10/12/95

Outrigger Stations for The MMA

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During every MMA Science workshop there have been three science areas where it is desireable to make higher resolution observations: stellar continuum; circumstellar masers; and a subset of extra-galactic objects. Accepting that the largest 40 element array of the MMA will be 3 km in size, it would be very useful to be able to explore higher resolution observations at minimal cost.

Occasionally using only 34 antennas in the central 3 km array while 6 are deployed as outriggers seems to be a useful way of exploring both high resolution MMA science and the related frontiers of phase calibration and self-calibration.

The following is a summary of a simple approach where one achieves 10 and 30 km diameters in the u-v plane. Three lines of roads, power, and optical fiber link what is initially four stations. The following mathematics is expressed in MathCAD syntax so the same document can be used both for writing this memo and carrying out calculations with different parameters.

$\theta := \begin{pmatrix} 60 \\ 180 \\ 300 \end{pmatrix}$ are the clockwise angles of the arms and $j := 0 .. last(\theta)$ is the range index for arms,

$\theta := \theta \cdot \frac{\pi}{180}$ converts θ to trig function units of radians, and

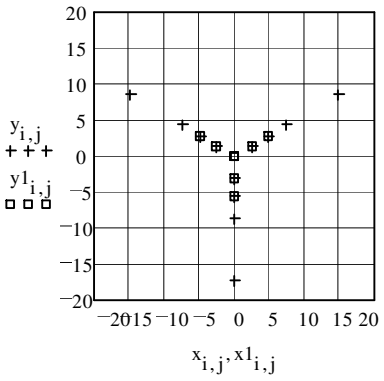
$r := \begin{bmatrix} 3 \\ 5.5 \\ 8.7 \\ 17.3 \end{bmatrix}$ are radial distances in km for the four stations and $i := 0 .. last(r)$ is the range index for stations.

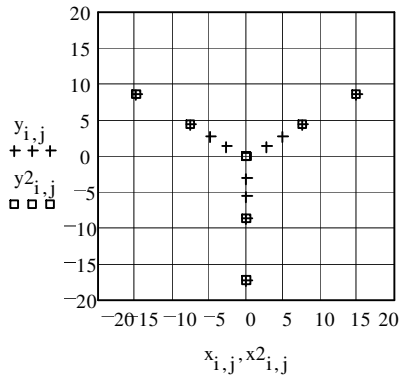
These distances are adopted so that the outrigger configurations surrounding the 3 km inner array have radii of 10 and 30 km in the u-v plane, so there is a factor of three increase in resolution for each case over the inn 3 km configuration. All of these numbers can be further optimized; at the moment the u-v coverage involving outriggers for the 10 km configuation is nearly uniform outside the u-v coverage of the inner 3 km array.

$x_{i,j} := r_i \cdot \sin(\theta_j)$ $\quad y_{i,j} := r_i \cdot \cos(\theta_j)$ $\quad x = \begin{bmatrix} 2.598 & 0 & -2.598 \\ 4.763 & 0 & -4.763 \\ 7.534 & 1.065 \cdot 10^{-15} & -7.534 \\ 14.982 & 2.119 \cdot 10^{-15} & -14.982 \end{bmatrix}$ $y = \begin{bmatrix} 1.5 & -3 & 1.5 \\ 2.75 & -5.5 & 2.75 \\ 4.35 & -8.7 & 4.35 \\ 8.65 & -17.3 & 8.65 \end{bmatrix}$ computes Earth surface (x,y) coordinates for stations,

$x1_{i,j} := if[(i=0)+(i=1), x_{i,j}, 0]$ and $y1_{i,j} := if[(i=0)+(i=1), y_{i,j}, 0]$ computes the 10 km array stations, and

$x2_{i,j} := if[(i=2)+(i=3), x_{i,j}, 0]$ and $y2_{i,j} := if[(i=2)+(i=3), y_{i,j}, 0]$ computes the 30 km array stations.





Figures 1-2. 10 & 30 km configurations where the center of the 3 km array is a square, stations are +'s, and occupied stations are +'s in squares.

The arm angles were chosen so the NW and NE arms would roughly surround Mount Chajnantor in Chile if the MMA were located at the site near San Pedro de Atacama.

Since the MMA antennas will be transported over roads, most of the cost will be in running roads, power, and optical fibers along the three arms, therefore one may not need to minimize the number of possible stations.

Finally, the resolution of the 3, 10, and 30 km arrays will be 0.08"λ(mm), 0.024"λ(mm), and 0.008"λ(mm), allowing the imaging down to 10-15 mas discussed at the 1995 MMA workshop in Tucson.