MILLIMETER ARRAY
MEMO NO. 80

Further simulation of (possible) MMA configurations

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1. Overview

The scientific goals of the MMA require that it be located on a high, dry site offering the possibility of baselines at least 3 km in length. The previous atmospheric site test and configuration studies show three candidate sites appear to meet these needs. Two are in the Apache National Forest near Springerville Arizona, and one is in the Magdalena Mountains near Socorro, New Mexico. The preliminary array layouts for the largest configurations at each candidate site were presented in the MMA memo 60.

The main goal of the current design is to provide workable configurations for further detail site evaluation, especially the feasibility and the environmental impact study. Using the digitized elevation model, we have carried out further studies of all four standard configurations for each site and general site layouts. In this memo we will present the configurations for each site and discuss limitations and problems. We will discuss the detailed design procedure and tools in a separate memo.

The designs presented here are initial designs to help with the site selection. The current limitations could well be removed after further feasibility study, and the designs could be improved with more extensive simulations.

2. Design and Simulation Detail

The MMA consists of 40 8-meter antennas. With four standard configurations, the MMA will be imaging objects on size scales ranging from many arc-minutes down to one tenth of an arc-second. The resolutions differ approximately by a factor of 3 for each configuration (Table 1). The highest resolution will come from the largest configuration, with baselines of a few kilometers.

Observing Mode

The array will be operated in one of two modes, the *Conventional Synthesis* or *Mosaicing* imaging mode. The *Conventional Synthesis* mode will be used mainly for high resolution imaging. The source will be tracked for several hours and the earth-rotation synthesis will help to improve the Fourier-plane (UV) coverage. *Mosaicing* mode will be used for low resolution imaging with the most compact array. Operated like a hybrid single dish and interferometer instrument, the array will be pointed successively to a grid of points spanning the region to be imaged. The array needs to generate uniform UV coverage for both high resolution *Conventional Synthesis* and low resolution *Mosaicing* imaging. To ensure uniform UV coverage for sources of low declinations, arrays are elongated in the North-South direction.

The *Mosaicing* imaging also requires the array to generate similar UV coverage at each pointing position, maximum surface sensitivity and minimum shadowing. The constraints on the compact configuration are: the beam shape should not change too much as a source is tracked through a few hours, the short spacing coverage must be very good, and there cannot be too much shadowing.

General Principle

Earlier theoretical work (Cornwell 1989) showed that an array consisting of antennas pseudo-randomly distributed on an ellipse could sample the UV plane uniformly. Using this principle, we built model array, and selected the best according to both good UV coverage and minimal shadowing. We usually started from this

Table 1. Standard MMA configurations

Configuration	Array Size East-West North-South	Resolution (θ_{HPBW})	Ratio East-West/North-South
A	2,000× 3,000	$0''.08\ \lambda_{mm}$	1.5
B	600× 900	$0''.28\ \lambda_{mm}$	1.5
C	200× 240	$1''.0\ \lambda_{mm}$	1.2
D	70 × 84	$3''.5\ \lambda_{mm}$	1.2

array, and tried to fit the array to the site topography. For the standard D array, the theoretical array is generated by putting antennas within an ellipse and the minimum spacing between any antenna pairs is greater than 10 meters.

Low declination observations

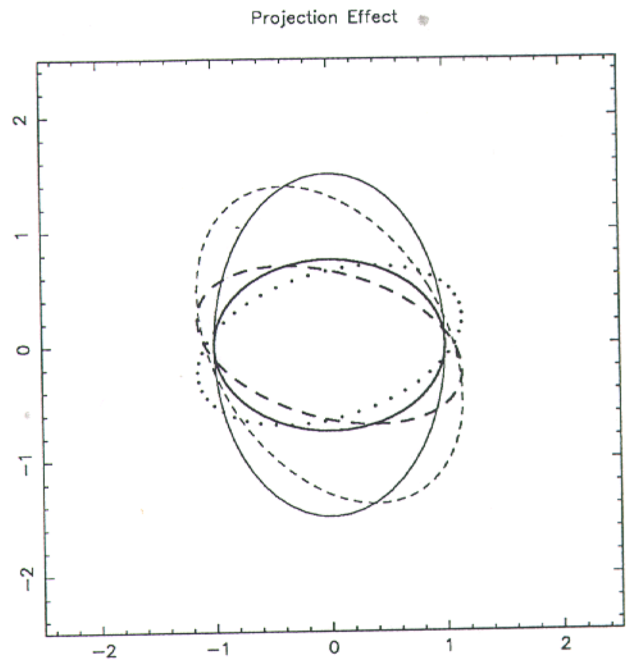
For low declination observations, the constraints on the compact array are incompatible and some compromises must be made.

To avoid shadowing and maintain a more circular beam at low declinations, the array needs to be stretched in the North-South direction. On the other hand, the synthesized beam of an elongated array will vary (in shape and orientation) with time, depending on the pointing positions in the sky.

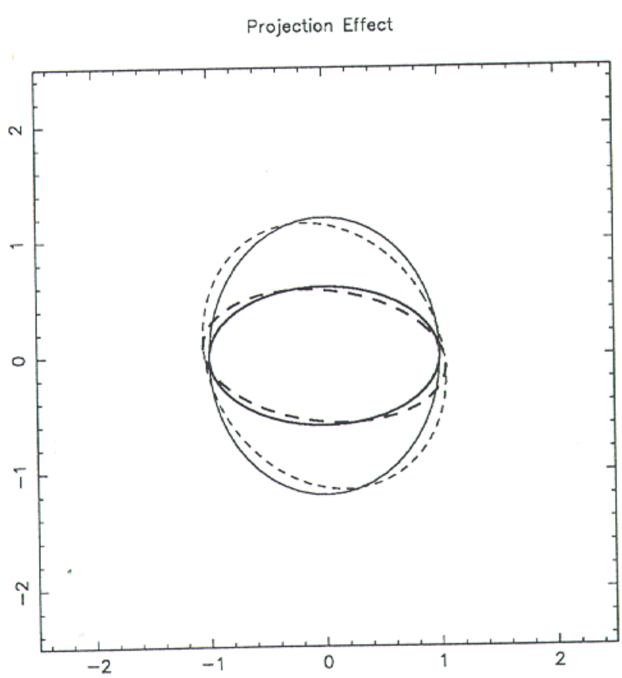
The shadowing can be improved by stretching the array by $1/\cos(\theta)$ (θ is the source elevation) in the direction of the source. The projection of the array in the plane of sky is a circle in this direction and is an ellipse in other directions. If the elongation is in the North-South direction, the synthesized beam will be a circle (or close to a circle) when the source transit. While the source is away from the transit, the array generates a different UV coverage, depending on the distance of the source to the transit. Then the synthesized elliptical beam may be different in orientation and shape. In *Conventional Synthesis* mode, this actually improves the UV coverage. In *Mosaicing* mode, the UV coverage at each pointing

Figure 1 The projection of the array in the plane of the sky will change with time. The more elongated the array is and the more inclined with respect to the plane of the sky, the more quickly it varies with time. The very elongated array is not an ideal configuration for *Mosaicing* sources at very low declinations. To help minimize the difference in the UV coverage, two pointings symmetric to the transit could be added together. This plot shows the projections of an array when observing a source of $\delta = -30°$ at different hourangles. The heavy lines show the array projected in the plane of sky. The thin lines show the real size and orientation of the array. The solid and dashed lines show the observations at 0 hour and 2 hour angles respectively. The dotted line shows the observing coverage at -2 hour.

ratio 1.5



ratio 1.2



position should be the same, or in other words, only the data within the common UV coverage can be used. Then an elongated array is not ideal for *Mosaicing* low declination sources. One approach to solve this problem is to keep the standard array close to a circle and combine the data taken at pointings symmetric to the transit when ' Mosaicing '.

To maintain near circular beam shape over a wide range of declinations, the ratio for A and B configurations was 1.5. Considering the need for *Mosaicing* observations, we used a ratio of 1.2 for the two smaller arrays.

Array layout criteria and evaluation

In accommodating these configurations to the topography of each site, we have considered the following restrictions:

- UV coverage
- Existing forbidden areas, buildings, roads, highways, rivers, reservoirs, ponds, cinder or gravel pits, etc.
- Potential environmental problems, such as the visual pollution
- Steep inclines and rough, rocky terrain
- View to the south
- Distance to the control building

Simulation

To test and evaluate the quality of the design, for each hypothetical configuration, we have used programs in AIPS and SDE to simulate the UV coverage of observations in both *Conventional Synthesis* and *Mosaicing* mode. Basic simulation input parameters are listed in Table 2.

In *Conventional Synthesis* mode, the duration of an observation was determined by that the airmass [1] vary less than 40% during the observation. In *Mosaicing* mode, two short observations made when the source is at the same distance to or away from the transit have been combined.

Table 2. Simulation input parameters

a. Long synthesis observations

Frequency: 2.3E+11 Hz				
Elevation limits: 10°				
Integration Time: 600 seconds				
Air mass change: 40%				
Declination of Sources	−30°	0°	30°	60°
Hour angle limit (hours)	±2.5	±2.9	±3.6	±4.7

b. Mosaic observations

Frequency: 2.3E+11 Hz			
Elevation limits: 10°			
Pointing	0^h	1^h	2^h

c. Imaging Parameters

Array	Cell Size	Image Size
A	0.02 × 0.02	1024 × 1024
B	0.10 × 0.10	512 × 512
C	0.30 × 0.30	256 × 256
D	1.00 × 1.00	128 × 128

The beam parameters were derived from fitting a two-dimensional Gaussian function to each beam images. Because sometimes the synthesis beams are not Gaussian functions, values lower than 10% on the beam images have been ignored.

[1] the amount of airmass is a function of the source elevation and reach the minimum when the source pass transit

3. Results and Discussion

Configurations proposed for each site are presented in both geographical and local coordinates (Figure 2). To allow the dynamic re-configuration of the array for observations at very low declination, we arrange the smallest D-array in the center of the C-array. The complete listing of antenna positions of each array can be found in Appendix A. The plots of UV coverage of simulations are showed in Appendix B. Corresponding beam fits and the inner sidelobe levels are listed in Appendix C.

3.1 *Magdalena Mountains Site*

The Magdalena Mountains are located about 40 km west of Socorro, New Mexico. At around 10,500 feet elevation, the site is irregularly shaped and mostly in the scientific preserve for the atmosphere and astrophysical research (Figure 3).

Extended Configuration

We propose two alternatives for the most extended configuration: the North ridge Array and the Timber ridge array.

North ridge array (Figure 2 and Figure 3): this array was based on the previous design (MMA memo 60), with some changes. The array extends to only Lat 34°00′15, mainly because beyond this point the access road must go through a very rocky area, which would increase the cost of road construction[2]. Antennas 38,39 have been moved mainly because of the access, and they are not so critical in the UV coverage. The rest of the antennas were positioned slightly differently, to optimize the resulting UV coverage. Part of the array is outside the science preserve and this may be a potential problem.

Timber Ridge Array (Figure 2 and Figure 3): Instead of having an arm going up to the North Ridge, we have considered the alternative of extending the array along

[2] Since these studies, a road consultant has suggest new alternatives which should relieve these difficulties. Thus one may wish to reconsider this configuration.

Figure 2. Proposed configurations. On the left are plots in geographical corrdinates, while the plots on the right are in local coordinates. The cross and heavy dots are antenna positions. The numbers are antenna numbers. The contour and gray scale plot show the elevation variation.

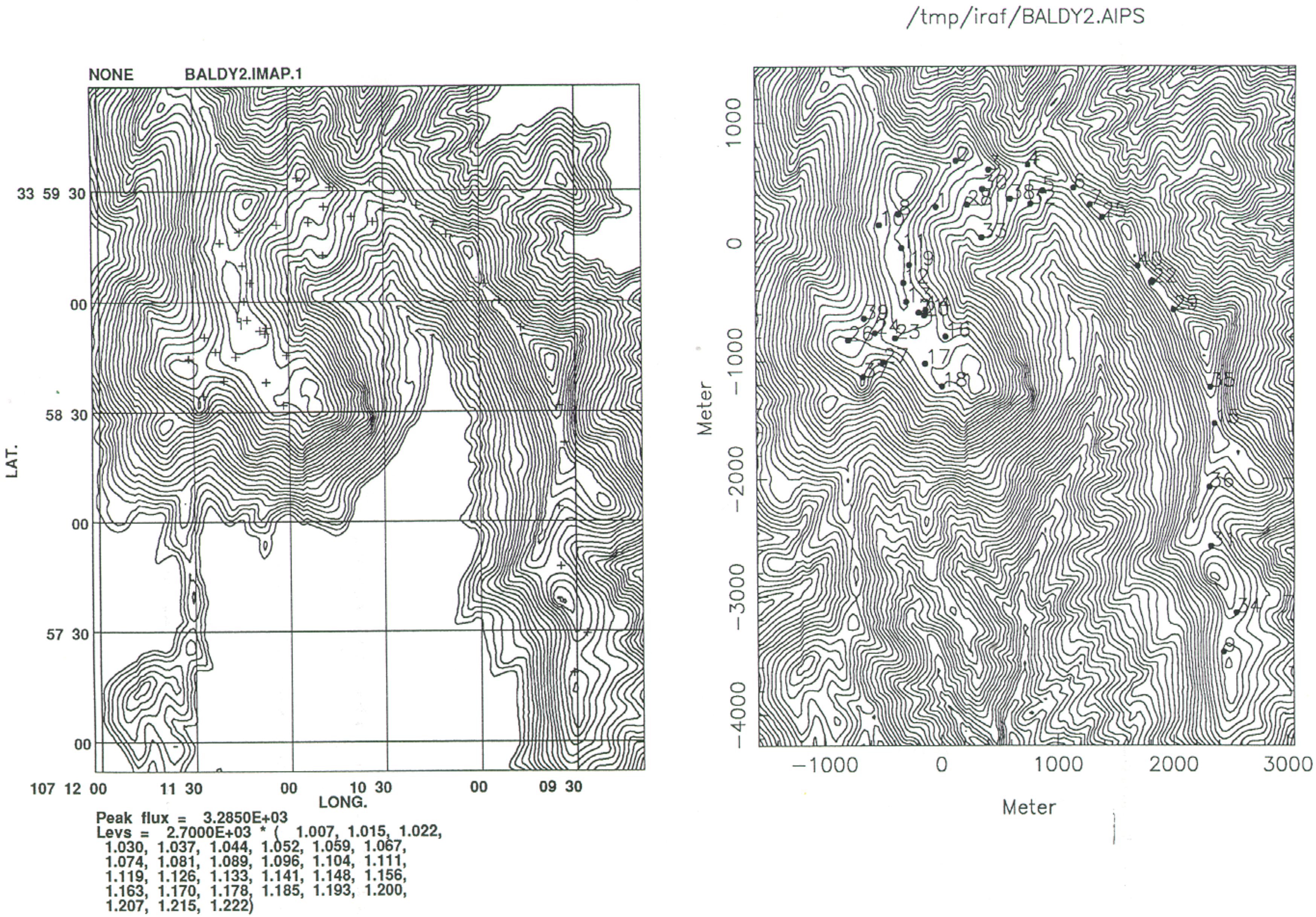


Figure 2 a. Magdalena Mountains Site: A array, Timber Ridge Array The lowest contour is 2700 meters, the contour levels are 20 meters.

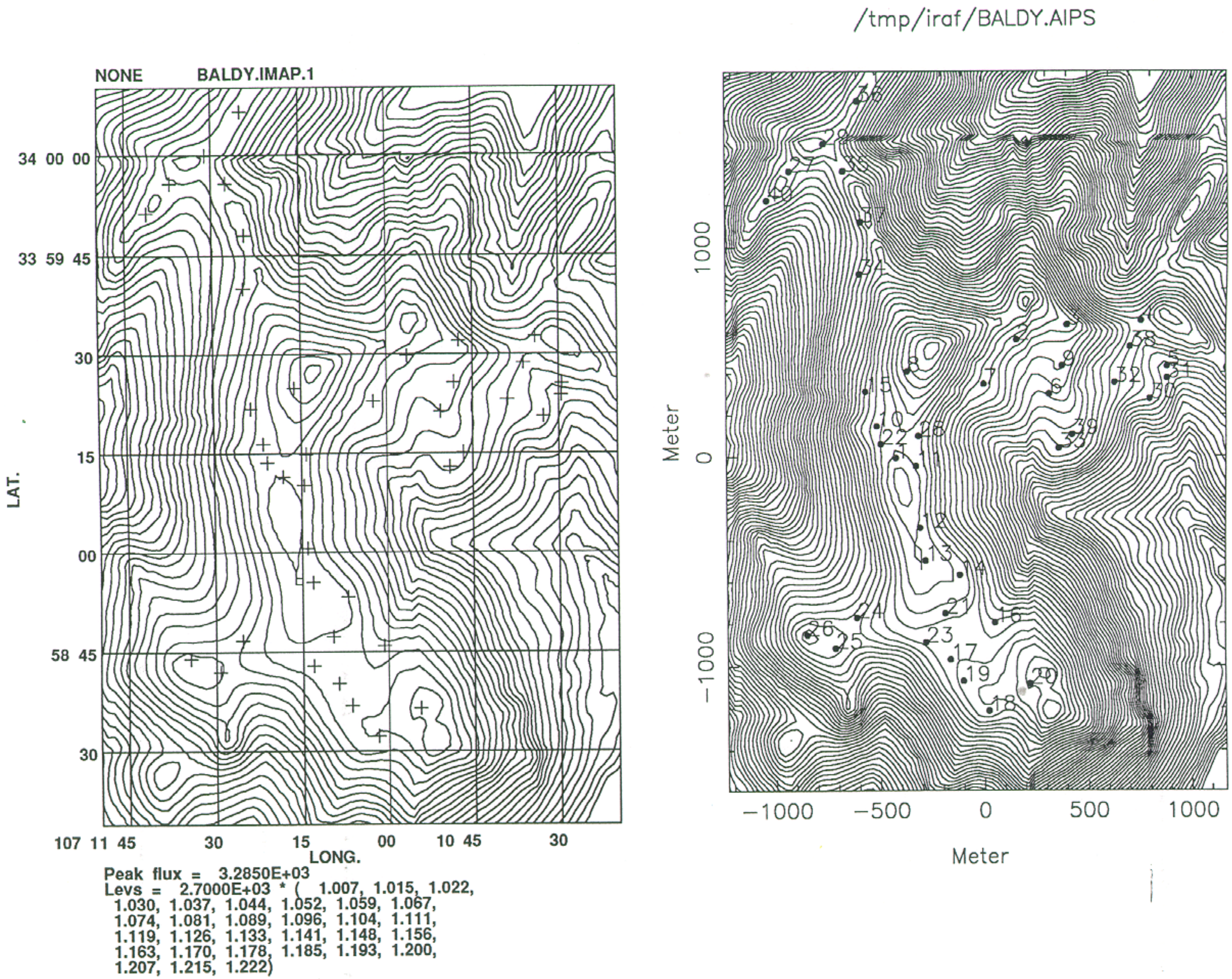


Figure 2 b. Magdalena Mountains Site: A array, North Ridge Array The lowest contour is 2700 meters, the contour levels are 20 meters.

