Configuration Choices for the Allen Telescope Array

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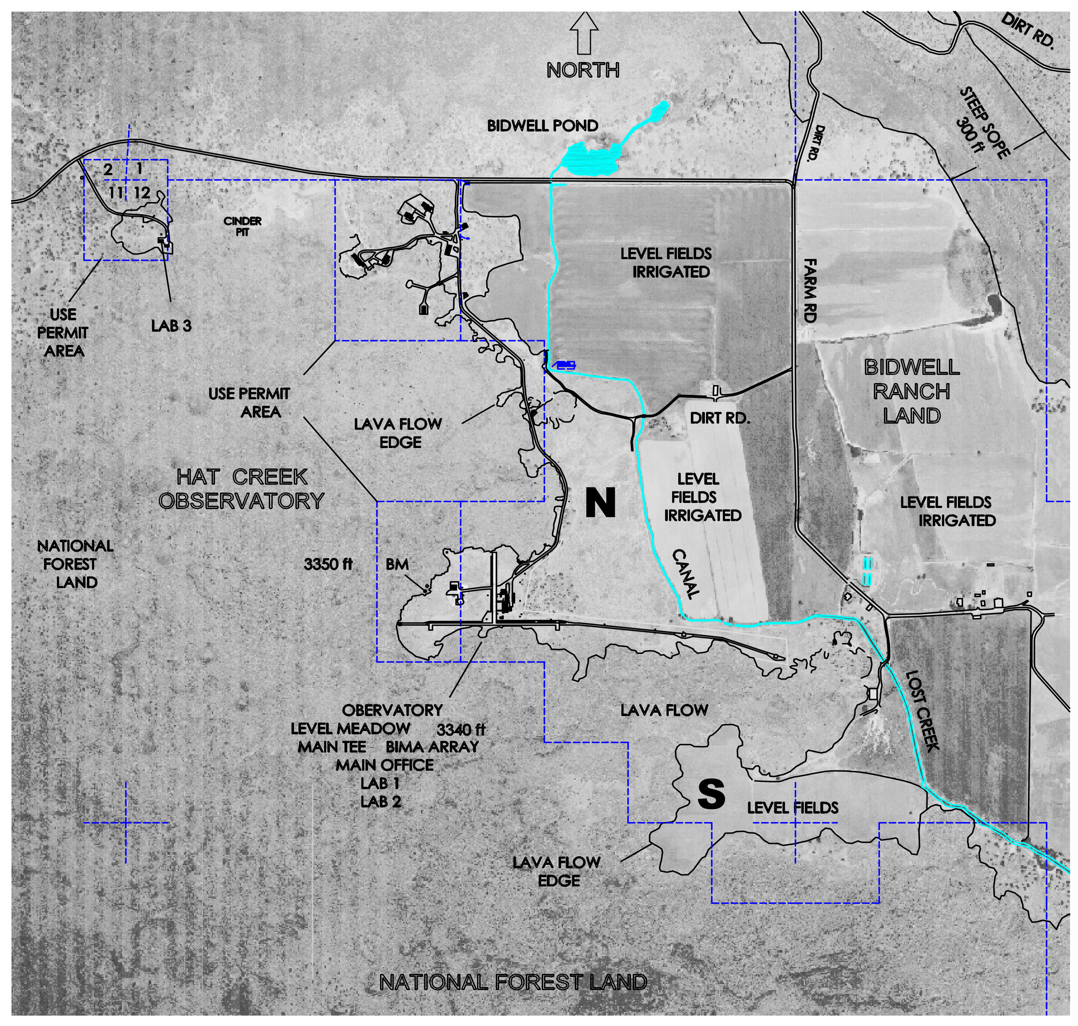
Introduction

The Allen Telescope Array (ATA) is an array of 500 five metre parabolic antennas presently under design by the Radio Astronomy Laboratory and the SETI Institute, for construction by 2005. The telescope will be a unique interferometer for its sensitivity to very extended emission, filling the gap in observing phase-space between the largest single-dish telescopes and the Very Large Array, and operating from 500 MHz to 10 GHz. With construction funded by the SETI Institute, it will be a powerful general-purpose instrument with particular strengths in the areas of:

- SETI
- Pulsar observing
- Imaging HI in the Milky Way and nearby galaxies
- Studies of polarisation in our galaxy
- Measurement at cosmological distances of HI in absorption against quasars
- Spectral line studies over the complete range 500 MHz – 10 GHz.

