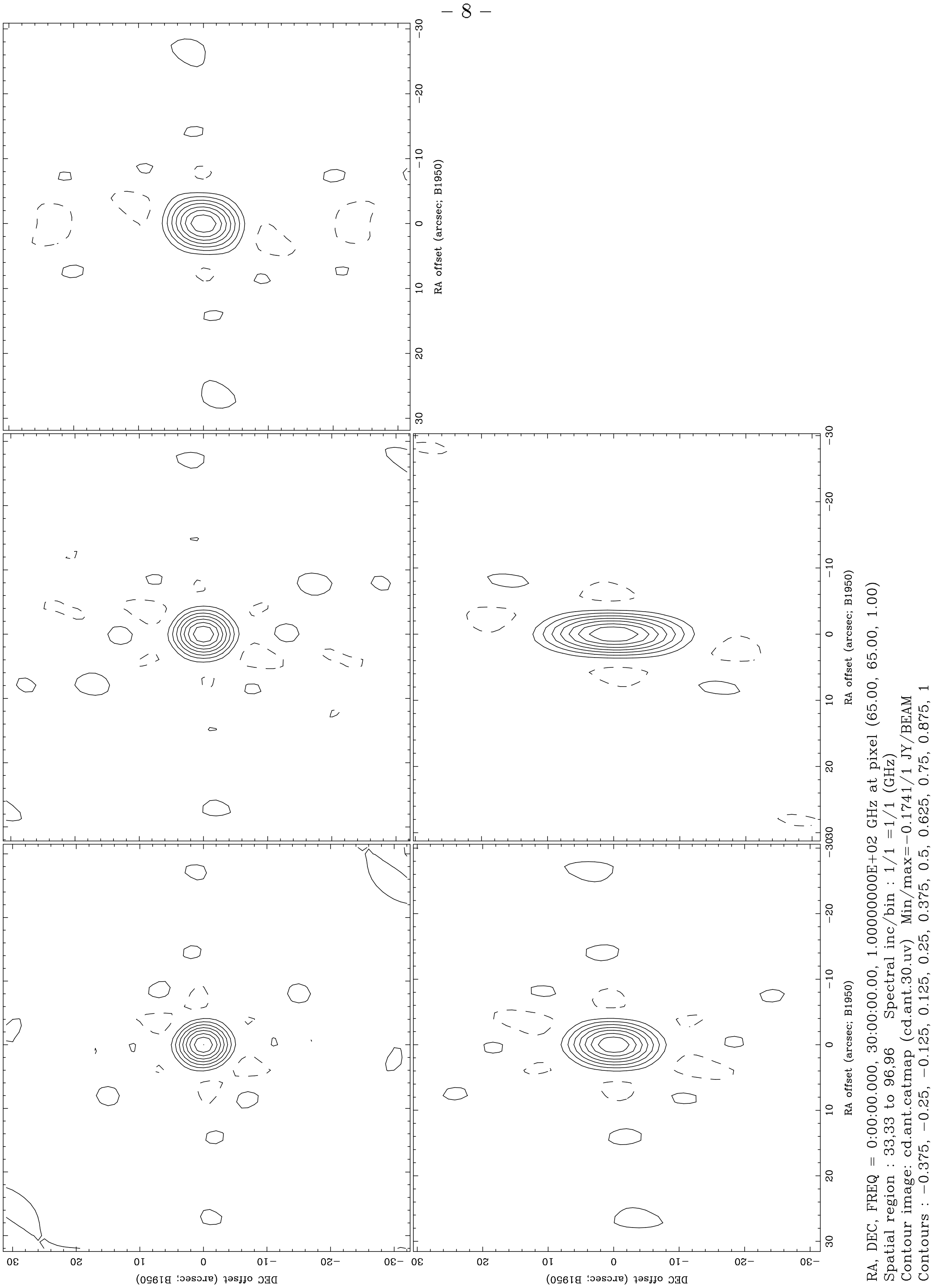

Fig. 3.— beam pattern for new c-array with a 2 hour observation at DEC 30, 10, -5, -15, -30

