Astronomical Data Analysis Software and Systems XV
ASP Conference Series, Vol. 351, 2006
C. Gabriel, C. Arviset, D. Ponz and E. Solano, eds.

The CARMA Project

Stephen L. Scott

Caltech, Owens Valley Radio Observatory

Marc W. Pound

Astronomy Department, University of Maryland

Abstract. CARMA has merged the BIMA millimeter array and the OVRO millimeter array and will add the new SZA array to form a unique 23 antenna heterogeneous imaging array with three different antenna sizes. The instrument will have imaging capabilities at millimeter and centimeter wavelengths, with a bandwidth of 8 GHz and resolution of 0.13 arcseconds. The university based nature of CARMA will provide hands on training for young astronomers and serve as a testbed for technical innovation. CARMA is located at 7200′ (2200 m) at a new site in the Inyo National Forest in California and is currently in the commissioning phase. The current status of the project is presented in this paper, including infrastructure, hardware and software.

1. Introduction

The Combined Array for Research in Millimeter-Wave Astronomy (CARMA) combines two existing millimeter-wave arrays, Caltech's Owens Valley Radio Observatory (OVRO) array and the Berkeley-Illinois-Maryland Association (BIMA) array at Hat Creek, and adds the new Sunyaev-Zeldovich Array (SZA) to form a 23 antenna heterogeneous array. Significant hardware upgrades have been made to the two existing arrays and a new control system written to both modernize and make them compatible. The detailed capabilities of CARMA[1] and its software are described in Scott et al. 2004.

Civil construction began at the new high site, called Cedar Flat, in July of 2004. All 15 of the existing antennas were moved, reassembled, and fringes obtained with a new software system in August of 2005. Here we present some of the highlights of this intense and rapid construction, a review of the current status, and th schedule for future development. A retrospective of the software effort to date is also given.

[1] `http://www.mmarray.org/`

2. Construction

The construction of the SZA began in 2001 and it is now in scientific operation at the Owens Valley site. Its eight antennas have a diameter of 3.5 meters. The SZA is operating with 8 GHz of correlator bandwidth with coarse resolution for continuum observations of the Sunyaev-Zeldovich effect, pending its merging with CARMA in 2006.

Three new buildings were constructed at Cedar Flat: a control building, a fabrication shop, and an electrical generation station. The control building includes two rooms for the current resident observers, living room, kitchen, lab, correlator and computer rooms. There is also a control room that looks out over the central array area. The control building is completely functional and has been continuously occupied by observers since July. The lab contains spares and equipment for diagnosis of electronic modules. The fabrication shop contains the space and equipment necessary to maintain the mechanical aspects of the array. The electrical generating station contains two diesel generators, one of which runs to provide 500 KW of power for the site while the other is on standby.

Initial construction provided 25 stations for the compact E and D configurations. Eleven more stations for the C-array are under construction and will be completed by the end of November 2005.

3. Antenna Moves

The most exciting aspect of the construction phase was the moving of the antennas. The nine BIMA antennas, with a diameter of 6.1 meters, were broken into three pieces consisting of the base, the alidade, and the primary reflector with the feed leg assembly. The primary fit horizontally on a truck as a very wide load for the 300 mile journey from Hat Creek. Nineteen electrical or telephone wires had to be raised during the trip.

The six OVRO antennas, with a 10.4 meter diameter, had a shorter but more harrowing journey to Cedar Flat. Again the antennas were broken into three pieces: the base, the primary and the feed leg assembly. A special cradle was built to mount the primary and tip it vertically so that it could pass through the single lane section of a narrow rock canyon on its 15 mile journey over Westgard Pass to Cedar Flat.

4. Current Status and Future Schedule

Wiring, outfitting and commissioning of the antennas are continuing. Eleven of the antennas can be driven, and five have working receivers. The correlator is in place with 1.5 GHz of bandwidth. The software is 65% complete, giving enough functionality for first light, including hardware verification and characterization. Fringes have been obtained between all of the working receivers, from both types of antennas, as is shown in Figure 1.

The schedule for future developments at CARMA is given in Table 1.