A key challenge in the design of the instrument is the determination of a suitable array configuration. Over the coming months the design group will be preparing for a preliminary design review of configuration options. In this poster we outline the constraints for the design and highlight some recent investigations. We invite input from interested parties!



Site and Instrument Constraints

The ATA will be build at the site of the BIMA millimetre interferometer, in Hat Creek Valley, northern California. Land is presently leased by the observatory from the US Forest Service and local landowners. Many dishes of the 1hT will be placed on these existing leases, which are largely bounded by lava flows and irrigated land. Additionally, the use of new areas is being negotiated to improve the beamshape of the array when imaging at resolutions requiring 1km baselines. Each dish of the array will be linked to the central laboratory by RF fibres, as well as by power and control connections which might be daisy-chained or in a star configuration. A significant part of the optimisation challenge will be keeping cabling to a reasonable cost. Pulling the design in the opposite direction is the desire to minimise RFI impact. Welch and Dreher (1999) have noted that a more extended array can significantly reduce the effect of RFI due to the increased rate of lobe rotation.

Aerial photograph of the Hat Creek site, with principal features marked. Note the central 'T' of the BIMA array and the extended arms to the east and north, along which the placement of antennas would be most convenient. Additional space is being sought in the fields marked N and S.

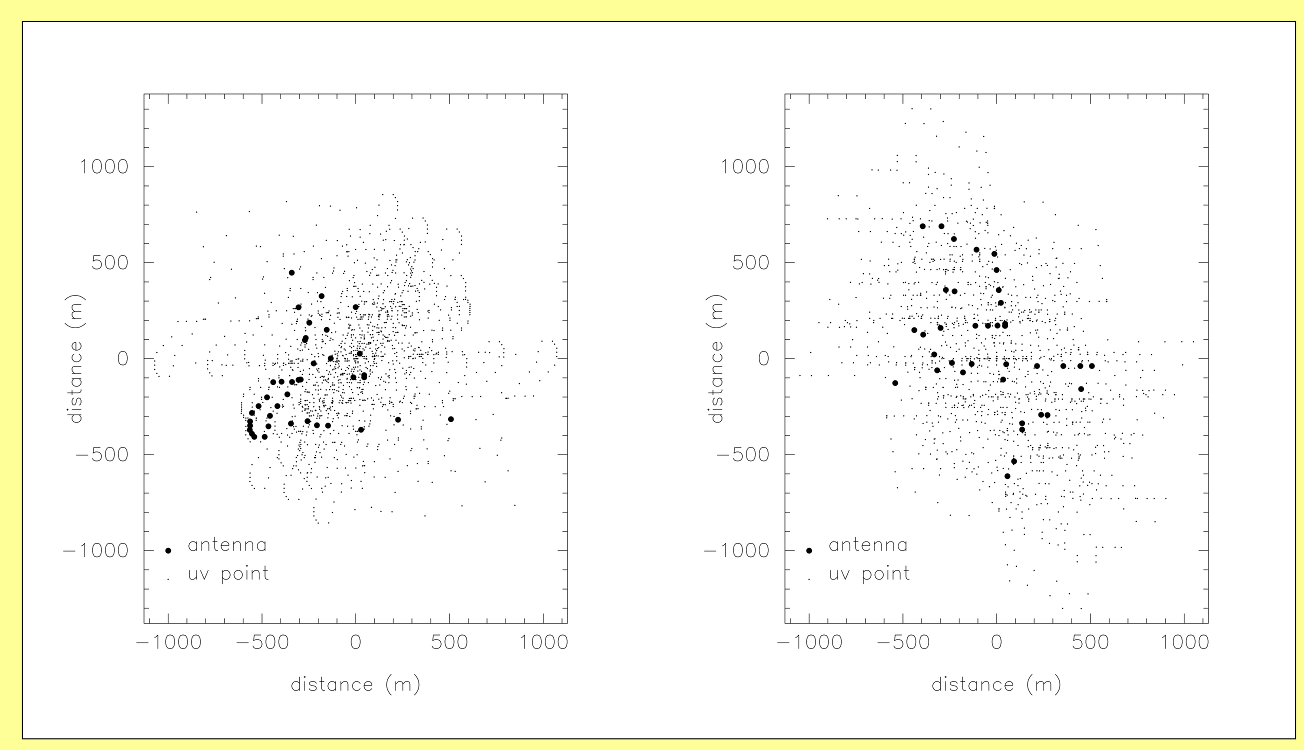
Optimisation for the Hat Creek Site

We have used a Kohonen self-organising neural network algorithm (Keto 1997) to optimise the placement of antennas on the Hat Creek site. This algorithm attempts to provide a uniform *u-v* coverage. In our application we have chosen to weight the desired *u-v* coverage with a gaussian distribution to provide a better beamshape.

