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COMMENTS ON THE UHF/VHF EXPANSION PROJECT FOR THE VLA UPGRADE

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INTRODUCTION:

Upon reading the detailed summary of the meeting held at the AOC on June 26th, it has become apparent that several very important compromises to the existing VLA operation are believed to be necessary in order to enhance the low frequency performance of the array. The implementation of the low frequency prime focus system would certainly result in such operational concessions. However, there is another option to low frequency expansion, the co-array approach, that will not compromise the existing VIA operation. This approach involves independent antennas located permanently near VIA "A" array stations and use is made of the existing VIA infrastructure for power, data transmission, and control. The idea of a co-array is not a new one; Perley and Erickson [1] proposed such a system for 75 MHz operation in 1984. Although the cost advantage of the prime focus approach is usually cited as the principal argument against any co-array option, the foundation for such an argument is certainly not clearly based on the discussions at the June 26th meeting. The purpose of this memorandum is to highlight the shortcomings of the prime focus approach and to suggest that the co-array option be considered for the entire UHF/VHF (75 MHz through 1000 MHz) upgrade.

SHORTCOMINGS OF THE PRIME FOCUS APPROACH:

1. The existing VIA antennas have no exact prime focus. The VLA antennas are shaped reflectors which differ from true paraboloids by about 1 cm [2]. The phased-array feed approach would theoretically correct for this difference, but several years of development work is necessary before such an approach can be made practical. All of the other methods discussed at the meeting do not correct for this focusing error. Although considered small, this error is a compromise to performance of the UHF/VHF prime focus system.

2. At least 90 cm must be added to the subreflector travel. In essence, the travel mechanism for the current subreflector must be modified to ensure that the low frequency feeds are positioned at the optimum focal point [2]; otherwise, the performance of the UHF/VHF feeds would be compromised severely. Adding the 90 cm of additional travel is not at all a trivial matter; it requires costly modifications to the FRM and quadrupod legs. Furthermore, this modification, together with the UHF/VHF feeds and associate cryogenic receivers, adds weight to the end of a long moment arm yielding additional gravitationally-evoked torques about the main reflector backup structure causing additional surface distortion and pointing problems.

3. The size of the existing subreflector cannot be increased. If the existing subreflector were to be made larger to improve the L-band performance at the lower band edge (which has been proposed recently), then the problem of clearing the subreflector for low frequency operation becomes much

more difficult. Hence, limiting the size of the subreflector is an indirect compromise to future L-band performance.

4. System performance at ALL bands is to be reduced by at least ten percent. It has been estimated that the blockage and scatter attributed to the current 75 MHz and 327 MHz feeds increase the system noise temperature at L-band by ten percent [2]. For the proposed prime focus system, this effect could be present at all bands and may be a complex function of frequency [2]. NRAO has spent a substantial amount of time and money to reduce the noise temperature of the front-end electronics, and it would be a pity to simply compromise this work to obtain moderate performance at low frequencies.

5. Reduction in reliability at all frequencies. Because of the proposed "Swiss Army Knife" approach to low frequency feed placement, all such feeds would be mounted on motorized swing-arm structures. If a problem were to occur in the retraction of a feed arm, then the entire antenna would be off-line until the problem was repaired. Hence, the overall reliability of the VLA is compromised by the addition of the low frequency feeds at the prime focus.

6. Compromise in flexibility. The proposed UHF/VHF prime focus system does not permit operation of any high frequency receivers when low frequency observations are in progress. However, there may be future scientific applications where such dual frequency operation is highly desirable or even deemed essential.

ADVANTAGES OF THE CO-ARRAY APPROACH:

1. There would be no inherent compromise to the optimum performance of the existing high frequency array. This is perhaps the single most important advantage of having a separate array for low frequency operation. The planned upgrades to the existing VLA high frequency systems, including the increase in subreflector size, could be accomplished without concern about accommodating the low frequency requirements. A first-class telescope with unsurpassed state-of-the-art performance at L-band and above is far better than a telescope with compromised performance at all frequencies.

