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SZA location at CARMA site

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ABSTRACT

In this memo we investigate locations for the SZA which give good heterogeneous configurations with the 10.4 and 6.1 m antennas, without changing the existing SZA or CARMA configurations. This is a nice option. The SZA and CARMA can be used as independent subarrays, or as a 23-antenna array without building a new set of stations, or re-configuring the array.

Change Record

Revision	Date	Author	Sections/Pages Affected
	Remarks		
1.0	2004-Jun-09	MCHW	1-1
	Original email text mailed to CARMA working group		
1.2	2004-Jun-23	MCHW	1-6
	Draft memo		
1.3	2004-Jun-28	MCHW	1-8
	added more discussion, table and figures		
1.4	2004-Jun-29	MCHW	1-8
	submitted as CARMA memo		

1. INTRODUCTION

The CARMA telescope is being designed as a heterogeneous array with 10.4, 6.1 and 3.5m antennas, and antenna configurations providing spacings from $\sim$ 4 m to 2 km. In the first years of CARMA, the 3.5m antennas will be used for SZ observations using a separate correlator. The current CARMA antenna configurations for Cedar Flat are based on studies of the uv-coverage and synthesized beam characteristics to provide good imaging using nine 6.1 and six 10.4m antennas, which we will refer to as the CARMA-15 array. (CARMA memo 19 and 20)

The SZA with eight 3.5m diameter antennas has been constructed in the Owens valley with six antennas in a compact, 12m diameter array and the other two antennas at $\sim$ 50m radius provide longer baselines which can be used for point source subtraction over the same field of view imaged by the compact array. The SZA will be used as a stand alone array, and then moved to the Cedar Flat site as a part of a 23-antennas array (CARMA-23).

The detailed layout for fiber and power on the Cedar Flat site is now being made, and we must consider where to locate the SZA on the Cedar Flat site.

There are two approaches for locating the SZA on Cedar:

The default plan is to locate the SZA well clear of the CARMA-15 configurations. This plan is appropriate for the SZA's life as an independent array, and would allow adding short SZA baselines to CARMA-15 data. This mode is the same as the ALMA Compact array (ACA) of 7m antennas which will be used to provide short spacings for the ALMA array of 12m antennas. This option defers thinking about CARMA-23 configurations but we will then have to build additional stations for the 3.5m antennas close to the existing CARMA-15 stations and working antennas in order to obtain good uv sampling with the 23-antenna array.

In this memo we investigate locations for the SZA which give good heterogeneous configurations with the 10.4 and 6.1 m antennas, without changing the existing SZA or CARMA configurations. This is a nice option. The SZA and CARMA-15 can be used as independent sub-arrays, or as CARMA-23 without building a new set of stations, or re-configuring the array.

2. RESULTS

We tried to locate the SZA compact array of six 3.5m diameter antennas close the the most compact CARMA E-configuration to provide short baselines between SZA and CARMA-15 antennas in several different orientations. The SZA antennas should be south of the CARMA antennas to avoid shadowing at low elevation angles when observing sources the the south.

The two SZA antennas at $\sim$ 50m radius provide longer baselines for the SZA which will be used for point source subtraction over the same field of view imaged by the compact SZA array. While we could also use CARMA-15 for point source subtraction from the SZA images, the SZA and CARMA antennas will initially be used independently with different receiver bands and separate correlators. In fact, if the two outrigger

SZA antennas are located close to other CARMA stations, then these provide additional short baselines for the 23-antenna array.

To find suitable locations for the SZA, we plotted uv-tracks and synthesized beams for the 23-antenna array. The uv-plots and beams were used to find an SZA location which gives good uv-coverage and low sidelobe levels over a range of declinations.

An SZA location $\sim$ 30m south of station 65 provides short baselines between SZA and CARMA antennas and uv-tracks which are complementary to the CARMA E uv-tracks. Station 32/47/65 is used in the CARMA C, D and E configurations and we will refer to this as the center of the CARMA array. In Table 1 we list the antenna positions with the SZA located 30m south of the CARMA array using station 32/47/65 = (0,0) = (398873.19, 4126389.51) in UTM, 1927 NAD, UTM Region 11 coordinates.