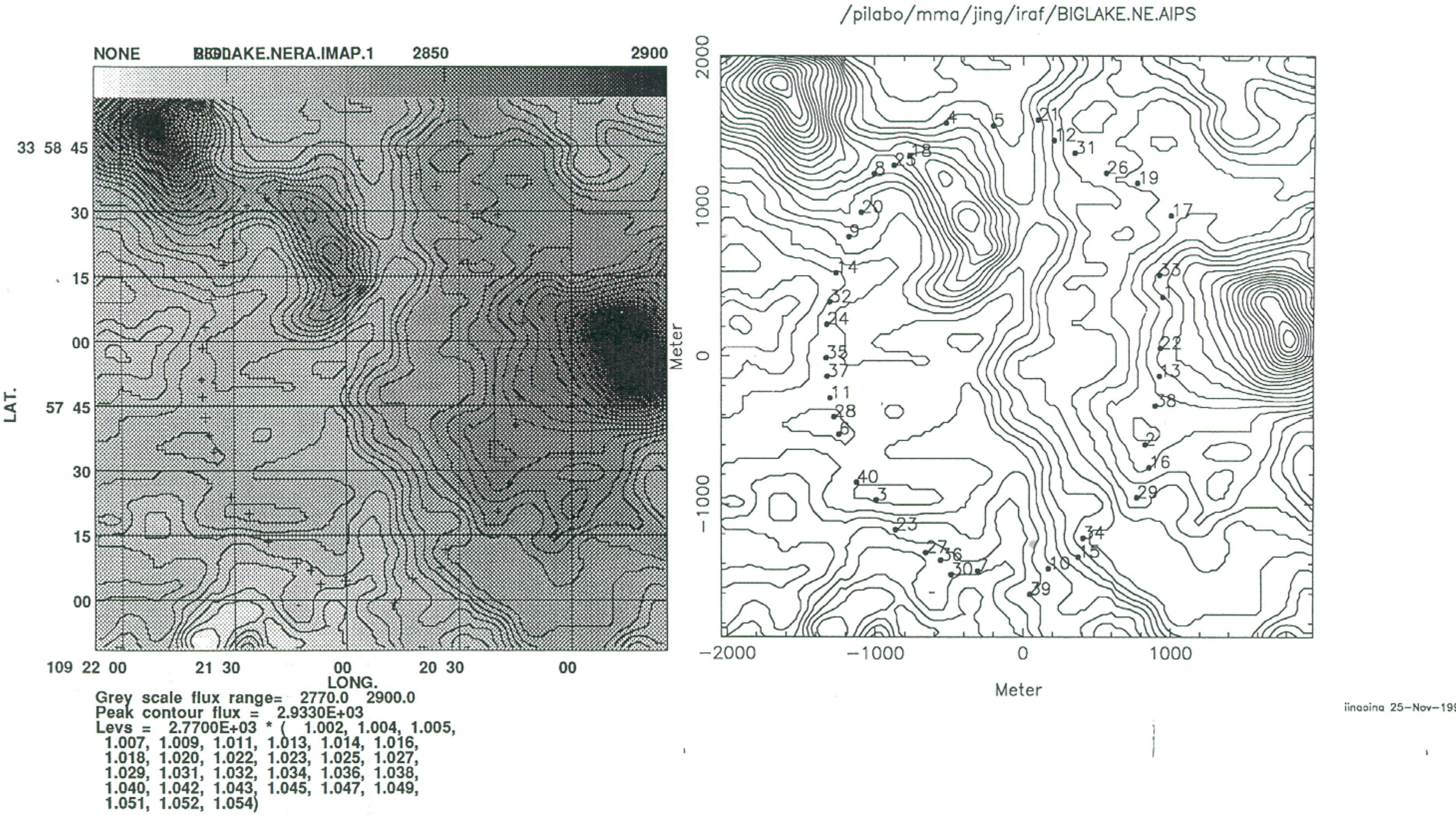


Figure 2 c.Springerville Site: A array, Biglake North-East Array The lowest contour is 2770 meters, the contour levels are 5 meters.

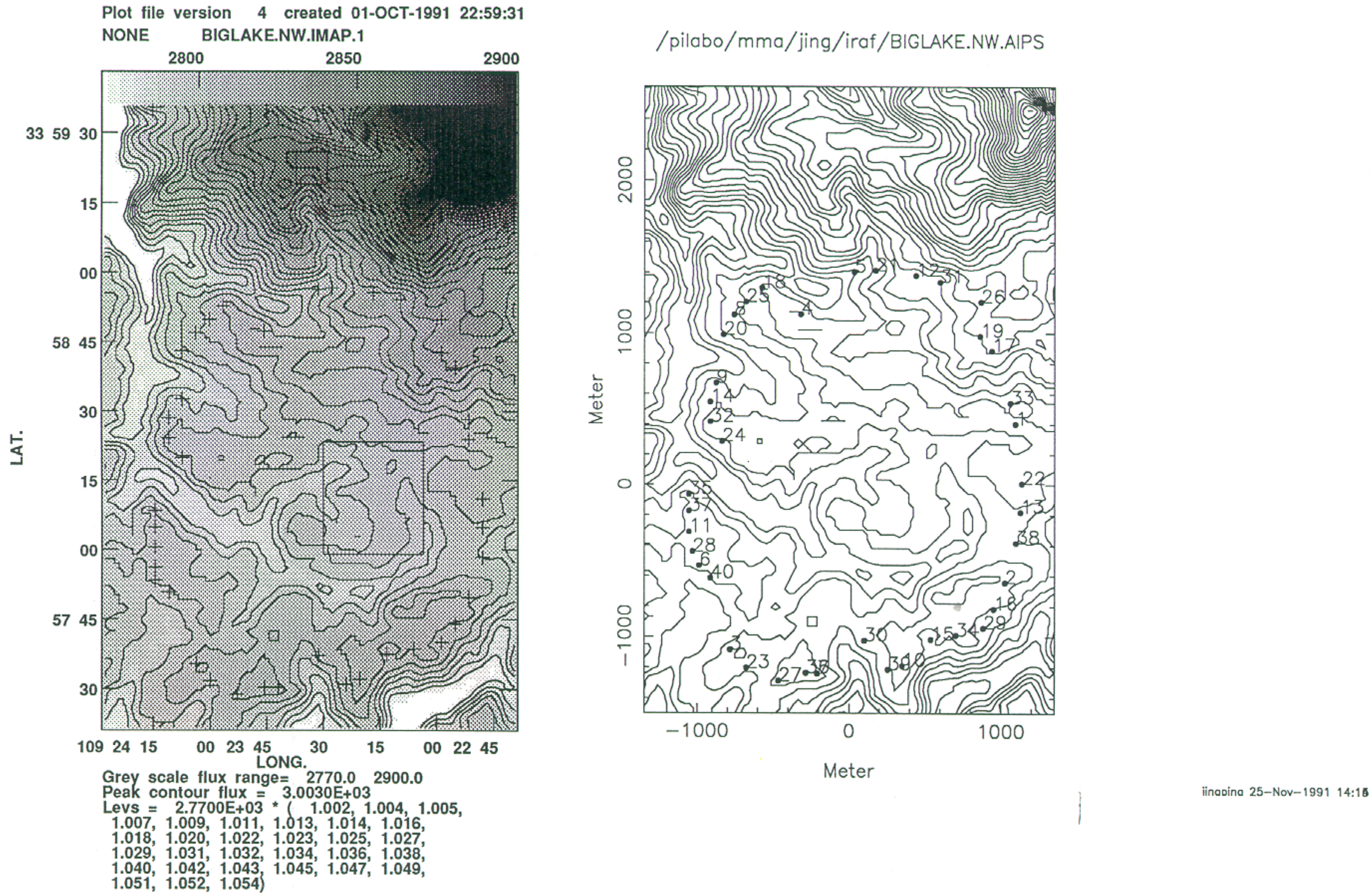


Figure 2 d. Springerville Site : A array, Biglake North-West Array

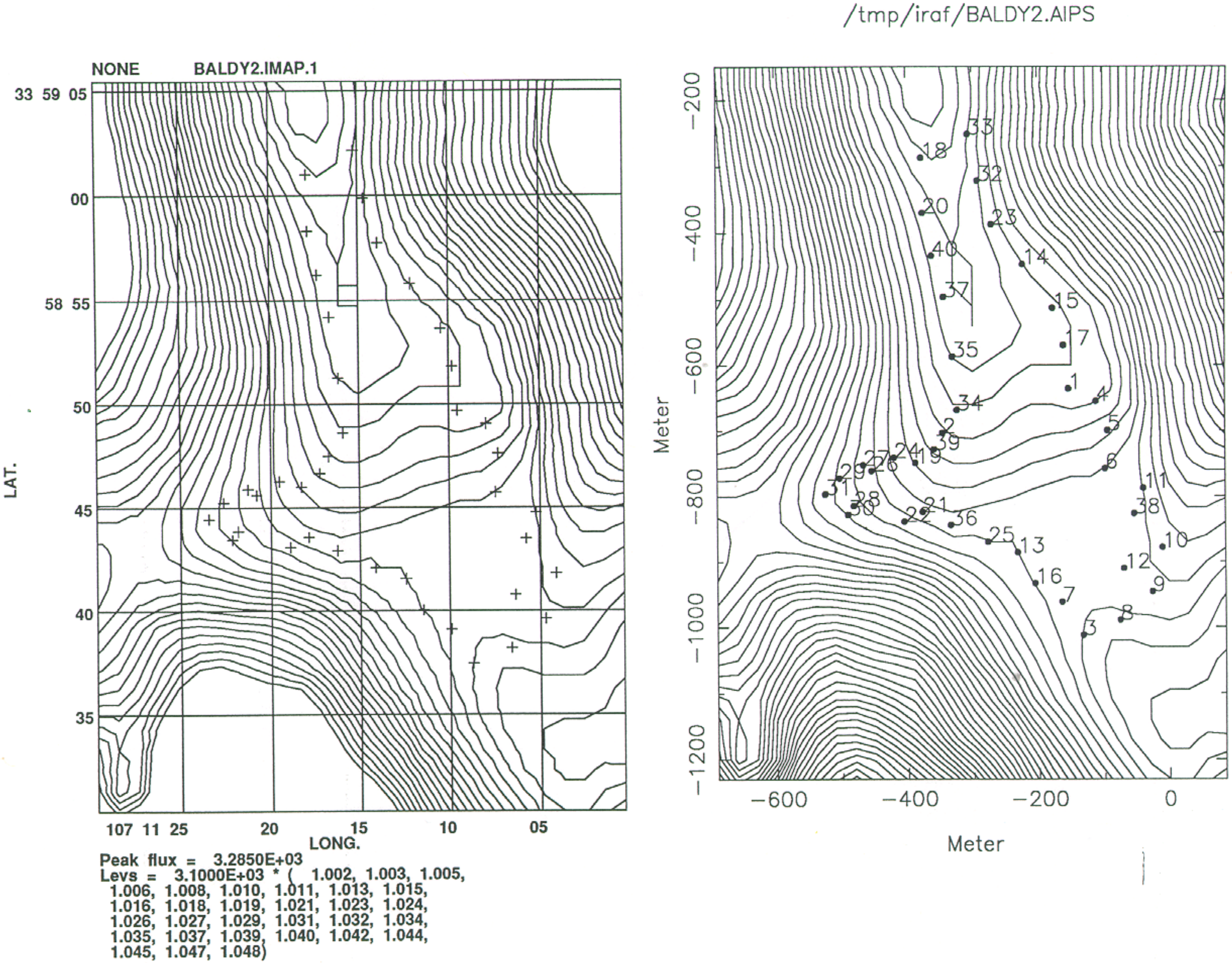


Figure 2 e. Magdalena Mountains Site: B arrays. The lowest contour is 3100 meters, the contour levels are 2.5 meters.

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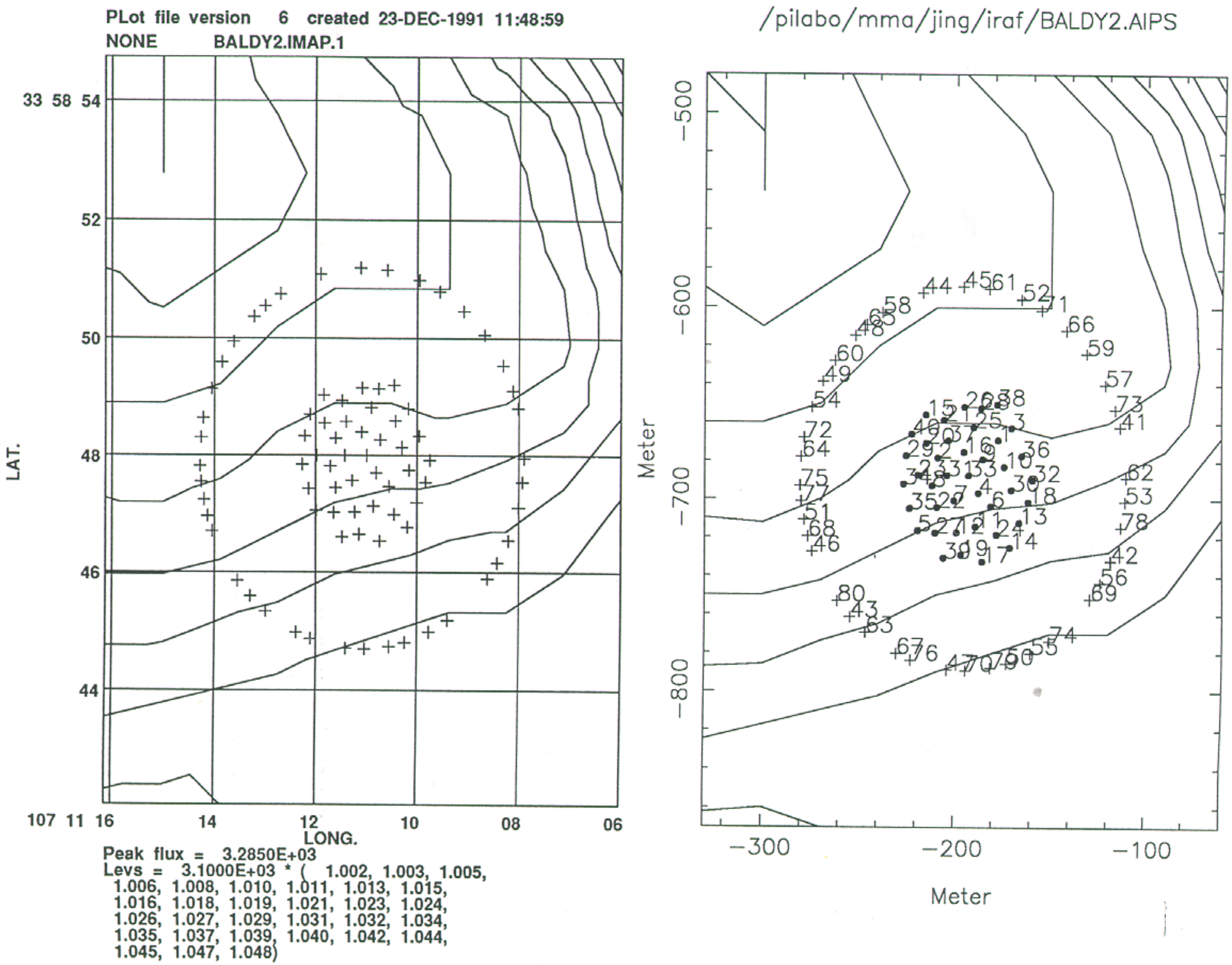

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Figure 2 f. Magdalena Mountains Site: C and D arrays The lowest contour is 3100 meters, the contour levels are 2.5 meters. The antennas on the ring are in C-array.

the Timber Ridge. We found a configuration which will provide good UV coverage and a bit higher resolution simply because we extended both the East-West baseline and the North-South extension of the array. The topographic map shows that all antennas have clear view to the South.

Compact Array

All the rest of the standard configurations could fit in the central open area. The B-configuration was fit quite tightly in this area. The C, D and C/D configurations were arranged on a slope, this would allow better UV coverage when observing sources of low declinations and minimize the shadowing problem.

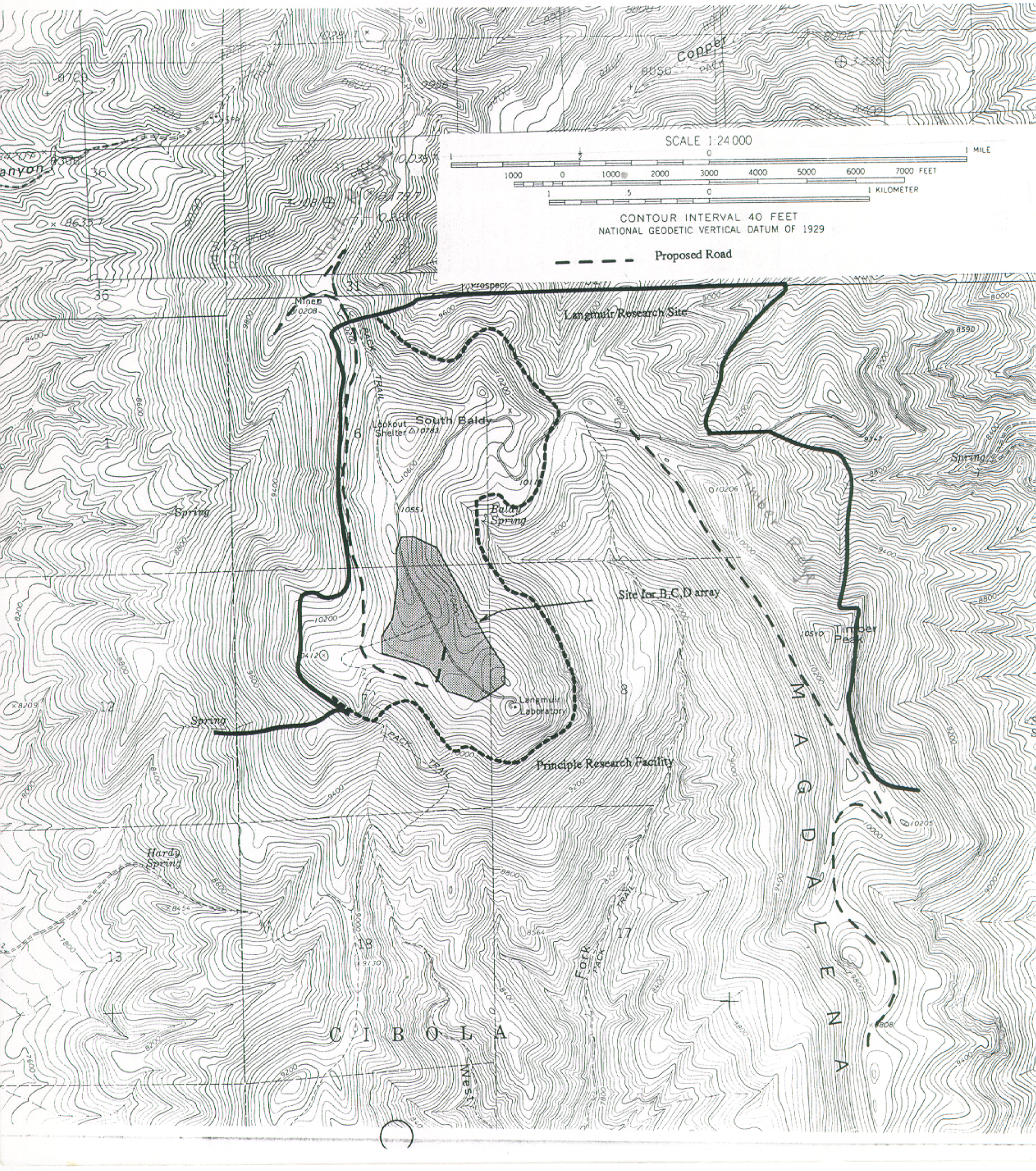
3.2 *Springerville Site*

The Springerville site is about 10 miles south of Springerville and Eagar, Arizona at 9200 feet elevation. There is a recreational area at its southern end (Biglake and Crescent Lake) which is heavily used during the summer months. One of the major highways (273) to the recreation area goes between the two proposed sites (Figure 4). A, B, and C configurations are impossible to hide from view of the highway. Even for the smallest D configuration, only very limited area may be hidden. Fortunately, the highway is usually closed in the winter.