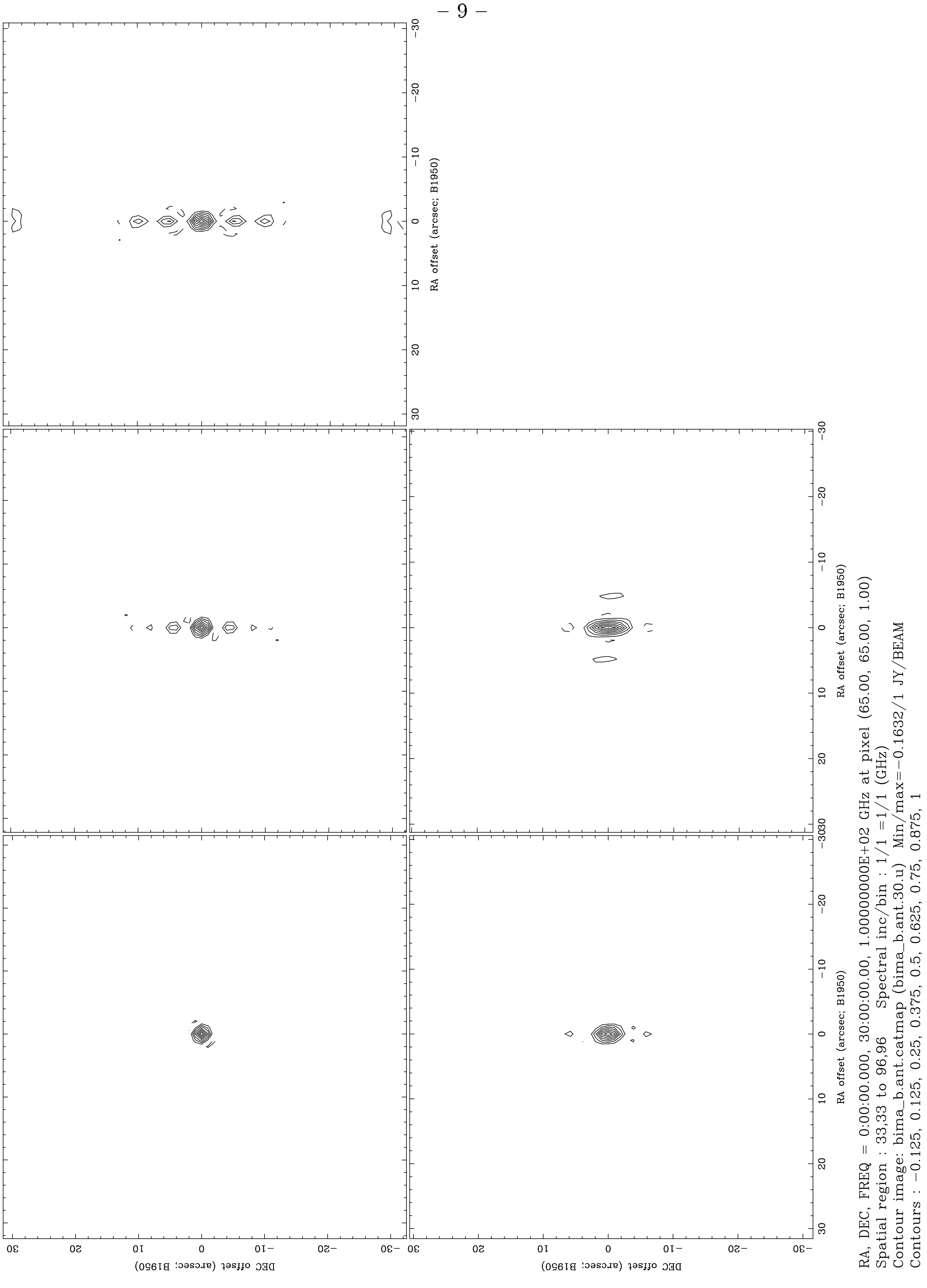

Fig. 4.— beam pattern for old b-array with an 8 hour observation at DEC 30, 10, -5, -15, -30