Figure 1 & 2 show the uv-tracks for source declinations +45 and -15 degrees. We used standard **unix csh** scripts to plot the data and keep a table of the results. These scripts are similar to those used for ALMA and ATA simulations, but are more complex because of the different antenna sizes used in the 23-antenna array. The script generates uv-data for a point source with thermal and atmospheric phase noise and plots the uv-coverage and synthesized beam. A Gaussian fit is made to the synthesized beam, and the results written into the table. The brightness sensitivity, beam FWHM, and residual sidelobe level after the fit are calculated. We used antenna gains 43, 126 and 383 Jy/K assuming 75% aperture efficiency for the 10.4, 6.1 and 3.5 m antennas at 230 GHz. Because of the different antenna gains, the brightness sensitivity depends on the placement of the 6 and 10m antennas in the CARMA E-configuration. The best SNR is obtained with natural weighting for each antenna. The synthesized beam and brightness sensitivity vary by $\sim$ 20%, depending of the placement of the 6 and 10m antennas in the CARMA configuration. In this study, we used a geometric mean 73 Jy/K for baselines between 6 and 10m antennas, and a geometric mean 167 Jy/K between 3.5 and 6 or 10m antennas.

In Table 2 we compute the % of unshadowed data using a 6.1m antenna diameter for the CARMA E-configuration. For the 23-antenna, EZ array we used a 3.5m antenna diameter since the SZA antennas are located to the south of the 6 and 10m antennas. Because of the different diameters of the antennas, the antenna shadowing depends on the height and relative placement of the 6.1 and 10.4 m antennas and cannot be calculated simply from the projected uv-spacing. (The apparent large gain in unshadowed data and sensitivity at declination -30 degrees is due to our use of a simple 3.5m shadow in the EZ configuration). A more precise shadowing calculation could be made from a model of the antenna structure and placement of the antennas. For each configuration we simulated observations from -2 to +2 hours sampled at 36 sec intervals. In practice, observations will be interrupted by calibrations, not sampled symmetrically about transit and shadowing and flagging of data will be calculated at the observatory.

3. DISCUSSION

3.1. uv-coverage

The CARMA-23 EZ configuration gives slightly higher resolution than the E-configuration because of the 30m offset between the CARMA and SZA arrays. The 30m north-south offset produces uv-tracks from the cross correlations between the CARMA and SZA arrays which are offset from the CARMA-15 uv-tracks and nicely fill the uv-plane. The two outrigger antennas in the SZA give uv-tracks which fill gaps in the uv-coverage for the CARMA E-configuration, which is a nice bonus.

3.2. image fidelity and calibration

The brightness sensitivity is not much changed because the eight 3.5m antennas do not add much collecting area. However, the sensitivity to large scale structures is improved by sampling shorter uv-spacings, and the density of uv-samples is more than doubled which improves the image fidelity. In BIMA memo 73, we simulated imaging for three representative models: eight point sources, Cas A, and an eye chart. In all three models, the image fidelity improved as the uv-sampling was increased. More complex images require better uv-sampling. There is still a central hole in the uv-sampling, but the hole is smaller which means that there is less information which needs complementary single dish observations. If we use the 10.4m antennas to obtain the single dish observations, there is a large region of overlap in spatial frequencies which can be used to cross calibrate the single dish and interferometer observations. The heterogeneous interferometer observations by themselves provide an excellent cross calibration of the gains of the 3.5, 6.1 and 10.4m antenna gains.