North West Site

This site is the area mostly on the west of highway 273. The Little Colorado River starts in the middle of the site and runs along the West side of the site to the north. Another stream, Seven Springs, runs along the south of the site. On the north are areas with quite steep slopes. An ellipse of 2.2×2.8 km just barely fits in this area (Figure 4). Ten antennas of the A array locate on the east side of the highway. The B-array is also arranged close to the center of the A-array, but right next to the highway. To avoid the potential visual pollution, the C and D arrays are put on the North end of the site, behind Wahl Knoll and close to Bill Riley

Fig. 3


SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
Proposed Road
Langmuir Research Site
South Baldy
Lookout Shelter
Baldy Spring
Site for B,C,D array
Langmuir Laboratory
Principle Research Facility
Timber Peak
Spring
Hardy Spring
Mine
Prospect
Copper
PACK TRAIL
C I B O L A
M A G D A L E N A

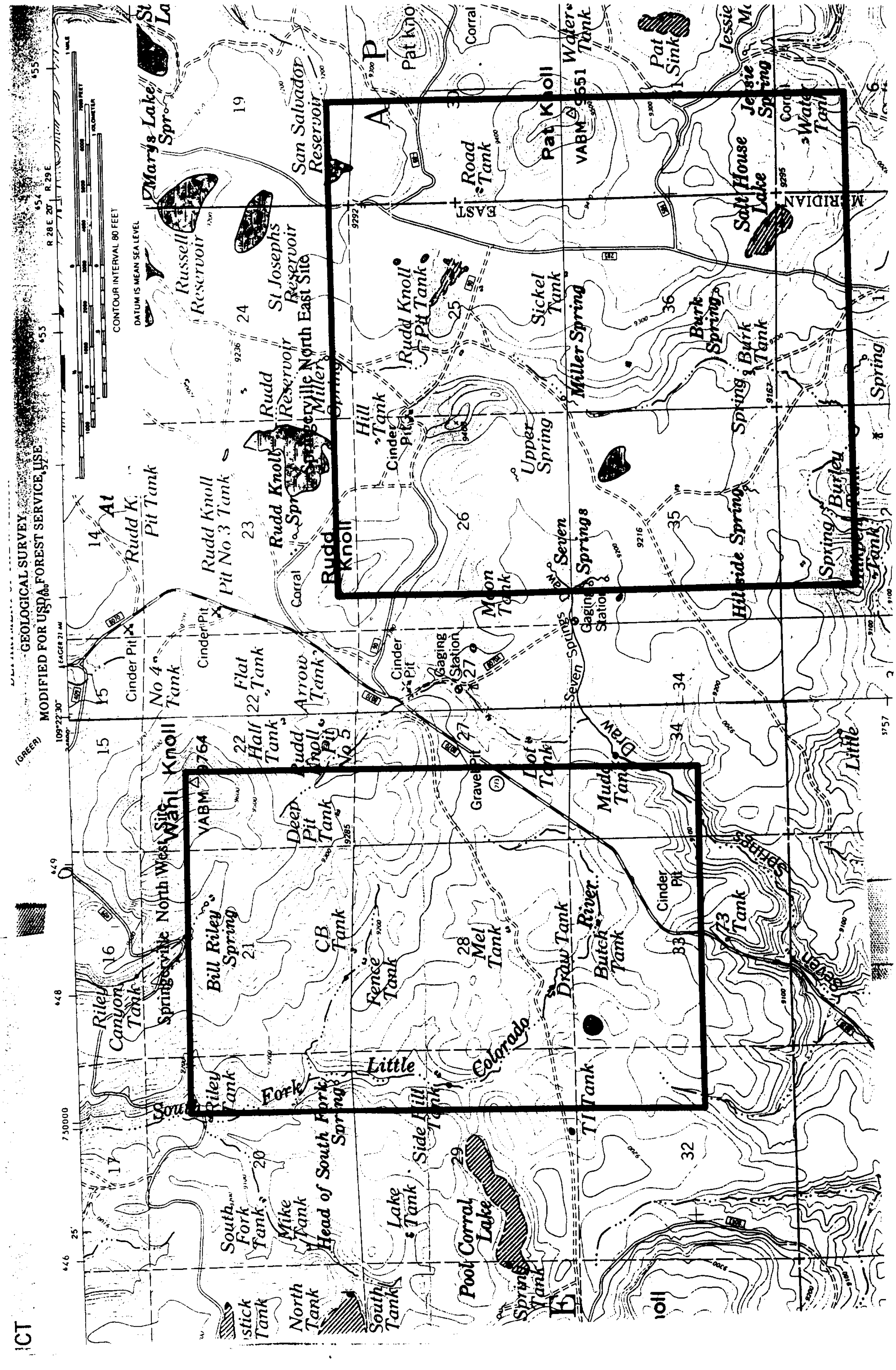

GEOLOGICAL SURVEY
MODIFIED FOR USDA FOREST SERVICE USE
CONTOUR INTERVAL 80 FEET
DATUM IS MEAN SEA LEVEL
R 28 E
R 29 E
San Salvador Reservoir
Russell Reservoir
St Josephs Reservoir
Springerville North East Site
Rudd Reservoir
Rudd Knoll
Rudd Knoll Pit No 3 Tank
Pat Knoll
Road Tank
Rudd Knoll Pit Tank
Sickel Tank
Miller Spring
Burk Spring
Burk Tank
Hill Tank
Cinder Pit
Upper Spring
Seven Springs
Moon Tank
Gaging Station
Hillside Spring
Burley Tank
Salt House Lake
Jessie Spring
Pat Sink
MERIDIAN
Wahl Knoll
VABM 9764
Springerville North West Site
Bill Riley Spring
CB Tank
Deep Pit Tank
Half Tank
Fence Tank
Mel Tank
Draw Tank
Butch Tank
Mud Tank
Little Colorado River
South Fork
Riley Tank
Riley Canyon Tank
Side Hill Tank
Head of South Fork Spring
South Fork Tank
Mike Tank
Lake Tank
Pool Corral Lake
North Tank
South Tank
TI Tank
Flat Tank
Arrow Tank
No 4 Tank

Figure 4

Spring (Figure 2 and Figure 4). The control building and other buildings can also be easily hidden in this valley.

North East Site

The site is on the east of the highway. The site has a slope to the west, so the visual pollution is still a major concern here. Miller Spring runs in the middle of the site. Another dirt road cuts through the site. Rudd Knoll is on the North-West corner of the site. Three lakes are scattered around. A campground is located on the north side of the Rudd Knoll. An array of 2×3.2 kms can be easily fit into this area. (Figure 4). On the east of the road 285 and around route 584, there is a low area, which could host the smaller configuration and the buildings.

3.3 *Hybrid compact configuration*

As discussed previously, low declination observations have more constraints on the compact configurations. The constraints are not compatable and configurations for the low declination observations must be designed. We present two sets of configurations here and the simulation results intend to show the problems and possible direction for further study. More effort needs to be spent on this configuration.

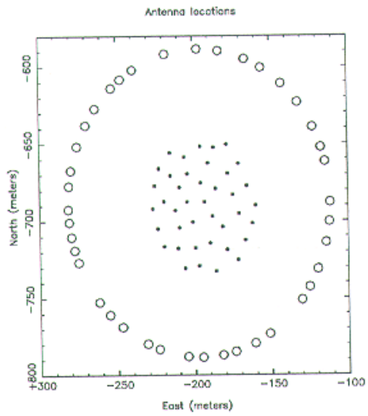
First we show that the shadowing can be improved by removing the shadowed D array antennas to selected existing C array stations (Figure 5). This will not require extra antenna stations. In the second series (Figure 6), we show the arrays optimized for low declination observation. A complete new set of antenna stations are needed for this configuration. Second we show arrays formed by moving the shadowed antennas to new stations which are optimized for particular declinations.

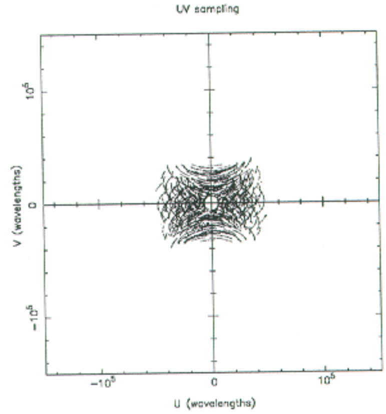
Table 3. Synthesized-beam major-axis and minor-axis full-widths at half-maximum, θ_1 and θ_2, at $\lambda = 1mm$, for the *mosaic* imaging (using hybrid configuration and assuming uniform weighting).

Array File	Declination	Hourangle	Synthesized		Beam
			θ_1	θ_2	Position Angle
DEC-20.EL	−10	2	3.6	2.4	88
		1	3.5	2.5	85
		0	3.5	2.5	83
	−20	2	3.7	2.7	79
		1	3.5	2.8	77
		0	3.5	3.0	75
	−30	2	3.8	3.4	-88
		1	3.7	3.5	70
		0	3.7	3.3	87
DEC-29	−10	2	2.3	1.8	92
		1	2.3	1.8	93
		0	2.2	1.8	93
	−20	2	2.6	2.2	-87
		1	2.4	2.2	-73
		0	2.2	2.1	100
	−30	2	2.7	2.5	-9
		1	2.8	2.4	-2
		0	2.8	2.3	-1
DEC-30.PAC	−10	2	3.0	2.4	-88
		1	2.9	2.4	88
		0	2.8	2.4	86
	−20	2	3.1	2.7	-80
		1	2.9	2.8	77
		0	2.9	2.9	50
	−30	2	3.1	3.0	-39
		1	3.3	2.9	-5
		0	3.5	2.8	-2
DEC-30	−10	2	3.5	1.7	93
		1	3.6	1.6	92
		0	3.3	1.6	96
	−20	2	3.5	1.7	-81
		1	3.4	1.8	-85
		0	3.5	1.8	-88
	−30	2	3.5	2.1	-86
		1	3.3	2.2	-85
		0	3.5	2.2	-88

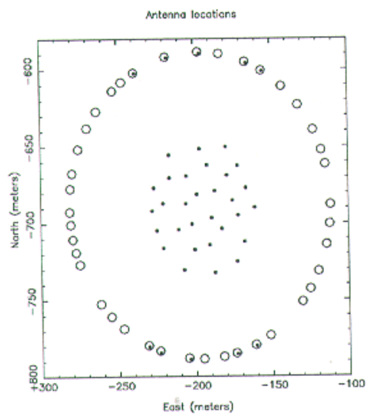
Figure 5. Hybrid C/D configurations. Plots on the left show antenna stations. The cross marked all standard C array antenna stations. The heavy dots are actual C/D array antenna positions. The array is formed by moving the shadowed antennas to selected existing standard C array stations. Plots on the right are corresponding UV coverage for observations at $\delta = -30°$ (source is tracked from -2HA to 2HA. While the antennas were all in standard D-configuration, more than half of the base lines were shadowed. Using the existing C-array stations, this could be improved.

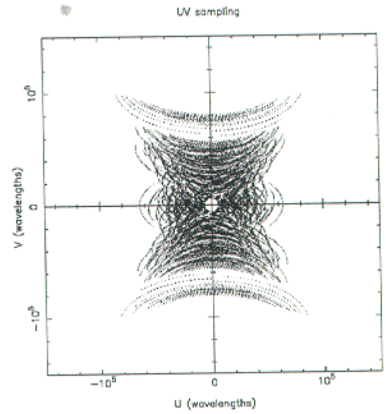
D Only





Option 1





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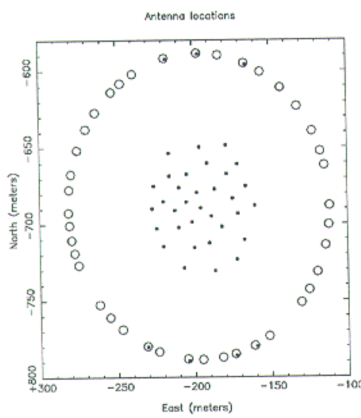

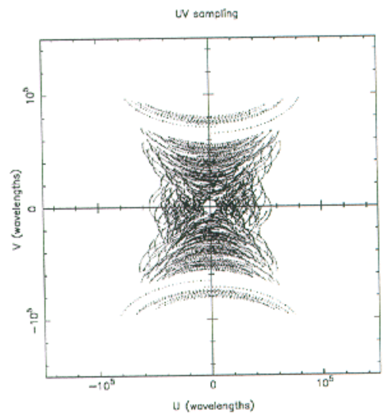

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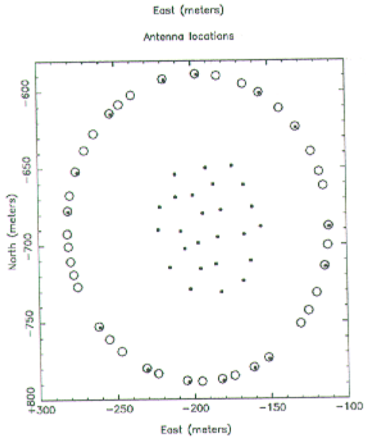

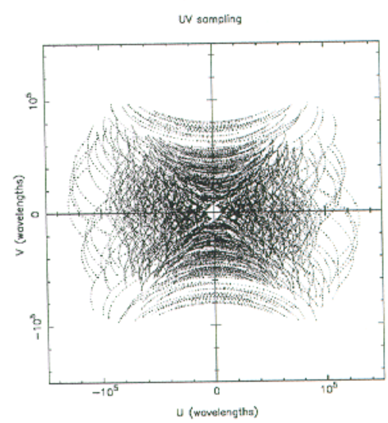

Figure 6. Compact configurations optimized for low declination observations. For each configuration, we plot: (1) the antenna positions; standard C array antenna stations are marked by cross, actual antenna stations of the optimized array are marked with the heavy dots. (2) the UV coverage when pointing to 2, 1, and 0 hours from the meridian and $\delta = -30°$. Two pointings symmetric with the meridian have been added together. The beam fits were listed in Table 3.

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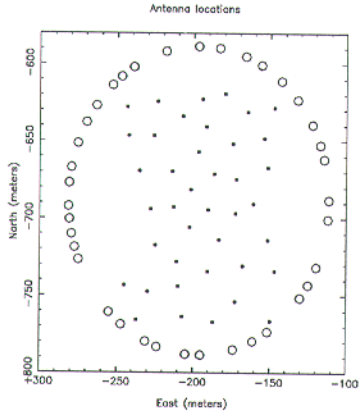

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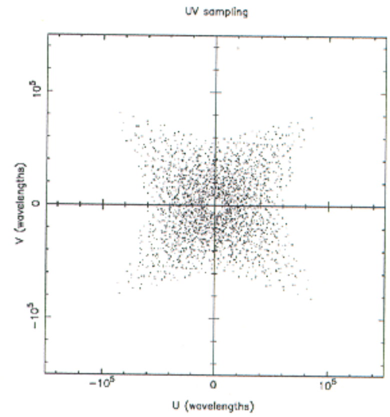

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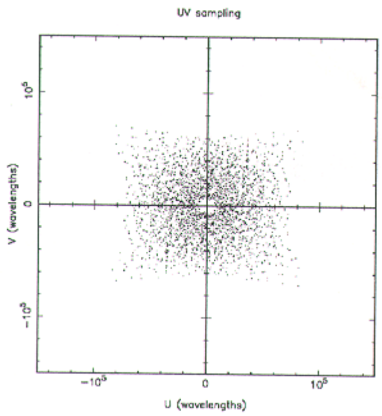

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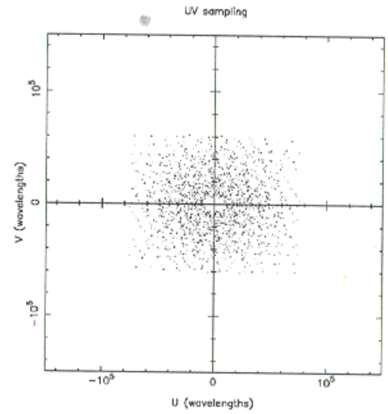
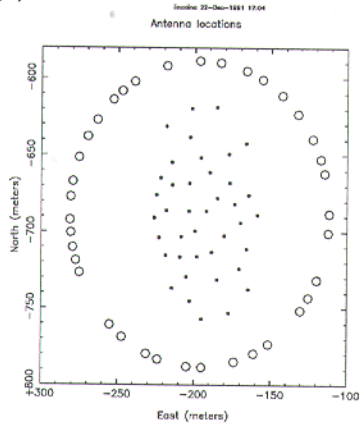


DEC-20.EL.STN



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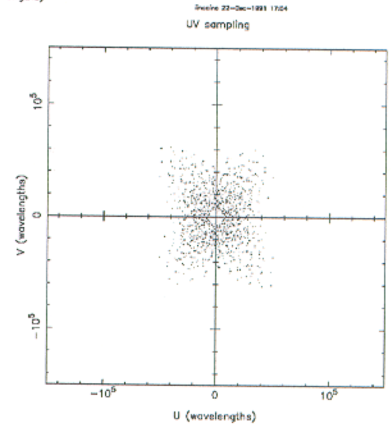

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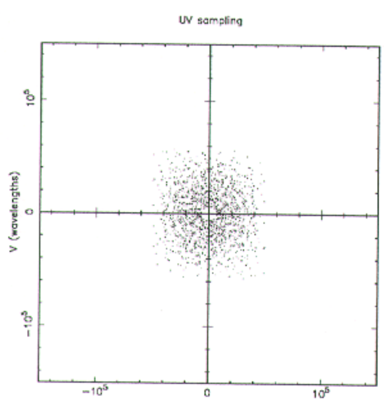