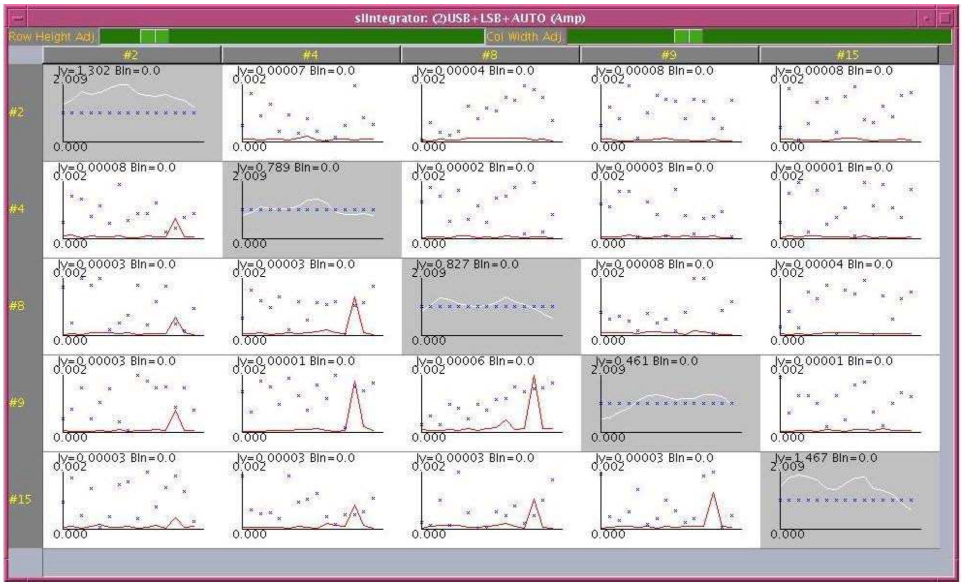

Figure 1. Spectral plots of the SiO maser in Orion. The table cells show the correlations between the different antenna pairs. The upper right has the upper sideband (showing no signal), the lower left the lower sideband with the SiO emission. The lines show amplitude, and the points are the phase, as plotted in realtime by the CARMA Data Viewer, as described by Pound et al. 2001.

Table 1. CARMA Schedule

Date	Functionality
Nov 2005	C-array and Transporter
Dec 2005	Shared Risk Science begins
Spring 2006	SZA moved to Cedar Flat
April 2006	Software complete
Mid 2006	Correlator expansion to 4 GHz
Fall 2006	OVRO drive upgrade
Fall 2006	B-array and most A-array stations
Fall 2008	Remaining 4 A-array stations

5. Software Retrospective

The software design was presented in detail at ADASS XIII, and we can now review how the design and execution have proceeded over the last two years. The overall design proved workable, and is substantially unchanged from the original concept. The distributed team has worked well and the schedule has been maintained. Estimates of the effort required for a given task may have been 10 to 20 % low, and code reviews have been sacrificed to keep on schedule. The project began at a time when our chosen compiler and platform (gcc and Redhat Linux) were evolving. The upgrade to gcc 3.4 and CentOS provided a much better platform but at the cost of disruption of the development cycle. Tinderbox, acting in support of a continuous integration development paradigm, has proven invaluable. Threading was not afforded a high enough priority early in the project, and has made clean program shutdown elusive. Deployment of the software into a package usable by the observers (environment, scripts, permissions) should have been assigned as a specific task with allocated resources. The administrative resources required to manage the project were inadequately budgeted. Frequent releases (every three months) have provided incentive, formal testing, and opportunities to inventory progress.

References

Scott, S. L., Amarnath, N. S., Kraybill, J. C., Beard, A. D., Daniel, P., Gwon, C., Hobbs, R., Mehringer, D., Plante, R., Pound, M. W., Rauch, K. P., Teuben, P. J. 2004, "The CARMA Software System", in ASP Conf. Ser., Vol. 314, ADASS XIII, ed. F. Ochsenbein, M. Allen, & D. Egret (San Francisco: ASP), 768

Pound, M. W., Hobbs, R., Scott, S. L., 2001, "A Corba And Java Based Data Viewer For Radio Interferometers", in ASP Conf. Ser., Vol. 238, ADASS X, ed. F. R. Harnden, Jr., F. A. Primini, & H. E. Payne (San Francisco: ASP), 82