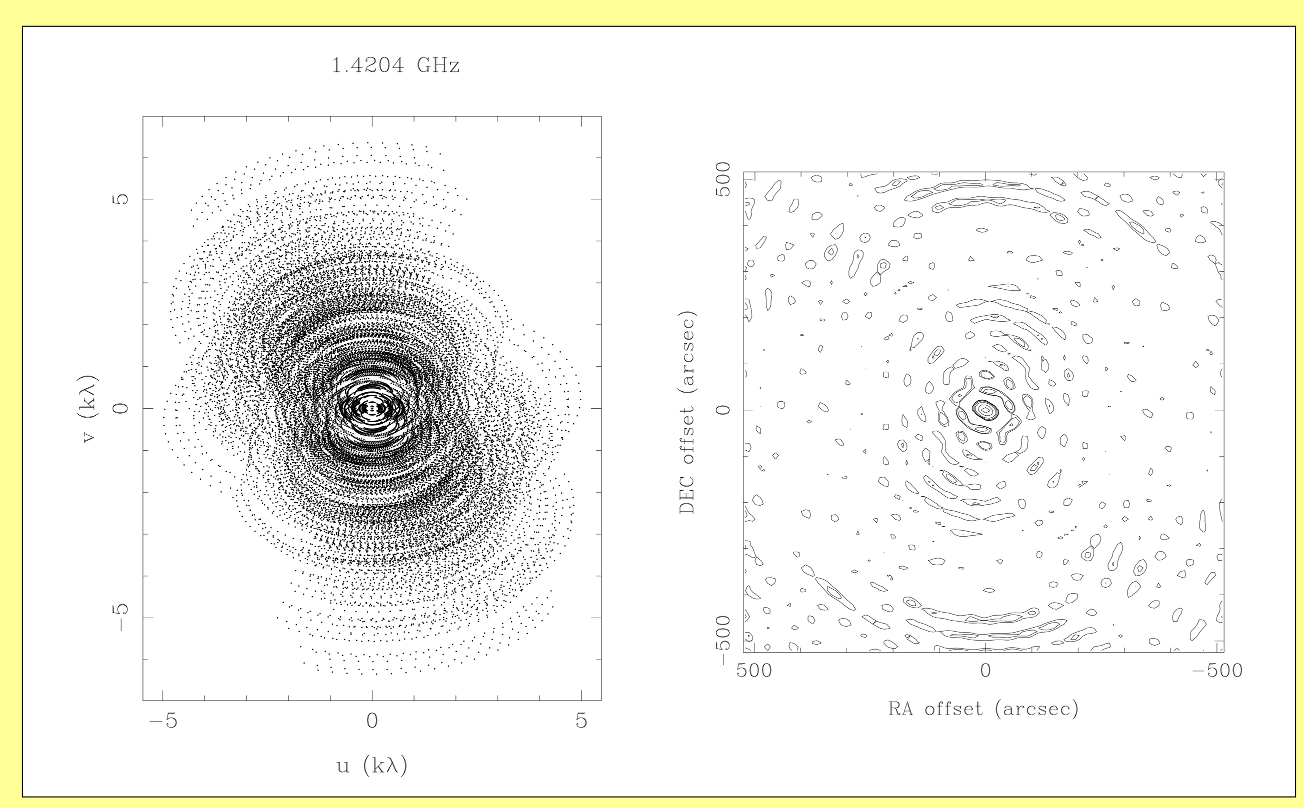
As originally implemented, unconstrained by topography, the algorithm led to solutions based on the Reuleux triangle. However, our site precludes this configuration on all but the smallest size scales. Instead, we have modified the code to accept a topographical constraint. In the two analyses presented here, the antennas were initially randomly placed within the available area. Attempting to find optima such as the Reuleux triangle, the algorithm almost inevitably pushed the antennas against the boundaries of the available site. Although desirable for the farmer, who keeps much arable land, the regular boundaries lead to poorer beamshapes. The algorithm so constrained has entered a local minimum, rather than the best solution. As the number of antennas is increased, this effect becomes severe. We plan to try an alternative algorithm (Kogan 2000) which has been used to optimise ALMA configurations with topological constraints.