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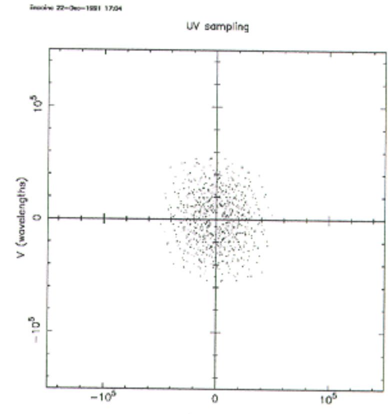

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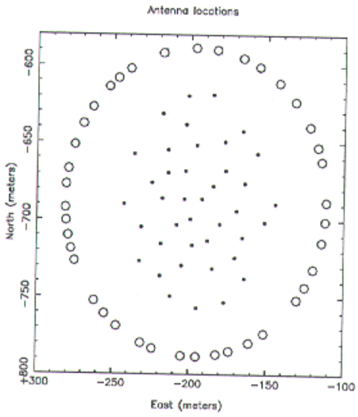

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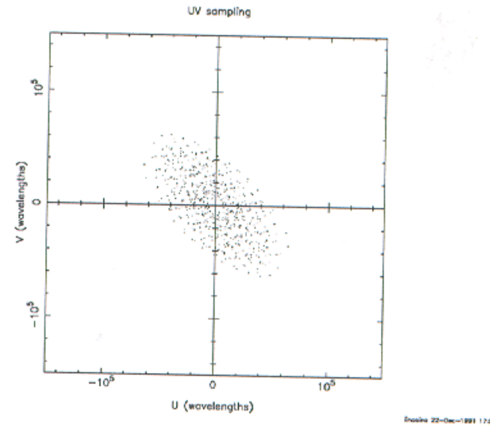

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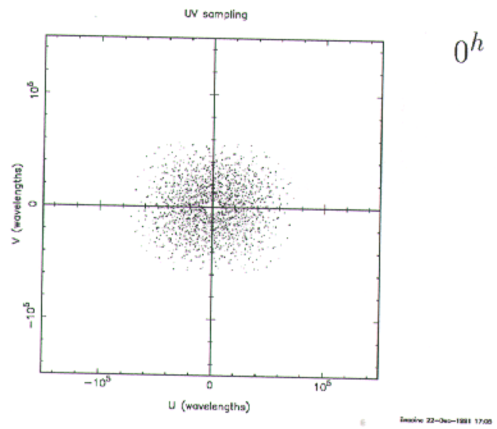

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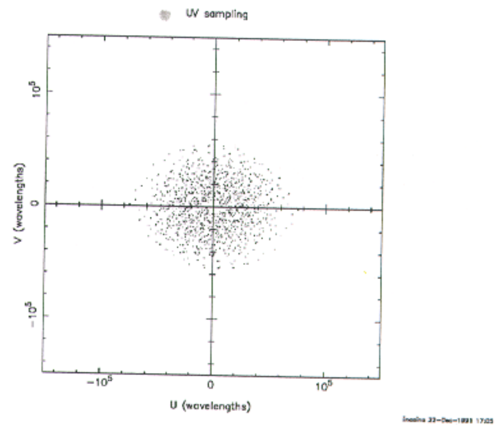
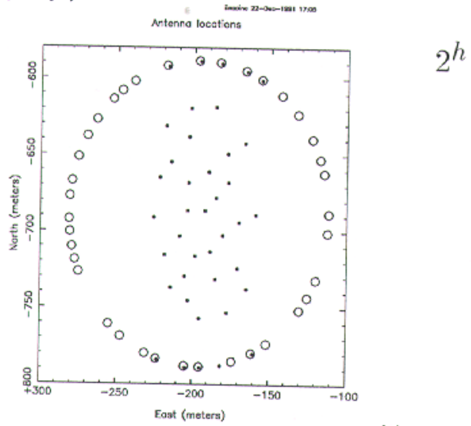
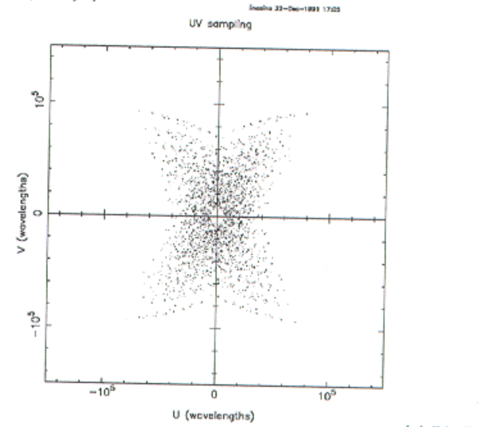


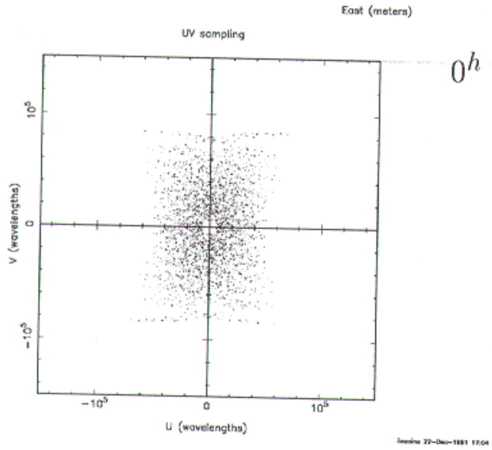
DEC-30.STN



2^h



1^h



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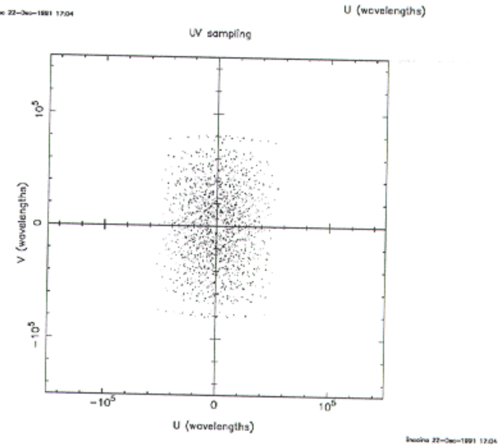


APPENDIX A

Lists of antenna coordinates and elevations of proposed arrays. The names of the sites and configurations are listed at the bottom of each page. Listings in the tables are: (1) antenna numbers, (2) Latitudes [3 columns], (3) Longitudes [3 columns], and (4) Elevations.

Biglake: North east

Ant #	LAT. (D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	57	54.85	109	20	22.27	2840
2	33	57	46.85	109	20	22.95	2839
3	33	57	43.49	109	20	40.88	2831
4	33	58	2.86	109	20	35.97	2831
5	33	58	3.23	109	20	33.17	2832
6	33	57	47.40	109	20	43.51	2830
7	33	57	40.37	109	20	34.22	2837
8	33	58	0.33	109	20	40.59	2832
9	33	57	57.57	109	20	42.81	2828
10	33	57	40.73	109	20	30.12	2842
11	33	57	49.28	109	20	44.09	2832
12	33	58	2.48	109	20	29.11	2837
13	33	57	50.40	109	20	21.94	2840
14	33	57	56.01	109	20	43.56	2828
15	33	57	41.35	109	20	28.44	2843
16	33	57	45.53	109	20	23.67	2839
17	33	57	57.41	109	20	23.31	2840
18	33	58	1.68	109	20	38.76	2831
19	33	57	59.26	109	20	24.59	2840
20	33	57	58.81	109	20	41.99	2831
21	33	58	3.09	109	20	31.34	2833
22	33	57	51.83	109	20	21.86	2840
23	33	57	42.58	109	20	39.82	2832
24	33	57	53.07	109	20	44.29	2829
25	33	58	0.98	109	20	39.81	2832
26	33	58	0.65	109	20	25.99	2840
27	33	57	41.32	109	20	37.71	2834
28	33	57	48.30	109	20	43.83	2831
29	33	57	44.58	109	20	24.35	2841
30	33	57	40.32	109	20	32.93	2839
31	33	58	1.83	109	20	27.72	2839
32	33	57	54.22	109	20	44.10	2827
33	33	57	55.90	109	20	22.61	2839
34	33	57	42.05	109	20	27.15	2844
35	33	57	51.34	109	20	44.35	2831
36	33	57	40.92	109	20	36.71	2835
37	33	57	50.39	109	20	44.28	2832
38	33	57	48.85	109	20	22.23	2840
39	33	57	40.48	109	20	31.20	2841
40	33	57	44.44	109	20	41.75	2831

Biglake: North east

Ant #	LAT.(D M S)			LONG. (D M S)			ELV. (meters)
1	33	58	4.28	109	20	13.02	2854
2	33	57	31.99	109	20	17.71	2849
3	33	57	19.89	109	21	25.94	2811
4	33	58	42.21	109	21	8.22	2821
5	33	58	41.61	109	20	56.30	2816
6	33	57	34.30	109	21	35.35	2810
7	33	57	4.44	109	21	0.26	2791
8	33	58	31.22	109	21	26.34	2831
9	33	58	17.54	109	21	32.73	2818
10	33	57	4.92	109	20	42.36	2803
11	33	57	42.31	109	21	37.55	2809
12	33	58	38.42	109	20	40.96	2831
13	33	57	47.05	109	20	13.90	2853
14	33	58	9.65	109	21	36.00	2805
15	33	57	7.46	109	20	34.79	2815
16	33	57	26.99	109	20	16.62	2845
17	33	58	22.04	109	20	10.76	2844
18	33	58	35.01	109	21	17.43	2840
19	33	58	29.14	109	20	19.55	2842
20	33	58	22.82	109	21	29.61	2823
21	33	58	42.84	109	20	45.04	2823
22	33	57	53.17	109	20	13.59	2855
23	33	57	13.44	109	21	21.02	2797
24	33	57	58.42	109	21	38.30	2808
25	33	58	33.05	109	21	21.35	2833
26	33	58	31.36	109	20	27.60	2839
27	33	57	8.46	109	21	13.44	2792
28	33	57	38.14	109	21	36.57	2811
29	33	57	20.40	109	20	19.85	2837
30	33	57	3.66	109	21	7.01	2791
31	33	58	35.66	109	20	35.73	2838
32	33	58	3.30	109	21	37.59	2807
33	33	58	9.12	109	20	13.82	2856
34	33	57	11.58	109	20	33.59	2822
35	33	57	51.07	109	21	38.54	2809
36	33	57	6.77	109	21	9.69	2792
37	33	57	47.03	109	21	38.26	2808
38	33	57	40.48	109	20	15.00	2848
39	33	56	59.35	109	20	47.09	2799
40	33	57	23.79	109	21	30.86	2809

Biglake: North east

Ant #	LAT.(D M S)			LONG. (D M S)			ELV. (meters)
1	33	57	48.36	109	19	59.77	2864
2	33	57	40.36	109	20	0.45	2852
3	33	57	36.99	109	20	18.38	2850
4	33	57	56.36	109	20	13.47	2854
5	33	57	56.74	109	20	10.67	2858
6	33	57	40.90	109	20	21.01	2848
7	33	57	33.88	109	20	11.72	2848
8	33	57	53.84	109	20	18.09	2847
9	33	57	51.08	109	20	20.31	2843
10	33	57	34.23	109	20	7.62	2845
11	33	57	42.79	109	20	21.59	2845
12	33	57	55.99	109	20	6.61	2861
13	33	57	43.90	109	19	59.44	2858
14	33	57	49.52	109	20	21.06	2843
15	33	57	34.86	109	20	5.94	2845
16	33	57	39.04	109	20	1.17	2847
17	33	57	50.91	109	20	0.81	2865
18	33	57	55.19	109	20	16.26	2850
19	33	57	52.76	109	20	2.09	2865
20	33	57	52.32	109	20	19.49	2845
21	33	57	56.60	109	20	8.84	2859
22	33	57	45.34	109	19	59.36	2860
23	33	57	36.09	109	20	17.32	2850
24	33	57	46.58	109	20	21.79	2841
25	33	57	54.48	109	20	17.31	2848
26	33	57	54.16	109	20	3.49	2864
27	33	57	34.82	109	20	15.21	2850
28	33	57	41.80	109	20	21.33	2846
29	33	57	38.08	109	20	1.85	2846
30	33	57	33.82	109	20	10.43	2847
31	33	57	55.34	109	20	5.22	2863
32	33	57	47.72	109	20	21.60	2841
33	33	57	49.41	109	20	0.11	2864
34	33	57	35.56	109	20	4.65	2845
35	33	57	44.85	109	20	21.85	2843
36	33	57	34.42	109	20	14.21	2850
37	33	57	43.90	109	20	21.78	2844
38	33	57	42.36	109	19	59.73	2856
39	33	57	33.99	109	20	8.70	2846
40	33	57	37.95	109	20	19.25	2850

Biglake: North east

Ant #	LAT. (D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	57	58.60	109	20	29.36	2837
2	33	57	58.31	109	20	30.53	2836
3	33	57	58.81	109	20	29.10	2838
4	33	57	57.71	109	20	29.74	2835
5	33	57	57.07	109	20	30.92	2835
6	33	57	57.48	109	20	29.49	2835
7	33	57	57.58	109	20	30.21	2835
8	33	57	57.83	109	20	30.64	2836
9	33	57	58.28	109	20	29.66	2837
10	33	57	58.08	109	20	29.23	2837
11	33	57	57.14	109	20	29.79	2835
12	33	57	57.04	109	20	30.16	2835
13	33	57	57.20	109	20	28.94	2836
14	33	57	56.78	109	20	29.12	2835
15	33	57	59.04	109	20	30.77	2837
16	33	57	58.21	109	20	30.09	2837
17	33	57	56.55	109	20	29.66	2834
18	33	57	57.55	109	20	28.76	2836
19	33	57	56.66	109	20	30.07	2834
20	33	57	58.56	109	20	30.76	2836
21	33	57	58.95	109	20	30.41	2837
22	33	57	57.46	109	20	30.54	2835
23	33	57	58.01	109	20	30.92	2836
24	33	57	57.00	109	20	29.38	2835
25	33	57	58.83	109	20	29.84	2838
26	33	57	59.17	109	20	30.02	2838
27	33	57	57.03	109	20	30.58	2835
28	33	57	59.15	109	20	29.69	2838
29	33	57	58.34	109	20	31.15	2836
30	33	57	57.76	109	20	29.09	2837
31	33	57	58.01	109	20	30.35	2836
32	33	57	57.93	109	20	28.68	2837
33	33	57	57.88	109	20	30.00	2837
34	33	57	57.86	109	20	31.19	2836
35	33	57	57.44	109	20	31.08	2835
36	33	57	58.34	109	20	28.90	2837
37	33	57	58.60	109	20	30.34	2836
38	33	57	59.21	109	20	29.38	2838
39	33	57	56.61	109	20	30.41	2834
40	33	57	58.71	109	20	31.04	2836

Biglake: Northwest

Ant #	LAT.(D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	58	23.98	109	23	7.82	2803
2	33	57	50.00	109	23	10.38	2804
3	33	57	35.69	109	24	18.10	2798
4	33	58	47.38	109	24	0.54	2808
5	33	58	52.45	109	23	45.82	2804
6	33	57	52.84	109	24	24.10	2796
7	33	57	30.63	109	23	56.59	2801
8	33	58	47.27	109	24	17.01	2799
9	33	58	32.70	109	24	21.46	2792
10	33	57	32.27	109	23	35.65	2803
11	33	58	0.81	109	24	28.23	2797
12	33	58	55.65	109	23	32.42	2823
13	33	58	5.05	109	23	6.57	2798
14	33	58	28.64	109	24	22.90	2794
15	33	57	37.85	109	23	28.61	2799
16	33	57	44.37	109	23	13.12	2800
17	33	58	39.57	109	23	13.67	2830
18	33	58	50.58	109	24	8.97	2805
19	33	58	42.71	109	23	16.57	2830
20	33	58	43.00	109	24	19.66	2795
21	33	58	53.25	109	23	39.02	2811
22	33	58	16.09	109	23	6.30	2804
23	33	57	31.84	109	24	14.11	2796
24	33	58	20.21	109	24	20.02	2795
25	33	58	50.01	109	24	14.07	2800
26	33	58	50.03	109	23	16.37	2831
27	33	57	29.10	109	24	6.11	2801
28	33	57	56.63	109	24	27.35	2798
29	33	57	40.32	109	23	15.69	2797
30	33	57	38.94	109	23	45.51	2799
31	33	58	54.24	109	23	26.47	2825
32	33	58	24.43	109	24	22.90	2796
33	33	58	28.44	109	23	9.11	2806
34	33	57	38.74	109	23	22.46	2800
35	33	58	8.80	109	24	28.23	2796
36	33	57	30.75	109	23	59.38	2802
37	33	58	5.25	109	24	28.23	2797
38	33	57	58.48	109	23	7.67	2796
39	33	57	31.51	109	23	39.16	2800
40	33	57	46.96	109	24	13.30	2795

Biglake: Northwest

Ant #	LAT.(D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	58	14.33	109	23	22.27	2798
2	33	58	6.33	109	23	22.95	2793
3	33	58	2.97	109	23	40.88	2792
4	33	58	22.34	109	23	35.97	2796
5	33	58	22.71	109	23	33.17	2800
6	33	58	6.88	109	23	43.51	2789
7	33	57	59.85	109	23	34.22	2796
8	33	58	19.81	109	23	40.59	2792
9	33	58	17.05	109	23	42.81	2787
10	33	58	0.21	109	23	30.12	2797
11	33	58	8.76	109	23	44.09	2787
12	33	58	21.96	109	23	29.11	2799
13	33	58	9.88	109	23	21.94	2794
14	33	58	15.49	109	23	43.56	2788
15	33	58	0.83	109	23	28.44	2797
16	33	58	5.01	109	23	23.67	2794
17	33	58	16.89	109	23	23.31	2796
18	33	58	21.16	109	23	38.76	2794
19	33	58	18.74	109	23	24.59	2797
20	33	58	18.29	109	23	41.99	2789
21	33	58	22.57	109	23	31.34	2799
22	33	58	11.32	109	23	21.86	2795
23	33	58	2.06	109	23	39.82	2792
24	33	58	12.55	109	23	44.29	2791
25	33	58	20.46	109	23	39.81	2794
26	33	58	20.13	109	23	25.99	2799
27	33	58	0.80	109	23	37.71	2793
28	33	58	7.78	109	23	43.83	2789
29	33	58	4.06	109	23	24.35	2795
30	33	57	59.80	109	23	32.93	2797
31	33	58	21.31	109	23	27.72	2800
32	33	58	13.70	109	23	44.10	2791
33	33	58	15.38	109	23	22.61	2796
34	33	58	1.53	109	23	27.15	2797
35	33	58	10.82	109	23	44.35	2789
36	33	58	0.40	109	23	36.71	2794
37	33	58	9.87	109	23	44.28	2787
38	33	58	8.33	109	23	22.23	2793
39	33	57	59.96	109	23	31.20	2797
40	33	58	3.92	109	23	41.75	2792