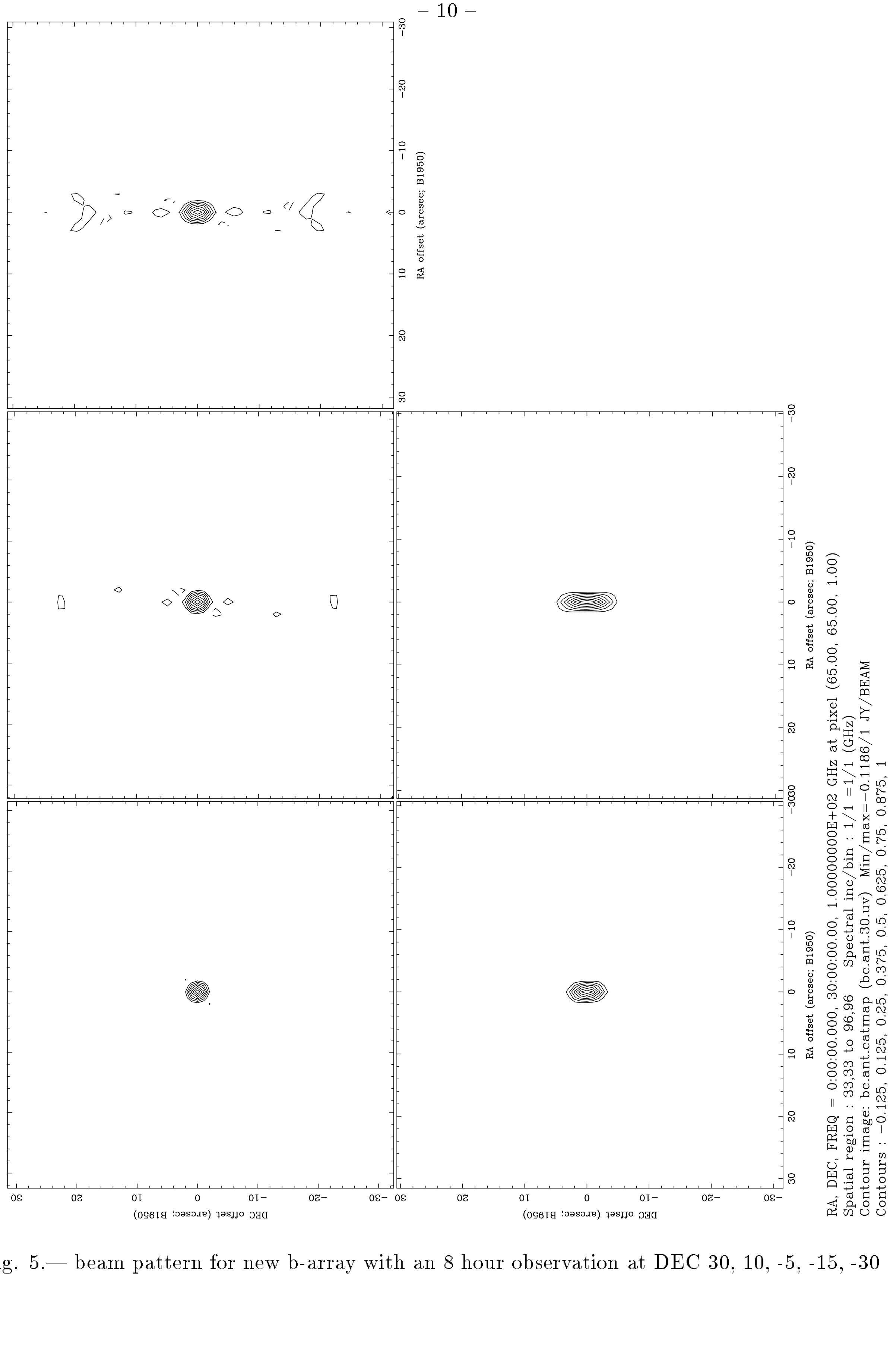

Fig. 5.— beam pattern for new b-array with an 8 hour observation at DEC 30, 10, -5, -15, -30