Although these studies only included forty antennas, the snapshot *u*-v coverage is already excellent (note for interest the superior coverage of the GMRT's irregular Y over the VLA configuration). If each point was replaced by a configuration of approximately 10 antennas the *u*-v points in the figure would grow correspondingly. The advantages of such a configuration would include.

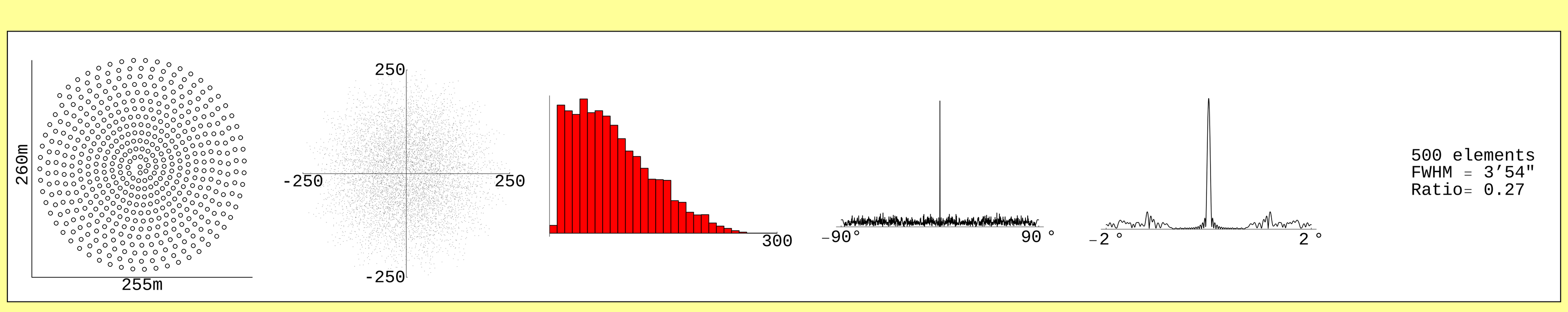
- Additional sensitivity to the most extended structure
- Ease in management and construction, with regular sub-arrays
- Reduced overall wiring cost compared to an array of 500 fully-distributed antennas
- The ability to increase the imaging bandwidth (for fixed computing power) by correlating beams formed with each of the 40 sub-arrays, rather than with all 500 antennas.



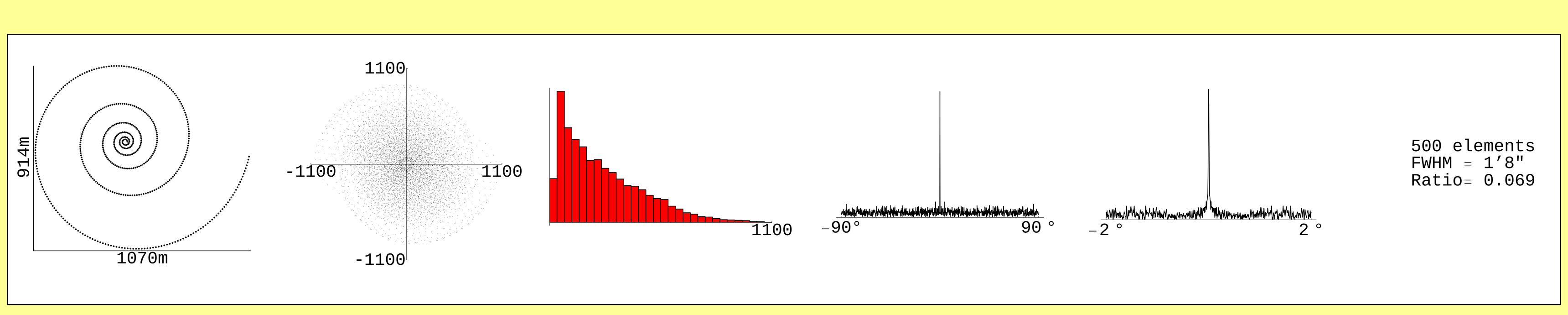
Antennas and *u-v* snapshot coverage at zenith for the present site with additional land 'N' (left) and 'N+S' (right). The symmetry of the latter distribution results in much improved *u-v* coverage.