Biglake: Northwest

Ant #	LAT.(D M S)			LONG. (D M S)			ELV. (meters)
1	33	59	23.30	109	23	45.50	2862
2	33	59	21.04	109	23	45.69	2863
3	33	59	20.08	109	23	50.77	2855
4	33	59	25.57	109	23	49.38	2860
5	33	59	25.68	109	23	48.59	2861
6	33	59	21.19	109	23	51.51	2856
7	33	59	19.20	109	23	48.88	2850
8	33	59	24.86	109	23	50.69	2861
9	33	59	24.07	109	23	51.32	2861
10	33	59	19.30	109	23	47.72	2851
11	33	59	21.73	109	23	51.68	2859
12	33	59	25.47	109	23	47.43	2863
13	33	59	22.04	109	23	45.40	2862
14	33	59	23.63	109	23	51.53	2861
15	33	59	19.48	109	23	47.24	2851
16	33	59	20.66	109	23	45.90	2863
17	33	59	24.03	109	23	45.79	2863
18	33	59	25.24	109	23	50.17	2861
19	33	59	24.55	109	23	46.15	2864
20	33	59	24.43	109	23	51.08	2861
21	33	59	25.64	109	23	48.07	2863
22	33	59	22.45	109	23	45.38	2862
23	33	59	19.83	109	23	50.47	2855
24	33	59	22.80	109	23	51.74	2861
25	33	59	25.04	109	23	50.47	2861
26	33	59	24.95	109	23	46.55	2864
27	33	59	19.47	109	23	49.87	2851
28	33	59	21.45	109	23	51.61	2857
29	33	59	20.39	109	23	46.09	2857
30	33	59	19.19	109	23	48.52	2850
31	33	59	25.28	109	23	47.04	2864
32	33	59	23.12	109	23	51.68	2861
33	33	59	23.60	109	23	45.59	2863
34	33	59	19.68	109	23	46.88	2857
35	33	59	22.31	109	23	51.75	2859
36	33	59	19.36	109	23	49.59	2851
37	33	59	22.04	109	23	51.73	2859
38	33	59	21.60	109	23	45.49	2862
39	33	59	19.23	109	23	48.03	2851
40	33	59	20.35	109	23	51.02	2855

Biglake: Northwest

Ant #	LAT.(D M S)			LONG. (D M S)			ELV. (meters)
1	33	59	23.02	109	23	48.11	2861
2	33	59	22.73	109	23	49.28	2861
3	33	59	23.22	109	23	47.85	2861
4	33	59	22.12	109	23	48.49	2858
5	33	59	21.48	109	23	49.67	2855
6	33	59	21.90	109	23	48.24	2858
7	33	59	22.00	109	23	48.96	2858
8	33	59	22.24	109	23	49.39	2858
9	33	59	22.70	109	23	48.41	2861
10	33	59	22.49	109	23	47.98	2858
11	33	59	21.55	109	23	48.54	2858
12	33	59	21.45	109	23	48.91	2855
13	33	59	21.62	109	23	47.69	2858
14	33	59	21.20	109	23	47.87	2856
15	33	59	23.45	109	23	49.52	2861
16	33	59	22.62	109	23	48.84	2861
17	33	59	20.96	109	23	48.41	2855
18	33	59	21.97	109	23	47.51	2858
19	33	59	21.07	109	23	48.82	2855
20	33	59	22.97	109	23	49.51	2861
21	33	59	23.36	109	23	49.16	2861
22	33	59	21.88	109	23	49.29	2858
23	33	59	22.43	109	23	49.67	2858
24	33	59	21.42	109	23	48.13	2856
25	33	59	23.24	109	23	48.59	2861
26	33	59	23.59	109	23	48.77	2862
27	33	59	21.44	109	23	49.33	2855
28	33	59	23.56	109	23	48.44	2862
29	33	59	22.76	109	23	49.90	2861
30	33	59	22.18	109	23	47.84	2858
31	33	59	22.42	109	23	49.10	2858
32	33	59	22.34	109	23	47.43	2858
33	33	59	22.30	109	23	48.75	2858
34	33	59	22.28	109	23	49.94	2858
35	33	59	21.86	109	23	49.83	2858
36	33	59	22.76	109	23	47.65	2861
37	33	59	23.01	109	23	49.09	2861
38	33	59	23.63	109	23	48.13	2862
39	33	59	21.02	109	23	49.16	2855
40	33	59	23.12	109	23	49.79	2861

Baldy: Timber ridge

Ant #	LAT. (D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	58	49.67	107	11	9.54	3208
2	33	58	47.48	107	11	16.75	3204
3	33	58	37.47	107	11	8.72	3192
4	33	58	49.05	107	11	7.96	3205
5	33	58	47.61	107	11	7.30	3197
6	33	58	45.72	107	11	7.45	3190
7	33	58	39.11	107	11	9.93	3188
8	33	58	38.21	107	11	6.60	3192
9	33	58	39.61	107	11	4.72	3187
10	33	58	41.80	107	11	4.13	3182
11	33	58	44.75	107	11	5.22	3183
12	33	58	40.77	107	11	6.38	3188
13	33	58	41.55	107	11	12.44	3184
14	33	58	55.80	107	11	12.11	3209
15	33	58	53.66	107	11	10.42	3211
16	33	58	40.03	107	11	11.46	3185
17	33	58	51.82	107	11	9.81	3210
18	33	59	1.01	107	11	17.88	3221
19	33	58	46.00	107	11	18.28	3195
20	33	58	58.30	107	11	17.83	3215
21	33	58	43.56	107	11	17.88	3189
22	33	58	43.08	107	11	18.92	3184
23	33	58	57.74	107	11	13.91	3213
24	33	58	46.26	107	11	19.51	3191
25	33	58	42.08	107	11	14.15	3185
26	33	58	45.61	107	11	20.77	3185
27	33	58	45.89	107	11	21.25	3180
28	33	58	43.86	107	11	21.81	3179
29	33	58	45.24	107	11	22.61	3175
30	33	58	43.43	107	11	22.13	3175
31	33	58	44.45	107	11	23.43	3175
32	33	58	59.88	107	11	14.70	3218
33	33	59	2.16	107	11	15.24	3219
34	33	58	48.61	107	11	15.92	3210
35	33	58	51.25	107	11	16.16	3214
36	33	58	42.91	107	11	16.28	3188
37	33	58	54.20	107	11	16.65	3219
38	33	58	43.48	107	11	5.78	3189
39	33	58	46.66	107	11	17.23	3202
40	33	58	56.21	107	11	17.32	3218

Baldy: Timber ridge

Ant #	LAT.(D M S)			LONG. (D M S)			ELV. (meters)
1	33	58	48.81	107	11	8.02	3205
2	33	58	46.55	107	11	8.21	3196
3	33	58	45.60	107	11	13.29	3197
4	33	58	51.08	107	11	11.90	3210
5	33	58	51.19	107	11	11.11	3210
6	33	58	46.70	107	11	14.04	3203
7	33	58	44.71	107	11	11.41	3191
8	33	58	50.37	107	11	13.21	3212
9	33	58	49.59	107	11	13.84	3212
10	33	58	44.81	107	11	10.24	3190
11	33	58	47.24	107	11	14.20	3203
12	33	58	50.98	107	11	9.96	3210
13	33	58	47.55	107	11	7.93	3200
14	33	58	49.14	107	11	14.05	3209
15	33	58	44.99	107	11	9.77	3189
16	33	58	46.17	107	11	8.42	3192
17	33	58	49.54	107	11	8.32	3208
18	33	58	50.75	107	11	12.69	3212
19	33	58	50.06	107	11	8.68	3208
20	33	58	49.94	107	11	13.61	3212
21	33	58	51.15	107	11	10.59	3210
22	33	58	47.96	107	11	7.90	3200
23	33	58	45.34	107	11	12.99	3193
24	33	58	48.31	107	11	14.26	3206
25	33	58	50.55	107	11	12.99	3212
26	33	58	50.46	107	11	9.08	3210
27	33	58	44.98	107	11	12.39	3193
28	33	58	46.96	107	11	14.13	3203
29	33	58	45.90	107	11	8.61	3192
30	33	58	44.70	107	11	11.04	3190
31	33	58	50.79	107	11	9.56	3210
32	33	58	48.64	107	11	14.21	3209
33	33	58	49.11	107	11	8.12	3205
34	33	58	45.19	107	11	9.40	3189
35	33	58	47.82	107	11	14.28	3206
36	33	58	44.87	107	11	12.11	3191
37	33	58	47.55	107	11	14.26	3206
38	33	58	47.11	107	11	8.01	3196
39	33	58	44.74	107	11	10.55	3190
40	33	58	45.86	107	11	13.54	3199

Baldy: Timber ridge

Ant #	LAT. (D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	58	48.59	107	11	10.42	3205
2	33	58	48.30	107	11	11.60	3203
3	33	58	48.80	107	11	10.17	3205
4	33	58	47.70	107	11	10.80	3202
5	33	58	47.06	107	11	11.99	3199
6	33	58	47.47	107	11	10.55	3202
7	33	58	47.57	107	11	11.28	3203
8	33	58	47.82	107	11	11.71	3203
9	33	58	48.27	107	11	10.72	3202
10	33	58	48.14	107	11	10.30	3202
11	33	58	47.13	107	11	10.86	3198
12	33	58	47.03	107	11	11.23	3199
13	33	58	47.19	107	11	10.00	3198
14	33	58	46.77	107	11	10.19	3198
15	33	58	49.03	107	11	11.84	3205
16	33	58	48.40	107	11	11.09	3203
17	33	58	46.54	107	11	10.73	3198
18	33	58	47.54	107	11	9.83	3202
19	33	58	46.65	107	11	11.14	3199
20	33	58	48.55	107	11	11.82	3205
21	33	58	48.94	107	11	11.48	3205
22	33	58	47.45	107	11	11.61	3203
23	33	58	48.00	107	11	11.98	3203
24	33	58	46.99	107	11	10.45	3198
25	33	58	48.82	107	11	10.90	3205
26	33	58	49.16	107	11	11.08	3205
27	33	58	47.02	107	11	11.64	3199
28	33	58	49.14	107	11	10.76	3205
29	33	58	48.33	107	11	12.21	3204
30	33	58	47.75	107	11	10.16	3202
31	33	58	48.00	107	11	11.42	3203
32	33	58	47.92	107	11	9.75	3202
33	33	58	48.00	107	11	10.99	3202
34	33	58	47.85	107	11	12.26	3204
35	33	58	47.43	107	11	12.14	3199
36	33	58	48.33	107	11	9.96	3202
37	33	58	48.58	107	11	11.40	3205
38	33	58	49.20	107	11	10.45	3205
39	33	58	46.60	107	11	11.48	3199
40	33	58	48.70	107	11	12.11	3205

South Baldy: North ridge

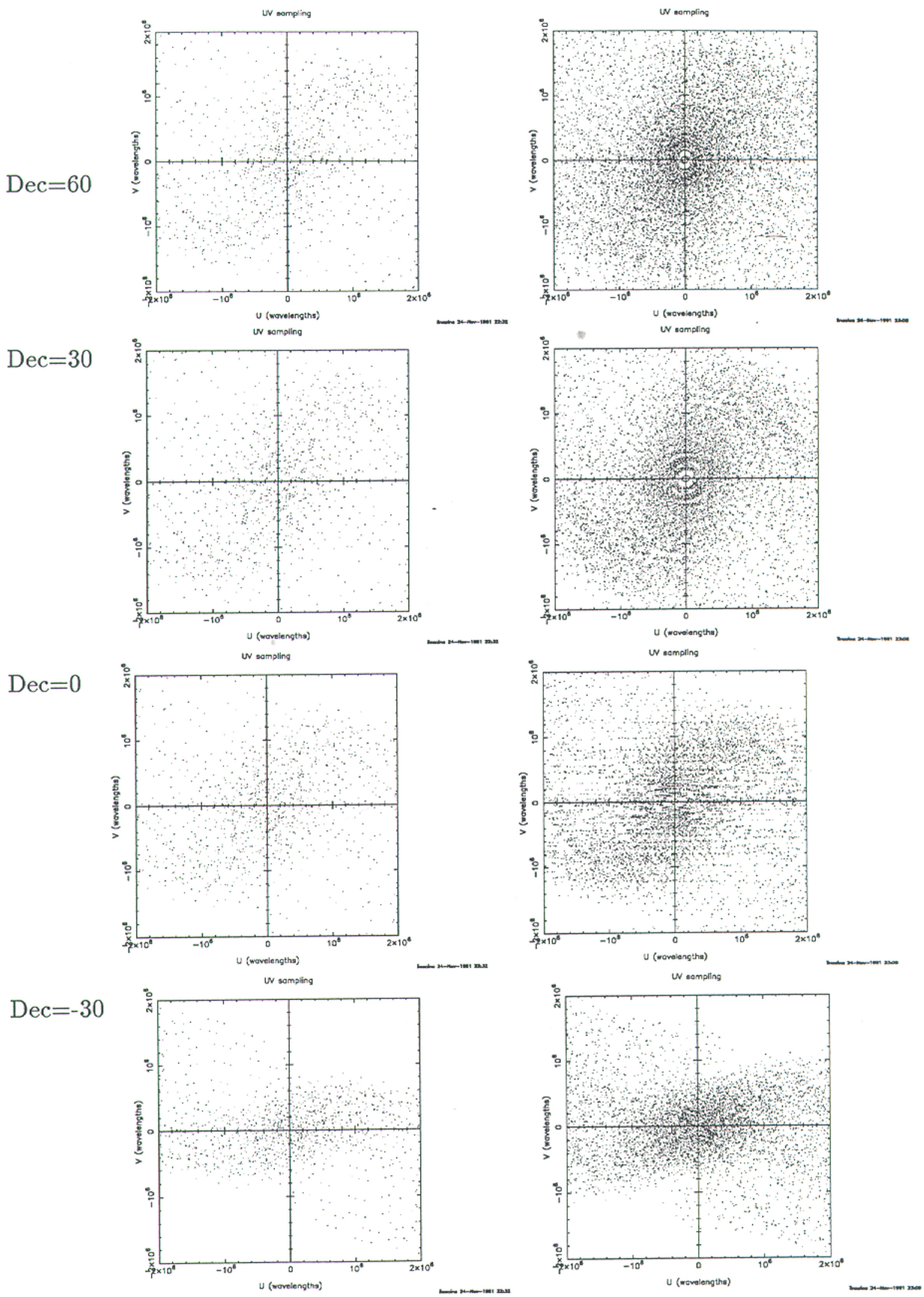
Ant #	LAT.(D	M	S)	LONG. (D	M	S)	ELV. (meters)
1	33	59	11.48	107	11	18.20	3221
2	33	59	29.80	107	10	56.43	3145
3	33	59	32.08	107	10	47.39	3135
4	33	59	32.72	107	10	34.09	3020
5	33	59	25.60	107	10	29.47	2975
6	33	59	21.34	107	10	50.61	3094
7	33	59	22.90	107	11	2.34	3157
8	33	59	24.90	107	11	16.21	3256
9	33	59	25.70	107	10	48.26	3110
10	33	59	16.41	107	11	21.61	3206
11	33	59	10.17	107	11	14.59	3221
12	33	59	0.57	107	11	14.03	3218
13	33	58	55.46	107	11	13.13	3218
14	33	58	53.21	107	11	7.01	3208
15	33	59	21.79	107	11	23.66	3178
16	33	58	45.85	107	11	0.73	3169
17	33	58	40.19	107	11	8.76	3188
18	33	58	32.25	107	11	1.84	3199
19	33	58	36.86	107	11	6.45	3196
20	33	58	36.41	107	10	54.44	3222
21	33	58	47.25	107	11	9.67	3194
22	33	59	13.61	107	11	20.88	3212
23	33	58	42.86	107	11	13.13	3182
24	33	58	46.64	107	11	25.46	3157
25	33	58	41.97	107	11	29.31	3165
26	33	58	43.97	107	11	34.45	3173
27	33	59	55.79	107	11	37.15	3097
28	33	59	14.86	107	11	14.16	3213
29	33	59	59.99	107	11	31.00	3121
30	33	59	20.59	107	10	32.66	2989
31	33	59	23.77	107	10	29.56	2976
32	33	59	23.12	107	10	38.96	3025
33	33	59	12.92	107	10	48.97	3057
34	33	59	40.03	107	11	24.69	3108
35	33	59	55.82	107	11	27.51	3109
36	34	0	6.50	107	11	24.95	3112
37	33	59	48.03	107	11	24.43	3122
38	33	59	28.68	107	10	36.13	3016
39	33	59	15.05	107	10	46.61	3065
40	33	59	51.34	107	11	41.21	3088

Baldy: Timber ridge

Ant #	LAT. (D M S)			LONG. (D M S)			ELV. (meters)
1	33	59	19.96	107	11	4.74	3153
2	33	59	32.45	107	10	58.32	3174
3	33	59	30.01	107	10	47.84	3132
4	33	59	31.38	107	10	35.22	3020
5	33	59	24.26	107	10	30.60	2975
6	33	59	25.04	107	10	20.57	3007
7	33	59	20.56	107	10	15.18	3036
8	33	59	17.95	107	11	16.64	3235
9	33	57	17.62	107	9	32.07	2999
10	33	59	15.07	107	11	22.73	3206
11	33	59	8.83	107	11	15.71	3221
12	33	58	59.23	107	11	15.16	3218
13	33	58	54.12	107	11	14.26	3218
14	33	58	51.87	107	11	8.14	3208
15	33	58	20.56	107	9	34.72	3097
16	33	58	44.51	107	11	1.85	3169
17	33	58	37.15	107	11	8.32	3192
18	33	58	30.91	107	11	2.96	3199
19	33	59	4.14	107	11	13.27	3195
20	33	58	50.37	107	11	8.55	3209
21	33	58	51.12	107	11	10.28	3210
22	33	58	59.31	107	9	54.95	3090
23	33	58	44.05	107	11	17.85	3189
24	33	58	45.50	107	11	24.20	3167
25	33	59	17.20	107	10	11.31	3043
26	33	58	43.55	107	11	32.71	3160
27	33	58	37.54	107	11	21.67	3107
28	33	59	20.55	107	10	54.71	3093
29	33	58	51.86	107	9	48.06	3099
30	33	59	24.74	107	10	49.87	3111
31	33	57	46.64	107	9	36.01	2995
32	33	59	20.74	107	10	34.43	2999
33	33	59	11.57	107	10	50.09	3057
34	33	57	28.38	107	9	27.83	3003
35	33	58	30.64	107	9	36.08	3121
36	33	58	3.04	107	9	36.44	3033
37	33	58	33.47	107	11	28.09	3120
38	33	59	22.05	107	10	41.01	3032
39	33	58	49.47	107	11	27.72	3127
40	33	59	3.79	107	9	59.68	3066