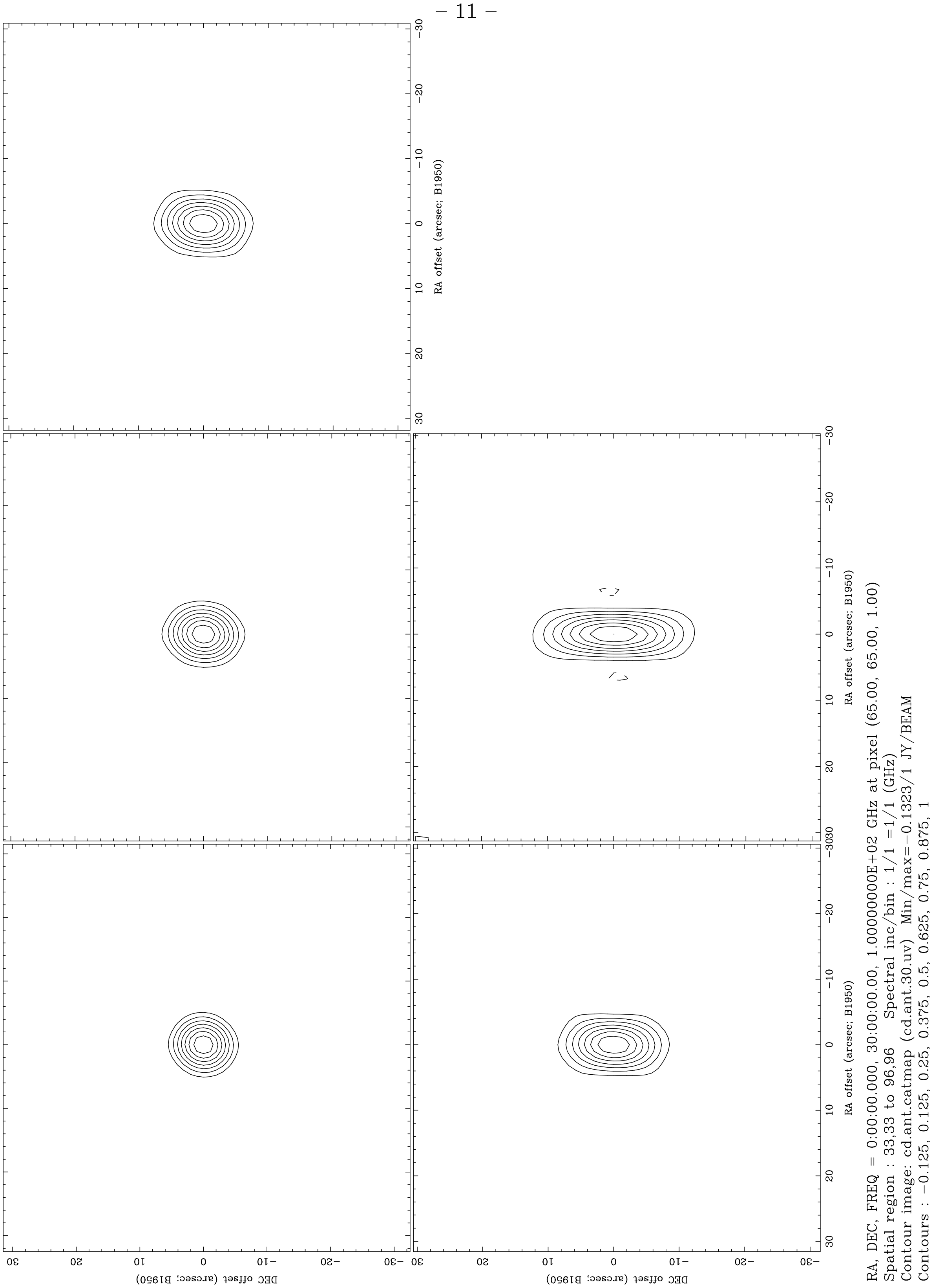

Fig. 6.— beam pattern for new c-array with robust weighting at DEC 30, 10, -5, -15, -30

