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Feb. 3, 1995

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Notes on Meeting of the MMA System WG, Feb. 2, 1995

The following notes are my impression the most important things discussed, rather than a precise record of the proceedings of the meeting. Please let me know if you disagree with my conclusions or if I have omitted something important.

(1) Tasks of the Working Group

The initial approach should be to review the specifications of the MMA that directly affect the system design. The original specs. are outlined in the 1990 proposal document, and some more recent requirements are found in the conclusions of the Advisory Committee meetings of 1993 and 1994. Specifications can be divided into two classes: baseline specs. that indicate performance that must be met, and enhanced specs. that represent desirable enhancements in performance. In this second category we may not be able to afford all the ideas that have been proposed. Thus we need to estimate the cost of such enhancements in dollars and in increased complexity, and to indicate any trade-offs involved. Similar cost and complexity estimates should be made for some of the limits of the specifications, for example for the extremes of the frequency coverage. The intention is to provide a basis on which choices can be made by the Advisory Committee later in the year.

The next task will be to produce a recommended system design at the block diagram level. This will cover the signal paths from the front-end outputs to the correlator output, but will not include antennas, front ends or computers. Where questions affecting performance remain, design options should be specified. Where hardware tests will be required to determine choices, the equipment required and the measurements to be made should be outlined. This information will provide a plan of action so that development can be started as soon as funding allows.

(2) IF Subsystem

Design of the signal path between the front ends and the delay/correlator requires answers to two main questions:

> analog or digital transmission on the fiber?
>
> what is the channelization scheme for inputs to the correlator?

In the analog-or-digital choice, analog transmission results in a somewhat simpler system, with less equipment at the antennas. However, considerations of dynamic range may drive us to digital transmission. At the last two meetings of the Advisory Committee, I have mentioned the required dynamic range for mapping with the MMA. A figure of 40 dB has always been acceptable. (Also, there has been no objection to the suggestion that analog transmission would be adequate.) In the experience of members of the working group, 40 dB is certainly a high enough requirement, and for much of the current work at millimeter wavelengths the dynamic range is more like 20 dB.

If the frequency response of the transmission system is stable, it can be calibrated. It is the variation with temperature, etc. that fundamentally limits the closure phase accuracy, and hence the dynamic range. Experience with the VLA waveguide indicates that the the continuum component can be subtracted to about 1 part in 300 in general, 1 part in 1000 with considerable work, and 1 part in 10,000 with a great deal of work. These figures may be taken as an indication of the accuracy to which the power spectrum of a signal that has traversed the waveguide is known. How do these figures relate to dynamic range in brightness maps? One would expect analog transmission in the fiber to be better than in the waveguide because the fiber will have direct runs from the antenna to the electronics building without couplers at the stations that cause reflections in the waveguide. What kind of laboratory test could be done to determine whether analog transmission in the fiber is satisfactory? Are there test observations that can be done with the California arrays that would throw light on this problem?

The channelization question is somewhat simpler since it is basically a compromise between instrumental complexity, and the flexibility of the correlator in terms of the number of lines that can be observed simultaneously. The technichal considerations are well known. It was noted that at the last Advisory Committee meeting the block diagram presented showed four IF channels at the correlator input and some people remarked that they would like more. Barry proposed that we adopt a deadline for resolving the channelization, and I suggest the April meeting.

(3) Correlators.

It has been suggested that as many as three correlators should be considered: a general purpose digital correlator with specs. similar to those outlined in the proposal document (p. 142); a special high-resolution correlator (for certain galactic observations) that would have an overall bandwidth of less than 1 MHz; and a wideband continuum correlator. It was generally agreed that the general purpose correlator could be made to handle any high resolution requirements, and so a special high-resolution correlator is not required. Thus the 2 GHz digital correlator is part of the baseline specification of the array, but the broadband continuum correlator can be regarded as an optional enhancement. Some estimate of the cost of the broadband correlator is needed so that is can be weighed against other options.

For the baseline correlator the choice of the FX or lag approach can best be decided by a making a design study, including special chip design, for each of these possibilities. This will be a fairly large task for the development phase. The question of whether the two studies should be done independently or by the same group was briefly discussed.

For the wideband correlator it was noted that the bandwidth is likely to be limited by the correlator itself. The transmission system could probably handle as much as 10 GHz per fiber, i.e. 20 GHz total, using a separate fiber for each polarization. However, 10 GHz is likely to be about the maximum bandwidth for a correlator. To avoid serious bandwidth smearing a 10 GHz correlator would have to be constructed as a series of narrower bandwidth units operating in parallel. The bandwidth of these individual channels would be about 1 GHz. Steve Padin has constructed an analog correlator for Owens Valley. This covers 15 baselines with a bandwidth of 2x1 GHz each [see Padin, S., IEEE trans on Inst. and Meas., 43, 782-5, 1994 (Dec.)]. For 780 baselines and 10 GHz bandwidth, a correlator for the MMA would be 260 times larger than Steve's machine. The possibility of using optical techniques for the cross correlation (but not the transformation to an image) was briefly discussed and did not seem very promising.

Jack Welch pointed out that at millimeter wavelengths the strength of the lines in the spectrum relative to the continuum is much greater than at centimeter wavelengths. Continuum measurements must not be contaminated by line emission. This is another reason for having a number of parallel channels in the continuum correlator, and some independent tunability of these channels would be a nice feature.

(4) Total Power Capability

How many antennas would need to be outfitted for total power measurements? Is a nutating subreflector being considered in the antenna design? (Socorro WG members please check this last point with Peter Napier.) Jack's point about the problem of separating continuum emission from lines also means that the total power measurements must be made with exactly the same filtering as the cross correlation measurements. Thus if the final channelization of the signal is performed in the electronics building, it will be logical to do the total power detection at the same location, with identical filtering, rather than at the antenna. Transmission of the signals to the electronics building will involve ALC, so some form of gain measurement will also be required.

(5) Dates of Meetings

It was agreed that meetings will be held on the first Thursday of each month from 12.30 to 2.00 pm, Eastern time. The next meeting will be on March 2. The call-in number is (804) 984-0622.