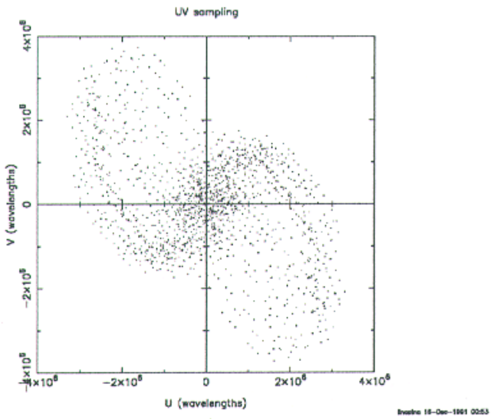
APPENDIX B

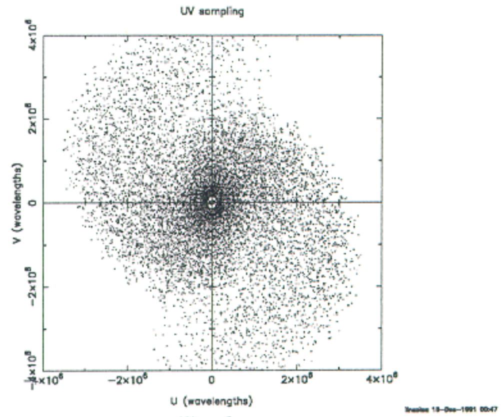
Figure 2. The plots here show the Fourier-plane (UV) coverages of simulations using proposed standard arrays. Simulation parameters of observations are listed in Table 2. Presented here are results for A arrays of all three sites, B arrays of the Magdalena mountain site and Springerville North-East site, C and D arrays of Magdalena mountain site only. The UV coverages of arrays not presented are very similar to the corresponding results showed here. From top to the bottom are coverages when observing sources at declinations of $60°$, $30°$, $0°$ and $-30°$ respectively. On the left are results of short (10 minutes) observations and on the right are those of long synthesis observations. Only every 7th sampling points are showed for long synthesis observations. Coverages for the A arrays are presented twice on different scales, first the central -2 to 2 mega-wavelengths, then the whole -4 to 4 mega-wavelengths.



a. Magdalena Mountains Site: A array, Timber Ridge Array

Dec=60





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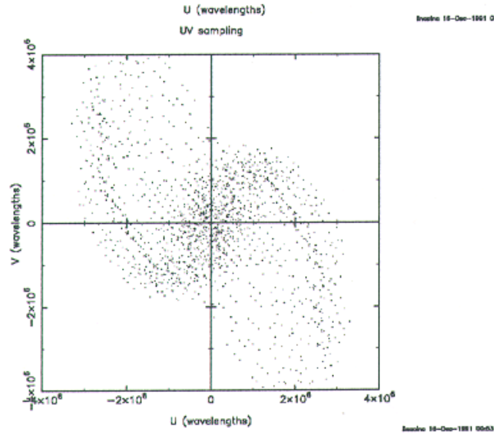

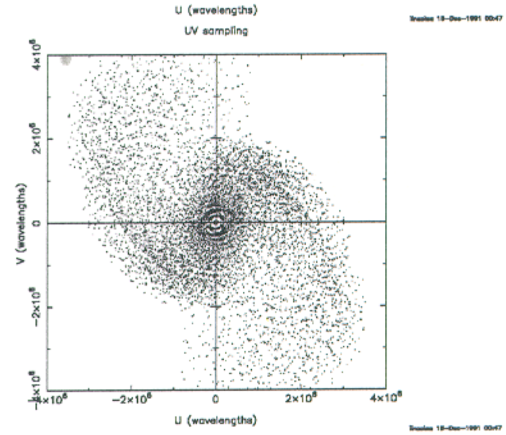

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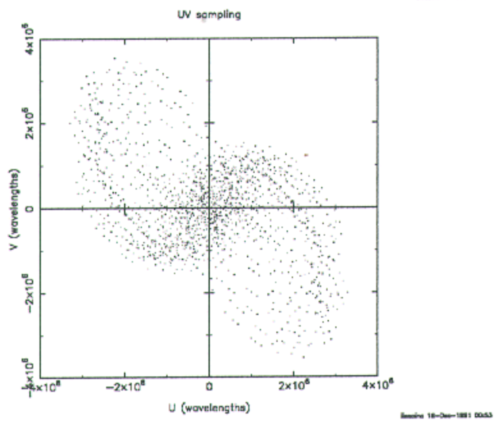

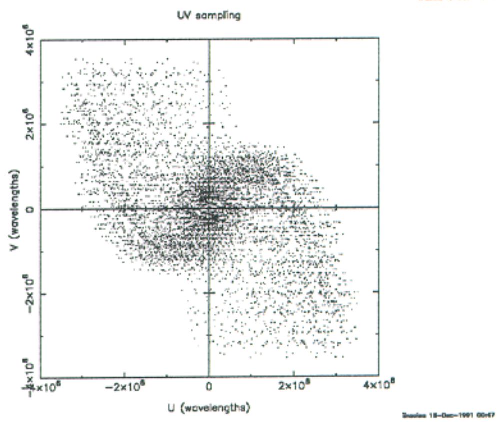

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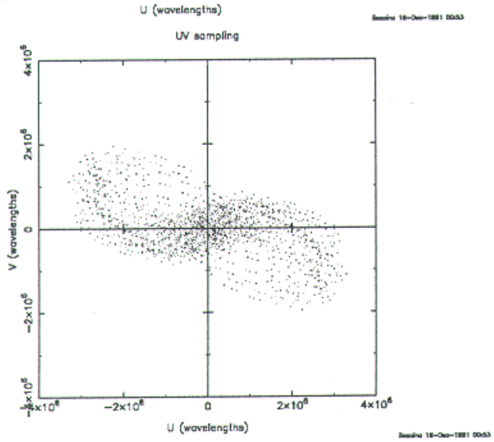
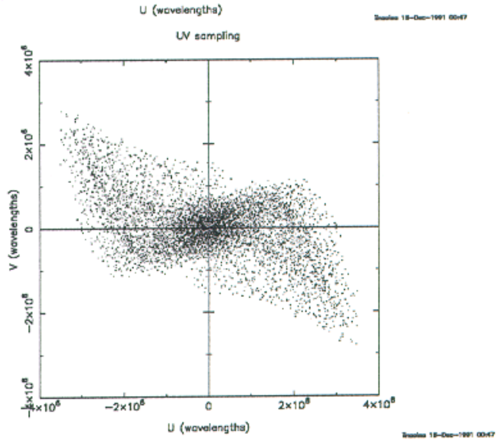


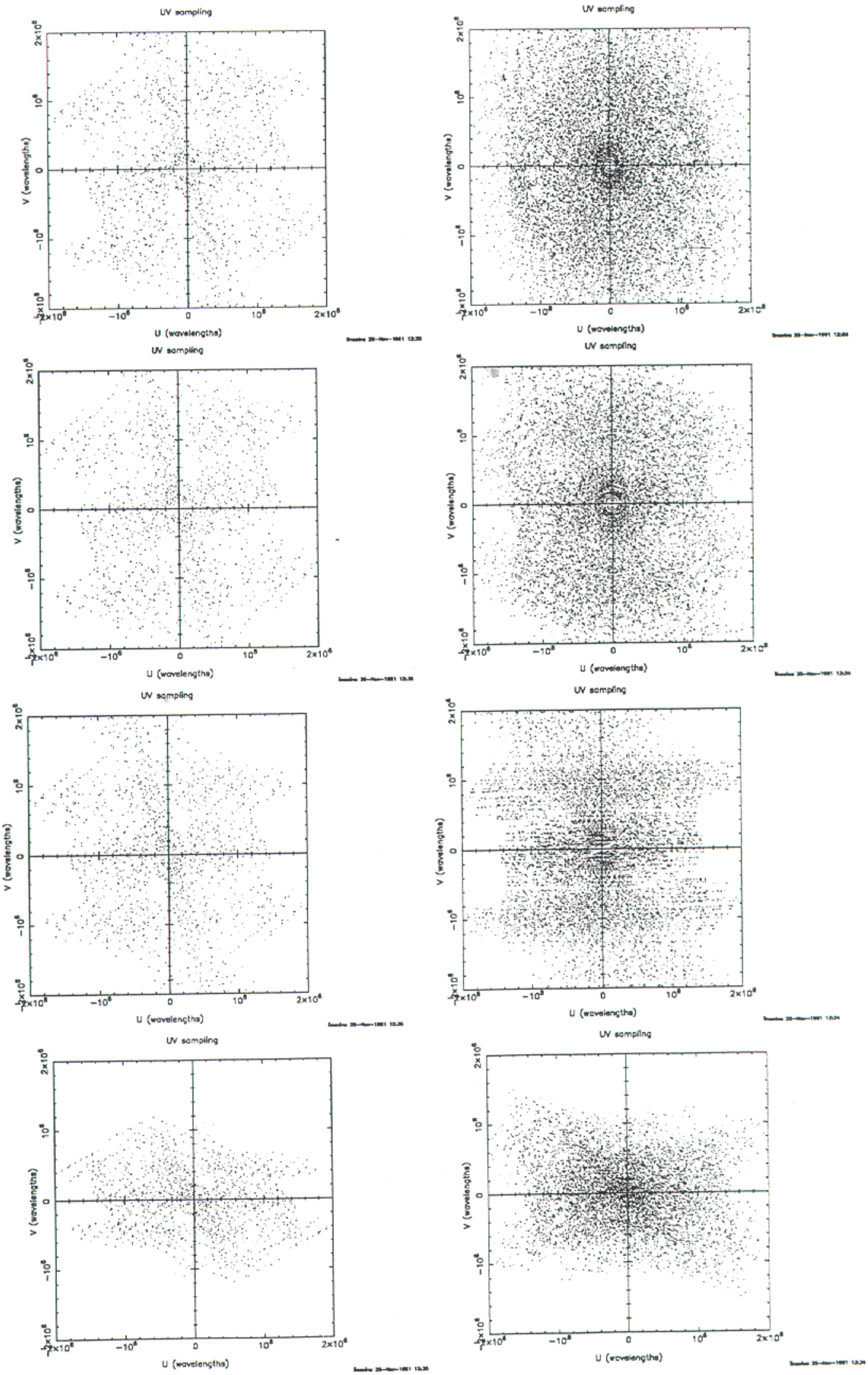


Dec=60

Dec=30

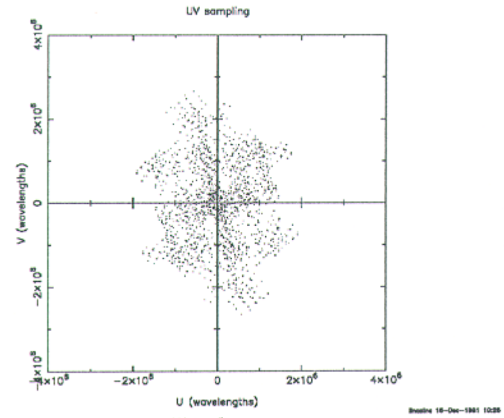
Dec=0

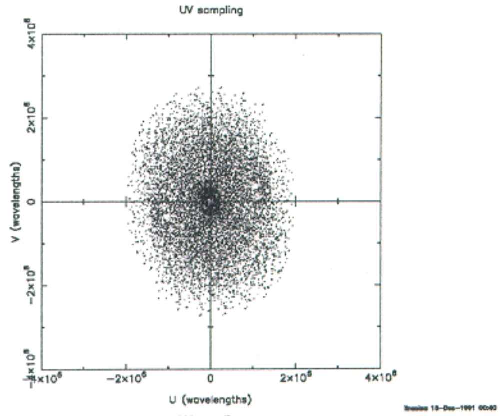
Dec=-30



b. Magdalena Mountains Site: A array, North Ridge Array

Dec=60





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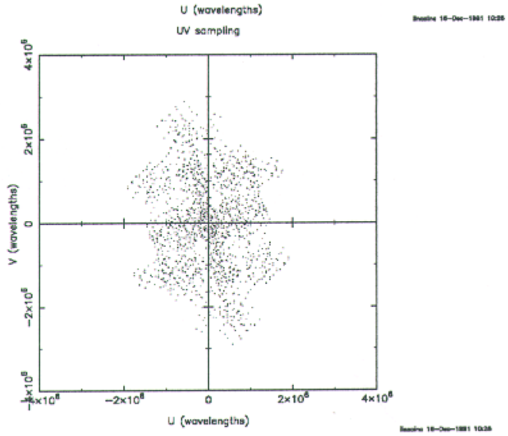

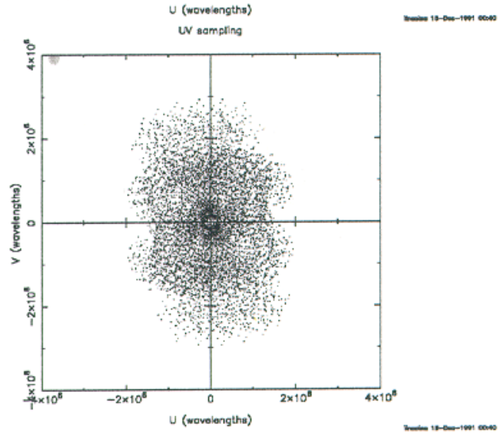

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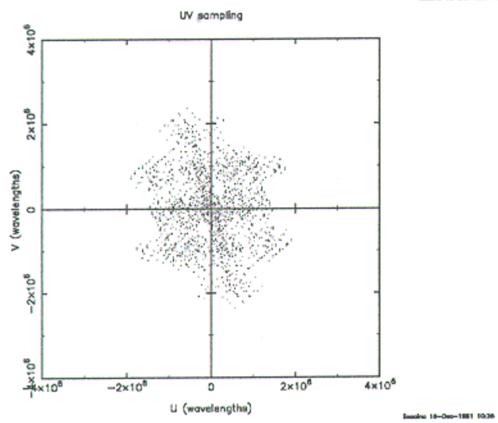

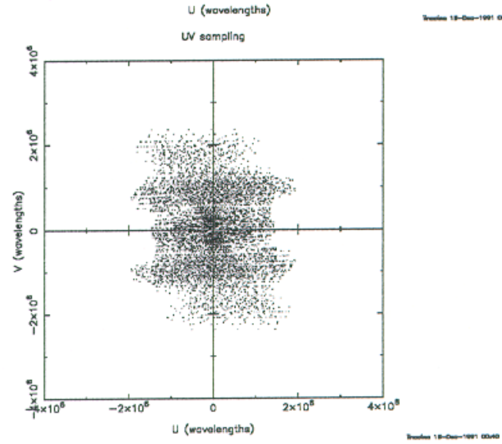

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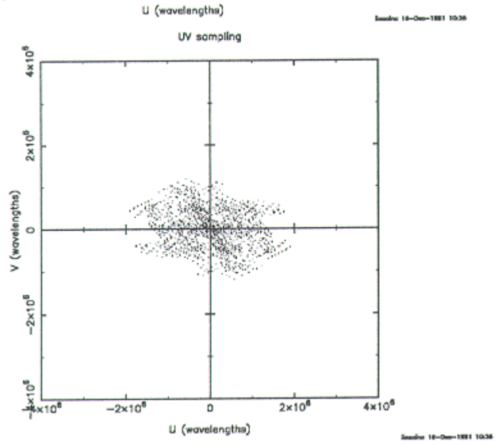
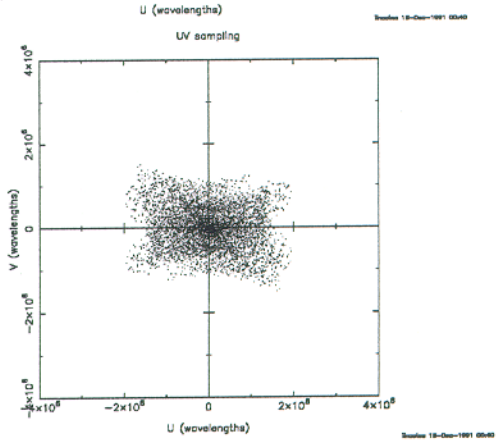
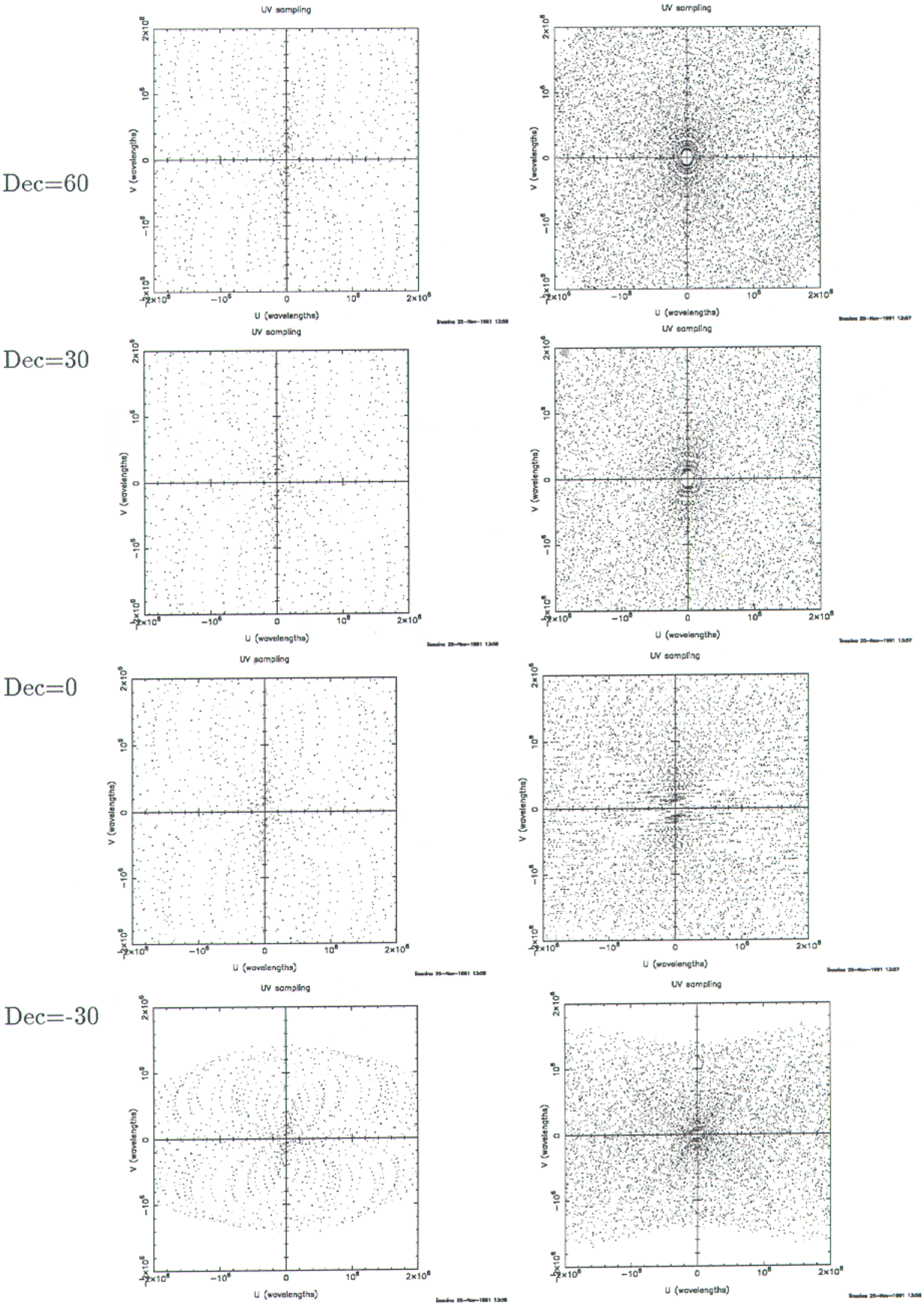
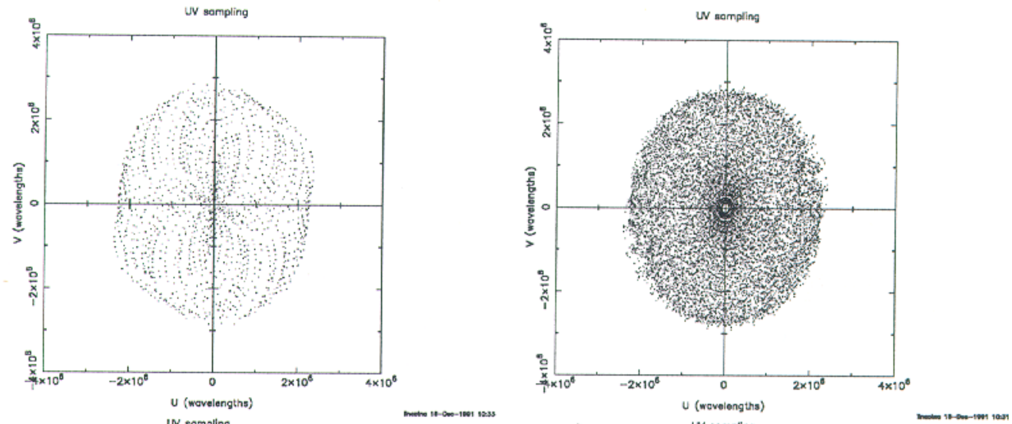