2. An array could be optimized specifically for low frequency operation. The use of a fixed-size paraboloidal antenna is a severe constraint at frequencies below a few hundred megahertz. Perhaps banks of phased elements would be more appropriate at these frequencies. The structure of the antenna could therefore change as a function of frequency. Furthermore, fast frequency switching can be incorporated into the design of the low frequency array.

3. The arrays could be operated either independently or in parallel yielding more operational flexibility. Such parallel operation is simply not practical with the proposed prime focus system.

4. The reliability of both arrays would not be compromised. A reduction in the number of single-point failure mechanisms would result in improved reliability for both arrays.

5. The amount of time required for future upgrades to the low frequency system can be reduced. Upgrading the low frequency array would be de-coupled from the current VLA maintenance and upgrade schedule; hence, future changes could be made relatively quickly.

SUGGESTIONS FOR FURTHER STUDY:

The following suggestions are made for the purposes of evaluating the co-array approach:

1. It is imperative that an extensive survey of the interference environment be performed prior to the design of ANY low frequency system. The results of the survey will naturally guide the receiver and feed designs into definite bands, thus reducing the cost and complexity of the array.
2. Design the array to cover only those bands that are deemed accessible based on the interference survey. Each element in the co-array would be a hybrid system consisting of sub-arrays of antennas that are designed specifically to meet the observational requirements for a given band.
3. The sensitivity specification issue must be studied more carefully in order to support strongly the need for cryogenic receiver systems.
4. A pointing scheme should be designed to accommodate the hybrid antenna approach. Antennas may be grouped together on a single mount or steered independently using several mounts.
5. Design the Cassegrain L-band feed and subreflector assembly to lower the operating frequency as far as possible without compromise to any existing system.
6. A first-order cost estimate can be determined once the above issues have been studied carefully.

REFERENCES:

[1J Perley, R. A. and W. C. Erickson, "A Proposal for a Large, Low Frequency Array Located at the VLA Site," VLA Scientific Memorandum No. 146, April 14, 1984.

[2] "The UHF/VHF Prime Focus Systems for the Future VLA Upgrade," R. Sramek ed., VLA Upgrade Memo No. 2, July 21, 1995.

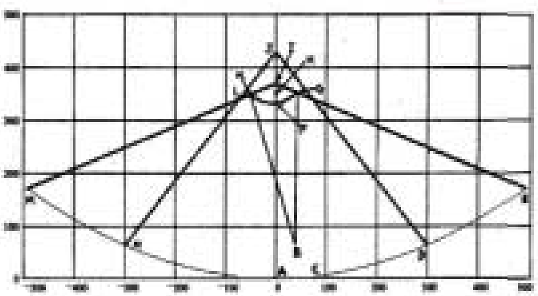

Figure 1. VLA Cassegrain geometry. The lines DJ and NJ are the nominal inside surfaces of the quadruped legs (locations provided by R. Brolo) and the lines BGE and BKM are the rays which travel from the edge of the primary reflector to the secondary focus. The coordinates of the labeled points are as follows:

A. Primary reflector vertex	0,0	I. Intersection of edge rays	0,371.096
B. Secondary focus	38.0,68.0	J. Virtual intersection of quadruped legs	0,430.00
C. Radius of unpaneled area	78.0,4.234	K. Long edge of subreflector	-91.855,350.511
D. Bottom of quadruped inside surface	297.244, 65.82	L. Intersection of edge ray with quadruped leg inner surface	-72.787,341.417
E. Primary reflector edge	493.136,179.888	M. Primary reflector edge	-493.136,179.888
F. Intersection of secondary surface and primary axis	0,370.80	N. Bottom of quadruped inside surface	-297.244,65.82
G. Short edge of subreflector	41.078,334.075	Angle AIB: Edge ray angle	17.891 deg
H. Real B-prime focus for primary	0,294.18		

* Note: The VLA asymmetric subreflector is specified in VLA Specification A13620N1. The values for the subreflector edge shown here are the exact geometric optics edges and are slightly larger than the values in Spec A13620N1 which are given only on a 0.5 in rectangular grid. The origin of coordinates for the profile given in Spec. A13620N1 is (0,333.708).