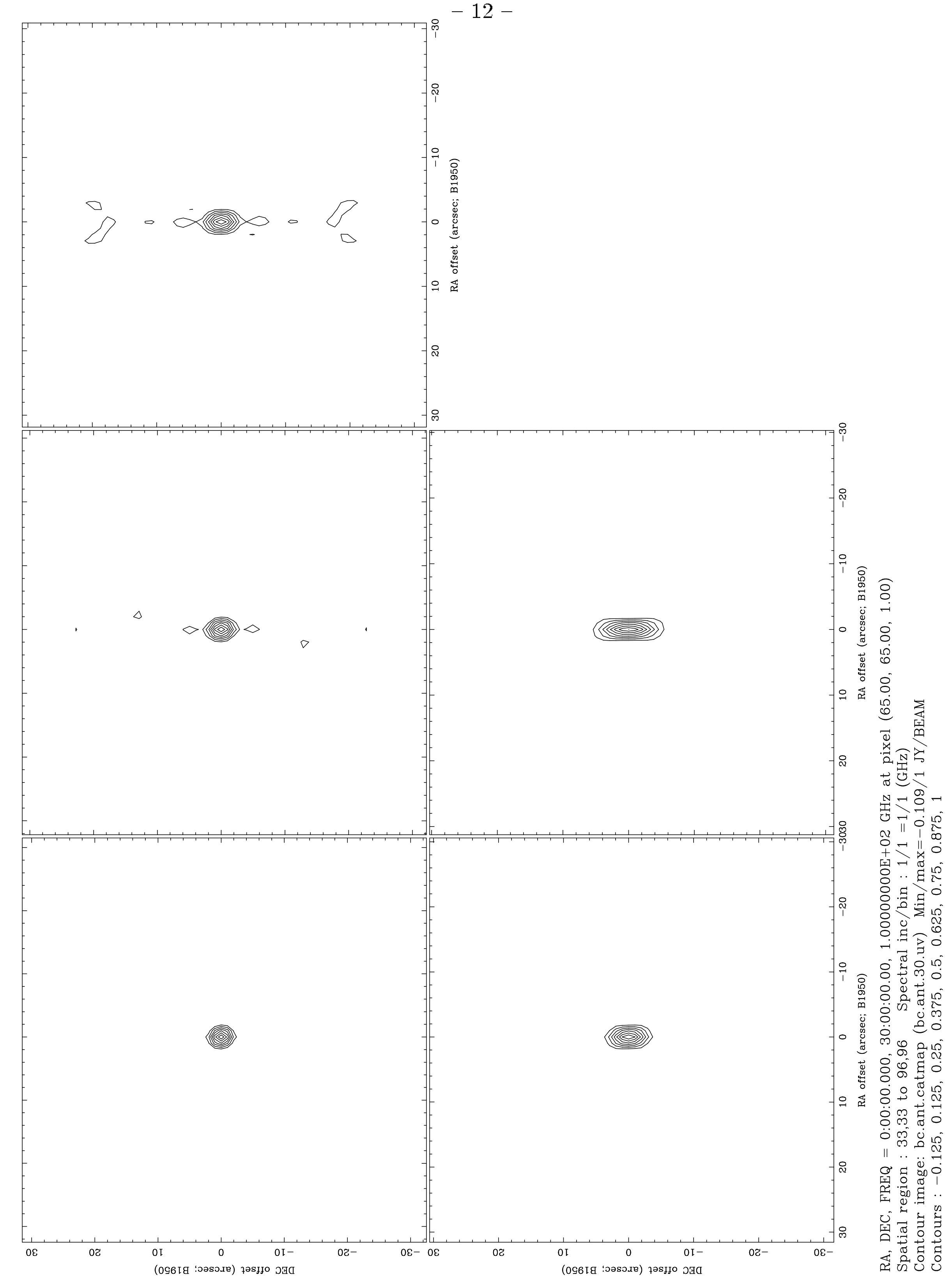

Fig. 7.— beam pattern for new b-array with robust weighting at DEC 30, 10, -5, -15, -30