3.3. shadowing

At low declination there is more antenna shadowing, but short antenna spacings can be recovered from the projected antenna spacings. Since shadowing of a 6 or 10m antenna by a 3.5m antenna affects all baselines to the shadowed antenna, there is also a loss in sensitivity caused by shadowing. The compact SZA array of 3.5m antennas are located on a concrete pad without specific station positions for each antenna. The CARMA-23 efficiency can be improved by moving the 3.5m antennas on the concrete pad to reduce shadowing at low declinations. We could plan for this by extending the concrete pad for the SZA to the south, somewhat larger than the needed by the current SZA. The SZA outrigger station SZA8 (see Table 1) should be moved $\sim$ 12m south to avoid shadowing station 52 when the CARMA-15 antennas are the D-configuration. This does not significantly change the results listed in Table 2.

REFERENCES

BIMA memo 73, Image Fidelity, Melvyn Wright, May 1999.

CARMA memo 5, Compact Configuration Evaluation for CARMA, Melvyn Wright, Sep 2002

CARMA memo 19, Version 1 CARMA Configurations for Cedar Flat, Tamera Helfer and Melvyn Wright, February 2004.

CARMA memo 20, Version 2 CARMA Configurations for Cedar Flat, Tamera Helfer, February 2004.

CARMA memo 23, Lots in Translation: A Revised Center Location for the CARMA C/D/E Arrays, Glen Petitpas, March 2004.

Table 1: CARMA E and SZA antenna positions

Station	North[m]	East[m]
61	10.50	-0.85
62	13.23	8.58
63	3.05	-7.75
64	4.46	7.15
65	0.00	0.00
66	3.62	19.70
67	-0.37	-20.02
68	-7.31	-11.54
69	-9.06	12.00
70	-16.88	-2.27
71	25.17	24.00
72	33.42	6.80
73	36.07	-18.60
74	15.73	-29.23
75	-22.37	12.62
SZA1	-30.00	0.00
SZA2	-32.47	-5.81
SZA3	-27.94	-5.67
SZA4	-24.67	1.61
SZA5	-35.98	0.50
SZA6	-30.20	4.96
SZA7	25.95	-21.21
SZA8	0.95	38.79