c. Springerville Site: A array, Biglake North-East Array

Dec=60



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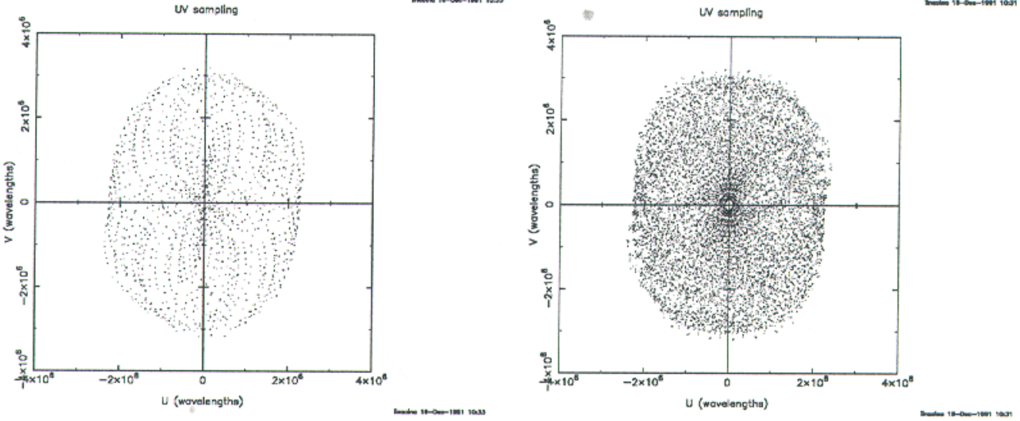

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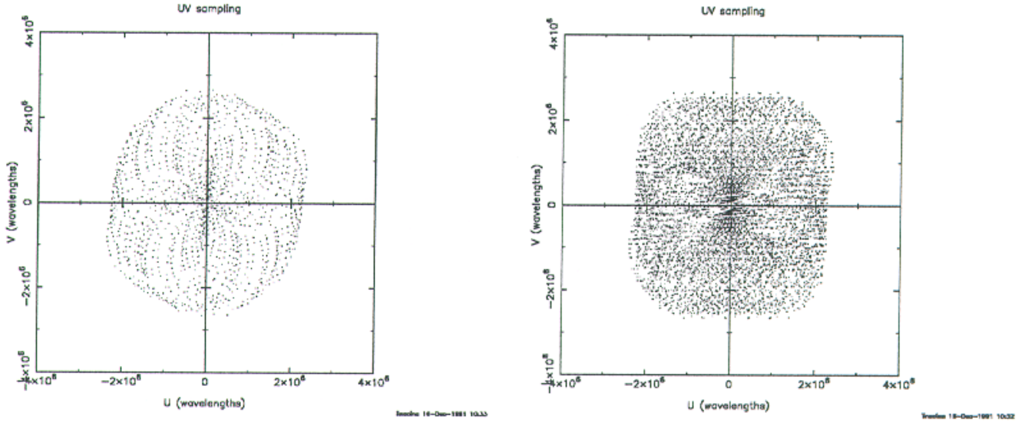

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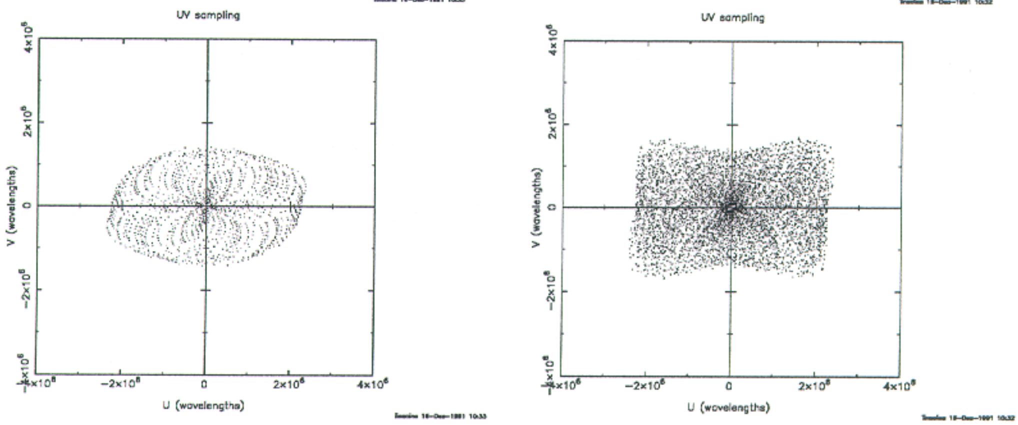
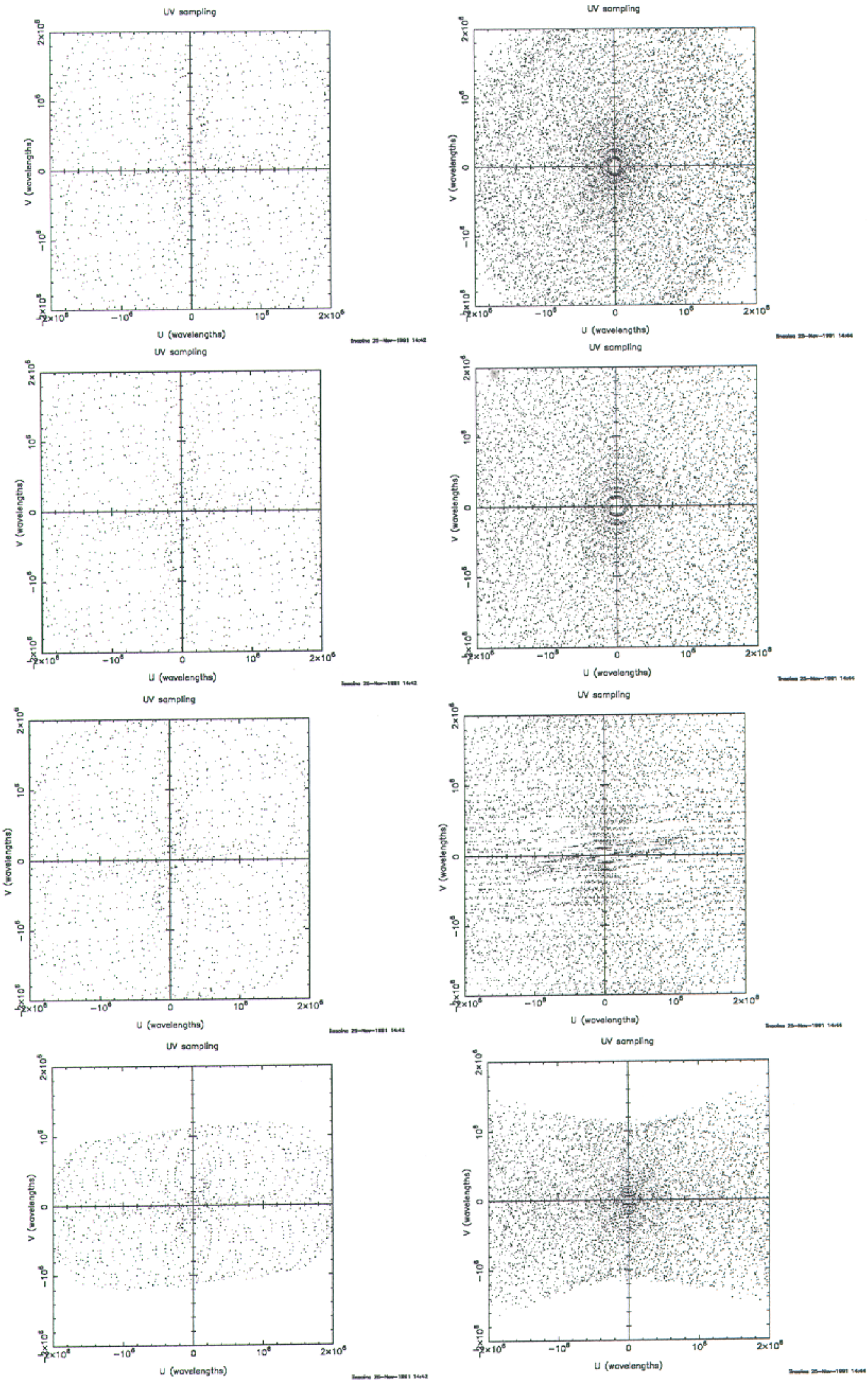


Dec=60

Dec=30

Dec=0

Dec=-30



d. Springerville Site: A array, Biglake North-West Array

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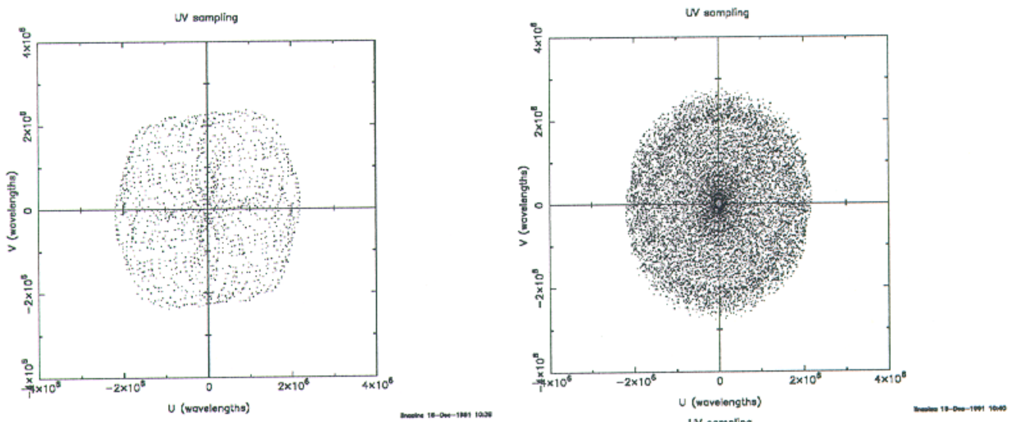

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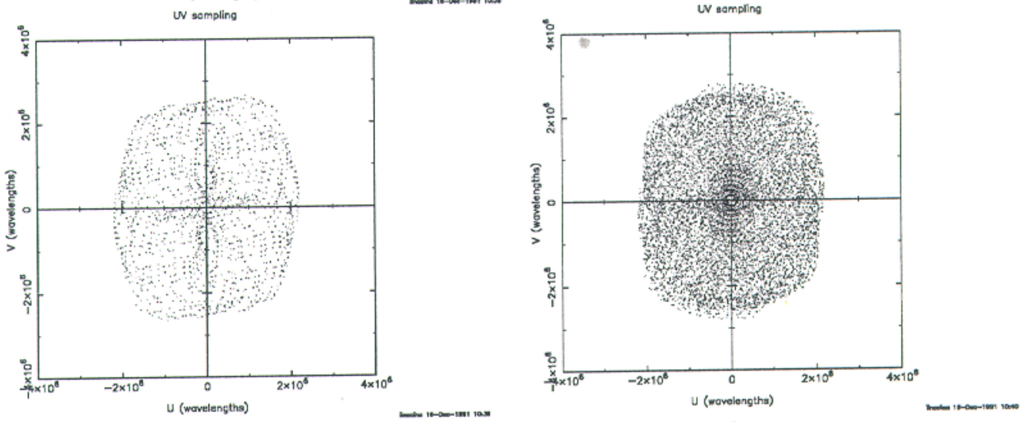

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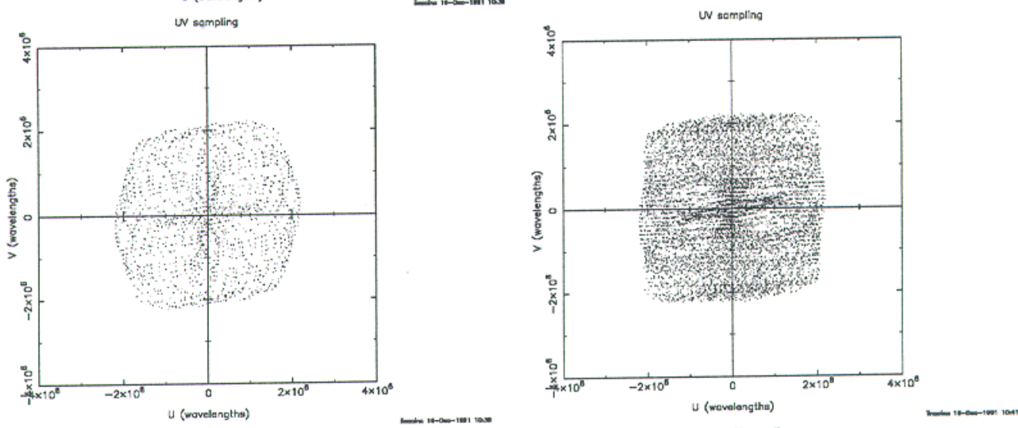

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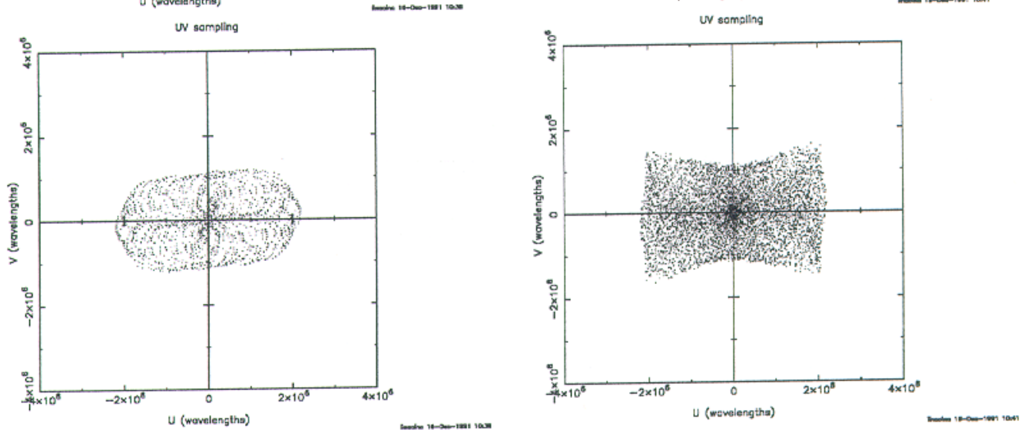
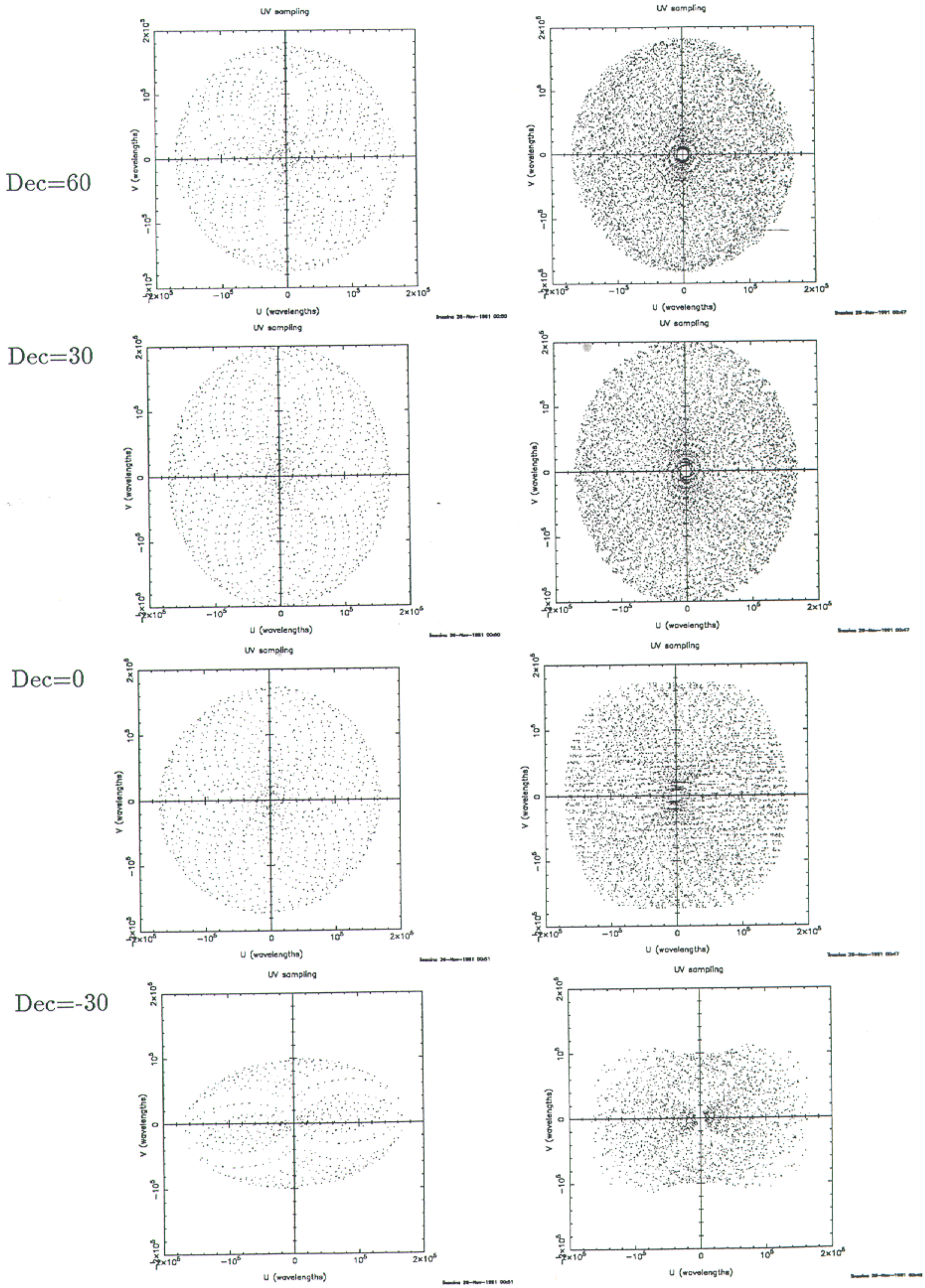