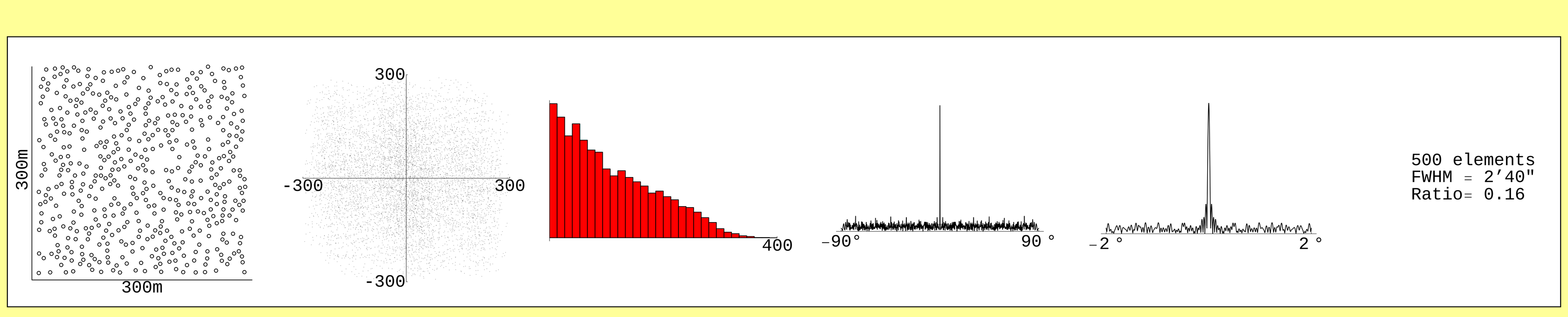
Six-hour *u-v* coverage and beam for the right-hand configuration above. The contours are logarithmic, with the lowest 1%.



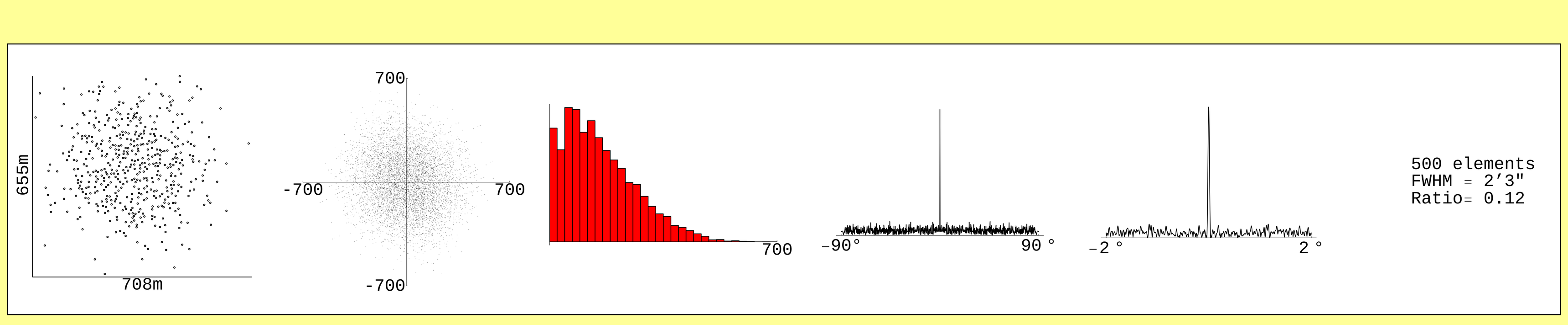
Archimedean spiral (equally-spaced layers). See text for description of the figures.



Equiangular spiral (local tangent makes a fixed angle with the radius vector)



Random distribution



Gaussian distribution

Idealised Configurations

Here we present simulations of idealised configurations investigated using the *Mathematica* package. For each configuration the following are shown:

- antenna distribution
- *u-v* coverage from a subset of antennas (20%; due to computational limitations)
- a histogram of the *u-v* coverage, normalised for the area of the concentric rings of integration
- one-dimensional voltage beam profiles at two angular scales
- FWHM of the main lobe and ratio of the power in the main lobes to that in the main and sidelobes.

Of particular interest is the archimedean spiral, which produces remarkably low close-in sidelobes. Further optimisation may make possible matching of this area to the elemental primary beam. Many variants are not shown – consult the authors for additional figures. The package developed for these simulations contains many general functions which may be of use to others considering similar studies.

References
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Keto, E., ApJ, 475, 843, 1997
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