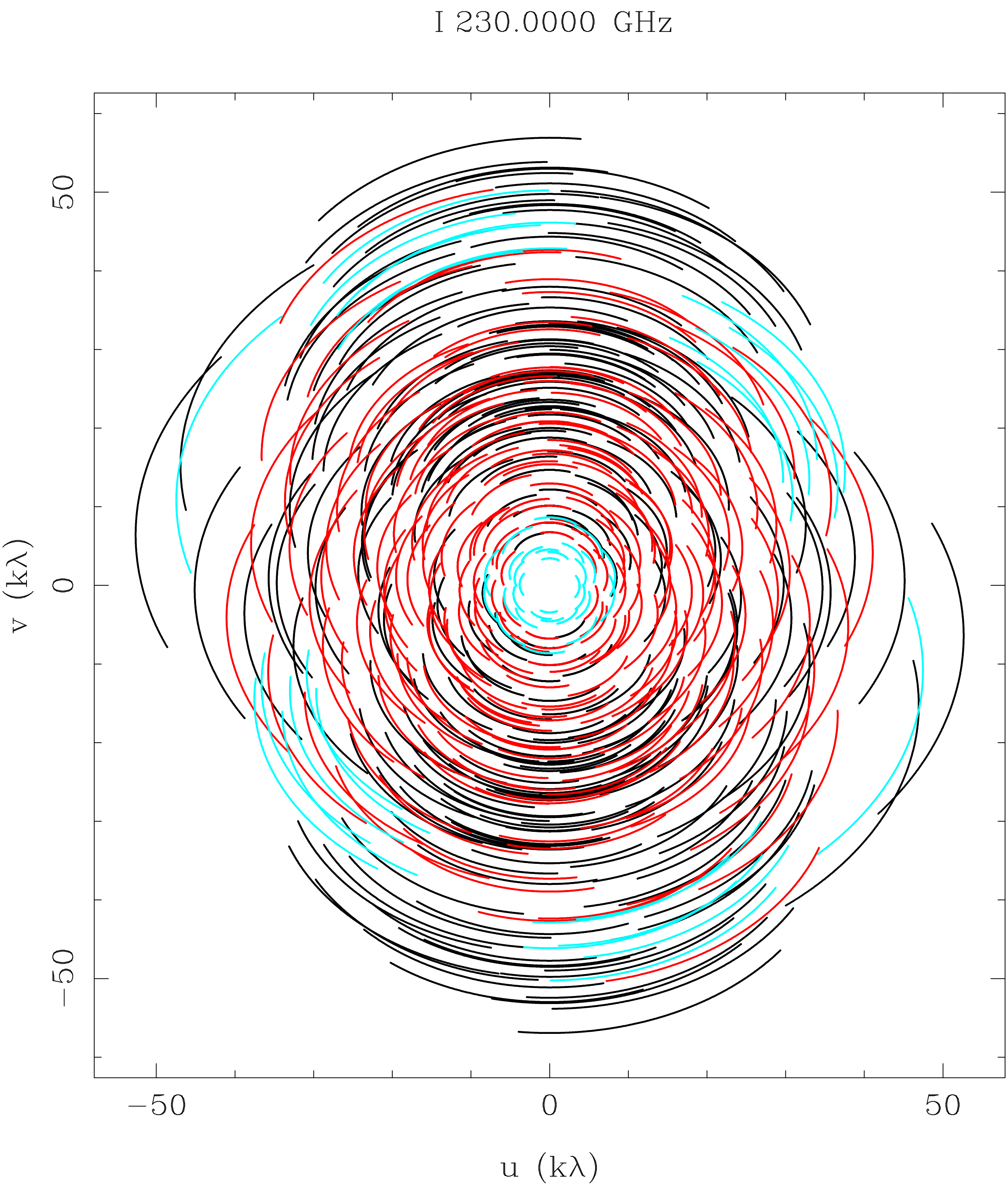

Fig. 1.— *uv* coverage obtained with a 23-antenna array at declination +45 degrees. The 15-antenna CARMA E configuration is shown in red. The 8-antenna SZA is in blue, and cross correlations between the two subarrays are in black.