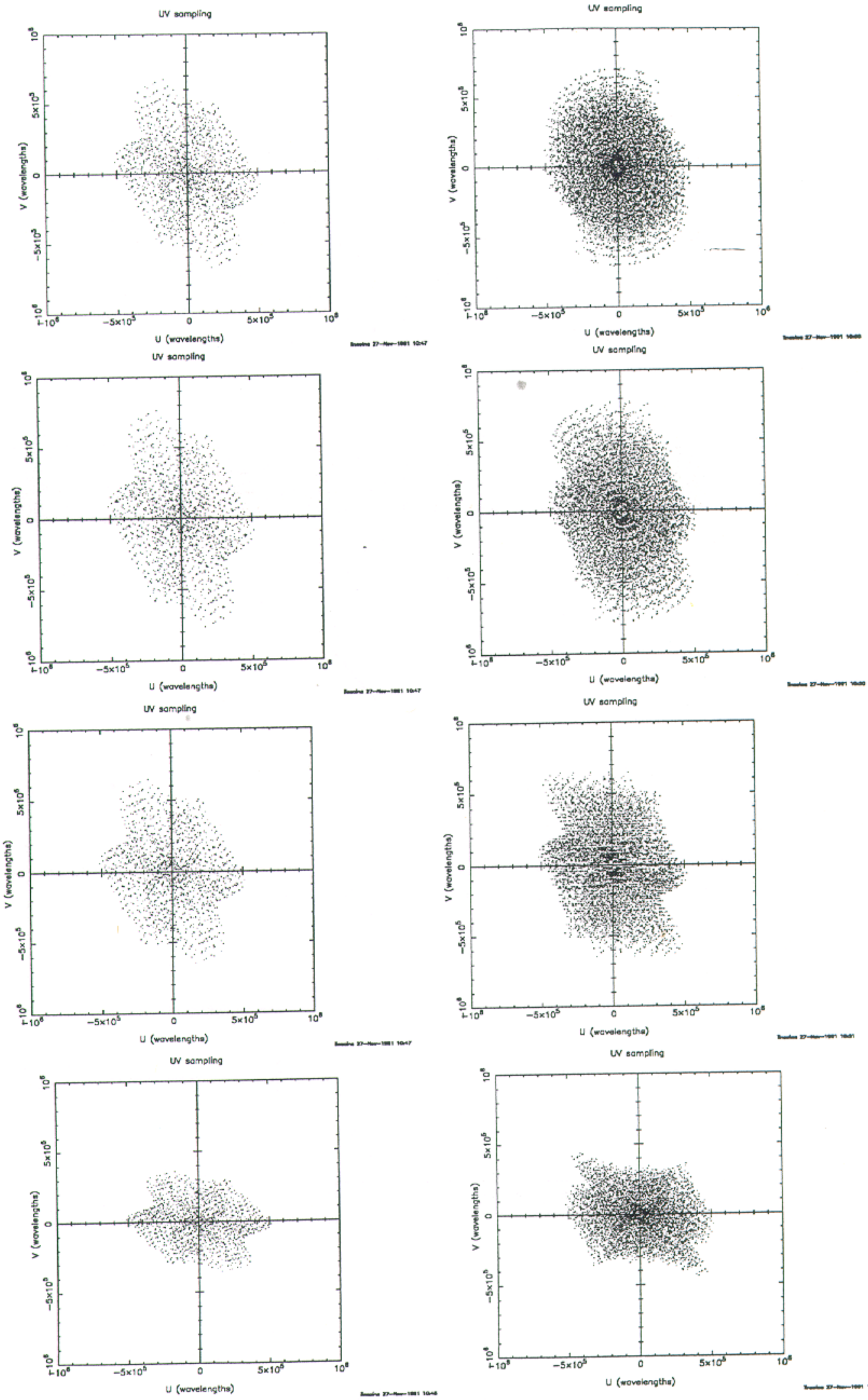
e. Magdalena mountain Site: C array, North-West Array

Dec=60

Dec=30

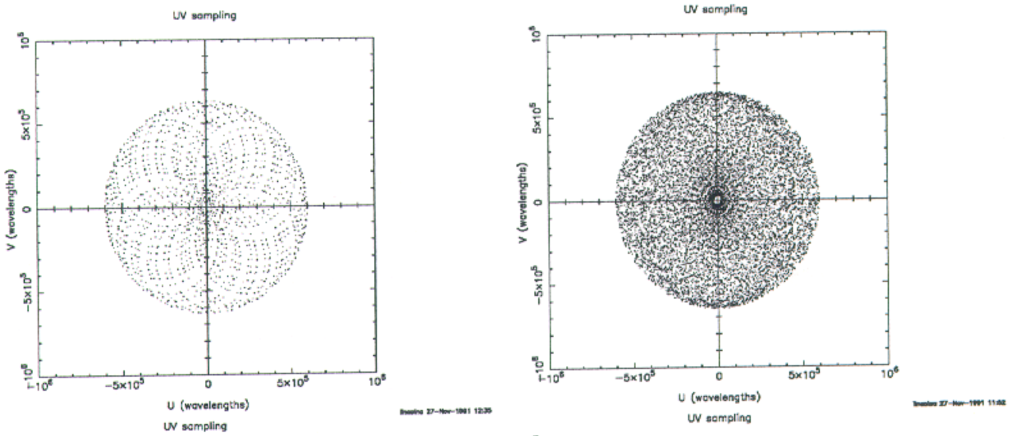
Dec=0

Dec=-30



f. Magdalena moutain Site: B array

Dec=60



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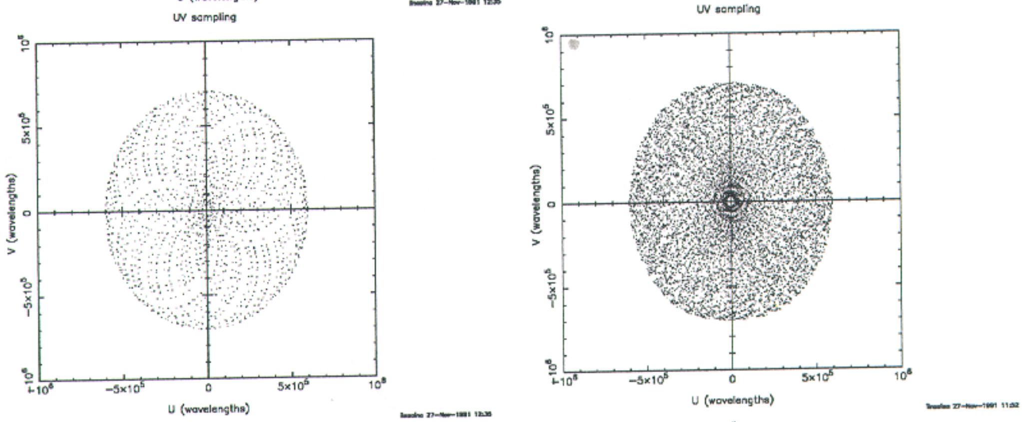
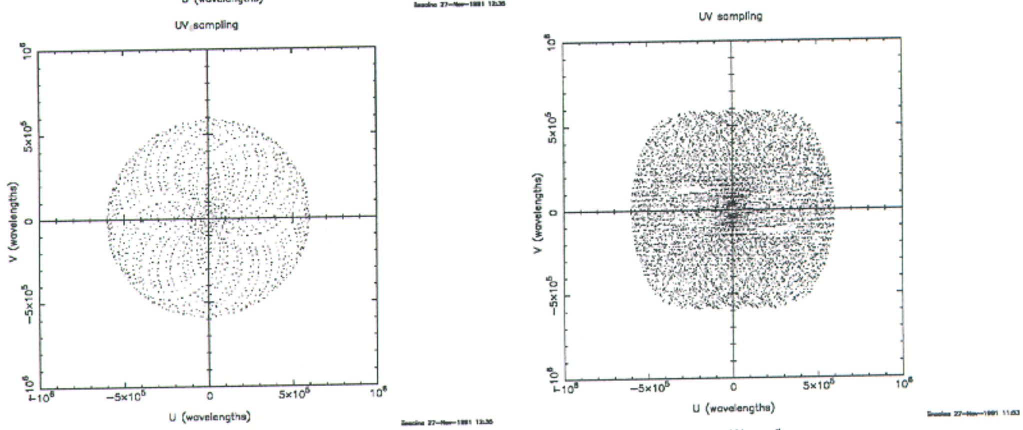
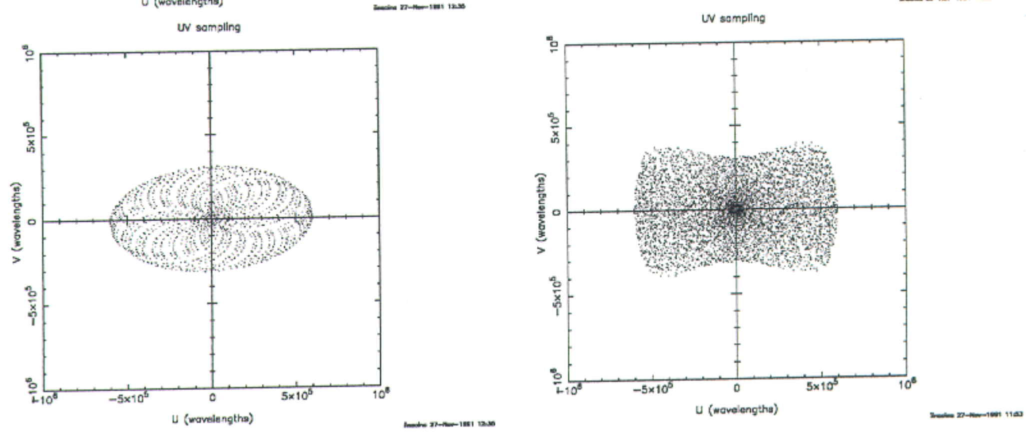


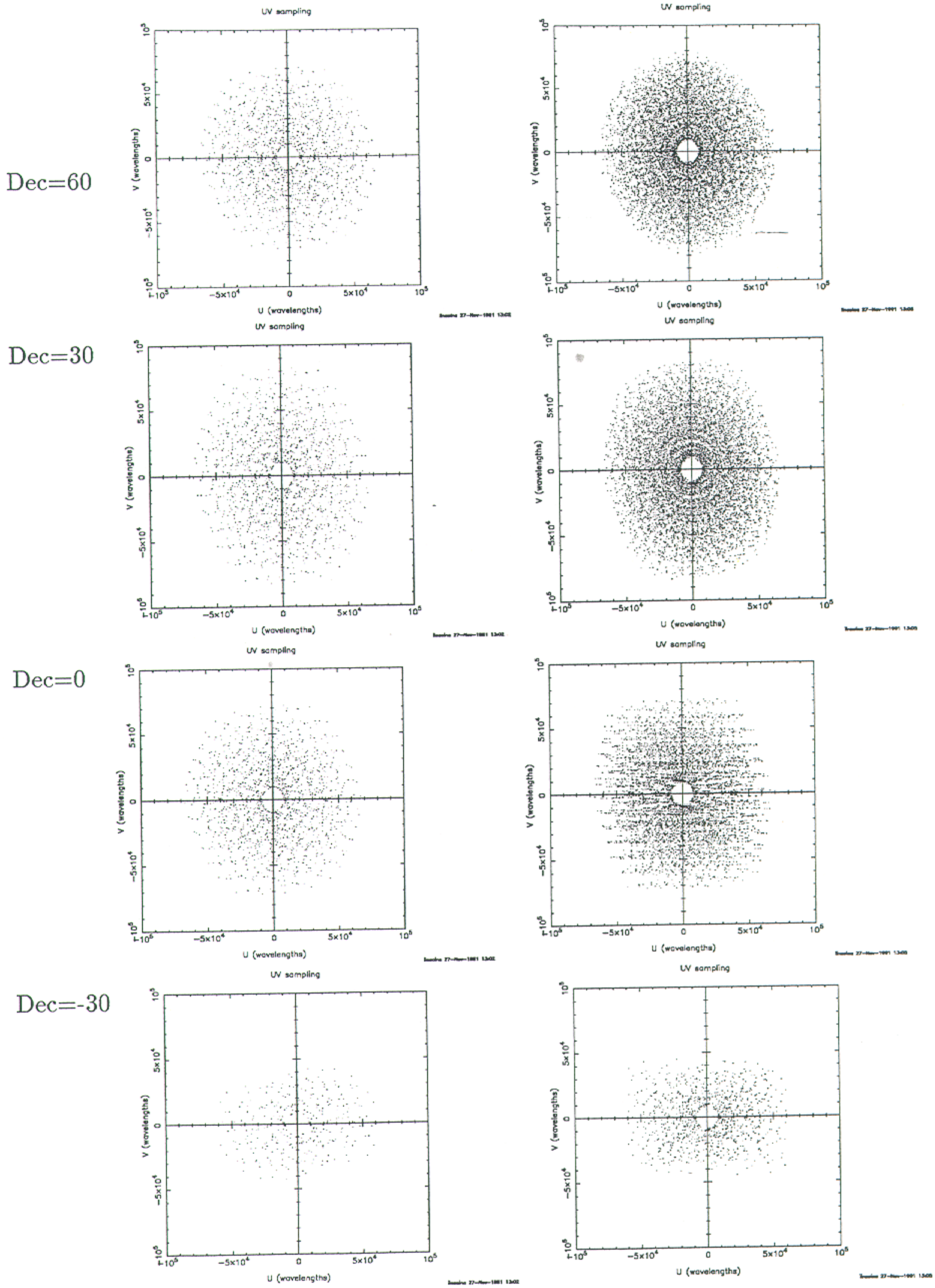
Dec=0



Dec=-30



g. Springerville Site: B array



h. Magdalena mountain Site: D array

APPENDIX C. Synthesized-beam major-axis and minor-axis full-widths at half-maximum, θ_1 and θ_2, and sidelobe level, for selected simulations at $\lambda = 1$ mm.

Site	Dec.	Weight	Synthesized		Beam	Side lobe (%)	
			θ_1''	θ_2''	Angle(°)	rms	max
Springerville North East A-array	60	Uniform	0.077	0.063	−89	0.29	9
	30	Uniform	0.077	0.058	−89	0.37	10
	0	Uniform	0.078	0.065	−88	0.77	15
	−30	Uniform	0.118	0.075	−2	0.37	13
	60	Natural	0.084	0.068	−90	0.42	13
	30	Natural	0.080	0.062	−89	0.51	16
	0	Natural	0.079	0.073	−80	1.00	18
	−30	Natural	0.131	0.082	−3	0.51	18
Springerville North West A-array	60	Uniform	0.084	0.072	−86	0.25	9
	30	Uniform	0.081	0.066	−87	0.38	10
	0	Uniform	0.085	0.074	−87	0.66	16
	−30	Uniform	0.131	0.077	−2	0.39	13
	60	Natural	0.091	0.074	−89	0.42	12
	30	Natural	0.088	0.071	−89	0.63	15
	0	Natural	0.086	0.082	−72	0.95	17
	−30	Natural	0.150	0.089	−2	0.65	18
Magdalena North Ridge A-array	60	Uniform	0.112	0.081	85	0.26	7
	30	Uniform	0.113	0.076	84	0.33	10
	0	Uniform	0.124	0.087	81	0.32	15
	−30	Uniform	0.170	0.106	13	0.37	11
	60	Natural	0.134	0.098	88	0.31	9
	30	Natural	0.135	0.092	88	0.50	11
	0	Natural	0.136	0.114	86	0.70	20
	−30	Natural	0.224	0.140	10	0.62	8
Magdalena Timber Ridge A-array	60	Uniform	0.076	0.060	46	0.23	6
	30	Uniform	0.082	0.055	43	0.50	10
	0	Uniform	0.094	0.056	37	0.39	11
	−30	Uniform	0.153	0.063	13	0.29	14
	60	Natural	0.095	0.086	1	0.33	6
	30	Natural	0.110	0.098	−30	0.67	9
	0	Natural	0.136	0.099	−11	0.68	8
	−30	Natural	0.219	0.100	1	0.44	14
**	60	Uniform	0.076	0.069	34		
	30	Uniform	0.086	0.081	33		
	0	Uniform	0.103	0.099	79		
	−30	Uniform	0.165	0.070	8		
	60	Natural	0.135	0.103	−53		
	30	Natural	0.144	0.098	−49		
	0	Natural	0.168	0.106	−31		
	−30	Natural	0.251	0.111	−4		

** Synthesized-beams of the Timber Ridge A array are not Gaussian functions. When ignoring the points lower than 0.3 on the beam images, the beam fits are different.

APPENDIX C.
Continued.

Site	Dec.	Weight	Synthesized	Beam		Side lobe (%)	
			θ_1''	θ_2''	Angle(°)	rms	max
Magdalena South Baldy B-array	60	Uniform	0.401	0.292	77	0.26	13
	30	Uniform	0.404	0.261	78	0.31	13
	0	Uniform	0.450	0.283	75	0.50	13
	−30	Uniform	0.514	0.359	17	0.35	17
	60	Natural	0.508	0.382	77	0.38	7
	30	Natural	0.491	0.341	75	0.54	7
	0	Natural	0.490	0.382	66	1.06	13
	−30	Natural	0.679	0.476	14	0.63	10
Springerville North East B-array	60	Uniform	0.296	0.264	88	0.23	10
	30	Uniform	0.290	0.246	89	0.31	12
	0	Uniform	0.304	0.265	88	0.34	16
	−30	Uniform	0.495	0.264	−2	0.31	18
	60	Natural	0.342	0.284	89	0.37	13
	30	Natural	0.322	0.265	−90	0.45	15
	0	Natural	0.326	0.313	−15	0.76	16
	−30	Natural	0.590	0.333	−2	0.41	16
Magdalena South Baldy C-array	60	Uniform	1.058	0.982	−90	0.31	13
	30	Uniform	1.052	0.855	−90	0.3	14
	0	Uniform	1.069	0.894	−90	0.51	19
	−30	Uniform	1.399	0.996	−3	0.57	20
	60	Natural	1.193	1.070	83	0.62	14
	30	Natural	1.132	0.946	−90	0.73	17
	0	Natural	1.114	1.039	88	0.99	15
	−30	Natural	1.545	1.259	−9	0.94	21