National Radio Astronomy Observatory

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To: Distribution

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Subject: Cost Equation of Millimeter Wave Array

The following is an estimate of the cost equation for the telescopes and receivers of a millimeter array in units of 1983 k$ and assuming 1983 technology. The costs include design and labor.

1) Antenna System Cost, A$

For N antennas of diameter D in meters with accuracy $\lambda/16$ where λ is in millimeters,

$$A\$ = 64 \cdot \frac{(D/6)^{2.7}}{\lambda/3} \cdot N + 100N + 500$$

2) Front-End System Cost, F$

For N antennas; M frequency bands, each 20% wide; K beams per antenna; and dual polarization,

$$F\$ = 40 \cdot M \cdot \sqrt{K} \cdot N + 200 \cdot M$$

3) LO System, L$

For a general purpose 30 to 270 GHz system generating low power for SIS mixers,

$$L\$ = 70 \cdot N + 100$$

4) IF Transmission, I$

For 2 GHz bandwidth transmission at average baseline lengths, D in km with D < 3,

$$I\$ = 15 \cdot (D + 2) \cdot N + 100$$

5) Correlator

For a hybrid filter-bank-digital correlator with a total of J filters per antenna, analyzing M frequencies in a total bandwidth of B GHz, the cost is,

$$C\$ = \frac{2 \cdot C \cdot B \cdot M \cdot N^2}{J} + .6 \cdot J \cdot N + 200$$

where C is the total (labor, power supplies, etc.) cost in k$ for 10^9 multiplications/s. For the VLA correlator C = 0.91 and the figure is comparable for the VLBA correlator. With the rapid advances in digital technology, I suggest a value C = 0.5.

The number of filters which minimizes the correlator cost, J_o, and the minimum cost is,

$$J_o = 1.8 \sqrt{C \cdot B \cdot M \cdot N}$$

$$C\$ = 1.2 \cdot J_o \cdot N + 200 = 2.16 \cdot N \sqrt{C \cdot B \cdot M \cdot N} + 200$$

As an example, if C = 0.5, B = 2 GHz, M = 1,000 channels, and N = 16 antennas, then J_o = 228 and C$ = $4,572k. If N was changed to 2 (i.e., a prototype interferometer), then J_o = 80 and C$ = $393k. These figures are for a single polarization; the B or M available for each of two polarizations is 1/2 of above or 1/4 if full polarization synthesis is required.

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(see attached list)