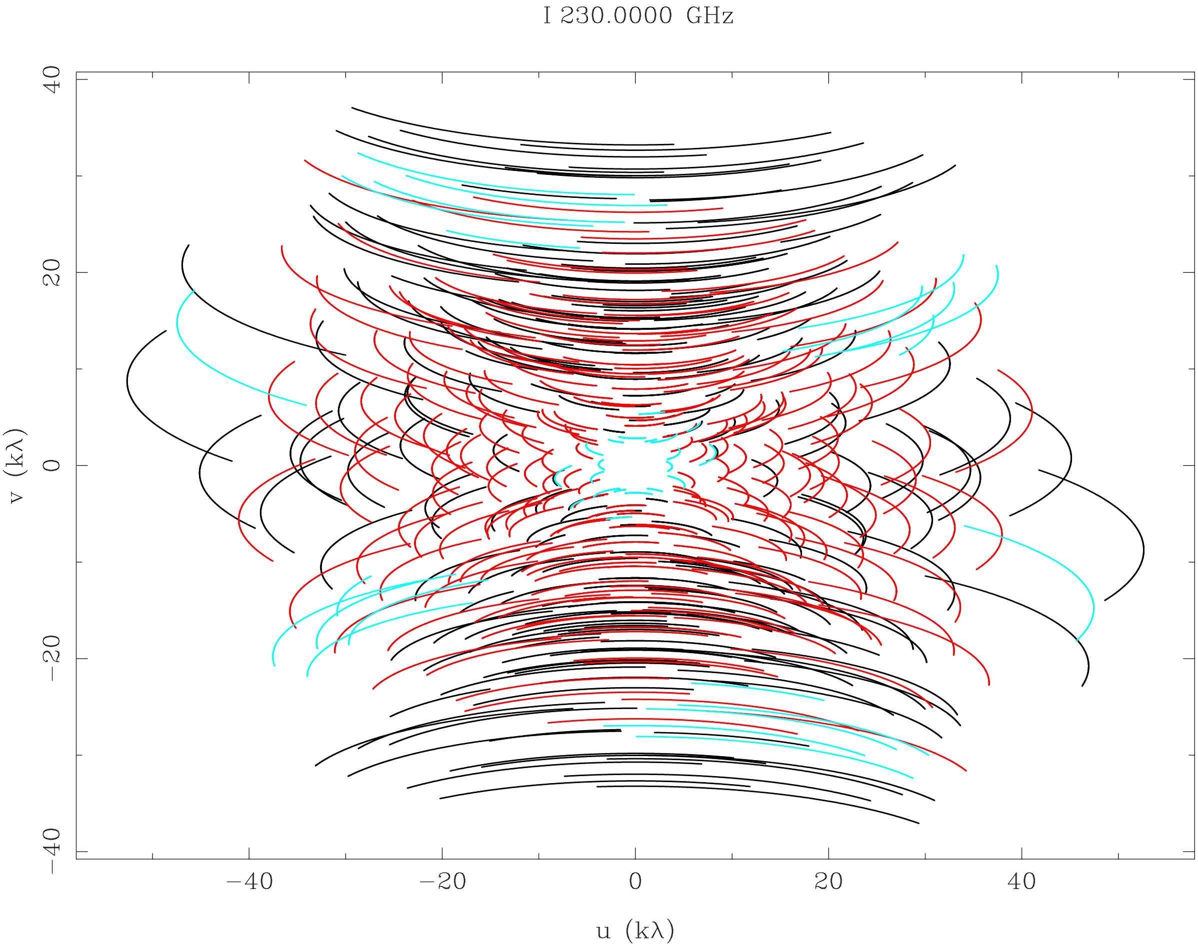

Fig. 2.— *uv* coverage obtained with a 23-antenna array at declination -15 degrees. The 15-antenna CARMA E configuration is shown in red. The 8-antenna SZA is in blue, and cross correlations between the two subarrays are in black.

Table 2: CARMA E, and EZ configurations

Config	DEC	Rms	FWHM	Tb rms	Sidelobe[%]			Nvis	uv-min	uv-max
	degrees	[mJy]	[arcsec]	[mK]	Rms	Max	Min	[%]	[m]	[m]
EZ	75	0.19	4.61 x 4.33	0.22	1.4	6.0	-5.4	100	3.6	69.6
EZ	60	0.17	4.53 x 3.79	0.23	1.4	6.8	-5.6	100	4.2	69.9
EZ	45	0.16	4.54 x 3.54	0.23	1.5	7.5	-5.7	100	4.5	74.1
EZ	30	0.16	4.55 x 3.54	0.23	1.6	7.4	-6.7	100	4.5	74.7
EZ	15	0.17	4.56 x 3.79	0.23	1.8	10.2	-8.7	100	4.2	73.5
EZ	0	0.19	4.67 x 4.33	0.22	2.4	39.5	-6.5	100	3.6	69.6
EZ	-15	0.25	5.97 x 4.49	0.22	1.9	11.9	-6.4	87	2.7	69.6
EZ	-30	0.43	9.60 x 4.39	0.24	1.8	8.7	-6.5	70	1.8	69.6
E	75	0.21	4.92 x 4.41	0.22	1.5	6.7	-6.2	100	6.9	57.6
E	60	0.19	4.50 x 4.18	0.23	1.7	7.7	-6.4	100	7.5	63.9
E	45	0.18	4.48 x 3.93	0.24	1.7	8.1	-6.6	100	7.5	66.3
E	30	0.18	4.48 x 3.94	0.24	1.8	8.8	-6.7	100	7.5	66.3
E	15	0.19	4.52 x 4.20	0.23	2.0	12.5	-6.9	100	6.9	66.3
E	0	0.22	4.99 x 4.43	0.23	2.6	44.9	-10.1	100	6.0	64.5
E	-15	0.29	6.25 x 4.30	0.25	2.1	18.4	-7.6	85	5.1	60.6
E	-30	0.63	8.56 x 3.88	0.44	2.3	14.4	-9.0	50	3.3	55.5